The CED 1902
Owners handbook

Version 2.1

September 1997

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Potential for Radio/Television Interference *(USA only)*

The 1902 generates and uses radio frequency energy and may cause interference to radio and television reception. Your 1902 complies with the Specification in Subpart J of Part 15 of the Federal Communications Commission rules for a Class B computing device. These specifications provide reasonable protection against such interference in a residential installation. However there is no guarantee that interference will not occur in a particular installation. If the 1902 does cause interference to radio or television reception, which can be determined by turning the 1902 off and on, you can try to eliminate the interference problem by doing one or more of the following:

- Re-orient the receiving antenna
- Re-orient the position of the 1902 with respect to the receiver
- Move the 1902 away from the receiver
- Plug the 1902 into a different outlet so that the 1902 and the receiver are on different branch circuits

If necessary, consult CED or an experienced radio/television technician for additional suggestions. You may find the booklet *How to Identify and resolve Radio/TV Interference Problems*, prepared by the Federal Communications Commission, helpful. This booklet is available from the US Government Printing Office, Washington DC 20402, Stock no. 004-000-00345-4.

To comply with FCC rules, Part 15 J Class B Computing device, use only shielded interface cables.

Use of symbols

This symbol is used on the CED-approved power supply, to denote that the electrical isolation is to IEC Type B standard.

This symbol is used on the 1902 case to show that the electrical isolation is to IEC Type BF standard.

∼ This symbol is used on the power supply to indicate the mains input is for AC power only.

⎓ This symbol is used on the power supply to show that the outputs are DC only.

Attention, consult accompanying documents.

Mode of operation

The 1902 is suitable for continuous use.

Protection

The 1902 offers Class I protection against electric shock. To maintain the safety standard, accessory equipment attached to the 1902 must also comply with relevant safety requirements. Such as IEC601-1 or the relevant IEC standard e.g. IEC950 configured to comply with IEC601-1-1.

The 1902 is not protected against ingress of water.

The 1902 is not protected against flammable anaesthetic mixtures. It must NOT be used in the presence of such mixtures.

Life support

CED products are not authorised for use as critical components in life support systems without the express written approval of the chairman of the board of directors of CED. *Life support systems* in this context are systems which support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided, can be reasonably expected to result in a significant injury to the user. A *critical component* in this context is any component of a life support system whose failure to perform can reasonably be expected to cause the failure of the life support system, or to affect its safety or effectiveness.

Overview

In modern computer-based instrumentation, it is highly desirable that all the functions of the instrumentation should be machine-readable and controllable by the computer. The 1902 meets this requirement, with the control being applied through one of the most universal means, the RS232 serial line.

This manual describes the specification, maintenance, and operation of the current version of the CED 1902 (formerly known as the 1902 Mark III).

Figure 1: The CED 1902

The 1902 has been type-tested and found to meet the requirements of the German VDE 0871 B and the USA FCC Part 15 J Class B radio frequency interference specifications when used with suitable power supplies and cables.

The 1902 meets the safety requirements of BS 5724 (IEC 601-1) when used with a CED-approved power supply, BSI certificate no 221/000018, issued 17 September 1997.

The 1902 also has industrial users, for whom the isolation may not be relevant. It is possible to power the unit from other power supplies (see page 29) but it is important to note that the 1902 does not meet BS 5724 if used with other than the CED-approved power supplies.

Functional organisation

To the user, the 1902 comprises two completely separate functional blocks: the waveform signal conditioner and the pulse conditioner.

The waveform conditioner provides one channel of output, with the input selected by program from a range of input connections, and a comprehensive set of conditioning controls: gain selection, filtering and offsetting, and over-range detection. The 1902 may readily be adapted to different specialised signal sources beyond the programmable range, by exchange of internal modules. The characteristics of these modules are readable by the computer.

The pulse conditioner is much simpler, providing one output channel of pulses, derived from a choice of two inputs selected by program.

Features of the 1902, all selected by program control, are:

- Differential or single-ended transducer waveform inputs (Non-isolated, non-patient)
  - Optional isolated electrode input
  - Optional ECG 5-lead input selection
- Gains from 1x to 100,000x in steps of 3x
- AC/DC coupling switch
- 12-bit DC offset
- Low-pass filters, 100 Hz, 500 Hz, 1 KHz or straight through
- High-pass filters, 50 Hz, 100 Hz, 200 Hz or straight through
- Selectable mains-frequency notch filter, 50 or 60 Hz
- Overload indicators, readable by computer
- Trigger input converter from high-level pulses or switch closures to TTL with program-selectable choice of 2 inputs (non-isolated)

Accessories

The 1902 is supplied with a test and calibration program, `TEST1902` for the IBM PC/AT. The CED programs `SIGAVG`, `CHART` and `Spike2` provide full operational 1902 control.

A full set of user connectors is provided, as are the serial line control cable and the power take-off cable from 1401, if the separate power supply is not specified.

See page 30 for further connector details.

