Group3 Control

User's Manual

Device Interface Software	5.0i
CNA Module Software	5.0g
F Board Software	5.0c
Loop Controller Software	5.1

Processor boards from serial number 1065

17 August 2007

Thank you for purchasing and using Group3 Control equipment. We hope you will join the growing number of people who are enthusiastic about the features Group3 Control has to offer.

Group3 has been designing and building specialised control systems since 1983. We are constantly upgrading and improving our products and the supporting documentation. We welcome input from our customers, so if there are aspects of the system you particularly like, or things you would like to see implemented, improved or developed in the way of hardware, software or documentation please contact your Group3 representative, or Group3 directly with your suggestions.

The Group3 website (http://www.group3technology.com) contains some pages of information on Group3 products. This site will be updated regularly, and you may choose to check it from time to time, to learn about recent developments.

Listed on the "What's New" page are the recent developments and enhancements to the product range, grouped by the year of introduction.

The page "User Technical Notes" lists current versions of software, and also details past versions, with a brief list of the features they introduced.

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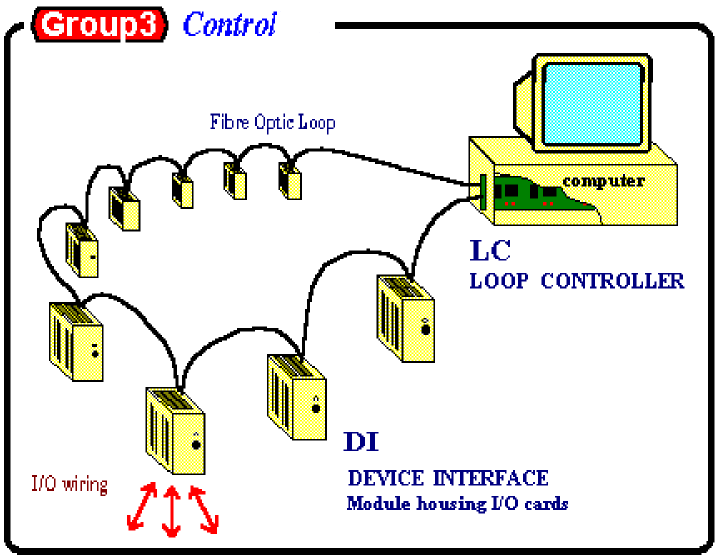
1. GROUP3 CONTROL - OVERVIEW

Group3 Control is a fibre optically linked distributed control system. Data is sent over fibre optic cables to small intelligent outstations (Device Interfaces or DIs) that contain the I/O boards - ADCs, DACs, digital, motor drivers, etc.
A Loop Controller (or LC) card plugs into the control computer and handles all the communications on the fibre loop.



A Typical Group3 System

To read inputs and set outputs the control computer merely reads and writes to a Dual Port RAM on the LC. The microprocessor on the LC then lifts this information, packages it appropriately and sends it out on the loop.

Within each DI is a processor that decodes the information in the message packet and sets outputs accordingly, repacks the message with any input information and sends it back on the loop. The LC in the control computer then unpacks the input information and puts it in the Dual Port RAM, from where the control program can get the value of the inputs. In this manner information is transmitted over the loop at up to 1.152 Mbaud, continually refreshing outputs and scanning inputs. The transfer of information is completely transparent - the systems engineer does not have to understand the communications protocols at all.

Communication with the device interfaces is by fiber optics, providing not only superior noise immunity and high voltage isolation, but fast data transfer as well.

Group3 Control's modular architecture produces a cost-effective, high-performance control system that is easily configured to a particular application.
A wide variety of I/O boards is available, allowing a great deal of flexibility in setting up the distribution of control points in a system. A DI can be populated with just the type of I/O required at that point. The I/O boards available are listed overleaf.

I/O boards:-	Type	features
	A	2 analog inputs, 1 analog output, 8 digital channels.
	B	24 digital channels, each configurable as input or output.
	C	8 analog inputs, 16 bit resolution, differential inputs.
	D	8 analog outputs, 14 bit resolution.
	E	4 DC motor drivers, pulse density modulated.
	F	2 serial communications ports.
	G	4 stepper motor drivers.
	H	4 encoders, quadrature input.
	J	2 precision analog outputs, 16 bit resolution.
	K	1 GPIB / IEEE 488 Controller.

The CNA, a new combined processor, I/O and signal conditioning module has recently been introduced, offering 2 analog inputs, 1 analog output, 8 optocoupled digital inputs, and 8 relay contact digital outputs. The unit is housed in a small aluminium case, and has built in PID closed loop control capability.

The small size of device interfaces means that they can be located close to the monitored and controlled points, reducing the length of wiring harnesses. This presents a significant cost saving, but also leads to a reduction in electromagnetic interference (EMI) received by signal lines in electrically noisy environments.

Each device interface module has an auxiliary port to be used for diagnostic and system configuration purposes. Connecting a terminal to this port allows the user to control and monitor all outputs and inputs on the device interface.

An installation can easily be expanded to cater for the growing needs of a user. Up to 16 device interfaces, each with 3 I/O boards, can be connected on a single fiber optic loop. More loops can be added for expansion.

To complete the control system Group3 recommends, and can supply, a number of commercially available software packages to provide a user interface at the computer. These packages provide for data acquisition, control, automation, data logging etc.

Group3 Control - Key Features

- Distributed control using small Device Interfaces.
- Flexibility in configuring systems of any size.
- Fiber optic communication for noise immunity and high voltage isolation.
- Communication handled entirely in hardware.
- Diagnostic ports on device interfaces for system development and debugging.
- Scientific accuracy - 16 bit accuracy on analog channels.
- Fast polling rate even in large systems.
- Loop Controllers for PC computers, and for VME, CAMAC and STD crates
- Choice of software packages for operator interface.

2. Group3 DEVICE INTERFACES

2.1 Introduction

Device Interfaces are small control modules that house the Input and Output (I/O) boards in a Group3 system. They are available in two sizes, accepting one, or three I/O boards. There is also an integrated module available, designated CNA, that combines the functions of several components into one unit.

Each Device Interface unit contains a processor circuit board to handle the fiber optic loop communications, and to service the I/O boards.

A range of different I/O boards (analog inputs, analog outputs, digital channels, motor drivers etc.) allows flexible tailoring of each Device Interface to the control requirements at each point. Software resident in the Device Interface automatically recognises the I/O boards installed and configures itself to provide the appropriate control and monitoring features.

The product family has been designed for ease of mechanical installation. The units are physically small, and mount by simply clipping onto a standard 35mm DIN rail. The DI modules are powered by low-voltage ac or dc - either is accepted without adjustment.

Fiber optics are used for communication to reduce transient pickup, and to provide high voltage isolation.

The DI processor board incorporates several features to ensure reliable operation:
in addition to the checks built into the microprocessor itself there is a separate supervisor (watchdog) chip to reset the microprocessor if it detects incorrect operation as a result of an unusually powerful electrical transient. The software running within the DI is of a multitasking nature, and one of the independent tasks is a dedicated self checking process that continually monitors all the other tasks and variables in the microprocessor. If anything is found to be out of normal bounds then a reset is forced.

A diagnostic port on each Device Interface allows system monitoring, configuring and debugging - a feature not previously available in a product of this type. The diagnostic port is invaluable at all phases of system commissioning. By using a standard terminal the engineer can access a Device Interface independently of the fiber optic communication loop. A built-in menu system provides for a wide range of diagnostic, simulation, and set-up functions. A restricted access level security system prevents undesirable tampering by unauthorised personnel.

2.2 Device Interface Features

- Two sizes are available, accepting 1 or 3 I/O boards, and the CNA integrated module.
- Includes processor board to service I/O boards and handle loop communications.
- Fiber optics for communications reduce transient pickup.
- Complete electrical isolation by fiber optics and on-board switch-mode power supply.
- Powered by low-voltage ac or dc.
- Loop address is set by accessible switch.
- Diagnostic port allows unit-by-unit setup, calibration, debugging, and I/O simulation, control and monitoring.
- No adjustments on board - all setup and calibration is implemented by software through diagnostic port.
- Selection of I/O boards allows flexible tailoring to control and monitoring requirements.

2.3 Device Interface Specifications

Model number	CNx-yyy for example CN3-BCD where x = no. of I/O boards = 1 or 3 and y = A,B,C,D,E,F,G,H,J,K denoting I/O boards fitted
Standard board	Processor board fitted
Additional boards	10 types of I/O boards are available:

type A fast analog/digital I/O board
type B 24-channel digital I/O board
type C 8-input analog board (ADCs)
type D 8-output analog board (DACs)
type E 4-DC motor driver board
type F 2-serial communication ports
type G 4-stepping motor driver board
type H 4-encoder input board
type J 2-precision analog output (DACs)
type K 1-GPIB / IEEE 488 controller

Boards may be fitted in any combination, except that only one K board is permissible in a DI.

Device Interface Specifications - continued

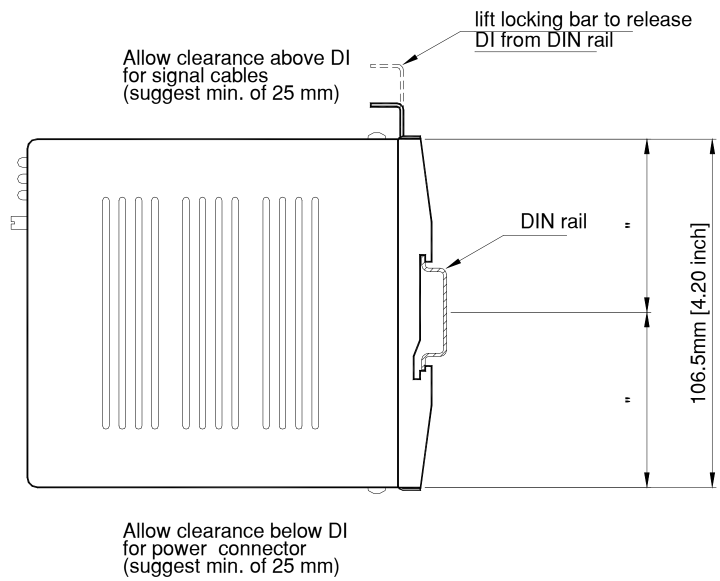
System communications	fiber optic loop
Fiber optic cable	H-P HFBR Versatile Link series plastic cable, 40 meters max. per link Spectran HCS, silica core Versatile Link cable 500 meters max. per link H-P HFBR ST connectored glass cable 3000 meters max. per link
Units on loop	16 max.
Loop address	0 through F (hexadecimal) set on switch accessible on the outside
Communication modes	ASCII character strings at 9600 baud SDLC loop mode at 1.152 Mbaud DI to DI communications mode
Diagnostic port	mini-DIN receptacle for connecting to any standard serial terminal
Serial data format	ASCII character strings, 9600 baud NRZ, 7 data bits, 2 stop bits, even parity, no handshaking, standard RS-232C levels
Power requirements	accepts AC, or DC of either polarity AC: 14 to 26Vrms absolute max., 13VA max., 9VA typical DC: 19 to 36V absolute max., 9W max., 6W typical See page 2-7 for further information. Motor driver I/O boards require additional power - see page 2-18
Galvanic isolation	200V min. between power input and active circuitry
Ambient temperature	Operating 0 to 55°C Non-operating -20 to 75°C
Memory retention	Configuration stored for 10 years min.

Device Interface Boards - Quick Reference Guide by Function

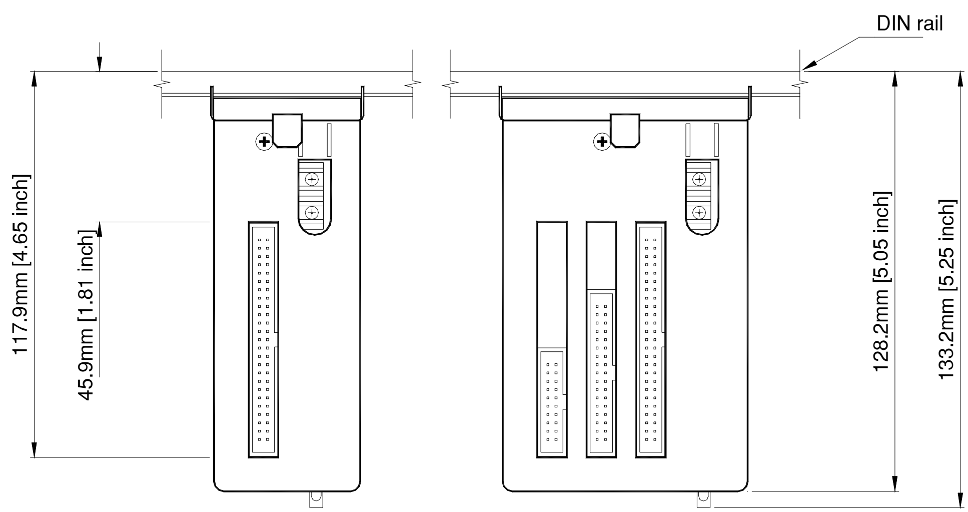
DI processor	
Power requirements	See Power Requirements page 2-3
Diagnostic port data	RS232, 9600 baud, 7 data & 2 stop bits, even parity
Fiber Optics	Transmit port is closest to mounting plate, receive closest to front.
Digital Channels	Type A and Type B boards
Maximum applied voltage	40 volts. (revision B only, earlier versions 5V max.)
Input thresholds	TTL levels, internal 1kΩ pullup to +5 volts.
Output Drivers	Open collector, 40 volt 100mA max. - sink to ground.
Analog Inputs	Type A and Type C boards
Selectable ranges	Full scale of 50mV, 5V, 10V, unipolar or bipolar
Input resistance	180kΩ
Maximum input voltage	±30V
Analog Outputs	Type A, Type D and Type J boards
Output ranges	5V, 10V, unipolar and bipolar
Minimum resistive load	2kΩ
DC Motor Drivers	Type E board
Maximum drive	30 volts, 1 amp for each motor
Serial Comm's Ports	Type F board
Fiber Optics	Hewlett Packard Versatile Link plastic core cable.
Stepper Motor Drivers	Type G board
Maximum drive	50 volts, 180mA from the I/O board directly, or generates logic signals for external power drivers.
Encoders	Type H board
Maximum input rate	120 kHz with 1 board in DI, 40 kHz with 3 boards in DI.
GPIB / IEEE 488	Type K board
Controller , Talker and Listener on the IEEE 488 bus	

Group3 Device Interfaces
Outline Dimensions

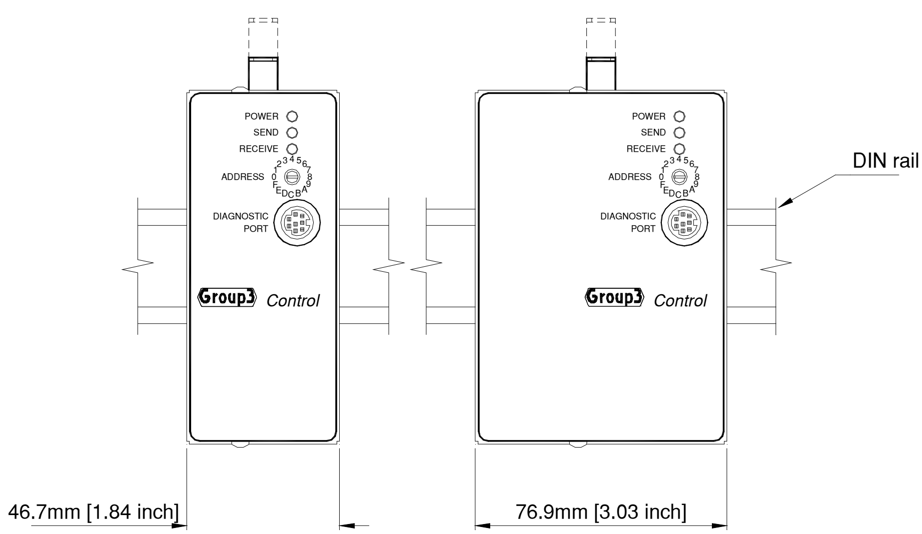
side view all models



top view



front view



CN1 CN3

2.4 Device Interface Processor Board

Every Device Interface uses a processor board which handles all the communications on the fiber optic loop, services the I/O boards in the DI and operates the diagnostic port. Indicators, connectors, and a switch accessible to the user are described below.

LED Indicators

Three LEDs are visible on the front panel:

POWER	(green)	lit continuously if power is applied to the Device Interface.
SEND	(red)	flashes when the Device Interface transmits a message
RECEIVE	(red)	flashes when the Device Interface receives a message.

The two red LEDs appear to be continuously lit when the loop is running correctly at many hundred messages per second.

Address Switch

The loop address for the Device Interface is set on the 16-position rotary switch below the LEDs on the front panel. Each Device Interface on a loop must be set to its own unique address. The switch can be changed with power on, and the new address takes effect in one second maximum.

Diagnostic Port

The diagnostic port is a bi-directional serial port using standard RS-232C voltage levels.
Connection to the diagnostic port is through an 8-way MiniDin receptacle located below the address switch on the front panel.

Pin assignments for the MiniDin 8 are shown below:

pin	**signal**
1	Transmit data output
2	Receive data input
3	(constant high level)
4	Not connected
5	Not connected
6	Not connected
7	+5 volts output (85 mA max.)
8	Signal ground
9	Chassis ground

Group 3 can supply a 2 meter cable with a MiniDin8 plug on one end and a DB25 receptacle on the other end, suitable for use with a serial port on a standard keyboard terminal or on a PC computer. The Group3 part reference is DPC2.

Communication parameters are fixed by software and are not user adjustable.

Data encoding	NRZ (Non Return to Zero)
Baud rate	9600
Data bits	7
Stop bits	2
Parity	even

No hardware or software handshaking flow control is used.

Power Requirements

The processor board contains a switch mode power supply which provides the power for this board and accompanying I/O boards. The power input accepts AC, or DC of either polarity with the following ranges:

AC: 14V to 26Vrms absolute maximum, 13VA max., 9VA typical
DC: 19V to 36V absolute maximum, 9W max., 6W typical.
The maximum power ratings apply to Device Interfaces fitted with three F, G and/or K boards, or two F, G, and/or K boards plus one other board other than F, G, or K. Only one K board can be used in a Device Interface – this is a software limitation.

Power is supplied through a 2-way connector located on the bottom of the Device Interface. The mating plug required is a Phoenix Contact part no. MSTB 2,5/2-ST. One is supplied with each Device Interface.

The Device Interface power circuitry is isolated from its signal circuits, so power can be reticulated to several units in parallel from the one source.

Fiber Optic Ports

The fiber optic send and receive ports for the communication loop are located on the top of the Device Interface. As standard the ports accept Hewlett-Packard HFBR series plastic fiber optic cables fitted with HFBR-4501 (gray) and HFBR-4511 (blue) connectors. A connector of each color is fitted to each cable. The blue connector is inserted into the blue (receive) fiber optic port (towards the front of the DI), and the gray connector goes to the gray (send) port (towards the back of the DI).

Maximum cable length supported for plastic cable is 40 meters in any one length. Repeaters are available from Group3 to extend this distance.

A new silica cored cable is available to fit the Versatile Link plastic transmitter/receiver parts - called HCS cable, by Spectran Corp. Using this cable with standard plastic components allows distances of up to 500 meters in any one length.

Device Interfaces can be supplied to order that are fitted with transmitters and receivers for ST connectored glass fibre optic cables. When glass cable is used cable lengths up to 3000 meters are supported.

CAUTION

Observe antistatic procedures when handling circuit boards.

The circuit boards form a precision scientific instrumentation system. The circuitry is protected against the normal static discharge from a human body **while it remains in the DI case,** (or the packing it is shipped in).

Whenever circuit boards are removed from their normal mountings, or when they are unpacked from the anti-static bags that they are shipped in, the handler MUST observe industry standard antistatic handling procedures.

This means working at a bench that has a grounded conductive top surface, and using a conductive wrist strap or similar to ground the operator.

Failure to observe these precautions can cause damage, which if not immediately noticeable, can lead to unreliable operation and premature failure.

2.5 Device Interface I/O Boards

Each DI has space in it to house either one, two, or three I/O boards. The I/O boards connect together, and to the processor board, by way of a row of pluggable interboard connectors.
If control requirements change, an I/O board can be removed from a DI and a different type of I/O board put in its place. A DI can be filled with any combination of I/O boards. On power up the processor board interrogates the I/O boards in the DI and configures itself and the I/O boards according to pre-stored settings.

Observe anti static precautions when handling circuit boards - see page 2-8.

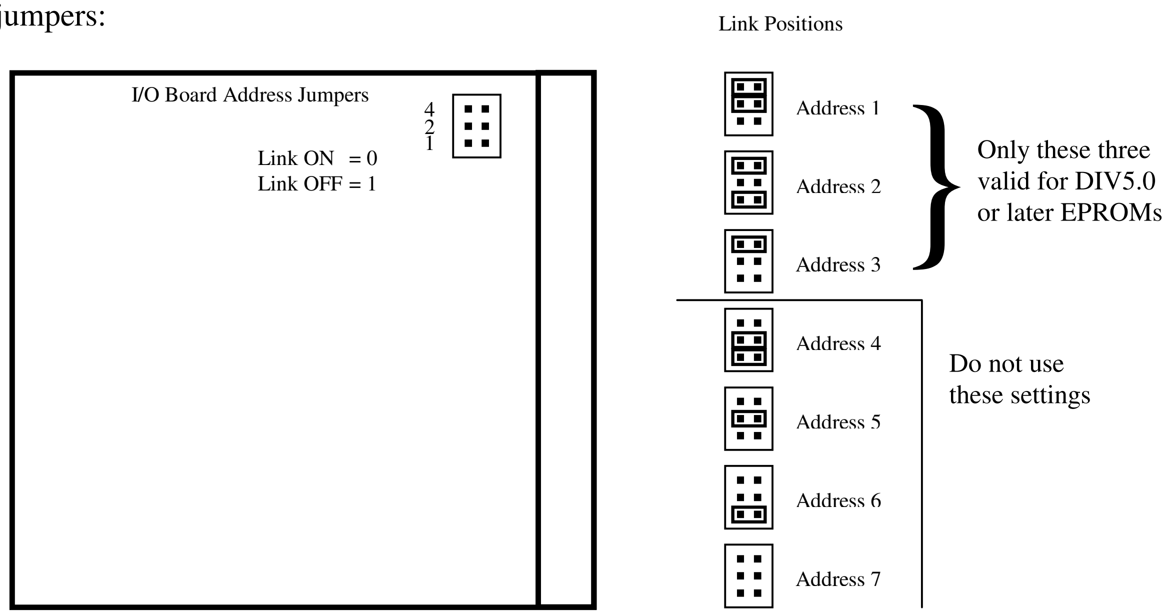
I/O boards have address jumpers that should be set so that each board in the DI has a unique address. The physical position of the I/O board in relation to the processor board is of no importance - it is the address as set by these jumpers that determines which board number is assigned to it.

The jumpers form a binary coded set - a link ON means that the bit is read as 0, a link OFF is read as a 1. All links ON is not allowed for an I/O board in a DI as board 0 is always the processor board. This leaves 7 other possibilities for the address jumper setting.

From **Version 5.0** of the DI software **onwards, only settings 1, 2, and 3 are valid.**

Earlier versions had allowed other settings, but in some circumstances this had led to problems, so board number settings are now limited to 1, 2, & 3. If upgrading EPROMS in an older DI, be sure to check the individual I/O boards jumpers, and change the settings if necessary.

I/O board jumpers:



Note that early versions of the Type B board (PCB number 16000028A) and of the Type D boards (PCB number 16000029A) have board jumpers in a different position and/or orientation.

2.5.1 Type A - Fast Analog and Digital I/O Board

This board provides 2 analog inputs, 1 analog output and 8 digital channels.
Designed as a high speed board, all channels are capable of being updated 500 times / second.
The 16 bit differential input channels have four independently selectable voltage ranges.
Values read range 0 to 64000 for a unipolar inputs, -32000 to +32000 for bipolar inputs
The 14 bit analog output channel has four selectable output voltage ranges.
Values range 0 to 16000 for a unipolar output, -8000 to +8000 for a bipolar output

The digital inputs have TTL thresholds; max. allowed voltage is 40 V (revision B only).
The digital outputs are open collector, sinking 100mA (max) to ground. The eight output pins each have free-wheeling catch diodes, the cathodes of which are commoned to the COM pin on the connector. This COM pin should be tied to the positive supply of the load if the outputs are switching inductive loads (relays). Otherwise leave unconnected.

User Adjustments

Analog channels: Select the range that best covers the signal you are controlling or monitoring. The range needs to be set for each analog channel on the board. This range selection also defines the polarity of the measurement.
Use the diagnostic port and a terminal to set the ranges - under the menu selection **S**ystem configuration **/ R**ange - (see section 3 of this manual)

Digital channels: Each channel can be used as an input or as an output - the selection does not take place at the DI. Each channel does need to be set for the polarity of the logic - both output and input polarities. These are adjusted through the diagnostic port, in the **S**ystem configuration **/ D**igital menu.
The factory default for polarities is **L** for low. This means for outputs that if the control computer sends a '1' to that channel, then the output driver will turn on, sinking current to ground, thereby turning on the load. Note that if you are only considering logic levels then this appears to result in an inversion - a '1' from the control computer results in a measured 0 volts on the pin of the board connector.
Inputs similarly are preset to **L** low polarities at the factory - if an input pin is actively clamped to 0 volts, a '1' will be read at the control computer.
The output drivers can be disabled on a channel by channel basis, by selecting **I** to Inhibit when altering output channel polarities.
If a channel is to be used as an input, then the polarity of its output drive must be set to **L**ow, or the output driver disabled.

Polarities of digital channels can get quite complex and confusing, with several adjustments to the polarities available in hardware and software.
Unless there are good reasons to change, leave all polarities set to the factory default of **L**ow.
Reset behaviour: On power up all digital outputs are cleared to OFF.

A jumper link on the board can be set to determine the behaviour of the outputs on a watchdog or self check reset. If the link is in the HOLD position the outputs will remain at their last value if a watchdog reset occurs. If the link is in the CLEAR position, the outputs will be cleared to OFF if a watchdog reset occurs.

Type A - Fast Analog and Digital I/O Board - Specifications

Analog Inputs	Resolution		16 bit
	Ranges	type A1	0 to 50mV,-50mV to 50mV, 0 to 5V,-5V to 5V,
		type A2	0 to 5V,-5V to 5V, 0 to 10V, -10 to 10V
		type A3	custom ranges to special order, 50mV to 10V
	Digital span		bipolar -32,000 to +32,000, unipolar 0 to 64,000
	Input Resistance		360kΩ differential 180 kΩ either input to analog common
	Common mode rejection ratio		80dB min.
	Common mode input voltage range		±12V (Maximum input voltage ±30V)
	Input settling time		5ms to 0.01% of full scale step
	Input latency		10ms max.
	Offset tempco		10mV/°C max.
	Gain tempco		50ppm/°C max.
Analog Output	Resolution		14 bits Accuracy 0.1%
	Digital span		unipolar 0 to 16000, bipolar -8000 to +8000
	Output ranges		0 to +5V, -5 to +5V, 0 to +10V, -10 to +10V
	1 bit change		0.3mV 0.6mV 0.6mV 1.2mV
	Output current load		5mA max. (Short circuit output current 25mA)
	Output impedance		100Ω max.
	Load impedance		2kΩ min, 1µF max.
	Offset tempco		20mV/°C max.
	Gain tempco		50ppm/°C max.
	Output settling		2 ms to 0.01% of full scale step
Digital I/O	Output drivers		open collector
		OFF state	Internal 1kΩ pull-up to +5V
		ON state	1 volt max. at 100 mA sink to ground
	Input compatibility		TTL switching levels, 40 volt max. (rev.B boards only)

Connectors

Digital 20-way double-row 0.1" spacing shrouded header.
Analog 10-way double-row 0.1" spacing shrouded header.
accepts flat ribbon cable socket connector.

Ground	GND	COM	Common of free wheeling diodes
	GND	DIG0	Digital channel 0
	GND	DIG1	Digital channel 1
	GND	DIG2	Digital channel 2
	GND	DIG3	Digital channel 3
	GND	DIG4	Digital channel 4
	GND	DIG5	Digital channel 5
	GND	DIG6	Digital channel 6
	GND	DIG7	Digital channel 7
	GND	nc	

Pin Numbers 2 1

Analog Input channel 0, - input	AI0-	AI0+	Analog Input channel 0, + input
	AGND	CGND	Chassis / Shield Ground
Analog Ground	AGND	AOUT	Analog Output
	AGND	CGND	Chassis / Shield Ground
Analog Input channel 1, - input	AI1-	AI1+	Analog Input channel 1, + input

Pin Numbers 2 1

Looking from TOP & FRONT of DI

2.5.2 Type B - 24 Channel Digital I/O Board

This board provides 24 bi-directional digital channels. The channels have open collector drivers for use as outputs, and TTL compatible levels for inputs. Each channel can be used as an input or as an output - the selection does not take place at the DI.

The digital inputs are TTL level compatible; maximum allowed voltage is 40 volts.
The digital outputs are open collector, sinking 100mA (max) to ground. The 24 output pins each have free-wheeling catch diodes, the cathodes of which are commoned to the COM pin on the connector. This COM pin should be tied to the positive supply of the load if the outputs are switching inductive loads (relays). Otherwise leave it not connected.

The board can be connected directly to the popular Opto 22 Digital I/O Mounting Rack system using standard 50-way flat ribbon cable.

User adjustments:

Polarities:
Each channel does need to be set for the polarity of the logic - both output and input polarities. These are adjusted through the diagnostic port, in the **S**ystem configuration **/** **D**igital channels menu.
The factory default for polarities is **L** for low. This means for outputs that if the control computer sends a '1' to that channel, then the output driver will turn on, sinking current to ground, thereby turning on the load. Note that if one is only measuring logic levels then this appears to result in an inversion - a '1' from the control computer results in a measured 0 volts on the pin of the board connector.
Inputs similarly are preset to **L** low polarities at the factory - if an input pin is actively clamped to 0 volts, a '1' will be read at the control computer.
The output drivers can be disabled on a channel by channel basis, by selecting **I** to Inhibit when altering output channel polarities.
If a channel is to be used as an input, then the polarity of its output drive must be set to **L**ow, or the output driver inhibited.

Polarities of digital channels can get quite complex and confusing, with several adjustments to the polarities available in hardware and software. Unless there are good reasons to change, leave all polarities set to the factory default of **L**ow

Reset behaviour:
On power up all outputs are cleared to OFF.
A jumper link on the type B I/O board can be set to determine the behaviour of the outputs on a watchdog or software self check reset. If the link is in the HOLD position the outputs will remain at their last value if a watchdog reset occurs. If the link is in the CLEAR position, the outputs will be cleared to OFF if a watchdog reset occurs.
The HOLD position may be preferable if a momentary turning off of outputs could lead to other interlocks tripping out, while the CLEAR position may be the best for a safety critical situation.

Type B - 24 Channel Digital I/O Board - Specifications

Number of channels 24, individually configurable as inputs and outputs.
Maximum allowed voltage on any signal pin: 40 volts (revision B boards only)

Outputs

Open collector, sink to ground.

OFF state internal 1kΩ pull-up to +5V
ON state 1 volt max. at 100 mA sink to ground.

All outputs have free wheeling catch diodes commoned to one pin of the connector. This pin should be connected to the external power supply of the load if switching inductive loads (eg. relays), to suppress inductive spikes.

On power up all outputs are cleared to OFF.
Behaviour of the outputs on a watchdog or software self check RESET can be set by a jumper to either HOLD the outputs at their last value, or CLEAR the outputs to OFF.

Inputs

TTL voltage level compatibility.
Maximum input low level is 0.8 volts.

Connector

50-way double-row 0.1" spacing shrouded header.
accepts flat ribbon cable socket connector.

