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GEM80-400 Series Controllers

Technical Manual

ALSTOM

ALSPA GEM80-400

Series Controllers

Technical Manual

Publication No. T1614
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ALSPA GEM80-400 SERIES CONTROLLERS

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ISSUE INFORMATION

The issue of various chapters of the GEM80-400 manual are individually controlled. The current issue status of the manual is :-

20/01/98	Issue 2	Major revisions to all sections
20/04/99	Issue 3	Inclusion of GEM80-400S Controller and minor corrections to all sections.

SAFETY INSTRUCTIONS

1. General

Electrical equipment represents a risk to life.

Safety instructions are given on the product, in this manual and other relevant manuals referred to in this manual.

Reference must be made to the instructions in this manual for any action taken when transporting, commissioning, operating, maintaining and disposing of the product.

Dangerous voltages appear on the circuitry. There can be moving parts and hot surfaces. Death, severe physical injury and extensive material damage can result if the instructions given in this manual are not observed.

Local safety regulations must be observed during erection, commissioning and maintenance of the product. Persons performing this work must be suitably skilled and should have been trained in that work for these products.

Electrostatic sensitive components are used within this product. Static handling precautions in accordance with Protection of Electrostatic Sensitive Devices, Part 1, General Requirements, EN 100015 Pt.1:1992 (CECC 00015:1992) must be observed.

All products weighing in excess of 20 kg (44 lbs) should be moved by mechanical handling equipment using the lifting points provided.

Radio transmitters (e.g. walkie talkies, mobile telephones) can cause incorrect operation. Transmitters with an output of more than 2 watts must not be used in the vicinity of the product. Transmitters with output power of 2 watts or less must not be used less than 2 metres (6 feet) from the product.

2. Intended use

These products are components designed for incorporation in installations, apparatus and machines.

In the European Union, a machine should not be taken into service until the machine has been proven to conform with the provisions of the Machinery (Safety) Directive, 89/392/EEC as amended.

In the European Union, the requirements of the EMC Directive, 89/336/EEC, and any amendments to that Directive should be established before any installation, apparatus or machine which incorporates the product is taken into service.

The product complies with the requirements of the Low Voltage Directive, 73/23/EEC as amended.

The product complies with the safety and EMC standards listed in the Specifications section of the manual.

The technical data and the information concerning the supply conditions should be taken from the rating plate and this manual, and must be strictly observed.

3. Transportation and storage.

The instructions for storage and transport specified on the packaging and in this manual must be followed.

The climatic conditions should be within the limits specified in this manual.

4. Erection and commissioning.

Erection and commissioning of, and cooling medium flow to, the product should be in accordance with the specifications given in the manual.

Erection and commissioning of the product must be carried out in line with any local electrical installation and wiring standards and IEC 364 or (in the United Kingdom) BS 7671.

The earth terminal must be connected to earth (safety ground) in accordance with local safety regulations and IEC 364-5-54.

The products must be protected against excessive mechanical stresses. In particular, no component must be bent or isolation distances altered during the transportation, handling, installation or maintenance of the product.

The degree of protection provided by the covers is for indoor use only.

Compliance with the requirements of EMC laws is the responsibility of the installer or the manufacturer of the machine. Instructions for erection and commissioning the product in accordance with the EMC requirements of the European Union are given in the manual and must be complied with. These instructions contain information on screening (shielding), earthing (grounding), wiring and relative positioning of electrical equipment.

Shrouds may be modified only as described in the manual.

5. Electrical connection

When working on the product, the local health and safety legislation must be observed.

Conductors, protective devices etc. should be provided in accordance with the requirements stated in the manual.

6. Operation

The product must not be used as a single item safety system. It may be used as a component in a voting safety system. Additional control and protective devices must be provided in accordance with the safety requirements of the installation.

Changes by means of the application software are admissible.

During operation all covers and doors must be closed. If covers are removed and not replaced before power is reapplied there is danger of serious personal injury and damage to property. Your attention is also drawn to the electromagnetic emission and susceptibility screening provided by the enclosure. These may be compromised when covers are removed or enclosure doors are open.

7. Maintenance and service

The information given in the documentation for maintaining and servicing the product must be followed.

8. Disposal

Local regulations must be followed when disposing of the product.

This technical manual should be regarded as part of the product. It should be stored with the product and passed on to any subsequent owner or user of the product.

Any question or doubt should be referred to ALSTOM DRIVES & CONTROLS

CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH

1. GENERAL

Care has been taken with selection of all components, interconnections, housing and packaging and in the design and manufacture of this equipment to minimize the risk to the health and safety of all personnel who are in contact with this equipment during its life, when the equipment is properly handled and used.

Modern high technology materials have been used in the manufacture of the equipment to ensure optimum performance. Some of these materials are toxic under certain conditions. Mechanical or electrical damage is unlikely to give rise to any direct hazard, but toxic vapours may be generated if the materials are heated to destruction and it is important that the recommendations given below are observed.

Care should be taken to ensure that all personnel who may handle, use or dispose of this equipment are aware of the necessary precautions.

2. DISPOSAL

This equipment or any part of the equipment should be disposed of in accordance with the relevant legislation; in the United Kingdom, disposal should therefore be carried out in accordance with the Deposit of Poisonous Waste Act 1972 and the Control of Pollution Act 1974, or with the latest legislation.

Some devices within this equipment may contain beryllium oxide as an isolating barrier. Such devices must be disposed of as harmful waste.

3. FIRE

The products when used within the specified limits do not present a fire hazard.

Electronic devices within this equipment may contain arsenic, beryllium, lead, mercury, selenium, tellurium or similar hazardous materials or compounds which, if exposed to high temperature may emit toxic or noxious fumes.

Most device encapsulation materials are flammable and care should be taken in the disposal of the equipment, and, in the event of a fire, the handling of damaged equipment. Toxic fumes may be emitted if the devices are burned.

4. HANDLING

Normal handling of the equipment is safe. However, care must be exercised with those devices incorporating glass or plastic. If these devices are broken or damaged, precautions must be taken against the hazards that may arise.

For broken glass or ceramic protective clothing such as gloves must be worn. For toxic materials, vapour, skin contact and inhalation must be avoided.

5. SUBSTANCES

Substances that may be included in this equipment are:-

Arsenic
Boric acid
Ethylene Glycol
Phosphoric acid
Phthalic acid
Tributylamine
Triethylamine

Certain substances such as those containing arsenic, indium, lead, lithium, selenium, tantalum, etc. may be toxic by ingestion or inhalation.

Electrolytic capacitors contain a non carcinogenic electrolyte which has a low acute toxicity which may cause slight irritation to the skin if contact is prolonged.

6. HAZARDOUS COMPONENTS

Components that may include hazardous substances are:-

Batteries	Lithium
Optical Devices	Arsenic
Electrolytic capacitors	Electrolyte.
All encapsulated Devices	Plastic (generates an inhalation risk in a fire).

7. PRECAUTIONS

Precautions to be followed in the event of damage to the equipment except where special precautions to be followed are listed above, include:-

After skin contact	-	wash thoroughly with soap and water. If contact is where the skin is broken, medical advice should be sought.
After eye contact	-	wash immediately with copious amounts of water and seek medical advice.
After inhalation	-	seek medical advice.

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Product Overview

1. Introduction

This section of the manual is mainly intended for the user who is familiar with previous GEM80 controllers, and only highlights features new to the GEM80-400 . Please refer to the relevant sections of this manual for more complete and detailed information.

The GEM 80-400 Standard Controller and the GEM80-400 Enhanced Controller have extended the already rich functionality of the existing GEM 80 controller series by offering a number of new features, each of which has been added with the aim of making the overall controller smaller, more cost effective and easier to use.

2. GEM 80-400 Series Controller Facilities

2.1. Serial Links

The controller has three physical serial ports, one of which is used as the main "programming port" but may also be used to connect to a printer or other similar device.

All three serial ports are galvanically isolated from the GEM80-400 and may be directly connected to plant equipment via the front panel mounted, industry standard, D-types, and do not require termination panels. All the serial port connectors are provided with plant connector retention facilities.

The two general purpose serial ports provide RS232 and RS485 signal levels, and the Printer/Programming Port produces 20mA and RS232 signal levels. RS232 level CTS and RTS signals are provided by all ports.

Each of these serial ports has a pair of visual line activity indicators, one monitoring the receive line and one monitoring the transmit line. This facilitates fault finding and commissioning of the serial links.

The general purpose serial link ports can now communicate with up to 100 GEMSTART CCUs each, as opposed to the 64 allowed on previous controllers.

2.2. Real Time Clock

The GEM 80-400 Processor Module has an integral Real Time Clock device that continues to function during power supply interruptions, provided a battery is fitted.

The time and date may be read and written via the E-tables from the Data List screen of a suitable GEM80 programming tool. The clock E-tables are read-only when accessed directly by the ladder program, however they can be written to

indirectly using the CLOCK special function, S55. The Real Time Clock is Year 2000 compliant

2.3. RAM

The GEM80-400 Processor Module provides as standard:

- RAM to store and execute a 20000 instruction user Ladder program +
- RAM to provide up to 30000 data tables +
- RAM to store up to 30000 bytes of User Messages (P-table messages).
- RAM to store up to 64K of IMAGEM formats (4 IMAGEM pages)

The user messages are stored in an area of on-board RAM separate to the data tables, in order to provide more data table space to the user program., and to avoid the complication in the User Programme caused by storing user messages in Off - Line memory. Otherwise the user messages may be created, used, saved and loaded in the same way as the GEM80/160, GEM80/310 and GEM80-400 Controllers..

The GEM80-400 Processor Module also provides 64K (4 IMAGEM pages) of IMAGEM format storage RAM which will allow IMAGEM applications to be used for smaller graphics applications without the need to purchase additional RAM modules. This saves expenditure and space.

2.4. Input Output Systems

All GEM80-400 Series Controllers allow some I/O to be used in the controller subrack.

2.4.1. Basic and Verification I/O

The GEM80-400 Controller provides 256 bits of Basic I/O and up to 1024 words of Verification I/O. Verification I/O Expander Modules may be used to provide additional Basic I/O capacity.

The Basic I/O addresses supplied directly by the controller (as opposed to via Verification I/O Expanders) are set to addresses A/B0 to A/B15. A/B addresses above these are used to access Verification I/O Modules or Basic I/O Modules via Verification I/O Expanders.

Faults detected during transfers to and from Basic and Verification I/O Modules will set bits in the F-tables and do not automatically trip the controller. This allows the user program to determine if a particular transfer fault is critical to the application and if necessary to shut down in an orderly fashion.

2.4.2. Fast I/O

The GEM80-400S version of the controller provided five slots of Fast I/O in place of the Basic or verification I/O modules. One of these slots is dedicated to the Fast I/O Driver so that four slots are available for Fast I/O Modules. No further extension of the fast I/O capacity is possible with the 400S version. If more than four Fast I/O Modules are required then the GEM80-400 Enhanced Controller must be used and additional Fast I/O subracks fitted.

3. Additional User Programming Facilities

3.1. Ladder Diagram Enhancements.

The GEM 80-400 Series Controllers provide several additional GEM80 Ladder Diagram Instructions and Special Functions that are all aimed at reducing the overall complexity and instruction count of a given user application program.

Symbol	Instruction	Comment
Coil_1 --(S)-- G0.1	Set Coil Rung input <> 0 then Bit =1 Rung input = 0 then Bit unchanged	Can be used wherever a coil ----()-- can be used.
Coil_1 --(R)-- G0.1	Reset Coil Rung input <> 0 then Bit = 0 Rung input = 0 then Bit unchanged	Can be used wherever a coil ----()-- can be used.
LABEL- 10	Label Identifies position 10 in the ladder user program.	Can be jumped to with a JUMP instruction
-- JUMP- 10	Jump Start executing next rung after LABEL 10.	Only jumps to rungs later in the program are permitted.
SE01/1 --[SQ]- W100	Sequence Element.	See Chapter 2

Special Function Number	Mnemonic	Description
S125	TON	Timer with on delay
S126	TOFF	Timer with Off delay
S127	TP	Timer with Pulse output
S128	TOGGLE	Toggle Flip Flop
S129	ONESHOT	One-Shot: on for one scan
T111	SEQGRP	Sequence Group Control
T112	SR	Set Reset Flip Flop
T113	RS	Reset Set Flip Flop

3.2. Rack Id

During the power up sequence the GEM80-400 Processor Module copies from the Rack Id switches to the Rack Id V-table. The user may define this value by setting the 2 decade rotary switches mounted on either the GEM80-400 Processor Module or, in the case of the GEM80-400 Enhanced Controller, on the backplane of the controller subrack.

The rack Id V-table may be read by the user program to determine, for example, if the user program is executing in the system it was intended for, or used to tailor user generated report messages with system location information.

3.3. GEM80-400 Alphanumeric Display

Any non zero value written to "F1" by the user program to activate a User Requested Watchdog Trip is also written to the four-character front panel mounted alphanumeric display. This allows an application program to provide visible diagnostic information to the system operator or maintenance engineers. Application error numbers are prefixed with a "!" and system error numbers are prefixed with a "#".

3.4. System Log

The controller maintains a battery backed and time stamped log of the last 100 system events. Programming errors detected by the compiler, during an attempted compilation of a user program, are also recorded in the System Log.

The errors may be displayed at the same time as the user program (providing a suitable GEM80 programming tool is being used, such as Gemesys 3), as an aid to fault finding. Each compilation error contains a rung and instruction reference. See also paragraph 7.4 of this section

3.5. Architecture Improvements

Both the software and hardware architecture of the GEM 80-400 have been significantly improved (with respect to previous GEM80 controllers). Amongst the large number of performance enhancing improvements included in the GEM80-400 systems are:

- the use of a faster processor,
- storing the data required to execute a ladder program in the faster on-board RAM,
- reducing the system overheads,
- allocating the time assigned to the operation of the processor module self checks to be a percentage of the user program scan time.

4. Expandability and Adaptability

4.1. User Program Storage Capacity

The user program storage capability of the GEM 80-400 Processor Module may be expanded from 20000 to 40,000 ladder instructions by attaching an optional RAM sub-module. This sub-module is fitted directly to the GEM80-400 Processor Module and does not require any additional rack space.

4.2. User Program Storage in EPROM

The user program source, P-tables and user messages may be stored in EPROM by fitting a FLASH EPROM sub-module. This sub-module is fitted directly to the GEM80-400 Processor Module in the same way as the RAM sub-module and does not require any additional rack space.

The use of an EPROM sub-module, once successfully programmed, allows the system to be used without a battery fitted, thus reducing maintenance.

The user program may be quickly transferred to and from EPROM by issuing a simple command from the programming tool.

4.3. I/O Modules

I/O Subracks to contain the Basic and Verification I/O Modules may be mounted either underneath the controller subrack or in a separate cubical (subject to certain distance and cabling restrictions).

The GEM 80-400 Processor Module provides one ribbon connection for Basic I/O and one ribbon connection for Verification I/O. Verification I/O addresses may be converted to Basic I/O addresses by using I/O subrack mounted Verification Expander Modules.

4.4. FIP

The GEM 80-400 Processor module has an inherent but optional FIP communication ability. FIP is a high speed data distribution and collation local area network that supports a dual redundant media and a maximum of 255 nodes. (See the GEM 80-400 FIP Interface User Information sheet for more information.)

5. GEM 80-400S and 400 Enhanced System Specific Features

5.1. Central Highway

The GEM 80-400S Controller provides space for up to 5 single width Central Highway Modules to be fitted in the controller subrack, and is compatible with the following modules:

8268-410x	STARNET Module	single width
8284-400x	IMAGEM Graphics Display Module.	single width
8272-4004	256K RAM Module (without arbiter)	single width
8279-400x	GEMLAN-D Module	double width

Each slot will accept any of the modules listed above

The RAM cards are used to provide either Off-line storage memory, or additional IMAGEM format storage RAM.

By placing the Central Highway Modules in the appropriate slots, most system configurations can be catered for. This feature gives the user the ability to enhance a system without the need to modify or add backplanes.

Should a need arise for a system that cannot be catered for using the factory pre-set configuration, systems may be rapidly tailored to an individual user's requirement.

The GEM80-400 Enhanced Controller also has five central highway slots which can utilise any of the above modules. In addition, if Fast I/O capability is required a Fast I/O Driver module 8300-4003 may be fitted. In this case the slot position is fixed and the 8300-4003 must be fitted to the slot on the immediate right of the GEM80-400 Processor Module.

5.2. IMAGEM CRT Monitor Frequency Selection

The 8284-400x IMAGEM Graphics Display Module has been improved and now produces the higher frequency video signals that are used by readily available high quality video monitors. However, the 8284 may be configured to use the same monitors as the 8219 IMAGEM Module by placing a jumper or wire-link between the pair of wire wrap posts associated with the slot or slots containing the 8284-400xs. These wire wrap posts are accessible once the power supply module has been removed.

5.3. Fast I/O capability

The Fast I/O Modules are accessed in the normal way via C- and D-tables. Status linking is not provided.

5.3.1. Fast I/O with GEM80/400S Controllers

Fast I/O modules may be used within the GEM80-400S system by fitting a 8300-4003 Fast I/O Driver Module in the controller subrack, and adding the Fast I/O modules together with their appropriate connectors in the four Fast I/O slots available.

Where the Fast I/O Modules require a -15V supply then this must be provided by means of a separate power supply. See Chapter 6 for details.

5.3.2. Fast I/O with GEM80-400 Enhanced Controllers

Fast I/O Modules may be used within a GEM80-400 Enhanced system by moving the coding plug for slot 1 from the Central Highway position to the Fast I/O position, fitting a 8300-4003 Fast I/O Driver Module in the controller subrack, and connecting the controller subrack to Fast I/O Subracks using the 50-way ribbon cable connector mounted on the rear of the GEM80-400 Enhanced Controller Backplane.

The Fast I/O Modules are accessed in the normal way via C- and D-tables. Status linking is not provided.

6. Compatibility

6.1. I/O

The GEM 80-400 Processor Module is compatible with:

- All Basic I/O Modules (excluding the block I/O)
- All Verification I/O Modules
- Verification I/O Expanders
- Verification Remote I/O
- GEMSMART I/O
- GEMSTART CCU
- ESP (all variants)
 - All Fast I/O Modules

6.2. User Program

The GEM 80-400 Series Ladder Diagram Programming Language incorporates all of the features that the normal GEM 80/131, GEM 80/16x, GEM 80/3xx Controllers possess, and has an instruction capacity that should allow most user application programs to be ported with little or no difficulty

In general, the following points should be considered when porting user application programs:

- P-table layout. (The layout closely matches that of the GEM 80/131.)
- Relying on the I/O transfer failure to automatically shut down the controller.
- The use of undocumented V-table 'Features'.
- Timing dependent upon the controllers free running scan time.
- 131 user programs that use the "DELAY" instruction may need the associated VALUE parameter dividing by 10.
- Q-tables are reserved for floating point operations and should not be used for general workspace.
- Any user programs that expect Verification I/O Modules at A/B 0 to A/B15.

7. Maintenance and Installation Cost Reduction Features

7.1. System Level Considerations

The major hardware components of the previous GEM 80 controllers have been combined onto a single module. This saves a considerable amount of space in the controller subrack, simplifies ordering and reduces site spares stock.

The space made available may be used for up to 8 I/O modules, in the case of the GEM 80-400 Standard Controller and up to 5 Central highway Modules in the case of the GEM 80-400 Enhanced Controller. This should help to reduce the number of I/O Subracks required and reduce the installation cost for smaller systems.

The serial links should be easier to commission and maintain as each serial link, including the Printer/Programming Port, has a dedicated pair of line activity indicators. The serial link statistics have also been improved and now provide more specific error information to the user.

The plant serial links may be connected directly to the processor module's front panel or via a readily available passive termination rail. RS232 and RS485 level serial port signals remove the need to use active termination panels, thus reducing maintenance, installation space requirements and cost.

Access to all of the controller, plant and wiring may be made from the front of the module. No access is required to the rear of the host rack when commissioning the GEM80-400 module. This should once again reduce installation and maintenance costs.

7.2. Spares

The GEM80-400 Processor Module will accept the 20K byte variants of the RAM and EPROM sub-modules used by the GEM80/131.

Spare GEM80-400 Processor Modules for sites with a mix of Standard and Enhanced Controllers may be supported by stocking the GEM80-400 Processor Module for the Enhanced Controller, which may be easily converted to a Standard Controller Processor Module by removing its screening panel.

The processor module's battery is the same type as that used on the GEM80/131 and is readily available from third parties.

The GEM80/160 Series Controllers will accept the same versions of IMAGEM, STARNET, GEMLAN-D and RAM Modules as the GEM80-400 Controllers.

7.3. Alphanumeric Display

The GEM80-400 Processor Module has a four-character alphanumeric display mounted on the front panel. This is used to provide a local visual indication of the state of the controller and reduces the need to use a programming tool for routine maintenance.

The use of the "!" and "#" prefixes to identify user program detected errors and system errors respectively, and the use of TEXT messages to identify the system state should make it easy to rapidly identify the source of a particular problem without needing to find and connect a GEM80 programming tool. This should both reduce plant downtime and improve fault reporting.

Errors detected by the user program may be output to the display by writing a user supplied three digit decimal error code to F1 which will also cause a user requested watchdog trip. Values greater than 999 will be displayed as "!!!!".

7.4. System Log

The new System Log function records and time-stamps the last 100 system events. These events are stored in the GEM 80-400 Processor Module's battery backed memory, the time being provided by the integral real time clock.

System events include: Power on, power off, resetting of the real time clock, clearing of the fault log, system error messages, system information messages, and compilation error messages.

The contents of the System Log may be displayed, saved to a file, printed and cleared by issuing a simple command from a suitable GEM80 programming tool, such as Gemesys 3.

The System Log is of assistance during the program development and modification phases, as explained above, and during the normal operation of the system as it provides the opportunity to maximise the plant run time without losing vital diagnostic information that can now be investigated at a more convenient time.

See also paragraph 3.4 of this section

7.5. Key Switch

A security key switch is mounted on the front panel of the GEM 80-400 Processor Module. The Key Switch governs the controller's mode of operation and has three positions labelled as HALT, PROG and NORMAL.

Note...In order to get the controller running, in addition to setting the Key Switch to PROG or NORMAL, a suitable GEM 80 programming tool will be required, to issue the run command.

HALT

When the Key Switch is moved to the HALT position, the controller will enter the halted state and reject any subsequent instructions to run. If the controller was running when the switch was moved to HALT, a message to this effect is put in to the System Log.

PROG

With the Key Switch in the PROG position, all functions of the controller are available. This position is intended to be used for commissioning and maintenance of the user program.

NORMAL

As the name implies, this is the position that is suggested for the normal use of the system. With the Key Switch in this position, the controller will prevent any modification, via the programming ports, of the user program and data tables (except M-tables). The controller will still accept Halt and Run commands, and allow the user program to be archived and monitored.

The Key Switch has the additional use of being able to reset the remote programming edit lock. This feature is activated by moving the Key Switch from PROG to HALT or NORMAL, and then returning it to the PROG position.

The Key Switch provides a mechanism, to help prevent a person remote to the controlled machine accidentally causing the controlled machine to be operated in an unsafe way, but must never be considered a substitute for hardwired interlocks and other normal safety precautions.

All GEM80-400 controllers have the same key pattern and it is the responsibility of the user to police the use of the keys.

7.6. Battery

The GEM 80-400 Processor Module and central highway RAM Modules maintain the user program and data when the system power is unavailable.

The battery used by the controller may be replaced while the system is active. It is mounted by a clip, behind the front panel of the module.

Note that batteries must be replaced while the module is powered in order to prevent data corruption.

The GEM 80-400 controller will produce a battery low warning when the battery is within 3 weeks of the end of its useful life.

This battery low warning is delivered by flashing the word 'BATT' on the GEM 80-400 Processor Module's front panel alphanumeric display, and setting the associated flags in the F-table.

The user program can test the battery warning flags and could, via the application program and communication hardware, request that the battery be renewed.

A GEM80-400 system may be configured to operate without a battery by using EPROM sub-modules.

A system with a valid user program in EPROM and without a battery (or fitted with a dead battery) will normally default to the halt state at power up and will require an explicit run command to run the user program. However the default power up state may be set to "RUN" by setting the Mode Switch to the NORMAL position, and setting the switch on the GEM 80-400 Processor's EPROM sub-module to the "protect" position. This mode of operation has been included to allow automatic start up of "maintenance free" remote systems and should be used with extreme caution.

The user program, in an EPROM system without a battery, must assume that all data tables apart from the P-tables will be cleared at power up.

7.7. Controller Firmware Update.

The executive code or "Firmware" that provides the GEM80-400 Processor Module with its characteristic functionality is stored in FLASH EPROM and may be updated by the user on site using a user friendly, DOS based, PC compatible, firmware update utility. (See Chapter 9 - Maintenance and Fault Finding.)

This firmware update utility communicates with the GEM80-400 front panel programming port in the same way as a PC based GEM80 programming tool and will normally be able to use the same serial link connection lead.

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1. Introduction

1.1. Manual Overview

This manual describes the operation, installation and maintenance of the GEM 80-400 Series Controllers. It is intended to be used by qualified Technical Personnel engaged in operating and maintaining plant that is controlled by GEM 80 equipment. The subjects covered by the chapters of this manual are detailed below:

1.1.1. Chapter 1 - Introduction

This chapter gives a general description of the GEM 80-400 Standard and Enhanced Controllers. A typical system layout is detailed and all the components are described. Also included are controller specifications and environmental, handling and storage requirements together with safety information.

1.1.2. Chapter 2 - Controller Architecture and Program Operation

This chapter gives brief details of the internal architecture and operation of the controller. The GEM 80 Instructions and Special Functions Set, and the use of data tables are also given.

1.1.3. Chapter 3 - I/O Highway

This chapter describes the I/O highway used in the controller, and details the I/O module addressing techniques and the installation of I/O modules.

1.1.4. Chapter 4 - Communications

Data communication from the GEM80-400 Processor Module to other controllers and to intelligent devices, such as printers, is covered in this chapter. The built-in communication methods (using the ESP protocol) are described; Point-to-Point and Multi-drop. Full details of configuring the communication ports are given; communication with GEMSTART CCU (Contactor Control Unit) and Starnet is also explained.

1.1.5. Chapter 5 - Central Highway Modules

The GEM80-400S and 400 Enhanced Controllers can accommodate many combinations of Central highway Modules including IMAGEM, STARNET, GEMLAN-D RAM and a Fast I/O Driver. Details of these modules and their

interconnections are shown in this chapter. The GEM80/400S controller accommodates fast I/O modules in the controller subrack and the 400 Enhanced controller can accommodate them in additional Fast I/O subracks. The details are given in this chapter

1.1.6. Chapter 6 - Power Supplies

This chapter provides full details of the modules used in the controller Subracks and those used in Fast I/O Subracks. Also described is the method of allocating power to the controller modules

1.1.7. Chapter 7 - Installation

Detailed instructions are given here for the installation of the controller.

1.1.8. Chapter 8 - Commissioning

This chapter describes how the GEM 80-400 Controller is prepared for use once it has been installed.

1.1.9. Chapter 9 - Maintenance and Fault Finding

Here general cleaning and inspection procedures are described in addition to lists of the Error Messages that can be generated by the GEM 80-400 Series Controllers. Fault table information and serial link statistics are also given in this chapter.

1.1.10. Chapter 10 - Spares and Reorder Codes

This chapter lists the ordering codes for Subracks, modules, optional extras and spares: in addition, the names of battery suppliers are also given.

1.1.11. Chapter 11 - Watchdog and Safety Circuits

This chapter details the safety features, such as earth connections, emergency stops and watchdog circuitry, which users must be aware of and incorporate into their system.

1.2. General Information

A Programmable Logic Controller (PLC) is a solid state electronic device, designed to interact with the industrial environment. It employs an easily programmable memory for the internal storage of instructions. These instructions can implement many functions including relay replacement, logic, arithmetic and data manipulation. These functions control machines and processes via the

controller's analogue or digital input/output modules that interface with either locally or remotely located plant equipment.

GEM80 controllers have been successfully installed in many countries, in industries as diverse as Automotive, Mining, Electricity Generation, Water Treatment, Food, Oil, Gas and Steel.

A typical GEM80-400 controlled system can be detailed as follows. The controller communicates with system and plant components in a variety of ways including ribbon cable highways, serial communication links and programming tool connection ports. Communication to the user is via a four-character alphanumeric display. Safety in a fault situation is provided by the watchdog contacts; the three-position halt, prog, run Mode Switch provides added security.

To make a working system it is necessary to:

- (1) Select a controller.
- (2) Select I/O equipment.
- (3) Select Central Highway Modules (applicable to Enhanced Controllers only)
- (4) Mount and wire the equipment and connect plant services and output devices to I/O.
- (5) Hard-wire watchdog and safety circuits.
- (6) Connect a suitable GEM80 programming tool, such as Gemesys 3, and enter a program.

This manual details how such a system can be achieved. Before handling GEM80 equipment your attention is drawn to the sections detailing 'Handling Precautions for Printed Circuit Boards' and 'Safety and Handling Information', later in this chapter.

1.3. GEM80-400 Series Controller

The GEM80-400 Series Controller, which currently consists of the Standard and Enhanced models, is a medium/large powerful PLC which is designed to control and monitor processes and machinery for complex industrial plant applications.

The GEM80-400 Controller is compatible with other controllers in the GEM80 range, utilising the same I/O structure and a modified version of the existing control language. They may be programmed via a suitable GEM80 programming tool, such as Gemesys 3, using the GEM80 Ladder Diagram Programming Language. The controller communicates with external devices via a number of I/O modules accommodating both Basic and Verification I/O, and can be configured to suit a wide variety of applications.

The GEM80-400 Controller can handle extensive digital and analogue control, in addition to report generation. The flexible structure allows interface to a variety of plant equipment while the extended GEM80 Instructions and Special Functions Set covers most requirements.

In large distributed systems, the availability of several multi-drop serial links makes the system ideally suited for centrally supervised or co-ordinated operations.

As can be seen from the Specification, later in this chapter, the GEM 80-400 Controller provides considerable memorysize and I/O capacity.

Figures 1.1 and 1.2 and 1.2A illustrate the GEM80-400 Standard Controller the GEM80/400S Controller and GEM80-400 EnhancedController respectively

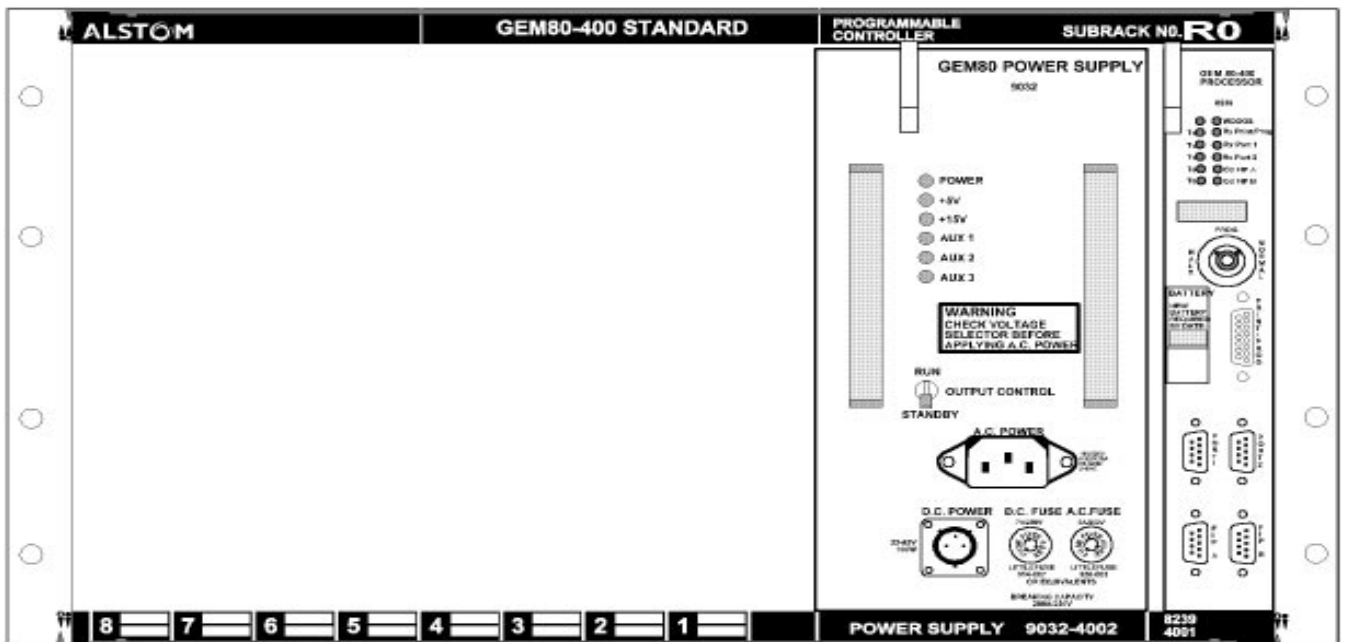


Figure 1.1 -GEM80-400 Standard Controller.

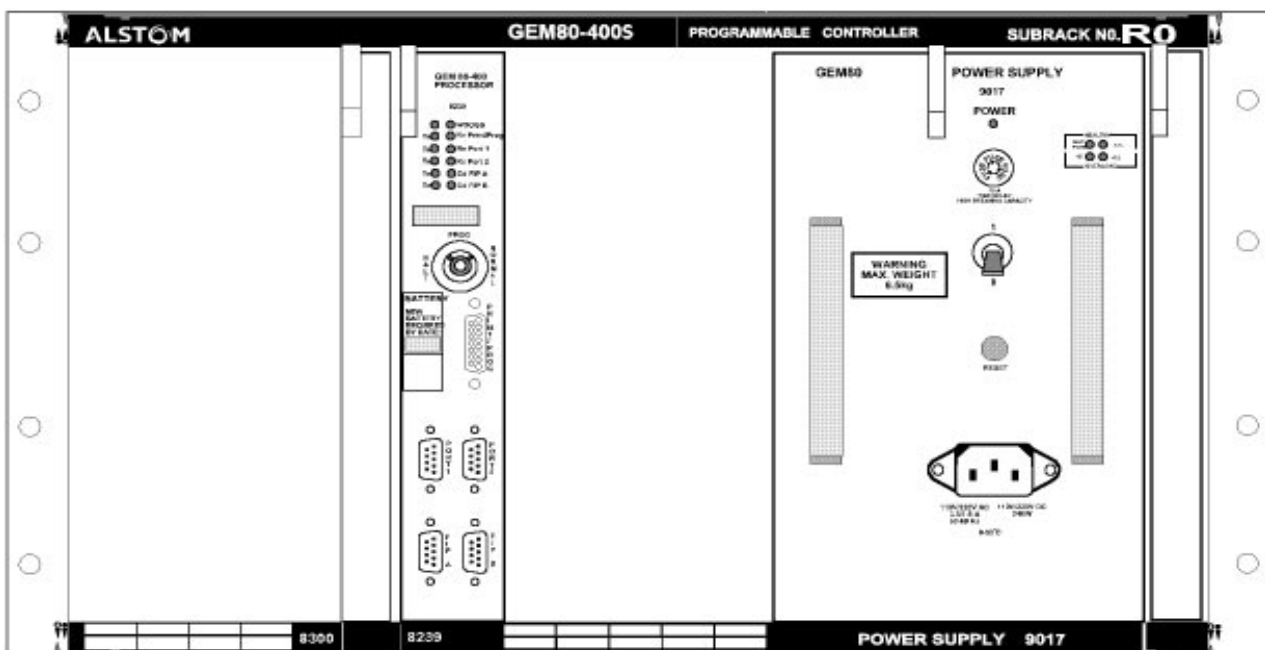


Figure 1.2 GEM80 - 400S Controller

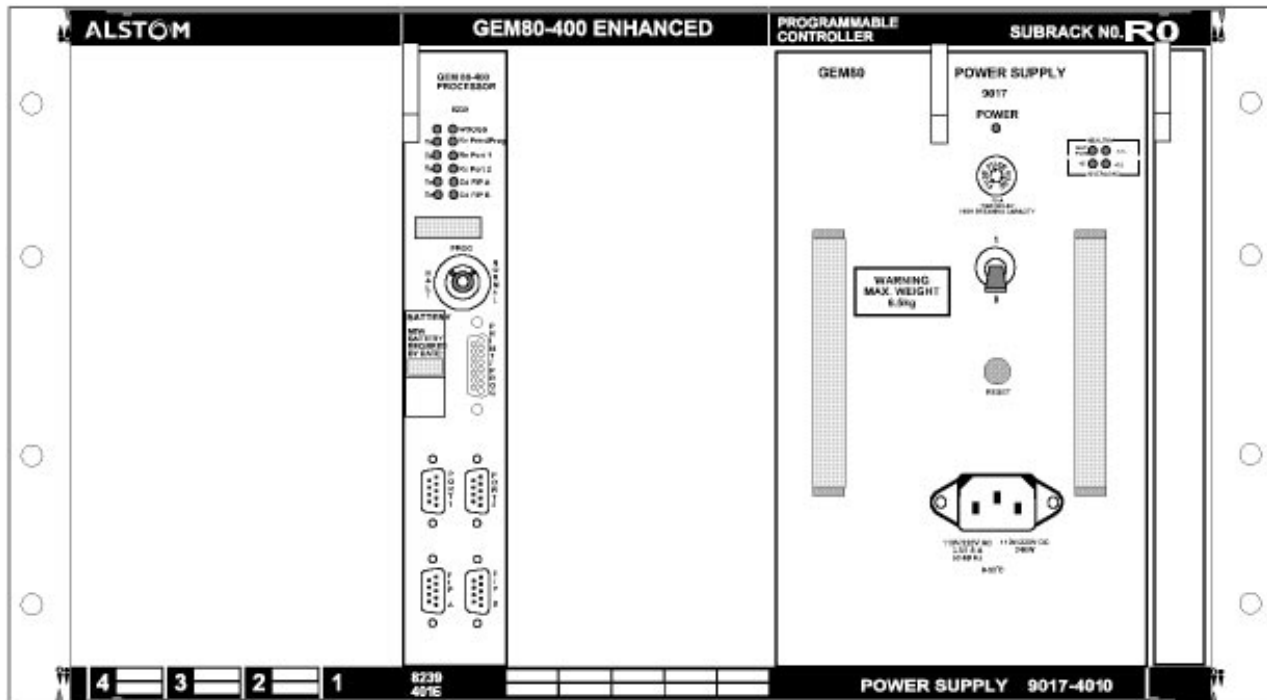


Figure 1.2A GEM80-400 Enhanced Controller

It should be noted that the GEM 80-400 Enhanced Controller may be fitted with either a 9017 or 9018 Power Supply Module. In this example, a 9017 Power Supply Module is illustrated. Note different versions have slightly different front panels

Throughout the remainder of this manual, the details given can be assumed to apply to both GEM 80-400 Controllers, Standard and Enhanced, unless otherwise stated or inferred. Hence, for clarity, the terms 'Standard' and 'Enhanced' will be omitted from non-specific text relating to the controllers; 'GEM 80-400 Controller' will be adopted as the general title.

1.4. GEM 80-400 Controller System

The GEM 80-400 Controller, together with its power supply (Standard - 9032, 400S - 9017, Enhanced - 9017 or 9018) and backplane assembly, is housed in a single 19 inch subrack. This subrack can also accommodate up to eight Basic and Verification I/O Modules for the Standard Controller, up to four Basic and Verification I/O Modules for the Enhanced Controller or up to four Fast I/O Modules for the 400S controller. In addition, the 400S and Enhanced Controllers can house almost any combination of Central Highway Modules and RAM Modules in the remaining five slots.

Extra I/O modules, together with any power supplies, may be accommodated in additional I/O Subracks which are connected to the GEM 80-400 Controller through the I/O highway. There are also two GEM 80 RS485/232 Serial Communications Ports, (which may be used to connect to other GEM 80 controllers and to communicate with system and plant components), an RS232/20mA Printer/Programming Connection Port and two FIP Communication Ports.

As a safety measure, two pairs of watchdog relays are fitted to the backplane. These watchdogs open in the event of a detected controller failure. Refer to Chapter 11 of this manual for further details.

1.4.1. Processor Module

The 8239 Processor Module is used to handle all I/O highway communication, serial communication and to run the control program and the ladder compilation.

The processor module houses the memory required for program and data storage, and its associated memory together with serial communication, I/O and suitable programming interfaces. The standard memory can be increased by adding a plug-in memory expansion board to the main system board. A battery is fitted to the module so that the contents of RAM and the integral real time clock are retained when the mains power supply is switched off. Expansion board memory is battery backed while plugged into the module.

The front panel of the processor module carries the connectors for the two Serial Communications Ports, the two FIP Communication Ports and the Printer/Programming Connection Port. The access cover for the memory support battery is also located on the front panel. Twelve LED's are positioned on the front panel; two green LED's indicate the status of the watchdog, while ten yellow LED's provide five pairs of outgoing and incoming serial communication and FIP network connection indicators.

The front panel also houses a three-position key switch, providing halt, program and normal positions; this is an aid to security and safety, and protection against external program corruption. A four-character alphanumeric display provides improved diagnostics, imparting information such as controller status and faults to the user.

1.4.2. Power Supply

The power supply module provides the power required for all of the modules contained in the controller subrack, including the basic and verification I/O modules. A limited power capacity may be available for consumption elsewhere in the system, e.g. additional I/O modules in an I/O subrack. However, if the power requirement of any additional I/O modules exceeds the available remaining current, further power supply modules will be required. In the case of a 400S or Enhanced system incorporating a Fast I/O Driver, additional Fast I/O Modules always require additional power supplies to be fitted. See chapter 7 for details

1.4.3. Backplanes

The Backplane assembly is a PCB (printed circuit board) which carries connectors and the associated circuitry for the processor module and the power supply module. The I/O highway is extended on to the backplane that is fitted with one Basic and one Verification I/O ribbon connector. The backplane also carries a terminal block for various external connections, e.g. watchdog circuits and auxiliary outputs from the power supply.

1.4.4. Basic and Verification I/O Highways

The Basic and Verification Input/ Output Highways are medium speed, parallel, digital highways used for transferring data between the controller and I/O modules or Operator Input Units. Physically, these highways consist of 26-way ribbon cables which can be up to 30 metres long, although loading restrictions apply beyond 10 metres.

The Basic and Verification I/O Modules are designed for connecting to such devices as push-buttons, relays, lamps, solenoids, interlocks and limit switches. They provide an interface between the controller circuits and plant-side circuits.

The Operator Interface Units comprise LCD units, thumb-wheel switches, etc., which allow operators to input control commands to GEM 80 controllers and to monitor plant status.

Full details of Basic and Verification I/O Modules and Operator Interface Units are given in the relevant Product Data Sheets. Further information is also available in Chapter 3 of this manual.

1.4.5. Serial Communication Links

Communication to GEM 80-400 Controllers and other peripherals, such as printers, keyboards and other controllers, is most commonly achieved by using the GEM 80 ESP (Extended Simple Protocol); other protocols are available. Further details can be found in Chapter 4 of this manual and in the 'Serial Communications Manual', Publication No.T457.

1.4.6. Printer/Programming Connection Port

A Printer/Programming Connection Port is provided on the front of the processor module. A suitable GEM 80 programming tool, such as Gemesys 3, can load, dump or edit ladder programs via this connection, or a printer can be connected directly to the controller.

1.4.7. Watchdog Contacts

Watchdog circuits and relay contacts provide a means of disconnecting the plant from the controller and any I/O Subracks, hence shutting down the plant in the event of a serious problem in either the plant or the controller. (See Chapter 11 for more details).

1.4.8. Fast I/O Driver

There is a wide choice of equipment for connection to the Fast I/O Driver. Applications utilising the GEM 80-400 Enhanced Controller fall into the following categories:

- (1) Analogue I/O
- (2) Counter Inputs
- (3) Extra Serial Communications Ports (Programmable Serial Communications 8847 allows data exchanges with almost any other mini, micro or mainframe computer)

Full details are given in the relevant GEM 80 Product Data Sheets and User Information Sheets. The incorporation of a Fast I/O Driver within one of the slots in a 400S or Enhanced Controller is described in Chapter 5 of this manual.

1.4.9. Video Processor Outputs

Plant video monitors can be connected to GEM 80-400 Enhanced Controllers if an IMAGEM Module is fitted in to one of the five Central Highway slots of the controller subrack. This enables alarms, plant mimics and interactive operator controls to be displayed in colour. A video program port is provided on the front of the IMAGEM Module thus enabling a suitable GEM 80 programming tool, such as Gemesys 3, to program the Video. Further details are available in the relevant IMAGEM Technical Publications, and Chapter 5 of this manual.

1.4.10. Additional Facilities

- On-line program changes.
- Remote programming from serial links.
- Built-in text editor for generation of printer port messages.
- Flexible data table sizes.
- Battery-backed, integral, real time clock for time and date.
- Comprehensive monitoring supported by diagnostic messages.
- Transfer of user program and preset data to FLASH EPROM.
- Floating-point mathematics including trigonometric, logarithmic and exponential functions.
- Large range of built-in, pre-written software routines, now extended to provide additional facilities.
- Plug-in RAM boards for memory extension.
- System Log.
- Multiple combinations of Central Highway Modules and RAM modules in Enhanced system.
- Firmware update using FLASH EPROM.

1.5. GEM 80-400 Controller System

1.5.1. Subrack Assembly

1.5.1.1. Mechanical Structure

The Subrack is manufactured from flame retardant, polycarbonate resin material with flame resistance to UL94-V0; it is delivered fully assembled. Integral guides provide slots for module insertion and a slot selection strip ensures that only the slots relevant to the application are used. Reference should be made to individual instruction sheets supplied with the equipment. Unused slots have single or double blanking panels fitted, as appropriate. See Chapter 10 of this manual for ordering codes.

A retention mechanism has been built into the subrack to provide module security in high shock or vibration applications. This consists of two sliders which pass through notches cut into the upper and lower edges of the PCBs. Pointers at each end of the sliders indicate whether the modules are locked '●' or unlocked '○'. When the controller is being used, these sliders should be left in the locked position.

Not all previously supplied modules are mechanically compatible with the moulded subrack; any queries about compatibility should be referred to GEM 80 Customer Support or your local representative.

The subrack has been designed to facilitate either front or rear mounting, details of which are contained in Chapter 7 of this manual.

The subrack, containing the processor module, the power supply module, the I/O modules and, in the case of an Enhanced system, any Central Highway Modules, is referred to as the 'controller subrack'. I/O modules and additional power supply modules require mounting in a separate subrack that is referred to as the 'I/O subrack'.

1.5.1.2. Controller Subrack Labelling

A label indicating the controller model (GEM 80-400 Standard or GEM 80-400 Enhanced) and the subrack reference number (R0 for a controller subrack, usually R1 or R2 for an I/O subrack) is fitted into the upper rail of the subrack. The lower rail holds a label that indicates the power supply and processor module type numbers, in addition to enumerating the I/O module slot positions. The lower rail label of the GEM 80-400 Enhanced Controller identifies also the five Central Highway slots. Module address references are marked on the lower rail label by the user. The user should mark module reorder numbers, with a proprietary marking pen, in the space provided on this label.

A Switch Setting Label is fitted on the inside of the right-hand side cheek of the subrack. Refer to Chapter 7 of this manual for details of marking this label.

1.5.1.3. Fitting Controller Modules

Before installing or changing any modules, ensure that the power supply to the host subrack is switched off.

Each module occupies one slot position and modules are inserted from the front of the subrack. Care should be taken to ensure that the module slides directly down the allocated slots and enter the backplane connectors with the minimum of force.

Modules are withdrawn by disengaging the sliders and operating the ejection handle to release the connectors. The module can then be pulled along the slots and lifted clear of the subrack.

1.6. GEM 80-400 Controller Modules Description

1.6.1. 8239 Processor Module

The 8239 Processor Module is shown in Figure 1.3. Details of the processor module can be found in Chapter 2 of this manual.

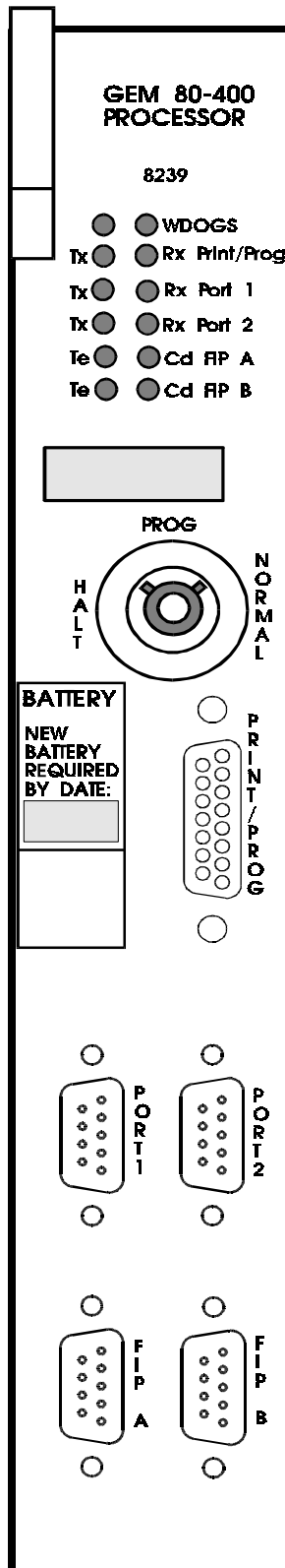


Figure 1.3 - 8239 Processor Module

1.7. 9032 Power Supply

The 9032 Power Supply Module is illustrated in Figure 1.4; this module is used specifically with the Standard Controller. It should be noted that the 9032 Power Supply Module is factory-set to 220V. This setting may need to be adjusted, depending on the user's requirements. The specification for the power supply module is contained in Chapter 6 of this manual.

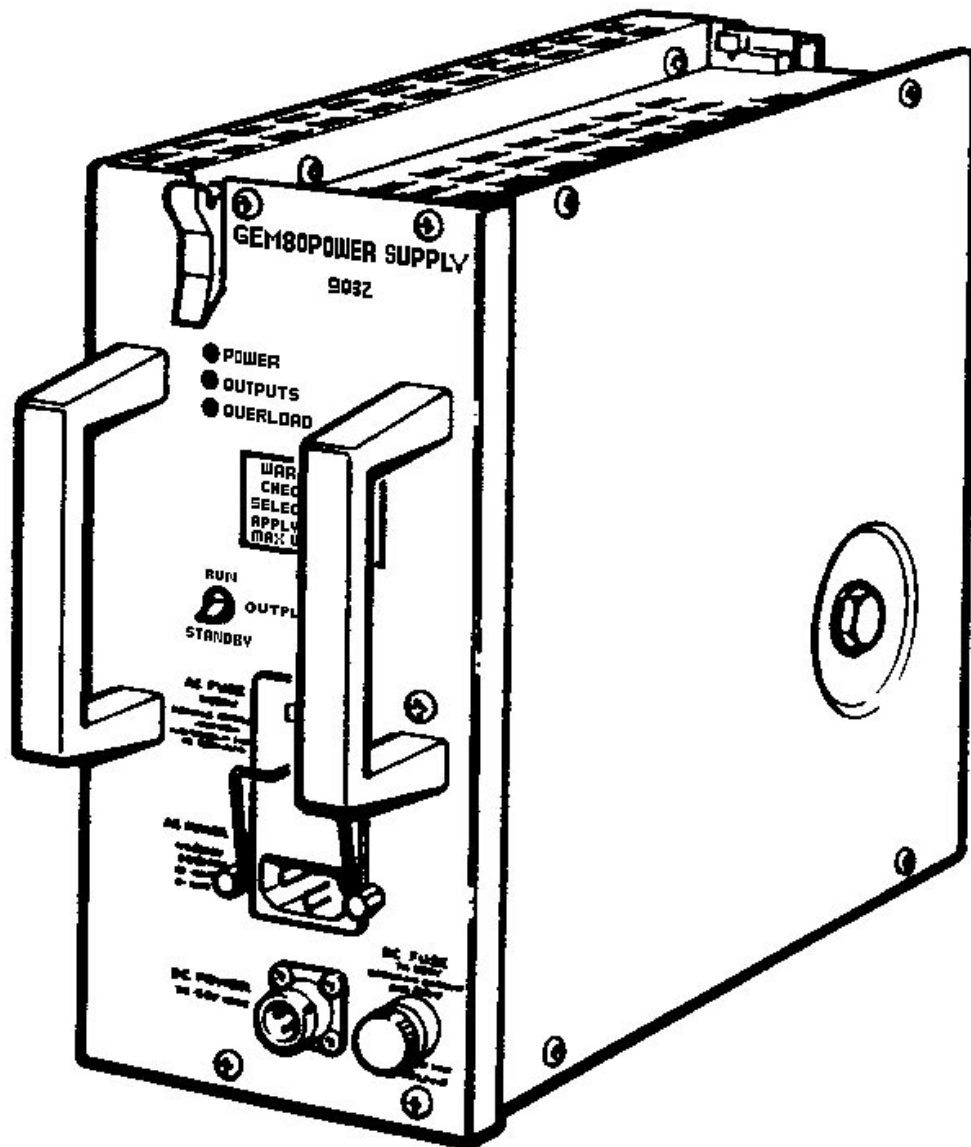


Figure 1.4 - 9032 Power Supply Module

Note: Different versions of this power supply may have slightly different front panels with two fuses and five LED's.

1.8. 9017/ 9018 Power Supply Module

The Enhanced Controller Subrack contains either one 9017 (ac or dc) or one 9018 (dc only) Power Supply Module, dependent upon the user's supply requirements.

The 9017 Power Supply Module is illustrated in Figure 1.5. Detailed specifications of both power supply modules are contained in Chapter 6 of this manual; recommendations for determining power requirements are also given here

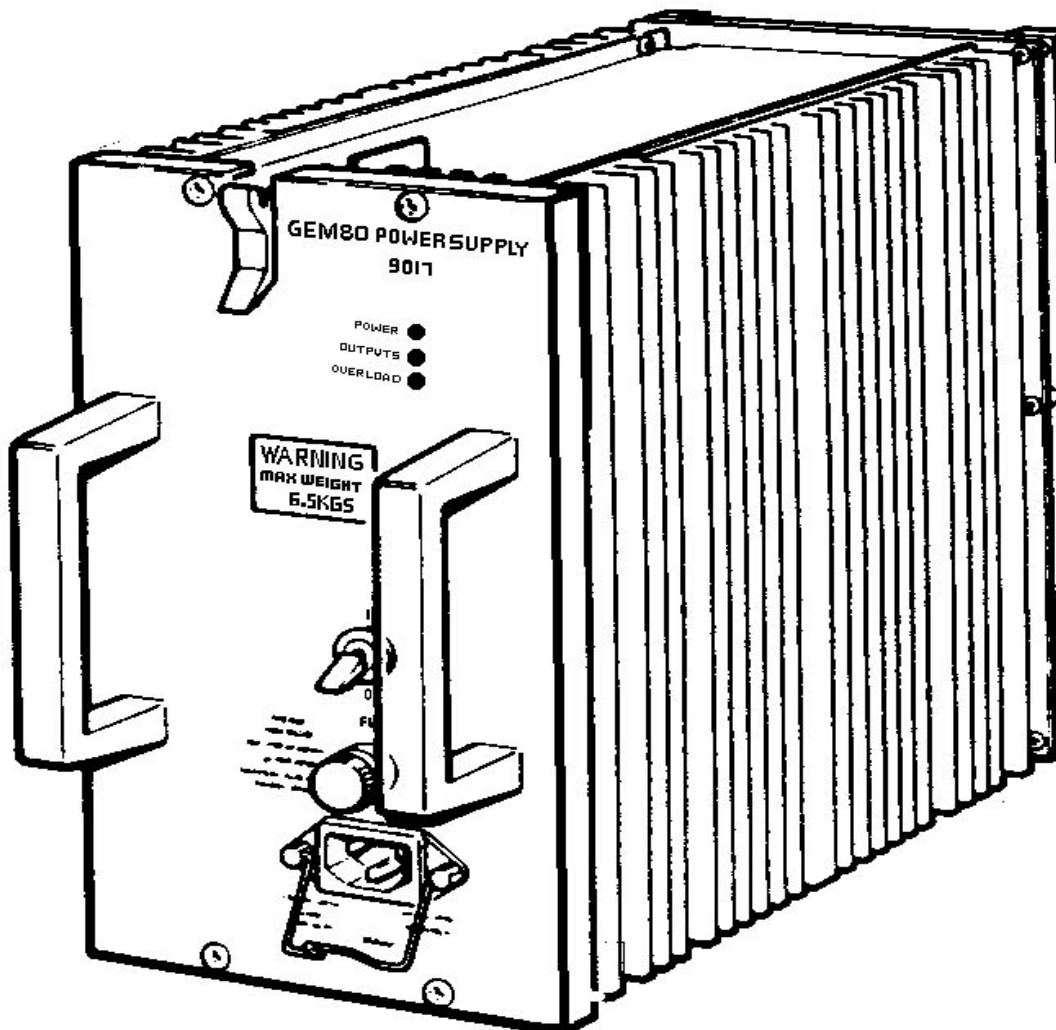


Figure 1.5 - 9017 Power Supply Module

Note: Different versions of this power supply may have slightly different front panels .

1.9. I/O Modules

These modules interface analogue and digital signals, to and from the plant, with the controller. They provide a high noise immunity by using Opto-isolators for each plant signal. Detailed information on the complete range of I/O modules is contained in

their respective User Information Sheets. A selection of Basic and Verification I/O Modules is shown in Figure 1.6.

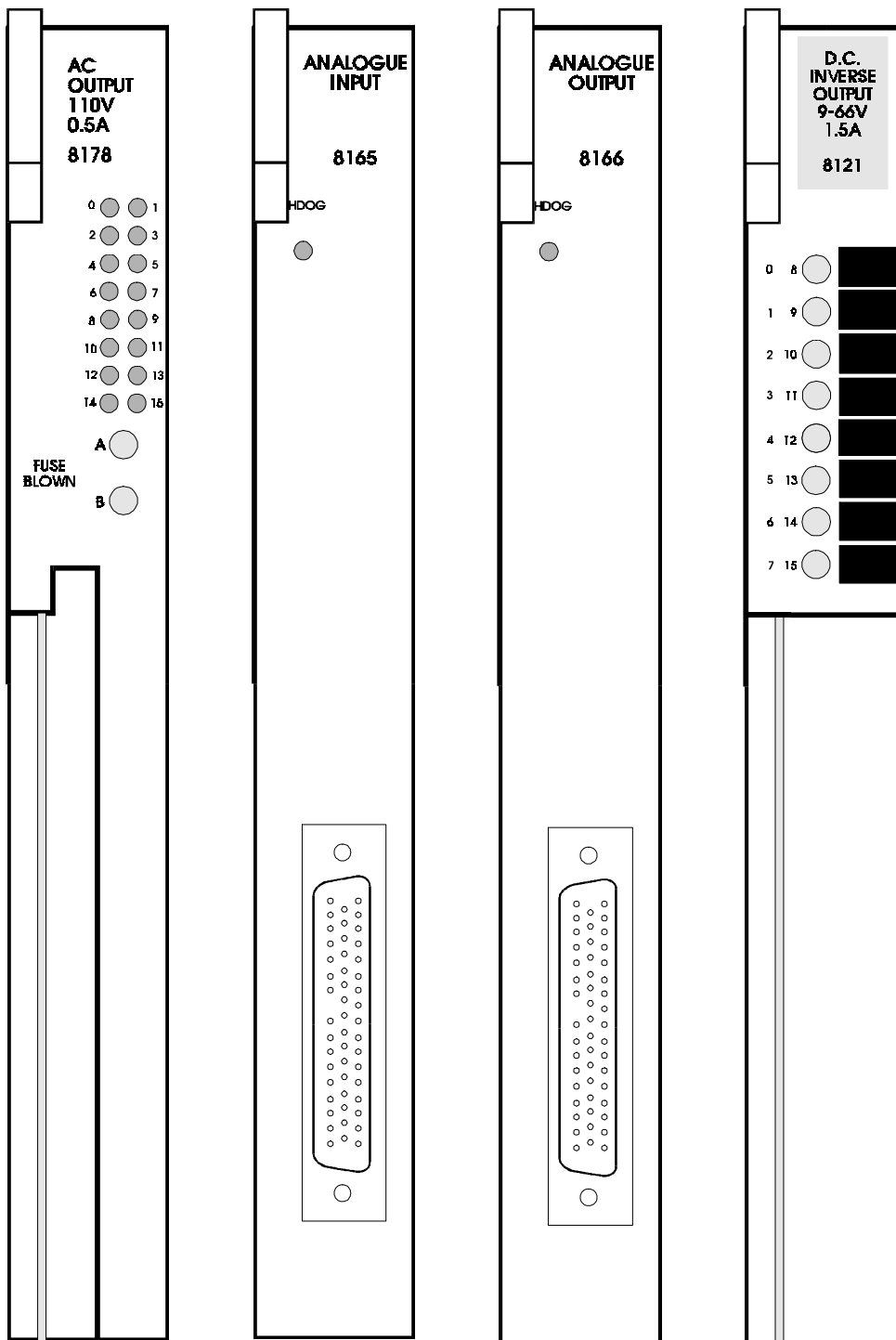


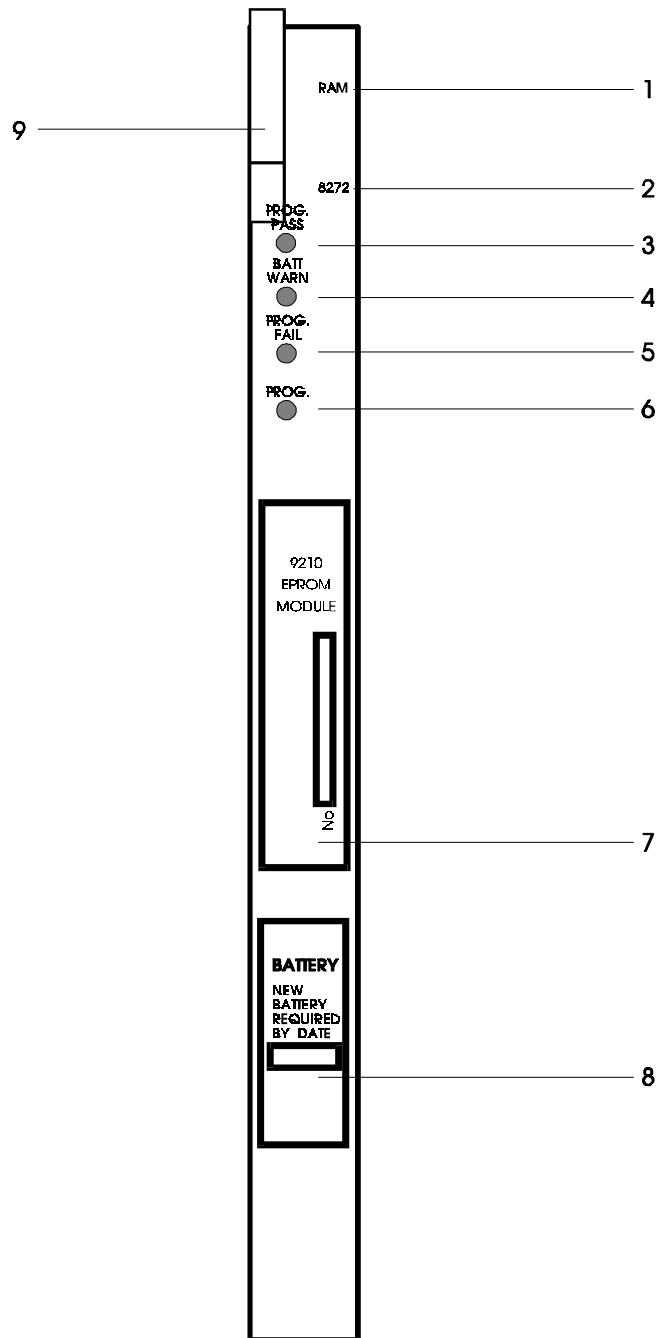
Figure 1.6 - Basic and Verification I/O Modules

1.10. Central Highway Modules

1.10.1. 8272 Memory Module (RAM)

This module contains up to 256K bytes of static random access memory (RAM) arranged in blocks of 64K bytes and sub-divided into a number of areas. Detailed

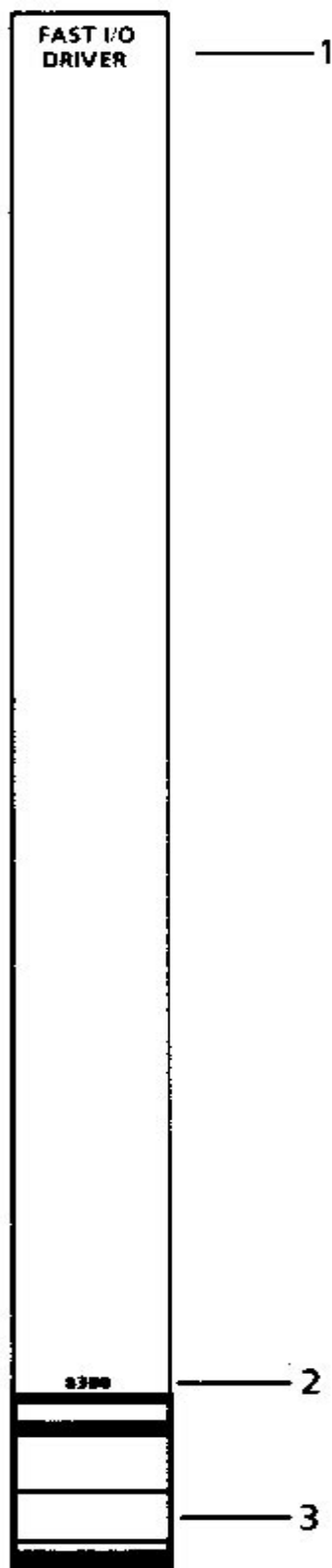
information on these areas is contained in Chapter 2 of this manual. The 8272 Memory Module is illustrated in Figure 1.7.



- | | |
|--|--------------------------------|
| 1. Module Function Label | 6. 'PROG' LED |
| 2. Module Type Number | 7. EPROM Sub-module - optional |
| 3. 'PROG PASS' LED | 8. Battery Pack |
| 4. Battery Low LED (lit for battery low) | 9. Ejection Handle |
| 5. 'PROG FAIL' LED | |

Figure 1.7 - 8272 Memory Module

Figures 1.8 to 1.11 illustrate, respectively, the following Central Highway Modules: Fast I/O Driver, IMAGEM, STARNET and GEMLAN-D. Refer to the individual Product Data Sheets and Technical Manuals for additional data of these modules.



1. Module Function Label
2. Module Ordering Number
3. Ejection Handle

Figure 1.8 - Fast I/O Driver Module

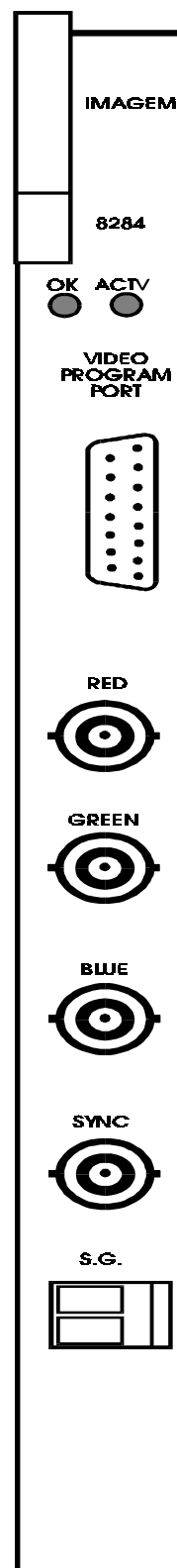


Figure 1.9 - IMAGEM Module

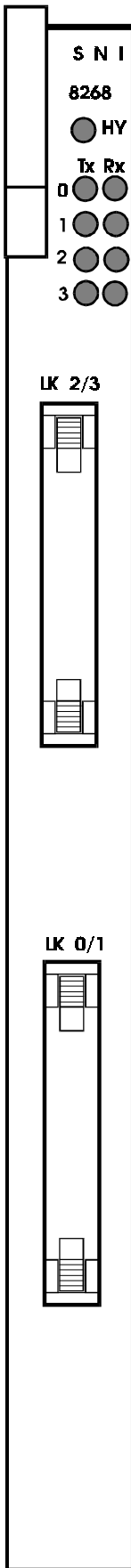


Figure 1.10 - STARNET Module

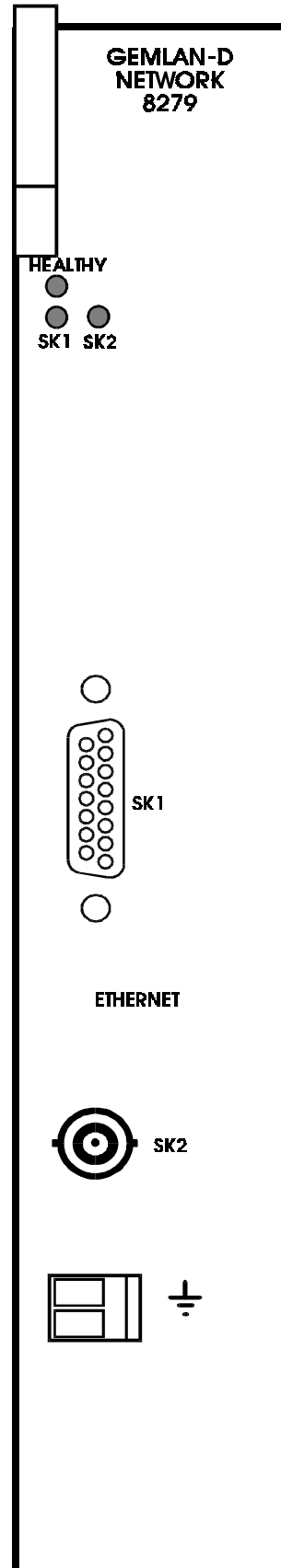


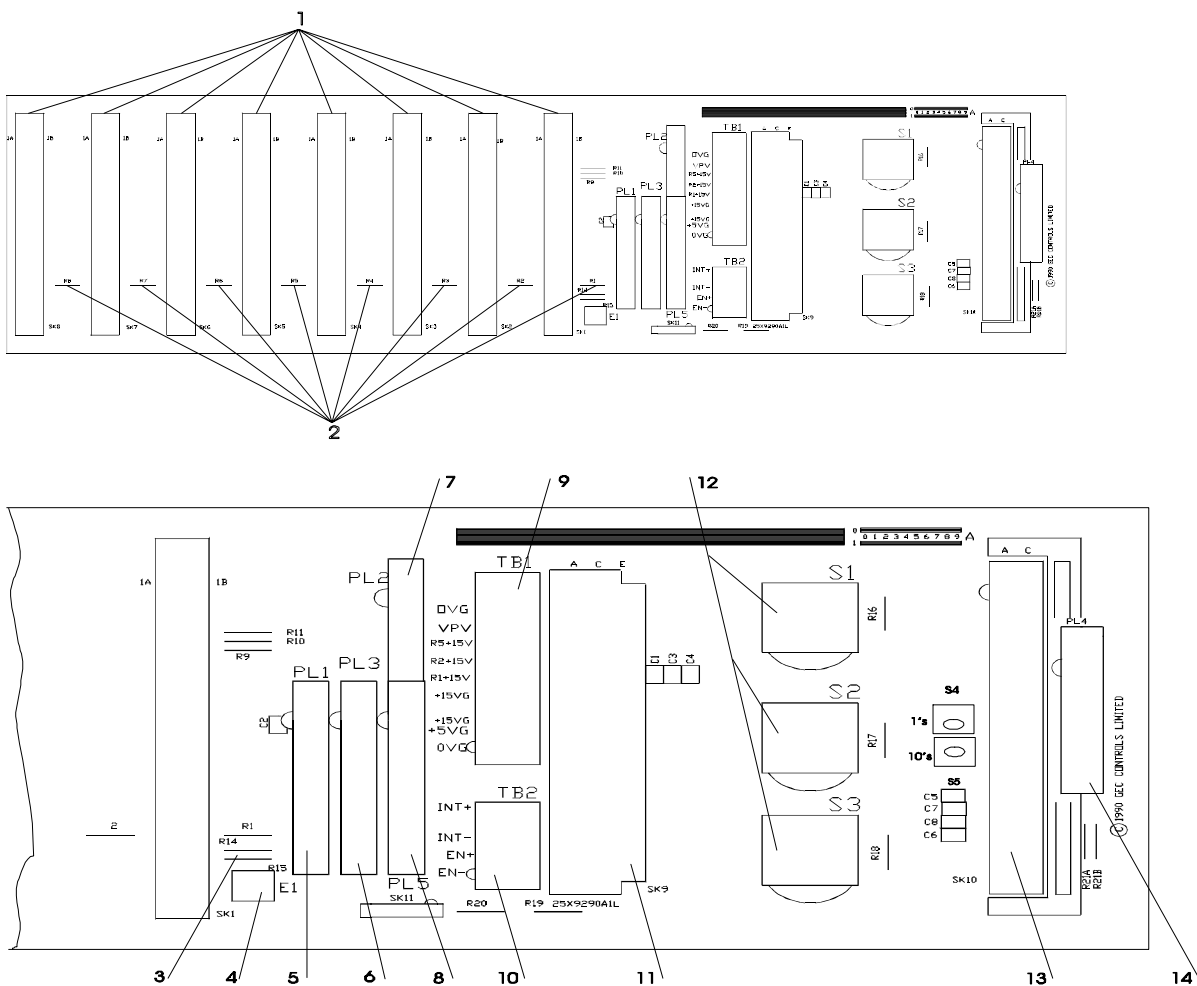
Figure 1.11 - GEMLAN Module

1.11. GEM80-400 Controller Backplanes Description

Some early controllers may be fitted with backplanes which differ slightly from those shown in figures 1.12 to 1.15.

1.11.1. Upper Backplane

Figures 1.12 and 1.13 detail, respectively, the Upper Backplane of the Standard and Enhanced Controllers.