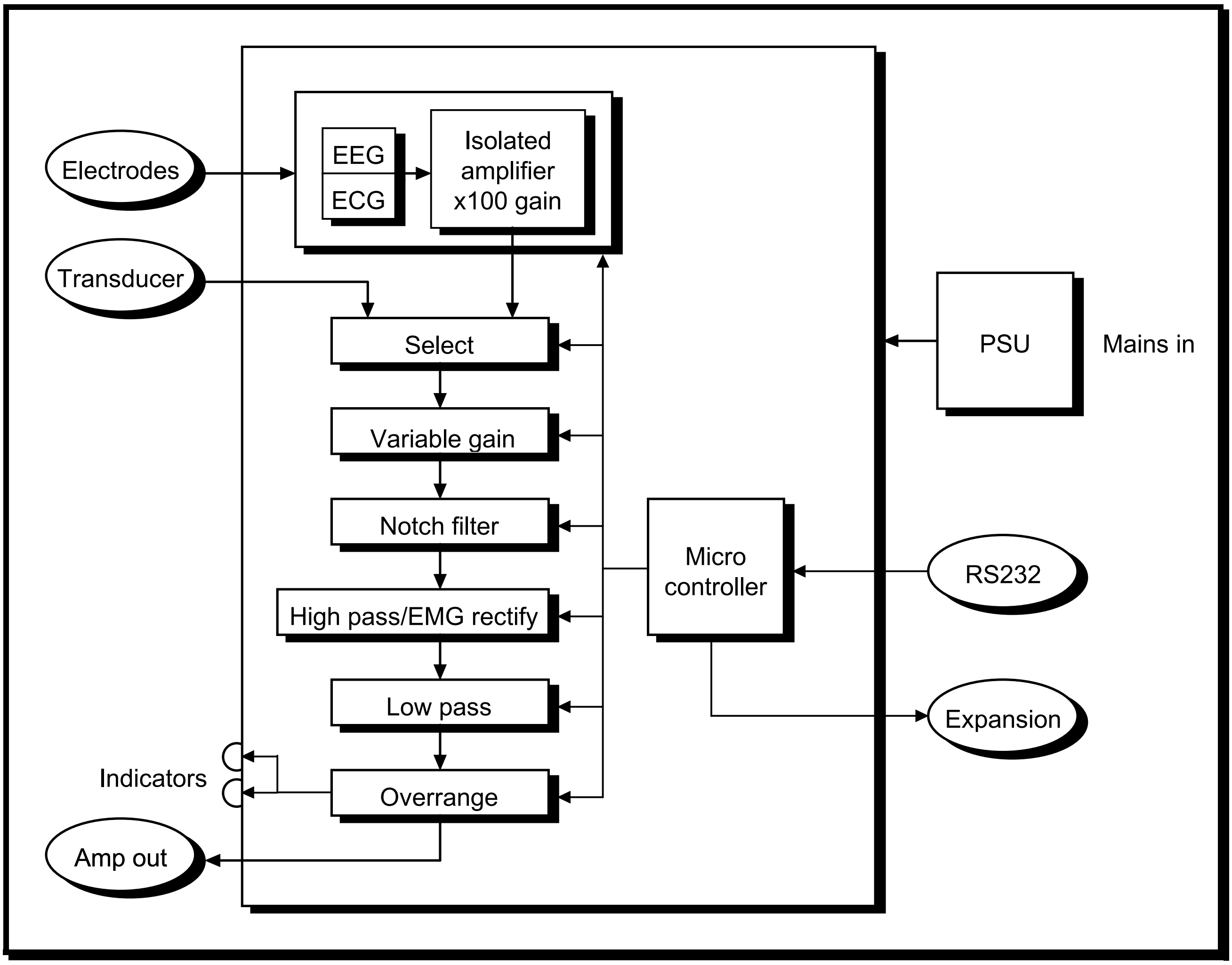

Figure 2: Waveform signal flow in 1902

Connections

The 1902 needs power and RS232 cables connected to function. Both are applied to connectors on the back panel.

Power

The power cable connector from the power supply has a socket with a row of pin positions, one of which is blanked to provide a polarising key. Offer this socket to the connector marked **Power In**, checking that you have the connector correctly oriented. Push firmly home.

If the CED power supply is being used, this must be connected to normal AC mains by the standard IEC cable provided. These power supplies are available for two ranges of mains voltages. Check on the label that you have the correct type for your local power. There are no switches on the 1902 or the power supply.

RS232

⚠

The RS232 cable for the 1902 has a 9-way D-type connector socket at one end and will have a suitable connector for your computer at the other end; see page 28. Offer the 9-way D-type to the D-type plug on the back of the 1902 and the other end to your computer's RS232 port. You will have to check which port is appropriate for the software you intend to use. Make sure that the jack screws on both connectors are screwed home, to reduce the possibility of radio/television interference.

Data cables ⚠ The waveform and trigger circuit data cables are described in the Specification chapter below. The outputs from these signals are via BNC connectors, which can be connected to measuring equipment by standard BNC cables.