	Pin 2	Pin 1	
Ground	GND	COM	Common of free wheeling diodes
	GND	DIG0	Digital channel 0
	GND	DIG1	Digital channel 1
	GND	DIG2	Digital channel 2
	GND	DIG3	Digital channel 3
	GND	DIG4	Digital channel 4
	GND	DIG5	Digital channel 5
	GND	DIG6	Digital channel 6
	GND	DIG7	Digital channel 7
	GND	DIG8	Digital channel 8
	GND	DIG9	Digital channel 9
	GND	DIG10	Digital channel 10
	GND	DIG11	Digital channel 11
	GND	DIG12	Digital channel 12
	GND	DIG13	Digital channel 13
	GND	DIG14	Digital channel 14
	GND	DIG15	Digital channel 15
	GND	DIG16	Digital channel 16
	GND	DIG17	Digital channel 17
	GND	DIG18	Digital channel 18
	GND	DIG19	Digital channel 19
	GND	DIG20	Digital channel 20
	GND	DIG21	Digital channel 21
	GND	DIG22	Digital channel 22
	GND	DIG23	Digital channel 23

Pin Numbers 2 1

Looking from TOP & FRONT of DI

2.5.3 Type C - 8-Input Analog Board

This board provides eight analog input channels. The channels have differential inputs, and provide 16 bit resolution.
Each channel can be set individually to have one of four input ranges.

Digital values range 0 to 64000 for unipolar inputs, -32000 to +32000 for bipolar inputs.

For ground referenced (single input) signals, tie the inverting (-) input of that channel to analog ground, and apply the signal to be measured to the non-inverting (+) input.

User Adjustments

Range selection:

Select the range that best covers the signal you are monitoring.
The range needs to be set for each analog channel on the board. This range selection also defines the polarity of the measurement.
Use the diagnostic port and a terminal to set the ranges - under the menu selection **S**ystem configuration **/ R**ange - see section 3 of this manual for a full description of the diagnostic port functions.

Ensure that the ranges, and in particular the unipolar or bipolar nature of the selected ranges are noted down, so that the control software can be configured accordingly. The input readings at the control computer will exhibit strange behaviour if the polarities as set at the DI do not correspond to those the control software is configured for.

Filtering:

The user can select various time constants for a software based time averaging filter, and optionally a window within which the filtering is active.

The action of the filter is as follows:

while the raw input value remains within the window width of the average value, the value reported is the updated average. However if the raw input rapidly jumps in value by more than the window width, the averaging is temporarily suspended, and the new reported value will be the actual instantaneous value, not a time average. In this way the reported value can be heavily filtered to eliminate small random noise, but still quickly track a large rapid input change.

The filter constant and window width are adjusted through the diagnostic port, using the **S**ystem configuration **/ F**ilter menu. See section 3 for more details.

Type C - 8-Input Analog Board - Specifications

8 analog input channels, differential inputs.

Resolution	16 bit	
Input ranges	type C1	0 to 50mV,-50mV to 50mV, 0 to 5V,-5V to 5V
	type C2	0 to 5V,-5V to 5V, 0 to 10V, -10 to 10V
	type C3	custom ranges to special order, 50mV to 10V
Digital span	bipolar	-32,000 to +32,000
	unipolar	0 to 64,000
Input Resistance		360kΩ differential
		180 kΩ either input to analog common
Common mode rejection ratio		80dB min.
Common mode input voltage range		±12V
Maximum input voltage		±30V
Input settling time		5ms to 0.01% of full scale step
Input latency		10ms max.
Offset tempco		10mV/°C max.
Gain tempco		50ppm/°C max.
Polling rate		125 times per second each channel

Connector

34-way double-row 0.1" spacing shrouded header.
accepts flat ribbon cable socket connector.

Description	Pin 2 side	Pin 1 side	Description
	nc	nc	
Chassis / Shield Ground	CGND	AGND	Analog Ground
Analog Input channel 7, - input	AI7-	AI7+	Analog Input channel 7, + input
	CGND	AGND	
Analog Input channel 6, - input	AI6-	AI6+	Analog Input channel 6, + input
	CGND	AGND	
Analog Input channel 5, - input	AI5-	AI5+	Analog Input channel 5, + input
	CGND	AGND	
Analog Input channel 4, - input	AI4-	AI4+	Analog Input channel 4, + input
	CGND	AGND	
Analog Input channel 3, - input	AI3-	AI3+	Analog Input channel 3, + input
	CGND	AGND	
Analog Input channel 2, - input	AI2-	AI2+	Analog Input channel 2, + input
	CGND	AGND	
Analog Input channel 1, - input	AI1-	AI1+	Analog Input channel 1, + input
	CGND	AGND	
Analog Input channel 0, - input	AI0-	AI0+	Analog Input channel 0, + input

Pin Numbers 2 1

Looking from TOP & FRONT of DI

2.5.4 Type D - 8-Output Analog Board

This board provides eight single ended analog outputs of 14 bit resolution.

Digital values range 0 to 16000 for unipolar outputs, -8000 to +8000 for bipolar outputs.

The outputs are referenced to the analog ground, which is common to all analog channels in the same DI.

User Adjustments

Analog output ranges: Select the range that best covers the signal you wish to generate. Use the diagnostic port and a terminal to set the range - under the menu selection **S**ystem configuration / **R**ange - see section 3 of this manual for a full description of the diagnostic port functions.

Ensure that the ranges, and in particular the unipolar or bipolar nature of the selected ranges are noted down, so that the control software can be configured accordingly. The outputs at the DI will exhibit strange behaviour if the polarities as set at the DI do not correspond to those the control software is configured for.

Type D - 8-Output Analog Board - Specifications

Analog Outputs

8 single ended outputs, referenced to a common analog ground.

resolution	14 bits	
Accuracy	0.1%	
digital span	unipolar	0 to 16000 bits
	bipolar	-8000 to +8000 bits
Output ranges	range 1	0 to +5V
	range 2	-5 to +5V
	range 3	0 to +10V
	range 4	-10 to +10V
1 bit change	range 1	0.3mV
	range 2	0.6mV
	range 3	0.6mV
	range 4	1.2mV
Output current load	5mA max.	
Short circuit output current	25mA	
output impedance	100Ω max.	
Load impedance	2kΩ min, 1µF max.	
Offset tempco	20mV/°C max.	
Gain tempco	50ppm/°C max.	
output update rate	125 times per second	

Connector

20-way double-row 0.1" spacing shrouded header.
accepts flat ribbon cable socket connector.

Chassis / Shield Ground	CGND	CGND	Chassis / Shield Ground
	AGND	CH7	Analog Output channel 7
	AGND	CH6	Analog Output channel 6
	AGND	CH5	Analog Output channel 5
Analog Ground	AGND	CH4	Analog Output channel 4
	AGND	CH3	Analog Output channel 3
	AGND	CH2	Analog Output channel 2
	AGND	CH1	Analog Output channel 1
	AGND	CH0	Analog Output channel 0
Chassis / Shield Ground	CGND	CGND	Chassis / Shield Ground
Pin Numbers	2	1	

Looking from TOP & FRONT of DI

2.5.5 Type E - 4-DC Motor Driver Board

This board has four channels for controlling small D.C. motors. Each motor can have independently variable speed, direction and acceleration.

Digital figures for speed vary 0 to 255, though many motors have too much friction to start turning unless the speed is above about 30.

Acceleration ranges in value from 0 to 255. With a setting of 1 a motor will take 25 seconds to reach full speed from standstill, with a setting of 5 it takes 5 seconds, with a setting of 20 it takes 1.25 seconds, and with a setting of 50 the motor reaches full speed in 0.5 seconds. The human ear or eye can only notice accelerations that are of a very low value, say 1 to 30, while any acceleration figure much above that appears to produce almost instantaneous full speed.

Direction control has values of
0 for off (motor windings open circuit)
1 for forward
2 for reverse
3 for stopped (motor windings shorted out)

Drive to the motors is controlled by pulse density modulation; the cycle time is divided into 256 sections, each of one pulse width. The number of drive pulses, as set by the speed setting, are evenly distributed over the 256 pulse cycle time, resulting in much smoother drive at low speeds when compared to a simple pulse width modulated speed control.

The pulse width is programmable to optimise the drive according to the inductance and inertia of the motors used. The pulse width selected is common to all motors.

Power for the motors is provided externally by the user, independently for each motor.
Each channel can control up to 30 volts, 1 Amp maximum. The external supply positive should be connected to the requisite motor supply pin on the board connector, and the external supply negative connected to the ground pin of the board connector.
The outputs from the driver chips are in a full bridge configuration so the two motor terminal outputs must not be shorted to the power supply or to ground.

The board includes a stable 5 volt reference output for energising position sensing potentiometers, which could be read using a type C analog input board.

User Adjustments

Pulse Width / Cycle Time.

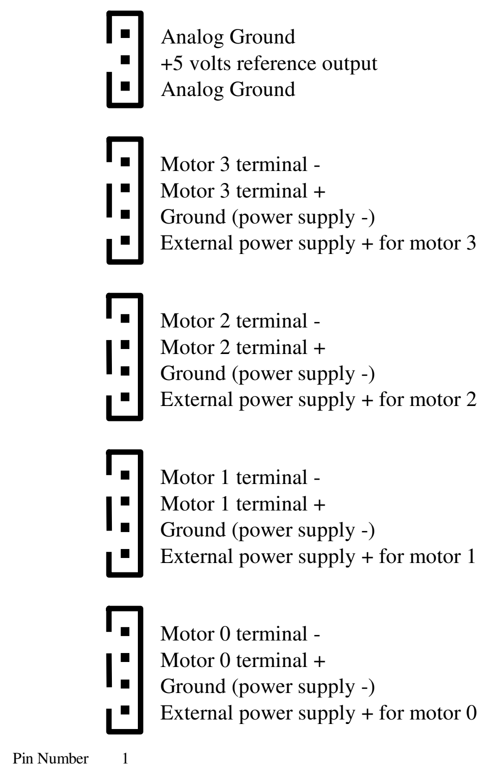
The pulse width and cycle time are directly related - the cycle time being 256 times the pulse width. The user can select from a number of different cycle times by using the **S**ystem configuration / **M**otor parameter control menu from the diagnostic port on the DI. The modulation used is best determined by trial and error, balancing smooth slow running and start up torque for the particular motor being used. In general it is best to use the longest cycle time possible without the slow running being too erratic. If a very short cycle time is used on a motor with high inductance then the current in the windings may not be able to rise to a sufficient value in time, and the motor will not work.

2.5.5 Type E - 4-DC Motor Driver Board - Specifications

Driver output channels	4, reversible, pulse density modulated
Pulse width	0.02 to 3.54 ms programmable in 8 binary steps giving total cycle times of 7 to 910 ms.
Supply voltage	30 volts D.C. max. referenced to a common ground. each channel supplied individually.
Load current	1 Amp max per channel
Speed resolution	8 bits (0:255)
Acceleration resolution	8 bits (0:255)
Stop modes	motor windings open-circuit, or short circuited (braking)
Reference voltage output	5 ±0.1V, 10 mA max load, 30 mA short circuit

Connectors

Motors	4-way AMP shrouded header accepts AMP Mod. IV Wire-Applied Housing 102241-3
Reference	3-way AMP shrouded header, as above.



Looking from TOP & FRONT of DI

2.5.6 Type F - 2 Serial Communications Ports

This type-F serial interface board has two serial send/receive channels (ports), and is used to interface devices with serial communications facilities into a Group3 Control system. Each port is independently configurable.

The use of fiber optics provides isolation from ground loops, provides immunity to transient interference and allows communication across voltage gradients.

The RS232 option (revision A boards) is **NOT ISOLATED and NOT PROTECTED**, and is therefore a potential entry point for noise and interference. It is intended for use only in benign environments, and with short cables only.
The preferred serial data link remains the fiber optic ports. A fiber optic to RS232 converter, the Group3 FTR, is available to convert fiber optic signals to RS232 voltage levels for instruments without fiber optic data ports.

There are two communication protocols. The first is a general serial mode, in which X-on/X-off (CTRL-S/CTRL-Q) flow control is available. Additionally, The receiver of the F board can be set to recognise any character as a message terminator. Flow control and the terminating character can both be disabled to allow full binary serial communications. If this is used, a timeout option can be enabled which retrieves buffered data after a short time period (two character durations).
Port 0 can transmit and receive at up to 38.4kbaud. Port 1 is limited to a maximum rate of 19.2kbaud, unless full duplex (simultaneous and continuous transmit and receive) is required on both ports, in which case Port 1 is limited to a maximum of 9600 baud.

The second protocol allows communication with Group3 Digital Teslameters. Up to 8 teslameters can be connected in a fiber optic loop and accessed through each port. Readings of Field (and Temperature, if available) are automatically placed in the Loop Controller in the host computer.

User Adjustments

Each serial port needs to be set up through the diagnostic port, using the "**S**ystem Configuration" / "**S**erial Fibre Optic Board" menu. Baud rate, number of stop bits, number of data bits, nature of parity, flow control, a terminating character and message termination options (terminator and/or timeout) need to be set for each channel. See chapter 3 for more details. The timeout option is useful for preventing characters becoming stuck in the receive buffer when no terminator character is used.

Transmitted data goes out on both the fiber optic ports and the RS232 ports. There is a three pin jumper for each channel to select either the fiber optic receive or the RS232 receive for that channel. The jumpers are positioned just below the RS232 connector, and have a 0 and 1 written in copper beside them to indicate the channel they refer to.
If the jumper is set to bridge the two pins labeled "fibre" then that channel receives data from the fiber optic port. If the jumper is set to bridge the two pins labeled "wire" then the receive data is taken from the RS232 connector.

Type F - 2 Serial Communications Ports - Specifications

Ports	two, completely independent
Serial Baud Rates	2400, 4800, 9600, 19.2K, (38.4K, possible on port0 only)
Number of data bits	7 or 8
Number of stop bits	1 or 2
Parity	even, odd, or none
String terminator (receive)	any character (0 to 255) or disabled
Flow control	X-OFF/X-ON (CTRL-S/ CTRL-Q) or disabled
Buffering	1000 byte on each port, transmit and receive
Fiber optic cable	Hewlett Packard HFBR series, 40 meters max. length

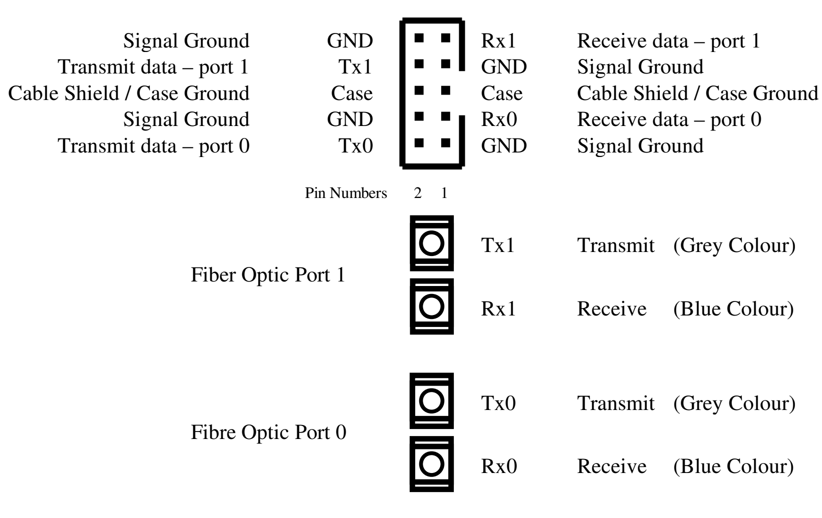
X-on/X-off (CTRL-Q/CTRL-S) Flow Control

If an external device sends data faster than the F board can process it, the receive buffer fills up. If enabled, flow control can prevent the subsequent loss of serial data by turning the data source off and on. When the buffer is more than 80% full, the send port will transmit a CTRL-S character for each character received. When the buffer has been emptied to 20%, the send port will transmit a CTRL-Q character. Similarly an external device can control the flow from the send port by transmitting CTRL-S and CTRL-Q to the receive port. If flow control is enabled, and no characters have been received for more than one second, the port will send out the XON character, once per second. This is designed to prevent the comm's locking up if a control character is corrupted.

Connector Pinout

Note that the RS-232 connector is only present on revision A circuit boards.

RS-232



Looking from TOP & FRONT of DI

2.5.7 Type G - 4-Stepping Motor Driver Board

This board generates the logic levels necessary to drive 4 stepping motors. Each channel has independently programmable acceleration and final sustained speed.

Each motor channel can be set to Position mode, or to Continuous Run mode, in which the motor acts as a variable speed drive. Position control is achieved by sending the channel a 32 bit number representing the desired absolute position (±2,147,483,648 steps from a settable zero).

The following are set by the control program in the Loop Controller's dualport RAM for each motor channel:

- Whether the motor is to be used in Position mode or Continuous Run mode.
- In Position mode, the desired position (±2,147,483,648).
- In Continuous Run mode, the motor direction (stop-free, forward, reverse or stop-locked).
- The maximum step rate (0 to 5000 steps/sec).
- Acceleration (0 to 255).
- Whether the motor should move in half step or full step increments.
- What state the motor should be in when it comes to a stop - free to rotate (windings off) or locked (windings energised).

The four drive signals generated for each stepping motor are provided as open collector outputs capable of sinking 180mA each. In Quadrature drive mode (see below) small motors can be driven directly, or the signals can be used to drive the motor via high current devices. In the other drive modes, Clock & Direction or Dual Clock output, this board generates logic signals that are used to control a commercially available stepper motor driver power module.

Eight digital inputs are provided which can be set to act as limit switches, automatically shutting off drive to the motor, or they can be used as general inputs.

Four analog inputs of eight bit resolution (values of 0 to 255) are also available. They could be used as a fairly low resolution check on the absolute motor position by sensing position potentiometers. A 5V reference is provided to power the potentiometers.

User Adjustments

Through the diagnostic port of the DI the user can configure each motor channel by using the **S**ystem / **M**otor parameter menu. The user needs to define:

- What drive mode is used: quadrature (four direct signals), clock and direction signals, or a dual clock mode.
- Whether the digital inputs are to be used as limit switches, and if so, their polarity.

If the channel is defined as Clock & Direction or as a Dual Clock output mode then the polarity of the Half step/Full step signal, and the Windings Off signal are selectable.

When defined as limit switches, the digital channels unconditionally stop the motor when activated. If during testing it appears that the motor is not working, check the state of the limit switch inputs, their polarities, and whether the limit function of the switches is enabled.

Type G - 4-Stepping Motor Driver Board - Specifications

Number of motors 4

Output signals	open collector	180 mA, 50 V maximum
	pull up to motor power	10kΩ
Input parameters	maximum step rate	4500 steps/sec (one motor active at a time)
		700 steps/s (two motors active at the same time)
		500 steps/s (all motors active at same time)
	Desired position	± 2,147,483,648 steps (32 bit) from zero
	acceleration	256 levels (8 bit)
Input signals	digital inputs	1kΩ pull up to 5 volts, to be switched to ground
		maximum input 5V minimum input 0V
	analog inputs	as an 8 bit digital value, approx. 20mV per bit
		maximum input 5V minimum input 0V
5V reference	max. output current (total both pins)	50 mA
	recommended potentiometer value	500Ω minimum.
Connector type	20-way double-row 0.1" spacing shrouded header.	
	accepts flat ribbon cable socket connector.	

Motor Power for motors 2 & 3	MPWR23	MGND	Motor Ground	
Digital Input 7	I7	I6	Digital Input 6	
Motor 3 Direction / Phase D	M3D	M3C	Phase C / Clock	**Motor 3**
Half/Full Step / Phase B	M3B	M3A	Phase A / All Windings Off	
Motor 2 Direction / Phase D	M2D	M2C	Phase C / Clock	**Motor 2**
Half/Full Step / Phase B	M2B	M2A	Phase A / All Windings Off	
Digital Input 5	I5	I4	Digital Input 4	
Digital Ground	DGND	MGND	Motor Ground	
Analog Ground	AGND	AN3	Analog Input 3	
+5 volt analog reference	+5V	AN2	Analog Input 2	

Motor Power for motors 0 & 1	MPWR01	MGND	Motor Ground	
Digital Input 3	I3	I6	Digital Input 6	
Motor 1 Direction / Phase D	M1D	M1C	Phase C / Clock	**Motor 1**
Half/Full Step / Phase B	M1B	M1A	Phase A / All Windings Off	
Motor 0 Direction / Phase D	M0D	M0C	Phase C / Clock	**Motor 0**
Half/Full Step / Phase B	M0B	M0A	Phase A / All Windings Off	
Digital Input 1	I1	I0	Digital Input 0	
Digital Ground	DGND	MGND	Motor Ground	
Analog Ground	AGND	AN1	Analog Input 1	
+5 volt analog reference	+5V	AN0	Analog Input 0	

Pin Numbers 2 1

Looking from TOP & FRONT of DI

Notes:
MGND, DGND and AGND are internally connected.
Connections to MPWR01 and MPWR23 are required if the internal 10kΩ pull-ups on the open collector outputs are needed, or if these outputs are to be used to directly drive small stepping motors. Free wheeling diodes are provided on the outputs, commoned to the MPWR01 or MPWR23 pins, to suppress any inductive spikes from the motor windings.
MPWR pins need not be connected if external pull-ups are used, and the outputs are used to drive logic inputs.

2.5.8 Type H - 4-Encoder Input Board

The Type H Encoder Board accepts inputs from four quadrature encoders. A dedicated up/down counter for each encoder allows the four channels to operate independently and at high speed.
Applications include rotary position encoders, shaft speed detectors, and 'soft pot' operator interface control knobs (such as the Hewlett-Packard HRPG series of miniature encoders).

Each channel accepts the two outputs from a quadrature encoded source, such as an incremental optical shaft encoder. The inputs have built-in digital filters for rejecting noise on the incoming quadrature signals. A 5 volt supply is provided at each input connector to power the encoder.

The counts are accumulated in the Loop Controller, and are limited to the range -32,768 to +32,767. A constantly increasing count will eventually be clamped at +32,767. Any further positive counts are not recorded. As soon as the count direction is reversed the accumulated count will be decremented.
A similar clamp at -32,768 occurs for a decreasing count.

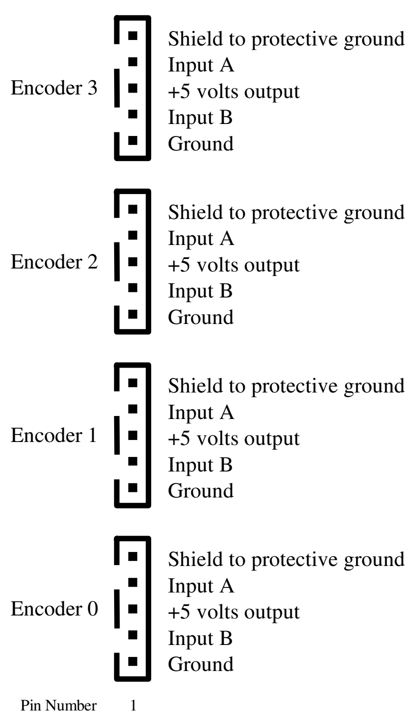
Since loop controller software version 5.1 (May 2006) the H board can be optionally used with 4-byte encoders, increasing the limits to ±4,000,000,000. This is a software configuration at the computer.

Specifications:

Number of encoders	4
Input signals	2 quadrature signals per channel, LO level <1.5V, Hi level >3.5V
Noise rejection	inputs have 2 volts hysteresis, and are digitally filtered
Input pulse repetition rate	120kHz max. with 1 I/O board in Device Interface 80kHz max. with 2 I/O boards in Device Interface 40kHz max. with 3 I/O boards in Device Interface
Supply to Encoders	+5 Volts, 50 mA each Maximum, 200 mA total.

Connectors

5-way AMP shrouded header
accepts AMP Mod. IV Wire-Applied Housing 102241-3



Looking from TOP & FRONT of DI

Notes:

- The shield connection from each encoder cable is connected to the DI case.
- The DI case itself should be grounded if the installation will allow.

2.5.9 Type J - Dual Precision Analog Output Board

This board provides two single ended analog outputs of 16 bit resolution.

The outputs are referenced to the analog ground, which is common to all analog channels in the same DI.

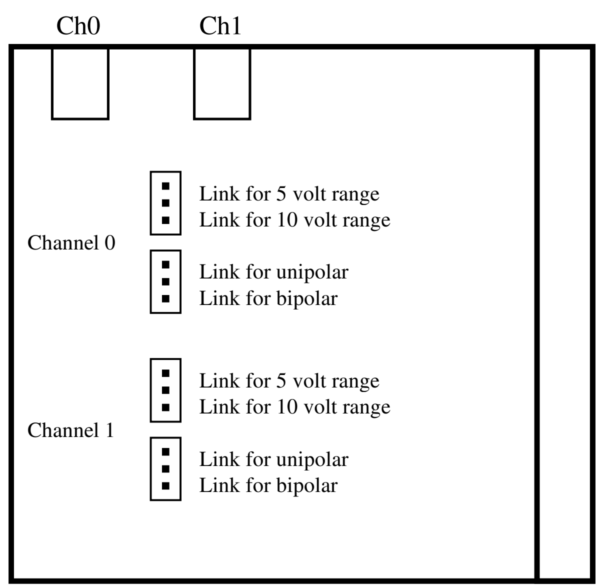
Digital values range 0 to 64000 for unipolar outputs, -32000 to +32000 for bipolar.

User Adjustments

Ranges: Select the range that best covers the signal you wish to generate.

In order to preserve the accuracy of the output it was necessary to adjust ranges and polarities using gold plated jumper links on the board. To adjust the range the jumpers on the board must be set to the desired positions, and the diagnostic port used to inform the software in the DI of what the hardware links are set to. See the diagram below.
Use the diagnostic port and a terminal to set the range - under the menu selection **S**ystem configuration / **R**ange - see section 3 of this manual for a full description of the diagnostic port functions.

Ensure that the ranges, and in particular the unipolar or bipolar nature of the selected ranges are noted down, so that the control software can be configured accordingly. The outputs at the DI will exhibit strange behaviour if the polarities as set at the DI do not correspond to those the control software is configured for.

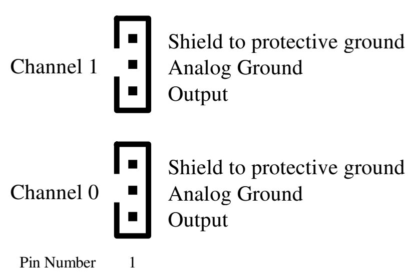


Type J - Dual Precision Analog Output Board - Specifications

Resolution	16 bits	
Accuracy	0.005%	
Monotonicity	16 bit	
Digital span	unipolar	0 to 64000 bits
	bipolar	-32000 to +32000 bits
Output ranges	range 1	0 to +5V
	range 2	-5 to +5V
	range 3	0 to +10V
	range 4	-10 to +10V
1 bit change	range 1	75 µV
	range 2	150 µV
	range 3	150 µV
	range 4	300 µV
Short circuit duration	indefinite	
Short circuit current	20 mA	
Output impedance	1Ω max.	
Load impedance	1 KΩ min.	
Offset tempco	20mV/°C typ.	
Gain tempco	5ppm/°C typ.	

Connector

3-way 0.1" spacing shrouded header.
accepts AMP Mod. IV Wire-Applied Housing 102241-3



Looking from TOP & FRONT of DI

Notes:
The shield connection from each channel is connected to the DI case.
The DI case itself should be grounded if the installation will allow.

2.5.10 Type K - GPIB / IEEE 488 Controller

The Type K I/O board provides full GPIB/IEEE488 talker/listener/controller capability over the fiber optic loop of a Group3 Control system. The Device Interface software allows the use of only one K board in a Device Interface.

Power supplies, controllers and measuring instruments with a GPIB interface can now be integrated into the computer control system, taking advantage of the high voltage isolation provided by the fiber optic cables.

A maximum of 8 GPIB devices can be controlled by one type K board.

The connector on the K board is a 0.1” two row box header. Note this is not a standard IEEE488 specified connector. There are two ways to achieve the conversion -

1) The pinout of the K board connector allows direct conversion to IEEE488 using ribbon cable, with insulation displacement connectors at each end - the 2x13 bump polarised socket to suit the K board at one end, and an IEEE488 compatible plug at the other. The ribbon cable should be kept as short as possible, since the shielding, if present, is not as good as a genuine IEEE488 cable. The ribbon cable option is adequate for benign environments.

2) Use a Group3 signal conditioner - the SCTK. This is a DIN rail mount module that accepts a 2x13 bump polarised ribbon cable connector at one end, and has a rigidly mounted IEEE488 connector at the other. It has circuitry on board to actively protect all the IEEE488 signals. It is recommended if a securely mounted connector is required, and should be used in all electrically noisy environments.

User Adjustments

The controller needs to be set up through the diagnostic port, using the **S**ystem configuration / **G** - GPIB configuration menu.

The following parameters should be set appropriately:-

primary address
secondary address (if any)
default EOS character
default time out period
defaults for asserting EOI

See page 3-15 for more details on how to adjust these.

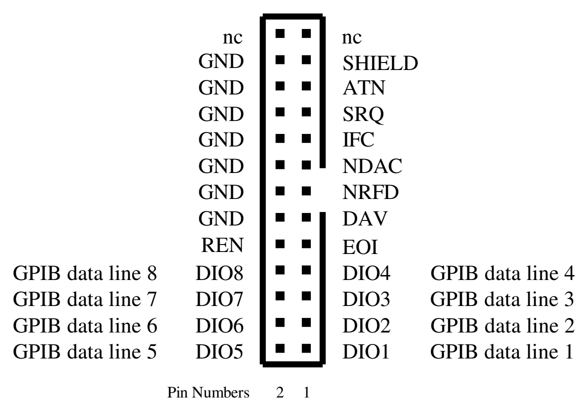
Type K - GPIB / IEEE 488 Controller - Specifications

Performs all IEEE 488.1 interface functions.
Meets all IEE 488.2 requirements.

Use only one K board in a Device Interface.

GPIB/IEE488 Capability:	SH1	- Source handshake
	AH1	- Acceptor handshake
	T5 or TE5	- Talker or Extended Talker
	L3 or LE3	- Listener or Extended Listener
	SR1	- Service request
	RL1	- Remote/local
	PP1 / PP2	- Parallel Poll local/remote configuration
	C1,C2,C3,C4,C5	- Controller, all capabilities
	E1,E2	- bus drivers tri-state/open collector

Connector 26-way double-row 0.1" spacing shrouded header.
accepts flat ribbon cable socket connector.



Looking from TOP & FRONT of DI

2.6 IDENTIFYING I/O BOARD TYPES AND SERIAL NUMBERS

There are several ways of identifying the types of I/O boards present in a Device Interface.

1 Device Interface Label

A label on the front of the Device Interface indicates the I/O boards present as the unit was configured by Group3. The model number on the Device Interface label is made up as follows:

CN# - *a b c*

where **#** = 1 or 3 according to the number of I/O board slots in the DI
and ***a, b,*** and ***c*** are the I/O board type designators (see below), ***a*** being the I/O board on the right or nearest to the processor board.

When the Device Interface is reconfigured by the user, the label may no longer be correct. There are other ways of determining the types of boards in the unit.

2 I/O connectors

Each type of I/O board has a unique arrangement of connectors visible through the slot in the top of the DI. The connector styles are set out below:

board	description	connector style(s)
A	fast analog/digital	10-way and 20-way dual-row header
B	24-channel digital	50-way dual row header
C	8-ch analog input	34-way dual row header
D	8-ch analog output	20-way dual row header
E	dc motor driver	four 4-way & one 3-way single row hdr
F	fiber optic serial	fiber optic ports, and 10-way header
G	stepping motor driver	two 20-way dual row headers
H	4 encoder channels	four 5-way single row headers
J	2-ch analog output	two 3-way single row headers
K	GPIB/IEEE488 controller	one 26-way dual row header

3 Diagnostic Port

Connect a terminal to the diagnostic port on the DI. The main menu appears, with the serial number of the processor board.
From the main menu, type **B**. A list of the I/O boards in the DI will appear on the terminal screen. The serial number of each I/O board is also displayed. (boards manufactured before 1995 will not display serial numbers)

I/O board serial numbers are of the form: ***Xcnnn***

where ***X*** is the I/O board type, e.g. C for 8-channel analog input board,

c is the I/O board category; it defaults to 1 if only one category exists,

nnn is a three digit sequence number unique to the board.

For example, C2138 is I/O board type C2 (5V and 10V ranges), sequence number 138.

Processor board serial numbers have the letters PR in place of ***Xc***.