- 1. Eight connectors for I/O modules (SK1 - SK8)
 - 2. Module interlock resistors (R1 - R8)
 - 3. Output enable circuit links (R14 and R15)
 - 4. Earth terminal (E1)
 - 5. Basic I/O ribbon cable connector (PL1)
 - 6. PL3 is not used
 - 7. PL2 is not used
 - 8. Verification I/O ribbon cable connector (PL5)
 - 10. Module interlock/enable terminal block (TB2)
- | | |
|------|-----|
| INT+ | EN+ |
| INT- | EN- |

- 9. Power terminal block (TB1)
- | |
|---|
| 0VG - 0V |
| VPV - Verification Power Valid - not used |
| R5 +15V - Verification Input |
| R2 +15V - Not used |
| R1 +15V - Basic Input |
| +15VG - 15VG Output |
| +15VG - |
| +5VG - 5VG Output |
| 0VG - 0V |
- 11. Power supply module connector (SK9)
 - 12. Address decoder switches (S1 - S3)
 - 13. Processor module connector (SK10)
 - 14. PL4 not fitted

Figure 1.12 - GEM 80-400 Standard Controller Upper Backplane Type 20X 9290 with exploded view of right-hand end

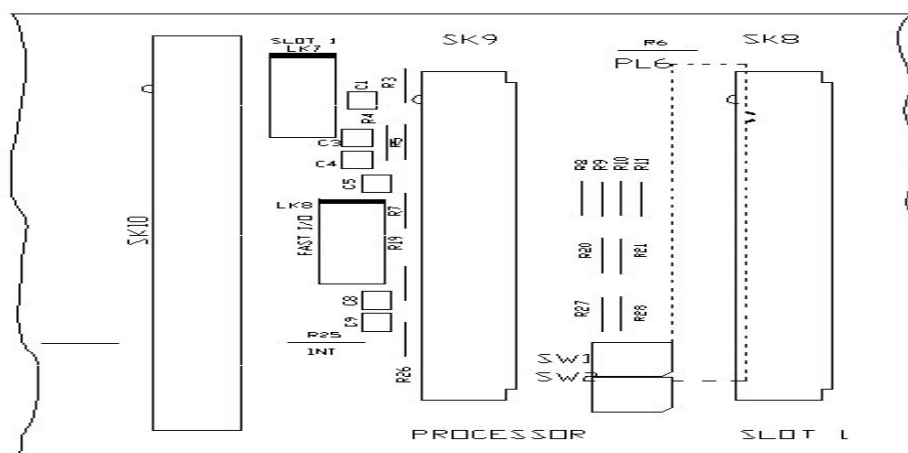
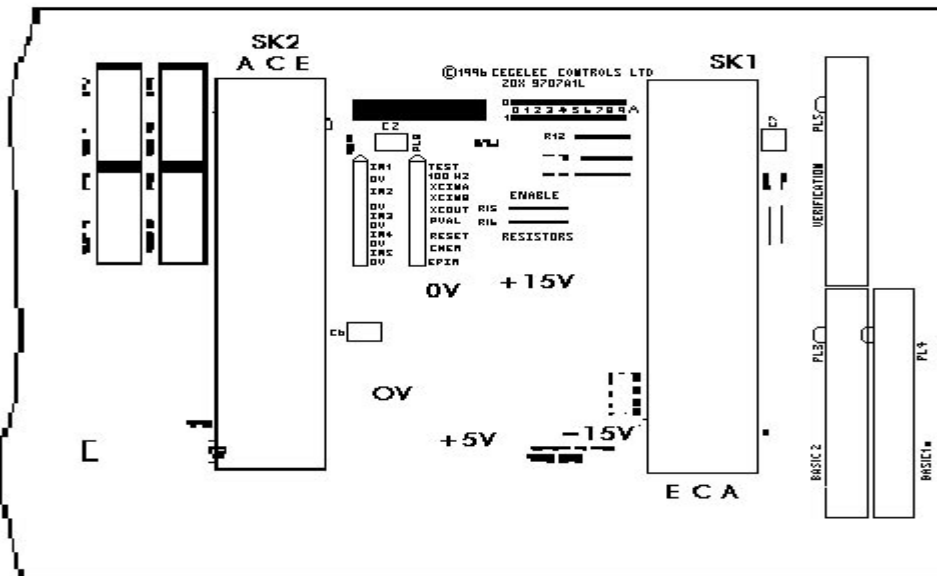
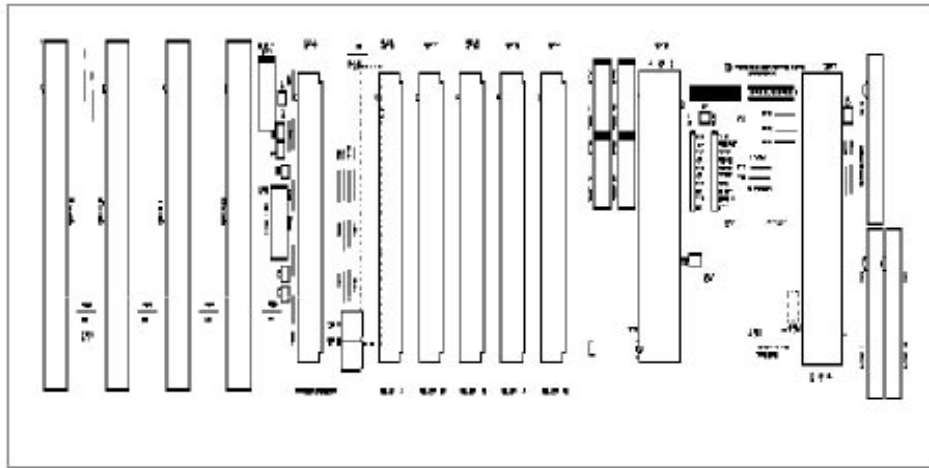
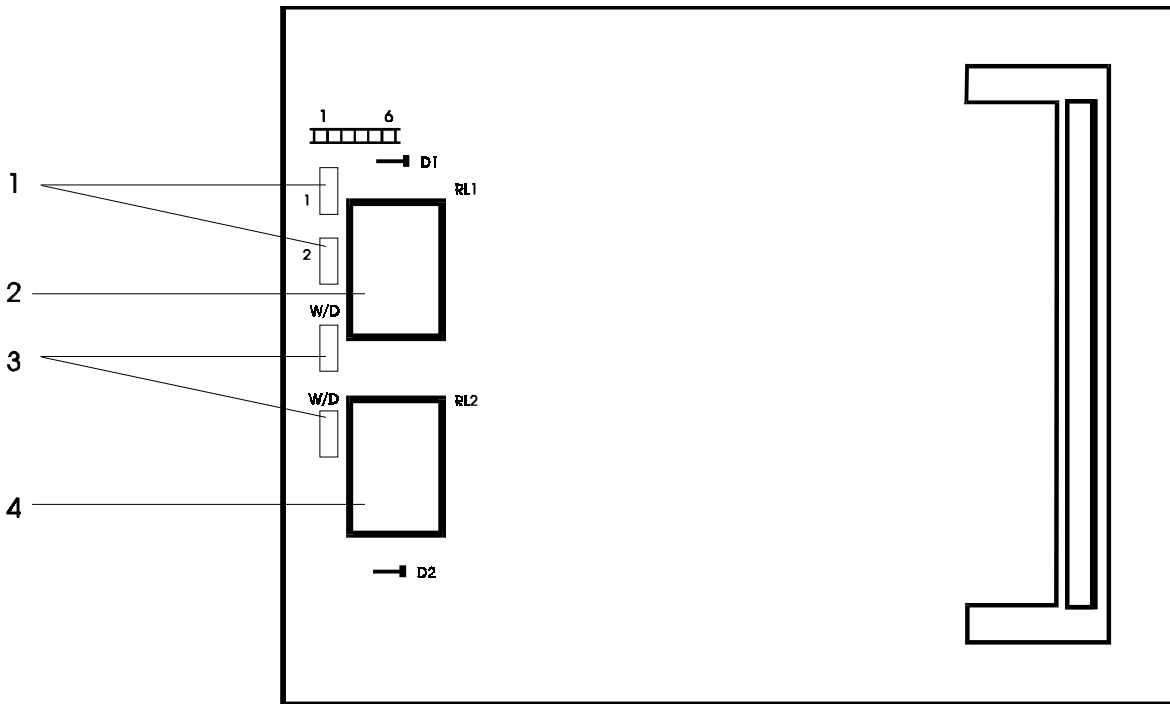


Figure 1.13 - GEM 80-400 Enhanced Controller Upper Backplane type 25X9707 with exploded view centre and right-hand end

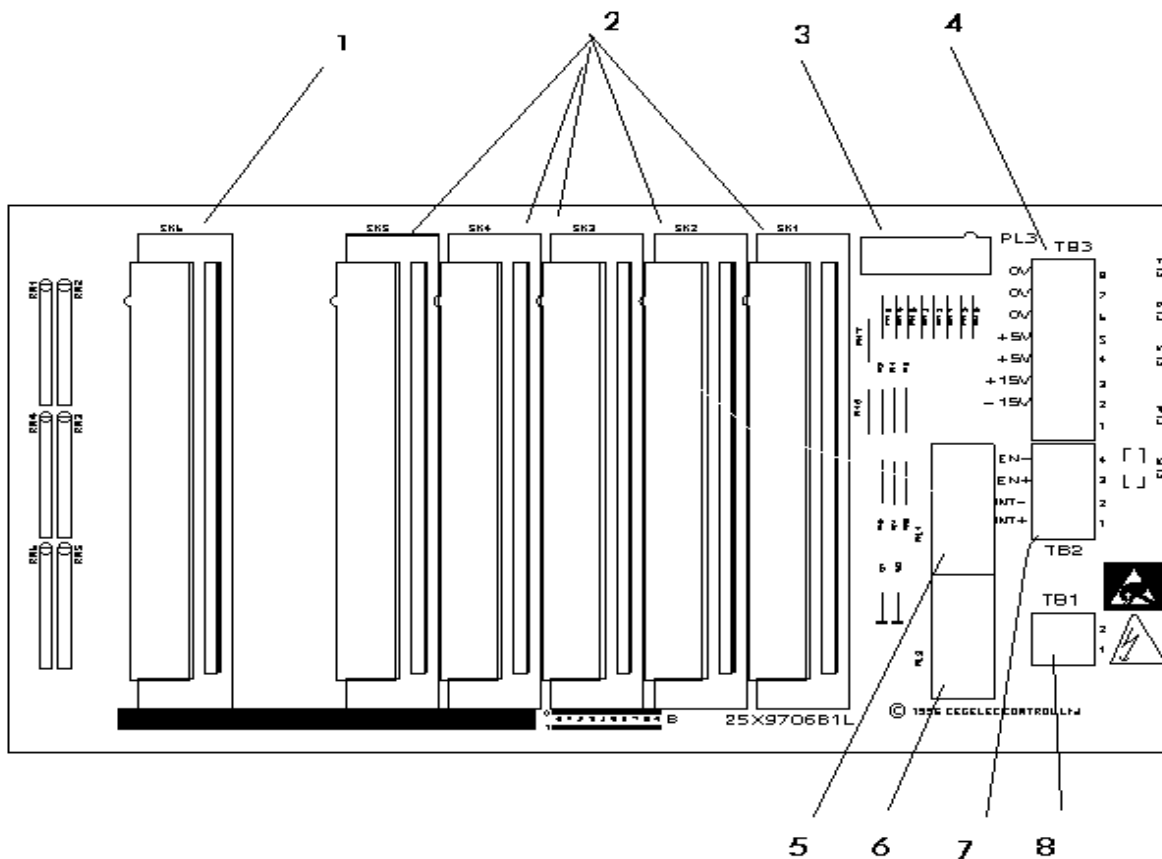
The upper backplane for the GEM80-400S Controller 25X9710 is very similar to the 25X9707 except that it has five fast I/O connectors at the left hand end rather than four basic/ verification connectors. In addition it has two Faston connectors immediately to the left of the processor connector to allow a -15V fast I/O supply to be connected. See chapter 6 for details

1.11.2. Lower Backplane



- 1. Not Used
- 2. Watchdog Relay 1 (RL1)
- 3. Watchdog Circuit Push-on Terminals (W/D)
- 4. Watchdog Relay (RL2)

Figure 1.14 - GEM80 Standard Controller Lower Backplane Type 25X8259



- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Processor module connector (SK6) 2. Five connectors for central highway modules (SK5-SK1) 3. Interface to upper backplane (PL3) 4. Power Terminal Block (TB3) <ul style="list-style-type: none"> 8 - 0VG Signal Ground 7 - 0VG Signal Ground 6 - 0VG Signal Ground 5 - +5V Output 4 - +5V Input 3 - +15V Output 2 - +15V Input 1 - Not Used | <ol style="list-style-type: none"> 5. Watchdog Relay 1 (RL1) 6. Watchdog Relay 2 (RL2) 7. Interlock & Enable Terminal block <ul style="list-style-type: none"> 4 - Enable Output 3 - Enable Input 2 - Interlock Output 1 - Interlock Output 8. Watchdog Terminal Block (TB1) <ul style="list-style-type: none"> 2 - Watchdog Terminal 2 1 - Watchdog Terminal 1 |
|--|---|

Figure 1.15 - GEM80-400 Enhanced Controller Lower Backplane Type 25X9706

The lower backplane for the GEM80-400S Controller 25X9711 is very similar to the 25X9706 except that it has an additional fast I/O connectors at the left hand end.

1.12. Specification

Controller	Standard	400S and Enhanced
Memory Capacity	-	Up to 1Mbyte of off-line RAM for data storage, including 512Kbytes for additional video formats.
	Memory support - battery or EPROM	
Typical Instruction Capacity	20,000 instructions + 30,000 data tables, as standard; this can be expanded to give 40,000 instructions by fitting optional memory expansion boards. NOTE Early controllers were limited to 16,000 and 36,000 User Instructions	
I/O Capacity	Provision for up to 8 Basic and Verification I/O Modules.	For 400S version Provision of up to 4 Fast I/O modules in. For Enhanced version. Provision for up to 4 Basic or Verification I/O Modules. Fast I/O - Up to 24 slots are available for Fast I/O Modules.
	Basic I/O Highway providing 16 words (up to 256 points) of I/O. One Basic I/O and one Verification I/O port for connecting additional I/O Subracks. Up to 1024 x 16-bit words of Verification I/O which can be converted to Basic I/O. Remote I/O - See 'Remote I/O Verification User Information Sheet', Publication No.T463.	
Video	Not available	Video processors - up to 4 IMAGEMs; video memory - 64K expandable, by the addition of an 8272 Memory Module, to 544K.
Serial Link Communication	Three serial communication ports: Ports 1 & 2: RS485/RS232 ports, isolated, individually configurable for use as ESP tributary or control ports, printer/programming ports, or GEMSTART CCU ports . Port 3: RS232 or 20mA port, isolated, used for direct connection to a printer or a suitable GEM 80 programming tool, such as Gemesys 3.	
Network Communication	-	GEMLAN-D Network Communication Ports and STARNET Communication Ports are available if these Central Highway Modules are fitted.
	2 FIP Communication Ports (optional).	
Program	Enhanced GEM 80 Ladder Diagram Language	
Execution Speed	Approximately 1ms per 1000 instructions	

Voltage Input	9032 Power Supply Module, 88-121V ac (110V nominal), or 204-264V ac (240V nominal) @47-63Hz OR 22-85V dc (48V nominal). Maximum wattage rating: 90W. Note...Factory-set to 220V.	9017 Power Supply Module, 88-264V ac @45-63Hz, or 88-250V dc; maximum wattage rating: 260W. 9018 Power Supply Module, 19-60V dc; maximum wattage rating: 220W. 400S Controllers A separate -15V supply is required if Fast I/O module require it. Enhanced Controllers Power supply modules type 8917 or 8918 are incorporated into Fast I/O Subracks if a Fast I/O Driver is fitted. Their maximum wattage rating is 350W and 320W respectively.
Temperature	Operating: 0 to 60°C, except with GEMLAN-D: 0 to 50°C. Storage: -25 to 70°C.	
Environment and Tests	Tested to GEM 80 Environmental Standards. UL Approval, PLC Specifications UL508 Industrial Control Equipment. CSA Approval, C22-2-142 Process Control Specifications.	
Mounting	19 inch (483mm) panel mounting conforms to IEC 297-1 (1975) Dimensions of Panels and Racks.	
Dimensions	Height = 356mm; Width = 483mm; Depth = 332mm.	
Weight	Standard Subrack (empty) = 6.26kg; 400S and Enhanced AC Subrack (empty) = 7.012kg; Enhanced DC Subrack (empty) = 6.122kg; Processor Module = 0.932kg; 9032 Power Supply Module = 5.944kg; 9017 Power Supply Module = 5.306kg; 9018 Power Supply Module = 5.39kg; 8917 Power Supply Module = 6.714kg; 8918 Power Supply Module = 6.794kg. Note...(1) Processor Module includes screen, EPROM Memory Sub-module (0.062kg) and FIP Sub-module (0.11kg). (2) Total weight of subrack depends on number and type of I/O modules fitted.	

1.13. Site Requirements

The area in which GEM80 equipment is to be installed must fulfil the following conditions:

- (1) An environment must be maintained as detailed in the 'Environment' section of this chapter.
- (2) A power supply must be available as detailed in the 'Power Supply Requirements' section of this chapter
- (3) Adequate access must be available for maintenance and commissioning

1.13.2. Environment

The following environmental conditions apply for GEM80-400 equipment:

Temperature	-	0 to +60°C operating (0 to 50°C if GEMLAN fitted) -25 to +70°C storage
Humidity	-	5 to 95% RH non-condensing
SO ₂	-	25ppm Vol./Vol.
H ₂ S	-	15ppm Vol./Vol.
Nitrous Oxides	-	15ppm Vol./Vol.

Do not use GEM80 equipment in corrosive atmospheres (e.g. Benzene, acid fumes, etc.) without taking special precautions.

In dusty atmospheres, great care must be taken to prevent dust from penetrating the GEM80 modules.

Rapid changes in temperature should be avoided as this may cause condensation on GEM80 equipment in areas of high humidity.

1.13.3. Power Supply Requirements

GEM80-400 Standard Controllers can be operated from a 9032 Power Supply Module providing either 88-121V ac (110V nominal) or 204-264V ac (240V nominal) @ 47-63Hz OR 22-85V dc (48V nominal). It should be noted that the 9032 Power Supply Module is factory-set to 220V. This setting may need to be adjusted, depending on the user's requirements.

GEM80-400 Enhanced Controllers can be operated either from a single-phase ac supply or a dc supply. The input voltage must be within one of the following ranges: 88-264V ac @ 45-64Hz or: 88-250V dc, 9017 Power Supply Module, OR: 19-60V dc, 9018 Power Supply Module. Chapter 6 gives full details of the power supplies.

If any doubt exists regarding the adequacy of the supply, it may be advisable to fit a line conditioner (ferro-resonant CVT) in the feed to the controller.

1.13.4. Receipt of GEM80-400 Processor Module

When the equipment arrives on site it should be carefully unpacked and inspected for any sign of damage. The modules contain ESDs (electrostatic sensitive devices) and the rules detailed in the 'Handling Precautions for Printed Circuit Boards' section of this chapter must be observed. Some modules contain lithium batteries which should be treated as detailed in the 'GEM80 Batteries (Memory Support) - Safety Precautions for Disposal and Handling' section of this chapter.

The complete consignment should be checked against the delivery note for any loss in transit. If any damage has occurred, or any parts are missing,

Cegelec Industrial Controls Ltd, Kidsgrove, should be contacted immediately and the following details quoted:

- (1) List of damaged or missing items
- (2) Description of any damage.
- (3) Package numbers.
- (4) Delivery/Advice Note numbers, dates and any other reference numbers such as order and item numbers.

Note... Failure to inform Cegelec Industrial Controls Ltd, Kidsgrove of damage to goods or shortages within three days from receipt of equipment will be held to free Cegelec Industrial Controls Ltd from liability.

1.13.5. Storing GEM 80 Before Installation

Equipment which is not required for immediate installation should be stored in a clean, dry atmosphere at a reasonably constant temperature (-25 to +70°C). To minimise the ingress of fine dust, the equipment should be covered with a suitable canvas, tarpaulin or heavy duty polythene sheet. Any loose equipment should be kept in the original packing, which should be resealed after the delivery inspection.

Where equipment is unavoidably subjected to high humidity (e.g. for short pre-commissioning periods during installation in a humid location) it is recommended that the cubicle be fitted with anti-condensation heaters and the equipment be thoroughly dried out prior to the first application of power. Such heaters should then be automatically switched on whenever the GEM 80 equipment is subsequently shut down.

Some GEM 80 modules contain electrolytic capacitors which degrade if the system is not powered up. Where inactive storage times are expected to be in excess of 9 months, the shelf life of electrolytic capacitors may be exceeded, it is essential that units with electrolytic capacitors (power supplies and some Compact I/O Modules) are powered up every 9 months.

1.13.6. Radio Frequency Interference (RFI)

This section is intended as a guide for users who wish to operate Cegelec Industrial Controls Ltd electronic products in the vicinity of a radio transmitter. The transmitter may be of the static or the hand-held portable type. Unrestricted use of a transmitting device could result in a malfunction of the equipment. This in turn could cause a breakdown of plant equipment and injury to personnel. Cegelec Industrial Controls Ltd products are designed to function satisfactorily within a RFI field strength of 10V/m over a frequency range of 30MHz to 1GHz.

1.13.7. Transmitter Output

The field strength generated by a radio transmitter, received at a point 'p' in free space, is a function of the power output of the transmitter and the distance from the transmitter aerial.

$$E = \sqrt{\{ (377Pt) / (4\pi r^2) \}} \text{ or}$$

$$r = (5.5 / E) \sqrt{Pt}$$

where E = Field strength at point 'p', in Volts per metre (V/m).
 Pt = Power output of the transmitter, in Watts.
 r = Distance of point 'p' from the transmitter, in metres.

Note...At two metres, the power required to give a field strength of 10V/m is 13 Watts.

The following assumptions have been made in the formula above:

- (1) The antenna gain is unity.
- (2) The antenna is isotropic.
- (3) The transmitter and the products are in free space.
- (4) Far field conditions exist, where the wave impedance is 377Ω .
- (5) In the near field, both the electric and the magnetic components of the field must be considered.

Calculations based on the formula above which result in distances less than two metres are incorrect.

1.14. Handling Precautions for Printed Circuit Boards

1.14.2. Introduction

A number of microelectronic devices on equipment PCBs (printed circuit boards) are subject to permanent damage due to static (electrostatic potentials) encountered in routine handling, testing and shipping, unless special precautions are observed. For example, static electricity can be generated simply by an operator moving on a chair, brushing against benches or walls, or walking across the floor, and so, appropriate action must be taken to discharge this 'personal static' when handling individual PCBs. Once the PCBs are plugged into a subrack they are protected from any static damage.

This section details action for the protection of PCBs from static damage.

1.14.3. Protection of Equipment from Static Damage

Protective measures are required when handling PCBs to prevent damage to ESDs. When handling PCBs containing ESDs the following rules must be observed:

- (1) Personnel handling PCBs shall NOT wear outer clothing which will generate a static charge, e.g. synthetic materials like nylon, cotton is preferable.
- (2) All personnel handling PCBs shall put themselves in contact with a grounded surface before removing PCBs from their protective packing or from equipment, see the 'Recommended Antistatic Equipment' section, later in this chapter. The antistatic equipment should be kept on during all PCB handling.
- (3) Avoid finger contact with devices on the PCB and with its connectors
- (4) If it is necessary to place PCBs down 'unprotected', place on a static shielding bag, refer to the section 'Recommended Antistatic Equipment', in this chapter
- (5) PCBs shall be protected by a static shielding bag when out of equipment

1.14.4. Protection During Arrival, Handling and Storage at Site

If PCBs are shipped in their own individual packing, remove them from the cardboard box but leave them in the protective static shielding bag, or with the conductive foam shorting strip on, until they are plugged into the equipment. If the boards are to be stored for any length of time, leave them in the original packing until they are needed.

1.14.5. Protection During Setting Up of Equipment

The following precautions must be taken during testing/setting up operations on equipment containing PCBs with ESDs:

- (1) All test equipment must be grounded to a common earth point.
- (2) The system power and test equipment must be switched OFF before inserting or withdrawing PCBs
- (3) When possible, power supply voltages should be applied before signal inputs, and should be maintained until signal inputs are removed
- (4) Dielectric strength and insulation resistance tests should not be carried out with the PCBs installed in the equipment
- (5) Do not use audible continuity tests on PCBs.
- (6) Do not use 'Freeze' Aerosols on PCBs.

1.14.6. Protection During Maintenance and Spares Handling

If it is necessary to return any PCBs to Cegelec Industrial Controls Ltd for repair, they must be enclosed in a static shielding bag, and suitably protected by wrapping in foam plastic, and packed in a box labelled 'Caution Static Sensitive PCBs'.

1.14.7. Reference Reading

BS 5958: Code of Practice for the Control of Undesirable Static Electricity - Part 1.

BS 5783: Code of Practice for Handling of Electro-Static Sensitive Devices.

1.14.8. Recommended Antistatic Equipment

The following 3M's Antistatic Equipment is recommended for use:

- (1) Velostat Wrist Strap Type 2063 - Strap with IMO resistor and alligator clip.
- (2) Transparent Static Shielding Bags Type 2100 - size 254mm x 305mm (i.e. 10in x 12in).

1.15. Safety and Handling Information

1.15.2. Earthing

The equipment must be properly earthed in accordance with the instructions given in Chapter 6.

1.15.3. High Voltages

Dangerous voltages arising from the mains supply and feedback from the plant wiring may be present within the controller.

1.15.4. Power Down Before Removing Modules or Connectors

To allow safe access, the GEM80 power and, where applicable, plant-side power should be switched off before any module is withdrawn or replaced.

1.15.5. Power Down Safety Procedure

When maintaining or working on plant controlled by the GEM80-400 controller, the controller and the plant-side power supplies should be 'locked off' using a padlock, or similar mechanical locking mechanism, to prevent the system being inadvertently powered up. The Output Control or ON/OFF switch on the power module must NOT be relied on to immobilise the controller.

1.15.6. On-line Programming

Controllers which are executing, accept on-line program changes, but the controller will freeze all outputs and ignore all inputs for approximately 1 millisecond per 1000 instructions on recompilation with large programs.

Note...(1) The controller cannot tell whether the program change is safe and simply carries out the instructions given.

(2) Recompilation can cause problems when modules such as counters are incorporated in a system. It is the user's responsibility to ensure the safe operation of plant equipment when this facility is utilised.

1.15.7. Testing a GEM 80 System

In test modes, GEM80 output signals must be disconnected or in some way deactivated to prevent accidental mobilisation of plant and machinery, or other possible hazards.

1.15.8. Watchdog and Safety Circuits

The requirements for watchdog and safety circuits of Chapter 11 must be designed into the system.

1.15.9. System Status Indication

When the green LEDs labelled WDA, WDB, and RUN on the front panel display of the processor module are illuminated, the controller is running the user program and may be controlling moving machinery.

The four-character alphanumeric display provides the user with the following indications:

Run	-	System running
Halt	-	System halted
#nnn	-	Fault shutdown (nnn = error number)
!nnn	-	User watchdog trip (nnn = user error code)
Test	-	Full system self test
TRun	-	Run, Test Inputs
THlt	-	Halted, Test Inputs
BATT	-	Battery low warning
BOOT	-	System checks that main code is present and correct.
F/W	-	Controller is in Firmware update mode; all GEM80 functions are suspended.

1.16. GEM 80 Batteries - Safety Precautions for Disposal and Handling

1.16.2. Handling

WARNING

Until the GEM 80 battery is completely discharged, the cells contain lithium metal which reacts vigorously with water. It also burns readily in many gases. The electrolyte is a non-corrosive, but flammable liquid.

The GEM 80 lithium batteries must never be recharged. GEM80 batteries should be stored in a dry area and, for maximum shelf-life, the temperature should generally be kept between -10 and +35°C.

1.16.3. Disposal

Under no circumstances must any GEM80 battery be crushed, incinerated or disposed of in normal waste. Discharged or unwanted batteries are to be returned to the following address for disposal:

ALSTOM DRIVES & CONTROLS
West Avenue,
Kidsgrove,
Stoke-on-Trent,
Staffordshire,
ST7 1TW
ENGLAND

They must be securely packaged and any exposed electrical connections adequately covered with insulating tape to avoid short circuit during transit. The package should be marked 'Spent Batteries'.

1.16.4. Damage

Should any GEM 80 batteries become physically damaged, the following procedure must be adopted:

- (1) Where applicable, disconnect the battery and remove from the equipment
- (2) Avoid touching any liquids or internal cell components.
- (3) Cover any exposed electrical connections with insulating tape
- (4) Place the battery in a plastic bag or container and seal.
- (5) Return to the address given under the section 'Disposal'.
- (6) If electrolyte enters the eye, wash thoroughly with water and continue flushing for at least 15 minutes. Seek medical attention immediately.
- (7) If the skin, clothing or equipment comes into contact with the electrolyte, wash thoroughly with water.

In the event of a fire, the cell may rupture. However, the amount of lithium involved is very small so any lithium fire will be very minor, lasting only a few minutes. It is best to isolate the supply but only to investigate when all signs of combustion have ceased. Avoid fume inhalation. Cell remains should then be disposed of as described earlier in (1) to (7) of this section.

Many types of extinguisher are ineffective against lithium; BCF types used on lithium may result in poisonous gases being generated. Graphite based dry powder extinguishers are effective. In practice an extinguisher should not be required and the previous paragraph gives the best course of action.

The 'COSHH Regulations 1988 and Completed Cell/Batteries' states the following:

'7. Lithium Copper Oxide Batteries

Lithium content becomes hazardous (fire and corrosion) if exposed to air and water. The electrolyte is highly flammable.

Substance	Risk	Type of Hazard
Lithium Foil	High	May ignite in air. Evolves Hydrogen (flammable) with water which becomes corrosive.
Electrolyte (Dioxolane / Lithium Perchlorate)	High	Highly flammable. On evaporation leaves white residue which is strongly oxidising.
Copper Oxide / Graphite	Low	Irritant
Separator	Low	Wet with electrolyte.

Additional information:

Manufacturer: Renata

Battery Type: LITHIUM BATTERY CR2477N.

Cegelec Order No. 20T0319/01.

Approximate Weight: 15 g.

Lithium Content: 0.95grams per cell

Classification: HAZARDOUS

Packing Specification: 406

2. Controller Architecture and Program Operation

2.1. Controller Architecture

The GEM 80-400 Controllers are single processor system containing all the necessary logic components of a PLC (Programmable Logic Controller), i.e. ladder diagram interface to the user, memory for ladder programs, data tables, workspace and an interface for communication with the Plant.

In order to provide a larger capacity, a memory expansion sub-board is mounted directly onto the circuit board. A Central Highway, in the form of a PCB (printed circuit board) backplane, provides high-speed interconnection between the Processor, Basic and Verification I/O Modules and, in the case of the Enhanced version, Central Highway Modules and/or RAM cards in the subrack. The Processor controls the data movement between the I/O Highway, Serial Communication Ports or the Printer/Programmer Port to the memory modules, and executes the compiled user program.

The Fast I/O Driver, which may be fitted in the Enhanced Controller only, provides a buffer for data exchanges between the Central Highway and any Fast I/O Modules. The IMAGEM Processors, which can be fitted in the GEM 80-400 Enhanced Controller, output a picture from data stored in the video memory and Host Controller memory.

Figure 2.1 shows a typical architecture of a GEM 80-400 Controller. In the following description the GEM 80-400 Processor Module resides in an Alspa 80-75 host subrack, however this could equally be any other based subrack conforming to *bus Specification REV C.1 October 1985*.

The RAM is battery backed with a typical support life, after one year powered up, of 9 weeks minimum at 70°C or 47 weeks minimum at 40°C. Battery low indication, on the GEM 80-400 Processor Module, is given by a message, 'BATT', on the alphanumeric display of the processor front panel. On GEM80-400 Processor Modules fitted with an EPROM sub-module, the compiled program and the P-table can be transferred to EPROM memory for increased security. See later in this chapter for further details.

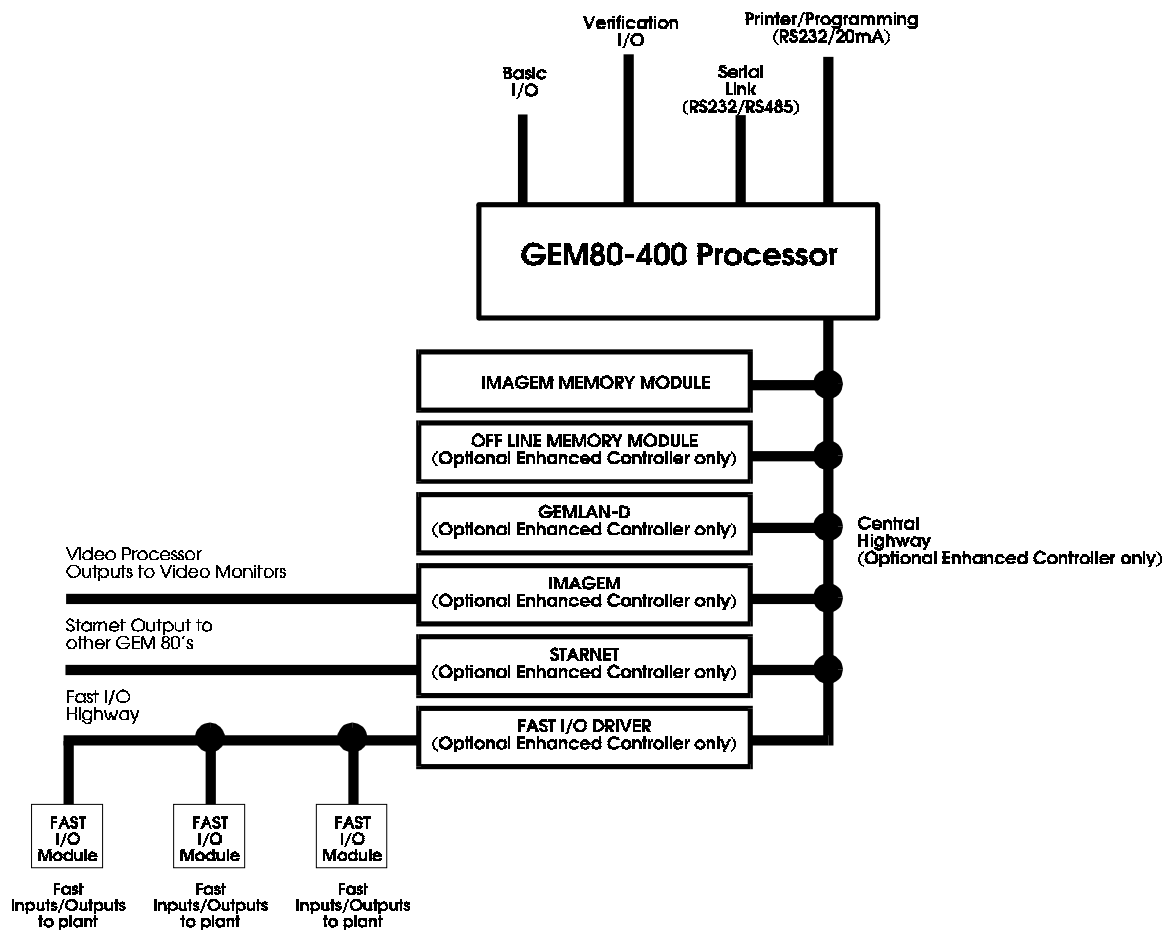


Figure 2.1 - GEM80-400 Controller Module Architecture

2.2. Operation Cycle

The controller operation can be divided into three separate phases:

- a start-up procedure (Initialisation),
- an operating cycle (Operating Phase),
- a fault shut-down procedure (Error Handler).

The start-up procedure includes checking the controller (self-test) and compiling of the user program and, on satisfactory completion, allows the system to be run. The second phase is the operating cycle proper, where the controller inputs and outputs data based upon the user program and plant information. The third phase is dependent upon the continual self-checks carried out by the controller or on the detection of a system fault. In the event of a fault, the controller enters a fault shut-down phase and is designed to shut down in an orderly fashion. Figure 2.2 shows the operating cycle in more detail

The cycle time may be either undefined, in which case the program free runs and repeats as soon as it can, or it may be preset to a regular defined interval. If a repetition interval has been set which is shorter than either the program execution time or the I/O scan time, the repetitive cycle will not be regular and the controller free runs. The output scan is the first item in the cycle. If a regular

repetition interval has been preset, a waiting period is inserted after the program execution at the end of the cycle. The program execution time itself varies due to blocks within the user program, and so the waiting period also varies in order to make the cycle time up to the preset interval. The timing of the output scan is therefore held to a regular interval, varying very little, which is an advantage for continuous analogue control applications. Data written by the user into the P-table determines whether the controller is free-running or preset. See the 'P-Data Table' section, later in this chapter, for details. Cycle time calculation and measurement is discussed in the 'Calculating and Program Scanning Interval' section of this chapter.

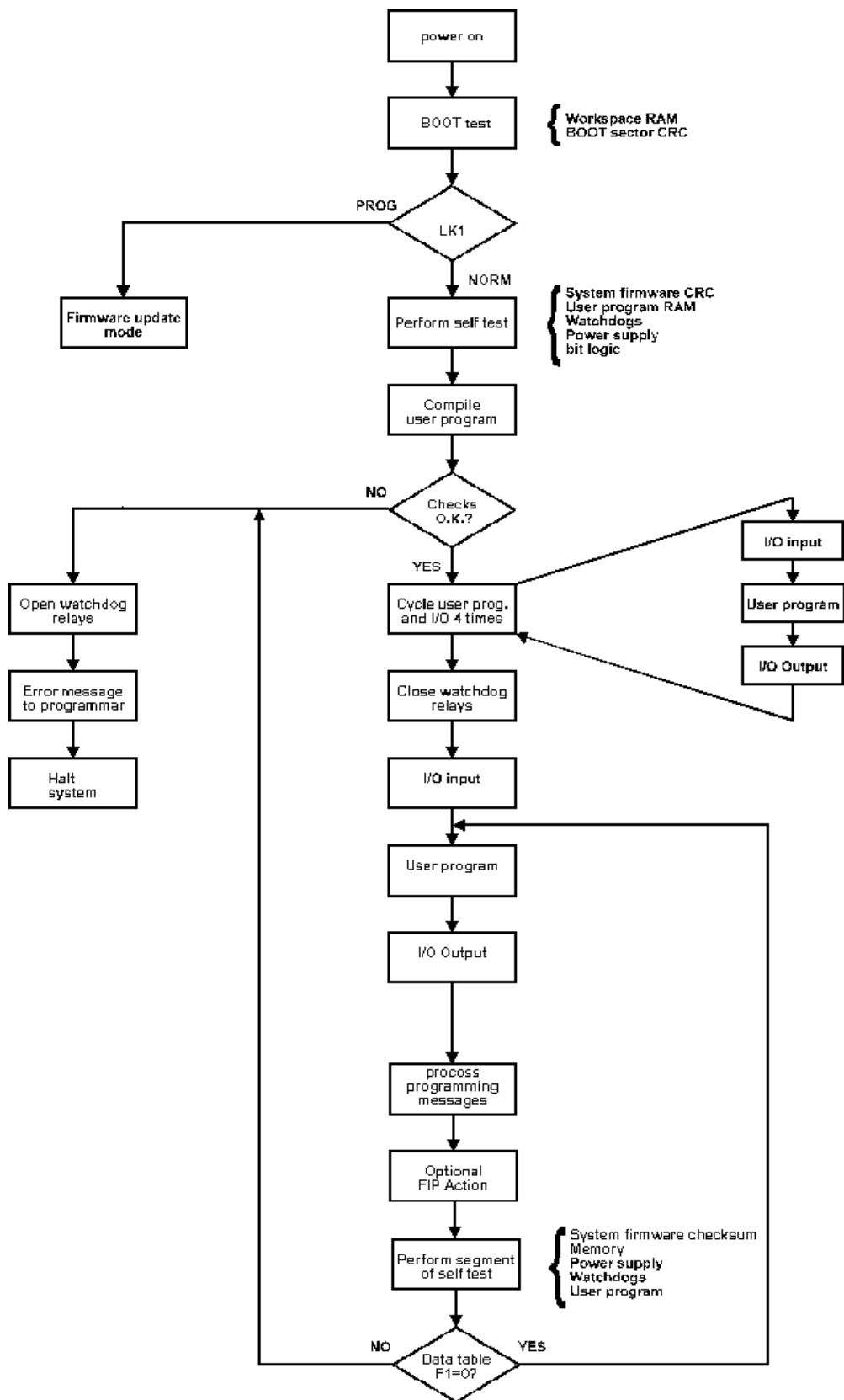


Figure 2.2 - GEM80-400 Controller Operating Cycle

2.2.1. Start-up Procedure, Initialisation

At switch-on, the controller initiates a self-test cycle. This cycle comprises a series of self tests which are performed to check the following:

- (1) Memory;
- (2) Operating system EPROMs;
- (3) User program.

On completion, the I/O is cleared and then the user program is compiled. If a fault is detected, the controller remains in the 'Halt' condition and the Error handling routine is invoked, see the 'Fault Shutdown Procedure, Error Handling' section of this chapter. Faults are reported as a code number and a text message. These error numbers can be seen on the alphanumeric display on the front panel of the processor.

After a successful self-test, the controller compiles the user program and, in doing so, carries out a number of checks. If compilation is successful, the Watchdog relay energises. See Chapter 11 of this manual for more detailed information. If no errors are detected the Operating phase is cycled at least 3 times with the Watchdog contacts open. If no errors are generated by these Operating cycles the Watchdog contacts are closed and the controller then begins its normal Operating phase.

2.2.2. Operating Cycle, Operation Phase

This is a continuous cycle and is the normal condition of the controller. During this cycle the processor will set the output data. While this is happening the processor is executing the user program. The processor reads input data from the input modules, which the processor then uses in the program, i.e. the output data is computed by the user Program. The serial data in the J/K-data tables is updated at the beginning of each cycle.

At the end of each program cycle part of the continuous system self-tests are performed and if any errors are generated the error handler is invoked which can initiate a controller shutdown in the event of a fault.

2.2.3. Fault Shutdown Procedure, Error Handling

A segment of the self-test program is performed at the end of each program scan and any detected fault results in the Error Handler being invoked which sends an error message to the Printer/Programming port and an error code to the processor display, inserting an entry into the System Log. The error handler then tests the error status flags to determine the category of the failure. Depending on the nature of the fault, action is then taken to ensure that the controller goes to a safe condition. The controller can be restarted by switching the power off and then on again, after the fault has been cleared.

There are three categories of error and these are detailed in Table 2.1.

Table 2.1 Error Categories.

Category	Definition	Action by Controller
Catastrophic Error	Controller totally unreliable (e.g. firmware corrupted).	(a) Watchdog contacts opened. (b) Controller halted. (c) No communication to a suitable GEM80 programming tool (no error message).
Fatal Error	Failure of controller functions (e.g. Basic I/O failure).	(a) Watchdog contacts opened. (b) Controller halted. (c) Controller will communicate with a suitable GEM80 programming tool (error message generated).
Lock Error	Error which can be recovered by clearing the program store and reloading the program (e.g. program corrupt on power up).	(a) Watchdog contacts open. (b) Program halted. (c) Controller will communicate with a suitable GEM80 programming tool.

2.3. System Self-tests

While the GEM80-400 system is 'powered up' the system undergoes a number of continuous tests. These are:

- (1) Read/write memory test of all used RAM. This includes system work space, object code and data table RAM.
- (2) A 16-bit checksum test of the following data areas: source code, object code, V-table, P-table and EPROM.

Note...(i) CRC of operating system EPROM is checked at system power up.
(ii) Source code only checked before any compilation takes place.

- (3) The power supply to the processor module.
- (4) The battery power supply
- (5) The system watchdogs.
- (6) The bit unpacking logic.

The above tests, in their entirety, are performed on power up before the system is allowed to 'run'. If tests (1), (2), (3), (5) or (6) fail it is deemed a fatal error; the system is 'halted' (if not already), 'locked' and an error message issued to a suitable GEM80 programming tool, if connected. Information on the self-test system is detailed in Chapter 9 of this manual.

Note...Some errors, notably error number #710 'Battery Failure' do not generate any of the above error status flags, in this case the error message is sent to the Printer/Programming port and a fault bit is set in F2.4 but the Watchdog contacts are not opened and the system is not halted.

2.4. States of the GEM 80-400 Controller

The current 'state' of the controller is displayed on the processor front panel display via simple mnemonics, and on the display of a suitable GEM80

programming tool, such as Gemesys 3, if connected. These 'states' are defined as follows:

2.4.1. Halted, Normal Inputs

Inputs are being read into input tables.
Outputs are set to values in output tables.
Controller watchdogs are open.
User program is scanned once when the program is single cycled.
Programming activity (local or remote) is active
ESP Control and Tributary activity is suspended
Terminal and Printer activity is suspended
GEMSTART CCU communications are suspended.

Controller display: "Halt".

2.4.2. Halted, Test Inputs

Inputs are not being read.
Outputs are set to values in output tables.
Controller watchdogs are open.
User program is scanned once when the program is single cycled.
Programming activity (local or remote) is active
ESP Control and Tributary activity is suspended
Terminal and Printer activity is suspended
GEMSTART CCU communications are suspended.

Controller display: "THlt".

2.4.3. Running, Normal Inputs

Inputs are being read into input tables.
Outputs are being set to values in output tables.
Controller watchdogs are closed.
User program is being scanned continuously.
ESP, terminal and printer ports are functioning.
GEMSTART CCU communications are functioning.

Controller display: "Run".

2.4.4. Running, Test Inputs

Inputs are not being read.
Outputs are being set from output tables.
User program is being scanned continuously.
Controller watchdogs are open.

ESP, terminal and printer ports continue to function 9 all tables set to zero if link not connected.

GEMSTART CCU communications are suspended.

Controller display: "Trun".

2.4.5. Non-Fatal Shutdown

Inputs are not being read.

Outputs remain at last output value.

User program is not being scanned.

Controller watchdogs are open.

ESP, terminal and printer ports are suspended.

ESP programming ports continue to function.

GEMSTART CCU communications are suspended.

All controller functions enabled except 'run' mode.

Controller display: "#nnn" for system fault, where nnn = error code.
"!nnn" for user watchdog trip, where nnn = user error code.

Examples of faults: User Program CRC failure.
Watchdog Self-test failure.

Recovery Mechanism: Power Cycle.

2.4.6. Fatal Shutdown

Inputs are not being read.

Outputs remain at last output value.

User program is not being scanned.

Controller watchdogs are open.

ESP, terminal and printer ports are suspended.

Front programming port only continues to function.

GEMSTART CCU communications are suspended.

Controller display: "#nnn".
Examples of faults: Firmware CRC failure.
Source/data table RAM failure.

Recovery Mechanism: Power Cycle.

2.4.7. Extremely Fatal Shutdown

Inputs are not being read.

Outputs remain at last output value.

User program is not being scanned.

Controller watchdogs are open.

ESP, terminal and printer ports no longer function.

Front programming port no longer functions.

GEMSTART CCU communications no longer function.

Controller display: "#nnn".
Fault: Corrupt system kernel.
Recovery action: Replace firmware FLASH EPROMs.

GEMSTART CCU communications are suspended so that the watchdogs on the GEMSTART CCUs can drop out when the controller watchdogs trip. GEMSTART CCUs have no other way of following the state of the system watchdogs except by this enforced time-out.

Note...(1) The state of the controller under various fault conditions is given by F-table error codes (see Chapter 9).
(2) The GEM80-400 Processor Module will power up in the state it was in at the last power down.
(3) The checksum of the user Ladder Diagram, should always be correct when the system is 'powered down'.

2.5. Serial Communications

Serial communications activity, including the Printer/Programmer Port, interrupts the Controller Operating cycle and is processed as required, returning to the Operating cycle on completion. For further information, the operation of the serial link is discussed in Chapter 4.

2.6. Program Scan Times

GEM80-400 Controllers operate on a repetitive I/O scan and program execution cycle. The cycle time may be either:

- (1) Free-running - The program free-runs and repeats as soon as it can.
- (2) Preset - This is a regular defined interval where the preset value is set in a P-table. However, when the scan time is greater than the preset value, the cycle time becomes irregular.

2.6.1. Free-running Cycle Time

The processor performs a cycle which is represented diagrammatically in Figure 2.2. This cycle consists, basically, of:

- execution of the user program (a Ladder program scan),
- exchange of I/O data with the user data tables (an I/O scan),
- the number of accesses to the GEM80-400 table RAM causing a freeze between scans,
- any FIP access overhead, if the optional FIP interface is fitted and configured and partial self-test.

The total cycle scan time is the sum of the times taken by each individual function plus the time taken by any serial communication activity. The free-running cycle time is therefore variable.

2.6.2. Preset Cycle Time

If the cycle time is preset to a fixed value, the processor inserts a waiting period at the end of each ladder program cycle and any serial communication activity time is subtracted from this wait period to give a substantially constant cycle time. The preset cycle time, which is stored in a P-table, must of course be longer than the free running time. This is the way to run the controller wherever time dependent GEM80 Special Functions are used, for instance, if smooth ramp staircase functions are required. The smooth ramp is dependent upon the scan time being less than the interval defined in the P-table.

2.6.3. Calculating the Program Scanning Interval

The scanning interval of the controller depends on many factors, making it difficult to derive an accurate estimate of the scan interval. For most applications, a reasonable estimate of the scanning interval can be made by adopting the method detailed below.

The scanning interval can be considered to be the sum of nine components:

Scan Interval = $T_b + T_w + T_o + T_i + T_f + T_c + T_{fip} + T_s$, where:

- (1) T_b = The time taken to execute all of the bit logic instructions (e.g. --]/[--, --] [-- and --()--) in the ladder program. To calculate T_b , count the number of bit logic instructions in the ladder program and then use the relationships given below to calculate the value.
 - (i) For a 20K system, each bit logic instruction takes $1.35\mu\text{s}$
 - (ii) For a 36K system, each bit logic instruction takes $1.5\mu\text{s}$
- (2) T_w = The time taken to execute all of the word logic instructions (e.g. AND, OR, XOR and INV) in the ladder program. To calculate T_w , count the number of word logic instructions in the ladder program and then use the relationships given below to calculate the value.
 - (i) For a 20K system, each word logic instruction takes $0.9\mu\text{s}$
 - (ii) For a 36K system, each word logic instruction takes $1\mu\text{s}$.
- (3)&(4) T_i & T_o = The time taken to scan all plant inputs and outputs. T_i and T_o are dependent upon the number and type of I/O being scanned and can be calculated by using the formulae given below.
 - (i) $T_i = N_{vi} \times 200 + N_{bi} \times 120 + N_{ei} \times 400 \quad \mu\text{s}$
 - (ii) $T_o = N_{vo} \times 200 + N_{bo} \times 170 + N_{eo} \times 400 \quad \mu\text{s}$, where:
 N_{vi} = number of words of Verification Inputs to be scanned.
 N_{bi} = number of words of Basic Inputs to be scanned directly.
 N_{ei} = number of words of Basic Inputs to be scanned via an 8191 Expander Module.

Nvo = number of words of Verification Outputs to be scanned.
Nbo = number of words of Basic Outputs to be scanned directly.
Neo = number of words of Basic Outputs to be scanned via an 8191
Expander Module.

- (5) Tf = the time taken to execute all the GEM80 Special Functions and other instructions (e.g. DELAY, COUNTER, ADD, SUB, etc.). This can be calculated by summing the individual execution times for the Special Functions and Instructions given in Table 2.1.
- (6) Tc = the time added to the scan time due to serial link activity. This is dependent upon baud rate, the number of tables being transferred, and the controller scan time. For each baud rate, the maximum overhead is 9ms per port when transferring 32 tables. For each baud rate, this maximum is reached at a particular controller scan time (calculating by summing Tb, Tw, To, Ti and Tf) and below this scan time the overhead is a percentage of the controller scan, see Table 2.2.
- (7) T_{fip} = the time taken to read consumed data from the FIP data base and write produced data to it. This is only applicable if the optional FIP interface is fitted and the FIP configuration special function is present in the user ladder program. This time does not include the execution time of the FIPCFG special function, as this should only be executed once, not in successive scans.
- (8) Ts = the time added to the scan time due to the system overhead, time taken performing self-checks, etc. Ts has two components, a fixed component of 1.4ms and a second component that is a maximum of 6% of the controller scan time calculated so far

Table 2.2. Serial Link Overhead

Baud Rate	Serial Link Overhead as a % of Controller Scan	Cut Off (Scan Time)
19200	13.00	72ms
9600	6.50	144ms
4800	3.25	288ms
2400	1.62	576ms
1200	0.81	1.152s
600	0.40	2.304s
300	0.20	Not reached
110	0.07	Not reached

2.7. Program Operation

2.7.1. Programmer Units

To obtain the correct display of diagnostic messages and to use the on-line program change facility a suitable GEM80 programming tool, such as Gemesys 3, is required.

2.7.2. Remote Programming

Suitable GEM80 programming tools, such as Gemesys 3, can operate on a multi-drop serial link connected to several controllers at whatever signalling rate is selected by the user. The signalling rate which will be satisfactory for the given distance between the controller and a GEM80 programming tool, can be found by consulting the 'Serial Links User Information Sheet', Publication No.T456, and the 'Serial Communications Manual', Publication No.T457. See the 'Remote Programming' section of Chapter 4 for further details.

2.7.3. Program and Data Table Capacity

The user messages are stored in a separate area to the data tables, and do not take up data table space; however, they do take up half of a P-table address per character and therefore reduce the number of P-table addresses available to the user program.

2.7.4. Message Output Facility

The controller includes facilities for entering and editing message format definitions. These definitions are similar to the 'pictures' or 'images' found in some programming languages, and can include either or both literal and replacement characters. The message formats are handled as a single list which the controller automatically shuffles as the definitions are entered, edited or deleted. A print-out facility lists the message formats in a numbered and readily understandable form. Text messages edited in a suitable GEM80 programming tool, such as Gemesys 3, can be stored in the GEM80 data tables. The controller can be programmed to output messages to selected serial ports using the GEM80 Special Functions S38 PRITEXT and T38 PRINT.

2.7.5. Connecting a Suitable GEM80 Programming Tool

A suitable GEM80 programming tool, such as Gemesys 3, is connected to the Printer/Programming Port, Port 3, of the GEM80-400 Processor Module via a lead, appropriate to that programming tool. When a suitable GEM80 programming tool is connected to Port 3, the GEM80-400 Processor Module automatically detects its presence and selects the correct baud rate (either 9,600 or 19,200 baud). Wiring details for the Printer/Programming Connection Port are given in the 'Printer/Programming Port (Port 3) Connections' section of Chapter 4.

2.7.6. Program Compilation

The user program is stored in two forms: as 'source' code for editing purposes and 'compiled' form for execution by the processor. Conversion from source code to compiled code is called 'Compilation' and is carried out under the following conditions, for RAM based systems:

- (1) At power up (automatically).
- (2) On halt/run transitions (automatically).
- (3) When the user issues a RECOMPILE command while the program is running.

(4) On single cycle when the program has been changed since the controller was last running.

Compilation not only converts the program into an executable form but also checks the source program to verify that it can be executed. Any error detected during compilation prevents the program being executed and if the controller was previously running a version of the program it continues to run this 'old' program. The errors are reported by text messages and can be displayed by a suitable GEM80 programming tool, such as Gemesys 3; a detailed discussion of compilation and associated problems is given in Chapter 9 of this manual.

Errors detected during compilation will prevent the program being executed.

2.7.7. On-line Program Changes

There are two versions of the program held in memory, compiled and uncompiled. The uncompiled source program can be edited while the compiled program is running and controlling the plant. This edited version can be printed out or copied to disk without halting the controller. To incorporate the changes made during an editing session, the user can issue a RECOMPILE command from a suitable GEM80 programming tool, such as Gemesys 3. The controller will pause for a short time (typically one millisecond per 1000 instructions) while compilation is in progress and during this time, all outputs are frozen and inputs are ignored. If compilation is successful, the controller will run the modified program. If not, the controller will run the previous compiled program. A message to this effect will be displayed on the display on the processor front panel.

Note...Any change to P-data tables above P149 will affect the running program immediately without recompilation being necessary. The 'Data Tables' section, later in this chapter, gives more information about the controller data tables.

The on-line RECOMPILE command does not affect data table contents. After any RECOMPILE command has been successfully executed, flag bit E0.6 is set ON for one program cycle, and then set OFF again. This flag bit can be used to initiate any block of instructions that needs to be executed once only. For instance, after recompiling, data tables may reside in different locations to those previously occupied. Therefore, by using the E0.6 bit to initiate a block containing S20, GEM 80 Special Function LOCATE instruction, it is possible to find the absolute addresses of the table locations used by the ladder program.

Note...On-line program changes cannot be made on EPROM based systems.

2.7.8. Off-line Program Debugging

Using TEST INPUTS mode, a program can be de-bugged on a system in the office with no I/O present. Program timing is not significantly altered compared with when the I/O is present. When the TEST INPUTS mode is selected from a suitable GEM80 programming tool:

- (1) The Watchdog contacts do not close.
- (2) Input scanning is executed but the A-tables are not updated.

-
- (3) Output scanning is executed.
 - (4) All I/O self tests are suspended.
 - (5) All compilation checks on the presence of both Basic and Verification I/O are suspended.
 - (6) All Serial Link protocols function normally during TEST INPUTS mode except for GEMSTART CCU communications which are suspended.

2.7.9. Loading Programs

Before loading a program, it is recommended that a CLEAR STORE command is always issued, for the following two reasons:

- (1) The area of memory that holds printer messages is not normally write-accessible except via the message editor facility. The CLEAR STORE command allows data to be loaded into the area.
- (2) The controller allocates memory space for the data tables according to the content of the ladder program. The CLEAR STORE command sets all data table areas to their minimum size, and ensures that unnecessary space has not been allocated by the previous version of the program.

When a CLEAR STORE command is issued, the whole of the P-table is cleared except for P0 to P149. These table locations include the configuration data for the serial links. These sections of P-table are not cleared because the GEM80-400 Processor Module may be programmed either from the front port of the processor, or remotely via one of the serial ports. If the controller lost data about the serial port configurations, it might become impossible for the controller to communicate with a remote programming tool. This data is therefore retained even when the rest of the memory is cleared.

Note...When the data being loaded includes messages, the message area, made write-accessible by the CLEAR STORE command, becomes write-protected again after compilation, except via the message editor.

2.7.10. Programming the Controller

User programs for operating the GEM80-400 Processor Module are written in the GEM80 Ladder Diagram Programming Language. Full details of how to use this programming language, how to program the controller and the use of the Standard Instruction Set are contained in the 'GEM80 Programming Manual', Publication No.T391.

Note...EPROM based systems cannot be programmed, only downloading to a suitable GEM80 programming tool, such as Gemesys 3, is allowed.

2.8. User Program

2.8.1. Introduction

This section contains only brief details of GEM80 Ladder Diagram programming and the subject is dealt with, in detail, in the 'GEM80 Programming Manual', Publication No.T391.

2.8.2. Ladder Diagram Language

The controller user program uses the GEM80 Ladder Diagram Programming Language which can be illustrated by a simple example:

The circuit for a relay, energised by a push-button, would be represented in GEM80 Ladder Diagram Programming Language as shown in Figure 2.3. A normally open push-button or contact is represented by a -] [- symbol and a relay coil by a -()- symbol. A0.0 and B1.1 are data table addresses. A0.0 (bit 0 of 16-bit word A0) is an input data table and stores the state of I/O equipment connected to the controller relating to address A0.0. B1.1 (bit 1 of 16-bit word B1) is an output data table and, depending on the result of executing the user program, B1.1 is set to 1 or 0 and the I/O equipment connected to the controller relating to B1.1 is controlled by this signal.

This very simple example shows the basic idea of the ladder diagram language. The instruction set is very large and while it is easy to understand and program in GEM80 Ladder Diagram Programming Language, the language is also very powerful. It offers considerable advantages in simplicity, reliability, flexibility and power over relay and integrated circuit logic systems for industrial applications.

Figure 2.4 shows two rungs of a ladder diagram program. Each rung is composed of elements and up to 10 series elements are allowed in each rung. Figure 2.6 also shows that a rung can have several branches. Each rung may have up to 5 parallel branches and up to 20 loops (branch open/branch closed).

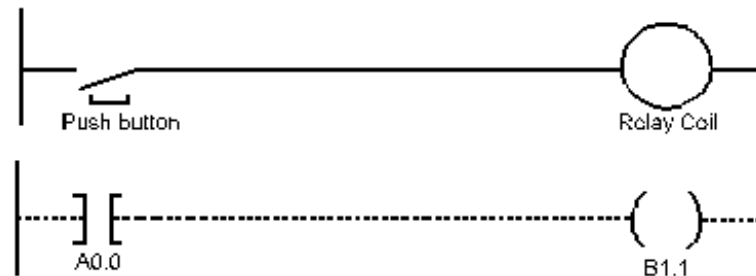


Figure 2.3 - Ladder Diagram Language

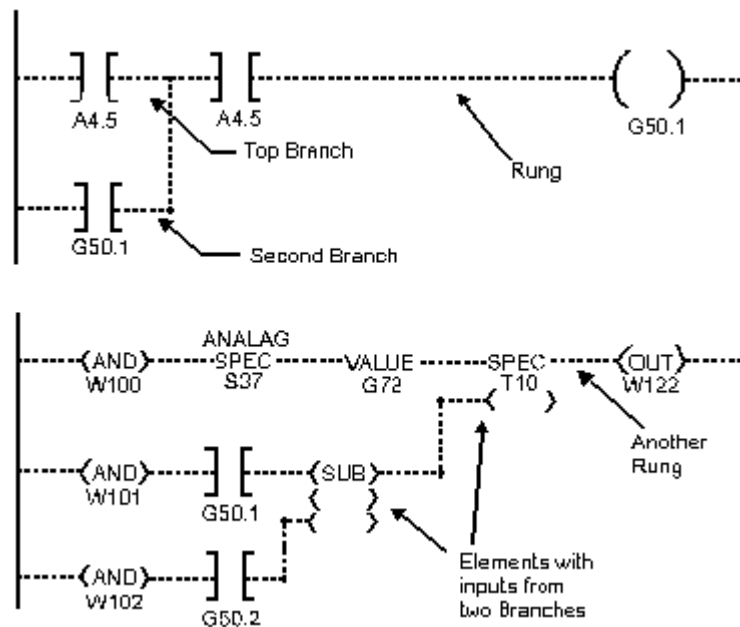


Figure 2.4 - Two Rungs of Ladder Diagram Language

2.8.3. Instruction Set

The comprehensive instruction set includes standard GEM80 Instructions and GEM 80 Special Functions. They fall into the following categories:

- (1) Relay Replacement Functions;
- (2) Logic Functions;
- (3) Maths Functions (Integer and Floating Point);
- (4) Signal Processing;
- (5) Closed Loop Control;
- (6) Binary Tests;
- (7) Binary Manipulation;
- (8) Numerical Tests;
- (9) Numerical Manipulation;
- (10) Block Instructions;
- (11) Data Moving Instructions;
- (12) Code Conversion;
- (13) Serial Port Alphanumeric Input and Output;
- (14) Output Functions;
- (15) GEM80-400 Additional Special Functions.

Details of the Standard Instruction Set are contained in the 'GEM 80 Programming Manual', Publication No.T391. However, GEM80-400 Additional Instructions, namely: Set Coil, Reset Coil, Jump, Label and Sequelem, are not contained in the 'GEM80 Programming Manual', Publication No. T391, but are detailed at the end of this chapter. Table 2.1 details the instruction set.

Table 2.1 - GEM80-400 Controller Instruction Set

Some functions are only available in certain controllers . See end of table for details

	Function	Instruction	GEM 80 Special Function	Remarks	Number of Instructions	Number of Table Locations used by VALUE	Execution Time in μ s
1. Relay Replacement Functions	N/O contact	---] [---	-	Functions as a normally open relay contact	1	-	1.35
	N/C contact	---]/[---	-	Functions as a normally closed relay contact	1	-	1.35
	Coil	---()---	-	Functions as a relay contact	1	-	2.75
	Set coil	---(S)---	-	Set retentive coil	1	-	-
	Reset coil	---(R)---	-	Reset retentive coil	1	-	-
	Output	OUT	-	Outputs 16-bit word to a specified data table location	1	-	1
	Time Delay	DELAY	-	Time range 100ms to 54 minutes	1	-	7
	Counter	COUNT	-	Counter with a capacity of 32,767 (resettable)	1	-	12
	Sequencer	SEQR	-	16-step Sequencer with reset	1	-	7
2. Logic Functions	Logic AND	AND	-	Bit-by-bit ANDing of 2 x 16-bit words	1	-	*0.3/0.85/4.15
	Logic AND group of words	ANDGRP	T24	Bit-by-bit ANDing of 2 groups of 16-bit words	2	3	See Note 1
	Logic OR	OR	-	Bit-by-bit ORing of 2 x 16-bit words	1	-	*0.3/0.85/4.15
	Logic OR group of words	ORGRP	T25	Bit-by-bit ORing of 2 groups of 16-bit words	2	3	See Note 1
	Logic exclusive OR	XOR	-	Bit-by-bit XORing of 2 x 16-bit words	1	-	*0.3/0.85/4.15
	Exclusive OR group of words	XORGRP	T26	Bit-by-bit XORing of 2 groups of 16-bit words	2	3	See Note 1
	Invert	INV	-	Inverts each bit of 16-bit word	1	-	0.2
	Invert group	INVGRP	S25	Inverts each bit of a group of 16-bit word	2	3	See Note 2
	Sequence diagnostics	SEQDIAG	T19	Enables automatic monitoring of any sequence of events	2	11 + N (See also Note 3)	<12
3. Math Functions	Addition	ADD	-	Addition of Floating point/Integer values, limits +32767 to -32768	1	-	*5.7/6.35/5.9
	Array addition	ADDARRAY	T12	Addition of arrays, limits +32767 to -32768	2	3	See Note 4
	Subtraction	SUB	-	Subtraction of Floating point/Integer values, limits +32767 to -32768	1	-	7
	Array subtraction	SUBARRAY	T13	Subtraction of arrays, limits +32767 to -32768	2	3	See Note 4
	Multiply	MULT	T10	Multiplication of Floating point/Integer values, limits +32767 to -32768	1	-	9
	Array multiplication	MULARAY	T14	Multiplication of arrays, integer multiplication limits +32767 to -32768	2	3	See Note 5
	Division	DIV	T11	Division of Floating point and Integer values, integer division limits +32767 to -32768	2	1	14
	Array division	DIVARRAY	T15	Integer division limits +32767 to -32768	2	4	See Note 6
	Linear conversion	LINCON	S11	Provides arithmetic calculation	2	4 (See also Note 7)	68

	Function	Instruction	GEM 80 Special Function	Remarks	Number of Instructions	Number of Table Locations used by VALUE	Execution Time in μ s
	Array linear conversion	CONARRAY	S10	Provides multiplication, division and addition calculations for two arrays of data, i.e. performs LINCON on array	2	3 + 3N (See also Note 9)	See Note 8
	Square root	SQRT	S12	Square root, limits +32767 to -32768	2	1	78
	Checksum	CHKSUM	T9	Calculates the checksum of data table contents	2	1	See Note 10
	Standard Deviation	STDDEV	T18	Calculate mean and standard deviation of a number of values	2	11	See Note 11
	Sine	SIN	S70	Provides the sine of an angle, FP	1	-	2
	Cosine	COSINE	S71	Provides the cosine of an angle, FP	1	-	2
	Tangent	TANGENT	S72	Provides the tangent of an angle, FP	1	-	77
	Arc sine	ASIN	S80	Provides the angle of a sine function, FP	1	-	41
	Arcosine	ACOS	S81	Provides the angle of a cosine function, FP	1	-	62
	Arc tangent	ARCTAN	S82	Provides the angle of a tangent function, FP	1	-	58
	Degrees to radians	DEGRAD	S75	Converts degrees to radians	1	-	13
	Radians to degrees	RADDEG	S85	Converts radians to degrees	1	-	13
	Log to the base 10	LOG10	S73	Provides the logarithm to the base 10 of a value, FP	1	-	102
	Log to the base e	LOGE	S74	Provides the logarithm to the base e of a value, FP	1	-	102
	Pi	PI	S77	Provides 'Pi' in FP	2 OR 1	-	2.1
	Exponential	EXP	S84	Raises 'e' to a specified power, e^x , FP	2 OR 1	-	46
	Power	POWER	T70	Raises a value to a specified power, x^y , FP	1	-	112
	Floating point scale	FSCALE	T73	Multiplies a value to a specified power of 10, $x \times 10^y$, FP	1	-	112
4. Signal Processing	Debounce input signal	DBOUNCE	S0	Provides signal conditioning to logic signals prone to spurious or transient problems	2	5 (See also Note 7)	36
	Function generator	FGEN	S30	Approximate continuous function	2	4 + N (See also Note 9)	125
	Dead band	DEDBAND	S31	Deadband offset	2	3 (See also Note 7)	18
	Limiter	LIMIT	S32	Limits input between high and low limits	2	3 (See also Note 7)	28
	Ramp generator	RAMP	S33	Comprehensive ramp generator (includes rounding), variable rate with output limits	2	15 (See also Note 7)	287
	First order time constant	ANALAG	S37	First order digital filter to smooth fluctuating numerical values	2	5 (See also Note 7)	61
	Time constant	TCONST	S60	Digital filter programmable time constant	2 OR 1	- OR 6	\approx 500
	Ramp generator	RAMPGEN	S61	Time independent ramp generation	2 OR 1	- OR 13	\approx 900
5. Closed Loop Control	Absolute 3 term controller	PIDABS	S34	Provides absolute proportional, integral and derivative control with absolute output	2	15 (See Note 7)	165

	Function	Instruction	GEM 80 Special Function	Remarks	Number of Instructions	Number of Table Locations used by VALUE	Execution Time in μ s
	Incremental 3 term controller	PIDINC	S35	Provides incremental, proportional, integral and derivative control with incremental output	2	9 (See Note 7)	144
	Incremental output	INCOUT	S36	Incremental output with limits and deadband	2	5 (See Note 7)	94
	PID control	PIDCON	T60	Mode selectable time independent PID control	2	-	-
	Programmable PID control	PIDSIM	T61	Programmable PID control	2	20	-
6. Binary Tests	High state	HISTATE	S3	Reports bit number of highest bit of 16-bit word set on (1)	1	-	16
	Bits ON	BITSON	S26	Reports number of bits set on (1) in a group of 16-bit words	2	2	See Note 12
	Compare group	CMPGRP	T21	Compares two groups of 16 bits and reports details of the first difference	2	3	See Note 13
	Get bit	GETBIT	T22	Performs a test of on state individual bits in group of words	2	2	50
7. Binary Manipulation	Swaps 1/2 locations	SWAP	S4	Swap 1/2 locations	1	-	1
	Shift	SHIFT	S27	Left and right shift on a group of 16-bit words	2	3	See Note 14
	Rotate	ROTATE	S28	Left and right rotation on a group of 16-bit words	2	3	See Note 14
	Put bit	PUTBIT	T23	Allows setting and resetting of individual bits in groups of words	2	3	See Note 15
	Shifts bits in words	QSHIFT	T27	Shifts bits of words left or right	1	0	7-10
	Rotate bits in words	QROTATE	T28	Rotates bits of words left or right	1	0	8-24
8. Numerical Tests	Compare	COMPARE	T0	Compares two inputs and shows whether they are equal, unequal, etc. These GEM 80 Special Functions report if:	2	1	11
	Comparison	EQ	T1	(a) X=Y, Test for equality	1	0	3
	-	NE	T2	(b) X \neq Y, Test for inequality	1	0	3
	-	GT	T3	(c) X greater than Y	1	0	3
	-	LT	T4	(d) X less than Y	1	0	3
	-	GE	T5	(e) X greater than/= Y	1	0	3
	-	LE	T6	(f) X less than/= Y	1	0	3
	Select maximum in array	MAXARAY	S13	Finds maximum value in array	2	3	See Note 16
	Select minimum in array	MINARAY	S14	Finds minimum value in array	2	3	See Note 16
	Select maximum	MAX	T7	Finds maximum of two inputs	1	0	15
	Select minimum	MIN	T8	Finds minimum of two inputs	1	0	15
	Compare Array	CMPARAY	T16	Array comparison	2	4	See Note 17
	Delay Array	DELARAY	S15	Multiple delay array	-	-	See Note 18
	Negate	NEGATE	S5	Changes the sign of a number	1	0	1.5
	Absolute	ABS	S6	Makes a number positive	1	0	1.5
	Non-zero	NONZERO	S7	Convert non-zero input into integer -1	1	0	1.5
9. Numerical Manipulation	Floating point to integer conversion	FPOINT	S76	Floating point to integer	-	-	-
	Error flag	FPFLAGS	S78	Floating point maths error	1	-	-

	Function	Instruction	GEM 80 Special Function	Remarks	Number of Instructions	Number of Table Locations used by VALUE	Execution Time in μ s
	Integer conversion	FIX	S79	Convert floating point to BCD	2	-	-
10. Block Instructions	Enclose conditionally executed rungs	START OF BLOCK	-	Conditionally executed block of ladder diagram instructions can be nested to a depth of 16	1	-	1.5
	-	END OF BLOCK	-	-	1	-	-
	-	JUMP	-	JUMP forward to LABEL	-	-	-
	-	LABEL	-	LABEL associated with JUMP	-	-	-
	-	SEQELEM	-	Sequence element	-	-	-
11. Data Moving	Locate data table address	LOCATE	S20	These two GEM 80 Special Functions, S20 and T20, are usually used together for moving groups of data from one area of memory to another. May be used for locating an internal address required by various GEM 80 Special Functions. Provides pointer to data table	2	1	100
	Move data between data table addresses	MOVE	T20	Commonly used in conjunction with S20, moves blocks of data tables	2	0 or 1	See Note 19
	Cyclic store	STORE	T30	First in first out store	2	4 + N (See Note 20)	130
	Get word	GETWORD	S19	Indirect data access	2	1	96
	Fill array	FILL	T17	Fill array with value	2	0 or 1	See Note 21
	Put word	PUTWORD	T29	Indirect output of word	2	1	96
	Collate	COLLATE	T37	Collates random bits or words into a group of adjacent data table locations	1	0	See Note 22
12. Code Conversion	BCD input conversion	BCDIN	S1	Converts up to 4 decades of BCD to binary	1	0	36
	BCD output conversion	BCDOUT	S2	Converts binary to up to 4 decades of binary coded decimal	1	0	32
	Convert gray code to binary	GRAYBIN	S9	Converts gray code input to binary	2	1	29
13. Serial Port Alpha-numeric Input and Output	Print text	PRITEXT	S38	Enables messages stored in controller memory to be output to serial port/printer	2	(C + 1)/2 (See Note 23)	144
	Print	PRINT	T38	Enables user definable messages to be output on a serial port/printer	2	N (See Note 25)	See Note 24
	Character input	CHARIN	T39	Read input from serial port	2	(C + 1)/2 (See Note 23)	115
	Message store OR retrieval	GETTEXT	S21	Store message strings	2 OR 1	2	-
14. Output Functions	Output	OUTPUT	S8	Intermediate output from rung	2	1	1.5
15 Starnet	Configure Ports	CONFIG	T33	Used to configure STARNET ports	2	1	See note 29
	Send Message	SEND	T34	Transmit outgoing data	2	2	See note 30
	Receive Message	RECEIVE	T35	receive incoming data	2	3	See note 31
	Log Statistics	STATS	T36	Report STARNET errors and statistics	2	1	1300

	Function	Instruction	GEM 80 Special Function	Remarks	Number of Instructions	Number of Table Locations used by VALUE	Execution Time in μ s
Off Line Data Manipulation	Clear Off Line Data	CLEAR	S29	Resets off line data	2	0 or 1	
	Put Off Line data	GET	T31				
	Get off line data	PUT	T32				
GEMLAN D	Opens a communication channel	LOPEN	T62	See GEMLAN D Manual T1603	2	2	See note 27
	Requests Data	LREAD	T64	See GEMLAN D Manual	2	6	See note 27
	Sends Data	LWRITE	T63	See GEMLAN D Manual	2	6	See note 27
	Closes Communication channel	LCLOSE	S62	See GEMLAN D Manual	2	2	See note 27
	History record of status changes	LSTATUS	S63	See GEMLAN D Manual	2	4	See note 27
15. GEM 80-400 Additional Special Functions	Time Delay	TON	S125	Timer with ON Delay	2	1	7
	Time Delay	TOFF	S126	Timer with OFF Delay	2	1	7
	Time Delay	TP	S127	Timer with Pulse Output	2	1	7
		TOGGLE	S128	Toggle Flip-flop	2	1	7
		ONESHOT	S129	One-shot, ON for one scan	2	1	7
		SEQGRP	T111	Sequence Group	2	See Note 28	
		SR	T112	SR Flip-flop	1	-	2.75
		RS	T113	RS Flip-flop	1	-	2.75
		CLOCK	S55	Real time clock	2	6	68
	FIPCFG	S145	FIP configuration (FIP interface module required)	2	See Note 26	See Note 27	

* Constant/Table/Floating Point

Notes on Table 2.1

- (1) $100 + (6 \times Qty)$ - Array with array; $75 + (5 \times Qty)$ - Array with constant
- (2) $63 + (3 \times Qty)$
- (3) $N = 2 \times$ Number of transitions
- (4) $115 + (10 \times Qty)$ - Array with array; $95 + (9.5 \times Qty)$ - Array with constant
- (5) $115 + (8 \times Qty)$ - Array with array; $95 + (8 \times Qty)$ - Array with constant
- (6) $120 + (14 \times Qty)$ - Array with array; $100 + (13 \times Qty)$ - Array with constant
- (7) Typically uses stated number of locations in both preset and working tables
- (8) $62 + (40 \times Qty)$ - Array with array; $55 + (38 \times Qty)$ - Array with constant
- (9) $N =$ number of tabulated points or array length
- (10) $36 + (13.5 \times Qty)$
- (11) Acquire 540μ s, Reset 250μ s, Calculate 14,500, Acquire + Calculate 18,000
- (12) Simple 43, Group $43 + (38 \times Qty)$
- (13) $72 + (8 \times Qty)$
- (14) $80 + (8 + (0.5 \times \text{shift}) \times Qty)$
- (15) Simple 22, Group 54
- (16) $43 + (6 \times Qty)$
- (17) $136 + (10 \times Qty)$ - Array with array; $100 + (8.5 \times Qty)$
- (18) Reset 194, Run $136 + (13 \times qty) + (7 \times qty \text{ while running}) + (17 \times qty \text{ when reset})$
- (19) $72 + (0.7 \times qty)$
- (20) 4 + store length
- (21) $94 + Qty$
- (22) $360 + (11 \times \text{message number}) + (110 \times \text{number of words}) + (120 \times \text{number of bits})$
- (23) $(\text{message length})/2$

-
- (24) For text (4 × message number) + 190, for text and numbers (4 × message number) + (260 to 575)
 - (25) N = quantity of numbers to be output
 - (26) Number of table locations used is variable. see FIP Manual T1653.
 - (27) Time of execution is dependant on a number of factors and is impossible to predict.
 - (28) See later in chapter for examples of this function.
 - (29) 5800+ 600 per channel
 - (30) 700 + 800 per block of 111 words + (7 * Qty. of locations)
 - (31) 900 + 500 per block of 111 words + (7 * Qty. of locations)

Certain special functions are only available in the FP (Floating Point) versions of the GEM80/400 Processor. These are

Floating Point Maths Functions	S70-S82, S84, S85, T70, T73
GEMLAN-B Special Functions	S86-S88, T86-T89
Control Special Functions	T60, T61, T18

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2.9. GEM80 Special Functions

2.9.1. Introduction

GEM 80 Special Functions are pre-written software routines, called up in the ladder diagram program. Gemesys 3 accesses the GEM 80 Special Functions via the use of their mnemonic name, or their 'S' or 'T' table name. The GEM80 Special Functions are detailed in Table 2.1 and cover multiply, divide, function generator, closed loop controls, etc. GEM80 Special Functions are described, in detail, in Software Data Sheets and, briefly, in the 'GEM80 Programming Manual', Publication No.T391.