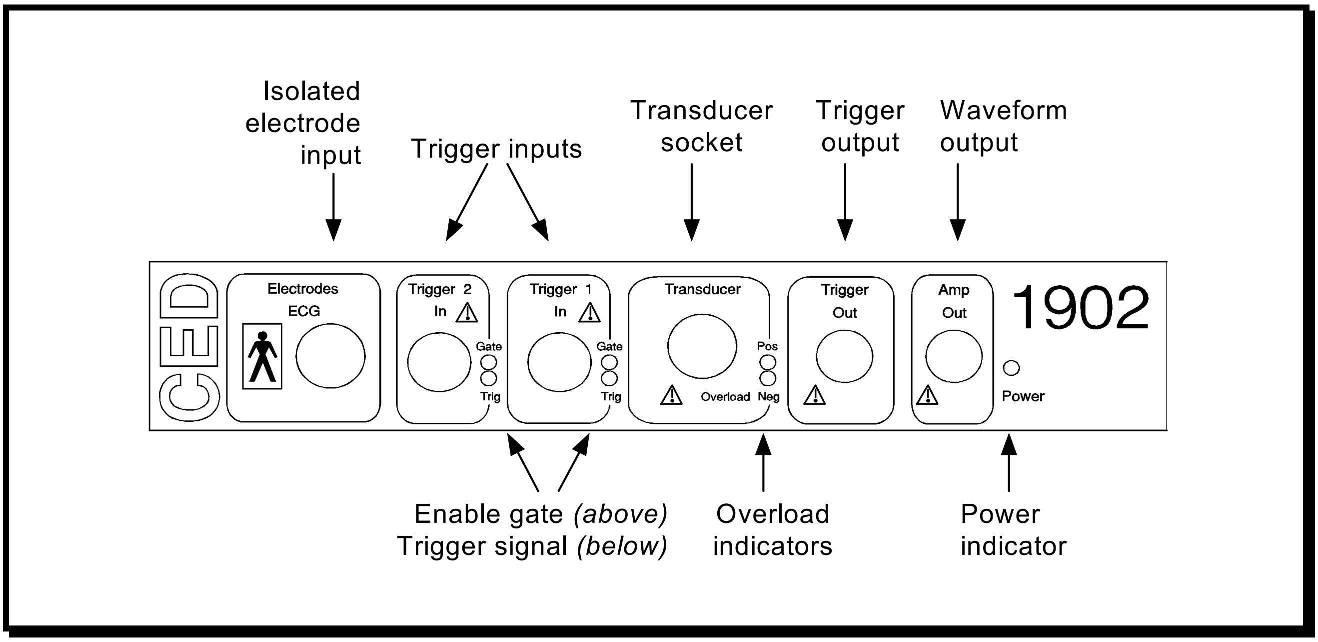

Figure 3: 1902 front panel connections

Software

The 1902 has an internal read-only memory that holds the characteristics of the options fitted, and suitable names (in English) for the options. This simplifies the task of any controlling software. Full support for the options of 1902 is built into the CED programs `SIGAVG` and `CHART`, with others to follow.

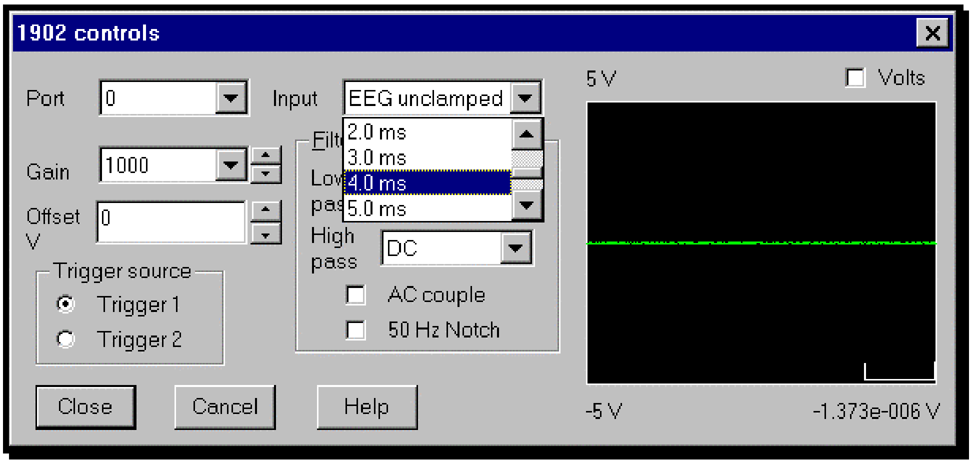

Figure 4: Windows95 clamp selection

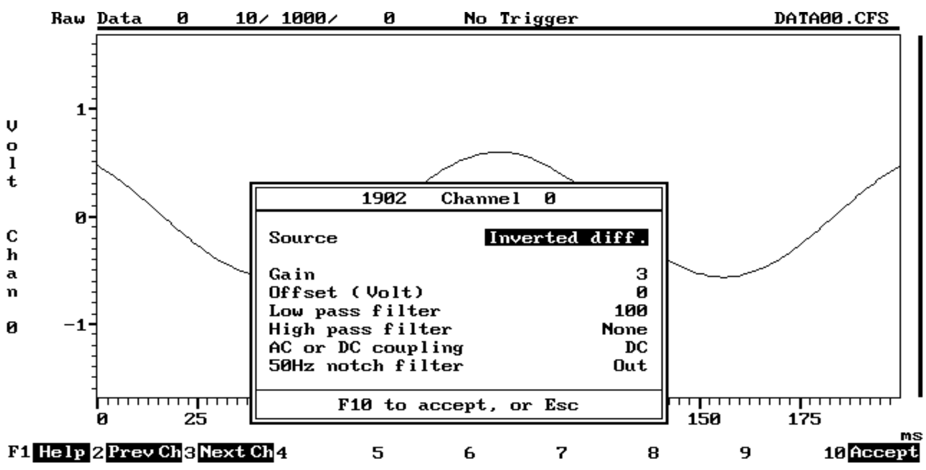

Figure 5: The 1902 popup in SIGAVG sampling

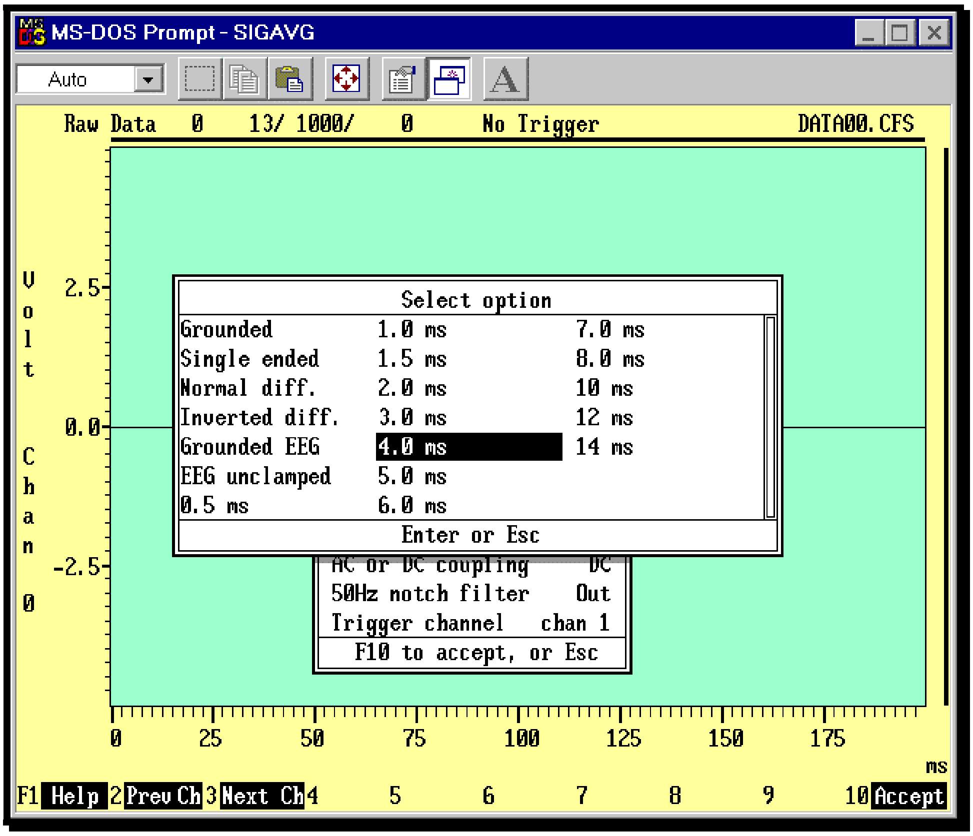

Figure 6: MS DOS clamp selection

Explanation of software commands

A full list of the software commands can be found on pages 35 to 44 of this manual.