4 Serial number on mounting bar (from August 1993).

Observe anti static precautions when handling circuit boards - see page 2-8.

The I/O board's serial number is shown on the rear surface of the mounting bar which attaches the board to the rear panel. The serial numbers of all boards in the DI can be checked by removing the back plate. Proceed as follows:

a) Unplug all cabling from the DI.
b) Remove the DI case by removing its two fixing screws, one on top and one underneath near the rear of the case, then slide the case off.
c) If the DI has a green plastic DIN rail clamp, remove it by undoing the screw at the rear of the clamp, and slide the clamp off sideways.
d) Remove the back plate by removing the screws passing through it into the mounting bars.

The serial numbers are now exposed.

Reassemble the DI in the reverse order, making sure that correct orientation of the rear plate is observed. When replacing the cover, note that the address switch actuator and the three LEDs must pass through their holes in the cover.

5 Serial numbers on I/O board (from June 1993).

The same serial number as on the mounting bar is marked on the printed circuit board, near the back edge between the two mounting bar attachment screws. In most cases the I/O board must be removed from the mounting plate before this number can be seen.

Observe anti static precautions when handling circuit boards - see page 2-8.

2.7 CNA module - Integrated Device Interface

The CNA is a precision control and monitoring module that is designed to be used as part of a Group3 Control system. It is functionally equivalent to a type A board and Processor and the signal conditioners all rolled into one unit.
The CNA can also implement closed loop control, as it has PID algorithm built in to it.

It is housed in a low profile metal case, and is designed as a very rugged, small, inexpensive unit to aid the implementation of a distributed control system.
The unit consists of a main circuit board contained entirely within a metal enclosure, linked by a short length of 40way ribbon cable to an I/O board (SCA) mounted on top of the case.

User Adjustments

Since this module effectively incorporates a DI processor board, all the adjustments to processor board parameters detailed in section 3 apply - such as display options, communications mode, timeout action, access passwords, etc.

I/O channels need to be set up using the diagnostic port:-

Analog Inputs: Select the desired range; -10 to +10 volts (default), or -100 to +100 mV
Set the desired filter factor and filter window.

Analog output: Select either the -10 to +10 volt range (default), or 4 to 20 mA range.

Digital Inputs: Set the polarities (default is LOW)

Digital Outputs: Set the polarities (default is LOW)

Reset behaviour: On power up all digital outputs are cleared to OFF.
A jumper link on the main board can be set to determine the behaviour of the outputs on a watchdog or self check reset. If the link is in the HOLD position the outputs will remain at their last value if a watchdog reset occurs. If the link is in the CLEAR position, the outputs will be cleared to OFF if a watchdog reset occurs. The modules are shipped with the link in the CLEAR position. If the link needs changing see the section on "Removing the main board from a CNA module"

Adjustments to the top I/O board - the SCA

Removing the shield plate gives access to various resistors to allow for voltage division on the analog channels (default is a 1:1 - straight pass-through, no division),
Resistors are also accessible to alter the nature of the digital inputs - whether the input opto-couplers are used to sense contact closures (the default), or are to be powered by the input signal itself. Details about these adjustments are given in the following pages.

CNA Module - Specifications

Features:

Two Analog Input channels,

16 bit resolution, bipolar, each with differential inputs.
Input Ranges: 10 Volt (1 lsb = 0.3mV) and
100mV (1 lsb = 3µV)
Input Impedence 94kΩ
Both channels sampled 33 times per second.
Channel 0 can be used as the feedback input, if PID control is selected.

One Analog Output channel.

16 bit resolution,
Output signal selectable as: -10 to +10 volt range, (1 lsb = 0.3mV), or
4 to 20 mA current output. (1 lsb = 0.2 µA)
output Impedence 100Ω

The analog output acts as the closed loop PID control output, if selected.

Eight Digital Inputs,

Opto-couplers on each channel can be selected to operate in two modes:
Signal powered channels are completely independent,
Require minimum of 5mA signal.
Contact closure channels share a common return potential
(which is isolated from the rest of the unit up to 500V)

Eight Digital Outputs,

Reed relay contacts, Switching 100 volt, 500mA maximum.
Max. switched power - 10W
Isolation of contacts from rest of unit - 300 volts

Communications by fiber optic cables at 1.15Mbaud.
Entire unit is isolated from the controlling computer.

Power supply input required:
18 to 36 volt DC, or 14 to 26 volt (rms) AC, 3 Watts.
Unit contains an internal switch mode supply, providing isolation up to 200 volts.

Fully featured Diagnostic Port, allowing configuration and local control over-ride from a terminal with an RS-232 serial port.

Two stage transient suppression
all I/O pins on the main board have fast acting, voltage limiting components installed, coupled with further suppression and isolation on the I/O board.

Connectors

Analog channels on I/O board
- each has a 4 position screw terminal block, 3.81mm pitch

Digital channels on I/O board
- each has a 3 position screw terminal block, 3.81mm pitch

Between the boards - 40 pin dual row 0.1" spacing boxed header on main board,
40 way ribbon cable with matching socket attached to I/O board.

Diagnostic Port - 8 way miniDIN round socket.

Power connector. Phoenix MSTB, 2 pole connector

Data -
Fiber optics - Hewlett Packard Versatile Link plastic cable connector,
or ST connector for glass cored cable

Case.

Aluminium extrusion 140 x 92 x 29 mm
Main board slides into slots within the hollow section
I/O board slides into slots extruded on the outside of the case.
Stainless steel endplates with integral DIN rail locking system.

Aluminium shield plate mounted over top of I/O board, covering components but allowing access to the screw terminals.
Single captive knurled metal screw secures shield plate.

Mounting.

Stainless Steel DIN rail clamp is integral to the metalwork of the unit.

Unscrewing one captive knurled screw, and unplugging the 40way ribbon cable allows the I/O board to be slid out from the housing, leaving all the I/O wiring still in place. Moving the DIN rail locking bar then allows the main unit to be lifted off the rail.

No tools are required to remove the main module from an installation, allowing quick replacement or upgrades.

Physical size:

Maximum dimensions of entire unit, with DIN rail mounting
160 mm long x 92 mm wide ,
x 52 mm high off the backplate that the DIN rail is bolted to.
(approx 6" x 3 " x 2")

Removing the main board from a CNA module

1) Lift the locking bar to release the unit from the DIN rail.

2) unscrew the knurled nut that secures the shield plate - make sure the screw is fully retracted - the shield plate can remain in place.

3) unplug the 40 way ribbon cable connector from the end of the case. Note that the end of the ribbon cable that is attached to the SCA I/O board is permanently attached to that board - do not try to remove it!.

4) slide out the SCA I/O board from the aluminium extrusion case - all the I/O wiring to the screw terminal blocks can remain in place.

5) take the main body of the unit over to an approved anti-static workstation.

6) unscrew the four screws on the end that has the 40 way connector on it. The screws on the other end (the one with the LEDs, switch etc.) should be left securely fastened.

7) Gently lift the end plate out over the 40 way connector and push it down out of the way so that the inner circuit board can be withdrawn. There is enough flexibility in the stainless steel backplate to allow the circuit board to be withdrawn, but do not bend the backplate any further than necessary or permanent deformation will result.

There are three reasons that a user may wish to gain access to the main board.
- to change the EPROM - see the general notes in section 11.2 on upgrading EPROMs.
- to replace the fuse - use Shurter OMF63, 3 amp rating.
- to change the behaviour of digital outputs on an internally generated RESET.
  There is a 3 pin header, with a mini-link jumper on it, up by the 40 way connector.
  The two possible positions are labelled on the board as "Hold" and "Clear".

Re-assembly

Essentially the reverse of the above procedure, but take note of the following:-

- when sliding the main board back into the case make sure both sides go into the lowest slot possible.

- ensure the LEDs and switch shaft protrude through the holes in the other end plate.

- guide the end plate over the 40 way connector housing.

- when replacing the screws, do not overtighten, or the aluminium thread will strip. If this does happen, replace the screw with a longer shafted #4 self tapping screw.

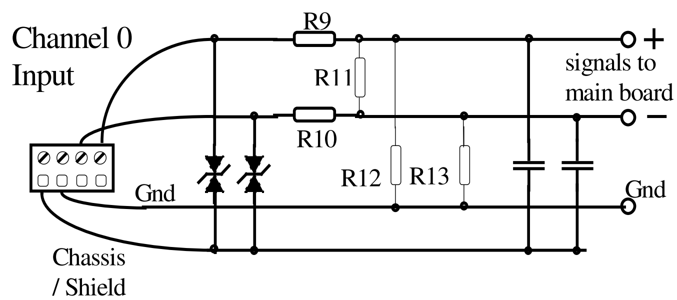
SCA Adjustments

The shield plate can be removed by unscrewing the knurled screw a turn or two - it does not need to be released completely. Gently lift the other end of the shield plate to "pop" it off the plastic stand-off, then slide the plate out from under the head of the knurled screw.

Underneath the shield plate there are a number of resistors that can be changed to alter the signal levels of the analog channels, and others to alter the operation of the optocouplers on the digital inputs.

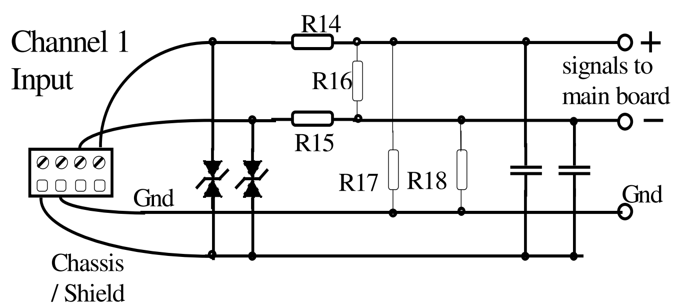
Analog Channels:

Analog Inputs 0 and 1.
The resistive dividers can be set to function in the following manner:-



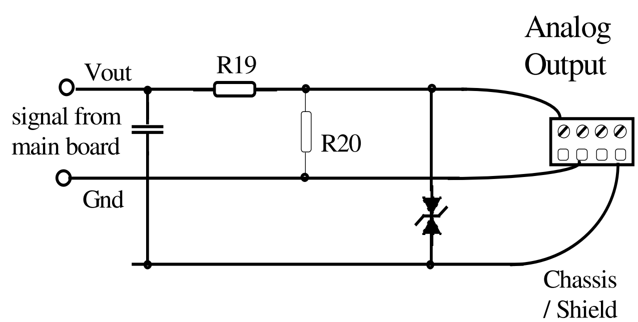
Considering Channel 0:
As shipped, R9 and R10 are installed as 10Ω resistors. This feeds the signal through unmodified. If the signal needs to be attenuated, then there are two methods.

1) For sensing voltages greater than 10 V:- use R9 and R12 as the divider on the +input, and R10 & R13 as the divider on the -input. The values should be at least a few tens of Kohm - it depends on how much load the signal can support. To preserve balance in the system, choose R9=R10 and R12=R13, Resistors should be precision 0.1% tolerance, so as not to introduce differential errors as the absolute value of the signal varies.



2) To divide smaller voltages down, so as to use the 100mV range on the inputs, a more accurate way is to use R9, R10, and R11 as the voltage divider resistors.

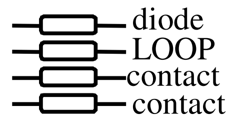
Analog Output:
R19 is installed as a 10 ohm resistor, effectively passing the signal through. If the output voltage needs to be scaled down, then replace R19, and choose R20 to suit. The sum of R19 and R20 should not be less than 2kohm



Digital Inputs

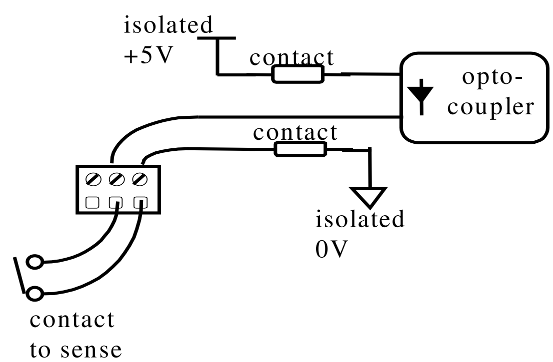
The digital inputs are isolated from the rest of the CNA module by opto-couplers. By positioning selected resistors in the long socket strip under the shield plate, these inputs can be used in two different ways - Contact Closure, or Loop Powered. Note that a channel should either have two 330R resistors in the "contact" positions, OR one appropriate resistor in the LOOP position, never all three resistors. The diode remains in the sockets in either case.

Each channel:-



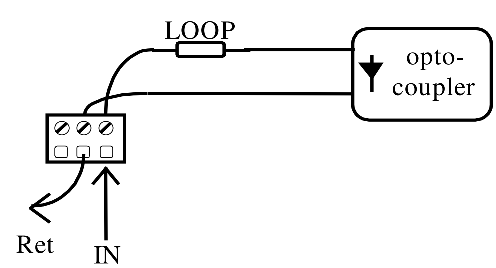
1) Contact Closure. (as-shipped)
In this mode two 330 ohm resistors are required, installed in the positions labelled "contact". Closing an external contact allows a small current of 5 mA to flow through the opto-coupler, thereby triggering the input. The current is supplied by a small DC to DC converter, providing 5V DC isolated from the rest of the module.
Note that this isolated 5 volt supply is used by all the input channels that are set to sense contact closure - therefore all contacts sensed by this module must be at the same potential.

for contact closure:-



2) Loop powered. Some or all of the input opto-couplers can be set to be turned on by a signal loop applied externally. The two 330 ohm resistors must be removed from the positions labelled "contact", and one resistor of the correct value placed in the position labelled "LOOP". The current must flow into the terminal labelled "IN", and out of the terminal labelled "ret" (for "return"). The resistor value should be selected to limit the current flow through the opto-coupler to 10 mA or so.
Suggested values are:
for a 5 volt signal, use 330R
for a 12 volt signal, use 1K ohm
for a 24 volt signal, use 2K2

for loop powered:-



Each channel set to "LOOP" mode is isolated from all other channels.

PID control

The CNA module has an embedded PID control algorithm that can be invoked by sending the appropriate command, or by selecting it through the diagnostic port.
As a general I/O device, without PID, all inputs are general purpose inputs, and the value sent to the analog output is used directly to set the output voltage.

If the unit is being a controller, with PID invoked, then the value sent by the control computer to the analog output data location is the desired setting for the control variable - the setpoint.

Also, when used in PID controller mode, certain digital inputs can be selected to have local and immediate effects, or they can be used as general digital inputs. The main benefit of activating their special functions is to prevent a large build-up of the time integral term of the PID function if, for instance, the power supply is not switched on, or is in slew rate limited mode.

There is also a facility to send a command over the loop to a module operating in PID mode, to hold the output at its current value.

It is envisaged that these PID mode options, and the facility to switch between modes are really to be seen as aids in the development and setting up of a system, rather than something that would be needed once a machine has entered production.

Using PID

The module can be set to execute a PID algorithm, to hold a control variable steady no matter what external drifts and influences there are.
If set into PID mode, the module uses Analog input channel 0 as the feedback input, and the analog output is altered by the module itself to achieve a desired value on the feedback input. This is closed loop control - all the control computer has to do is send the module what the desired input value is - the setpoint. The module then alters the analog output so as to achieve the new desired input value, as fast as possible, with minimum overshoot. Tuning of the loop coefficients is a complicated process - we will describe a couple of approaches.

If the unit is set to operate in PID mode, then the user has the option to enable various special uses of certain inputs, to reset or halt the PID algorithm.

Selecting PID coefficients

First, a word of warning - when you select PID, you are handing control of the programming output over to the module - if you have incorrect PID coefficients then the module will faithfully use them! It is very much like a computer - if you put garbage data into it, you will get garbage out, very quickly. If your module is being used to program a multi kW power supply, then drastic things can happen.

Make sure that the probe is connected and powered up before you invoke PID - if the probe is not connected, you won't get any feedback signal, and the controller will just swing the power supply to full scale, trying desperately to get the input signal to change.
You can only tune a closed loop system if the loop is in fact closed - the system has to be live to some extent. However, when setting up a system for the first time we suggest you minimise the consequences if you enter incorrect numbers - e.g. don't have beam running, and be ready to hit an emergency cut off at any time!.

You will need some method of displaying the response of the system over a period of a few seconds - digital scope, computer data logger, chart recorder etc,

There are whole text books on control theory and how to optimise the coefficients in a PID control system to get the fastest response with minimal errors. Such a treatise is beyond the scope of this manual, but we will attempt to describe a couple of ways of getting a system running with reasonable efficiency. Also remember that some theoretical approaches to the subject assume that you have available ideal components - eg a power supply with unlimited voltage and current capability - this is seldom so!.

Systems can have quite non-linear responses to inputs - tuning optimally for small scale step changes may mean that when a large step is requested the power supply is not capable of supplying the voltage or current, and so goes into slew-rate limited mode. This can allow large error terms to build up, and significant overshoot can result.
In some cases it may be more sensible to de-tune from optimal small step response, to allow for maximum rate of change on large step inputs without pushing the power supply into current or voltage limiting. After all, the large step inputs are going to take the most time to respond to, and may be more important to tune for. Small step inputs will be actioned more quickly just because they involve smaller changes. It really depends on how the system will be used once set-up - just be aware of the compromises involved.

The Simple Method

This method will get your system up and running with the least chance of having it burst into oscillation , forcing you to hit the STOP button. It will not necessarily produce the fastest transitions, but it gives you the chance to play slowly with the system, to get a feel for it. If you want to go straight for fully optimised tuning, then see the next section entitled "Tuning for Ultimate Sensitivity", on page 2-40.

Start with Integral term only - use the diagnostic port to set the P and D terms to zero.

The module runs the PID algorithm every 30ms.This means that if you give a command to the module to action a step change in output, the module will calculate the error (difference between the actual output and the new desired output), multiply it by the Integral term, and add it to the actual output, every 30ms.

For example, if the present, actual output is zero volts, and you give a command for a full scale change (for this module that is 10 volts) then the resulting error is 10V. This will be multiplied by the Integral term, and the result added to the output every 30ms.
Of course as the actual output approaches the desired output the error gets less and less, but initially at least the error is maximum, as stated.

If you set the Integral term to 0.01, then with a 10V error, every 30ms the output will have 10V x 0.01 = 0.1V added to it. So adding steps of 0.1volt to the output means that the output will take 100 steps to reach 10 volts, and 100 steps at 30ms per step will take 3 seconds. This is highly approximate, because of the diminishing error, but at least it gives you an idea of the order of magnitude.

Another way to approach a completely new system is to decide how long you think you need to observe the response of the system - we would suggest about 10 seconds for a full scale swing - nothing ought to change so fast that you can't hit the STOP switch!.

So ten seconds amounts to approximately 333 periods of 30 ms. Taking the required swing of 10 volts at the start, and dividing it into 333 steps gives 0.03V (30mV) per step. So we want 30mV added to the output every 30ms to get a total of 10V change in ten seconds.
At the start the maximum error is 10 volts, and the module will multiply this by the integral term (**I**) to get 30mV as the step increment

10V x **I** = 30mV => **I** = 0.003

The above two approaches give you a starting value for the Integral term, so you can watch the behaviour of the system, check your monitoring instruments etc.

You will most probably want to increase the speed of the response, so increase the Integral term - doubling the value will approximately halve the time taken to attain the final value.

As you increase the speed of the system, keep an eye on the behaviour of the power supply - it may go into voltage or current limit. If this happens the controller can not make the system respond any faster - you are at the limits of what the power components are capable of.

If you are not being limited by the other components, you can try adjusting the other PID terms - the Proportional term, and the Differential term.

A larger **D** will give a faster rise initially, but may increase overshoot and oscillation.
Bear in mind that the Differential term is a time based factor so, if you are trying to calculate it, you need to know that the controller does the PID calculations every 30ms. Time must be expressed in terms of this 30ms period.

Increasing **P** too much may lead to uncontrolled, exponentially increasing oscillations, so take care, only do small changes, - and be ready with the STOP switch!.

In general, an optimised system will have the **D** term at approximately one quarter the value of the **I** term.

D = **I**/4

Tuning for Ultimate Sensitivity

This method derives the PID coefficients from empirically determined values. It does involve provoking oscillations in the system, so care must be taken to ensure there are no consequences in other parts of the machine. To use this method effectively the components in the system must be sized so that everything is operating in a linear mode - it cannot be used if the power supply is entering voltage limiting mode during step changes.

By considering the design of the control loop, determine the overall gain of the process.

Consider a 10% step increase into the power supply. If the controller output were to be disconnected from the power supply, and 10% increase independently added to the input of the power supply, by what percentage of its full range would the feedback transducer value change? The overall process or loop gain, designated **K,** is the ratio

change in transducer output	(as a percent of full scale)
programming input step	(as a percent of full scale)

The **change in transducer output** is the change in the output of the feedback transducer when used in the system. This is the feedback supplied to the controller module.- e.g a magnetic field sensor, producing 0-10 volts output for a 0 to 1 Tesla field.

The **programming input step** is the step input injected at the programming input. This is the output that the controller normally generates to feed into , for example, a 0 to 150 amp power supply with a 0-10volt programming input.

For the sake of this example, let us say that the power supply is a 0 to 150 amp output, controlled by a 0 to 10 volt programming input. The magnet is designed to produce a field of 1T for a current of 150A, and the field sensor produces a 0-10 volt output for a 0-1 T field.
In this case a 10% step input to the power supply will increase the current by 15amps, increasing the field by 0.1T, so the sensor will increase its reading by 10% of its full scale.

So the overall gain is:- $\mathbf{K} = \frac{10\%}{10\%} = 1$

If the components of a system have been sized optimally then the ratio K is likely to be 1, otherwise the feedback sensor span or the supply are oversized for what they are required to do.

Use the diagnostic port to set the **I** and **D** terms to zero.

Set the **P** term to a value such that **P.K** = 2

For our example, set **P**=2

Now begins a process of trying to find the value of **P** which causes the system to break into oscillation. Take care as the value approaches the optimum, because if you exceed the optimum the oscillations will grow exponentially in amplitude.

Now alter the setpoint to say 30% of full scale, allow time for the system to settle, then add another 10% - ask for 40% of full scale. Observe the trace of the sensor feedback. It should rise, overshoot, then settle back to the desired level.

Set the setpoint back to 30%, then increase **P** by the same amount again. Ask for 40% output, and watch the systems response. The overshoot and ringing should increase.

Continue the process of increasing **P** , giving a 10% step increase in setpoint, and watching the behaviour of the system. You are trying to find the value of **P** for which a small step input causes the system to go into oscillations of constant amplitude - that is, the oscillations neither die away, as they did at the start, nor increase in amplitude.

Note down this ultimate value of **P**, designated $\mathbf{P_u}$

Also measure and note the period (in seconds) of the oscillations at this value, designate it $\mathbf{T_u}$

Text books indicate that empirically it has been found that the optimum values for the coefficients in a PID system are as follows:

$\mathbf{P} = 0.6\ \mathbf{P_u}$
$\mathbf{I} = 0.5\ \mathbf{T_u}$
$\mathbf{D} = 0.125\ \mathbf{T_u}$

However, these equations are not immediately applicable because, for the Group3 controller, time must be expressed in units of the 30ms recalculation rate of the PID algorithm.
The period (in seconds) of the oscillations, designated $\mathbf{T_u}$ above, must be divided by 33 to express it in units of the 30ms PID rate .

The above equations then become:
These are the values to be entered into the Group3 controller.

$\mathbf{P} = 0.6\ \mathbf{P_u}$
$\mathbf{I} = 0.015\ \mathbf{T_u}$
$\mathbf{D} = 0.0038\ \mathbf{T_u}$

These values are supposed to produce the fastest response with minimum overshoot, and quickest settling. However, as with all generalisations, use them as a reasonable approximation, and watch closely as you first start the controller using these new coefficients.

3 Group3 Diagnostic Port

Introduction

The diagnostic port provides the facility for configuring and monitoring the module (Device Interface / CNA / DNA). Operating parameters and configuration set-up are stored in non-volatile memory within the module. This approach eliminates the need for hardware switches and trim-pots as well as improving overall system reliability and ease of use. The diagnostic port is designed to interface to an ASCII terminal, which could be a PC running a standard terminal emulation program, such as MS-Windows 'Terminal', or a small hand-held terminal.

The features of the diagnostic port for each module can also be accessed from the main control computer, by using appropriate software. The diagnostic port functions can be accessed by either the main computer over the network, or by the diagnostic port on the module, but not by both at the same time. To switch between the two options, press **<ESC>** or **<Enter>** on the keyboard you wish to have control.

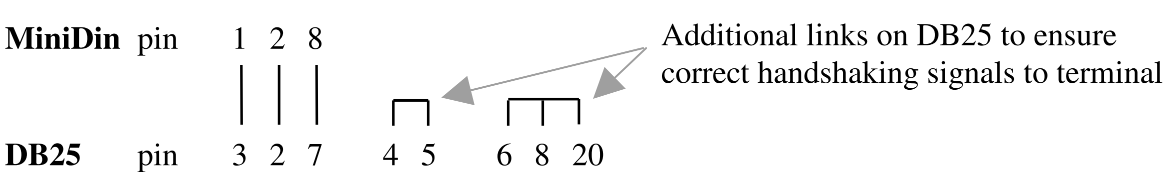
Note that the diagnostic port cable must be disconnected from the module while the system is operating in the vicinity of electrical transients and high voltage discharges.

Diagnostic Port Connector

Electrical: Standard RS232C voltage levels. No hardware handshaking.
Connector: MiniDin 8.

Pin	Use	Pin	Use
1	Transmit data (output)	6	Not Connected - factory use only
2	Receive data (input)	7	Five volts output (85 mA max.)
3	(constant high level)	8	Signal ground
4	Not Connected - factory use only	9	Chassis ground
5	Not connected		

A diagnostic port cable, length 2 meters, with a MiniDin 8 connector on one end and a DB25 connector on the other is available from Group3, part number DPC2. The wiring between the connector pins is given below:



Diagnostic Port communication parameters are fixed in software, and are not user adjustable.

Baud Rate	9600
Data Bits	7
Stop Bits	2
Parity	even
Flow control	none

Diagnostic Port Menu System

Overview - Refer to the Menu "tree" diagram - following.

The diagnostic port software has a hierarchical menu structure in the user interface. To use the diagnostic port a correctly configured terminal should be attached to the port. Pressing **Esc**, or **X** will bring up the main menu screen. Any invalid keystrokes will print **???** on the terminal and redraw the current menu. In all sub-menu levels typing **X** will back up one level and display the previous menu.

Most of the system set-up parameters are under the menu selection **S**ystem. This covers things such as communications, security, analog ranges and filter settings, etc.

To view and adjust the I/O values of a module there are a series of sub-options under **I** for I/O monitoring. A typical sequence required to perform a local control or monitoring function is as follows:

1. select the function required - simulate input, set an output, etc.
2. select the channel/channels - n, n-m, n,m,o or A for all
3. enter the values required.

These steps are described in detail in the following pages.

Channel Selection

Various diagnostic port menu selections will prompt the user to enter the channel or channels to act upon. This channel selection prompt occurs after the function to be performed has been specified. A channel selection can be made in any of the following ways:-
(n, m, o represent any valid channel numbers for that board)

n	a single channel
n-m	a range of channels
n,m,o	several individual channels
A	all channels.

Security

To restrict access to certain critical menu options and prevent undesirable tampering with critical parameters such as calibration factors, a security system consisting of three different access levels (low, medium and high) is available. The access level of the module runs at either low, medium or high and all menu options are assigned one of these levels. The access level of the module determines which menu options can be selected. When the module is turned on its access level defaults to low. The access level of the module can be raised to medium or high by entering the appropriate access code.

To select a menu item which only requires low level access the access level of the module can be set to anything. To select a menu item which requires medium level access the access level of the module must be set to medium (or high). To select a menu item which requires high level access the access level of the module must be set to high.

Security codes must be set up for medium and high level access before the security system provides this blocking. When shipped from the factory, the security system is disabled - there are no passwords assigned to the medium and high levels and the main menu will display “Access: Unrestricted”.

See also the **Access Level** section later in this chapter.

Diagnostic Port Menu Map

Subscripts:

- **H** High level access required
- **M** Medium level access required
- ***** Master password required

Main Menu

- **B** Board selection
- **D** Display
  - **S** Small Terminal
  - **T** Dumb Terminal
  - **P** Percentage
  - **V** Volts
  - **H** Hexadecimal
  - **D** Decimal
- **I** I/O Control — ***(See next page)***
- **M** Monitor communications – received/sent message counts
- **S** System
  - **B** Board selection
  - **C** Communication
    - $\mathbf{M}_H$ Mode
      - **S** SDLC Loop Mode
      - **D** DI to DI Mode
    - $\mathbf{Z}_H$ Zero O/P's on comm's timeout
    - $\mathbf{T}_H$ Select comm's Timeout value
    - $\mathbf{B}_H$ Send Beacon on comm's timeout
  - **R** Range
    - $\mathbf{I}_H$ Input Ranges
    - $\mathbf{O}_H$ Output Ranges
  - **F** Filter
    - $\mathbf{F}_H$ Filter factors
    - $\mathbf{W}_H$ Window filters
  - **D** Digital channels
    - $\mathbf{I}_H$ Input channel polarities
    - $\mathbf{O}_H$ Output channel polarities
  - **M** Motor parameter *(E board)*
    - $\mathbf{M}_H$ Modulation Timing
  - **M** Motor parameters *(G board)*
    - **0..3** select motor
    - $\mathbf{D}_H$ Drive mode
    - $\mathbf{U}_H$ Upper limit switches
    - $\mathbf{L}_H$ Lower limit switches
    - $\mathbf{F}_H$ Full / Half step polarity
    - $\mathbf{W}_H$ Windings off polarity
  - **G** GPIB Config'
    - **K** select Group3 K board
    - **0..7** select remote GPIB device
    - $\mathbf{P}_H$ Primary address
    - $\mathbf{E}_H$ Extended address
    - $\mathbf{I}_H$ timeout
    - $\mathbf{T}_H$ EOS character
    - $\mathbf{C}_H$ EOS compares
    - $\mathbf{S}_H$ send EOI on EOS
    - $\mathbf{R}_H$ end Read on EOS

continued next column

System *(continued)*

- **S** Serial parameter
  - **0,1** select other port
  - $\mathbf{B}_H$ Baud rate
  - $\mathbf{D}_H$ Data bits
  - $\mathbf{S}_H$ Stop bits
  - $\mathbf{P}_H$ Parity
  - $\mathbf{T}_H$ Terminating character
  - $\mathbf{E}_H$ terminator - enable/disable
  - $\mathbf{I}_H$ timeout - enable/disable
  - $\mathbf{F}_H$ Flow control - enable/disable
- **P** PID settings *(CNA)*
  - $\mathbf{C}_H$ enable PID Control mode
  - $\mathbf{N}_H$ Invert PID
  - $\mathbf{R}_H$ dig-in-5 Resets PID
  - $\mathbf{H}_H$ dig-in-6 Holds PID
  - $\mathbf{P}_H$ Proportional term
  - $\mathbf{I}_H$ Integral term
  - $\mathbf{D}_H$ Differential term
  - $\mathbf{U}_H$ Upper limit on Integral
  - $\mathbf{L}_H$ Lower limit on Integral
  - $\mathbf{W}_H$ PD dead-zone Window
- **T** Output zeroing on timeout
  - $\mathbf{Z}_H$ Zero on timeout
  - $\mathbf{-}_H$ No action on timeout
- **E** EEPROM access
  - **C** Clear Reset code
- **A** Access level
  - $\mathbf{H}_H$ set High
  - $\mathbf{M}_M$ set Medium
  - **L** set Low
  - $\mathbf{C}_*$ Change passwords
    - **H** High level p/w
    - **M** Medium level p/w
- $\mathbf{ZP}_H$ Zero / restart processor

I/O Control *(continued)*

I I/O Control ***A Board***
- **[D]**$_{M}$ Disable - use local value for output
- **[E]**$_{M}$ Enable - use network value for output
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[O]**$_{M}$ Output - set value of an output
- **[T]**$_{M}$ Toggle state of last modified dig' chan's
- **[C]**$_{M}$ Clear simulated and disabled status

I I/O Control ***B Board***
- **[D]**$_{M}$ Disable - use local value for output
- **[E]**$_{M}$ Enable - use network value for output
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[O]**$_{M}$ Output - set value of an output
- **[T]**$_{M}$ Toggle state of last modified dig' chan's
- **[C]**$_{M}$ Clear simulated and disabled status

I I/O Control ***C Board***
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[C]**$_{M}$ Clear simulated status

I I/O Control ***D Board***
- **[D]**$_{M}$ Disable - use local value for output
- **[E]**$_{M}$ Enable - use network value for output
- **[O]**$_{M}$ Output - set value of an output
- **[C]**$_{M}$ Clear disabled status

I I/O Control ***E Board***
- **[D]**$_{M}$ Disable - use local values for motor
- **[E]**$_{M}$ Enable - use network values for motor
- **[O]**$_{M}$ set control and direction of motor
- **[S]**$_{M}$ Speed – set speed of motor
- **[A]**$_{M}$ Acceleration – set accel' for motor
- **[C]**$_{M}$ Clear disabled status

I I/O Control ***F Board Port (Geneal Serial Mode)***
- **[I]**$_{M}$ Input - input simulated text
- **[O]**$_{M}$ Output - set text for output
- **[P]** Port - select other port
- **[R]**$_{M}$ Reset comm's
- **[M]**$_{M}$ Mode – toggle: General Serial / DTM

I I/O Control ***F Board Port (DTM Mode)***
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[C]**$_{M}$ Clear simulated status
- **[R]**$_{M}$ Reset comm's
- **[D]** DTM - select a DTM
- **[0..9]** select a DTM
- **[P]** Port - select other port
- **[M]**$_{M}$ Mode – toggle: General Serial / DTM
- **[G]**$_{M}$ Gather information on connected DTMs
- **[N]**$_{M}$ New DTM - add new DTM to simulate

I I/O Control ***G Board***
- **[D]**$_{M}$ Disable - use local values for output
- **[E]**$_{M}$ Enable - use network values for output
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[O]**$_{M}$ Output - set value of an output
- **[M]** Motor - select motor to adjust
- **[0..3]** select motor to adjust
- **[Z]**$_{M}$ Zero – zero motor position
- **[C]**$_{M}$ Clear simulated and disabled status

I I/O Control ***H Board***
- **[I]**$_{M}$ Input – input simulated increment
- **[Z]**$_{M}$ Zero – zero an encoder count in DI

I I/O Control ***J Board***
- **[D]**$_{M}$ Disable - use local value for output
- **[E]**$_{M}$ Enable - use network value for output
- **[O]**$_{M}$ Output - set value of an output
- **[C]**$_{M}$ Clear disabled status

I I/O Control ***K Board***
- **[I]**$_{M}$ Input - input simulated text
- **[O]**$_{M}$ Output - set text for output
- **[R]**$_{M}$ Reset Comm's

I I/O Control ***CNA***
- **[D]**$_{M}$ Disable - use local value for output
- **[E]**$_{M}$ Enable - use network value for output
- **[S]**$_{M}$ Simulate - use simulated input value
- **[A]**$_{M}$ Actual - use actual input value
- **[I]**$_{M}$ Input - input simulated value
- **[O]**$_{M}$ Output - set value of an output
- **[T]**$_{M}$ Toggle state of last modified dig' chan's
- **[C]**$_{M}$ Clear simulated and disabled status
- **[R]**$_{M}$ Reset PID integral
- **[H]**$_{M}$ Hold PID integral

Main Menu

This screen shows the module software version number, the board category and serial number. These are followed by the current access level and the main menu options – which are:

B	**Board Selection**
D	**Display Options**
I	**Input / Output Control and Monitoring**
M	**Monitor Communications**
S	**System Configuration**

B Board Selection

Many of the functions available through the diagnostic port deal with the installed I/O boards one at a time. This menu option displays a list of the I/O boards installed in the Device Interface, along with their serial numbers. The display shows which I/O board is currently selected and allows another I/O board to be selected if required. A degree of auto selection of the boards takes place where possible. For instance if an F Board was present in the DI but not selected, pressing **S** in the System menu would cause the F Board to be selected automatically.