2.9.2. Array and Group GEM 80 Special Functions

Array and Group GEM80 Special Functions require a LOCATE GEM80 Special Function to precede them. Array and Group GEM80 Special Functions use addresses of data tables as inputs (in VALUE set-up list). These must be obtained using the LOCATE GEM80 Special Function in the program since the internal addresses move about when a program is recompiled. Constants, which are derived by inspection of the output from LOCATE in a different program, should not be used. As a general rule LOCATE must be used every time an internal address is required.

2.9.3. Implied Addresses in GEM 80 Special Functions

Where addresses are implied, e.g. when using LOCATE and MOVE, the user must include a dummy rung or rungs to declare the highest address.

2.9.4. Use of Floating Point GEM 80 Special Functions

Integer or floating-point numbers can be passed along a rung from one function to another. Integer to floating-point conversion is performed automatically when required by outputting a result into an appropriate Q-table.

Floating-point to integer conversion must be performed explicitly by the user, using the FPOINT GEM80 Special Function, otherwise a compilation error will occur. Where a function can operate in integer or floating-point form, if all inputs to the function are integer, it will perform an integer calculation and output an integer value. If any or all the inputs are floating-point, a floating-point calculation is performed and the output is floating-point. Where a function references a table, reference to a Q-table gives a floating value. Other tables give an integer value.

2.9.5. Program Capacity

The program/instruction capacity of the GEM80-400 Controller depends on the amount of memory installed. The amount of memory installed is detected by the controller hardware. On start up the following message is sent to the Printer/Programming Port: 'GEM 80 XXXX Instructions in RAM' for RAM based systems or 'GEM 80 XXXX Instructions in EPROM' for EPROM based systems. Table 2.3 gives details of the program and data table capacities available to the user:

Table 2.3 - Program and Data Table Capacity

Number of User Instructions	Data Tables	Maximum Number of P-Tables	Expansion Required
20,000	30,000	30,000	No
40,000			Yes

Note...

- (1) The P-tables are part of the total data tables available.
- (2) The maximum number of data tables does not include data tables allocated by the system e.g. P-tables 0 to 149.
- (3) The maximum number of data tables and instructions is fixed for each memory size, i.e. there is no trade off between data tables and instructions.

2.10. Program Development

Programs can be developed prior to installation and commissioning, and by connecting the 8902 I/O Simulation panel, limited operational tests can be performed on the newly developed programs. For further information on program development, see Sections 1 and 3 of the 'GEM80 Programming Manual Ladder Diagram Language', Publication No.T391.

2.11. Programming Procedures

2.11.1. CLEAR STORE

Before loading a program, the user is recommended to always issue a CLEAR STORE command, for the following two reasons:

- (1) The area of memory used for holding printer messages is not normally write-accessible except via the message editor facility. The CLEAR STORE command allows data to be loaded to the whole of the P-table.
- (2) The controller allocates memory space for the data tables according to the content of the program. To ensure that unnecessary space has not been allocated by the 'old' version of the program, use of the CLEAR STORE command sets all data table areas to their minimum size first.

2.11.2. Declare Highest Address

Since data table sizes are computed by the controller from the user program (see the 'Data Table Sizes' section, later in this chapter), in some cases where addresses are not specifically stated in the user program, problems can occur. If the user wishes to access and use any P-table he must explicitly declare the table in the program, so securing the address range.

For example:

```

---<AND>-----<OUT>
  P6000                G0

```

Figure 2.5 - P6000 Highest Address

Some GEM80 Special Functions use groups of addresses which are not specifically written in the user program (LOCATE, MOVE, etc.) and the user must declare the highest address in each table where this occurs. For example:

```

---<AND>---<AND>---<AND>---<OUT>
  G6000   W800   R50    G1

---<AND>-----<OUT>
  Q2000                Q2000

```

Figure 2.6 - Declaring Highest Address

2.11.3. Storing Programs

As programming proceeds and especially when complete, copies of the program should be dumped onto suitable media even if they are untested, so that at each stage as the program is developed, a nearly up to date copy of the program is available. This enables the programmer to back track quickly if necessary, by clearing store and re-loading, and gives back-up should unforeseen problems occur. Both program instructions and P-table can be stored onto suitable media and, in fact, two records should be maintained by alternately dumping the program first onto one media then the other at each stage of development. On completion, you should store two identical final programs which should be filed separately in two secure locations.

2.11.4. Storing Program and Presets in EPROM

The user program, user messages and P-tables (presets) may be transferred to EPROM for more permanent storage.

You will need one EPROM memory module type 9291-4024 for the data stored on board the GEM80-400 Processor Module.

The 9291-4024 FLASH EPROM Memory Module plugs onto the GEM80-400 Processor Module in the same position as the 9291-4004 memory module. Refer to the section 'Effect of Fitting a Memory Expansion Board', in Chapter 8 of this manual, for fitting instructions.

The 9291-4024 uses FLASH EPROMs which may be erased and reprogrammed, in situ, by the GEM80-400 Processor Module. The contents of the memory module may be protected from accidental modification by moving the write protect switch (mounted on the FLASH EPROM Memory Module), from the "program" position to the "protect" position.

When the system is "running in EPROM", the data is stored in the following locations:

	9291-4024 FLASH Memory Module	GEM80-400 on-board RAM
Source for User Program	YES	NO
Compiled User Program	NO	YES (See Note 1)
User Text Messages	YES	YES (See Note 2)
P-Tables	YES	YES (See Note 2)
Other Data Tables	NO	YES

Notes...(1) Generated by the compiler at power up using the user program source.

(2) Copied from the 9291-4024 FLASH Memory Module at power. The controller cannot write to these areas.

2.11.5. Transferring Program and Presets to EPROM

The system is transferred to and from EPROM (including the FLASH EPROM) by writing commands in the form of values into the S0 table location. A suitable GEM80 programming tool, such as Gemesys 3, provides a considerably enhanced EPROM control interface. Please refer to the relevant programming tool manual for details.

Valid S0 commands are as follows:

- 0 Run from RAM
- 1 Run from EPROM
- 2 Program EPROM

Note...S0 may only be changed when the controller is halted. When the controller is running S0 is write protected.

2.11.6. Programming EPROM

To transfer the system into EPROM, halt the controller and set S0 to 2. This causes the following sequence of events to occur:

- Stop scanning I/O
- Check EPROM areas:
 - Any Video processors halt and display the "EPROM FORMAT"
 - The word "PROG" is written to the front panel alphanumeric display
 - The required EPROM storage areas are checked to ensure that they are present and programmable

If the check on the IMAGEM format area is unsuccessful the IMAGEM formats will not be transferred to EPROM, however, the transfer of the rest of the system will still be attempted.

If the check on the onboard or requested Off-line areas is unsuccessful, the transfer operation is aborted:

- error messages are sent to the System Log and programming tool, and the corresponding error code is displayed
- the "PROG FAILED" LED lights to indicate which sub-module caused the failure
- the controller remains halted
- S0 remains unchanged. The controller cannot be run until S0 is set to 0
- Any IMAGEM Modules are restarted.

Program EPROM areas:

- the on-board FLASH EPROM is programmed
- the "PROG" LED on the front panels of the 8272 Memory Modules light, in turn, as any Off-line blocks are programmed
- if the IMAGEM video formats are to be transferred to EPROM, the "PROG" LED on the front panels of the 8272 Memory Modules light, in turn, as the Video Formats are programmed

If an any area of EPROM fails to program:

- error messages are sent to the System Log and programming tool, and the corresponding error code is displayed
- the "PROG FAILED" LED lights to indicate which sub-module caused the failure
- the controller remains halted
- S0 remains unchanged. The controller cannot be run until S0 is set to 0
- Any IMAGEM Modules are restarted.

Switch to EPROM:

- the "EPROMS Successfully Programmed" message is sent to the System Log and programming tool
- the "PROG PASSED" LEDs light on any 8272 Memory Modules
- the S0 table is set to 1
- the controller remains halted
- the word "Halt" is written to the alphanumeric display
- any IMAGEM Modules restart.


```

* * * * * START OF BLOCK * * * * *

  --<AND> -----<OUT>
    123             F1

* * * * * END OF BLOCK * * * * *

```

Figure 2.7 - Watchdog Trips and User Program

G10.0 is set on only when the watchdog trip is required, and only when G10.0 is on will the block be obeyed. Then AND 123 puts code 123 into F1 (i.e. a non-zero code) so the watchdog trip will occur.

If G10.0 re-sets to zero before the next scan, the obey block is not obeyed and the non-zero F1 code is maintained (as it should be).

Restart procedure is the same as for any other F1 trip, so that if a programmer is connected it will display F1 = 123 and the author of the user program must have documented the meaning of F1 = 123 in such a way that a rectification procedure can be initiated. For example, F1 = 123 may be a shut-down occurring because a limit switch signal has not been received. Once this has been rectified, G10.0 should be arranged to reset to zero and the controller power should be turned on and off (resetting F1). The system can then be re-started.

THE FOLLOWING TYPE OF RUNG MUST NOT BE USED:

```

--- <AND> --- ] [ ----- <OUT>
    123      G10.0      F1

```

Figure 2.8 - Incorrect use of F1

The reason being that while G10.0 is off, zero is written into F1. If other rungs are writing non-zero (requesting a watchdog trip) this rung over-writes that request back to zero. It is therefore impossible for a non-zero code to be maintained in F1 for the required length of time, i.e. 100ms plus total scan time.

2.13. Data Tables

The data tables consist of 16-bit binary words of data stored in the memory and accessed by their address.

Each data table location may hold:

- (1) 16 ON/OFF bits,
- (2) a numerical value in the range -32,768 to +32,767 or
- (3) floating point numbers, i.e. the contents of Q-table addresses.

Several different tables are required, each storing data relating to a particular function (e.g. the P-table stores preset data, the J and K-tables store data received and transmitted via the serial communication links respectively, and so on).

2.13.1. Data Table Addressing

The data tables are addressed using the initial letter of the table followed by a number e.g. P41 points to the word 41 in the P-table. If, for example, we were to look at the content of data table address G1 it may be:

BIT NUMBER	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ACTUAL VALUE	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0

To address individual bits in the P-table a decimal value is used, e.g. P41.2 points to bit 2 in word 41 of the P-table. If we were only interested in the content of one bit of G1, for example, bit 4, we would examine the data table address G1.4 and find that G1.4 = 1.

However, such a search is not possible with Q-tables, see the 'Floating Point Numbers' section, later in this chapter. Table 2.4 shows the data table addresses available and information that can be found in these memory locations.

2.13.2. Data Storage Formats

2.13.2.1. Integer Numbers

The data table content can be interpreted as:

- (1) An equivalent decimal number.
- (2) 16 individual bits each of value 1 or 0.
- (3) An equivalent hexadecimal number.

For example, address G2 may contain:

BIT NUMBER	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ACTUAL VALUE	1	0	1	0	1	1	0	0	0	0	1	1	0	1	0	1

which can be interpreted as:

BINARY	1 0 1 0 1 1 0 0 0 0 1 1 0 1 0 1,
DECIMAL	-21451,
HEXADECIMAL	@AC35

2.13.2.2. Decimal

As shown in the above example, when converting from binary to decimal, 2s complement notation is used. Bit 15 is taken as the sign bit and the number

displayed will be a signed integer within the range +32,767 to -32,768. When bit 15 = 1, a negative number is represented and when bit 15 = 0, a positive number or zero is represented.

2.13.2.3. Hexadecimal

The numbers are to base 16 and are denoted by a preceding '@'. The range of numbers covered is from @0000 to @FFFF.

2.13.2.4. Text

Text strings are stored using the ASCII format for use as messages.

2.13.2.5. Floating Point Numbers

GEM 80 controllers normally deal in 16-bit integer values. However, certain GEM 80-400 Controllers use a maths co-processor which allows floating-point arithmetic. Each floating-point number is held as 2 consecutive tables in the Q-table. Thus the floating-point locations are addressed as Q0, Q2, Q4, Q6 etc. GEM80 Special Functions to deal with the floating-point operations are detailed earlier in this chapter. Where a floating-point location is addressed by a floating-point instruction, checks are made to ensure that the correct table location is referenced. If there is a fault, a compilation error is given. Where Q-tables are accessed by other instructions then no checks are made. Q-tables can be accessed by a GEM80 programming tool, such as Gemesys 3, in the usual way and are displayed with an exponent in the data tables. When monitoring rungs, floating-point numbers are displayed to 2 decimal places. The 'Program Operation' section of this chapter gives more information on using GEM80 programming tools. Floating-point numbers are stored in Q-tables as follows:

Qn: bits 0 to 15 of number
 Qn+1: bits 16 to 31 of number

The 32-bit floating-point number is defined as:

bit 31: sign (0= positive, 1= negative)
 bits 30 to 23: biased exponent (+@7F)
 bits 22 to 0: significand, with implied integer bit (1) and binary point.

Special values held are:

'not a number' - sign - as required
 exponent - all 1's
 significand - any value except all 0's

'Infinity' - sign - as required
 exponent - all 1's
 significand - all 0's

Numbers are rounded to the nearest value, or if equally close, to an even number.

2.13.3. Data Table Content and Addresses

Table 2.4 shows the addresses for the controller and also the information which is to be found in these memory locations.

2.13.4. Data Table Sizes

Data table E is a fixed size (as shown in Table 2.4). Data table sizes are calculated by the controller from the user program so that if, for example, the highest G-table address in the user program is G345 then G0 to G345 will be reserved.

Where addresses are implied (e.g. when using LOCATE and MOVE GEM 80 Special Functions) the user must include a dummy rung or rungs to declare the highest address. See the 'Declare Highest Address' section, earlier in this chapter, for full details.

When constructing the user program it should be borne in mind that memory wastage will occur if large gaps of unused data tables are left with only high numbered and low numbered tables used. Also, even if only one or two bits of a word are used, (e.g. G104.1) the whole word G104 is reserved by the controller.

Programming tools, such as Gemesys 3, cannot work with bit addresses above 999.15. This restriction means for example, G999.15 can be used, but address G1000.1 cannot be used, as individual bits cannot be accessed. However, word G1000 can be used and words up to 24,000 can be used where access to individual bits is not required. The limitation is on the programming tool itself where there is space only for 7 characters on the screen.

2.13.5. Action of Clear Store on Data Tables

The CLEAR STORE command has the following effects:

- (1) Removes the ladder diagram program from memory, including expanded RAM systems.
- (2) Resets all data tables to zero except the E, F, V tables and P-table numbers 0 to 149, which have to be retained so that serial link configurations can be maintained. This is essential for remote programming.
- (3) Removes all user defined messages.

Table 2.4 - GEM80-400 Data Tables

-	Function	Data Table	Content	Min. Table Size	Max. Table Size	Cleared to Zero at Halt/Run Transition	Cleared to Zero at Power Off/On	Cleared to Zero by Clear Store Command
I/O	Basic and Verification I/O Highway Data	A	This table of addresses stores the states of INPUT transducers connected to the Basic and Verification I/O Highways	0	1040 (16 + 1024) words (each 16 bits)	YES Except if R0.0 set	YES	YES
		B	This table of addresses stores the OUTPUT states (derived from the execution of the user program for output to the Basic and Verification I/O Highways)	0		YES Except if R0.0 set	YES	YES
	Fast I/O	C	This table stores INPUT data sent to the controller from Fast I/O Modules	0	Size depends on Fast I/O equipment	YES Except if R0.0 set	YES	YES

		D	This table stores OUTPUT data derived from the execution of the user program for output to the Fast I/O Modules	0		YES Except if R0.0 set	YES	YES
	Serial Communication Links Data	J	This table stores data RECEIVED by the controller through the serial communication links	0	1536 words (each 16 bits)	YES Except if R0.0 set	YES	YES
		K	This table stores data derived by execution of the user program for TRANSMISSION on the serial communication links	0		YES Except if R0.0 set	YES	YES
	Serial Link Control	I	This table enables the user program to control serial link exchanges, ESP control	120	120	YES	YES	YES
VIDEO CONTROL PRESET DATA	-	L	IMAGEM tables, Video Format Control Data	32	-	YES	YES	YES
		P0 to P149	Controls Program Repetition Interval, System Identification Codes, Serial Link operational data (signalling rate, printer data, etc.), Verification I/O data STARNET & FIP	150	-	NO	NO	NO
		P150 on	Available for use in the user program for GEM 80 Special Functions, printer text messages and storing text messages	-	-	NO	NO	YES
GENERAL WORK SPACE	-	R	These retained workspace tables are available for the user program to use for storing counter values, sequencers and general data	1	-	NO	NO	YES (Except for R0)
		W	Retained workspace. Note...Tables only cleared when power first applied to system or by clear store command	0	-	NO	NO	YES
		G, H	These tables are available for the user program to use for storing counter values, sequencers and general data	0	-	YES Except if R0 set	YES	YES
		N, O, U	These tables are available to the user for STARNET message exchange and control when STARNET fitted, or as General Workspace when not used by STARNET	0	-	YES	YES	YES
TIMING AND FLAGS	-	E	These tables are written to by the controller and indicate overflow, time, date and timing flags.	9	9	NO	NO	NO

FAULT CODES	-	F	These tables contain fault codes, which are written by the controller as a result of the built-in self-test routines or as a result of execution of the user program. (Some tables are available for the user to use as desired.)	400	-	NO	YES	NO
MAINTAINER	-	M	Available for user programmed test. Write access from programmer with key removed. Accessible in data list mode only.	0	-	YES	YES	YES
FLOATING POINT	-	Q	Available to user for floating point data only	0	-	YES	YES	YES
EPROM	-	S	Available to the user for RAM/EPROM control (only values 0,1 and 2 used)	1	1	NO	NO	YES
MEMORY USAGE	-	V	Available to the user for READ only and internal system use. These tables contain internal controller statistics.	67	67	NO	NO	NO

2.13.5.1. P-Data Table

Data written to the P(Preset)-table falls into the following categories:

- (1) Data entered by the user to control the program scan (repetition time) and serial link operational data.
- (2) Preset data values entered by the user for use in the program, and addresses P150 upwards.
- (3) Storage of Printer Text Messages. The user should access printer text messages through the editor system.
- (4) Configuration of Verification I/O tables.
- (5) FIP configuration where FIP is fitted uses P120 to P122

The P-data table is not cleared at power-off or at halt/run transition, although a clear store command will clear (P150 upwards). The content of the other P-tables can be altered by over-writing. Like other data tables, the size of the P-table is derived by the controller as described in the 'Data Table Sizes' section earlier in this chapter.

Table 2.5 - P-Data Table Contents

Address	Content	Remarks
P0	Available for user's system identification code	-
P1	Program repetition interval (scan rate) Range 0 OR 10 to 2000 or 4000 (ms), zero for free-running	Resolution 1ms. Maximum scan time is 2000 ms or 4000 ms if an expansion RAM card is fitted. If negative numbers are inserted the sign is ignored and if numbers greater than 2000 or 4000 are inserted the scan time limits to the maximum,

P2	Length of preset message area in bytes. Note...This effectively limits the message length	Should not be written to by user. Automatically updated by message editor.
P3-P9	Reserved	-
P10-P29	Serial link configuration data for Serial Port 1	See Chapter 4
P30-P49	Serial link configuration data for Serial Port 2	"
P50-P58	Serial link configuration data for Serial Port 3	"
P59	GEMLAN-D offset configuration data for GEMLAN with P Tables	See relevant documentation for details
P60 - P72	Starnet Table Exchange Configuration	
P73-P89	Reserved for future system use	See Chapter 4
P90	Reserved	-
P91	Reserved	-
P92	Offset of configuration data for Verification I/O configuration data, within P-tables.	See relevant Data Sheets for Verification I/O Modules
P93-P99	Reserved for future system use	
P100-P115	File sizes for Off Line RAM	File sizes are in the range 0-32000 words. Specifying 0 de-configures the block and all subsequent non-zero entries are ignored. Specifying a negative value selects a file size of the absolute value of the number entered and indicates that the contents of all files in that block are protected by a checksum calculation
P100	File size for block 0	
P100-P115	File sizes for blocks 1-15	
P116	Off line Data Storage in EPROM Flags	Each bit corresponds to a block of off-line storage. (Bit 0 = Block 0 etc.) If the bit is set, that block of data is also copied when the user program is copied to EPROM
P120-P122	FIP Configuration	
P123-P149	Reserved for future system use	

2.13.6. E-Data Table

The E-data table contains timing markers, flags and duration of previous program scan. The table is available for the user program to read. The information contained in the E-table locations is shown in Table 2.6.

Table 2.6 - E-Data Table Contents

Address	Content	Remarks
E0.0	0.1 second timing marker	Set ON for one program cycle at 0.1 second intervals
E0.1	1 second timing marker	Set ON for one program cycle at 1 second intervals
E0.2-E0.5	Reserved	-
E0.6	Recompile flag marker	Set ON for one program cycle after a recompile
E0.7	Limit flag set ON or OFF after each ADD or SUB instruction	Can be used more than once in program. Set ON if result in Error due to + or - 32767 limits.

Address	Content	Remarks
E0.8 Port 1 E0.9 Port 2 E0.10 Port 3	.Buffer filling flags for Serial Port 1, Serial Port 2, Serial Port 3. Set ON when insufficient room in printer buffer for one complete line of output. Prevents buffer overflow when using the PRINT GEM80 Special Function	-
E0.11	Reserved	-
E0.12 Port 1 E0.13 Port 2 E0.14 Port 3	Buffer empty flags for Serial Port 1, Serial Port 2, Serial Port 3. Set ON when all pending printer output has been transmitted by a port.	-
E0.15	Reserved	-
E1 E2 E3	Seconds (0 - 59) Minutes (0 - 59) Hours (0 - 24)	Time
E4 E5 E6	Days (1 - 31, as appropriate to the month) Months (1 - 12) Years 1991 - 2090	Date
E7	Duration of previous program scan	In 1ms units. On a run to halt transition, or on a single cycle, this is set to 100.
E8	Running clock OR Cumulative total of cycle times (0 to @FFFF)	In 1ms units. This has a resolution of 1ms. It is a 16-bit unsigned value. On halt-to-run transition, or on a single cycle, it is updated by 100ms. Resets to zero at @FFFF.

2.13.7. Real Time and Date

This is generated from an integral real time clock. The accuracy is better than one minute per month and the clock runs from the battery. The integral calendar is correct for the lengths of all months up to the year 2090 and is fully Year 2000 compliant. Addresses E1 to E6 store the time and date (see Table 2.6). To set the correct time and date simply write the correction into these tables with a suitable GEM80 programming tool, such as Gemesys 3. More information on suitable GEM80 programming tools is contained in the 'Program Operation' section of this chapter. If writing to the real time clock is required from the GEM80-400 ladder program the CLOCK special function (S55) must be used.

Note

If the battery is not present or has insufficient charge and the power is cycled the clock will default to 12:00 1/1/1993 and will need to be set to the correct time on restart

The time and date cannot be modified directly by the host controller.

Note.....

Early versions of the GEM80-400 Controller are not Year 2000 compliant. The Processor Module must be at design status E06 or greater to be compliant. Modules with serial numbers less than 439 will not be complaint unless they have been returned to ALSTOM Drives & Controls, Kidsgrove for update.

2.13.8. Program Scan Times

E7 holds the duration of the previous program scan.

2.13.9. F-Data Table

Table 2.7 - F-Data Table Contents

Address	Content	Remarks
F0	Reserved	-
F1	User required watchdog trip	Any non-zero value placed in F1 by user program trips the watchdog, terminates program execution and displays a fixed diagnosis message on a suitable GEM 80 programming tool screen
F2	System fault bits	See Below
F2.0	-	Set to 1 if previous program cycle exceeds preset scan time
F2.1	-	Set to 1 for one scan if recompile successful.
F2.2	-	Set to 1 if recompilation will occur on the current scan
F2.3	-	Reserved
F2.4	Battery condition. Onboard battery low warning bit	Set to 1 if battery power low
F2.5	Battery condition. Central Highway battery low warning bit	Set to 1 if battery power low on any modules connected to the Central Highway
F2.6 to F2.15	Reserved	-
F3	FIP Run Time Fault Flag	-
F4	FIP Configuration Fault Information	-
F5- to F9	Reserved	-
F10 to F69	Serial link diagnostics	See Chapter 9
F10 to F29	Serial link diagnostics for Serial Port 1	-
F30 to F49	Serial link diagnostics for Serial Port 2	-
F50 to F69	Serial link diagnostics for Serial Port 3	-
F70 to F129	Serial link statistics	See Chapter 9
F70 to F89	Serial link statistics for Serial Port 1	-

F90 to F109	Serial link statistics for Serial Port 2	-
F110 to F129	Serial link statistics for Serial Port 3	-
F130 to F199	Reserved	-
F200 to F329	Basic and Verification I/O status linking bits	2 bits per I/O address, bit 0 = fault/fail, bit 1 = warning. For Basic I/O both bits are set if an error is detected
F330 to F499	Reserved	-
F500 upwards	-	These tables are available to the user program

2.13.10. I-Data Table

The I-data tables are allocated as shown in Table 2.7.

Table 2.8 - I-Data Table Content

Address	Content	Remarks
I0 to I39	User control mode for serial port 1	-
I40 to I79	User control mode for serial port 2	-
I80 to I119	User control mode for serial port 3	-

2.13.11. J/K-Data Tables

The J- and K-tables are allocated when serial communications ports are configured in the P-Tables. The allocations depend upon the communications protocols in operation (Chapter 4 refers).

Table 2.9 - J/K-Data Table Content

Address	Content	Remarks
J/K0 to J/K511	Serial port 1	-
J/K512 to J/K1023	Serial port 2	-
J/K1024 to J/K1535	Serial port 3	-

2.13.12. R-Data Table

There is one R-table permanently declared in the system which has the function of selecting whether or not certain data tables are retained. R0.0 is set to retain tables. The R-table is not part of the user allocation.

2.13.13. V-Data Table

The V-tables are used by system software and may be read but not written to by the user.

Table 2.10 V-Data Table Content

Address	Content	Remarks
V0	Not used	-
V1	Compilation count, moving flag.	Low byte contents are incremented after each successful compilation High Byte bit 1 =1 Moving (See note 1)-
V2 to V47	Used by system software for data table offsets and lengths	-
V48 to V51	Reserved for system usage	-
V52	Length of the message area in bytes	-
V53 to V57	Reserved for system usage	-
V58	V-table checksum	-
V59	User program checksum	-
V60	P-table checksum	-
V61	Rack Identification	-
V62	Mode Switch position	0 = halt, 1 = program, 2 = running
V63	No. of pages of Off Line memory available	-
V64	Firmware issue	This is copied from the firmware issue in the format A_
V65-V66	Reserved for System Usage	

Note 1 1 bit 8 is set prior to recompile action and reset when recompile is complete.

2.14. GEM 80-400 Additional Instructions

2.14.1. Set/Reset Coils

2.14.1.1. Function

To set a single bit in a data table location to 1 if the rung input is 1, otherwise the bit is unchanged. To set a single bit in a data table location to 0 if the rung input is 1, otherwise the bit is unchanged.

2.14.1.2. Format

ABCDEF G
 --(S)--+ SET
 G12.3

BCDEF G
 --(R)--+ RESET
 12.3

2.14.1.3. Operation

If the rung input to the SET coil is ON (i.e. any non-zero number on the rung), the particular bit given by the address below the coil is set to 1. If the rung input to the SET coil is OFF (i.e. the number on the rung input is zero), the bit remains in its previous state.

If the rung input to the RESET coil is ON (i.e. any non-zero number on the rung), the particular bit given by the address below the coil is set to 0. If the rung input to the RESET coil is OFF (i.e. the number on the rung input is zero), the bit remains in its previous state.

The remaining 15 bits in the table location are not affected, and remain in whatever state they were previously.

You cannot operate a Set/Reset coil with a floating point number.

2.14.1.4. Program Entry

The instruction is selected from the 'Rung Element Tool Bar' in the usual manner. A dialogue box is initiated into which is entered the bit address and any data relevant to the instruction.

2.14.1.5. Programming Rules

Normal decimal/hex entry procedures for bit address apply.

A retentive coil can only be the last element in a rung. It may also only be placed in the top branch of a rung that has parallel branches. Only one coil can therefore appear in any rung. A pair of rungs, using the same bit address of a data table location, are required to set and reset a single retentive coil.

A retentive coil can be the only element in a rung. Such a rung would apply the ON state to the SET or RESET coil instruction.

A retentive coil cannot be operated by a floating point number. Any attempt to do so will produce a compiler error message, and the program will not run.

Note...When contacts from a retentive coil are used in a program, they are entered and appear as standard contact symbols. There is no indication in the contact symbol that the associated coil is retentive.

2.14.1.6. Monitoring

The state shown by the monitoring symbols indicate the ON or OFF state of the bit stored in a data table location. It should be particularly noted that an ON state driving a RESET coil will be observed as the output bit OFF, because the reset signal turns the memory bit OFF.

2.14.1.7. Operation Within Blocks

Any coil contained in a BLOCK that is not being obeyed will remain in whatever state it was in, even though the rung may be displayed when monitoring as though it were trying to drive it to the opposite state.

2.14.1.8. Print-Outs

When displayed on the screen of a suitable GEM80 programming tool, such as Gemesys 3, the Set/Reset coils are cross-referenced in the same manner as a Coil.

2.14.1.9. Application Notes

Example Program

	SETIP		MEMORY		This rung sets		
+-	[-----]		(S)	+-	the retentive		
	A1.0		G12.3		coil		
	RESETIP		MEMORY		This rung		
+-	[-----]		(R)	+-	resets the		
	A1.1		G12.3		retentive coil		
		MEMORY			This rung		
+-	[---+]	[-----]	/	[-----]	()	+-	uses the
	G2.0	G12.3	G2.2	G3.0		memory to	
						perform some	
+-	[---+					logic	
	G2.1						

In this example, the first two rungs implement an R-S flip flop with reset priority. The output is used in the third rung to perform a logic operation.

2.14.1.10. Searching for Retentive Coils

The instructions may be located using the 'Search' facility in the usual manner.

2.14.1.11. Compatibility with GEM80 Programming Tools

The SET and RESET retentive coil instructions are extensions to the GEM80 Ladder Programming Instruction Set. The instructions can be used only with controllers and programming tools with support them, such as Gemesys 3.

2.14.2. JUMP/LABEL

2.14.2.1. Function

The JUMP and LABEL instructions are provided as a pair of complementary instructions. The JUMP allows the flow of execution of a ladder program to jump forward to a LABEL later in the program. The LABEL instruction is equivalent to a rung containing a single instruction.

2.14.2.2. Format

```

          JUMP
+--      -->>
          15

+----- LABEL:
          15

```

In this example, 15 is used for the JUMP and LABEL number.

2.14.2.3. Operation

If the rung input to the JUMP instruction is ON (i.e. any non-zero number on the rung at the point immediately before the JUMP), the execution of the ladder program jumps to the label number shown below the JUMP symbol. If the rung input to the JUMP instruction is OFF (i.e. the number on the rung input is zero), execution of the ladder program continues on the next rung (i.e. no jump occurs).

Only forward jumps are permitted in a program. It is permissible to have more than one jump instruction pointing to the same label, but it is not possible to have more than one label with the same number.

2.14.2.4. Program Entry

To create a JUMP, begin a rung with the elements that determine the condition under which the JUMP is to be obeyed. The instruction can then be selected from the 'Rung Element Tool Bar' in the usual manner. The number of the LABEL to be JUMPed to is entered from a dialogue box.

The JUMP symbol will appear at the right hand rail (end) of the rung, with a line drawn from the last of the condition elements.

To create an unconditional JUMP, enter a LINK as the first element in the rung, followed by the JUMP instruction as described above.

To create a LABEL, select the LABEL instruction, as the first element in the rung, from the 'Rung Element Tool Bar'. This causes the LABEL to appear and initiates a dialogue box, into which the Label number is entered.

2.14.2.5. Programming Rules

A JUMP or LABEL number must be in the range 0 to N, where N is the largest LABEL number allowed by the controller. For the GEM80-400 Processor this limit is 15 inclusive.

A program can contain only one LABEL with a given number.

A program can contain any number of JUMP instructions with a given number, but forward JUMPs only are allowed.

On pressing ESC at the end of rung edit, the rung is rejected if:

- a) a JUMP number is entered for which a LABEL exists earlier in the program,
- b) a LABEL number is entered for which a JUMP exists later in the program, or
- c) a duplicated LABEL number is entered.

When the program is downloaded and compiled in the controller, a compiler error is reported if a JUMP number or LABEL number exceeds the number range permitted in the controller, or if a JUMP number is found with no matching LABEL.

A controller will accept and run a program which contains a LABEL number which has no corresponding JUMP, though the LABEL instruction has no effect.

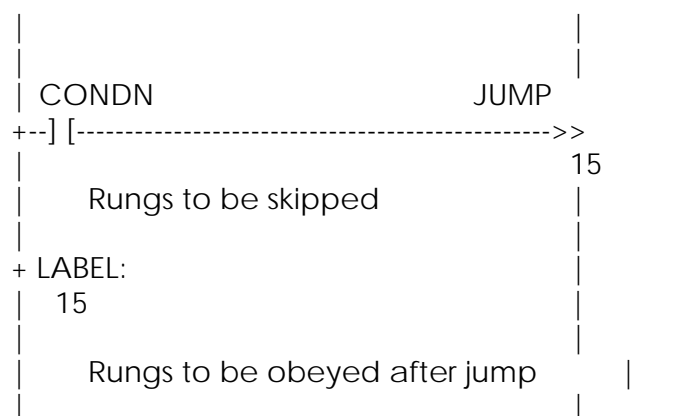
There are no restrictions on the level of 'block' nesting permitted for JUMP and LABEL instructions. It is permissible to JUMP from the middle of any block, and start execution at a LABEL in the middle of any block.

2.14.2.6. Monitoring

When monitoring rungs appear do not produce the expected results, it is usually because they are not being executed. This may be because they are in a block which is not being obeyed, or because they are in a part of the program skipped by a JUMP instruction.

2.14.2.7. Application Notes

Example Program



This program illustrates the simplest form of JUMP. If the JUMP condition is true, execution moves directly to the LABEL later in the program. It should be noted that, in the absence of any conditional blocks, the rungs at the end of this example program would be obeyed whether or not the JUMP occurs. The JUMP only affects the skipping of intermediate rungs.

2.14.2.8. Searching for Jump/Label

The JUMP and LABEL instructions may be located using the 'Search' facility in the usual manner, the label number (if required) is entered into the ADDRESS/CONSTANT field.

2.14.2.9. Comments Associated with Jump/Label

The instructions leading up to and including a JUMP instruction are treated as a rung. Similarly, the single instruction of a LABEL is treated as a rung containing just a single instruction. Both JUMP and LABEL rungs can have rung comments associated with them, to aid the understanding of an application program.

2.14.2.10. Cross Referencing on Ladder Printout

The printout cross reference feature (when selected), prints the rung that will be jumped TO against each JUMP instruction, and the rungs which jump to a LABEL against each LABEL instruction. It also appends a summary list to the end of the ladder printout. This indicates the rung which the label number relates to and the rungs that jump to this label for each label.

2.14.2.11. Compatibility with GEM80 Programming Tools

The JUMP and LABEL instructions are extensions to the GEM80 Ladder Programming Instruction Set. The instructions can be used only with controllers and programming tools which support them, such as Gemesys 3.

2.14.3. SEQELEM

2.14.3.1. Function

The sequence element instruction, SEQELEM, performs a sequential function chart (SFC) STEP and following TRANSITION, with a built-in timer which may be used for alarm generation or, automatically, to force the following transaction.

The operation of the built-in timer is equivalent to that of the TON Special Function (Timer with ON delay). It should be noted that there are minor differences as follows:

- (1) TON stores a 'timer initialised' bit in the same location as the 'remaining duration', whilst SEQELEM stores it in a different location.

- (2) SEQELEM includes a facility to freeze its timer part way through, whilst TON has no such built-in facility.

2.14.3.2. Format

The symbol 'Zm' is used to refer to the address associated with the SEQELEM instruction, which is the base address of a set of 4 adjacent table locations used as a parameter list.

For this example, W100 is used as the address for the SEQELEM instruction, and the mnemonic for address W100 is SE01/1 (representing step number 1 of sequence number 01).

```
SE01/1
[SQ] - -
W100
```

2.14.3.3. Operation

Definitions

SEQUENCE	-	A collection of SEQUENCE ELEMENTs
SEQELEM	-	A sequence element, comprising the combination of a STEP and a TRANSITION condition.
STEP	-	An element in a SEQUENCE
TRANSITION	-	The condition which decides when one STEP COMPLETES and the next STEP is ENABLED
ACTIVE	-	When ENABLED and an INHIBIT signal is not applied, a STEP is ACTIVE and produces ACTIONS.
ACTIONS	-	The outputs from STEPs which drive the plant.
COMPLETE	-	The status of a STEP when it has been ENABLED and the TRANSITION condition has subsequently been true.
STEP INHIBIT	-	An inhibit signal, specific to a particular STEP, which prevents the ACTIONS of the STEP.
RESET	-	RESET signal, specific to a particular STEP, which returns that STEP to RESET STATUS.
RESET STATUS	-	Quiescent condition of a STEP, after it has been RESET, but before it has been ENABLED.
GROUP	-	GROUP signals are common to all the sequence elements in a SEQUENCE, and are provided by the SEQGRP special function.
GROUP INHIBIT	-	An inhibit signal, common to a group of SEQELEM instruction, which prevents the ACTIONS of all STEPs.
GROUP HOLD	-	A hold signal, common to a group of SEQELEM instructions, which prevents any STEPs from being ENABLED, and which therefore prevents any progress through the SEQUENCE.
GROUP RESET	-	RESET signal that is applied to all STEPs in a group of SEQELEM instructions.
GROUP SIMULATE	-	A signal, common to a group of SEQELEM instructions, which aids testing, by allowing all STEPs in a

SEQUENCE to have a TRANSITION when the built-in timer expires.

Fundamental Concepts and Definitions

- A STEP starts only when it has been ENABLED.
- A STEP is ENABLED only when it receives an ENABLE input and GROUP HOLD is not applied.
- A STEP becomes ACTIVE when it has been ENABLED and neither STEP INHIBIT nor GROUP INHIBIT are applied i.e. the conditions are valid for ACTIONS to start.
- A STEP remains ACTIVE until the TRANSITION condition is true for enabling the next STEP. At this point the first STEP is COMPLETED.
- A STEP remembers when it has been COMPLETED, and can only be RE-ENABLED after it has been RESET.

Logical States

A single sequence element instruction represents a single STEP in a SEQUENCE, together with the associated TRANSITION to the next STEP. A sequence element can exist in the following states:

- RESET STATUS - Quiescent state, ready for operation
- ENABLED - STEP has received an ENABLE input signal, but conditions for ACTION are not yet satisfied, i.e. an INHIBIT signal is applied.
- ACTIVE - STEP is ACTIVE, with actions happening, waiting for TRANSITION conditions to move onto next STEP in SEQUENCE.
- COMPLETE - STEP has been COMPLETED, following a TRANSITION condition.

In addition, the TRANSITION condition may be true for any of the above states. The SEQUELEM instruction takes as its rung input the ENABLE input, and provides as its rung output the COMPLETED output. The SEQUELEM instruction differs from other instructions in the GEM80 instruction set, because its address is used as the base address for a parameter list of 4 adjacent data table locations. All data elements, apart from the ENABLE input and COMPLETED output mentioned above, are held and used in the parameter list.

Program Rung Data

Symbol	Location	Use	Range
X	Rung input	Step ENABLE	Non-zero ENABLES the STEP provided that it is not inhibited by STEP INHIBIT or GROUP INHIBIT.
Zm	Location for parameter list	Address if start of parameter list (4 locations)	Any write-enabled table useable by GEM 80 instructions.
Q	Rung output	Step COMPLETE.	ON (@FFFF) if step is COMPLETE.

Data in Parameter List

Title	Location	Use	Range
	Zm bits 0 to 7	INPUTS	
TRANSITION	Zm bit 0	Transition condition input.	ON (1) = Transition condition TRUE.
STEP INHIBIT	Zm bit 1	Inhibit input to prevent actions from this step.	OFF (0) = Permit STEP ACTION. ON (1) = INHIBIT STEP ACTION.
TIMER INITIALISED	Zm bit 5	Used by SEQELEM to initialise correctly on start up.	Must be set to OFF by user program on start up to ensure correct initialisation. Set ON by SEQELEM once SEQELEM timer initialised.
ENABLE (internal)	Zm bit 6	Alternative to rung input (X) for ENABLING the step. (typically used during testing)	ON (1) = ENABLE step. If manually writing data to this bit, the user must be particularly careful not to leave it set ON; that would have the effect of permanently enabling the step.
RESET	Zm bit 7	Input which RESETs STEP and sets rung output (Q) to zero.	ON (1) = Perform reset. If manually writing data to this bit, the user must be particularly careful not to leave it set ON; that would have the effect of permanently resetting the step.
Zm bits 8 to 15 OUTPUTS			
STEP ACTION	Zm bit 8	Output which is set ON when STEP INHIBIT is not true and STEP is ENABLED.	ON (1) = STEP currently ACTIVE.
STEP ENABLED	Zm bit 9	Output which is set ON when the STEP has been ENABLED.	ON (1) = STEP ENABLED.
STEP USED	Zm bit 10	Output used to indicate whether a step has been ENABLED or COMPLETED.	OFF (0) = Step not used. ON (1) = Step has been ENABLED or COMPLETED.
ALARM CONDITIONS	Zm bit 11	Output used as alarm when step is ENABLED and STEP INHIBIT inputs are preventing ACTIONS.	ON (1) = Alarm active.
TIMER EXPIRED	Zm bit 12	Output used to indicated that timer has expired.	ON (1) = Timer expired.

Title	Location	Use	Range
ACTION INITIATED	Zm bit 13	Output which is a pulsed version of STEP ACTION, and is held ON for one scan. If action is reset due to application of an INHIBIT signal, then on a restart of action this output is NOT set.	ON (1) = Start of step action.
STEP ACTION MEMORY	Zm bit 14	Memory of STEP ACTION required to formulate ACTION INITIATED.	Reserved
STEP COMPLETE	Zm bit 15	Output used to indicate that STEP has been COMPLETED (same as rung output Q).	ON (1) = Step COMPLETED.
Zm + 1 CONFIGURATION INPUTS			
TIMED STEP	Zm + 1 bit 0	Configuration input which determines whether STEP COMPLETE is set when timer expires before a transition is detected.	ON (1) = Timer expiry or TRANSITION sets STEP COMPLETE output.
INHIBIT TIMER	Zm + 1 bit 1	Configuration input which disables timer output.	ON (1) = Timer disabled.
TIME ENABLED	Zm + 1 bit 2	Configuration input which causes the timer to run while the step is ENABLED rather than from STEP ACTION.	ON (1) = Timer runs while step is ENABLED. OFF (0) = Timer runs only while STEP ACTION is TRUE.
Zm+2 & Zm+3 TIMER INPUTS / OUTPUTS			
TIMER REMAINING DURATION	Zm + 2	Output used to indicate remaining delay time.	Zero to Required Duration. Required Duration whilst timer reset. Decreases in 0.1s units whilst timer active. Limited at zero when time expired.
TIMER REQUIRED DURATION	Zm + 3	Set by user program to determine duration of timer.	1 to 32767. Set by user to determine time in 0.1s units. Negative values are treated as zero time.

Fault Conditions

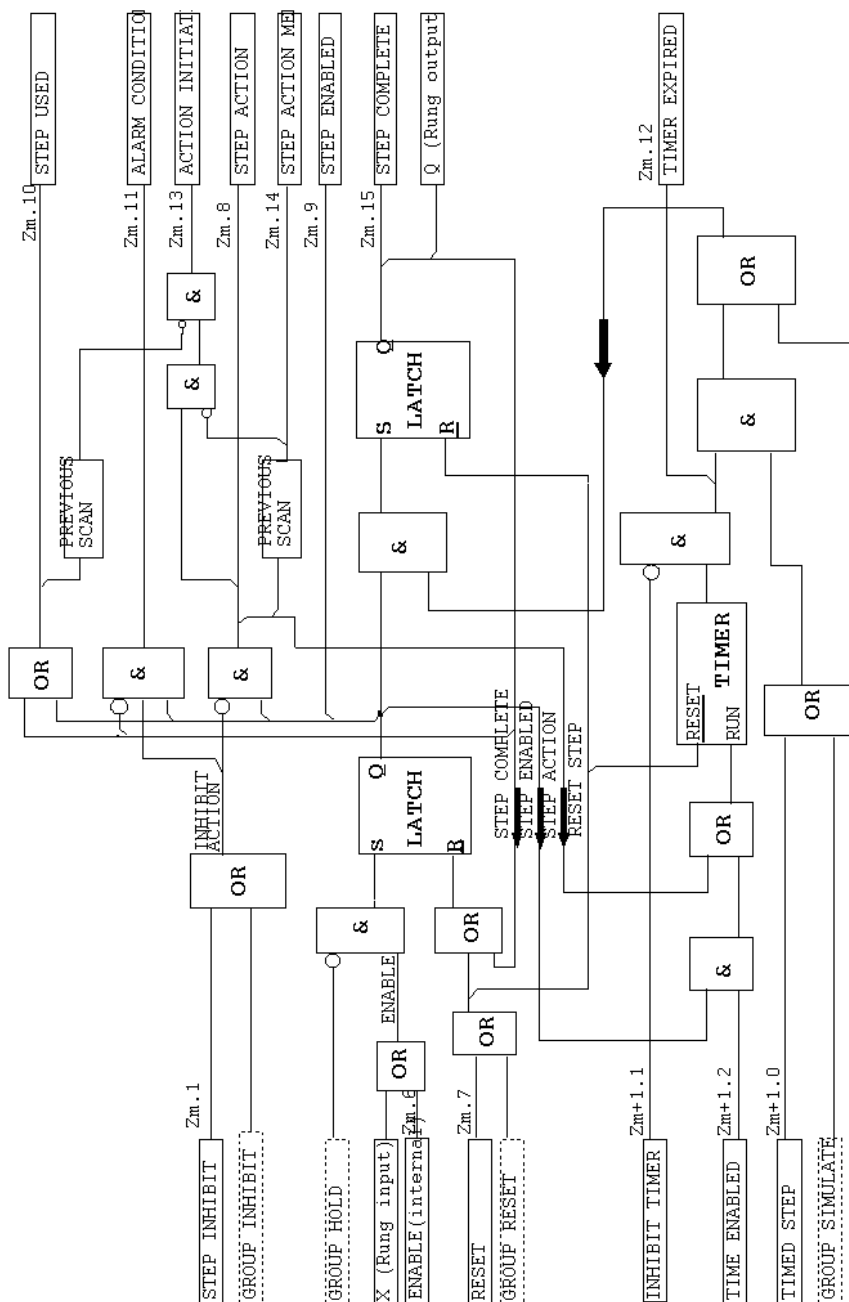
Condition	Result
Invalid parameter list location : a) Number instead of address. b) Zm in write protected memory. c) Zm in table not useable by GEM 80 instructions d) Zm + 3 beyond end of data table memory area.	Compiler error message. Controller does not allow program to run.
Negative Required Duration. Contents of (Zm + 3) negative.	Treated as zero duration. Remaining Duration held at zero.

Logic Diagram

In addition to the inputs and outputs already described, there are four additional 'GROUP' inputs whose logic states are determined by the SEQGRP (sequence group) Special Function. The usage of these GROUP inputs is as follows:

Symbol	Condition	Result
--------	-----------	--------

GROUP INHIBIT	This input is used as a GROUP INHIBIT input for all SEQUELEMs, to INHIBIT all ACTIONS.	ON (1) = INHIBIT all GROUP ACTIONS.
GROUP HOLD	This input is used to HOLD the initiation of all STEPs in the GROUP, by either the rung input (X) or by the internal ENABLE input. This has the effect of holding the sequence.	ON (1) = GROUP HOLD activated.
GROUP RESET	This input is used to RESET all SEQUELEMs in the GROUP.	ON (1) = GROUP RESET activated.
GROUP SIMULATE	This input is used for simulation of sequence elements, to force all the STEPs to use the internal timer to trigger their STEP COMPLETE output.	ON (1) = GROUP SIMULATE mode active.



Timing Diagrams

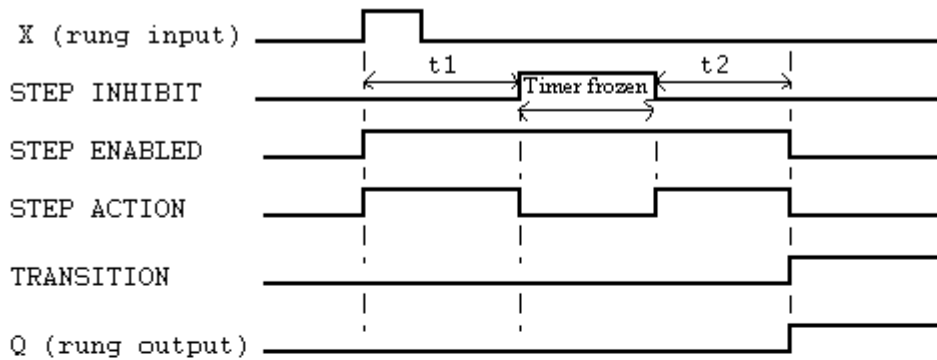
The following two diagrams illustrate how the function block logic behaves in the two main cases of:

- (1) TRANSITION occurring before the timer expires,
- (2) Timer expiring before the occurrence of a TRANSITION,

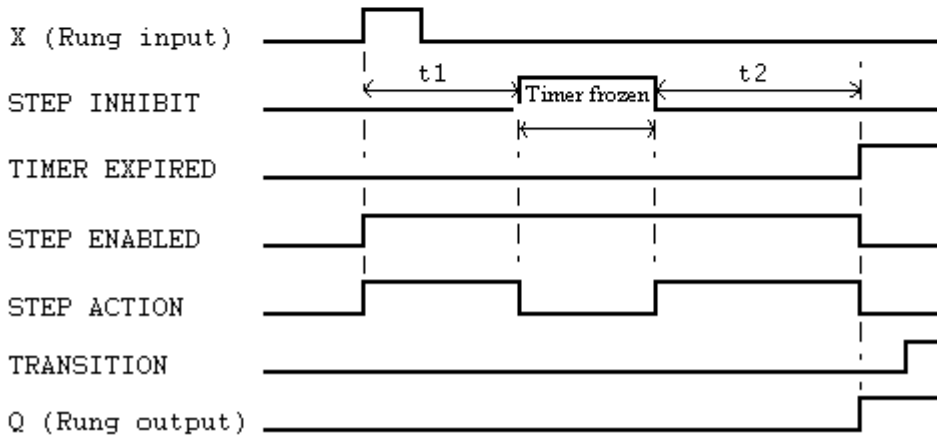
where SEQELEM is configured to complete its step on the expiry of the timer.

Note...The timer 'freezes' when a STEP is ACTIVE and the STEP INHIBIT signal is true.

a) Transition occurs before timer expires. $t1+t2 < \text{Timer}$.



b) Timer expires before transition occurs. $t1+t2 = \text{Timer}$.



These diagrams are drawn for the case where all GROUP, HOLD and RESET inputs as well as the TIME ENABLED input are FALSE, and the TIMED STEP input is TRUE.

Note...The timer is not frozen if the TIME ENABLED signal is configured to be ON.

2.14.3.4. Program Entry

The instruction can be selected from the 'Rung Instruction Tool Bar' in the usual manner. This initiates a dialogue box into which is entered the instruction data.

A SEQELEM can appear at any position in a rung except against the right hand rail. It should be noted that a SEQELEM against the left hand rail is permanently ENABLED, which can be a valid arrangement if a SEQUENCE is contained in a block which is obeyed only when the SEQUENCE is to be ENABLED.

2.14.3.5. Application Notes

The logic of the SEQELEM instruction is such that it may be used freely with other instructions, forming a rung with up to 5 parallel branches each with up to 8 SEQELEM instructions. Larger sequences can easily be constructed by continuation onto further rungs, or by sub-dividing individual steps to become sub-sequences.

Group control of SEQELEM instructions within a program, for such functions as reset and simulation, is provided by the Sequence Group Special Function, SEQGRP.

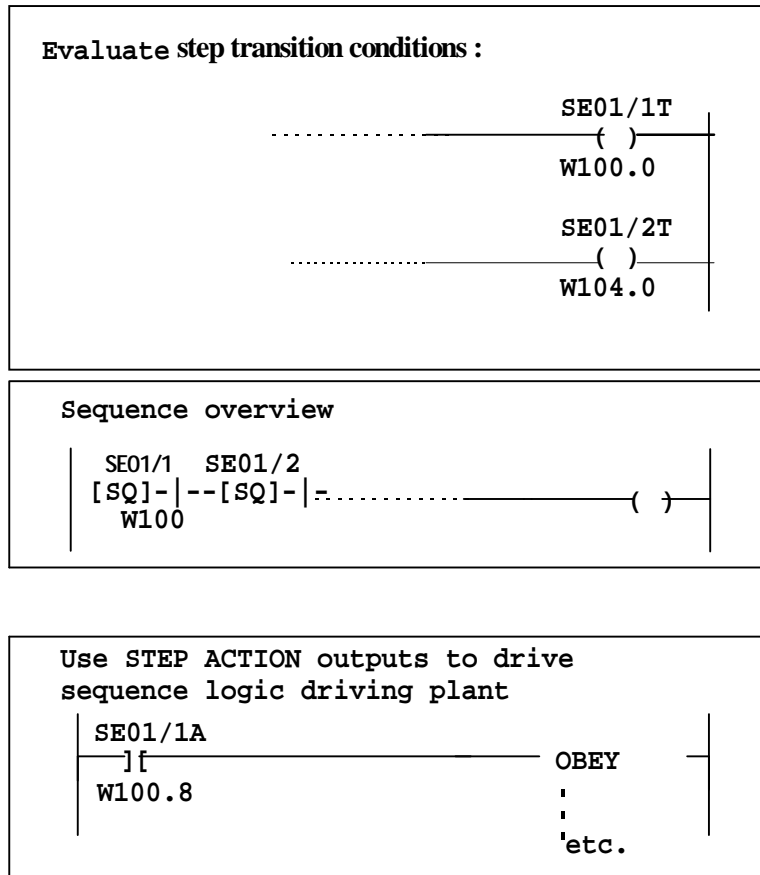
Use of SEQGRP Special Function

The user must ensure that a SEQGRP (Sequence Group) Special Function is executed before any SEQELEM instructions, otherwise the sequence may default to an unexpected mode.

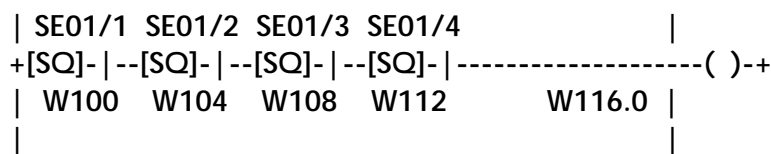
A possible pitfall in a program with several sequence groups is to include some extra sequence elements at the beginning of the program, ahead of the first SEQGRP Special Function. Under these conditions, the mode selected at the end of the previous program scan would be effective, which could give unexpected results.

Overview of Examples

The application examples which are described here are all shown in the form of a 'sequence overview'. Refer to the following figure, illustrating the overall program structure, as an aid to understanding how the 'sequence overview' fits into the overall program structure.



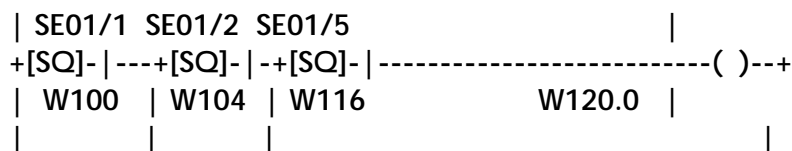
Example Program for a Simple Sequence

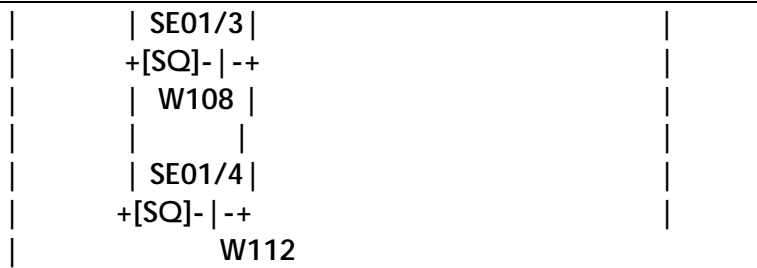


This example uses mnemonics SE01/1 to SE01/4 for STEPs 1 to 4 of SEQUENCE number 01. Step 1 is ENABLED on the first execution of the rung. Step 2 is ENABLED only when a TRANSITION occurs on W100.0 or if the timer internal to STEP 1 is ACTIVE and has expired. STEPs 3 and 4 are ENABLED in a similar manner.

Example Program for Parallel Execution of SEQLEMs

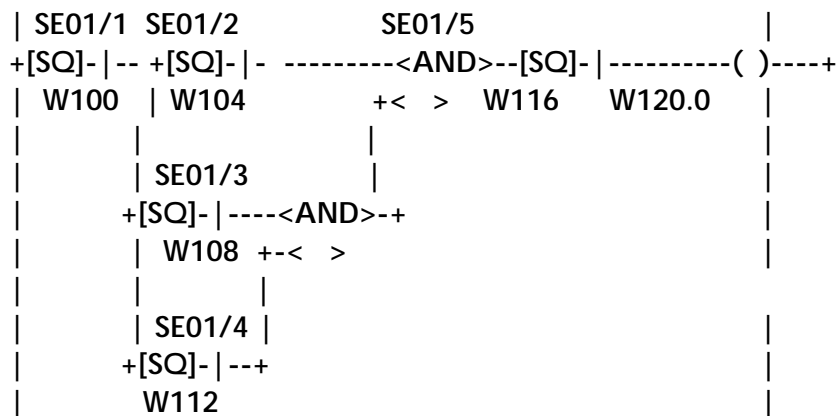
a)





This example uses mnemonics SE01/1 to SE01/5 for STEPs 1 to 5 of SEQUENCE number 01. STEPs 2, 3 and 4 are ENABLED as soon as STEP 1 is COMPLETED. STEP 5 is ENABLED by the COMPLETION of one of STEP 2, STEP 3 or STEP 4, whichever is COMPLETED first. Subsequent COMPLETION of the other STEPs from 2, 3 and 4 do not re-ENABLE STEP 5.

b)



This example uses mnemonics SE01/1 to SE01/5 for STEPs 1 to 5 of SEQUENCE number 01. STEPs 2, 3 and 4 are ENABLED as soon as STEP 1 is COMPLETED. However, unlike case a), STEP 5 is ENABLED only after COMPLETION of ALL of STEPs 2, 3 and 4.

Example Program Showing Sequences Continuing Between Rungs

```

| SE01/1 SE01/2 SE01/3 SE01/4 SE01/5 SE01/6 |
+[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|+-----()-----+
| W100 W104 W108 W112 W116 W120| W0.0 | | | | | |
| | | | | | | |
| SE01/A SE01/B SE01/C SE01/D | | |
+[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|-----+ |
| W200 W204 W208 W212 | |
| | | | | | | |
|SE01/6C SE01/7 SE01/8 SE01/9 SE01/10 SE01/11 |
+--] [---[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|+-----()-----+
|W120.15 W124 W128 W132 W136 W140 | W0.1 | | | | | |
| | | | | | | |
|SE01/DC SE01/E SE01/F SE01/G SE01/H | |
+--] [---[SQ]-|--[SQ]-|--[SQ]-|--[SQ]-|-----+ |
|W212.15 W216 W220 W224 W228 | |
| | | | | | | |

```

This example uses mnemonics SE01/1 to SE01/11 for STEPs 1 to 11 of SEQUENCE number 01, and SE01/A to SE01/H for the parallel STEPs A to H. The example shows that large SEQUENCES may be handled in a simple manner by using the STEP COMPLETE output to link SEQUENCES, which are on separate rungs, together. The SEQUENCE comprising STEPs 1 to 11 is continued by using the STEP COMPLETE output of STEP 6 (W120.15), similarly the SEQUENCE comprising STEPs A to H is continued using the STEP COMPLETE output of STEP D (W212.15).

Example Program Showing Conditional Branch Using SEQELEM

```

| SE01/1 COND1 SE01/3U SE01/2 SE01/4 |
+[SQ]-|----+--] [-----]/[---[SQ]-|----- +[SQ]-|-----()--+
| W100 |W1.0 W108.10 W104 | W112 W116.0 | | | | |
| | | | | | | |
| | |COND2 SE01/2U SE01/3 | | |
| | +--] [-----]/[---[SQ]-|----- + | |
| | W2.0 W104.10 W108 | | |

```

This example uses mnemonics SE01/1 to SE01/4 for STEPs 1 to 4 of SEQUENCE number 01, where STEPs 2 and 3 are alternative paths. After COMPLETION of STEP 1 the state of the conditions W1.0 and W2.0 will determine whether STEP 2 or STEP 3 gets executed first. Once STEP 2 or STEP 3 has been ENABLED, the STEP on the other branch is prevented from being ENABLED by the STEP USED signal (either W104.10 or W108.10).

The conditions W1.0 and W2.0 should of course be mutually exclusive, but the use of the STEP USED output of the SEQELEMs guarantees that only one of these STEPS will be executed. The STEP on the top branch will have priority should both W1.0 and W2.0 be permissive; this is due to the order of evaluation of the ladder rung.

Example Program Showing a Sub-sequence Structure

Initialisation rung :

```

|
+------( )---+
|
|           W205.1 |
|
|
|
| SE01/1 SE01/2 SE01/3
+ [SQ]- | --[SQ]- | --[SQ]- | -----( )--- +
| W200  W204  W208           W228.0 |
|
| SE01/2O SE01/4 SE01/5 SE01/6 SE01/7 SE01/2T |
+---] [-----[SQ]- | ---[SQ]- | --[SQ]- | --[SQ]- | -----( )--- +
| W204.9 W212  W216  W220  W224  W204.0 |
|

```

This example uses mnemonics SE01/1 to SE01/7 for STEPs 1 to 7 of SEQUENCE number 01. It shows how it is possible to create a sub-sequence in a program. The example illustrated uses STEPs 4, 5, 6 and 7 as a sub-sequence for STEP 2.

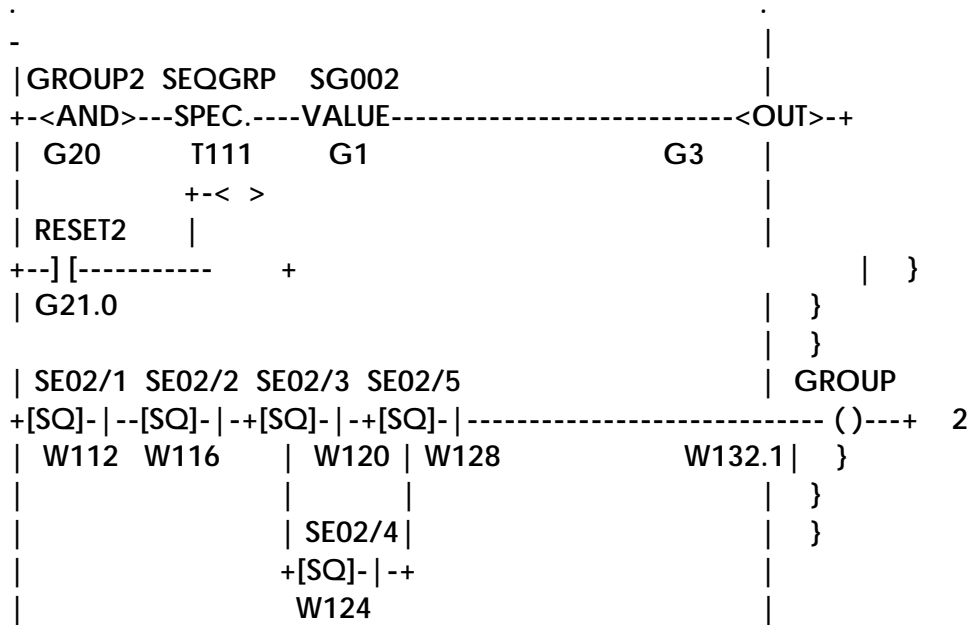
The INHIBIT TIMER input for STEP 2 (W205.1) is set ON to disable the timer operation for STEP 2 as it is now composed of STEPs 4, 5, 6 and 7 which are themselves timed. When STEP 1 has been completed, STEP 2 is ENABLED which in turn ENABLES STEP 4 in the sub-sequence through the STEP ENABLE output of STEP 2 (W204.9). The sub-sequence is then stepped through in the normal manner until the TRANSITION input of STEP 2 (W204.0) is set after the completion of STEP 7. STEP 2 is then COMPLETE and STEP 3 is ENABLED.

Example Program Showing the Use of SEQGRP Special Function

```

|
| GROUP1 SEQGRP SG001
+-<AND>---SPEC.----VALUE----- --<OUT> +
| G10      T111  G0                G2  |
|          +-< >                    |
| RESET1   |                        |
+---] [-----+                      |
| G11.0                    | }
|                            | }
| SE01/1 SE01/2 SE01/3      | GROUP
+ [SQ]- | --[SQ]- | --[SQ]- | -----( )---+ 1
| W100  W104  W108           W132.0 | }
|                                    | }

```



This example uses mnemonics SE01/1 to SE01/3 for STEPs 1 to 3 of SEQUENCE number 01, and SE02/1 to SE02/5 for STEPs 1 to 5 of SEQUENCE number 02. The value of GROUP1 (G10) will determine the states of the group variables :

- GROUP HOLD (bit 0)
- GROUP SIMULATE (bit 8)
- GROUP INHIBIT (bit 9)

and RESET1 (G11.0) will determine the state of the GROUP RESET input.

These values will then be used within the GROUP1 sequence which comprises STEPs 1, 2 and 3 of SEQUENCE number 01. The values of GROUP2 and RESET2 will determine the states of the same GROUP inputs as before, to be used within the GROUP 2 sequence comprising STEPs 1 to 5 of SEQUENCE number 02.

Example Program Showing Presetting of Values

The example which follows is the same as under sub-heading 4.6, extended to show a typical method of copying preset data from the P-table to a working data table. This sets up the mode of SEQELEM instructions and the Required Duration for their built in timers. It should be noted that the copying occurs only on the first power up of the controller, or if the controller store is cleared (for example if a spare processor module has to be substituted). The copying does not occur on halt to run transitions, or on power off/on, so the elements of a sequence are capable of remembering the state of the plant through a shutdown period.

```

|
+---]/[----- OBEY +
| W0.0 BLOCK |
|
| ***** START OF BLOCK 1 ***** |
| LOCATE MOVE |
+---<AND>---SPEC.---VALUE---SPEC.---VALUE---<OUT>--+
| 0 S20 P200 T20 100 F100 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
+---<AND>---SPEC.---VALUE--+
| 0 S20 W200 |
|
+----- ( )--+
| W0.0 |
| ***** END OF BLOCK 1 ***** |
| SE01/1 SE01/2 SE01/ |
+ [SQ]- |--[SQ]- |--[SQ]- |----- ( )--+
| W200 W204 W208 W228.0 |
| SEQ01/20 SEQ01/4 SE01/5 SE01/6 SE01/7 SE01/2T |
+---] [---[SQ]- |--[SQ]- |--[SQ]- |--[SQ]- |----- ( )--+
| W204.9 W212 W216 W220 W224 W204.0 |
|

```

Preset values:

```

P200 0 *** DATA FOR STEP 1 *****
P201 @2 Mode for step 1 - timer inhibited - bit 1 ON
P202 0
P203 0 Required Duration not needed since not used
P204 0 *** DATA FOR STEP 2 *****
P205 @1 Mode for step 2 - timed step - bit 0 ON
P206 0
P207 500 STEP2 Timer Required Duration
P208 0 *** DATA FOR STEP 3 *****
P209 0 Mode for step 3 no bits ON
P210 0
P211 800 STEP3 Timer Required Duration
P212 0 *** DATA FOR STEP 4 *****
P213 0 Mode for step 4 no bits ON
P214 0
P215 600 STEP4 Timer Required Duration
P216 0 *** DATA FOR STEP 5 *****
P217 0 Mode for step 5 no bits ON
P218 0
P219 1200 STEP5 Timer Required Duration
P220 0 *** DATA FOR STEP 6 *****
P221 0 Mode for step 6 no bits ON

```

P222 0
P223 750 STEP6 Timer Required Duration
P224 0 *** DATA FOR STEP 7 *****
P225 0 Mode for step 7 no bits ON
P226 0
P227 3200 STEP7 Timer Required Duration

Searching for Sequence Element Instructions

The instruction may be located using the 'Search' facility in the usual manner.