Cleaning and maintenance

The 1902 needs regular cleaning and regular re-calibration to remain in good condition. Before cleaning, remove power and all cables from the 1902 unit.

The exteriors of the 1902 case and the power supply should be cleaned annually to remove deposits of foreign matter, with a soft cloth moistened with water. Avoid spilling drops of water or any other liquid on the 1902.

Check the sockets for pieces of paper or fluff. If any are seen, remove them with a pin.

Check the cables visually for fraying or other mechanical damage.

Re-calibration

Re-calibration should be done every 6 months to retain the specified offset accuracy, but if small discrepancies can be tolerated the interval may be extended to 3 years. The program `TEST1902`, provided with the unit for IBM compatibles, tests the serial line communications with 1902 and also guides the user through the offsetting procedure.

Recalibration procedure

Re-calibration should be done by a competent technician. You will need:

- a digital voltmeter capable of resolving to 1 microvolt, with a cable to mate with the internal test connector, a Radiall Subclic socket, see page 31
- an oscilloscope with bandwidth of 10 MHz and sensitivity of 5 mV per division, to attach to the same test connector
- a small cross-point screwdriver for undoing the outer case
- a small, flat-bladed, insulated trimming tool for adjusting potentiometers
- a sinewave generator capable of generating 50 or 60 Hz at some ±3 volts, for adjusting the mains notch filter

Opening the 1902

The 1902 comprises a circuit board mounted in an inner case, enclosed by an outer case. You will need to remove the inner case and take off its lid to do the re-calibration.

1. First, remove power and all cables from the 1902.
2. At each side of the back panel of the outer case is a small black screw. Undo these with the cross-pointed screwdriver.
3. Push the BNC connectors on the front of the case so that the inner case slides out by a couple of centimetres, dislodging the back panel. You can now see that the inner case is also restrained by an earthing strap of yellow/green wire, attached by a small screw.
4. Undo the screw and lock-washer from the inner case and slide the metallic inner case out of the black outer case.
5. You must now remove the lid. There are 4 small screws near the corners of the inner case that hold the lid down onto the base, clamping the circuit board. Undo these four screws and their lock-washers, to allow you to lift off the lid.
6. Replace the RS232 and the power cables and apply power. You are now ready to run the calibration software.
7. On an IBM PC/AT or PS/2 compatible computer, run the program `TEST1902` (provided with the unit, or freely available from CED in Cambridge). Full instructions appear on the screen.

Storage and operating environment

The storage and operating environment for 1902 must not go outside the temperature range of 0° to +50° Celsius, in conditions of non-condensing humidity which should not exceed 95% saturation, in an atmospheric pressure range of 500 hPa to 1060 hPa.

Service

Servicing other than re-calibration should not be attempted by end users. The 1902 can only be serviced by CED, at:

Cambridge Electronic Design Limited,
Science Park,
Milton Road,
Cambridge CB4 4FE,
UK

Telephone (+44) 1223 420186
Fax (+44) 1223 420488

A full set of circuit diagrams can be supplied to authorised personnel on request. There will be a charge for this service.

Main amplifier

The main amplifier comprises an AC/DC switch, a programmable-gain, non-inverting amplifier, two overload indicators, a programmable selection of low-pass and high-pass filters, a selectable mains notch filter and programmable selection of input sources.

Maximum bandwidth	DC to 50 KHz (in DC mode) 0.15 Hz to 50 KHz (in AC mode)
Gain accuracy	±2%
Standard filter configuration	Butterworth
Filter type (low and high pass)	2nd order (12 dB/octave)
Low pass filter cut-off frequency	100 Hz, 500 Hz, 1 KHz or max. according to gain
High pass filter cut-off frequency	1 Hz, 10 Hz, 100 Hz or DC
Mains (50 or 60 Hz) notch cut	50 dB (typical)
Overload indicator	2 yellow LEDs (1 for each polarity) indicate when output exceeds ±6 V approximately
Input impedance	1 GOhm
Input bias current	±50 nA max.
Range of gains available	1x to 100 000x in steps of 3x
Bandwidth for gains over 3000x	25 KHz

Bridge transducers

The 1902 expects typically to connect to the Washington type D range of isometric force displacement transducers (or others by arrangement). These are half-bridge types needing a nominal 5V excitation and usually used with binding adapters to complete the bridge. The 1902 can provide the DC excitation. This is the input to use with strain gauges.

Single-ended transducers

The typical transducer for this input is the Washington type T1 isotonic lever transducer. This type has a voltage output proportional to the angle of a freely-rotating shaft. The 1902 provides the ±12V DC power required by the transducer.

Wire colours

The "Wire colour" columns in the tables below are for your convenience if you have to make up cables. The diagrams of the user connectors show the arrangement of the solder cups, i.e. the view is from the **rear** of the **plug**.