D Display Options

The display options menu is used to specify the type of terminal in use on the diagnostic port and to choose the units in which analog values are to be expressed.

Terminal Type

S	**Small Terminal**	32 characters x 16 rows
T	**Dumb Terminal**	

Units Selection

The diagnostic port can display analog values in one of several units. The selected units are used both for displaying analog values and also when the user is required to enter analog values.

P	**Percentage**	values are shown as a percentage of full scale
V	**Volts/Amps**	values are expressed as true voltages (or amps as appropriate)
H	**Hexadecimal**	values are shown as a hex number
D	**Decimal**	values are shown as a decimal number

The decimal option represents analog voltages as a decimal count of bit increments. The range is -32000 to 32000 for 16 bit bipolar values, 0 to 64000 for 16 bit unipolar values, -8000 to 8000 for 14 bit bipolar values and 0 to 16000 for 14 bit unipolar values.

I Input / Output Control and Monitoring

To aid in control system commissioning and testing, a facility for monitoring or simulating inputs and controlling outputs is available. It is sometimes useful to simulate "hardwire" an input to a known state for checking control system software operation. The outputs can also be controlled from the diagnostic port, and overwriting of outputs by data from the communication can be disabled.

Simulation of inputs and disabling of communication to outputs is accessible only in medium access level. Inadvertently leaving channels simulated or disabled can cause confusion - it appears to another operator as if the module is not working properly. To remind users that some I/O is simulated, a message reading “SIMULATED DATA” is displayed at the top of every menu screen until the channels are cleared of simulated data. Once simulation has been finished with, clear all simulations using [**C**].

Underneath the menu heading for this screen are several letters in square brackets, indicating key-press options. Only options relevant to the currently selected board are displayed.

[**D**] Changes the status of the chosen output(s) to **D**isabled and outputs the value entered using the [**O**] option, rather than the value from the network.

[**E**] Changes the status of the chosen output(s) to **E**nabled and outputs the value from the network, rather than the value entered using the [O] option.

[**S**] Changes the status of the chosen input(s) to **S**imulated and uses the value entered using the [**I**] option, rather than the actual measured value. [S] and [A] can be used to toggle between the actual and simulated values.

[**A**] Changes the status of the chosen input(s) to **A**ctual, and uses the actual measured value, rather than the simulated value to send over the network. [S] and [A] can be used to toggle between the actual and simulated values.

[**I**] Prompts the user to enter a value which is sent over the network to the control computer - automatically switching the status of the chosen input(s) to **S**imulated. The control computer receives this entered value as if it were a true reading. The entered value is held in a "simulation" register, and is kept for future use when the input is switched back to 'actual'.

[**O**] Prompts the user to enter a value which is then output - automatically switching the status of the chosen output(s) to **D**isabled. The channel will output the entered value regardless of what value the control computer is sending over the network.

[**C**] Clears all status flags - all inputs read the actual value (status: **A**ctual) and all outputs are controlled from the network (status: **E**nabled). The values entered using the [I] option remain stored, and can be used again by using the [S] option. Note that [C] only clears the Enabled/Disabled status, it does not clear the value of the output. An output may remain at the value set by the [O] option until a new packet of I/O data is sent over the network from the control computer.

The monitoring menu indicates with an **S** or **a** (or the text **Simulate** or **Actual**) as to whether simulated or actual values are being used as the input values to send over the network. Similarly for outputs the display reads **D** or **e** (or the text **Disabled** or **Enabled**) to indicate whether or not an output is disabled from network control and using the locally entered value.

Special Options:-

Digital Channels (type A and B boards and CNA)

[**T**] Toggles the states of the last selected digital output channels **D**isabled for simulation. Channels that were OFF turn ON, or those that were ON turn OFF.

[**O**] Under the [O] option for digital output channels there is the facility to have the output(s) perform a **R**epeat toggle function. The selected channel(s) will repeatedly turn On then Off with a one second period. Press any key to end the repeat toggle. This is to facilitate the checking of the operation of mechanical devices like relays and solenoids, or for general tracing of wiring etc.

DC Motor Control Board (type E)

[**S**] Disables the motor from loop control and sets the desired speed.

[**A**] Disables the motor from loop control and sets the desired acceleration.

[**O**] Disables the motor from loop control and allows the user to set the output control to Forward, Reverse, Stopped or Braked.

Serial Communications Board (type F)

[**I**] **DTM Mode:**
Input - asks whether Field or Temperature input, switches the chosen input to simulated status, and inputs the entered value onto the loop.
General Serial Mode:
Allows entered text to be sent as input data to the LC and displays data sent from the LC (talk and listen to the Loop Controller from the diagnostic port).
Ctrl-Z returns from this mode to loop control.

[**O**] Allows entered text to be sent as output data to the serial devices and displays returned data (talk and listen to the serial devices from the diagnostic port).
Allows control and monitoring of serial devices without having a Loop Controller or control computer / software running.
Ctrl-Z returns from this mode to loop control.

[**P**] Port select - selects the other serial port on the F board.

[**R**] Reset the F board - re-initialise communications. Historical use.

[**D**] Select a DTM. The terminal will prompt for entry of a DTM address.

[**0..9**] Select a DTM directly by single digit address. (0,1,2..9).
Data can be simulated for only one DTM at a time.
This option allows the user to select which DTM to simulate data for.
The currently selected DTM has an asterisk beside its number.

The following three options will NOT operate if the loop communications are running. The port definition, as specified in the Loop Controller (by the control computer) takes absolute priority.

[M] Mode - toggles between General Serial and DTM mode on the current port.

[G] Gather information about DTMs. - scans for DTMs on the current port.

[N] New DTM. Adds a new DTM to the screen, for which simulated values can then be entered (using the [I] command). Used to simulate DTM readings if the DTMs are not actually connected to the port.

Stepper Motor Board (type G)

[M] Select a motor. The terminal will prompt for entry of the motor number.
[0..3] Select a motor directly by number. (0,1,2 or 3).
Selects the motor upon which to operate.

[S] Simulate an input - asks whether Position, Analog or Digital input is to be switched to simulated status and inputs the simulation value onto the loop.

[A] Actual input - asks whether Position, Analog or Digital input is to be switched back to actual status, and inputs the actual value onto the loop.

[I] Input - asks whether Position, Analog or Digital, switches the chosen input to simulated status, and inputs the entered value onto the loop.

[O] Output - asks whether Position, Speed or Acceleration and prompts the user to enter a value which is then output. Simulation of any output automatically disables the whole motor from loop control.

[Z] Zeros the actual position step count. (sets 'home' position).

Encoder Board (type H)

[I] Inputs a count to be sent over the loop and accumulated in the Loop Controller.

[Z] Zeros the count of all four encoder channels at the DI. Note that the true accumulation of encoder counts takes place in the Loop Controller and is not altered by this command. Zeroing that count must take place at the computer.

GPIB Controller Board (type K)

[I] Allows entered text to be sent as input data to the LC and displays data sent from the LC (talk and listen to the Loop Controller from the diagnostic port).
Allows simulation of GPIB devices when they are not actually present.
Ctrl-Z returns from this mode to loop control.

[O] Allows entered text to be sent as output data to the GPIB devices and displays returned data (talk and listen to the GPIB devices from the diagnostic port).
Allows control and monitoring of GPIB devices without having a Loop Controller or control computer / software running.
Ctrl-Z returns from this mode to loop control.

[R] Resets the GPIB controller. The K board will issue an IFC command.

CNA Controller Module

These two items appear if PID control mode is enabled.

[R] Resets the PID, and sets the control output to zero. Pressing [R] again, or [C] reverts to normal PID mode.
This mimics the action of Digital-input-5 if it is enabled to function as PID reset. Dig-in-5 is simulated and set to value 1.

[H] Puts the PID in Hold mode and causes the control output to be held at its current value. Pressing [H] again, or [C] reverts to normal PID mode.
This mimics the action of Digital-input-6 if it is enabled to function as PID hold. Dig-in-6 is simulated and set to value 1.

A status line on the screen indicates the current mode: Normal / Held / Reset.
If in both reset and hold, reset mode overrides.

M Monitor Communications

Displays a running total of the number of messages received / replied-to that were addressed to this module. This can be a useful indicator that the network is running at correct speed. The counts can be reset to zero by pressing **C**.

S System Configuration

System configuration allows the selection of different communications protocols and parameters, analog input and output voltage ranges, analog input filtering, motor control parameters, PID parameters, diagnostic port access levels and more. All system configurations can be viewed by anyone but changes can be made only with high level access.

C Communication

The display shows:

Device Address	as set by the rotary switch
Communication mode	SDLC Loop or DI to DI / CNA to CNA
Beacon on timeout	Yes / No
Zero outputs on timeout	Yes / No
Comm's timeout	time in milliseconds

M Select Communication Mode

Two communication modes are available to the user.

S SDLC Loop Mode

For communication with a Group3 Loop Controller.

D DI to DI / CNA to CNA Mode

For a stand-alone signal telemetry system (see section 9.1)

Z Zero Outputs on Communication Timeout

Enabling this feature causes the specified output channels to be forced to zero or an inactive state if a communication timeout is detected. Pressing Z toggles this feature on and off. See also the **T** option under the **S**ystem Configuration menu for specifying which channels are zeroed.

T Select Communication Timeout Value

The timeout value can be entered in units of milliseconds, where the timeout period must be greater than 10 ms and less than 65535 ms (65 seconds).

B Send Beacon on Timeout

If communications stops and this feature is enabled, then after the same preset time used for the "Zero Outputs on Communication Timeout" the module will commence transmission of a periodic beacon signal to the Loop Controller. This can be a useful feature to locate a break in the fiber optic loop. If the Loop Controller has communications enabled and the loop is broken, it will make use of the beacons to report the address of the module closest to the downstream side of the break.

R Input / Output Range

Each analog channel has a configurable voltage range. A summary of these is displayed along with options for changing the input and output ranges. Comprehensive lists of the available ranges for each board type can be found in sections 2.5 (DI boards) and 2.7 (CNA) of this manual.

I Input Range
O Output Range

F Analog Input Filter

The module software features a non-linear filtering algorithm which can combine fast tracking of large, rapid input changes with heavy filtering of slowly changing signals. Through the diagnostic port the user can set the filtering time constant and the window within which the filtering is active. The action of the filter is as follows:

While the raw input signal remains within a window width of the previous filtered value, the reported value is the updated filtered value. However, if the raw input signal rapidly changes by more than a window width, the filtering is temporarily suspended, and the new reported value will be the actual instantaneous value, not a time average. In this way the reported value can be heavily filtered to eliminate small random noise, but still quickly track a large, rapid input change.

F Filter Factor

After selecting a channel the user can then select a filter time constant. The choices vary according to the number of I/O boards in the DI. Note that if the filter window width is set to 0 then no time averaged filtering will take place, no matter what value this filter constant is set to.

W Filter Window

Enter the voltage by which the input must rapidly deviate from the running average value before filtering is disabled.

A window width of 0 will effectively disable filtering, and the reported value will always reflect the instantaneous measured value.

If the non-linear window filtering is not required, but ordinary time averaged filtering is wanted, then choose a window width equal to the full-scale range of the channel.

D Digital Channels

Each digital channel can be configured individually for either active high or active low logic.

Note (type A and B boards only): if a channel is to be used as an input only, then the polarity of the same-numbered output channel should be set to **L** or **I**, otherwise the output channel may be turned on and permanently clamp the input channel. For the CNA the input and output channels are completely independent and this is not necessary.

I Input Channels

Select the input channel(s) to be configured, then
H for active High or **L** for active Low (L is the factory default).

O Output Channels

Select the output channel(s) to be configured, then
H for active High or **L** for active Low, (L is the factory default).

Note (type A and B boards only): there is a third option: **I** to inhibit the output driver. In the "DI to DI" comm's mode the output drivers of channels used for inputs must be inhibited.

M Motor Parameter Control (Type E Board)

The DC Motor Driver Board (type E) uses pulse density modulation to control the speed of each motor. The currently selected pulse width and hence cycle time of the pulse stream is displayed on this screen and can be changed. The selected pulse width for a board is used as the basic timing to govern all four of its motors.

M Modulation Timing

A list of the available pulse widths and associated cycle times is displayed and from this the user can select a new pulse width. Optimum modulation is determined by trial and error, balancing smooth slow running and start up torque for the particular motors being used.

M Motor Parameter Control (Type G Board)

The Stepper Motor Driver Board (type G) provides several programmable functions and modes of operation. The following menu options are for configuring these.

0..3 Select Stepper Motor - select the motor to work with: 0, 1, 2, or 3

D Drive Mode

Three different drive modes are available. The mode chosen depends on the type of current-driver to be used. Pressing **D** will cycle through the options:

quadrature	four output signals can directly drive a small motor
clock and direction	two output signals, one clock pulse for each step
dual clock	one output pulses for clockwise rotation, the other for counter-clockwise rotation

U Upper Limit
L Lower Limit

These menu options allow the digital inputs on the board to be defined as limit switch inputs. When defined as limit inputs, the digital channels unconditionally stop the motor if the appropriate digital input is de-activated.

Pressing either **U** or **L** will cycle through the settings:
inactive / active low / active high

If a drive mode of either “clock and direction” or “dual clock” is selected then two extra menu options appear to allow setting of the polarity of the outputs designated for the “Full step / Half step” signal, and the “All windings off” signal.

F Full / Half Step Polarity — active high / active low
W Windings Off Polarity — active high / active low

Pressing either **F** or **W** will toggle the setting for that option.

G GPIB Controller Configuration (Type K Board)

This Menu displays and allows configuration of the GPIB address, EOS identifier character, and other communications parameters for the Group3 GPIB Controller (K) board and eight remote GPIB devices connected to the same GPIB bus. When entering this menu the first displayed configuration screen is for the Group3 K board.

This menu allows a user to inform the DI of the specific set up data of each device on the GPIB bus - such things as what EOS character to look for when communicating with a particular device, what time out to use etc. Note that this menu does not allow the user to change the settings of devices other than the Group3 K board, it is merely used to tell the DI what those devices have already been set to. If individual device set up information is not entered then the DI will operate using the default values mentioned in this section.

K Select Group3 K Board
0..7 Select Remote GPIB device

Select a GPIB device to view / change the set-up configuration. Pressing K will select the Group3 K board. Pressing 0,1,2..7 will select one of eight possible devices that can be connected to the Group3 K board.

The display presents a set-up screen and menu for the currently selected device - Group3 K board or remote GPIB device.

After setting the parameters for one remote GPIB device, pressing the number of the next device will change the screen to allow set-up of that one. Pressing **K** will return to the set-up screen for the Group3 K board.

P Primary Address

Allows setting of the primary GPIB address for this device.
Primary addresses are in the range 0 to 30 (0 to 1E hex).

E Extended Address

Allows setting of the extended GPIB address for this device.
Extended addresses are in the range 96 to 126 (60 to 7E hex).
Setting the extended address to -1 (= 255) through the diagnostic port has the effect of disabling secondary addressing. This is the default condition.

I Timeout

The user is given a choice of 16 time periods to select from -
0 (= no timeout) and times from 35microseconds to 290 seconds.
The timeout period is the length of time within which an I/O operation (reading or writing to a GPIB device) must complete, or the action will be aborted. If the I/O operation is aborted, the timeout flag bit will be set in the controller to inform the controller of the failure of the operation.

A typical timeout period is 2.2 seconds.

T EOS Character

The EOS or End-Of-String character is a predefined byte that is sent as the last byte of a message string, to indicate its end. This menu option allows selection of an EOS character. This character is then used until either the default is changed through the diagnostic port, or a command is issued from the control computer to set the EOS character to something else.

The EOS character can be set to any value, a typical one being <LF>, or $0A_{hex}$.

C EOS Compares - 7-bit / 8-bit

This sets whether to do full 8-bit compares when looking for an EOS character, or to just compare the lower 7 bits. 7 bit compares are used if working just with ASCII or ISO data formats. 7 bit compares are the default.

Note: the EOS character is not automatically appended to strings written out onto the GPIB bus. It must be explicitly included in the data string to be sent.

Pressing C will toggle the setting.

S Send EOI on EOS - enabled / disabled

Enabling "send EOI on EOS" will cause the K board to assert the EOI line when it detects the EOS character as it writes a data string onto the GPIB bus. The default is disabled.

Pressing **S** will toggle the setting.

R End Read on EOS - enabled / disabled

Enabling "end read on EOS" will cause the K board to terminate a read operation when it receives an EOS character. The default is disabled.

Pressing **R** will toggle the setting.

S Serial Fiber Optic I/O Board Parameters (Type F Board)

The Serial I/O Board Menu displays the currently selected port's communication parameters and string terminator.

0,1	**Select Port**		
B	**Baud Rate**	Set to 2400, 4800, 9600, 19200, (and 38400: on port 0 only)	
D	**Data bits**	Set data bits to 7 or 8	(press to toggle setting)
S	**Stop bits**	Set stop bits to 1 or 2	(press to toggle setting)
P	**Parity bits**	Set parity bits to Even, Odd, or None	(press to toggle setting)
T	**Terminating Character**		(see below for options)
E	**Terminator**	enabled or disabled	(press to toggle setting)
I	**Timeout**	enabled or disabled	(press to toggle setting)
F	**Flow Control**	enabled or disabled	(press to toggle setting)

The F board will send a received message or part of a received message to the Loop Controller for three possible reasons:

- The terminating character was detected in the incoming message and terminator detection is enabled. The returned message includes the received terminator.
- No characters have been received by the port for a period greater than two character durations and timeout detection is enabled.
- There are 29 bytes of received data ready to return to the Loop Controller. This is the message buffer size for data being returned to the Loop Controller.

T Terminating Character

Allows the user to define the string terminating character used by the F board port to detect the ends of messages sent to it by an external device. It can be any numeric value: 0 to 255 (00_{hex} to FF_{hex}). If flow control is enabled then the two standard flow control characters should not be used: Ctrl-Q (11_{hex}) and Ctrl-S (13_{hex}).

The terminating character can be entered in one of three ways:

- **Keystroke:** Press the appropriate character key on the keyboard. This will work for all printable ASCII characters, except for forward-slash '/'. The '/' character can be entered by pressing it twice: '//'. The keystroke may also be a control key sequence: hold the **Ctrl** key and press an alphabet key (A..Z). Control key sequences won't work for Ctrl-M and Ctrl-S and may not work for Ctrl-C and Ctrl-Q, depending on the terminal.
- **ASCII Abbreviation:** Type in a standard ASCII abbreviation for any control character (value 0 to 31), prefixed with a forward slash '/'. eg /CR. See the table of standard ASCII abbreviations following.
- **Hex Value:** Type in the numeric value of any character, in hexadecimal, prefixed with a forward slash '/' and the character 'X'. eg /X0D.

Standard ASCII Abbreviations	**Hex Value**
NUL	00
SOH	01
STX	02
ETX	03
EOT	04
ENQ	05
ACK	06
BEL	07
BS	08
HT	09
LF	0A
VT	0B
FF	0C
CR	0D
SO	0E
SI	0F
DLE	10
DC1	11
DC2	12
DC3	13
DC4	14
NAK	15
SYN	16
ETB	17
CAN	18
EM	19
SUB	1A
ESC	1B
FS	1C
GS	1D
RS	1E
US	1F

Some common terminator characters:				
Character	**Displayed As**	**Keystroke Entry**	**ASCII Abbrev' Entry**	**Hex Entry**
line feed	LF (0A)	CTRL J	/LF	/X0A
carriage return	CR (0D)		/CR	/X0D

P PID Settings (CNA)

The module can be set to run in PID (closed loop) mode.

In non-PID mode, the analog output is taken from the network and reproduced on the hardware as requested.

In PID mode, the module uses analog input channel 0 as the feedback input, and the analog output is altered by the module itself to achieve a desired value on the feedback input, no matter what external drifts and influences there are. This is closed loop control. All the control computer has to do is send the module the desired input value - the setpoint. The module then alters the analog output so as to achieve the new desired input value, as fast as possible and with minimum overshoot.

PID refers to **P**roportional, **I**ntegral and **D**ifferential loop coeficients stored in the module. These can be adjusted by the user to achieve optimal control of the loop. Tuning of the loop coefficients can be a complicated process and guidance on this topic is given in section 2.7 of this manual.

If the module is set to operate in PID mode, then the user can optionally enable certain digital inputs for special uses - to reset or hold the PID algorithm when they are asserted.

C use PID Control mode

Pressing C will alternately enable or disable the use of PID.

N invert PID

Can be used to invert the sense of the PID algorithm. Sometimes a PID loop will require an inverting function - for instance if the feedback sensor is one where an increase in the sensed variable results in a decrease in the sensor output. The default is “disabled” - only enable with caution - wrong use will result in the system locking up at full scale output!

Pressing N will alternately enable or disable the invert function.

R Dig In 5 Resets PID

Digital input 5 can be used to control the PID algorithm. It can be used to reset the PID if, for instance, the device being controlled is not switched on. Feeding a “power on” signal into DigIn5, and enabling the reset function will prevent the build up of a large, and erroneous, integral term if the device being controlled is actually switched off.

H Dig In 6 Holds PID

Digital input 6 can be used to control the PID algorithm. It can be enabled to act as a “Hold” control - the actual analog output is held constant at its current output value while DigIn6 is switched on.

P Proportional term

Enables the user to enter the proportional term for use in the PID algorithm.

I Integral term

Enables the user to enter the integral term for use in the PID algorithm.

D Differential term

Enables the user to enter the differential term for use in the PID algorithm.

U Upper limit on Integral

Enables the user to set the upper limit beyond which the integral term will not be allowed to climb. Placing a limit on the integral value allows for quicker recovery when control is regained - the PID calculations do not have to spend a long time reducing an extremely large accumulated integral after a positive step input.

L Lower limit on Integral

Enables the user to set the lower limit below which the integral term will not be allowed to pass. Placing a limit on the integral value allows for quicker recovery when control is regained - the PID calculations do not have to spend a long time reducing an extremely large accumulated integral after a falling step has been programmed.

If the upper integral limit has the same value as the lower integral limit then both limits are disabled.

W PD dead-zone Window

This feature sets a window, about the set-point, within which the P and D terms are not used in the loop calculations. The function becomes Integral-only when the sensor input is within a window width of the set point.

This feature can be useful to smooth the output once the system has attained the setpoint.

For example, in a system where P is a large number, a single bit of flicker on the input sensor, when multiplied by the P term, could lead to many bits of flicker on the output.

If the PD dead-zone window is set to 0, this feature is disabled.

T Output Zeroing On Timeout

Each analog output channel, digital output channel and DC motor channel can be configured individually to be forced to zero / inactive if a communication timeout is detected. See also the **Z** option under the **C**ommunication sub-menu.

Z Zero on Timeout

Select the output channel(s) to be zeroed on timeout.

- No Action on Timeout

Select the output channel(s) **not** to be zeroed on timeout.

E EEPROM Access

This screen displays a number called the last reset code. If this code is non-zero it represents a particular mode of memory corruption and indicates that the module was forced to reset by its internal self checking program. Memory corruptions are cured on reset and such resets are almost always the result of an unusually powerful electrical transient in which case this code is likely to change each time the module is reset.

If resets persist and the code changes each time then the electrical isolation and shielding of the module should be examined.

If resets persist and the code remains the same each time then consult the factory, quoting this code.

C Clear reset code in EEPROM

This option clears the value of the reset code, which is stored in EEPROM. If the user wishes to monitor this code over time it will be necessary to perform this operation each time a non-zero reset code is detected.

A Access Levels and Security

The access level feature restricts the use of certain critical menu commands to those persons with appropriate authorisation. On power up the default access level for the module is “low” but it can be set to any level through this menu. Additionally, if a user attempts an operation that requires a security level which is higher than the current access level of the module then the user is prompted for the relevant access code.

High and medium level codes are configured using the **C** sub-menu command which first prompts for the master access code to be entered. The master access code is provided in an envelope shipped with each module (DI / CNA).

If the high and medium level access codes are set to zero then the security features are disabled and anyone has unrestricted access to all functions. This is convenient in the initial stages of setting up a system to avoid having to log in each time to make adjustments. However it is recommended that security codes be established once installation is complete.

Having security enabled (non-zero access codes) also adds to the robustness of the system in the event of electrical disturbance. If a spark disrupts the program and the internal self checking processes find the program in an area, randomly doing things that require an access code, but the security level has not been granted, then the module will reset itself. If access codes are left at zero this checking can not take place.

H set High Level

The high level access code is required to lift the module access to this level.

M set Medium Level

The medium (or high) level access code is required to lift the module access to this level.
No access code is required to reduce the module access to this level.

L set Low Level

This is the default level on power up.
No access code is required to reduce the module access to this level.

C Change Passwords

This menu option prompts for the master access code to be entered. Its sole purpose is to change the high and medium level access codes.

H High Level p/w

Set the high level password.

M Medium Level p/w

Set the medium level password.

ZP Zero / Restart Processor

This sub command of the **S**ystem menu forces the module to restart itself, without removing power.

4 Loop Controllers - Hardware Description

There are a number of LCs adapted to different computers. The dualport RAM structure makes it relatively easy for Group3 to adapt the card to other computer architectures. Consult your Group3 Control representative for the latest list of LCs available.

There are two Loop Controllers designed for a PCI bus slot on a PC computer:
LC1-PCI controls a single loop.
LC3-PCI controls three independent loops from a single bus slot.

Similarly there are two Loop Controllers that operate from an ISA computer bus slot:
LC1-ISA controls a single loop.
LC3-ISA controls three independent loops from a single bus slot.

LC2-VME is a VME card that can control two loops from a VME crate.

LC-STD controls a single loop from an STD bus crate.

LC1-CAM controls a single loop from a CAMAC crate.
LC2-CAM controls two loops from a single slot in a CAMAC crate.

Note that on the multi-loop LCs (LC3-PCI, LC3-ISA, LC2-VME, and LC2-CAM) the different loops are completely independent - one loop could be used for talking to another LC, and the others could be set to control Group3 DIs (the most common type of control installation).

Plastic fiber cable connectors are supplied as standard, but ST or SMA glass fiber connectors can be fitted to order. Maximum fiber optic cable length:

plastic cable	40m
glass cable	3000m

The dualport RAM onboard each Loop Controller is the only point of access the computer has to the system being controlled. The system configuration is stored in dualport RAM by the computer and all data exchange takes place via this dualport RAM. For information on configuring the dualport RAM onboard a Loop Controller refer to the “Group3 Control Loop Controller Programmer’s Manual”.

4.1 PCI Bus Loop Controllers: LC1-PCI & LC3-PCI

The LC1-PCI and LC3-PCI are Loop Controller cards designed to operate Group3 Control modules from a PCI bus slot. The LC1 drives a single fiber optic communication loop, while the LC3 allows three completely independent loops to be controlled from one slot. A maximum of 16 PCI LCs can be controlled from any one computer. For example 5 LC3's and 1 LC1 gives the maximum of 16 Loop Controllers. LC1 and LC3 cards can be mixed in a system.

The PCI Loop Controllers are Plug and Play devices. The computer BIOS allocates the memory addresses of their dualport RAMs on start up and the user does not need to be involved in that process. These cards require a system driver to be installed on the computer to provide application programs with an access address to the dualport RAM of each Loop Controller upon request. This driver software is supplied on a disk with each Loop Controller card and instructions for installing the driver are available as a text file, *install.txt*, on that disk.

The only hardware setting the user needs to be aware of is the rotary switch on the top edge of the circuit board. This is shipped from the factory set at position '0', and there is only need to alter this setting if two or more PCI Loop Controller cards are to be installed in the same computer. The switch is there to allow the user and the application software to distinguish between the different Loop Controllers in the same computer.

- The switch on the LC1-PCI sets the loop number for that card.
- The switch on the LC3-PCI sets the loop number (call it **n**) of the top transmitter/receiver pair - the one furthest from the gold edge fingers. The number of the middle loop is one more than the switch setting (**n**+1), and the number of the bottom loop is two more than the switch setting (**n**+2).

If using several Loop Controller cards in one computer remember that the switch settings must be different, and that the three loops of an LC3-PCI occupy three consecutive numbers.

Specifications

Physical

LC1-PCI	100 x 120mm
LC3-PCI	100 x 290mm

Dimensions do not include the gold-plated edge connector.
A standard metal mounting plate is fitted to one edge of the card.

