process measurement solutions

# 3595 Series
# Isolated Measurement Pods and Cards

# Installation Guide

# GENERAL SAFETY PRECAUTIONS

The equipment described in this manual has been designed in accordance with EN61010 "Safety requirements for electrical equipment for measurement, control and laboratory use", and has been supplied in a safe condition. To avoid injury to an operator or service technician the safety precautions given below, and throughout the manual, must be strictly adhered to, whenever the equipment is operated, serviced or repaired. For specific safety details, please refer to the relevant sections within the manual.

The equipment is designed solely for electronic measurement and should be used for no other purpose. Solartron accept no responsibility for accidents or damage resulting from any failure to comply with these precautions.

## GROUNDING
To minimize the hazard of electrical shock it is essential that the equipment is connected to a protective ground whenever the power supply, measurement or control circuits are connected, even if the equipment is switched off.

All IMP and VIMP units must be connected to ground using the marked case stud before control or signal leads are connected. Where mains power supply units are used, the protective earth (E) terminal must be connected to the mains installation earth. The ground connection must have a current rating of 25A.

## AC SUPPLY VOLTAGE
Never operate the equipment from a line voltage or frequency in excess of that specified. Otherwise, the insulation of internal components may break down and cause excessive leakage currents.

## FUSES
Before switching on the equipment check that the fuses accessible from the exterior of the equipment are of the correct rating. The rating of the ac line fuse must be in accordance with the voltage of the ac supply.

Should any fuse continually blow, do not insert a fuse of a higher rating. Switch the equipment off, clearly label it "unserviceable" and inform a service technician.

## EXPLOSIVE ATMOSPHERES
NEVER OPERATE the equipment, or any sensors connected to the equipment, in a potentially explosive atmosphere. It is NOT intrinsically safe and could possibly cause an explosion.

*Continued overleaf.*

# SAFETY PRECAUTIONS (*continued from previous page*)

## SAFETY SYMBOLS

For the guidance and protection of the user, the following safety symbols appear on the equipment:

| SYMBOL | MEANING |
|---|---|
| ⚠ | Refer to operating manual for detailed instructions of use. In particular, note the maximum voltages permissible at the input sockets, as detailed in the Specification. |
| ⚡ | Hazardous voltages. |

## NOTES, CAUTIONS AND WARNINGS
For the guidance and protection of the user, Notes, Cautions and Warnings appear throughout the manual. The significance of these is as follows:

NOTES      highlight important information for the reader's special attention.
CAUTIONS   guide the reader in avoiding damage to the equipment.
WARNINGS   guide the reader in avoiding a hazard that could cause injury or death.

## AVOID UNSAFE EQUIPMENT
The equipment may be unsafe if any of the following statements apply:

- Equipment shows visible damage.
- Equipment has failed to perform an intended operation.
- Equipment has been subjected to prolonged storage under unfavorable conditions.
- Equipment has been subjected to severe physical stress.

*If in any doubt* as to the serviceability of the equipment, don't use it. Get it properly checked out by a qualified service technician.

## LIVE CONDUCTORS
When the equipment is connected to its measurement inputs or supply, the opening of covers or removal of parts could expose live conductors. The equipment must be disconnected from all power and signal sources before it is opened for any adjustment, replacement, maintenance or repair. Adjustments, maintenance or repair, must be done only by qualified personnel, who should refer to the Maintenance Manual.

## EQUIPMENT MODIFICATION
To avoid introducing safety hazards, never install non-standard parts in the equipment, or make any unauthorized modification. To maintain safety, always return the equipment to Solartron for service and repair.

## Introduction

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**Figure 1.1   Example of IMP System.**

# 1    THE IMP SYSTEM

The 3595 series of Isolated Measurement Pods (IMPs) are multi-channel data collecting stations, designed to be remotely operated by a host computer or data logger.  The host is linked to the IMPs by the S-Net cable, which is a simple two-wire cable of up to 1.5km (4950 feet) in length.  The S-Net cable is used to convey data to and from the host, and may also be used to convey power to the IMPs.

An example of an IMP system is shown in Figure 1.1.  This example is not necessarily typical, but it shows the various ways in which IMPs may be used.

To communicate (via S-Net) with the IMPs, the host must use an interface module.  The types available are listed in Table 1.1.

**Table 1.1   3595 Interface Modules**

| Type | Function |
|------|----------|
| 3595 4A | Interfaces between S-Net and any IBM Personal Computer. |
| 3595 4B | Interfaces between S-Net and any IBM Personal Computer and can be used in dual redundancy systems.. |
| 3595 6A | Interfaces between S-Net and the DEC Q-Bus, thus linking S-Net to industry standard DEC minicomputers. |
| 3595 8A | Interfaces between S-Net and the GPIB (IEEE 488) or RS232. |
| 3595 9A | Interfaces between S-Net and the Ethernet.  Incorporates up to four '4A or '4B Interfaces, thus allowing up to four S-Nets to interface with the Ethernet.  (Housed in 485mm wide rack) |
| 3595 9B | Interfaces between S-Net and the Ethernet.  Incorporates a single '4A or '4B Interface.  (Housed in all-mounted case, sealed to IP53 Standard) |

The installation and operation of each of these interfaces is described in the relevant operating manual.  (See Table 1.5 in this chapter).

To obtain data from specific sensors within the monitored system the host sends appropriate commands to the relevant IMP(s).  Each IMP has a unique address and contains a microprocessor that is able to interpret the commands addressed to it and to take appropriate action.  Nominated channels within the addressed IMP(s) are thus scanned and the measurement results, in digital form, are sent back to the host.  The functions of the various types of IMP are summarized in Table 1.2.

**Table 1.2  IMP Functions.**

| IMP Type | IMP Functions |
|----------|---------------|
| 3595 1A | Provides twenty channels of solid-state switching for measuring voltage, current and temperature. |
| 3595 1B | Provides ten channels of solid-state switching for measuring voltage, resistance, temperature and the outputs from strain gages. |
| 3595 1C | Provides twenty channels of reed-relay switching for measuring voltage, current and temperature. |
| 3595 1D | Provides four channels of isolated analog output. |
| 3595 1E | Similar to the 35951C, but allows a higher voltage between channels. |
| 3595 1H | Provides an  enhanced version of many of the facilities provided by the '1A, '1B, '1C, '1E, '2A and '2B IMPs.  Twenty channels are provided: eighteen of these can be used for an analog or digital status input, and two channels can be used either for a digital status and event count input or for a control logic output.  Channel to channel isolation is 200V. |
| 3595 1J | Same facilities as the '1H.  Channel to channel isolation is 500V. |
| 3595 2A | Provides twenty channesl of transformered-isolated switching, in which each channel can be configured as an input or as an output. |
| 3595 2B | Provies thirty two channels of transformer-isolated switching, in which channels 1-28 can be configured as an input and channels 29-32 can be configured as an input or output. |
| 35959 3D | Provides an RS232 to S-Net interface for inputting data from hand-held vibration data collectors. |

IMPs can receive their power either from the host via the S-Net cable, or directly from a local dc source.

Also available in the 3595 Series are the Vibration IMPs, or VIMPs.  These can be mixed with IMPs, in the same system, but they are always powered from a local PSU, the 359595D.  The functions of the two VIMPs currently available, the 35951F and G, are summarized in Table 1.3.  A Serial IMP, the 359593D, provides an RS232 to S-Net interface, which allows hand-held vibration data collectors to send data to a Host Computer.

**Table 1.3  VIMP Functions.**

| VIMP Type | VIMP Functions |
|-----------|----------------|
| 3595 1F | Provides sixteen channels of vibration measurement, together with four trigger inputs, one event input and one alarm output. |
| 35951 G | Provides thirty-two channels of vibration measurement, together with eight trigger inputs, one event input and two alarm outputs. |

## 2          APPROACH TO INSTALLATION

This manual contains full details of how to install an IMP system.  These include: how to decide on the S-Net cabling and IMP power requirement; how to site and mount the IMPs; and how to connect S-Net and the sensor wiring to the IMP connector blocks. Sections 2.1 through 2.3 below introduce each of these aspects in turn and point to the relevant chapter(s) in the manual.

### 2.1          S-NET CABLES AND IMP POWER REQUIREMENTS

If IMPs are to be powered from the host then the length of the S-Net cable that can be used is determined by the number of IMPs connected to S-Net, the cable gage and the power supply voltage.  Where IMPs are powered locally, of course, this limitation does not apply.  The limitation never applies to VIMPs, which are always powered locally.

A further limitation on cable length is imposed by signal attenuation due to the cable impedance.  This is the only limitation imposed for locally powered IMPs, but it also applies for remotely powered IMPs, where permitted within the limitation mentioned in the previous paragraph.  With the standard recommended cables the maximum permitted length is 1km.  A low-loss 18 gage (AWG) cable is also available, which permits a maximum cable length of 1.5km.

When choosing the type of cable and power supply, bear in mind any future expansion of the system.

Details regarding the choice of S-Net cable and IMP power supply unit are given in Chapter 2 of the manual.  Further details, regarding the connections to be made to the power supply units, are given in Chapter 4.

### 2.2          IMP MOUNTING

IMPs may be mounted according to the layout of the monitored system and the measurement data requirements.

Typically, IMPs are distributed around the system, each IMP being mounted close to the sensors that it is to monitor.  Thus sensor leads can be kept short, which is less costly and minimizes noise pickup.

In large systems there may be many sensors at each measurement point, and possibly established sensor channels.  In this case several IMPs may be mounted together in a rack.

In a clean area, where a particularly high density of measurement channels is required, IMPs can be rack mounted in the form of IMCs (Isolated Measurement Cards).  IMCs are simply IMPs without their cases.  For each type of IMP an IMC version is available. The product numbers of the IMP and IMC equivalents are shown in Table 1.4.

**Table 1.4  IMP/IMC Equivalents.**

| Description | IMP Type | Con.Type | IMC Type | Con. Type |
|---|---|---|---|---|
| 20 Channel, solid state, 3-pole | 35951A | 35953A | 359551A | 359553A |
| 10 Channel, solid state, 3-pole | 35951B | 35953B | 359551B | 359553B |
| 20 Channel, reed-relay, 3-pole<br>20 Channel, high voltage | 35951C<br>35951C | 35953A<br>35953D | 359551C<br>359551C | 359553A<br>359553D |
| 4 Channel, analog output | 35951D | 35953E | 359551D | 359553E |
| 20 Channel, reed-relay, 3-pole<br>20 Channel, high voltage | 35951E<br>35951E | 35953A<br>35953D | 359551E<br>359551E | 359553A<br>359553D |
| 20 Channel, digital input/output | 35952A | 35953C | 359552A | 359553C |
| 32 Channel, switch input/output | 35952B | 35953F | 359552B | |
| Rack Mounting frame | 359591A | | 359591B | |

Up to 14 IMCs can be fitted in the appropriate rack (359591B).  IMCs function in exactly the same way as IMPs, but because they are not protected from their environment by the casing, some performance figures cannot be guaranteed: for instance, in the presence of high humidity (see the general IMP and IMC specifications at the end of Appendix B) or rapid airflow across the cards.

> **WARNING:** Care must be taken when working with IMCs.  High voltages may be present on any part of the printed circuit cards; you are not protected by the casing, and you may receive and electric shock if you touch one of the inputs.

> **NOTE:** All references to IMPs in this Installation Guide are also applicable to the corresponding IMCs, unless otherwise stated.

The mounting of IMPs and IMCs is described in Chapter 3 of this manual.

## 2.2.1  VIMP Mounting

VIMPs are always mounted singly, through brackets attached to them.

## 2.3  IMP CONNECTIONS

All connections to an IMP are made via a detachable connector block.  This allows the IMP to be easily removed from the system and replaced by another, should the need for service arise.

**Chapter 4** of the manual contains the general instructions for making connections. These cover the sealing of all cable entries to the IMP and **details of the S-Net connections**.  Also mentioned, towards the end of Chapter 4, are the IMP address switches.

**Details of the sensor connections are given in Chapters 5 through 10 and 12**, which cover specific types of IMP.

**Practical advice on which type of sensor to use** for a particular application is given in **Appendix A** of the manual.

## 2.4    EMC

All IMPs meet the requirement of EN50081-2:1994 for emission and EN50082-2:1995 for immunity.  Note, however, that high levels of radiated or conducted radio frequency interference, as defined in EN50082-2, may reduce the accuracy of low level measurements.  In such cases, which are unusual in practice, the interference can be mitigated by removing the source or by screening.

# 3    ASSOCIATED DOCUMENTATION

Listed below in Table 1.5 is the documentation available for the IMP system.  Full documentation is normally supplied with the system, but extra copies can be obtained on request.

**Table 1.5   IMP System Documentation.**

| Product No. | Manual Title | Part No. |
|:-----------:|:-------------|:--------:|
| 3595 | IMP Installation Guide. | 35952061 |
| 3595 | Calibration of 3595 Series IMPs: Operating Manual. | 35952233 |
| 3595 1F/1G | Vibration IMP Programmer's Manual. | 35952200 |
| 3595 4A | IBM PC/S-Net Adaptor Operating Manual. | 35952060 |
| 3595 4B | IBM PC/S-Net Interface Operating Manual. | 35952232 |
| 3595 6A | IMP/DEC Q-Bus Operating Manual. | 35952090 |
| 35957 | IMP Q-Bus RSX Driver User Manual. | 35952096 |
| 3595 7D | VMS Fast IMP Q-Bus Driver. | 35955018 |
| 3595 7E | IMP/IBM PC Advanced Language Drivers. | 35952157 |
| 3595 7F | VMS Fast IMP Q-Bus Driver. | 35952167 |
| 3595 71B/73B | IMPULSE Data Acquisition Software. | 35952091 |
| 3595 74A | IMPVIEW Operator Manual | 35952245 |
| 3595 75A | LabVIEW/BridgeVIEW Drivers for IMPs: User Guide | 35952288 |
| 3595 8A | GPIB/RS423 IMP Interface. | 35952103 |
| 3595 93A/B | IMP Foundation Module. | 35952094 |

# 2

## S-Net Cable and IMP Power

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# 1      S-NET CABLE AND IMP POWER CONSIDERATIONS

In most applications, communication signals and IMP power are both delivered via the S-Net cable. The cable should consist of a twisted pair of multi-stranded wires, with a screen around them. Supported cable types are listed in Table 2.1. Specifications for the cables are critical and are listed in Section 2. Unscreened cables can be used, but not in electrically hostile environments where the communication signals may be subject to interference.

Where IMPs are to be powered via the S-Net cable, this power must be supplied by the host computer/logger, either directly from its own circuits or indirectly from a supplementary power supply. Alternatively, an IMP can be powered locally from a 12V, 24V or 48V d.c. supply.

When powering IMPs via the S-Net cable, it is essential that the cable core is of an adequate gauge. The actual gauge required depends on the number of IMPs to be powered, their distribution along the cable, and the power supply voltage. It is safest to assume the worst case distribution of the IMPs - this is where all IMPs are grouped at the end of the cable furthest from the host.

IMPs that are to be powered locally do not affect the S-Net gauge requirement. However, with a mix of locally powered and S-Net powered devices the gauge requirement must always be considered.

> **NOTE:** When deciding on a particular gauge of cable, bear in mind any future system expansion. Installing a cable that is able to cope with your projected requirements will save you the bother and expense of changing the cable at a later date.

Each IMP consumes approximately 1W, (1.2W at power-up). (35951D Analog Output IMPs can, in some applications, require more. In these circumstances they need special consideration: refer to Chapter 7, Section 5 for details.) Generally, the thickest cable used is 12 AWG (3.4mm²), and the thinnest should not be less than 24 AWG (0.2mm²). Always err on the side of thicker, rather than thinner, cable. The graphs in Section 2 in this chapter are provided as an aid to cable selection.

Table 2.1 lists the cables supported by Solartron Instruments as being particularly suitable for linking IMPs to a host computer/logger. The cables are intended for general-purpose use. Note that the 18 AWG cable is a low loss type and an acceptable signal level is maintained with up to 1.5km of this cable.

**Table 2.1   Cables Recommended for S-Net.**

| Cable Gauge (Single Conductor) | Cable Type and Manufacture | Solartron Part No. |
|---|---|---|
| 12 AWG | Brand-Rex T12459 | 480120940 |
| 16 AWG | Alpha 9820, Belden 9860, Brand-Rex T12460 | 480120910 |
| 18 AWG | Belden 9250, Brand-Rex CD8920251 | 480121040 |
| 20 AWG | Alpha 9818, Belden 9207, Belden 9815 (direct burial), Brand-Rex BC 57207 | 480120920 |
| 24 AWG | Alpha 2400, Belden 8641, Brand-Rex BI56641 | 480120700 |

Approximately 10 metres of 24 A.W.G. Belden 8641 cable are provided with each Solartron interface card/logger. This is sufficient for small data acquisition systems or for testing purposes. All the recommended cables are U.L. approved. Alpha and Belden cables are widely available from cable stockists. Equivalent cables are available, in lengths of 100 metres, from Solartron Instruments - see Solartron part numbers in Table 2.1 above.

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**CAUTION:** All IMP and VIMP units must be connected to ground using the marked case stud before control or signal leads are connected. Where mains power supply units are used, the protective earth (E) terminal must be connected to the mains installation earth. The ground connection must have a current rating of 25A.

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## 2     CABLE SELECTION

Figures 2.1 and 2.2 indicate the minimum wire gauge for S-Net supply voltages of 24V and 48V. Each figure shows the "No. of IMPs" plotted against "cable length (km)", for four different gauges of cable. The area enclosed by each curve, and the X and Y axes, represents the various combinations of IMPs versus distance that can be accommodated by the particular cable gauge. The gauges are identified in the table that accompanies each figure.

**Example:** The S-Net supply is 24V, and 10 IMPs are to be powered via the cable. The total cable length is approximately 300 metres. For a 24V supply, refer to Figure 2.1, and note that lines drawn from the "10 IMPs" and "0.3 km" points intersect in the area covered by the 16AWG cable. The point of intersection also lies within the area covered by the 12 AWG cable. Therefore, although 16 AWG is the thinnest cable that can be used, the 16AWG cable and the thicker 12 AWG cable are both suitable.

Having determined a suitable cable gauge, select one of the preferred cable types. Cables other than those preferred may be used but in order to ensure error free communications these cables must conform to the following specification:

- Characteristic impedance in the range 80 ohms to 120 ohms.

- Attenuation at 326kHz of less than 9dB per kilometre.

- Mutual capacitance between conductors of less than 60pF per metre.

**NOTE**    The power consumption of universal IMPs is 1.5 times that of other IMPs. This is reflected in the graphs shown in Figures 2.1 and 2.2: Figs 2.1a and 2.2a relate to the universal IMPs and Figs 2.1b and 2.2b relate to other IMPs.

**a)**
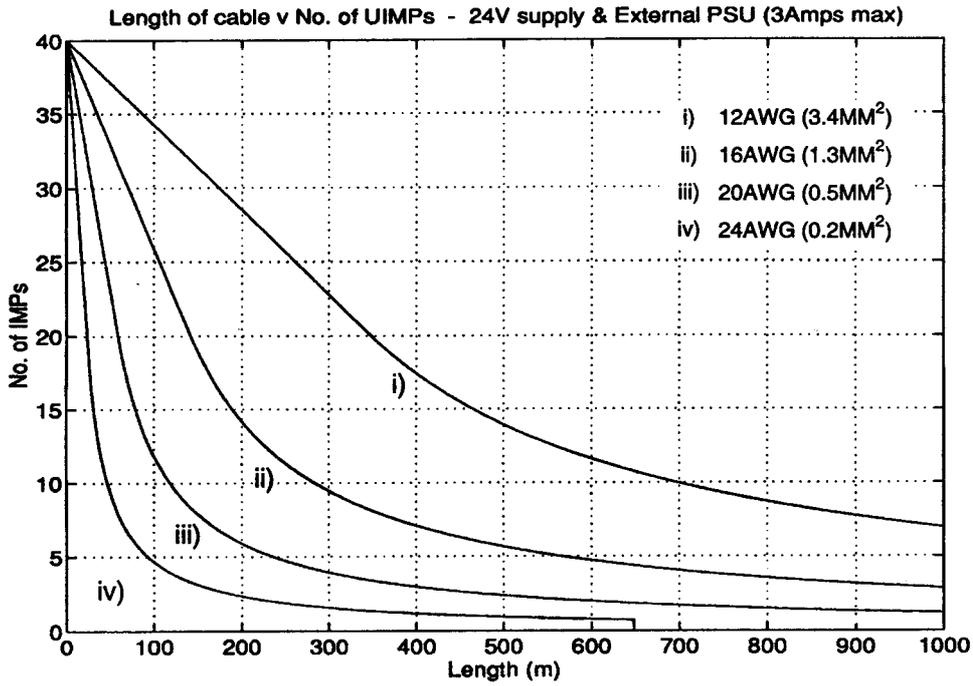


**b)**
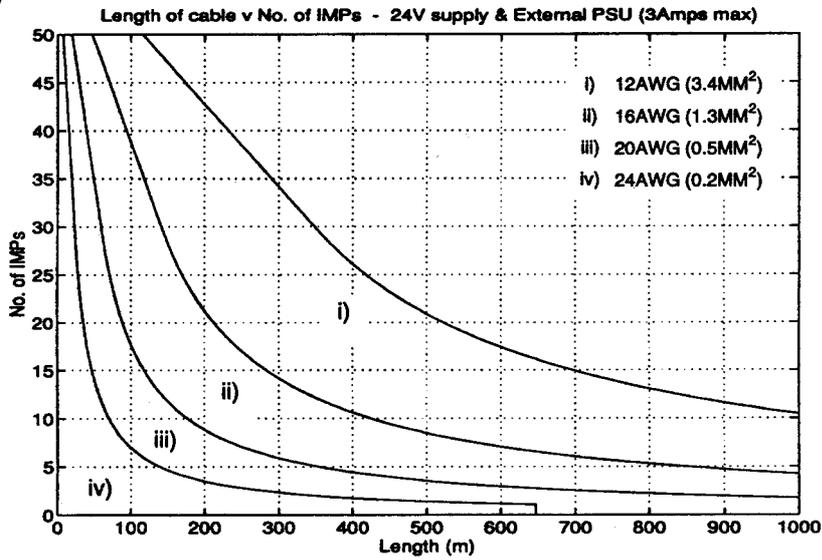


**Figure 2.1  Minimum recommended wire gauge for a 24V power supply for: a) Universal IMPs and b) other IMPs.**

**a)**

**Length of cable v No. of UIMPs - 48V supply & External PSU (3Amps max)**



Legend:
- i)   12AWG (3.4MM$^2$)
- ii)  16AWG (1.3MM$^2$)
- iii) 20AWG (0.5MM$^2$)
- iv)  24AWG (0.2MM$^2$)

Y-axis: No. of IMPs (0 to 50)
X-axis: Length (m) (0 to 1000)

**b)**

**Length of cable v No. of IMPs - 48V supply & External PSU (3Amps max)**



Legend:
- i)   12AWG (3.4MM$^2$)
- ii)  16AWG (1.3MM$^2$)
- iii) 20AWG (0.5MM$^2$)
- iv)  24AWG (0.2MM$^2$)

Y-axis: No. of IMPs (0 to 50)
X-axis: Length (m) (0 to 1000)
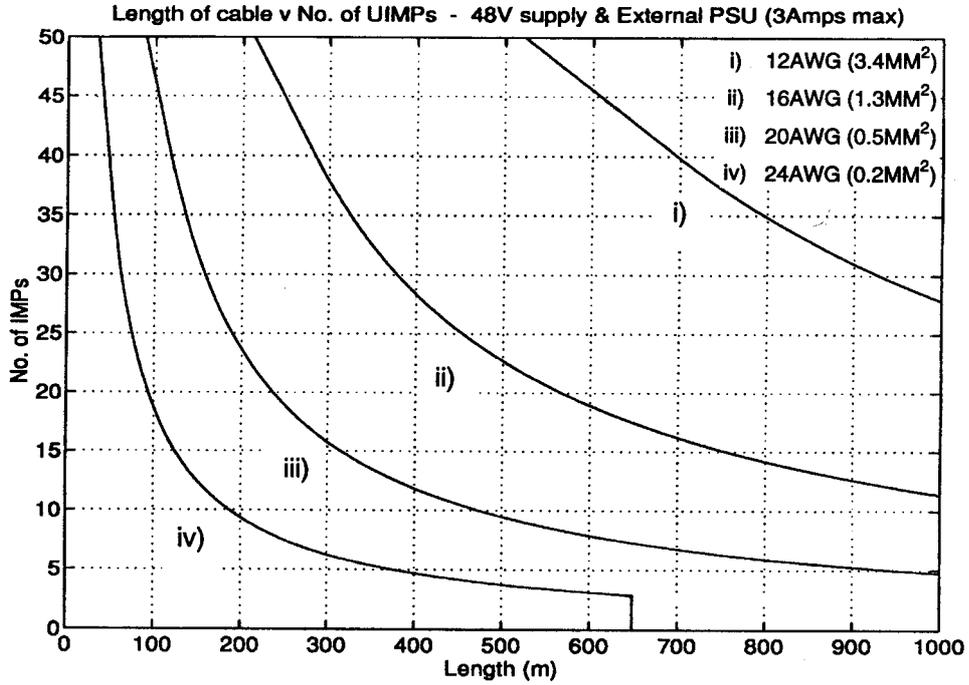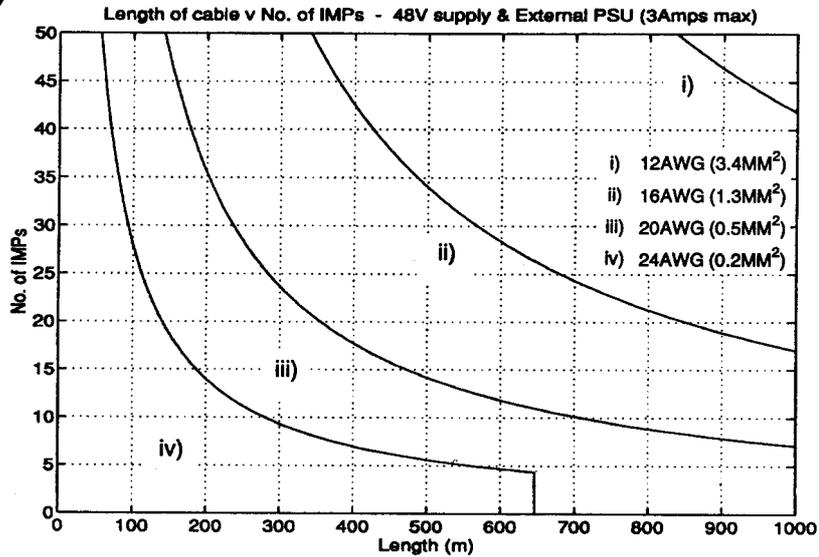
*Figure 2.2  Minimum recommended wire gauge for a 48V power supply for : a) Universal IMPs and b) other IMPs*

# 3    POWER SUPPLY UNITS

## 3.1    IMP POWER SUPPLY UNITS

> **CAUTION:** The 3595 95A, B, and D units are all configured for 240VAC input by the manufacturer.  They must be adjusted for the local mains supply voltage where necessary.

The 3595 95A power supply unit is a 48VDC power supply designed for installation at the host end of the network.  It will supply 140 Watts, providing adequate power for a worst case system with 50 IMPs on a single network.  It is a ventilated unit, and must therefore be fitted in a protective enclosure.  Users must comply with the installation instructions supplied with the unit.

The 3595 95B power supply unit is designed for installation at the remote end of an S-Net network and will normally be fitted close to the IMPs.  The unit is enclosed in a protective cabinet together with a DIN rail for field wiring connections.

The 95B unit operates at 48VDC and may be used as a power source for transducer conditioning as well as for powering IMPs.  The unit is capable of supplying 50 watts, but it is recommended that no more than 20 Universal IMPs or 30 IMPs of any other type are connected to any one unit.  This is to avoid problems with excessive heat dissipation within the protective enclosure.  Full instructions are supplied with the unit.

> **NOTE:** It is permissible for a battery-powered S-Net system to have a charger permanently connected.  The batteries themselves provide adequate smoothing of the charger output.  A battery powered system must be protected by a fuse.

## 3.2    CONNECTION TO AC (MAINS) SUPPLY

The 3595 95A and B Power Supplies are intended for permanent installation.

To comply with EN61010 the installation must meet the following safety requirements:

1.  To allow a power unit to be isolated from the ac supply, the supply must be routed through a switch or circuit breaker.

2.  The switch (or circuit breaker) must be in easy reach of the operator.

3.  The switch (or circuit breaker) must be clearly identified as the means of isolation of the power unit.

4.  The maximum current drawn from the ac supply must be limited, by a fuse or trip, to a maximum of 13A.

The installation of the 3595 95A and B Power Supplies is described in Sections 3.2.1 and 3.2.2.

### 3.2.1 Installation of the 3595 95A Power Supply

1. The voltage selector must be set to correspond with the local ac supply voltage. The unit has a link that is open for a 240V (nominal) supply and closed for a 115V (nominal) supply.

2. The ac supply must be connected as follows:

   a. line to terminal 'L',

   b. neutral to terminal 'N',

   c. earth (ground) to terminal 'E'.

### 3.2.2 Installation of the 3595 95B Power Supply

1. The voltage selector must be set to correspond with the local ac supply voltage. The unit has a link that is open for a 240V (nominal) supply and closed for a 115V (nominal) supply.

2. The ac supply must be connected as follows:

   a. line to terminal 'L',

   b. neutral to terminal 'N',

   c. earth (ground) to terminal 'E'.

3. The ac supply cable must be firmly secured by the clamping bush of the cable gland supplied. This gland accommodates round cables of diameter 4mm through 7mm. The installation cabling should also be secured to the wall or support structure in accordance with good installation practice.

   The earth (ground) of the ac supply must be connected to the earth stud marked

   that is located inside the enclosure.

#### 3.2.2.1 *Ensuring Electromagnetic Compatibility of the 359595B*

To conform with the EU directives regarding electromagnetic compatibility the cable carrying the 48V output of the 3595 95B must be fitted with the common mode choke (ferrite suppression core) supplied. The choke should be fitted, between the PSU output terminals and the Klippon terminals, so that the cable passes through the choke twice. Pass the dc cable through the choke, loop it

round, and pass it through again:
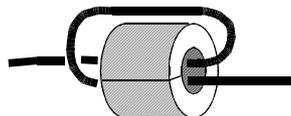
## 3.3        359595D VIMP POWER SUPPLY

The 359595D Power Supply Unit provides sufficient local power for the vibration measurement circuitry one VIMP or two, of either type (35951F or 35951G). [Note that a VIMP must also receive a supply from S-Net for the S-Net interface circuit.]

Figure 2.3 shows the outline dimensions of the 359595D Power Supply Unit, in sufficient detail to allow the user to determine a suitable installation site.
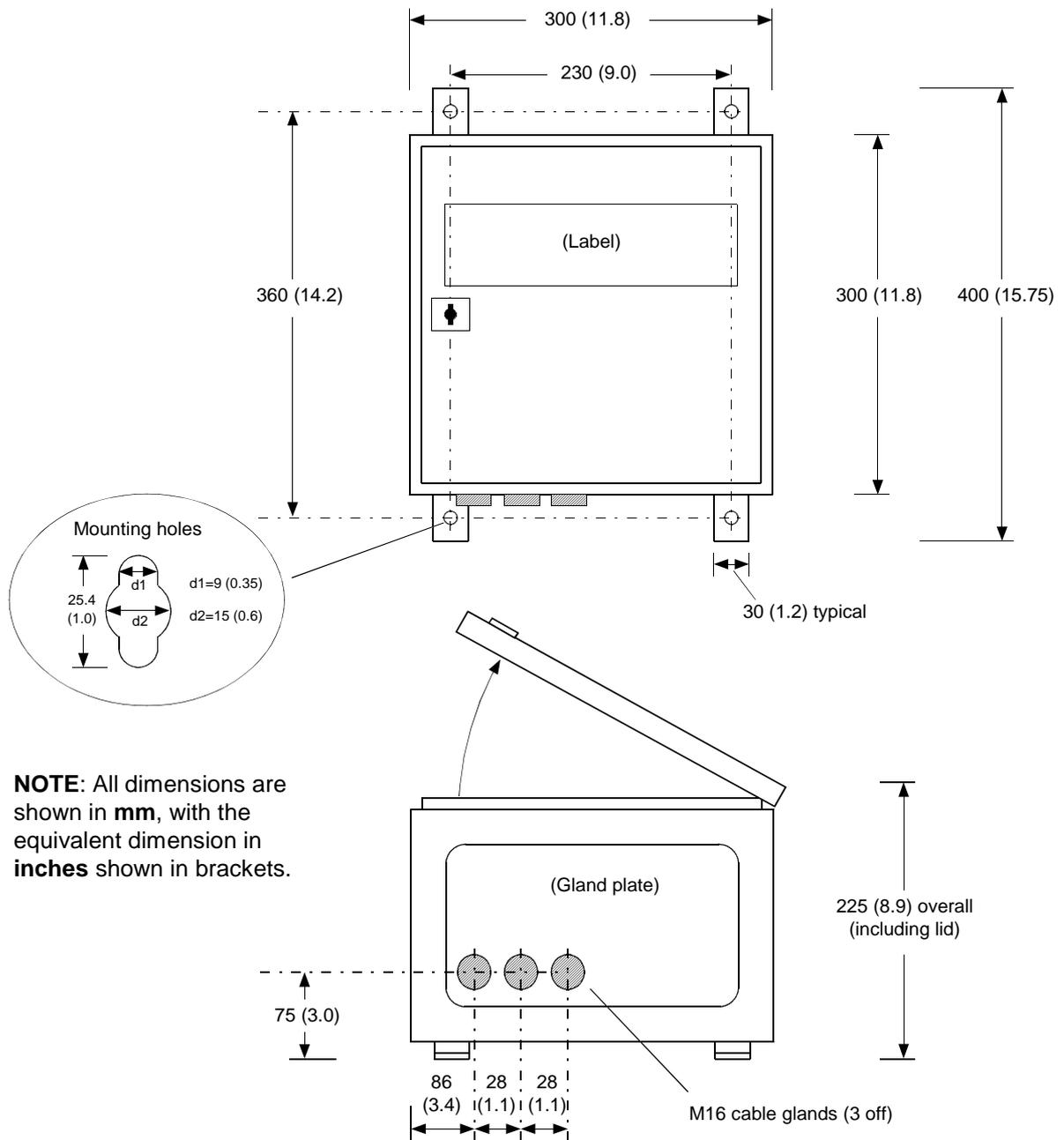


**Figure 2.3**    *Outline dimensions of the 359595D Power Supply Unit.*

### 3.3.1    VIMP Power Supply Cable

Cable of adequate gauge should be used to connect the 359595D Power Supply to the 35951F or 35951G VIMP.  The gauge should be such that less than 200mV is dropped across the line carrying the +5V supply.  Assuming that an identical gauge is used for the other lines, i.e. those carrying the -5V, -12V and +12V supplies, then no problems should be encountered.

To enable the installer to make the correct connections, the supply terminals on the 35953G Connector Block and the corresponding terminals on the 359595D Power Supply are clearly labelled.

## Siting and Securing an IMP

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# 1       IMP SITING OPTIONS

Depending on your system monitoring requirements, IMPs may be sited in any one of three ways:

- Individual IMPs, of any type, may be distributed throughout the system.

- In established plants where sensor outputs are already channeled to a central measuring point, some IMPs (types '1A through '1E, '2A and '2B) may be neatly housed in a rack.

  *VIMPs (Vibration IMPs, type '1F and '1G) are always distributed throughout the system. Universal IMPs, types '1H and '1J, also, are primarily intended for distribution around the system, but, if necessary, they can be stacked on each other.*

- In a clean area, a high density of isolated measurement channels can be obtained by using IMCs (Isolated Measurement Cards). These perform the same functions as IMPs type '1A through '1E, '2A and '2B, but they are not enclosed in a protective case. (To meet European standards for EMC the IMCs must be installed in a suitable enclosure - for example the VERO IMRACK 3400.)

Securing instructions for each of these options are given in Sections 2, 3, and 4.

When distributing IMPs throughout the system, choose installation sites that are relatively free from moisture, vibration and corrosive substances.  If a 'damp' installation cannot be avoided, mount the IMPs vertically with the connector end pointing downwards.  Any excess moisture will then tend to drain away from the vulnerable areas where cables enter the IMP.

In particularly hostile environments it is recommended that each IMP is mounted inside a sealed protective box and that the S-Net cable is enclosed in a sealed protective duct. See Appendix B in this manual for the IMP environmental specification.

Provision is made for securing the IMPs to permanent features on site, such as stanchions and bulkheads.  The general approach is to use four bolts.  The bolting depends on the IMP type.  See Figures 3.1 through 3.3.

Before any control or signal leads are connected, the external case of the IMP must be grounded through the M4 studs provided.  Where ac power supply units are used, the protective ground terminal (E) must be connected to the ac installation ground.  The ground connection must have a rating of 25A.

**SECTION A: MOUNTING HOLE**

Grounding stud detail.

Note that there is a grounding stud on both sides of the IMP case.

Overall IMP dimensions: 485mm x 215mm x 34.5mm

**TOP VIEW**
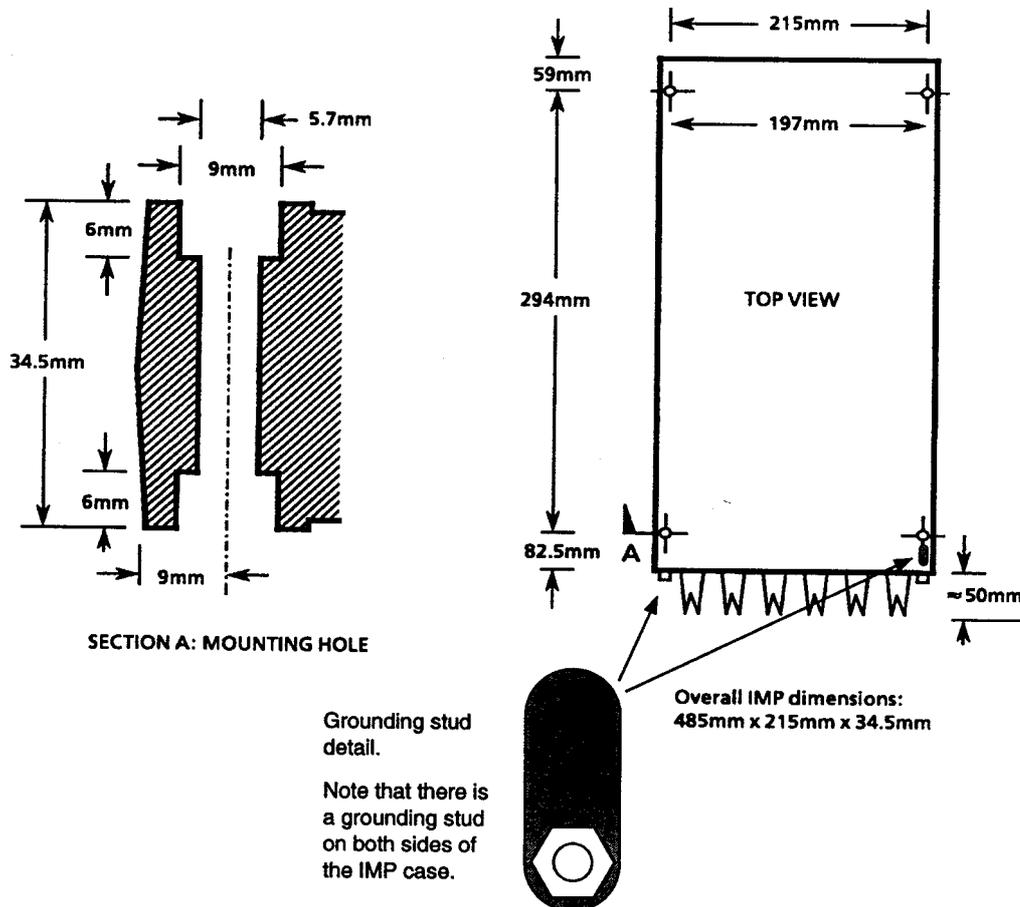
**Figure 3.1  Location of bolt holes on IMPs type '1A through '1E, '2A and '2B.**

VIMPs are always used singly, and are secured by bolting through the two brackets shown in Figure 3.2.
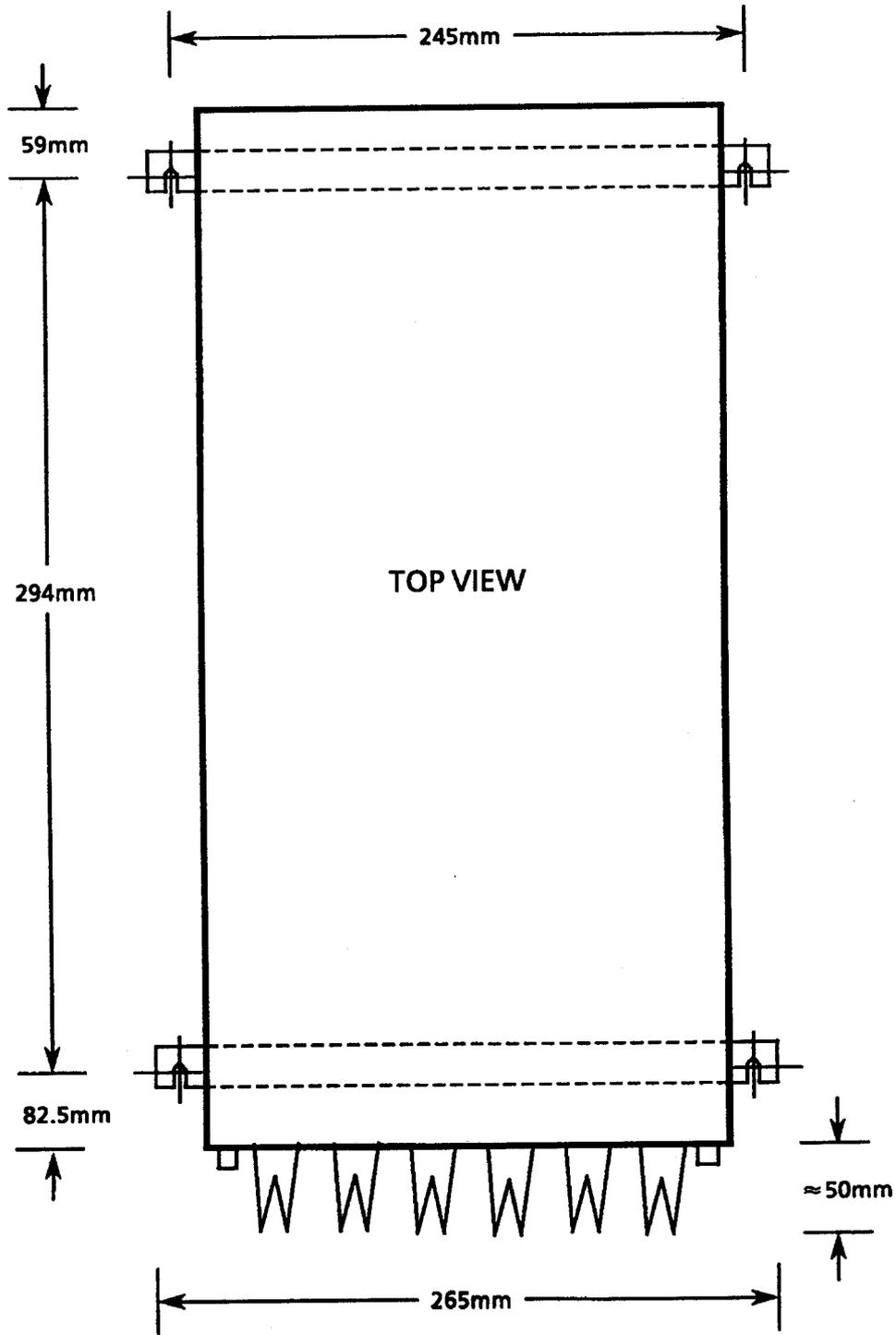


**Figure 3.2  Location and dimensions of VIMP bolt brackets.**
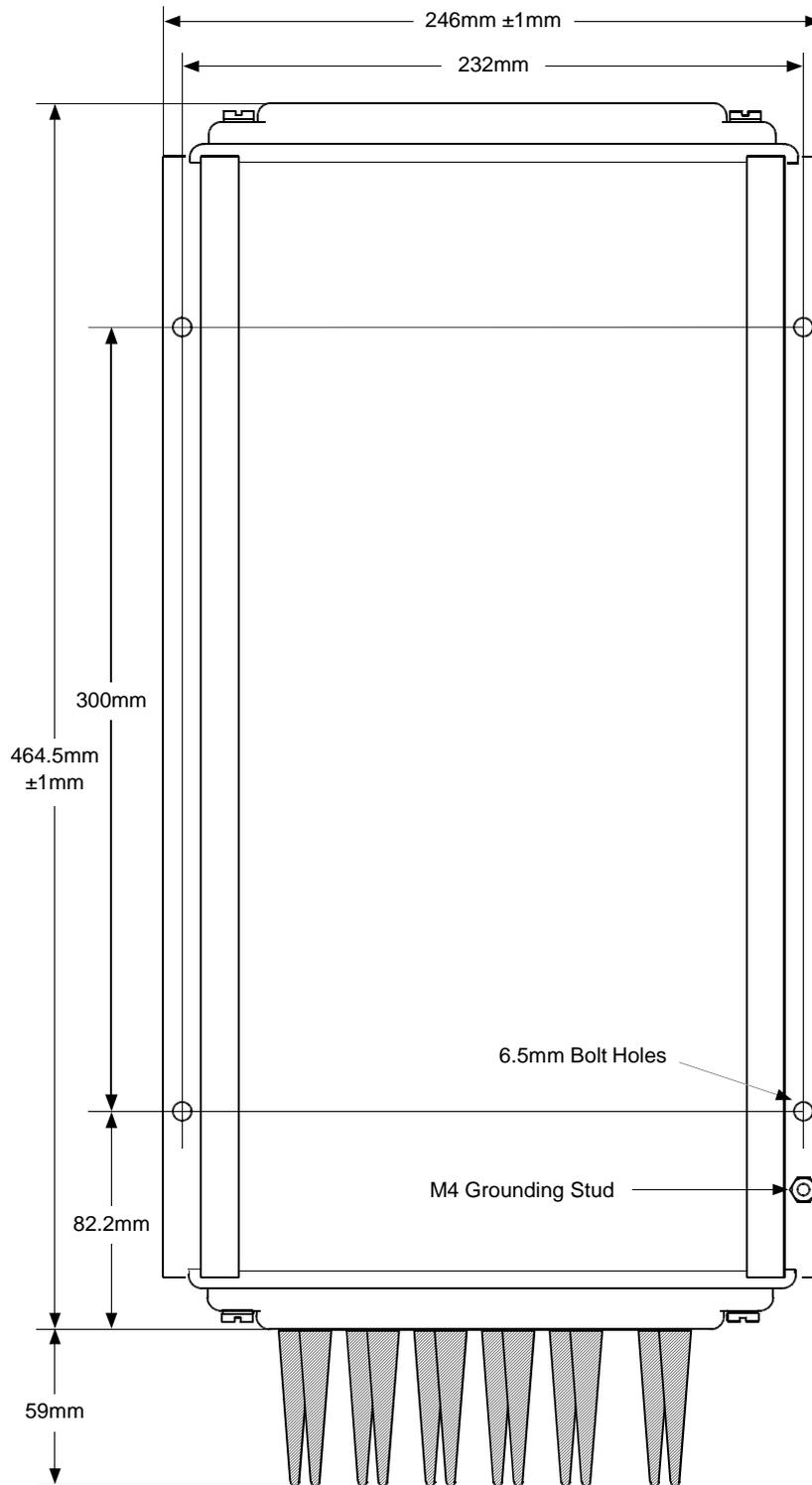
**Figure 3.3   Location of bolt holes on Universal IMPs type '1H and '1J.**

**INSTALLATION NOTES FOR '1H AND '1J UNIVERSAL IMPS**

- The weight of the unit, including the connector block, is 2.5kg.

- Before bolting a '1H or '1J IMP to a flat surface, remove the rubber feet.

- It is preferable to mount '1H and '1J IMPs in a vertical attitude. In a damp environment any excess moisture then tends to drain away from the vulnerable areas where cables enter the IMP.

- Each time the case of a '1H or '1J IMP is opened, from either end, a new dessicant bag must be inserted before the case is closed. Packs of 10 dessicant bags are available to order (product number 359594F).

  *If a new desiccant bag is not immediately available, it is possible to reactivate the contents as follows: open the bag and empty the clay granules onto a suitable tray; then place the tray in a low-temperature (140°C) oven for between 7 and 8 hours; finally, allow the tray and clay granules to cool in a dry environment, before returning the clay granules to the bag and closing it. Note, however, that the ability of the clay granules to absorb moisture is degraded each time they are reactivated: therefore,* **this method should be employed only in an emergency** *and no more than twice with the same granules.*

- For safety, the case must be grounded at the stud provided (see Figure 3.3).

A rack mounting kit is available as an accessory, part number 359591A.  Each kit allows 10 IMPs to be housed in a standard 19" rack.  The overall dimensions of the assembled kit are: 483mm x 510mm x 266mm (19" x 20" x 10.5").  (See Figure 3.9.)