Pin	1902 function	Single-ended	Differential	Wire colour
1	Ground	Ground	Ground	
2	+12V power	+12V power		
3	–12V power	–12V power		
4	+5V power		Excitation	
5	Bridge input +ve	Output	Bridge output +ve	
6	DAC output			
7	Bridge input –ve	Link to pin 1	Bridge output –ve	
8	No connection			
Shell	Mains earth	Screen	Screen	

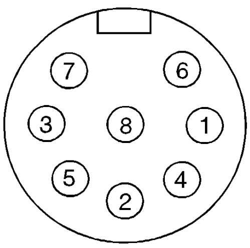

Figure 7: 8-pin DIN

Non-isolated input socket

The patient must NOT be connected to this input socket.

The power output is intended only for driving transducers. They should have impedances greater than 500 Ohms (5 Volt) or 1200 Ohms (12 Volts).

Isolated input

An internal option provides the 1902 with a medical-specification isolation pre-amplifier and associated isolated power supply. This amplifier can be DC blocked, with a corner frequency of 0.15 Hz. Any resistive electrode balancing network is expected to be external to this unit.

Front end type	**Low noise EEG**	**Standard EEG**	**ECG**
Input impedance	10 GOhm	1 MOhm	
Input bias current at 25ºC	±150 pA	±50 pA	
Noise referred to input, 1 Hz – 10 KHz	0.3 µV rms.	5 µV rms.	
Common-mode rejection at 50 Hz	100 dB	80 dB	
Common-mode voltage range	±1 V	±5 V	
Input offset voltage, initial adjusted	less than 10 µV after 1-hour warm up		
Input offset voltage vs. temperature	50 µV/ °C		
Input offset voltage vs. time	100 µV / 1000 hours		
Gain ranges	x1,000 – x1,000,000	x100 – x100,000	
Gain step sequence	1, 3, 10		
Gain accuracy	±2%		
Bandwidth, all gains	10 KHz		
Isolation voltage, continuous	1500 V d.c.		
Isolation voltage, peak for 5 sec	2500 V peak		
Input-output leakage at 240V, 50 Hz	1 µA maximum		
Input clamp option	0.5 – 14 ms		

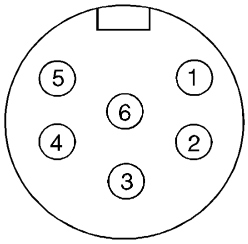

Figure 8: 6-pin DIN

Pin	EEG function	ECG function	Wire colour
1	+ve input	Left leg	
2	–ve input	Left arm	
3	Buffer input*	Right arm	
4	Buffer output*	Vagus	
5		Right leg driven	
6	Common	Common	
Shell	Mains earth	Mains earth	

* Available with 1902-4BFR buffer option. See page 24.

The ECG lead configurations are leads:
I, II, III, aVR, aVL, aVF and V.

1902 input clamp option

The input clamp option (1902-4IC) is designed for use with triggered subject stimulation where the stimulus would otherwise overload the 1902 amplifier input stages. Such overloads may not be electrically damaging, but the amplifier may take several seconds to regain normal operation after an overload, thus making it difficult to measure fast subject responses to the stimulus.

The types of stimulus where clamping can be useful include fast magnetic field changes and electrical (somatosensory) pulses.

It should be noted that the 1902 low-noise EEG input has been shown in its unclamped form to be as good as or better than other commercially available isolated amplifiers when dealing with this type of stimulus. In experimental situations where, for example, EMG recordings are taken from the hand during magnetic stimulation to the brain, clamping is generally not necessary. However, when very fast responses (e.g. 2-10 milliseconds after stimulation) are to be measured or recordings taken from the facial area during stimulation to the head, then input clamping can prevent amplifier input saturation and allow these recordings to be made successfully.

How does the clamp work?

The clamp input has special switching circuits that operate at the isolated electrode input. The switches are opened and closed by a timing unit that is in turn triggered by a trigger pulse at the Trigger2 front panel input. Note that the signal on the trigger input is referenced to system ground and is electrically isolated from the electrode connections. The trigger light does not need to be set to the Trigger2 input for the triggers to be fed to the clamp circuit.

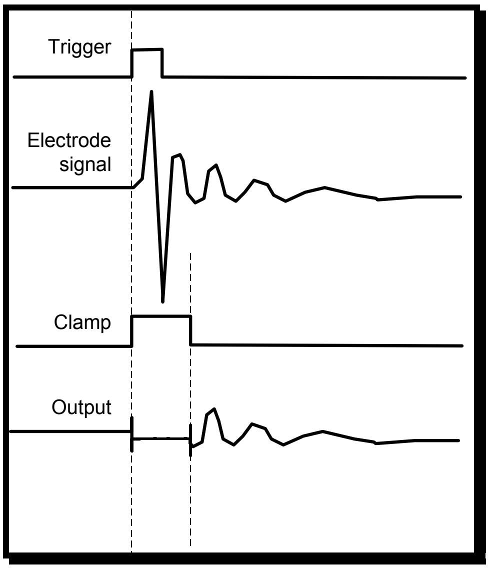

Figure 9: Clamped waveform

The timing unit can generate pulses in the range 0.5 to 12 milliseconds. The length of pulse is determined by the input source selected by software. On receipt of a positive-going edge on the Trigger2 input, the timing unit generates a pulse of the selected length. This pulse operates switches that disconnect the electrode inputs from the input amplifier and instead connect the signal electrode inputs via a low resistance to the common electrode. At the same time, the amplifier inputs are connected to a local signal source. This is normally ground, but can be a low-pass filtered version of the input signal. During the length of the timing pulse, the inputs will appear to be “clamped” either to ground or to an average value of the input during the last few milliseconds. At the end of the timing period, the input is “unclamped” and the amplifier will jump to a state representing the new value of the inputs.

Figure ***9*** illustrates this.

Selection of timing values

In addition to the four non-isolated input selections (ground, normal differential, reverse differential and single-ended) and the two isolated selections (Grounded EEG and Unclamped EEG), there are 13 new isolated input settings. These are given times in milliseconds:

0.5ms, 1.0ms, 1.5ms, 2.0ms, 3ms, 4ms,
5ms, 6ms, 7ms, 8ms, 10ms, 12ms, 14ms

As far as the user is concerned, these are normal EEG inputs. However, the clamp circuit is armed, and on a trigger will clamp for the selected length of time.