Fiber optic connectors (transmit and receive for each loop) for H-P plastic fiber cable are accessible through the mounting plate. The transmit connectors are gray, and the receive connectors are blue. ST or SMA glass fiber connectors can be factory fitted to special order.

On the LC3-PCI the port with the lowest address is furthest from the edge connector.

PCI Bus Interface

The whole of dualport RAM appears as memory mapped I/O - controlled outputs are set and inputs monitored solely by writing and reading from memory locations.

Dualport RAM capacity 2048 bytes per Loop Controller.

Interrupts

PCI Loop Controllers can use interrupts to notify the host computer that new data has arrived. Interrupts can be enabled or disabled as required simply by setting or clearing bit-1 in the Communications Enabled byte of the dualport RAM system area. If enabled, an interrupt will be generated by the Loop Controller if:

LC to DI Mode

- New data from an I/O board has arrived in over the loop, and it has different values from the data already present in the dualport for that board.
- Data has been received for a type F board, type K board, or over-the-loop diagnostic port.
- Data for a type F board, type K board, or diagnostic port has been sent.

LC to LC Mode

- A block of data has come in and has been placed in a Receive Data Area.

Serial: General Serial Mode

- Data has been placed in the Receive Buffer.
- Data in the Send Buffer has all been sent.

Serial: DTM Loop Mode

- Data (field, temperature and error) has been stored for a DTM.
- An error code has been stored for a DTM.

See sections 4.7, 5.5 and 6.3 in the “Group3 Control Loop Controller Programmer’s Manual” for specific information about how the interrupts are used on the PCI Loop Controller as well as the note in section 3.1.

4.2 ISA Bus Loop Controllers: LC1-ISA & LC3-ISA

The LC1-ISA and LC3-ISA are Loop Controller cards designed to operate Group3 Control modules from an ISA bus slot. The LC1-ISA drives a single fiber optic communication loop, while the LC3-ISA allows three completely independent loops to be controlled from one slot. The only limit to the number of ISA Loop Controllers used in a computer is the number of available ISA slots. LC1 and LC3 cards can be mixed in a system.

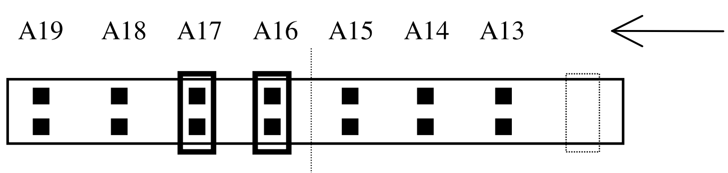
Communication between the computer and each LC takes place through dualport RAM installed on the LC card. This dualport RAM is accessed directly from the computer's address bus. Jumpers are provided on the LCs to place the dualport RAM at a suitable position within the computer's address range.

Operating these cards in a 32-bit environment requires a system driver to be installed on the computer to provide application programs with an access address to the dualport RAM of each Loop Controller upon request. This driver software is supplied on a disk with each Loop Controller card and instructions for installing the driver are available as a text file, *install.txt*, on that disk..

On an ISA Loop Controller the dualport RAM is intended to be placed in the area between 640k and 1M bytes, where free address space can usually be found. Conflict with other devices in the system (such as shadow RAM) must be avoided. The LC base address is determined by comparing PC address lines A13 to A19 with the jumper settings. The base address of the dualport RAM can be placed anywhere between 0 hex and FE000 hex in increments of 2000 hex (8192 bytes).

The absence of a jumper on a particular address line corresponds to a 1.
The presence of a jumper corresponds to a 0.

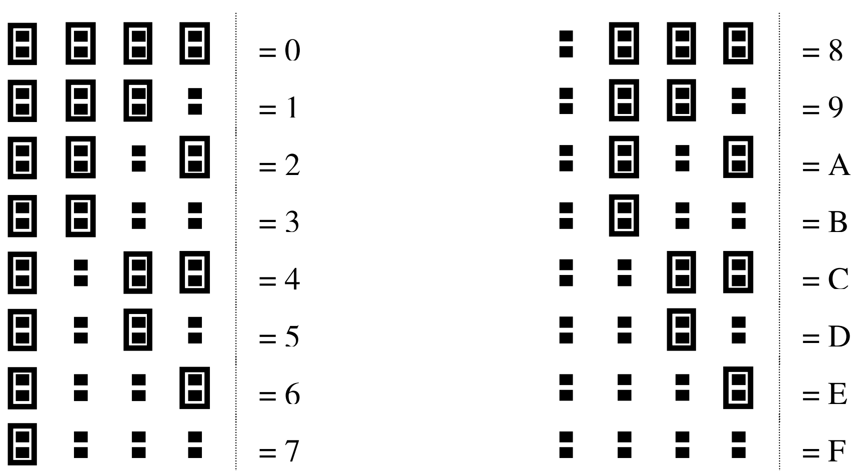
Dual row pin header P2 on Loop Controller card



address line of PC

Factory setting = CE000 hex.
Note: A12 is wired to read as 0

Hexadecimal coding table: = no jumper = 1 = jumper in place = 0



- The address jumpers on an LC1-ISA set the base address for the dualport RAM on that card.
- The address jumpers on the LC3-ISA set the base address of the top transmitter/receiver pair - the one furthest from the gold card edge fingers. The base address of the middle loop is 2048 bytes (800 hex) more than the address jumpers, and the base address of the bottom loop is 4096 bytes (1000 hex) more than the address jumpers. With the jumpers set for CE, as per the factory setting, the base addresses of the three loops are CE000, CE800, and CF000.

Note: Care must be taken if mixing the current ISA bus LC's with the earlier versions (pre 1993). These LC cards have 1Kbyte dualport RAMs (boards labeled 16000032A for LC1s, 16000048 for LC3s). They also have an eighth jumper to set A12 as well. If mixing old and new versions check that the address jumpers are set so that the memory areas used by the boards are different - it is not sufficient that the jumpers just appear to be set to physically different pins.

Specifications

Physical

LC1-ISA	100 x 115mm
LC3-ISA	100 x 300mm

Dimensions do not include the gold-plated edge connector.
A standard metal mounting plate is fitted to the one edge of the card.

Fiber optic connectors (transmit and receive for each loop) for H-P plastic fiber cable are accessible through the mounting plate. The transmit connectors are gray, and the receive connectors are blue. ST or SMA glass fiber connectors can be factory fitted to special order.

On the LC3-ISA the port with the lowest address is furthest from the edge connector.

ISA Bus Interface

The whole of dualport RAM appears as memory mapped I/O - controlled outputs are set and inputs monitored solely by writing and reading from memory locations.

Dualport RAM capacity	2048 bytes per Loop Controller.
Base address	Jumper selected from 00000_h to $FE000_h$ in increments of 2000_h (8192 bytes) Factory setting $CE000_h$ LC3 loops are spaced at increments of 800_h

Interrupts

This board does not generate interrupt signals.

4.3 VME Bus Loop Controllers: LC2-VME

The LC2-VME is a Loop Controller card designed to operate Group3 Control modules from a VME bus crate. Two completely independent loops are controlled from the one LC2-VME card. Up to eight LC2-VME cards can be installed in one VME crate. Communication between the computer and each LC takes place through dualport RAM installed on the LC card.

Specifications

Physical

Standard double-height VME board (160 x 233mm), with a 20mm wide front panel.

VME backplane connector J1/P1 only required.

Fiber optic connectors (transmit and receive for each loop) for H-P plastic fiber cable are accessible through the front panel. The transmit connectors are gray, and the receive connectors are blue. ST or SMA glass fiber connectors can be factory fitted to special order.

Indicator LEDs for transmit and receive data (each loop) are on the front panel.

VME Bus Interface

The whole of dualport RAM appears as memory mapped I/O - controlled outputs are set and inputs monitored solely by writing and reading from memory locations.

Dualport RAM capacity 2048 bytes per Loop Controller.

The LC2-VME uses the VME Short Addressing scheme: 8-bit data and 16-bit address. This means that sequential locations in the LC2-VME dualport RAMs are addressed as alternate (odd) bytes over the VME bus. For this reason, although each loop has 2k bytes of dualport RAM, it occupies 4k of VME address space, and each LC2-VME card with two loops occupies 8k of the 64k short address space. Jumpers are provided to position this 8k block within the 64k short address range.

The LC2-VME responds to Address Modifier codes of 29 and 2D, as standard. Other address modifiers can be implemented to special order.

The board uses the standard VME 16 MHz SYSCLK signal to generate the delays required before issuing DTACK. Four rising edges of SYSCLK are required to complete a data transfer cycle, so access cycle times are between 248ns and 310ns.

Interrupts

This board does not generate interrupt signals.

4.4 STD Bus Loop Controllers: LC-STD

The LC-STD is a Loop Controller card designed to operate Group3 Control modules from an STD bus crate. A single LC-STD card controls one loop. The number of LC-STD cards that can be installed in the STD crate is only limited by the number of available slots in the crate. Communication between the computer and the LC takes place through dualport RAM installed on the LC card.

Specifications

Physical

Standard STD board (approx. 165 x 115mm), with gold plated edge connector to suit STD bus backplane.

Fiber optic connectors (transmit and receive) for H-P plastic fiber cable. The transmit connector is gray, and the receive connector is blue. ST or SMA glass fiber connectors can be factory fitted to special order.

STD Bus Interface

The whole of dualport RAM appears as memory mapped I/O - controlled outputs are set and inputs monitored solely by writing and reading from memory locations.

Dualport RAM capacity   2048 bytes per Loop Controller.

The standard LC-STD uses 8-bit data and 16-bit address lines.

The dualport RAM can be positioned in either I/O space or Memory space by placing a jumper to allow access by either the IORQ or the MEMRQ signal. The 2 Kbyte block of dualport RAM can be set at a base address in either of these 64K (16bit) address spaces by setting jumpers on the base address jumper pins.

The LC-STD can also support the 24-bit address scheme of the STD bus specification, by taking the upper 8-bits (A16-A23) from the multiplexed address/data bus. This option requires some additional components to be added to the 16-bit address board.

The board will issue a WAITRQ if both the STD processor and the LC-STD processor try to access the same dualport RAM location simultaneously.

STD signals SYSRESET and PBRESET will reset the processor on the LC-STD.

Interrupts

The hardware is in place to issue interrupt (INTRQ, INTRQ1, or INTRQ2, selectable by jumper) signals to the STD processor. The Loop Controller software now supports interrupts but a small hardware modification is required to LC-STD cards already in use before this feature can be used. In the meantime these jumpers should be left off. See the *Interrupts* section for the PCI Loop Controller in this chapter.

4.5 CAMAC Loop Controllers: LC1-CAM & LC2-CAM

The LC1-CAM and LC2-CAM are Loop Controller cards designed to operate Group3 Control modules from a CAMAC crate. The LC1-CAM drives a single fiber optic communication loop, while the LC2-CAM allows two completely independent loops to be controlled from one slot. The only limit to the number of CAMAC Loop Controllers that can be used in a CAMAC crate is the number of available slots. Communication between the computer and each LC takes place through dualport RAM installed on the LC card.

Specifications

Physical

Standard single slot width CAMAC module (approx. 310 x 200 x 17mm), with gold plated edge connector to suit CAMAC backplane.

Fiber optic connectors (transmit and receive for each loop) for H-P plastic fiber cable are on the front panel of the module. The transmit connectors are gray, and the receive connectors are blue. ST or SMA glass fiber connectors can be factory fitted to special order.

LEDs on the front panel indicate data on the fiber optic cables and another LED lights to indicate **X** - "CAMAC command accepted".

CAMAC Interface

The whole of dualport RAM appears as memory mapped I/O - controlled outputs are set and inputs monitored solely by writing and reading from memory locations.

Dualport RAM capacity 2048 bytes per Loop Controller.

There is an address register on the CAMAC Loop Controller which can be written to from the CAMAC write lines. The address written into this register remains there until written over or power is removed. This address register holds the address lines used to access a particular location in either of the dualport RAMs.

To write an address to this register the user must perform a write operation - CAMAC function F(16).A(2) writes to the address register, from CAMAC lines W01-W11. Note that only the lower 11 bits are used.

All data written into or read out from the dualport RAMs is transferred eight bits (one byte) at a time.

Having used F(16).A(2).N( ) to write the address to the address register, the following CAMAC commands are available.

F(0).A(0).N( ) reads one byte from this address in the DP RAM of loop 0, onto R1-R8.
F(16).A(0).N( ) writes one byte to this address in the DP RAM of loop 0, from W1-W8.

F(0).A(1).N( ) reads one byte from this address in the DP RAM of loop 1, onto R1-R8.
F(16).A(1).N( ) writes one byte to this address in the DP RAM of loop 1, onto W1-W8.

The user must set up the data areas of the dualport RAM as described in sections 4, 5 and 6 of the “Group3 Control Loop Controller Programmer’s Manual”. From then on:

- To set an output channel the user writes the address of that channel to the address register, then writes the desired value to that address.
- To read an input channel the user writes the address of that channel to the address register, then reads the data from that address.

Interrupts

This board does not generate interrupt signals.

5 SIGNAL CONDITIONERS

Group3 signal conditioners are a range of DIN rail mounting modules that are matched to the more popular I/O boards. The signal conditioners have three functions:

1) Transient Attenuation.
   The circuits place silicon transient suppressors and RC networks on all signal lines. These serve to drastically attenuate any transients picked up by the signal wires, thereby protecting the DI from damage or upset.

2) Signal level alteration.
   The analog channel signal conditioner circuit boards have provision for resistive dividers to be inserted in the signal path. This allows large input voltages to be scaled down to a range that the I/O boards can handle.
   The digital signal conditioner boards have provision for external pull-up resistors if the internal 5 volt pullups are not sufficient. (eg on a 24 volt logic control system).

3) Breakout of signal wiring.
   The I/O boards have ribbon cable type I/O connectors. The signal conditioners accept the ribbon cable from a DI and provide rows of screw terminals to accept the signal wires. These screw terminals are much easier to connect individual wires and cable shields to.

Signal conditioners are highly recommended where DIs are to be installed in any electrically noisy environment. Their prime function is to shunt any high energy transients picked up by the signal wiring to chassis ground, before the transient can enter the DI and cause damage or upset.

There are five new one-piece signal conditioners, called SCTB, SCTC, SCTD, SCTE, and SCTK, available for use with I/O boards of type B, C, D, E and K respectively.
The original two board versions, SC50 + PB50B1, SC34 + PB34C1, and SC20 + PB20D1 are still available as replacement parts, or for special purposes.

Type A boards require combinations of signal conditioner boards for the analog channels (SC10 + PB10A1), and a separate combination for the digital channels (SC20 + PB20A1).

There are two other options for the type B digital board:

SC50 + PB50B2 offers 24 optocouplers, each channel configurable as input or output.

SC50 + PB50B3 offers 24 reed relays, outputs only, as a set of switched contacts.

The circuits and component layouts of the signal conditioners follow.

Install the signal conditioners as close as possible to the DIs, so that the ribbon cables joining the two can be kept as short as possible. The signal conditioners can be mounted on the same length of DIN rail as the DI, or on a separate length just above the DI. Try to keep the ribbon cables routed away from the external signal wiring, so that transients can not bypass the signal conditioners.

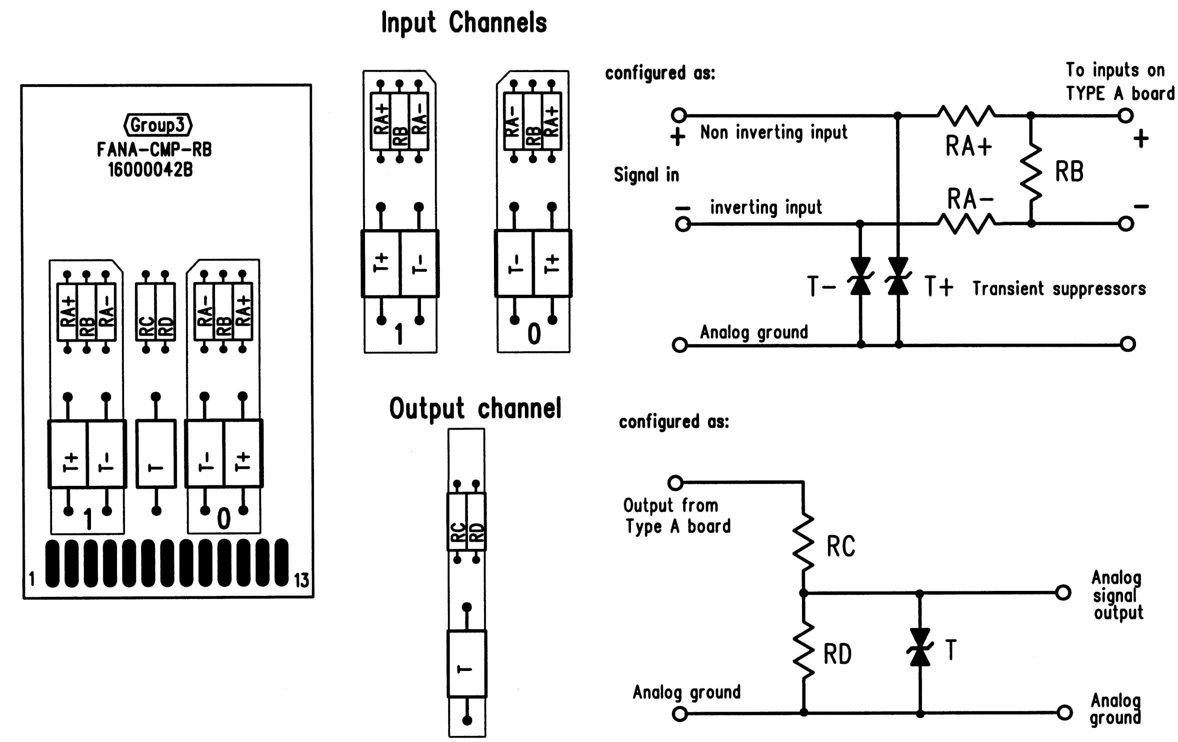
The new SCTB, SCTC, and SCTD have three rows of screw terminals. The top row is the I/O signals, the middle row is commoned for signal ground wires, and the third row is commoned for the shield connections from the shielded twisted pair cables that are recommended for all signal wiring. A separate, short length of heavy gauge wire should be used to connect the row of shields to a good low impedance chassis or rack ground nearby. See section 7 - Installation for further comments, and the section on grounding at the end of that section - page 7-6.

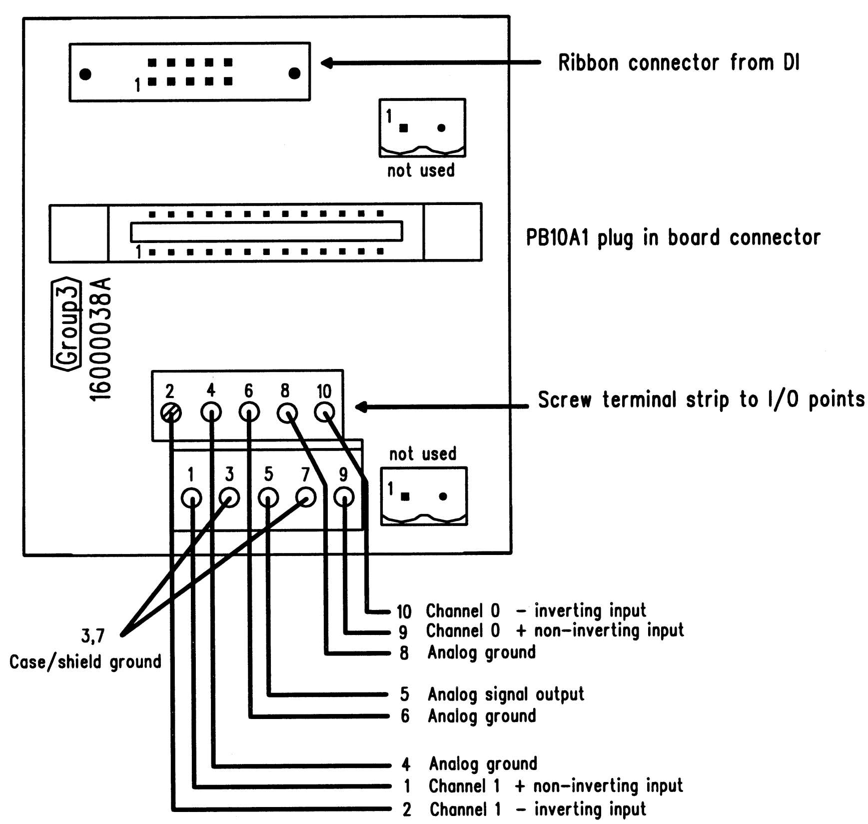
The signal conditioner for the DC motor driver board - SCTE - has four groups of four screw terminals, one group for each motor. A short length of heavy gauge wire should be used to connect the screw terminal labelled "chassis" to a good low impedance chassis or rack ground nearby.

The signal conditioner for the GPIB controller board - SCTK - allows the transition from the 26 way ribbon cable header on the type K board to the bulkier GPIB standard connector. The SCTK has circuitry to clamp the voltages on the GPIB signal lines to allowed limits. A short length of heavy gauge wire should be used to connect the screw terminal labelled "chassis" to a good low impedance chassis or rack ground nearby.

Signal conditioning for analog channels of type A board

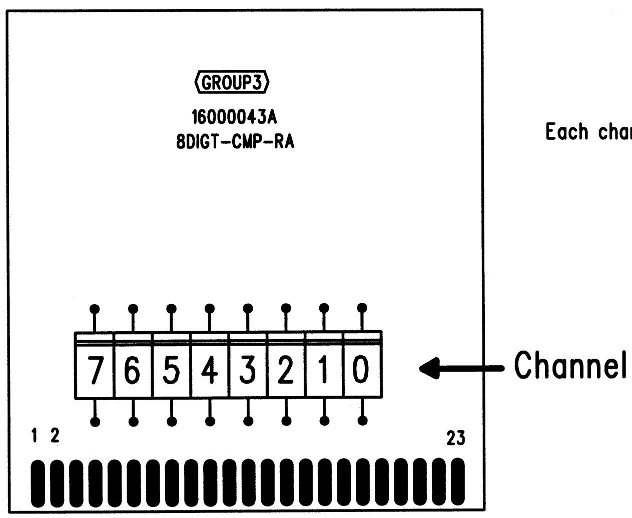
(Requires PB10A1 plug in board and SC10 base)



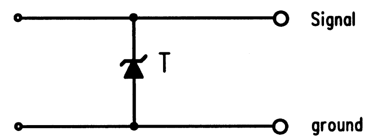


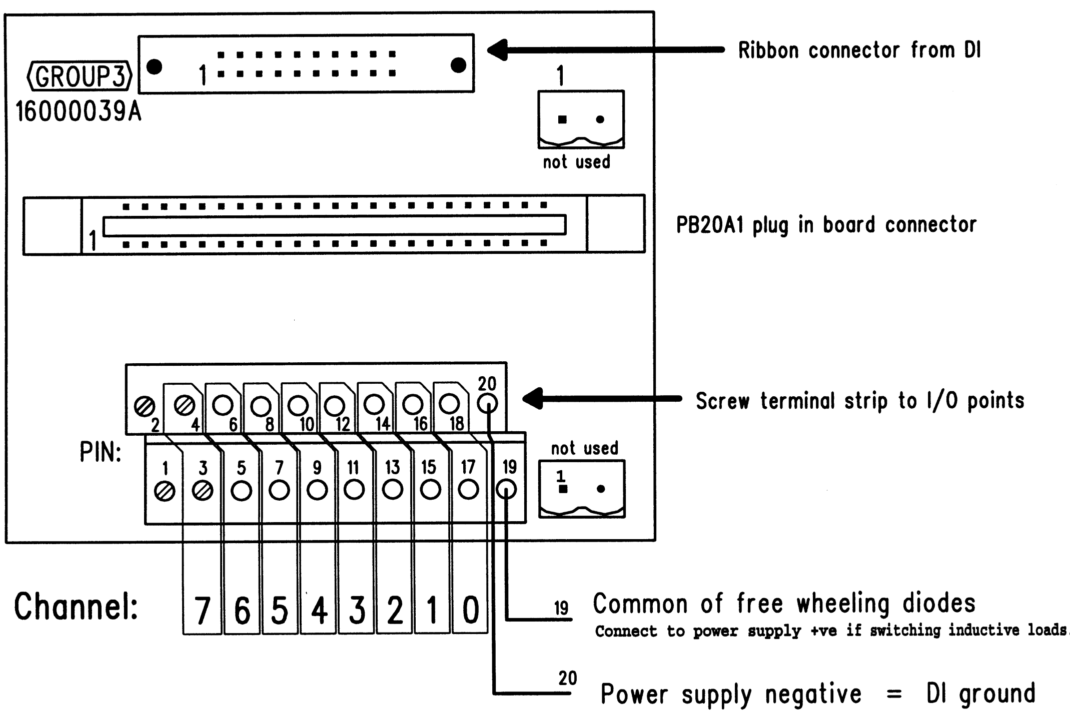
Signal conditioning for digital channels of type A board

(Requires PB20A1 plug in board and SC20 base)

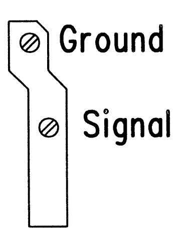


Each channel configured as:





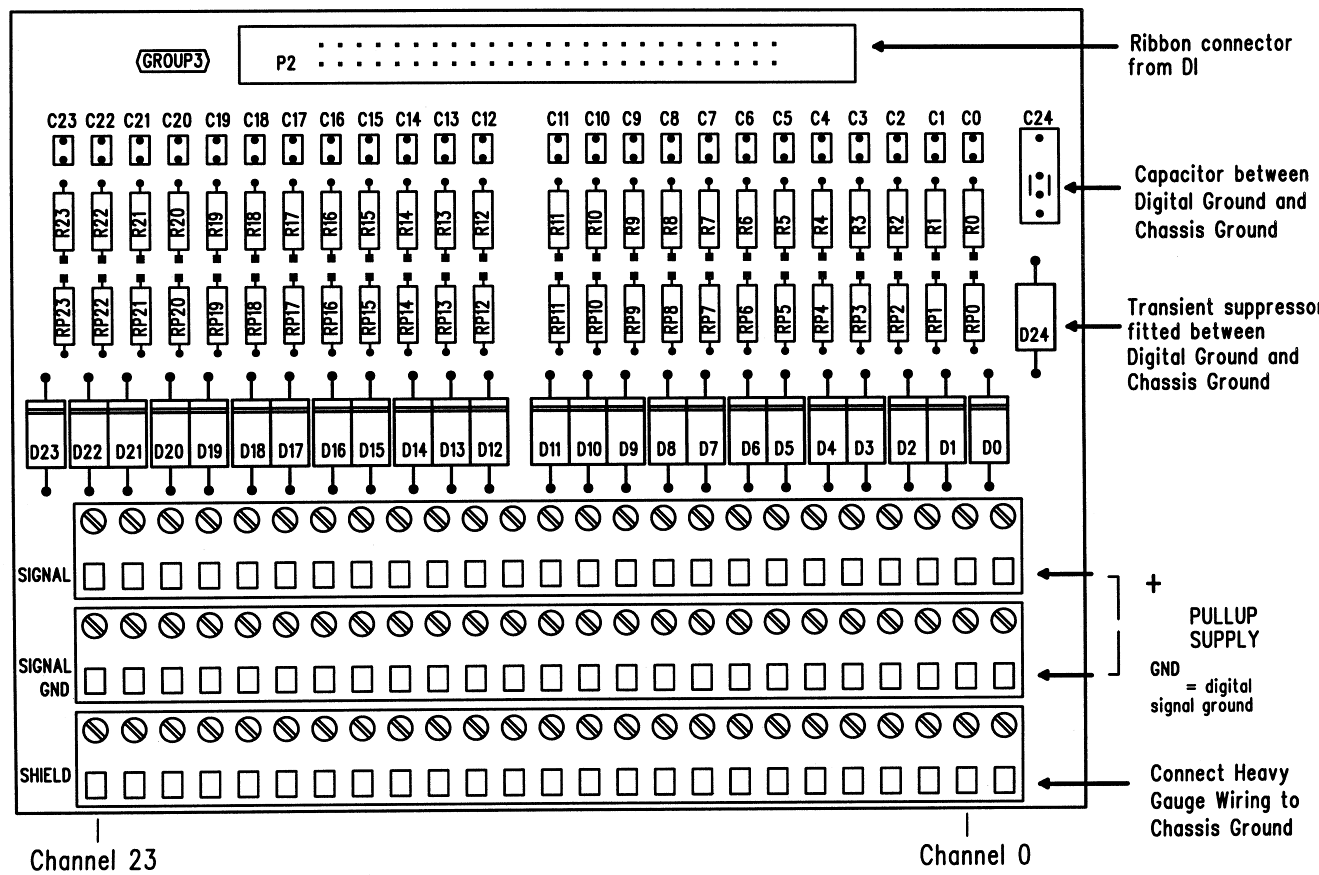
Each channel:

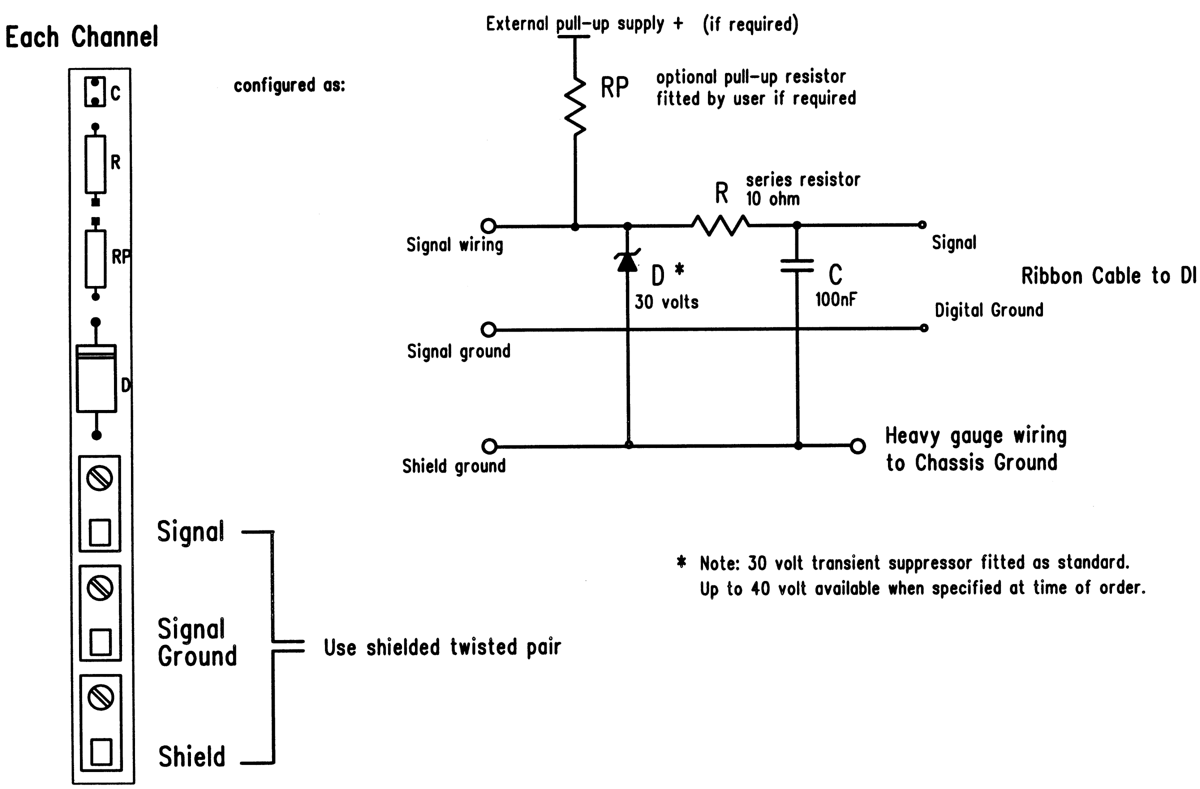


As an output: Terminal is pulled to ground
Open collector, 100mA max

As an input: Pull terminal pin to ground

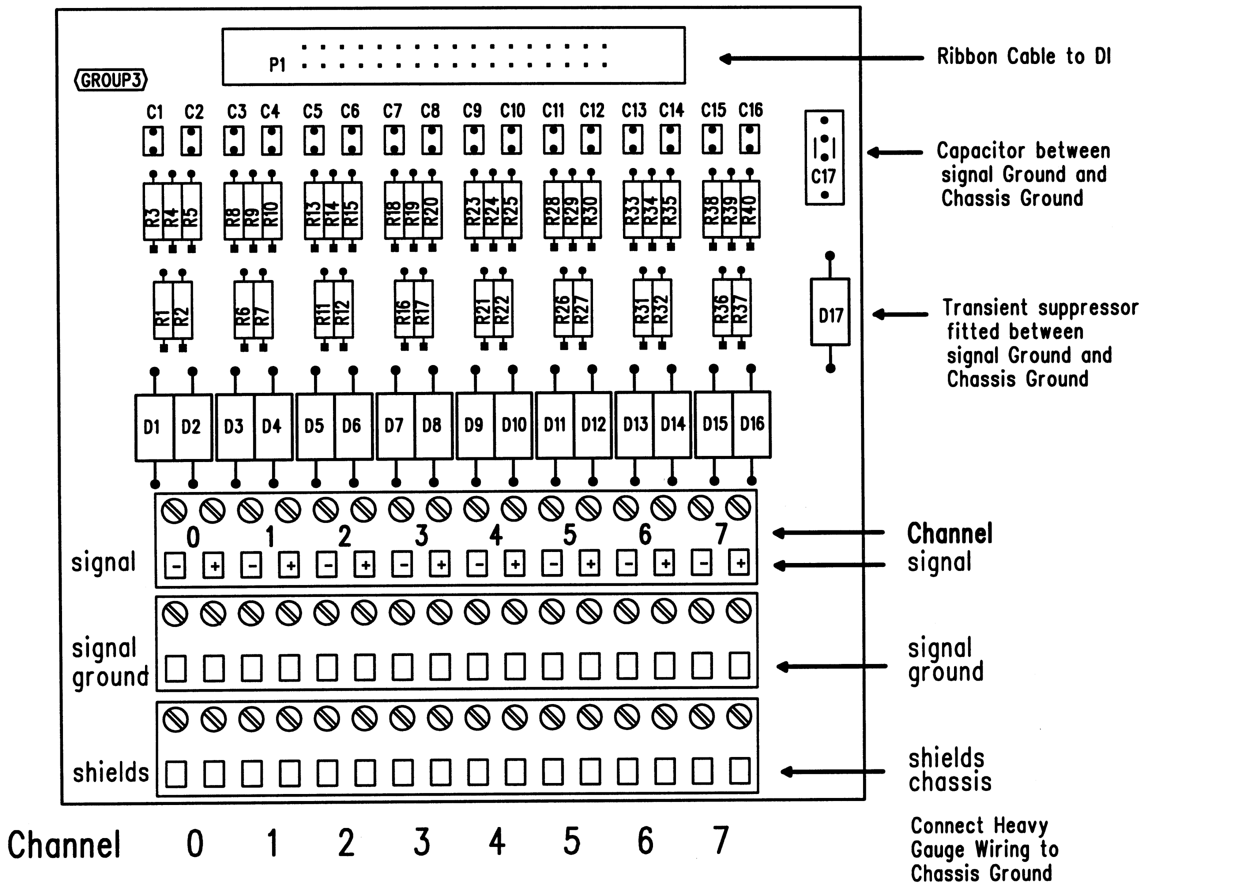
Signal conditioning for type B board - using SCTB