Each kit contains:

- 2 side panels

- support trays

- plastic runners

- 2 rear trims

- 2 front trims (1 upper, 1 lower)

- 2 rack ears

- 2 clamp bars (1 upper, 1 lower)

- 1 pack of screws, nuts and washers

**STEP 1**     Fix the support trays (4 off) to the side panels (2 off), using M4 pan head screws and crinkle washers.  (See Figure 3.4.)  Add 1 plain washer to fixing hole if the panel hole is a slot.
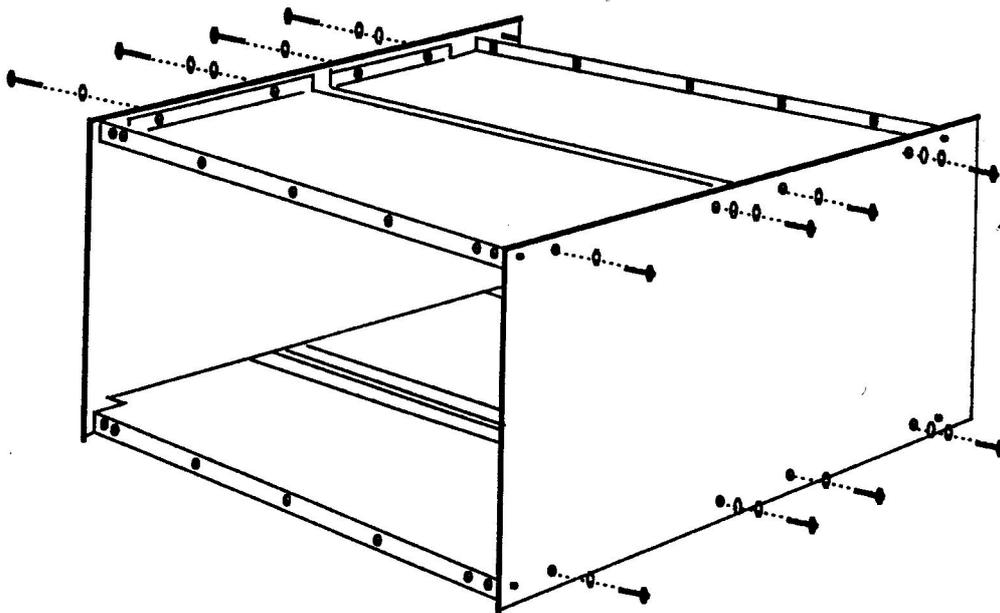


*Figure 3.4  Assembly of support trays and side panels for IMP mounting frame*

**STEP 2**    Slide the plastic runners (4 off) into the support trays.  (See Figure 3.5.)
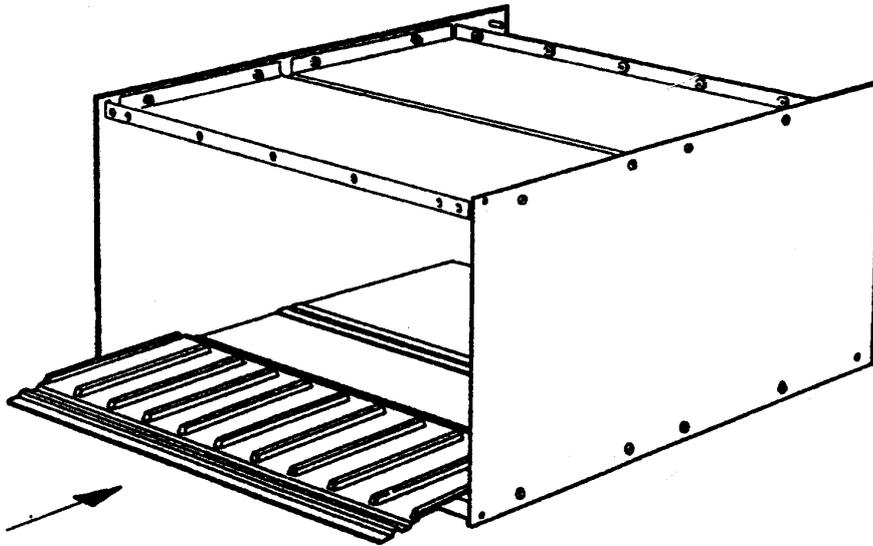
*Figure 3.5  Sliding the plastic runners into an IMP mounting frame*

**STEP 3**    To secure the plastic runners at the rear of the mounting frame, fix the two rear trims with M4 countersunk screws.  (See Figure 3.6.)
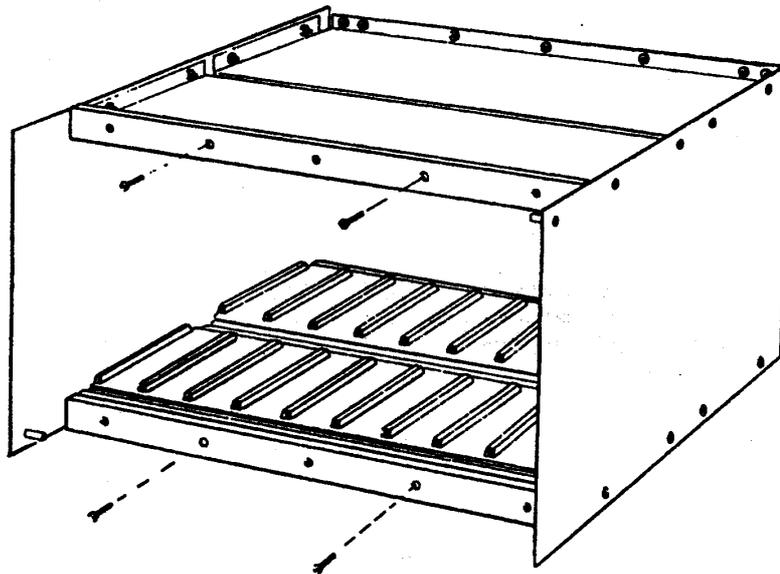
*Figure 3.6  Fixing the rear trims on an IMP mounting frame*

**STEP 4**    To secure the plastic runners at the front of the mounting frame, fix the upper and lower front trims with M4 countersunk screws.  Fix a rack ear at each side of the mounting frame, using M4 pan head screws and crinkle washers.  (See Figure 3.7.)
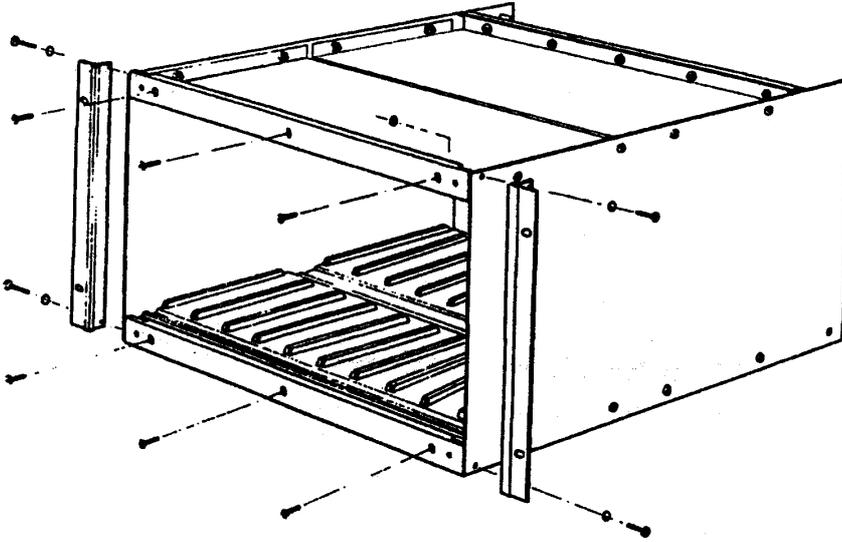


**Figure 3.7  Fixing the front trims and rack ears on an IMP mounting frame**

**STEP 5**    At the rear of the unit fix the lower clamp bar in its lowest position, using M4 pan head screws with plain and crinkle washers.  Then fix the upper clamp bar (with earthing studs), in its highest position, using M4 pan head screws with plain and crinkle washers.  (See Figure 3.8.)
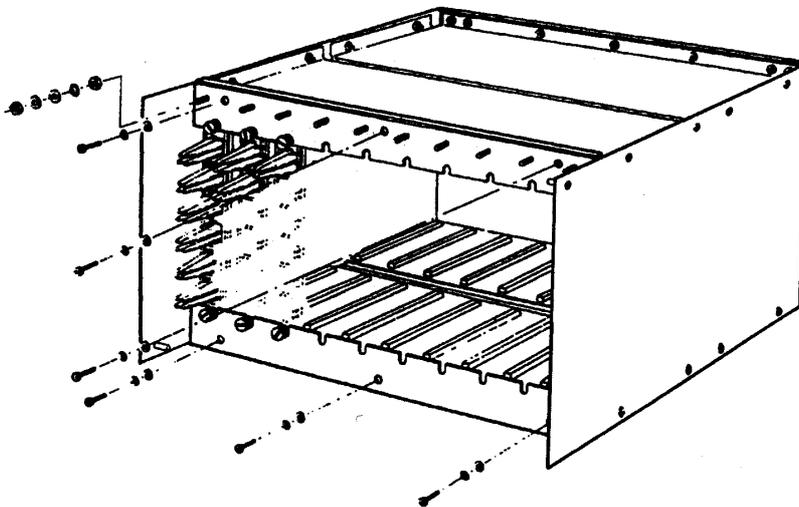


**Figure 3.8  Fitting the clamp bars on an IMP mounting frame**

**STEP 6**    Slide all of the IMPs into the mounting frame (Figure 3.9).  Then raise the lower clamping bar and lower the upper clamping bar, so that the connector block screws rest inside the open slots.  Fix the clamping bars by tightening the M4 screws.
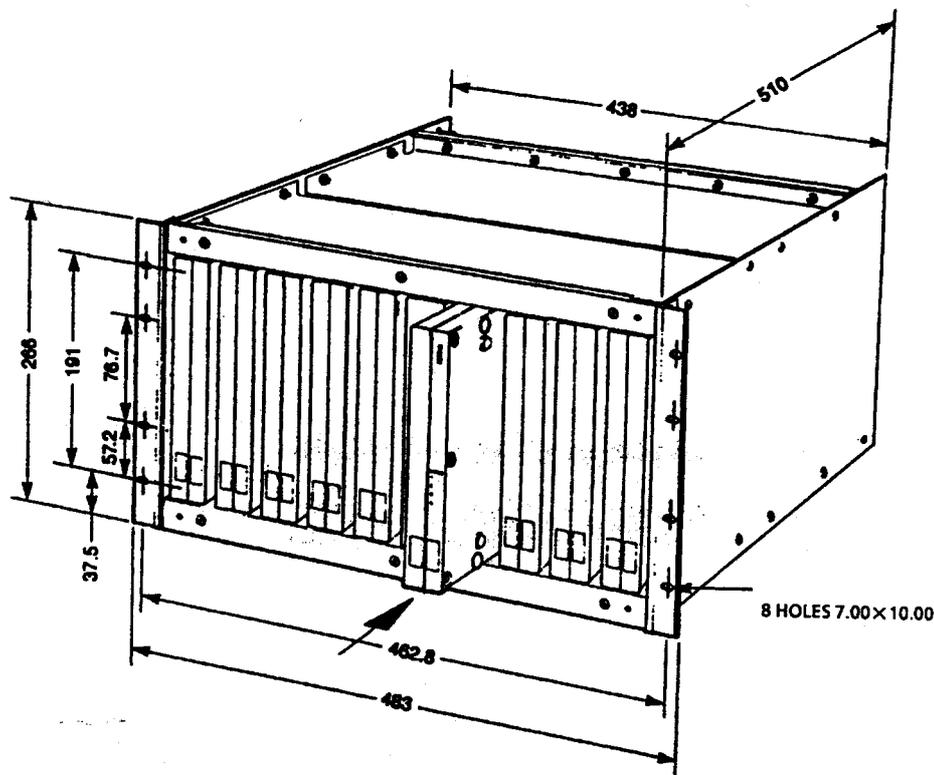


*Figure 3.9  Sliding an IMP into an assembled mounting frame.*

## 3.1    IMP GROUNDING

Grounding studs, threaded M4, are provided in recesses on both sides of each IMP enclosure.  It is normal practice to connect one of the studs to the chassis of the equipment on which the IMP is to be mounted.  Grounding enhances the screening effect of the enclosure, thus improving the IMP's immunity to electrical interference.

Grounding can be done with a short length of wire, equipped with ring terminals at either end.  First connect one end of the wire to the IMP enclosure grounding stud.  Once the IMP has been fitted into the mounting frame, and drawn fully into place by the knurled connector block screws, the free end of the grounding wire can be fastened to the adjacent grounding stud of the upper clamp bar.

( Note: that the IMP enclosure and the internal circuitry are electrically isolated from each other, and can withstand a potential difference of up to 500V.)

The mounting frame must be grounded locally.  Either one of two grounding points should be used.  These points consist of studs (two supplied) which can be screwed into tapped bosses at the rear of the frame side panels.

Isolated Measurement Cards (IMCs) are mounted in a frame, which, in turn, is mounted in a standard 19 inch rack.  The mounting frame is built up from a 359591B Rack Mounting Kit, which is available as an accessory.  Kit assembly instructions and IMC fitting and removal instructions are given below, in Sections 4.1 through 4.4.

**4.1    ASSEMBLING A 359591B RACK MOUNTING KIT**

Before assembling the rack mounting kit, ensure that you have a clear level space on which to work and check that you have a full kit of parts.  A 359591B should contain:

- Two side panels, each fitted with a rack ear.

- Two measurement card support assemblies.

- Two connector card support assemblies.

- One pack of screws, nuts and washers.

These items are identified in Figures 3.10 and 3.11.  (Should any item be missing, contact your Solartron agent immediately.)

When you are ready to start, proceed as follows:

1.    Using the M5 x 10mm screws and M5 crinkle washers supplied, fit the support assemblies to the side panels.

       *The numbers shown beside the screws in Figure 3.11 refer to the holes in the side panels.  Each panel has 48 holes along the top and bottom edges. Numbering from front to rear, hole 1 is under the rack ear, and holes 24 and 25 are used by the jointing plate.  The measurement card support assembly is deeper than the connector card support assembly and is fixed at the front of the mounting frame, adjacent to the rack ears: the numbers printed on the front bar face inwards, as indicated in Figure 3.11.  The connector card support assembly is fixed so that the numbers face inwards and towards the rear of the mounting frame.*

2.    Attach the grounding pillar in either of the positions shown in Figure 3.11.  The pillar assembly details are shown in Figure 3.10
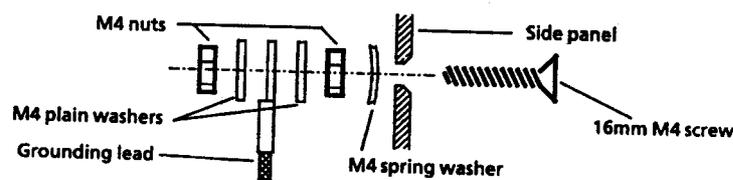


***Figure 3.10  Grounding pillar assembly.  (Viewed from rear of mounting frame.)***

> **WARNING:** To reduce the possibility of electrical shock, take the following precautions:
>
> - Install the IMC mounting frame in an enclosure e.g. a cabinet, and fit blank panels in any unused IMC positions.  (Also ensure that IMCs can not be accessed from the top or bottom of a mounting frame.)
>
> - Connect the mounting frame to ground through the grounding pillar.  Both the mounting frame and the enclosure in which it is mounted must be grounded.  (The design of the enclosure will determine the EMC performance of the system.)
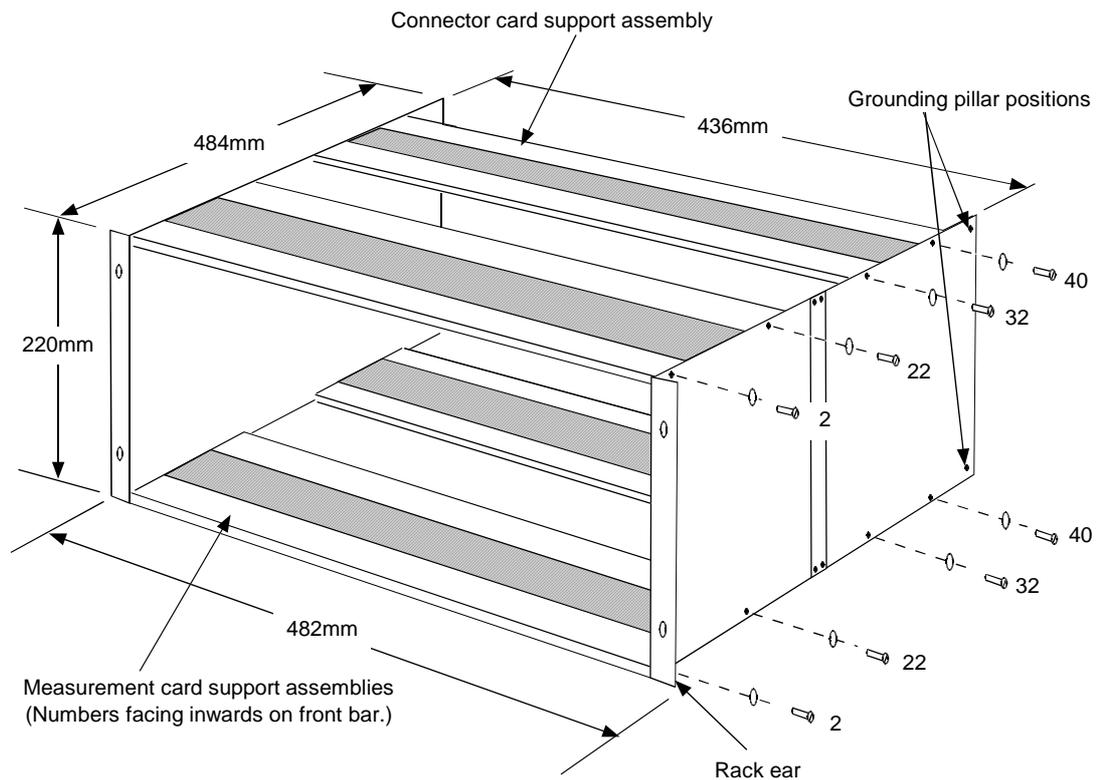


*Figure 3.11   Assembly of IMC mounting frame.*

**359552B Measurement Card**

Location of power source Links
H402 and H401 →

412.5

200      188.9      217.4

28      30

(All dimensions in mm)
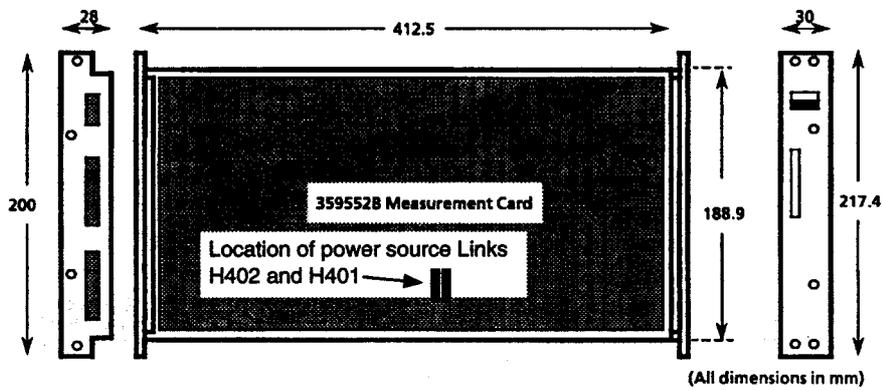
The external dimensions of each IMC, with the connector card plugged into the measurement card, are shown in Figure 3.12.

**Figure 3.12  IMC Dimensions.**



417.5

115.6      284.6

**Connector
Card**      **Measurement Card**

Location of power source Links
LK503 and LK502

217.4      188.9      217.4

412.5

30      29      30

(All dimensions in mm)
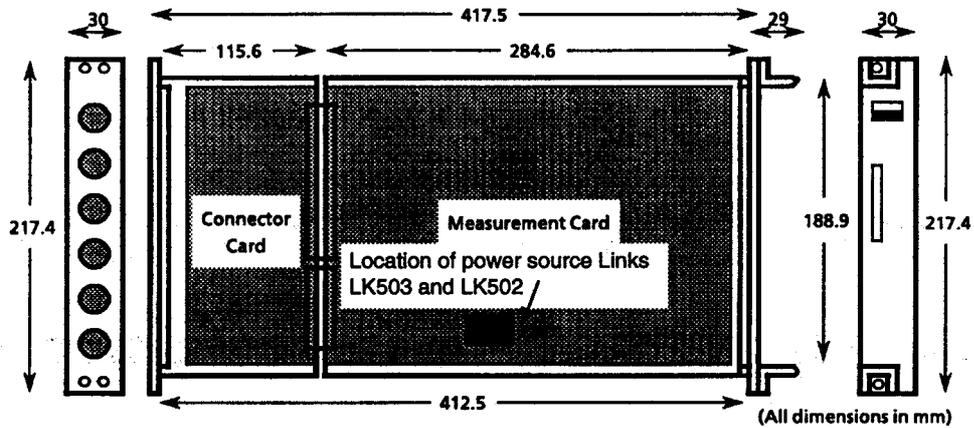
**Figure 3.13  359552B IMC Dimensions.**

## 4.2      FITTING IMCS

The two parts of each IMC are installed separately, as follows:

1.      Fit the measurement card from the front of the mounting frame, by sliding the metal plate into the guides in the card support assemblies until the front panel of the card is flush with the edge of the frame.

2.      Secure the measurement card, using the captive screws located within the card ejectors.

3.      Make the desired connections to the connector card.

4.  Fit the connector card from the rear of the mounting frame, sliding the metal plate into the guides in the card support.  Take care to ensure that the connectors mate easily with the corresponding connectors on the measurement card.

5.  Secure the connector card, using the four captive screws in the panel.

### 4.2.1     Fitting the 359552B IMC

The 2B IMC has no connector blocks so the card is fitted into the rack as follows:

1.  Fit the measurement card from the front of the mounting frame, by sliding the metal plate into the guides in the card support assemblies until the front panel of the card is flush with the edge of the frame.

2.  Locate the two support plates to the rear of the frame so that the locating pins on the plates line up with the holes on the rear of the IMC.

3.  Secure the support plates to the frame.

4.  Push the card into place until the locating pins pop into the card then secure the measurement card, using the captive screws located within the card.

5.  Make the desired connection to the D-type connectors.

### 4.3     REMOVING IMCS

> **WARNING:** Do not attempt to remove any connector card until you are sure that the power to both the S-Net and the system being measured has been disconnected. High voltages may be present at the input terminals.

To remove an IMC, proceed as follows:

1.  Undo the measurement card securing screws.

2.  Separate the measurement and connector cards by pulling the measurement card extractor handles outwards, i.e. away from each other.  This will lever the measurement card partially out of the mounting frame.

3.  If required, slide the measurement card from the front of the mounting frame.

4.  If required, slide the connector card from the rear of the mounting frame.

### 4.3.1 Removing the 359552B IMC

To remove a 2B IMC, proceed as follows:

1. Disconnect the D-Type connectors.

2. Undo the measurement card securing screws.

3. Push the card loose, from the locating pins, from the rear of the mainframe.

4. If required, slide the measurement card from the front of the mounting frame.

## 4.4 SELECTING THE IMC POWER SUPPLY SOURCE

Like the IMPs, the IMCs can be powered either from the Host, via S-Net, or from a local power supply unit. Two internal links (or jumpers, in the case of the 359552B IMC) must be inserted for power from S-Net or removed for local power. Unlike the IMPs, there is no need to send an IMC back for modification: the links (or jumpers) are easily accessible and you can adjust them yourself.

The location of the power supply links for IMCs with a separate connector block is shown in Figure 3.12. The location of the power supply jumpers on the 359552B IMC is shown in Figure 3.13.

The connections to be made for the IMC power supply are described in Chapter 4, Section 4.

## 4.5 ENVIRONMENT

To meet European standards for EMC the IMCs must be installed in a suitable enclosure - for example the VERO IMRACK 3400. IMCs fitted in an IMC rack and enclosed in this way have been tested to:

EN 50081-2 Generic emission, industrial
EN 50082-2 Generic immunity, industrial

Although IMCs use the same printed circuit boards as IMPs, they lack the environmental protection provided by the IMP housing. Therefore some of the specifications are derated; these are detailed in Appendix B.

The following precautions can be taken to minimise these effects:

1. Avoid rapid movements of air across the IMCs; do not use forced air cooling.

2. Keep IMC enclosures away from areas of high humidity.

3. Ensure that the enclosure is sealed as far as possible from dust, dirt , etc.

---

**WARNING:** There is no integral shielding of the input connections on the connector card. It is therefore vital that users are prevented from touching any part of the IMC circuitry, which may carry voltages up to 500V. Note that this may arise even with low signal levels, if there is a high common-mode voltage present.

The IMC mounting frame must be fitted within an enclosure such that it is impossible to make contact with ANY part of the IMC circuitry during operation.

---

# 5        RACK MOUNTED UNIVERSAL IMPS

To allow Universal IMPs to be rack mounted, a rack mounting frame is available for a
standard 19 inch rack.  The mounting frame is built up from a 359591G Rack Mounting
Kit, which is available as an accessory.  Kit assembly instructions and IMP fitting and
removal instructions are given below, in Sections 5.1 through 5.4.

## 5.1        ASSEMBLING A 359591G RACK MOUNTING KIT

Before assembling the rack mounting kit, ensure that you have a clear level space on
which to work and check that you have a full kit of parts.  A 359591G Rack Mounting
Kit should contain:

- Two side panels (35952320A).
- Two IMP support trays (35952321A).
- Eight support tray stiffening bars (12872010A).
- One grounding point strip (35952322A).
- Three fascia strips, one with Solartron logo (35952324A).
- Two rack ears.
- One pack of nylon IMP guides.
- One pack of screws and washers.

Should any item be missing, contact your Solartron agent immediately.

When you are ready to start, proceed as follows:

1.   On each support tray, on the opposite side to the flanges, screw four stiffening bars,
     using the M3×8mm screws and crinkle washers provided.  Ensure that each bar is
     the correct way round, longitudinally, so that all four fixing screws can be inserted.

2.   On each support tray, on the opposite side to the stiffening bars, press in the nylon
     IMP guides.  If you wish, you can press in just sufficient guides for the IMPs you
     currently wish to install.  Remember, however, that it is far easier to install the
     guides at this stage, so if you intend to install more IMPs in the rack at a later date it
     is better to press in sufficient guides for them now.

3.   Screw the support trays to one of the side panels, using the M4×8mm screws and
     crinkle washers provided.  Ensure that the grounding screw on the side panel and the
     nylon guides on the support trays are pointing towards the rack interior.  Start at one
     end and insert each M4 screw without fully tightening it, until all four screws are
     inserted.  Then fully tighten all four screws.

4.   Screw the other side panel to the support trays in the same way as in step 3.  Ensure
     that the grounding screws on the side panels are at the same end of the rack.  This is
     the rear end.

5.   Screw the grounding strip to what will be the top support tray, at the rear, using the
     M3×5mm and crinkle washers provided.  The strip must be oriented with the fixing
     holes at the bottom − that is, with inscription "IMP EARTHING POINTS" the right
     way up and below the grounding studs.

     *(Procedure continued on next page.)*

6. Screw a plain fascia strip to the lower support tray, at the rear, using the M3×5mm screws and crinkle washers provided. The strip must be oriented with the fixing holes at the top.

7. Screw the two fascia strips to the front of the rack mounting frame, using the M3×5mm screws and crinkle washers provided. The top fascia should have the screw holes at the bottom and the bottom fascia should have the screw holes at the top.

8. Screw a rack ear to each side of the rack at the front, using the M4×8mm screws and crinkle washers provided.

The rack is now ready to be installed in a 19 inch cabinet, and should look like the example shown in Figure 3.14.
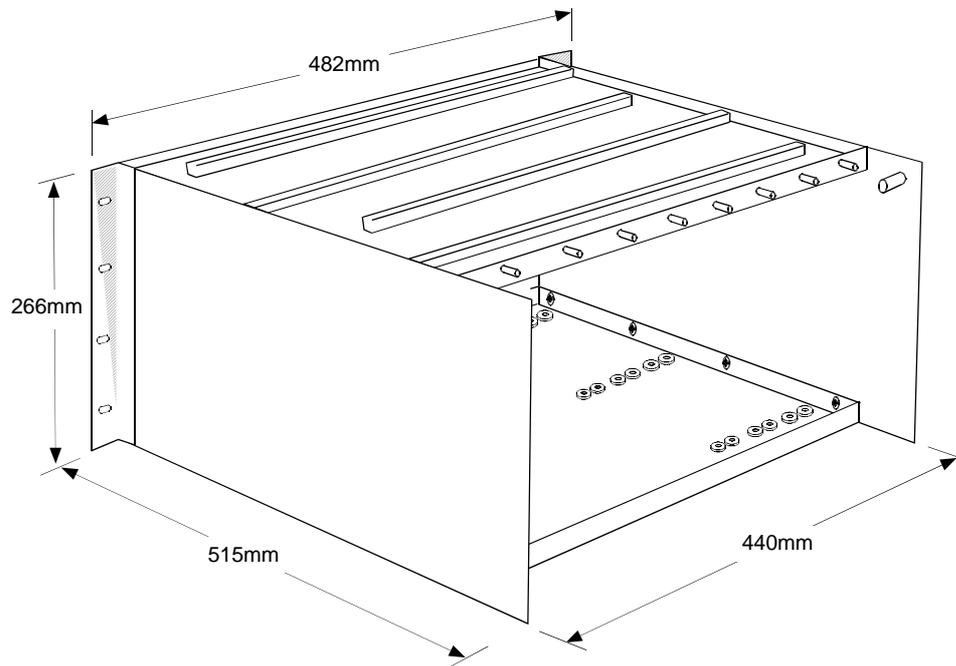


**Figure 3.14   An assembled 359591G rack, viewed from the rear.**

## 5.2 FITTING THE RACK MOUNTING FRAME INTO THE RACK

The rigid construction of the 359591G rack mounting frame and the comparative lightness of the universal IMPs allows the frame to be secured and supported in the rack by the rack ears alone.

To install the mounting frame:

1. Hold the frame against the front of the rack in the required position, with the holes in the rack ears aligned with the fixing points on the rack.

2. Secure the frame to the rack by bolting through the rack ears into the fixing points. Start by inserting a fixing screw in the bottom of each ear to hold the frame in place. Then insert the remaining screws and tighten all screws to secure and support the frame.

3. Connect a grounding braid between the rack mounting frame and the cabinet - use one of the grounding studs located at the rear of the frame, on the side panels.

The frame is now ready for the universal IMPs to be fitted into it.

## 5.3    FITTING THE UNIVERSAL IMPS INTO THE RACK

Universal IMPs can be installed, in the rack mounting frame, with the connector block fitted.  The procedure is:

1. On each IMP to be mounted in the rack securely attach a short length (approx. 150mm) of grounding braid to the grounding stud.

2. Remove the back fascia strips from the rack mounting frame.

3. Slide each universal IMP into the rack mounting frame from the back, engaging the flanges of the IMP case between the relevant pair of nylon guides.  Ensure that the grounding braid on each IMP remains protuding from the rear of the rack mounting frame.

4. When all IMPs have been installed in the rack, screw the fascia strips back onto the rear of the rack mounting frame, using the M3×5mm screws and crinkle washers removed in step 2.

5. At the rear of the rack mounting frame, attach the IMP bonding braids securely to the corresponding studs on the grounding fascia.

6. At the rear of the rack mounting frame, complete the connections to each IMP in turn: remove the connector block, make the relevant connections, and refit the connector block.  This will help to ensure that all connections are made correctly.

## 5.4    REMOVING THE PCBS FROM RACK MOUNTED UNIVERSAL IMPS

The connector block and the main pcb can be removed from a universal IMP whilst the IMP is in the rack.  Simply undo the two endcap securing screws and withdraw the pcb from the IMP case.  (Initially, some effort may be required to separate the two pcbs from each other.)

# 4

## IMP Connections

## Contents

### List of Figures

## *List of Tables*

# 1    IMP CONNECTOR BLOCKS

For installation purposes, an IMP can be considered as comprising two parts:

a.  The main cast-aluminium enclosure containing the electronic circuitry.  This enclosure has mounting holes, for securing the IMP in close proximity to the signal source.

b.  A detachable connector block, to which all IMP connections are made, via screw terminals.  Each connector block is retained in its IMP enclosure by two knurled screws.  Once a block has been withdrawn its screw terminals can be accessed by removing the cover.  The cover is secured by two cheese head screws.

Various IMPs and connector blocks are available.  It is essential that the correct block is used with the appropriate IMP.  The connector blocks and IMPs should be paired as shown in Table 4.1.

*Table 4.1   IMP and Connector Block Functions.*

| IMP | Connector Block | Measurement Function |
|---|---|---|
| 35951A | 35953A | Voltage, current, temperature (thermocouple). |
| 35951C | 35953A | Voltage, current, temperature (thermocouple). |
| 35951B | 35953B | Voltage, resistance, strain gages, temperature (PRT or RTD or PT100). |
| 35951D | 35953E | Analog Output. |
| 35951E | 35953A | Voltage, current, temperature (thermocouple). |
| 35951H | 35953J | Universal IMP (Channel-to-channel isolation 200V). |
| 35951J | 35953J | Universal IMP (Channel-to-channel isolation 500V). |
| 35952A | 35953C | Digital input/output. |
| 35952B | 35953F | Switch input/output. |
| 359593D | 35953H | RS232 to S-Net Interface. |
| | | |
| Vibration IMPs | | |
| 35951F | 35953G | Vibration signal measurement (16 inputs). |
| 35951G | 35953G | Vibration signal measurement (32 inputs). |

Details of the 39593J connector block, used by the Universal IMPs type '1H and '1J, are given in Chapter 12.

For IMPs type 35951C and 35951E, an optional connector block (35953D) is available with built-in attenuators.  These permit higher voltages to be measured.

**Note:**    The molded rubber protector supplied with each IMP should be fitted to the edge connector of the connector block whenever it is removed from the IMP.  If required, additional environmental protection can be provided for the connector block by fitting a dummy IMP case (359592A).

---

**WARNING:** Several IMP types are capable of withstanding up to 500 volts between input channels.  This means that **potentially lethal voltages**, sourced from the system being monitored, may be present on the connector blocks.

**To ensure operator safety** extreme care must be taken to isolate high voltages from the connector block whenever channel connections are being altered.

---

## 2　CABLE ENTRY SEALING

To maintain the environmental specification, all connections to the IMPs must be properly sealed.  Protective rubber "boots" (Figure 4.1) are provided for this purpose and the "teats" on these should be cut to a length such that leads passed through them are firmly gripped, thereby forming a seal.

Tip of "teat" cut off to allow insertion of connecting lead
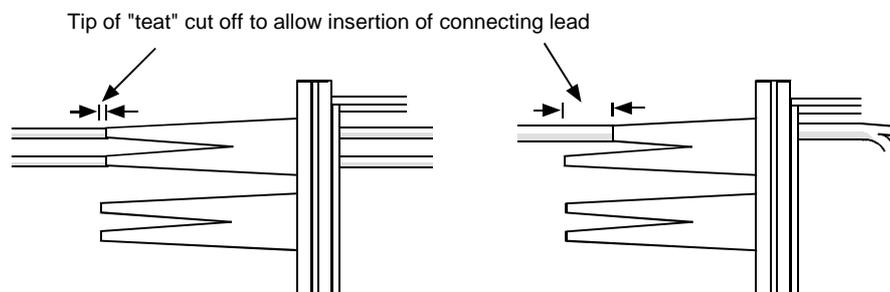


Note that on multiple teat boots, you may use one or more teats, as required by the type of lead in use.  Do not, however, cut unused teats.

**Figure 4.1   Sealing the IMP connections with protective boots.**

To effect a good seal, it is important that the cross-section of the leads is more or less circular.  With twisted pairs a waterproof sealing compound such as "Bostic" may be necessary.  (See Figure 4.2.)



No sealing problems.　　　No sealing problems.　　　Use a waterproofing compound such as Bostik to effect a seal.
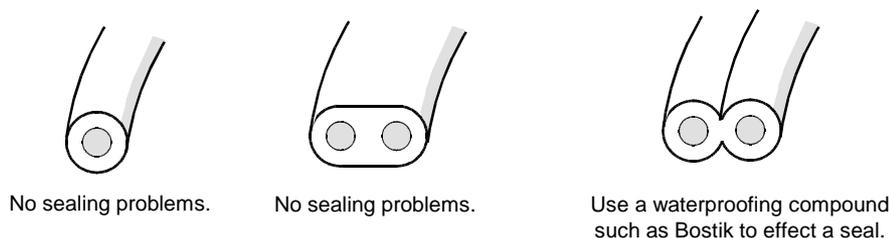
**Figure 4.2   Cross-sections of typical leads.**

The general procedure for making connections to an IMP is given below.  Details of the S-Net connections are given in Section 3 in this chapter, whilst specific IMP terminations are described in Chapters 5 through 9.

The general procedure is:

1.　Undo the two cover retaining screws and withdraw the cover from the rear of the connector block.

2.　With a sharp blade, cut the tip off a rubber teat for each lead to be connected.  (To ensure a good seal, be careful not to cut off too much in one go!)

3.　Push the first lead to be connected through the prepared teat.  To ease its passage the lead may be lubricated with silicone grease and, if necessary, a sleeve expansion tool used to stretch the teat slightly prior to lead insertion.

4. Strip off a 6mm length of insulation from each wire and connect as shown in the relevant IMP/connector block chapter.  With multi-wire leads having a separate cover, remove just sufficient of the outer cover to allow wire separation: ensure that the outer cover remains sealed by the boot.

5. Connect the remainder of the output leads, as described in Steps 3 and 4.

6. Refit the connector block cover, remembering to locate the two "nibs" on the rear of the cover under the pcb, before locating the screws in their respective bushes and tightening them down.

**Note:**    Users who require to use multicore, armoured, or other thick cables may choose the optional 35963 series of industrial (glanded) connectors; these offer industry standard glands as an alternative cable entry.  Cable glands are described in Section 4.

## 2.1    CABLE GLAND DETAILS (359563 SERIES CONNECTORS)

The 359563 Series connector blocks are each fitted with six nylon cable glands, that provide a moisture-proof seal for the cable entry (see Figure 4.3).  The glands are fitted with Nitrile compression bushes, nylon skid washers and M16 nylon clamping bushes. Four of the clamping bushes allow for a cable outer diameter of 3.5mm to 6.5mm, whilst the other two allow for an outer diameter of 6.5mm to 10.5mm for the S-Net connections in and out.  Unused glands must be sealed with the M16 stopping plugs provided.
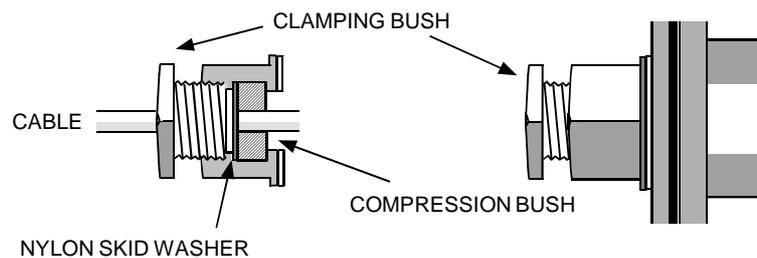


*Figure 4.3    Cable gland details of 359563 Series Connectors.*

To seal a cable effectively, slacken off the clamping bush, pass the cable through the clamping and compression bushes then, having connected the cable to the terminals, tighten the clamping bush until the compression bush expands to seal the cable entry.

## 2.2    CONSIDERATIONS FOR LARGE DIAMETER S-NET CABLES

The diameter of a low a.c. attenuation S-Net cable (18 AWG) is too large to allow the cable to pass through a multi-teat boot, or gland, on an IMP connector block.  For a 3595 Series connector block, with multi-teat boots fitted, there are two solutions to this problem: you can either use a uni-teat boot, which allows the passage of a large diameter cable, or you can prepare the cable as described in Section 2.3.  Preparing a cable reduces the diameter over a short length which is then able to pass through a multi-teat boot, or gland.

Uni-teat boots are available under Part No. 359594A.  This number orders a pack of twenty rubber sleeves for large diameter S-Net cables.

Uni-teat boots can not be fitted, in place of glands, to 35963 Series connector blocks. In this case, therefore, the only solution is to prepare the cable so that it passes through the gland (see Section 2.3).

## 2.3 PREPARATION OF LARGE DIAMETER S-NET CABLES

To allow a large diameter S-Net cable to pass through a multiple-teat boot, or gland, the cable should be prepared as shown in Figure 4.4.

Large Diameter S-Net Cable

Diameter too large to pass through teat or gland.

1. Cut back the outer cover:

2. Cut back the braid and fashion it into a pigtail:

3. Solder a wire to the braid, for the shield connection:

4. Fit a pvc sheath over the wires:

5. Seal the join with a heat-shrink sleeve:

The sheathed wires may now be passed through the teat or gland.
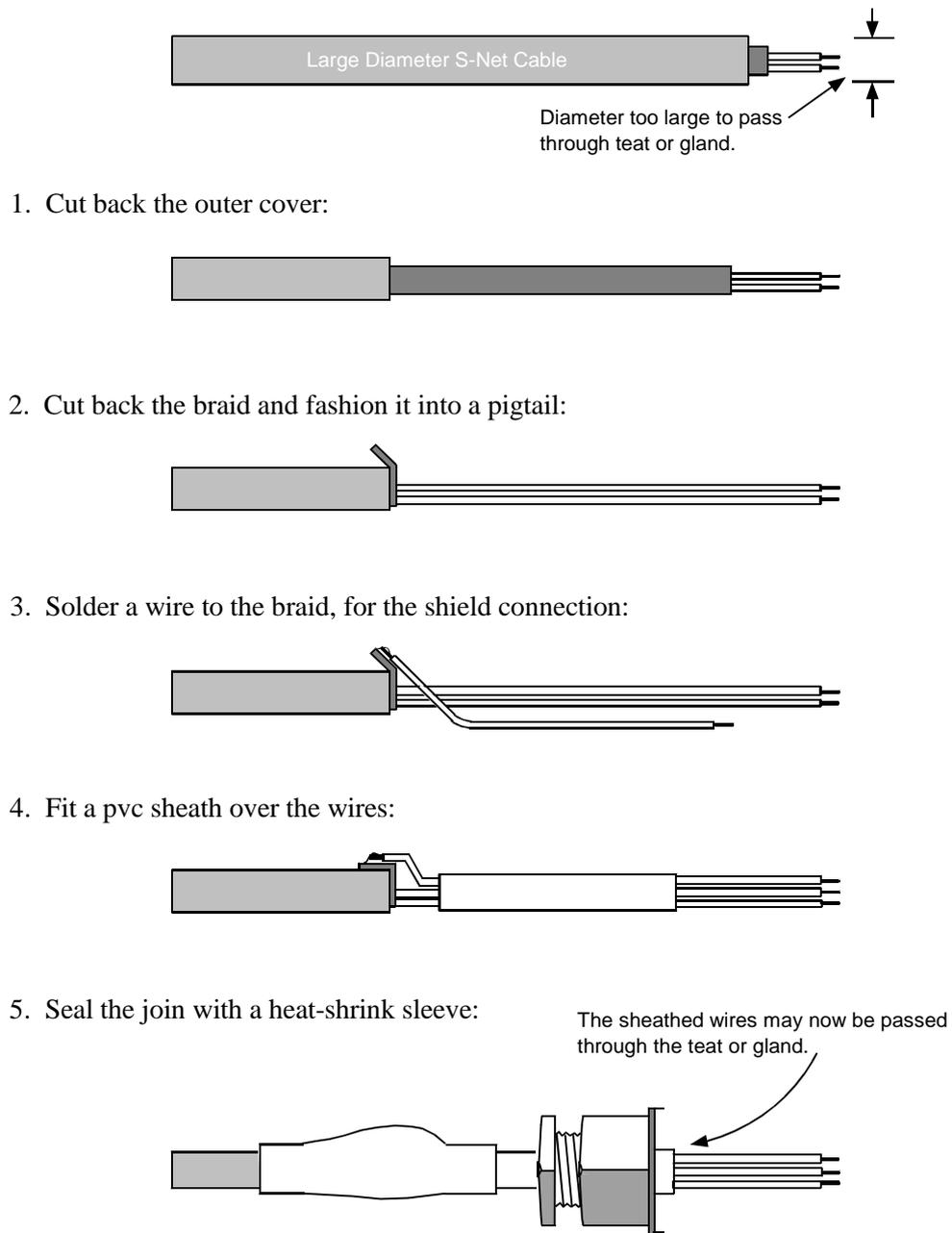
**Note that the diameter of the sheathed wires should be at least 6.5mm for gland sealing.**

*Figure 4.4   Preparing a large diameter S-Net cable.*

# 3        S-NET CABLING

S-Net allows up to 50 IMPs (the actual number depending on the host interface) to be connected into a distributed measurement system and, using low-loss cable, the total cable length involved can be up to 1.5k meters.  S-Net conveys all control signals from the host to the IMPs, and all measurement data and status signals from the IMPs back to the host.  A dc supply can be conveyed from the host to the IMPs by maintaining a dc level (for example, 48V) across the twin wires of S-Net.

## 3.1        S-NET CONNECTIONS

The S-Net terminals, local power terminals and the IMP address switches (S1 and S2) are located on the connector block, as shown in Figure 4.5.  To connect the S-Net cable, remove the connector block cover to gain access to the terminals and make the appropriate connections.  When using the Belden 8641 cable supplied by Solartron, connect the black lead to '+', the white lead to '−' and the braid to 'S'.
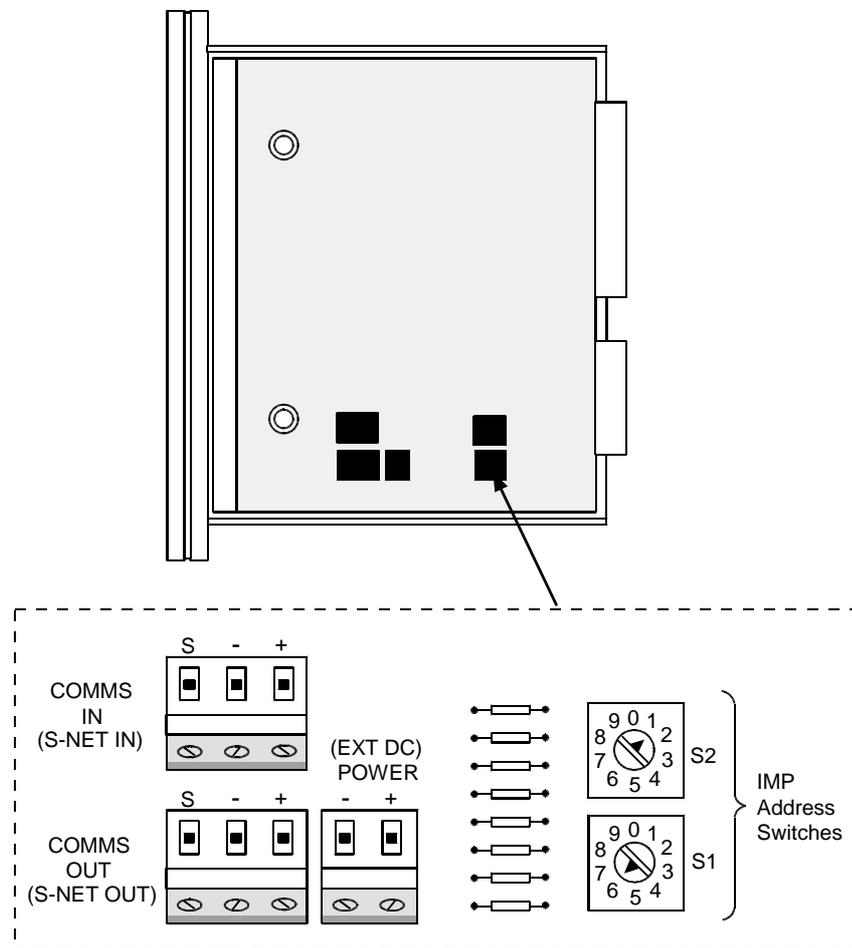


***Figure 4.5   S-Net terminals, power terminals and IMP address switches.***

The 359552B IMC differs from the other modules by using a 9-way D-Type connector for the S-Net rather than the connector block. The S-Net connections made to the D-Type connector are shown in Figure 4.6.
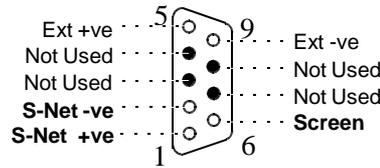


**Figure 4.6   S-Net connections for the '2B.**

The voltage delivered to the IMP can be measured across the "+" and " - " terminals, but this should be done only during setting up since a voltmeter can impose an undesirable load on the rest of the network.

IMPs are multi-dropped from the S-Net cable, as shown in the example in Fig 4.7. Polarity must be strictly observed, that is the '+' to '+', '−' to '−', and 'S' (screen) to 'S' connections must be maintained throughout the network. No universal color coding scheme can be specified for connecting the IMPs, as the colors may vary according to the type of cable being used. The colors shown in Figure 4.7 are those of the Belden 8641 cable, supplied by Solartron. **Note that the S-Net cable should have a minimum length of 500mm (20 inches) between IMPs and 1 metre (39ins) between VIMPs.**
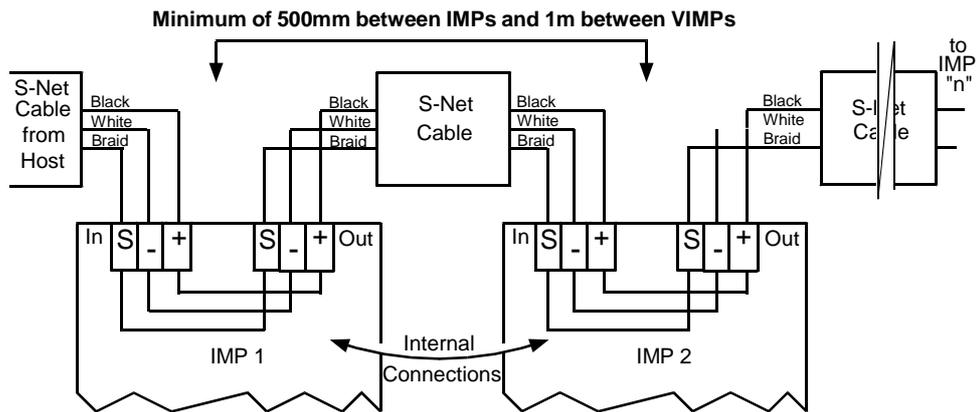


**Figure 4.7   Multi-dropped connections of IMPs from the S-Net cable.**

When replacing the connector block cover, remember to locate the two "nibs" on the rear of the cover under the pcb, before locating the screws in their respective bushes and tightening them down.

## 3.2      S-NET TERMINATION

The IMPs, and S-Net Interface in the host computer, are high impedance devices, whilst the S-Net cable which interconnects them has a characteristic impedance of approximately 100Ω. Therefore, to avoid signal reflections, the S-Net cable must be correctly terminated at both ends.

The way in which the S-Net cable is terminated depends on where the Interface is placed in the S-Net system. The two possibilities are shown in Figs 4.8a and 4.8b.
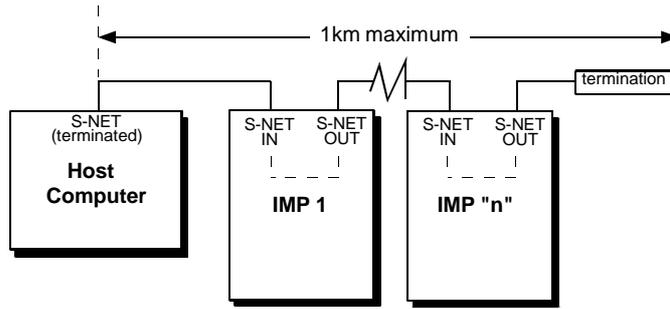
a) *S-Net terminations with the Interface at the end of the S-Net.*
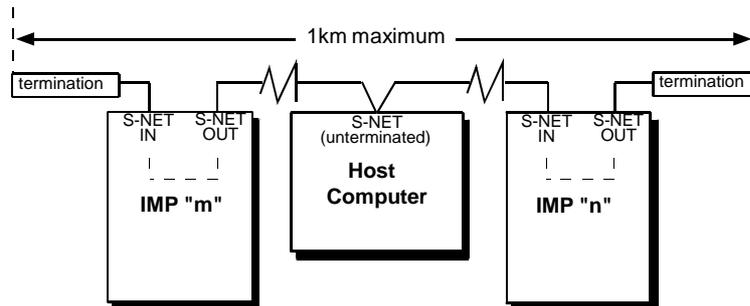


b) *S-Net terminations with the S-Net Interface connected between two IMPs on the S-Net.*

**Figure 4.8   S-Net terminations.**

Standard Solartron interfaces have a built-in terminator, which can be linked in or out of circuit, as required.  The terminator is linked "in-circuit" for the single-ended configuration shown in Figure 4.8a, but is not linked when the Interface is placed between two IMPs (Figure 4.8b).  The interface is supplied with the terminator in circuit.  See the appropriate interface card operating manual for details.

A terminator must also be fitted to the "S-NET OUT" terminals of the IMP(s) at the end(s) of the S-Net cable.  In the configuration shown in Figure 4.8a the IMP at the opposite end to the Interface must have a terminator fitted, whilst in the configuration shown in Figure 4.8b the IMPs at either end of the S-Net must each have a terminator fitted.

Two terminators (part number 35900222) are supplied with the host computer interface card, as part of the accessory kit.  They are of the molded type and fit into the "S-NET OUT" terminals of the IMP(s) at the end(s) of the network, as shown in Figure 4.9a.

(Suitable termination can also be provided by a 120$\Omega$ 1/4W resistor in series with a 0.1$\mu$F, 100V capacitor, as shown in Figure 4.9b.)
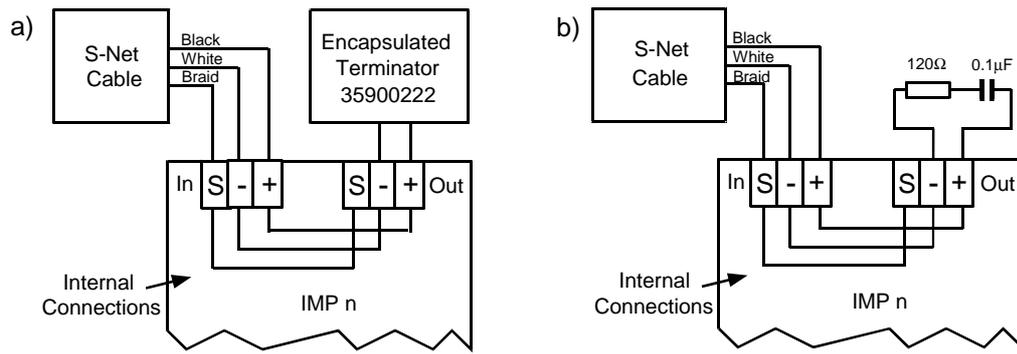
*Figure 4.9   Terminating the S-Net at an IMP.*

## 3.3     IN-LINE CONNECTIONS FOR OCCASIONAL IMPS

At a site where an IMP is used only occasionally it is permissible for S-Net to be
connected by means of in-line connectors.  This allows the IMP to be inserted into the
network when required and removed when it is not.  Figure 4.10 shows the simple
connections involved.
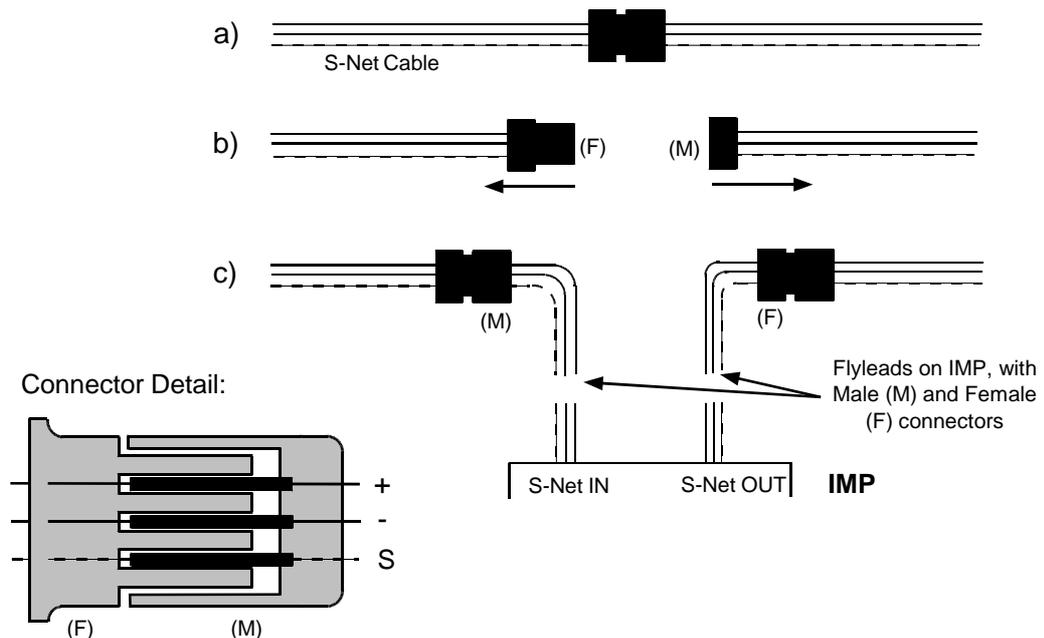


*Figure 4.10   In-line connections for occasional IMPs.*

The connectors should be of good quality and electrically matched, and must not
incorporate filters or attenuators.  Where the IMP is sited in a clean and dry
environment a professional audio/video connector such as the Neutrik/ITT XLR Series
can be used.  Where moisture is likely to present then an appropriate sealed connector
must be used.  In a particularly hostile environment, it is recommended that the in-line
connectors are protected to the same degree as the IMPs and S-Net cable.

## 4     IMP AND IMC POWER SUPPLY

Normally, power is supplied to each IMP or IMC down the S-Net cable (sourced via a socket on the rear panel of the interface card or from the host's power supply). Alternatively, local power can be supplied to IMPs or IMCs at their EXT DC (POWER) terminals.

To set up an IMP or IMC to receive its power supply from one source or the other, two links must be adjusted. The procedure for this is as follows:

- Return IMPs Type 3595 1A, '1B, '1C, '1D, '1E, '2A, '2B and '3D to a Solartron Service Centre for modification. Do not attempt to open any of these units, as you may destroy the sealing of the cork gasket.

- Universal IMPs Type 3595 1H and '1J can be opened up and the links adjusted, as described in Chapter 12, Section 6, of this manual.

- The links on the IMCs are easily accessible and may be adjusted as described in Chapter 3, Section 4.4, of this manual.

For all IMPs, and for all IMCs except the 3595 52B, the EXT. DC terminals are arranged as shown in Figure 4.5.

External power for the IMC 3595 52B is routed through the same 9-way D-Type connector as that used by S-Net. The external dc connections on this are shown in Figure 4.11.
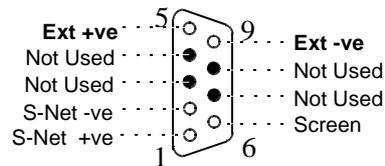


*Figure 4.11   External power connections for IMC 3595 52B.*

**CAUTION:** The host, a local power supply, or an IMP may be damaged if the IMP receives local and remote power simultaneously. This can happen if an external supply is connected to an IMP or IMC with the power supply links inserted.

## 4.1    POWER SUPPLY UNITS AVAILABLE

The power supply units available for IMPs are the 359595A and the 359595B.

The 359595A is designed to provide power for the IMPs from the host end of the network.  It can provide up to140 Watts of power, at 48Vd.c, which is sufficient power for a worst case system with 50 IMPs on a single network.  The 359595A is a modular unit and must be fitted in an enclosure.  This is to prevent any possibility of contact with live parts through the ventilation holes, and to protect the unit from adverse operating conditions such as damp and excessive dust.  Users must comply with the installation instructions supplied with the unit.