Compatibility with Programming Units and Controllers

The SEQELEM instruction is an extension to the GEM80 ladder programming instruction set. The instruction can be used only with controllers and programming tools which support it.

Accuracy of Timing

For accurate operation of the timer built into each SEQELEM instruction, it is important for the user to arrange for the rung containing a SEQELEM instruction to be executed on every program scan during timing.

It is quite normal to enclose a set of rungs in a conditional block which is switched on or off depending on the mode. Sequence elements inside such conditional blocks will operate quite satisfactorily while the block is being executed. Timing will freeze whilst the block is not being executed.

The user must avoid any program organisation which causes rungs containing active sequence elements to be executed intermittently. For example, executing a rung containing a sequence element instruction on alternate scans would give inaccurate and unpredictable timing.

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3. I/O HIGHWAY

3.1. Introduction

Data input to the GEM80-400 Controller through the Basic and Verification I/O ribbon cables is stored in the A-table. Data to be output by the controller through the Basic and Verification I/O ribbon cables is stored in the B-table. Faults occurring during the transfers are reported into the F-table.

The GEM80-400 Controller can directly address 16 words of Basic I/O, fixed at addresses 0 - 15, and 1024 words of Verification I/O. Additional Basic I/O may be addressed by converting Verification I/O to Basic I/O using an 8191-4004 Verification I/O Expander. Each Expander can convert up to 32 words of Verification I/O to Basic I/O.

There are slots for eight I/O modules in the Standard Controller subrack and slots for four I/O modules in the Enhanced Controller subrack. Basic and Verification I/O Modules may be mixed in the controller subracks.

On the Standard Controller subrack, the I/O ribbon connectors are located on the upper backplane to the left of the power supply. On the Enhanced Controller subrack, there are two connectors at the right hand side of the upper backplane to allow additional I/O subracks to be connected to the highways with ribbon cables.

3.2. Fault Reporting and Detection

The GEM80-400 Controller checks transfers on the Basic I/O Highway by reading back the data patterns it writes onto the highway. If the controller detects any faults, it sets an F-table bit corresponding to the address of the I/O module addressed. The F-table bits for Basic I/O are at F200 and F201; there are 2 bits per address. If the controller detects any failures when data is being transferred, the corresponding F-table bit is set to 1 (producing patterns such as @0005, @0050, @5005 in F200 and F201).

In addition, the controller tests the Basic I/O Highway by writing out test patterns and reading back the results. If any of these test patterns are incorrect, all the odd bits in F200 and F201 are set to 1 (producing the data pattern @AAAA in both tables).

If both tests fail, combinations of the two patterns are seen.

WARNING

Earlier model GEM80 Controllers would trip the watchdogs if any faults were detected on Basic I/O. The GEM80-400 Controller will not trip automatically under these circumstances. This allows you to determine which I/O addresses are necessary for correct operation of the plant.

IN THE EVENT OF F-TABLES BEING SET, THE ASSOCIATED INPUTS DROP TO ZERO AND THE ASSOCIATED OUTPUTS FREEZE. IT IS THE USER'S RESPONSIBILITY TO TAKE ANY NECESSARY ACTION WITHIN THE PROGRAM TO ENSURE SAFE PLANT OPERATION UNDER THESE CONDITIONS.

If failures are detected when critical inputs or outputs are being addressed (see Chapter 9 of this manual for details of fault finding), the user program could use F-table bits to trip the controller watchdogs by setting F1 to any non-zero value.

The Verification I/O Highway provides greater security against the transfer of corrupted data between the controller and the GEM80 I/O Modules. The Verification I/O transfer provides 'address/data checkwords' and 'data confirm words' during the I/O transfer. Outputs are not written to the plant by the I/O module unless the address/data checkword sent by the controller is mathematically verified. Inputs are not written into the A-tables unless the checkword received by the controller is correct. If the data is not successfully transferred after two retries, an F-table is set for that address and the value read or written remains at the last value transferred correctly.

The F-table bits for Verification I/O are at F202 to F2xx; there are 2 bits per address. The odd numbered bit indicates warning, this results in patterns such as @5555; the even numbered bit indicates fault/fail.

3.3. Typical I/O System

Figure 3.1 shows a typical I/O system using Basic I/O, Verification I/O and Verification I/O converted to Basic I/O using 8191 expanders.

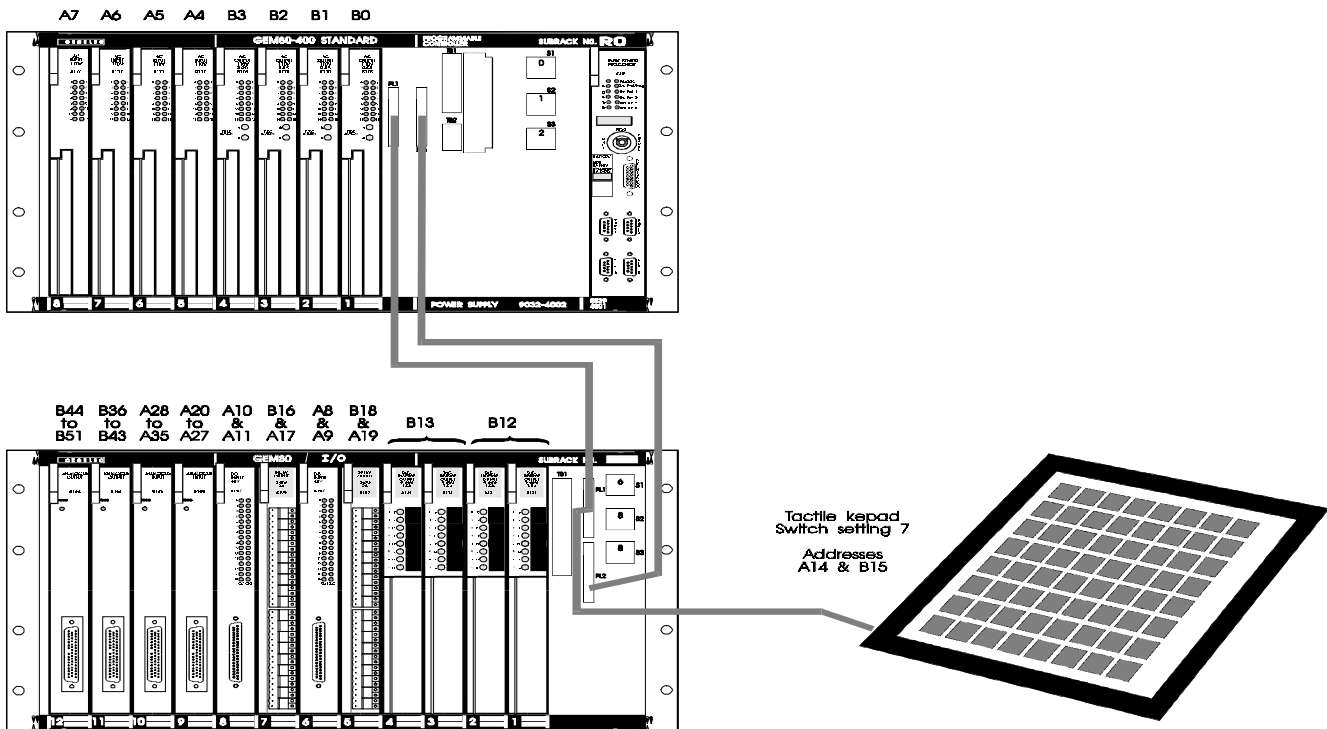


Figure 3.1 - Typical I/O System

Details of how to set up such a system are contained in the following sections.

3.4. Addressing I/O Modules in the Controller Subracks

The most convenient method of arranging the I/O modules in a complete system is to start with the 8-point modules, continue with the 16-point modules and finish with the 32-point modules, ensuring that all module details and addresses are progressively recorded. The 'I/O Subrack User Information Sheet', Publication No. T1432 gives more detailed instructions.

It is important to be aware of the details and addresses of all the modules fitted and to ensure that an address is used ONCE ONLY. It is also necessary to calculate the current in each of the ribbon cables. In order to assist in recording these parameters, a blank table, Table 3.14, has been provided at the end of this chapter, which can be copied as required.

Caution...

Ensure that each module has a unique address or the system will not work. Also ensure that where subrack switches are not being used for addressing, they are set to position 8 or 9.

3.4.1. GEM80/400S Controller

The 400S Controller does not have any slots allocated in the controller subrack to basic or verification I/O. The five I/O slots available at the left hand end of the subrack are allocated to Fast I/O.

3.4.2. Enhanced Controller

The Enhanced Controller has space for four I/O modules in the controller subrack itself. The addresses of I/O modules in the subrack are fixed as shown in Table 3.1.

Table 3.1 - Enhanced Controller Basic I/O Module Addresses

Slot No.	8-Point Address	16-Point Address	32-Point Address
1	A/B 0.0 to 0.7	A/B 0	A/B 0 & 1
2	A/B 0.8 to 0.15	A/B 1	A/B 2 & 3
3	A/B 1.0 to 1.7	A/B 2	A/B 4 & 5
4	A/B 1.8 to 1.15	A/B 3	A/B 6 & 7

3.4.3. Standard Controller

The Standard Controller has space for eight I/O modules in the controller subrack itself.

There are three address decoder switches located behind the power supply on the upper backplane, as shown in Figure 3.1. Each switch has ten settings numbered 0 to 9. Settings 0 to 7 select module addresses for specific subrack slots. If a switch is not used it should be set to 8 or 9.

Setting the address of the I/O modules depends upon the type of Basic I/O Module, i.e. 8-, 16-, or 32-point module.

Note...Each I/O address may only be used once, either for input, or output.

3.4.3.1. 8-Point Basic Modules

Note...GEM80 uses 16 bit words. Each word may be a word of input or a word of output, but not both. Therefore 8-point modules must be installed in pairs of input modules or pairs of output modules.

The I/O subrack accepts 8-point modules in any slot as all slots are user addressable. A decoder switch, S1 or S2, selects the addresses for a group of four adjacent 8-point modules. S1 selects addresses for slots 1, 2, 3 and 4, and S2 selects addresses for slots 5, 6, 7 and 8.

Table 3.2 shows how the switch settings control the slot addresses.

Table 3.2 - 8-Point Basic Module I/O Slot Addresses Determined by Switch Settings

	Slots Controlled by S2				Slots Controlled by S1			
	8	7	6	5	4	3	2	1
S1/S2 Setting	Resulting Address of I/O Module in Slot				Resulting Address of I/O Module in Slot			
0	1	1	0	0	1	1	0	0
1	3	3	2	2	3	3	2	2
2	5	5	4	4	5	5	4	4
3	7	7	6	6	7	7	6	6
4	9	9	8	8	9	9	8	8
5	11	11	10	10	11	11	10	10
6	13	13	12	12	13	13	12	12
7	15	15	14	14	15	15	14	14
Bits	8..15	0..7	8..15	0..7	8..15	0..7	8..15	0..7

3.4.3.2. 16-Point Basic Modules

16-point modules, located in slots 1 to 6, are allocated addresses according to the setting of the three address decoder switches S1, S2 and S3. Modules located in the highest numbered slots are fixed at addresses 6 and 7.

Table 3.3 shows how the switch settings control the slot addresses.

Table 3.3 - 16-Point Basic Module I/O Slot Addresses Determined by Switch Settings

	Fixed Address Slots		Slots Controlled by S3		Slots Controlled by S2		Slots Controlled by S1	
	8	7	6	5	4	3	2	1
S1/S2/S3	Resulting Address of I/O Module in slot							
0	7	6	1	0	1	0	1	0
1			3	2	3	2	3	2
2			5	4	5	4	5	4
3			7	6	7	6	7	6
4			9	8	9	8	9	8
5			11	10	11	10	11	10
6			13	12	13	12	13	12
7			15	14	15	14	15	14

3.4.3.3. 32-Point Basic Modules

Decoder switches do not affect 32-point modules, their addresses are fixed by slot position. Table 3.4 shows how addresses are allocated by slot position.

Table 3.4 - 32-Point Basic Module I/O Slot Addresses Determined by Slot Position

Slot No.	8	7	6	5	4	3	2	1
Address	14 & 15	12 & 13	10 & 11	8 & 9	6 & 7	4 & 5	2 & 3	0 & 1

3.5. Addressing Additional Basic I/O Modules

Additional Basic I/O Modules may be addressed using extension subracks connected on the Basic I/O ribbon cable. It must be noted that addresses used in the extension subracks must not conflict with addresses in the controller subrack itself.

3.5.1. 12-Slot I/O Subrack (8859-4003)

This subrack accommodates up to twelve 8- or 16-point modules or up to eight 32-point modules and its application is fully explained in the User Information Sheet, Publication No. T1504.

Details applicable to the 12-slot I/O Subrack are included here to assist the user in configuring a complete system.

Note...When used via an 8191-4004 Verification I/O Expander or Remote I/O system, add the base address of these modules to the I/O addresses.

3.5.1.1. 8-Point Modules

S1 selects addresses for slots 1, 2, 3 and 4, S2 selects addresses for slots 5, 6, 7 and 8, and S3 selects addresses for slots 9, 10, 11 and 12.

Table 3.5 shows how the switch settings control the slot addresses.

Table 3.5 - 8-Point Modules I/O Slot Addresses Determined by Switch Settings

	Slots Controlled by S3				Slots Controlled by S2				Slots Controlled by S1			
	12	11	10	9	8	7	6	5	4	3	2	1
S1/S2/S3	Resulting Address if I/O Module in Slot											
0	1	1	0	0	1	1	0	0	1	1	0	0
1	3	3	2	2	3	3	2	2	3	3	2	2
2	5	5	4	4	5	5	4	4	5	5	4	4
3	7	7	6	6	7	7	6	6	7	7	6	6
4	9	9	8	8	9	9	8	8	9	9	8	8
5	11	11	10	10	11	11	10	10	11	11	10	10
6	13	13	12	12	13	13	12	12	13	13	12	12
7	15	15	14	14	15	15	14	14	15	15	14	14
bits	8..15	0..7	8..15	0..7	8..15	0..7	8..15	0..7	8..15	0..7	8..15	0..7

3.5.1.2. 16-Point Modules

16-point modules located in slots 1 to 6 are allocated an address according to the setting of the three address decoder switches S1, S2 and S3. Modules located in the highest numbered slots are fixed at addresses 10 to 15.

Table 3.6 shows how the switch settings control the slot addresses.

Table 3.6 - 16-Point Modules I/O Slot Addresses Determined By Switch Settings

	Fixed Address Slots						Slots Controlled by S3		Slots Controlled by S2		Slots Controlled by S1	
	12	11	10	9	8	7	6	5	4	3	2	1
S1/S2/S3 Setting	Resulting Address of I/O Module in Slot											
0	15	14	13	12	11	10	1	0	1	0	1	0
1							3	2	3	2	3	2
2							5	4	5	4	5	4
3							7	6	7	6	7	6
4							9	8	9	8	9	8
5							11	10	11	10	11	10
6							13	12	13	12	13	12
7							15	14	15	14	15	14

3.5.1.3. 32-Point Modules

Decoder switches do not affect 32-point modules, their addresses are fixed by slot position. Table 3.7 shows how addresses are allocated by slot position.

Table 3.7 - 32-Point Modules I/O Slot Addresses Determined By Slot Position

Slot No	12	11	10	9	8	7	6	5	4	3	2	1
Address	14 & 15		12 & 13		10 & 11		8 & 9		6 & 7	4 & 5	2 & 3	0 & 1

3.6. Addressing Operator Interface Units (Basic I/O)

9005 Tactile Keypad
8944 Thumbhole Input
8932/33 Decade Display

Each of these units has an address decoder switch with ten positions, numbered 0 to 9, except the 9005, which has 16 positions numbered 0 to F. Settings 0 to 7 correspond to addresses 0 to 15. Each switch position corresponds to 2 address locations (32 I/O points) in the controller. Settings 8 and above are not used. Refer to the relevant User Information Sheets for further details.

3.7. Addressing Modules on the I/O Highway

The GEM80-400 Controller can handle up to 1,024 words on the Verification I/O Highway which can contain either 16,384 ON/OFF states, 1,024 numeric values (range +32,767 or -32,768), or any mixture. The controller also has 16 words of Basic I/O fixed at addresses 0 to 15.

Note...It must be noted that Verification Units may not be addressed within this range, as this would cause address clashing.

Verification I/O Modules may be positioned in any of the slots in the subrack. The precise address is determined by switches on the module and is not affected by its slot position. Again, care must be taken to avoid addresses overlapping.

The Verification I/O Highway is carried on a 26-way ribbon cable which fits to the second ribbon cable socket, at the rear of the controller subrack; see Figures 1.12 and 1.13 for details of these connections.

Figures 1.12 and 1.13 show the location of the connections on the upper backplane of the controller subracks. The Verification I/O ribbon can be 'daisy chained' to successive Verification I/O Subracks. However, there is a limitation on the length of ribbon cable used, imposed by the method of feeding the +15V supply. If the +15V power is directly

connected to the I/O subrack, the limiting factor is cable capacitance in which case, the following formula applies:

$$L = 83 - 0.42(M + S)$$

where:

L = Total ribbon length in metres.
M = Quantity of modules on the Verification I/O ribbon, including: I/O modules, Processor Module, Verification I/O Expanders and Remote I/O Controllers.
S = Quantity of subracks.

If the +15V power is supplied via the Verification I/O ribbon, the equivalent formula for length becomes:

$$L = 52 - 0.42(M + S).$$

Refer to the following Technical Publications for further information on Verification I/O:

'8165 User Information Sheet', Publication No. T1476
'8166 User Information Sheet', Publication No. T1477
'8199 User Information Sheet', Publication No. T1448.

3.8. Converting Verification I/O to Basic I/O

If there is a requirement for more than 256 bits of Basic I/O, 8191 Verification I/O Expanders can be used to convert from the Verification I/O Highway to the Basic I/O Highway. Each 8191 provides up to 512 points (32 words) of Basic I/O.

3.8.1. Verification I/O Expander 8191-4004

3.8.1.1. Introduction

The 8191-4004 Verification I/O Expander Module fits into the right-hand end of the 12-slot I/O Subrack 8859-4003. The module converts the Verification I/O Highway into one or two Basic I/O ribbons. This allows Basic I/O Modules to be used on the Verification I/O Highway and assigned any valid address. It is a double width module that does not occupy any I/O space, appearing to the host controller as an n x 16-bit I/O module, where n is the range of addresses selected by the range switch, up to a maximum of 32 addresses.

It outputs the Basic and Verification I/O Highways on three ribbon connectors on the front panel of the module as well as onto the backplane of the subrack via two more ribbon cable connectors mounted on the circuit board. The top connector, PLO, provides Basic I/O Highway connections while the lower connector, PLO, provides Verification I/O Highway connections. Ribbon cables from PLO and PLO connect to corresponding connectors on the upper backplane of the subrack. The Verification ribbon input from the processor

module or from the previous Expander Module is connected to ribbon socket PLO of the 8191 Expander Module. This ribbon can then be daisy-chained on to the next 8191 Expander Module.

3.8.1.2. Address Setting

The expander module occupies a maximum of 32 Verification I/O address words. The maximum number of Verification I/O addresses is 1024 words (16 to 1039) which is 2^{10} . Therefore, to allow the module to be allocated any required address within the range of 16 - 1039, subject to the capacity of the host controller, ten address switches (out of the twelve available) are required.

Two banks of address switches, SW3 and SW4, are used to set the base address of the 8191 Expander Module itself on the Verification I/O Highway. Once this base address has been established, the range switches, SW1 and SW2 are then set to the range of Basic I/O addresses to be used (up to a maximum of 32). The twelve switches are located at the bottom rear corner of the module and are accessible without removing the plastic protective cover. They are in a group of eight, bits 0-7, and a group of four, bits 8-11. When a switch is in the ON position, that bit is a logical '1'.

Figure 3.2 shows the layout of the address switches and illustrates that the switch for bit 4 is set to the logical '1' position, giving a base address of 16 for the 8191 Expander Module.

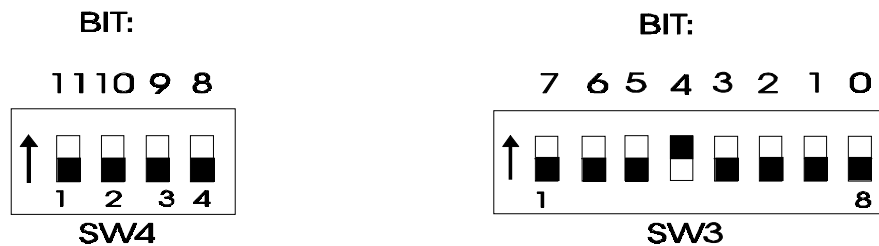


Figure 3.2 - Address Switches

3.8.1.3. Range Setting

As mentioned previously, the module can accommodate up to 32 addresses. The Range Switches (SW1 and SW2) are used to indicate to the host controller the size of the block of addresses to which the module will respond.

The Range Switches are located above and adjacent to the address switches and take the form of two 16-position hexadecimal rotary switches, the positions being identified 0 to F. They should be set within the range @00 to @1F (0 to 31 decimal). If, for example, they are both set to 0 and the address switches are set to the address 35, the module responds only to address 35. If, however, the range switches are set to @1F (31 decimal), the maximum allowable, the module will respond to addresses in the range 35 to 66 (35 + 31).

If the switches are set to @20 or higher, neither Basic I/O ribbon is scanned.

Figure 3.3 shows the Range Switches set to @19 (25 decimal). If the address of the module is set to 320, the module will respond to addresses within the range 320 to 345.

SW1

SW2

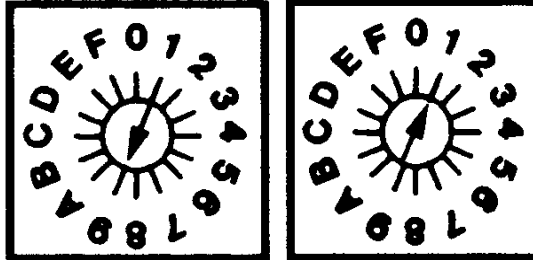


Figure 3.3 - Range Switches

CAUTION

When setting the range switches in conjunction with the base address switches care should be taken to ensure that any address in the range of addresses does not overlap the addresses range of another configured expander as this will cause highway errors. Care should also be taken to ensure that the last configured address (base address plus the address range) does not exceed the Verification I/O address range (up to 1039).

e.g. if the base address was set to 1010 and the range to @1F (31 decimal), the last two configured addresses 1040 and 1041 would be outside the Verification I/O address range, and would not be addressable.

Table 3.8 shows how the range switches affect the address block size.

Table 3.8 - Range Switch Operation

Range Switch Setting		Top Address	Range Switch Setting		Top Address
S2	S1		S2	S1	
0	0	Base (n)	1	0	n + 16
0	1	n + 1	1	1	n + 17
0	2	n + 2	1	2	n + 18
0	3	n + 3	1	3	n + 19
0	4	n + 4	1	4	n + 20
0	5	n + 5	1	5	n + 21
0	6	n + 6	1	6	n + 22
0	7	n + 7	1	7	n + 23
0	8	n + 8	1	8	n + 24
0	9	n + 9	1	9	n + 25
0	A	n + 10	1	A	n + 26
0	B	n + 11	1	B	n + 27
0	C	n + 12	1	C	n + 28
0	D	n + 13	1	D	n + 29
0	E	n + 14	1	E	n + 30
0	F	n + 15	1	F	n + 31

The module address corresponds to the first address of the address block. When the size of the address block is set by the Range Switch, care must be taken to ensure that the automatically assigned addresses in the block do not overlap any other previously allocated addresses as this will cause highway errors.

It must be remembered that the base address of the module must be at least the number of addresses in the block less than the maximum number of I/O addresses available in the host controller. If this rule is not observed it will result in the loss of one or more of the top addresses in the block. For example, if the maximum I/O address of the host controller is 512 I/O words and the module is given a base address of 491, only 22 addresses are available. If the range switches are then set to @1D (block size of 30), the top 8 addresses will be unavailable or lost.

3.9. Fault Indication

Each word of I/O has a corresponding pair of bits in an F-table location to indicate incorrect operation of that address. The least significant bit of each pair is the fault bit and the most significant bit is the fail bit. Under normal operation, all the F-table locations monitoring I/O operation are at zero.

If any of the strobe or data lines for a particular ribbon are not working correctly, the fail bit and the fault bit are set in all the F-table locations for that ribbon to indicate that all data is being transferred incorrectly.

Failure of the expander module or a highway fault results in all bits in the appropriate F-table (F200 to F329) locations being set to 1.

If the controller or expander module finds a fault with the Basic I/O ribbons, a pattern of bits is written into the appropriate F-table locations.

If any address lines become shorted together or to a supply, only the fault bits in the F-table locations for those addresses are set to 1.

Figure 3.4 shows the fault bit/address relationship for Basic I/O Ribbon which has an address range of zero to fifteen.

If the controller had any strobe or data lines shorted on the Basic I/O, the bit pattern 1111 1111 1111 1111 (all the fail bits) would be set in tables F200 and F201.

If the address line A6 is shorted to 0V, the fault bits will be set for addresses 12 and 13 in fault table F201. The bit pattern will be 0000 0101 0000 0000.

The F-table associated with its block of 8 I/O addresses can be calculated by using the formula:

$$Fn = (n/8) + 200$$

where n is the I/O address used. E.g. to find the F-table associated with A/B 49

$$Fn = (49/8) + 200 = 6 + 200 = F206$$

The remainder of this integer division is used to identify the relevant low order bit of the pair associated with the I/O address in the F-table.

49/8 = 6 remainder 1.

Multiply by 2 to obtain the low order bit, 2. F206 bits 2 and 3 correspond to A/B 49

Table 3.4 gives the complete list of I/O fault tables with there corresponding addresses.

Table 3.15 - Fault Table / I/O Address relationship

Fault Table	I/O Address		Fault Table	I/O Address		Fault Table	I/O Address		Fault Table	I/O Address	
Fn	From	To	Fn	From	To	Fn	From	To	Fn	From	To
200	0	7	232	256	263	264	512	519	296	768	775
201	8	15	233	264	271	265	520	527	297	776	783
202	16	23	234	272	279	266	528	535	298	784	791
203	24	31	235	280	287	267	536	543	299	792	799
204	32	39	236	288	295	268	544	551	300	800	807
205	40	47	237	296	303	269	552	559	301	808	815
206	48	55	238	304	311	270	560	567	302	816	823
207	56	63	239	312	319	271	568	575	303	824	831
208	64	71	240	320	327	272	576	583	304	832	839
209	72	79	241	328	335	273	584	591	305	840	847
210	80	87	242	336	343	274	592	599	306	848	855
211	88	95	243	344	351	275	600	607	307	856	863
212	96	103	244	352	359	276	608	615	308	864	871
213	104	111	245	360	367	277	616	623	309	872	879
214	112	119	246	368	375	278	624	631	310	880	887
215	120	127	247	376	383	279	632	639	311	888	895
216	128	135	248	384	391	280	640	647	312	896	903
217	136	143	249	392	399	281	648	655	313	904	911
218	144	151	250	400	407	282	656	663	314	912	919
219	152	159	251	408	415	283	664	671	315	920	927
220	160	167	252	416	423	284	672	679	316	928	935
221	168	175	253	424	431	285	680	687	317	936	943
222	176	183	254	432	439	286	688	695	318	944	951
223	184	191	255	440	447	287	696	703	319	952	959
224	192	199	256	448	455	288	704	711	320	960	967
225	200	207	257	456	463	289	712	719	321	968	975
226	208	215	258	464	471	290	720	727	322	976	983
227	216	223	259	472	479	291	728	735	323	984	991
28	224	231	260	480	487	292	736	743	324	992	999
229	232	239	261	488	495	293	744	751	325	1000	1007
230	240	247	262	496	503	294	752	759	326	1008	1015
231	248	255	263	504	511	295	760	767	327	1016	1023
									328	1024	1031
									329	1032	1039

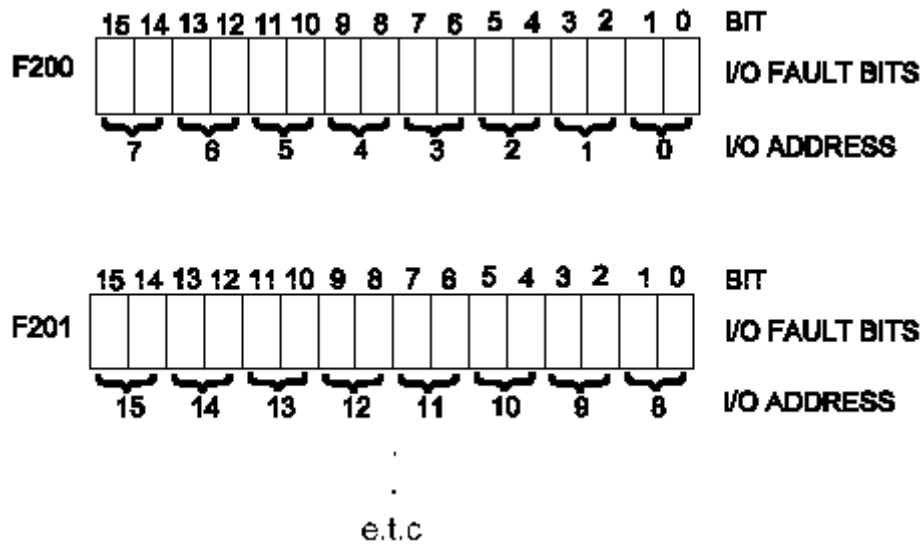


Figure 3.4 - Fault Bit/Address Relationship

WARNING

Earlier model GEM80 Controllers would trip the watchdogs if any faults were detected on Basic I/O. The GEM80-400 Processor Module will not trip automatically under these circumstances. This allows you to determine which I/O addresses are necessary for correct operation of the plant.

IN THE EVENT OF F-TABLES BEING SET, THE ASSOCIATED INPUTS DROP TO ZERO AND THE ASSOCIATED OUTPUTS FREEZE. IT IS THE USER'S RESPONSIBILITY TO TAKE ANY NECESSARY ACTION WITHIN THE PROGRAM TO ENSURE SAFE PLANT OPERATION UNDER THESE CONDITIONS.

3.9.1. Data Table Addresses

The method of addressing used in GEM80 is best illustrated by the examples shown in Figures 3.5 and 3.6. In Figure 3.5, a GEM80-400 Controller is shown connected to an 8859 I/O subrack via an 8191 Verification I/O Expander. Only the Basic I/O Modules are shown in this example to emphasise the data table content.

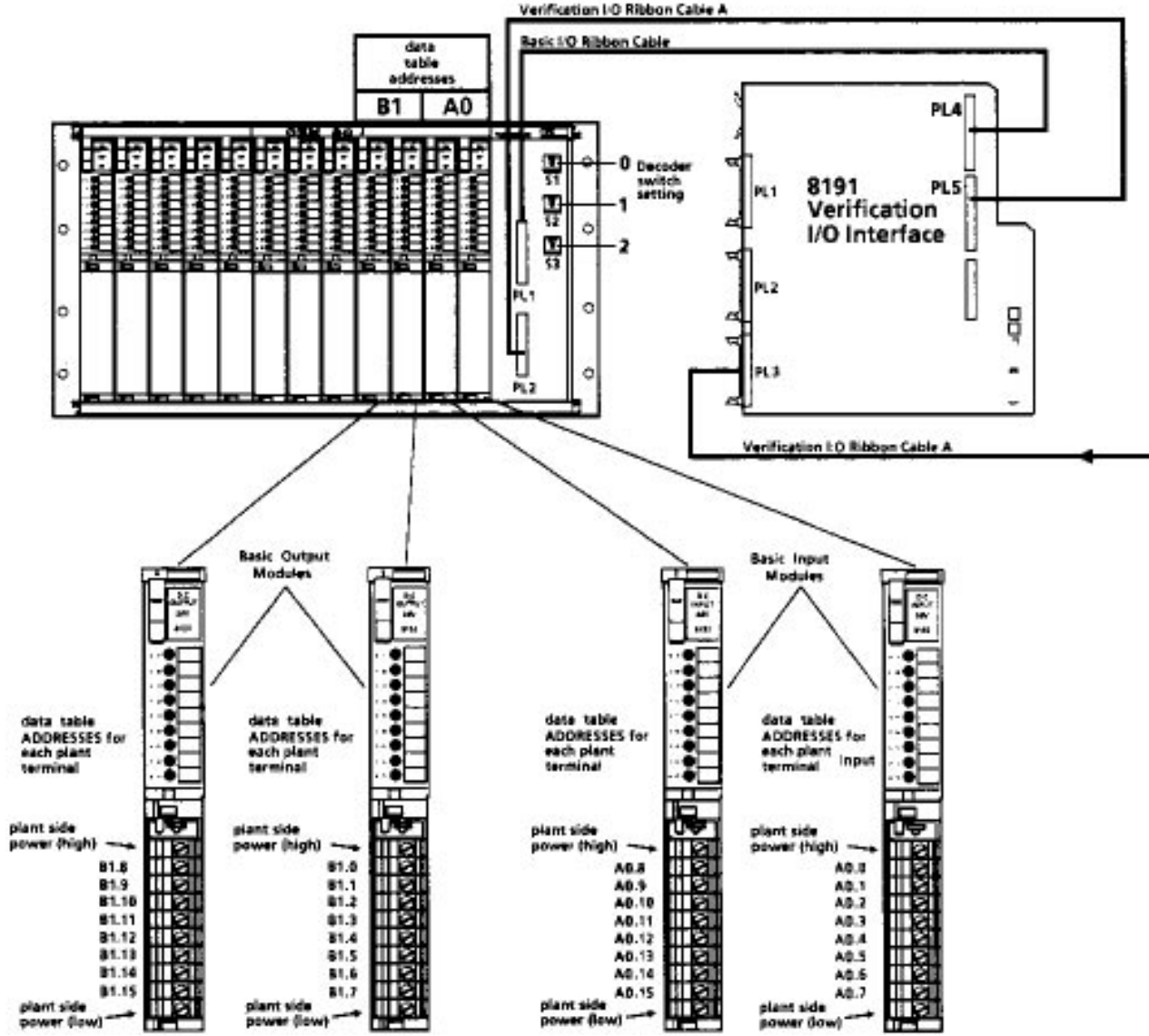


Figure 3.5 - I/O Subrack Connected to GEM 80-400 Controller (Part 1)

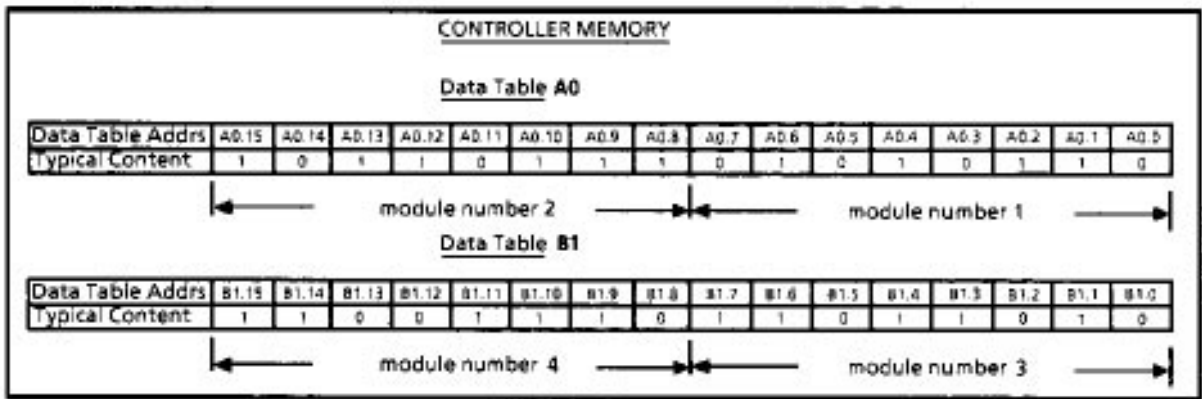
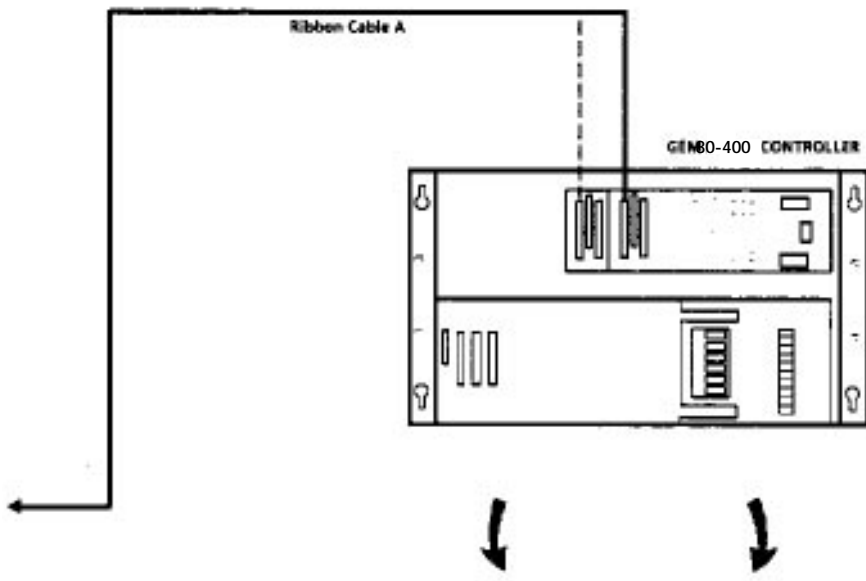


Figure 3.5 - I/O Subrack Connected to GEM80-400 Controller (Part 2)

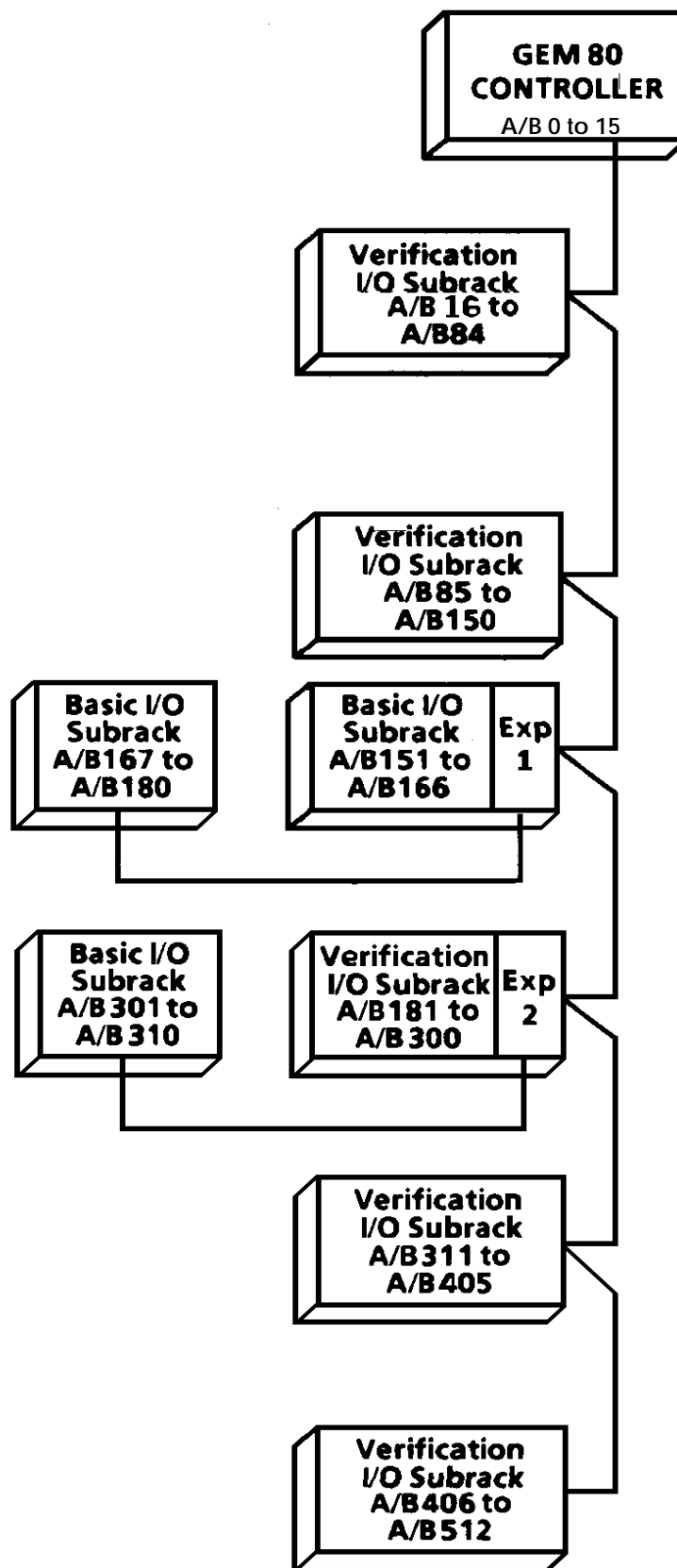


Figure 3.6 - Typical Verification I/O System

The 8191 Verification I/O Expander base selection switches are set to 0. The range switches are set to 12, allowing further Basic I/O Modules to be addressed in a second subrack. The top address decoder switch (S1), on the 8859 I/O Subrack, is set to zero, so module numbers 1 to 4 are addresses 0 and 1. Module numbers 1 and 2 are Basic Input Modules and as input addresses are A-table, so module numbers 1 and 2 must be address A0.

Each module has 8 I/O points (8 channels), so the two modules together have a total of 16 I/O points (16 channels) forming one 16-bit word, A0. Word A0 will store the input states for these 16 points.

Module numbers 3 and 4 are Basic Output Modules and as output addresses are B-table, so data table B1 stores the 16 output states for these points.

In this example, address A0 is Input so address B0 does not exist and also B1 is Output so address A1 does not exist. Addresses are allocated to words 0 to 511 as A or B according to whether Input or Output modules are fitted.

Pairs of 8-point modules form one 16-bit word, so each pair of 8-point modules must be either Input modules or Output modules. Each 16-point module provides one word of I/O and thus each slot can be addressed by one 16-bit word, in the A- or B-table. Each 32-point module provides two consecutive words of Input or Output data. Full details of addressing and connecting I/O modules are given in the 'I/O Subracks User Information Sheet', Publications No. T1503 and T1504.

In the example in Figure 3.6, a system needs A/B0 to A/B512 of I/O. The requirement is broken down as follows:

Verification I/O Modules - A/B16 to A/B150,
 A/B181 to A/B300,
 A/B311 to A/B512.

Basic I/O Modules - A/B0 to A/B15
 A/B151 to A/B180,
 A/B301 to A/B310.

The I/O modules are to be sighted in four locations:

1. A/B0 to A/B180;
2. A/B181 to A/B310;
3. A/B311 to A/B405;
4. A/B406 to A/B512.

The subracks are shown separately to illustrate the 'daisy chaining' capability of the Verification I/O ribbon.

Note...The subracks are labelled as being Basic or Verification in order to emphasise the different address requirement.

In practice, both Basic and Verification I/O Modules can be accommodated in the same subrack. As previously explained, the 8191 Verification I/O Expander must be employed when Basic I/O Modules are to be addressed.

The base address of each 8191 is set by the two DIP switches SW3 and SW4; SW3 gives the least significant digits (see Figure 3.2). The range of the address 'window' is set by the two hexadecimal switches SW1 and SW2, with SW1 giving the least significant digit (see Figure 3.3).

Expander No.

Base Address = 151: SW4 = 0000, SW3 = 10010111.
Range = 29: SW2 = 1, SW1 = D.

Expander No.

Base Address = 301: SW4 = 0001, SW3 = 00101101.
Range = 9: SW2 = 0, SW1 = 9.

Expander No.

Base Address = 560: SW4 = 0010, SW3 = 00110000.
Range = 15: SW2 = 0, SW1 = F.

3.10. Power for Basic and Verification I/O Equipment

3.10.1. Introduction

Basic I/O Modules require a +15V logic supply, while Verification I/O Modules require 15V and 5V logic supplies. Controller subracks do not require external power as this is supplied directly from the controller power supply.

The modules may be situated either in the controller subrack or in additional 12-slot I/O subracks. Additional I/O subracks require discrete wiring to provide this power to the I/O modules via the I/O backplane. The 15V supply can be supplied in one of three ways:

- (1) From the controller power supply through the I/O ribbon cable;
- (2) From the controller power supply through separate power supply cable;
- (3) From an external power supply provided by the user.

The 5V supply, for Verification I/O Modules, must be supplied from discrete wiring and is not available from the ribbon cables.

3.10.2. I/O Power Consumption

When configuring a system, the logic power consumption of the I/O modules must be determined. The power requirements of I/O modules are detailed in Section 1 of the current price list, see also any relevant User Information Sheets.

Table 3.14, a combination of Tables 3.10, 3.11 and 3.12, may be used to calculate spare capacity from the controller subrack. This page may be photocopied as required.

Spare capacity from the controller power supply may be used to supply further I/O subracks. These may be supplied using the Basic and Verification I/O ribbon cables or using discrete wiring. The I/O ribbon cables have a current carrying capacity which is limited by cable length. Table 3.9 shows the current obtainable for different cable lengths. Therefore, if the current consumed is greater than the ribbon capability, the supply will have to be discretely wired.

Table 3.9 - I/O Ribbon Cable Current Carrying Capacity

Length of I/O Ribbon (Metres)	Maximum Current Carried (Amps)
10	2.1
15	1.4
20	1.05
25	0.84
30	0.7

Note that for all lengths up to 10m the maximum current is 2.1A.
 For lengths greater than 10m the current carrying capacity may be calculated as follows:

$$\text{Length in Metres} = \frac{21}{\text{Current in Amps}}$$

The maximum length for a Basic I/O ribbon cable is 30m.

Table 3.10 - Standard Controller

Slot No.	8	7	6	5	4	3	2	1		Total	PSU	spare
Module									8239	(mA)	9032	capacity
Current at +5v									2500		7000	
Current at +15V									500		2000	

Table 3.11 - Enhanced Controller

	4	3	2	1		1	2	3	4	5	Total	PSU	spare
Module					8239						(mA)	9017	capacity
Current at +5V					2500							12000	
Current at +15V					500							8000	

Table 3.12 may be used to calculate the current consumption for a 12 slot I/O subrack.

Table 3.12 - 12-Slot I/O Subrack

Slot No.	12	11	10	9	8	7	6	5	4	3	2	1		
Module														Total (mA)
Current : at +5v														
Current : at +15V														

3.10.3. Power for 8191 Verification I/O Expanders

It is recommended that copies of Tables 3.10 and 3.11, given at the end of this chapter as part of Table 3.14, should be completed as an aid to addressing and to draw attention to the system +5V and +15V requirement of I/O Modules.

Note...Care must be taken to ensure that the controller power capacity or ribbon cable capacity is not exceeded.

In order to establish the amount of power required, copies of Table 3.12, given at the end of this chapter as part of Table 3.14, should be filled in for each rack. Table 3.13 (Example of full table filled in) shows an example of how this is done. Current consumption figures can be found in Chapter 6 of this manual or in the relevant User Information sheets. To establish the power available in the controller power supply module, see the 'Power Supply Modules Specification' section of Chapter 6.

Chapter 6 gives full details of the power available from the following power modules: 9017, 9018, 9032, 8917, 8918. Subtract the consumption figures given in Tables 6.1 and 6.2 for the Central Highway Modules to obtain the power available to the Basic and Verification I/O equipment. In addition to the power consumed by the I/O equipment, the 8191 Verification I/O Expander requires its own power which is drawn from either discrete wiring or through the Verification I/O ribbon cable. The current carrying capacity of this cable is specified in Table 3.9. The 8191 requires 900mA for its own use and it can be seen that with 3 or more expanders being used, the maximum current for the I/O ribbon cable will be exceeded. The power drawn by the 8191 Verification I/O Expander through the Verification I/O ribbon cable for the I/O modules fitted and for its own requirements can be reduced by supplying the requirement through discrete wiring.

The Verification I/O Modules require a +5V supply. This is not available on the Verification I/O ribbon. The +5V is therefore supplied either from the power module in the I/O subrack in which the Verification I/O Module is fitted, a power module from an adjacent subrack or a separate (external) supply.

3.10.4. Powering I/O Modules through the I/O Highway Ribbon Cables

The simplest method of powering an I/O subrack is through the I/O ribbon cables, provided the current carrying capacity of the cables is not exceeded and the capacity of the power supply module is not exceeded.

The total current should not exceed 2.1A, and the voltage drop in the cable must not exceed 3V. The current carrying capacity of I/O Ribbon cables up to 30m in length is given in Table 3.9. The remaining current available, if any, can be taken by discrete wiring from the backplane terminal block.

When the Basic I/O ribbon cable is used to power the 8859-4003 12-slot I/O subrack a link must be connected between Terminals 4 and 6 of Terminal Block TB1 (on the 12-slot subrack backplane) to connect the ribbon cable supply to the subrack backplane.

When the Verification I/O ribbon cable is used to power the 8859-4003 12-slot I/O subrack a link must be connected between Terminals 6 and 9 of Terminal Block TB1 (on the 12-slot subrack backplane) to connect the ribbon cable supply to the subrack backplane.

If sufficient capacity is available from the power supply module and the ribbon cable has sufficient carrying capacity, more than one subrack can be powered from each I/O Ribbon cable. Figure 3.7 shows multiple subracks powered from the Basic I/O Ribbon cable.

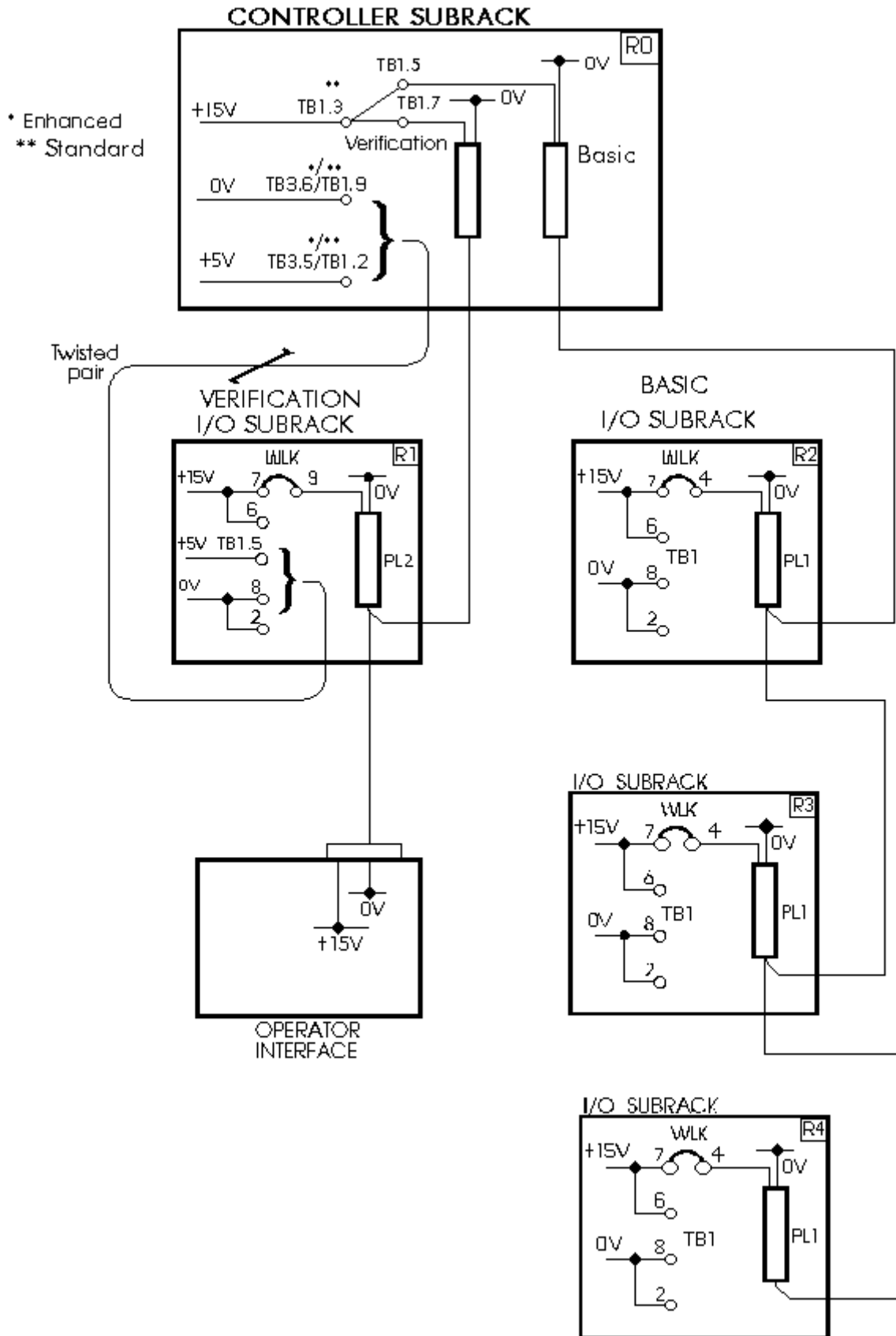


Figure 3.7 - Powering I/O Equipment from Power Module via I/O Ribbon Cables
3.10.5. Powering I/O Subracks from the Controller Power Supply Using Discrete Wiring

If the controller power supply module has sufficient capacity but the capacity restrictions of the I/O ribbon cables are exceeded, additional I/O subracks should be connected to the controller power supply using discrete wires. The power supply wiring is connected to TB1.3 (Standard) or TB3.4 (Enhanced) for +15V and TB1.9 (Standard) or TB3.6 (Enhanced) for 0V on the terminal block on the controller backplane and TB1.7 (+15V) and TB1.8 (0V) on the I/O subrack backplane. Figure 3.8 shows the method of connecting I/O subracks using discrete wiring. No additional links are required on the I/O subrack backplane; this is to avoid feedback.

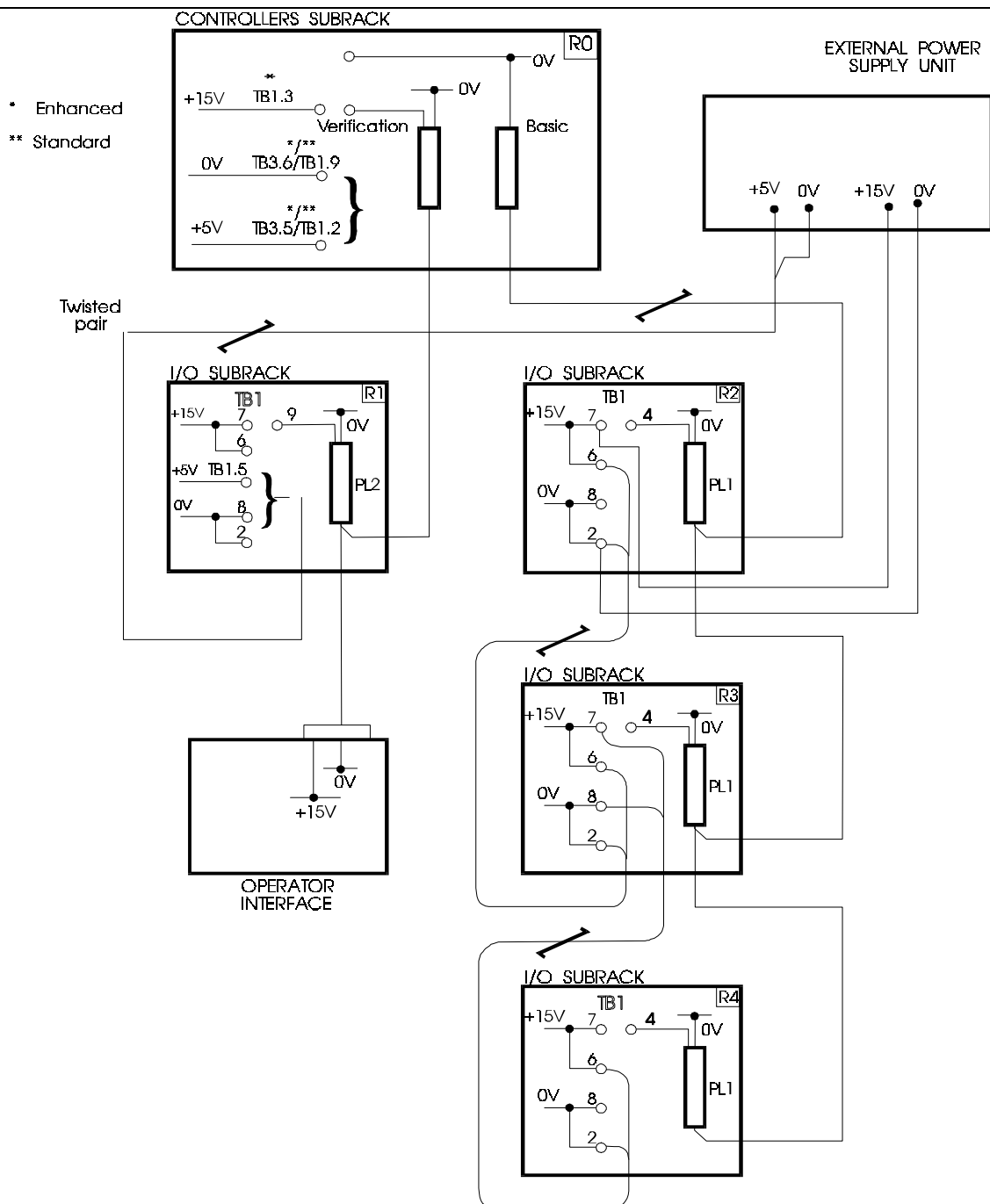


Figure 3.8 - Powering I/O Subracks Using Discrete Wiring

The length limit for discrete wires depends on the size of the wires used. The terminals on the subracks can accommodate wire sizes up to 2.5mm², but 1.0 or 1.5mm² wire sizes should be adequate.

3.10.6. Connecting an External Power Supply

3.10.6.1. External +15V Power Source

If required, the I/O subracks can be fed from an external power supply module (+15V), connecting +15V to TB1.7 and 0V to TB1.8 on the 12-slot I/O subrack. The

external supply must be capable of +15V \pm 0.5V with 50mV maximum peak-to-peak ripple. In order to prevent damage to PCBs under fault conditions, the power supply should be set to trip at a current overload of 10A.

It is recommended that a suitable method of monitoring the external supply is used to notify the controller of a system fault and the appropriate action must then be taken by the user.

3.10.7. Powering the Verification I/O Expander Module

3.10.7.1. Powering via Ribbon Cables

Power to I/O equipment may be supplied through Verification I/O ribbon cables.

In addition to the power consumed by the I/O equipment, the 8191-4004 Verification I/O Expander Module requires its own power which can be drawn through the Verification ribbon cable. Figure 3.7 shows the connections for this option. Link LK5 on the Expander must be fitted in position 'B' when power is supplied through the Verification I/O ribbon cables. Figure 3.9 shows the position of LK5 on the module.

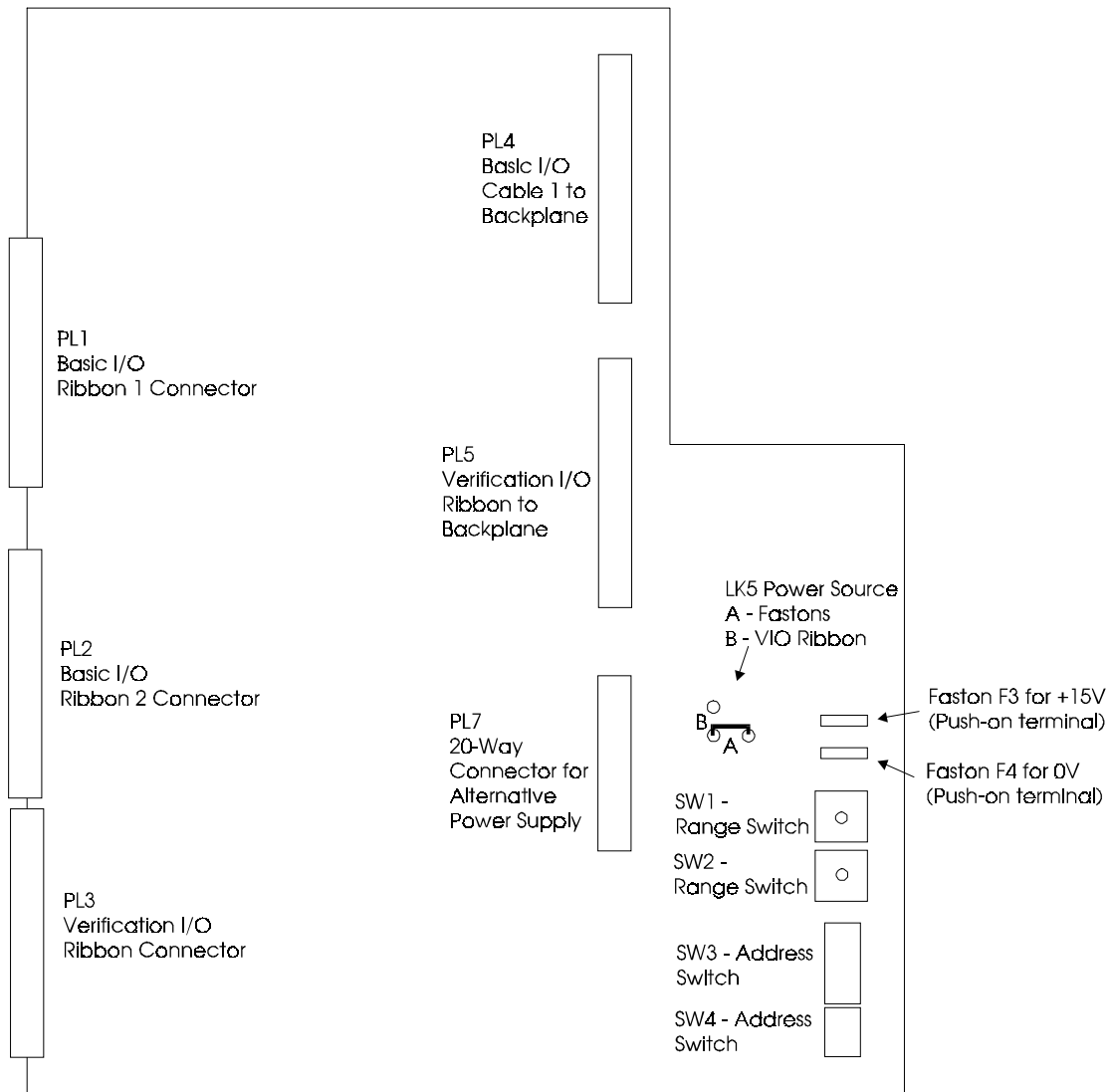
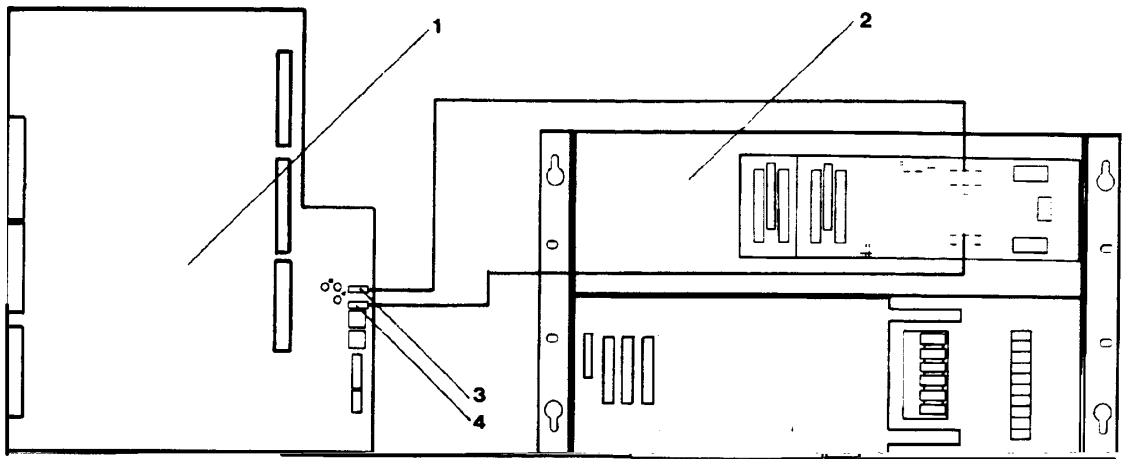


Figure 3.9 - 8191-4004 Verification I/O Expander Module

3.10.7.2. Powering via Terminals on the Controller Backplane

I/O power may be drawn from the controller power supply module via the terminals TB4 (+15V) and TB3 or TB5 (0V) on the controller backplane and connected to the 8191-4004 Verification I/O interfaces through the push-on terminals F3 (+15V) and F4 (0V). See Figure 3.10 for details. Where this method is used, LK5 must be placed in the 'A' position. With the link in this position the Verification I/O Ribbon +15V is isolated from the +15V of the separate supply.



1. 8191 Verification I/O Module
2. GEM80 Controller
3. Push-on Terminal for +15V
4. Push-on Terminal for 0V

Figure 3.10 - Powering Verification I/O Expander Module from Power Supply Module

When +15V power is supplied from an external +15V power pack, LK5 on the 8191 Verification I/O Expander Module must be placed in the 'A' position. See Figure 3.10 for the position of LK5. The +15V supply should be connected to push-on terminal F3 and the 0V connected to F4 in the controller.

3.10.8. Powering Verification I/O

Verification I/O Modules require an additional +5V supply. If Verification I/O Modules are fitted to a subrack without a built-in power supply, +5V must be fed to the subrack by a separate cable connected between the controller backplane and the I/O subrack backplane terminal block. However, the supply can be fed from an external power source. Full details of the subrack backplane connections are given in the 'I/O Subracks User Information Sheet', Publications

No. T1503 and T1504. Figures 1.12 and 1.13 show the +5V connection to the GEM 80-400 Controller backplane.

The +5V supply should be connected to the 12-slot I/O subrack via a twin twisted pair cable (+5V/0V connecting 5V to TB1.5 and 0V to TB1.8). This wiring is in the 'Very Clean' category. The +15V connection to the Verification I/O subrack can be taken from either the backplane connectors, the I/O ribbon itself or from an external supply, as described in the section 'Power for Basic and Verification I/O Equipment' of this chapter.

3.11. Basic and Verification I/O Ribbon Cables

WARNING: DO NOT INSERT OR REMOVE RIBBON CABLES WITH THE POWER ON.

3.11.1. 26-Way Ribbon Cable for Basic and Verification I/O Highway

These cables connect to the Basic I/O or Verification I/O Highway sockets on the controller subrack and then to each item of Basic or Verification I/O equipment in turn with a 'daisy chain' arrangement.

The ribbons are in the 'very clean' category (refer to Chapter 7). They should be kept as short and flat as possible.

There are two cabling options available which may be ordered:

- (1) Standard ready assembled cables;
- (2) Parts only to assemble as required.

3.11.1.1. Standard Ready Assembled Cables

These cables are for use in simple systems connecting between the controller subrack and up to three subracks of I/O modules. There are four different cables available, each having a pre-defined length between the first socket (Controller) and the 2nd socket (1st I/O subrack) - length A. The length between I/O subracks (sockets 2, 3 & 4) is one metre in each case, see Figure 3.11 for details.

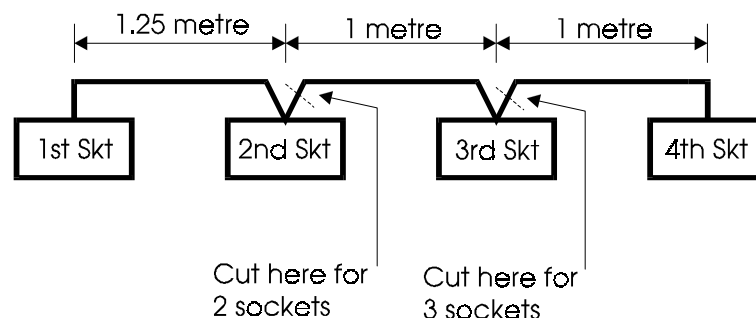


Figure 3.11 - Standard Ready Assembled I/O Ribbon Cables

If you require either 2- or 3-socket cable, the ribbon cable should be cut as close as possible to the last socket required.

Ensure that the standard dimensions suit the installation. Ordering codes for standard ready assembled cables are given in Chapter 10 of this manual.

3.11.2. Making Your Own Cables

The following parts should be used when making I/O ribbon cables:

- | | | |
|--------------|---|--|
| Ribbon Cable | - | 26-way flat ribbon, width 33mm ITT type 455-240-26, Spectra type 843-191-2801-026 or equivalent. |
| Connectors | - | Harting type 0918 526 6813 connector.
Polarising key in position 2. |

See Appendix A for cable assembly information. Full details of the pin-out connections used by the Basic I/O and Verification I/O ribbon cables is given in the 'I/O Subracks User Information Sheet', Publications No. T1503 and T1504.

WARNING

ALSTOM DRIVES & CONTROLS accepts no responsibility for failure of non-standard ribbon cables or damage to any equipment caused by the connection of faulty non-standard ribbon cables

3.12. Length Limits for 26-Way Basic I/O Ribbon Cables

The Basic I/O equipment draws current from the Expander Modules through the Basic I/O ribbon cable. The Basic I/O Product Data sheets detail these currents. The length of Basic I/O ribbon cables is limited by the current carrying requirements. The method of calculating the permissible length of cable is shown in the 'I/O Power Consumption' section, earlier in this chapter. Table 3.9 details maximum currents.

3.13. Segregation of 26-Way Basic and Verification I/O Highway Ribbon Cable

These ribbon cables are noise sensitive; they should be as short as possible and segregated from 'noisy' cables. With cubicle mounted controllers, it is not recommended to run this cable outside the cubicle, or cubicle suite. Chapter 7 covers the cabling and segregation of these I/O ribbons.

3.14. I/O Module Interlock System

I/O subracks include a circuit consisting of links within the Basic and Verification I/O Modules and subracks. This is arranged so that when all the modules are

fitted, a series chain of links is completed giving a short circuit. If, however, a module is removed, the series chain of links is broken giving an open circuit. It is envisaged that this system could be used to interlock with a relay coil or an input channel of an I/O module. This may, if required, be part of the system-healthy checks in the user program, so that if the I/O input channel to which these interlocks connect is high, all I/O modules are fitted. Connections for this are shown in Figure 3.13. For the circumstances where the I/O subrack is not completely full of modules, a shorting link in the form of a 0Ω resistor is fitted on the backplane so that the series chain of interlocks would be completed by the 0Ω resistors if no modules were put in the subrack. To activate the module interlock system, it is necessary to cut out the 0Ω resistors at each connection where an I/O module is fitted, see Figure 3.14.

Note...The 0Ω resistor is located immediately to the right of the I/O module connector as illustrated in Figure 3.14. A typical module interlock circuit is shown in Figure 3.13.