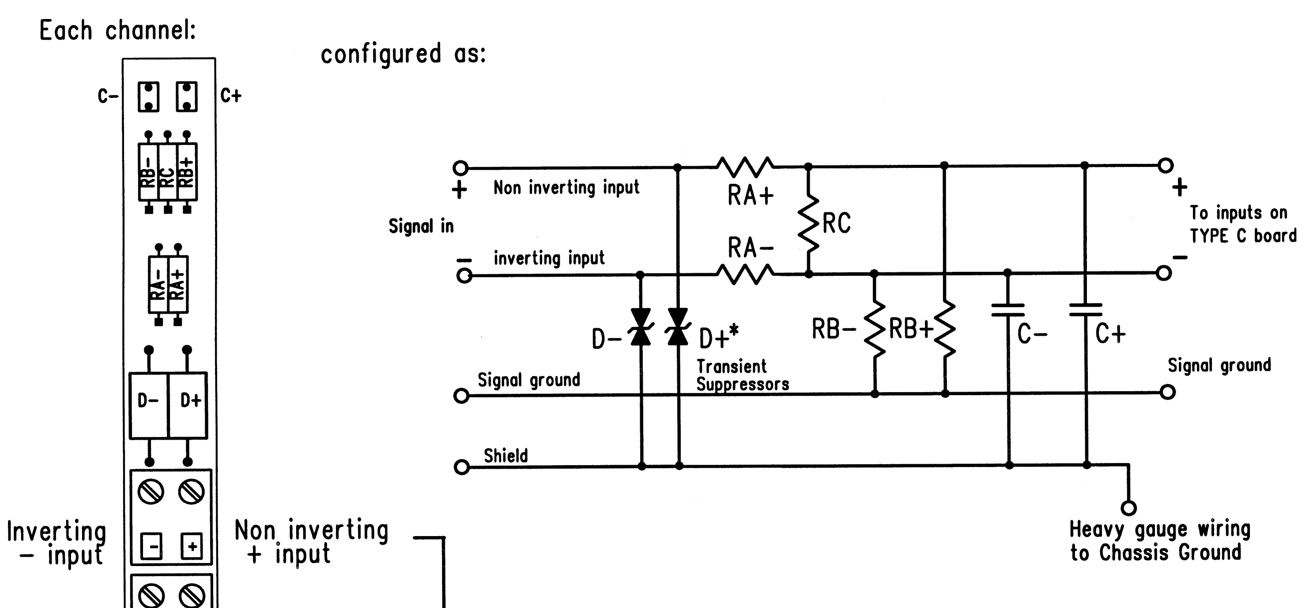




* Note: 30 volt transient suppressor fitted as standard.
Up to 40 volt available when specified at time of order.

Signal conditioning for type C board - using SCTC

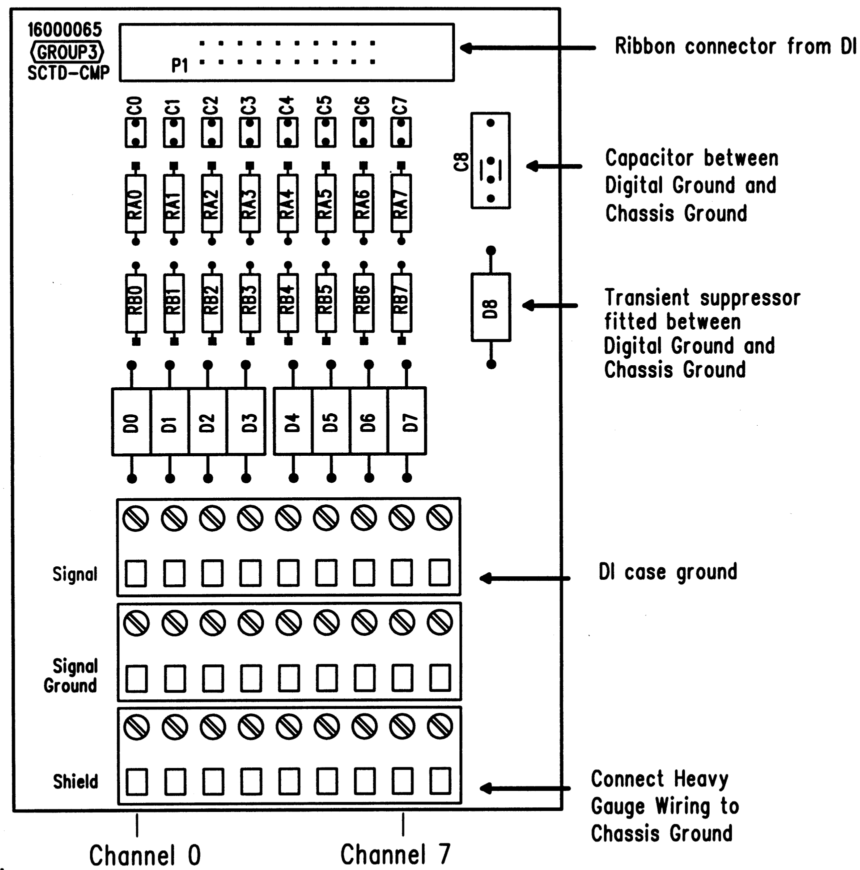




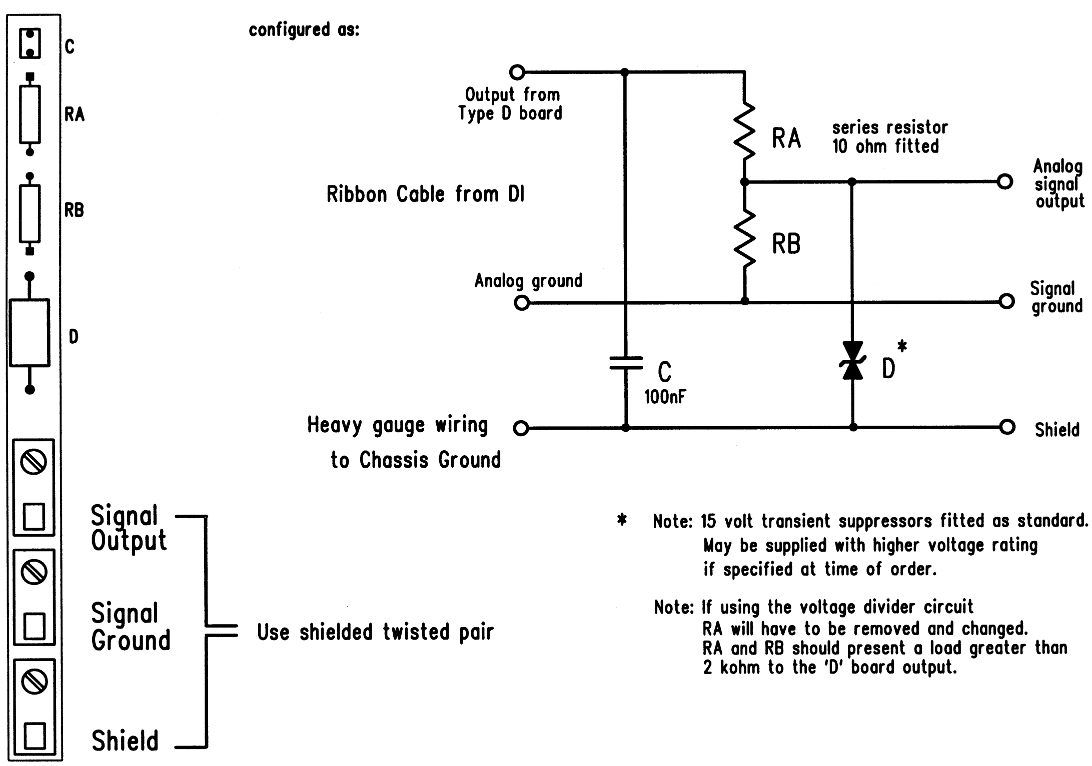
* Note: 15 volt transient suppressors fitted as standard.
May be supplied with higher voltage rating if specified at time of order.

Note: RA+ and RA– are fitted as 10 ohm as standard
If using the voltage divider circuit RA+ and RA– should be removed and the correct voltage divider resistors fitted

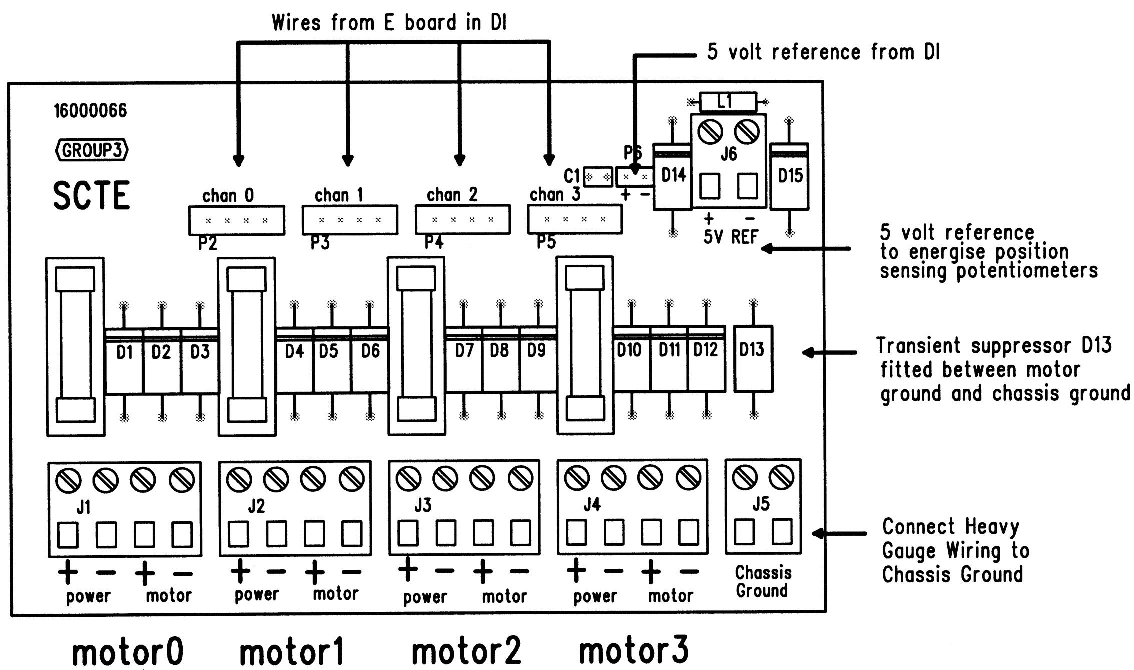
Signal conditioning for type D board - using SCTD



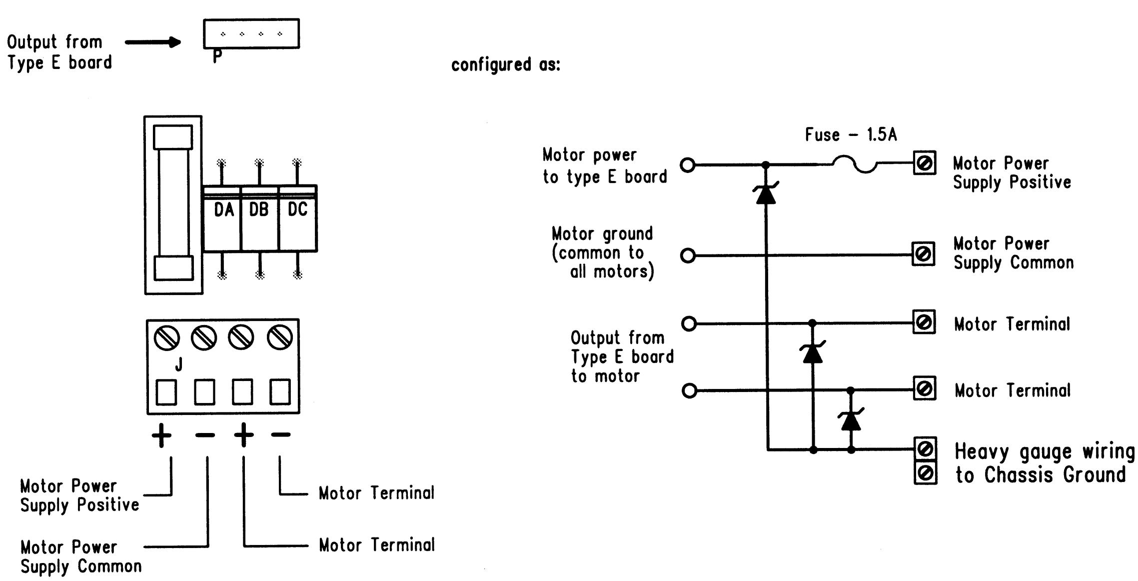
Each channel:



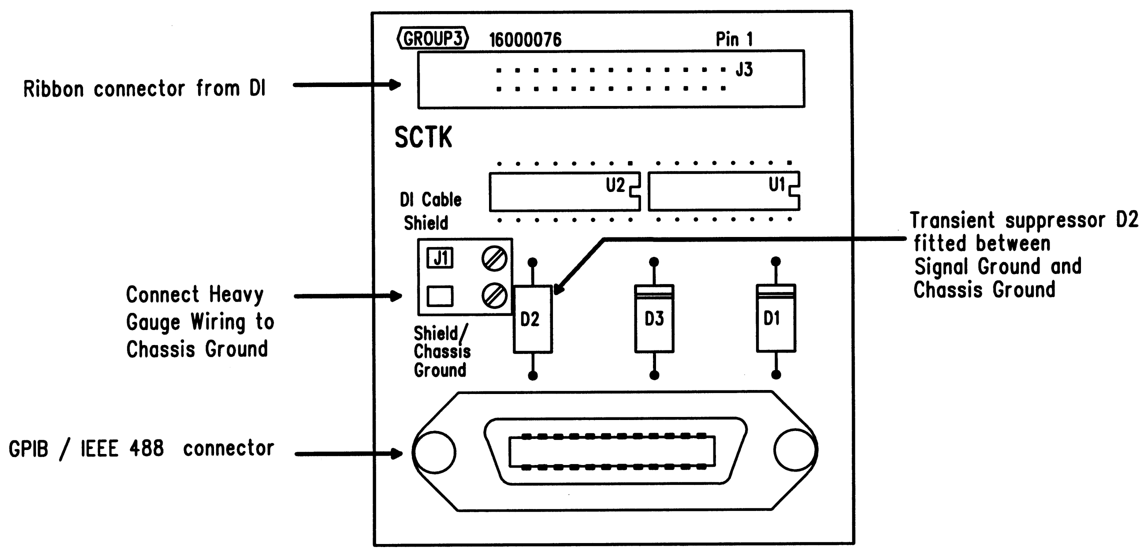
Signal conditioning for type E board - using SCTE



Each channel:



Signal conditioning for type K board - using SCTK



An SCR clamping structure is connected to each GPIB signal line which limits voltages on the line to below 6V.

Photocopy this form and record the set-up of your installation

TYPE A Analog/Digital - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Analog Inputs

Range		Ch0	Ch1
	0 - 50 mV		
	-50 to +50 mV		
	0 - 5 V		
	-5 to +5 V		
	0 - 10 V		
	-10 to +10 V		
	other		
	other		

Filter		Ch0	Ch1
	no filtering		
	Filter factor : 1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
Filter Window	- voltage		

Analog Output

Range	Ch0
0 - 5 V	
-5 to +5 V	
0 - 10 V	
-10 to +10 V	

Digitals

Input Polarity

Channel	07	06	05	04	03	02	01	00
Active High								
Active Low								

Output Polarity

Channel	07	06	05	04	03	02	01	00
Active High								
Active Low								
Inhibited								

TYPE B 24 Digital channels - setup parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Input Polarity

Channel	23	22	21	20	19	18	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Active High																								
Active Low																								

Output Polarity

Channel	23	22	21	20	19	18	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Active High																								
Active Low																								
Inhibited																								

Photocopy this form and record the set-up of your installation

TYPE C Analog Input - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Range		Ch0	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
	0 - 50 mV								
	-50 to +50 mV								
	0 - 5 V								
	-5 to +5 V								
	0 - 10 V								
	-10 to +10 V								
	other								
	other								

Filter

Filter factor :		Ch0	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
	no filtering								
	1								
	2								
	3								
	4								
	5								
	6								
	7								
	8								
Filter Window	- voltage								

TYPE D Analog Output - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Range		Ch0	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6	Ch7
	0 - 5 V								
	-5 to +5 V								
	0 - 10 V								
	-10 to +10 V								

Photocopy this form and record the set-up of your installation

TYPE E DC Motor - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Pulse width / Cycle time
(All four motors)

Option	Pulse width ms	Cycle time ms	
0	3.55	910	
1	1.77	455	
2	0.89	228	
3	0.44	114	
4	0.22	57	
5	0.11	28	
6	0.06	14	
7	0.03	7	

TYPE F Serial I/O board - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

PORT 0

Baud rate

2400	
4800	
9600	
19.2k	
38.4k	

Data bits

7	
8	

Parity

Odd	
Even	
None	

Stop bits

1	
2	

String terminator [ ]

PORT 1

Baud rate

2400	
4800	
9600	
19.2k	
38.4k	

Data bits

7	
8	

Parity

Odd	
Even	
None	

Stop bits

1	
2	

String terminator [ ]

Photocopy this form and record the set-up of your installation

TYPE G Stepper Motor - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Mode

		Motor 0	Motor 1	Motor 2	Motor 3
Run Mode	Position control				
	Continuous run				
Stop Mode	Windings energised				
	All Windings Off				
Step Increment	Full step				
	Half Step				
Drive method	Quadrature				
	Clock & Direction				
	Dual Clock				
All Windings Off polarity	Active low				
	Active high				
Step Increment polarity	Full step low				
	Full Step high				

Limits

		Motor 0	Motor 1	Motor 2	Motor 3
Lower Limit	Inactive				
	Active				
Upper Limit	Inactive				
	Active				
Lower Limit polarity	Normally Closed				
	Normally Open				
Upper Limit polarity	Normally Closed				
	Normally Open				

TYPE J Analog Output - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Range

	Ch0	Ch1
0 - 5 V		
-5 to +5 V		
0 - 10 V		
-10 to +10 V		

TYPE K GPIB / IEEE 488 - Set-up Parameters

Loop [ ] Base address **DI Box** [ ] Switch setting **Board** [ ] Jumper setting

Board Primary Address [ ]

Board Extended Address [ ]

Default EOS Character [ ]

Default timeout [ ]

Default EOS actions:

	YES	NO
Send EOI on EOS		
Terminate read on EOS		

6. Group3 CONTROL SYSTEM DESIGN

6.1 Guidelines for determining the hardware required for an installation.

The number and type of Device Interface units (DIs) required is determined by the number of I/O channels, the physical layout of the units, and the different electrical potentials in the system.

Electrical potentials

All channels within a DI case must be at the same potential.
This is all channels on all cards in the same DI. Give some thought not just to normal running conditions, but also to what happens on a breakdown. If there is a chance that, say, one power supply could drift from the potential of another supply on a breakdown, then the two supplies should be controlled and monitored using a separate DI for each.

Physical Layout

To take advantage of the noise immunity offered by the fiber optic cable, the DIs should be placed as close as possible to the device they are controlling. All copper wires bringing signals to the DI should be as short as possible - preferably less than half a metre. Place the DI right at the back of the power supply, switch panel etc. This means that in a noisy environment two supplies more than a metre or so apart , even if they are at the same potential, should really be controlled using a separate DI for each. This wiring length restriction can be relaxed if the DI and supplies are inside a shielded rack enclosure. Digital signals can be isolated using relays or optocouplers (available on Group3 signal conditioners) to overcome these distance limitations. This will permit, for example, all the signals from the physically distributed door safety switches to be sensed from one type B digital board.

DIs required:

Bearing in mind the two important factors above, it is necessary to determine the I/O cards needed for the DIs, and which size DI to use at each point. DIs are available that accept one or three I/O cards. A DI does not have to be fully populated to function, so a slot could be left empty to allow for future expansion at that point. A DI can be populated with any combination of I/O boards - all different or all the same. A single type A board in a one slot DI offers the smallest way to control and monitor a typical power supply, providing two analog inputs, one analog output and 8 digital I/O.

Complete this form for each potential and/or physical location

Photocopy this form and fill out one for each potential level or separate location in the machine. All channels within a particular Device Interface have to be referenced to the same potential.

Name the potential or location (e.g. Ion Source Potential, Control Rack Cabinet #1, etc)

Digital Inputs - how many on/off inputs ?
(sensors, switches, thermal cut-outs etc)

Digital Outputs - how many on/off outputs ?
(relays, contactors, LED indicators, etc)

Analog Inputs - how many analog values to measure ?
(voltages, pressures, temps, positions etc.)

Analog Outputs - how many analog values to generate ?
(programming voltages, etc.)

DC motors - how many small DC motors ?
(valve opening, slit positioning, etc.)

Serial Comms. - how many serial comms. ports ?
(RS232 to instruments, etc.)

Stepper Motors - how many stepper motors ?
(positioning, rotation, etc.)

Encoders - how many encoders ?
(Shaft rotation, programmable control knob, etc.)

Precision Output - how many precision analog outputs?
(programming outputs to 16 bit accuracy)

GPIB / IEEE488 - how many GPIB instruments do you need?

Digital I/O (Digital Inputs + Digital Outputs)	divide by 24 and round up	Number of **B** boards
Analog In	divide by 8 and round up	Number of **C** boards
Analog Out	divide by 8 and round up	Number of **D** boards
DC Motor	divide by 4 and round up	Number of **E** boards
Serial Comm's	divide by 2 and round up	Number of **F** boards
Stepper Motor	divide by 4 and round up	Number of **G** boards
Encoders	divide by 4 and round up	Number of **H** boards
Precision Out	divide by 2 and round up	Number of **J** boards
IEEE488	divide by 8 and round up	Number of **K** boards

+

Add up to give total number of I/O boards

Divide by 3
(Assuming CN3s)

Number of DIs required
(CN3e + PROC)

Note: The above table leads to the simplest Group3 Control configuration. No mention has been made of the **CNA** module , or the **Type A** board. This is a combination analog and digital board, with 8 digital I/O, 2 analog inputs and 1 analog output. Consider using the **CNA** if you have just a few mixed channels at one location, for example if you need to control and monitor a single power supply at a location.
You will need to adjust the numbers of digital, and analog channels in the table above to reflect those channels being handled by the CNA or type A boards.

To complete the system you will require:
1) Loop Controller:- one LC for every 16 DIs,
2) Signal Conditioners for each I/O board,
3) Ribbon cables to join I/O boards to their signal conditioners
4) Fibre Optic cables to link DIs and the LC
5) Power supplies for the DIs.
6) if using commercial software packages, the appropriate driver module.
7) Diagnostic Port cable, or small diagnostic terminal with plug fitted.

Remember this is the number of DIs required to house the I/O boards for this potential / location. Complete one of these forms for each potential / location in the machine to estimate the full requirements of the system.

6.2 A Step by Step Guide to determining hardware requirements.

1 Make a list of all the equipment to be controlled and monitored.
List each power supply, interlock, current monitor, temperature sensor etc.

2 For each piece of equipment **determine the analog and digital signals needed** for control and monitoring. For analog signals, establish the range and polarity of signal present.

For example a listing for a typical power supply may have:

voltage control, 0 to 10 volt - requires an analog output from module

voltage readback, 0 to 20 volt - requires analog input to module
(with 2:1 resistive divider)
current readback, 0 to 200 amps, - requires analog input to module
read as 0 to 50mV across a shunt
on/off control - requires a digital output
over temperature warning requires a digital input
cooling flow warning requires a digital input

So, to institute full control and monitoring of this power supply would require a total of 1 analog output, 2 analog inputs and 3 digital channels from a Group3 DI.

List every control or readback channel in the system, with the sort of detail as shown in the example above.
This takes some thought and considerable time on a big system, but it has to be done at some point if instituting computer control.
These channel by channel lists are also essential when configuring a control software package, so a neat orderly listing defining all the channels at the start of a project saves time in the long run.

3 Separate the channel listings into voltage potential levels.

eg separate into one section all the channels that are up at the ion source potential, into another all the channels at ground potential etc.

All the channels being controlled or monitored from a particular DI must be at the same potential, and any potential difference has to be traversed using fiber optic cables to another DI. So there are times when only a few out of the eight analog channels on an I/O card can be used. For example if the Ion source level only requires 4 analog inputs to monitor it, then the remaining 4 analog inputs cannot be used to measure any signal at other potentials.

4 **Further subdivide the lists** at each potential level **into channels that are in the same physical location.**

In an electrically noisy environment the signal wires should be kept as short as possible to minimise transient pick-up. Part of the system's reliability comes from keeping signal wiring short and using the fiber optic cable to traverse any distance. Ideally signal wiring should not be more than about half a meter long. This means that equipment within a rack cabinet could be controlled from one DI, but that equipment in a separate rack cabinet a few meters away should be controlled by another DI.

5 **Determine the I/O boards and DIs required.**

There should now be a series of lists of channels, separated according to voltage potentials, and further subdivided according to physical location.
On a small system all of the channels at the same potential and at the same location could be controlled or monitored from a single DI, but usually the channels have to be assigned to a number of I/O boards , which are then housed in the appropriate number of DIs.
Divide the number of each type of channel in the subsystem by the number of channels on that type of I/O board (see list below). Rounded up to the nearest integer this gives the number of each type of I/O board required for that subsystem.

Type	number of channels per I/O board
A	2 analog in, 1 analog out, 8 digital
B	24 digital
C	8 analog input
D	8 analog output
E	4 DC motors
F	2 serial comms ports
G	4 stepper motors
H	4 encoders
J	2 precision analog out
K	1 GPIB / IEEE 488 port

These I/O boards will then need to be housed in DIs. There are two sizes of DIs available - housing one or three I/O boards. A DI does not need to be filled to capacity, so unless there are severe space constraints it is sensible to standardise on three slot DIs. This also allows for future expansion at that point.

A DI can be filled with any combination of up to three I/O boards. They can be all the same, or all different, or a mixture. The only exception is that there can only be one Type K board in each DI. If several DIs are needed at one point then it does not matter which I/O boards go in which DI.

The only time the allocation of I/O boards might have importance is on a lightly loaded loop where speed of response is important. In this case it is best to avoid three eight channel analog boards in the same DI.
If there are more than 12 I/O boards on the entire loop then the I/O board combinations do not have any effect on the performance of an individual channel.

So at this point it should be possible to draw up a list of the DIs, filled with the required I/O boards. eg

CN3-BCD	a DI with a 24 digital, an 8 analog input, an 8 analog output boards.
CN3-BBB	a DI with three 24 digital channel I/O boards.
CN3-CE	a DI with an 8 analog input, a 4 DC motor driver, and a spare slot.
CN1-A	a single slot DI with a Type A combination board.

6 Loop Controller(s)

The Group3 loop controllers handle the communications on the fiber optic loop, allowing the control computer to talk to the DIs.
A single loop can have up to 16 DIs operating on it.
There are some points that need to be considered before deciding on the number of loops an installation requires.

1) Response Time.
   On average the response time of a particular channel on alarge system is 1.25 ms per I/O board on the loop. 16 DIs can contain up to 48 I/O boards, so the response time on a fully loaded loop can be nearly 60ms. If this is not acceptable then the heavily loaded loop should be split into two smaller loops, each requiring a loop controller.

2) Power Supplies.
   Communications on the loop will be broken if a DI does not have power supplied to it. If power can routinely be disconnected from some DIs, but control is still wanted from channels in other DIs then these two sets of DIs should be controlled on separate loops. For example, frequently the DIs at Ion Source potential derive their power supply from an Ion Source level generator, which can be switched on and off independently from the rest of the accelerator. If for instance the vacuum system at ground level is to be controlled continuously, whether or not the ion source generator is operating then the two levels should be controlled from separate loops.

There is no inherent limit to the number of loop controllers that can be installed in one computer. The hardware design of the loop controller makes each loop appear to the control computer as a small (2 Kbyte) section of memory. All the communication is handled by the processor on the loop controller so adding more loop controllers into a computer does not slow down the computer hardware. The only limit to the number loops that can be run from a single computer is the number of expansion slots available in its chassis - but even then another computer can be added to the first on a network.

Deciding which type of loop controller will depend on the hardware your institution has, or intends to use.
If you are designing a new system from scratch it is probably most cost effective to choose to use a PC. They are inexpensive, widely available, and can operate with a number of very useable software packages.

Loop controllers currently available are:

LC1-ISA controlling one loop from one ISA expansion slot of a PC.
LC3-ISA controlling three independent loops from one ISA slot of a PC.

LC1-PCI controlling one loop from one PCI expansion slot.
LC3-PCI controlling three independent loops from one PCI slot.

LC2-VME controlling two independent loops from one slot in a VME crate.
LC-STD controlling one loop from one slot in an STD crate.
LC1-CAM controlling one loop from one slot in a CAMAC crate.
LC2-CAM controlling two loops from one slot in a CAMAC crate.