The 359595B is designed to be installed close to the IMPs, at the remote end of an S-Net network.  It is enclosed in a protective cabinet, together with a DIN rail for field wiring connections.  It can provide up to 50 Watts of power, at 48Vd.c,  but it is recommended that no more than 20 Universal IMPs ('1H and '1J) or 30 IMPs of any other type are connected to any one unit.  This is to avoid problems with excessive heat dissipation within the protective cabinet.  In addition to powering IMPs, the 359595B can be used as a power source for transducer conditioning.  Full instructions are supplied with the unit.

**Note:** The 359595A and B units are both configured for 250VAC input by the manufacturer.  They must be adjusted for the local mains supply voltage where necessary.

### 4.1.1    Power Supply Connections

**Warning**: Before attempting to connect a power supply unit, you must disconnect the ac supply.

**On the 3595 95A** the connections are made directly to screw terminals contained in the unit.  To gain access to these terminals undo the two screws which hold the terminal block cover.  Figure 4.12 shows the connections to be made.  Replace the terminal block cover after the connections are made.
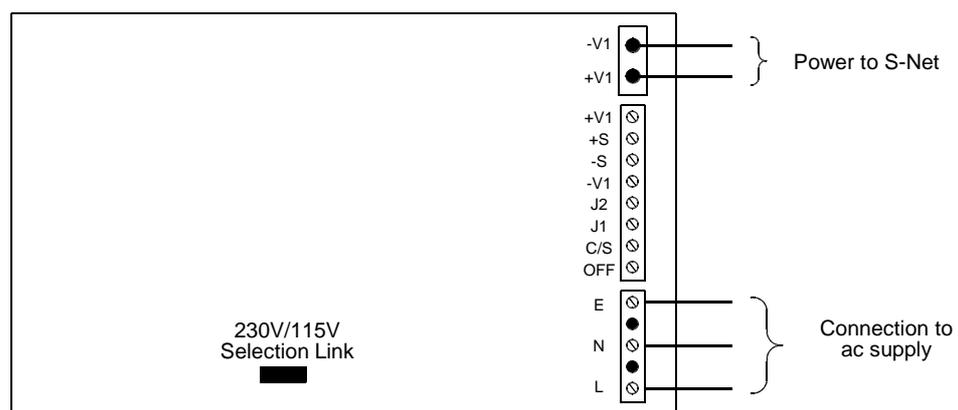


*Figure 4.12   Connections to the 3595 95A power unit.*

The **3595 95B** connections are shown in Figure 4.13.

Klippon terminals can be fitted to the interior of the 3595 95B cabinet. To use these terminals, connect a wire link between each klippon terminal and the corresponding terminal on the internal power supply unit. Then connect S-Net and the ac supply connections to the klippon terminals, as shown.

Access to the screw terminals on the internal power supply unit is gained through slots in the cover.
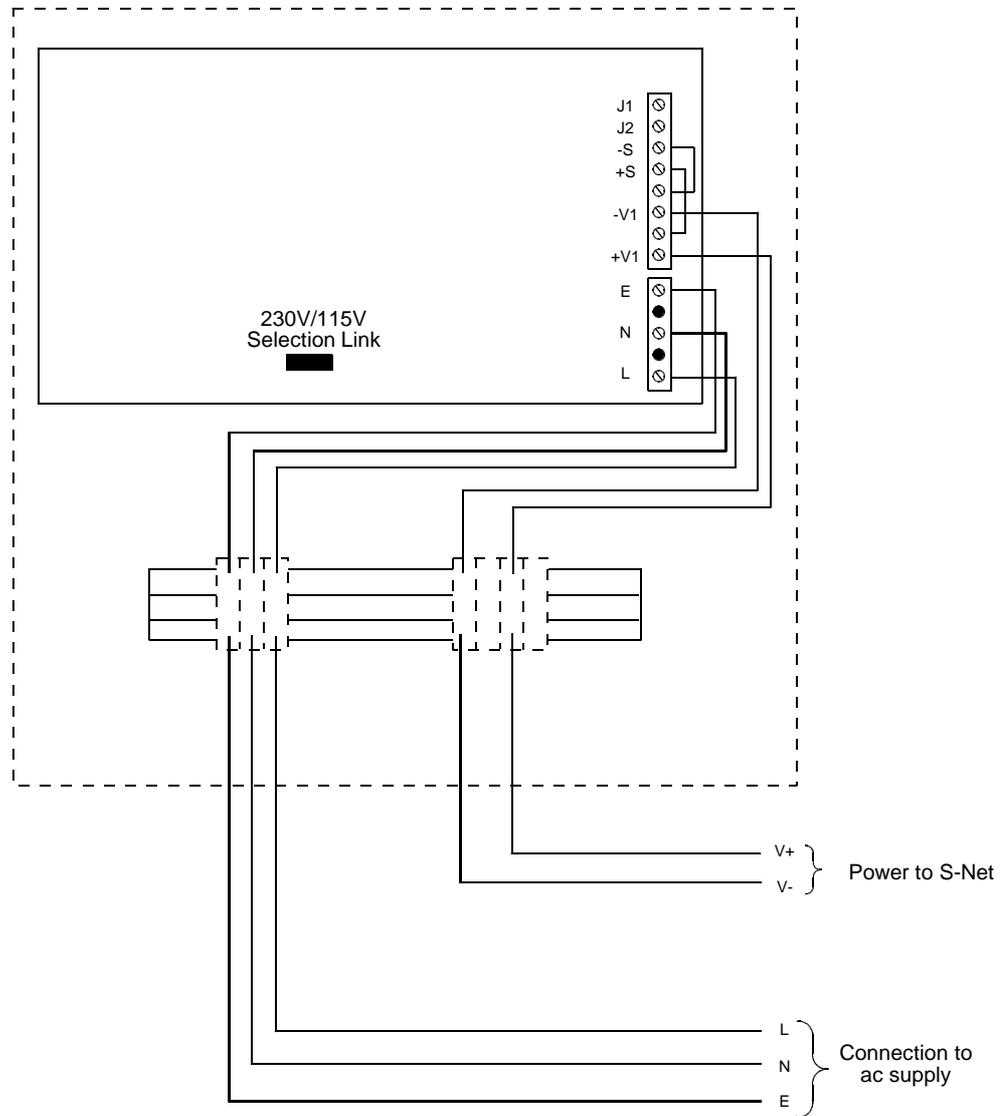


*Figure 4.13   Connections to the 3595 95B power unit.*

## 4.2    VIMP POWER SUPPLY UNIT

The vibration measurement "front end" of a VIMP is always powered locally, from a 359595D Power Supply Unit.  This unit can provide sufficient power for two VIMPs, of either type (35951F or G).  [Note that a VIMP must also receive power from S-Net, for the S-Net interface.]

### 4.2.1    Fitting Feet to the VIMP Power Supply Unit

The four mounting feet of the 359595D Power Supply Unit are bolted individually to the unit.  In each case, the bolt is fed through a hole in the corner of the case from the inside and screwed into the foot on the outside.

**WARNING:** The feet of the power supply unit constitute exposed metalwork and therefore ***they must be grounded***.  To ensure this a star washer must be fitted beneath the head of each foot fixing bolt, on the inside of the unit.  See Figure 4.14.
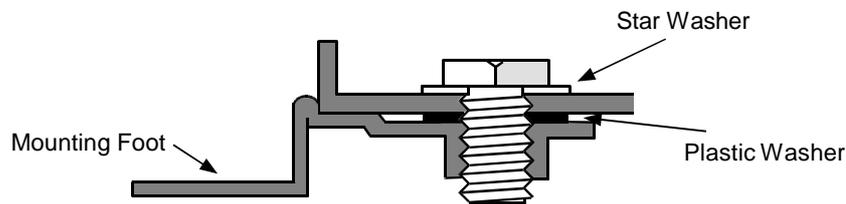


*Figure 4.14   Foot securing detail for the 359595D Power Supply Unit.*

***To maintain sealing*** a plastic washer must be fitted between the case and each foot, on the outside of the power supply unit.  See Figure 4.14.

# 5    SENSOR CONNECTIONS

All connections from the measurement sensors (for example, thermocouples and strain gages) are made at the IMP connector block.  As each IMP can receive an input from up to thirty-two sensors, it is advisable to keep a record of them.  For this purpose,each IMP connector block has a label onto which details can be written, using most types of pen.  The layout of the label corresponds to that of the connector block terminals.

Details of the sensor connections for each type of IMP are contained in Chapters 5 through 10.

## 6 IMP ADDRESS SWITCHES

To enable coherent communication between the host computer and the IMPs, each IMP must have a unique, fixed address. The same thing applies to the VIMPs, and the information given below applies equally to these units.

An IMP address is set up by means of the two rotary switches S1 (units) and S2 (tens) on the connector block pcb. As an example, the address switches (Figure 4.15) are shown set to 16.
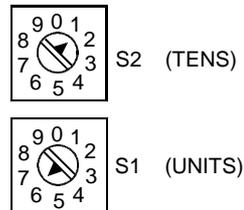


**Figure 4.15   IMP address switches, set to '16'.**

An IMP reads its address at power-up. Hence, if the address of an IMP is changed, the new address will not be registered until the IMP is next powered-up.

**Note:** If an application program for the host computer has already been written, references to IMPs at specific addresses may have been included. In this case, it is essential that each IMP is assigned the same address as that used in the application program.

# 5

## IMPs  3595 1A,C,E
## + Connector Blocks 3595 3A,D
### (also covers IMCs 3595 51A,C,E and Connector Blocks 3595 53A,D)

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# 1    INPUT CONNECTIONS

The IMPs 35951A, 35951C and 35951E each have twenty switched channels which can be individually configured to measure voltage, current or temperature (by thermocouple).
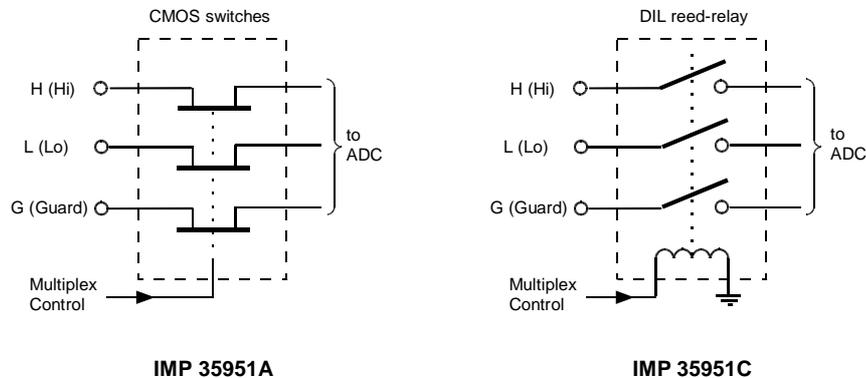


**Fig 5.1    Schematic of the channel inputs.**

For general applications, the IMPs are used with the 35953A connector block.  This block provides three connections per channel: H (Hi), L (Lo), and G (Guard), the latter giving protection against series and common mode interference.  Whilst it is not essential to terminate unused channel inputs, it is nevertheless good practice to link terminals H, L and G.  Alternatively, the IMP can be commanded to "skip" unused channels.  In an electrically noisy environment, it is advisable to implement *both* the above precautions.

For the 35951C and 35951E IMPs only, where voltages larger than 10V are to be measured, the 35953D connector block with built-in attenuators is required.  35953D also has three connections per channel: HA (Hi Attenuated), HP (Hi P) and L (Lo).  A Guard connection is permanently wired within the connector block to provide protection against series and common mode interference.  As with the 35953A connector block, it is not essential to terminate unused channel inputs, but it is nevertheless good practice to link terminals HA, HP and L.  Alternatively, the IMP can be commanded to "skip" unused channels.  In an electrically noisy environment, it is advisable to implement *both* the above precautions.

Note that interference rejection is more effective with the 35953A connector block owing to the separate Guard terminal.  Therefore, for any critical measurement or where severe interference (series or common mode) may occur, it is advisable to use the 35953A connector block.

---

**WARNING:** Several IMP types are capable of withstanding up to 500 volts between input channels.  This means that **potentially lethal voltages**, sourced from the system being monitored, may be present on the connector blocks.

**To ensure operator safety** extreme care must be taken to isolate high voltages from the connector block whenever channel connections are being altered.

---

## 2    INTERNAL ORGANISATION

The IMP is shown schematically in Figure 5.2, and consists basically of:

a.    the microprocessor,

b.    a logic array to handle network communications,

c.    an input multiplexer to switch through the twenty channels,

d.    an Analogue-to-Digital Convertor (ADC).

The ADC in the IMP is of the Solartron pulse-width type.  The integration (measurement) time has a default value of 20ms which automatically tends to cancel out interference derived from 50Hz mains supplies.  For those countries using 60Hz supplies, the integration time can be set to 16.66ms by command from the host.
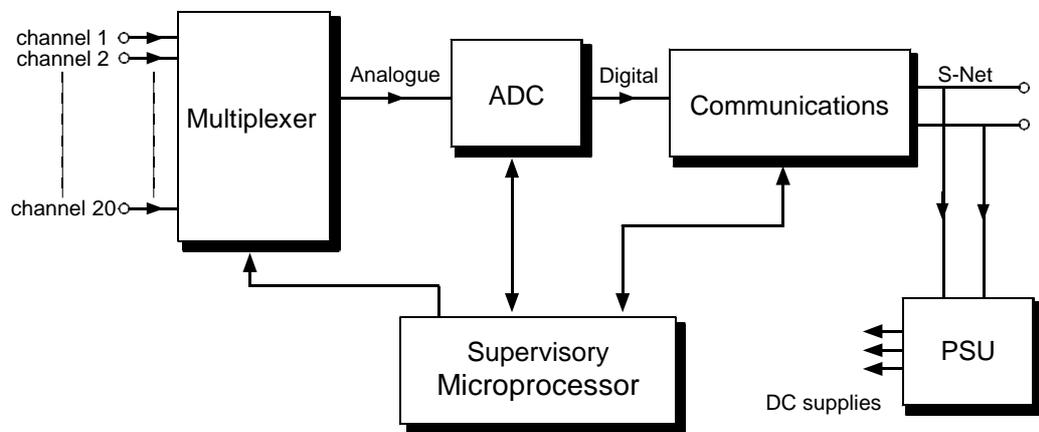


***Fig 5.2    Schematic of the IMP operation.***

# 3    MEASUREMENT PREPARATIONS

## 3.1    VOLTAGE

Voltage can be measured with either the 35953A or 35953D connector blocks.  Ranges 20mV, 200mV, 2V, 10V and autorange are available.  With the IMPs 35951C and 35951E only, voltages above 10V can be measured on the 10V range, using the attenuated (50:1) input of the 35953D connector block.  In this case, all results received by the host must be multiplied by 50.

For optimum protection against electrical interference, when using the 35953A connector block, connect the G(Guard) terminal to L(Lo) as shown in Fig 5.3.  G(Guard) must not be left disconnected since it forms an integral part of the measurement circuitry.

With the 35953D connector block, the Guard is permanently connected to Lo internally and requires no action by the user.
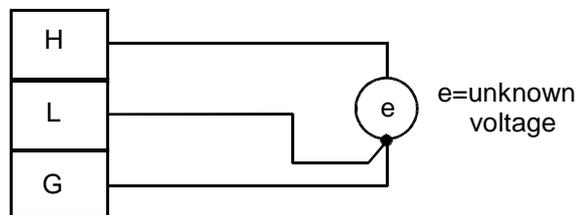


*Fig 5.3    Voltage measurement with the 35953A connector block.*
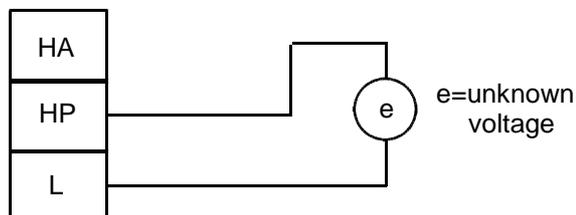


*Fig 5.4    Voltage measurement with the 35953D connector block.*
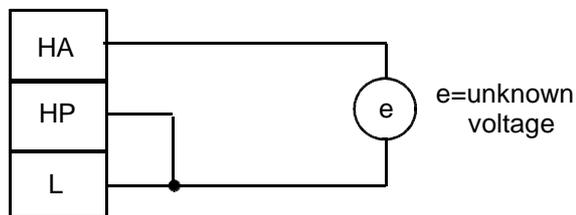


**Note**:  When voltages are measured via the attenuated (50:1) input all results received by the host must be multiplied by 50.

*Fig 5.5    Attenuated voltage measurement with the 35953D connector block.*

## 3.2    CURRENT

The IMP derives the value of the current by measuring the voltage (V) developed across a fixed precision resistor (R), then calculating the ratio V/R.  The ranges available are: 200µA, 2mA, 20mA, 100mA and autorange.  Scaling within the IMP assumes that the value of resistor R is 100Ω.  Other values of resistance can be used but the results must be re-scaled accordingly.  For example, if a 1000Ω resistor is used, results received by the host must be divided by 10.

For optimum protection against electrical interference when using the 35953A connector block, connect the G(Guard) terminal to L(Lo) as shown in Fig 5.6.  G(Guard) must never be left disconnected since it forms an integral part of the measurement circuitry.

In the 35953D connector block, the Guard is permanently connected to Lo internally and requires no action by the user.

*A 100Ω resistor must be soldered to the 'R' termi-nals on the connector block pcb for each channel that is to measure current.*



**Fig 5.6    Current Measurement with the 35953A connector block.**

*A 100Ω resistor must be soldered to the 'HP' and 'L' terminals on the connector block pcb for each channel that is to measure current.*
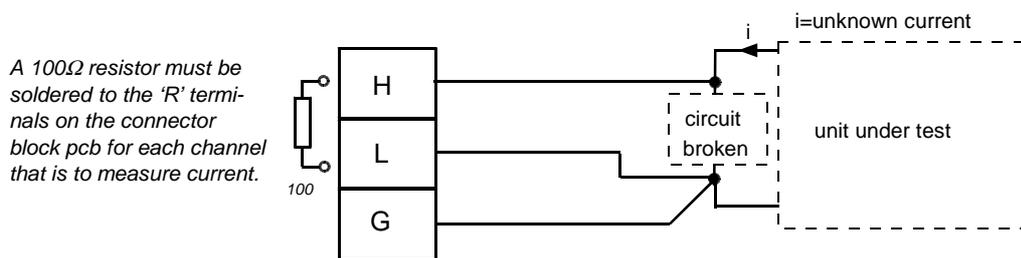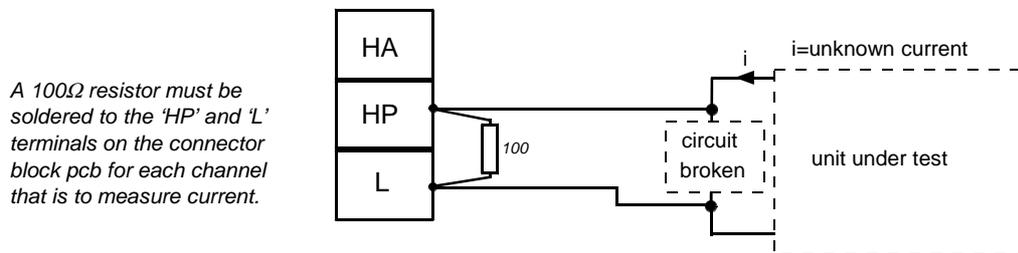


**Fig 5.7    Current Measurement with the 35953D connector block.**

## 3.3 TEMPERATURE

The IMP calculates temperature by measuring and linearising the voltage produced by a thermocouple (types E, J, K, R, S, T, B and N, can be accommodated).

The reference[1] junctions can be formed at the connector block terminals, as shown in Figure 5.8a. In this case, built-in thermistors (35953A connector block only) sense the local (ambient) temperature.

Alternatively, an external reference junctions can be used, and held at a user-defined temperature (for example: 0°C, in a bath of melting ice), as shown in Figure 5.8b. Copper leads are used to join the cold junction to the connector block. There are actually two reference junctions, formed where the copper leads join Metals A and B: these junctions must be maintained at the same temperature.

For optimum protection against electrical interference when using the 35953A connector block, connect the G(Guard) terminal to L(Lo) as shown in Fig 5.8. G(Guard) must not be left disconnected since it forms an integral part of the measurement circuitry.
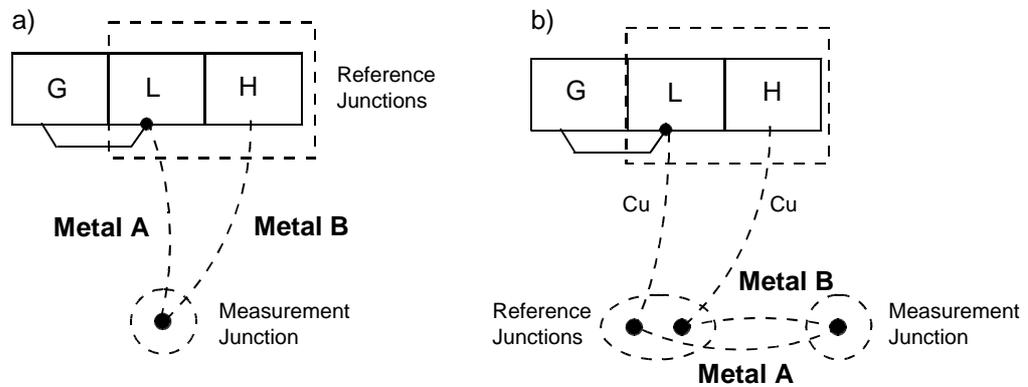


***Fig 5.8    Temperature measurement with the 35953A connector block.***


# 4       LED DISPLAYS

The four LEDs visible at the end face of the IMP convey certain user-confidence information when illuminated. They are allocated as shown in Table 5.1.

**Table 5.1   Meaning of the LED Display.**

| LED | Meaning | Comment |
|-----|---------|---------|
| 1 | Power on. | O.K. |
| 2 | Calibration error. | Re-calibrate IMP. |
| 3 | ADC error. | Have IMP checked out. |
| 4 | IMP scanning - that is, active. | O.K. |

---

[1] Historically known as 'cold' junctions, but now called, more aptly, *reference* junctions: likewise, the junction originally known as 'hot' junctions is now called a *measurement* junction.

# 6

## IMP 3595 1B
## + Connector Block 3595 3B
*(also covers IMC 3595 51B and Connector Block 3595 53B)*

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# 1    INPUT CONNECTIONS

The IMP 35951B has ten switched (solid-state) channels which can be individually configured to measure voltage, resistance, temperature (PRT) or strain.
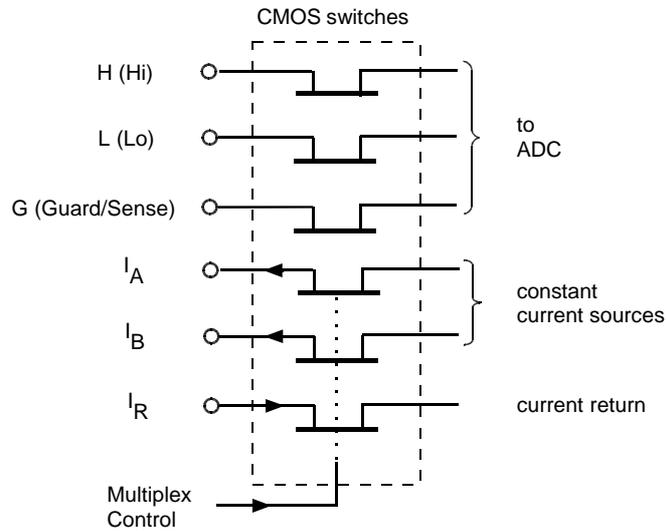


*Fig 6.1    Schematic of an input channel.*

Six switched connections are provided for each channel: H (Hi), L (Lo), G (Guard/Sense), $I_A$ (supply current A), $I_B$ (supply current B) and $I_R$ (return current). Two other (unswitched) terminals, $I_{R2}$ and S2, are provided for use in quarter-bridge strain gauge measurement. Whilst it is not essential to terminate unused channel inputs, it is nevertheless good practice to link terminals H, L and G. Alternatively, the IMP can be commanded to skip unused channels. In an electrically noisy environment, it is advisable to implement both the above precautions.

## 2  INTERNAL ORGANIZATION

The IMP is shown schematically in Figure 6.2, and consists basically of:

a.  the microprocessor,

b.  a logic array to handle network communications,

c.  an input multiplexer to switch through the ten channels,

d.  an Analogue-to-Digital Converter (ADC).

The ADC in the IMP is of the Solartron pulse-width type. The integration (measurement) time has a default value of 20ms which automatically tends to cancel out interference derived from 50Hz mains supplies. For those countries using 60Hz supplies, the integration time can be set to 16.66ms by command from the host.
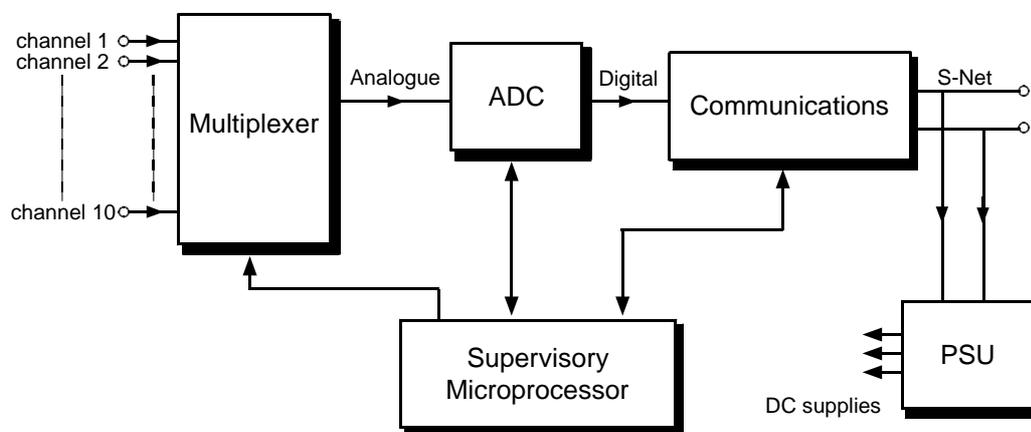


***Fig 6.2    Schematic of the IMP operation.***

# 3 MEASUREMENT PREPARATIONS

## 3.1 VOLTAGE

Connect the unknown voltage to the H, L and G terminals as shown in Figure 6.3. The terminals $I_A$, $I_B$ and $I_R$ are unused. For protection against electrical interference, connect the G-terminal as shown. **The guard terminal must not be left disconnected since it forms an integral part of the measuring circuitry**.
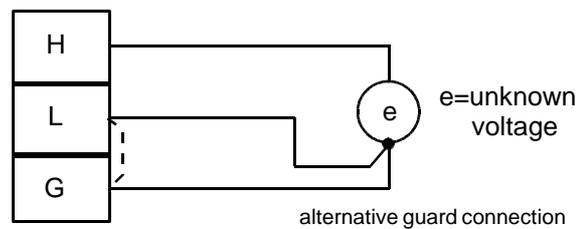


*Fig 6.3    Voltage measurement connections.*

Three nominal measurement ranges are available: 20mV, 200mV, 2V, and autorange.

## 3.2 RESISTANCE

Resistance can be measured using the four-wire or three-wire method. **Note that resistance measurements are returned in units of kohms on all ranges.**

### 3.2.1 Resistance Measurement, Four-wire

Connect the unknown resistance to the terminals as shown in Figure 6.4. The wires from the H and L terminals should be connected as close as possible to the body of the unknown resistance. No guard connection is needed: the circuitry associated with the $I_R$ terminal automatically provides interference rejection, as well as acting as current return. Note that the four-wire method has greater thermal stability, and gives a more accurate measurement, than the three-wire method described in Section 3.2.2.
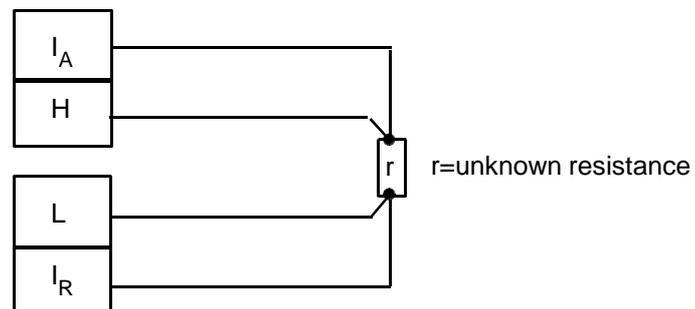


*Fig 6.4    Resistance measurement connections, four-wire.*

Three nominal measurement ranges are available: 25Ω, 250Ω, 2.5kΩ, and autorange. A current drive of 0.8mA is automatically supplied by the IMP via the $I_A$ and $I_R$ terminals.

### 3.2.2    Resistance Measurement, Three-wire

Three-wire resistance measurement is sometimes preferred because three-core cable is cheaper than four-core: the results, however, are less accurate than with the four-wire method and have a reduced thermal stability. The method of connection is shown in Figure 6.5. The three conductors should be identical so that the lead resistances may be effectively nulled.
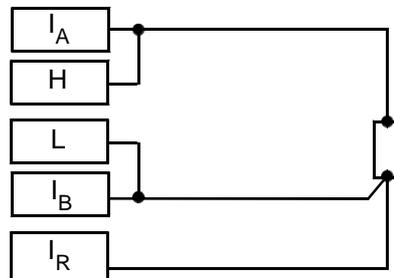


***Fig 6.5    Resistance measurement connections, three-wire.***

## 3.3    TEMPERATURE

Temperature is derived by measuring and linearising (to IEC 751) the resistance of a platinum resistance thermometer (PRT), otherwise known as a resistance thermometer device (RTD). The linearisation within the IMP assumes that a 100$\Omega$ PRT is used.

### 3.3.1    Four-Wire PRT

Many different color codes are used by the manufacturers of PRTs, therefore a standard color-code scheme cannot be defined. However, a general method of connection is shown in Figure 6.6 and this assumes that a 4-wire PRT is used. 3-wire PRT's can be used but then $I_A$ and H, or $I_R$ and L, will have to be joined together at the PRT. Note that the 4-wire method has greater thermal stability, and enables a more accurate measurement to be obtained, than the 3-wire method described in Section 3.3.2.
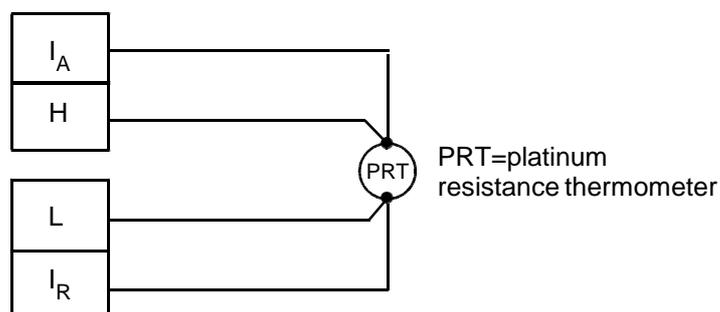


***Fig 6.6    Temperature measurement connections, four-wire.***

No Guard connection is needed, as the circuitry associated with the $I_R$ terminal automatically provides interference rejection, as well as acting as current return.

### 3.3.2 Three-Wire PRT

The three-wire method of connecting a PRT is sometimes preferred to the four-wire method, due to the saving in sensor cable cost. The three-wire method does, however, give a less accurate signal, with reduced thermal stability, than the 4-wire method. An example of the three-wire connection is shown in Figure 6.7. For the lead resistances to be effectively nulled, the conductors should be identical.
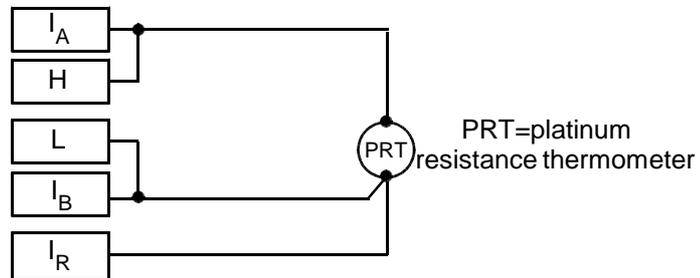


*Fig 6.7   Temperature measurement connections, three-wire.*

### 3.4   STRAIN

For the measurement of strain, full-, half-, quarter-bridge and 3-wire configurations of resistive strain gauges can be accommodated. It is intended that the bridges be energized by the dual-current supply, built into the IMP. Measured results are converted to microstrain by the IMP microprocessor before being transferred to the host.

Strain gauges can also be energized, in the traditional way, by an external voltage. In this case, the user must provide the voltage and also process the results to convert them into microstrain. It should be noted that the dual-current method offers several advantages over the voltage method, the most important being that it eliminates the effect of lead resistance variations with temperature. This applies particularly to half- and quarter-bridge configurations.

For the IMP to convert results to microstrain, it must know the gauge factors for the active gauges in each bridge. This information must be input to the host, which then passes it on to the appropriate IMP. In all bridge applications, efforts should be made to construct bridges with gauges from the same production batch, so that all have identical gauge factors and temperature coefficients. The gauge factor then becomes G (usually between 2 and 2.2) multiplied by the number of active gauges.

**Note:** An *active* gauge is one that is subject to strain; gauges used either as dummies or to provide temperature compensation are considered to be *inactive*.

Before starting to log readings from the bridges, it is essential to record the unstrained (initial) outputs, as these are required as references for subsequent calculations. This recording is commanded by program instructions from the host.

For the bridge configurations shown on the following pages, it should be noted that the G-terminal is used for voltage sensing. The $I_R$ terminal automatically provides interference rejection, as well as acting as current return for the specific bridge.

The energizing current can be set to 8mA or 1.6mA for the full-bridge configuration. For half- and quarter-bridge\ configurations, the currents can be set to 4mA or 0.8mA. Typically, the larger of the two currents is used for bridges constructed of gauges from 120Ω to 350Ω; the smaller of the currents is used for gauges of greater than 350Ω. In all cases, ensure that the product of bridge resistance and energizing current does not exceed 2V, as this is the maximum input voltage for the IMP. **Do not**, for example, energize a 1kΩ full-bridge with a 4mA current as this will produce 4V at the IMP terminals!

**Note:**

1.  The dual-current compliance voltage is greater than 17V, i.e. if an e.m.f. is present in the external circuit, the IMP can generate over 17V in order to force the selected energizing current through the bridge.

2.  The sensor warm-up period provided by the IMP is:

    $1250\mu s < t < 1406\mu s$, for 20ms integration and
    $1041\mu s < t < 1172\ \mu s$, for 16.67ms integration.

    The effect of the warm-up period on the measurement timing is shown in  Figure 6.8.



$t$=sensor warm-up time
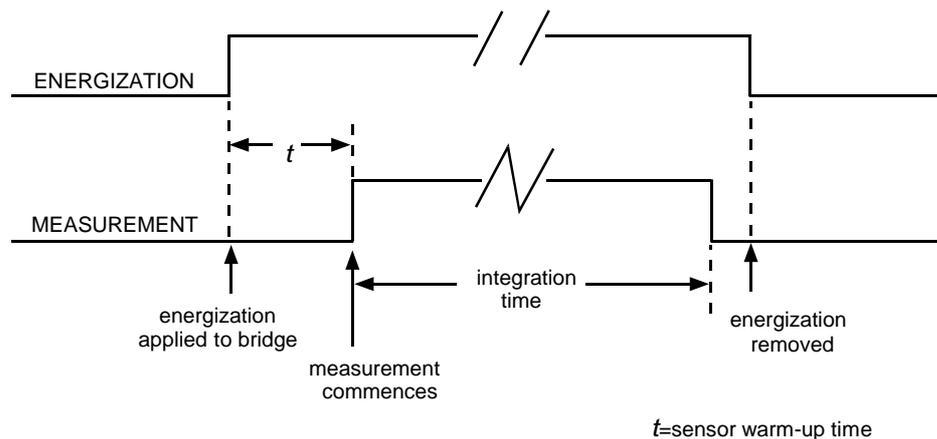
***Fig 6.8    Effect of IMP sensor warming period on measurement timing.***

### 3.4.1 Full-Bridge gauge

A full-bridge strain gauge consists of four gauges, mounted at the measurement site. In principle all four gauges are active, although in practice some may be replaced by dummies (resistors or gauges used to provide temperature compensation). Typical examples of use are: (a) measuring the output of a load cell, and (b) measuring the strain on a beam in bending: four active gauges are used, two on the top face of the beam and two on the bottom. (See Appendix A for explanation of technique.)

Figure 6.9 shows the schematic of the full-bridge measurement circuit. In this circuit the $I_A$ and $I_B$ terminals supply the energisation currents, whilst the H and L terminals are used to measure the bridge out-of-balance voltage. On initialization, the ADC is disconnected from the H and L terminals and connected instead to the $I_B$ and G terminals. The bridge voltage can then be measured.
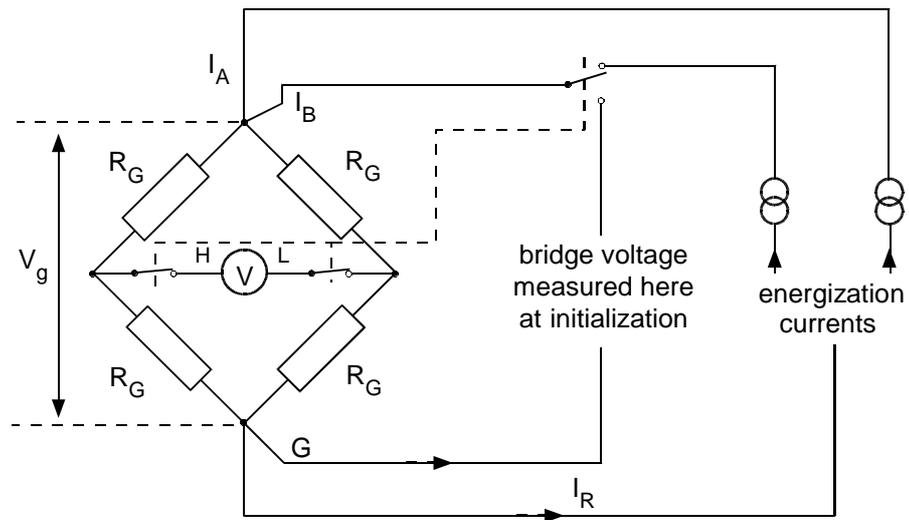


***Fig 6.9   Schematic of the full-bridge measurement circuit.***

**Initialization.** On initialization, the IMP measures the gauge voltage, Vg, whilst the bridge is energized with constant current $I_A$. The IMP microprocessor uses the following algorithm to calculate strain:

$$\varepsilon = \frac{4.(Vx\text{-}Vo)}{GVg}$$

In μstrain:

$$\mu\varepsilon = \frac{4.(Vx\text{-}Vo).10^6}{GVg}$$

where :

      V0 = initial "out of balance" voltage
      Vg = gauge voltage (at initialization)
      Vx = strained "out of balance" voltage
      G  = gauge factor (for one active gauge).
            use 2G for two active gauges       } gauges must be
            use 3G for three active gauges     } identical.
            use 4G for four active gauges       }

The full-bridge measurement connections to the IMP connector block are shown in Figure 6.10. Note that the $I_B$ and G terminals must be connected to the $I_A$ and $I_R$ terminals at the bridge, *not* at the IMP. This is because $I_B$ and G fulfill the dual function of measuring the gauge voltage during initialization and supplying the energisation current. If a screened cable is used to connect the gauges, then the screen should be connected only to $I_R$ on the connector block.
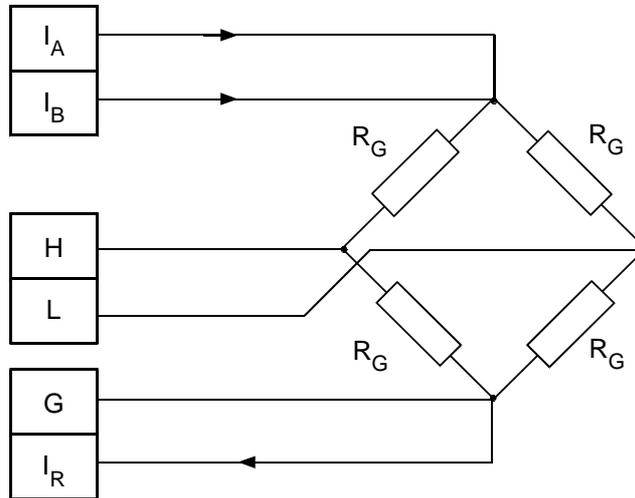


***Fig 6.10    The full-bridge measurement connections.***

### 3.4.2    Half-Bridge gauge

A half-bridge strain gauge of two gauges, mounted at the measurement site. In principle both gauges are active, although in practice one may be replaced by a dummy (a resistor or gauge used to provide temperature compensation). The upper half of the bridge is replaced by the dual-current supply of the IMP. A typical application with two active gauges would be in measuring the strain on a beam in bending: two active gauges are used, one on the top face of the beam and one on the bottom.

Figure 6.11 shows the schematic of the half-bridge measurement circuit.
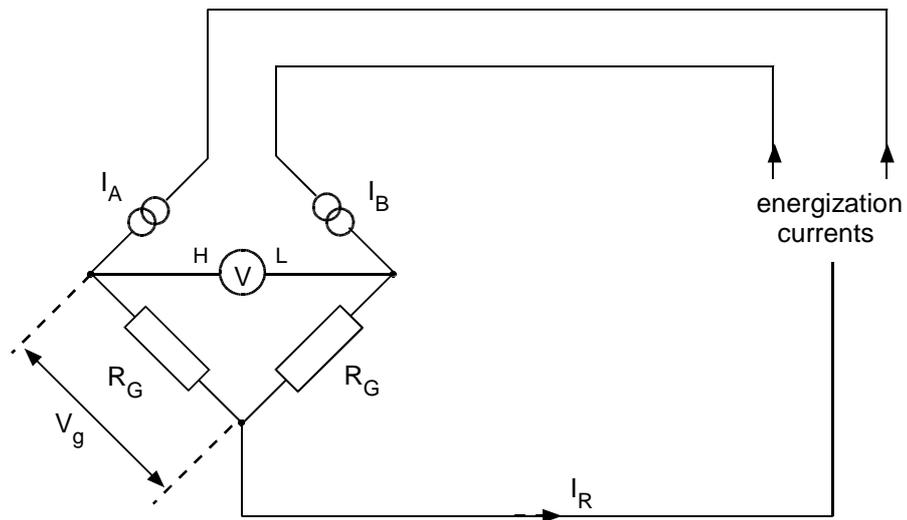


***Fig 6.11    Schematic of the half-bridge measurement circuit.***

**Initialization.** On initialization, the IMP switches $I_B$ off, $I_A$ on and measures the gauge voltage, Vg. The IMP's microprocessor uses the following algorithm to calculate strain:

$$\varepsilon = \frac{(Vx\text{-}Vo)}{GVg}$$

In µstrain:

$$\mu\varepsilon = \frac{(Vx\text{-}Vo) \cdot 10^6}{GVg}$$

where :     Vo = initial "out of balance" voltage
            Vg = gauge voltage (at initialization)
            Vx = strained "out of balance" voltage
            G  = gauge factor (for one active gauge)
                 use 2G for two active gauges (which must be identical)

The five-wire measurement connections for the half-bridge gauge are shown in Figure 6.12. Note that terminals H and $I_A$, and L and $I_B$, should be joined at the bridge, *not* at the IMP. If a screened cable is used to connect the gauges, then the screen should be connected only to $I_R$ on the connector block. This method of connecting a half-bridge ensures that the measurement results are unaffected by the lead resistances, therefore the leads need not be identical.

A simplified, three-wire, connection method for the half-bridge is described in Section 3.4.3. This is a cheaper method, but it does demand that identical leads be used.
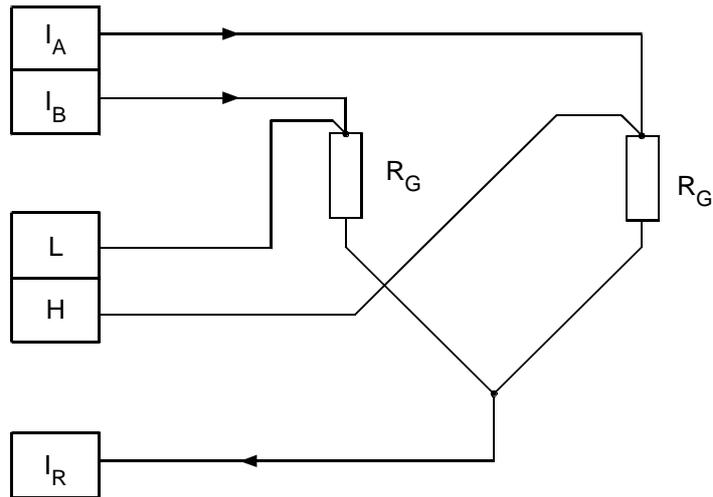


***Fig 6.12    Half-bridge measurement connections, five wire.***

### 3.4.3    Three-Wire Connection of Strain gauges

The three-wire method for strain measurement (Figure 6.13) uses a simplified method of wiring whereby three wires only are run from the connector block. Use gauge factor G for one active gauge or 2G for two (identical) active gauges.

Note, however, that for correct 3-wire measurement *it is essential* that the wires *x* and *y* are of equal length and cross-section. This ensures that a resistive balance is maintained in the presence of temperature changes, so that strain measurements are unaffected.

**Ensure that wires x and y are of**
**equal cross-section and length.**



(a) for a dummy installed at the
                                connec-

(b) *for a dummy (or second gauge)*
                                *local to*
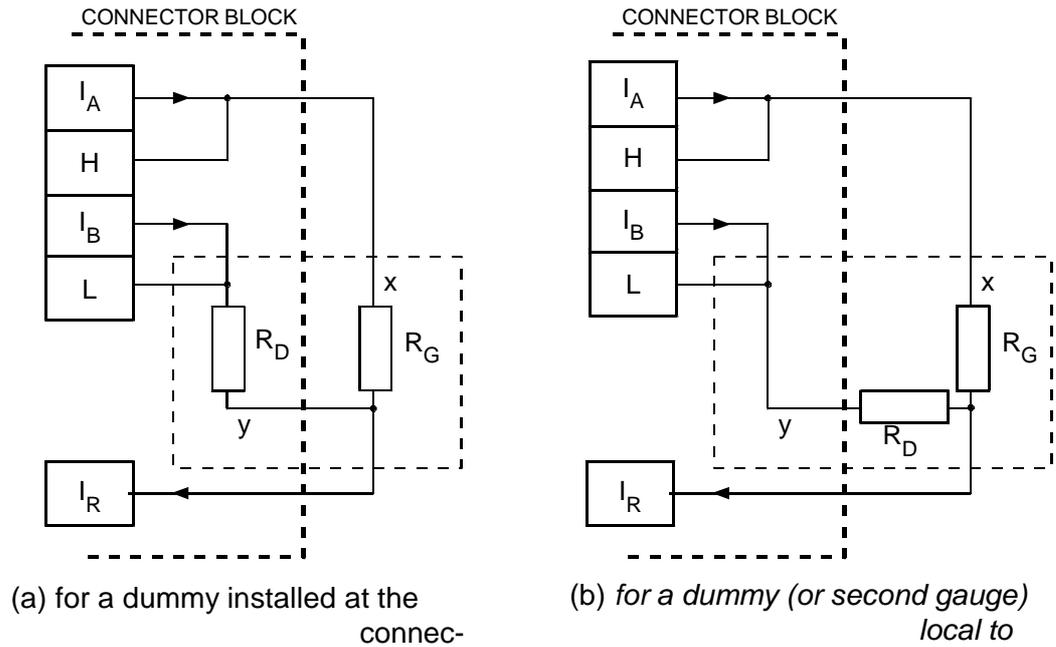
*Fig 6.13    Three-wire connection of strain gauges.*

### 3.4.4    Quarter-Bridge gauge

A quarter-bridge strain gauge consists of a single (active) strain gauge at the measurement site. The upper half of the bridge is replaced by the dual-current supply of the IMP, which leaves the final quarter of the bridge to be completed. This done by connecting a dummy to the connector block. The dummy may be either a precision resistor of the same value as the nominal gauge resistance or another (unstrained) gauge which then provides temperature compensation for the active gauge.

The quarter-bridge system shown in Figure 6.14 uses a common dummy, that is, one that can be shared by any number of channels. The $I_A$ and $I_B$ terminals supply the energisation currents, whilst the H and L terminals measure the bridge out-of-balance voltage as each strain gauge is switched in. Amplifier "a" maintains the bridge output L at the reference voltage and amplifier "b" maintains equal potentials at the lower ends of $R_G$ and $R_D$.

This method greatly reduces the cost of wiring (and dummies). A typical application for a quarter-bridge shared-dummy set-up would be in measuring the strain in a series of supporting pillars. Temperature compensation is effected by mounting the dummy strain gauge onto a piece of material identical to that of the pillars, and physically adjacent to them.
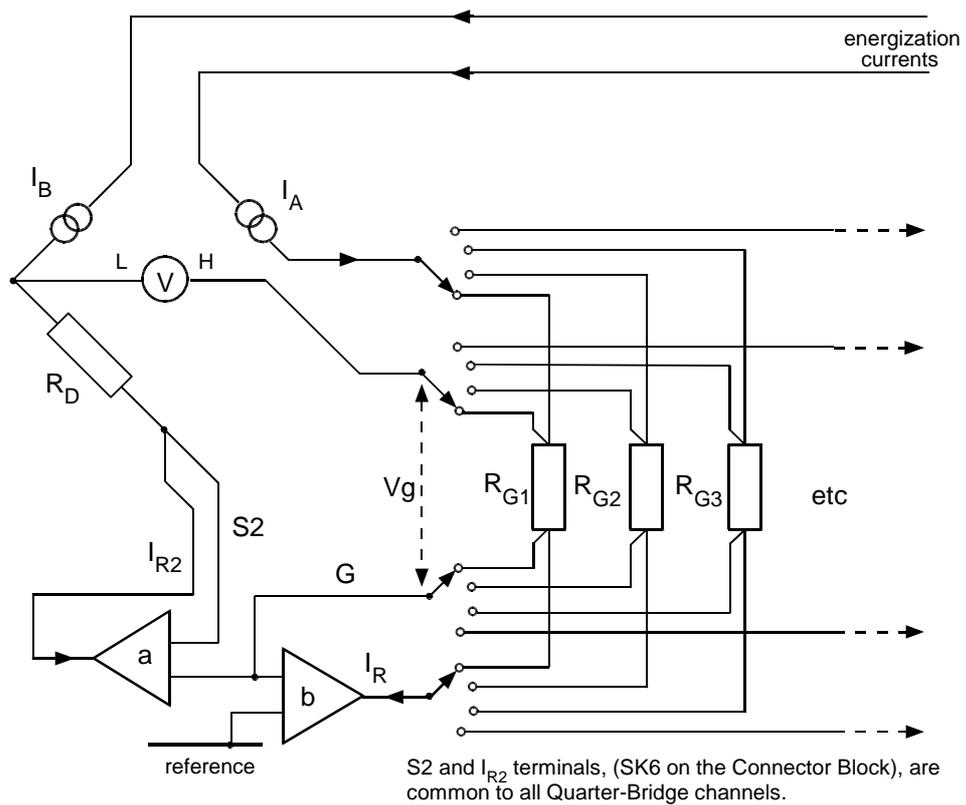


**Fig 6.14   Quarter-bridge shared-dummy measurement circuit.**

**Initialization.** On initialization, the IMP switches off $I_B$ and measures the gauge voltage, Vg. The IMP's microprocessor uses the following algorithm to calculate strain:

$$\varepsilon = \frac{(Vx\text{-}Vo)}{GVg}$$

In μstrain:

$$\mu\varepsilon = \frac{(Vx\text{-}Vo)\,.\,10^6}{GVg}$$

where :  V0 = initial "out of balance" voltage
Vg = gauge voltage (at initialization)
Vx = strained "out of balance" voltage
G  = gauge factor

The quarter-bridge measurement connections for use with an remote dummy (i.e. remote from measurement site, at connector block) are shown in Figure 6.15. A 120Ω ± 0.1% resistor is supplied with the IMP to effect bridge completion when 120Ω gauges are used. Note that the S2 and $I_{R2}$ terminals are shared by all quarter-bridge channels of the IMP.
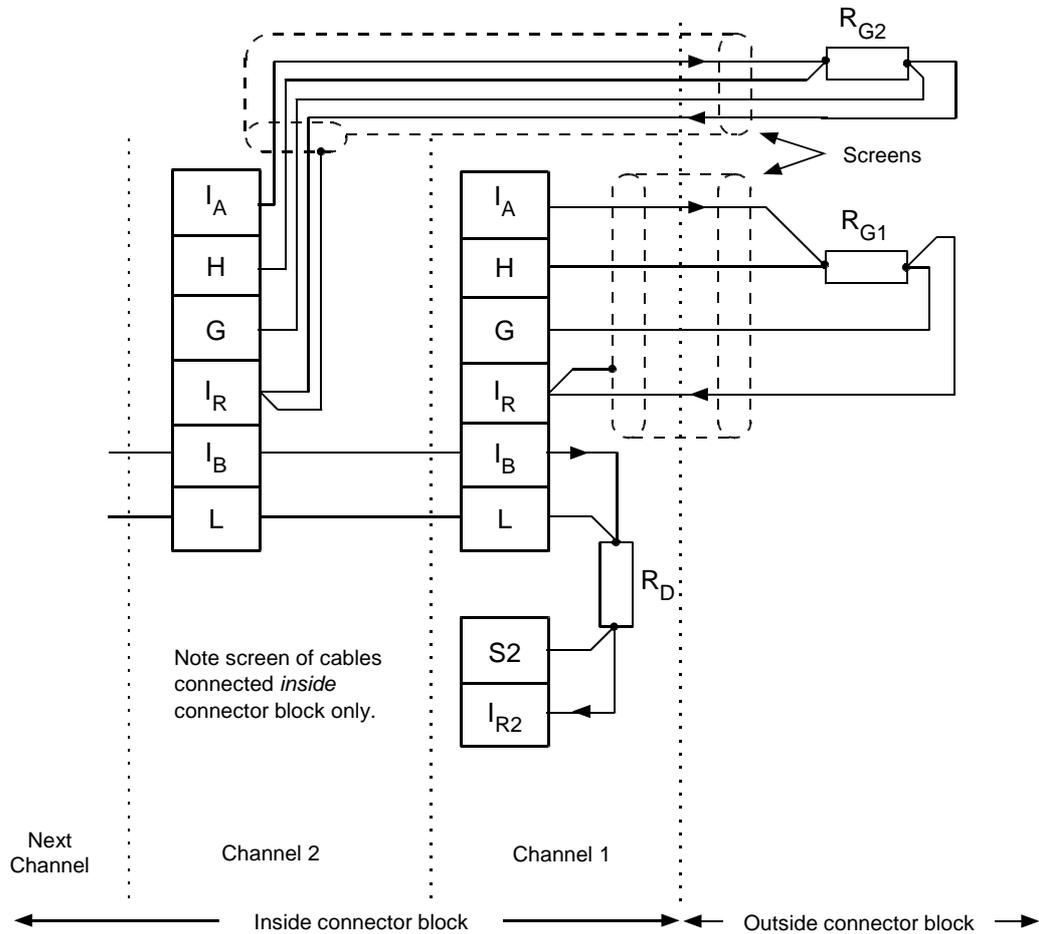


***Fig 6.15    Quarter-bridge measurement connections, with remote dummy.***

The quarter-bridge measurement connections for use with a local dummy (i.e. at measurement site) are shown in Figure 6.16.
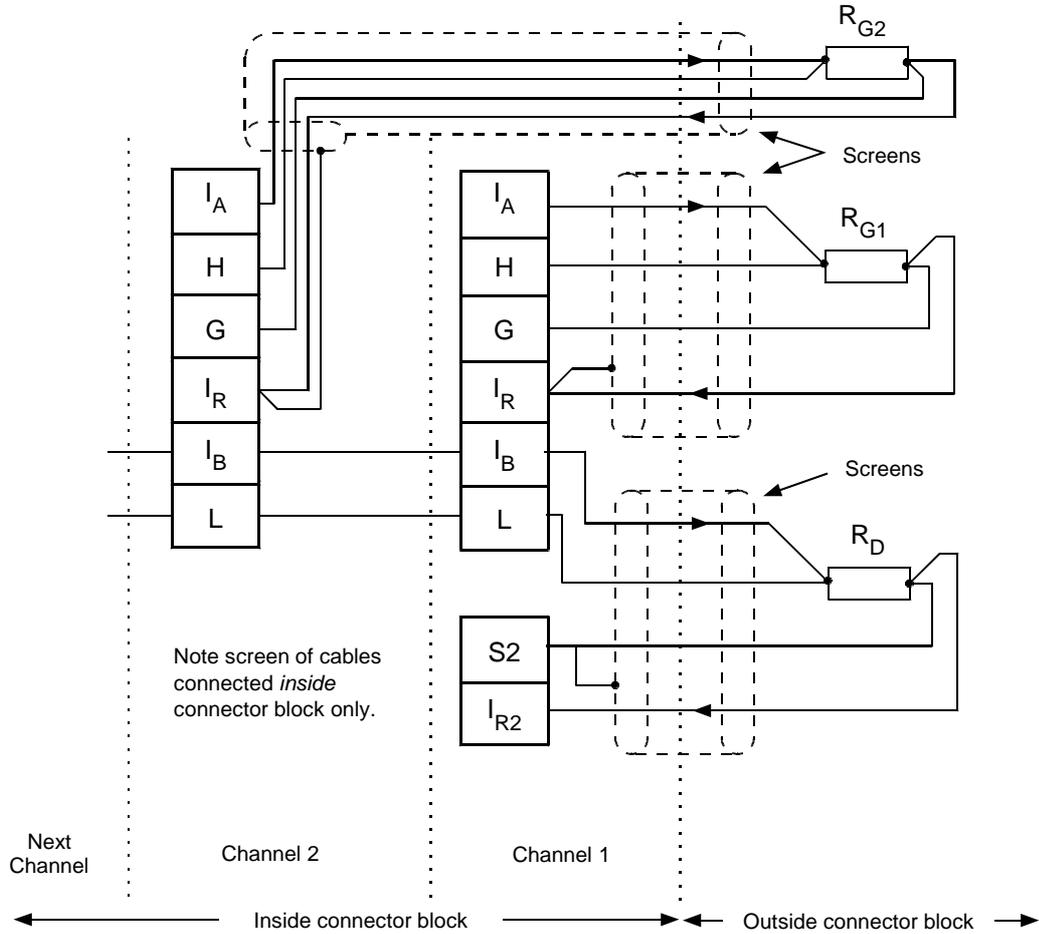


**Fig 6.16    Quarter-bridge measurement connections, with local dummy.**

# 4        LED DISPLAY

Four LEDs, visible at the end face of the IMP, convey certain user-confidence information when illuminated. They are allocated as shown in Table 6.1.