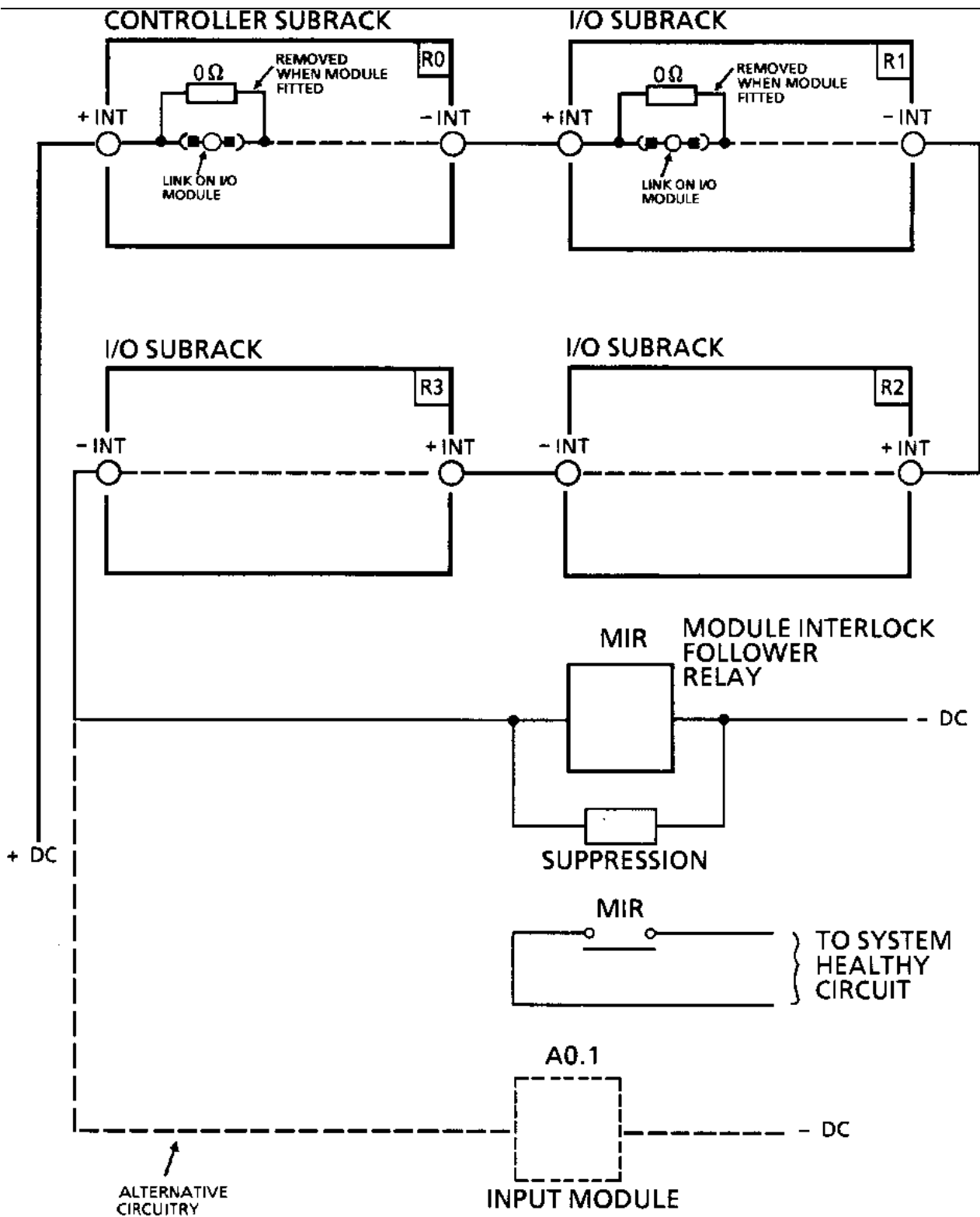
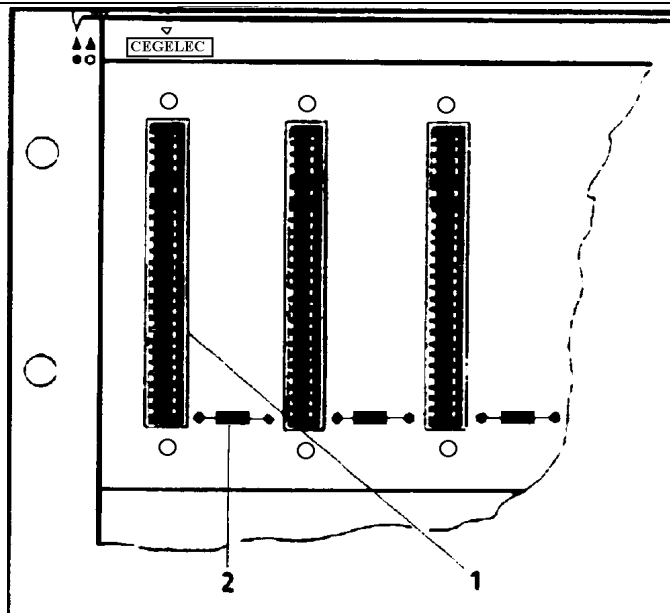


Figure 3.13 - Typical Module Interlock Circuit



1. Edge Connector for I/O module
2. Associated 0Ω resistor (cut out when module is to be fitted)

Figure 3.14 - I/O Module Interlock System, 0Ω Resistor

3.14.1. I/O Module Interlock Circuit Ratings

Circuit restrictions	-	Volt-free contact. For use in dc circuits only with of 50V dc and 0.5A peak.
Operation	-	Closed when all I/O modules are fully inserted into the rack.
Connections	-	Terminals on subrack backplane. Remove the power module for access. Maximum wire size 2.5mm ²

Notes...1. All wiring is 'DIRTY' category. 2. Maximum size of wiring that can be terminated at +INT and -INT terminals is 2.5mm².

3.15. Output Enable Modules

Some output modules incorporate 'output enable' circuitry. This ensures that all outputs are held in the 'OFF' state until:

- (1) An enable signal at +15V dc $\pm 3.5V/\pm 10\%$ is present and
- (2) GEM80 controller initiates the output 'ON'.

The enable signal is applied to the controller subrack and will enable all 'output enable' modules contained in the subrack. The enable signal would normally be provided via the watchdog follower relay so that the outputs are inhibited on initial switch-on and when the watchdog opens.

Another GEM80 subrack which has this feature is: 8859-4003 - 12-slot I/O subrack.

3.15.1. Output Enable Connections

Output enable connections to the controller subracks are shown in Figures 3.15 and 3.16. Figure 3.15 illustrates the use of GEM80 +15V power supplies and Figure 3.16 illustrates the use of external +15V power supplies. Resistors R7 and R8 (or R14 and R15) should be removed as indicated. The 0Ω resistors shown in dotted outline should be removed when used with the relevant power supplies.

Note...Each Output Enable Module connected using the GEM80 power supply draws an additional 10mA.

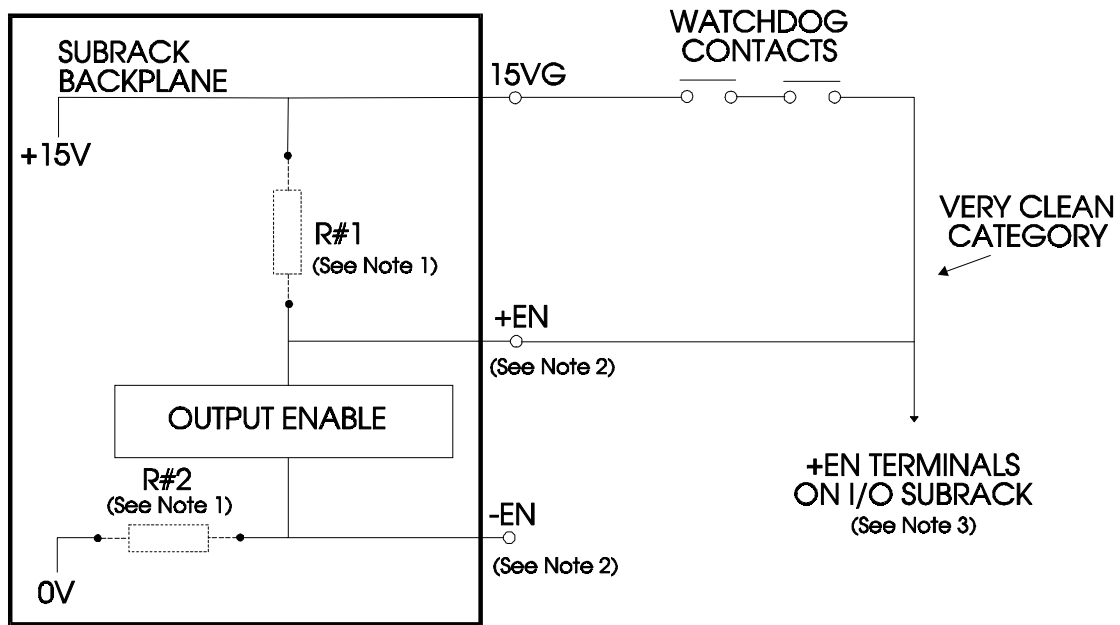


Figure 3.15 - Connection of Output Enable Signal using the GEM80 Power Supply

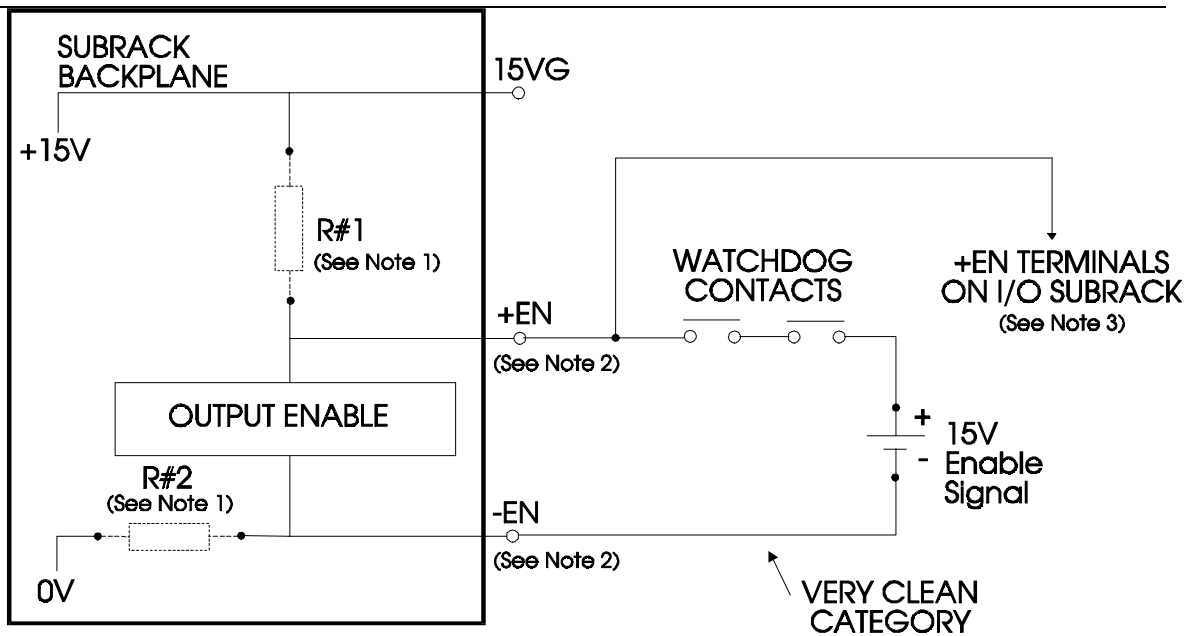


Figure 3.16 - Connection of Output Enable Signal using an External Power Supply

Note...1. R#1 and R#2 should be fitted if the +15V enable is to be supplied from the GEM80 power supply and the watchdog contacts are not being used in the output enable circuit. If the GEM80 power supply is being used via the watchdog contacts, R#1 should be removed. If an external power supply is being used to supply the enable R#1 and R#2 should be removed.

Note...2. The enable terminals TB2.2 and TB2.1, +EN and -EN respectively on the 8-slot I/O subrack and Standard Controller Subrack are TB1.12 and TB1.13 respectively on the 12-slot I/O subrack and TB2.1 & 2 respectively on the Enhanced Controller Subrack.

Note...3. Each Output Enable Module connected using the GEM80 power supply draws an additional 10mA.

Note...4. The 0Ω resistor designators for R#1 and R#2 are shown in Table 3.10.

Table 3.10 - Output Enable Resistor Designators.

Subrack Order Number	Description	Resistor Designator	
		R#1 (+15V)	R#2 (0V)
8855-4010	GEM80-400 Enhanced Controller	R15	R16
8857-4020	GEM80-400 Standard Controller	R14	R15
8857-4006	8-slot I/O subrack	R14	R15
8859-4003	12-slot I/O subrack	R15	R14

3.16. Wiring Segregation

The segregation category depends on the power supply providing the enable signal. If the signal is derived from the controller power supply or another GEM80 power module, it is considered to be 'very clean' and must be segregated from any 'dirty' plant-side wiring. If, however, the signal is supplied from a remote power supply which is also supplying 'dirty' circuits, the enable wiring can be run with other 'dirty' plant-side wiring. It MUST NOT be run alongside 'clean' or 'very clean' wiring.

3.16.1. Wiring Size

The maximum size of wiring which can be terminated at +EN and -EN terminals is 2.5mm². These terminals are located on Terminal Block, TB2 on the upper backplane of the I/O subrack.

Note...The +EN connection MUST be 'very clean'. To prevent interference pick-up, the -EN wire MUST be run to other subracks as a twisted pair with the +EN wire.

3.17. Example of Addressing

An example of I/O addressing using the GEM80-400 Enhanced Controller follows; refer to the 'Standard Controller' section earlier in this chapter. A system has a requirement for a combination of Basic and Verification I/O Modules. There are:

- six Verification Analogue Modules, which require a total of 96 addresses (6 x 16),
- two Verification Relay Modules, which require a total of 4 addresses (2 x 2),
- a number of Basic I/O Modules, requiring an additional 25 addresses.

Note...In this example, we have not taken account of the termination panels, and used worst case figures, i.e. all channels on.

The first Basic I/O addresses, 0 - 15, are fixed on the GEM80-400 Controller; access to the next available address is via an 8191-4004 Verification I/O Expander Module. The base address of this module is set to 16 and the range switches are set to n + 31, giving a range of 16 - 47. The Verification I/O Modules are set by address switches as the Expander.

Note...Care must be taken when setting the addresses on Verification I/O Modules to ensure that address clashing, between I/O modules and the Expander Module, does not occur, as this can cause problems during commissioning. Relevant F-tables should be monitored when adding Verification I/O Expander Modules and I/O modules to the system.

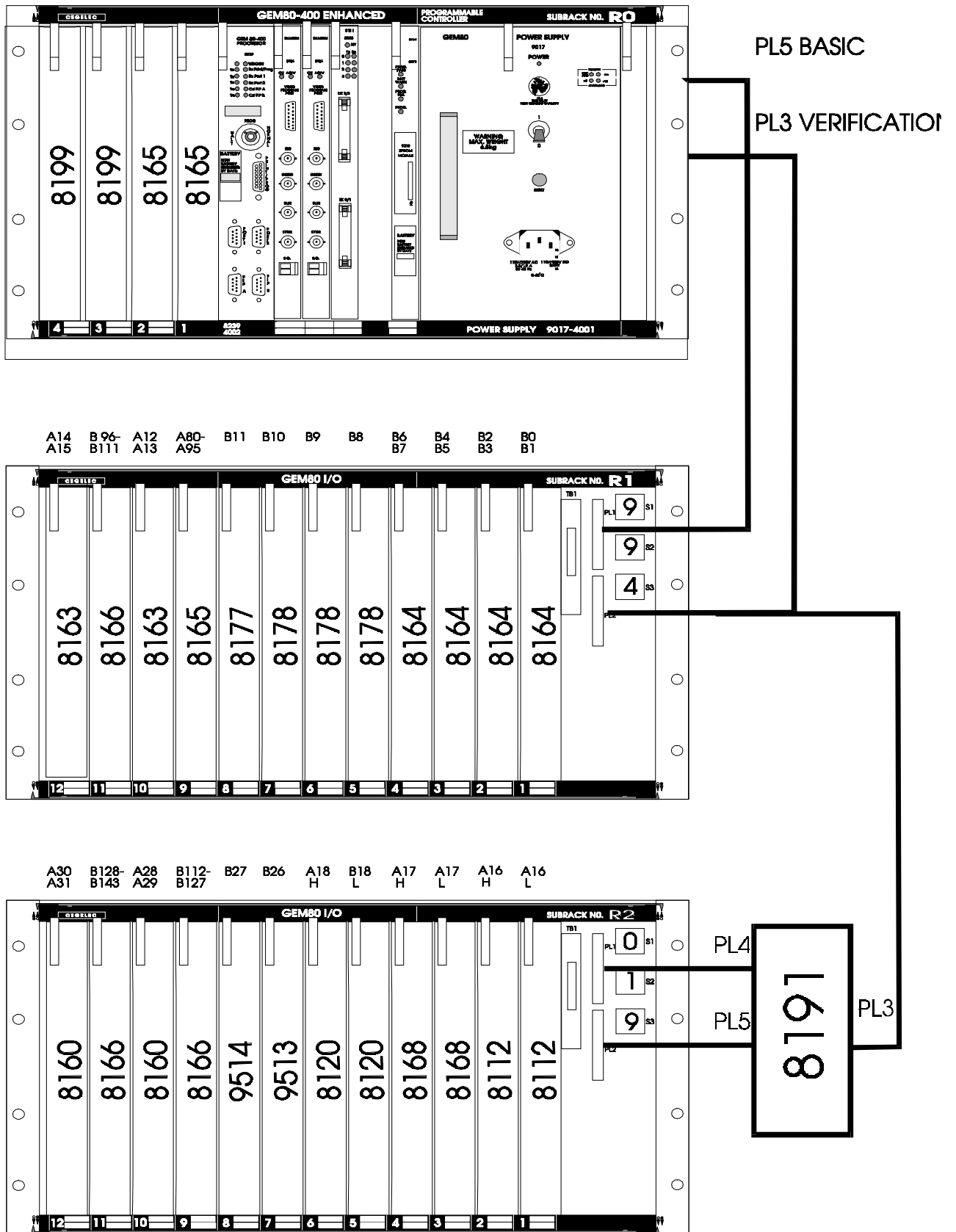


Figure 3.17- GEM80-400 Enhanced Controller and I/O System

Table 3.13 - Example Table

Rack 0													
Slot No.	8	7	6	5	4	3	2	1			Total (mA)	PSU	spare capacity
Module									8239			9032	
Current: at +5v									2500			7000	
Current: at +15V									500			2000	
Rack 0													
Slot No.	4	3	2	1		1	2	3	4	5	Total (mA)	PSU	spare capacity
Module Rack 0	8199	8199	8165	8165	8239	8284	8284	8268	8272			9017	
Current: at +5V	300	300	290	290	2500	200	200	1700	1000		6780	12000	5220
Current: at +15V	450	450	40	40	500	-	-	-	-		1480	8000	6520
Rack 1													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	Total (mA)
Module	8163	8166	8163	8165	8177	8178	8178	8178	8164	8164	8164	8164	
Current: at +5v		290		290									580
Current: at +15V	140	40	140	40	16	205	205	205	320	320	320	320	2271
Rack 2													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	Total (mA)
Module	8160	8166	8160	8166	9514	9513	8120	8120	8168	8168	8112	8112	8191
Current: at +5v		290		290									580
Current: at +15V	90	40	90	40	180	70	8.4	8.4	6.8	6.8	6.5	6.5	900
Rack 3													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	Total (mA)
Module													
Current: at +5v													

Current: at +15V														
Rack 4														
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1		
Module														Total (mA)
Current: at +5v														
Current: at +15V														

Table 3.14 - Controller and I/O Subrack Form (Photocopy as required)

Rack 0													
Slot No	8	7	6	5	4	3	2	1			Total (mA)	PSU 9032	Spare capacity
Module									8239				
Current: at +5v									2500			7000	
Current: at +15V									500			2000	
Rack 0													
Slot No.	4	3	2	1		1	2	3	4	5	Total (mA)	PSU 9017	spare capacity
Module						8239							
Current at +5V						2500						12000	
Current at +15V						500						8000	
Rack 1													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	
Module													Total (mA)
Current: at +5v													
Current: at +15V													
Rack 2													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	
Module Rack 2													Total (mA)
Current: at +5v													
Current: at +15V													
Rack 3													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	
Module Rack 3													Total (mA)
Current: at +5v													
Current: at +15V													
Rack 4													
Slot No.	12	11	10	9	8	7	6	5	4	3	2	1	
Module Rack 4													Total (mA)
Current: at +5v													
Current: at +15V													

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4. Communications

4.1. Introduction

GEM80-400 Controllers may transfer and receive controller memory data using serial communications links. The serial ports can be used for the following types of application:

- (1) Operating the GEM 80-400 Controller as part of a distributed controller network, i.e. data table exchange with other GEM 80 controllers or other intelligent devices, or supervisory operations or co-ordinated operation of GEM 80 controllers. Details are given in the 'Data Tables' section.
- (2) Supplying controller data, i.e. alphanumeric characters for intelligent devices, printers, VDUs or keyboards, to a computer for statistical analysis and data logging. See the 'Communication with a Printer, VDU or Suitable GEM80 Programming Tool' section for details.
- (3) Connecting the controller to a suitable GEM80 programming tool, such as Gemesys 3, or a printer.
- (4) Communication with, and connection to intelligent serial devices and Central Highway Modules, such as GEMLAN-D and STARNET.

The GEM80-400 Controller has three serial communications ports, namely Port 1, Port 2 and Port 3. A 9-way 'D'-type connector is used to connect Ports 1 and 2, and a 15-way 'D'-type connector is used to connect Port 3; these are situated on the front panel of the processor module. Port 3 is an RS232/20mA port and is used to connect either a printer or a suitable GEM 80 programming tool, such as Gemesys 3, to the controller; it also provides a monitoring facility. Ports 1 and 2 are general purpose RS485/RS232 serial ports which support four different GEM80 serial communications protocols, these are:

- (1) Extended Simple Protocol (ESP);
- (2) ESP with flexible data tables;
- (3) GEMSTART CCU;
- (4) ASCII (Printer/VDU Terminal).

The signalling rate is user adjustable between 110 and 19,200 bits per second. These rates are selected by preset data, P-tables, for each port. Figure 4.1 shows the serial port connections.

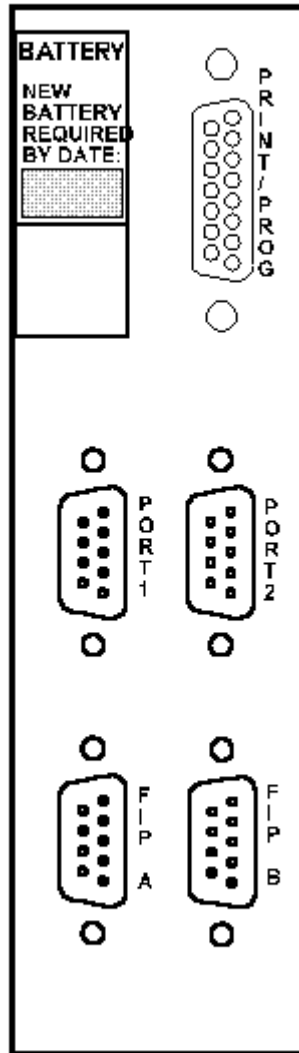


Figure 4.1 - Serial Port Connections

Note...In the case of GEM80-400 Enhanced Controllers, further serial ports can be added using Fast I/O Serial Communications Modules and/or STARNET Modules. See the relevant User Information Sheets for connection details.

4.1.1. Connecting Serial Ports 1 and 2

Serial Ports 1 and 2 produce RS232 and RS485 format signals. The connectors are 9-way, female, 'D'-type socket connectors with threaded retention pillars. The pinouts are as shown in Figure 4.2:

Pin Connection

1	RS485 RXA (Rx+)
2	RS232 Rx
3	RS232 Tx
4	RS485 RXB (Rx-)
5	Signal Ground
6	RS485 TXA (Tx-)
7	RTS
8	CTS
9	RS485 TXB (Tx-)

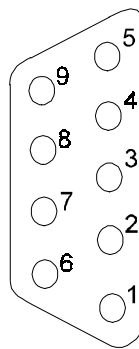


Figure 4.2 - Serial Ports (Ports 1 and 2) Pinouts

The RS232 output from Port 1 or 2 may be converted to 20mA current loop using a suitable active converter.

4.2. GEM80-400 to other GEM80 Controllers

Some GEM80 controllers other than the GEM80-400 provide a form of 'RS422' serial links. These may be connected via a ribbon cable to a 8587-4003 Termination Unit, to convert to RS485 and thus allow communication to a GEM80-400, as shown in Figure 4.3. See 'Serial Interface Termination Units and Panel Combined User Information', Publication No.T456 and the 'GEM80 Serial Communications Manual', Publication No.T457 for connection details.

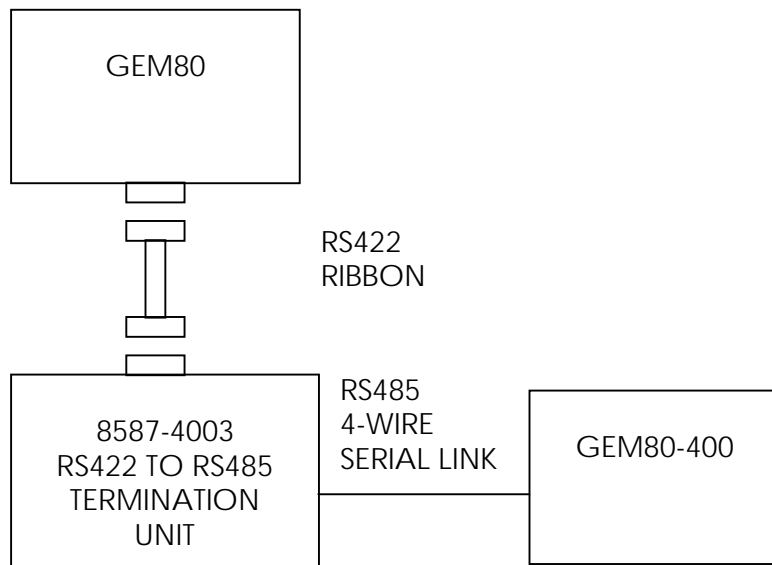


Figure 4.3 - RS485 Serial Link Between a GEM80-400 Controller and another GEM80 Controller

4.2.1. Communication Protocols

The GEM80-400 Controllers have a built-in facility for communicating with other GEM80 equipment using a communication protocol called ESP (Extended Simple Protocol). ESP enables a GEM80-400 Controller to transmit and receive the contents of up to 128 data tables at any one time through a serial communications link to other GEM80 controllers. The protocol uses asynchronous communication with 1 start bit, 8 data bits and 1 stop bit. The protocol provides high confidence that data transmission errors are detected at the receiving end and that detected errors are corrected by automatic re-transmission. It remains compatible with some earlier model GEM80 controllers whose limit is 32 data tables, provided that message lengths are restricted to 32 words or less on the route to that system. Full details about the operation and application of GEM80 serial links may be found in the 'Serial Communications Technical Manual', Publication No.T457.

The GEM80-400 Enhanced Controller may be additionally fitted with STARNET, GEMLAN-D or Fast I/O communications facility. Further details of these facilities are given later in this chapter and in the relevant User Information Sheets.

Some versions of the GEM80-400 Enhanced Controller also support FIP communications networks.

4.2.2. Data Tables

The GEM80-400 Controller uses the following data tables for serial communications:

Table 4.1 - Data Tables used for Serial Ports 1, 2 and 3

Data Table	Content	Port 1	Port 2	Port 3
J	Holds INPUT data received by the controller	J0 to J511	J512 to J1023	J1024 to J1535
K	Holds OUTPUT data to be transmitted to other controllers	K0 to K511	K512 to K1023	K1024 to K1535
P	Data entered by the user into this table configures operation parameters for the serial port (signalling rate, control port or	P0 to P29	P30 to P49	P50 to P58
I	Holds information about control of serial link for user-control mode	I0 to I39	I40 to I79	I80 to I119 Reserved
F	Fault diagnosis table Link statistics (see Chapter 9 for further information)	F10 to F29 F70 to F89	F30 to F49 F90 to F109	F50 to F69 F110 to F129
E	Timing and Flags	See Chapter 2 for further information		

4.2.3. Configuring the Serial Ports

Ports 1, 2 and 3 are configured by presetting data in the P-data table, and then entering a RECOMPILE command (powering down is not required). The type of serial port is determined by the value entered in P11 for Port 1, P31 for Port 2 or P51 for Port 3, and the function of the rest of the P-table locations is dependant upon this value. The signalling (baud) rate is user defined between 110 and 19,200 bits per second. The rate is selected by entering the baud rate in P10, P30 or P50 for Ports 1, 2 and 3 respectively. The following values of baud rate are allowed within the limits given in Tables 4.2 to 4.5: 110; 300; 600; 1,200; 2,400; 4,800; 9,600 and 19,200.

If a baud rate other than the above is selected then the controller defaults to 9600 baud with a timeout value of 13.75 seconds

4.3. Serial Link Communication System

Communications can be established by Point-to-Point Serial Link, where RS232 is recommended provided that the distance does not exceed the maximum allowed by the RS232 specification, or Multi-drop Serial Link, where RS485 is the recommended signal.

4.3.1. Point-to-Point Serial Link

A point-to-point serial link between two controllers may be implemented using RS232 or RS485. The serial communication port of one controller is set up as a control port and the other as a tributary port, see Figure 4.4. The control port is responsible for controlling all activity on the serial link, and the tributary responds only when a message inviting a reply is addressed to it. Figure 4.5 shows a typical example of a point-to-point serial communications link between two GEM 80-400 Controllers (RS232). Up to 128 input and output words can be exchanged at any one time, and the serial link can be operated in either free-running mode or user-control mode depending on data set in the control port P-table. For further information and details relating to modes, see the following sections later in this chapter, 'Free-Running Mode' and 'User-Control Mode'. A GEM 80-400 Controller acting as a tributary may receive and transmit up to 128 words. The data that needs to be written into the P-table, and where data arrives and is transmitted from, for a tributary port, is detailed in the sections 'Operation as an ESP Tributary Port' and 'Operation as an ESP Control Port', later in this chapter.

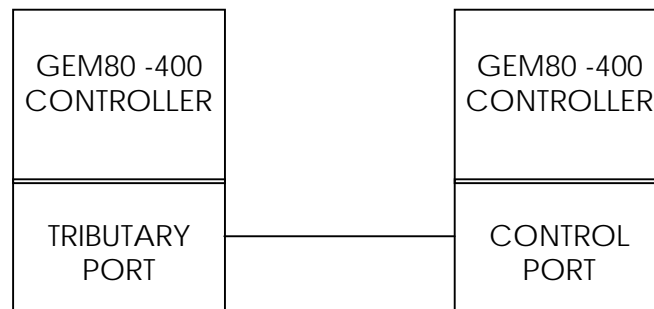


Figure 4.4 - Point-to-Point Serial Link

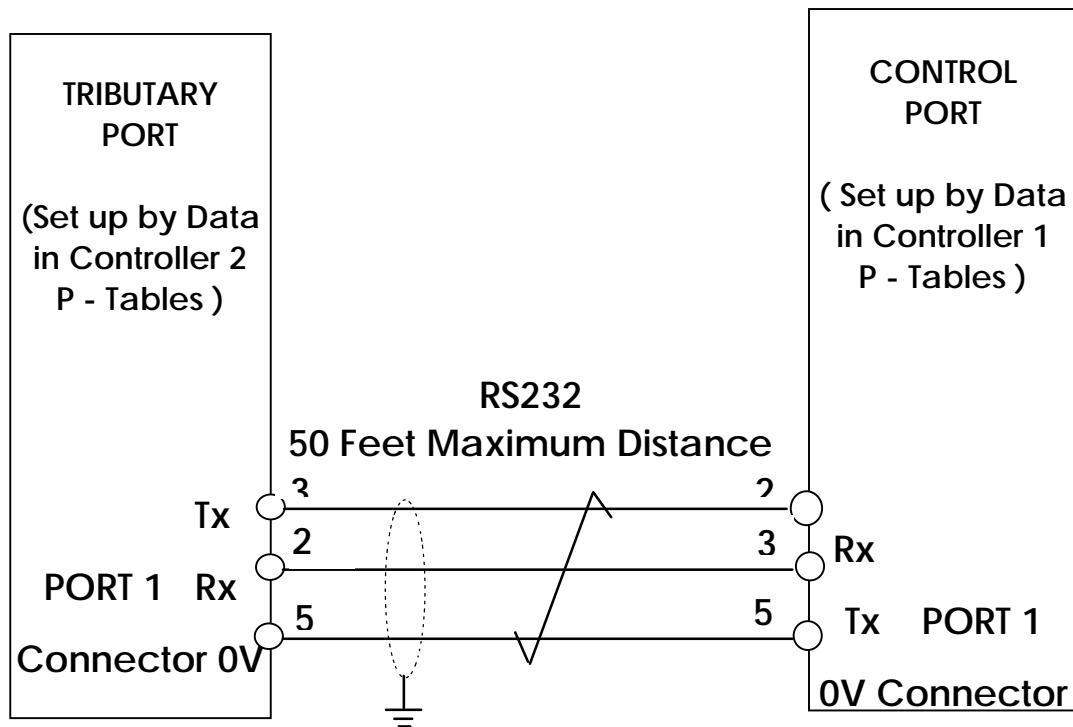


Figure 4.5 - Point-to-Point Serial Communications Link Between Two GEM80-400 Controllers, RS232

4.3.2. Multi-drop Serial Link

A multi-drop serial link between controllers may be implemented using RS485. Figure 4.6 shows a multi-drop serial link in which 4 controllers can interchange data; the control port of GEM80-400 Controllers can communicate with up to 8 tributary ports (or 15 tributary ports if in user control mode with flexible data tables). The serial communication port of one controller is set up as a control port and the others are set up as tributary ports. The control port communicates with each tributary on a cyclic basis. Direct communication between tributaries is not possible, though data can be exchanged between tributaries via the control port provided that the facility exists in the user program of the controller having the control port. Figure 4.7 shows an example of a typical multi-drop link. Up to 128 input and output words of data can be exchanged at any one time and the serial link can be operated in either free-running mode or user-control mode depending on data set in the P-tables. There is a maximum limit of 512 input and output words to/from all controllers at the control port end. The data that must be written into the P-table and where data arrives and is transmitted from is detailed in the following sections, 'Operation as an ESP Tributary Port' and 'Operation as an ESP Control Port', later in this chapter.

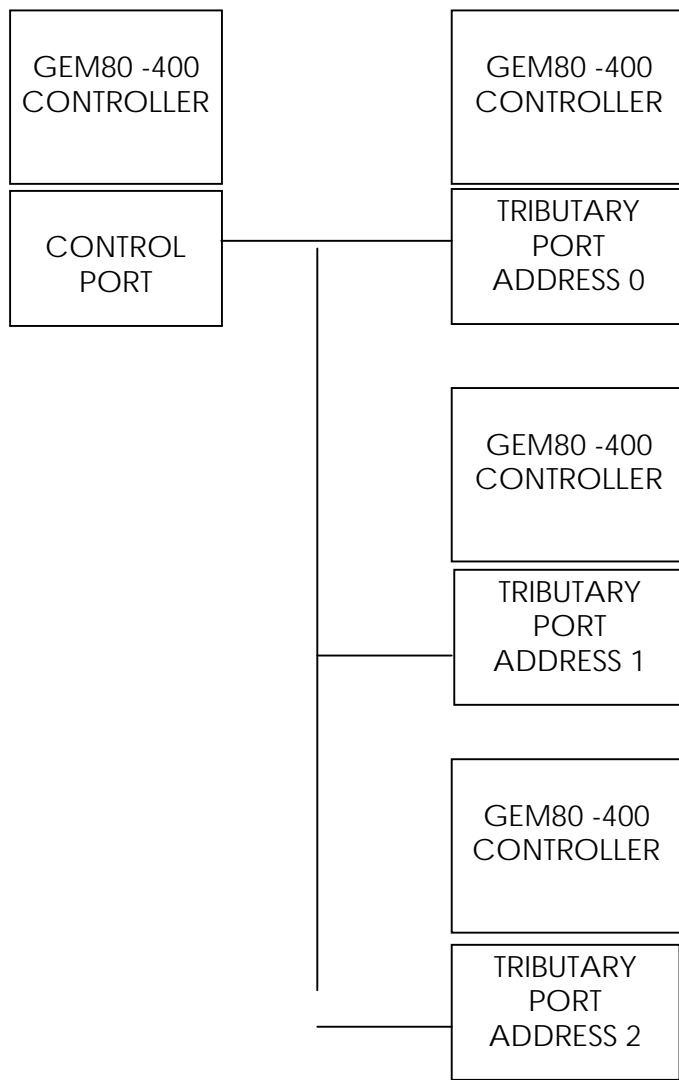


Figure 4.6 - Multi-drop Serial Link

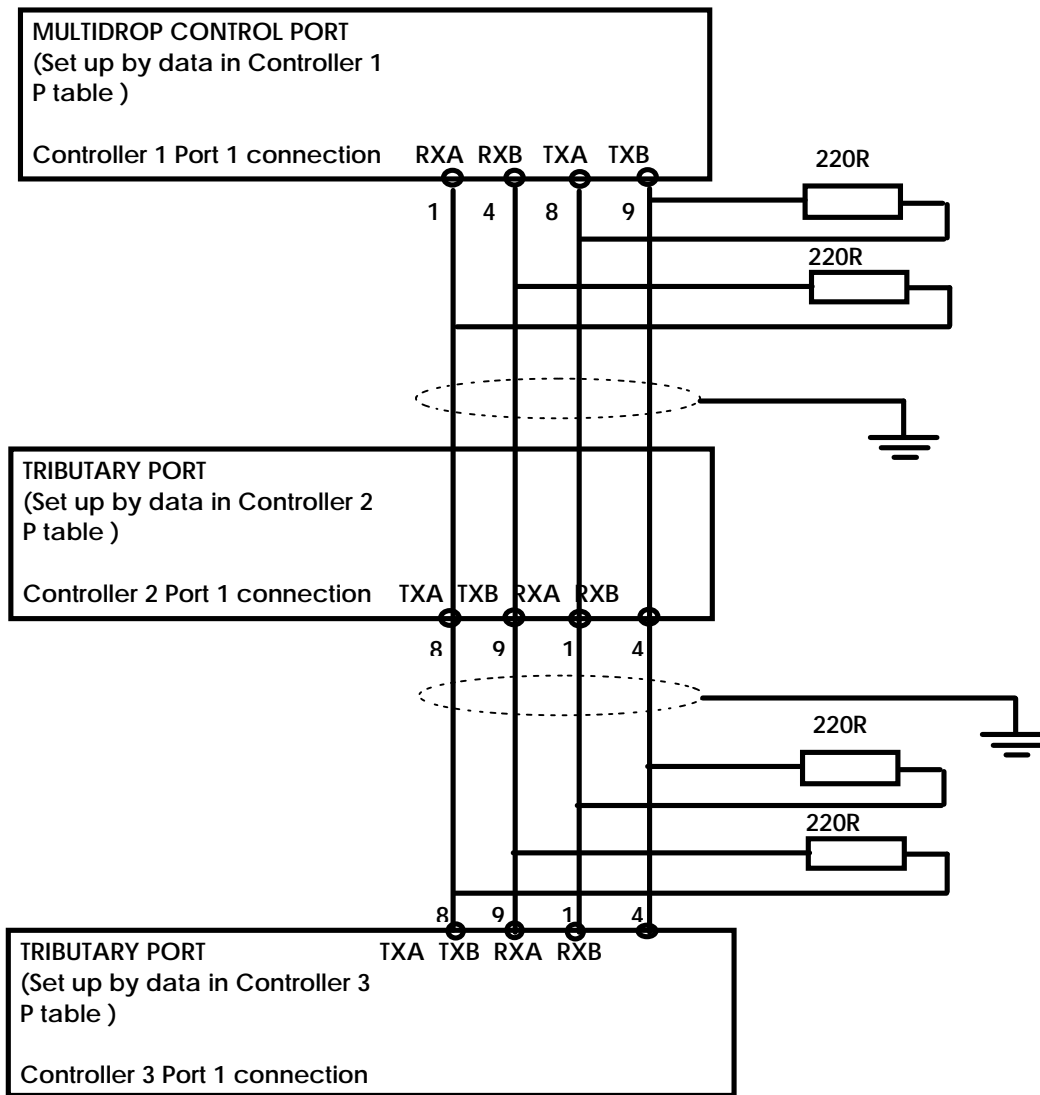


Figure 4.7 - Multi-drop Serial Communications Link Between Three GEM80-400 Controllers, RS485

4.3.3. Serial Links Cabling and Connection

Serial Ports 1, 2 and 3 are accessed via 'D'-type connectors on the front panel of the GEM80-400 Processor Module. If necessary, these may be wired out to a breakout termination unit to allow ease of wiring, especially where cable screen termination and termination resistors are required. An example of a suitable breakout unit, which breaks a 9-way 'D'-type connection into screw terminals is a KLIPPON RD9F (Cat.No.068356). It should be noted that the drop of the cable must be limited to 2 metres.

4.3.4. Using the Printer/Programming Port

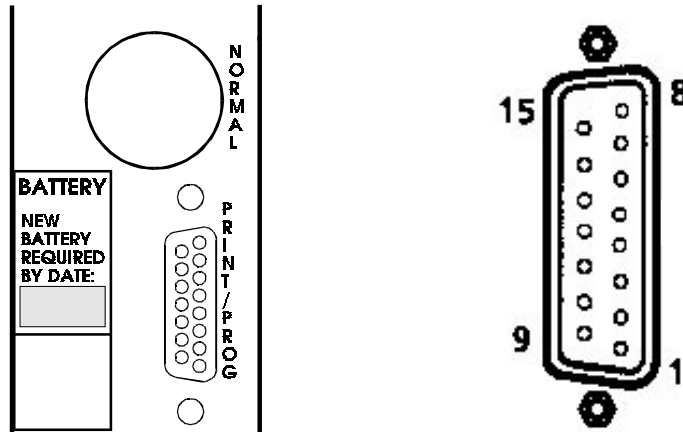
The GEM80-400 Controller automatically detects whether either a printer or a suitable GEM80 programming tool, such as Gemesys 3, is connected to Port 3.

This is achieved by fitting a link in the Printer/Programming cable connector; see Figure 4.8 for

details. When used to program, the port may be used at either 9,600 or 19,200 baud. The baud rate is automatically selected by the GEM80. Suitable GEM80 programming tools, such as Gemesys 3, have the option under the set-up menu to select the faster baud rate. Selection of the faster baud rate enables faster communication with the GEM80, allowing faster downloading of tapes and faster monitoring, etc.

4.3.5. Printer/Programming Port (Port 3) Connections

The Printer/Programming port connector is a 15-way, female, 'D'-type socket connector with threaded retention pillars. The pinouts are as shown in Figure 4.8:



	Pin	Connection
connected 20 mA Connections	(1	RX+) External current source required
	(2	RX-) Do not use GEM80 supply except when
	(3	TX+)to a local programming tool otherwise isolation
	(4	TX-) may be compromised
	(5	15V)
	(6	0V) NOT AVAILABLE FOR USER
	(7	15V)
	(8	0V)
RS232 Connections	(9	RXD
	(10	TXD
	(11	CTS
	(12	RTS
	(13	See Note
	(14	0VA) Isolated
	(15	5VA)

Figure 4.8 - Printer/Programmer Port (Port 3) Pinouts

Note...If the Printer/Programmer port is to be connected to a printer using RS232, link the following:

- Pin 13 to Pin 15
- Pin 1 to Pin 7
- Pin 2 to Pin 8.

If it is to be connected to a suitable GEM80 programming tool, such as Gemesys 3, using RS232 then link the following:

Pin 1 to Pin 7
Pin 2 to Pin 8.

4.4. Communication with a Printer, VDU or Suitable GEM 80 Programming Tool

4.4.1. Specification

4.4.1.1. Application

Input/Output to and from intelligent devices.
Output of text and numeric data to printer, Teletype (TTY) compatible VDU, etc.
Input of characters or strings from keyboard.
Option of automatic echoing and editing of input. Also supports XON-XOFF protocol in this mode.
Free format of input and output data to any serial device.

4.4.1.2. Characteristics

RS232/RS485
ASCII character set (equivalent to ISO-7). 1 start bit, 7 or 8 character bits, optional parity (none, odd or even) and 2 stop bits.
Parity options configurable by preset data for odd, even or no parity.
Automatic insertion of up to 132 null characters as 'padding' at the end of each line, to suit particular printers.

4.4.1.3. Capacity

Buffer for up to 1020 characters in each direction.
Line length up to 132 characters.
Indications when the output buffer has room for one full line or is completely empty.
Buffers empty automatically as data transferred.

4.4.1.4. Setting up a Printer/Keyboard Port

Table 4.2 shows the P-table addresses and the data the user must write to these addresses to enable the port to operate as a Printer/Keyboard Port. Changes to the P-table are implemented on RECOMPILE (no need to power-down).

Table 4.2 - P-Tables for Printer/Keyboard Port

Port 1	Port 2 2	Port 3	Contents
P10	P30	P50	Baud rate (110 to 19,200)
P11	P31	P51	0
P12	P32	P52	0 = Printer mode 1 = Terminal mode 2 = Free format mode
P13	P33	P53	No. of characters per line (1 to 132)
P14	P34	P54	No. of padding characters (1 to 131)
P15	P35	P55	Parity Enable 0 = 8 data bits no parity 1 = 7 data bits plus 1 parity bit 2 = 8 bits plus 1 parity
P16	P36	P56	Parity Select 0 = even parity 1 = odd parity
P17	P37	P57	Not used

4.4.2. Operation of a Printer/Keyboard Port

The Printer/Keyboard Port can operate in either 'Direct Mode', 'Terminal Mode' or in 'Free Format Mode'.

Note...This port will operate in all controller operating states, i.e. halted, running, normal input and test inputs.

4.4.2.1. Direct Mode

This mode is intended for use with a printer and a separate serial input device, such as a matrix keyboard. The port has two cyclic buffers, one for input and one for output. Data can only be written to the output buffer, and read from the input buffer, by means of GEM80 Special Functions. You cannot otherwise access these buffers from your ladder diagram program. All characters received from the keyboard are directly transferred to the input cyclic buffer as they arrive. The only exception is that, if parity is enabled, any character with a parity error is replaced by @FF. Output data is taken from the output cyclic buffer after the previous output has finished. However, transmission does not commence until an ETX (@03) character or an end-of-line marker is found. An end-of-line marker is transmitted as carriage-return (@0D), line-feed (@0A), plus any user defined quantity of NUL (@00) characters. An ETX character is not itself transmitted, but simply initiates output from the cyclic buffer, allowing partial lines to be output.

Note...Many printers do not print any characters until a carriage-return or line-feed is received.

4.4.2.2. Terminal Mode

This mode is specifically intended for interactive operator interfacing using a suitable GEM80 programming tool, such as Gemesys 3, VDU and keyboard

terminal or VDU terminal. It performs the functions of auto-echoing and line editing without the need for user programming.

The terminal is expected to have the following characteristics (ASCII character names are shown in parentheses):

- (1) Pressing the carriage-return key generates @0D (CR).
- (2) Pressing the Delete/Rub out key generates @7F (DEL).
- (3) Receipt of @0D, @0A (CR, LF) moves the cursor to the left-hand edge of the screen on the next line, scrolling the display if on the last line of the screen.
- (4) Receipt of @00 (NUL) performs no action.
- (5) Receipt of @07 (BEL) sounds an audible alarm.
- (6) Receipt of @08 (BS) moves the cursor one character position to the left.
- (7) Receipt of @20 (SP) blanks out the current display position.
- (8) Receipt of @1A (SUB) displays a non-blank character.

As for direct mode, the port has an input cyclic buffer and an output cyclic buffer. Data can be written to the output buffer, and read from the input buffer, by means of GEM80 Special Functions. This is the only way to access these buffers from the GEM80 Ladder Diagram User Program.

However, the input channel has a separate input line buffer in addition to the input cyclic buffer. All received characters are initially stored in the line buffer. They are only transferred to the input cyclic buffer when a @0D (CR) is received and, until this happens, cannot be read by the controller.

As characters are received into the line buffer, they are echoed back to the VDU via the output channel and are displayed on the VDU screen, with the following exceptions:

1. Any non-printing character other than CR, DEL, XON or XOFF is discarded (not loaded into the line buffer) and echoed as BEL.
2. XOFF is discarded, and causes output (including echoing) to be suspended.
3. XON is discarded, and causes output suspended by XOFF to resume.
4. DEL is discarded, and causes the previous character loaded into the line buffer to be removed. It is normally echoed as BS, SP, BS. However, if the line buffer is already empty, BEL is echoed.
5. CR is echoed as CR, LF, plus the user-defined quantity of NUL characters. It is stored in the line buffer as an end-of-line marker (@0A). Once this has been done, the contents of the line buffer are transferred to the input cyclic buffer and the line buffer is then cleared.
6. Any character other than CR which would cause the line buffer to contain as many characters as the user-programmed line length is discarded and echoed as BEL.
7. When parity is enabled, any character received with a parity error is

replaced in the line buffer with @FF and is echoed back to the VDU as SUB. Thus, if the VDU displays an upside-down question mark for SUB (@1A), the operator will be able to back space to any symbol of this type on the line and overkey the character to re-transmit it to the printer/Keyboard Port. However, after the end of the line has been reached, as indicated by CR, any such error cannot subsequently be corrected.

XOFF and XON are generated automatically by some VDUs (e.g. DEC VT101 set up for smooth scroll). They may also usually be generated by keying Ctrl-S and Ctrl-Q respectively.

Output data is taken from the output cyclic buffer after the previous output has finished. However, transmission does not commence until an ETX (@03) character or an end-of-line marker (@0A) is found.

The exception to this is if the program calls for output to commence while the operator is also keying in data on the keyboard. In this case, the output will skip to a new line (by sending CR, LF, and NULs if programmed), then display the output line. Upon completion of the output line, the contents of the line buffer are re-output (preceded by CR-LF plus NULs if the cursor is not already at the left-hand margin), followed by the echo of any characters which were entered during the output.

4.4.2.3. Free Format Mode

This mode is intended to be used with any serial device. This mode is the same as the direct mode except that all data from 00H to FFH can be transmitted and received and no formatting of the data will take place. The transmit data is sent as soon as it is placed in the transmit buffer by the GEM80 Special Functions. The detection of parity errors is reported by setting an error bit in the CHARIN GEM80 Special Function to indicate a parity error.

Using this mode the user should be able to control serial devices using simple serial link protocols by manipulating the received and transmit data in the ladder program.

4.4.3. Operation of Printer/Terminal Buffer Store

The buffers used by Printer/Terminal Ports utilise the memory space which would otherwise have been used for J- and K-tables if the port had been configured as a control or as a tributary port. The blocks of J- and K-table addresses given in Table 4.5 for the particular port must NOT be:

- referenced in the user program;
- used for the value tables of GEM80 Special Functions;
- written to via a suitable GEM80 programming tool, such as Gemesys 3, (although they may be monitored).

To furnish the user program with information regarding the state of the output buffer, two flags called the 'empty flag' and the 'filling flag' are provided. The empty flag is set ON between program scans when the cyclic buffer is empty and all characters have been transmitted. It is set OFF by execution of any GEM 80 Special Function which outputs to that buffer. The filling flag is set ON during execution of any GEM80 Special Function which outputs to the cyclic buffer and leaves it with room for less than one line of output. The quantity depends on the preset line length. It is reset between program scans by the printer driver removing characters from the buffer so that room for one full line is once more available.

A special case of the filling flag being set occurs when a GEM80 Special Function attempts to output more characters than there is space for in the buffer. In this case the output is truncated so as not to overwrite the data already in the buffer; the last character to be placed in the buffer is an exclamation mark (!), and the appropriate fault code is generated by the GEM 80 Special Function. Overflow of the input buffer can occur, resulting in the oldest data being overwritten and lost. See Table 2.5 - E-tables for more information.

4.4.4. Alphanumeric Input

Alphanumeric information can be input to the controller through any of the serial ports using the GEM80 Special Function T39, CHARIN. See the Software Data Sheets for further details.

4.4.5. Alphanumeric Output

Alphanumeric information can be output on any of the serial ports using the GEM80 Special Function S38, PRITEXT. General text and numeric output are provided by the GEM80 Special Function T38, PRINT. See the Software Data Sheets for further details.

4.4.6. Editing Alphanumeric Output Messages

4.4.6.1. Printer Port Messages

The items used by PRINT to generate output are called messages and may contain fixed text and format definitions for numeric output in any combination. The fixed text may also contain end of line markers so that one message can generate several lines of output.

The messages are stored as part of the P-table and may be loaded and dumped with the user program. They are protected from access by GEM80 Special Functions and from being written to by a suitable GEM80 programming tool, such as Gemesys 3, when in data list mode. If an attempt is made to write

to the message area of the P-table the messages will be moved and the extra P-table created filled with zeros.

The quantity of messages that can be stored in a system is restricted only by the memory occupied by data tables and the user program. Remember that data table P2 contains the length of the preset message area in bytes and is therefore limited to the maximum number that can be stored. Each message can contain up to 255 bytes, although this could define considerably more characters for output because a numeric format definition only occupies 2 bytes. The system is provided with an editor to enable the user to enter, examine, update and take a hard copy of the messages available to the user program. The editor is accessed using a suitable GEM80 programming tool, such as Gemesys 3, connected to any tributary port (this includes the front panel port). Where more than one GEM80 programming tool is connected, a similar locking mechanism to that described in the 'Remote Programming' section is implemented. The lock is released when the Exit command is executed.

Messages are entered in a manner which is intended to be similar to the way they will be displayed when used by PRINT. Fixed text is enclosed by quotes ("); format definitions employ a pictorial representation where '^' (caret) is used to represent leading spaces, '0' is used to represent leading zeros and '#' is used to represent significant digits.

End of line markers are entered by typing carriage-return and may be placed inside or outside quotes. A comma is used to separate format definitions from each other and from fixed text.

A format definition specifies how the contents of one data table will be formatted for output. Four quantities need to be specified:

- the field width;
- whether leading zeros are to be output;
- the number of characters after and including the decimal point and
- the scaling as a power of ten.

The first two quantities are limited to a maximum value of 15.

Examples:

"This is a fixed text containing 2 end-of-line markers"

^^^##.#	defines a field width of 7, including 1 decimal place;
^^^#.#	as above but including 2 decimal places;
000#.#	as above but including leading zeros.

With appropriate scaling the second format above could display as '1.23' or '123.45' depending on the value in the data table, i.e. the field width is fixed, not the quantity of leading spaces. The same is true if leading zeros are specified.

4.4.6.2. Using the Editor

After loading a program containing messages, the program must be compiled before using the editor. The editor cannot be entered until this has been done. Whenever the editor is ready to accept input it will output the 'greater than' symbol, '>', known as the prompt. Entry of input is terminated in one of two ways:

- (1) By pressing the ESC key which aborts the current command.
- (2) By pressing the 'less than' symbol, '<', known as the terminator.

The terminator is only recognised when not enclosed by quotes, i.e. not part of the fixed text. An editor command consists of:

- (a) A command identifier which tells the editor what to do.
- (b) An optional command body which supplies additional information to the editor.
- (c) A terminator which signals the editor to start processing the command.

The command identifier may be a single character or the entire command name, e.g. the exit command may be entered as E or EX or EXIT. The exit and help commands do not require a command body. The command identifiers and their actions are as follows:

E

Stands for Exit. Terminates the editing session and causes the programming tool to return to initial selection.

H

Stands for Help. Displays a list of the available commands on the programming tool screen.

D, L

Stand for Display and List respectively. The actions of the commands are very similar. The command body is a list of messages whose contents are to be displayed. The structure of this input is a list of 'output requests' separated by commas. Each output request may contain a single message number or a range represented by two numbers separated by a dash (-). Zero length messages are not displayed. For example the following commands could be used to display messages 1, 2 and 3:

D1,2,3 or
D1-2,3 or
D1,2-3 or
D1-3.

The output of each message is prefixed with the message number and has the terminator appended. One blank line is output before any subsequent display. Output of a list of messages may be aborted by pressing the ESC key. The difference between D and L is that D produces output only on a suitable GEM80 programming tool screen while L produces a listing on the printer attached to the programming tool. A format definition will be displayed as it was entered, except that the leading spaces/zeros and significant digits will be displayed in a

normalised form, with only one significant digit before the decimal point. For example, a format entered as ^###.## will be displayed as ^#.##.

M

Stands for Message and is the command for adding new messages and replacing existing ones. The editor automatically repositions other messages if the size of an existing message is changed. The command body contains the message number to be updated, followed by an equals symbol (=), followed by the new contents. This may consist of fixed text delimited by quotes and format definitions to describe how a data table value will be output. The different fields are separated by commas. A format definition uses '0', '#', and '^' to pictorially describe the layout of the number in terms of character positions before and after the decimal point (if present). The caret (^) is used to signify leading spaces, a zero (0) is used to signify leading zeros and the hash symbol (#) significant digits. If a message contains format definitions, a subsequent prompt is issued to request the user to enter the scaling values to be applied to the data table contents. The scaling is entered as '/' or '*', followed by a number which is a power of ten; the '/' indicates division and the '*' multiplication. Each scaling value may be separated from the others by an optional comma. End-of-line markers may be included in the message by typing carriage-return either within a block of fixed text or between format definitions. In the latter case quotes are not needed but the preceding format definition must end with a comma. Non-printing characters (or characters not available on the keyboard) may be included in fixed text by entering their hexadecimal value preceded by '@' and delimited by a comma, e.g. '@' itself may be entered as '@40,'.

4.4.6.3. Errors

The following error messages are produced by the editor, and the likely cause is given where appropriate:

- | | |
|-------------------------------|--|
| 'Unrecognised command' | - The first letter of the current line was not a command identifier. |
| 'Invalid command line' | - The current command line does not conform to the structure expected by the editor. An arrow indicates the approximate point where the error was detected. The usual cause is a misplaced or missing comma or quote during message entry. |
| 'Message not found' | - The message number supplied to Display or List was beyond the highest message currently stored. |
| 'Insufficient space for item' | - While attempting to create space for a new (or expanded) message, the editor found that there was not enough memory available. The message is not stored and any existing messages are left unchanged. |

4.5. Serial Communication Between Two or More GEM 80 Controllers (ESP Protocol)

When communication is required between two or more GEM80 controllers, the serial port of one of the controllers must be used as a control port and the rest as tributaries. The control port can receive data from and transmit data to all the tributaries, and controls the transmission and reception of data within the system. The tributaries can only receive data from and transmit data to the control port, though data can be transferred between tributaries via the control port. Table 4.3 shows the P-table, J-table, K-table and I-table data to be set to configure a GEM80-400 Controller as an ESP tributary.

Table 4.3 - Configuring an ESP Tributary Port

Port 1	Port 2	Contents
P10	P30	Baud rate (110 to 19,200)
P11	P31	1
P12	P32	0 = Free running 1 = User control
P13	P33	Tributary address (0 to 14)
P14	P34	Number of tables to be transmitted (free running mode only) 0 to 32 for fixed data tables 0 to 128 for flexible data tables
P15 to P29	P35 to P49	Unused
J0 to J511	J512 to J1023	J-table (Data received by the controller)
K0 to K511	K512 to K1023	K-table (Data to be transmitted by the controller)
I0	I40	Flags - SEND FLAG is bit 0 of the words shown on the left (I0, I40) RECEIVE FLAG is bit 8 of the words shown on the left (I0, I40)
I1	I41	Quantity of words received or transmitted - bits 8-15 received length bits 0-7 length to transmit

4.5.1. Operation as an ESP Tributary Port

Data table transfers and I-table examinations only occur between user program scans. For J/K-table exchanges between controllers the user can select either user-control mode or free-running mode. In either mode an indication is provided in F10 bit 0 for Port 1, or F30 bit 0 for Port 2, when a port has not received a valid message for a period of approximately 30 seconds.

4.5.1.1. Free-Running Mode

When free-running mode is selected, the reply to a received message is generated immediately at the end of the program scan, the quantity of locations for the reply being taken from the P-table.

4.5.1.2. User-Control Mode

User-control mode uses data in the I-table to control the generation of a reply. The I-table is set to indicate reception and length of received message. The transmission of the reply is initiated at the end of the program scan in which the I-table bit is set. The length of the message transmitted is taken from the I-table. The following description is for Port 1 but applies equally to Port 2 if the relevant data tables are substituted. When a message is received, the data is placed in J0 onwards (as when free-running). The number of locations written is placed in bits 8 to 15 of I1 (this may be extracted using the GEM80 Special Function SWAP (S4) and masking the result) and bit I0.8 is set ON. The user is thus notified of the arrival of a message. Appropriate action may then be taken and the data for the reply placed in K0 onwards. The length of this data is placed in bits 0 to 7 of I1. When the user has set bit I0.8 OFF and I0.0 ON the reply will be generated. I0.0 will be set OFF to indicate this.

Note...ESP tributary ports will only operate when the controller is in the following states: Running, Normal Inputs; Running, Tests Inputs. They will not operate when the controller is in any other state.

4.5.2. Operation as an ESP Control Port

ESP control ports can be used either with fixed J/K data tables, with message length limited to a maximum of 32 words, or with flexible data tables that allow a maximum message length of 128 words per route (subject to a total J/K table allocation of 512 words on all routes). Table 4.4 shows the P-table addresses and data the user must write into these addresses to enable the port to operate as a control port. When the port is configured as an ESP control port, data is received and transmitted at the data table addresses shown in Table 4.5. I-table information to operate the serial link in the user control mode is shown in Tables 4.6 and 4.7. Recompile to implement any changes to the P-table. Changes to transmission lengths and tributary selections are effective immediately.

Note...ESP control ports will only operate when the controller is in the following states: Running, Normal Inputs; Running, Tests Inputs. They will not operate when the controller is in any other state.

Table 4.4 - Configuring an ESP Control Port

Port 1	Port 2	Contents
P10	P30	Baud rate (110 to 19,200)
P11	P31	2 (ESP Control Port Mode)
P12	P32	0 = Free running 1 = User control
P13	P33	Bits 0 to 7, enable transmission to addresses 0 to 7
P14	P34	Number of tables to be transmitted to address 0
P15	P35	Number of tables to be transmitted to address 1
P16	P36	Number of tables to be transmitted to address 2
P17	P37	Number of tables to be transmitted to address 3
P18	P38	Number of tables to be transmitted to address 4
P19	P39	Number of tables to be transmitted to address 5
P20	P40	Number of tables to be transmitted to address 6
P21	P41	Number of tables to be transmitted to address 7

Table 4.5 - J- and K-Tables for an ESP Control Port

Port 1	Port 2	Function
J/K0 to 31	J/K512 to 543	Tributary address 0
J/K32 to 63	J/K544 to 575	Tributary address 1
J/K64 to 95	J/K576 to 607	Tributary address 2
J/K96 to 127	J/K608 to 639	Tributary address 3
J/K128 to 159	J/K640 to 671	Tributary address 4
J/K160 to 191	J/K672 to 703	Tributary address 5
J/K192 to 223	J/K704 to 735	Tributary address 6
J/K224 to 255	J/K736 to 767	Tributary address 7

Table 4.6 - I-Table for an ESP Control Port

Port 1	Port 2	Contents
10	140	Transmit and receive flags bit 0 - Transmit flag tributary address 0 bit 1 - Transmit flag tributary address 1 bit 2 - Transmit flag tributary address 2 bit 3 - Transmit flag tributary address 3 bit 4 - Transmit flag tributary address 4 bit 5 - Transmit flag tributary address 5 bit 6 - Transmit flag tributary address 6 bit 7 - Transmit flag tributary address 7 bit 8 - Receive flag tributary address 0 bit 9 - Receive flag tributary address 1 bit 10 - Receive flag tributary address 2 bit 11 - Receive flag tributary address 3 bit 12 - Receive flag tributary address 4 bit 13 - Receive flag tributary address 5 bit 14 - Receive flag tributary address 6 bit 15 - Receive flag tributary address 7
11	141	Tributary 0, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
12	142	Tributary 1, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
13	143	Tributary 2, Tx and Rx message length (bits 0 to 7, (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
14	144	Tributary 3, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15, (Rx) = 0 to 32)
15	145	Tributary 4, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
16	146	Tributary 5, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
17	147	Tributary 6, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
18	148	Tributary 7, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 32 bits 8 to 15 (Rx) = 0 to 32)
19 to 139	149 to 179	Unused

Table 4.7 - I-Table for an ESP Control Port Using Flexible Data Tables

Port 1	Port 2	Contents
I0	I40	Transmit and receive flags bit 0 - Transmit flag, Route 0 bit 1 - Transmit flag, Route 1 bit 2 - Transmit flag, Route 2 bit 3 - Transmit flag, Route 3 bit 4 - Transmit flag, Route 4 bit 5 - Transmit flag, Route 5 bit 6 - Transmit flag, Route 6 bit 7 - Transmit flag, Route 7 bit 8 - Receive flag, Route 0 bit 9 - Receive flag, Route 1 bit 10 - Receive flag, Route 2 bit 11 - Receive flag, Route 3 bit 12 - Receive flag, Route 4 bit 13 - Receive flag, Route 5 bit 14 - Receive flag, Route 6 bit 15 - Receive flag, Route 7
I1	I41	Route 0, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I2	I42	Route 1, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I3	I43	Route 2, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I4	I44	Route 3, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I5	I45	Route 4, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I6	I46	Route 5, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I7	I47	Route 6, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I8	I48	Route 7, Tx and Rx message length (bits 0 to 7 (Tx) = 0 to 128 bits 8 to 15 (Rx) = 0 to 128)
I9	I49	Route 0, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I10	I50	Route 1, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I11	I51	Route 2, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)

I12	I52	Route 3, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I13	I53	Route 4, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I14	I54	Route 5, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I15	I55	Route 6, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I16	I56	Route 7, Tx and Rx addresses (bits 0 to 7 (Tx) = 0 to 15 bits 8 to 15 (Rx) = 0 to 14)
I17 to I39	I57 to I79	Unused

4.5.2.1. Configuring Ports 1 and 2 as an ESP Control Port

Table 4.4 shows the P-table data to be set to configure a GEM80-400 Controller as an ESP control port and Table 4.8 shows the P-table data for an ESP control port using flexible data tables.

Table 4.8 - Configuring an ESP Control Port Using Flexible Data Tables

Port 1	Port 2	Contents
P10	P30	Baud rate (110 to 19,200)
P11	P31	3 = Flexible ESP Control Port Mode
P12	P32	0 = Free running Mode 1 = User control Mode
P13	P33	bits 0 to 7 enable transmission to addresses 0 to 7, bits 8 to 15 unused
P14	P34	Number of tables to transmit/assigned - route 0 (Maximum Value 128)
P15	P35	Number of tables to transmit/assigned - route 1(Maximum Value 128)
P16	P36	Number of tables to transmit/assigned - route 2(Maximum Value 128)
P17	P37	Number of tables to transmit/assigned - route 3(Maximum Value 128)
P18	P38	Number of tables to transmit/assigned - route 4(Maximum Value 128)
P19	P39	Number of tables to transmit/assigned - route 5(Maximum Value 128)
P20	P40	Number of tables to transmit/assigned - route 6(Maximum Value 128)
P21	P41	Number of tables to transmit/assigned - route 7(Maximum Value 128)
P22 to P29	P42 to P49	Unused

NB The maximum total number of tables to be shared between all the tributaries is 256.

4.5.3. J- and K-Tables for an ESP Control Port with Flexible Data Tables

When an ESP control port is configured for flexible data tables, $P11/31 = 3$, the tables are assigned dynamically according to the two-byte values set in P14 to P21/P34 to P41. The number of tables assigned to a route is the greater of high and low byte set in each P-table (P14 to P21/P34 to P41). Each route is assigned consecutively, e.g.:

P-table	Bits 8 to 15 (J - tables)	Bits 0 to 7 (K-tables)	J/K-tables assigned.
P14 = 0020	0	32 ₁₀	assigns the first 32 tables to J0 to J31 and K0 to K31
P15 = 3420	52 ₁₀	32 ₁₀	assigns the next 52 tables to J32 to J83 and K32 to K83
P16 = 1002	16 ₁₀	2 ₁₀	assigns the next 16 tables to J84 to J99 and K84 to K99
P17 = 0048	0	72 ₁₀	assigns the next 72 tables to J100 to J171 and K100 to K171

4.5.4. Operation as a Control Port

Data table transfers occur only between user program scans, and the I-table is also only examined between scans in the user-control mode. If a message is received that is longer than the space allocated, the message is truncated and a fault flag is set; see Chapter 9 for further information. The control port can be operated in the free-running mode or the user-control mode and the user can select either of these options.

4.5.4.1. Free-Running Mode

When free-running mode is selected the controller cycles round the routes indicated in the preset data to be in use and attempts a J/K exchange, transmitting the quantity of locations requested in the P-table. If a valid reply is not received after the system of retries has been exhausted, the route is classified as failed and the corresponding bit in F10/F30 is set ON. In the event of a tributary failing to communicate, the errors are not clocked up on a cyclic basis but only after 8 complete scans of the remaining active tributaries, i.e. the scan rate is one-eighth of its original rate. If a failed route recommences communication, the F-table bit is set OFF and the route is no longer classified as failed.

4.5.4.2. User-Control Mode

User-control mode allows the user to vary the length of transmissions and to dynamically select the next route for transmission. If flexible data tables are used (P11/P31 = 3), the user may also select the tributary address for that route dynamically. To initiate a message transfer on a route, proceed as follows:

- (a) Set the Tx message length in the I-table
- (b) If P11/P31 = 3 (flexible data tables), set the Tx address in the I-tables.
- (c) Set the transmit data in the appropriate K-tables.
- (d) Set the transmit flag for the route in the I-table - the message will be

transmitted immediately

- (e) The reply message, if received, is placed in the J-tables and the length, if using flexible data tables, is placed in the appropriate I-tables. The receive flag is then set to inform the user program of the arrival of the reply message and the link statistics are updated to show that the transfer was successful. If a reply is not received (after three retries), a fault is flagged in the Fault Table (F10/F30) and the link statistics are updated to show that the transfer was not successful, and the type of error.

Note...The Receive flag for a route must be cleared by the user before another message can be sent down that route.

4.5.4.3. Extended Time-out Option

When a GEM80 control port outputs a message, it waits a period of time (which varies with the signalling rate) before assuming that the tributary is not going to respond. When communicating with a tributary port configured in user-control mode, the GEM80-400 control port provides the option of increasing the standard time-out values. This is achieved by setting the signalling rate to the negative of that required, e.g. to select extended time-outs on port 1 at a signalling rate of 9,600 bits/s, P10 should be set to -9,600. Table 4.9 shows the relationship between the signalling rate and the time-out period.

Table 4.9 - Time-out Periods

SPEED Bits/s	MAXIMUM TIME (seconds)					
	MESSAGE LENGTH (words)					
	0 - 32		33 - 64		65 - 128	
	Standard	Extended	Standard	Extended	Standard	Extended
19200	0.5	1.00	1.00	2.00	2.00	4.00
9600	0.75	1.5	1.5	3.00	3.00	6.00
4800	1.00	2.00	2.00	4.00	4.00	8.00
2400	1.25	2.5	2.5	5.00	5.00	10.00
1200	1.75	3.5	3.5	7.00	7.00	14.00
600	2.75	5.5	5.5	11.00	11.00	22.00
300	5.00	10.00	10.00	20.00	20.00	40.00
110	13.75	27.5	27.5	55.00	55.00	110.00

4.5.4.4. Broadcast Message Facility

The Broadcast Message Facility is available only in user-control mode when using flexible data tables. It allows a message to be sent to all tributaries at the same time. No replies are returned by the tributaries and there are no retries or acknowledgements. To initiate a broadcast message on a route proceed as follows:

- (a) Set the Tx message length in the I-tables.

- (b) Set the Tx address in the I-tables to 15.
- (c) Set the transmit data in the appropriate K-tables.
- (d) Set the transmit flag for the route in the I-table.
- (e) When the message has been transmitted, the transmit flag is automatically cleared.

Notes...

- (1) The tributaries do not reply to a broadcast message.
- (2) Tributaries which are in use in user-control mode must not attempt to reply to a broadcast message.
- (3) When a broadcast message is initiated, the fault flags are NOT updated.

4.6. GEMSTART CCU (Contactor Control Unit)

4.6.1. Introduction

GEMSTART CCU (Contactor Control Unit) provides the necessary control and protection facilities required for Low Voltage Motor Starter applications. Within the GEM80-400 Controller, the GEMSTART CCU option is selected by the P-table configuration shown in Table 4.10. The facility allows direct control of GEMSTART CCUs by a GEM80-400 Controller through the RS485 serial link ports. Using a suitable GEM80 programming tool, such as Gemesys 3, the user can view and edit the GEMSTART CCU data tables by way of the Printer/Programming port on the processor module of the host GEM80-400 Controller.

Note...A GEMSTART CCU port will operate only when the controller is in the Running, Normal Inputs state. It will not operate in Running, Test Inputs, Shutdown or 'halted' states.

Table 4.10 - Configuration as a GEMSTART CCU (Contactor Control Unit) Port

Port 1	Port 2	Contents
P10	P30	Baud rate (300 to 9,600)
P11	P31	6 (selects GEMSTART mode), 8 (selects Enhanced GEMSTART CCU mode)
P12	P32	0 (selects free running mode)
P13	P33	Lowest CCU address (0 to 99)
P14	P34	Highest CCU address (0 to 99)
P15	P35	Table letter for configuration data (any valid table letter)
P16	P36	Table index for configuration data (any valid table number)
P17	P37	Configuration flag
P18 to P29	P38 to P49	Not used

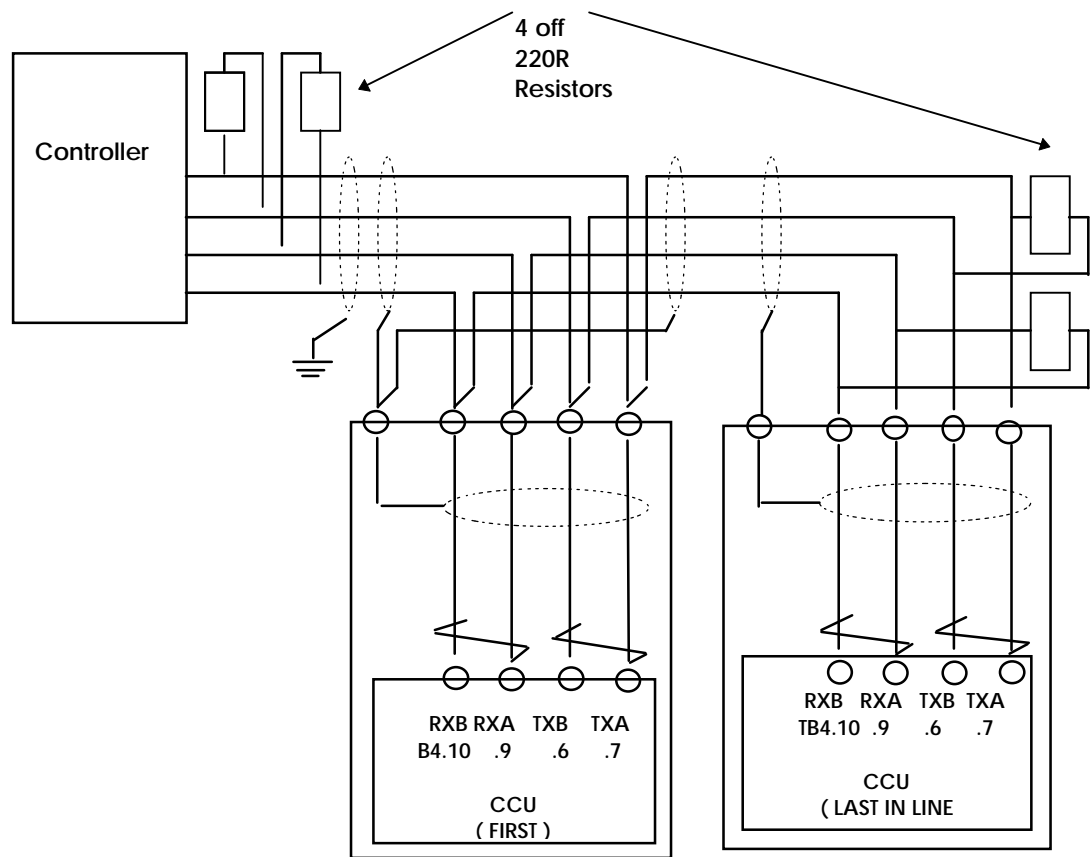


Figure 4.9 - GEM 80-400 Controller to GEMSTART CCU Interface

4.6.2. P-Tables

Table 4.10 shows the configuration data which must be entered into the P-table if the GEM 80 serial links are to operate in the GEMSTART CCU mode. Table 4.11 illustrates the value of the P-table entry which determines the various operating modes of serial ports Port 1 and Port 2.