See Figure 4 and Figure 6 for how these input selections appear in DOS- and Windows-based software.

Connection of external equipment

The clamp circuit begins to operate within a few tens of microseconds of receiving a trigger, and is in the fully-clamped state after about 200 microseconds. The circuit can best deal with large potentials on the electrode inputs if they do not arrive before this time. The implication is that, if possible, the clamp circuit should be triggered marginally before the stimulator. One way of achieving this is to use external positive trigger pulses about 0.5 to 1.0 milliseconds in duration, trigger the 1902 from the front (rising) edge and trigger the stimulator from the trailing (falling) edge. The 1902 clamp time should be selected to be 0.5 to 1.0 milliseconds longer to compensate.

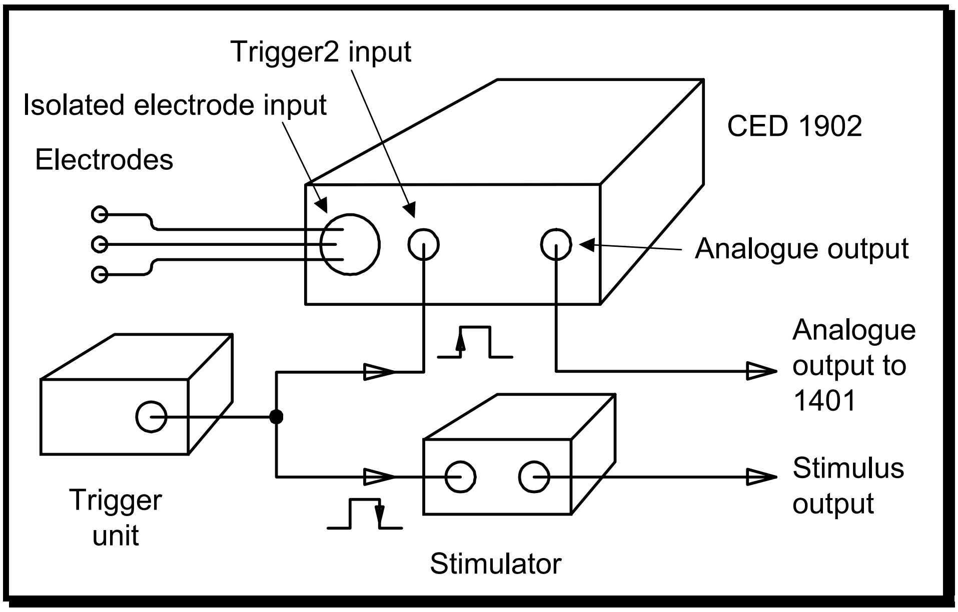

Figure 10: Clamping before stimulus

1902 input buffer option

The input buffer option (1902-4BFR) is designed for use in multi-channel configurations where a common reference potential is required. The buffer option is completely housed inside one of the channel boxes (usually channel 0) of a multi-channel configuration. It uses spare pins on the 6-pin input DIN connector to take an input signal in, buffer it and feed it back out. The user may then connect the output of the buffer to one terminal of several normal input channels without imposing additional load on the reference electrode. The presence of the buffer option does not affect the normal operation of the channel that houses the buffer.

Why use a buffer?

To understand why a buffer amplifier may be necessary, an explanation of the effects of input impedance is required, since these practical considerations receive scant attention in medical instrumentation literature. Figure 11 shows a single channel using two electrodes (plus common). The electrode–skin junction is represented as a pure voltage generator with output resistance. The capacitance of the cable and the input capacitance of the amplifier are shown. It is important that the time-constants formed by the series resistance of the skin–electrode junction and the combined capacitance of the cable and amplifier input are balanced between the channels. Since the capacitances tend to be similar, the emphasis is on ensuring that the electrode contact resistances are balanced, and the usual way of achieving this is to attempt to make them as close to zero as possible. Unbalance in the time constants causes differential phase-shifts in the input, which translates into a reduction in common-mode rejection.

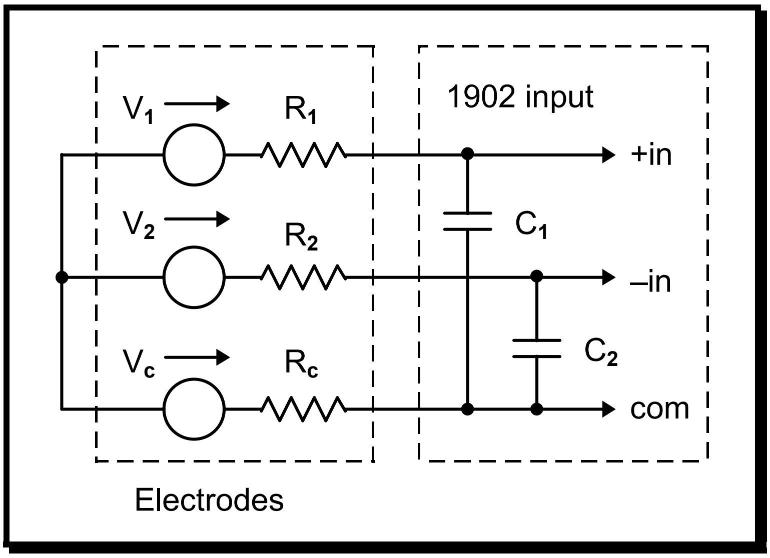

Figure 11: Channel with unshared electrodes

Impedance mismatch

The table shows the calculated degradation of CMRR with impedance mismatch. Note how an initial small mismatch causes the steepest fall-off in performance.

Impedance mismatch (KOhm)	CMRR @ 50Hz (dB)
0	>120
0.5	90
1	84
2	78
5	70
10	64
20	58

Shared electrodes

Figure 12 shows the situation when two channels are used, sharing a reference electrode. The shared electrode now "sees" a load equal to twice the load seen by each of the non-shared electrodes.