**Table 6.1    Meaning of the LED Display.**

| LED | Meaning | Comment |
|:---:|---|---|
| 1 | Power on. | O.K. |
| 2 | Calibration error. | Re-calibrate IMP. |
| 3 | ADC error. | Have IMP checked out. |
| 4 | IMP scanning, i.e. active. | O.K. |

# IMP 3595 1D
# + Connector Block 3595 3E
### (also covers IMC 3595 51D and Connector Block 3595 53E)

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# 1 INTRODUCTION

The 35951D Analog Output IMP has four channels of isolated analog output. Each channel has two sets of outputs, one for voltage in the range -10V to +10V and the other for current in the range 0mA, or 4mA, to 20mA. The basic circuit of an analog output channel is shown in Figure 7.1.
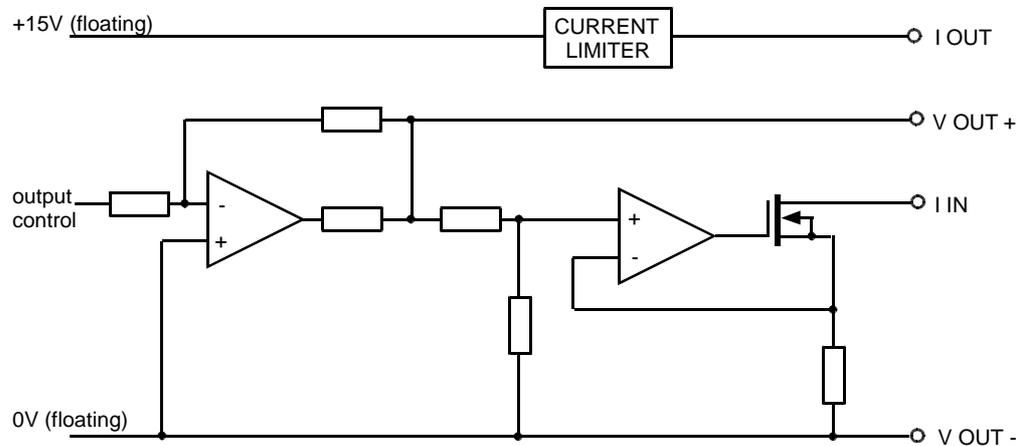


*Figure 7.1    Basic circuit of the output stage of an analog output channel.*

On each channel the voltage and current outputs are always both active, and are interdependent. For example, should a voltage change be requested (with the CHnVOx command) then the current through a load connected across the current terminals would change also. Therefore, each channel should be used either for voltage or for current output, not both.

When a specific current output is requested, with the command CHnIOx, the voltage across the current terminals is adjusted to give the specified current through the current load.

To protect the current output against externally applied voltages (caused, for example, by a short-cicuit to the VOUT- terminal) a current limiter limits the output current to 25mA.

## 2 INTERNAL ORGANISATION

The IMP is shown schematically in Figure 7.2 and consists basically of:

- The microprocessor.

- A logic array to handle network communications.

- Four analog output channels.
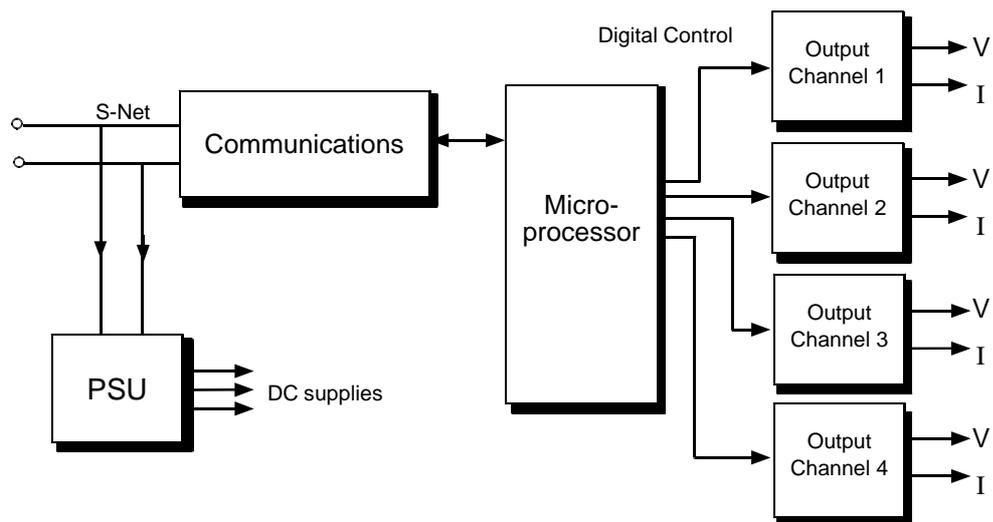


*Figure 7.2    Internal organisation schematic of the 35951D.*

# 3    DEFAULT OUTPUT VALUES AND MINIMUM CURRENT

For one second after power-up the values of voltage and current present at the channel outputs are: volts=-10V and current=0mA. The outputs then assume their default state.

Depending on the application, the default state may be zero output or a low current and voltage. The choice is made by opening or closing a split-pad on the 35953E connector block. The default outputs and the corresponding split-pad states are listed in Table 7.1.

The state of split pad SP1 also decides the minimum current that can be requested with the command CHnIOx. If the default output current is 4mA then the minimum current is 4mA also.

**Table 7.1    Output Default States**

| Split Pad State | Default Voltage O/P | Default Current O/P | Minimum Current |
|---|---|---|---|
| open | 0V | 0mA+0.1mA | 0mA |
| closed | 2V±0.1V | 4mA | 4mA |
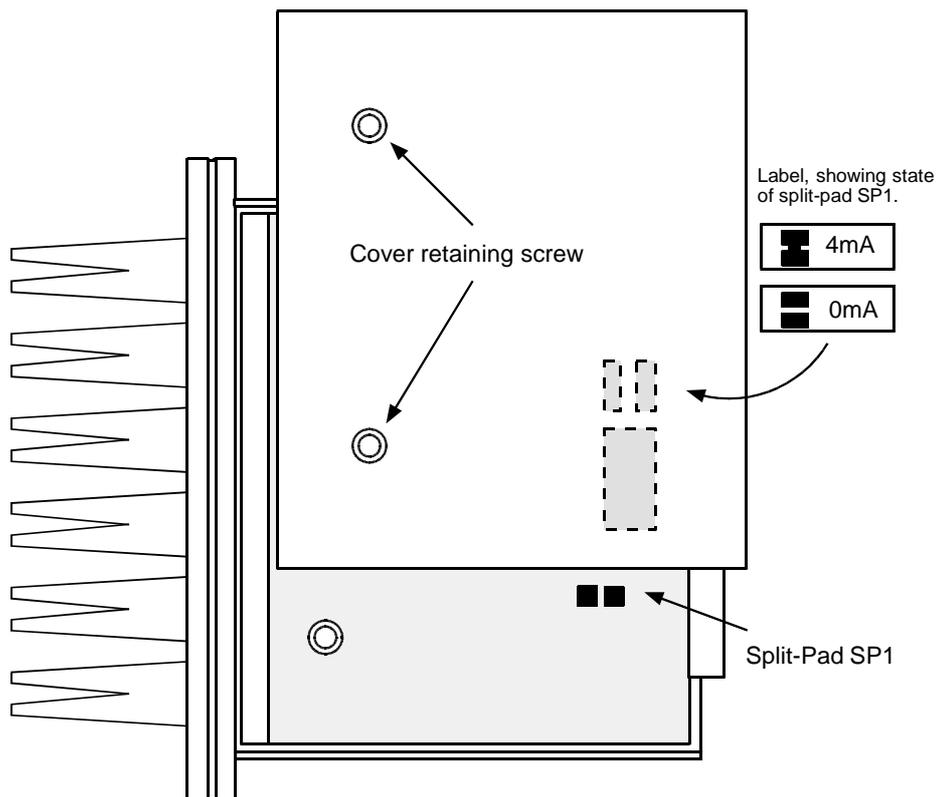


**Figure 7.3    Location of split-pad SP1 in connector block 35953E.**

The location of the split-pad (SP1) is shown in Figure 7.3.  To access the split-pad, undo the two (captive) cover retaining screws of the 35953E and lift the cover clear, withdrawing the cover from the rear of the connector.  (When replacing the cover, remember to locate the two "nibs" on the rear of the cover under the pcb, before locating the screws in their respective bushes and tightening them down.) A label on the 35953E shows the split-pad state, and the corresponding minimum current, presently selected. Remember to remark the appropriate label – for example, with a spot or cross if the split-pad state is changed.

# 4      OUTPUT CONNECTIONS

Analog output connections to the 35953E connector block are made by passing the leads through the protective boots and connecting them to the appropriate terminals within the block.  (See Chapter 3, Section 3.) The terminal assignments are shown on the connector block label.

## 4.1     VOLTAGE CONNECTIONS

For the voltage output, connect the VOUT+ and VOUT- terminals to the INPUT+ and INPUT - terminals respectively of the device to be controlled (see Figure 7.4).

Each channel is isolated, therefore either terminal can be connected to ground; or ground need not be connected at all and the output allowed to float.
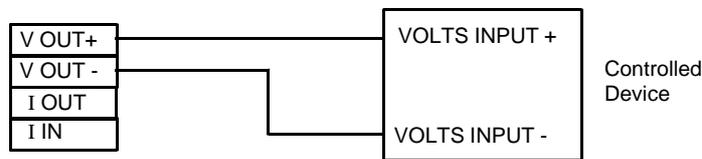


**Figure 7.4    Voltage output connections.**

## 4.2     CURRENT CONNECTIONS

There are three ways in which the current outputs can be used:

(a)     IMP supplied current, as shown in Figure 7.5.
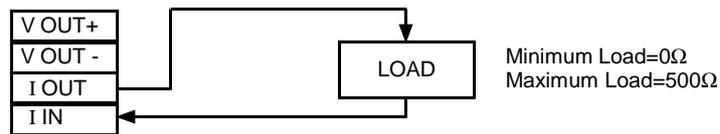


**Figure 7.5    Connections for IMP supplied current**

(b)     Externally supplied current sink, as shown in Figure 7.6.



| V | Min Load | Max Load |
|---|---|---|
| Min 12V | 0Ω | 450Ω |
| 18V | 170Ω | 750Ω |
| 24V | 470Ω | 1050Ω |
| 30V | 790Ω | 1350Ω |
| Max36V | 1180Ω | 1650Ω |
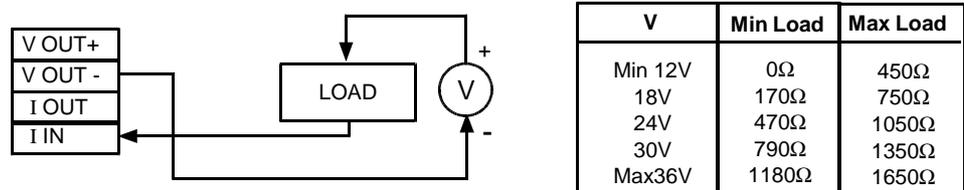
**Figure 7.6    Connections for externally supplied current sink.**

(c)    Externally supplied current source, as shown in Figure 7.7.



| V | Min Load | Max Load |
|---|---|---|
| Min 12V | 0Ω | 450Ω |
| 18V | 170Ω | 750Ω |
| 24V | 470Ω | 1050Ω |
| 30V | 790Ω | 1350Ω |
| Max36V | 1180Ω | 1650Ω |
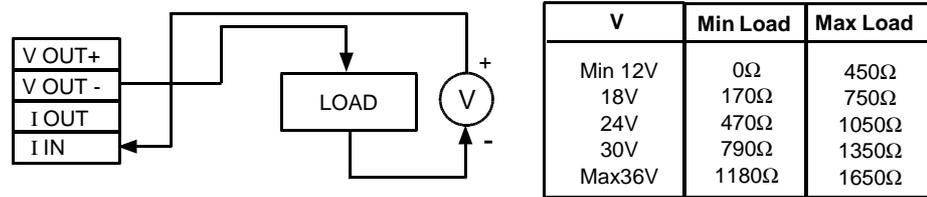
*Figure 7.7    Connections for externally supplied current source.*

**Note:**  If the minimum load in the tables shown in Figures 7.6 and 7.7 is greater than the load in your application then the effective load can be increased by connecting a resistor in series with the load.  For example, if the current output supply voltage is 24V and the load resistance is 250Ω then a 470Ω in-series resistor increases the total load to 720Ω, which is greater than the minimum load of 470Ω.  This example is illustrated in Figure 7.8.
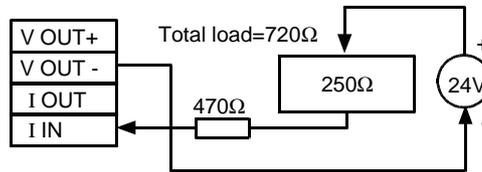


*Figure 7.8    Example: increasing the effective load with a series resistor.*

## 5       POWER AND CABLING CONSIDERATIONS

Normally the power consumption of the 35951D is less than 1.1W and so it can be considered as just another IMP, with no special considerations. However, if any of the output channels are used for current output with the arrangement shown in Figure 7.5 then the IMP consumes up to 3.1W and the following points MUST be considered when deciding on the power supplies and system cabling:

1.  If local power is to be used then the power supply must be able to deliver 3W at between 10V and 50V.

2.  If the IMP is to be powered via the S-Net then the following two points should be noted:

    a.  The IMP consumes the equivalent of three normal IMPs,

    b.  There must be at least 30V across the network at the point where the IMP is fitted.

## 6       LED DISPLAY

The four LEDs visible at the end face of the IMP convey certain user-confidence information when illuminated. They are allocated as shown in Table 7.2.

**Table 7.2   Meaning of the LED Display**

| LED | Meaning | Comment |
|:---:|---|---|
| 1 | Power on. | O.K. |
| 2 | Calibration error. | Recalibrate IMP. |
| 3 | Not allocated. | - - - |
| 4 | Changing output. | Executing an analog output command. |

# 8

## IMP  3595 2A
## + Connector Block 3595 3C
### (also covers IMC 3595 52A and Connector Block 3595 53C)

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# 1 INPUT/OUTPUT CHANNELS

The 35952A IMP provides twenty transformer-isolated channels that can be configured individually as inputs or outputs.  As an input, a channel can record status, can capture and count events, or can measure time periods and frequency.  As an output, each channel, which consists of a transistor switch, closes for a logic '1' (short-circuits the output terminal to common) and opens for a logic '0'.

Three terminals are provided for each channel: INPUT, OUTPUT and COMMON.

A 5V, 20mA, short-circuit-protected power supply is available at the 5V OUT terminals. This supply can be connected across contacts in the external plant, so that their open or short-circuit status can be recorded.  It can also be used to energise lamps, relays, etc, when the channel is configured as an output.
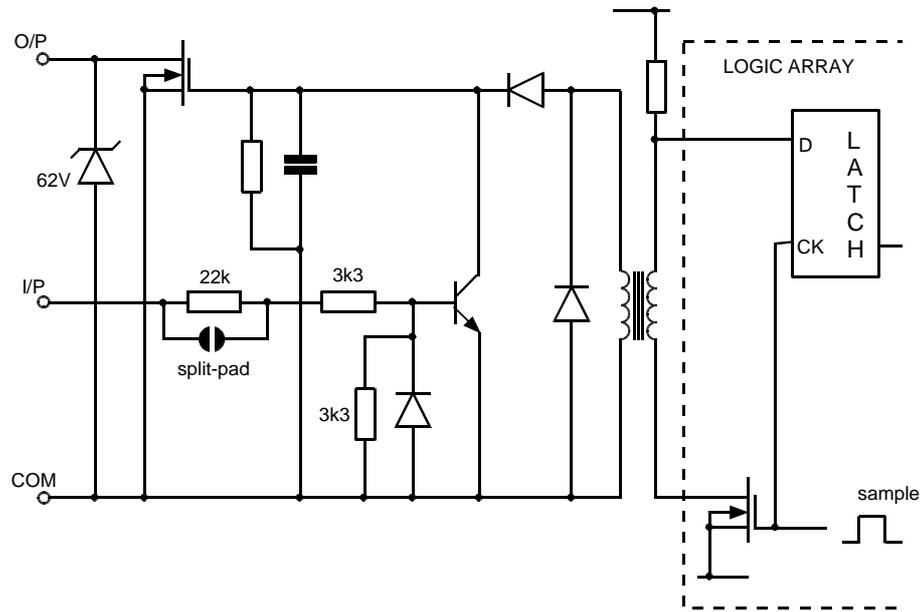


*Fig 8.1    Input/output channel circuit.*

## 2    INTERNAL ORGANISATION

Basically, the IMP consists of a microprocessor and six logic arrays, as shown in Figure 8.2.  One array handles the network communications, whilst each of the other arrays receives four input channels.
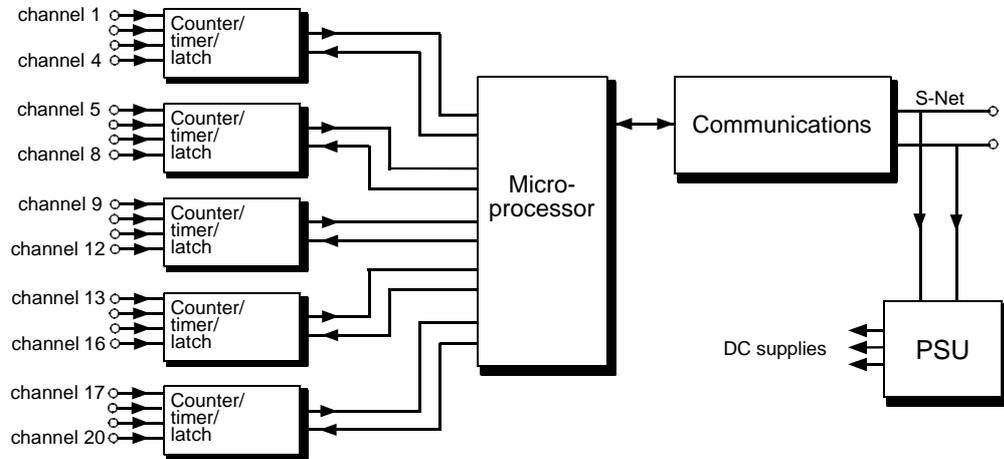
**Fig 8.2    Schematic of the IMP operation.**

Each logic array contains four identical status/event circuits.  The circuit schematic is shown in Figure 8.3.
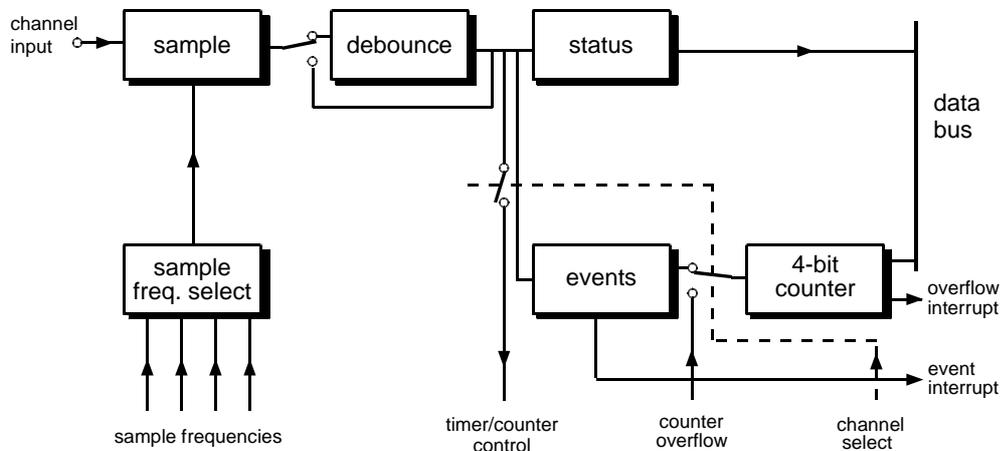
**Fig 8.3    Schematic of a status/event circuit.**

Each array has its own frequency/period circuit (Figure 8.4), which is shared by the four channels in that array. If two or more channels are to measure frequency or period, using long measurement times, then it is beneficial to distribute these channels throughout the arrays: up to five measurements (one in each array) can then take place simultaneously. For more information on frequency/period measurement see Section 6.4.
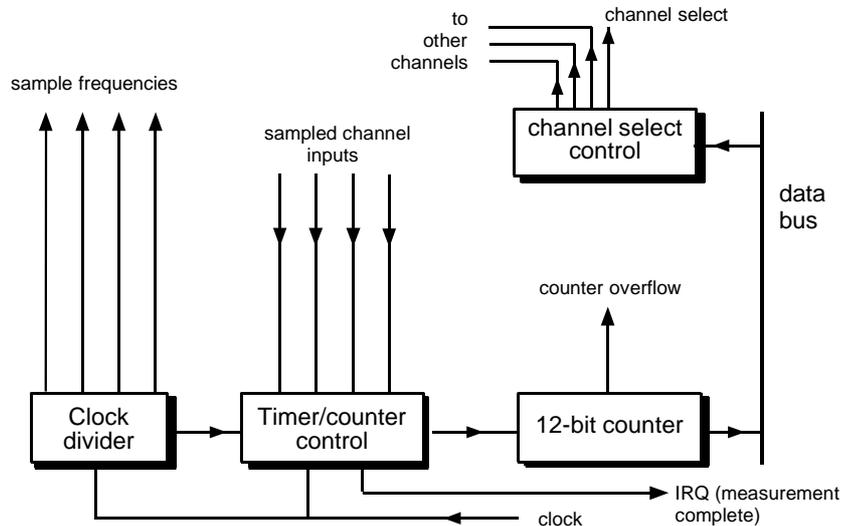


*Fig 8.4    Schematic of a sampling frequency and timer/counter.*

## 3        LOGIC LEVEL CONVENTION

When relating logic levels to input or output currents and voltages, IMPs conform to the positive logic convention. By this system, logic '1' represents the presence, and logic '0' the absence, of the current or voltage. logic '1' is always more positive than logic '0', as shown in Figure 8.5.

The threshold levels for logic '1' and 0 are given in the Specification (Appendix B).
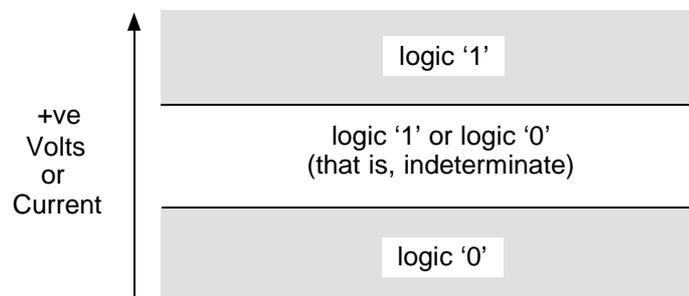


*Fig 8.5    Positive logic convention.*

# 4        LOGIC THRESHOLD LEVELS: INPUT CHANNELS

All inputs are compared with pre-set voltage threshold levels in order to ascertain the logic states of those inputs.  Two pairs of threshold levels are offered for each channel; they can be set individually by means of split-pads SP1 to SP20 (one split-pad per channel) in the connector block.  The split-pad numbers correspond to the channel numbers.



a) input thresholds with split-pad shorted.            b) input thresholds with split-pad open-circuit.
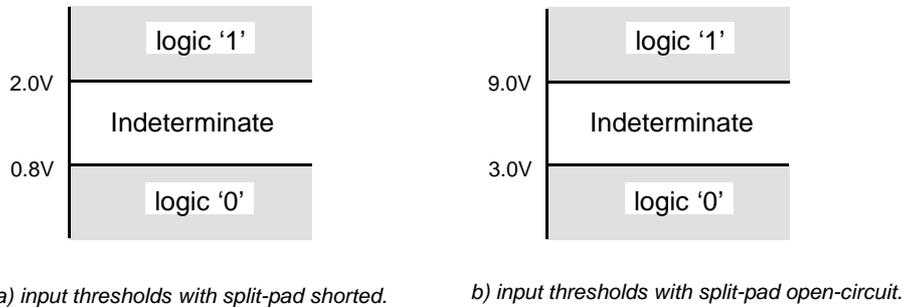
### Fig 8.6    Input channel thresholds

Note that voltage levels situated between the selected thresholds are considered to be indeterminate.  This means that it is impossible to predict whether such a voltage level will be interpreted as a logic '0' or a logic '1'.

# 5        SAMPLING RATE

In common with all multi-channel logging instruments, IMPs do not monitor their input channels continuously, but examine them at regular intervals.  The frequency of examination is known as the sampling rate.  Several sampling rates are provided for all the measurement functions, that is 20Hz, 1kHz, 10kHz and 100kHz.

When setting up the system to be monitored, study Sections 5.1 and 5.2 to determine the best sampling rate to use for your particular application.  Having selected a suitable sampling rate, you should obtain repeatable results.

## 5.1        20HZ, 1KHZ SAMPLING

Debounce is applied at these sampling rates; giving protection against contacts bouncing on closure, as may occur with industrial switches, contactors, reed-relays etc.  With debounce applied, four successive samples must detect the same logic level after a logic transition has occurred before that transition is recognised.  This ensures that no false transitions are recorded.  See Figure 8.7.

Use 20Hz sampling for large contacts, such as industrial relays.

Use 1kHz sampling for small contacts, such as reed-relays.
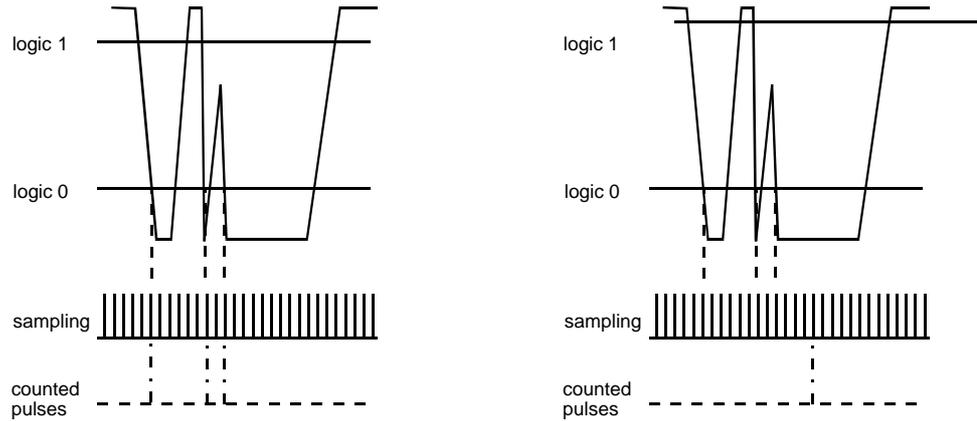
*a) No debounce applied: three pulses output to the counter instead of one = incorrect measurement.*

*b) Debounce applied: one pulse only output to the counter = correct measurement.*

### Fig 8.7    Contact Closure: 20Hz, 1kHz sampling.

## 5.2      10KHZ, 100KHZ SAMPLING

These sampling rates are intended for use with signals not subject to contact closure bouncing.  Hence, debounce is not applied.  100kHz sampling would normally be used, but for signals prone to glitches (spurious transitions) 10kHz sampling might produce more consistent results.  For example:
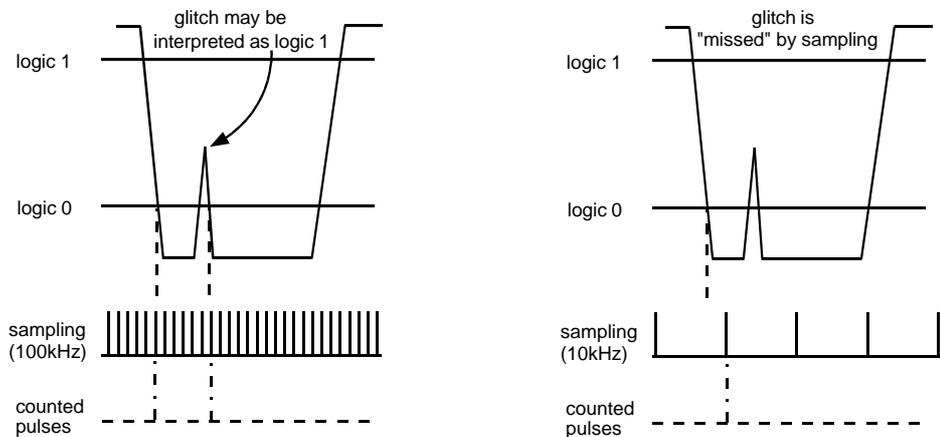


*a) Glitches can generate extra pulses if too high a sampling rate is used, giving an incorrect measurement.*

*b) The same waveform with a lower sampling rate : one pulse only is output to the counter, giving a correct measurement.*

### Fig 8.8    Solid State Switching: 10kHz, 100kHz sampling.

**Note**: whilst a lower sampling rate does not guarantee correct results when glitches are present, it does increase the probability of obtaining correct results.

# 6    MEASUREMENT PREPARATION

Normally, only two wires are connected to any group of IN, OUT and COMMON terminals.



(a) as input                    (b) as output
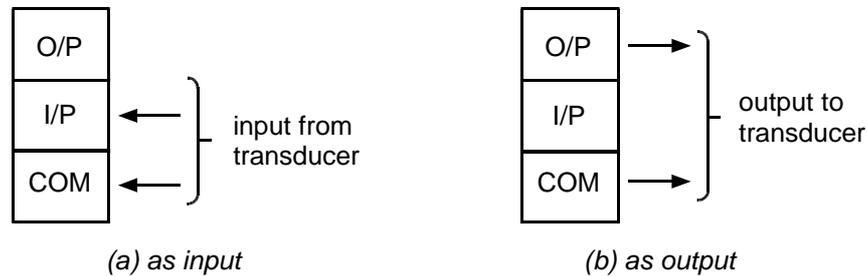
***Fig 8.9    Connection Terminals.***

Note that the connection terminals of a channel should be used either for an input transducer or for an output transducer, not both.  Signals received from the input transducer may be coupled back to the output and, if an output transducer is connected also, produce an unexpected change.

## 6.1    STATUS

The purpose of status measurement is to ascertain the logic state of a signal.  Inputs are judged to be at logic '1' or logic '0', according to the selected input threshold levels. Remember that a logic level between the selected thresholds may be interpreted either as logic '0' or logic '1'.



a) input thresholds with split-pad shorted.          b) input thresholds with split-pad open-circuit.
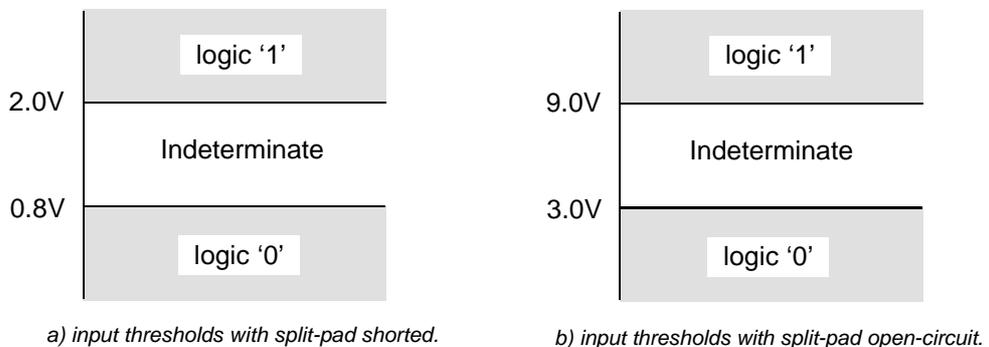
***Fig 8.10    Input channel threshold levels.***

The sampling rate can be selected from 20Hz, 1kHz, 10kHz or 100kHz, 20Hz being the default setting.  Debounce is applied to 20Hz and 1kHz sampling, in which case a status decision is taken only after four successive samples have shown the input to be at the same level.

The rate at which signal status is determined depends upon the frequency with which the host issues status measurement commands.

A 5V, 20mA short-circuit-protected power supply is available at the connector block to facilitate the detection of contact closures in the external plant. Up to twenty pairs of contacts can be connected, but each pair must have its own current-limiting resistor, as shown in Figure 8.11: this avoids one contact closure shorting out the 5V supply to the other contact pairs. The voltage drop caused by the current-limiting resistor must not be so large that the input threshold level cannot be reached (see Figure 8.10). The optimum value is 4.7kΩ, which limits the supply current to 1mA: hence, if all twenty pairs of contacts are closed simultaneously, the current drawn is still only 20mA.
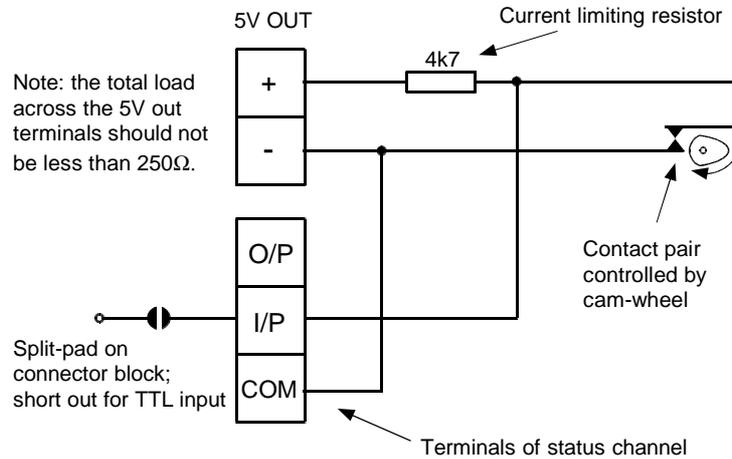


*Fig 8.11    Input/output channel circuit.*

Where the status of a TTL signal is to be determined, short-circuit the relevant Channel split-pad in the connector block. As a rule, a resistor should be fitted between the signal and the TTL 5V supply, unless the TTL output is from a buffer device; for example, LS244. Other TTL or LS TTL devices have a low output current when driven high and, for these devices, a 4.7kΩ resistor should be fitted between the signal and TTL 5V supply. This ensures that the TTL signal voltage reaches the logic '1' threshold.

Remember that the 5V OUT supply of the IMP may also be powering output circuits; for example, as shown in Figure 8.20.

## 6.2    EVENT CAPTURE

The purpose of event capture is to determine when a logic transition occurs, noting the date, time (to 1ms resolution) and the polarity of the transition.  A special buffer, used by all event capture channels, stores the event information.  The buffer can store up to 1500 events and, once full, keeps a count of how many events are then discarded (up to 64k).

The transitions recorded can be +ve, -ve, or both.

+ve transition:    a signal which passes from logic '0' to logic '1'
-ve transition:    a signal which passes from logic '1' to logic '0'

Note that the total number of events that can be captured depends on the capture rate (Table 8.1).  For details, refer to the host interface/logger operating manual.

**Table 8.1   Capture Rate and Event Resolution v. Sample Rate**

| Sample Rate | Maximum Capture Rate | Event Resolution |
|:---:|:---:|:---:|
| 20Hz | 5/s | 200ms |
| 1kHz* | 100/s | 4ms |
| 10kHz | 100/s | 1ms |
| 100kHz | 100/s | 1ms |

* default value

Debounce is applied to 20Hz and 1kHz sampling.  With debounce, an event is considered to be valid only after four successive samples have shown the input to be at the same level (see Figure 8.7).  Therefore, with 20Hz and 1kHz sampling, events are not captured until some time after they have occurred, that is captured events have been subject to delay.  The actual delay is 200ms for 20Hz sampling and 4ms for 1kHz sampling.  If these delays are large enough to be significant, results received by the host must be adjusted accordingly.  Input threshold levels apply, as illustrated in Figure 8.10.

**Note**: To ensure that a logic transition is recorded, it must pass through the indeterminate region, from one logic state to the other, as shown in Figure 8.12 (a).
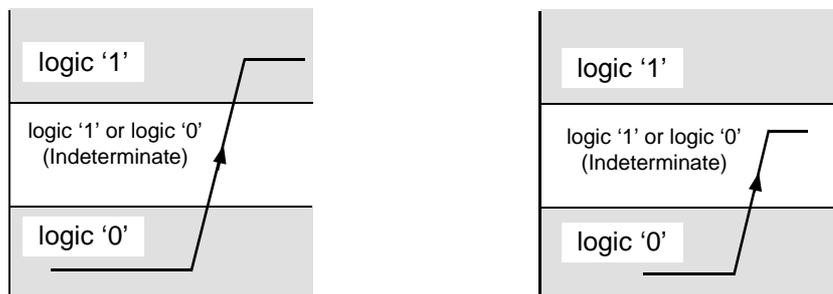


*a) +ve transition guaranteed to be recorded.*          *b) Either no transition, or +ve transition recorded.*

**Fig 8.12    Logic Transitions.**

## 6.3    COUNT (EVENTS)

This facility permits a number of events (as defined in Section 6.2) to be counted. The events (transitions) to be included in the count can be +ve, -ve, or both. Two types of count are offered: increment or totalise. The general way it operates is as follows:

Increment:  On receipt of a measurement trigger, an event count is started. Then, on receipt of another measurement trigger, the event count is stopped, the result sent to the host interface, and another count begun.

Totalise:    On receipt of a measurement trigger, events are counted until a halt or incremental count command is received. In the latter case the counter is cleared, prior to starting the incremental count. If a clear command is received at any time, the counter is reset to zero and a new count started on receipt of the next measurement trigger.

The maximum number of events that can be recorded, per channel, by the event counting circuitry is 16,777,215, after which the count continues from zero. No other indication of this is given.

**Table 8.2   Count Rate v. Sample Rate**

| Sample Rate | Max. Count Rate (using one channel) | Max. Count Rate (using 20 channels) |
|:-----------:|:-----------------------------------:|:-----------------------------------:|
| 20Hz | 2.4/s | 2.4/s |
| 1kHz* | 124/s | 124/s |
| 10kHz | 4900/s | 750/s |
| 100kHz | 15000/s | 750/s |

* default value

Debounce is applied to 20Hz and 1kHz sampling. With debounce, an event is considered to be valid only after four successive samples have shown the input to be at the same level.

### 6.3.1    Maximum Count Rate, Using One Channel

With 20Hz, 1kHz and 10kHz sampling, the maximum count rate can be obtained only if the mark:space ratio of the input signal is 1:1.  Any deviation from this ratio will lower the maximum count rate as shown in Figure 8.13.

With 100kHz sampling, the maximum count rate can be obtained with a mark:space ratio of between 1:1 and 5.7:1 (or vice-versa).  Any increase in the mark:space ratio lowers the maximum count rate as shown in Figure 8.13.  (The sharp steps in the 100kHz curves are due to software constraints.)
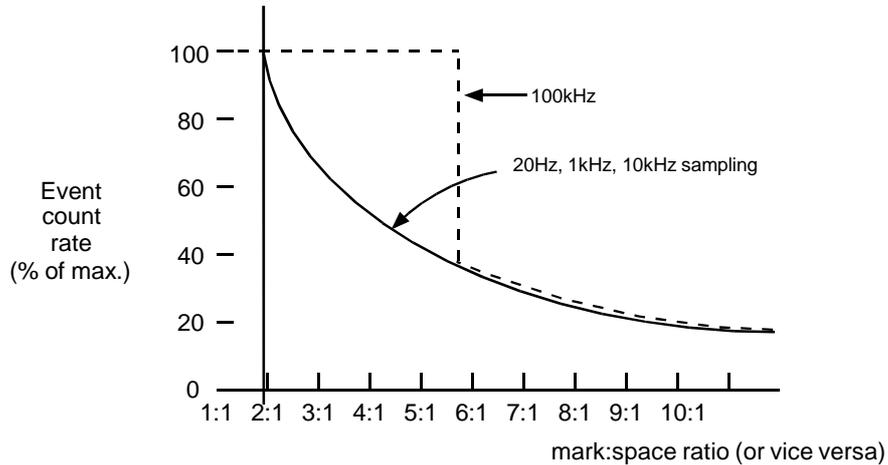


***Fig 8.13    Effect of mark:space ratio on event count rate (single channel).***

### 6.3.2    Maximum Count Rate, Using All Channels

With 20Hz and 1kHz sampling, the maximum count rate can be obtained only if the mark:space ratio of the input signal is 1:1.  Any deviation from this ratio will lower the maximum count rate as shown in Figure 8.14.

With 10kHz and 100kHz sampling there is virtually no restriction on the input signal mark:space ratio.  (The sharp steps in the 10kHz and 100kHz curves are due to software constraints.)
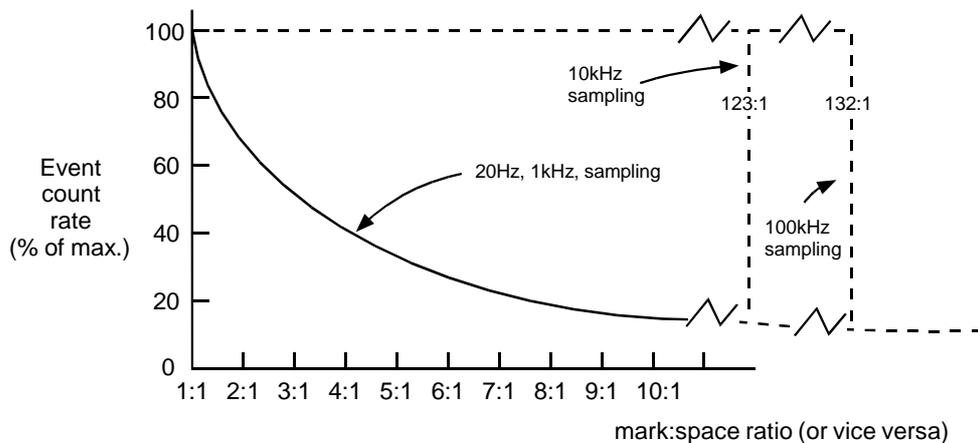


***Fig 8.14    Effect of mark:space ratio on event count rate (all channels used).***

## 6.4    FREQUENCY AND PERIOD: INTRODUCTION

The IMP has five logic arrays, each handling four input channels (see Figure 8.3 and 8.4).  For the reason that the timer/counter section of each logic array is common to four channels, only one frequency/period measurement per logic array can be conducted at any one time.  If more than one channel of a logic array is programmed to measure frequency/period, then those measurements are conducted sequentially.  Thus, if speed of results is important, frequency/period measurements should be distributed amongst the logic arrays in order to avoid, or reduce, measurement queuing.  This is particularly important if a *scan all channels* command is issued, since all channels (of all logic arrays) must have completed their measurements before results can be released to the host.

The channels are allocated to logic arrays in the following blocks of four:

> channels 1 to 4
> channels 5 to 8
> channels 9 to 12
> channels 13 to 16
> channels 17 to 20

**Example**: Suppose that three channels are to measure frequency, with a measurement time of 10 seconds, the remaining channels being either unused or measuring status/events.  If the three 10 second measurements were placed, say, on channels 1 to 3, more than 30 seconds would be required to complete a *scan all channels* command.  However, if the three measurements were distributed between logic arrays, say on channels 1, 5 and 9, measurements would occur simultaneously, thus reducing the overall scan time to little more than 10 seconds.

## 6.5    FREQUENCY

Frequencies can be measured from just under 50kHz down to 1Hz.  Several sampling rates are provided (Table 8.3) with debounce being incorporated in the 20Hz and 1kHz rates.  Signals of less than 1Hz can be measured by using Event Capture (Section 6.2).

**Table 8.3   Maximum Input Frequency v. Sample Rate**

| Sample Rate | Max. Input Frequency |
|:---:|:---:|
| 20Hz | 2.4Hz |
| 1kHz | 124Hz |
| 10kHz | 4.9kHz |
| 100kHz* | 49kHz |

*default value.

The maximum input frequency which can be measured with a given sampling rate depends upon the mark:space ratio of the input signal. The maximum input frequency, that is 2.4Hz, 124Hz, and so on, can be measured only if the mark:space ratio is 1:1. Any deviation from 1:1 (in either direction) will lower the maximum measurable input frequency as shown in in Figure 8.15.
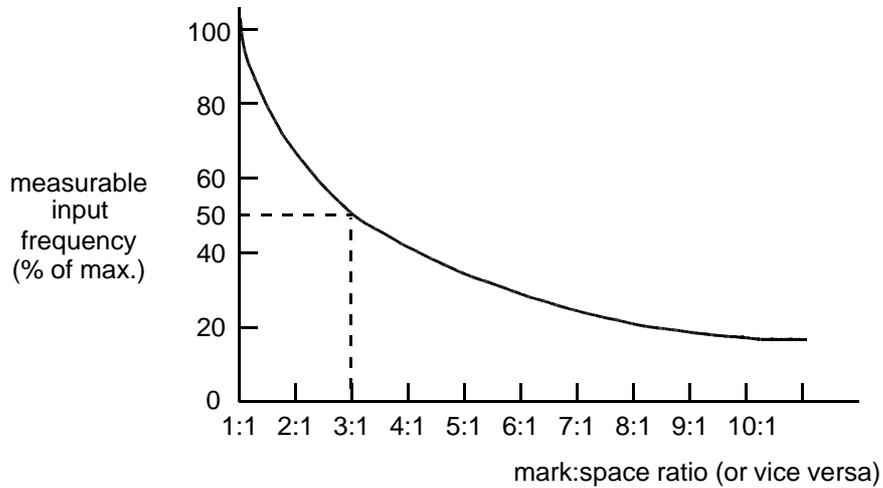


**Fig 8.15    *Effect of mark:space ratio on measurable input frequency.***

The accuracy and resolution of results depends upon the choice of measurement time, as shown in Table 8.4. The longer times give the greater accuracy (less uncertainty) in the final result.

**Table 8.4   Result Resolution v. Measurement Time**

| Measurement Time | Result Resolution |
| --- | --- |
| 10s | 0.1Hz |
| 1s | 1Hz |
| 100ms | 10Hz |
| 10ms | 100Hz |

It is essential to use a measurement time that is adequate for the expected input frequency. For example, when measuring 2Hz (period 500ms), there is no point in using a measurement time of 100ms since only 20% of the input signal would be seen. A better measurement time to use 10 seconds, which measures for 20 complete cycles.

## 6.6    PERIOD

Time periods (single pulses or whole cycles) can be measured from 20μs up to 25s (longer periods can be measured with Event Capture). Several sampling rates are provided, as shown in the table below, debounce being incorporated in the 20Hz and 1kHz rates. When selecting the sampling rate, ensure that the period of the input signal does not drop below the corresponding minimum input period in the table, or, an incorrect measurement will result.

**Table 8.5   Minimum Input Period & Result Resolution v. Sample Rate**

| Sample Rate | Min. Input Period | Event Resolution |
|:---:|:---:|:---:|
| 20Hz | 400ms | 50ms |
| 1kHz | 8ms | 1ms |
| 10kHz | 200µs | 100µs |
| 100kHz* | 20µs | 10µs |

* default value

The minimum input period that can be measured with a given sampling rate depends largely on the mark:space ratio of the input signal.  The minimum input period, (400ms, 8ms, and so on) can be measured only if the mark:space ratio is 1:1.  Any deviation from 1:1 (in either direction) will increase the minimum measurable input period as shown in Figure 8.16.
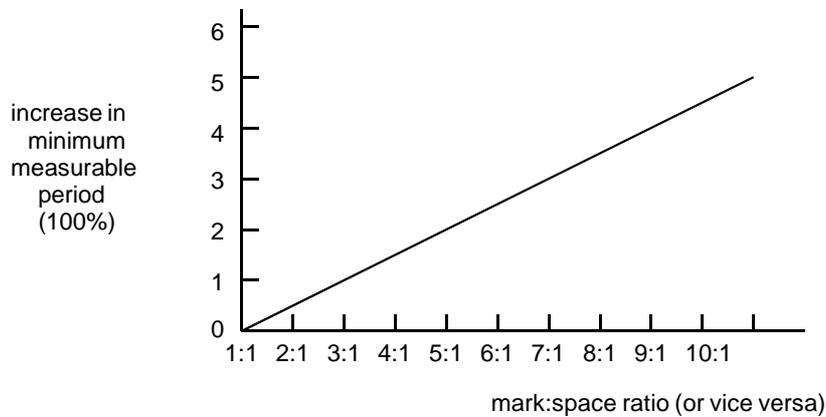


*Fig 8.16    Effect of mark:space ratio on minimum measurable period.*

## 6.6.1    Periods Examined

When measuring cyclic waveforms, the number of cycles (periods) to be included in a measurement can be selected as: 1, 10, 100, or 1000.  There are two main benefits in consideêring larger numbers of periods:

a.   The already small measurement uncertainty (±1 bit, inherent in all digital measurement systems) becomes insignificant.

b.   Many signals exhibit some frequency or phase shift (for example, mains-derived signals), no matter how small.  In this case, a measurement result will probably be required that represents the average value of the input period.  The only way to obtain such an average is to take into account as many periods as is practicable (that is 1000 periods).  Note that the measurement of cyclic signals starts and stops with the -ve edge of the signal, as shown in Figure 8.17.
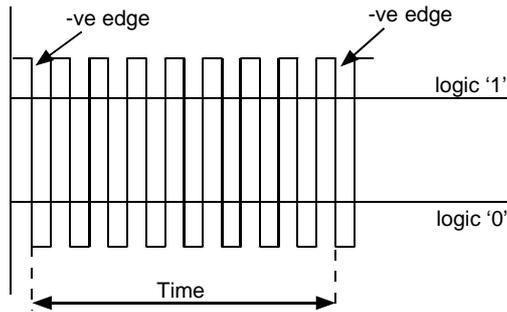
*Fig 8.17    Measurement of 10 periods.*

### 6.6.2    Pulse Width

For a one-shot (single pulse) signal, it is possible to measure either a positive pulse (start with +ve transition and end on -ve, as illustrated in Figure 8.18) or a negative pulse (start with -ve transition and end on +ve).
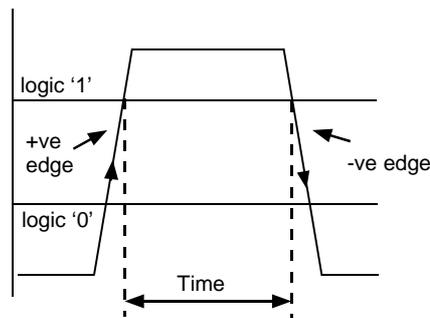


*Fig 8.18    Single pulse measurement, positive pulse.*

### 6.6.3    Time-Out

The following fixed time-out periods are available: 200ms, 2s, 20s and 50s.  The default value is 2s.  If one period is to be examined, the time-out must be at least double the expected period.  For more than one input period, the time-out must be greater than the input period multiplied by the number of periods examined.

For example, to measure one input period of about 50ms, a time-out of 200ms would be satisfactory.  However, to measure ten time periods of 50ms, a time-out of at least 50ms×10 = 500ms would be required.  A time-out of 2s would therefore be suitable.