Note...P10 to P17 take effect only on RECOMPILE (no need to power down). P17, which determines the configuration to use if there is a configuration conflict can be changed with a suitable GEM 80 programming tool, such as Gemesys 3, and takes immediate effect.

Table 4.11 - Determining Operating Mode of a Serial Port

Port	Data Table Address	Content	Mode
1	P11	0	PRINTER
		1	TRIBUTARY
		2	CONTROL
		3	CONTROL (Flexible J/K table allocation)
		6	GEMSTART CCU
		8	ENHANCED GEMSTART CCU

2	P31	0	PRINTER
		1	TRIBUTARY
		2	CONTROL
		3	CONTROL (Flexible J/K table allocation)
		6	GEMSTART CCU
		8	ENHANCED GEMSTART CCU
3	P51	0	PRINTER

4.6.3. J/K-Tables

These tables hold the data to be sent and the data that is received from the GEMSTART CCU. Four locations in each table are reserved for each GEMSTART CCU. The interpretation of the data contained in these tables is detailed in the 'GEMSTART CCU Technical Manual', Publication No.78234.

4.6.4. I-Tables

This table is used to control serial link exchanges. I0.0 for Link 1 or I40.0 for Link 2 are used as SEND flags when the GEM80 sends new configuration data to the GEMSTART CCU. The user sets up the new configuration data in the user tables and places the address of the affected GEMSTART CCU in I1. On setting I0.0, the new configuration is continually transmitted to the GEMSTART CCU until the addressed unit acknowledges the data. The I0.0 flag is then cleared automatically.

4.6.5. User Specified Tables

The user can specify, using P15 and P16 or P35 and P36, which table is used to contain the configuration data for the GEMSTART CCUs. The user specified tables must be allocated in contiguous locations with 5 words per GEMSTART CCU plus 5 words to hold the Processor control information when P11 =6 (GEMSTART CCU Mode) or 10 words per CCU and 10 words to hold the Processor control information if P11=8 (ENHANCED GEMSTART CCU Mode). The allocated tables are then split, the first 5 or 10 tables for CONTROL data (non user changeable), the rest of the tables containing CONFIGURATION DATA (user changeable). The configuration tables are used in order of GEMSTART CCU address starting at the address in P13 (or P33), and ending at the address in P14 (or P34). The control information should not be changed, otherwise the configuration is lost. During re-compilation only the configuration data used before re-compiling is considered valid. Therefore, any new GEMSTART CCU included in the scan will have its configuration data set to zero. The GEM80 configuration data will be updated by the GEMSTART CCU once communications are established. If the control information in the user tables is altered, all the GEMSTART CCUs on the scan will have the GEM80 controller's copy of the configuration data set to zero. Again this will be updated by the GEMSTART CCUs during the first few scans. To program the GEMSTART CCU from the GEM80, the configuration data is placed in the user selectable tables at the appropriate address.

For example: If P11=6, P15 =61= ASCII 'R' and P16 = 5, the configuration information starts at R5. R5 to R9 contain the control data (non-user changeable) R10 contains the start of the configuration data for GEMSTART CCU 0, R15 for GEMSTART CCU 1, etc. If P11=8 then R5 to R14 contains the control data and R15 contains the start of the configuration data .

See the 'GEMSTART CCU Technical Manual', Publication No.78234 for details of the values to place in these tables. Once the desired values have been placed in the tables, the I-table can be used to re-configure the GEMSTART CCU by placing the GEMSTART CCU address in I1 (I10/I41 for Link 2) and setting I0 to 1 (I9/I40 for Link 2). After the message has been sent and acknowledged by the GEMSTART CCU, I0 will be cleared to 0.

4.6.6. F-Tables

These tables are used for diagnostics and error counting. Refer to Chapter 9 of this manual for further details.

4.7. Remote Programming

Remote programming and monitoring facilities are available on all ports. These facilities are available when the controller port is configured as an ESP tributary. The controller automatically recognises the programming messages without any additional switching. A suitable GEM80 programming tool, such as Gemesys 3, must be used, since it has a selectable signalling rate and the slow signalling rate necessary for long distance serial links can be set up.

When remote programming is being undertaken the system prevents more than one programming channel from altering the program simultaneously, by activating a locking mechanism. The lock is released by issuing a Run or Re-compile command. Should a user neglect to issue such a command, the system will release the locking mechanism after a period of five minutes in which no access to the locked item has been made. If the user program lock has been activated by a user on another port, any attempt to access the user program will result in a LINK REJECTED message being displayed on the GEM80 programming tool of the user who is locked out. If the message editor lock has been activated, the editor option is removed from the initial menu. See also sections 'On-line Program Changes' and 'Programming Tools', in Chapter 2.

Note...Remote programming cannot be achieved if the key switch is in the Normal position.

4.8. Termination of Serial Links

For successful communication when using RS485 communication links, it is important that the serial link cable is correctly terminated. This is achieved by fitting a 220 Ω , 0.25W resistor across each pair of Rx and Tx wires.

Note...The termination resistors should be placed at each end of the link.

4.9. Maximum Length of Serial Links

The maximum length of cable associated with RS485 and RS232 is 3Km and approximately 15m, respectively. A discussion of this topic is available in Serial Links Technical Publications such as the 'Serial Communications Manual', Publication No.T457.

4.10. Cable Connection Details

4.10.1. Cable

RS485: For a 4-wire serial link, use two twisted pairs with an overall screen having a maximum capacitance of 180nF/km and a maximum resistance of 40 Ω /km.

A recommended cable type is: BELDON 9729

4.10.2. Connectors

Ports 1 and 2: 9-way 'D'-type connector.
Port 3: 15-way 'D'-type connector.

4.10.3. Segregation

Ensure that 600mm (2 feet) exists between the serial link cabling and electrically 'dirty' wiring. Chapter 7 of this manual provides further information on this topic.

4.11. STARNET

4.11.1. Introduction

The GEM80 STARNET Module fits into the Central Highway of the GEM 80-400 Enhanced Controller to provide four additional serial links, with each link being an independent communication facility configurable by software.

Two STARNET Modules can be fitted to each controller as standard and up to 5 may be fitted if required. This gives a total of 8 or 20 serial links, with each link being an independent communication facility configurable by software. Each port can be configured to provide a range of data rates up to 180k bits/s and a

choice of two protocols, HDLC (High Level Data Link Control) or ESP (Extended Simple Protocol). For full details of the STARNET Module, including more information on operation, software and connections, see the 'STARNET User Information Sheet', Publication No.T464, and refer also to Chapter 5 of this manual.

4.12. FIP Networks

The GEM80-400 Controller is able to support FIP communications. For further details consult the FIP Communications Manual (T1653)

5. Central Highway Modules

5.1. Introduction

The GEM80-400S and GEM80-400 Enhanced Controller subracks provide 5 slots which may be fitted with Central Highway Modules.

The following tables list the Central Highway Modules which may be fitted into the controller subrack together with the number of subrack slots they require. The tables also list the maximum number of a particular module type that the default Enhanced Controller configuration caters for.

Central Highway Processor Modules	Ordering Code	No. of Central Highway Slots Required	Max. No. Permitted in Subrack by Factory Default Configuration
STARNET	8268-410x	1	2
IMAGEM Processor	8284-400x	1	2
GEMLAN-D	8279-400x	2	2

Central Highway RAM Modules	Ordering Code	No. of Central Highway Slots Required	Max. No. Permitted in Subrack
256K RAM (without arbiter)	8272-4004	1	5

Fast I/O Equipment	Ordering Code	No. of Central Highway Slots Required	Max. No. Permitted in Subrack
FAST I/O Driver Module	8300-4003	1	1

Table 5.3 - Central Highway Modules

Note.... The Fast I/O Driver does not take up one of the five Central Highway slots in the GEM80-400S Controller. It has its own separate dedicated slot in the fast I/O area.

The way in which these modules are used by the system is dictated by the slot into which they are installed.

Most system requirements can be satisfied by using the default configuration, as explained below; those that cannot, but will physically fit into the 5 slots, can be catered for by contract specific configuration wiring. Please contact Customer Support for further details.

Figure 5.1 defines how a system, with the default configuration, would use modules.

After selecting the Central Highway Module layout needed to satisfy the system requirements, we strongly recommend that, as part of the system installation

procedure, the layout is recorded in the space provided on the lower subrack label. This may be done by sliding off the protective cover strip, writing the full ordering code (e.g. 8284-4001) of each module onto the label, and then replacing the cover strip.

The user may, as an option, mechanically code each Central Highway slot to prevent a module, other than the one intended for the slot, being installed. This coding is implemented by inserting mechanical coding pegs into the mechanical coding strip, situated on the backplane, at the side of each slot's connector. A peg should be inserted wherever the module, intended for that slot, has a tab broken off its coding strip. Coding pegs are not supplied as standard but may be obtained by contacting Customer Support.

Modules must not be inserted or removed from the controller sub-rack while power is applied.

5.2. Central Highway Processor Modules

The factory default controller subrack supplies each slot occupied by a Central Highway Processor Module with a "Unit ID" the value of which is indicated by Figure 5.1.

This Unit ID is used by the system to differentiate between modules of the same type, i.e. to distinguish between IMAGEM 0 and IMAGEM 1, STARNET 0 and STARNET 1, etc.

Two modules of the same type must, therefore, be fitted to slots that supply different unit IDs.

Double width modules take their Unit ID from the leftmost of the two slots that they occupy.

The first or only IMAGEM Module must be fitted in a slot that supplies a Unit ID of 0.

Certain modules contain an integral switch to select their Unit ID. If modules of this type are used, the switch must be set to the default position to allow the module to use the Unit ID supplied by the slot.

5.3. Central Highway Ram Modules

The factory default configuration allows a RAM Module to provide the system with either Off-line or IMAGEM memory.

5.3.1. Off-line Memory

Off-line memory is used by the system to store large quantities of data. The user refers to this memory by using a "Block Number". Block numbers are allocated to 64K blocks of physical memory, during a search for Off-line RAM, performed by the controller at power up.

As the Central Highway space is searched from left to right (viewed from the front of the controller subrack), the first 64K block of RAM configured as Off-line memory, on the leftmost RAM Module, will become Block Number 0, the next block, Block Number 1, etc.

As a consequence of this technique, the block number of a physical block of Off-line memory will change if the number of detected Off-line blocks to the left of it changes. The user program could check for this potential problem if each block had its block number written to itself during the commissioning of the system.

The user program could also use the "OFF-LINE fitted" V-table, V63, to determine how many Off-line RAM blocks were detected at power up, and compare this with the number that ought to be present.

The default configuration will allow a maximum of ten 64K blocks of Off-line memory. The number of blocks and the size of each block is determined by the values contained in the Off-line set up tables P100 to P115. See chapter 2 for details.

5.3.2. IMAGEM Memory

A RAM Module may be used to supply the system with IMAGEM memory additional to the 64K supplied by the GEM80-400 Processor Module.

This memory is used by IMAGEM Modules installed in the rack to store format, function and character definitions. The IMAGEM Modules check the memory at power up and will provide a warning (a purple screen) if the amount or the validity of the memory has changed.

We strongly recommend that IMAGEM formats, functions, etc. are archived before any changes are made to the physical memory, and that the IMAGEM store is then cleared and reloaded.

5.4. Fast I/O Equipment

5.4.1. GEM80-400S Controller

The GEM80/400S controller has a five slot Fast I/O Highway fitted to the left hand end of the controller subrack. The right most slot is taken up by the fast I/O driver leaving four slots for fast I/O modules. No central highway slot is required to accommodate Fast I/O in this controller configuration.

5.4.2. GEM80-400 Enhanced Controller

The only Fast I/O Module that can be installed within the GEM80-400 Enhanced Controller subrack is the Fast I/O Driver Module. Other Fast I/O Modules may be installed into a separate Fast I/O subrack.

Central Highway Slot 1 is the only slot that can be configured to use a Fast I/O Driver Module. Slot 1 may be configured for a Fast I/O Driver Module by moving

a multi-coder link from its default Central Highway site to its Fast I/O site. These multi-coder link sites are situated on the upper backplane, slightly to the left of the GEM80-400 Processor Module and are labelled "Fast I/O" and "SLOT1". Multi-coder links should always be fitted so that the red stripe is closest to the top of the subrack.

The system, and module, may be damaged if a Fast I/O Driver Module is fitted to any slot configured to accept a Central Highway Module, other than a Fast I/O Driver Module, and visa versa.

The Fast I/O Driver communicates with the Fast I/O subrack using a 50-way ribbon connector situated behind Slot 1 on the rear of the upper backplane. The upper backplane connector for Slot 1 provides wire wrap pins which may be used in the same way as the GEM80/300 Fast I/O Driver backplane.

When intelligent Fast I/O modules are fitted a simple heart beat should be used between the modules and the host processor to detect module failure as status linking is not supported by GEM80-400 systems.

5.5. Summary

1. The default configuration of a GEM80-400 Enhanced system is given by Figure 5.1
2. Configurations that will physically fit in 5 slots, and cannot be satisfied by the default configuration, can be catered for by contract specific configuration wiring.
3. A Fast I/O Driver Module may only be fitted to Central Highway Slot 1 of a GEM80-400 Enhanced Controller , and only after the slot has been correctly configured.
4. All Central Highway Processor Modules of the same type must have different Unit Ids..
5. A double width module takes its Unit ID from the leftmost of the two slots it occupies.
6. The first or only IMAGEM Module must be fitted in a slot with a Unit ID of 0.
7. Any on-board Unit ID switches must be set to their default position.

5.6. General Principles of Assigning Modules to Slots

1. Firstly, assign slots to any modules that must be fitted to a particular slot. This may be because only one slot will provide the functionality required, or that the required configuration needs to use all of one type of functionality.
2. Assign any modules that can only be used in one position as a result of 1 above.

3. Repeat 1 and 2 until there is a choice.
4. Assign any double width modules to two adjacent slots, attempting to cover up any unwanted functionality.
5. Assign single width modules to cover up unwanted functionality.
6. Redo steps 3 and 4 to obtain the most logical layout.
7. Record the chosen layout in the space provided on the lower rail label.
8. If required, code the slots, using the optional coding pegs, to match the module specified.

Note...If two double width modules of the same type are required, they must be fitted to Slots 1/2 and Slots 4/5. The Slot 3 may then be used for an IMAGEM Module, or a RAM Module to provide Off-line Memory.

Example

Suppose that a system requires:

1 GEMLAN-D Module,
2 IMAGEM Modules,
and some Off-line RAM.

Modules required:

1 off	8279-400x	GEMLAN-D	2 SLOT 1 < Maximum permitted
2 off	8284-400x	IMAGEM	2 SLOT 2 = Maximum permitted
1 off	8272-4004	256K-RAM	1 SLOT 1 < Maximum permitted

- (1) A GEM80-400 Enhanced Controller is required as Central Highway Modules are being used.
- (2) The modules require 5 slots (they will fit into the subrack).
- (3) The default configuration should be able to be used as the numbers of each type of module required do not exceed the default configuration maximums.

Referring to Figure 5.1:

The First IMAGEM could be fitted to slots	1	2	3	4	5
The Second IMAGEM could be fitted to slots:	1	2	3	4	5
The RAM Module could be fitted to slots:	1	2	3	4	5
The GEMLAN-D could be fitted to slots:	1	2	3	4	5

Possible configurations are:	1	2	3	4	5
	G0	G0	R0	I1	I0
	R01	G1	G1	I1	I0
	R01	I1	G0	G0	I0
	I0	I1	R0	G1	G1

Where:

G0	=	GEMLAN-D accessed as GEMLAN-D 0
G1	=	GEMLAN-D accessed as GEMLAN-D 1
I0	=	IMAGEM 0
I1	=	IMAGEM 1
R0	=	RAM Module used for OFF-LINE memory
R01	=	RAM Module split between OFF-LINE and IMAGEM memory

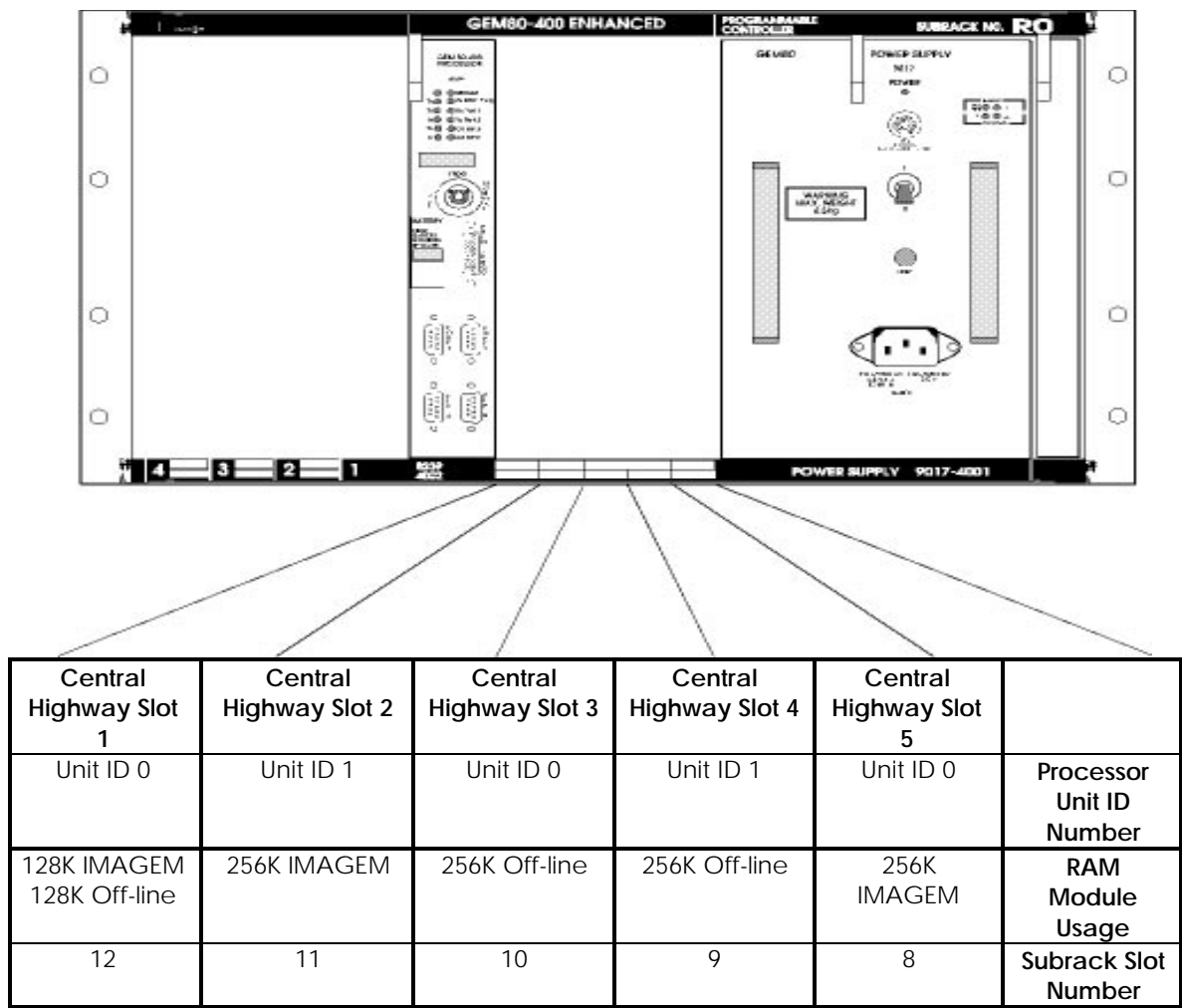


Figure 5.1 - Default Configuration of a GEM 80-400 Enhanced Controller

Note...The Central Highway Modules contain ESDs, the 'Handling Precautions for Printed Circuit Boards' of Chapter 1 must be observed.

5.7. IMAGEM

5.7.1. Introduction to IMAGEM

The IMAGEM Processor Module is a single width video output processor module. The IMAGEM Video System accesses the controller's data tables for display data and for control information. The display is specified by user-defined formats which contain textual, numeric, presentation and control information.

Up to four formats can be displayed at any one time on each IMAGEM Video System. The formats themselves are stored in a battery-supported memory on the Central Highway, and are common to all IMAGEM Video Systems in that subrack. The system is designed to be self-contained, and needs no support other than a suitable GEM80 programming tool, such as Gemesys 3, and a suitable monitor. Full details for programming and using the IMAGEM Video System are given in the 'IMAGEM Programming Manual', Publication No. T390.

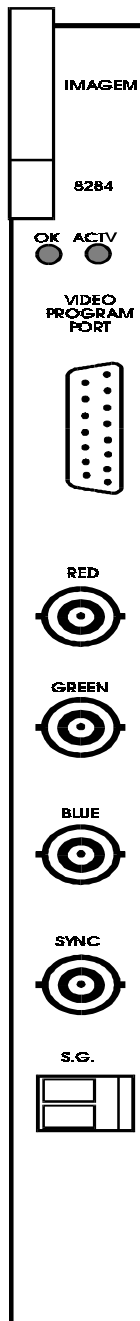


Figure 5.2 - IMAGEM Module

Note...The Signal Ground (S.G.) must be connected to a clean ground to provide a suitable ground connection for the front end circuit.

5.7.2. L-Data Table

The display is controlled by the content of the L-table (see Table 5.1) and the controller writes data to the L-table to select the required display. The video processor outputs one picture at a time and each picture can be divided into four formats. When displaying more than one format on the screen at the same time, they may overlap. When this occurs a format called by a higher L-table number will overwrite any format called by a lower L-table number where it overlaps.

Details that are outside the screen area can be included when programming the definition of a format. By using a WINDOW command, any particular rectangular area that has been defined can be selected to appear on the monitor screen. If the formats being displayed at any particular time do not fill the complete area of the screen, the unfilled area continues to display whatever was previously called up. This could, when first using the system, be part of the IMAGEM default format.

Formats are defined using the IMAGEM Display Language, which uses easily remembered English keywords. Apart from instructions affecting the presentation (e.g. sizes and colours), each format will normally consist of text (including both letters and numbers) and graphic constructions.

Table 5.1 - L-Table

Location	Function
L0 to L3	IMAGEM 0 display formats, L0 = format 1, L1 = format 2, L2 = Format 3, L3 = format 4
L4 to L7	IMAGEM 1 display formats, L4 = format 1, L5 = format 2, L6 = format 3, L7 = format 4
L8 to L11	IMAGEM 2 display formats, L8 = format 1, L9 = format 2, L10 = format 3, L11 = format 4
L12 to L15	IMAGEM 3 display formats, L12 = format 1, L13 = format 2, L14 = format 3, L15 = format 4
L16	Screen update counter for IMAGEM 0
L17	Write status information for IMAGEM 0
L20	Screen update counter for IMAGEM 1
L21	Write status information for IMAGEM 1
L24	Screen update counter for IMAGEM 2
L25	Write status information for IMAGEM 2
L28	Screen update counter for IMAGEM 3
L29	Write status information for IMAGEM 3
Remainder of L-table	Used to transfer data from IMAGEM to processor

5.7.3. Connecting Video Monitors

Figure 5.2 shows an IMAGEM Processor Module. The front panel shown has four outputs, three outputs to drive a colour monitor (RGB) and a composite sync. output which must be used to ensure correct synchronisation of colour monitors

or colour printers. When 'daisy-chaining' monitors, make sure that the 75Ω/high impedance input switches on each monitor are correctly set. Set the last monitor switches to 75Ω and all previous monitors in the chain to high impedance. Also illustrated, on the front panel, is the Video Program Port to which a suitable GEM80 programming tool, such as Gemesys 3, may be connected.

Further details are available in the relevant IMAGEM Technical Publications.

Also included in T493 are details of recommended coaxial-axial cables and connectors.

If a monochrome monitor is to be connected, the IMAGEM program must be written to display various shades of the chosen colour (either RED, GREEN or BLUE). The monitor is then connected to the relevant connector on the termination panel and to the composite sync. output. Figure 5.3 illustrates the IMAGEM connections to be made on the upper backplane of the Enhanced Controller subrack.

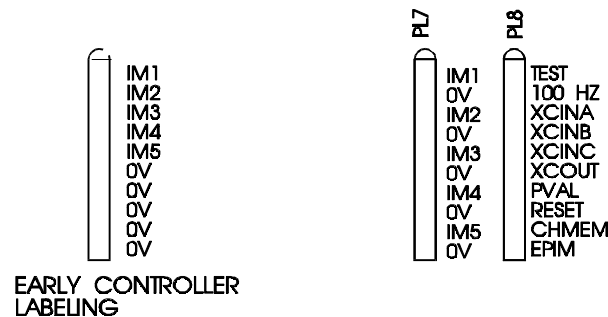


Figure 5.3 - IMAGEM Connections on the Enhanced Controller Subrack Upper Backplane

5.8. IMAGEM CRT Monitor Frequency Selection

The 8284-400x IMAGEM Processor Module has been improved and now produces the higher frequency video signals that are used by readily available, high quality, video monitors. However the 8284 may be configured to use the same monitors as the 8219 IMAGEM Module by placing a jumper or wire-link between the pair of wire wrap posts associated with the slot or slots containing the 8284-400xs. These wire wrap posts are accessible once the power supply module has been removed. See figure 5.3 above. To configure the slot to be compatible with the older style monitors connect a wire link between IM1 and 0V if the 8284 module is in slot 1. IM2-IM5 correspond to slots 2 to 5

5.9. IMAGEM Compatibility

GEM80-400 Enhanced Controllers accommodate the IMAGEM graphic video only and NOT character-based video systems.

Further details of IMAGEM programming, suitable monitors and power supply modules, and other information on the video is available in either the Product Data Sheets or the 'IMAGEM Programming Manual' Publication No. T390.

5.10. STARNET

5.10.1. Introduction

GEM80 STARNET Modules provide the GEM80-400 Enhanced Controller with a fast and flexible communications facility for running a master/slave protocol. Figure 5.4 illustrates a STARNET Module.

Each STARNET Module fits into the Central Highway of a GEM80-400 Enhanced Controller to provide up to four independent serial communications ports. Individual links can be point-to-point or multi-drop, but must include only one primary (or master) together with its associated secondaries (slaves). The primary device controls all activity on the link, allowing the secondaries to communicate only when given permission.

The STARNET Module, which may be fitted in a GEM80-400 system, is a single width module providing four communication ports. Two STARNET Modules can be fitted as standard, and up to five may be fitted if required.

Each STARNET Module is software configurable to provide a range of data rates up to 180k bits per second and a choice of two transmission protocols. High Level Data Link Control (HDLC) or Extended Simple Protocol (ESP).

The STARNET system offers two methods of data transfer control. Data Table Exchange, where dedicated data tables are used as transmit and receive storage, and the GEM80 Special Function option where data can be transmitted from and received into any pre-specified write enabled data locations. For further details, refer to Chapter 4 of this manual, and the relevant STARNET Technical Publications (T464).

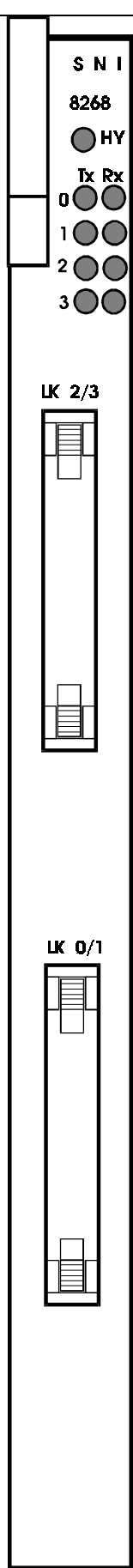


Figure 5.4 - STARNET Module

5.10.2. Power Supplies

The STARNET Module plugs directly into the GEM80-400 Enhanced Controller Central Highway and draws power from the GEM80 controller power module. External power supply connections are not necessary. Each module draws approximately 1.7A at +5V from the GEM80 controller power module.

For further information, see the 'STARNET User Information Sheet', Publication No. T464.

5.11. GEMLAN-D

5.11.1. Introduction

The GEMLAN-D Module provides a fully integrated DECnet interface for GEM 80 systems, enabling plant data and instructions to be transmitted at high speed between GEM80 controllers and DECnet devices via an ETHERNET Local Area Network (LAN). Figure 5.5 illustrates a GEMLAN-D Module.

Network communications between GEM80 controllers allows data to be read from or written to data tables or off-line storage. A networked DECnet device executing user application software can run or halt the GEM80 controller, download or upload GEM80 programs, or read data from and write data to GEM80 data tables or off-line storage.

The user interface to GEMLAN-D is provided by five additional GEM 80 Special Functions in the GEM80-400 Enhanced Controller. These GEM80 Special Functions give the user the ability to transfer data tables and off-line storage contents to and from a remote controller or DECnet device executing the appropriate software.

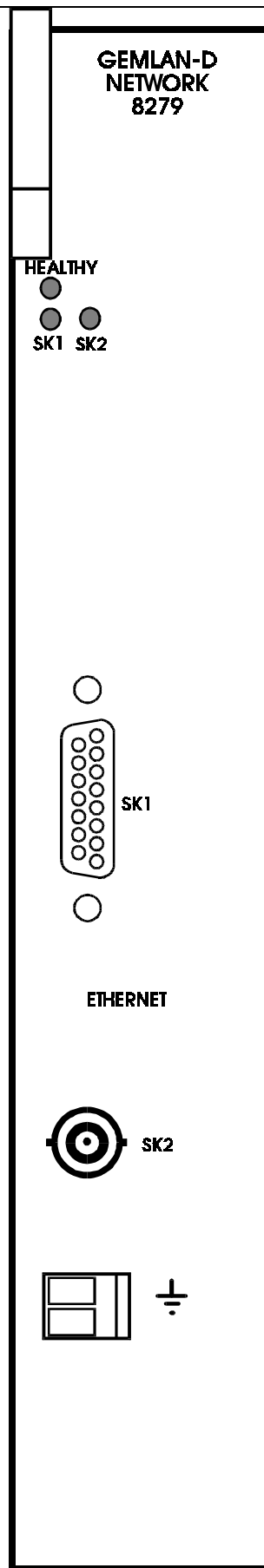


Figure 5.5 - GEMLAN-D Module

5.11.2. Hardware

The GEMLAN-D Module is a double width module that fits into a GEM80-400 Enhanced Controller subrack. Network connections to the module are made via the connectors on the front panel. GEM80 system connection is made via connectors at the rear of the module. The front panel of the GEMLAN-D Module provides connection points for ISO 8802-3 10base5 (ThickWire) and 10base2 (ThinWire) networks.

5.11.3. Installation

The GEMLAN-D Module connects to the Central Highway of the GEM80-400 Enhanced Controller. The backplane of the controller may be mechanically coded so that it can locate only certain modules in specific Central Highway slots; this function is not performed by the factory but must, if required, be carried out by the user. For more information regarding mechanically coding, please contact Customer Support, Cegelec Industrial Controls Ltd.

5.11.4. Operation

Note...It must be noted that, unlike most other GEM80 equipment, the operating temperature of GEMLAN-D is 0 to 50°C, and not 0 to 60°C. Therefore, a GEM80-400 Enhanced system incorporating GEMLAN-D must be operated within the temperature range 0 to 50°C.

The function of the GEMLAN-D Module is to allow GEM80 systems and DECnet devices to communicate on a DECnet network.

The GEM80 user interface to GEMLAN-D consists of five GEM80 Special Functions:

- LOPEN
- LCLOSE
- LREAD
- LWRITE
- LSTATUS

These GEM80 Special Functions are used to open and close channels between a client and server, read data from a remote machine on the network, write data to a remote machine on the network and to query the current state of a specific local channel. GEMLAN-D also provides an interface that allows a DECnet device user access to GEM80 control/programming capabilities.

5.11.5. Connections

The attachment of a GEMLAN-D Module to an ETHERNET network requires some user supplied equipment and cables. Any necessary items should be obtained from third party vendors specialising in ETHERNET equipment.

For further details and information regarding the GEMLAN-D Module, refer the 'GEMLAN-D Module Technical Manual', Publication No. T1603.

5.12. Fast I/O

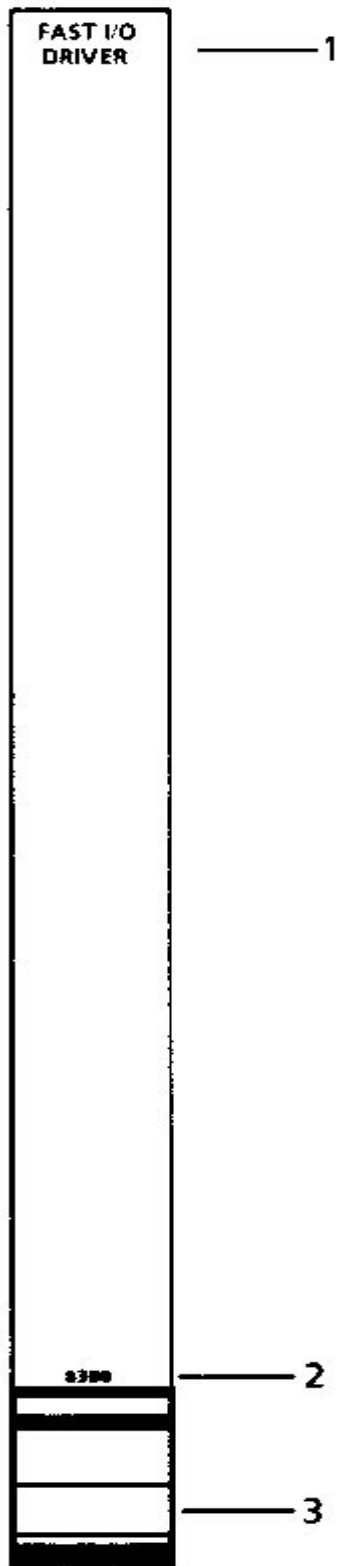
5.12.1. Introduction

Fast I/O equipment can be incorporated into the GEM80-400S and GEM80-400 Enhanced Controllers. It is not possible to include Fast I/O into the GEM80-400 Standard Controller.

The Fast I/O equipment itself is detailed in GEM80 Product Data Sheets and User Information Sheets, note particularly its use in conjunction with GEMSTART CCU. The wide choice of equipment is designed for applications falling into three categories:

- (1) Analogue I/O.
- (2) Counter Input.
- (3) Extra Serial Communication Ports (Programmable Serial Communication 8847 allows data exchanges with almost any other mini, micro, or main-frame computer).

Figure 5.6 illustrates a Fast I/O Driver that must be incorporated in any GEM80-400 Controller system if Fast I/O Modules are to be included.



- 1. Module Function Label
- 2. Module Ordering Number
- 3. Ejection Handle

Figure 5.6 - Fast I/O Driver

5.12.2. Adding Fast I/O Equipment

5.12.2.1. Adding Fast I/O to GEM80-400S Controllers

Any of the range of Fast I/O modules can be added to the 400S controller. The Fast I/O section of the subrack comprises the five slots at the left hand end. The right most slot is reserved for the Fast I/O Driver and is labelled 8300 on the subrack label. A Fast I/O Driver type 8300-4003 must be included in this slot if any Fast I/O Modules are required to be fitted. No other module type can be fitted into this slot. No other wiring or link changing is required to be made to the Upper Backplane except for the connecting of a -15VDC supply if required by the Fast I/O Modules to be used. Details of the Power Supply and its wiring are given in Chapter 6. Each Fast I/O Module kit is supplied with its own bespoke lower backplane which must be fitted to the subrack in the appropriate slot and any scaling links which are required must be made. See User Sheet for the particular modules for details.

5.12.2.2. Adding Fast I/O to GEM80-400 Enhanced Controllers

This section details how to connect a single Fast I/O Rack to a GEM80-400 Enhanced Controller. If further racks are required please contact Customer Support.

The only Fast I/O Module that can be installed within the GEM 80-400 Enhanced Controller subrack is the Fast I/O Driver Module. Other Fast I/O Modules may be installed into a separate Fast I/O subrack.

Central Highway Slot 1 is the only slot that can be configured to use a Fast I/O Driver Module. Slot 1 may be configured for a Fast I/O Driver Module by moving a multi-coder link from its default Central Highway site (SLOT 1 LK7) to its Fast I/O site (Fast I/O LK8). These multi-coder link sites are situated on the upper backplane, slightly to the left of the GEM 80-400 Processor Module and are labelled "Fast I/O LK8" and "SLOT1 LK7". See Figure 1.13 for details of the upper backplane. Multi-coder links should always be fitted so that the red stripe is closest to the top of the subrack.

The system, and module, may be damaged if a Fast I/O Driver Module is fitted to any slot configured to accept a Central Highway Module, other than a Fast I/O Driver Module, and visa versa.

The Fast I/O Driver communicates with the Fast I/O subrack using a 50-way ribbon connector situated behind Slot 1 on the rear of the upper backplane. The upper backplane connector for Slot 1 provides wire wrap pins which may be used in the same way as the GEM80/300/310 Fast I/O Driver backplane.

The Controller subrack does not provide -15V, this is required for some Fast I/O modules. The Fast I/O subrack **must** have a 12 Slot Subrack which includes a PSU. The PSU will not only supply the module voltage requirements but also the PSU cross coupling for correct system initialisation.

The cross coupling is achieved by the following :-

R0 PL8 Pin 1 (TEST) -- R1/U08/W1) e.g. CPU Subrack, Plug 8 Pin 1 --- Fast I/O Subrack, Upper backplane Slot 8, Pin W1

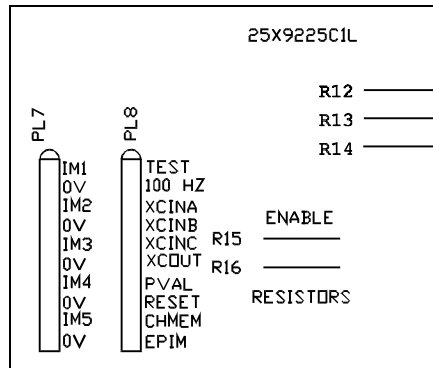
R0 PL7 Pin 10
(0V)

-- R1/U06/W20

) - Twisted pair between Subracks
)

R0 PL8 Pin 3 (XCINA) -- R1/U06/W6)
) - Twisted pair between Subracks
 R0 PL7 Pin 8 (0V) -- R1/U06/W19)

Remove R12 on the Enhanced GEM80-400 Upper backplane



Fast I/O Group Enable links - Wired from rear subrack pins (nearest to 50 Way ribbon header)

R0/U8/C28 (Slot 1) -- R1/U20/C07)
) - Twisted pair between Subracks
 R0/U8/C27 (Slot 1) -- R1/U20/C06)

Safety Earth and Signal Ground

The Fast I/O Subrack 0V must be connected to the Controller Subrack 0V , this is achieved by connecting Faston F12 on the Fast I/O Subrack to TB3.6 on the Controller Subrack. Faston F15 on the Fast I/O subrack should then be used to provide the system with its Signal Ground connection point. This is to prevent two wires connected to TB3.6 .

The additional Fast I/O Subrack must have the safety earth connected to a suitable earth.

The Safety Earth and Signal Ground wiring should be connected using 2.5²mm.

5.12.3. C/D-Table Mapping for Fast I/O Input and Output Data

Data INPUT to the controller from Fast I/O equipment is stored in the C-table, and Data to be OUTPUT by the controller is stored in the D-table. For each Fast I/O Module, there are 32 x 16-bit words reserved for INPUT and 32 x 16-bit words reserved for OUTPUT. For instance, the Fast I/O Module in the first slot of the Fast I/O Subrack will be accessible via C/D0 to C/D31; the Fast I/O Module in the second slot of the Fast I/O Subrack will be accessible via C/D32 to C/D63, etc. The lowest table addresses for any given slot are referred to as the 'base addresses', e.g. C/D0, C/D32, etc. The actual addresses are detailed in Table 5.2 and are related to the Fast I/O Module number.

The Fast I/O Module number is derived from the position in which the Fast I/O Module is fitted in the subrack.

Table 5.2 - Fast I/O Addresses

C & D-Table Address	Module Number	400S Controller Fast I/O Slot	12-Way Fast I/O Subrack Slot
0 to 31	0	1	9
32 to 63	1	2	10
64 to 95	2	3	11
96 to 127	3	4	12
128 to 159	4		13 First
160 to 191	5		14 Fast
192 to 223	6		15 I/O
224 to 255	7		16 Subrack
256 to 287	8		17
288 to 319	9		18
320 to 351	10		19
352 to 383	11		20
384 to 415	12		-
416 to 447	13		-
448 to 479	14		-
480 to 511	15		-
512 to 543	16		9
544 to 575	17		10
576 to 607	18		11
608 to 639	19		12
640 to 671	20		13 Second
672 to 703	21		14 Fast
704 to 735	22		15 I/O
736 to 767	23		16 Subrack
768 to 799	24		17
800 to 831	25		18
832 to 863	26		19
864 to 895	27		20
896 to 927	28		-
928 to 959	29		-
960 to 991	30		-
992 to 1023	31		-

Fast I/O addresses are included in the scan, starting from the base address for a particular module slot, continuing to the highest address declared in the ladder scan for that module. The scanning then jumps to the base address for the next module slot. The controller works out separately which C-table and which D-table addresses to include in the scan.

For example if address C47 is included in the ladder program, then normally addresses C32 to C47 inclusive are scanned.

When compilation is attempted, the program will not run if an invalid Fast I/O address is used, because there will not be any response from the invalid address. The screen of a suitable GEM80 programming tool, such as Gemesys 3, displays a diagnostic message.

6. Power Supplies

6.1. Power Supply Requirements

The GEM80-400 Controller requires one of the following supplies:

Standard -	88 to 121V ac, or 204 to 264V ac, single phase, 47 to 63Hz AND/OR 22 to 85V dc - 9032-4002 or 9032-4010 Power Supply Module.
400S & 400 Enhanced -	88 to 264V ac, single-phase, 45 to 63Hz - 9017-4002 or 9017-4010 Power Supply Module, OR 88 to 250V dc - 9017-4001 or 9017-4010 Power Supply Module, OR 19 to 60V dc - 9018 Power Supply Module.
400S	-15VDC if Fast I/O modules require it.

The Standard Controller subrack will contain a 9032 Power Supply Module; the Enhanced Controller subrack will contain either a 9017 or a 9018 Power Supply Module, depending upon the user requirement. This module will supply all the power requirements for the processor modules, memory modules, I/O modules and Serial Link equipment in the controller subrack. It is the user's responsibility to calculate the total power consumption of any I/O equipment used and decide whether sufficient power is available from the controller power supply module or if it is necessary to provide additional power supply modules. Table 6.1 details the specification of the 9017, 9018 and the 9032 Power Modules.

When a 9017-4001 Power Supply Module is fitted in earlier GEM80-400 Enhanced Controllers, the incoming ac power supply must be connected to the terminal block as illustrated in Figure 6.1. The terminal block is located adjacent to the lower backplane and the terminals project inside the subrack. The supply cable is fed through the lower hole in the side plate, see Figure 6.2, and the terminals are accessible after the power supply module has been removed. The user should also ensure that the power connector on the flying lead from the filter assembly, see Figure 6.2, is securely fitted into the Power Input socket on the front panel of the power supply module.

The 9017-4010 Power Supply has in-built EMC filtering so later Enhanced controllers are not fitted with the power input terminal block or filter assembly shown in Figs 6.1 and 6.2. Power input is connected directly to the PSU mains connector.

If a 9017-4010 PSU is required to be fitted to an earlier controller it is recommended that direct connection is made to the PSU by-passing the subrack filter.

A 9017-4001 PSU must not be fitted to controllers which do not have a filter assembly as this will affect the EMC performance of the system.

If an over-current, over-voltage or under-voltage condition occurs, the power supply will shut down. Repeated tripping will require further investigation into the cause of the fault.

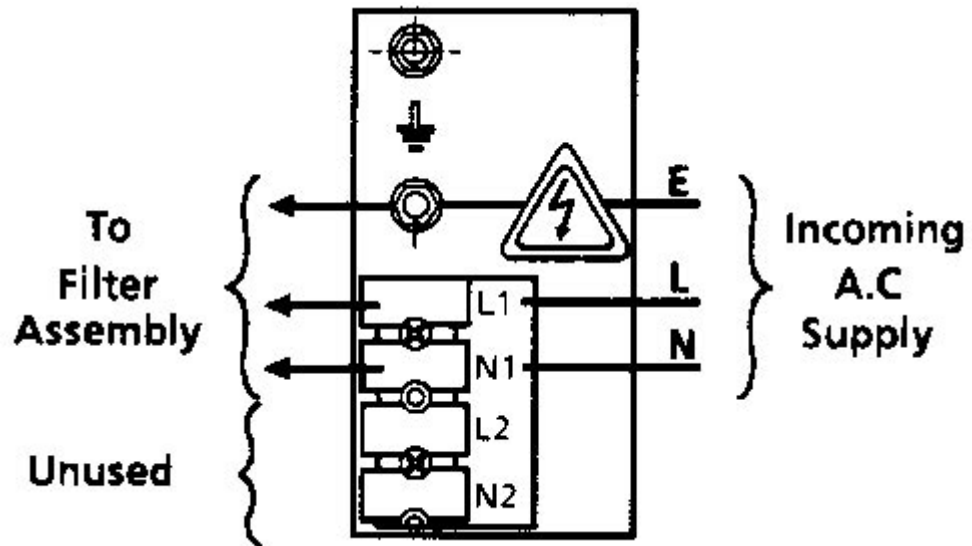


Figure 6.1 - Power Input Terminal Block

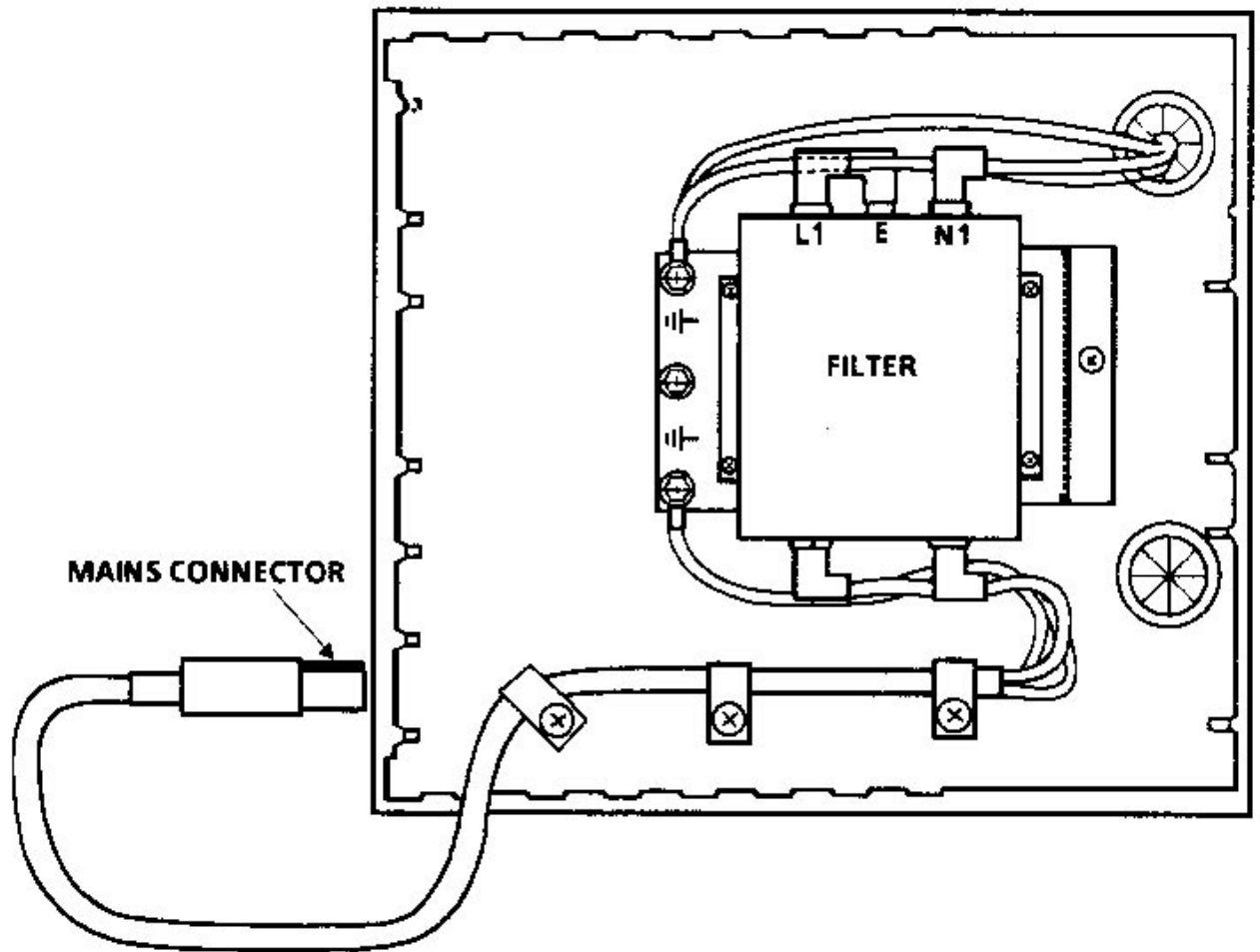


Figure 6.2 - Filter Assembly for 9017-4001 Power Supply

6.2. Power Supply Specification

6.2.1. Controller Power Supply Module Specification

Table 6.1 details the specification of each of the controller power supply modules.

Table 6.1 - GEM80-400 Controller Power Supply Modules Specification

-	9017 Power Module	Comments	9018 Power Module	Comments	9032 Power Module	Comments
Input Voltage Operating Range	88-264V ac 45-63Hz or 88-250V dc	Earth input can be floating, positive or negative. Single range (no adjustment necessary)	19-60V dc	Earth input can be floating, positive or negative. Single range (no adjustment necessary)	88-121V ac 45-63Hz or 204-264V ac 45-63Hz or 22-85V dc	Two ac ranges switch selectable. (Nominal power input 110 or 220V ac 50/60Hz 22 to 85V dc)
Current Available (in Amps) at 0-60°C	12.0A at +5V, 8.0A at +15V (9017-4001) 25.0A @ +5V 8.0A @ +15V (9017-4010)	-	12.0A at +5V, 6.0A at +15V	-	7.0A at +5V, 2.0A at +15V	The current available from the 15V rail may be increased up to a maximum of 5A by trading off 2A at +5V for every additional 1A required at +15V
Consumption	40W per power module when supplying the full rated load. Consumption decreases approximately linearly with a decreasing load 310W for 9017-4010.	For ac operation, input current at full rated load consists of pulses of approximately 25A peak and 0.5ms duration each half cycle. For dc operation, the input current is substantially constant.	200W per power module when supplying the full rated load. Consumption decreases approximately linearly with a decreasing load.	The input current is substantially constant (not pulsating).	100W per power module when supplying full rated load. Decreases approximately linearly with decreasing load.	For ac operation, input current at full rated load consists of pulses of up to 3.5A peak and up to 5.5ms duration each half cycle. For dc operation, input current is substantially constant.

Inrush	1.8A maximum at 121V ac, 4.2A maximum at 264V ac, 4A at 250V dc (9017-4001) 21A @ 121VAC 45A @ 264VAC 43A@250VDC (9017-4010)	For ac operation, current peaks decay over approximately 350ms. For dc operation, the current decays exponentially with 87ms time constant. Suitable for operation from a current limited source. 10mS for 9017-4010	3.6A at 24V, 7.2A at 48V (i.e. 0.15A per volt)	Current decays exponentially with 87ms time constant. Suitable for operation from a current limited source.	50A at 110V ac, 25A at 240V ac, 86A at 48V dc (i.e. 1.8A/V)	For either ac or dc operation, current peak decays exponentially with a 4ms time constant. Suitable for operation from a current limited source.
Input Supply Interruption	30ms ride-through on 110V ac at full load. 170ms ride-through on 220V ac at full load. $\geq 8mS @ 110V$ $\geq 20mS @ 220V$ (9017-4010)	Shut-down after ride-through time. Automatic recovery when the supply resumes.	6ms ride-through on a nominal 24V at full load. 50ms ride-through on a nominal 48V at full load.	Shut-down after ride-through time. Automatic recovery when the supply resumes.	20ms ride-through on 110V or 220V ac at full load. 20ms ride-through on nominal 48V at full load.	Shut-down after ride-through. Automatic recovery when supply resumes.
Undervoltage Protection OR Shut-down	Shut-down if any output voltage falls 5% below nominal value.	-	Shut-down if any output voltage falls 5% below nominal value.	-	Shut-down if any output voltage falls 5% below nominal value.	-
Overvoltage Protection OR Shut-down	Shut-down if any output voltage rises 20% above nominal value.	-	Shut-down if any output voltage rises 20% above nominal value.	-	Shut-down if any output voltage rises 27% above nominal value.	-
Self-test	Undervoltage detection circuits tested regularly by the processor.	-	Undervoltage detection circuits tested regularly by the processor.	-	No self-test when used for Basic and Verification I/O.	-
Status Indication LEDs	Power ON (green) Control supply healthy (Green) Overload (Red)	-	Power ON (red). Control supply healthy (green). +5V overload (red). +15V overload (red).	-	Power ON (green). +5V healthy (green). +15V healthy (green)	-

The Red 'POWER' LED on the 9017-4001 Power supply indicate that an incoming supply is present at the unit and could therefore be illuminated whether the power supply itself was switched on or off.

The Green 'POWER' LED on the 9017-4010 however, only illuminates when there is an incoming supply, the power supply is switched on and the internal control supply is healthy.

6.2.2. Fast I/O Power Supply GEM80-400S Controller

If any fast I/O modules are fitted into the 400S controller which require a -15VDC supply then a separate cubicle mounted supply must be fitted. The supply should be capable of supplying 1 Amp at 15VDC $\pm 0.5V$.

6.2.3. Fast I/O Subrack Power Supply Module

Table 6.2 details the specification of power supply modules. used in Fast I/O Subracks

Table 6.2 - Fast I/O Subrack Power Supply Modules Specification

-	8917 Power Module	Comments	8918 Power Module	Comments
Nominal Power Input	110-240V ac 50/60Hz. Single phase 110-220V dc	Single range (no adjustment necessary).	24-48V dc	Single range (no adjustment necessary).
Operating Range	88-264V ac 45-60Hz, or 88-250V dc.	Input can be floating, positive earth, or negative earth.	19-60V dc	Input can be floating, positive earth, or negative earth.
Current Available (in Amps) at 0-40° C	26.0A at +5V, 7.0A at +15V, 1.0A at -15V.	-	20.0A at +5V, 6.0A at +15V, 1.0A at -15V.	-
Current Available (in Amps) at 0-60° C	16.9A at +5V, 4.55A at +15V, 0.65A at -15V.	-	13.0A at +5V, 3.9A at +15V, 0.65A at -15V.	-
Consumption	350W per power module when supplying full rated load. Consumption decreases approximately linearly with decreasing load.	For ac operation, input current at full rated load consists of pulses of approximately 35A peak and 0.5ms duration each half cycle. For dc operation, input current is substantially constant.	302W per power module when supplying full rated load. Consumption decreases approximately linearly with decreasing load.	Input current is substantially constant (not pulsating).

Inrush	2.6A maximum at 121V ac, 6A maximum at 264V ac, 4A at 250V dc.	For ac operation, current peaks decay over approximately 500ms. For dc operation, current decays exponentially with 125ms time constant. Suitable for operation from a current limited source.	3.6A at 24V, 7.2A at 48V, (i.e. 0.15A per volt).	Current decays exponentially with 125ms time constant. Suitable for operation from a current limited source.
Input supply interruption	30ms ride-through on 110V ac at full load. 170ms ride-through on 220V ac at full load.	Shutdown after ride-through time. Automatic recovery when supply resumes.	6ms ride-through on nominal 24V at full load. 50ms ride-through on nominal 48V at full load.	Shutdown after ride-through time. Automatic recovery when supply resumes.
Under-voltage shutdown	Shutdown if any output voltage falls 5% below nominal value.	-	Shutdown if any output voltage falls 5% below nominal value.	-
Over-voltage shutdown	Shutdown if any output voltage rises 20% above nominal value.	-	Shutdown if any output voltage rises 20% above nominal value.	-
Self-test	Under-voltage detection circuits tested regularly by the processor.	-	Under-voltage detection circuits tested regularly by the processor.	-
Multiple power modules	All power modules tested simultaneously with more than one power module.	Power modules cross-interlocked for controlled system start-up/shutdown. A fault on any power module will cause system shutdown.	All power modules tested simultaneously with more than 1 power module.	Power modules cross-interlocked for controlled system start-up/shutdown. A fault on any power module will cause system shutdown.
Status Indication LEDs	Power ON (red). Control supply healthy (green), +5V overload (red), +15V overload (red), -15V overload (red).	-	Power ON (red). Control supply healthy (green), +5V overload (red), +15V overload (red), -15V overload (red).	-

6.3. Controller Power Distribution and Consumption

The user must check that the power consumed by the various GEM80 equipment does not exceed the power available from each power supply module.

6.3.1. Power Consumed from Power Supply Module

Table 6.3 details the power consumed by each item of equipment.

Table 6.3 - Current Consumption in Milliamperes

-	+5V	+15V	-15V
Controller Processor Module	2,600	500	-
8272 Series RAM/EPROM Modules Extra for EPROM Sub-module	1,000 500	30	-
IMAGEM Video Processor	2280	-	-
STARNET Module	1630	-	-
GEMLAN-D Module	3000*	250	-
Fast I/O Driver	1750	120	-
8191 Expander Unit	-	900	-
8924 20mA Serial Unit Extra per 20mA source	220	10 20	20
8587 HDLC Termination Unit	170	120	-
See relevant Data Sheets for specific I/O Modules	-	-	-

* 6000mA during reset

Note...The current consumption for the 8191 Expander Unit is 900mA when the power source is via the Verification I/O ribbon alone. If an external power supply is connected, the current consumption is split, approximately in half, into 2 x 450mA. See also any relevant User Information Sheets for further details of current consumption.

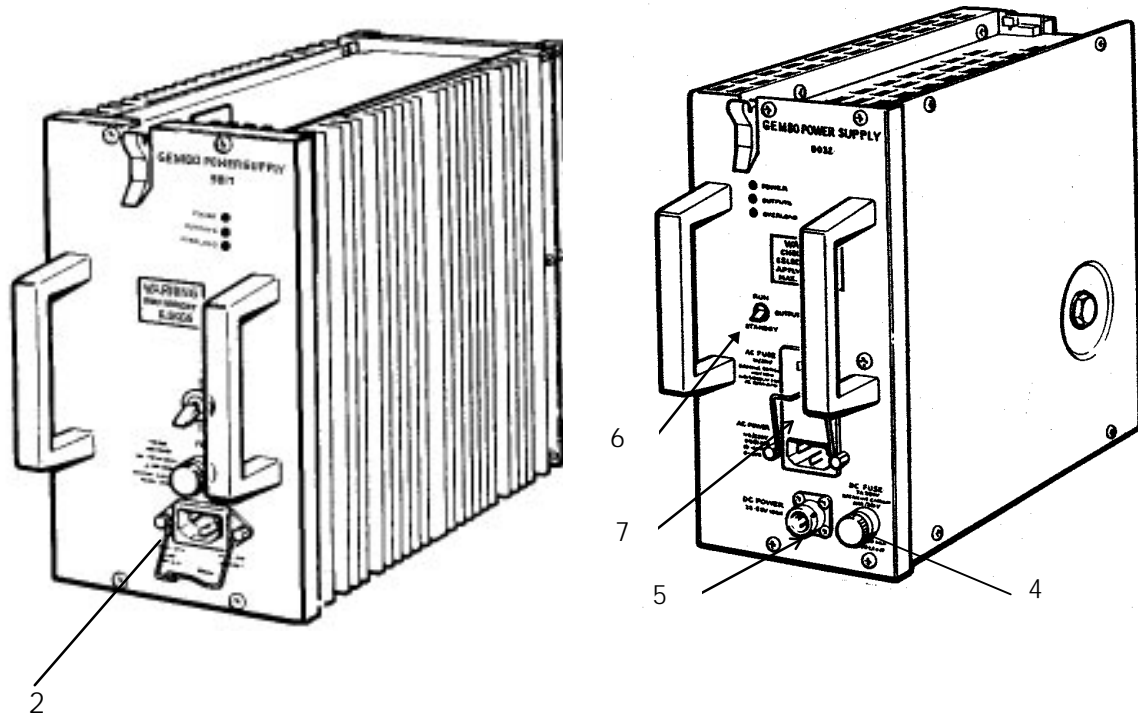
6.3.2. Controller Power Distribution

- (1) All controllers will have one power supply module which supplies all controller power including host controller to:
 - (a) Basic I/O equipment,
 - (b) Verification I/O equipment,
 - (c) Serial links,
 - (d) Fast I/O Driver (available only with 400S and 400 Enhanced Controller systems).
- (2) The 400S controller can have two power modules. The module in the controller subrack supplies all the equipment in that subrack as detailed in (1) above.. The -15VDC supply for the Fast I/O equipment is provided by a separately mounted power supply provided by the user.
- (3) The 400 Enhanced controller can have up to three power modules. The modules in the Fast I/O subracks supply power to the Fast I/O equipment. The module in the controller subrack R0 supplies all the equipment in that subrack as detailed in (1) above.

6.4. Power Supply Connections

6.4.1. AC Fed Only

Power input connections are on the front of the 9032 Power Supply Modules as shown in Figure 6.3. AC power input is via the ac power connector which is supplied loose with the equipment. Line, neutral and earth connections are as marked on the connector. It is necessary to set the ac voltage selector as required. The connections for the safety earths for an ac fed GEM80 are shown in Figure 6.4.



- 2. AC Power Input Socket
- 4. DC Input Anti-Surge Fuse
- 5. DC Power Input Socket
- 6. Output Control Switch
- 7. Combined AC Power Input, AC fuse holder and AC voltage selector.

Figure 6.3 - Power Supply Module AC and DC Connections

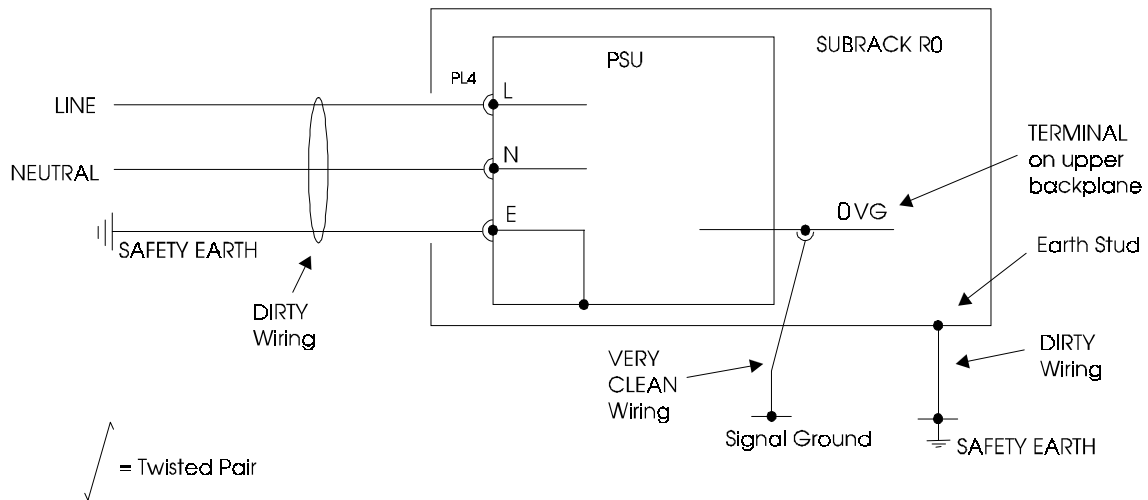


Figure 6.4 - Signal Ground and Safety Earth Connection for AC Input

6.4.2. DC Fed Only

Power input connections for dc are on the front of the 9032 Power Supply Module as shown in Figure 6.3. The system is designed for negative earth

connection only. A 3-metre lead is available for the dc power input socket, order code 8891-4072. The wires are colour coded as follows:

Positive - Brown,
Negative - Blue,
Earth - Yellow/green.

Connections for power input safety earths and signal grounds for dc only fed GEM80 are shown in Figure 6.5.

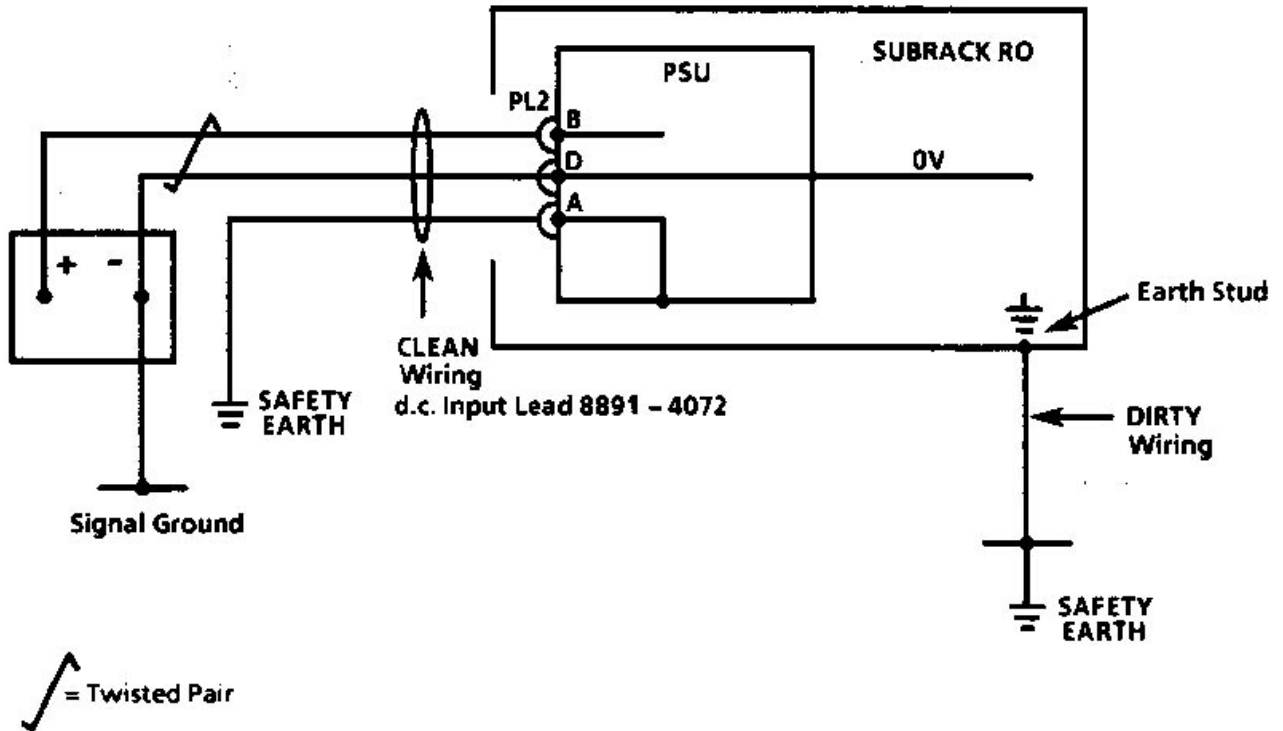


Figure 6.5 - Signal Ground and Safety Earth Connection for DC Input

6.4.3. AC and DC Fed

Power input connections for ac and dc fed controllers are shown in Figure 6.3. It is necessary to set the ac voltage selector as required. There is an internal diode OR which allows both ac and dc supplies to be present at the same time. Typically, for 24V dc no power is drawn from the dc input but above 40V dc some power is drawn depending on the ac voltage. The dc circuit is not isolated from the output of the power supply, though it is isolated from the ac input by a transformer. The system is designed for negative earth connection with signal ground and safety earths connected as shown in Figure 6.6.

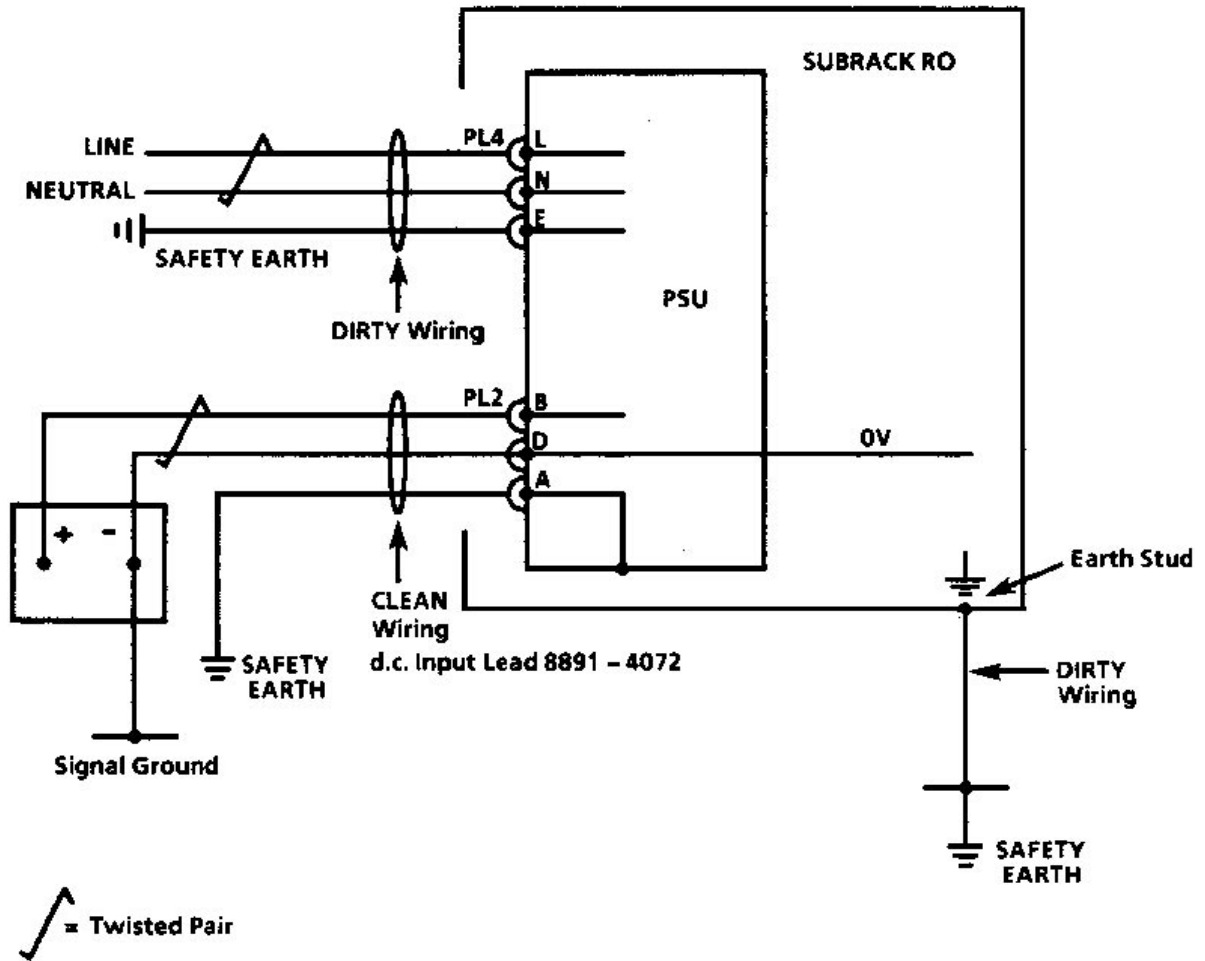
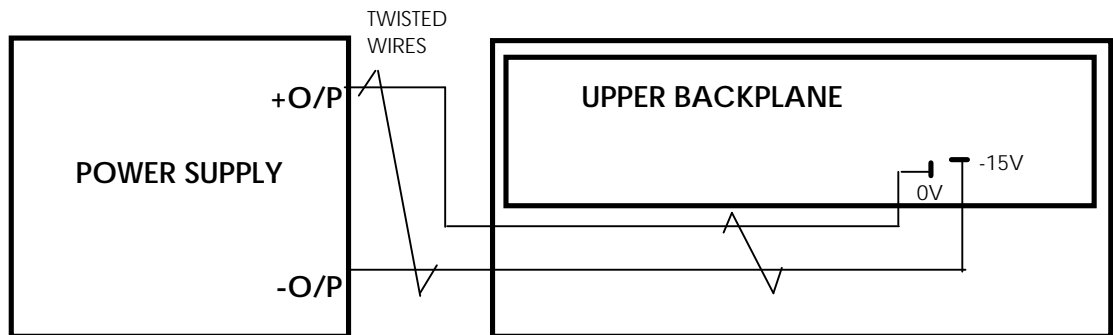


Figure 6.6 - Signal Ground and Safety Earth Connection for AC and DC Input

6.4.4. -15VDC Fast I/O Power Supply

If the Fast I/O modules fitted to the controller subrack require a -15VDC supply the user must fit a suitable power supply which is connected by means of a pair of twisted wires to the rear of the controller subrack. The connections to the subrack are made via two Faston connectors which are located at the bottom of the upper backplane just to the left of the processor connector (when viewed from the rear). The connections are shown in figure 6.7. The wires from the power supply to the subrack are in the category 'Clean' as defined in figure 7.5



7. Installation

7.1. Subrack Specification

The subrack is delivered fully assembled. Module guides, on a 0.4-inch pitch, are an integral part of the subrack.