7 Signal Conditioners

The prime function of the Group3 signal conditioner range is transient absorption.
They are highly recommended in any electrically noisy environment.
These signal conditioners are small DIN rail mounted circuit boards that handle all the signals to/from a single I/O board.
They also ease the task of installation wiring by providing rows of screw terminals to attach the signal wiring to. The connectors on the top of the DI I/O boards are ribbon cable type pin headers, and a ribbon cable is used to connect the I/O board to the signal conditioners.

The circuitry consists of high speed, high power (1 ps, 1.5 kW) silicon transient absorbers, followed by a small RC network. The analog channels also have provision for voltage divider networks to bring the signal down to allowable levels.
See the section on signal conditioners for full details. Suffice to say here that any I/O boards operating on an electrically noisy machine should have a signal conditioner installed as well.

Signal conditioners available are:

SCTB	for Type B boards, 24 channels of digital signals
SCTC	for Type C boards, 8 channels of analog input
SCTD	for Type D boards, 8 channels of analog output
SCTE	for Type E boards, 4 DC motor drivers
SCTK	for Type K boards, GPIB / IEEE 488 controller
SC10/PB10A1	for analog channels of Type A board
SC20/PB20A1	for digital channels of Type A board.
SC50/PB50B2	optocouplers for 24 digital channels of Type B board
SC50/PB50B3	reed relay outputs for Type B board

8 Fiber optic cables.

The standard fiber optic cable used is Hewlett Packard simplex plastic cored cable.
The core diameter is 1.0mm, external diameter of 2.2mm, and terminated at one end with a gray 'Versatile Link' style connector (HP part no HFBR-4501) and at the other with a blue 'Versatile Link' style connector (HP part no HFBR-4511).
The maximum length of any one piece of plastic cable for use with Group3 Control is 40 meters. Each DI receives, decodes and re transmits the loop data, so every cable in the system could be 40 meters. If a greater distance is required a plastic cable repeater is available, so there can be multiples of 40 meters between DIs, or between DI and computer.
Alternatively, a new HCS, silica cored fiber that fits the plastic connectors is available. Maximum distance with this new cable is 500 meters in any one length.
Another option is to order the hardware with glass fiber optic cable transmitters and receivers. The hardware supports ST (bayonet type) or SMA (screw type) connectors. Using glass cored cable distances of up to 3000 meters can be covered with one cable.

In general, if the distance can be covered with plastic cable then it is best to specify this. The plastic cable is the standard product, and is generally less expensive than the glass type. It is also more robust, and is much easier to terminate.

See the pages in the Hewlett Packard Optoelectronics Designers Catalog for further specifications and details on terminating of cables.

9 Power supplies

The DIs require a local supply of 24 volts (nominal), DC or AC. See page 2-7 for details.
Each DI has an internal isolating (to within a few hundred volts) power supply so DIs can be powered from the same supply without getting ground loop problems.

A domestic wall plug power supply of a suitable voltage can be used provided it has a suitable power and voltage rating.

In a noisy environment it is not recommended to power the DIs off a reticulated industrial 24 volt supply - it is much better to use an individual supply for each DI.

Group3 recommends their small DIN rail mounted power supply, model PS12D15, capable of powering one or two DIs. See page 2-7 for power requirements. This unit provides an isolated 24 volt DC, 15W output from a universal mains AC input (100 to 240 volt AC). The isolation is particularly valuable in a noisy installation to reduce mains-borne transients.

10 Diagnostic Port cable

To allow a standard terminal to talk to the DI diagnostic port.
The pin-out of the connector on the DI is given in section 2.4, or a ready built cable is available from Group3, part number DPC2.

Following the preceding points 1 to 10 should generate a list of the DIs, with the I/O boards, the loop controller(s), signal conditioners and accessories - in fact the complete list of Group3 hardware required to complete an installation.

6.3 Software

Control software is required to permit control and monitoring to be performed by the computer, and for the status to be displayed on the computer.

6.3.1 PC based control packages.

One huge advantage of using a PC as the control computer is that it allows use of any of a number of commercially available control software packages. These packages have had hundreds of man years of programming experience put into them - a level of input no single physics institution could hope to give to a project. The packages are also fully documented, come with on line help, and offer support and upgrades.
Using one of these commercial packages a complete novice can get a simple system under control in a week or two. It is useful to have someone in the organisation who has some previous knowledge of such packages, but by no means essential.
Most of the packages support networks of computers, so several computers can share control data.

For some packages two pieces of software are needed to institute control - the standard commercial package of choice, and a program supplied by Group3 that allows the standard commercial package to talk to the Group3 loop controller.

The pricing of the commercial packages sometimes depends on the number of channels that are being monitored and controlled, but a small system can be upgraded to a bigger system at a later date.

Packages currently supported by Group3 are:

InTouch, by WonderWare Corp,
LabVIEW, by National Instruments,

Other packages that have been used to run Group3 hardware are:-

Control3, and other custom software by Pyramid Technical Consultants
ControlView, by Allen Bradley.
VISTA, by Vista Control Systems inc.

- a number of custom written interface software drivers, particularly for the VME and CAMAC loop controllers.

1) InTouch.

Very graphical - the user can draw any screen pictures, and animate the objects according to monitored values - objects can move, meter needles point to the correct value, tanks fill, warnings flash etc.

This package has the best graphics, on line help, and is the easiest for a complete beginner to start up with. It has all the value displays, historical data logging, alarms and graphing one could want. Its automatic control language is a bit limited - action scripts are easy to write, but have to be written in a script language similar to BASIC. A further module is available, at a price, to allow control functions to be written in 'C'.

It is a windows based program, and communicates through the DDE protocol, which can slow down the graphics update if many values all change at once. Pricing depends on the number of channels, with changes at 64, and 256 points. Requires an additional program from Group3, a DDE driver called G3DDE.

2) LabVIEW

Scientific analysis and control package. A limited range of graphical elements to choose from. Has a very good range of data analysis tools. It has a very fast update rate. Becomes easy and very powerful once the basics have been learned, but is very cryptic to a novice. It is really like computer programming using graphics rather than lines of code. As such the language and concepts used would be easier for a computer programmer to learn. Not recommended for a novice unless someone else in the institution has some previous knowledge of it.

Pricing not dependent on the number of channels in the system, and considerably less expensive than alternatives for big systems.

Requires an additional program from Group3, called LVDRVR, which operates as a module within LabVIEW.

The above comments are only a few brief statements on what are very complex software programs. Certain programs have features that others lack. If you are uncertain which package is most suitable for your application please ask your local Group3 representative for further comments.

Alternatively, the user may write control software to drive the Group3 system and operate the controlled plant. Sufficient information is given in the Loop Controller Programmers Manual to allow a software engineer to write code that will configure the LC and set up communication on the fiber optic loop.

This is the usual approach for people using the VME and CAMAC loop controllers.

Group3 has developed a comprehensive C++ toolkit to greatly speed up the writing of code to drive a Group3 system. It contains sample code and routines to handle all the set-up tasks, and to access all I/O data in a Loop Controller. It handles all the dual port arbitration and error handling.

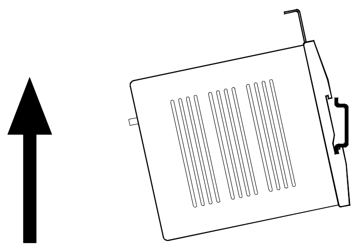
6.3.2 Other control computers.

VME, CAMAC, and STD based control systems are very diverse so no general comments can really be made about control software. The Group3 hardware gathers all the information from the I/O boards on the fiber optic loop and places it in a memory that is accessible from the VME, CAMAC, or STD crate bus. The addresses at which the data is placed in memory is detailed in the Loop Controller Programmers Manual. The control system software engineer then has to write code to allow the overall control program access to this memory. Programs like VISTA and EPICS allow easy access to memory, so interfacing to similar packages usually presents litle problem.

MOUNTING A DI
ONTO A DIN RAIL

DIN rail

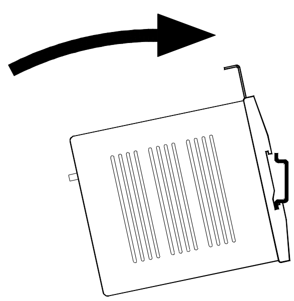
1



Lift the locking tab on the backplate

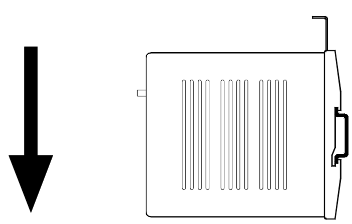
Lift the DI up to the DIN rail, hook the bottom edge of the DIN rail fully into the lower slots of the backplate.

2



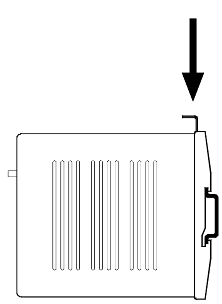
Rotate the DI to a vertical position.

3



Slide the DI downwards, so that the top edge of the DIN rail is hooked by the backplate.

4



Push down the locking tab.

7. INSTALLATION

7.1 Getting Started - a summary

This is a summary of the steps required from unpacking the Group3 hardware through to getting a system operational. It assumes that the system has been designed appropriately (see section 6 **Group3 Control system Design**), and correct installation practice has been followed (see the following pages).

1 Fit 35mm DIN rail where DIs are to be installed.

The DIs clip onto a 35mm DIN rail which is mounted horizontally, on vertical back panels. DIs can be positioned close together. If signal conditioners are used, they should be mounted next to the DIs and connected to them with flat ribbon cable.

2 Connect up the DIs to the controlled equipment.

Make up the signal wiring using shielded cables. Wiring can be connected directly to the DIs, using double-row Berg housings, but it is generally recommended that signal conditioners are used. Make external signal connections to the screw terminals on the signal conditioners.

3 Connect the DIs to a power source.

The power connector is located on the bottom of the DI. A suitable cable connector is supplied with each unit. Power is low-voltage ac or dc (see specs.) and can be reticulated to several DIs in parallel without causing interaction or ground loop problems. Model PS24D15 power supply is a convenient power source for one or two DIs.

4 Configure the DIs.

Each DI must be set to its own unique address on the loop, using the 16 position address switch on the DI front panel.

Use the diagnostic port on each DI to configure the DI for the system. Go through the system configuration menu, as described in section 3 of this manual.

5 Fit a Loop Controller (LC) card into the control computer.

Set the address jumpers so the Dual Port RAM addresses do not conflict with other plug in cards in the computer. For most applications the factory setting will be acceptable, but if it needs to be changed see section 4.

To install the card, first make sure the computer power is off. Plug the card into an empty slot, and secure it with the fixing screw.

6 Connect the LC to the DIs using fiber optic cable.

Run a cable from the LC send port to the first DI receive port (blue, closer to the front of the DI), then another cable from the first DI send port to the next DI receive port. Continue around the loop, connecting the send port of each DI to the receive port of the next DI in sequence. The final cable runs from the last DI send port to the LC receive port.

7 Run the control software in the computer.

At this point the two red LEDs on the front of each DI on the loop should appear continuously lit. Check that control outputs respond to commands from the control computer, and that changes to input values are conveyed back to the computer. If not see section 8 - Commissioning / Fault Finding.

7.2 Installation Practice

1) Check the DIs contain the correct boards.

If using new DIs shipped from the factory the I/O boards contained in the DI module will correspond to the label on the front of the DI. However, over time boards tend to get swapped around and DIs reconfigured, so it pays to check them on the bench before installing them.

The easiest way to check is to apply power (see specifications on page 2-3) and use the diagnostic port and a terminal (see chapter 3). On powering up the DI will identify itself, then press 'B' on the terminal keyboard to get a listing of the I/O boards. Check this is as it should be. If it isn't, or if you do not have a terminal handy, the boards will have to be checked visually. Board types can be determined by the connector headers, visible through the slots in the top of the DI. Each type of board has a distinct type and placing of connectors. (see the specification sheets in chapter 2 for details). Board address jumpers can only be visually checked by opening up the DI case. The I/O boards within a DI must have different address settings. See page 2-9 for more details.

Observe anti-static precautions when handling circuit boards - see page 2-8

2) Position the DIs as close to the controlled points as possible.
Keep all signal wiring as short as possible.

Mount the DI behind the power supplies etc, right beside the control inputs.

The main idea here is to keep all signal wires as short as possible, to minimise the pick up of transients.

The stainless steel backplates of the DIs clip onto standard 35mm DIN rails. If the rail is steel, then generally the DI case is automatically grounded by the backplate. If aluminium DIN rails are used then frequently the anodised finish will effectively insulate the backplate, and adequate grounding will not be automatic. In these cases run a short grounding lead from under one of the screws on the backplate to a nearby chassis ground point.

In almost all circumstances it is a good idea to have the case of the DI grounded.

However, very occasionally this has caused problems. In these rare circumstances it may be necessary to isolate the DIN rail from the plate it is mounted on.

The DIs and signal wiring should really be within an enclosure of some sort - a rack enclosure or something similar. In high voltage machinery there can be very fast, massive changes in potential when an arc-over or breakdown occurs. This can easily capacitively couple through to exposed signal wiring. If the wiring can not be enclosed, place shield plates to form a Faraday cage to screen the wiring from any such rapid capacitively coupled noise.

3) **Position the signal conditioners right next to the DIs.**

Again the idea is to minimise transient pickup by the ribbon cables connecting the signal conditioner to the DI. The signal conditioners can be mounted on the same length of DIN rail as the DI, or on a separate piece of rail nearby.

Make sure the ground/chassis connection from the signal conditioners is installed

4) **Check the signal levels**

Check that the signal levels are within the allowable limits, as given in the specifications of the I/O boards. If necessary use resistive dividers to bring the signals within allowed voltage limits. The range of analog signal conditioners have provision for resistive dividers - it is easier to insert the appropriate resistors before wiring up all the signals.

5) **Use shielded cable for all signal wiring**

Terminate the shields at the signal conditioner screw terminals only, not at the other end of the signal wires. Use shielded twisted pair where possible.

Use a short heavy gauge wire to take the shield common of the signal conditioner to a chassis ground point nearby.

6) **Connect the signal conditioners to the DIs**

Use ribbon cables with the appropriate connectors on them to connect the DI I/O boards to their corresponding signal conditioners. Keep the ribbon cables as short as possible, but do not have them taut. Route them away from the signal wiring bringing the signals to the signal conditioners. Try to avoid transients coupling through from external signal wiring to the ribbon cables, thereby bypassing the signal conditioners.

7) **Apply power to the DI**

Connect the DI to a low voltage AC or DC supply (see DI specifications).

If using a mains plug-pack type supply it would be wise to run the mains power to it through an in-line type filter unit. Also put the low voltage wire to the DI through ferrite torroid for a few turns just before the DI connector.

If using a Group3 power supply (model PS24D15) position this close to the DI.

The green power LED indicator on the front of the DI should light up, and the red send LED should blink, if the option "send beacon on timeout" is enabled from the diagnostic port - this is the factory default. (the DI will be trying to send out a message that it is not receiving any messages at its receive port)

8) **Use the diagnostic port to configure the DI**

See chapter 3 for full details of the diagnostic port operation.

Check the communications protocol is set correctly (under SYSTEM menu)

Check the I/O boards are correct (main menu, press B for board selection)

Select each board in turn and check the parameters for each are correct.

- check polarities
- check analog range settings, filter and filter windows
- check motor drive parameters

Record these setup parameters.

Return to the main menu (press 'X' a few times) and then press 'I' to go to the I/O control and monitoring menu. The I/O values for the currently selected board should be displayed - check that they have sensible values. At this stage outputs can be set to values using the [O] option.

BUT be careful!! outputs will be set, supplies could be turned on, motors start etc. Always be safety conscious and check with all other personnel working on the installation before altering anything.

9) Connect up the DIs with fiber optic cable.

The DIs are connected in a loop, starting at the control computer, leading to the first DI, chaining on to the second DI, etc then back to the control computer. The fiber optic cable from the transmit port on the control computer is plugged into the receive port on the first DI. The receive port is the one closest to the front of the DI, color coded blue if using plastic fiber optics. then run a cable from the send port of the first DI (the gray port) to the receive port of the second DI. Chain on in this manner, til the send cable from the last DI is taken back to the control computer.

Route the cables so that they will not be crushed or kinked if equipment is moved, or rack drawer slides withdrawn etc.

Operationally it does not matter what order the DIs are connected up in on the loop, but it is more convenient for fault finding if they are chained together in numerical order.

If power is on to all the DIs on the loop then the send LED on the first DI should be blinking, and both send and receive lights on all DIs downstream of it, as they pass the message through.

10) Install the loop controller in the control computer

The PCI Loop Controllers are Plug and Play devices - the computer BIOS allocates the actual memory addresses on start up, and the user does not need to be involved in the process.

The cards require a system driver to be installed on the computer. This driver software is supplied on disk with the Loop Controller card. Instructions for installing the driver are enclosed with the disk, and are also available as a text file, install.txt, on the disk

If using ISA Loop Controllers check that the address jumpers on the card are set so as to not cause conflict with other cards in the computer. (Make sure the power to the control computer is off before removing the card to check). See section 4 for full details on the address jumpers. The factory default of CE00:0 for PC loop controllers will be satisfactory for most installations.

Plug the card in to an available slot.

Observe anti-static precautions when handling circuit boards - see page 2-8

Connect the fiber optic cable leading to the first DI to the send port on the loop controller. Connect the cable leading from the last DI to the receive port on the loop controller.

This completes the installation of the Group3 hardware.

7.3 Software Setup

Each software package is different, so this section can only give some brief, general comments. Most packages have some form of I/O point definition list. It is generally easier and more efficient to define all the I/O points or tags at the start, before starting to draw control screen graphics etc.
You will need the list of all I/O points, along with polarities and ranges that you defined initially. This has probably evolved a bit from the list you ordered the hardware from, so maybe it would be best to use the channel by channel set up record you generated when first configuring the DI.

You may have settled on names for each I/O point, but there is a balance between making the name self explanatory but long, or cryptic and short. Some packages have restrictions on name length, and/or on the length of algebraic expressions written using the tagnames. Use the shortest name possible without getting too cryptic. Remember that every tag in the system will need a unique name.

Make sure you define each I/O point with the same polarity and range settings as you recorded from the diagnostic port. Remember that the raw number for analog channels, as found in the loop controller, can have different values depending on the polarity setting of that channel.
Raw data ranges are:

Analog inputs 16 bit (type A and C boards)	unipolar	0 to 64000
(& CNA)	bipolar	-32000 to +32000
Analog outputs 14 bit (type A and D boards)	unipolar	0 to 16000
	bipolar	-8000 to +8000
Analog outputs 16 bit (type J board)	unipolar	0 to 64000
(& CNA)	bipolar	-32000 to +32000
DC motor speed (8 bit, type E board)		0 to 255
DC motor acceleration		0 to 255
DC motor control		0 to 3
Analog inputs 8 bit (type G board)	unipolar	0 to 255
Digital channel of type G board		0 to 255
Positions of type G board (32 bit)	-2147483647 to +2147483648	
acceleration		0 to 255
Speed (stepping rate)		0 to 5000
Encoder counts (type H board)		-32768 to +32767 or -4,000,000,000 to +4,000,000,000 (see note in section 2.5.8)

Some control programs can get temporarily overloaded if a lot of channels all change at once. Unless great care is taken in installation the 16 bit analog inputs are bound to have some noise and flutter on them. This can unnecessarily overload the system, particularly if they are measuring slow changing parameters such as temperatures or magnet currents. For these channels, and in general unless the full speed accuracy is required, use the filtering within the DI, and use filtering (or a deadband system) within the control software package. These measures should reduce unnecessary overhead for the control software.

7.4 Electronics in Accelerators

Some general comments regarding installing electronics in accelerators.

Modern accelerators have been designed and built with electronic control of some sort in mind, but if installing Group3 equipment on earlier accelerators there are a few things that may require modification.

GROUNDING

Accelerators produce very fast, high power transients so a low impedence grounding system is essential for each potential level.
Ideally a single point ground for each rack should be used, but this usually results in wiring that is too long. The usual compromise is that within a potential level each power supply is commoned back to a very heavy copper buss (30 x 10 mm)bar running through the machine. Use short heavy gauge (6mm or more) wiring to connect to the buss bar. Allowing long looping grounding wires to allow rack slides to be withdrawn has led to problems - it is much better to use short leads that have to be unbolted.
At the frequencies generated by transients around an accelerator the steel sheeting of rack sliders etc have too high an impedence to be useful as a grounding system. Use heavy copper wiring for all grounds.
The ion source is usually one of the noisier sections of an accelerator so particular care must be taken with grounding there.

Miscellaneous comments

The power supply leads running up to the source filament and arc must go through a large ferrite torroid, to try to block some of the noise generated by the ion source.
For high currents a single core, with a bifilar winding must be used to prevent saturation of the ferrite core.

8. COMMISSIONING / FAULT FINDING

Firstly a word of caution, without wanting to sound too depressing:-

On a complex hardware and software system it is extremely unlikely that everything will work 100% first time.

Be prepared for some time to be spent commissioning and debugging the entire system. There are likely to be software mistakes (such as defining an analog channel in the software package as unipolar when the DI is set for bipolar) and hardware mistakes (for instance, a shield wire not grounded, thereby allowing transients in to upset one of the DIs.)

Here are some stages in the commissioning process, with things to try if all is not working correctly.

Power up all the DIs on the loop. Start the control software, including the Group3 driver if one is needed. Keep things simple at the start and do not turn on any high voltages on the machine just yet.

Communications
Make sure that the loop is communicating correctly.
Both red LEDs on the front of every DI on the loop should appear continually lit.

This is not a fool proof check, being necessary but not sufficient to guarantee good communications. Further checks can be done by reading the message count in each DI through the diagnostic port (see section 3, page 10) or by reading the number of messages sent and received in the dual port RAM of the loop controller (requires the Loop Controler Programmers Manual to give the locations)

If the LEDs are not continually lit, check:

Fiber optic cables
are they - routed correctly - transmit of one DI to the receive of the next.
- unbroken & terminated correctly. Check for red light at the receive end of plastic cored cables.

Loop controller
- is it transmitting pulses of red light down the fiber optic cable? (only visible if plastic cable is being used) - if not it is probably a software setup problem or hardware conflict within the computer.

DIs all have power on - the green LED should be lit on the front of each DI.

DIs configured correctly - check communications protocol,
- I/O board selection.

If a DI appears to undergo a continual series of resets every few seconds while just powered up (with no fiber optic communications) then it is possible that some calibration data of the analog I/O boards has been altered so that it is out of acceptable limits. Contact your Group3 representative or the factory direct for instructions on what to do if this occurs.

Loop Controller

check the address jumpers on the loop controller (see section 4) against the address settings of other expansion cards in the computer. There must not be a conflict.

Software

check the software configuration and setup.

> is the main software program set to use the correct application directory.
> sometimes there are a number of directory settings that have to be altered if changing over to another application.
>
> is the software told the correct loop base address, as on the loop controller jumpers.
>
> do the definitions of the DIs in the software setup correspond with the actual DIs - check DI address switch, and I/O boards they contain.
>
> check the Group3 driver program is running (if applicable)
> It is always best to start these driver programs before starting the main control software package.

Sometimes software might not get initialised properly, or gets upset if things are not all done in the right order. If all else fails, turn off the computer and start it up again.

Communications on the loop must be established before going on to further tests.

If you can't get a complex loop going, maybe start with just one DI powered up on the bench. This allows you to confirm that the loop controller is being initialised properly, and that communications can be established with each DI singly in turn.
Make a separate small test application (in another directory!) to allow you to check your setup and configurations.

Use this method of dividing off the problem into small manageable parts. Complex systems of hardware and software are very confusing and it is easy to spend a long time trying to track down a problem in the system as a whole.

It may take a little time to make a small test application in the software package, but it will probably end up saving a lot of time in the long run.

Once good communications are established you can move on to checking the function and operation of the control software.

check that changes to inputs are reflected on the screen of the control computer.

Use the diagnostic port features at the DI to check what the DI is actually reading. The fault may be with the sensor or wiring, rather than with the DI setup or software. Always check at the DI level with the diagnostic port before doing much else.

Use the I - Monitor Inputs/Outputs feature.
Also use the [I] function to simulate known input values. This makes it easier to check your control software readouts are responding correctly.

for analog channels:

if strange behaviour is noticed at about half full scale then probably the software is set for one polarity but the DI is set for the other.

If the objects on the screen exhibit too much or not enough travel then check the range settings in the DI, and check the scaling factors used in defining the point in the control software.

some control programs can get temporarily overloaded if a lot of channels all change at once. Unless great care is taken in installation the 16 bit analog inputs are bound to have some noise and flutter on them. This can unnecessarily overload the system, particularly if they are measuring slow changing parameters such as temperatures or magnet currents. For these channels, and in general unless the full speed accuracy is required, use the filtering within the DI, and use filtering (or a deadband system) within the control software package. These should reduce unnecessary overhead for the control software.

For digital channels:

check the definitions of polarity for the channel, both in the DI and in the control software.

if a digital output channel is not responding check that the output is not Inhibited -
check through the diagnostic port.

if a digital input is not responding check that the polarity of that channels output driver is set low. If it is set high, and the control software is trying to set the output off (as it should be for an input channel), the output driver will actually be turned on, and will clamp the I/O pin low, so the input will always be read as low.
Polarities of digital channels can get quite confusing and complex, with several different adjustments to the polarity available. Unless there are good reasons to change polarities leave them all set to the factory default of Low.

Once all channels are operating correctly turn on the high voltage supplies.

This will probably unleash a new set of problems.

Because each and every accelerator is so different the operation of a control system is only specific to one machine, and the operational reliability is critically dependent on the installation practice followed.

Switching on the high voltage will most probably uncover some installation deficiencies.

Noise problems will most probably be indicated by one or more DIs performing a reset when there is arcing or a discharge from the high voltage sections. The reset is evident by the LEDs on the front of the DI blinking for a second or so, and possibly a message on the control screen saying "loop inactive" or similar. Note that if one DI does a reset then all the DIs will have blinking lights, as they loop through the message from the resetting DI.

If this occurs check:

the shields of the signal wiring

the chassis grounding from the signal conditioners

the grounding of the supplies within the accelerator (see note on page 7-6)

The grounding of the DI case. Note that in general the case should be grounded, but it has been seen in some installations that this causes problems. Try disconnecting the grounding of the case.

If problems still persist, try to track down which DI is receiving the interference. The error message on the control screen sometimes says "loop broken just before DI n", where n is the address of a DI. It will be the DI just before this that is receiving resets.

If it is a complex loop of DIs try to isolate off one or two DIs at a time, and run them on a loop of their own for a while, to see if they are the source of the resets.

At this point it is sensible to try to create some repeatable arc over, to create known noise source. Using wire or pipe, create a spark gap bridging the extraction voltage, or the acceleration voltage. Adjust the gap and the voltage so the arcs occur every second or so. This gives some repeatable noise source from which some statistics can be built up, so that modifications to the installation can be sensibly evaluated.

Some further simple things to try, which have proved effective in some installations:

Fit Group3 Signal Conditioners if this has not already been done. These should be used as a matter of course in any high voltage installation.

Run the low voltage power lead to the DI through a ferrite torroid for a few turns, just before it enters the DI.

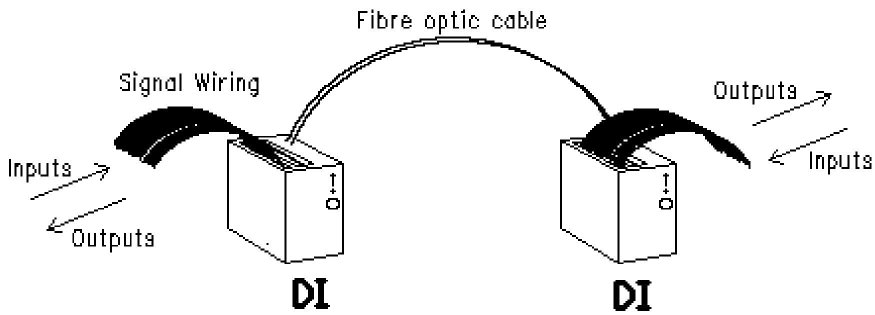
Use clamp on ferrites on the ribbon cables connecting the DI to the signal conditioners.
Place the ferrites at the DI end of the ribbon cables, to filter out any noise that has been picked up by the ribbon cable itself.

Place shielding plates over the DIs and any exposed wiring to screen them from capacitively coupled transients.
The DIs and signal wiring should really be within an enclosure of some sort - a rack enclosure or something similar. In high voltage machinery there can be very fast, massive changes in potential when an arc-over or breakdown occurs. This can easily capacitively couple through to exposed signal wiring. If the wiring can not be enclosed, place shield plates to form a Faraday cage to screen the wiring from any such rapid capacitively coupled noise.

On very powerful pulsed or unusually noisy machines it may be necessary to enclose all the control electronics in a shielded screened cabinet, and use feed through capacitors to bring any outside signal wiring into the system.

9. FURTHER APPLICATIONS OF GROUP3 HARDWARE

9.1 DI to DI communications mode



Group3 Device Interfaces connected with just two fiber optic cables provide noise free transmission of many analog and digital signals in difficult environments.
High voltage isolation and long distance transfer of signals are simple to implement using this low cost system.

The system uses the same well proven hardware of the computer based system, but in a new configuration in which two Device Interface (DI) modules communicate with each other, not with a computer.

If, for example, a signal voltage is presented to an analog input channel in one DI, the exact same voltage will be generated by a corresponding output channel in the other DI module. Digital on/off channels are similarly replicated by the system - if a switch is closed that grounds a digital input channel in one DI, the corresponding output in the other DI will be clamped to its ground level.

The transmission of data is over two fiber optic cables, providing noise immunity and voltage isolation for electrical signals present at each end of the cables.
Two fiber optic cables are easier to install and considerably less expensive than a bundle of shielded cables over long distances. If glass fiber optic cables are used the DIs can be up to 3000 metres apart. Plastic fiber optic cables can be used for distances up to 40 metres.

The DI modules and I/O cards are standard components of the Group3 Control range, so at a later date they could be used as part of a full computer based control system if required.

Boards available to use for this system are:-

Type A Combined analog and digital board.
In this system provides 1 analog input, 1 analog output, and 8 digitals

Type B 24 digital channels,

Type C Eight analog inputs. (ADCs)

Type D Eight analog outputs. (DACs)

Some examples:
If a type B board in one DI is matched to another B board in the other DI, it gives 24 channels of digital on/off signals. Each channel can be set to operate in either direction.

A type A matched to another type A gives two analog channels, one in each direction, and eight digital channels.

Two DIs, each with 3 boards - a B, C, and a D, gives 24 digital signal lines, and 8 analog monitoring channels, and 8 analog control channels.
Two DIs each with 3 type B boards give 72 digital lines.
Two DIs each with 3 analog boards give 24 analog signals.

If the range settings of the analog channels are set appropriately then it is possible to have the system insert a gain factor during transmission. For example a 0-50mv input signal could be transformed to a 0-10 volt output just by setting the input and output ranges to those values.

System Specifications

Isolation

Fiber optically isolated, so essentially no limit to the voltage isolation, and no noise pick up during transmission.

Distance

Using plastic fiber optic cable - up to 40 metres in one length. Repeaters are available to extend this distance if required.
Using glass fiber optic cable - up to 3000 metres

Resolution

Analog inputs have 16 bit resolution, analog outputs have 14 bit resolution, so the overall system transmission resolution is 14 bits

Speed

The speed of signal transmission varies according to the number and type of I/O boards used, The delay in transmitting digital on/off signals is 2ms for 24 channels, the delay for two DIs loaded with B, C, and D boards is 25ms.

The DI to DI communications mode is selected to allow two DI modules to communicate directly with each other, without the need for a loop controller or computer.
This feature is contained in software DI V3.1, dated February 1995 or later.

Two DIs are required, one set to switch address 0, the other set to address 1, connected by two fibre optic cables.
The boards within the DI must have their board address jumpers set differently, but the actual setting is not important unless there are multiples of kind in the same DI.