## 6.7 DIGITAL OUTPUT

Each channel can be configured as a digital output, to drive such things as indicators, reed-relays. In this configuration the output consists of an open-drain MOSFET (see Figure 8.1), which can be regarded simply as a resistance switch:

For switch closed, the resistance between O/P and COM $\approx 10\Omega$.
For switch open, the resistance between O/P and COM $\approx 10M\Omega$.
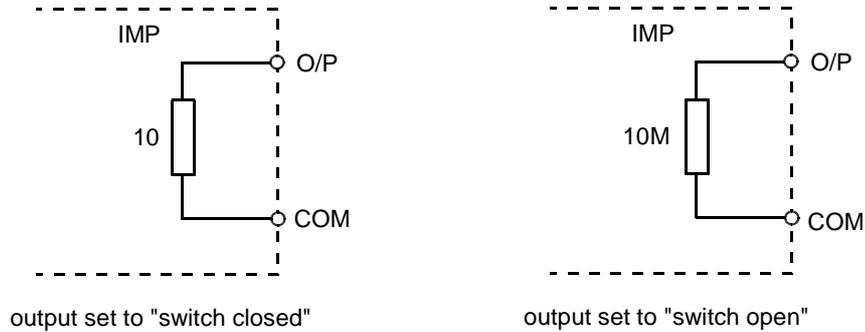


*Fig 8.19   Equivalent circuits of the digital outputs.*

The rating of the FET is 80V, 1W with a steady-state current sink capability of 100mA. Over-voltage protection of the FET is provided by the 62V zener diode.

A +5V, 20mA power source is provided at the connector block for the energisation of such output devices as low-power transducers and lamps. The power supply is short-circuit protected against overloads.

A typical arrangement of digital outputs with load energisation by the IMP 5V supply is shown in Figure 8.20.
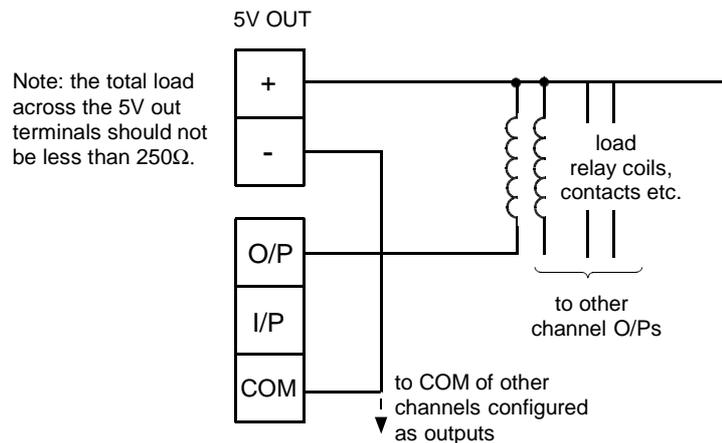


*Fig 8.20   Digital output, with the load energised from the IMP.*

# 7    LED DISPLAY

The four LEDs visible at the end face of the IMP convey certain user-confidence information when illuminated.  They are allocated as shown in Table 8.6.

**Table 8.6   Meaning of the LED Display.**

| LED | Meaning | Comment |
|:---:|---------|---------|
| 1 | Power on. | O.K. |
| 2 | Not allocated. | --- |
| 3 | Event buffer full. | 'Lost' events being counted. |
| 4 | IMP scanning (active). | O.K. |

# 9

## IMP 3595 2B + Connector Block 3595 3F

*(also covers IMC 3595 52B)*

# Contents

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## List of Tables

# 1    INPUT/OUTPUT CHANNELS

The 35952B IMP provides thirty-two transformer-isolated channels, four of which can be configured as output if required (channels 29-32).  As an input, a channel can record status or capture events.  As an output, each channel, which consists of a transistor switch, closes for a logic '1' (short circuits the output terminal to common) and opens for a logic '0'.

The signals applied to the inputs can take one of two forms :

a.   As a volt free contact switch.  In this case the logic level recorded will be a '1' with the contact open and a '0' with the contact closed.

b.   As a voltage input.  In this case a logic '0' will be recorded when the voltage $V_{in}$ is $0 \leq V_{in} \leq 3V$ and a '1' when the voltage is $9 \leq V_{in} \leq 120V$.

# 2    INTERNAL ORGANISATION

Each pair of channels is applied to a hybrid circuit which conditions the signal for the rest of the circuit.  The outputs of the 16 hybrid circuits are multiplexed and the resultant bit stream is monitored by a microprocessor.  The network communications is handled by a logic array.
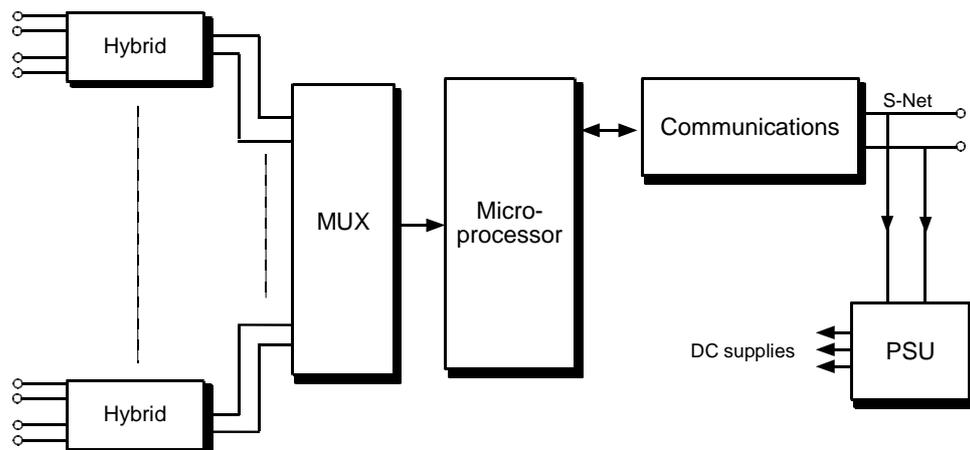


*Fig 9.1    Schematic of the IMP operation.*

# 3        LOGIC LEVEL CONVENTION

When relating logic levels to input or output currents and voltages, IMPs conform to the positive logic convention.  By this system, logic '1' represents the presence, and logic '0' the absence, of the current or voltage.  Logic '1' is always more positive than logic '0', as shown in Figure 9.2.

The threshold levels for logic '1' and 0 are given in the Specification (Appendix B).
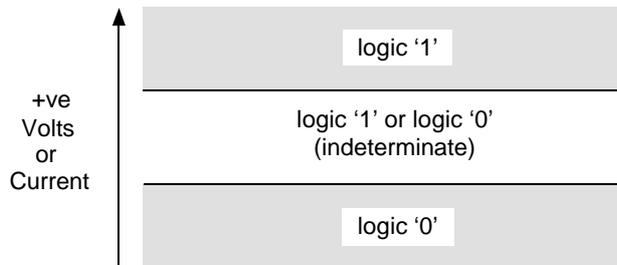


*Fig 9.2    Positive logic convention.*

# 4        LOGIC THRESHOLD LEVELS: INPUT CHANNELS

All inputs are compared with pre-set voltage threshold levels in order to ascertain the logic states of those inputs.



*a) input thresholds for volt free contact.*      *b) input thresholds for voltage input.*
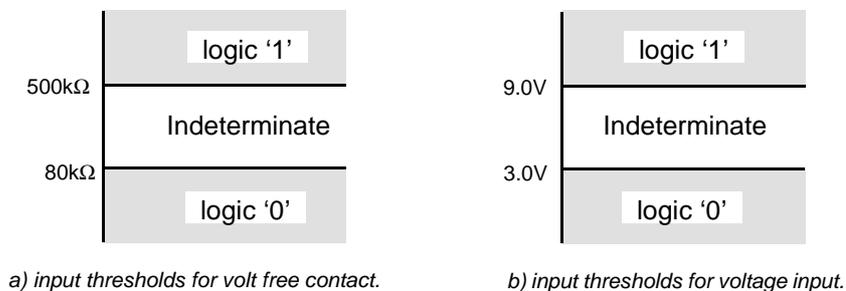
*Fig 9.3    Input channel thresholds.*

Note that levels situated between the selected thresholds are considered to be indeterminate.  This means that it is impossible to predict whether such a level will be interpreted as a logic '0' or a logic '1'.

# 5        SAMPLING RATE

The inputs are sampled every 20ms.  A logic level is recognised if four successive samples are stable.

## 6 MEASUREMENT PREPARATION

Normally, only two wires are connected to any group of IN, OUT and COMMON terminals.



*(a) as input (1-32)*                    *(b) as output (29-32)*
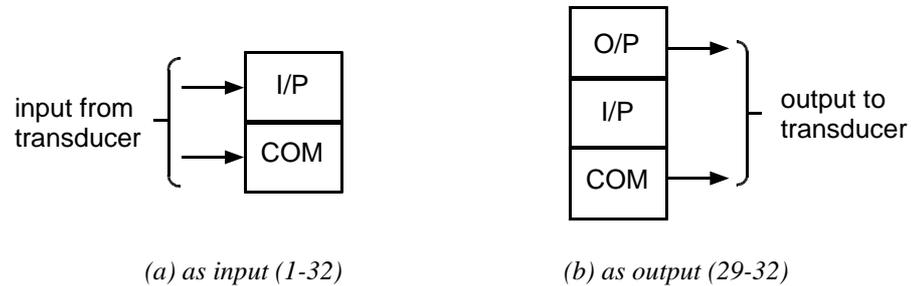
### *Fig 9.4    Connection terminals.*

Note that the connection terminals of a channel should be used either for an input transducer or for an output transducer, *not both*.  If this rule is not observed, signals received from the input transducer may be coupled back to the output and produce an unexpected change on a connected ouput transducer.

Normal switch contacts do not require a voltage energisation source (contact wetting) since their resistance is measured by the IMP or IMC.  Any switch input has a maximum input current of 80μA sourced from the IMP or IMC.

If existing switch contacts are already energised, they are measured as voltages automatically.

If a group of switch contacts are wired with a common return wire, associated common terminals of the IMP or IMC should be connected together.

### 6.1    IMC CONNECTIONS

Connections to the IMC are made through three connectors, PL 1, PL2 and PL3.   The connections are detailed in Figures 9.5 and 9.6.  PL1 is used for the connections to S-Net, PL2 is used for inputs I1-I18, and PL3 is used for inputs I19-I32 and outputs O29-O32.

> **WARNING:** Where only one of the two 37-way connectors is fitted, there may be a risk of high common mode voltages at the unused connector.  For this reason the covers supplied with the IMC must be fitted to unused connectors.
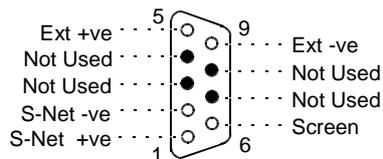


### *Fig 9.5    Pin functions of the S-Net connector.*
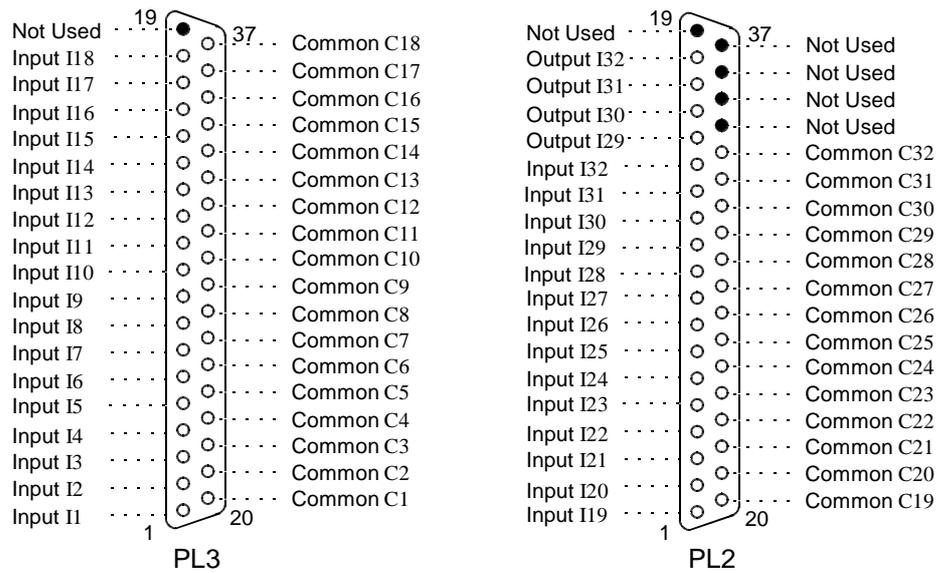
*Fig 9.6   Pin functions of input and output connectors.*

## 6.2      STATUS

The purpose of status measurement is to ascertain the logic state of a signal.  Inputs are judged to be at logic '1' or logic '0', according to the selected input threshold levels. Remember that a logic level *between* the selected thresholds may be interpreted either as logic '0' or logic '1'.



*a) input thresholds for volt-free contact.*



*b) input thresholds for voltage input.*
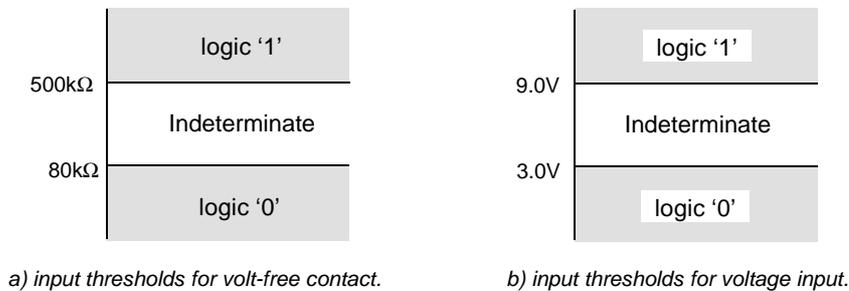
*Fig 9.7      Input channel threshold levels.*

## 6.3      WATCHDOG

Once the watchdog is enabled the watchdog output (channel 32) will go from a *off* state to a *on* state.  If a time-out period passes without the watchdog being patted (receiving a reassurance signal) the output is reset into its power off state.

Note that enabling the watchdog overrides any previous channel configuration on channel 32.

## 6.4 EVENT CAPTURE

The purpose of event capture is to determine when a logic transition occurs, noting the date, time and the polarity of the transition. A special buffer, used by all event capture channels, stores the event information. The buffer can store up to 128 events and, once full, keeps a count of how many events are then discarded (up to 64k).

The transitions recorded can be +ve, -ve, or both:

+ve transition:    a signal which passes from logic '0' to logic '1'

-ve transition:    a signal which passes from logic '1' to logic '0'

## 6.5 DIGITAL OUTPUT

Channels 29-32 can be configured as a digital output, to drive such devices as indicators and reed-relays. In this configuration the output consists of an open-drain MOSFET, which can be regarded simply as a resistance switch:

For switch closed, the resistance between O and C $\approx 10\Omega$.

For switch open, the resistance between O and C $\approx 10M\Omega$.



output set to 'switch closed'          output set to 'switch open'

***Fig 9.8    Equivalent circuits of the digital outputs.***

The rating of the FET is 80V, 1W with a steady-state current sink capability of 100mA. Over-voltage protection of the FET is provided by a 62V zener diode.

A typical arrangement of digital outputs with load energisation by the an external supply is shown in Figure 9.9.
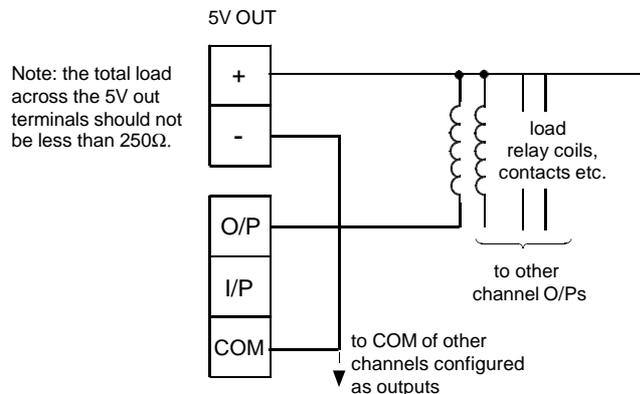


***Fig 9.9    Digital Output.***

# 7    LED DISPLAY

The four LEDs visible at the end face of the IMP convey certain user-confidence information when illuminated.  They are allocated as shown in Table 9.1.

**Table 9.1   Meaning of the LED Display.**

| LED | Meaning | Comment |
|:---:|---|---|
| 1 | Power on. | O.K. |
| 2 | Not allocated. | --- |
| 3 | Event buffer full. | 'Lost' events being counted. |
| 4 | IMP scanning (active). | O.K. |

# 10

## *VIMPs  3595 1F,G + Connector Block 3595 3G*

## *Contents*

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# 1    VIMP OVERVIEW

VIMPs are IMPs that can measure vibration and they are available in two versions: the 3595 1F and the 3595 1G. The 3595 1F can measure vibration on up to 16 channels, and each measurement can be synchronized with any one of four trigger inputs: there is also an event input that can select a VIMP program in accordance with a critical machine state, and an alarm output. The 3595 1G is similar to the 3595 1F, but has 32 vibration input channels, eight trigger inputs, one event input (the same) and two alarm outputs. Each type of VIMP may be programmed from the Host Computer for a number of vibration measurement tasks.

The 3595 1F is housed in a dual IMP case, whilst the 3595 1G is housed in a triple IMP case. A detachable connector block, the 3595 3G, contains the screw terminals through which all connections are made, and the VIMP address switches: the 35951F embodies one such connector and the 35951G two. User-configureable 'jumpers' (plug-in wire links) on the analog input cards provide for the selection of the range and coupling for each vibration input channel and for the coupling of each trigger input. The jumpers are accessed by opening part of the VIMP assembly.

## 1.1    VIMP POWER SUPPLIES

A VIMP is powered from two sources: S-Net conveys power to the communications module, whilst a 3595 95D Power Supply, local to the VIMP, supplies the vibration measurement front end.

### 1.1.1    S-Net Power Source

The power conveyed on S-Net to the VIMP can be sourced by the Host computer itself or by an external supply unit connected to the 34954B Interface. Details are given in the 34954B User Manual (Chapter 2, Section 7).

The S-Net cable for supplying power to a VIMP must be given the same consideration as when supplying an IMP. Guidance on the cable to use is given in Chapter 2 of this Installation Guide. The connection details are given in Chapter 4.

### 1.1.2    Local Power Source

The 3595 95D Power Supply is able to supply the vibration measurement front ends of two VIMPs.

As a guide to mounting the 3595 95D, the Installation Guide contains the following mechanical details: Chapter 2, Section 3.3 –dimensions; Chapter 4, Section 4.3.1 –feet fitting and grounding instructions.

As a guide to making the correct connections, the local supply terminals on the 35953G Connector Block and the corresponding terminals on the 3595 95D Power Supply are clearly labelled. The layout of the 35953G Connector Block is shown in Figure 10.2. Guidance on choosing a suitable local supply cable are given Chapter 2, Section 3.3.1 of the Installation Guide.

## 2 INTERNAL ORGANIZATION

A simplified block diagram, representing the internal organization of the VIMP, is shown in Figure 10.1. Each of the main functions of the VIMP is indicated by a named functional block, and a simple description in terms of these blocks is given below.

The VIMP operates in accordance with a number of task (tour) programs, each of which is executed, as required, by **DIGITAL SIGNAL PROCESSING**. For normal operation, with the VIMP in its 'On-line' mode, the task programs are written into the VIMP memory from the Host computer, via S-Net and the **S-NET INTERFACE**. Alternatively, with the VIMP in its 'Local' mode the same programs can be written into memory via the **RS232 INTERFACE**. The latter method is generally used for test purposes, but it can also be used to operate the VIMP from a local Monitor PC. Once the required task programs are present in the VIMP memory the program to be used is selected by an appropriate command, either from the Host Computer or from the Monitor PC.

An **EVENT INPUT** allows an external event, such as a critical machine state, to select an appropriate task program. This program would be one of those previously written into the VIMP memory.

Each task program allows the VIMP to acquire data for a specific machine state. In accordance with the selected program, the **DIGITAL SIGNAL PROCESSING** selects specific **VIBRATION INPUTS** in a specific order and for each input may select a specific **TRIGGER INPUT**. On the occurrence of the selected trigger the vibration signal is measured by an analog-to-digital converter (ADC), which includes, at its input, a selectable hardware filter. The digital output of the ADC is passed to **DIGITAL SIGNAL PROCESSING** for FFT analysis, averaging and alarm detection. The vibration data thus processed may be transmitted, on request, to the Host Computer or the Monitor PC.For test purposes, the **EXTERNAL MONITOR** outputs of the ADC allow the selected vibration input and its companion trigger signal to be monitored by an external device. For this, the VIMP is operated in its 'test' mode.
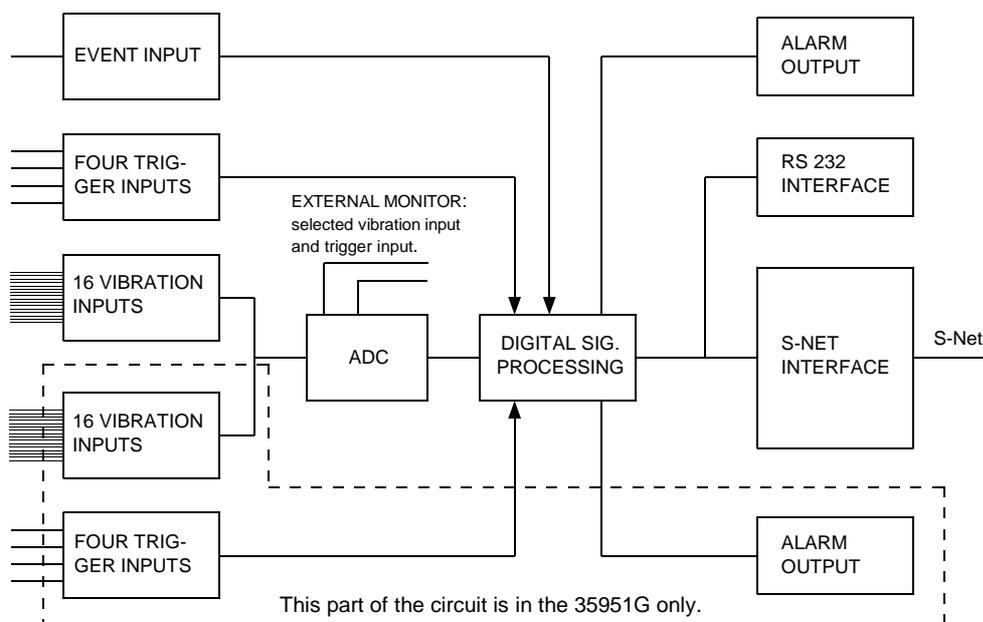


*Fig 10.1    Simplified block diagram of the 35951F/G VIMP hardware.*

# 3     MEASUREMENT CONNECTIONS

Measurement connections are made to the 35953G Connector Block. The 16-channel VIMP (35951F) uses one such connector block, whilst the 32-channel VIMP (35951G) uses two.

A 35953G Connector Block is secured in the VIMP casing by two captive knurled screws and can be conveniently removed from the VIMP for connections to be made. To do this, simply undo the two securing screws and withdraw the connector block from the VIMP casing. (Initially, it may be necessary to undo the screws with a screwdriver.) Access to the measurement connection terminals is obtained by removing the two cover securing screws and lifting the cover clear.

The VIMP measurement connections are as follows:

- 16 (32) analog input channels,

- 4 (8) synchronization input channels,

- 1 event input,

- 1 (2) alarm output(s).

The numbers in brackets indicate the channel complement of the 35951G VIMP.

Details of each type of VIMP measurement connection are given in Section 4. Information on measurement connections generally is given in Chapter 4 of the 3595 Installation Guide, together with details of the S-Net connections and VIMP/IMP addressing.

Note that the connection of S-Net to a 35951G (32-channel VIMP), and the VIMP address setup, must be made at the connector block relating to the lower 16 channels. (This is the connector block that is located in the upper section of the case when the VIMP is laid flat on its mounting brackets.) No S-Net connection should be made to the other connector block and the address switch settings on this block are disregarded.
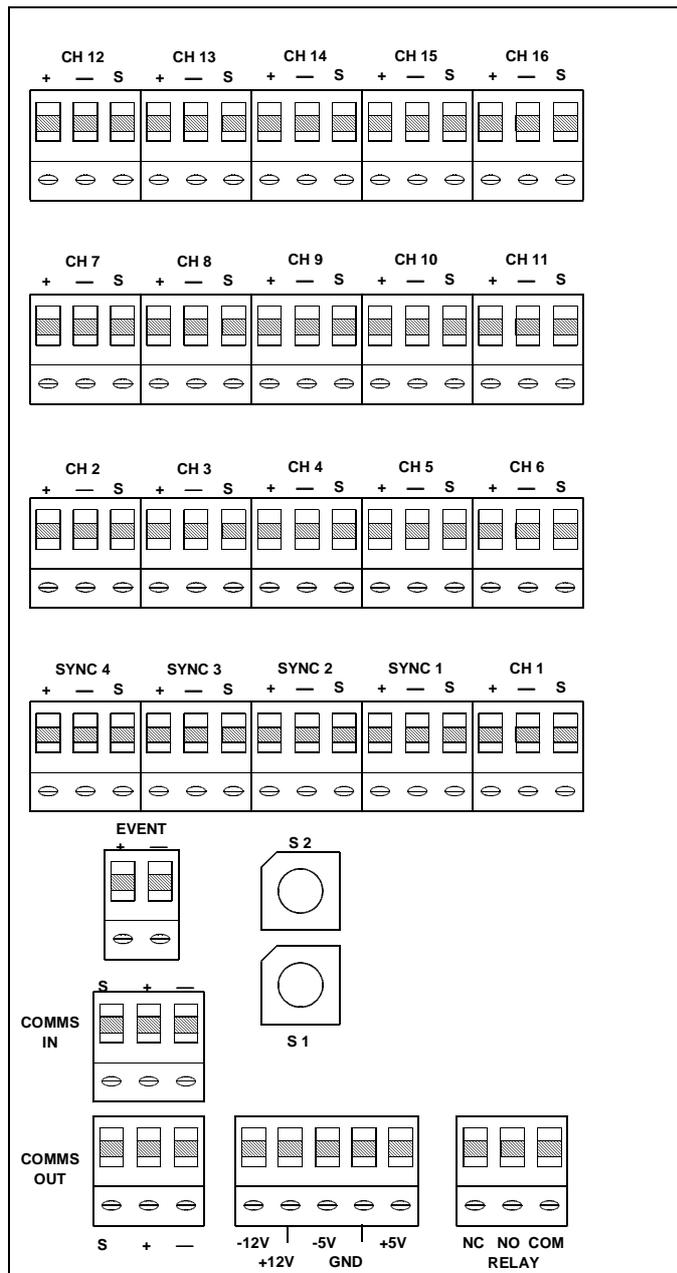
*Fig 10.2     Layout of Connector Block 35953G.*

**WARNING:** To ensure operator safety, and to maintain the IP55 Specification regarding the protection against ingress of moisture, the 35951G VIMP must *always* be operated with *both* 35953G Connector Blocks fitted.

Once the measurement connections have been made, replace the connector block cover and secure with the two securing screws. Then insert the connector block into its recess in the VIMP casing and screw in the two knurled screws. The knurled screws may be turned initially with the fingers, but should finally be tightened with a broad-bladed screwdriver.

# 4 MEASUREMENT PREPARATION

This section describes the connections, the function, and the installation background for each type of measurement input/output.

## 4.1 ANALOG INPUT CHANNELS

The analog input channels provide for the acquisition of a variety of dynamic signals. These signals may be acquired from transducers such as accelerometers, velometers or displacement probes, but the connections are the same in each case: '+', '−', and 'S' (screen).

The terminal sets for the analog input channels are labelled 'CH1' through 'CH16'. For the 32-channel VIMP, channels 17 through 32 are connected to terminal sets 'CH1' through 'CH16' on the second connector block.

For each channel, 'jumpers' (i.e. plug-in wire links) are used to configure the input range and coupling. Jumper configuration is described in Section 5 of this chapter.

### 4.1.1 Selecting the Optimum Input Voltage Range

To select the optimum input voltage range the following criteria should be met:

1. To avoid an overload condition the input range setting jumpers must be set to accommodate the largest signal expected from the transducer.

2. To achieve the highest resolution it is important to select the lowest input voltage range that satisfies criterion 1.

As far as the input ranges are concerned it is the peak value of the signal that is important for setting the range, not the rms or peak-to-peak. This is because the input ranges available are with respect to the peak value of the signal.

In practice, to select the optimum range it is necessary to know the maximum peak level of the signal expected under normal operating conditions. (In this case, 'normal operating conditions' means the range of machine operation under which you would expect to make measurements.) To measure this peak value the VIMP can be used, and the following procedure is suggested:

1. Set up the VIMP input ranges to the maximum range, i.e. their factory default setting of 10V.

2. Log the peak signal at the highest acquisition rate available.

3. Continue logging until an adequate representation of the normal operating conditions has been recorded.

4. Search through the data to identify the peak signal and then select the VIMP input ranges according to criteria 1 and 2 above.

If you can't measure the input signal over the complete operating range of the machine then you should estimate the peak value that is likely to occur.

To get a rough idea of the signal levels present, measure the peak value using a low cost handheld peak meter. Then estimate how much larger this value could get over the complete machine operating range. This saves the time involved in:

a.  logging data over a period of time with the VIMP, and

b.  breaking down the casework on two occasions, rather than one, initially to set up coupling and finally to set up the input range.

This proceedure holds true for signals measured downstream of the ac/dc coupling. (Large dc offsets can be rejected by ac coupling the signals allowing a more sensitive range to be selected.)

## 4.2    SYNCH CHANNELS

The synch channels provide for the input of trigger signals from the machine(s) being monitored. Trigger signals enable measurements to be synchronized with the shaft rotation, so that phase data can be obtained and multiple measurements can be synchronized across the entire machine.

Trigger signals are connected to the terminal sets SYNC1 through SYNC4. Individual terminals in the sets are labelled '+', '−' and 'S', as for the analog input channels. For the 32-channel VIMP, four more trigger signals may be connected to four identical terminal sets on the second connector block.

For each synch channel, jumpers are used to configure ac or dc coupling. Jumper configuration is described in Section 5 of this chapter.

Synch channels are assigned to analog input channels by the task (tour) programming.

## 4.3    EVENT TRIGGER

The event trigger input is activated by a positive-going digital input from the machine being monitored. Using such a signal enables the VIMP to respond to a significant machine state, such as machine on-load.

In the EVENT terminal set there are two terminals, labelled '+' and '−', which are connected internally to an opto-isolator. An event is signified by making the '+' terminal more positive than the '−' terminal by a potential in the range 2.9Vdc through 5.5Vdc. This range is defined by a 270Ω resistor fitted in the 'R1' position on the connector board. Other voltage ranges may be configured by changing the resistor value, but the input current range thus obtained should always be 5mA through 15mA.

## 4.4    ALARM OUTPUT

When the VIMP detects an alarm state the alarm output(s) may be used to trip the machine being monitored and/or to drive an alarm indicator. The 16-channel VIMP has one alarm output, whilst the 32-channel VIMP has two.

An alarm output is in the form of switched contacts, controlled by an internal relay, which are connected to the RELAY terminal set. The terminals are labelled 'NC' (normally closed), 'NO' (normally open) and 'COM' (common): with the alarm relay

de-energised 'NC' is connected to 'COM', and with the relay energised 'NO' is connected to 'COM'.

The action of the alarm relays is programmed by the task software, in which the energised and de-energised relay states are specified by 'ON' and 'OFF'. Thus an alarm relay may be programmed to switch either ON or OFF for an alarm state.

# 5    JUMPER CONFIGURATION

Jumpers (i.e. wire links) are used to configure the range and coupling for the analog input channels and the coupling of the sync channels. Section 5.1 explains how to open up the VIMP and Section 5.2 shows how to configure the jumpers thus accessed. *NOTE: Jumper configuration is essentially a job for an experienced installation engineer.* Spare jumpers (Part No. 351502100) may be ordered from Solartron.

## 5.1    ACCESSING THE VIMP JUMPERS

To access the VIMP jumpers, you must remove the outer shell of the VIMP input card housing. The procedure depends on the type of VIMP being configured, 35951F (dual case) or 35951G (triple case). The relevant procedures are given in Sections 5.1.1 and 5.1.2.

### 5.1.1    Accessing the Jumpers in the 35951F VIMP

The procedure for accessing the jumpers in the 35951F (dual case) VIMP is as follows:

1. Undo the knurled nuts securing the 35953G Connector Block and withdraw it from the VIMP assembly.

2. Loosen the bolts securing the VIMP to its installation point. If the VIMP is bonded to ground through the VIMP case (through the point indicated in the diagram following Step 4) use an M4 nut spinner to remove the nut and star washer securing the ground lead, and remove the lead from the VIMP.

3. Lift the VIMP clear of the installation point and lay it on its mounting brackets in a convenient working space.

4. Remove the eleven M5 socket-head screws that secure the outer shell of the VIMP input card housing to the VIMP assembly. For this you will need a 4mm Allen key. If you have not aready removed the M4 nut and star washer mentioned in Step 2, do this now. The positions of the eleven M5 screws are indicated by the letter 'B' in the following diagram:
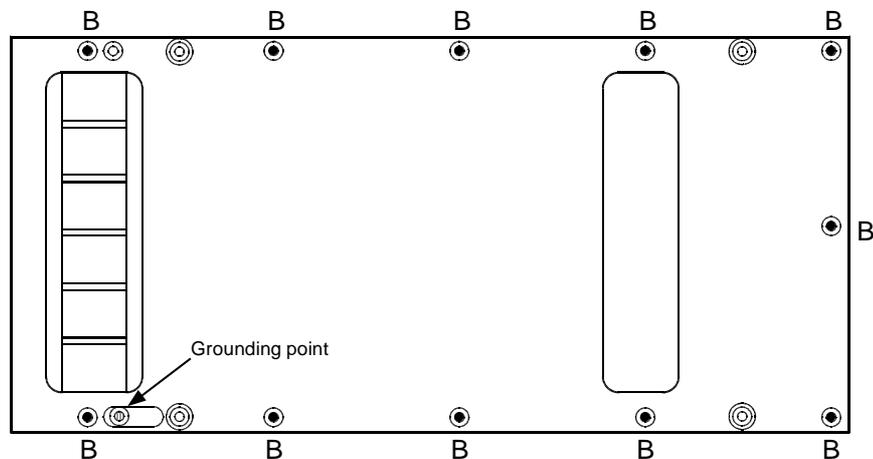
5. Lift the outer half-shell of the VIMP input card housing away from the VIMP assembly. **Take care not to damage the neoprene-bonded cork gasket**: this may adhere to both half-shells—if so, use a thin-bladed screwdriver or palette knife to ease the gasket away from the face of the half-shell you intend to remove. Take care also not to lose the bag of desiccant which rests on the input card, or either of the two nut plates that are used to secure the connector block.
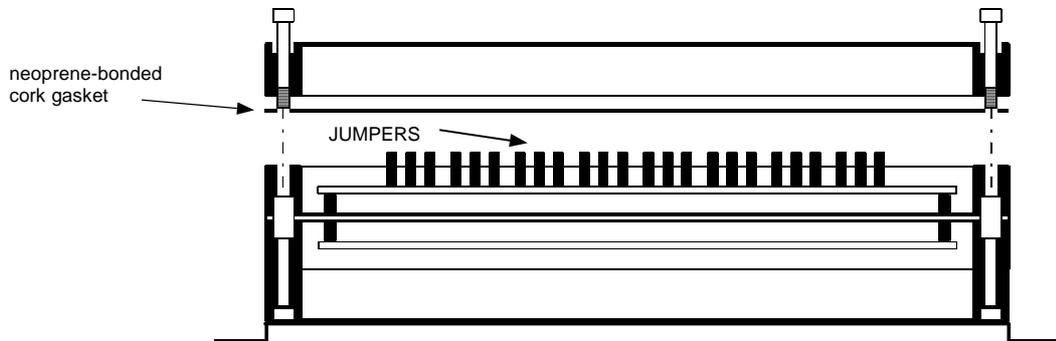


## 5.1.2   Accessing the Jumpers in the 35951G VIMP

The procedure for accessing the jumpers in the 35951G (triple case) VIMP is as follows:

1. Take each 35953G Connector Block in turn, undo the knurled nuts securing the block, and withdraw it from the VIMP assembly.

2. Loosen the bolts securing the VIMP to its installation point. If the VIMP is bonded to ground through the VIMP case (through the point indicated in the diagram following Step 4) use an M4 nut spinner to remove the nut and star washer securing the ground lead, and remove the lead from the VIMP.

3. Lift the VIMP clear of the installation point and lay it on its mounting brackets in a convenient working space.

4. Remove the eleven M5 socket-head screws that secure the half-shell at the top of the VIMP assembly to the half-shell at the bottom. For this you will need a 4mm Allen key. If you have not aready removed the M4 nut and star washer mentioned in Step 2, do this now. You must also remove an M4 nut and star washer from an identical position on the bottom half-shell. The positions of the eleven M5 screws are indicated by the letter 'B' in the following diagram:
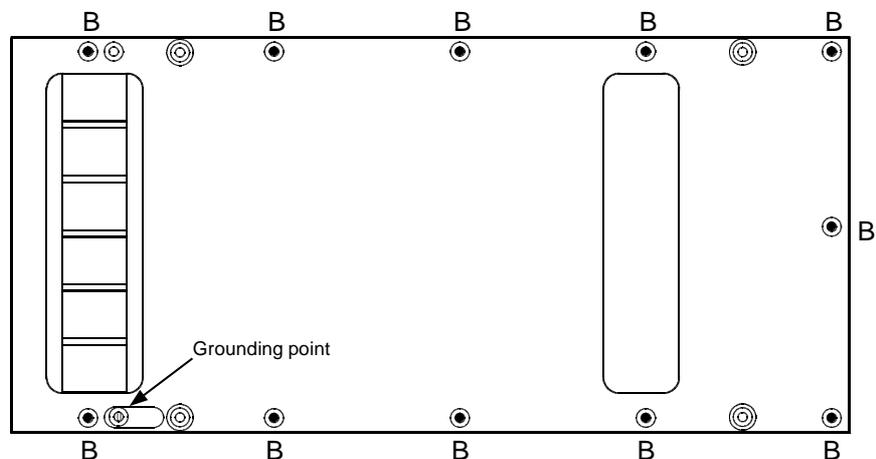
5. To access the jumpers for channels 1 through 16 lift the top half-shell away from the VIMP assembly; alternatively, to access the jumpers for channels 17 through 32 turn the assembly over onto its opposite face and lift the base half-shell away from the VIMP assembly. To avoid damage to the input cards, remove only one half-shell at a time: **do not rest the VIMP on the input card components. Take care not to damage the neoprene-bonded cork gaskets**: a gasket may adhere to both half-shells—if so, use a thin-bladed screwdriver or palette knife to ease it away from the face of the half-shell you intend to remove. Take care also not to lose either of the two bags of desiccant or any of the four nut plates.
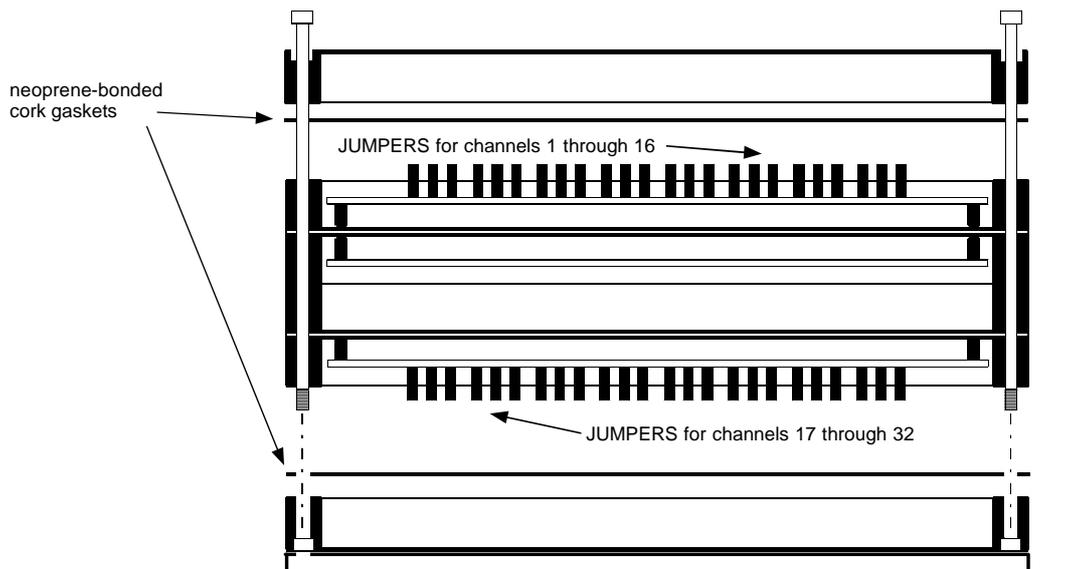
## 5.2 CONFIGURING THE VIMP JUMPERS: VERSION 1

Version 1 of the VIMP jumper layout relates to earlier models of the VIMP. (The jumper layout for later models is described in Section 5.3: the two versions are easily distinguishable from each other.) The jumper locations for version 1 are shown in Figure 10.3, whilst the jumper settings and associated functions are listed in Tables 10.1 through 10.3. To modify the jumper configuration, simply plug the jumpers IN, or take them OUT, as indicated.

**Note**: Jumper groups 'A' through 'P' relate to analog input channels 1 through 16 and 17 through 32.

In each jumper group LK1 selects the analog input coupling (Table 10.1) and LK2, LK3 select the analog input gain (Table 10.2).

The jumper pin configuration of jumper groups 'A' through 'P' is shown in the detail. Each plug-in jumper is able to link a pair of adjacent pins, pair 'a' or pair 'b'. Analog input options are selected by plugging IN jumper 'a' or jumper 'b', or leaving both jumpers OUT.

Synch channel jumpers. See Table 10.3.

JUMPER DETAIL

***Fig 10.3 Location of jumpers on the VIMP input card (35959552).***

### Table 10.1 Analog Input Coupling Options

| Coupling | LK1a | LK1b |
|:---:|:---:|:---:|
| a.c. | OUT | OUT |
| d.c. | OUT | IN |
| ICP | IN | OUT |

### Table 10.2 Analog Input Gain Options

| Range | LK2a | LK2b | LK3a | LK3b |
|:---:|:---:|:---:|:---:|:---:|
| 10V | IN | OUT | IN | OUT |
| 5V | IN | OUT | OUT | OUT |
| 2V | IN | OUT | OUT | IN |
| 1V | OUT | OUT | IN | OUT |
| 500mV | OUT | OUT | OUT | OUT |
| 200mV | OUT | OUT | OUT | IN |
| 100mV | OUT | IN | IN | OUT |
| 50mV | OUT | IN | OUT | OUT |
| 20mV | OUT | IN | OUT | IN |

**Table 10.3   Synch Channel Coupling Options**

| Synch Input | Jumper | Coupling Selected |
|:---:|:---:|:---|
| 1 | LK1 | For all links (LK1-4): |
| 2 | LK2 | link out = a.c. coupling; |
| 3 | LK3 | link in = d.c. coupling. |
| 4 | LK4 | |

## 5.3   CONFIGURING THE VIMP JUMPERS: VERSION 2

Version 2 of the VIMP jumper layout relates to later models of the VIMP.  (The jumper layout for earlier models is described in Section 5.2: the two versions are easily distinguishable from each other.)  The locations of the VIMP jumpers for version 2, and the jumper settings, are shown in Figure 10.4.  For the convenience of the installer the jumper settings are inscribed on the pcb, as shown in the figure details.  To set up or modify the jumper configuration, simply plug the jumpers in, or leave them out, as indicated.
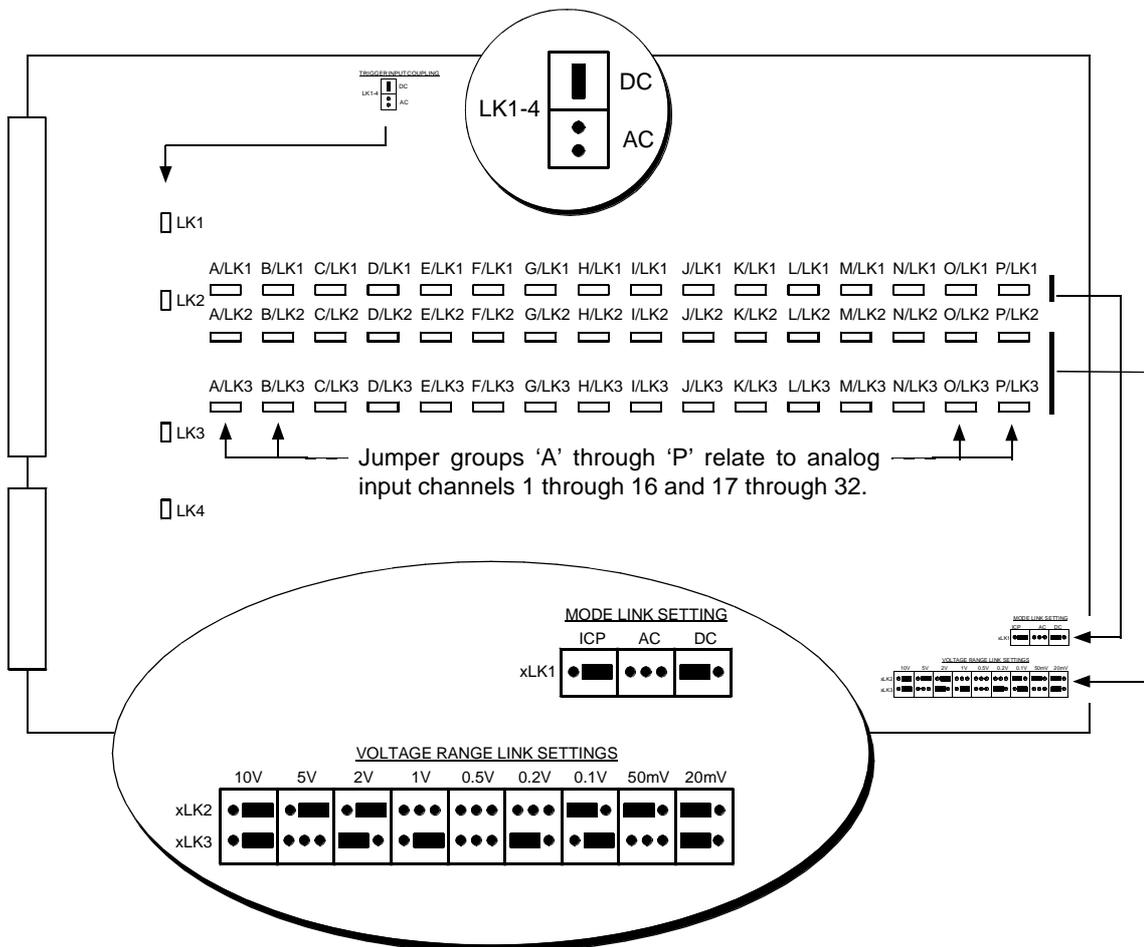


***Fig 10.4   The jumpers and jumper settings of the VIMP input card (35959552).***

## 5.4        REASSEMBLING THE VIMP

After the jumpers have been configured the VIMP must be properly reassembled, to ensure that the interior stays free of moisture.  The procedure depends on the type of VIMP being configured, 35951F (dual case) or 35951G (triple case).


### 5.4.1        Reassembling the 35951F VIMP

The procedure for reassembling the 35951F (16-channel) VIMP is as follows:

1.  Ensure that a serviceable neoprene-bonded cork gasket is correctly positioned around the edge of the half-shell attached to the VIMP assembly.  The gasket must be located over the bosses with raised shoulders so that its outer edges coincide with the 'closed' sides of the half-shell and the cross-piece at the 'open' side is aligned with the rubber seal around the input card.  (Spare neoprene gaskets can be obtained from Solartron, under Part No. 35952214.)

2.  Place the desiccant bag on the pcb.  Depending on the length of time that has elapsed since the VIMP was last opened, and the number of significant pressure changes, it may be necessary to fit a new desiccant bag (Part Number 450600420).  If a new desiccant bag is not immediately available, it is possible to reactivate the contents as follows: open the bag and empty the clay granules onto a suitable tray; then place the tray in a low-temperature (140°C) oven for between 7 and 8 hours; finally, allow the tray and clay granules to cool in a dry environment, before returning the clay granules to the bag and closing it.  Note, however, that the ability of the clay granules to absorb moisture is degraded each time they are reactivated: therefore, this method should be employed only in an emergency and no more than twice with the same granules.

3.  Place the two nut plates in the support grooves at the connector block end of the lower VIMP housing section.  The nut plates should be oriented with the longer tab at the bottom.

4.  Check that the inside face of the top half-shell has a rubber seal attached to the housing rib.  Carefully fit the top half-shell onto the lower one, ensuring that the two nut plates locate correctly into their corresponding slots.

5.  Check again that the edge of the neoprene-bonded cork gasket is flush with the outer edge of the VIMP on the three closed sides.  Then, look into the open end of the VIMP and check the alignment of the two rubber seals.  These should press together on either side of the neoprene gasket to give a moisture-tight seal around the input card.

6.  Fit an M5 socket-head screw into each of the screw-holes in the VIMP housing that are shown numbered below.  Pinch tighten the screws in positions 3, 4 and 11, then recheck the gasket and nut plate alignments.  Realign the gasket and nutplates as necessary, easing the screws in positions 3, 4 and 11 to do so.
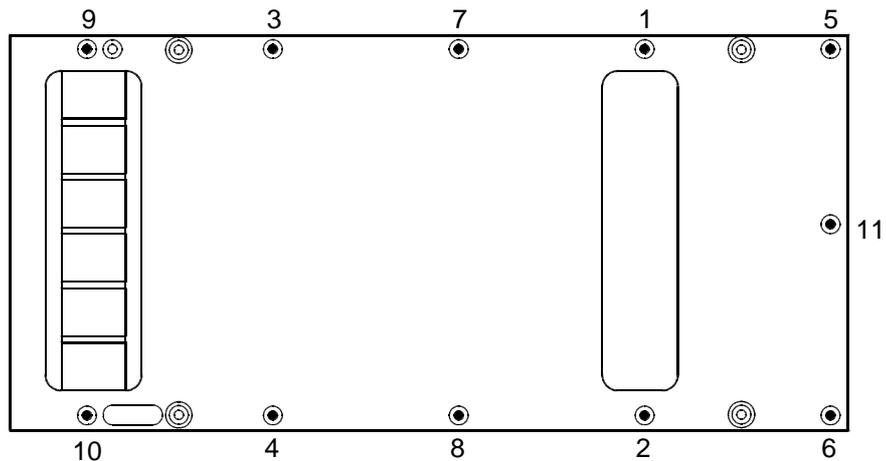
7. Tighten the M5 socket-head screws to a recommended torque setting of 3.5N.m, in the correct numbered sequence shown above. (Refit and tighten the M4 nut and star washer, if grounding point is not to be used.)

8. Hang the VIMP over its mounting bolts and tighten the bolts up to secure the VIMP to its installation point.

9. Where a VIMP grounding lead is used, reconnect it and secure with the M4 nut and star washer.

### 5.4.2    Reassembling the 35951G VIMP

The procedure for reassembling the 35951G (32-channel) VIMP is as follows:

1. With the input card for channels 1 through 16 protected by the top half-shell, place the VIMP on the work surface with the input card for channels 17 through 32 uppermost.

2. Ensure that a serviceable neoprene-bonded cork gasket is correctly positioned around the edge of the half-shell attached to the VIMP assembly.  The gasket must be located over the bosses with raised shoulders so that its outer edges coincide with the 'closed' sides of the half-shell and the cross-piece at the 'open' side is aligned with the rubber seal around the input card.  (Spare neoprene gaskets can be obtained from Solartron, under Part No. 35952214.)

3. Place the desiccant bag on the pcb.  Depending on the length of time that has elapsed since the VIMP was last opened, and the number of significant pressure changes, it may be necessary to fit a new desiccant bag (Part Number 450600420). If a new desiccant bag is not immediately available, it is possible to reactivate the contents as follows: open the bag and empty the clay granules onto a suitable tray; then place the tray in a low-temperature (140°C) oven for between 7 and 8 hours; finally, allow the tray and clay granules to cool in a dry environment, before returning the clay granules to the bag and closing it.  Note, however, that the ability of the clay granules to absorb moisture is degraded each time they are reactivated: therefore, this method should be employed only in an emergency and no more than twice with the same granules.

4.  Place the two nut plates in the support grooves at the connector block end of the lower VIMP housing section.  The nut plates should be oriented with the longer tab at the bottom.

5.  Check that the inside face of the top half-shell has a rubber seal attached to the housing rib and a rubber sleeve fitted to each of the four inner housing posts. Carefully fit the top half-shell onto the lower one, ensuring that the two nut plates locate correctly into their corresponding slots.

6.  Check again that the edge of the neoprene-bonded cork gasket is flush with the outer edge of the VIMP on the three closed sides.  Then, look into the open end of the VIMP and check the alignment of the two rubber seals.  These should press together on either side of the neoprene gasket to give a moisture-tight seal around the input card.

7.  Carefully holding the VIMP assembly together, turn it over so that it rests on its mounting brackets.

8.  Repeat steps 2 through 6.

9.  Fit an M5 socket-head screw into each of the screw-holes in the VIMP housing that are shown numbered below.  Pinch tighten the screws in positions 3, 4 and 11, then recheck the gasket and nut plate alignments.  Realign the gasket and nutplates as necessary, easing the screws in positions 3, 4 and 11 to do so.
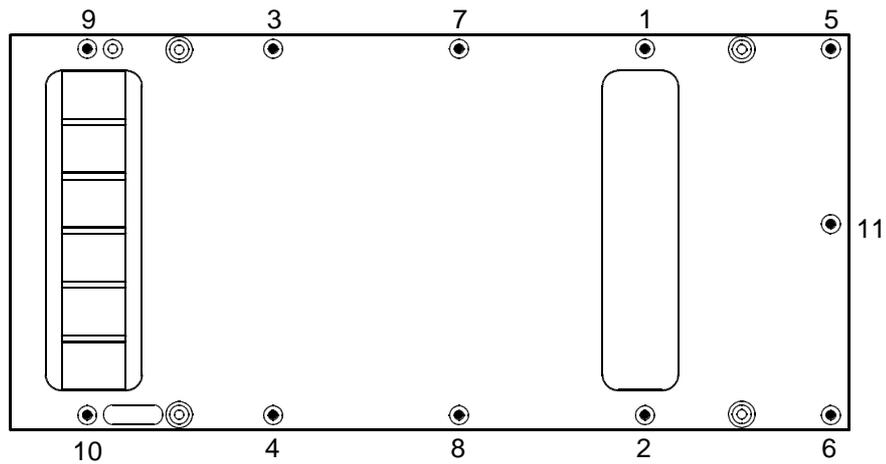


10. Tighten the M5 nyloc nuts to a recommended torque setting of 3.5N.m, in the correct numbered sequence shown above.  (Refit and tighten an M4 nut and star washer, where a  grounding point is not to be used.  Remember that this must be done both on the top and on the bottom half-shells.)