System builders must ensure that power supply modules are removed from subracks before shipping. Modules are inserted from the front of the subrack and are retained by two sliding strips built into the subrack which lock the modules in position by engaging slots at the top and bottom of the modules.

Dimensions for the subrack are illustrated in Figure 7.1, Subrack Dimensions.

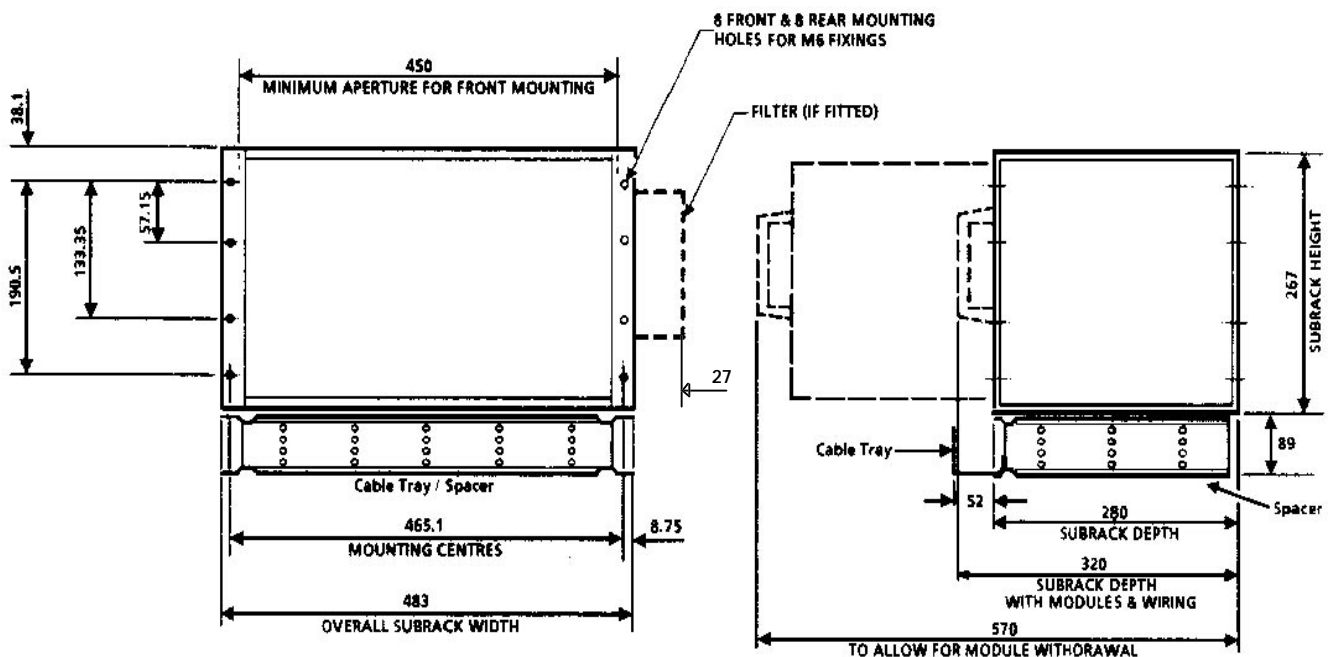


Figure 7.1 - Subrack Dimensions

7.1.1. Specification

Weight of Standard Subrack (empty)	:	6.26kg
Weight of Enhanced AC Subrack (empty)	:	7.012kg
Weight of Enhanced DC Subrack (empty)	:	6.122kg
Mounting	:	19 inch (483mm) panel mounting conforms to IEC 297-1(1975)
Temperature	:	Dimensions of Panels and Racks Operating: 0 to +60°C except in GEMLAN-D applications 0 to 50°C. Storage: -25 to +70°C

Humidity	:	5 to 95% RH non-condensing
SO ₂	:	25ppm Vol/Vol
H ₂ S	:	15ppm Vol/Vol
Nitrous Oxides	:	15ppm Vol/Vol
Dimensions	:	356mm high (8U) x 483mm wide x 332mm deep with modules and front connectors fitted. Allow 15mm for plant-side wiring.
Fire resistance	:	UL94V-0
UL Approval	:	PLC Specifications, UL508 Industrial Control Equipment
CSA Approval Specifications	:	C22.2-142 Process Control

7.2. Mounting

The subrack has a very simple mounting procedure which utilises the side plate front or rear flange for fixing purposes. Both front and rear flanges have four fixing holes. Under normal circumstances only the top and bottom holes are required to secure the subrack assembly, however in conditions of high shock/vibration it may be necessary to use the additional holes. To aid rear mounting, the top hole on each rear flange has a 'keyhole' shape.

7.2.1. Front Flange Mounting

Note...Front flange mounting requires a flat surface at the rear of the mounting panel.

To assist with the mounting procedure, threaded inserts have been fitted in the subrack fixing holes to accommodate the mounting screws. 7mm holes are required in the mounting panel to give clearance for the mounting screws. Mounting pegs are provided which enable the subrack to be held in the 'mounted' position prior to securing.

- (1) When direct access to the rear face of the mounting panel is possible, the subrack mounting procedure is as follows:
 - (a) Insert a mounting peg into the top fixing hole of each of the subrack flanges.
 - (b) Offer the subrack assembly up to the rear of the mounting panel and locate the two pegs in the top fixing holes of the panel. The pegs will hold the assembly in the correct fixing position.
 - (c) Fit and tighten the lower fixing screws
 - (d) Replace the mounting pegs with the upper fixing screws.
 - (e) Tighten all securing screws to a torque of 3.16 Nm (28 lbf.in).
- (2) If direct access to the rear of the mounting panel is NOT possible, the subrack assembly mounting procedure is as follows:

- (a) Ensure that the space at the rear of the mounting panel is a minimum of 600mm wide and 500mm deep with an aperture of 450mm.
- (b) Insert a mounting peg into the top fixing hole of each of the subrack flanges
- (c) Insert the subrack assembly sideways through the mounting panel aperture, rotate the subrack to offer the front of the assembly to the rear of the mounting panel and locate the two pegs in the top fixing holes of the panel. The pegs will hold the assembly in the correct fixing position.
- (d) Repeat items (1)(c) to (1)(e) above.

7.2.2. Rear Flange Mounting

Rear fixing is either by inserts fitted into the rear mounting panel or by Taptite screws. The length of the screws is 7mm plus the length required into the rear mounting panel; the screw head should be POSIPAN.

Subrack mounting using the rear flanges is carried out as follows:

- (1) Insert a mounting screw into each of the uppermost fixing holes on the mounting panel leaving at least 10mm of thread projecting.
- (2) Offer the subrack assembly up to mounting panel allowing the screw heads to pass through the keyhole shape. The subrack assembly will locate onto the screws and be held in position prior to securing.
- (3) Insert the two lower fixing screws.
- (4) Tighten all four screws to a torque of 3.16 Nm (28lbf.in).

7.3. Subrack Spacer/Wiring Tray

A spacer, which must be earthed, is fitted below the subrack to provide a 2U (88.5mm) space beneath the controller.

The controller subrack and any I/O subracks can be made up into one assembly prior to mounting in an enclosure. The spacer below an upper subrack is fitted to the top of the lower subrack. Fixing dimensions for each subrack are as shown in Figure 7.1 with a pitch of 356mm between the subracks. Mounting is similar to that described previously except that mounting pegs or mounting screws are only required to be fitted for the top subrack.

The wiring tray fits on to the spacer to form a channel in which plant-side cables can be laid. Holes for tying the cables down are provided in the bottom of the tray.

7.4. Installing GEM 80 in a cubicle

7.4.1. Introduction

When GEM80 equipment is supplied loose for the customer to mount in a cubicle, the installation procedure is as follows:

- (1) Plan the layout of GEM80 equipment in the cubicle.
- (2) Assemble the cubicle and fix it in position.
- (3) Mount the equipment in the cubicle.
- (4) Cable the equipment.
- (5) Connect the plant cables to the GEM80 equipment.
- (6) Set the address decoder switches and mark the labels.
- (7) Install the modules.

Where GEM80 equipment is supplied already fitted in the cubicles, the installation procedure is:

- (1) Move the cubicle and fix it in position.
- (2) Connect the plant cables to the GEM80 equipment.
- (3) Check the address decoder switches and mark the labels.
- (4) Install the modules.

Whenever it is necessary to handle GEM80 modules, the handling precautions detailed in Chapter 1 must be observed.

7.4.2. Equipment Layout

In laying out the equipment the following recommendations are made:

- (1) Determine whether plant cables will enter at the top or bottom of the cubicle, and leave adequate space for plant cable glanding.
- (2) Equipment or wiring which carries signals which could contain electromagnetic noise from the plant is termed 'dirty'. Equipment or wires which carry filtered, noise-free signals is termed 'clean'. Establish areas for mounting 'dirty' equipment such as I/O subracks. Establish areas for mounting 'clean' equipment such as controller, serial link termination units, etc.
- (3) If possible, fit 'dirty' equipment in separate enclosures from 'clean' equipment. Where all equipment is to be mounted in one cubicle, fit 'dirty equipment' near the entry of the plant cables. This prevents 'dirty cables' passing close to 'clean equipment'
- (4) Provide separate trunking for 'clean' and 'dirty' plant cables.
- (5) Fit a signal ground bar and safety earth bar in the GEM80 controller enclosure close to the point of entry of the plant cables.
- (6) Subracks should be mounted above each other to form a column of equipment to produce a cooling chimney effect. Do not obstruct the flow of air through the 'chimney'.

7.4.3. Examples of Cubicle Layout

Figures 7.2 and 7.3 show examples of typical cubicle layout. Clearly many different layouts are possible, depending on GEM80 equipment required, and the cubicle dimensions and fittings.

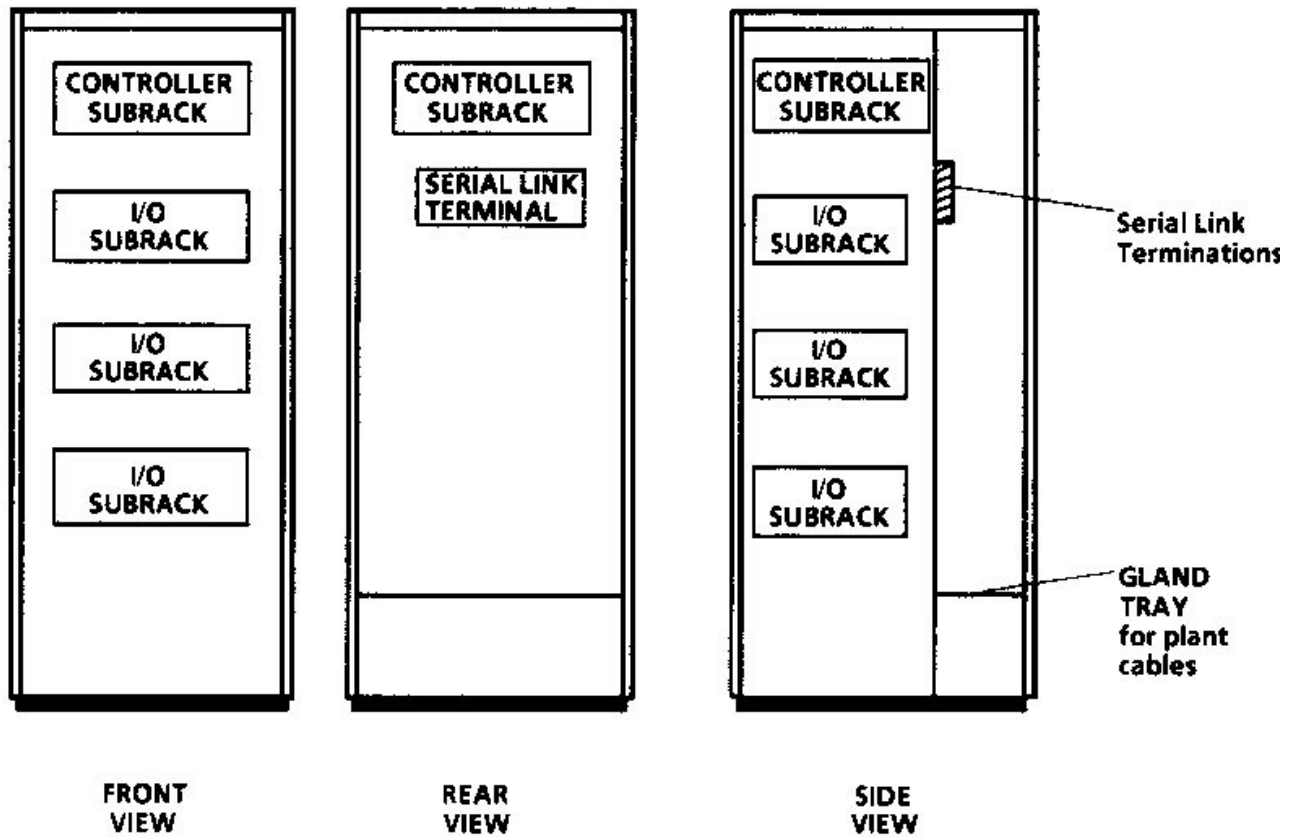


Figure 7.2 - Typical GEM80 Single Cubicle Layout

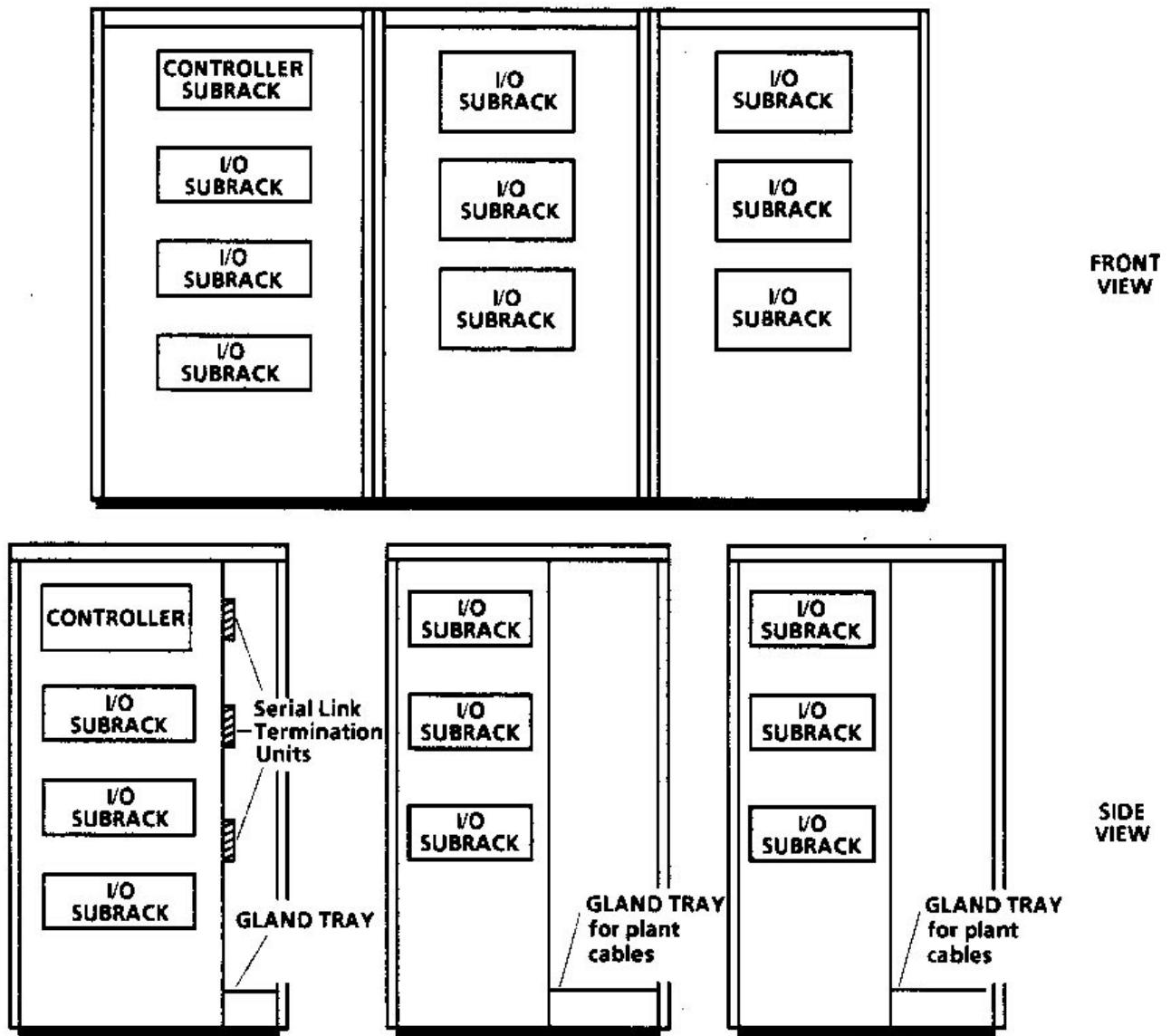


Figure 7.3 - Typical GEM80 3-Cubicle Layout

7.4.4. Position of GEM80 Controller

It is recommended that the controller be mounted at a reasonable height for access (i.e. between waist and eye level) to permit:

- (1) Connection of a suitable GEM80 programming tool, such as Gemesys 3.
- (2) Access to control switches.
- (3) Viewing indication devices.
- (4) Removal and replacement of modules.

7.4.5. Access Requirements

- (1) Access is required to the front of the controller.
- (2) Access to the front of the I/O subrack, for I/O module front panels, is required
- (3) Access is required to the front of the termination panels to allow connection and disconnection of plant wires and controller connections.
- (4) I/O address decoder switches, I/O ribbon cable connections and the

terminal blocks containing the Watchdog terminals and the power supply output terminals are accessible from the front of the Standard Controller subrack with the 9032 Power Supply Module and the 8239 Processor Module removed. These connections are accessible in the Enhanced Controller subrack by the removal of the blanking panel and the 9017/9018 Power Supply Module.

- (5) Clearance is required at the front of the subrack for the removal and fitting of the 8239 Processor Module, the Power Supply Modules, the I/O modules, any associated wiring and, in the case of an Enhanced Controller subrack, any Central Highway Modules and RAM cards.
- (6) Serial Ports 1 and 2 and the Printer/Programming Connection Port are all situated at the front of the 8239 Processor Module.

7.4.6. Heat Dissipation of I/O Modules

I/O equipment can, in some cases, produce large heat dissipation, see relevant Product Data Sheets for details. Where plant circuits use high operating currents, care must be taken to avoid hotspots and overheating; the ambient temperature in the enclosure must not exceed the environmental conditions for temperature, given in Chapter 1.

7.4.7. Minimum Panel Spacings

To help remove the possibility of noise problems, the minimum panel spacings given in Figure 7.4 must be achieved.

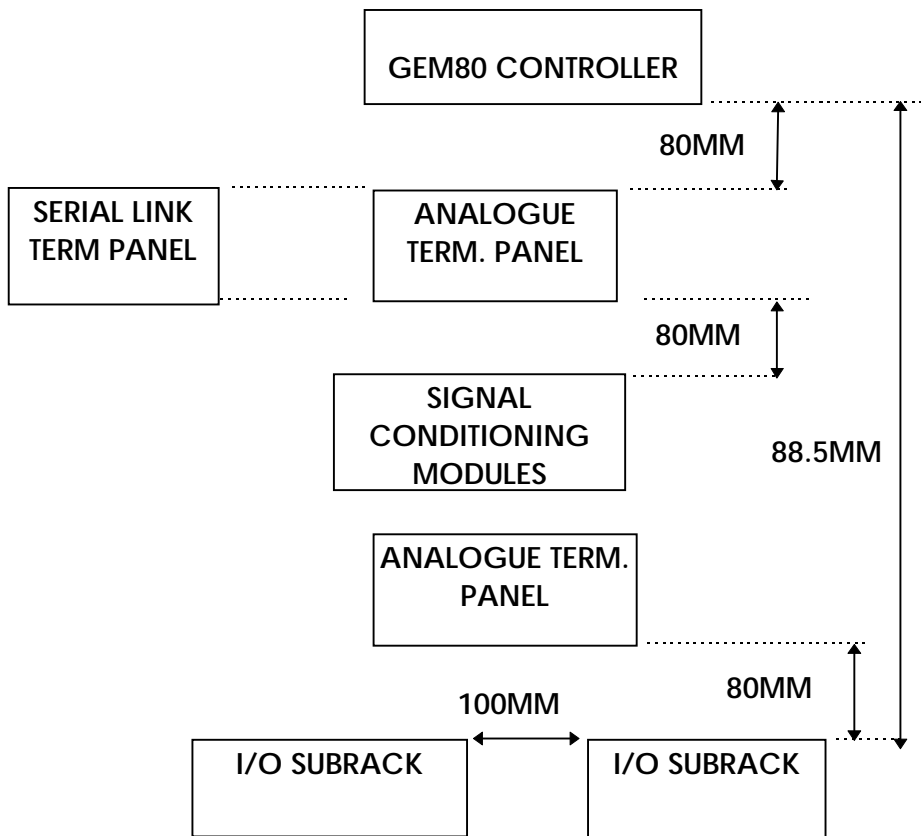


Figure 7.4 - Minimum Panel Spacings for GEM80 Controllers (dimensions in millimetres)

7.4.8. Cable Routing and Segregation

To help in removing the possibility of noise problems, GEM 80 interconnecting cables are categorised into groups and these separate groups must be run physically separated by at least the distances given in Figure 7.5.

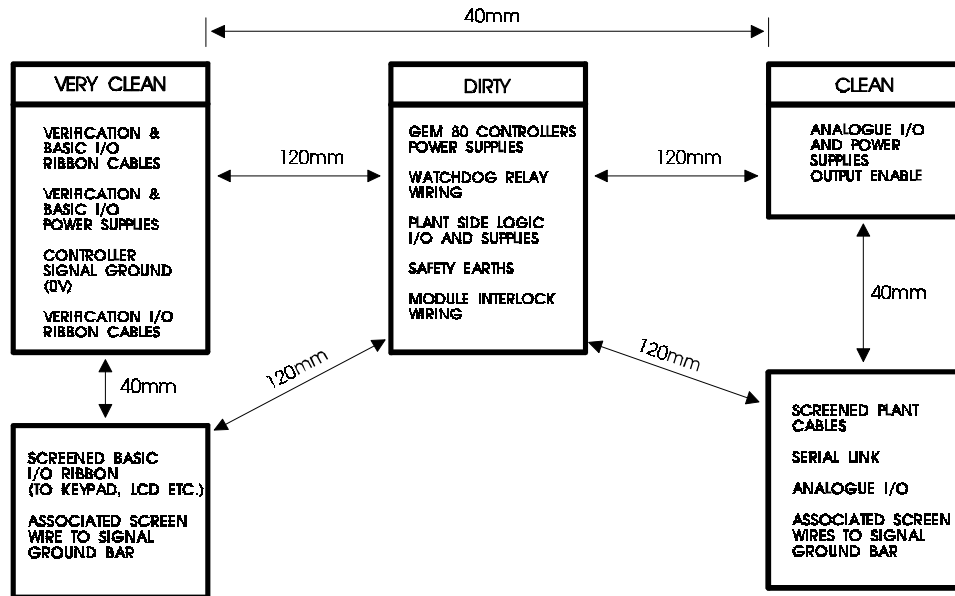


Figure 7.5 - Wiring Segregation

7.4.9. Pre-cut Ribbon Cable Lengths

Some GEM 80 equipment is supplied with ready-made ribbon cables of a pre-cut length, as detailed in the relevant Product Data Sheets.

7.5. Cabling GEM80

7.5.1. Tools for Cabling

7.5.1.1. Ribbon Cables

No special tools are required for the installation of factory-assembled ribbon cables. Special tools are required for assembling connectors onto ribbon cables and for the user wishing to assemble his own cables, details are given in Appendix A.

7.5.2. Safety Earth Wiring

It is essential that the GEM80 system is properly earthed and a safety earth circuit is connected. See Figures 6.4, 6.5 and 6.6 for the earthing arrangements.

Safety earth cable must be a minimum of 2.5mm² (green/yellow) insulated wire and must be fitted in accordance with the segregation requirements given in the 'Wiring Segregation Within GEM80 Cubicles' section of this chapter.

7.5.3. Signal Ground Wiring

7.5.3.1. Signal Ground Bar

This should be fitted in the controller enclosure. It should be insulated from the safety earth bar as shown in Figure 7.6. A removable jumper wire should be fitted between the safety earth bar and the signal ground bar. This link should be a minimum of 2.5mm².

The signal ground bar will be the local common point for all the enclosure signal ground wires.

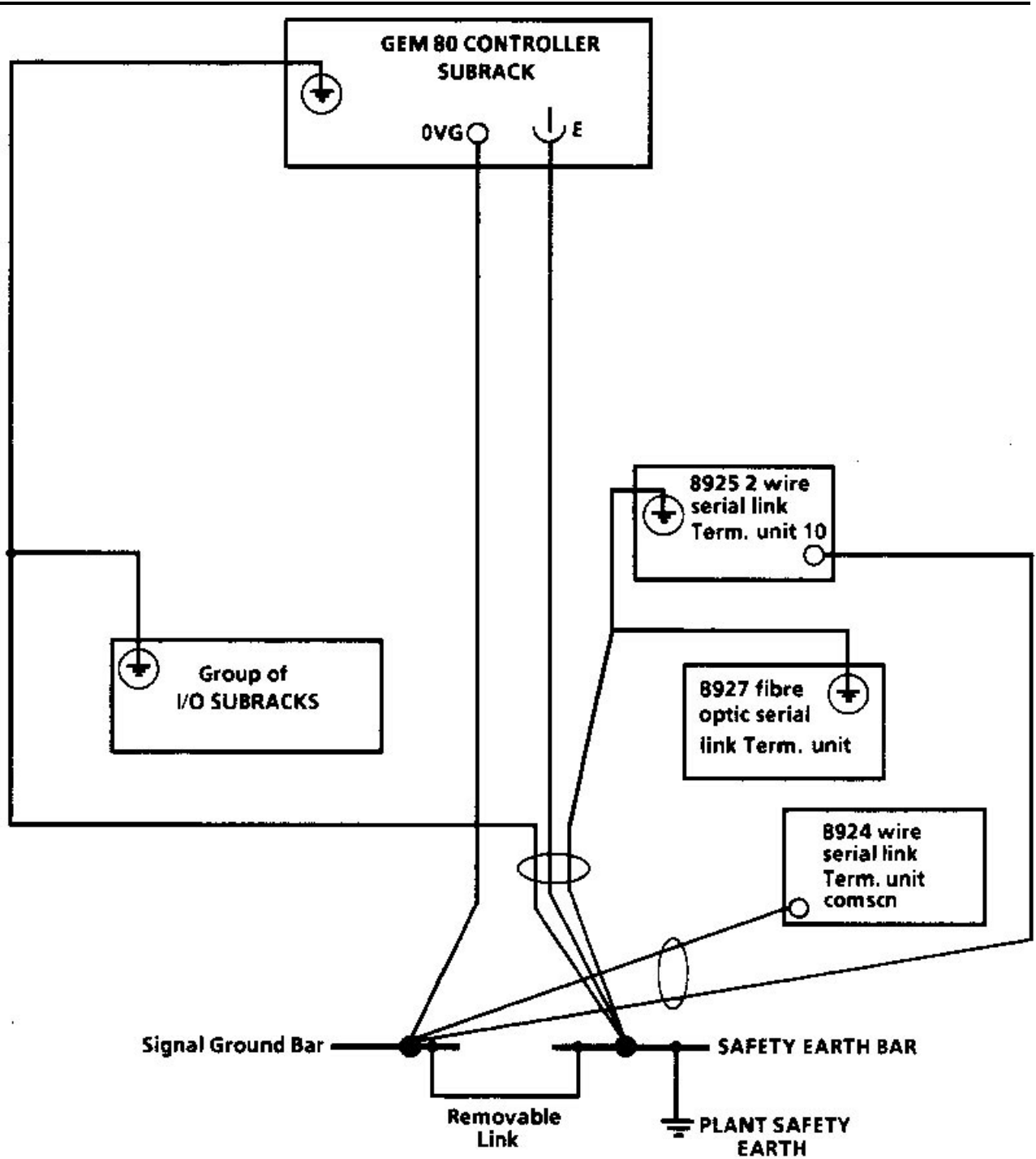


Figure 7.6 - GEM80-400 Controller Signal Grounds and Earthing - Typical Example

7.5.3.2. GEM80 0V

The system logic 0V is classified as very clean, it should be run directly from the 0V connection on the controller subrack to the signal ground bar. Minimum wire size should be 1.5mm² run as a VERY CLEAN wire in accordance with the segregation requirements given in the 'Wiring Segregation Within GEM80 Cubicles' section of this chapter. Figure 7.6 shows the location of the 0V connection.

7.5.3.3. Screen Signal Grounds

These should run from signal ground terminals on the termination units to the signal ground bar; the screens should be run to a star point, never in a loop. They should be run with the cable whose screen is being connected to signal ground, and in accordance with the segregation requirements in the 'Wiring Segregation Within GEM80 Cubicles' section of this chapter.

7.5.4. Wiring Segregation Within GEM80 Cubicles

Electrical noise and electromagnetic interference can be introduced into a microelectronic system through the cables and wires connected to it.

To avoid this, wiring which could carry noise (i.e. 'dirty' cables) needs to be kept away from cables which are sensitive to noise, these cables are then kept 'clean' (i.e. free of electrical noise).

The wiring segregation within the cubicle is shown in Figure 7.5. Wires which fall into the same group can be run together, however, wires falling into different groups cannot be run together, though paths may cross at right angles. Wires of different groups must be spaced apart by at least the distance shown in Figure 7.5.

Spacings may be reduced as follows:

- (1) For runs of less than one metre - spacings may be halved.
- (2) Within the vicinity of connections, a minimum spacing of 25mm should be aimed for.

7.5.5. Interconnecting GEM80

- (1) Connecting Power Supplies - see Chapters 3 and 6.
- (2) Connecting Basic and Verification I/O Highway Ribbon Cable - see Chapter 3.
- (3) Connecting Watchdog and Circuits - see Chapter 11.
- (4) Connecting Serial Links Ribbon Cables - see Chapter 4.
- (5) Other equipment - see relevant Product Data Sheets or User Information Sheets.

7.6. Plant Cabling External to GEM80 Cubicles

7.6.1. General

Conductors of 'clean' groups should always be kept separate from conductors of 'dirty' groups. It is also recommended that 'clean' analogue signals are run in a different cable from 'clean' digital signals. 'Clean' cables should be screened and the screens should be connected to signal ground at one end only to avoid earth loops. The preferred end is that at which the current or voltage source exists.

Any loose wires must be properly insulated and secured to prevent inadvertent contact with any metal parts or by persons needing to work on the equipment.

All plantside connectors must be mechanically restrained using the various locking mechanisms provided to prevent accidental disconnection.

7.6.2. Segregation

7.6.2.1. General

The spacing between 'clean' and 'dirty' cables should be at least 360mm (i.e. increased by a factor of 3 on spacings within the enclosure).

This distance may be halved (180mm) if cables are run in earthed steel conduit or trunking.

If the distance between the cable origin and the point of entry to the equipment is 10 metres or less, the spacing may be reduced to 90mm for cables enclosed in conduit or 180mm under other conditions.

7.6.2.2. Basic and Verification I/O Ribbons

These should not be run outside the cubicle but where this is impracticable, use screened ribbon, preferably in earthed steel trunking.

7.6.2.3. Signal Ground

In the majority of applications, the incoming safety earth wire is adequate for signal ground purposes. If it proves inadequate, or if the user has a separate clean earth system, a clean earth cable should be used.

This should be:

- (1) Run separately from all other cables
- (2) Insulated.
- (3) Kept clear of machinery bedplates/mounting brackets, etc., and any other noise generating equipment, such as electrical welding machines
- (4) As short as possible and connected directly to the clean earth system or as close to the plant earth source as is practicable
- (5) Run in 4/6mm² cable.

7.6.2.4. Further Information on Plant Cabling

For further information on plant cabling see Table 7.1 below.

Table 7.1 - Plant Cabling

Unit	Location of Connections	Size of Conductors	Remarks
Basic/Compact I/O Subrack	Lower, front part of individual 8-Point Basic/Compact I/O Modules	Up to 1.5mm ² ; one conductor per terminal	On 8-way I/O modules only, the plastic shroud must be fitted after plant terminations have been made. On 16-way modules, the shroud is integral. On 32-way modules there is a 'D'-type connector to the terminal rail.
Serial Link Termination Panel (4-wire)	Upper, front part of the termination panel.	Up to 2.5mm ²	Recommended cable is 16/0.20mm twin twisted pairs with overall screen. Maximum serial link cable lengths and recommended types are detailed in User Information Sheets.
Serial Communications Termination Panel	Upper and lower front part of the termination panel.	Up to 2.5mm ²	-
Analogue Termination Panel/Rail	Upper, front part of the termination panel/rail.	Up to 2.5mm ² .	See the Product Data Sheets for detailed information on plant terminations.
8150, 8151, 8165 and 8166 Compact Analogue I/O Modules	'D' Type connector on front of modules	Pre-formed cable. See Product Data Sheets.	Termination rail positioned to suit the installation.
Fast I/O Termination Panels	Ribbon cable connector backplane located at rear of subrack	Up to 2.5 mm ²	Type of cable to suit particular modules. See module data sheets

7.7. I/O Plant-Side Power Supply Connection

The I/O plant-side power supply cabling must be protected by a fuse and suitably rated cable.

7.8. Installation of Modules

After cabling the system, the controller modules can be fitted into the subrack. They contain static sensitive devices and the precautions of Chapter 1 must be observed. The layout of the modules in the controller subracks is shown in Chapter 3. The slots for the I/O modules are mechanically coded to suit the modules being fitted, therefore, a module will only fit into its designated position. These modules must be pushed home into the connectors at the rear of the subrack, so slightly more force will be required for the last few millimetres of travel.

7.8.1. Module Retention

MODULE RETENTION IS ONLY NECESSARY IN HIGH SHOCK OR VIBRATION APPLICATIONS WHERE THE MODULES COULD BECOME DISCONNECTED.

The subrack has integral sliders at the top and bottom front edges which pass through notches cut into the module PCBs. Open and closed indication is provided by a pointer

on the mechanism being positioned opposite the open or the closed symbols marked on the subrack flanges. The open position is shown by a circle '○' and the circle is filled in '●' to indicate the closed position.

Under normal conditions, retention should not be required, but the slider should be left in the locked position. To achieve module retention the following procedure should be adopted:

- (1) Ensure that the slider is in the open position.
- (2) Check that each module has a small slot cut into the upper and lower edges of the PCB approximately 10mm from the front edge.

Note...I/O modules may have a blanking plug fitted in the top slot. Before fitting the module into the subrack remove this plug but retain it for future use. Should it be required to insert the module into a metal subrack, the plug must be re-fitted.

- (3) Fit the modules into their correct positions in the subrack, ensuring that they are all fully inserted.
- (4) Move the top slider toward the left until the pointer is opposite the closed symbol
- (5) Move the bottom slider toward the right until the pointer is opposite the closed symbol. All modules will now be retained in position.

Note...Any one module without the cut in the PCB edge, still with the blanking plug on or not fully inserted will prevent the correct operation of the slider.

- (6) To remove a module, move the upper and lower sliders to the open position and eject the module.

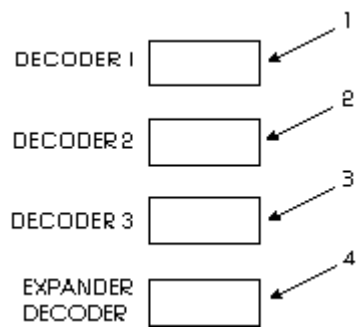
7.9. Address Decoder Switches and Address Marking

7.9.1. Address Decoder Switches

The Address Decoder Switches should now be set up, as discussed in Chapter 3.

7.9.2. Address and Module Label Marking

The data table addresses can be written on the self-adhesive label which is supplied loose for the user to stick on the inside of the right-hand cheek of the subrack. Figure 7.7 shows a decoder setting label which may be fitted to GEM 80-400 Standard subracks only. Module type and re-order numbers should be written on the lower rail 'slide in' label of the I/O subracks.



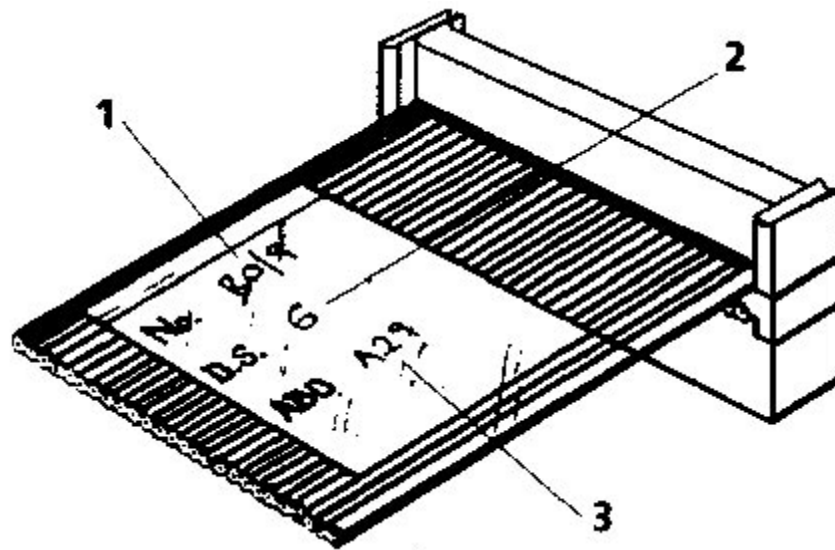
1. Decoder Switch Setting S1
2. Decoder Switch Setting S2
3. Decoder Switch Setting S3
4. Expander Decoder Switch Setting

Figure 7.7 - I/O Label

7.10. Ribbon Cable Connectors

There is a self-adhesive strip label on the cable next to the connector which has a 'write-on' area for identifying where it connects to and also other information; see Figure 7.8 for details.

If extra labels are required, they are available from ALSPA DRIVES & CONTROLS on Order Ref.20T0094/01 (10 labels per sheet).



1. Cable Destination (Subrack/Slot No. or Plug No.)
2. Decoder Setting of panel into which the cable plugs (if applicable)
3. Half-Panel Address or Address range (if applicable)

Figure 7.8 - Typical Example of Ribbon Cable Labelling

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8. Commissioning

8.1. Introduction

Your GEM80 controller and I/O will have to be configured to meet your particular requirements. It is extremely unlikely that these requirements are the same as those of other GEM80 customers. Therefore, we can only give you general commissioning procedures rather than specific ones for your particular system.

However, you should easily be able to pick out the parts of the procedures listed below which are relevant to your particular system.

8.2. Preparation

Before you start commissioning your GEM80 system, you should already have:

- Installed the equipment and cabled it up, including all earth (ground) connections as given in Chapters 7 and 11 of this manual.
- Cabled up the watchdog and safety circuits in accordance with the guidelines given in Chapter 11 of this manual and - most important - checked out the operation of these circuits (see the 'Safety Circuits Checks' section later in this chapter).
- Plugged in all modules, taking adequate care about how you handle them. If you don't know the rules to observe, refer to the safety and handling precautions detailed in Chapter 1. If for any reason a module will not plug in easily, it is highly likely that you are trying to fit the wrong type for the particular slot in the subrack, and the mechanical interlock is preventing you from plugging it in. In this case, don't try to force the module in, but first check that the module ordering code agrees with that given on the subrack label.
- A suitable GEM80 programming tool, such as Gemesys 3, with a stock of suitable storing media.
- Ensured that all pertinent regulations, particularly regarding the earthing of equipment, have been adhered to.

8.3. Documents Required

During commissioning the following documents will be required:

- A User/Technical Manual for the particular model of GEM80 programming tool you are using.
- 'GEM80 Ladder Diagram Programming Manual', Publication No.T300.

These will allow you to write test programs for checking out the equipment. In addition, you will need User Information Sheets or Technical Manuals, depending on your system configuration, for:

- Basic I/O Modules
- Verification I/O Modules

and, optionally, in the case of Enhanced Controller systems:

- Fast I/O Modules
- Extra Central Highway Modules (such as IMAGEM videos, GEMLAN-D Modules, STARNET and so on)

8.4. Overview of Commissioning Procedure

To commission a GEM80 system, you need to check out everything to eliminate errors. The larger the system, the more things there are to check.

For instance, the wireperson may have connected wires to the wrong terminals. They may have only made one mistake in every thousand terminations, but that's enough - your system won't work the way you expected it to until the error has been put right. If not checked, your system might even cause serious machinery damage by switching on wrong outputs.

So, commissioning requires a methodical, painstaking approach. Don't try to speed up the procedure by cutting corners, or you'll land yourself with problems. The basic principle is to start off with a small amount of equipment, check it out thoroughly, and then, when you're 100% certain that it all works, add a bit more equipment, check that, and so on. The recommended sequence for commissioning is as follows:

- Check the hardwired safety circuits into which the watchdog operates.
- Check the power supply module.
- Check the processor module.
- Add to this the Basic I/O, inputs first, then outputs.
- Add to this the Verification I/O, inputs first, then outputs.
- Add to this the Fast I/O, again inputs first, then outputs (optional, with Enhanced Controller systems only).
- Add to this the serial links to other controllers, printers or VDUs.
- Add to this any extra Central Highway Modules, such as offline data storage memory, videos and associated memory modules, GEMLAND Modules, STARNET Modules, etc. (again, optional with Enhanced Controller systems only).

8.5. Safety Circuits Checks

- (1) If possible, remove the control supply that feeds the safety circuit. If, however, this circuit is continuously energised from a main circuit-breaker which cannot readily be opened during commissioning, break the circuit using any convenient contact which can be held open, such as a stop lock-off emergency stop push-button. This is one reason why the

watchdog follower relay should be put at the neutral end of the circuit.

- (2) Check with a multimeter that there is no voltage, relative to ground, on either of the watchdog terminals on the GEM80 controller subrack, and that they are safe to work on. Then connect a shorting link across these terminals
- (3) Reconnect the supply to the safety circuit.
- (4) Check that the watchdog follower relay energises
- (5) Operate each contact in the safety circuit in turn, one at a time.
- (6) Check that in every case the watchdog follower relay drops out, and re-energises when each contact is re-made.
- (7) Break the supply as in paragraph 1 above, remove the shorting link across the watchdog contacts, then re-apply the supply again
- (8) Check that the watchdog follower relay remains de-energised
- (9) For further stages in commissioning, especially if your GEM80 controller drives moving machinery, you should have an emergency stop push-button which you can use as a panic button, sited close to where you are working. If there isn't one there, you may want to install one. Connect it in series with the rest of the safety circuit, and check it out in the same way as you did for all the other contacts.

8.6. Power Module Checks

- (1) Disconnect all I/O equipment by unplugging, from the subrack that contains the processor modules:
 - Basic I/O and Verification I/O ribbon cables;
 - any Serial I/O ribbon cables.
- (2) Withdraw all modules from the controller subrack sufficiently to break their edge-connector connections. The front panel of each module should be about 30mm from the front face of the subrack.
- (3) Check that the power module is of the correct type, that its voltage is correct and whether it is suitable for ac, dc or both.
- (4) Check also that the type number on the power module agrees with the subrack identification for its position.
- (5) Check that the switch on the power module front panel is set to STANDBY or '0', depending on the type of power module fitted.
- (6) Push the power module fully home into the subrack. Switch on the power to the subrack.
- (7) Check that the POWER indicator on the power module is illuminated.

- (8) Set the switch on the power module front panel to RUN or '1', depending on the type of power module fitted.
- (9) Check the LED indicators for healthy conditions.
- (10) Set the switch on the power module to STANDBY or '0', depending on the type of power module fitted. Remove the power input.
- (11) Check that the POWER indicator lamp on the power module is extinguished.
- (12) If your system has more than one power module, repeat the above procedure for each one, finally leaving all power modules in STANDBY or '0'.

8.7. Processor Module Checks

- (1) Plug the 8239 Processor Module into the subrack in the correct location.
- (2) Check that the lithium/manganese dioxide battery on the module is fitted as follows:
 - (i) Open the battery cover located on the module front panel.
 - (ii) Pull the exposed tab of the insulating strip. The battery will then make contact with the circuit.
 - (iii) Close the battery cover.
- (3) Check that the ordering code of each module agrees with that shown on the lower subrack label strip.
- (4) Power up the programming tool.
- (5) Connect the programming tool and any peripheral equipment, e.g. printer. Connect the programming tool to a suitable power supply in accordance with the instructions in the relevant programming tool manual and switch the programming tool on.
- (6) Connect the programming tool to the processor module in the subrack using a lead that is terminated by a 15-way, 'D'-type connector at one end and a suitable connector, appropriate to the programming tool in use, at the other end. Connect the 15-way 'D'-type connector to the Printer/Programming Port on the front panel of the processor module of the controller, and connect the other end to the programming tool.
- (7) Reconnect the power input to the subrack(s). Power up the GEM 80 equipment, then set the switch(es) on the power module(s) in the subrack(s) to RUN or '1'. When the GEM 80 is powered up, a sequence of program self-testing commences. This is indicated by the alphanumeric display, which provides the following messages: 'BOOT', then 'TEST' and then a status message. If a fault code appears, check it against the fault code list to ensure that it is a reasonable fault.

- (8) Check the watchdog sequence as follows:

Using the GEM80 programming tool, select the appropriate mode allowing monitoring/editing of GEM80 Ladder Diagram Rungs, and then in the relevant mode, select 'CLEAR STORE'. (Refer to the programming tool manual for details of modes, etc.) Ensure that a physical connection exists, i.e. check that the corresponding LEDs are illuminated.

- (a) Check reply on the programming tool.

- If there is no link failure, the reply will indicate 'GEM 80-400', in which case go to the check at (b).
- If no link is established, the screen will show 'NOT CONNECTED TO GEM 80'. If a link is established but fails subsequently, it will show 'LINK FAILURE'. In either case, continue with the checks below:

- (i) Check that a suitable, correct connection is in place then power any of the power modules STANDBY or '0' and RUN '1' again, to re-initiate the start up self-test routine. Repeat the CLEAR STORE command from the programming tool.
- (ii) Check the reply to see if the link failure has cleared. If so, proceed with the checks at (b) below:
- (iii) If the link failure is still present, check that:
 - the programming tool is correctly plugged into the processor module (as given in paragraph (6) above);
 - the power module is still operating;
 - all subrack modules are correctly plugged into the subrack;
 - no pins have been bent on any of the connectors at the rear of the modules.
- (iv) Repeat items (i) and (ii). If the link failure has cleared, continue with the checks at (b).
- (v) If none of these checks succeed, remove the processor module and remove the battery. Leave for 5 minutes, then replace the battery and replace the processor module.
- (vi) Repeat items (1) and (ii). Check that the system watchdogs operate. If the link failure has cleared, continue with the checks at (b).
- (vii) If this check fails, replace the processor module and repeat items (i) and (ii) above. If the link failure has cleared, proceed with the checks at (b) below.
- (viii) If the link failure is still present, note as much detail as possible, including any fault codes, and contact Customer Support, ALSTOM DRIVES & CONTROLS, Kidsgrove, with this information.

- (b) Set the controller into the RUN mode.
- (c) Check that the Watchdog LEDs on the Processor light and extinguish a number of times, and finally remain lit.
- (d) Simultaneously with (c) check that the Watchdog relays can be heard to click in and out and finally remain energised.
- (e) Also check that, if there are no breaks in the safety circuit (such as emergency stop push-buttons operated), the Watchdog follower relay follows the action of the Watchdog relay, and also finally remains energised.
- (f) Satisfactory completion of the Watchdog sequence indicates that the GEM80 system self-checks are healthy. Switch the power module in the controller subrack to STANDBY or '0'.

8.8. Central Highway Modules

This section is relevant only to those users commissioning a GEM80-400S or GEM80-400 Enhanced Controller system, please continue to the next section if your system is Standard.

Having established a working PLC system, insert one Central Highway Module and commission the system as given in the 'Processor Module Checks' section. Repeat this procedure for each Central Highway Module to be incorporated. Refer to the relevant User Information Sheets for additional information on the individual modules.

8.9. Loading an Initial User Program

The GEM80 controller will not scan the I/O until a suitable user program is entered and the processor module is in RUN mode, single cycle. Therefore a user program must be loaded before any I/O checks can be made. This program could be the actual one to be used for controlling the plant, or it could be a much simpler and shorter program which is keyed in as the I/O is checked. It is assumed here that a program is keyed in as the checks proceed.

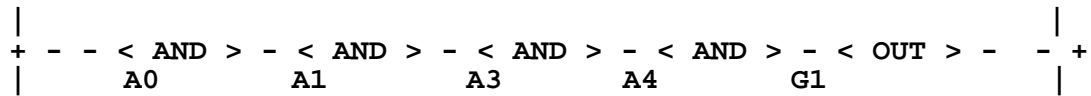
- (1) Connect the programming tool as given in the 'Power Module Checks' section, later in this chapter.
- (2) Power up the controller.
- (3) Key in a program and P-table data as required.
- (4) Re-compile the program. If you don't want to run the controller, you can do this with the SINGLE CYCLE command.
- (5) Switch the power OFF.

Each time in future that you want to modify the program, e.g. by adding further rungs, go into the edit mode, perform your modifications, then re-compile the program.

8.10. Basic and Verification I/O Logic Input Checks

A GEM80 series controller will only scan I/O addresses that are referred to in the user ladder program.

You can therefore begin by putting in a rung which contains a number of A-table references and outputs to an internal trash can workspace table location (e.g. G1), such as:



Each A-table word reference will cause the controller to scan all the bits contained in it, e.g. a reference to A3 in the ladder program will cause the controller to scan all the bits from A3.0 to A3.15.

Note...It should be noted that addresses above and below A3 are not scanned, i.e. A0-A2 and A4 onwards are not scanned.

To check the I/O inputs proceed as follows:

- (1) Check that the address and range switches are correctly set up on the 8191 Verification I/O Expander for the particular inputs you want to check. See Chapter 3 for the addressing principles.
- (2) Check the address switches on the Basic and Verification I/O Modules.
- (3) Check address decoder switches are correctly set on I/O Subrack backplanes relevant to the particular inputs you want to check.
- (4) Reconnect the I/O ribbon cables at the controller.
- (5) Check that I/O ribbon cables from expanders to subracks are complete.
- (6) Check plant cabling is completed to the Basic and Verification I/O equipment and to the plant input transducers.
- (7) Apply plant-side power to I/O input transducers but NOT to I/O output equipment.
- (8) Power up the GEM80 controller.
- (9) Set the programming tool connected to the GEM80 to 'MONITOR/EDIT GEM 80 AS DATA LIST' mode.
- (10) Select the ADDRESS ENTRY mode.
- (11) Check that the associated F-tables are cleared. Enter input references you want to check, e.g. A6.0, A7.1, etc.
- (12) Select MONITOR mode.
- (13) Operate the plant devices one at a time.

- (14) Check that each input state can be seen to change on the programming tool screen when the corresponding plant device is operated.
- (15) Check also each input by LED indication on the module front panel.

If checks (14) and (15) both fail for an input device, you may have:

a cable terminated on a wrong terminal or wrong module. Check the input LEDs to see whether another one changes state that ought not to.

If check (14) only fails, you may have:

- a decoder switch wrongly set on either an I/O Subrack or a Verification I/O Expander.
- a ribbon cable not plugged in.

If check (14) fails but not check (15), another possibility is that you haven't included a reference to the relevant A-table word in your test program. This may also be due to a conflict of addresses, e.g. Verification I/O Expander and Remote I/O Expander with overlapping addresses.

8.11. Other Basic and Verification I/O Input Checks

- (1) To test analogue inputs, operate the transducer to provide an input signal or where this is not possible, disconnect the transducer and simulate its output with a battery and potentiometer.
- (2) Check that a variation in each analogue input signal is registered as a change in value in the appropriate A-table word.
- (3) Check also that the values and changes of value are of the correct polarity. This is most important if the signal is used as the input to a closed loop control. If the polarity is wrong, it can usually be corrected by interchanging the connections on two adjacent terminals on a terminal rail.
- (4) Test any counter by operating it to provide an input.
- (5) Check that the relevant A-table word counts up. For bi-phase inputs, check that rotation in one direction causes counting up and in the other direction causes counting down and that the counter is operating in the correct sense. This is most important if the signal is to be used as the input to a closed loop position control. If the polarity is wrong, it can usually be corrected by interchanging the connections, for one of the two phases only, at a terminal rail. Check also that the relevant F-tables are cleared, i.e. no transient values.

Note...F-tables are not retained; the update of F-tables is dependent upon the success or failure of the scan.

8.12. Fast I/O Input Checks

If your controller does not include any Fast I/O Input Modules, skip to the 'Connecting Output Equipment' section of this chapter.

- (1) Switch OFF those power modules that feed the processor subrack and any separate Fast I/O subrack.
- (2) Insert the Fast I/O Driver Module in the processor subrack. Refer to Chapter 5 of this manual for details of the connection of a Fast I/O Driver. Note that the connections detailed must be in place before power is applied.
- (3) Plug in any Fast I/O Input Modules into the Processor or Fast I/O Subrack.
- (4) Switch on the power modules again. Assuming that the controller was previously running, it should come up running again.
- (5) Write one or more rungs into your test program that refer to the highest C-table address used by each Fast I/O Input Module. You do not have to declare every one, as you had to with A-table for the basic I/O inputs, but only the highest one per module.

Note...Once you have included a C-table reference in your program, the GEM 80 starts scanning the Fast I/O. If you have plugged in just the Fast I/O Driver Module but no Fast I/O Modules, then, once scanning starts, you will get a Fast I/O failure error message.

- (6) Set the programming tool to the DATA LIST mode, and monitor the C-table addresses you are using. Only a few of these addresses will actually appear in your user program.
- (7) Carry out tests generally along the same lines as for Basic and Verification I/O input. The only difference is that, with Fast I/O, all changes to inputs cause changes to the values in C-tables rather than A-tables, or D- tables rather than B- tables.
- (8) Additional types of modules in the Fast I/O range which have no equivalent in the I/O range are serial communications modules and dedicated controller modules. The details of these are quite complicated compared with normal input modules. Rather than unduly extend this chapter of the manual, we recommend you to study the User Information Sheets for these modules.

8.13. Basic, Verification and Fast I/O Output Checks

When you have proved as many of the controller inputs as practical, we recommend you to run a user program that drives the outputs. The I/O output only occurs when the I/O output is addressed by the ladder program.

To check the I/O output proceed as follows:

-
- Ensure that plant-side power is disconnected from the output modules.
 - With the GEM80 programming tool set to Data List mode (or suitable equivalent if Gemesys 3 is not your programming tool), check each I/O output in turn by writing 1 to the B-table addresses for Basic and Verification I/O and D-table for Fast I/O addresses and checking that the output at the appropriate module corresponds.
 - Check also that indicator LEDs light on the corresponding I/O output equipment when outputs are driven high by B-table or D-table bits that are '1'.
 - Ensure that the F-tables remain cleared at all times.

8.14. Connecting Output Equipment

Once you have checked the outputs and found them to operate correctly without plant-side power, the next stage in the commissioning procedure is to connect the plant-side power to them.

Check that each output device responds to the controller in an appropriate manner, e.g. when a B-table bit is set to 1, the corresponding coil or solenoid energises. The purpose of the checks, as for inputs, is to verify that all cabling has been correctly carried out.

At the GEM80 output modules, check that the output equipment has not overloaded any of the modules, i.e. on the respective modules, check the LEDs that indicate blown fuses. If any fuses have blown, the fault should be investigated and corrected. If, immediately after replacing a module, the fuse blows again, you are probably attempting to drive a load that is not correct for the module's output rating.

Note...The blown fuses must be replaced by fuses of the correct value. Such fuses are available from Cegelec Industrial Controls Ltd; refer to Chapter 10 of this manual for ordering codes.

8.15. Loading the User Program

When the power supply, and input and output checks have been completed satisfactorily the user program can be commissioned. The user program is downloaded from a suitable GEM80 programming tool, such as Gemesys 3.

In exactly the same way as for commissioning the hardware, you need to commission your program in a similar fashion. Don't expect it all to work first go. Commission a small part of the program first, check it as near to 100% as possible, add a bit more, and so on.

Information on user program commissioning can be found in the 'GEM80 Ladder Diagram Programming Manual', Publication No.T391.

8.16. Serial Links

If the system uses serial links, it is recommended that the program is first run with the serial links disconnected. If, as a result, the program has to wait for serial link data, the program can be altered temporarily, for commissioning purposes, so that the section of program that causes problems is by-passed, i.e. enclosed within START OF BLOCK and END OF BLOCK instructions.

When the system is working satisfactorily without the serial links, the serial links can be reconnected and the START OF BLOCK and END OF BLOCK instructions removed. The system can then be tested with the serial links connected.

Note...The Tx LEDs on the processor module, when it is configured as a Control Port, light when it attempts to transmit, even if no serial link connections are made.

There are several types of serial link. To keep this chapter reasonably brief, we cannot tell you in detail how to commission every individual type. Chapter 4 of this manual tells you what data to preset in the P-table for the various types of link, which are listed below:

(1) Printers or programming tools. Where you simply connect a printer, programming tool or VDU to your GEM80-400 Controller. Printer ports can be set to either direct or terminal mode.

(2) Second, there are ports talking to other GEM80 controllers and programming tools. These can be set to either free-running or user-controlled mode, with either standard or flexible table allocation.

Further information and examples of the P-table preset data for the various serial port configurations are given in the 'Serial Communications Manual', Publication No.T457.

8.16.1. Printer Ports

For outputting data to a printer or VDU, include the PRITEXT GEM80 Special Function in the program. The Printer port must be preset with the following data for the printer in use:

- the baud rate (bit/s),
- the character format (quantity of bits/character, odd/even/no parity), and
- any null characters required at the end of a print line (not normally needed on printers that have input buffer memory).

If these are correct, you should be able to output data messages from your program to the printer or VDU. The printer or VDU must, of course, be suitable for the signal level to which it is connected. The Tx LEDs will light when the GEM80 Special Function PRINT is set.

8.16.2. Processor Serial Links Connecting Controllers

Where serial links are used to provide communications between different GEM80 controllers, all the controllers must be commissioned before the serial links can be commissioned.

The simplest form of serial link is free-running with standard table allocation. For this type of link, write data into the K-table locations at the controller providing the control port, and check that it appears in the appropriate J-table locations of the tributary.

Similarly, if you have placed data into the K-table locations at one of the tributaries, the tributary should reply and the data should appear in the appropriate J-table locations at the control port.

For user-controlled serial link, you will also need to set values and bits in appropriate locations in I-table to initiate transmission, or to set message destinations.

Note...As with printer ports, control and tributary ports will only exchange data with each other if they are set to the same baud rate.

8.16.3. GEMSTART CCU Ports

The GEMSTART Contactor Control Unit (CCU) provides the necessary control and protection facilities required for Low Voltage Starter applications. Within the GEM80, the GEMSTART CCU option is selected by the P-table configuration shown in Table 4.10 of this manual.

8.16.4. Further Details

Refer to Chapter 4 of this manual for the P-table settings you need. See also the section on serial links in the 'GEM80 Programming Manual' for an introduction to ESP serial links. For further details on these, printer ports see the 'GEM80 Serial Communications Manual', Publication No.T457.

8.17. Fitting a Memory Expansion Board to the Processor Module

CAUTION...

The ESD precautions described in Chapter 1 must be observed while handling the 8239 Processor Module and the Memory Expansion board to prevent damage by electrostatic discharge.

To fit a memory board to the 8239 Processor Module proceed as follows:

- (1) Remove the processor module from the subrack and lay it on a clean, non-conductive, flat surface.
- (2) Remove the Memory board from its packing and pull up the four rivet fasteners at the corners of the board.
- (3) Position the memory board over the processor module and align the connector. Push home the memory board until the connectors are fully mated.
- (4) Push in the four rivet fasteners, applying only moderate force, until each one clicks into position.
- (5) Check visually that the memory board is correctly fitted and re-fit the processor module into the subrack.

8.18. Processor Modules fitted with FIP Interface Facility

If the processor is fitted with the FIP Interface facility then consult the FIP Manual T1653.

Some older controllers were fitted with separate FIP Interface modules. If attempting to fit an Interface board then the User Instructions sheet contained with the Interface should be followed. The same precautions are required as for fitting a Memory Expansion Module

8.19. A Few Final Comments

In the preceding paragraphs, we have not been able to tell you how to commission every type of unit or module you might have in your GEM80 system. However, we hope we have given you a sufficient introduction to commissioning for you to be able to see how, with the help of User Information Sheets and Manuals for particular products, you can commission any modules and units that have not been mentioned.

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9. Maintenance and Fault Finding

9.1. General

This chapter gives details of the upkeep and general maintenance requirements of the GEM80-400 Controller, and includes fault finding information which can be used in the event of either an in-service fault or faults which occur because of ladder program development.

GEM80 equipment requires very little maintenance. The memory support batteries have a long life expectancy, the period of which will depend upon the extent of their use.

9.2. Spare Modules

The fault finding procedures rely on substitution of suspected faulty modules with spare modules. These spare modules may be stored powered up (i.e. functional spares). It is recommended that all spare modules are powered up every 9 months to reform any electrolytic capacitors which may be fitted.

9.3. Cleaning and Visual Inspection of GEM 80

Cleaning and visual inspection of GEM80 should be carried out at time intervals determined by the customer. The equipment should be isolated from its main supplies and associated equipment.

9.3.1. General Maintenance and Cleanliness

- (1) Periodically, dust and dirt should be removed from enclosures using a vacuum cleaner, brushes and soft cloths.

CAUTION...

Never blow air into an enclosure to remove dust and dirt.

- (2) Visual checks should be made for signs of wiring or component damage and any damaged wiring or components should be renewed.
- (3) Check all terminations within enclosures for security.

9.4. Batteries

9.4.1. General

The battery life times depend on the proportion of time that the battery is supporting memory, and mains power is switched off.

The GEM80-400 Processor Module memory is supported by a 950mA/H lithium/manganese dioxide battery, which has a typical shelf-life of 6 years (4 years minimum) and a typical support life, after one year powered up, of 9 weeks minimum at 70°C or 47 weeks minimum at 40°C.

N.B. A type CR2477 battery **MUST** be fitted to modules having an orange battery holder, and type CR2477N **MUST** be fitted to modules having a grey battery holder

The memory modules which may be used with the GEM 80-400 Enhanced Controllers are supported by a lithium/copper oxide battery, which has a typical shelf-life of 10 years (5 years minimum). See chapter 10 for Replacement Suppliers.

The failure of any battery in a GEM80-400 system is detected and is represented by the message 'BATT' on the alphanumeric display of the processor module. In the case of an Enhanced system, if a 'BATT' message appears, check first the battery warning LEDs of any Central Highway Modules which may be fitted. If an LED is lit, replace the battery of that module as instructed in the User Information Sheet or Manual relevant to that module. If no LEDs are lit, or the system is Standard, replace the battery in the processor module, following the instructions given later in this chapter. Alternatively, an examination of the battery warning bits, F2.4 for the processor module battery low warning and F2.5 for Central Highway battery low warning, will indicate the faulty module.

When the battery warning message, BATT, is displayed, or when specified life times have expired, the batteries should be renewed.

9.4.2. Battery Connection Procedure

The battery is supplied with the GEM80-400 Processor Module, but not fitted. During transport and storage, an insulating strip, with the label 'Pull' on it, is wrapped around the battery, thus preventing connection to the circuit.

When the equipment is to be put into service, the battery must be electrically connected to the memory module in the following manner:

- (1) Open the battery cover located on the module front panel.
- (2) Pull the exposed tab of the insulating strip. The battery will then make contact with the circuit.
- (3) Close the battery cover.

The battery warning message, BATT, should disappear from the display.

9.4.3. Battery Replacement Procedure

Note...The system should be powered up while the battery is being changed to prevent the contents of the memory, i.e. user program and data tables, being lost.

Observe the safety and handling procedures detailed in Chapter 1; spares and reordering codes are detailed in Chapter 10.

The GEM80-400 Processor Module battery is replaced as follows:

- (1) Open the battery cover located on the module front panel.
- (2) Withdraw the battery.
- (3) Fit the new battery ensuring that the correct type and polarity is used.
- (4) Close the battery cover.
- (5) Dispose of the old battery as detailed in Chapter 1, 'GEM80 Batteries (Memory Support) - Safety Precautions for Disposal and Handling'.

In the 8272 Memory Module, the battery is replaced as follows:

- (1) Open the battery cover located on the module front panel.
- (2) Slide the battery out to its fullest extent.
- (3) Carefully disconnect the leads from the battery and remove the battery.
- (4) Fit the new battery and reconnect the lead with the red crimp to the positive terminal and the other lead to the negative terminal.
- (5) Slide the battery back into position and close the cover.
- (6) Dispose of the old battery as detailed in Chapter 1, 'GEM80 Batteries (Memory Support) - Safety precautions for Disposal and Handling'.

9.5. Fault Finding

9.5.1. Introduction

When a fault occurs in a system, it will be indicated initially by an error message number (error code) on the alphanumeric display of the processor module. Wherever the fault in the system, the GEM80 has built-in comprehensive fault finding facilities to indicate possible causes of the fault, not only throughout the plant but also within the GEM80 itself and these can be accessed by connecting a suitable GEM80 programming tool, such as Gemesys 3, to the processor module.

If a fault is detected which does not allow the controller to continue running, watchdogs are tripped, the controller halts, and the fault is reported at a suitable GEM80 programming tool by a three-digit error code and an English language text message. This message is displayed when the programming tool is connected. For example:

#601 CRC NOT STORED, PROGRAM MAY HAVE CHANGED

Not all error messages halt the controller. Error messages fall into five specific groups as shown in Table 9.1:

Table 9.1 - Error Messages

Error Message Number	Type of Error Message
#100 to #199	Compilation Errors
#400 to #499	Boot Code Test Errors
#500 to #699	System Status Errors
#700 to #799	Self-test Errors
#800 to #899	Interprocessor Communications Errors
#900 to #999	System Errors

In addition to the error messages, there is a data table which contains additional data for fault analysis and an area of memory which the user can program and document himself for fault analysis of problems in the plant. This data table, called the F-table, is covered in Chapter 2, and later in this chapter. Indicator lamps, and monitoring and test facilities are also available as detailed later in this chapter.

9.5.2. Monitoring and Test Facilities

It is possible to monitor program execution while the GEM80 is running, subject to observing the safety precautions detailed in Chapter 1 of this manual.

With a suitable GEM80 programming tool, such as Gemesys 3, connected, and the appropriate option of the initial screen selected, either specific rungs of ladder diagram or data table locations can be monitored. When monitoring a rung of ladder diagram program, contacts and coils are displayed as shown in Figure 9.1 to indicate their state (energised, de-energised, open or closed) and word mnemonics are replaced by the content of the element's data table.

...] [... Contact open
 —] [— Contact closed
 ...()... Coil de-energised
 —()— Coil energised

Figure 9.1 - Symbols Displayed in Monitor Mode

The control mode allows a choice of mode for the controller:

Halted, Normal Inputs; Halted, Test Inputs; Running, Normal Inputs; Running, Test Inputs; Non-Fatal Shutdown; Fatal Shutdown; Extremely Fatal Shutdown.

In Data Mode, up to 32 data tables can be displayed simultaneously and their contents monitored in hexadecimal, decimal, binary or ASCII text.

9.5.3. Indicators

9.5.3.1. Front Panel Indications

Where a fault is evident, a quick guide to the state of the system can be obtained from the front panel indications. Controllers have monitoring LEDs mounted on the module front panels. Chapter 1 details the meaning of these LEDs.

I/O modules have fuse indication LEDs on selected output modules; indicator lamps show the plant side state and the GEM80 logic side state. See the relevant User Information Sheets for details. The indication lamps give an idea of which parts of the system are faulty and, when the power module is healthy, a more detailed analysis of the problem will be required. Note also that other messages, via the alphanumeric display, provide indication of the state of the system.

9.5.3.2. Display

The four-character alphanumeric display provides the user with the following indications:

Run	-	System running
Halt	-	System halted
#nnn	-	Fault shutdown (nnn = error number)
!nnn	-	User watchdog trip (nnn = user error code)
Test	-	Full system self test
TRun	-	Run, Test Inputs
THlt	-	Halted, Test Inputs
BATT	-	Battery low warning
BOOT	-	System checks that main code is present and correct
F/W	-	Controller is in Firmware update mode; all GEM80 functions are suspended

9.6. User Program Checksum Calculations

All GEM80 controllers protect the user instructions running program and preset data from unnoticed corruption by calculating a checksum on the memory containing them. This is checked at start-up and also as part of the background self-test. When a change is made to the user program or preset data, the checksum is recalculated immediately.

9.7. Compilation and Compiler Error Messages (#100 to #199)

9.7.1. Compilation Error Messages

If a compilation error is detected, the compiler issues an error message number, in the range #100 to #199, and an error message. Compilation errors do not halt the controller, and the old program continues to run. Table 9.2 details the compilation error messages.

Table 9.2 - Compilation Error Messages

Code	Fault Message	Possible Causes	Recommended Recovery
#101	Source corruption. Error near instruction X, rung Y.	Could be caused by loading corrupt program. Could occur while programming, i.e. if lead becomes disconnected while inserting a complex rung.	Use back-up copy. Re-edit program with lead connected.
#102	Object RAM full.	Program too large for store.	Reduce program size. Add additional memory if capacity is available.
#103	Blocks over nested. Error near instruction X, rung Y.	Maximum depth of nesting is 16. End-of-block command overlooked.	Reduce nesting of blocks. Insert missing end-of-block command, if applicable.
#104	Data table RAM full.	Data tables are greater than 32,000 words (approximately). Use of large table location reference possibly accidental.	Reduce number of data table references in programme
#105	Basic I/O ref. Error at instruction data.	Same word referred to as both input and output, e.g. cannot refer to A0 and B0 in same program. Reference over table limit.	Words must be either input or output, not both. Change to within limits.
#106	Fast I/O fault or reference error at instruction data.	Reference to unused Fast I/O i.e. C- or D-table used by mistake.	Edit programme
#107	Special not included. Error at instruction X, rung Y, Special SZ or TZ.	The specified Special Function, 'SZ' or 'TZ' is not available in the controller. Special reference number entered wrongly.	Change for defined special, if possible. Edit program.
#108	Value missing or type incorrect. Error near instr. X, rung Y.	The user did not supply a required parameter or the correct type of parameter for a function.	Add/correct type of parameter required.
#109	Invalid address in value near instruction X, rung Y.	Non-existent address specified for VALUE. Writing to a write-protected data table. Insufficient tables after that in VALUE table for parameter.	Change to valid address. Change to a write-enabled table. Ensure highest table reference creates sufficient space.

Code	Fault Message	Possible Causes	Recommended Recovery
#110	Write protect violation. Error near instruction X, rung Y.	Cannot output to P- or V-tables.	Alter address to write-enabled data table.
#111	Illegal J/K reference. Error at instruction X, rung Y.	Attempting to access a J/K-table associated with a non-configured port, or one configured as a printer, or a reference over the table limit.	Configure port correctly, or change address to a different table. If port configured as a printer, then J/K-tables corresponding to that port cannot be used. If referencing outside the table limit, alter to be within the limits.
#112	Illegal S/T reference. Error at instruction X, rung Y.	S- or T- tables used other than in Special Function call.	Except for S0, S- and T-tables can only be used in Special Function calls.
#113	Reference over table limit. Error at instruction X, rung Y.	Attempt to read/write from non-existent location in a fixed sized table.	Alter instruction to be within the limits.
#117	Illegal L reference. Error at instruction X, rung Y.	Reference over limit.	Edit Programme
#118	Invalid off-line data file size. Block No. X.	Reference outside limits	Edit Programme
#119	Insufficient memory for off-line data.	Reference outside area available.	Edit Programme
#120	Value instr. present - not required. Error near instr. X, rung Y.	Value instruction is present, after Special Function, which is not needed.	Delete value instruction.
#121	No floating point variant possible. Error near instr. X, rung Y.	Instruction cannot use floating point data.	Convert to integer before input to Special Function.
#122	Instr. can't accept floating point. Error near instr. X, rung Y.	AND instruction which is not at the start of the rung, uses floating point.	
#123	Instruction can't accept integer. Error near instr. X, rung Y.	Floating point Special Function cannot use integer data.	Convert to floating point

Code	Fault Message	Possible Causes	Recommended Recovery
#124	Invalid Instruction encountered. Error at instr. X, rung Y.	User program has become corrupted.	Replace the specified instruction.

#125	Special Function without "S" or "T". Error at instr. X, rung Y.	A Special Function with a table letter other than 'S' or 'T' has been encountered.	Modify the Special Function.
#126	Cannot access odd floating point tables. Error at instr. X, rung Y.	Floating point values (in a pair of Q-table locations) are referenced by the even numbered location.	Modify the reference.
#127	Instruction has invalid letter. Error at instruction X, rung Y.	The associated table letter is outside the 'A-W' range.	Modify the instruction.
#128	Instruction needs a table location value. Error at instr. X, rung Y.	VALUE is not present, or is a constant where a table location is required.	Change to a required type of VALUE.
#129	Instruction needs a data value. Error at instruction X, rung Y.	The preceding Special Function requires a VALUE (either constant or table reference) to follow it.	Insert the appropriate VALUE.
#130	No value at end of instruction. Error near instruction X, rung Y.	The last instruction has been reached before the VALUE for a Special Function has been found.	Insert the appropriate VALUE.
#131	Rung stack underflow. Error near instruction X, rung Y.	User program has become corrupted.	Replace the specified instruction.
#132	Rung stack overflow. Error near instruction X, rung Y.	User program has become corrupted.	Replace the specified instruction.
#133	Rung imbalanced. Error near instruction X, rung Y.	Last rung not complete. Usually caused by halting transfer from the programming tool before transfer is complete.	Modify last rung.
#136	Invalid source of instructions.	The compiler is attempting to fetch instructions from an incorrect area of memory.	Power off/on and retry compilation. If problem persists replace controller.
#137	Invalid object region.	The compiler is storing object code to an incorrect area of memory.	Power off/on and retry. If problem persists replace processor module.