The intelligent pairing of input boards to output boards takes place automatically according to the following schedule:-

Digital	(Type B)	-->	Digital	(Type B)
Analog Input	(Type C)	-->	Analog Output	(Type D)
Combined A&D	(Type A)	-->	Combined A&D	(Type A)

Thus in two DIs configured as BCD, the B board will talk to the B board, the C boards will talk to the D boards, irrespective of what the board address jumpers are set to.
If there are multiples of a kind then the lowest address C board will talk to the lowest address D board etc.
Channel numbers within a board are matched: ie channel 1 talks to channel 1 etc.
On a Type A board the analog output channel is controlled from the first analog input channel of the corresponding A board; the second analog input channel is not used.

The hardware of the two DIs must be assembled as above, then a terminal used to configure the individual channels and communications protocol in both DIs.

The operation of the diagnostic port is described in section 3, so only a brief summary of essential features follows.

From the opening diagnostic port menu select SYSTEM CONFIGURATION select COMMUNICATIONS, then M to select the communications Mode, then select DI to DI to enable the correct communications protocol. This must be done to both DIs.

Configure the channels appropriately. All the features of standard Group3 Control I/O boards are available - eg analog input window filters etc. If direct transmission of a voltage is required then the analog ranges of corresponding channels must be set to the same value. However it is also possible to get, for example, a 0 to 50mV signal input to be output as a 0 to 5 Volt signal by setting the input and corresponding output range appropriately. Care must be taken to ensure that the ranges at either DI are either both unipolar (0 to x volts) or both bipolar (-x to +x volts).
DO NOT map a unipolar input to a bipolar output or vice versa.

The digital channels must be configured to Inhibit outputs for those channels being used as inputs or the digital channel may lock in a low state.
From the opening menu select SYSTEM CONFIGURATION (if there are multiple digital boards in the DI then the correct board will have to be selected first) then DIGITAL, then O for outputs.
The display asks for channel numbers - enter the numbers of the channels that are to be used as inputs on this board.
Then the user is prompted to alter polarities or Inhibit those channels. Press I to Inhibit them.

9.2 LC to LC communications mode

Group3 Loop Controllers can be used to provide a fiber optic data communications channel between computers. High voltage isolation and long distance transfer of data are simple to implement using this low cost system.

This use of the Group3 LC card allows two computers to share information, using fiber optic cables. Two LCs, one in each computer, continually exchange the data held in defined areas of their memories. If one computer writes some data into the transmit area of its memory, this data will automatically appear a few milliseconds later in the receive area of the other computer's memory. At the same time data can be transferred in the other direction as well.

The computers could be two of the same type (two PCs talking, or two VME crates talking to each other), or of different types (A PC talking to a VME crate, or a VME crate talking to an STD crate, for example). The LC to LC protocol thus provides an isolated communication channel between different computer platforms.

LC card

Each LC has a coprocessor on board that handles all data transfer on the fiber optic cables, and 2 Kbyte of dual port RAM that the host computer has access to. The LC card continuously sends the entire transmit area of its dual port RAM to the receive area of the other LC in the other computer. Thus the host computers are not involved directly in the communication with each other; they simply read and write to their dual port RAMs, while the LCs look after all communication overhead.

There are a number of LCs adapted to different computers;

LC1-ISA handles a single communication channel from an ISA slot
LC3-ISA can service three independent channels from an ISA slot.

LC1-PCI handles a single communication channel from a PCI slot
LC3-PCI can service three independent channels from a single PCI slot.

LC2-VME is a VME card that can control two channels from a VME crate.
LC-STD controls a single channel from an STD crate.
LC1-CAM controls a single channel from a slot in a CAMAC crate.
LC2-CAM controls two channels from a single slot in a CAMAC crate.

Note that on the multi channel LCs (LC3-PCI, LC3-ISA, LC2-VME, and LC2-CAM) the different channels are completely independent - one channel could be used as a communications channel, talking to another LC, and the others could be set to control loops of DIs as in a standard Group3 Control installation.

System Specifications

Isolation

Fiber optically isolated, so essentially no limit to the voltage isolation, and no noise pick up during transmission.

Distance

Using plastic fiber optic cable - up to 40 metres in one length. Repeaters are available to extend this distance.
Using glass fiber optic cable - up to 3000 metres

Communications

The communications on the fiber optic cables run at 1.152Mbaud. The protocol includes CRC checksums sent with each data packet. If the receiving LC detects a corrupted data packet it discards that packet and waits a millisecond or so for a new data packet.
Once started the LCs exchange information continually, as fast as they are able. The timing depends on the defined lengths of the data areas. The entire data area is sent as one data packet.
Some typical timing values are:

to send 2Kbyte in one direction	16ms
to send 1Kbyte in each direction	8ms
to send 2 bytes in each direction	1ms
to send 256 bytes, and receive 2 bytes	2ms

Fiber Optic Cables

LC cards can be fitted with transmitters and receivers for plastic fiber optic cable, using the Hewlett Packard Versatile Link plastic connectors, or for glass fiber optic cables with ST or SMA connectors.

Set-up

It is recommended that the Dual Port RAMs be partitioned into two areas - a send area and a receive area. These can be of equal or different sizes, but the receive area in one computer must be the same size as the corresponding send area of the other computer.

The full detailed description of the memory set-up requirements are available in a technical manual from your Group3 representative.

9.3 General Serial / LC to DTM Loop Communications Mode

The Group3 Loop Controller can be set to communicate directly with a loop of Group3 Digital Teslameters, continually gathering from them the latest magnetic field readings. The readings are automatically placed in the dualport RAM on the Loop Controller card. The computer can then get the latest field readings simply by reading the memory areas defined.

Another, more generalised mode of serial communications is also supported. In this mode any instrument that is controlled or monitored by ASCII commands can be driven over fiber optic cables from a Loop Controller. This mode can also be used for serial exchange of 8-bit binary data.

For RS-232 serially controlled instruments Group3 manufacture a small converter to change the fiber optic serial data to RS-232 data. This unit is called an FTR.

System Specifications

Isolation

Fiber optically isolated, so essentially no limit to the voltage isolation, and no noise pick up during transmission.

Distance

Using plastic fiber optic cable - up to 40 metres in one length. Repeaters are available to extend this distance.

Communications

The communications on the fiber optic cables run at 9600 baud as standard when talking to DTMs, but can be adjusted to any of the standard baud rates up to a maximum of 19,200 baud.
Once started in DTM mode the LC continuously interrogates and updates each teslameter in turn, taking 150ms for each teslameter.

Fiber Optic Cables

LC cards are fitted with transmitters and receivers for plastic fiber optic cable, using the Hewlett Packard Versatile Link plastic connectors to match directly with the fiber optic ports on the Group3 teslameters, or Group3 FTR (fiber optic to RS-232) data converters.

Set-up

The full detailed description of the memory set-up requirements are available in a technical manual from your Group3 representative.

10. MISCELLANEOUS ACCESSORIES

10.1 PS24D15 DIN rail mount power supply

The PS24D15 is a DIN rail mount power supply with an output of 24 volts DC, 15 Watts.

It has a universal rated input - 100 to 240 volts AC, 47 to 450 Hz.

Its output is isolated (2000 volt isolation rating) from the input mains, and contains inbuilt filtering. This makes it especially useful in a noisy installation to reduce the effect of mains borne transients.

It has an indicator LED for 24 volt DC output on.

This power supply is capable of powering two DIs.

10.2 Hand Held Terminal

A small hand held terminal is available to operate all the functions of the diagnostic port.
It is very convenient to use when commissioning or debugging an installation.
The terminal is powered from the diagnostic port of the DI, making it completely portable and not tied to power cords or batteries. It is small enough to be held in one hand, but has a 16 line by 32 character display, enough for all the diagnostic port menus.

Specifications:

16 line by 32 character LCD

45 key elastomeric keypad with all alphanumeric symbols.

Keys programmable for common sequences of keystrokes

Powered from the DIs diagnostic port.

1 meter long self coiling lead with mini DIN connector to suit diagnostic port socket.

Suitable for other uses:

Fully compatible with VT100 terminals.

fully programmable
communications parameters

EIA-232, EIA-422 or CMOS levels.

10.3 FOR - Fiber Optic Repeater

A small unit that receives and re-transmits data carried on glass or plastic cored fiber optic cables, to provide for increased transmission distances.
The transmitters and receivers can be for plastic cored or glass cored cable. With the appropriate selection of glass and plastic cable devices the unit can be used to convert between the two types of cables - receiving data on plastic cable and re-transmitting it on glass cable or vice versa. Five models are available:

model	**channels**	**receive**	**transmit**
FOR-1PP	1	plastic	plastic
FOR-1PG	1	plastic	glass
FOR-1GP	1	glass	plastic
FOR-2PP	2	plastic	plastic
		plastic	plastic
FOR-2PG	2	plastic	glass
		glass	plastic

Specifications

Fiber optic ports	receptacles for HP HFBR-3500 plastic fiber optic cables and/or glass fiber optic cables with ST connections. (SMA connectors fitted to special order).
Cable lengths	plastic: 40 meters maximum in any one length. glass: 3000 meters maximum.
Baud rate	0 to 1.2 megabaud
Indicators	LED on each channel flashes when data is received
Power requirements	9 to 20 volts DC at 200mA or 10 to 14 volts AC at 400mA RMS
Power connector	2-way detachable screw terminal block, accessible when cover is removed
Dimensions	73 x 66 x 20 mm
Mounting	two screw holes accessible when cover is removed.

10.4 FTR - Fiber Optic to RS-232 converter

The FTR is a small adaptor which provides bi-directional conversion between standard RS-232C serial ports and fiber optic cables. The device has a 25-way D connector which plugs into any standard RS-232C receptacle, and accepts Hewlett Packard snap-in fiber optic cables (HFBR-3500 series) up to 25 meters in length.

The device is ideal for establishing noise-free data transmission between computers and peripherals, avoiding ground loops and errors caused by pick-up of transients and interference radiated from industrial equipment. The device also allows data transmission through the voltage gradients often found in ion beam equipment.

SPECIFICATIONS

RS-232C signals	input: ±3 volts minimum, ±30 volts maximum output: ±9 volts nominal
RS-232C connector	25-way D type, male plug
RS-232C pin assignments	pins 2 and 3 used for transmit and receive signals as selected by pin jumpers inside device; pins 4, 5, 6, 8, and 20 may be pulled high by installing jumpers to assert auxiliary signals as required by RS-232C equipment. pins 11, 12, 13 can power device (see below). pin 1 is case ground, pin 7 is signal ground.
Fiber optic ports	individual send and receive ports to accept H-P HFBR- 3500 fiber optic cables up to 25 meters
Baud rates	50 baud to 40 kilobaud
Power source	9 to 12Vac/dc 100mA max. input from plugpack; or 5Vdc regulated, or 8 to 15V unregulated from RS-232-C device. can be jumpered from pins 11, 12, or 13 to FTR circuitry - may require internal wiring change to RS-232C device.
Typical applications	a) allows ordinary RS232C controlled equipment to be integrated into a Group3 Control system via fiber optics. b) two FTRs and two fiber optic cables can replace wired bi-directional link for reduced error rate and/or security of confidential data, or for traversing a voltage gradient. c) allows Group 3 devices (teslameter) with fiber optics to be used with RS-232C equipment (a computer serial port).

11 - Technical Notes

11.1 EPROM History and Compatibility

Any software upgrade is checked for compatibility with previous versions, but for best performance and to ensure access to the new features we strongly recommend that all EPROMs on the loop are upgraded to the same version number.

Version	Date	Features added / points to note
5.1	Mar06	LC: Added mode for using H boards with 32-bit encoders (s/w change only, no change to H board or DI s/w).
5.0	Mar01	Per channel output timeout zeroing. DI board numbering scheme changed to use absolute addresses. Streamline of diagnostic port display. "Parameter" mechanism for over the loop access to set-up data. Password security system overhauled. CAN now retains all operational data across soft-starts.
4.3	Jan99	Loop comm's speed increased, now ~0.8ms per I/O board.
4.2	Feb98	CNA module released. New error handling for F boards.
4.1	Dec97	CNA module support in LC software
4.0	Jul97	Improved serial data handling - relevant to Type F, K and H boards To access new features requires version 4.0 in LC and DI, and F-board. Support for ninth bit protocol on loop removed - SDLC now standard.
3.4	Dec96	High speed routines in LC. Several minor improvements
3.3	Sep95	K board added, DI configuration upload/download, monitor F board msgs. Faster Watchdog kick - required for new (16000027C) processor board. To access new features requires version 3.3 in LC and DI.
3.2	Apr95	Faster loop speeds, LC to LC communications mode added.
3.1	Feb95	DI to DI communications mode added.
3.0	Oct94	J board added, 2 ports on an F board, Diagnostics over the loop. Totally revised software - will not run SDLC in DI with non S2 micro - see "history" below

Other Notes:

Processor Revision, 1995.

The artwork and circuitry of the processor circuit board was changed in 1995, to version 16000027C - distinguished by having the microprocessor soldered directly to the board, rather than in a socket. A new watchdog chip was used that required more frequent servicing. This board requires DI version 3.3 or later. If someone wishes to install older software in one of these newer boards, a continual series of resets is likely to result.

A bit of early history:-

Early versions of DI software contained code to work around a problem inherent in the first issue of the 64180S microprocessor when running SDLC communications mode. A revised mask of the 64180S was incorporated into Group3 production from 1993 on - this revised chip has the marking **S2.**

In October 1994 a radically revised version of Group3 firmware - Version 3.0 - was issued. This version had many enhancements, but also dropped support for the early, non-S2 version micro when running SDLC. The only consequence of this arises if upgrading software on one of these very early DIs - if the existing software version , as shown on the EPROM label, is earlier than V3.0, then also check the microprocessor - the large square chip must have an S2 marking, along with HD64180SCP10 and another date code, if it is to run correctly in a DI.

A non S2 chip will work without problem in a loop controller or an F board.

It would be very rare to find an old DI in an installation that had not been upgraded already, but the history is mentioned here, just in case there are some still remaining.

11.2 EPROM Upgrading Procedure

There are four different types of EPROM involved in a Group3 Control system - the one on the processor board of a DI, the one on a loop controller, the one on a Type F serial communications I/O board, and the one in the CNA module. This technical note outlines the procedures involved in upgrading the EPROM based software of a Group3 system.

The EPROMs are:

Board	Labelled as	example label	Generic chip type required
DI	DI V-.-	DI V4.3	27C020, 120 ns or faster
LC	LC V-.-	LC V4.3	27C010, 120 ns or faster
F-board	F V-.-	F V4.3	27C010, 120 ns or faster
CNA	CNA V-.-	CNA V4.3	27C020, 120 ns or faster

Any software upgrade is checked for compatibility with previous versions, but to ensure best performance and access to the new features offered by an upgrade we strongly recommend that all EPROMs on the loop are upgraded to the same version number.

CAUTION *Observe antistatic procedures when handling circuit boards.*

The circuit boards of Group3 Control form a precision scientific instrumentation system. The circuitry is protected against the normal static discharge from a human body **while it remains in the DI case,** (or the packing it is shipped in).

Whenever circuit boards are removed from their normal mountings, or when they are unpacked from the anti-static bags that they are shipped in, the handler MUST observe industry standard antistatic handling procedures.

This means working at a bench that has a grounded conductive top surface, and using a conductive wrist strap or similar to ground the operator.

Failure to observe these precautions can cause damage, which if not immediately noticeable, can lead to unreliable operation and premature failure.

It is strongly recommended that any changing of electronic components on a circuit board is undertaken by someone experienced and competent in the procedure.

Comments on upgrading.

Although we recommend that all EPROMs on the loop are upgraded to the same version number, sometimes that is not easily done in a large installation.
Every effort is made before issuing a software upgrade to ensure that the new version is backwardly compatible with older versions. However, we can not practically test every possible combination of hardware and software versions that have existed since Group3 Control was launched, and software being of the nature that it is, there is a (very small) chance that some as yet undiscovered incompatibility exists between versions. This is why we strongly recommend that all EPROMs on a loop are upgraded to the same version.

If new DIs are being added to an existing loop, then the LC will probably need to be upgraded to a version to match the newest DI, but the existing DIs may well be able to be left in place exactly as is. Of course any new loop features, such as diagnostics-over-the-loop, will not be able to be used for the old DIs, but the old DIs will remain functioning as they did.

If a system is working satisfactorily, and no new features or equipment are to be added then there is no necessity to upgrade at all. "Old" software does not wear out or change its operating characteristics just because a new version is issued (despite what the Microsoft marketing departments might like you to believe!!.)

However the self correction software, which is a continually evolving and improving feature of Group3 Control, is generally enhanced with each issue of DI software. So there are tangible benefits to upgrading all DI software if at all possible, even if new features are not required for the existing DIs in the system.

Upgrading procedure:

The simplest procedure is to turn power off everything, and change the EPROMs but on some systems this may not be a wise move!.

To change the EPROM in the LC requires the control computer to be switched off - therefore all control on the loop(s) will be lost. This sometimes requires some planning ahead, to ensure that, for example, the vacuum system is not compromised, or that the safety interlocks are all OK.

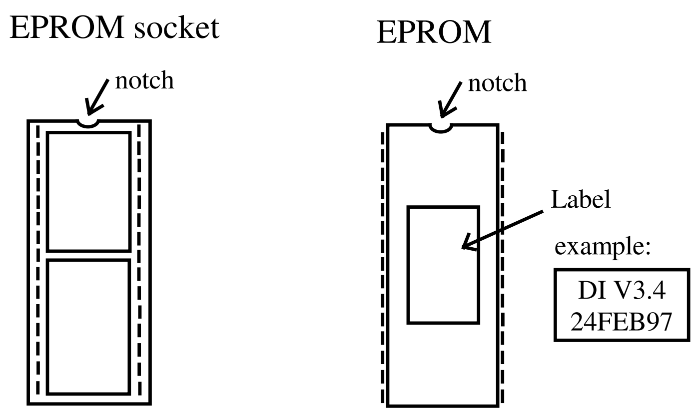
Similarly, changing a DI EPROM requires that the power and all I/O connectors to that DI are unplugged. All channels controlled by that DI will become open circuit - ensure that the system remains safe before this happens.
If one DI is removed from the loop, all communication on that loop is lost, so the behaviour of the other DIs on the loop must be taken into account. What happens will depend on the programmed settings for what action to take on loss of communications.

Changing an EPROM

Removing the EPROM.

Preferably use a proper IC extracting tool. Failing that, gently prise the chip from the socket using a flat bladed screwdriver. Lever the EPROM from both ends so as not to bend pins. Make sure you are trying to remove the chip from the socket, and not accidentally trying to prise the socket itself off the board!.

Take care not to damage the socket, any components on the board, or any tracks on the circuit board under the socket.



Replacing the EPROM.

Having removed the old EPROM the user can then erase it and reprogram it from the master supplied by the distributor, or plug in a replacement EPROM. When plugging in an EPROM make sure the orientation is correct. The socket on the board has a small notch at one end to match the small notch on the EPROM. Guide all the legs into the socket holes - check that no EPROM legs get bent outwards, or get folded back under the chip. Press the EPROM firmly into the socket by squeezing with fingers behind the board to support it. Do not simply press down on the EPROM with the board resting on a hard surface or some damage to components or the board itself may result.

Replacing the EPROM in a DI

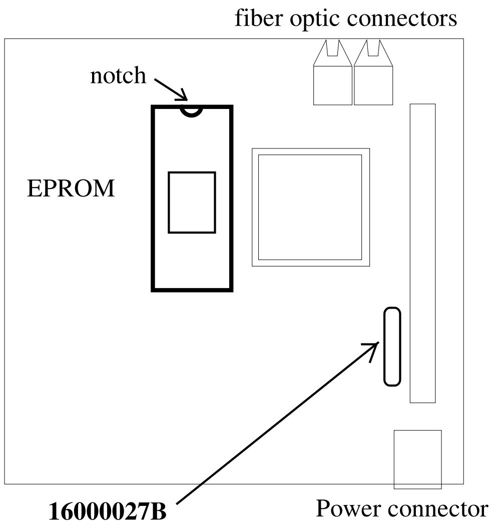
a) Unplug all cabling from the DI, and unclip the DI from the DIN rail.

b) Remove the DI case by removing its two fixing screws, one on top and one underneath near the rear of the case, then slide the case off.
If only replacing the processor EPROM there is no need to dismantle the DI any further.

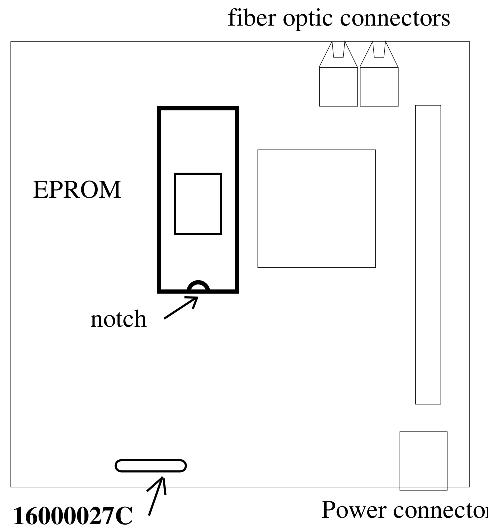
c) The EPROM is the large rectangular chip, labelled as **DI V-.-** and with the date of release under that.

Note which way the chip is facing. There is a small notch in one end of the package to identify the orientation. Note that the current production model of the processor board (16000027C) has the notch facing down, while the previous model (16000027B) had the notch facing up. If you have a mixture of board versions in your system do not get the EPROM orientations mixed up.

Older Version (16000027**B**)



New version (16000027**C**)



Remove the EPROM from the socket.

d) Plug in a replacement EPROM.

If the DI contains an F (serial communications) board that also requires a software upgrade then proceed to step c) of the following section.

Reassemble the DI in the reverse order. When replacing the cover, note that the shaft of the address switch and the three LED indicators must pass through the appropriate holes in the cover.

Re-mount the DI onto the DIN rail. Reconnect the power plug, connect up the fiber optic cables, and reconnect the I/O cables.
Nothing else needs to be done - the DI should function as it did before, but with the new features of the latest release of software.

Replacing an F-board EPROM.

a) Unplug all cabling and unclip the DI from the DIN rail. Remove the DI case.

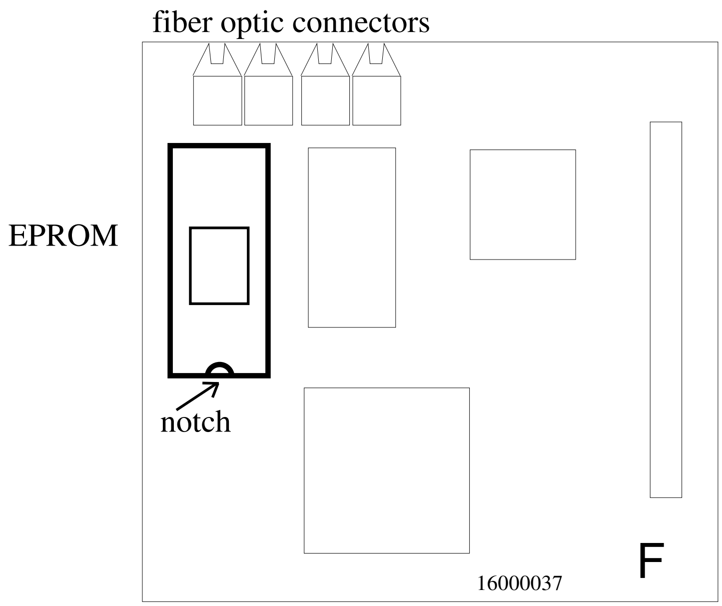
b) If the DI has a green plastic DIN rail clamp, remove it by withdrawing the screw at the rear of the clamp, and slide the clamp off sideways.

c) Remove the back plate by removing all the screws passing through it into the mounting bars.

Do not ever loosen the screws holding the aluminium bar onto each circuit board. These bars are aligned at the factory using a special jig. If they are moved it may well put excessive strain on the inter-board connectors when the DI is subsequently re-assembled.

d) Gently prise the F board from the I/O card stack. Use a screwdriver or other broad blunt instrument, and separate the boards by levering against the aluminium mounting bars and the mounting screws of the neighbouring I/O board. Take care not to damage any tracks on the circuit board. Do not try to separate the boards in one step - rather gently prise each end apart a millimetre or so at a time, otherwise the fine pins on the inter-board connector could be damaged.

e) The F board EPROM is the large rectangular chip, labelled as **F V-.-** and with the date of release. Note which way the chip is facing. There is a small notch in one end.



f) Remove the EPROM from the socket.

g) Plug in a replacement EPROM.

h) Reassemble the board stack. Take great care to align the inter-board connector correctly before squeezing the stack back together.

i) Replace the backplate, taking care to get it orientated correctly. Sometimes the I/O boards have to be levered apart by fractions of a millimetre to get the screw holes in the bars to line up with the holes in the backplate.

j) Reassemble the DI in the reverse order. When replacing the cover, note that the shaft of the address switch and the three LED indicators must pass through the appropriate holes in the cover.

Re-mount the DI onto the DIN rail. Reconnect the power plug, connect up the fiber optic cables, and reconnect the I/O cables.

Nothing else needs to be done - the DI should function a it did before, but with the new features of the latest release of software.

The only exception to this is if upgrading an older F board - it is advisable to re-initialise the board, (under the System Config / EEPROM access section of the diagnostic port) and to reset the communications parameters.

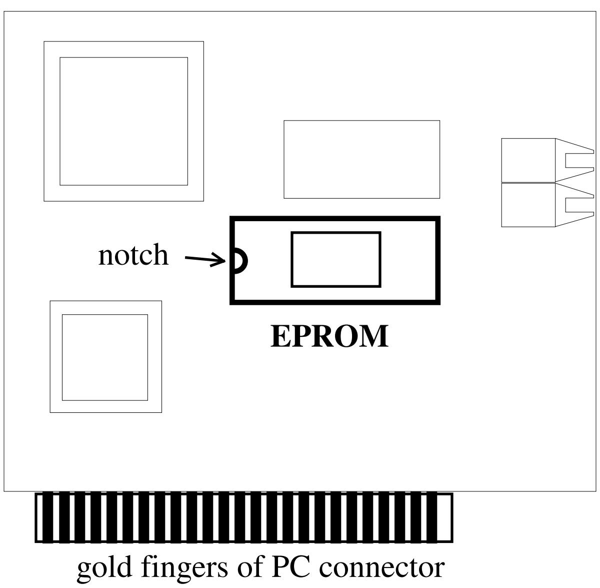
Replacing an LC EPROM.

Note that all loop controllers use the same EPROM software, whether they are PC, VME, CAMAC, or STD computer based.
Note also that each loop of a loop controller has its own EPROM, and if upgrading, all loops should really be brought up to the latest version. This means that LC3s would require 3 of the latest EPROMs, and that the CAMAC and VME controllers require 2 EPROMs.

a) Turn off the computer and remove the loop controller from its slot.
Do not touch the gold plated fingers at the edge of the card.

b) The EPROM is the large rectangular chip, labelled as **LC V-.-** and with the date of release.
Note which way the chip is facing. There is a small notch in one end of the package.

Remove the EPROM from the socket.



LC1-PC

Note that the LC3-PC is essentially the same layout repeated three times.

c) Plug in a replacement EPROM.

d) replace the Loop Controller in its slot. Check that the fiber optic cables are replaced correctly.

Nothing else needs to be done - the system should function a it did before, but with the new features of the latest release of software.

Interface Software

No change is required to the PC software in order to continue operating an existing system. However, to access new functions it may be necessary to upgrade the LabVIEW driver or the DDE server to match the software version of the EPROMs.

11.3 Calculating Update Speed in a Group3 Control System

There are two operating speeds that determine the overall polling interval of a particular channel in a system.

1) The speed of the DI processor in servicing the I/O cards in a particular DI.

2) The speed of messages passing around the fibre optic loop, the loop polling interval.

An overview of the Group3 system is necessary;

Within a Device Interface box (DI) there is a processor card, and a number of I/O boards. The DI processor services the I/O cards, updating them and reading input values which it then stores. This servicing of the I/O boards occurs continuously with a basic interval of 1ms.
Completely asynchronously to the I/O board servicing, the Loop Controller polls the DI asking for information about a particular I/O board or group of I/O boards. The DI supplies this information from its memory. Then the Loop Controller will ask for information about the next I/O board, and so on round the loop.

1) Considering the DI processor servicing the I/O boards in more detail:-

Every millisecond the DI processor performs a service call on an I/O board.
The boards are cycled through in a strict rotation, 1ms per board.
Thus if there are 3 boards in a DI, a particular board will receive a service call once every 3ms.

For certain boards 1 service call can read and update all the channels for that board, so the whole board can be serviced in a single millisecond. Other boards require several service calls to update all channels on that board. The table below outlines the number of service calls required to update an entire board:-

Type	nature	number of service calls to update all channels.
A	Fast Analog	1
B	Digital	1
C	ADC	8
D	DAC	8
E	DC motor	4
F	Serial Comms	1
G	Stepper motor	4
H	Encoder	1
J	16 bit DAC	2
K	GPIB / IEEE488	1

This table is necessary to work out channel polling intervals, as described later.

Consider the worst case of a DI loaded with three 8-channel analog boards. One channel is serviced every one ms, so it will take the DI processor 24ms to work its way around all channels in that DI. So within the DI an individual channel is serviced every 24ms. How long it takes for this information to reach the control computer then depends on how many I/O boards there are on the loop.

2) Loop Speed.

In software versions prior to V4.3, one message on the loop updated or read out all the channels of one I/O board.
Version 4.3 introduced a new messaging structure, where one message was able to service all the I/O boards in a DI. This multi-board messaging is automatically used for board types B,C,D,H,&J. The remaining boards A, the motor boards E & G, and the serial boards F & K, have data strings that are too long to join together into one message, and have to be serviced by a dedicated message to each board.

So the most popular and common boards - the digital and analog I/O boards can be automatically combined in one message, and this produces a faster overall network response.
On average, in a large system of mostly analog and digital channels, it takes 0.8ms to service each board on the loop.

So a simple rule for estimating polling interval on the loop is:-

0.8ms per I/O board on the loop

As stated at the start there are two intervals to consider - the DI servicing interval, and the loop polling interval. The average and worst case response times must take into account both of these intervals.

Here are some rules for working out the overall polling interval for a particular channel in a particular DI:-

1) Take the number of service calls required to service that board ________
(from the table above)
Multiply by the number of I/O boards in the DI x ____

DI servicing interval = ______

This is the DI servicing interval, the number of milliseconds between service calls for that particular channel, within that DI.

2) The second number required is the loop polling interval,
Take the number of I/O boards on the loop _____
Multiply this by the loop speed of 0.8 ms per I/O board x 0.8

Loop polling interval = ____

Now the **effective polling interval** for a particular channel, as seen at the loop controller will be **the larger of the two numbers** calculated above.

The second parameter of concern is the response time for a particular channel in a system. Of course on average this will be the polling interval as worked out above.

The worst case response time will be the sum of the loop polling interval and the DI servicing interval.
This is the case where the input change occurs just after a particular channel has been serviced by the DI processor, and then the loop message for that board arrives just before the DI is due to service that channel again, thereby carrying away old information. The control computer then has to wait another loop polling time to get the new measured value.

If speed is critical on some channels, then a multi-loop controller system should be implemented; one or more loops should be kept just for the high speed points, and kept as lightly loaded as possible, while the other loops should be used for the remaining channels where speed is less critical.

GROUP3 TECHNOLOGY LTD

LIMITED WARRANTY

Group3 Technology Ltd. (hereinafter called the Company) warrants instruments and other products of its manufacture to be free from defects in materials and workmanship that adversely affect the product's normal functioning under normal use and service for a period of one year from the date of shipment to the purchaser.

The obligation of this warranty shall be limited to repairing or replacing, at the discretion of the Company and without charge, any equipment which the Company agrees is defective as set out above within its warranty period. The Company will reimburse lowest freight rate two-way charges on any item returned to the Company's factory or any authorised distributor or service centre, provided that prior written authorization for such return has been given by the Company.

This warranty shall not apply to any equipment which the Company determines to have become defective owing to mishandling, improper installation, alteration, negligence, inadequate maintenance, incorrect use, exposure to environmental conditions exceeding specifications, or any other circumstance not generally acceptable for equipment of a similar type.

The Company reserves the right to make changes in design without incurring any obligation to modify previously manufactured units.

No other warranties are expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The Company is not liable for consequential damages.

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