11. Hang the VIMP over its mounting bolts and tighten the bolts up to secure the VIMP to its installation point.

12. Where a VIMP grounding lead is used, reconnect it and secure with the M4 nut and star washer.

# 6      LED DISPLAY

Four LEDs on the end face of the VIMP convey certain user confidence information when illuminated.  The function of each LED is as follows:

**HEARTBEAT**      Illuminated when VIMP processor is active.

**COMMS**      Illuminated whilst VIMP and Host are communicating.

**RESET**      Illuminated during reset.

**POWER**      Remains illuminated whilst the VIMP is powered.

# 7    LOCAL SETUP PANEL

## 7.1    LOCAL CONTROL CONNECTION FOR RS232

The VIMP can be controlled locally, using the RXD and TXD lines, through an RS232 serial connection made on the local setup panel.  This panel is on the lower end of the VIMP, i.e. the end at which the measurement connections are made.  The RS232 connection is made through a sealed receptacle on the VIMP.

A five metre RS232 cable, type 359594G, is available from Solartron.  At one end this has a mating plug for the receptacle on the VIMP: at the other end is a 9-way D-type socket for connection to the controlling PC.

Users who wish to make up their own cable can obtain a mating plug, for the receptacle on the VIMP, from:

> W.W. Fischer, Electrical Connectors Ltd.
> Unit 6, Stratfield Park,
> Elettra Avenue,
> Waterlooville,
> Hants   PO7 7XN
>
> Tel. (01705) 241 122     Fax (01705) 257 596

Note that the cable you use must conform to the RS232 Standard.

The type of plug you can use has several variations, although some aspects of its design are fixed by that of the receptacle.  One example of a suitable mating plug has the Part Number S **103 A 057** *-opt* / 6.7 -U.  This breaks down as follows:

S = straight plug (unsealed).  This is one of the plug *style* options.  Some of the other styles available are SE (= sealed straight plug), WS (= right angled plug), and WSE (= sealed right angled plug).  For information on the other styles available contact W.W. Fischer.

**103** = the series number of the plug, which represents its size.  This is fixed by the size of the receptacle.

**A** = the *contact protection*.  In general, this means that the plug has pin contacts.  This is fixed by the socket contacts on the receptacle.

**057** = the code for the contact configuration.  This is fixed by the contact configuration of the receptacle.

6.7 = the maximum diameter (mm) of the cable clamping collet.  This depends on the diameter of the cable you intend to use and should be specified as indicated in Table 10.1.

### Table 10.4   Collet Sizes for Series 103 Plugs

| Unsealed Plug Type S Collet | | Unsealed Plug Type U Collet | | Sealed Plug | |
|---|---|---|---|---|---|
| Cable Diam. Range (mm) | Diam. to Specify (mm) | Cable Diam. Range (mm) | Diam. to Specify (mm) | Cable Diam. Range (mm) | Diam. to Specify (mm) |
| 1.7 - 2.2 | 2.2 | 2.2 - 3.2 | 3.2 | 1.7 - 2.2 | 2.2 |
| 2.2 -2.7 | 2.7 | 3.2 - 4.2 | 4.2 | 2.2 -2.7 | 2.7 |
| 2.7 - 3.2 | 3.2 | 4.2 - 4.7 | 4.7 | 2.7 - 3.2 | 3.2 |
| 3.2 - 3.7 | 3.7 | 4.7 - 5.2 | 5.2 | 3.2 - 3.7 | 3.7 |
| 3.7 - 4.2 | 4.2 | 5.2 - 5.7 | 5.7 | 3.7 - 4.2 | 4.2 |
| 4.2 - 4.7 | 4.7 | 5.7 - 6.2 | 6.2 | 4.2 - 4.7 | 4.7 |
| 4.7 - 5.2 | 5.2 | 6.2 - 6.7 | 6.7 | 4.7 - 5.2 | 5.2 |
| 5.2 - 5.7 | 5.7 | - | - | 5.2 - 5.7 | 5.7 |
| 5.7 - 6.2 | 6.2 | - | - | 5.7 - 6.2 | 6.2 |
| 6.2 - 6.7 | 6.7 | - | - | - | - |

U (or S) = the type of collet used for *unsealed* plugs (for example, style S or WS).  Type U is for use with unscreened (unshielded) cable or with screened (shielded) cable that is **not** connected to the plug body.  Type S is for use with screened cables that are connected to the plug body.  The type to use depends on whether the cable, if screened, is grounded at the other end: grounding at both ends should be avoided as this may result in signal interference.  For *sealed* plugs (e.g. style SE or WSE) the collet type need not be specified, unless ordered separately.  (Part Numbers for individual plug components can be obtained from W.W. Fischer.)

*opt* = a three digit option number with which you can specify various options such as plug finish, insulation and housing.  Details are available from W.W. Fischer.

The connections to be made to the mating plug are listed in Table 10.2.  The numbering of the mating plug pins is shown in Figure 10.4.

### Table 10.5   RS232 Cable Connections

| Mating Plug for VIMP Receptacle | | 9-way D-Type Socket Pin No. |
|---|---|---|
| Pin No. | Function | |
| 1 | Not used | - |
| 2 | Not used | - |
| 3 | RXD (input) | 3 |
| 4 | TXD (output) | 2 |
| 5 | Not used | - |
| 6 | Not used | - |
| 7 | GND | 5 |
| - | Screening Braid | Shell |

Note that Table 10.2 gives the RS232 functions as they apply at the VIMP, i.e. pin 3 is the RXD input to the VIMP and pin 4 the TXD output from the VIMP.
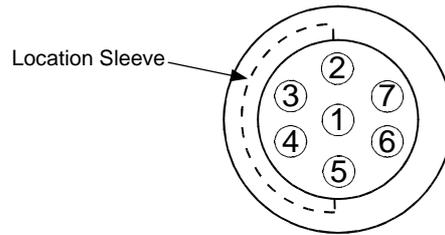
*Fig 10.5    Pin numbers of RS232 mating plug (rear view).*

**7.2     SELECTABLE VIBRATION AND SYNC INPUTS**

Three BNC connectors on the Local Setup Panel provide for the monitoring of a selectable vibration input and a selectable sync input.  The connector functions are as follows:

**NODE A**      This connector carries the buffered signal from the input signal path. (Whichever channel is, or was, the last to be selected has its signal available at this point.)  The node can be monitored during commissioning to check that the correct range selection has been made for the selected channel.

**SYNC**        This connector carries the sync output and allows a selected sync input to be monitored.  There are four sync channels on a 35951F and eight sync channels on a 35951G.  (Whichever channel is, or was, the last to be selected has its sync input available at this point.)

**COMMON**     This connector carries the common return for the **NODE A** and **SYNC** connectors.

The outer shell of each BNC connector is grounded.

---

**CAUTION:**  All connectors on the Local Setup Panel are specially sealed to prevent the ingress of moisture to the VIMP interior.  Where no mating connection is made to any of these connectors, the connector cap provided must be fitted.

---

## Serial IMP 3595 93D + Connector Block 3595 3H

# Contents

# 1       THE COMMUNICATION "GATEWAY"

The Serial IMP provides an interface between RS232 and S-Net.  The primary purpose of this device is to allow the vibration data acquired by hand-held Analyzer/Collectors to be up-loaded to the Host Computer.

The Serial IMP may be powered either from S-Net or from a local power supply.


# 2       SERIAL IMP CONNECTIONS

Connections are made to the Serial IMP through the 35953H Connector Block.  This is secured in the VIMP casing by two captive knurled screws and can be conveniently removed from the IMP for connections to be made.  Simply undo the two securing screws, initially using a broad-bladed screwdriver to untighten the screws, and withdraw the connector block from the IMP casing.  Access to the connection terminals inside the block is obtained by removing the two cover securing screws and lifting the cover clear.

The RS232 connections to be made to the Serial IMP are as follows:
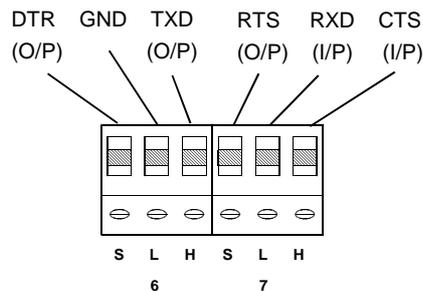


Note that this diagram shows the RS 232 connections as they apply at the IMP.  For example, RTS (O/P) is the "Ready To Send" output of the IMP and CTS (l/P) is the "Clear To Send" input.

Details of the S-Net connections, and of the IMP address switches S1 and S2, are given in Chapter 4 of the Installation Guide.

Once the connections have been made, replace the connector block cover and secure with the two securing screws.  Then insert the connector block into its recess in the VIMP casing and screw in the two knurled screws.  The knurled screws may be turned initially with the fingers, but should finally be tightened with a broad-bladed screwdriver.

# 12

## IMP 3595 '1H and '1J + Connector Block 35953J

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# 1 THE '1H AND '1J UNIVERSAL IMPS

The '1H and '1J IMPs are intended for compact systems that must cope with a wide variety of input signals and measurement types. Each IMP provides eighteen channels that can be used for an analog or digital input and two channels that can be used for a digital input or output.

The facilities provided by the '1H and '1J IMPs are an enhanced version of many of the facilities provided by the '1A, '1B, '1C, '1E, '2A, and '2B IMPs. The '1H and '1J IMPs can, therefore, be used in place of these IMPs, where a comparatively small number of channels are dedicated to a variety of signal types. This avoids the cost of redundant channels and provides for system economy.

The only difference between the '1H and the '1J IMPs is that of the channel-to-channel isolation of Channels 1-18. For the '1H this is 200V whilst for the '1J it is 500V. (The channel-to-channel isolation of Channels 19 and 20, on both types of IMP, is 120V.)

For all connections to the measurement channels, S-Net, and external power, the '1H and '1J IMPs use the 3595 3J Connector Block.

## 1.1 UNIVERSAL IMP CONSTRUCTION

The Universal IMP is available in two case styles:

- The **3595 1H** and **'1J** Universal IMPs are housed in the new aluminium case described in Section 1.1.1. These IMPs use a connector block type 3595 3J, which is described in Section 3 in this chapter.

- The **3595 551H** and **'551J** Universal IMPs are equivalent to the 3595 1H and '1J, but they are contained in standard IMP cases. Both the '551H and the '551J use connector block type 3595 553J. This has the same functions as a 3595 3J connector block, but it has been re-scaled to fit the standard IMP case. The only difference in use is in the way the channel cable screening is grounded, to conform with the EMC directive. This is explained in Section 3.

### 1.1.1 Universal IMP in Aluminium Case

The construction of Universal IMPs in an aluminium case differs from that of previous IMPs, although the general proportions are similar.

The case is an open-ended aluminium box-like structure. At either end the case is closed off with diecast aluminium endcaps, each secured with two captive screws. A weatherproof seal between each endcap and the case is afforded by a conductive elastomer gasket. The endcaps and case have a durable painted finish.

Inside the case the main pcb is attached to one endcap and is engaged in grooves that run the full length of the case. Four LEDs on the pcb convey user reassurance information, and are visible through windows in the endcap. The main pcb can be removed for servicing by undoing the captive screws and sliding the pcb, with its endcap, away from the case. (Initially, some effort may be required to separate the pcb from the 3595 3J Connector Block.)

The 3595 3J Connector Block fits, with its attached endcap, into the opposite end of the IMP case. The connector block can be removed from the IMP case in the same way as the main pcb. This allows the IMP connections to be made. A description of the 3595 3J Connector Block is given in Section 3 of this chapter.

A Universal IMP can be bolted to the measurement site through four holes provided in the case flanges. It is preferable to mount Universal IMPs in a vertical attitude. In a damp atmosphere any excess moisture then tends to drain away from the vulnerable areas where cables enter the IMP. Further details on mounting IMPs, including recommendations for a particularly hostile environment, are given in Chapter 3.

## 1.2 ADDITIONAL FACILITIES

The '1H and '1J Universal IMPs have many facilities not available in other types of IMP. These facilities are:

- Report of thermocouple loop resistance between the H and L terminals.

- Channel unit conversion, with function $y = mx + C$.

- Post-linearisation of measured input, with a user-defined fifth order polynomial.

- High and low level alarm checking, with alarm output selectable from Channel 19 or Channel 20.

- Synchronisation of auto scans with IMP real-time clock.

- Three result modes, selectable from:

  — Real-time      Same result format as a normal IMP readout.

  — Time-tagged    A *bookmark* and *time tag* are appended to each scan and to each single measurement. A bookmark contains the date, whilst the time tag contains the time of day,

  — Historical     In this mode scans and single measurement are each *preceded* by a bookmark and time tag. The historical mode is used in conjunction with a FIFO (first in, first out) buffer in the IMP memory. Should communication fail on S-Net, the IMP is able, when operating at one scan a second, to store measurement data for approximately five minutes. When communication on S-Net is re-established the IMP is able to output the stored data quickly to the Host, on a lengthened Stream 2.

- Save and Restore control database.

- Hardware and Software watchdogs, with output from Channel 20.

- Auto-start after a power-up or hardware watchdog timeout.

- Firmware upgrade without IMP disassembly (using flash memory technology).

The commands and responses for the above facilities are described in Part 2 of the Operating Manual for your particular S-Net Interface.

# 2        CHANNEL FUNCTIONS

Each of the 20 channels in a '1H and '1J IMP can be set to measure a wide variety of input signals. However, setting up a channel to measure a specific signal is a two-fold process. First you must make the appropriate connections to the channel input, as described in Section 4 of this chapter, and then the relevant commands must be issued from the Host to define the channel mode. IMP commands are described in Part 2 of the Operating Manual for your particular S-Net Interface.

Channels 1 through 18 can each be set to measure any of the analog or status inputs listed in Table 12.1. Channels 19 and 20 can be set to measure any of the digital inputs listed in Table 12.2.

### Table 12.1   Measurement Types for Channels 1 through 18

| Measurement Type | Choice of Input |
|---|---|
| DC Voltage | 20mV, 200mV, 2V, 12V, autorange. |
| DC Current | 200µA, 2mA, 20mA, 100mA, autorange. (This assumes that a 100Ω shunt resistor is fitted on the connector block.) |
| Temperature (thermocouple) | Thermocouple types E, J, K, R, S, T, B, and N, with internal or external cold (reference) junction compensation. (Open circuit detection and loop resistance measurement are available.) |
| Resistance | Four-wire configuration for: 25Ω, 250Ω, 2k5Ω, 25kΩ, autorange. Three-wire configuration for: 1k5Ω, 25kΩ, autorange. Two-wire configuration for: 500Ω, 25kΩ, autorange. |
| Temperature (RTD) | 100Ω platinum, 10Ω copper. |
| Status | TTL, 3V/9V, volt-free contact. |

### Table 12.2   Measurement Types for Channels 19 and 20

| Measurement Type | Comments |
|---|---|
| Status | TTL, 3V/9V |
| Event Count | Increment or Totalise. (Maximum count is 16,777,215 (24bits), after which the count continues from zero) |
| Frequency | 8mHz to 49kHz. (Time averaging longer than scan period does not delay other results.) |
| Period | 160s to 20µs, with resolution of 10ms. (Time averaging longer than scan period does not delay other results.) |

Channel 20 can also be used as a watchdog output, whilst Channels 19 and 20 can be used, independently, as high and low level alarm outputs.

# 3    THE 35953J CONNECTOR BLOCK

All connections to the '1H and '1J IMPs are made through the 3595 3J Connector Block. (See Figure 12.1.) This is inserted into one end of the IMP case and is secured by two captive screws. A conductive elastomer gasket between the end cap of the connector block and the IMP case provides a weather- and RF-proof seal.
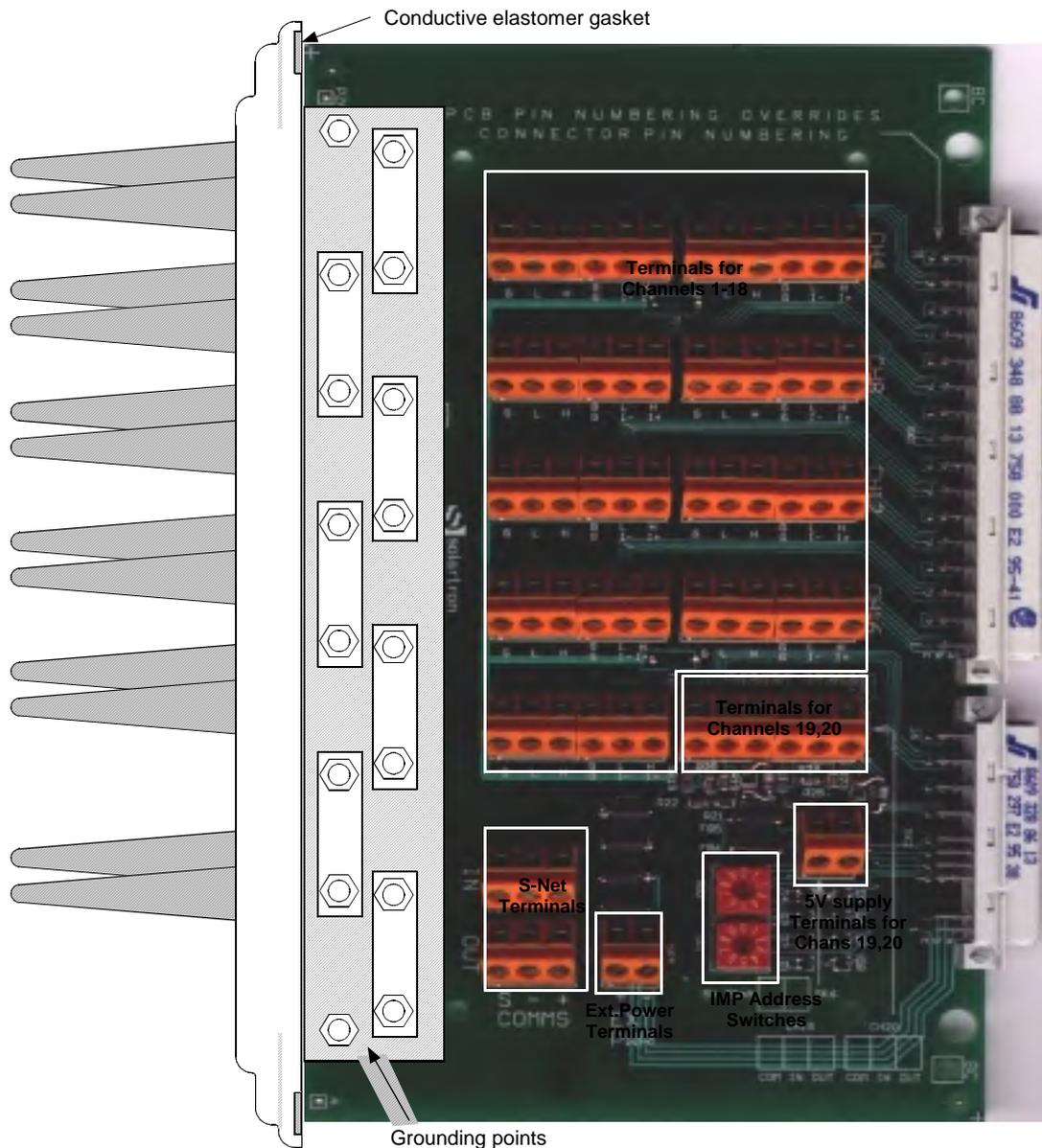


*Figure 12.1   The 35953J Connector Block.*

Six four-way PVC rubber 'boots' are provided on the end cap to ensure a weatherproof seal for cable entry. Optional single-way boots can be fitted instead, for larger cables. A cable clamping and grounding facility is provided between the boots and the terminals on the pcb. Insulating covers are fitted to each side of the connector block assembly. These are for safety and prevent the wires from becoming snagged between case and endcap when the connector block is reinserted in the case. General instructions for making IMP connections are given in Chapter 4.

## 3.1 THE 3595 553J CONNECTOR BLOCK

The 3595 553J connector block is a scaled-down version of the 3595 3J connector block. However, the layout of the two connector blocks is exactly the same. The setup and connection procedure is exactly the same for each type - with one exception, the method of grounding the screens of the channel cables.

The reduced size of the 3595 553J connector block does not provide for the inclusion of the grounding points shown in Figure 12.1. This means that, to conform with the EMC directive, a different method must be used to connect the channel cable screens to ground. It is suggested that the screens be connected together (in the same area as that occupied by the grounding points on the 3595 3J connector block) and a single grounding lead brought out via a boot and connected to a grounding stud on the case. It must be ensured that the screening connections are insulated to prevent any short circuits on the connector block.

# 4    MEASUREMENT PREPARATION

This section describes the background of each channel mode and the connections to be made for it. Sections 4.1 through 4.6 relate only to Channels 1 through 18, whilst Sections 4.7 and 4.8 relate only to Channels 19 and 20.

## 4.1    VOLTAGE MEASUREMENT (CHANS 1 - 18)

Connect the unknown voltage to the H, L and G terminals as shown in Figure 12.2. On the even numbered channels the I+ and I- notation should be disregarded.

For rejection of electrical interference, **the G-terminal must be connected** as shown. For optimum performance connect the guard as shown for channel CH 1. If this is impractical connect the G and H terminals together at the terminal block, as shown for CH 2.



*e* = voltage to be measured

CH 1          CH 2
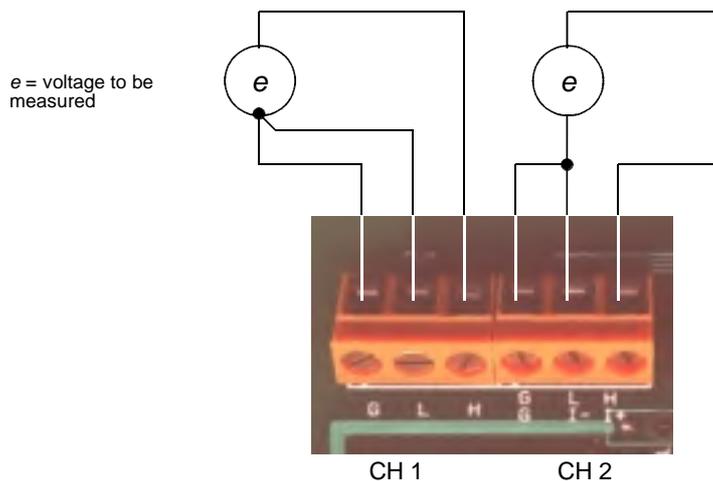
*Figure 12.2   Example of voltage connections.*

The voltage ranges available are the fixed ranges 20mV, 200mV, 2V, and 12V, and autorange.

## 4.2 CURRENT MEASUREMENT (CHANS 1 - 18)

The IMP derives the value of current $i$ by measuring the voltage ($v$) developed across a fixed precision resistor ($r$), then calculating the ratio $v \div r$.

**Note that resistor $r$ is fitted by the user, and must be fitted *only* for current measurements.**

The ranges available are: 200µA, 2mA, 20mA, 100mA and autorange. Scaling within the IMP assumes that the value of resistor $r$ is 100Ω. Other values of resistance can be used but the results must be re-scaled accordingly. For example, if a 1000Ω resistor is used, results received by the host must be divided by 10.

The current sensing resistor is fitted between the Hi and Lo channel inputs. This is normally done at the screw terminals on the connector block, but there are sites on the reverse side of the pcb where the resistor can be soldered.

For optimum rejection of electrical interference **the G (guard) terminal must be connected to L (low)**, as shown in Figure 12.3. **G (guard) must never be left disconnected** since it forms an integral part of the measurement circuitry. Ideally the guard should be connected as shown for channel CH 1, but if this is impractical use the alternative guard connection shown for channel CH 2.
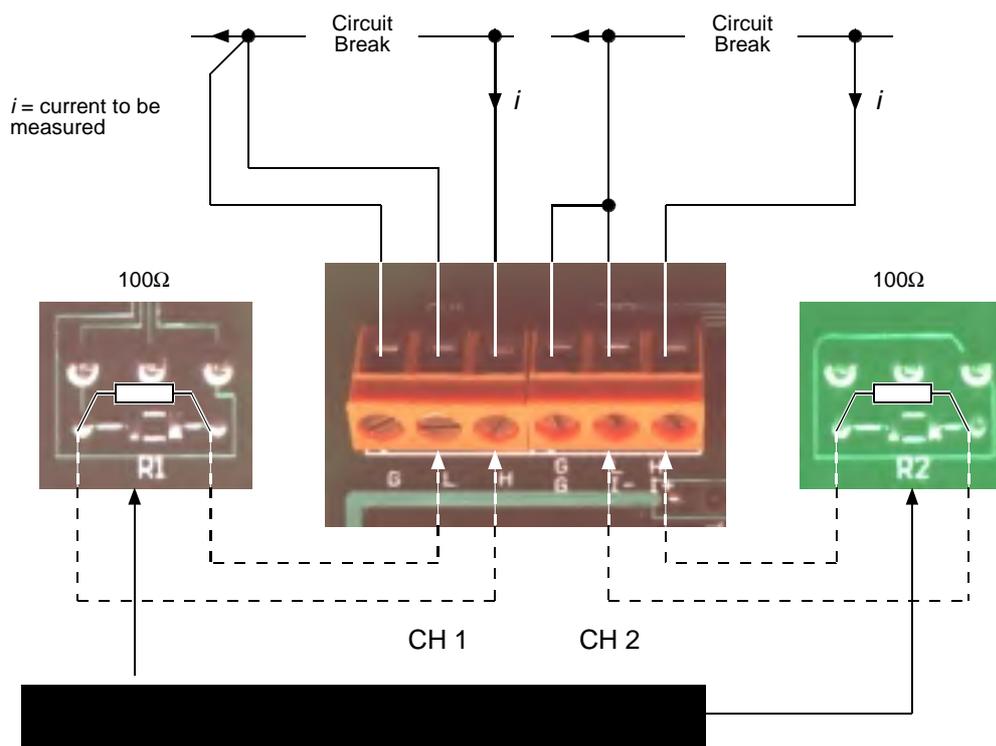


***Figure 12.3   Example of current connections.***

## 4.3 TEMPERATURE MEASUREMENT - THERMOCOUPLE (CHANS 1 - 18)

For temperature measurements by thermocouple the IMPs can accommodate thermocouple types E, J, K, R, S, T, B and N.

The 'cold' (reference) junction for thermocouples can take either of the two forms shown in Figure 12.4. Channel CH 1, in this example, uses the connector block terminals. Built-in thermistors sense the temperature in the interior of the connector block and the IMP adjusts the measurement value so that it refers to 0°C. The alternative is to use an external reference unit, as shown for channel CH 2. Here, copper leads are used to join the reference junctions to the connector block. In both cases extension/compensating cables are used to connect the reference junctions to the thermocouple.

For optimum rejection of electrical interference **the G (guard) terminal must be connected to L (low)** as shown in Figure 12.4. **The G terminal must not be left disconnected** since it forms an integral part of the measurement circuitry.
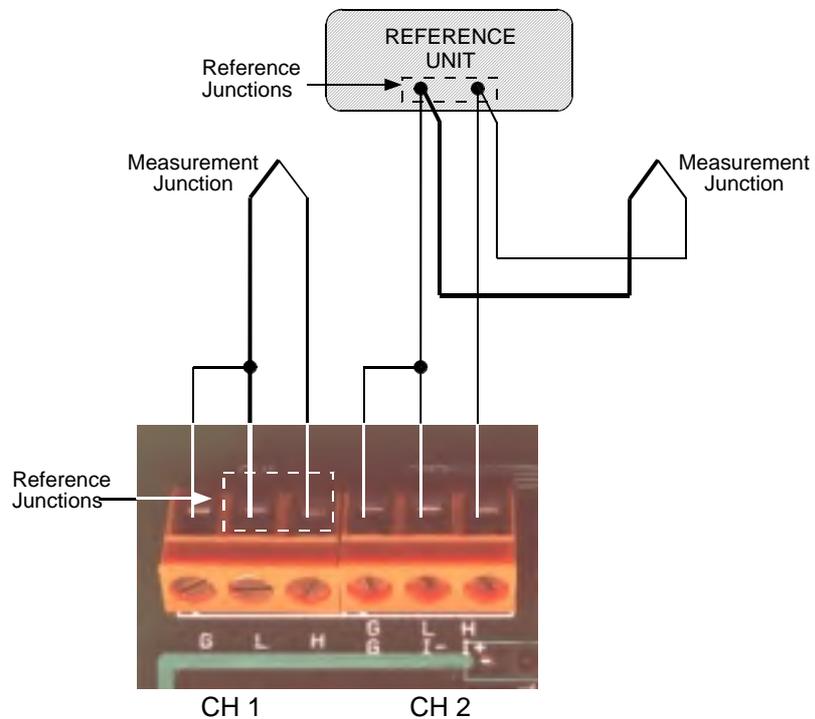


*Figure 12.4   Example of thermocouple connections.*

## 4.4 RESISTANCE MEASUREMENT (CHANS 1 - 18)

The resistance ($r$) of an external resistor is measured by passing a constant energizing current of known value ($i$) through the resistor and measuring the voltage $v$ developed across it. The resistance ($r$) is then computed from the equation $r=v\div i$.

The resistance to be measured can be connected in three ways: two-wire, three-wire, or four-wire. These are shown in Figure 12.5 and their uses are described in Sections 4.4.1 through 4.4.3.

A current drive of 800µA or 80µA, dependent on range and/or mode, is supplied by the IMP. The way in which this is applied depends on the measurement connections.

### 4.4.1 Two-wire Resistance Measurement

Two-wire resistance measurement is the least accurate and is intended primarily for use in volt-free contact status applications. The ranges are: 500Ω, 25kΩ, and autorange.

The current drive is supplied through the H and G terminals of the measurement channel. Therefore all channels from 1 through 18 can be used for two-wire resistance measurements.

### 4.4.2 Three-wire Resistance Measurement

Three-wire resistance measurement is sometimes preferred to the four-wire method, because three-core cable is cheaper than four-core. The results, however, are less accurate than with the four-wire method and have a reduced thermal stability. Also, for the lead resistances to be effectively nulled, the three conductors must be identical. The ranges are: 1.5kΩ, 25kΩ, and autorange.

On Channels 2, 4, 6, 8, 10, 12, 14, 16, and 18 the I– terminal is used for the current return. To compensate for the resistance of the input connection cables the current drive is applied alternately to the H and L terminals of Channels 1, 3, 5, 7, 9, 11, 13, 15, and 17. These are the only channels on which a measurement result is obtained.

### 4.4.3 Four-wire Resistance Measurement

Four-wire resistance measurement has greater thermal stability than the three-wire method, and gives a more accurate measurement. The ranges are: 25Ω, 250Ω, 2.5kΩ, 25kΩ, and autorange. The wires from the H and L terminals must be connected as close as possible to the body of the unknown resistance. The guard connection is not essential as the I– terminal provides interference rejection, but it is still good practice to use it.

The current drive is supplied by the I+ and I– terminals on Channels 2, 4, 6, 8, 10, 12, 14, 16, and 18. Again, the only channels on which a measurement result is obtained are Channels 1, 3, 5, 7, 9, 11, 13, 15, and 17.

a) Two-wire

b) Three-wire

$r$ = resistance to be measured

*not essential

c) Four-wire

CH 1    CH 2
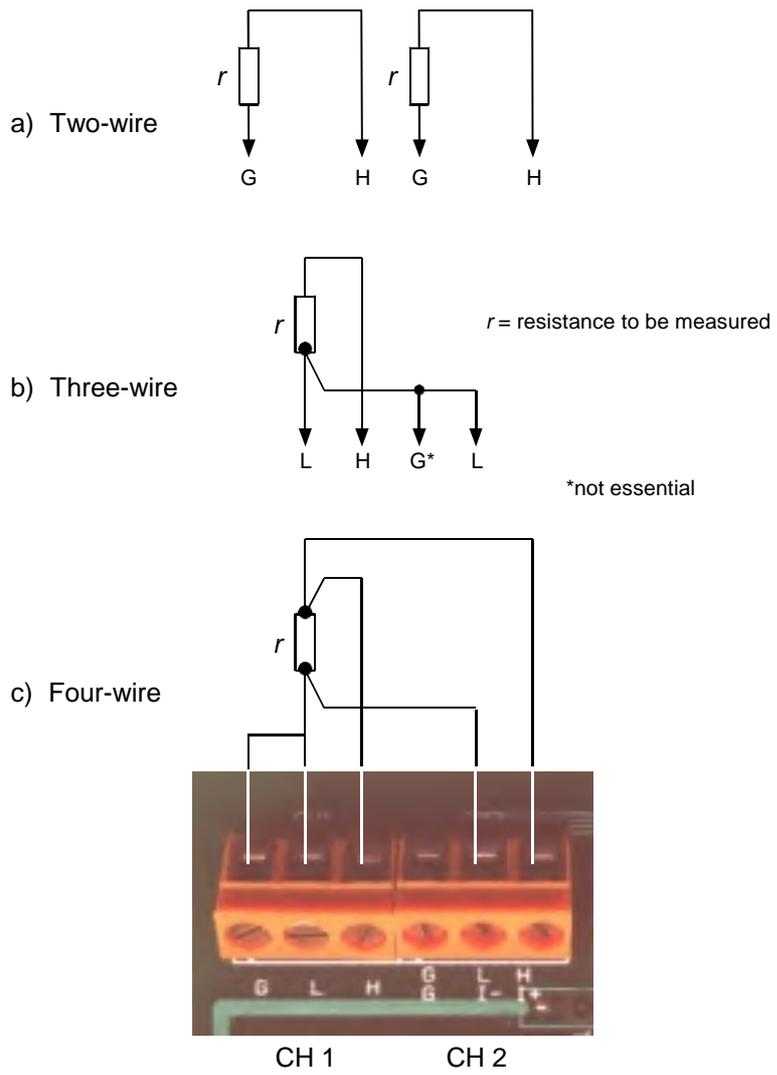
*Figure 12.5   Example of resistance connections.*

## 4.5    TEMPERATURE MEASUREMENT - RTD (CHANS 1 - 18)

Temperature measurements by an RTD (resistance thermometer device) rely on the predictable variation, with temperature, in the resistance of a platinum wire. The IMP can work with three-wire or four wire RTDs and the connections are exactly the same as for three- and four-wire resistance measurements. (See Figure 12.6.)

The IMP linearises temperature measurements by RTD to IEC 751. Linearisation can be selected either for a 100Ω RTD or for a 10Ω one.
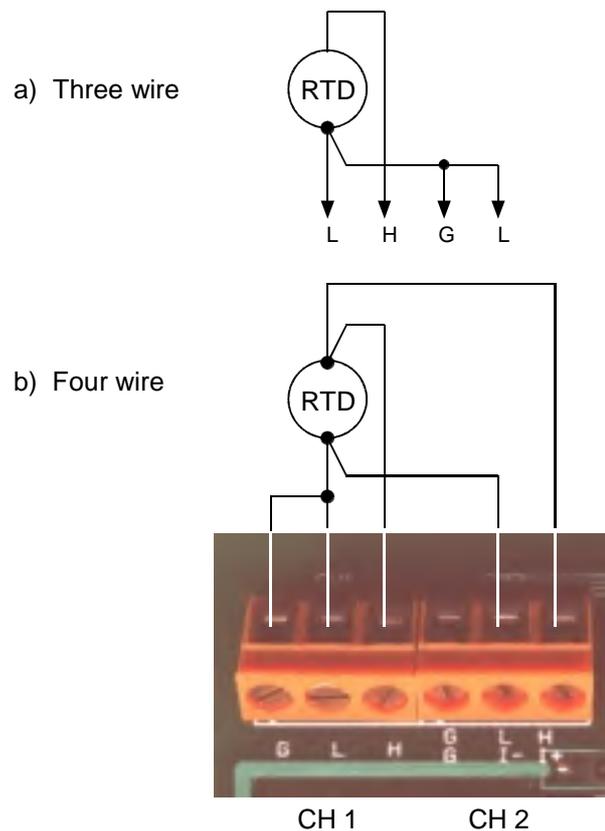


**Figure 12.6   Example of RTD connections.**

Many different color codes are used by the manufacturers of RTDs, therefore a standard color-code scheme cannot be defined. For the colour codes of a specific RTD refer to the manufacturer's specification.

The three-wire method of connecting an RTD is sometimes preferred to the four-wire method, due to the saving in sensor cable cost. The three-wire method does, however, give a less accurate signal, with reduced thermal stability, than the four-wire method. For the lead resistances to be effectively nulled, the conductors should be identical.

The four-wire method has greater thermal stability, and enables a more accurate measurement to be obtained. Any differences in lead resistance have no effect on the measurement.

The Guard connection is not essential, as the circuitry associated with the I− terminal automatically provides interference rejection, as well as acting as current return. However it is still good practice to make this connection.

## 4.6    STATUS INPUT (CHANS 1 - 18)

The purpose of status measurement on channels 1 through 18 is to ascertain the logic state of a signal.  Inputs are interpreted as logic '1' or logic '0'.

The logic levels to which Channels 1 through 18 respond may be selected with the CH MO command (codes 700 - 702).  Signal compatibility is thus offered for:

- TTL levels,
- 12V (nominal) levels,
- Two-wire voltage-free contact status.

The logic levels that the IMP interprets as a '1' or a '0' are shown in Figure 12.7.  To avoid errors, ensure that the input signal always occurs outside the *Indeterminate* region: *within* this region a signal may be interpreted as either logic '0' or logic '1'.  (To determine the status of voltage-free contacts the IMP measures the resistance between them.)
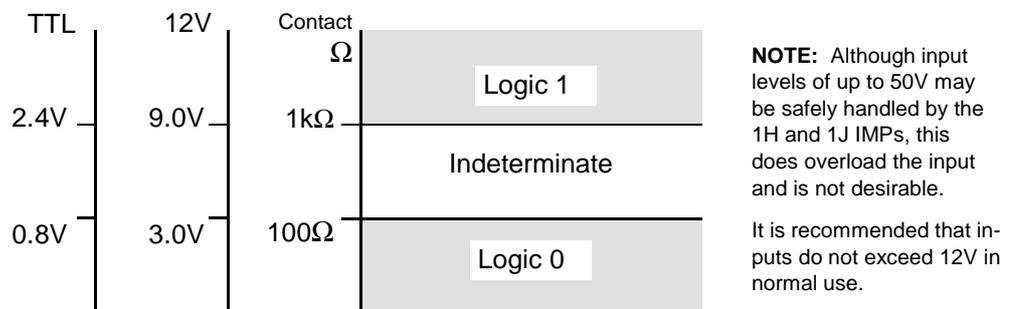


*Figure 12.7   Logic level interpretation on Channels 1 through 18.*

The rate at which signal status is determined depends upon the frequency at which the host issues status measurement commands (ME, TR, SP).

The connections for status measurements on channels 1 through 18 are shown in Figure 12.8.  (Note the difference between the connections for voltage logic and those for voltage-free contact logic.)
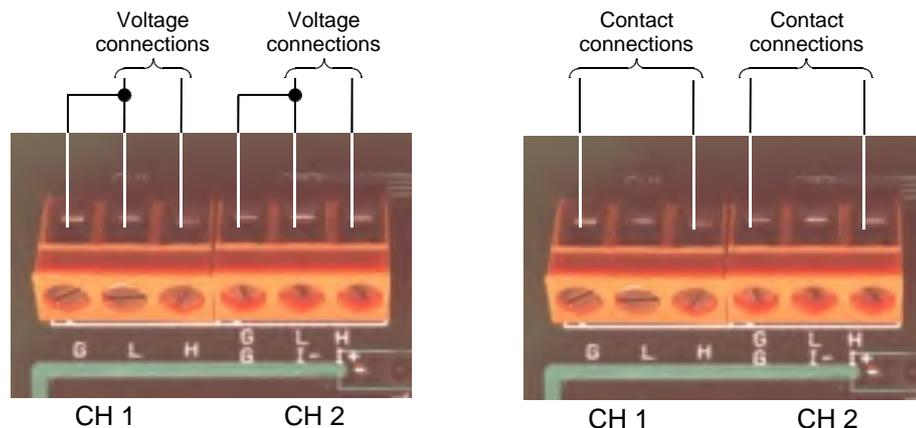


*Figure 12.8   Example of status input connections (Channels 1 through 18).*

## 4.7 STATUS INPUT AND EVENT COUNTING (CHANS 19, 20)

Channels 19 and 20 can be used to ascertain the status of a digital input and to count 'events'. Whereas a status signal tells you which of two possible states an external device is in, an event count tells you how many times that particular state has occurred.

### 4.7.1 Input Sampling Rate

In common with all multi-channel logging instruments, IMPs do not monitor their input channels continuously, but examine them at regular intervals. The frequency of examination is known as the sampling rate. Several sampling rates are provided for all the measurement functions, that is 20Hz, 1kHz, 10kHz and 100kHz.

When setting up the system to be monitored, study Sections 4.7.1.1 and 4.7.1.2 to determine the best sampling rate to use for your particular application. Having selected a suitable sampling rate, you should obtain repeatable results.

#### 4.7.1.1 20Hz, 1kHz Sampling

Debounce is applied at these sampling rates; giving protection against contacts bouncing on closure, as may occur with industrial switches, contactors, reed-relays etc. With debounce applied, four successive samples must detect the same logic level after a logic transition has occurred before that transition is recognised. This ensures that no false transitions are recorded. See Figure 12.10.

Use 20Hz sampling for large contacts such as industrial relays.

Use 1kHz sampling for small contacts such as reed-relays.
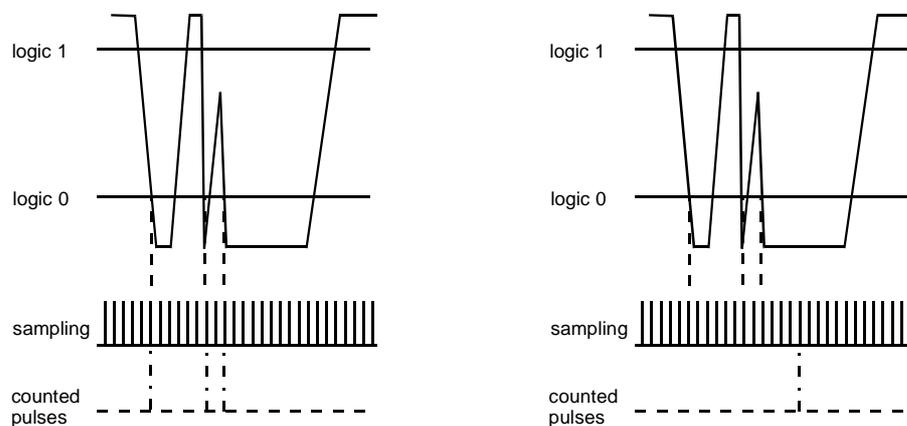


*a) No debounce applied: three pulses output to the counter instead of one = incorrect measurement.*

*b) Debounce applied: one pulse only output to the counter = correct measurement.*

**Figure 12.9    Contact Closure: 20Hz, 1kHz sampling.**

## 4.7.1.2    10kHz, 100kHz SAMPLING

These sampling rates are intended for use with signals not subject to contact closure bouncing.  Hence, debounce is not applied.  100kHz sampling would normally be used, but for signals prone to glitches (that is, spurious transitions) 10kHz sampling may produce more consistent results.  See the example in Figure 12.10.
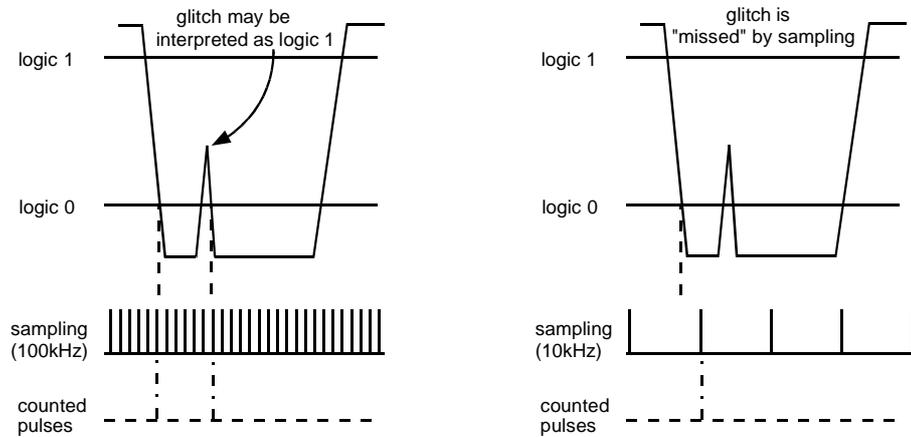


a) Glitches can generate extra pulses if too high a sampling rate is used, giving an incorrect measurement.

b) The same waveform with a lower sampling rate : one pulse only is output to the counter, giving a correct measurement.

**Figure 12.10    Solid State Switching: 10kHz, 100kHz sampling.**

**Note**: Whilst a lower sampling rate does not *guarantee* correct results when glitches are present, it does *increase the probability* of obtaining correct results.

## 4.7.2    Status Measurement

The purpose of a status measurement is to determine the logic state of a signal.  Inputs are interpreted as logic '1' or logic '0', as shown in Figure 12.11.



a) input thresholds with split-pad shorted.

b) input thresholds with split-pad open-circuit.
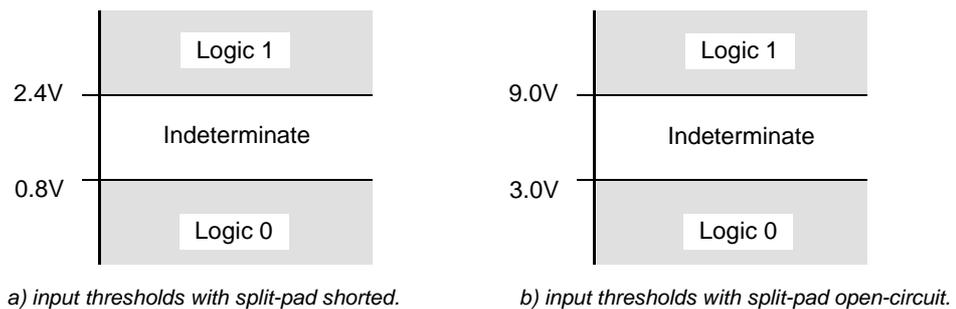
**Figure 12.11   Logic level interpretation on Channels 19 and 20.**

The logic levels to which Channels 19 and 20 respond may be preselected by split pads SP19 and SP20.  Signal compatibility is thus offered for TTL levels (Figure 12.11a) or 12V levels (Figure 12.11b).  To avoid errors, ensure that the input signal always occurs outside the *Indeterminate* region: within this region a signal may be interpreted as either logic '0' or logic '1'.

### 4.7.3    Contact Closure Connections

A 5V, 20mA limited power supply is available at SK6 on the connector block.  This allows contact closures to be detected in the external plant.  Each pair of contacts must have its own current-limiting resistor.  (See Figure 1212.)  This avoids one contact closure shorting out the 5V supply to the other contact pair.  The voltage drop caused by the current-limiting resistor must not be so large that the input threshold level cannot be reached.  A suitable value is 4.7kΩ, which limits the supply current to 1mA: with both pairs of contacts closed, the current drawn is 2mA.  Under normal operating conditions the current drawn must not exceed 5mA.  Should the rails become shorted, no damage will occur but the unit may malfunction.

Where the status of a TTL signal is to be determined, short-circuit the relevant Channel split-pad in the connector block.  As a rule, a resistor should be fitted between the signal and the TTL 5V supply, unless the TTL output is from a buffer device, for example an LS244.  Other TTL or LS TTL devices have a low output current when driven high and, for these devices, a 4.7kΩ resistor should be fitted between the signal and TTL 5V supply.  This ensures that the TTL signal voltage reaches the Logic 1 threshold.
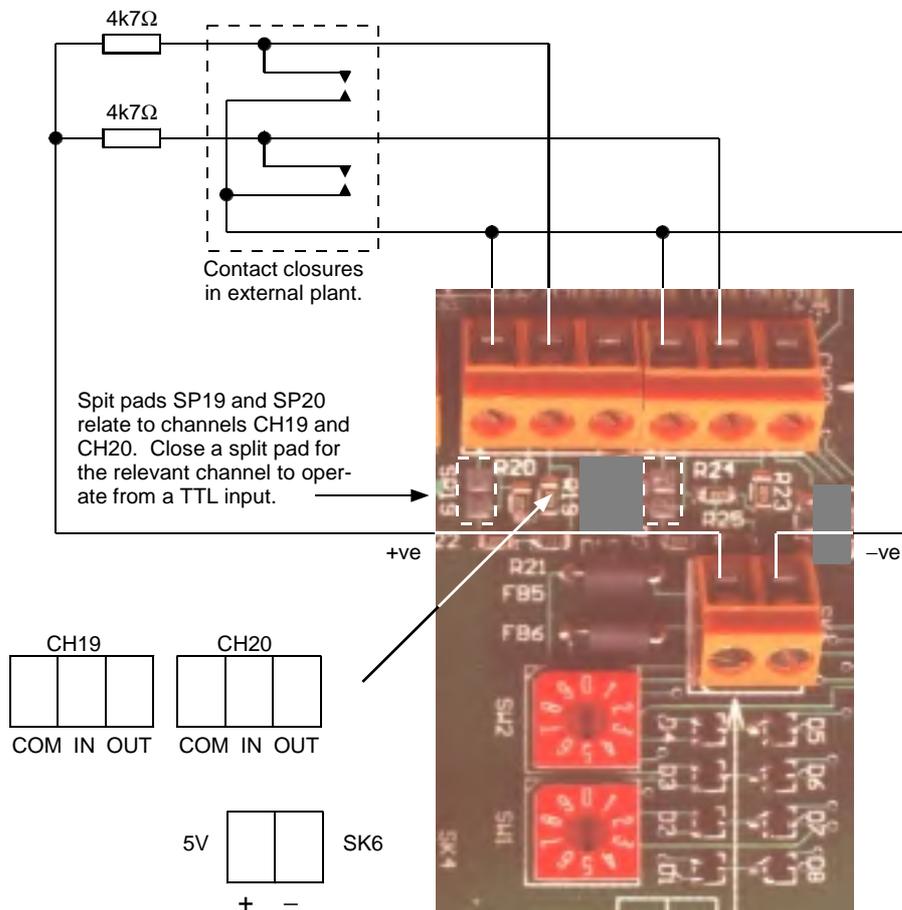


*Figure 12.12   Example of status input connections (Channels 19 and 20).*

### 4.7.4    Event Count

This facility permits a number of events to be counted.  The events (transitions) to be included in the count can be +ve, -ve, or both.  Two types of count are offered: increment or totalise.  These operate as follows:

**Increment**    On receipt of a measurement trigger, an event count is started.  Then, on receipt of another measurement trigger, the event count is stopped, the result sent to the host interface, and another count begun.

**Totalise**    On receipt of a measurement trigger, events are counted until an HA (halt) command is received or until the channel mode is set to event count increment.  In the latter case the counter is cleared, prior to starting the incremental count.  If a CL (clear) command is received at any time, the counter is reset to zero and a new count started on receipt of the next measurement trigger.

The maximum number of events that can be recorded, per channel, by the event counting circuitry is 16,777,215, after which the count continues from zero.  No other indication of this is given.

### 4.7.4.1    Maximum Count Rate

The maximum count rates obtainable, when using one channel, is shown in Table 12.3 −with events counted on both channels the rate is slightly lower.

**Table 12.3   Count Rate v. Sample Rate**

| Sample Rate | Max. Count Rate (*using one channel*) |
|:---:|:---:|
| 20Hz | 2.4/s |
| 1kHz* | 124/s |
| 10kHz | 4900/s |
| 100kHz | 15000/s |

*\* default value*

Debounce is applied to 20Hz and 1kHz sampling.   With debounce, an event is considered to be valid only after four successive samples have shown the input to be at the same level.

With 20Hz, 1kHz and 10kHz sampling, the maximum count rate can be obtained only if the mark:space ratio of the input signal is 1:1.  With 100kHz sampling, the maximum count rate can be obtained with a mark:space ratio of between 1:1 and 5.7:1 (or vice-versa).  Any deviation in these mark:space ratios lowers the maximum count rate as shown in Figure 12.13.  The sharp step in the case of 100kHz sampling is due to software constraints.
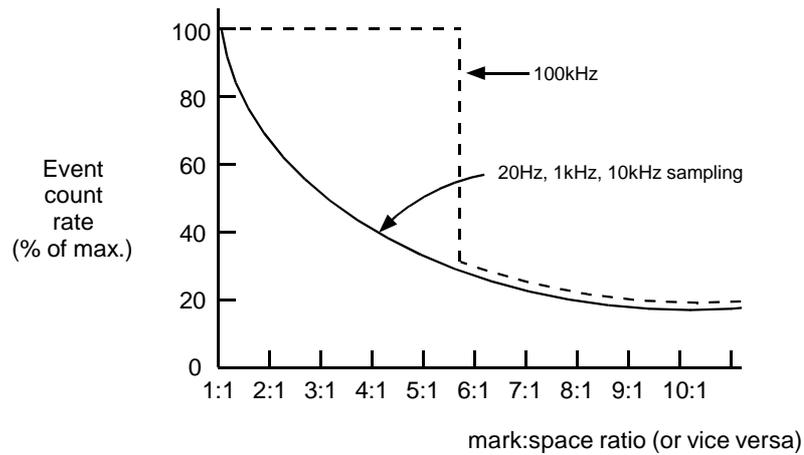
**Figure 12.13   Effect of mark:space ratio on event count rate.**

### 4.7.5      Frequency

Frequencies can be measured from 8mHz through 49kHz.  However, the maximum
frequency depends on the mark:space ratio of the input signal being 1:1.  Any deviation
from 1:1 (in either direction) will lower the maximum measurable input frequency as
shown in in Figure 12.14.
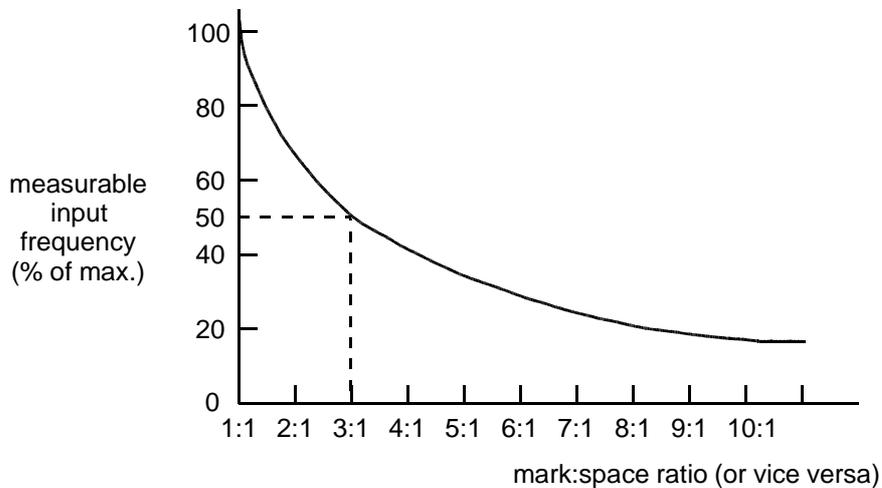


**Figure 12.14   Effect of mark:space ratio on measurable input frequency.**

The accuracy and resolution of results depends upon the choice of measurement time, as
shown in Table 12.4.  The longer times give the greater accuracy (less uncertainty) in
the final result.