#139	P-table limit exceeded for system. Error near instr. X, rung Y.	Reference to P-table higher than allowed by system.	Optimise program or fit larger memory expansion board.
#140	Unmatched JUMP (data) at instruction number X, rung Y.	A JUMP was specified but no corresponding LABEL to which to jump was specified.	Add LABEL at appropriate place or remove JUMP if unintended.
#141	Duplicate LABEL (data) at instruction X, rung Y.	A LABEL number was specified in more than one place.	Change LABEL number or remove LABEL if unintended.
#142	Reverse JUMP (data) at instruction X, rung Y.	An attempt to JUMP backwards in the ladder program was found.	JUMPs can only be forwards.
#143	LABEL number (data) exceeds maximum at instruction X, rung Y.	Maximum LABEL number is 15.	Reduce LABEL number.
#144	JUMP number (data) exceeds maximum at instruction X, rung Y.	Maximum JUMP number is maximum LABEL number i.e. 15.	Reduce JUMP number.
#145	Insufficient space for message editor strings	Too many user messages have been defined.	Reduce number of messages or shorten them.
#146	FIP configuration error at PX		Edit Programme
#147	FIP database creation error No.% X		Edit Programme
#148	Serial link configuration error at P%d.		Edit Programme

9.7.2. Compilation Checks

On compilation, the controller performs the following checks:

- (1) Matching data table sizes to program requirements by searching for the highest specified location in each table.

Note...

1. This does not take into account blocks of data used by GEM 80 Special Functions where only the first location is specified. If such a block of data is at the

end of a table, a specific reference must be included to create a large enough table.

2. Also note that existing data table locations will be removed if they are no longer required by a program that has been modified. This can create confusion in the case of the P-table since they may be created simply by attempting to access them through a suitable GEM80 programming tool, such as Gemesys 3. Consider the situation where an address list containing P1000 has been created and the value 21 written to it. The program (which contains no reference above P500) is then re-compiled. On re-entering the data list mode, the message INVALID ADDRESS is displayed. If the list is cleared and P1000 re-entered, it will be found to contain 0 and not 21. This is because P1000 had been deleted on recompilation, but then recreated when the data list was renewed.

- (2) Generating and checking the I/O configuration data for Basic and Verification I/O.
- (3) Checking the legality of data table accesses, e.g. OUT to a P-table is not allowed
- (4) Checks the structure of the user program, e.g. depth of nesting of Obey Blocks.
- (5) Checking the correctness of VALUE instructions with COUNT and DELAY GEM80 Special Functions. This checking ensures that if a VALUE is required, it is present and of an acceptable type (e.g. write-enabled data table).
- (6) Checking that there is a START OF BLOCK instruction for every END OF BLOCK instruction and vice versa, and checking LABEL and JUMP GEM80 Special Functions
- (7) Checking, in the case of an Enhanced Controller with a Fast I/O Drivers fitted, the existence of Fast I/O references.

9.7.3. Error Messages #105 and #106 and I/O Scanning

9.7.3.1. I/O Scanning

In a similar way to computing the sizes of data tables, so also, a GEM80-400 Controller computes what I/O ought to be present from the addresses appearing in the user program. The controller only attempts to read input data from, and send output data to those I/O devices whose addresses appear in the program. Refer also to the F-tables, F200 to F329, for further details. The rules that the controller uses in its computation of which I/O table words to scan are given here:

9.7.3.2. Basic and Verification I/O

Only those Basic and Verification I/O words appearing in the program are included in the I/O scan. For instance, if the program contains a contact referenced A1.0, the whole word A1 will be read from the input modules and units. If a module is fitted and set it to an address that is not referred to in the program, this module will not be scanned; no data will be read from or written to it.

When compilation is attempted the program will not run if any forbidden addresses have been used in the program, and the programming tool will display a diagnostic message.

Forbidden addresses are where A-table and B-table addresses have the same number (e.g. A4 and B4) or where addresses have a number greater than the maximum imposed by the hardware, i.e. greater than 1039.

9.7.3.3. Fast I/O

The Fast I/O Driver slot in the Controller subrack is allocated a possible 1024 C-table and 1024 D-table words. Thus, the Fast I/O Module in the first slot of the Fast I/O area of a GEM80-400S subrack or in the first slot of the Fast I/O Subrack of a GEM80-400 Enhanced Controller can use C0 to C31 and D0 to D31; the Fast I/O Module in the second slot can use C32 to C63 and D32 to D63, and so on. The lowest table addresses for any given slot are referred to as the 'base addresses', e.g. C0 and D0, C32 and D32, and so on.

When compilation is attempted, the program will not run if an invalid Fast I/O address is used because of lack of response from the invalid address, and a diagnostic message is displayed on the programming tool screen.

9.7.4. Programming Routine for Correction of Compilation Errors

To correct a program with several errors, the user should use the 'Search' facility to display and modify the first faulty rung. A recompilation gives information about the next error. This procedure may be repeated until the program compiles successfully.

Note...A single error may cause several to be reported, e.g. an incorrect I/O reference.

If the compilation is successful, the following message is displayed on the programming tool screen for 10/15 seconds, and held on the System Log:

'Compiled ("main"). Instructions available xxx. Data tables available yyy.'

Each compile error is reported as shown:

'#1xx <compile_error> at rung xxx: yyy, (instruction zzz).'

where xxx is the rung number (as used in the GEM80 programming tool Gemesys 3), yyy is the number of the instruction within the rung, zzz is the instruction number within the program.

CAUTION...

It should be noted that if the only reference to a B-table, or the only reference to a Fast I/O Module, is deleted from a program and a recompilation performed, the I/O hardware associated with that table will no longer be scanned. This could result in outputs being left in an uncontrolled state until the next power up.

9.7.5. Compilation Errors and the Controller

Compilation errors cause the controller to continue executing the previous successfully compiled version of the user program, and give a fault report from the failed compilation. The System Log, available only with Gemesys 3, can display up to 50 compiler error messages (out of 100 System Log locations).

When the controller is running and the user makes changes to the source version of the program, the status is displayed on the programming tool as CHANGED instead of RUNNING until such time as the user recompiles. If the controller is running with status CHANGED and there is a power interruption, the controller will go into halt mode after power-up and give a fault report: "PROGRAM DIFFERENT FROM RUNNING VERSION", or "POWER REMOVED WHILE PROGRAM IN A CHANGED STATE".

As part of the self-test procedures which the controller undertakes, there is a check that there has not been any alteration to program instructions and data in the P-table. Each time the user makes changes to his program or P-table data, the controller has to recalculate a CRC value. If power is interrupted before this calculation is complete, the warning message: "CRC NOT STORED, PROGRAM MAY HAVE CHANGED" is displayed on power up, and the controller goes into halt mode. The user may, however, run the program if desired.

9.8. System Status at Power Up (#500 to #699)

If, during the power-up self-test cycle, one of these fault conditions is detected, the GEM80-400 Controller will remain in the 'halt' condition and return the fault message until the fault is cleared. The fault messages are detailed in Table 9.3.

Table 9.3 - System Status Error Messages

Code	Fault Message	Possible Causes	Recommended Recovery
#501	Monitor Firmware CRC Test Fail.	Firmware has been corrupted.	Power off/on. If this does not work the board is permanently damaged.
#502	System Firmware CRC Test Fail.	Firmware has been corrupted. A failure occurred during firmware update.	Power off/on. Update firmware. If this does not work the board is permanently damaged.
#503	No Valid System Code Found.		Power off/on If this does not work the board is permanently damaged.

Code	Fault Message	Possible Causes	Recommended Recovery
#504	Invalid Monitor Mode Selected.	A 'jumper' link has accidentally been left on one of the brown test points, or the board is damaged.	Remove any 'jumper' links from brown test points.
#505	Workspace Ram Test Failed.	Faulty/static damaged RAM chips.	Power off/on. If this does not work the board is permanently damaged.
#506	Unsupported Firmware EPROM Type. L(%x) H(%x).	The flash EEPROM device types cannot be updated by the firmware update mechanism.	Keep at current firmware issue, if trying to do a firmware update. Otherwise new Flash EEPROMs required.
#602	Power removed while User Program in a Changed State.	The user program has been edited and the controller powered down before the program was recompiled. The controller will be halted on power up.	Recompile program.
#603	V-table corrupted program store cleared.	Memory corruption of important data occurred, treated as a new system. Could be caused by turning power off during compilation, or faulty processor module. It may be a flat battery, but battery warning should occur first.	Power off/on and reload. If problem persists, suspect processor or data table RAM module, and substitute spare. Check for flat battery and substitute spare if necessary.
#604	New System program store cleared.	Brand new system. Occurs if RAM boards are swapped or replaced.	Continue as for a new system.
#606	Unable to switch to RAM.	Failed to copy program to RAM when the S0 location was set to 0.	The RAM/EPROM module is probably faulty and should be replaced.
#607	Unable to switch to EPROM.	Failed to switch to EPROM when the S0 location was set to 1. EPROM is either blank, invalid or not present.	Check that valid EPROM sub-modules are inserted in all the modules and try again.
#608	Failed to program EPROMs.	One of the EPROM sub-modules contains faulty EPROMs.	Reset S0 to 0, replace EPROM sub-modules with erased EPROMs and try to program EPROMs again.
#610	EPROMs not programmable.	Failed to program EPROMs when the S0 location was set to 2, because EPROM is not blank.	Reset S0 to 0, replace EPROM sub-modules with erased EPROMs and try to program EPROMs again.

Code	Fault Message	Possible Causes	Recommended Recovery
#614	EPROMs not fitted.	Attempting to switch to EPROM or to program EPROM with sub-module missing.	Insert missing EPROM module and try once again.
#620	EPROM compatibility level does not match this system.	EPROMs were programmed in a different system to this one.	Blow user program into EPROM using the system on which it is required to run.
#621	Processor unable to suspend	This fault is most likely to occur with IMAGEM. A command which involves checking the user EPROM (e.g. RECOMPILE) was invoked while the IMAGEM system was displaying a long format.	Try the command again. If the fault persists, contact Cegelec Industrial Controls Ltd with details of the user program, the IMAGEM formats and the firmware issues.
#626	Write protect switch set, FLASH EPROM cannot be written to.	FLASH EEPROM memory sub-board write protect switch is in the 'PROTECT' position during an attempt to program.	Set protect switch to 'PROG' position and try again.
#627	FLASH EPROM not present or faulty.	The Processor cannot see a FLASH EEPROM memory sub-board.	Fit a FLASH EEPROM sub-board. Replace FLASH EEPROM sub-board.
#628	FLASH EPROM could not be written to successfully.	FLASH EEPROM memory sub-board cannot be programmed/erased.	Replace FLASH EEPROM sub-board.
#629	FLASH EPROM programming failed.	FLASH EEPROM memory sub-board cannot be programmed.	Replace FLASH EEPROM sub-board.
#630	FLASH EPROMs are empty.	User has requested that the controller runs the user program stored in EEPROM, but the EEPROM is empty.	Ensure EEPROM is programmed before switching to it.
#631	EPROM corrupted, Clear Store Required.	EPROMs have been corrupted whilst powered down.	Place the EPROM board in program mode. Clear store and reload the program.
#632	EPROM Program not Stored, Clear Store Required.	EPROM program not compiled before powering off.	Clear store and reload the program.
#633	New System, EPROMs empty.	Brand new system. Occurs if expansion boards are swapped or replaced.	EPROMs are empty, so load program.
#634	New System, Program in EPROMs.	Brand new system. Occurs if expansion boards are swapped or replaced.	Run program.

Code	Fault Message	Possible Causes	Recommended Recovery
#635	Program in EPROM is different from previous version.	EPROM board swapped for different program.	Verify new program is correct. Do not run the new program if it is incorrect. Clear store and reload correct program. Run new program.
#636	System Log cleared	The user requested Log clear has been executed.	(Information message only)
#637	System Power up.		(Information message only)
#638	System Store Cleared.	The user requested Store clear has been executed.	(Information message only)
#639	Sub-board removed during power down, store cleared		If a RAM sub-board; re-fit and reload user program. If an EPROM sub-board; re-fit and switch to EPROM
#640	Failed to Erase EPROM memory.	FLASH EPROM memory sub-board cannot be erased.	Replace FLASH EEPROM sub-board.
#641	Failed to Program EPROM memory.	FLASH EPROM memory sub-board cannot be programmed.	Replace FLASH EEPROM sub-board.

9.9. Self-test and Self-test Failure Error Messages (#700 to #799)

9.9.1. Self-test Error Messages (#700 to #799)

On the occurrence of self-test failure, the controller halts and it will not restart unless the fault is cleared and power switched off and back on again. Table 9.4 details these error messages. The CRC system referred to in Table 9.4 is discussed in the 'User Program Checksum Calculations' section of this chapter.

Table 9.4 - Self-test Error Messages

Code	Fault Message	Possible Causes	Recommended Recovery
#702	Object RAM checksum failure.	On-line corruption	Power off/on will re-initiate the RAM, but it may fail again. Substitute spare processor module and sub board if fitted.

Cod e	Fault Message	Possible Causes	Recommended Recovery
#703	User program checksum failure.	Source code corrupted.	Try clear store, power off/on and reload. If the problem persists,. Substitute spare processor module and sub board if fitted.
#704	V-table checksum test failure.	On-line RAM failure.	Power off/on (will give #603), then reload. If the problem persists, Substitute spare processor module and sub board if fitted..
#705	Processor local RAM failure	Failed processor module.	Substitute spare processor module and sub board if fitted.
#706	FLASH checksum error.	Faulty data table/source code.	Substitute spare processor module and sub board if fitted.
#707	Bit logic test failure.	Failed processor module.	Substitute spare processor module and sub board if fitted.
#708	Watchdog test failure. Status %d, State %d	Suspect failed processor module. Could be a faulty backplane but more likely to get #719 first in this case.	Substitute spare. If the problem persists, or #719 occurs, suspect backplane and substitute a spare subrack. Note the %d figures when returning the faulty items.
#709	PSU Test Failure	Suspect faulty PSU or Processor	Substitute PSU. If fault persists substitute processor
#710	Battery failure.	Flat or disconnected battery. Note...Watchdogs do not trip.	Dump program, change battery and reload.
#716	User requested watchdog trip F1 = data.	F1 set to non-zero value by user program.	Check user program software for reason. Power off/on to restart.
#717	Bus timeout @CS:IP = %x:%x	Faulty processor or RAM module.	If problem persists after power off/on, substitute a spare module. If the problem is intermittent, check installation/segregation .

Code	Fault Message	Possible Causes	Recommended Recovery
#718	Program corrupted during power down store cleared.	Only occurs on power-up. P-tables or instructions corrupted.	Clear store, power off/on and reload, check battery warning indication. If the problem persists, Substitute spare processor module and sub board if fitted.(see also #703).
#719	Watchdog self trip. Error No. %d	Watchdog detected error, contacts open. Faulty backplane or processor module Error No Watchdog Tripped 1 0 2 1 3 FIP 4 No apparent cause	Substitute processor module. If problem persists substitute spare subrack (see also #708)
#729	Basic I/O test failure.	Faulty connection, cable short, faulty I/O module or faulty processor module.	Investigate connections and referenced I/O device. If problem persists, substitute spare processor module and lastly, spare subrack.
#730	User program RAM test failure.	Faulty RAM on processor module or memory board.	Substitute spare processor module and sub board if fitted.
#731	Data table RAM test failure.	Faulty RAM on processor module.	Substitute spare processor module and sub board if fitted.
#732	Object RAM test failure.	Faulty RAM on processor module or memory board.	Substitute spare processor module and sub board if fitted.
#733	Firmware checksum failure.	EPROMs have failed.	Substitute spare processor module and sub board if fitted.
#734	Battery failure and power removed when in a changed state.	Battery has failed and changes to user program have been lost by power off/on.	Change Battery. Re-load user program and re-edit.

Code	Fault Message	Possible Causes	Recommended Recovery
#735	Failed P Message area RAM test.		Re-load backup program/P-tables/messages. If problem persists Substitute spare processor module and sub board if fitted.
#737	P-table checksum failure.		Re-load backup program/P-tables/messages.. If problem persists substitute spare processor module and sub board if fitted.
#738	Message editor checksum failure.		Re-load backup program/P-tables/messages and re-edit message. If problem persists substitute spare processor module and sub board if fitted.

Wherever % is shown the number displayed when the fault occurs should be noted and Customer Support contacted.

9.9.2. Self-test System

The self-test system operates as shown:

9.9.2.1. Execution

One full cycle of start-up tests at power up.
I/O tests repeated every scan.
Regular on-line repetition of running tests.

9.9.2.2. Faults which immediately trip the watchdog

- (1) AC supply break longer than the minimum 10ms ride-through period.
- (2) Power supply module failure.
- (3) Failure of processor module.
- (4) No response from system memory modules.
- (5) Power supply module confidence check.

9.9.2.3. Faults which trip the watchdog when detected by running tests

- (1) Alteration detected in the contents of the read only memory.
- (2) Failure of any part of the read/write memory to store and recall data.

9.9.2.4. Faults from which recovery is automatic

- (1) AC supply reapplied after a break.
- (2) Corrupt message received on the serial link.

9.9.2.5. Faults which the user may program to trip the watchdog

There is no restriction on the user programmable watchdog trips. Any ladder rung which writes a non zero value into F1 will cause a watchdog trip. It is recommended that the values chosen are different from the internally generated trip codes to ease fault finding

9.10. Interprocessor Communications (Error Messages #800 to #899)

Table 9.5 details the Interprocessor Communications Error Messages.

Table 9.5 - Interprocessor Communications Error Messages

Code	Fault Message	Possible Causes	Recommended Recovery
#806	IPC timeout to data.	Refer to #717	Refer to #717
#807	Task %i IPC error data.	Refer to #717	Refer to #717
#808	Processor timeout data.	Refer to #717	Refer to #717
#809	Chics error data while creating a message. Task %i	Refer to #717	If any of these faults occur, contact Cegelec Industrial Controls with the following information a) the controller ordering code; b) the firmware issue number c) the circumstances in which the fault Occurred d) the specific fault code
#810	Chics error data while waiting for message. Task %i		
#811	Chics error data while sending a message. Task %i		
#813	Pmes error. Wrong reply received.		
#814	Invalid processor reply data		
#815	Reply received from unknown processor data		
#816	Region access error data, task %i		

9.11. System Errors (Error Messages #900 to #999)

These errors concern internal maloperation of the executive software. Try power off/on; if the problem persists, it should be reported immediately with details of the fault message (they contain variable fields), user program and I/O configuration. Table 9.6 details the System Errors.

Table 9.6 - System Errors Error Messages

Code	Fault Message
#900	Unknown error data.
#901	%i task. Illegal task number used.
#902	%i task. Too many messages sent.
#903	%i task. No messages available.
#904	%i task. No messages to return.
#905	%i task. Message not received.
#906	%i task. Illegal interrupt number used.
#907	No room in region queue.
#908	Not in region when executing EXIT_PLC_REGION.
#909	Insufficient memory for organiser tables.
#910	Interrupt already defined.
#911	Insufficient memory for organiser tables.
#912	Insufficient memory for organiser tables.
#913	%i task performed return.
#914	Pascal error.
#915	Divide overflow.
#916	Range check overflow.
#917	Trap interrupt.
#919	%i task stack overflow.
#920	User Program not compiled.
#921	Transmit timeout on serial link data.
#922	Software watchdog trip.
#923	Too many interrupt levels defined.
#924	Organiser interrupt timeout (inter processor).
#925	Floating Point Unit error.
#926	%l task. Timeout in Start-up. %l task
#928	Unused interrupt @cs:ip = %x:%x
#929	Unused Opcode. @cs:ip = %x:%x
#931	Error message data is too long.
#932	Error message data has insufficient number of parameters.
#933	Error message data has excess parameters.
#934	Error message data ended prematurely.
#935	Error message data has invalid character.
#936	Error message data has invalid format specified.
#937	Error message data generated invalid hex character.
#938	Error message data invalid task number.
#939	Error message data included string too long.
#940	Could not switch state in Error Handler.
#941	Invalid state transition. State data, transition data.
#942	Invalid state data.
#943	Source pointer not in region.
#944	Source pointer beyond region.
#945	Invalid memory type data.

#946	Invalid memory size data.
#947	Invalid processor Id. data.
#948	Invalid call.
#949	Invalid return.
#950	Invalid switch.
#951	Memory board type not supported.
#952	EPROM types are Incompatible.
#957	Power failure.
#958	DMA 1 interrupt.
#959	DMA 0 interrupt.
#960	Single step error.
#961	INT0 interrupt.
#962	Escape Opcode error.
#963	Array bounds error.
#964	Invalid timer interrupt.
#965	FIP interrupt.
#966	Invalid key switch position.
#967	Invalid serial link interrupt.
#968	Unexpected Watchdog Interrupt.
#969	Unexpected Central Highway Interrupt.
#970	FIP error during initialisation data.
#971	CHICS memory RAM test failure.
#972	Invalid message received from STARNET Module data.
#973	Int1 Interrupt FIP Error
#974	FIP Generated Fatal Error no. %x
#975	FIP Network Initialisation failure
#976	FIP Medium invalid, error %x
#977	FIP RAM Test failure, error %x
#978	FIP BA Start error no %x
#979	FIP BA Stop error no. %x
#980	FIP Hardware/ Software incompatibility
#981	FIP Delete BA macro cycle error no %x
#982	FIP Create BA macro cycle error no. %x

%x value should be available when contacting Cegelec Customer Support for assistance

9.12. F-Table Usage

Data in the F-table provides further information on fault diagnosis. The contents of the F-table are detailed in Table 9.7. The Serial Link Diagnostics are shown in Tables 9.8 to 9.11. The F-tables are used by the system to store fault codes and Serial Link Statistics and are allocated as shown in Tables 9.12 to 9.14.

Table 9.7 - F-Table

Address	Content	Remarks
F0	Reserved	-
F1	User required watchdog trip	Any non-zero value placed in F1 by the user program trips the watchdog, terminates program execution and displays a fixed diagnosis message on the programming tool screen
F2	System fault bits	-
F2.0	-	Set to 1 if previous program cycle exceeds preset scan time

F2.1	-	Set to 1 if recompile successful. Set to 0 if unsuccessful
F2.2	-	Set to 1 if recompilation will occur on the current scan
F2.3	-	Reserved
F2.4	Battery condition. Onboard battery low warning bit	Set to 1 if battery power low
F2.5	Central Highway battery low warning bit	Set to 1 if battery power low
F2.6 to F2.15	Reserved	-
F3	FIP Run Time Fault Flags	
F4	FIP Configuration Fault Information	
F5	Reserved	-
F6	NMI Count	
F7 to F9	Reserved	
F10 to F69	Serial link diagnostics	See the Link Diagnostics section of this chapter
F10 to F29	Serial link diagnostics for Serial Port 1	-
F30 to F49	Serial link diagnostics for Serial Port 2	-
F50 to F69	Serial link diagnostics for Serial Port 3	-
F70 to F129	Serial link statistics	See the 'Link Statistics' section of this chapter
F70 to F89	Serial link statistics for Serial Port 1	-
F90 to F109	Serial link statistics for Serial Port 2	-
F110 to F129	Serial link statistics for Serial Port 3	-
F130 to F199	Reserved	-
F200 to F329	Basic and Verification I/O Fault Indication	See I/O Statistics section of this chapter
F330 to F499	Reserved	-
F500 upwards	-	These tables are available to the user program

9.13. Serial Communications Diagnostic F -Tables

Each of the three serial ports is allocated 20 F-tables as follows:

Port 1 - F10 to F29

Port 2 - F30 to F49

Port 3 - F50 to F69

The meaning of the data stored depends upon the working mode of the serial port, e.g. Printer, ESP Tributary, etc.

9.13.1. Printer Port

No fault diagnostics are available when any of the ports is used as a printer port.

9.13.2. ESP Tributary Port

Table 9.9 - ESP Tributary Port F-Tables

Port 1	Port 2	Port 3	Remarks
F10.0	F30.0	F50.0	Tributary failed (set when tributary has not been polled for at least 30 seconds).
F10.8	F30.8	F50.8	Last message received was truncated.

9.13.3. ESP Control Port

Port 3 is not available as a control port

Table 9.10 - ESP Control Port F-Tables

Port 1	Port 2	Remarks
F10.0	F30.0	Route 0 failed
F10.1	F30.1	Route 1 failed
F10.2	F30.2	Route 2 failed
F10.3	F30.3	Route 3 failed
F10.4	F30.4	Route 4 failed
F10.5	F30.5	Route 5 failed
F10.6	F30.6	Route 6 failed
F10.7	F30.7	Route 7 failed
F10.8	F30.8	Last message on route 0 was truncated
F10.9	F30.9	Last message on route 1 was truncated
F10.10	F30.10	Last message on route 2 was truncated
F10.11	F30.11	Last message on route 3 was truncated
F10.12	F30.12	Last message on route 4 was truncated
F10.13	F30.13	Last message on route 5 was truncated
F10.14	F30.14	Last message on route 6 was truncated
F10.15	F30.15	Last message on route 7 was truncated
F11	F31	Route 0 diagnostics
F12	F32	Route 1 diagnostics
F13	F33	Route 2 diagnostics
F14	F34	Route 3 diagnostics
F15	F35	Route 4 diagnostics
F16	F36	Route 5 diagnostics
F17	F37	Route 6 diagnostics
F18	F38	Route 7 diagnostics
F19 - F29	F39 - F49	Not used

The diagnostics words are defined as follows:

- bits 0 to 7 Address of last responding tributary
- bits 8 to 11 Fault code
- bits 12 and 13 Not used
- bit 14 Set when transfer failed
- bit 15 Set when transfer successful

Fault codes

- 0 Successful transfer
- 3 Transmission failed
- 4 Hardware error
- 5 NAK received
- 6 CRC of received message failed
- 7 Wrong terminator received
- 8 Received message too long

- 9 Data error (incorrect data format)
- 10 No tables assigned to this route

9.13.4. GEMSTART CCU Port

Port 3 is not available as a CCU port

The fault bits for the GEMSTART CCU protocol indicate which addresses are connected and are replying correctly to the master polls. The fault bit is set when an address has failed.

Table 9.11 - GEMSTART CCU Port F-Tables

Port 1	Port 2	Remarks
F10.0	F30.0	Address 0 failed
F10.1	F30.1	Address 1 failed
.	.	.
.	.	.
F13.14	F33.14	Address 62 failed
F13.15	F33.15	Address 63 failed
F14 to F29	F34 to F49	Not used

9.14. Serial Communications Links Statistics F-Tables

Each of the three serial ports is allocated 20 F-tables for Serial Link Statistics as follows:

- Port 1 - F70 to F89
- Port 2 - F90 to F109
- Port 3 - F110 to F129

The first two statistics for each port are in two locations each and can be interpreted as follows:

$$= (65,536 \times \text{Value in higher location number}) + \text{Value in lower location number}$$

The other statistics are stored in a single location and can have a maximum value of 65,535 (@FFFF). The meaning of the data stored depends upon the working mode of the port, as shown in the following tables:

9.14.1. Printer Ports

Link statistics not available when any of the ports is used as a printer port.

9.14.2. ESP Tributary Ports

Table 9.12 - ESP Tributary Port Link Statistics

Port 1	Port 2	Port 3	Contents
F70 and F71	F90 and F91	F110 and F111	Number of messages received
F72 and F73	F92 and F93	F112 and F113	Number of replies sent to control port

F74	F94	F114	Number of hardware errors (Framing errors)
F75	F95	F115	Number of time-outs
F76	F96	F116	Number of CRC errors in received data
F77	F97	F117	Number of data errors. Incoming message too large for b
F78	F98	F118	Number of transmit data errors
F79	F99	F119	Number of stuffing errors
F80	F100	F120	Number of ENQs received. Requests for a resend
F81	F101	F121	Mode error
F82	F102	F122	Transmission time-outs
F83	F103	F123	Overrun error
F84	F104	F124	Break error
F85 to F89	F105 to F109	F125 to F129	Not used

9.14.3. ESP Control Ports

Port 3 is not available as a control port

Table 9.13 - ESP Control Port Link Statistics

Port 1	Port 2	Contents
F70 and F71	F90 and F91	Number of message requests
F72 and F73	F92 and F93	Number of attempted transmissions (including retries)
F74	F94	Number of hardware errors
F75	F95	Number of time-outs. on receive
F76	F96	Number of CRC errors in incoming message
F77	F97	Number of NAK replies. Short messages received
F78	F98	Number of terminator errors
F79	F99	Number of data errors. message to big for buffer
F80	F100	Transmit time-outs
F81	F101	Overrun error
F82	F102	Break error
F83 to F89	F103 to F109	Not used

9.14.4. GEMSTART CCU Ports

Port 3 is not available as a CCU port

Table 9.14 - GEMSTART CCU Port Link Statistics

Port 1	Port 2	Contents
F70 and F71	F90 and F91	Number of message requests
F72 and F73	F92 and F93	Number of attempted transmissions (including retries)
F74	F94	Hardware errors
F75	F95	Time-outs
F76	F96	CRC errors
F77	F97	Data errors
F79 to F89	F99 to F109	Not used

9.15. I/O Statistics

There are 2 bits of statistics per I/O address, starting with F200.0 and F200.1 for I/O address 0.

The first 16 I/O addresses, (A/B0 to A/B15) are Basic I/O and therefore their statistics are reported in the first 16 pairs of statistics bits. For each pair of Basic I/O statistics bits, bit 0 is set if a fault occurs during data transfer to the address. If the Basic I/O self-test detects a fault, bit 1 in all pairs of Basic I/O statistics bits is set.

Following the Basic I/O statistics bits, are 1024 pairs of Verification I/O statistics bits, (thus starting at F202). For each pair of Verification I/O statistics bits, bit 0 is set to indicate a fault/failure and bit 1 is set to indicate a warning.

If a 8191 Expanders is used to convert a range of Verification I/O addresses to Basic I/O, the statistics bits for that address range behave like the Basic I/O statistics.

For further details see the 'Fault Indication' section of Chapter 3.

9.16. V-Data Tables

The majority of the locations in the V-table are for system internal functions and have no significance for the user. However, a few are useful and these are described in Table 9.15.

Table 9.15 - V-Table

Address	Content	Remarks
V0	Not used	-
V1	Compilation count, moving flag. Lower byte contents are incremented after each successful compilation	-
V2 to V47	Used by system software for data table offsets and lengths	-
V48 to V51	Reserved for system usage	-
V52	Length of the message area in bytes	-
V53 to V57	Reserved for system usage	-
V58	V-table checksum	-
V59	User program checksum	-
V60	P-table checksum	-
V61	Rack identification	Set using two BCD switches on the backplane
V62	Switch position	0 = halt, 1 = program, 2 = running
V63	Off-line pages available	Number of pages of off-line memory fitted
V64	Firmware issue	This is copied from the firmware issue in ASCII format
V65, V66	Reserved for system usage	

9.17. Clear Store Command

If the user issues a CLEAR command, part of the P-table is not cleared. This part (P0 to P149) is used to hold configuration data for serial links.

The reason for not clearing this section of P-table is that GEM80-400 Controllers may be programmed either from the front port of the processor, or remotely via one of the serial ports. Loss of data about the serial port configurations could make it impossible for the controller to communicate with a remote programmer, and so this data is retained even when the rest of the memory store is cleared.

Before loading a program, always issue a CLEAR STORE command, for the following two reasons:

- (a) The area of P-table that holds printer messages is not normally write-accessible, except via the message editor facility. The CLEAR STORE command allows data to be loaded to the whole of the P-table.
- (b) The controller allocates memory space for the data tables according to the content of your program. The CLEAR STORE command sets all data table areas to their minimum size, and ensures that unnecessary space has not been allocated by the previous version of program.

Note...When a program is loaded, any instructions and P-table data already in store are overwritten. If, as we recommended, store is cleared before loading, P0 to P149 (which are not cleared) will be overwritten by data from the program being loaded.

Where the controller is programmed remotely via one of the serial ports, the configuration data must be the same for this port as the values already in store, otherwise you will lose communication after a recompilation or power off/on.

Note...When the data being loaded includes messages, the message area, made write-accessible by the CLEAR STORE command, becomes write-protected again, except via the message editor, after recompilation.

9.18. Power Module Self-test and Manual Test

9.18.1. Self-test

Each output voltage: -5%, +20%.
Healthy lamp for each output.
Regular exercising of fault detection.

9.18.2. Manual test

Partial withdrawal from subrack disconnects load.

9.19. Intermittent Tripping Problems

GEM80 equipment is normally reliable in operation, provided that it is installed in accordance with the guidance given in Chapter 7 of this manual.

If the equipment does trip out, note the cause where possible and consequent remedial action. If repeated tripping occurs, keep a log of all trips detailing the fault code, possible explanation and the circumstances under which tripping occurred.

Possible causes of equipment tripping are discussed here:

9.19.1. Electrical Noise or Electromagnetic Interference

GEM80 equipment has been tested against noise immunity from RFI and EMC. However, high levels of RFI noise in close proximity to GEM80 equipment, especially the controller subrack, can trip out the system. Hand-held radio transceivers ('walkie-talkies') should not be used within 300mm of the controller. Segregation requirements and signal ground arrangements should be installed as detailed in Chapter 7.

9.19.2. Connector/Termination Problems

All connections should be checked. Suspect connections, e.g. mechanically damaged or corroded, should be re-terminated.

9.19.3. Overheating

The installation should conform to the environmental conditions detailed in Chapter 1. The I/O should be installed as per Chapter 7.

9.20. Firmware Update

The executive code or 'Firmware' that provides the GEM80-400 with its characteristic functionality is stored in Flash EPROM. This may be updated on site using a user friendly, DOS based, PC compatible firmware update utility. The firmware update utility communicates with the GEM80-400 front panel programming port in the same way as a PC based programming tool and will normally be able to use the same serial link connection lead.

The instructions given in the README.TXT file, supplied with the firmware update programme, should be followed in order to complete a successful firmware update. The link to put the module into firmware update mode is located near the back of the board in the centre between the two edge connectors. It should be set to the 'PROG' position for firmware update mode and returned to 'NORM' position, the normal position, following successful firmware update

9.21. Repairs to GEM 80 Equipment

GEM80 equipment is repaired by replacement of faulty modules and units. GEM 80 modules are not considered to be user repairable and any attempt to carry out repairs to modules will invalidate all warranties and guarantees. Cegelec Industrial Controls Ltd cannot accept responsibility for GEM80 equipment that has been repaired, other than by Cegelec Industrial Controls Ltd.

9.22. Fault Finding Back-up and Module Repair Service

To assist the user in the diagnosis and rectification of faults to GEM80 equipment, the following services are available from Cegelec Industrial Controls Ltd:

- (1) GEM80 Customer Support - available to any GEM80 user.
- (2) GEMSQUAD - a rapid 'service contract' scheme for complete GEM80 systems.
- (3) Service Exchange - a rapid repair scheme available for certain individual items of GEM80 equipment.
- (4) Normal Repair Service - available for repair of GEM80 equipment.

For Customer Support on any aspect of GEM80 applications, please call:

GEM80 Customer Support
Telephone: ++44 (0) 1782 781111
Fax: ++44 (0) 1782 781112

Any faulty modules should be returned for repair to:

Special Products and Repairs Dept,
ALSTOM DRIVES & CONTROLS
West Avenue,
Kidsgrove,
Stoke-on-Trent,
ST7 1TW
England.
Tel: ++44 (0) 1782 781128
Fax: ++44 (0) 1782 781041

Where user repair is required on a PCB, further information on PCB repair may be obtained on request, but when PCBs are repaired by the user, ALSTOM DRIVES & CONTROLS cannot accept any responsibility for faults which may arise.

Faulty modules or units for repair, should be returned in packing which includes antistatic bags next to the electronic circuitry. Where possible the original packing should be used.

CAUTION...

IF A COMPLETE SUBRACK IS TO BE SHIPPED, ANY POWER MODULE SHOULD BE REMOVED FROM THE SUBRACK AND PACKED SEPARATELY. CEGELEC INDUSTRIAL CONTROLS LTD CANNOT ACCEPT RESPONSIBILITY FOR ANY MECHANICAL DAMAGE TO THE SUBRACK IF IT IS SHIPPED WITH POWER MODULES FITTED.

10. Spares and Reorder Codes

10.1. Subracks

10.1.1. Controller Subracks

Model	For Use With Power Module Type	Ordering Code
GEM80-400 Standard Controller Subrack	9032-4010	8857-4020
GEM80-400 Enhanced Controller Subrack (AC Supply)	9017-4010	8855-4010
GEM80-400 Enhanced Controller Subrack (DC Supply)	9018-4001	8855-4008
GEM80-400S Controller Subrack	9017-4010	8855-4011

10.1.2. Fast I/O Subracks

Model	Power Module Type	Space for Fast I/O	Ordering Code
12-slot	110/220V ac/dc	12	8870-4115
12-slot	24/48V dc	12	8870-4114

The above Fast I/O Subracks are for optional use with GEM80-400 Enhanced Controllers, where Fast I/O Modules are required. Depending on the quantity of Fast I/O Modules, either one or two subracks may be required.

10.1.3. I/O Subrack

Model	Power Module	I/O Modules	Ordering Code
12-slot	-	12	8859-4003

The above I/O Subrack is for use with any model of GEM80-400 Controller, where additional I/O capacity is required.

10.2. Modules

10.2.1. Processor Modules

Model	Ordering Code
Standard Non FIP with Floating Point Maths (FP)	8239-4005
Enhanced Non FIP with FP	8239-4006
Standard with FIP with FP	8239-4007
Enhanced with FIP with FP	8239-4008
Standard Non FIP	8239-4015
Enhanced Non FIP	8239-4016
Standard with FIP	8239-4017

10.2.2. Fast I/O Modules

Details of the Fast I/O Modules are given on individual Product Data Sheets in the number ranges 884x and 886x, and are therefore omitted from this chapter.

10.2.3. Basic and Verification I/O Modules

Apart from the items given here, details of Basic and Verification I/O Modules in the number range 81xx and 95xx are given on individual Product Data Sheets and are therefore omitted from this chapter.

Module Type	Function	Equipment Called up by Ordering Code	Ordering Code
Verification I/O Expander Unit	To provide Basic I/O ribbons for up to 512 points of Basic I/O.	Expander unit only. Mounts in a 8859-4003 12-slot I/O subrack.	8191-4004

10.2.4. Central Highway Modules

The following ordering codes call up Central Highway Modules which may be used with the GEM 80-400S or GEM80-400 Enhanced Controller.

Module Type	Function	Slots Used	Equipment Called up by Ordering Code	Ordering Code
IMAGEM Processor (See Note 2)	For displaying data taken from the controller's data tables on a video monitor.	1	Video Processor Module	8284-4002
STARNET (See Note 3)	For inter-controller communications with block message facility.	1	STARNET Module	8268-4101
GEMLAN-D	Provides a fully integrated DECnet interface for GEM 80 systems.	2	GEMLAN-D Module	8279-4002
Fast I/O Driver	Required only when the system contains Fast I/O Modules.	1	Module only	8300-4003

Notes...

(1) The quantity of slots used must be taken into account when assessing how many modules can be fitted into a GEM80-400 Enhanced Controller subrack.

(2) Coaxial cable and connectors: Recommended alternative types of 75 Ω coaxial cable are: URM70 and RG59B/U. (The former type is more readily available in Europe, and the latter type in America.)

(3) Ribbon cables and termination units must be specified separately.

(4) The Fast I/O Driver is fitted in one of the Fast I/O Slots of a GEM80-400S controller and does not occupy a central highway slot.

10.2.5. Memory Modules

Module	Function	Equipment Called up by Ordering Code	Ordering Code
Read/Write Memory Module	256K RAM	Module only	8272-4004
FLASH Memory Module	20K instructions		9291-4024
RAM Module	20K instructions		9291-4004
256K EPROM Sub-module	For more secure storage of off- line and video data	EPROM Memory Sub-module, including unprogrammed EPROMs	9210-4001

10.3. Optional Extras

Item	Ordering Code
Serial Link Termination Unit providing terminals for one 20mA port, current loop for a STARNET Module	8924-0000
RS232 Termination Panel	9009-4001
RS232 Termination Panel for STARNET	9009-4002
Ribbon Cable to connect up to 2-off Serial Link Termination units to a STARNET Module	8891-4077
Wiring Tray	8890-4705
DC Input Lead for 9032 Power Supply	8891-4072
Blanking Panel, Single	8122-4001
Blanking Panel, Double	8122-4002
Serial Link Termination Unit providing terminals for one RS485 port	8587-4003
RS232 to 20mA converter, externally powered	8975-0000

10.4. Spares

Item	Ordering Code
Power supply module (88-264V ac or 88-250V dc)	9017-4010
Power supply module (19-60V dc)	9018-4001
Power supply module (110 to 220V ac power input with additional power input for 48V dc (non isolated, negative earth))	9032-4010
Fuse for ac power input on 9032 power module (3A, time delay, high breaking capacity)	82030/146
Fuse internal to 9032-4002 power module (7A, quick blow)	82030/171
Fuse internal to 9032-4010 power module (7A, Time lag)	82030/151
Female ac connector for 9032 and 9017 power supply	80720/101
DC input lead	8891-4247
Battery for processor module See chapter 9 for suitable type	S78802/350 Or S78802/352
Fuse for ac/dc power input on 9017-4001 power module (10A, time delay, high breaking capacity)	82030/153
Fuse for dc power input on 9018-4001 power module (15A, time delay, high breaking capacity)	82030/190
Battery for memory module	20T 0319/01
Key	88400/152

10.4.1. Replacement Battery Suppliers

ALSTOM DRIVES & CONTROLS

West Avenue,

Kidsgrove

Stoke -on - Trent

Staffordshire

ST7 1TW

Tel ++44 (0) 1782 781111

Fax ++44 (0) 1782 781112

11. Watchdog and Safety Circuits

11.1. Introduction

Power, 0V, and watchdog terminals are located on the backplane terminal boards which are shown in Figures 1.12 to 1.15. A safety earth stud is fitted to the terminal bracket. Safety earth studs are also located on the subrack side cheeks at the rear of the mains input filter. Further information on signal grounds, safety earths and watchdog contacts is detailed as follows:

- (1) Safety Earths - The equipment must be earthed by a secure safety earth connection of minimum cross-sectional area 2.5mm². See the 'Safety Earth Wiring' section of Chapter 7 for connection details.
- (2) Signal Grounds - See the 'Signal Ground Wiring' section of Chapter 7 for connection details.
- (3) Watchdog Contact - See 'Watchdog Contacts', later in this chapter, for connection details.

The controller includes automatic self-tests. For more details, refer to Chapter 9 of this manual. There are two types of test:

- those performed when the controller is initially powered up, and
- those performed continuously while the controller is running.

Diagnostic information obtained from these tests is stored in an area of memory known as the F-table, and diagnostic messages are sent to the screen of a suitable GEM80 programming tool, such as Gemesys 3, when connected to a processor. The controller includes two built-in relays called watchdog relays. These relays have their Normally Open (NO) contacts connected in series.

- When the system is running normally and in a healthy condition, the contents of table location F1 are zero. The Watchdog relays are energised, and their normally-open contacts are closed.
- When the system is tripped, either by the user program writing to F1 or by the self-test finding a fault, the Watchdog relays de-energise, their normally-open contacts open, and the controller halts.

The self-testing includes both hardware circuits and firmware routines, so that failures of microprocessor devices can be found rapidly. This allows the controller to be tripped, as soon as the fault is detected, before it can make any serious errors.

Note...If a microprocessor has gone down, it may not be possible to get any diagnostic information sent to the programming tool.

The watchdog relay also de-energises whenever you halt the controller. The controller can be tripped and the watchdog relays de-energised by writing a non-zero value to table location F1 from your program. Refer to Chapter 2 of this manual for further details.

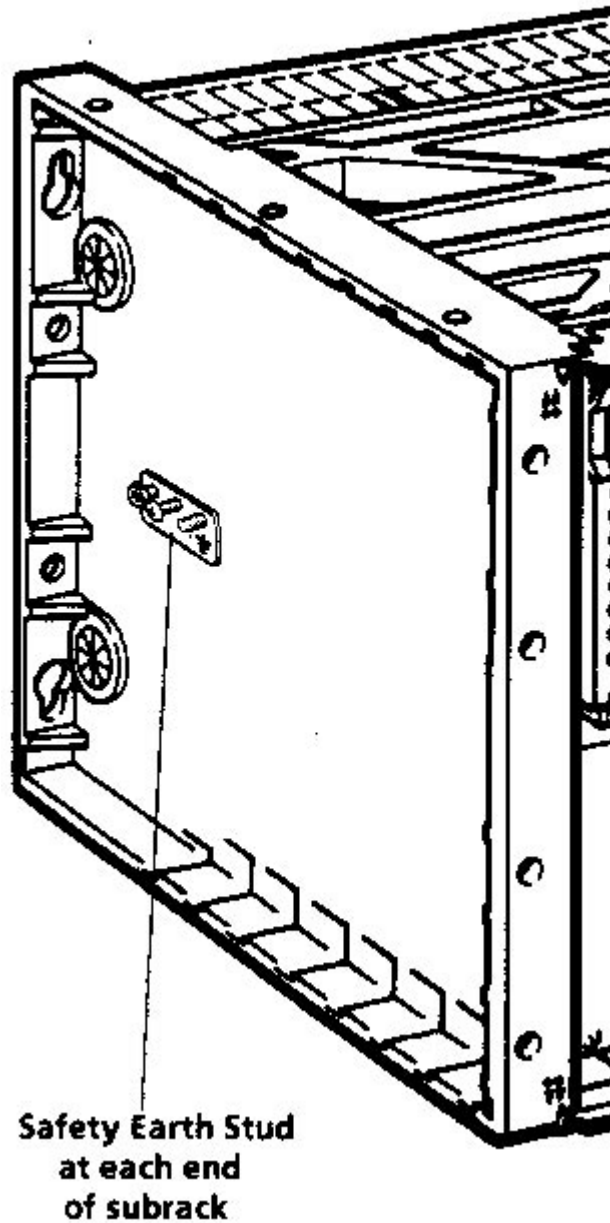


Figure 11.1 - Location of Safety Earth Studs

Safety earth studs are located on the subrack side panels at either end of the subrack. The equipment must be earthed by a secure safety earth connection of 2.5mm² minimum cross-sectional area.

11.3. Watchdog Contacts

The watchdog contact terminals of the Standard Controller are located on W/D, two watchdog circuit push-on terminals on the lower backplane. The watchdog contact terminals of the Enhanced Controller are located on TB1, the Terminal Block on the lower backplane. See Figure 11.2 for details of both controller connections.

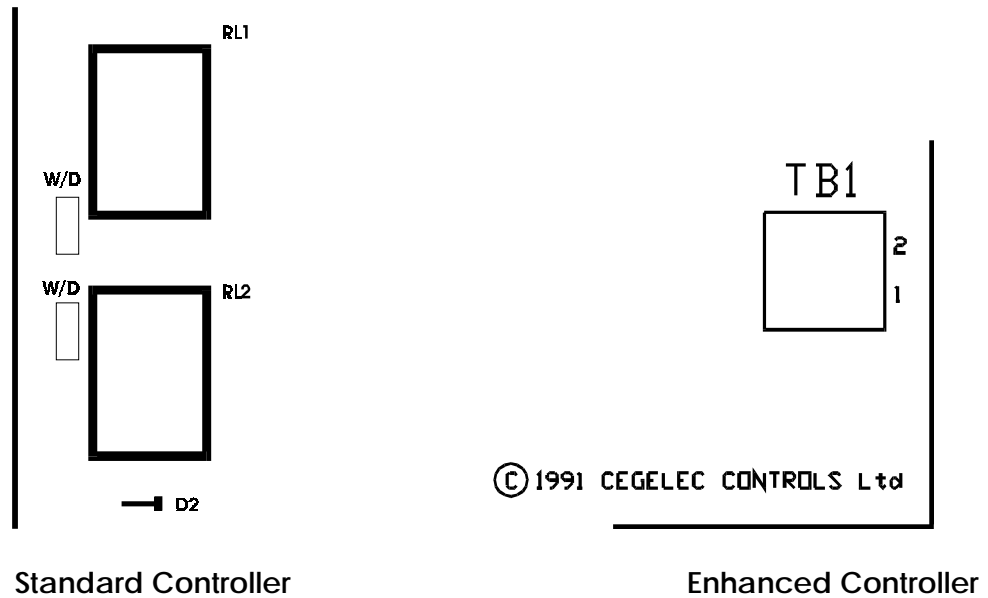


Figure 11.2 - Watchdog Contact Terminals

11.3.1. Typical Watchdog Circuits

Figure 11.3 shows an example of a typical watchdog safety circuit. The input equipment will be energised when the plant-side power supply is on. However, the output equipment will be energised only when the plant-side power supply and the user supplied watchdog follower relay are energised. Other interlocks, such as emergency stop push-buttons, can be connected in this circuit as required, in series with the watchdog contacts. Figure 11.3 shows just a single emergency stop push-button; in practice there could be several in series.

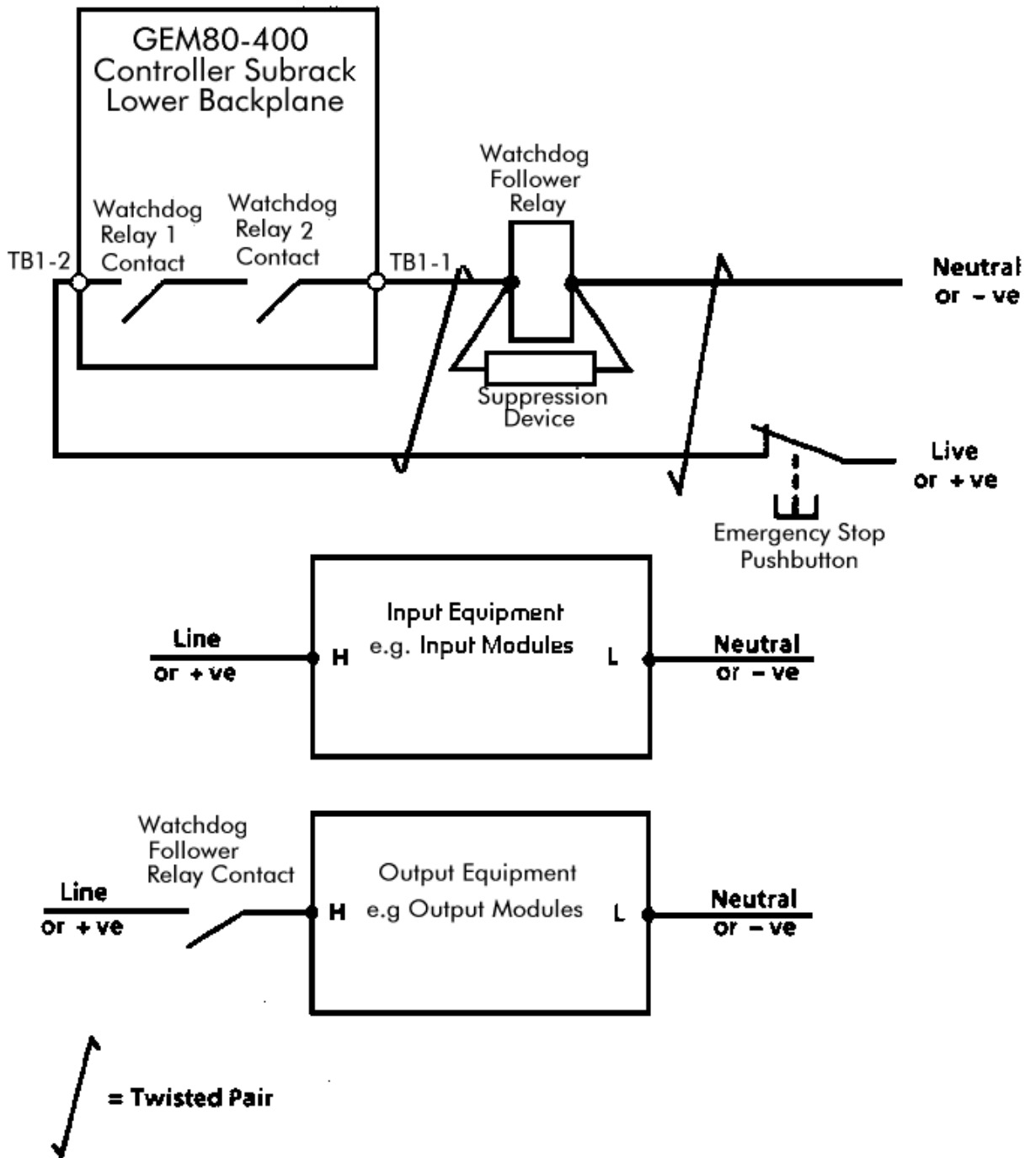


Figure 11.3 - Typical Watchdog Circuit

11.3.2. Watchdog Contact Ratings

11.3.2.1. Circuit

Two series connected volt-free contacts are provided.

11.3.2.2. Rating

11.3.2.3. Operation

Closed when the host controller is healthy and its status is running with normal inputs. Held closed during user program on-line re-compilation.

11.3.3. Watchdog Connections

Figures 1.14, and 1.15 show the location of the watchdog terminals.

11.4. Safety and the User Program

The program can be arranged to take particular courses of action when certain error conditions arise, but these only work while the controller is up and running correctly. For those exceptional conditions where it malfunctions, the controller does not necessarily respond to the instructions contained in the program. Therefore, safety circuits **MUST**:

- be hard-wired;
- operate independently of the controller.

Note...The key switch can be used to prevent unauthorised modification of the user program; if the key switch is in the Halt position the program cannot run.

11.5. Power Up Conditions

Whenever the controller is powered up, its output equipment can give spurious outputs until the watchdog relay has pulled in. During this time, the controller performs its start-up checks, and the state of the outputs cannot be guaranteed. You therefore need to suppress outputs until after the watchdog relay has pulled in. There are two ways in which you can do this:

- (1) Some types of output module include an output enable circuit which suppresses the outputs until a signal is applied to the I/O subrack. You can therefore arrange to apply the enable signal via a contact of a watchdog follower relay.
- (2) Other types of output module do not include this enable circuit so, the plant-side power must not be applied until after the watchdog has pulled in. Plant-side power must be applied via a contact of a watchdog follower relay.

Method (1) allows suppression of several outputs of different voltage levels with a single contact. This relies on the electronic circuitry of each module working correctly. Therefore, for ultimate safety, where outputs operate moving machinery or otherwise provide a personnel hazard, Method (2) should be used with one contact for each plant-side power voltage.

Note...If the controller is set up with its program in on-board EPROM sub-module, if a battery is not fitted to the processor module, if the write-protect switch is set to protect and the key switch is in the 'Normal' position, the controller will always come up in the RUN status when it is powered up, and the watchdogs will close. Also, all data tables, including R- and W-tables, are cleared.

If the controller has its program stored in EPROM with a battery fitted to the processor module, when the controller is powered up, it will be in the same status (RUN or HALTED) as it was when the power was switched off. However, if the battery should fail while the controller is powered down, the controller automatically comes up in RUN status the next time it is powered up, as for a system without a battery. To prevent this happening set the Flash EPROM module's write protect switch to 'PROG' position and/ or set the front panel keyswitch to the 'PROGRAM' or 'HALT' position.

11.6. Power Loss, Emergency Stops, Push-buttons and Moving Machinery

If there is a power cut to the controller, it will shut down in a controlled fashion, and re-start automatically when power is restored. If moving machinery must not start moving again without intervention by the operator, the plant-side power supply must not be applied until an external relay circuit has been operated. Where moving machinery must be stopped if the controller malfunctions, brakes and braking circuits must be hard-wired. While normal start/stop push-buttons can be wired via the I/O, emergency stop push-buttons must be hard-wired. Use a chain of normally closed push-buttons of the stop/lock-off type for emergency stop circuits. Mount them locally near moving equipment, so that any maintenance personnel can have confidence that, if the local button has been operated, no-one can start the equipment again until the local button has been re-set.

A Ribbon Cable Connections for GEM80

A1. Ribbon Cable Sizes

The ribbon cables detailed in Table A.1 are used on GEM80 equipment:

Table A.1 - Ribbon Cables used on GEM80 Equipment

Cable Used For	No. of Ways	Supplier *	Suppliers' Ref.
1) Basic and Verification I/O Highway 2) Serial Communications Highway	26	Spectra	455.240.26
1) Fast I/O Analogue Terminations	34 (17Pr)		132-2802-234

* Denotes ALSTOM DRIVES & CONTROLS recommended supplier

CAUTION...

Following problems with the termination of ribbon cables, the cable manufacturers advise that:

"ALL RIBBON CABLES ON REELS MUST BE STORED ON END"

Flat storage of these reels leads to compression of the conductor pitching, which results in incorrect termination on the connectors.

A2. Ribbon Cable Connectors

The connectors used are detailed in Chapters 3 and 4.

A3. Ribbon Cable Accessories

This is a kit which comprises:

One polarising pin
One label
Ordering Code 8890-4004

A4. Special Tools/Equipment Required for Ribbon Cable/Connector Assembly

The following tools will be required for assembly of connectors onto ribbon cables:

T & B/Ansley 779-2100 - Tool Frame

T & B/Ansley 779-2150	-	Die for use with Tool Frame (suitable for all GEM 80 ribbon cables)
T & B/Ansley 779-5030	-	Cable Cutter

These tools are available from:

Thomas & Betts Limited,
Sedgwick Road,
Luton,
Bedfordshire,
LU4 9DT.
Telephone: Luton (01582) 608101
Telex:(01582) 608816

A5. Ribbon Cable Installation

Ribbon cables used on GEM80 equipment are normally made up for the customer by Cegelec Industrial Controls Ltd. For the customer wishing to install his own ribbon cables the procedure detailed here should be followed:

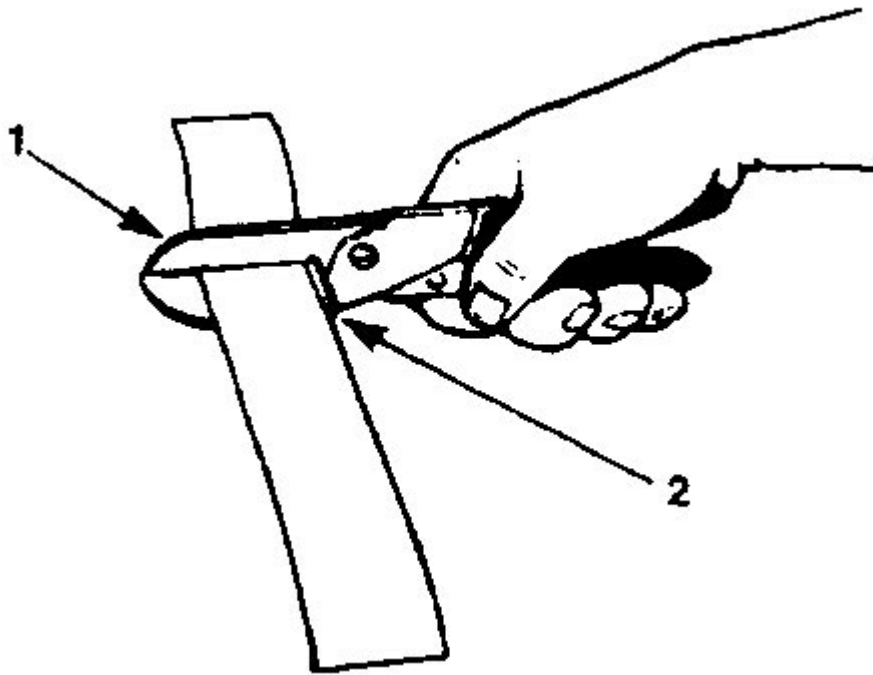
A5.1. Mechanical Polarisation

A polarising pin may be inserted into the socket if required. This pushes into the connector from the socket side.

Note...This operation must be completed BEFORE the connector is fitted to the ribbon cable.

A5.2. Termination Using Cable End Connectors

- (a) Cut the ribbon cable to length ensuring that edge of cable is flush with alignment guide on cable cutter as shown in Figure A.1.

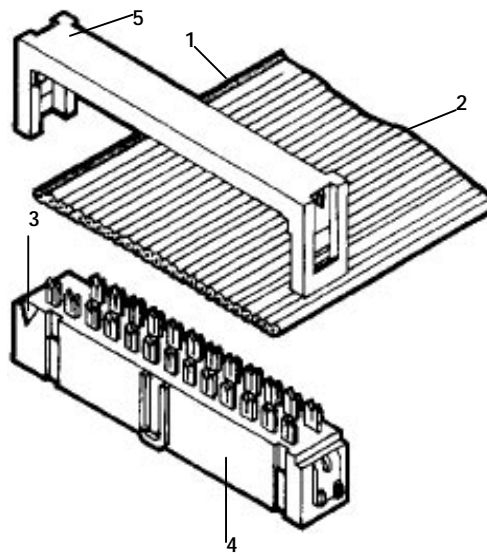


1. Cable cutter
2. Alignment guide

Figure A.1 - Ribbon Cable Cutting

- (a) Twisted pair ribbon cables must always be cut in the centre of a flat section.
- (b) Fit cover halfway onto insulation base plate ensuring that metal locking clips enter slots in cover (see Figure A.2).
- (c) Insert cable between cover and base plate WITH END OF CABLE FLUSH WITH EDGE OF BASE PLATE.

Note...Ensure that coloured edge of cable (or brown wire for twisted pair cable) is adjacent to identification mark (pin 1) detailed in Figure A.2. Also ensure that cable is inserted from the 'wrong side' since it will be doubled back when strain relief is fitted (see Figure A.5).



1. Coloured edge of cable (or brown wire for twisted pair cable)
2. Cable
3. Identification mark
4. Base plate
5. Cover

Figure A.2 - Cable End Connectors Fitting of Cable and Cover

- (e) Using T & B/Ansley hand tool fitted with die, press the cover down, ensuring that the cable does not move, so that contacts on the base plate penetrate the cable insulation (see Figure A.3). Ensure that the cover is pressed fully home as detailed at Figure A.4.

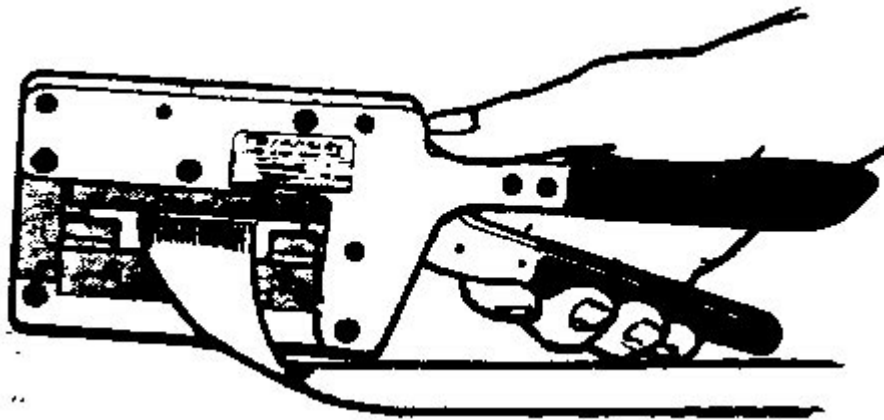
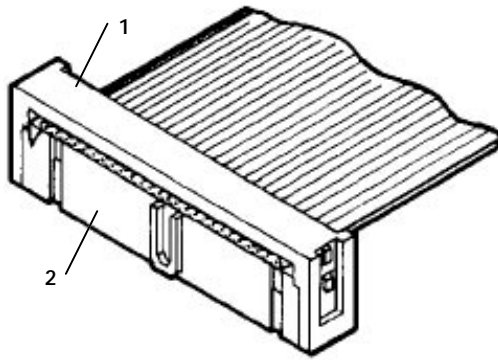


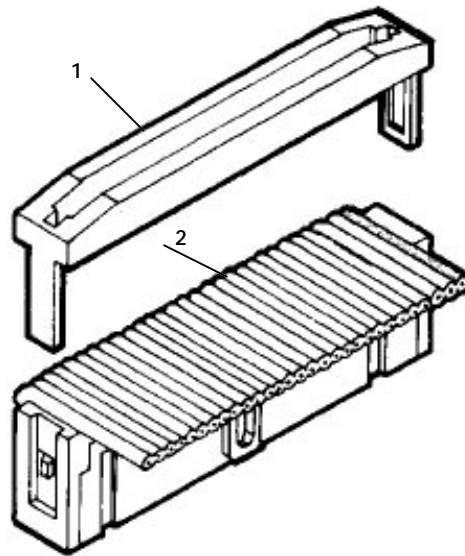
Figure A.3 - Use of Hand Tool



1. Cover
2. Base plate

Figure A.4 - Clamped Cable

- (f) Complete ribbon cable label for I/O assembly as detailed in Chapter 7 of this manual.
- (g) Push the strain relief down until the clips lock into the cover, indicated by a small 'click' (Figure A.6 shows the completed end termination).



1. Strain relief
2. Cable folded back

Figure A.5 - Fitting of Label and Strain Relief

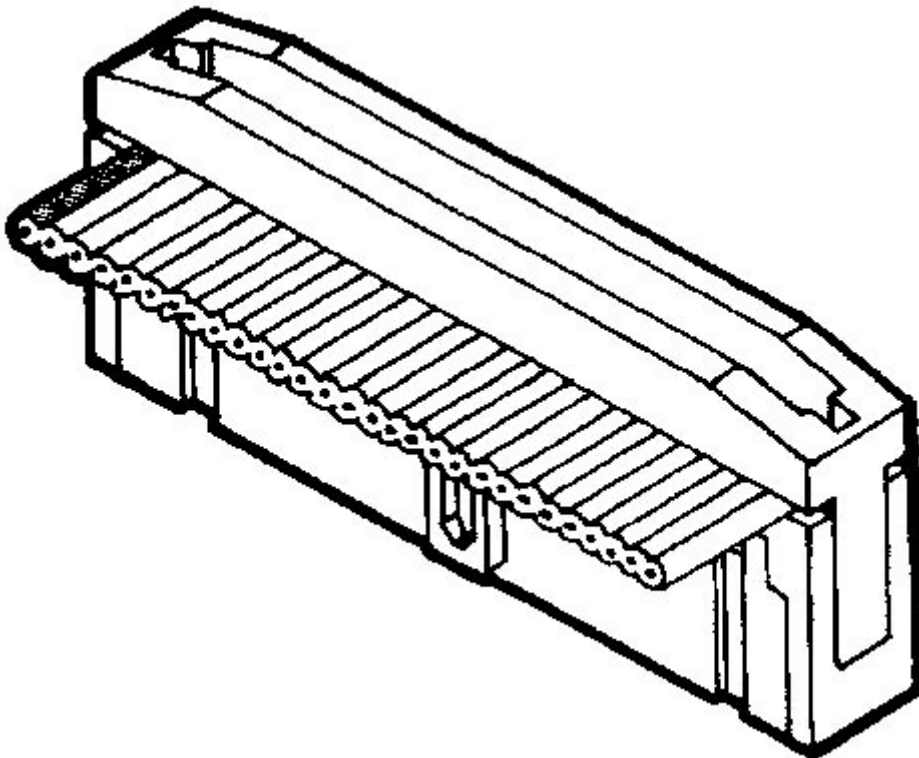


Figure A.6 - Completed End Connection

When fitting similar connectors at both ends, ensure that the cable is inserted from opposite sides of the connectors. The completed ribbon should be as illustrated in Figure A.7.

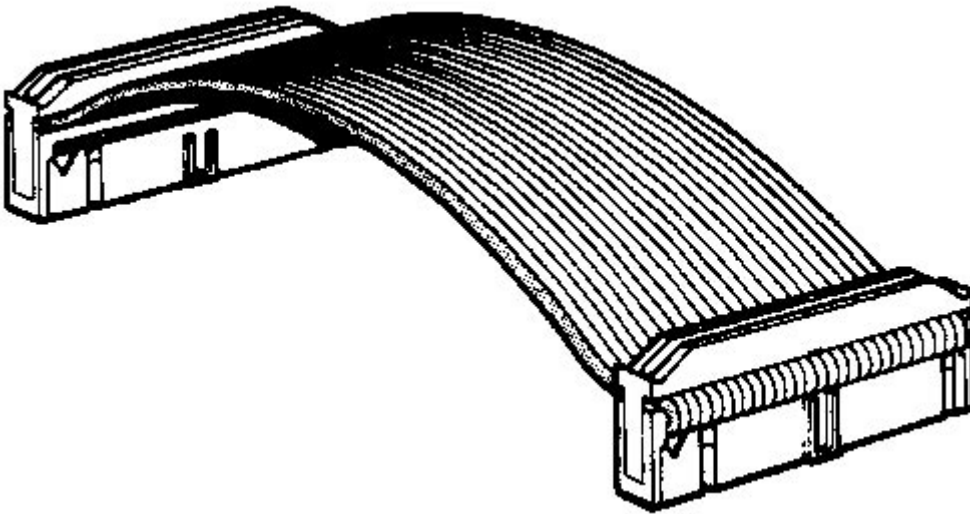
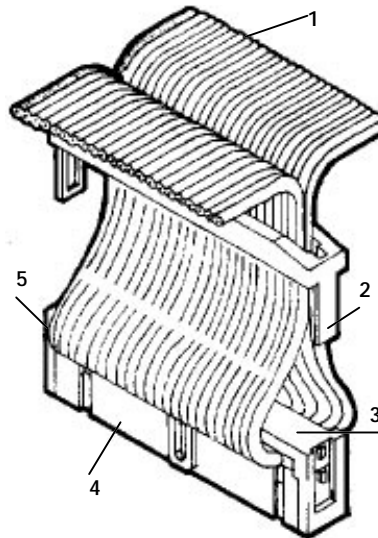


Figure A.7 - Completed Ribbon Cable

A.5.3. Terminating Middle Connectors

Notes...

1. This type of connector cannot be assembled unless one free end of cable is available. Always ensure that the amount of cable is sufficient to complete the length of run.
2. When using twisted pair cable, termination can only be made in the centre of flat sections.
 - (a) Pass free end of cable through slot in top of strain relief (i.e. side without clip).
 - (b) Thread enough cable through the slot to allow the connector to reach the header
 - (c) Mount the cover to the base plate as described in parts (c) to (e) of the 'Termination using Cable End Connectors' section of this chapter.
 - (d) Pass the free end of the cable back through the strain relief as in Figure A.8, and remove the slack before pushing the strain relief fully home as in the Termination Using Cable End Connectors' section, part (g), of this chapter.



1. Cable
2. Strain relief
3. Cover
4. Base plate
5. Identification mark

Figure A.8 - Cable Middle Connectors - Fitting of Strain Relief

A.5.4. Right Angled Bends in Cable

- (1) Where ribbon cable has to be run flat with a right angled bend, the cable can be folded in one of two ways, either a single fold as in Figure A.9 or, if this would cause the wrong edge to come out on top, the cable should first be doubled back as in Figure A.10

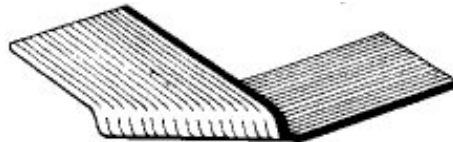


Figure A.9 - Right Angled Bend - Single Fold

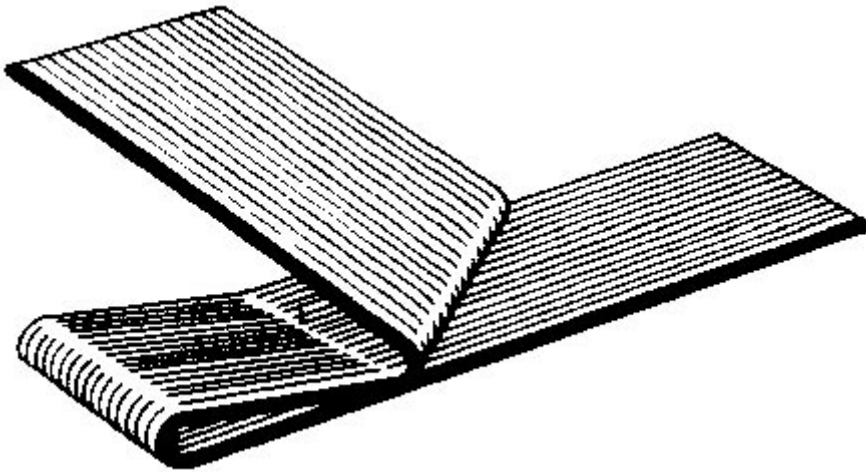


Figure A.10 - Right Angled Bend - Double Fold

A.5.5. Fitting Ribbon Cable Label

The label is wrapped around the ribbon cable as shown in Figure A.11. Refer to Chapter 7 for label marking.

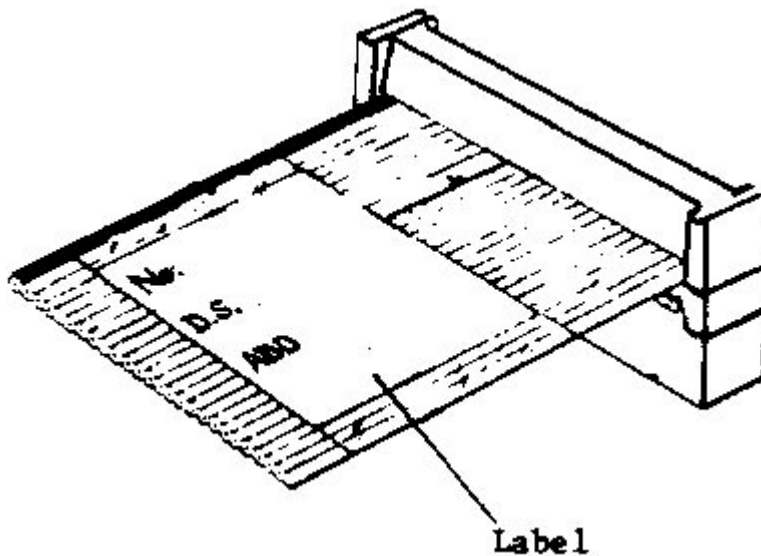


Figure A.11 - Label Fitting

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