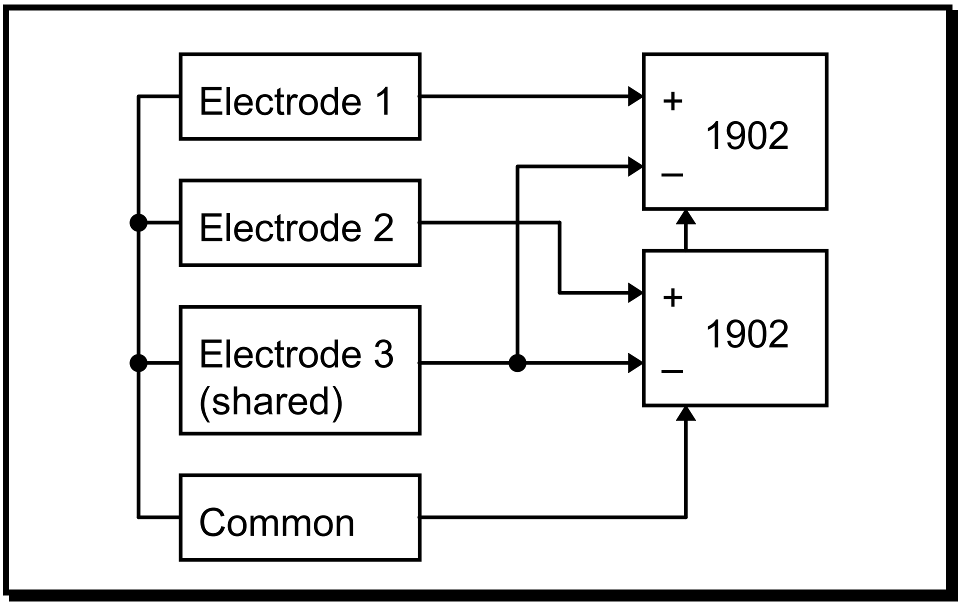

Figure 12: Channels with shared reference electrode

The table shows the calculated degradation of CMRR with input loading. It can be seen that the buffer circuit has clear advantages in multi-channel configurations.

	CMRR @ 50Hz (dB)	
Number of inputs	without buffer	with buffer
1	>120	>120
2	91	96
3	85	96
4	79	96
6	67	96
8	55	96

Drawbacks of using a buffer

There are several possible problems associated with the use of a buffer circuit:

1. The buffer introduces additional noise. The amplifier used in the 1902 buffer option is the same type as is used in the main inputs, so the resulting noise voltage is not more than $\sqrt{2}$ times that of an unbuffered configuration.

2. The buffer has to be **exactly** unity gain if the common-mode rejection performance is to be maintained. The standard circuit using an operational amplifier as a buffer falls short of unity gain by an amount proportional to the reciprocal of the open-loop gain of the amplifier at the frequency being considered. The 1902 uses a more sophisticated circuit that can be adjusted to exactly unity gain at (say) 50 Hz.

3. A buffer introduces some phase-shift in the signal passing through it. This can reduce the common-mode rejection of the multi-channel system, but the resulting performance is independent of the number of channels connected to the buffer output (see table above.)

Buffer connections

For wiring the buffer in, see the pinout table for the isolated input connector on page 17.

Figure 13 shows a multi-channel 1902 setup where each channel has separate + and − electrodes. There is a common electrode forming the bias current return path. Each channel produces an independent measurement of the potential difference between the electrodes associated with that channel. This type of arrangement is appropriate for measurement of parameters such as EMG where individual muscle sites are being examined.

Figure 14 shows a similar setup, but with a buffer circuit in operation. One electrode (the reference electrode) is taken to the buffer input, and the output of the buffer fed in parallel to the − inputs of all the channels. In this arrangement, each channel produces a measurement of the potential difference between the individual electrodes and the common reference electrode. Each electrode sees the same input capacitance load.

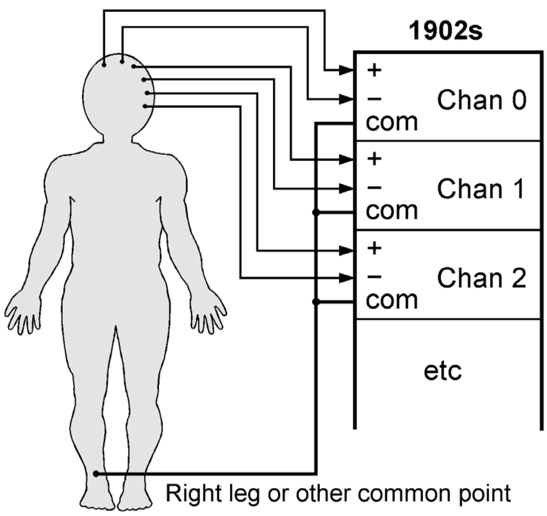

Figure 13: Multi-channel with separate electrodes

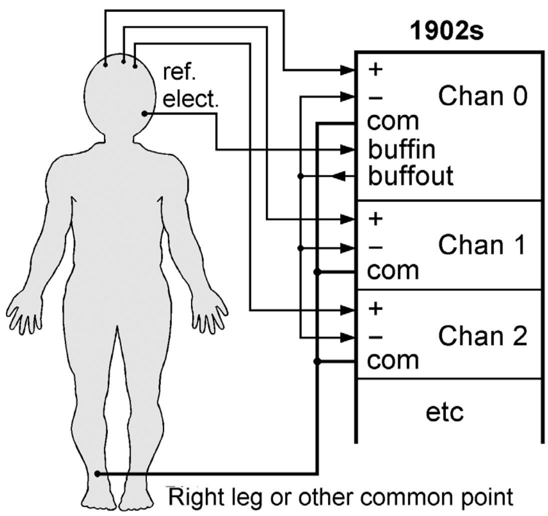

Figure 14: Multi-channel with buffered reference

EMG waveform processing option

The CED 1902 is designed to use internal plug-in modules for the isolated electrode input and for the output filters. The main purpose of this approach is to allow other types of input amplifier or output conditioning module to be exchanged with relative ease.