**Table 12.4   Result Resolution v. Measurement Rate**

| Measurement Time | Result Resolution |
|---|---|
| 10s | 0.1Hz |
| 1s | 1Hz |
| 100ms | 10Hz |
| 10ms | 100Hz |

It is essential to use a measurement time that is adequate for the expected input frequency.  For example, when measuring 2Hz (period 500ms) there is no point in using a measurement time of 100ms since only 20% of the input signal would be seen.  A better measurement time is 10 seconds, which measures over 20 complete cycles.

### 4.7.6     Period

Time periods (single pulses or whole cycles) can be measured from 20µs up to 160 seconds, with a resolution of 10µs.  The minimum input period that can be measured depends largely on the mark:space ratio of the input signal.  The minimum input period (20µs) can be measured only if the mark:space ratio is 1:1.  Any deviation from 1:1 (in either direction) increases the minimum measurable input period as shown in Figure 12.15.
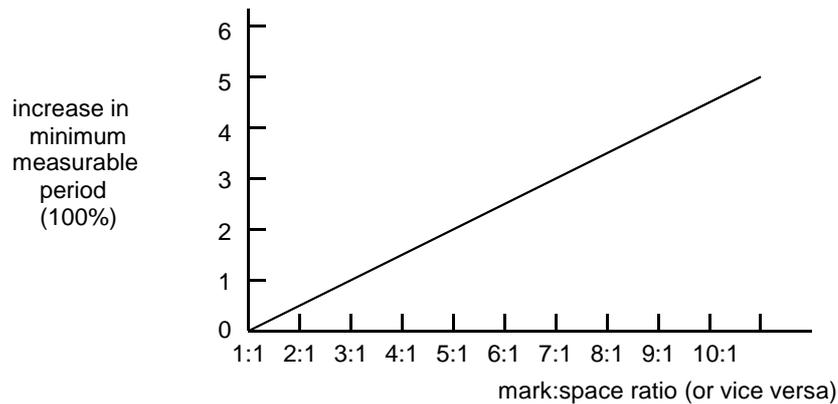


*Figure 12.15   Effect of mark:space ration on minimum measurable period.*

### 4.7.7     Periods Examined

When measuring cyclic waveforms, the number of cycles (periods) to be included in a measurement can be selected as: 1, 10, 100, or 1000.  There are two main benefits in considering larger numbers of periods:

- The already small measurement uncertainty (±1 bit, inherent in all digital measurement systems) becomes insignificant.

- Many signals exhibit some frequency or phase shift (mains-derived signals, for example) no matter how small.  In this case, the measurement result required is probably one that represents the average value of the input period.  The only way to obtain this is to cover as many periods as is practicable (that is, 1000 periods).  Note that the measurement of cyclic signals starts and stops with the -ve edge of the signal, as shown in Figure 12.16.
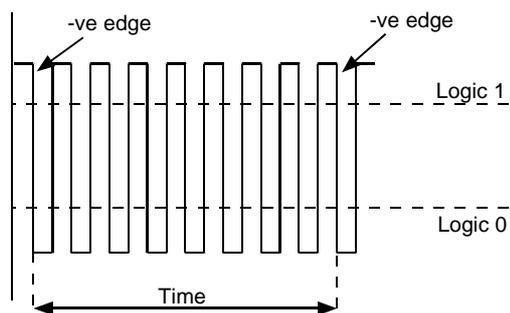
**Figure 12.16   Measurement of 10 periods, starting and stopping on − ve edge.**

### 4.7.8      Pulse Width

For a one-shot (single pulse) signal, it is possible to measure either a positive pulse (Figure 12.17) or a negative pulse.
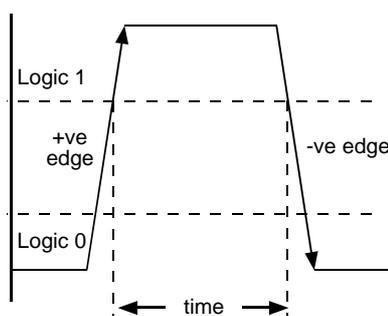


**Figure 12.17   Measurement of a Positive pulse.**

### 4.7.9      Time-Out

To avoid an IMP 'hanging' indefinitely, should an event fail to happen, a timeout period must be specified.

The following fixed time-out periods are selectable, with the CH TI command: 200ms, 2s, 20s and 50s.  The default value is 2s.  If one period is to be examined, the time-out must be at least double the expected period.  For two input periods or more the time-out must be greater than the input period times the number of periods examined.

For example, to measure one input period of about 50ms, a time-out of 200ms would be satisfactory.  However, to measure ten time periods of 50ms, a time-out of at least 500ms is required.  A fixed timeout period of 2s is therefore suitable.

## 4.8    DIGITAL OUTPUT (CHANS 19, 20)

Channels 19 and 20 can each be configured as a digital output, to drive low power devices such as indicators.   In this configuration the output consists of an open-drain MOSFET, which can be regarded simply as a resistance switch:

For switch closed, the resistance between OUT and COM $\approx 10\Omega$.

For switch open, the resistance between OUT and COM $\approx 10M\Omega$.

The rating of the FET is 80V, 1W with a steady-state current sink capability of 100mA. Over-voltage protection of the FET is provided by a 62V zener diode.

A +5V 20mA limited power source is provided, at SK6 on  the connector block, for the energisation of low-power transducers, lamps, and so on.  The power source is short-circuit protected against overloads.

A typical arrangement of digital outputs with load energisation by the IMP 5V supply is shown in Figure 12.18.



**NOTE**: The total load across the 5v supply should not be less than 1kΩ.
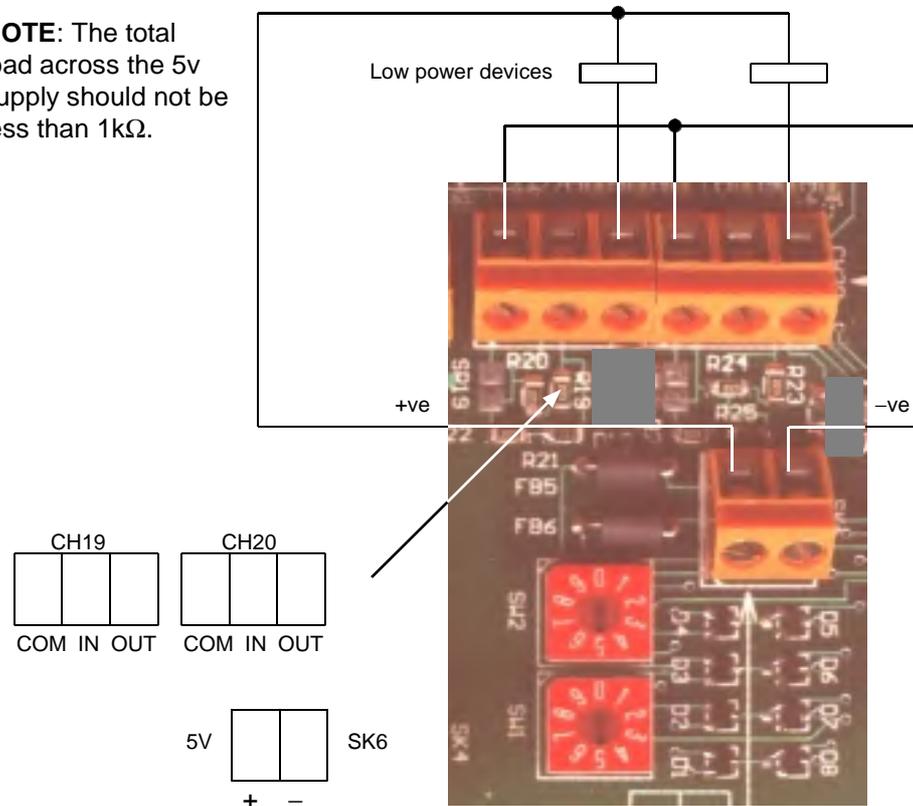
*Figure 12.18   Example of digital output connections.*

### 4.8.1 Watchdog

To monitor its correct operation the IMP has two types of watchdog: a hardware watchdog and a software watchdog. These may be enabled as required.

During normal IMP operations both watchdogs are 'patted' periodically by the software. For the hardware watchdog this is generated internally by the IMP firmware. The reassurance signal for the software watchdog originates from an ST command that must be sent by the Host.

Should a watchdog fail to be patted within a pre-defined timeout period then a watchdog alarm is given. For a hardware watchdog alarm the IMP is set to its power up (default) state: for a software watchdog alarm it is not.

The timeout period for the hardware watchdog is fixed at 1.2 seconds, whilst the timeout period for the software watchdog can be set, with the SW command, to an integer number of seconds from 1 through 255.

The output for both watchdogs is Channel 20. Enabling either watchdog, or both, overrides any mode previously selected for this channel. Normally the watchdog output is in the logic '0' (no alarm) state, but should a watchdog alarm occur the output is switched to the '1' (alarm) state.

With a watchdog enabled, power down forces Channel 20 to the alarm state.


## 5 LED DISPLAY

Four LEDs on the end face of the IMP convey the following user confidence information, when illuminated:

**Power**      Power is applied to the IMP.

**Cal Error**  The IMP has a calibration error: contact a Solartron Service agent to get it recalibrated.

**ADC Error**  The IMP has an ADC error: contact a Solartron Service agent to get it checked out.

**Scan**       The IMP is actively scanning predefined input channels.

For normal operation the state of the LEDs should be:

# 6    SELECTING THE POWER SUPPLY SOURCE
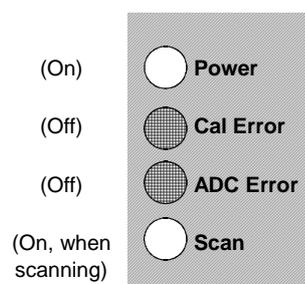
The '1H and '1J IMPs can be powered either from the Host, via S-Net, or from a local power supply unit.  Two internal 'jumpers' (LK701 and LK702) must be inserted for power from S-Net or removed for local power.  Normally an IMP is supplied with the jumpers inserted.

**CAUTION**:  The Host, the local power supply, or the IMP may be damaged if the IMP receives power from S-Net and the local supply simultaneously with the jumpers inserted.  (*Removing the jumpers disconnects S-Net from the internal dc supply lines of the IMP.*)

The jumpers are on the main PCB of the '1H and '1J IMPs (see Figure 12.19) and this PCB can easily be removed for jumper adjustment.  PCB removal is explained in Section 1.1 in the present chapter.

**NOTE**:  Power source adjustment by the user is recommended only for '1H and '1J IMPs.  These are the IMPs contained in the standard Universal IMP case.  Other types of IMP, including the '553H and '553J IMPs, must be returned to a Solartron Service Centre for adjustment.

*The case of any IMP other than the '1H and '1J is composed of two half-shells, sealed with a cork gasket and held together by socket-headed screws.  The standard case for a Universal IMP is the one described in Section 1.1.1 in this chapter.*

This is the location of the power source select jumpers LK701 and LK702.  These jumpers must be inserted for power to be obtained from S-Net, but removed if the IMP is to be powered locally.

Local power is connected to the IMP through the 'Ext. Power' terminals on the 35953J Connector Block.
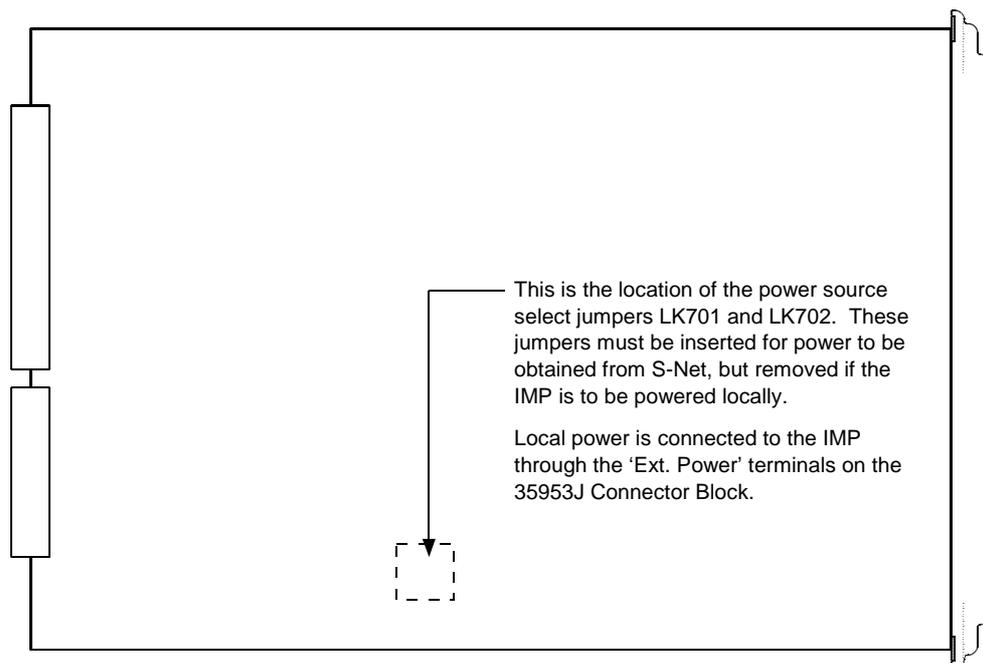
**Figure 12.19    Location of the power source selection jumpers.**

Guidance in the selection of S-Net cables for IMPs powered from S-Net is given in Chapter 2.  This chapter also lists the IMP power supplies available, both for supplies through S-Net and those local to the IMP.

# A

## Measurement Techniques

# Contents

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# 1    INTRODUCTION

This chapter is intended mainly for newcomers to data logging, or for those whose data logging experience is limited to making a few simple measurements.  To give you an idea of what is going on behind the scenes the chapter introduces the simple theory behind the measurement of various physical quantities, such as voltage, current and resistance.  It then progresses to more advanced measurements, such as strain gauging.  The intention is to give a clear understanding of all features of the 3595 IMPs, so that you can use these to solve your data logging problems.

The further aim of this chapter is to ensure that your measurement results, obtained with a 3595 IMP, truly reflect the system being monitored.  Although an IMP is capable of making extremely accurate measurements, it can measure only what is applied to its inputs.  This chapter instructs you how to use the interference rejection abilities of the IMPs to full advantage.  Some simple rules are included also, which ensure that the signals applied to the input channels are as clean as possible.

# 2    INPUT DATA

IMPs are available for measuring both analog signals and digital signals.  Digital signals are read directly into the logic circuitry of a 35952A IMP.  Analog signals, however, are converted into digital form by an Analog-to-Digital Converter (ADC) within the 35951A,B,C or E IMP.

Analog signals represent a continuously variable physical quantity.  Some quantities, such as voltage and current, may be measured directly, whilst others, such as temperature and strain, must be converted to electrical form with a transducer.  Typical transducers are thermocouples and platinum resistance thermometers (PRTs) for temperature monitoring and resistive elements (connected into a bridge circuit) for strain gauging.

Digital signals are those that are switched between two distinct logic states, for example +5V for logic '1' and 0V for logic '0'.  This type of signal is often derived from switch contacts on the system being monitored and represents status and event conditions.  These signals may be monitored singly or in groups, and compared with preset conditions.  Other digital signals may be pulse streams whose repetition rate is proportional to a physical quantity: typical transducers that output such signals are flowmeters and shaft speed indicators.

# 3    MEASUREMENT CONCEPTS

For each type of measurement that an IMP can make, this section introduces you to the simple theory behind it and guides you in using the technique best suited to your application.

## 3.1    VOLTAGE MEASUREMENT

The ADC of a 35951A,B,C or E IMP responds to dc voltages.  Therefore dc voltages, and transducers which produce dc voltage outputs, may be measured directly.  Other electrical quantities - current and resistance - are measured indirectly, as described in Sections 3.2 and 3.3.

## 3.2    CURRENT MEASUREMENT

A dc current (i) is measured by passing it through a resistor of known value (r).  By Ohms law, the voltage (v) developed across the resistor is directly proportional to the current.  (See Figure A.1.)  This allows the value of current (i) to be computed from the simple equation $i = v \div r$.  Current can be measured by IMPs type 35951A, C, or E.  Assuming that the value of the known resistor is $100\Omega$, the range of dc current measured is 0mA through 20mA.
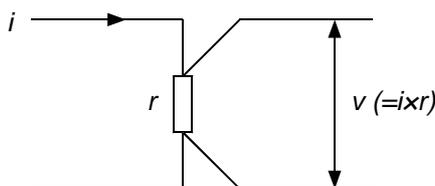


**Figure A.1   Principle of current measurement.**

For channels that are to measure current a $100\Omega$ precision resistor must be fitted to the appropriate terminals of the connector block.  See Chapter 5 for details.

## 3.3    RESISTANCE MEASUREMENT

The resistance (r) of an external resistor is measured by passing a constant energizing current of known value (i) through the resistor and measuring the voltage developed across it.  Again from Ohms law, the resistance (r) is computed from the equation $r = v \div i$. (See Figure A.2.)
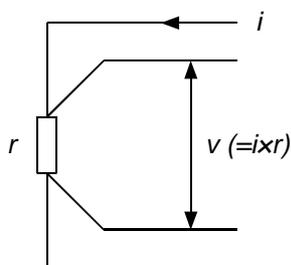


**Figure A.2   Principle of resistance measurement.**

With IMP type 35951B three nominal measurement ranges are available: 25Ω, 250Ω, 2.5kΩ, and autorange. A current drive of 0.8mA is automatically supplied by the IMP via the $I_A$ and and $I_R$ terminals. On all ranges the results are output in kohms.

Resistance can be measured using the four-wire or three-wire method. The four-wire method is the more accurate of the two and has greater thermal stability.
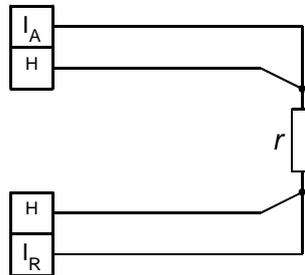


***Figure A.3   Resistance mesurement connections, four-wire.***

The connections for the four-wire method are shown in Figure A.3. To avoid errors due to lead resistance, the wires from the H and L terminals should be connected as close as possible to the body of the unknown resistance. No guard connection is needed: the circuitry associated with the $I_R$ terminal automatically provides interference rejection, as well as acting as current return.

The connections for three-wire resistance measurement are shown in Figure A.4. This method is sometimes preferred because three-core cable is cheaper than four-core.
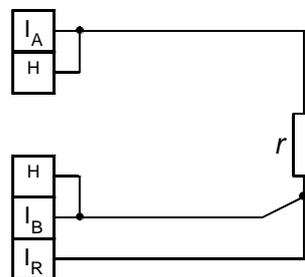


***Figure A.4   Resistance measurement connections, three-wire.***

By using both current sources the three-wire method compensates for the resistance of the wires between the H and L terminals and the unknown resistance, as shown by the following equation:

$$V_r = I_A\ (r_a + r_c + r) - I_B\ (r_b + r_c)\quad I_A.r$$

This method does, however, rely on currents $I_A$ and $I_B$ being exactly the same and on wires *a* and *b* (Figure A.4) being identical. (The composition of wire c is not critical.) Since this ideal is rarely achieved in practice, the three-wire method is less accurate than the four-wire method and has less thermal stability.

## 3.4 STRAIN MEASUREMENT

Strain measurement is the measurement of the change in shape of a material under stress. The two simplest types of strain are tensile and compressive and it is these to which most strain gauges are designed to respond.

Strain is the ratio of two lengths: the change in length ($\delta$l) of a test piece and the original length (l). Therefore strain has no dimensions. Since most strains measured by a strain gauge are relatively small, strain is said to be measured in *microstrains* ($\mu\varepsilon$) where one microstrain equals one micron ($\delta$l) per metre (l). (Note: a micron equals one millionth of a meter.)

### 3.4.1 Strain Gauges

Strain gauges are transducers whose resistance varies under an applied stress. There are two categories, metallic and semiconductor. Metallic gauges have a gauge factor G ($\delta\Omega/\Omega$/ microstrain) of approximately 2. Semiconductor gauges have a higher gauge factor, of approximately 100, but also have a high temperature coefficient which tends to limit their application.

One type of metallic gauge commonly used consists of an etched metal foil pattern (Figure A.5) on a suitable base, for example polyester. This is attached to the test piece by a suitable adhesive, for example epoxy resin. The actual adhesive used should suit both the sensor and the surface on which it is mounted and due consideration should be given to such factors as the humidity and temperature of the operating environment. Most suppliers should be able to advise you on the most suitable adhesive to use and the method of application.
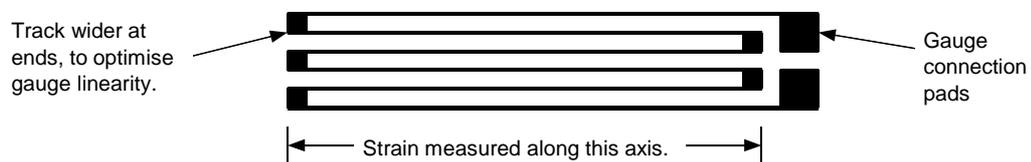


*Figure A.5   Typical etched-foil strain gauge.*

The unstressed resistance (R) of a strain gauge (typically 120$\Omega$) equals $\rho l/a$, where $\rho$ is the resistivity of the gauge material and *l* and *a* are the length and cross-sectional area of the track. When a test piece undergoes strain, the gauge attached to it is strained by the same amount. Tensile strain causes the gauge to stretch, which increases the length of track and reduces the cross-sectional area and thus increases the gauge resistance. Compressive strain produces the opposite effect and decreases the gauge resistance. This variation in resistance with strain is linear over the operating range of the gauge.

### 3.4.2 Strain Gauge Bridges

For strain to be measured it must be translated from a variation in resistance to a variation in dc voltage. This is done by connecting the strain gauge into a bridge circuit and energizing the bridge from a constant voltage or constant current supply. (See Figures A.6 through A.9.) The reason for having a bridge is that the changes in resistance with strain, especially with a metallic gauge, are inherently small and the

bridge allows the resultant small changes in voltage to be read directly: strain voltages may thus be measured at the best possible resolution.

Strain gauge bridges are often built up, by the user, from individual elements, for example the etched-foil strain gauge shown in figure A.5. (Alternatively, load cells, which work on the same principle, are a complete bridge in themselves.) Each arm of a strain gauge bridge can be either an active gauge or a dummy. Dummy gauges are either an unstressed gauge or a resistor of the same resistance as the active gauge. The form of a strain gauge bridge depends on the application and, to cope with all requirements, the IMP type 35951B provides for full, half and quarter-bridge configurations.

### 3.4.3    Temperature Compensation

With regard to strain gauging, temperature variation, in time and/or physical location, can result in three possible sources of error. Fortunately it is possible to compensate for all of these, but care must be taken. The error sources and their compensation are described below, in Sections 3.4.3.1 through 3.4.3.3. When compensation is properly applied all errors due to temperature variation should balance out, so long as the operating conditions of the gauge(s) are not exceeded.

#### 3.4.3.1    Differential Expansion

Differential expansion occurs where the change in dimension with temperature of the surface being monitored is different to that of the gauge. A temperature rise, for example, could cause the surface being measured to expand by a greater amount than the gauge would naturally expand. Since the gauge is bonded to the surface it is forced to expand by the same amount and therefore gives a false indication of strain.

This effect can be compensated for in two ways:

a.  by bonding the complete bridge to the surface being measured, in the same temperature environment,

b.  by using temperature-compensated gauges.

In a compensated gauge it is arranged for the resistivity of the gauge material to have a negative temperature coefficient, so that a possible increase in resistance, due to stretching by differential expansion, is cancelled out by a drop in resistivity of the gauge material. Temperature compensated gauges are designed for use with specific materials, such as stainless steel, mild steel and aluminium.

#### 3.4.3.2    Variation in Gauge Resistance

The resistivity of all strain gauges tends to vary with temperature, this effect being greater in semiconductor gauges than in metallic ones. Thus a change in temperature may alter the gauge resistance to give a false strain reading. To compensate for this, all elements of a strain gauge bridge should have the same temperature coefficient and be maintained at the same temperature. To minimize heating of the gauges the 35951B energizes each bridge in turn, just before measurement takes place.

### 3.4.3.3 Variation in Lead Resistance

The resistivity of the copper-wire leads connecting a strain gauge bridge to the IMP inputs tends to vary with temperature. However, this effects the strain indication only when the leads are actually included in the bridge network, as in the case in the three-wire bridge (see Section 3.4.4.4). To compensate, ensure that all input leads included in the bridge network are of the same length and are maintained at the same temperature. To minimize heating of the wires the 35951B energizes each bridge in turn, just before measurement takes place.

## 3.4.4 Which Type of Bridge Should I Use?

The newcomer to strain measurement might justifiably be confused over which type of strain gauge bridge best suits a particular application: full-bridge, half-bridge, four-wire quarter-bridge, or three-wire bridge. This section describes the advantages and possible disadvantages of each type of bridge in turn and should help you to reach a rational decision. Incidentally, the name given to each type of bridge relates to that part of the bridge which is located at the measurement site.

Generally the reason for using a half-bridge rather than a full-bridge, or a quarter-bridge rather than a half-bridge is a financial one: you need less gauges and/or leads. There is also the practical reason that, with less gauges and/or leads, installation is much simpler and there is less chance of making errors. There are a few trade-offs, however, and these are pointed out in the following bridge descriptions.

### 3.4.4.1 Full-Bridge

The full-bridge (Figure A.6) uses the most hardware - four gauges - all mounted at the measurement site, and six leads. If you are using a full-bridge device such as a load cell, then this is the only configuration possible. However, if you are using discrete elements such as etched foil strain gauges then you have the option of using four active gauges to obtain a bridge sensitivity of $4{\times}G$ or of using a mix of active and dummy gauges, for example two active and two dummy gauges, but with reduced sensitivity. (See Section 3.4.5 for gauge orientation.)
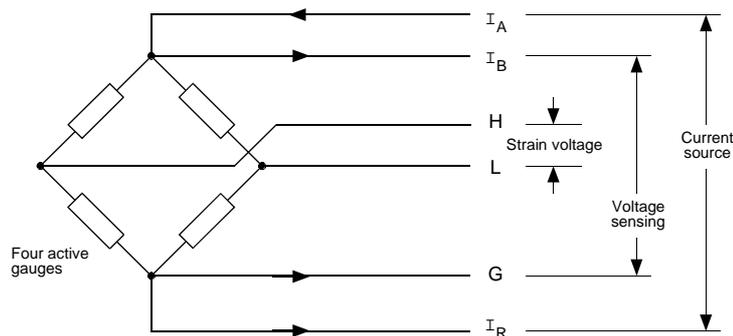


**Figure A.6   Full-bridge strain gauge configuration, voltage energized.**

With regard to temperature compensation ensure that all four bridge elements are mounted on the same material and are maintained at the same temperature. Since the level of voltage energization is sensed at the bridge any variation in lead resistance has no effect on the strain voltage.

### 3.4.4.2 Half-Bridge

The half-bridge (Figure A.7) uses just two gauges, both mounted at the measurement site. With both gauges active, this gives a bridge sensitivity of 2×G. The number of leads is reduced to five and, compared with a full-bridge with four active gauges, you have a saving of two gauges with a trade-off of half the sensitivity.
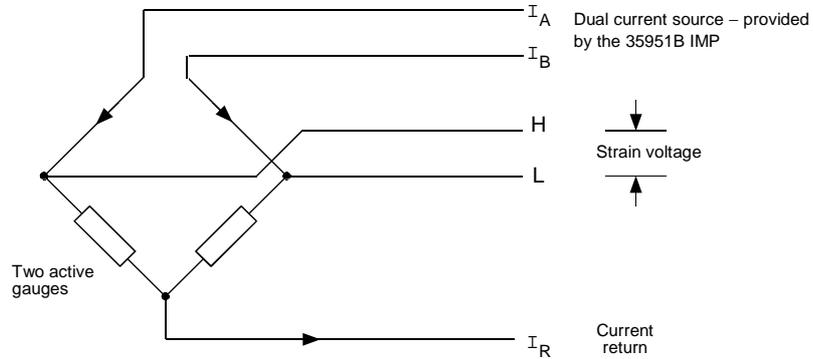


**Figure A.7   Half-bridge strain gauge configuration, current energized.**

With regard to temperature compensation ensure that both bridge elements are mounted on the same material and are maintained at the same temperature. Since the bridge is energized by a dual constant current source any variation in lead resistance has no effect on the strain voltage.

### 3.4.4.3 Four-Wire Quarter Bridge

The four-wire quarter-bridge (Figure A.8) is a variation of the half-bridge. It uses just one active gauge at the measurement site and shares a common dummy gauge with several other bridges. Thus bridge sensitivity is solely that of the active gauge ($\approx 2$ for a metallic gauge) but the number of lead wires is reduced to four and you need only one gauge per channel.
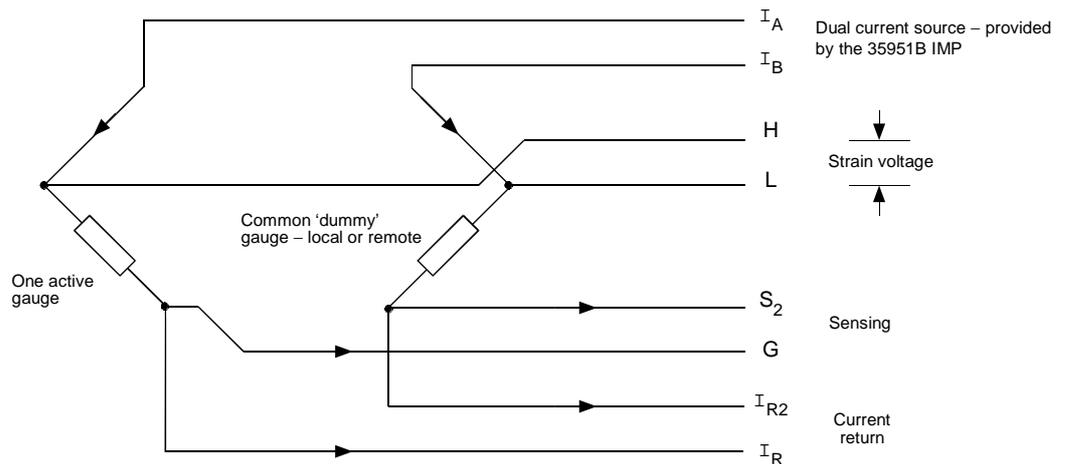


**Figure A.8   Four-wire quarter-bridge configuration, common dummy.**

To achieve adequate temperature compensation it is important that the common dummy enjoys the same environment as the active gauges. In an industrial application this is best done by mounting the common dummy in the same vicinity as it's active companions; it is then known as a local dummy.

The 3595 1B also gives the option of using a remote common dummy, connected at the IMP. This configuration could give problems with ordinary gauges, due to the difficulty of ensuring that the environment of the remote dummy is the same as that of the active gauge(s). However, with temperature compensated gauges the problem is reduced to ensuring that the temperature of the remote dummy (which can be a good quality resistor) is reasonably stable. Since the 0V current return for the active gauge is sensed at the gauge, and the 0V return for the common dummy is sensed at the dummy, the difference in lead lengths and any variation in lead resistance do not effect the strain voltage.

### 3.4.4.4   Three-wire bridge

The three-wire bridge (Figure A.9) is a another variation of the half-bridge. It is similar to the half-bridge described in Section 3.4.4.2, but the number of leads is reduced to three.



a) Half-Bridge            b) Quarter-Bridge
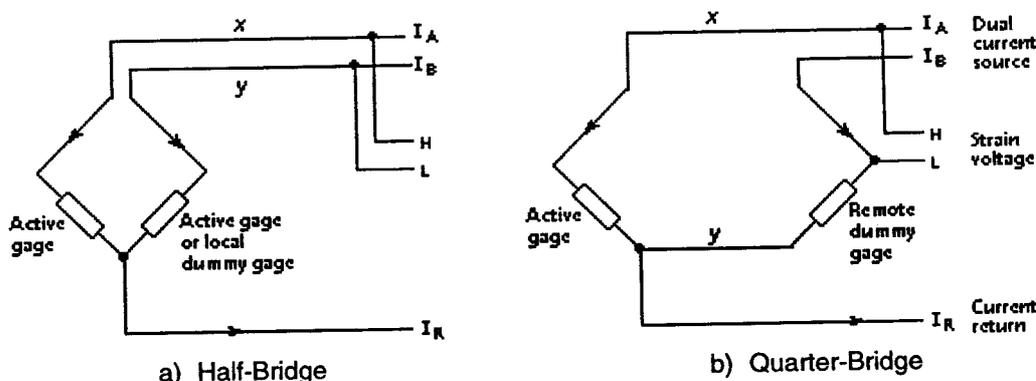
**Figure A.9  Three wire bridge configuration: half- and quarter-bridge.**

The resistance of the two leads (x and y in Figure A.9) is included in the bridge. Therefore, to balance the bridge, these leads should be identical. With regard to temperature compensation the leads should be routed alongside each other, so that any variation in lead resistance cancels out. With regard to bridge sensitivity the lead resistance should not be so high as to reduce the sensitivity unduly. The comments in Section 3.4.4.3 regarding the use of a remote dummy apply equally to the three wire bridge.

### 3.4.5 Strain gauge orientation

It is important that strain gauges are correctly orientated on the surface to be measured. In the example shown in Figure A.10 gauges A and D are under tension while gauges B and C are in compression; this bridge configuration allows the gauge factors to add up to a combined sensitivity of 4*G.
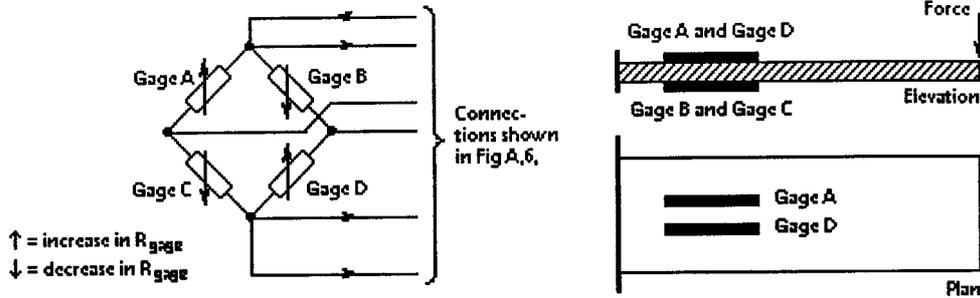


### Figure A.10 Example of strain gauge orientation.

The two strain gauges in a half-bridge are similarly oriented. For example, gauges C and D in Figure A.10 could be oriented the same way in a half-bridge. Note that dummy gauges bonded to the measured surface are mounted at right angles to the active gauge(s) – that is, to the line of stress.

### 3.4.6 Bridge Initialisation

All strain measurements are referenced to the zero stress condition. Since strain gauge bridges rarely have zero output for zero load, trimming resistors are sometimes employed to balance the bridge. This method is fine for simple systems with only one or two bridges, but is impractical for large systems. The 3595 1B IMP avoids the necessity of using trimming resistors by measuring the zero load output and subtracting this from the loaded output.

With zero stress applied, the IMP measures and stores the small strain voltage (v) for zero load. When stress is applied, the change in strain gauge resistance alters the balance of the bridge and produces a voltage V proportional to strain. The true strain value is computed from the voltage difference V-v, and other factors such as gauge factor.

### 3.4.7 Bridge energisation

Bridge energisation for strain gauge bridges measured by the 3595 1B IMP is provided by the modules integral dual current supply.

The range of strain that a 3595 1B IMP is able to measure depends on the gauge you are using. The dual current supply is able to cope with the dual current requirements of all commonly used strain gauges. The repeatability, and the limits of error obtained with the various types of bridge, are given in the Appendix B of this manual.

## 3.5    TEMPERATURE MEASUREMENT

To enable temperature to be measured, a temperature sensor must be used.  This converts the thermal energy into an electrical signal that an IMP can recognise.  The IMPs type 35951A, C and E measure temperature with a thermo-couple, whilst IMP type 35951B does the same with a platinum resistance thermometer (PRT).  To help you decide which type of sensor to use, Table A.1 compares their overall performances. Note that PRTs are also known as RTDs (resistance thermometer devices).

### Table A.1    Performance Comparison: PRTs v Thermocouples

| Aspect | Resistance Thermometer | Thermocouple |
|---|---|---|
| Range | -200ºC to 850ºC | -250ºC to 2000ºC |
| Accuracy | ±0.1ºC to ±1ºC | ±0.5ºC to ±5ºC |
| Stability | Excellent: output consistent with temperature over very long periods. | Tendency to drift - type K in particular. |
| Response time | 1 second to 50 seconds. | 0.05 seconds to 5 seconds. |
| Vibration tolerance | Not as tolerant of vibration as thermocouples generally, but 'supported' types are available for industrial use. | Mineral insulated types are suitable for arduous operation. |
| Noise susceptability | Less susceptible to electrical interference than thermocouples. | More susceptible to electrical interference than PRTs. |
| Size | Resistance thermometers, generally, are larger than thermocouples. | Some very small thermocouples are available. |
| Cost | A PRT normally costs between two and three times as much as a thermocouple of similar performance. | Thermocouples are cheaper: see opposite column. |
| Leads required | Ordinary copper leads. | To ensure accurate results the leads between the measuring junction and the reference junction(s) should be of the same (or similar) metals as those used in the thermocouple. |

A wide selection of temperature sensors is available, to suit all measurement environments.  Full details can be obtained from the sensor manufacturers.  Most manufacturers will also provide you with detailed information on how to install and use your chosen sensor to get the most accurate results.  Sections 3.5.1 and 3.5.2 give basic guidance on the use of PRTs and thermocouples.

## 3.5.1    Using a PRT

A PRT uses the principle that the resistance of a platinum wire varies predictably with temperature.  Therefore the connections made to the IMP (35951B) are the same as those for resistance measurement.  The PRT is energized by the module's integral dc supply.

To ensure an accurate result, four-wire PRTs should be used.  The color coding of the leadwires shown in Figure A.11 is that recommended by the British Standard BS1904:1984.  However, not all manufacturers adhere to this standard, so be careful.  If in doubt, refer to the manufacturer's data sheet.  Do not use four-wire *compensated* PRTs: these have leadwires color-coded blue, blue, red, and white and are *not* suitable for use with the 35951B.

For a PRT to give a true indication of temperature it should be placed in good thermal contact with the substance being investigated. Insertion probes should be inserted in a fluid to the distance recommended by the manufacturer. Surface probes should be mounted with a small amount of heat sink compound between the probe and the surface. See Figure A.12.
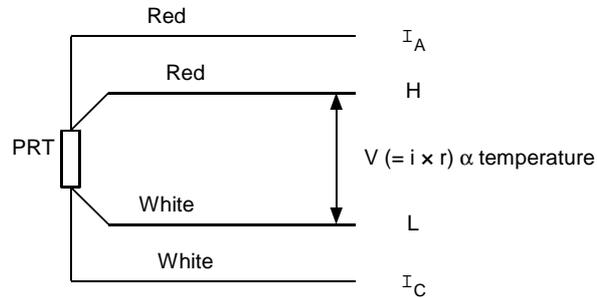


**Figure A.11   Temperature measurement with a PRT.**
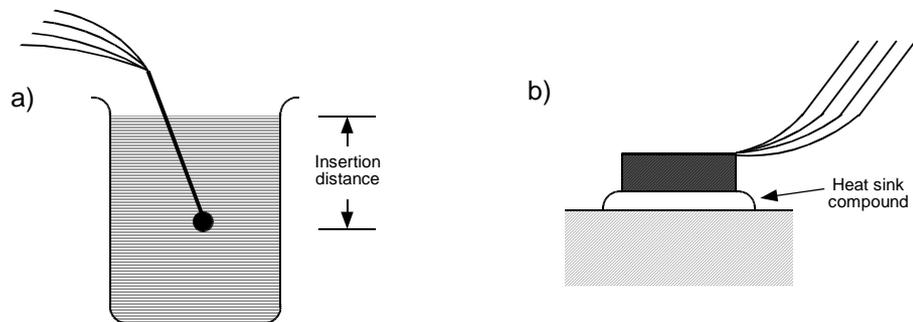


**Figure A.12   Installing a PRT: (a) insertion type; (b) surface mounted type.**

The three-wire method of connecting a PRT is sometimes preferred to the four-wire method, due to the saving in sensor cable cost. However, the three-wire method gives a less accurate result than the 4-wire method and has less thermal stability. An example of the three-wire connection is shown in Figure A.13. For the lead resistances to be effectively nulled, conductors 'a' and 'b' should be identical.
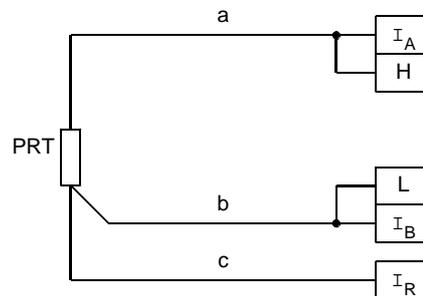


**Figure A.13   PRT connections, three-wire method.**

The comparison between the four-wire and three-wire connections is exactly the same for PRTs as it is for resistance measurements. For the principle of three-wire resistance measurement see Section 3.3 in this chapter.

The IMP type 35951B provides for the linearization of a PRT output to conform with the IEC 751 Standard. PRT temperature readings are available over two ranges, -200°C to 490°C and 490°C to 600°C, with the sensitivity and limits of error specified in Appendix B of the manual.

### 3.5.2 Using a Thermocouple

A thermocouple is simply a junction between two dissimilar metals, which develops an emf proportional to its temperature. A simple thermocouple can be made by twisting two suitable wires together, but, generally, it is best to use one of the purpose-built temperature sensors available from thermocouple manufacturers.

The principle of thermocouple measurement is illustrated in Figure A.14. Here it can be seen that a thermocouple circuit consists basically of a pair of thermocouple junctions connected in opposition. (The two emfs produced by the junctions act against each other). Since the two junctions are of the same type they produce equal emfs when held at the same temperature - in which case the resultant emf is zero. If the measurement junction is now heated (to 100°C for example) whilst the reference junction is maintained at 0°C, then the resultant emf is a function of the two temperatures. This principle applies for all thermocouple measurements and a wide selection of temperature sensors allows you to measure temperatures in the range -250°C through 2000°C.
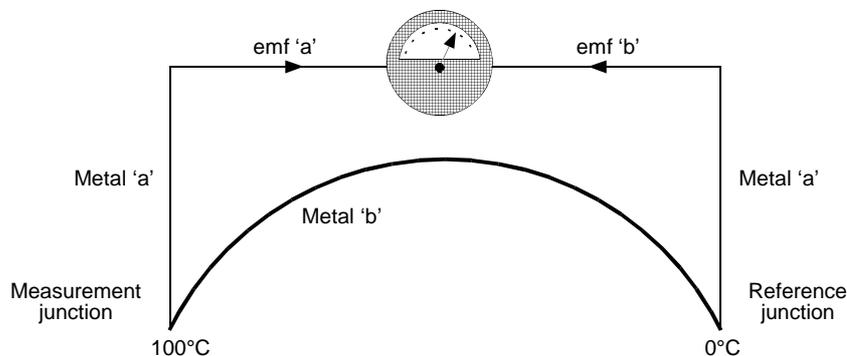


*Figure A.14   Thermocouple principle.*

Historically, the two thermocouple junctions are known as the 'hot' and 'cold' junctions, the cold junction being maintained at 0°C by a flask of melting ice. Recently, however, the two junctions have come to be known, more correctly, as the 'measurement' and 'reference' junctions. (When temperatures lower than 0°C are being measured the 'hot' junction is cooler than the 'cold' junction!)

Thermocouples may be connected to an IMP connector block in two different ways. One of these (Figure A.15) uses an external reference unit, whilst the other (Figure A.16) uses the IMP input connections themselves as reference junctions. In the latter case the ambient temperature of the input terminals is monitored in the connector block

and temperature compensation is applied automatically. (In these practical measuring circuits there are, of course, two reference junctions, one at the Hi input terminal and one at the Lo; but, since these two closely located terminals have a common temperature, they act as a single junction.)

Note the use of compensating/extension cables to connect the thermocouple sensor to the reference junctions. These cables contain single or multiple pairs of wires whose composition is the same as, or similar to, that of the sensor metals and this allows the measurement and reference junctions to be situated a suitable distance from each other. Use only those cables recommended by the thermocouple manufacturer, and make sure that they are connected the right way round. Most cables are color-coded to allow you to identify the positive and negative wires, but, be careful, the color codes vary from country to country. Thermocouple terminations are either color-coded in the same way or marked '+' and '−'.

An IMP type 35951B is able to operate with eight different types of thermocouple: B, E, J, K, N, R, S, and T. All measurement results are linearized to comply with the IEC 584 and BS 4937 Standards. The different temperature ranges thus made available are listed in Table A.2.
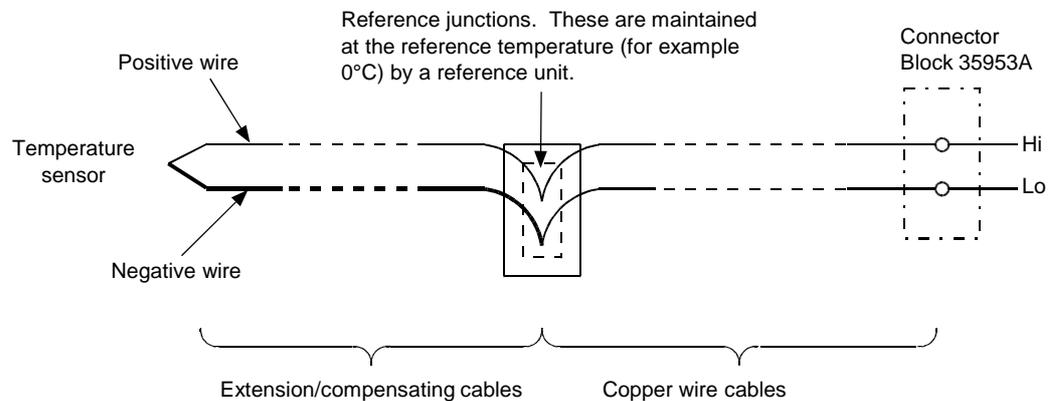


**Figure A.15   Thermocouple connections made through reference unit.**
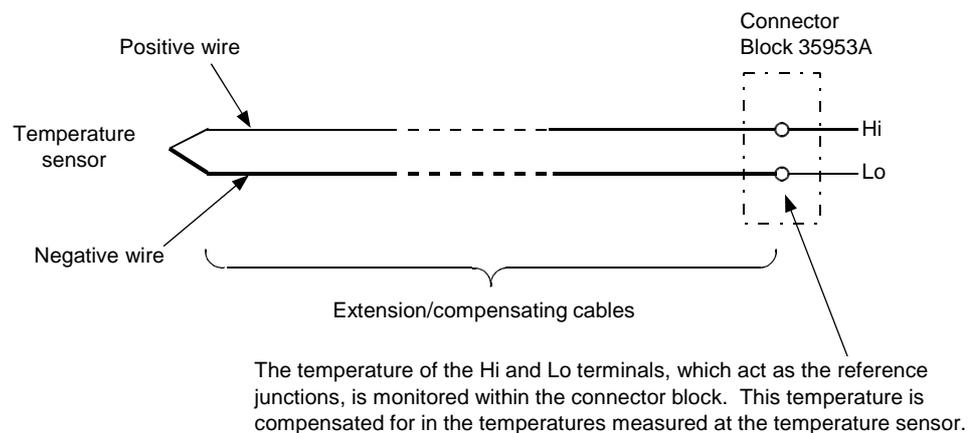


**Figure A.16   Thermocouple connections made direct to the connector block.**

**Table A.2  Thermocouple Ranges**

| Thermocouple Type | Overall Temp. Range (°C) |
|:---:|:---:|
| B | 80   to 1820 |
| E | -200 to 1000 |
| J | -210 to 1200 |
| K | -210 to 1370 |
| N | -210 to 1300 |
| R | -50  to 1760 |
| S | -50  to 1760 |
| T | -200 to 400 |

Full details of the individual temperature ranges are specified in Appendix B of the manual.

## 3.6       FREQUENCY MEASUREMENT

The IMP type 35952A is able to measure pulse repetition frequencies up to 49kHz.  This provides for the pulse streams produced by sensors such as flow meters and shaft speed indicators.

The 35952A is also able to measure period, which is useful for obtaining a satisfactory resolution in the measurement of low frequencies.  After obtaining a period measurement the host can compute the reciprocal value to obtain the corresponding frequency.

## 3.7       QUALITY OF MEASUREMENT

The quality of a measurement is expressed in terms of resolution and accuracy.  To appreciate the measurement ability of the IMPs it is important not to confuse these two terms.  Therefore, a concise definition of each one is now given.  Also defined is the term 'repeatability', which is another important aspect of measurement quality.

### 3.7.1      Resolution

Resolution describes the 'fineness' of a measurement.  In other words, it is the smallest amount by which your measurement result can change.  As an example, an IMP type 35951A, C or E is able, on its 20mV dc input range, to measure dc voltages with a resolution of 1µV (one millionth of a volt).  Thus you can measure voltages of 0.001mV, 0.002mV, 0.003mV, and so on, up to around 20.001mV.  Similarly, on the 12V dc range voltages can be measured with a resolution of 1mV, for example 5.001V, 5.002V, and so on.  (These figures assume an integration time of 20ms.)

### 3.7.2      Accuracy

Accuracy describes how closely the measured value approaches the actual value of a physical quantity.  Accuracy is quoted in the IMP specifications in terms of 'Limits of Error' and, for this reason, it is sometimes known as the 'uncertainty' of a measurement.  As an example, the limits of error on the 20mV range, with a 20ms integration period,

are specified as '±(0.02% rdg+5µV)'.  This means that if your measurement result (measured on the 20mV range, with an integration time of 20ms) is 10mV then the actual value is somewhere in the range of values 9.993mV to 10.007mV.  (The limits of error are ±7µV.)

The limits of error in the IMP specification are quoted for one year after calibration, and are applicable after a one hour warm-up period and with an ambient temperature of 20°C±3°C.  For ambient temperatures other than this a temperature coefficient must be taken into account.  If the 10mV result in the example above was obtained at an ambient temperature of 60°C then, from the temperature coefficient of the ADC (<(0.0015% rdg+0.2µV) per °C) the limits of error are increased by ±14µV, so that the actual value is somewhere in the range 9.979mV to 10.021mV.

For the limits of error of all types and ranges of measurement, the ADC temperature coefficients, and any special factors that affect measurement accuracy, see the IMP specifications in Appendix B of the manual.

## 3.7.3    Repeatability

Repeatability is an aspect of measurement quality that is particularly important when measurements are being compared with each other, rather than against an absolute standard such as the Standard Volt.  Repeatability means that successive measurements of a stable physical quantity remain substantially the same over long periods, assuming a stable ambient temperature.  This ensures that, even if an IMP is slightly out of calibration (after periods in excess of one year) the results of differential measurements are valid.

# 4    COMBATING INTERFERENCE

*Interference* is a general term for anything that influences a signal being measured to give a false result.  Usually the interference takes the form of an extraneous signal, which combines with the signal being measured at the ADC input.  Sometimes, however, errors in the result may be caused by a variation in performance with temperature (also known as 'drift').

Depending on the type of measurement being made, an IMP is able to reject specific types of interference, whilst accepting the signal to be measured.  It is still an advantage, however, to ensure that the signal being measured is as free of interference as possible. This is achieved by careful installation of sensors and input leads, as outlined in Section 4.6 in this chapter.

## 4.1    TYPES OF INTERFERENCE

Interference can be classified as follows:

(a)    in the way it appears at the input terminals, common mode or series mode, and

(b)    the interference content, dc or ac.

**Common mode interference** occurs when the interference source $e_{cm}$ is common to the Hi and Lo inputs of the IMP.  See Figure A.17.
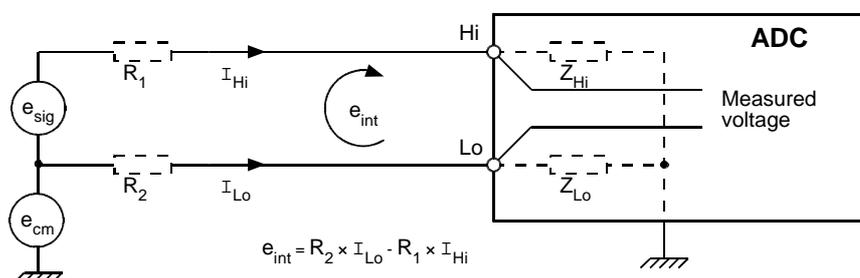


***Figure A.17   Common mode interference.***

Common mode interference does not affect the measurement directly.  If the input impedances $Z_{Hi}$ and $Z_{Lo}$ were equal, and the lead resistances $R_1$ and $R_2$ equal also, common mode interference would have no effect: the lead and input impedances would form a balanced bridge and, therefore, no voltage due to the interference $e_{cm}$ would appear across the Hi and Lo inputs.  In practice, however, the input impedances $Z_{Hi}$ and $Z_{Lo}$ are different, $Z_{Lo}$ generally being the lowest.  This imbalance results in an interference signal $e_{int}$ ($=R_2 \times I_{Lo} - R1 \times I_{Hi}$) across the Hi and Lo inputs, and common mode interference is thus converted into *series mode* interference.  A high resistance in the Lo input lead generally aggravates the problem.  In the IMPs the problem of common mode interference has largely been solved by using floating inputs.  Section 4.2 gives the details.

**Series mode interference** acts in series with the signal being measured (the 'wanted' signal $e_{sig}$). This type of interference may be due either to common mode interference, as explained above, or to interference mixed with $e_{sig}$. The way in which series mode interference is dealt with is explained in Sections 4.3 and 4.4.


## 4.2    COMMON MODE REJECTION

IMPs reject common mode interference by using a floating analog-to-digital converter (ADC) as shown in Figure A.18.
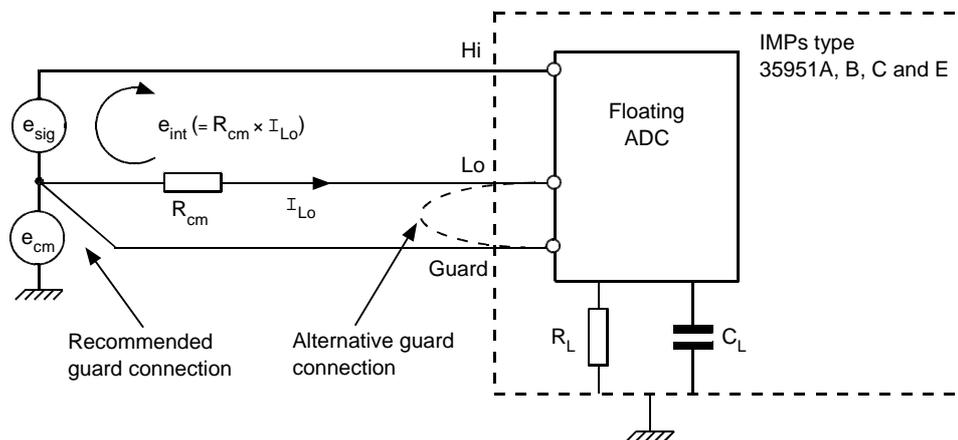


*Figure A.18   The use of a floating ADC for common mode rejection.*

The best rejection of common mode interference is obtained with Guard connected to the source of common mode.  Should this be impractical then guard must be connected to Lo.  With the latter method, common mode and series mode rejection is slightly degraded, due to the leakage through $R_L$ and $C_L$ (the leakage resistance and stray capacitance).

Note that the maximum value of common mode voltage between the IMP inputs and S-Net is specified as 500V, which implies a maximum common mode voltage of 500V between the inputs and ground.  Within this limitation, any leakage to ground should be negligable, but it depends on the number of IMPs in the system and on their individual common mode voltages.

As explained in Section 4.1, common mode interference is measurable only when converted to series mode interference.  It is standard practice, therefore, to deliberately insert a resistance $R_{cm}$ of known value into the Lo input lead when common mode rejection is measured during tests on the IMP's ADC.  The common mode rejection figures for the various IMPs (see Table A.3) are specified for an $R_{cm}$ value of 1kΩ. Usually, the resistance of the Lo input lead is much less than 1kΩ, in which case the rejection is correspondingly greater.  (Conversely, the common mode rejection will be less than that specified if the resistance of the low input lead is greater than 1kΩ!)

**Table A.3  Common Mode Rejection***

| IMP and Type of interference | Rejection | |
|---|---|---|
| | **20ms Integration** | **5ms/4.17ms/1.25ms/ 1.04ms Integration** |
| **IMPs 35951A, C, and E, and IMCs 359551A, C, and E** | | |
| dc | >140dB | >140dB |
| 50Hz/60Hz ±0.1% | >140dB | >80dB |
| 50Hz/60Hz ±1% | >120dB | - |
| **IMPs 35951C and E, with HV connector block 35953D** | | |
| dc | >100dB | >100dB |
| 50Hz/60Hz ±0.1% | >100dB | - |
| **IMP 35951B and IMC 359541B** | | |
| dc | >120dB | >120dB |
| 50Hz/60Hz ±0.1% | >120dB | >80dB |
| 50Hz/60Hz ±1% | >100dB | - |

*These figures assume that the guard terminal is connected to source and that there is a 1k$\Omega$ imbalance in the input leads.

Note the reduced rejection of 50Hz (60Hz) for integration periods other than 20ms. The reason for this is that the rejection specified for 20ms integration period includes 60dB of series mode rejection, which is not obtained for other integration periods. Note also that the common mode rejection of ac signals decreases as the frequency increases.

## 4.3    AC SERIES MODE REJECTION

The term *series mode rejection* (also known as 'normal' mode rejection) is generally applied to the rejection of line frequency interference, when this is acting in series with a 'wanted' dc signal. An IMP rejects series mode interference by *integrating* each dc measurement over a complete number of cycles of interference. Integration means continuously monitoring the input signal over the measurement period and computing the mean value. During this process the ac interference averages to zero.

Ac series mode rejection is effective only when the integration period of the IMP analog-to-digital converter is set to cover the period of the line voltage fundamental frequency, see Figure A.19. By default, the integration period is set to 20ms to reject 50Hz interference. Two other integration periods can be selected by remote command: 16.67ms for 60Hz supplies and 5ms for 400Hz supplies. (See Part 2 of the host interface manual for the relevant command.)
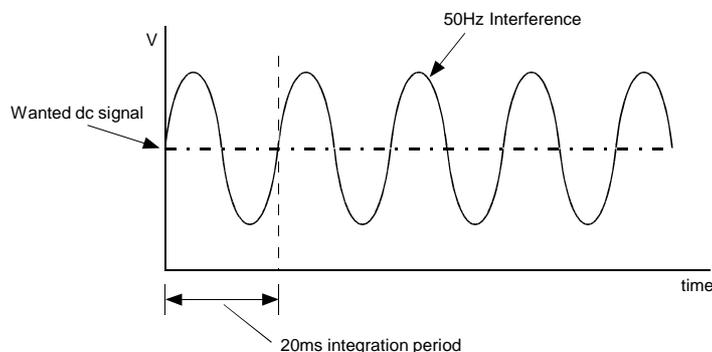


*Figure A.19   The rejection of ac series mode interference at 50 Hz.*

An integration period that is suited to the ac supply (for example 20ms for 50Hz or 16.67ms for 60Hz) gives a series mode rejection of >60dB at the fundamental supply frequency and its harmonics. Series mode rejection is not effective for the 'fast' integration periods (4.17ms, 1.25ms and 1.04ms). Therefore, in electrically noisy environments it is essential to use an effective integration period.

## 4.4    DRIFT COMPENSATION

Variations in measurement results, known as 'drift', can be caused by changes in the internal temperature an IMP, which in turn affect the performance of the ADC. To compensate for this, the IMP periodically measures two reference inputs and calculates from the results actually obtained the compensation to be applied for all readings.

Drift compensation measurements have very little effect on the input measurement rate and are transparent to the user.

## 4.5    AVOIDING INTERFERENCE

Interference in your measurement results will be largely avoided, and certainly minimized, if you follow the simple installation rules given below.

To avoid ac interference:

*   Use twisted pairs or screened leads to connect the sensor to the connector block terminals.

*   Avoid running the input leads near other cables carrying heavy ac currents or high ac voltages.

To avoid dc interference:

*   Try to avoid sources of thermal emf, such as nickel-iron relay contacts with copper connections.

*   Avoid high humidity, which can cause leakage across nominally good insulators.

*   Avoid moisture on exposed terminals, which may cause emfs to be generated by a corrosion process.

*   Do not fix cables to vibrating equipment, otherwise electrostatic potentials may be generated.

To avoid ac and dc interference:

*   Always connect Guard (Sense) to the Lo line: never leave it open-circuit.

*   Never leave unused channels open-circuit: always fit a Hi-Lo-Guard shorting link.

*   Always connect the IMP case (or the IMC frame) to a local ground point.

### 4.5.1 Preferred Guarding Connections

Figure A.20 below shows the preferred guarding arrangements for voltage- and current-based sensor connections to the IMP/IMC input terminals.

a) three-wire voltage, screened cable
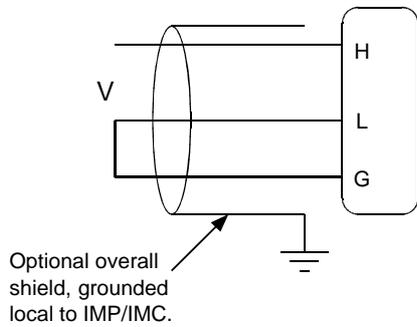
b) two-wire voltage, twisted pair
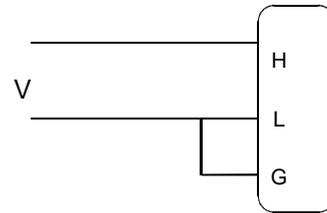
c) two-wire current, twisted pair
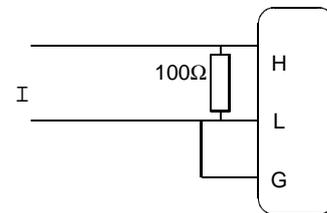
*Figure A.20    Preferred guarding arrangments.*

A twisted pair is recommended for the Hi and Lo leads as it is less susceptible to interference.  The three-wire arrangement (a) extends the guard circuit out to the sensor: this arrangement is particularly effective when used with a screened cable, grounded at the IMP/IMC.

### 4.5.2 Grounded Signal Guarding

Where one side of the sensor output is referred to ground (for example as in a 'grounded tip' thermocouple) use the guarding arrangement shown in Figure A.21.  Remember, however, that the sensor is always the source of common mode interference and defines the measurement reference.
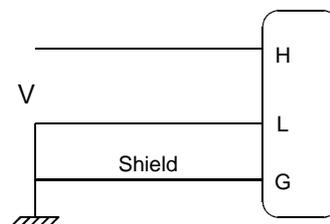
*Figure A.21    Grounded signal guarding.*

The shield connection shown in Figure A.21 extends the guard circuit to the local 'ground' (at the sensor) which may or may not be at actual ground potential. By allowing the guard to float at the common mode potential (the potential of the local ground) this guarding arrangement minimizes common mode interference, but certain limitations are imposed on ground connections at the IMP:

- The guard terminal must not be linked to Lo at the IMP, or to another ground point.

- With respect to the IMP's inter-channel isolation it is important to ensure that other sensors connected to the same IMP are all at a ground potential which does not exceed the maximum inter-channel voltage specified for the IMP.

Note that the IMP to IMP isolation is >500V. Therefore grounded sensor connections on one IMP should not effect other IMPs on the same network.

# 5    EFFECT OF PARALLEL INSTRUMENTATION

It is sometimes required for IMP input channels to be connected in parallel with those of other instruments, typically when measuring thermocouples. The purpose of this section is to remind the reader of the effect of this, and to offer some broad guidelines.

Voltage inputs only are considered. (If a 4-20mA transmitter is to be monitored by two instruments, IMPs or otherwise, the error imposed by the additional circuit is negligable. This is due to the relatively high voltage backing a 4mA to 20mA loop.)

In parallel instrumentation there are generally two scenarios:

- The IMP channel is connected to an existing measurement circuit, which has a sensor already connected to it, for example a chart recorder.

- Two IMP channels, usually from different IMPs, are connected to the same sensor for redundancy purposes.

In these two cases an error voltage is developed, which is a product of the second instrument's input leakage current and the sensor impedance.

## 5.1    INPUT LEAKAGE CURRENT

Input leakage current, rather than input impedance, is the best parameter to use when considering the effect of one instrument's input circuit on that of another.

Leakage current is a function of the input impedance of a measuring device, but there are other factors, for example input amplifiers and multiplexer circuits in particular. Therefore the fact that an ADC has a high input impedance, in the order of GΩ, often has little bearing on the actual input leakage. However, if the precise value for the leakage current is not available then the effective leakage current may be estimated by dividing the measured voltage by the ADC input impedance. For example, with a thermocouple output of around 200mV and an ADC input impedance of 100MΩ the leakage current approximates to 20nA.

The input impedance of the ADC within an analog IMP is 10GΩ, but this is degraded by the multiplexer circuitry so that the input leakage current is higher than expected, at 15nA. This is the case with all multi-channel instruments and is not always quoted - so beware!

Two examples of measurement errors due to leakage are given on the next page.

**Example 1**

An existing measurement system has a thermocouple connected to a 35951C IMP. The user wishes to connect a Phillips PM8238 30 channel chart recorder to the IMP measurement circuit. The measurement error due to leakage is approximately:

input leakage of chart recorder $\times$ thermocouple impedance

$$=100pA \times 300\Omega=3nV$$

in terms of °C this error is too small to consider.

**Example 2**

Two IMPs are connected to the same sensor for redundancy purposes. (This example also applies for an IMP connected in parallel to any existing measurement system.) The error due to leakage that is seen at each IMP is approximately:

IMP input leakage current $\times$ thermocouple impedance

$$=15nA \times 300\Omega=4.5\mu V$$

in terms of °C this represents an error of 0.1°C, which is significant when added to the overall uncertainty and is probably worth considering.

**Note:** When measuring thermocouples in this way always disable the IMP's open-circuit thermocouple detection facility

## 5.2     ACCUMULATED CHARGE

In addition to the errors caused by input leakage current, errors may arise due to charge injection from the other instrument during channel scanning. This occurs when the other scanner has just measured a high voltage and insufficient settling time has been allowed for the accumulated charge in the ADC to discharge.

It is recommended that instruments which have channels connected in parallel with another instrument are used to monitor sensors with similar output levels: do not mix high and low voltage sensors in this situation. Also, the timing should be arranged such that the two instruments do not scan together: leave an adequate settling time (>10ms) between channels measurements and thus allow any charge on the measurement circuit to decay away.

# B

## Specifications for IMPs type 35951H & J

## Contents

### List of Tables

**Table B.1   Channel Functionality of the Universal IMP**

| Measurement | Channels 1 - 18 | Channels 19, 20 |
|---|:---:|:---:|
| Volts dc | | |
| Current dc | | |
| Thermocouple (B, E, J, K, N, T, R, S) | | |
| Thermocouple (user 5th order polynomial) | | |
| Resistance (2/3/4 wire)* | | |
| RTD/PT100 (3/4 wire)* | | |
| RTD/CU10 (4 wire)* | | |
| Thermistor (user 5th order polynomial, 2/3/4 wire)* | | |
| Status (TTL, 3/9V, volt-free contact) | | |
| Status (TTL, 3/9V) | | |
| Frequency | | |
| Period | | |
| Counting | | |
| Digital Output | | |

*Note that 3- and 4-wire measurements use two channels.

All limits of error are for 1 year at 20°C±3°C.

# 1 Analog/Status Channels 1 - 18

Number of analog channels ..................................................... 18 (Channels 1 through 18)

Switching .................................................. reed relay, three-pole

Reed-relay life ..................................................... $>10^8$ operations

Maximum signal measured ................................................................. ±12V

Maximum input voltage ................................................................. ±14V

Overload protection, continuous ................................................................. 50V

Maximum voltage between any two inputs:

        35951H ........................................................ 200V

        35951J ........................................................ 500V

Common mode, between IMPs ................................................................. 500V

M.T.B.F. to MIL217E     64,000hrs (IMP) 69,000hrs (IMC)

## Measurement

Voltage dc, without optional connector ........................................................... 0 to ±12V

Current dc (assuming 100Ω shunt) ................................................................. 0 to 20mA

Thermocouple types ....................................................... B,E,J,K,N,T,R,S

Thermocouple Cold Junction ........................................................ External or Automatic

Thermocouple open circuit detection ........................................................ programmable

Resistance, 4 & 3 Terminal ................................................................. 0 to 2.5kΩ

Resistance Thermometer, 4 & 3 Terminal ........................................................ 100Ω PRT

## Interference Rejection

(Specifications are for 1kΩ imbalance in Hi and Lo leads)

*20ms/16.67ms Integration time:*

Normal mode, 50 or 60Hz ±0.1% ................................................................. >60dB

Effective common mode rejection,

        dc ......................................................... >140dB

        50 or 60Hz ±0.1% ....................................................... >140dB

        50 or 60Hz ±1% ......................................................... >120dB

*5ms/4.17ms/1.25ms/1.04ms Integration times:*

Normal mode, 50 or 60Hz ±0.1% ................................................................. >0dB

Effective common mode rejection, 50 or 60Hz ±0.1% ......................................... >80dB

## DC Voltage

Temperature coefficient of ADC .......................................... <(0.0015%rdg+0.2μV)per°C

*20ms/16.67ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|-------|-----------|-------------|-----------------|
| 20mV | 22.000 | 1μV | ±(0.02%rdg+5μV) |
| 200mV | 220.00 | 10μV | ±(0.02%rdg+0.01%fs) |
| 2V | 2.2000 | 100μV | ±(0.01%rdg+0.01%fs) |
| 12V | 12.000 | 1mV | ±(0.05%rdg+0.01%fs) |

*5ms/4.17ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|-------|-----------|-------------|-----------------|
| 20mV | 22.000 | 2μV | ±(0.02%rdg+20μV) |
| 200mV | 220.00 | 20μV | ±(0.02%rdg+0.04%fs) |
| 2V | 2.2000 | 200μV | ±(0.01%rdg+0.04%fs) |
| 12V | 12.000 | 2.5mV | ±(0.05%rdg+0.04%fs) |

*1.25ms/1.04ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|-------|-----------|-------------|-----------------|
| 20mV | 22.000 | 8μV | ±(0.02%rdg+80μV) |
| 200mV | 220.00 | 80μV | ±(0.02%rdg+0.16%fs) |
| 2V | 2.2000 | 800μV | ±(0.01%rdg+0.16%fs) |
| 12V | 12.000 | 8mV | ±(0.05%rdg+0.16%fs) |

## DC Current

Sensitivity, (assuming 100Ω shunt) ..................................................... 10nA

Error as for DC Voltage +error of shunt resistor+leakage currents.

## Thermocouples

The following temperature ranges are based on 20ms/16.67ms Integration times. All values are specified in degrees Celsius.

Error quoted is conformity to IEC584 (BS4937)

(IMC 359551A,C & E must be in draught-free enclosure: no forced cooling)

| Type | Mid Range | Error | Full Range | Error |
|------|-----------|-------|------------|-------|
| B (Pt-30% Rh/Pt-6%Rh) | 400 to1820 | <0.3 | 80 to 1820 | <2.0 |
| E (Ni-Cr/Cu-Ni) | -100 to 250 | <0.3 | -210 to 1000 | <0.5 |
| J (Fe/Cu-Ni) | -100 to 350 | <0.3 | -210 to 1200 | <0.7 |
| K ((Ni-Cr/Ni-Al) | -100 to 450 | <0.3 | -200 to 1370 | <1.0 |
| N (Nicrosil/Nisil) | -180 to 1280 | <0.3 | -250 to 1300 | <0.8 |
| T (Cu/Cu-Ni) | -100 to 400 | <0.3 | -200 to 400 | <0.5 |
| R (Pt-13%Rh/Pt) | 0 to 1600 | <1.0 | -50 to 1760 | <2.0 |
| S (Pt-10%Rh/Pt) | 0 to 1760 | <1.0 | -50 to 1760 | <1.5 |

Sensitivity, Types B,E,J,K,N,T ................................................................. 0.1°C

Sensitivity, Types R,S .......................................................................... 0.2°C

Total thermocouple error equals Conformity plus voltage errors.

Additional error when using automatic Cold Junction Compensation:

Range                -15 to 60°C ...................................... <0.4°C

                                  -20 to 70°C ...................................... <0.6°C

External Cold Junction range ................................................................ -30°C to 80°C

Open circuit detection threshold .............................................................. 1.9kW±0.1kW

## Resistance

### Resistance, 4-wire

Temperature coefficient:                                    < 0.003%rdg per °C

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 25Ω | 1.25mΩ | ±[0.03%rdg + 6mΩ] |
| 250Ω | 12.5mΩ | ±[0.02%rdg + 0.01%fs] |
| 2.5kΩ | 0.125Ω | ±[0.02%rdg + 0.01%fs] |
| 25kΩ | 1.25Ω | ±[0.02%rdg + 0.04%fs] |

*5ms/4.17ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 25Ω | 2.5mΩ | ±[0.03%rdg + 24mΩ] |
| 250Ω | 25mΩ | ±[0.03%rdg + 0.04%fs] |
| 2.5kΩ | 0.25Ω | ±[0.02%rdg + 0.04%fs] |
| 25kΩ | 2.5Ω | ±[0.02%rdg + 0.04%fs] |

*1.25ms/1.04ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 25Ω | 10mΩ | ±[0.02%rdg + 96mΩ] |
| 250Ω | 100mΩ | ±[0.02%rdg + 0.16%fs] |
| 2.5kΩ | 1.0Ω | ±[0.02%rdg + 0.16%fs] |
| 25kΩ | 10Ω | ±[0.02%rdg + 0.16%fs] |

### Resistance, 3-wire

Temperature coefficient:                                    < [0.003%rdg + 0.03Ω] per °C

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 1.5kΩ | 0.125Ω | ±[0.02%rdg + 0.2Ω + 0.017%fs] |
| 25kΩ | 1.25Ω | ±[0.02%rdg + 0.2Ω + 0.01%fs] |

*5ms/4.17ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 1.5kΩ | 0.25Ω | ±[0.02%rdg + 0.2Ω + 0.07%fs] |
| 25kΩ | 2.5Ω | ±[0.02%rdg + 0.2Ω + 0.04%fs] |

*1.25ms/1.04ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 1.5kΩ | 1Ω | ±[0.02%rdg + 0.2Ω + 0.3%fs] |
| 25kΩ | 10Ω | ±[0.02%rdg + 0.2Ω + 0.16%fs] |

**Resistance, 2-wire**

| | |
|---|---|
| Temperature coefficient: | < [0.003%rdg + 0.5Ω] per °C |

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 500Ω | 0.125Ω | ±[0.02%rdg + 50Ω + 0.05%fs] |
| 25kΩ | 1.25Ω | ±[0.02%rdg + 50Ω + 0.01%fs] |

*5ms/4.17ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 500Ω | 0.25Ω | ±[0.02%rdg + 50Ω + 0.02%fs] |
| 25kΩ | 2.5Ω | ±[0.02%rdg + 50Ω + 0.04%fs] |

*1.25ms/1.04ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| 500Ω | 1Ω | ±[0.02%rdg + 50Ω + 0.8%fs] |
| 25kΩ | 10Ω | ±[0.02%rdg + 50Ω + 0.16%fs] |

## Resistance Thermometer Devices (RTD)

### Resistance Thermometer Device (100Ω platinum), 4-wire

Conformity for 100Ω PRT (RTD) is to IEC 751

| | |
|---|---|
| Temperature coefficient: | < 0.03°C per °C |

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| -100 to 150°C | 0.1°C | 0.3°C |
| 490 to 600°C | 0.2°C | 1.2°C |

### Resistance Thermometer Device (100Ω platinum), 3-wire

| | |
|---|---|
| Temperature coefficient: | < 0.2°C per °C |

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| -200 to 600°C | 0.2°C | 2°C |

### Resistance Thermometer Device (10Ω copper), 4-wire only

| | |
|---|---|
| Temperature coefficient (over –100 to 150°C): | < 0.02°C per °C |

*20ms/16.67ms Integration time:*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| -200 to 600°C | 0.2°C | 2°C |

## 2    Digital Channels 19, 20

Number of channels .................................................................................... 2 (19 and 20)

Isolation, channel to channel or ground ................................................. 500V

Common mode, between IMPs ................................................................ 500V

M.T.B.F. to MIL217E .......................................... 145,000hrs (IMP) 155,000hrs (IMC)

### Inputs

Voltage between thresholds (0 and 1) .................................. 0.8 and 2.0V, or 3.0 and 9V

Maximum input ........................................................................................ 25V or 100V

Min. input drive current .......................................................................... 600μA

Input sample rates, programmable ..................................... 20Hz; 1kHz; 10kHz; 100kHz

4 sample debounce is used for 20Hz and 1kHz rates

Input functions
Status
Events,(time of +ve or -ve edge), accuracy................................................. ±1ms
Frequency........................................................................................ 49kHz max.
Frequency gate times, programmable .................................... 0.01; 0.1; 1 or 10s
Period, resolution ........................................................................... 10μs
Periods, averaged ........................................ 1; 10; 100; 1000; +ve or -ve pulse
Single shot, minimum width ....................................................... 10μs
Count (totalize or increment) ........................................... 24 bits (>16 million)

Outputs
FET switch (closed on logic '1')
Maximum withstand ............................................................................... 60V
Maximum sink per channel ................................................................. 100mA

### Digital Input Counting and Event Capture (per channel)

Maximum count rate per IMP is 15,000/s and is governed by software constraints. Thus for a worst-case input (all channels driven by the same signal) maximum count per channel is restricted to 750/s.
Maximum number of buffered events is 1500 per IMP.

| Sample Rates | 20Hz | 1kHz* | 10kHz | 100kHz |
|---|---|---|---|---|
| Count Parameters: | | | | |
| Maximum frequency | 2.4Hz | 124Hz | 4.9kHz | 49kHz |
| Minimum period | 400ms | 8ms | 200μs | 20μs |
| Resolution of period | 50ms | 1ms | 100μs | 10μs |
| Counts max. rate | 2.4/s | 124/s | 4900/s | 15,000/s |
| Event capture rate | 5/s | 100/s | 100/s | 100/s |
| Event resolution | 200ms | 4ms | 1ms | 1ms |

Figures assume an equal Mark/Space ratio    * indicates default setting

**Frequency**

Figures are for the default sample rate of 100kHz

| Gate Time | 10ms | 100ms | 1s | 10s |
|---|---|---|---|---|
| Minimum frequency | 100Hz | 10Hz | 1Hz | 0.1Hz |
| Resolution | 100Hz | 10Hz | 1Hz | 0.1Hz |
| Limits of Error | | ±(0.004%rdg+resolution) | | |

Frequency signals with a value less than 0.1Hz should be measured using the Event Capture mode.

All Limits of Error assume an equal Mark/Space ratio

**Period**

Figures are for the default sample rate of 100kHz.

| Periods averaged | 1 | 10 | 100 | 1000 |
|---|---|---|---|---|
| Resolution | 10μs | 1μs | 0.1μs | 0.01μs |
| Limits of Error | | ±(0.004%rdg+resolution) | | |

Period measurements have a programmable timeout applied. The timeout must be at least double the expected period. Timeouts of 200ms, 2s, 20s and 50s are available. The maximum period is therefore 25s. Period measurements greater than 25s should use the Event Capture mode. All limits of Error assume an equal Mark/Space ratio.

# 3    General Specifications

## Power Supply

Power supply ........................................................................... 10V to 50V d.c.

Power feed .................................................... via S-Net cable or IMP terminals

Power consumption of each IMP ........................................................... <1.8W

## Response Time

Results returned from all IMPs on S-Net ....................................................... <1s

## Isolation

IMP to S-Net ................................................................................... ±500V

IMP to IMP ............................................................................... 500V min.

## Analog to Digital Conversion

Analog to digital converter ........................................................... 15 bits+sign

Analog scanner leakage currents at 25°C±3°C:

35951A/1B ................................................................................... <60nA

Analog IMP channel crosstalk ......................................................... >120dB

ADC input impedance ................................................................. >10G$\Omega$

## IMP Environment

Storage temperature ................................................................. -25°C to 75°C

Operating temperature: ............................................................. -20°C to 70°C

Humidity, at 40°C (non-condensing): ...................................................... 95%

Vibration: operating for 2 hours: ....................................... 5g, 11Hz to 500Hz

Otherwise, to Def. Std 66/31 Issue 01 Cat. IV.

## IMP Packaging

Sealed aluminium casting to BS5490, IP55 (IEC 529) and NEMA ICS6 Class 4.
Dimensions ................................ 435mm×215mm×34.5mm (17.1"×8.5"×1.4")
Protrusion of cable boots .............................................................. 50mm (2")
Weight .............................................................................. 2.5kg (5.5lbs)

## Electromagnetic Compatibility

Complies with .................................................... EN50081-2 and EN50082-2

**Note:** High levels of radiated or conducted radio frequency interference, as defined in EN50082-2, may reduce the accuracy of low level measurements.

# C

## Specifications for IMPs type 35951A, B, C, D, E, F, G & 35952A, B

## Contents

*All limits of error are for 1 year at 20°C±3°C.*

# 1    35951A, C & E Analog Measurement IMP Specification

(Note: This specification also covers 359551A, C & E Analog Measurement IMC, but the performance figures quoted cannot be guaranteed when the IMC is installed in a non-hermetically sealed enclosure in humid environments)

## 35951A
Number of channels ................................................................................. 20
Switching ................................................................ solid-state, three-pole
Maximum signal measured .................................................................. ±12V
Overload protection, continuous .......................................................... 50V
Maximum voltage between any input and any guard ......................................... 14V
Common mode, between IMPs ................................................................ 500V
M.T.B.F. to MIL217E .......................................... 137,000hrs (IMP) 146,000hrs (IMC)

### Measurement
Voltage dc ...................................................................................... 0 to ±12V
Current dc (assuming 100Ω shunt) ......................................................... 0 to 20mA
Thermocouple types ......................................................................... B,E,J,K,N,T,R,S
Thermocouple Cold Junction ................................................. External or Automatic
Thermocouple open circuit detection .................................................. programmable

## 35951C & 35951E
Number of channels ................................................................................. 20
Switching ................................................................... reed relay, three-pole
Reed-relay life .............................................................. >$10^8$ operations
Maximum signal measured .................................................................. ±12V
Maximum input voltage   .................................................................. ±14V
Overload protection, continuous .......................................................... 50V
Maximum voltage between any two inputs:
      35951C .................................................................... 200V
      35951E .................................................................... 500V
Common mode, between IMPs ................................................................ 500V
M.T.B.F. to MIL217E .......................................... 64,000hrs (IMP) 69,000hrs (IMC)

### Measurement
Voltage dc, without optional connector ...................................................... 0 to ±12V
Current dc (assuming 100Ω shunt) ......................................................... 0 to 20mA
Thermocouple types ......................................................................... B,E,J,K,N,T,R,S
Thermocouple Cold Junction ................................................. External or Automatic
Thermocouple open circuit detection .................................................. programmable

## 35953D Optional High Voltage Connector
Voltage dc .................................................................................... 0 to ±250V
Overload protection, continuous .......................................................... 250V
Effective common mode rejection, dc ........................................................ >100dB
      50 or 60Hz ±0.1% .................................................... >100dB
      Attenuation Factor ...................................................... 50:1

*(Continued on next page.)*

**Interference Rejection - 35951A, C & E**
(Specifications are for 1kΩ imbalance in Hi and Lo leads)

*20ms/16.67ms Integration time:*
Normal mode, 50 or 60Hz ±0.1%...................................................................... >60dB
Effective common mode rejection,
                   dc ............................................................................ >140dB
                   50 or 60Hz ±0.1%.................................................... >140dB
                   50 or 60Hz ±1%...................................................... >120dB

*5ms/4.17ms/1.25ms/1.04ms Integration times:*
Normal mode, 50 or 60Hz ±0.1%....................................................................... >0dB
Effective common mode rejection, 50 or 60Hz ±0.1% ..................................... >80dB

**DC Voltage**
Temperature coefficient of ADC ...................................... <(0.0015%rdg+0.2μV)per°C
35953D High Voltage Connector introduces 100μV+0.04%rdg additional error.

*20ms/16.67ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|---|---|---|---|
| 20mV | 22.000 | 1μV | ±(0.02%rdg+5μV) |
| 200mV | 220.00 | 10μV | ±(0.02%rdg+0.01%fs) |
| 2V | 2.2000 | 100μV | ±(0.01%rdg+0.01%fs) |
| 12V | 12.000 | 1mV | ±(0.05%rdg+0.01%fs) |

*5ms/4.17ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|---|---|---|---|
| 20mV | 22.000 | 2μV | ±(0.02%rdg+20μV) |
| 200mV | 220.00 | 20μV | ±(0.02%rdg+0.04%fs) |
| 2V | 2.2000 | 200μV | ±(0.01%rdg+0.04%fs) |
| 12V | 12.000 | 2.5mV | ±(0.05%rdg+0.04%fs) |

*1.25ms/1.04ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|---|---|---|---|
| 20mV | 22.000 | 8μV | ±(0.02%rdg+80μV) |
| 200mV | 220.00 | 80μV | ±(0.02%rdg+0.16%fs) |
| 2V | 2.2000 | 800μV | ±(0.01%rdg+0.16%fs) |
| 12V | 12.000 | 8mV | ±(0.05%rdg+0.16%fs) |

**DC Current**
Sensitivity, (assuming 100Ω shunt) ....................................................................... 10nA
Error as for DC Voltage +error of shunt resistor+leakage currents.

**Thermocouples**

The following temperature ranges are based on 20ms/16.67ms Integration times. All values are specified in degrees Celsius.

Error quoted is conformity to IEC584 (BS4937)

(IMC 359551A,C & E must be in draught-free enclosure: no forced cooling)

| Type | Mid Range | Error | Full Range | Error |
|------|-----------|-------|------------|-------|
| B (Pt-30% Rh/Pt-6%Rh) | 400 to1820 | <0.3 | 80 to 1820 | <2.0 |
| E (Ni-Cr/Cu-Ni) | -100 to 250 | <0.3 | -210 to 1000 | <0.5 |
| J (Fe/Cu-Ni) | -100 to 350 | <0.3 | -210 to 1200 | <0.7 |
| K ((Ni-Cr/Ni-Al) | -100 to 450 | <0.3 | -200 to 1370 | <1.0 |
| N (Nicrosil/Nisil) | -180 to 1280 | <0.3 | -250 to 1300 | <0.8 |
| T (Cu/Cu-Ni) | -100 to 400 | <0.3 | -200 to 400 | <0.5 |
| R (Pt-13%Rh/Pt) | 0 to 1600 | <1.0 | -50 to 1760 | <2.0 |
| S (Pt-10%Rh/Pt) | 0 to 1760 | <1.0 | -50 to 1760 | <1.5 |

Sensitivity, Types B,E,J,K,N,T ........................................................................... 0.1°C
Sensitivity, Types R,S ...................................................................................... 0.2°C
Total thermocouple error equals Conformity plus voltage errors.

Additional error when using automatic Cold Junction Compensation:

| Range | -15 to 60°C ................................. <0.4°C |
|-------|-------------------------------------------------|
|       | -20 to 70°C ................................. <0.6°C |

External Cold Junction range ................................................................ -30°C to 80°C
Open circuit detection threshold .......................................................... 1.9kW±0.1kW

## 2    35951B Analog Measurement IMP Specification

(Note: This specification also covers 359551B Analog Measurement IMC, but the performance figures quoted cannot be guaranteed when the IMC is installed in a non-hermetically sealed enclosure in humid environments)

Number of channels ................................................................................. 10
Switching ............................................................... solid-state, six-pole
Maximum signal measured ................................................................. ±2V
Overload protection, continuous ...................................................... 50V
Maximum voltage between any input and any guard ................................. 14V max
Common mode, between IMPs .................................................... 500V
M.T.B.F. to MIL217E ........................................ 106,000hrs (IMP) 113,000hrs (IMC)

**Measurement**
Voltage dc .......................................................................... 0 to ±2V
Resistance, 4 & 3 Terminal ...................................................... 0 to 2.5kΩ
Resistance Thermometer, 4 & 3 Terminal ................................... 100Ω PRT
Strain ........................................................ three-wire, quarter-, half- and full-bridge
Sensor energization ........................................................... 0.8 or 4mA
Dummy supplied .................................................... 120Ω±0.1%±5ppm/°C

Interference Rejection - 35951B
(Specifications are for 1kΩ imbalance in Hi and Lo leads)

*20ms/16.67ms Integration time:*
Normal mode, 50 or 60Hz ±0.1% ........................................................ >60dB
Effective common mode rejection,

         dc ................................................................ >120dB
         50 or 60Hz ±0.1% ..................................... >120dB
         50 or 60Hz ±1% ........................................ >100dB

*5ms/4.17ms/1.25ms/1.04ms Integration time:*
Normal mode, 50 or 60Hz ±0.1% ........................................................ >0dB
Effective common mode rejection, 50 or 60Hz ±0.1% ..................................... >80dB

**DC Voltage**
Temperature coefficient of ADC ...................................... <(0.0015%rdg+0.2µV)per°C

*20ms/16.67ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|---|---|---|---|
| 20mV | 22.000 | 1µV | ±(0.02%rdg+5µV) |
| 200mV | 220.00 | 10µV | ±(0.02%rdg+0.01%fs) |
| 2V | 2.2000 | 100µV | ±(0.01%rdg+0.01%fs) |

*5ms/4.17ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|---|---|---|---|
| 20mV | 22.000 | 2µV | ±(0.02%rdg+20µV) |
| 200mV | 220.00 | 20µV | ±(0.02%rdg+0.04%fs) |
| 2V | 2.2000 | 200µV | ±(0.01%rdg+0.04%fs) |

*1.25ms/1.04ms Integration time:*

| Range | Full Scale | Sensitivity | Limits of Error |
|-------|------------|-------------|-----------------|
| 20mV | 22.000 | 8μV | ±(0.02%rdg+80μV) |
| 200mV | 220.00 | 80μV | ±(0.02%rdg+0.16%fs) |
| 2V | 2.2000 | 800μV | ±(0.01%rdg+0.16%fs) |

**Resistance**

Temperature Coefficient ......................................... <(0.003%rdg+0.0007%RL)per°C
The single lead resistance, RL, applies only to three-wire configurations.
Any lead resistance imbalance should be added to the error in three-wire configurations.

*20ms/16.67ms Integration time*

| Range | Sensitivity | Limits of Error |
|-------|-------------|-----------------|
| 25Ω | 1.25mΩ | ±[0.03%(rdg+RL)+6mΩ] |
| 250Ω | 12.5mΩ | ±[0.03%(rdg+RL)+0.01%fs] |
| 2.5kΩ | 125mΩ | ±[0.02%rdg+0.03%RL+0.01%fs] |

*5ms/4.17ms Integration time*

| Range | Sensitivity | Limits of Error |
|-------|-------------|-----------------|
| 25Ω | 2.5mΩ | ±[0.03%(rdg+RL)+24mΩ] |
| 250Ω | 25mΩ | ±[0.03%(rdg+RL)+0.04%fs] |
| 2.5kΩ | 250mΩ | ±[0.02%rdg+0.03%RL+0.04%fs] |

*1.25ms/1.04ms Integration time*

| Range | Sensitivity | Limits of Error |
|-------|-------------|-----------------|
| 25Ω | 10mΩ | ±[0.03%(rdg+RL)+96mΩ] |
| 250Ω | 100mΩ | ±[0.03%(rdg+RL)+0.16%fs] |
| 2.5kΩ | 1.0Ω | ±[0.02%rdg+0.03%RL+0.16%fs] |

**Resistance Thermometer Device**

Conformity for 100Ω PRT (RTD) is to IEC 751
Temperature coefficient ................................................ <(0.03+0.002%RL)°C per °C
The error introduced by the single lead resistance, RL, is an additional error which
applies only to three-wire configurations.
Any lead resistance imbalance should be added to the error in three-wire configurations.

*20ms/16.67ms Integration time*

| Range | Sensitivity | Limits of Error |
|-------|-------------|-----------------|
| -200 to 490°C | 0.1°C | ±[0.4+0.1%RL)°C |
| 490 to 600°C | 0.1°C | ±[1.2+0.1%RL)°C |

*5ms/4.17ms Integration time*

| Range | Sensitivity | Limits of Error |
|-------|-------------|-----------------|
| -200 to 490°C | 0.1°C | ±(0.6+0.4%RL)°C |
| 490 to 600°C | 1.0°C | ±(3.7+0.4%RL)°C |

*1.25ms/1.04ms Integration time*

| Range | Sensitivity | Limits of Error |
|---|---|---|
| -200 to 490°C | 0.4°C | ±(1.7+1.6%RL)°C |
| 490 to 600°C | 4.0°C | ±(14.1+1.6%RL)°C |

**Strain**

Repeatability at constant temperatures over 24 hours is ±2µε for all configurations.
Figures are for 120Ω gages with gage factor 2.
Measurement range for figures quoted is 0 to 10,000µε.

*20ms/16.67ms Integration time:*

| Type | Limits of Error | Temperature Coefficient |
|---|---|---|
| Full-bridge (8mA, 2 active gages) | ±(0.06%rdg+6µε) | <(0.33µε+0.004%rdg)per°C |
| Half-bridge (4mA, 1 active gage) | ±(0.06%rdg+8µε) | <(3.45µε+0.004%rdg)per°C |
| Quarter-bridge (4mA, 1 active gage) | ±(0.06%rdg+14µε) | <(8.45µε+0.004%rdg)per°C |

5ms/4.17ms Integration time

| Type | Limits of Error | Temperature Coefficient |
|---|---|---|
| Full-bridge (8mA, 2 active gages) | ±(0.06%rdg+24µε) | <(0.33µε+0.004%rdg)per°C |
| Half-bridge (4mA, 1 active gage) | ±(0.06%rdg+32µε) | <(3.45µε+0.004%rdg)per°C |
| Quarter-bridge (4mA, 1 active gage) | ±(0.06%rdg+56µε) | <(8.45µε+0.004%rdg)per°C |

1.25ms/1.04ms Integration time

| Type | Limits of Error | Temperature Coefficient |
|---|---|---|
| Full-bridge (8mA, 2 active gages) | ±(0.06%rdg+96µε) | <(0.33µε+0.004%rdg)per°C |
| Half-bridge (4mA, 1 active gage) | ±(0.06%rdg+128µε) | <(3.45µε+0.004%rdg)per°C |
| Quarter-bridge (4mA, 1 active gage) | ±(0.06%rdg+224µε) | <(8.45µε+0.004%rdg)per°C |

# 3    35952A Digital Input/Output IMP Specification

(Note: This specification also covers 359552A Digital Input/Output IMC)

Number of channels (may be an input or output) ..................................................... 20
Isolation, channel to channel or ground ............................................................ 500V
Common mode, between IMPs ....................................................................... 500V
M.T.B.F. to MIL217E ......................................... 145,000hrs (IMP) 155,000hrs (IMC)

**Inputs**
Voltage between thresholds (0 and 1) ............................0.8 and 2.0V, or 3.0 and 9V
Maximum input ...................................................................................... 25V or 100V
Min. input drive current ................................................................................ 600µA
Input sample rates, programmable ............................... 20Hz; 1kHz; 10kHz; 100kHz
4 sample debounce is used for 20Hz and 1kHz rates
Input functions
       Status
       Events,(time of +ve or -ve edge), accuracy ........................................ ±1ms
       Frequency .............................................................................. 49kHz max.
       Frequency gate times, programmable .............................. 0.01; 0.1; 1 or 10s
       Period, resolution ............................................................................ 10µs
       Periods, averaged................................... 1; 10; 100; 1000; +ve or -ve pulse
       Single shot, minimum width .............................................................. 10µs
       Count (totalize or increment) ........................................ 24 bits (>16 million)

**Outputs**
FET switch, which closes for a logic 1
Maximum withstand ........................................................................................ 60V
Maximum sink, per channel ........................................................................... 100mA
Energization supply, built in ....................................................................... 5V, 20mA

**Digital Input Counting and Event Capture (per channel)**
Maximum count rate per IMP is 15,000/s and is governed by software constraints. Thus for a worst-case input (all channels driven by the same signal) maximum count per channel is restricted to 750/s.
Maximum number of buffered events is 1500 per IMP.

| Sample Rates | 20Hz | 1kHz* | 10kHz | 100kHz |
|---|---|---|---|---|
| Count Parameters: | | | | |
| Maximum frequency | 2.4Hz | 124Hz | 4.9kHz | 49kHz |
| Minimum period | 400ms | 8ms | 200µs | 20µs |
| Resolution of period | 50ms | 1ms | 100µs | 10µs |
| Counts max. rate | 2.4/s | 124/s | 4900/s | 15,000/s |
| Event capture rate | 5/s | 100/s | 100/s | 100/s |
| Event resolution | 200ms | 4ms | 1ms | 1ms |

Figures assume an equal Mark/Space ratio
* indicates default setting

*(Continued on next page.)*

**Frequency**

Figures are for the default sample rate of 100kHz

| Gate Time | 10ms | 100ms | 1s | 10s |
|---|---|---|---|---|
| Minimum frequency | 100Hz | 10Hz | 1Hz | 0.1Hz |
| Resolution | 100Hz | 10Hz | 1Hz | 0.1Hz |
| Limits of Error | ±(0.004%rdg+resolution) | | | |

Frequency signals with a value less than 0.1Hz should be measured using the Event Capture mode.

All Limits of Error assume an equal Mark/Space ratio

**Period**

Figures are for the default sample rate of 100kHz.

| Periods averaged | 1 | 10 | 100 | 1000 |
|---|---|---|---|---|
| Resolution | 10μs | 1μs | 0.1μs | 0.01μs |
| Limits of Error | ±(0.004%rdg+resolution) | | | |

Period measurements have a programmable timeout applied. The timeout must be at least double the expected period. Timeouts of 200ms, 2s, 20s and 50s are available. The maximum period is therefore 25s. Period measurements greater than 25s should use the Event Capture mode. All limits of Error assume an equal Mark/Space ratio.

## 4        35952B Switch Input/Output IMP Specification

(Note: This specification also covers 359552B Switch Input/Output IMC)

Number of channels (may be 1-32 input or 1-4 output) ................................. 32 Total
Isolation, channel to channel or ground .............................................................. 120V
Common mode, between IMPs ........................................................................... 500V
M.T.B.F. to MIL217E ......................................... 124,000hrs (IMP) 130,000hrs (IMC)

**Inputs**
Voltage between thresholds (0 and 1) ...................................................... 3.0 and 9V
Resistance between thresholds  ........................................................ 80kΩ and 500kΩ
Maximum input ...................................................................................................... 120V
Min. input drive current ................................................................................... 600µA
Input sample rates ............................................................................................... 50Hz
4 sample debounce is used
Input functions
        Status
        Events, (time of +ve or -ve edge), accuracy ...................................... ±20ms
Maximum number of buffered events is 128 per IMP

**Outputs**
FET switch, which closes for a logic 1
Maximum withstand        60V
Maximum sink, per channel        100mA

**Watchdog**
Hardware Timeout        1.2s
Software Timeout: Programmable        1 to 255s

## 5    35951D Analog Output IMP Specification

(Note: This specification also covers 359551D Analog Output IMC, but the performance figures quoted cannot be guaranteed when the IMC is installed in a non-hermetically sealed enclosure in humid environments)

Number of channels ................................................................... 4
Output functions ......................................... Bipolar d.c. voltage, unipolar d.c. current
Isolation between channels ......................................................... 500V d.c.
Output noise ...................................................................................... <0.1%fs
Setting time to 1 bit ....................................... 75ms from transmission from host and
40ms between channel values
M.T.B.F. to MIL217E ........................................... 94,000hrs (IMP) 103,000hrs (IMC)

**Voltage Outputs**
Range ................................................................... -10.000V to +10.000V
Resolution ............................................................................. 5.12mV
Minimum load resistance ........................................................ 10kohm
Limits of error ........................................................ ±[0.1% rdg+10mV]
Temperature coefficient ........................................ ±[0.01% rdg+1mV]/ °C .....

**Current Outputs**
Range ................................................................... 0mA to 20.000mA
Resolution ............................................................................. 10.25µA
Output voltage compliance ..................................... 16V±1V at minimum current and
10V at maximum current
Current output limit ...................................................................... 25mA
Limits of error ........................................................ ±[0.1% rdg+20µA]
Temperature coefficient ........................................ ±[0.01% rdg+2µA]/ °C

## 6 General - IMP and IMC Specifications

Power supply ............................................................................ 10V to 50V d.c.
Power feed ........................................................... via S-Net cable or IMP terminals
Power consumption of each IMP ............................................................. <1.2W*
Results returned from all IMPs on S-Net.............................................................. <1s
IMP to S-Net ............................................................................................ ±500V
IMP to IMP .......................................................................................... 500V min.
Analog to digital converter .................................................................. 15 bits+sign

Analog scanner leakage currents at 25°C±3°C:
35951A/1B ................................................................................................ <60nA
35951C .................................................................................................... <15nA

Analog IMP channel crosstalk ................................................................... >120dB
Analog IMC channel crosstalk @ RH<50% .................................................. >120dB
Analog IMC channel crosstalk @ RH<75% .................................................. >100dB

ADC input impedance (all analog IMPs): ....................................................... >10GΩ

*The 35951D can consume more in certain circumstances.
See Chapter 7.

**IMP Environment**
Storage temperature ........................................................................ -25°C to 75°C
Operating temperature:....................................................................... -20°C to 70°C
Humidity, at 40°C (non-condensing): ................................................................ 95%
Vibration: operating for 2 hours:.................................................... 5g, 11Hz to 500Hz
Otherwise, to Def. Std 66/31 Issue 01 Cat. IV.

**IMP Packaging**
Sealed aluminium casting to BS5490, IP55 (IEC 529) and NEMA ICS6 Class 4.
Dimensions .......................................... 435mm×215mm×34.5mm (17.1"×8.5"×1.4")
Protrusion of cable boots ......................................................................... 50mm (2")
Weight ............................................................................................ 2.5kg (5.5lbs)

**IMC Environment**
Storage temperature ........................................................................ -25°C to 75°C
Operating temperature ....................................................................... -10°C to 60°C
Humidity, at 40°C (non-condensing) ................................................................ 85%
Vibration: operating for 2 hours .................................................... 1g, 11Hz to 500Hz
Otherwise, to Def. Std 66/31 Issue 01 Cat. II.

**IMC Packaging**
Dimensions ........................................ 420mm×218mm×30mm (16.54"×8.58"×1.18")
Protrusion of handles ....................................................................... 30mm (1.18")
Weight ......................................................................................... 1.23kg (2.69lbs)

**Safety**
complies with ....................................................... IEC 1010-1 (EN61010-1)

**Electromagnetic Compatibility (IMPs only)**
complies with .............................................. EN50081-2 and EN50082-2

*Note: High levels of radiated or conducted radio frequency interference, as defined in EN50082-2, may reduce the accuracy of low level measurements.*

# 7        35951F/G Vibration IMP Specification

**INPUTS**
Number of channels:

        35951F ............................................... 32 vibration+8trigger
        35951G ............................................ 16 vibration+4trigger

Voltage protection: ....................................................... 150V peak-to-peak
Maximum input (ac+dc): ...................................................................... 20V

**Vibration Inputs**
Input impedance: ......................................................................... 1MΩ
Ranges: ...................................................... ±20mV to ±10V, 9 ranges
ICP interface: ............................................. 4mA @ 24Vdc, configurable per channel
Coupling: ........................................................... AC/DC, configurable per channel
AC coupling: ...................................................... 1st order, 0.4Hz cut-off
AC highpass filters: ..................................... 10Hz or 70Hz, 2nd order; 2Hz, 4th order
ADC Resolution: ...................................................................... 16 bit
Channel crosstalk: ...................................................... -50dB (dc - 1kHz)

Channel accuracy*:
(dc coupled)
        Amplitude: ............................±3% up to half baseband freq.
        RMS Overall: ............................................. ±3.5%±0.4%FSR
Harmonic distortion*: ................................. -50dB (typical) up to half baseband freq.
Acquisition modes: ........................Free run, externally synchronized, event triggered
Envelope filters: ........................................................................ 8th order
        Ranges: ............................ 1.25-2.5, 2.5-5, 5-10, 10-20kHz

*Does not apply to 20mV range or 20kHz bandwidth.

**Trigger Inputs**
Source: ..................................................... Program assignable to any vibration input
Coupling: ........................................................... AC/DC, configurable per channel
Slope: ......................................................................................... +ve or -ve
Types: ........................................................ Analog level in the range ±10V, or TTL
Analog resolution: ...................................................................... 79mV
AC bandwidth: ................................................................................ 2Hz to 1kHz
Blocking voltage: ...................................................................... ±90Vdc
Time to lock: ...................................................................... 2 revolutions
Order analysis: .......................................................... PLL clock generation

**Event trigger**
Number of channels: .......................................................... 1 optical isolator
Slope: ........................................................................................ +ve edge
Energization: ................................................................................ 5mA - 15mA
Energization voltage: ............................... 2.9Vdc - 5.5Vdc, with 270Ω fitted resistor;
        other ranges selectable by resistor change

**PROCESSING**
**Time domain**
Block lengths: ..................................................... 256, 512, 1024, 2048, 4096, or 8192
Overall units: ................................................... Acceleration, velocity or displacement
Alarm types: ............................................................. RMS, peak, or peak-to-peak
Averaging: ...................................................................... 1-255 programmable

**Spectra**

Number of lines: ......................................................... 100, 200, 400, 800, 1600, 3200
Baseband frequency: .................................................. 25Hz, 100Hz, 200Hz, 500Hz,
1kHz, 2kHz, 5kHz, 10kHz or 20kHz
Windows: .............................................. Rectangular, hanning, flat-top or hamming
Spectral alarms: .................................................. 10 programmable frequency bands
Alarm types: .................................................. Above, below, in window, out of window
Averaging: .................................................................................. 1-4096 programmable
Average type: ............................................................................................................ RMS
Processing time: ........................................... 0.5s per 400 line spectrum per channel
Orders: .................................................................................................. 1-8 programmable
Watchdog clock: .................................................. Time and date stamp, resolution 1s

**OUTPUTS**

Alarm relays:
        35951F: ...................................................................................... 1 relay
        35951G ....................................................................................... 2 relays
Relay connections: ............................................. normally open and normally closed
Output rating: .......................................................................... 50Vdc at 60mA
Vibration input test: ............................................. single point from any analog input
Trigger input test: ................................................. single point from any trigger input
Status: .................................................................. Four LEDs indicate VIMP status

**STORAGE**

Memory buffer size: ........................................................................... 256Kbytes
Capacity: ..................................................... 100 tasks, 120 overalls+400 line spectra
Power fail holdup time: ............................................. 1 hour typical, without data loss

**MECHANICAL**

Dimensions:
        35951F:............................................ 430×215×69mm   (17.1×8.5×2.8")
        35951G: .......................................... 430×215×103.5mm  (17.1×8.5×4.2")
        359595D PSU: ................................. 300×300×200mm   (11.8×11.8×7.8")
        359595D Ser. IMP ............................ 430×215×35.4mm  (17.1×8.5×1.4")
Protection: .......................................................................................... NEMA 4, IP55

**ENVIRONMENTAL**

Temperature: ................................................................................... 0 to 55°C
Humidity: ......................................................................... 95% RH, non-condensing
Vibration: ...................................................................................... 1G, 11-500Hz

**POWER**

VIMP Power consumption: ................................................................... 15Watts max.
DC Inputs:

| | 35951F | 35951G |
|---|---|---|
| +12V | 500mA | 1A |
| −12V | 300mA | 600mA |
| +5V | 400mA | 400mA |
| −5V | 100mA | 100mA |

359595D PSU: ....................................................................... Powers 1 or 2 VIMPs

**COMMUNICATIONS**

Standard S-Net:

Data rate: ........................................................ 163kbits/s

Isolation: ................................................................. 500V

Connection: .............................................. Serial multi-drop

Max. distance: ..................... 1.5km (4950') before repeater

Test port: ...................................................................... RS232C, 9600Baud

# 8 Power Supply Specifications

The IMP power supply units available, their applications, and outputs are as follows:

| PSU Type | Application | DC Output(s) |
|---|---|---|
| 359595A | Installed at Host end of S-Net | 48V (3A) |
| 359595B | Installed at remote end of S-Net | 48V (1.1A) |
| 359595D | Local supply for VIMPs | +12V (1.5A), −12V (1A) |
| | | +5V (1.5A), −5V (150mA) |

Ac voltage selection (by link) .......................... 115V (92V-132V) / 230V (176V-264V)

Supply frequency ...................................................................... 45Hz-440Hz

Maximum input VA

359595A ..................................................................... 250VA

359595B, D .................................................................. 140VA

Connector type ...................................................................... Molex

Case conformance

359595A .......................................................................... Bare frame

359595B, D ................................................................. IP55/NEMA 4

| Size | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|
| 359595A | 210 | 115 | 60 |
| 359595B, D | 300 | 300 | 200 |

Weight

359595A .......................................................................... 1.2kg

359595B, D ..................................................................... 10kg

Storage temperature ...................................................... -40°C to +70°C

Operating temperature (outside unit) ..................................................... 0°C to +55°C

(output power derates at 2.5% per °C from 35°C)

Humidity for storage and operation ...................... 95% RH at 40°C (non-condensing)