The 1902-06 board is a replacement output filter module specifically designed for EMG waveform processing. It can be fitted as a replacement for the original high- and low-pass filter module at the output of the 1902 amplifier strip.

EMG signal processing

In the 1902-06 EMG processing board, the high-pass filter section of the original filter module is replaced by a switchable full-wave rectifier, and the low-pass filter section forms the traditional "leaky integrator" to smooth the output of the rectifier. In this way, the EMG signal can be processed to an "envelope" representing the energy in the EMG. The processed signal can be sampled by a computer-based data acquisition system at a rate substantially lower than that needed for the unprocessed EMG waveform. Typical reductions in rates are from 2KHz to 50Hz, with a corresponding reduction in required storage capacity of over 97%.

Filter and gain settings

In the first units, the low-pass filter settings have been chosen as 10Hz and 50Hz, to give two alternative heavy smoothing options, and 1KHz, to allow the raw EMG waveform to be passed through with only light filtering. Because the rectification and filtering process causes an effective reduction in amplitude for some EMG signals, a switchable x10 gain section has been incorporated after the low-pass filter. This allows the output of the 1902 fitted with the EMG filter board to present a processed signal of reasonable amplitude to the data acquisition equipment.

Control signals	"high-pass"	"low-pass"
disabled	direct x1 gain	direct
lowest frequency	rectified x1 gain	10 Hz
middle frequency	direct x10 gain	50 Hz
highest frequency	rectified x10 gain	1 KHz

EEPROM changes

The filter values may need to be changed in the EEPROM in the 1902. Use the `BLOW1902` program to change the low-pass values to the values given in the table above. It is currently not possible to inform the `BLOW1902` program that the high-pass values have been replaced by a rectifier and amplifier; we suggest you use "frequency" values such as 1, 2, and 3 to denote the various combinations of rectification and gain. Note that selecting a x10 gain does not alter the 1902 gain reported by the 1902 in response to a ?GS software interrogation command.

Start the `BLOW1902` program by running the `BLOW` batch file on the 1902 support diskette. Choose `f4:Upload` to retrieve the serial number and other details from the 1902. Select `f7:Filters` and change the high-pass and low-pass values as described in the previous paragraph. Use `f10:Quit` to get back to the main menu, then `f9:Blow` to store the information in the 1902. Return to DOS by using `f10:Quit` from the main menu.

Trigger circuit

The purpose of the trigger circuit is to accept signals from high impedance sources that would not be able to drive TTL inputs, such as sensors, or from switches. Trigger connections are made to two mini-DIN connectors on the front panel, one of which will be active, as shown by its yellow ‘Gate’ LED. Behind each connector is a comparator, which fires on a positive-going edge, giving a flash on its yellow ‘Trig’ LED. To use a switch that is normally open as a trigger source, connect pins 1 and 4 to one contact, and pin 3 to the other. Connect the screen to the switch body. Closing the switch raises the input from 0V to 2.5V. To use a switch that is normally closed, connect pin 1 to pin 3, the switch between pin 3 and pin 2, and the screen to the switch body.

Trigger input voltage range, operating	±15 V
no damage	±50 V
Input impedance	100 KOhm
Trigger threshold for +ve going input	+1.5 V approx.
Lower trigger threshold	+1.0 V approx.
Output pulse	TTL negative-going
Output pulse length	3 μs nominal
Output drive capability	2 LS TTL loads maximum

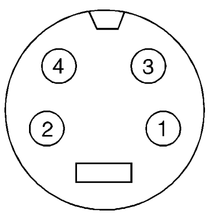

Figure 15: 4-pin mini DIN Non-isolated input

Pin	Function	Wire colour
1	Comparator input	
2	Trigger ground	
3	Internal pull up: 5V via 4K7	
4	Internal pull down: 0V via 4K7	
Shell	Mains earth	

RS232 cable

The standard RS232 serial line cable provided with the 1902 has a 9-way D-type socket connector to attach to the 1902, and the other end has a similar connector, suitable for normal AT type computers and the Acorn Archimedes range. If a PC type of computer is used, the connector for the computer must be changed for a 25-way D-type socket. For use with a Macintosh computer, an 8-pin mini-DIN connector is needed, and for an Acorn BBC B or Master, a domino 5-pin DIN.

Function	25D socket	9D socket	Mini-DIN	Dom. DIN	Wire colour
Signal ground	7	5	4, 8	C	
Data to 1902	2	3	3	B	
Data from 1902	3	2	5	A	
DTR to 1902	20	4	1	E	
CTS from 1902	5	8	2	D	
RTS	4	7			
CD	8	1			
DSR	6	6			

The functions DSR and CD must be connected to RTS for the IBM PC/AT computers. They are joined within the 1902 case so that a simple pin-for-pin cable can be used, or they may equally well be joined inside the cable socket. For the BBC these signals are not needed.

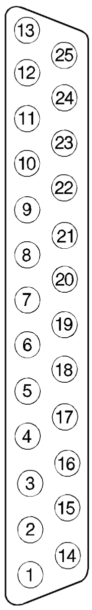

Figure 16: 25-way D socket

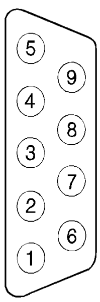

Figure 17: 9-way D socket

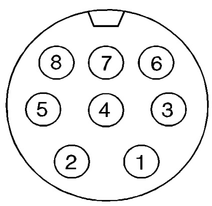

Figure 18: 8-pin mini DIN

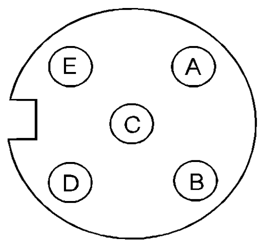

Figure 19: 5-pin domino DIN

For correct EMC performance it is essential that the serial line cable connectors have good quality metal shrouds, and that they are clamped with integral jack screws to the threaded posts provided on the 1902 and on the computer.

Power supply

The 1902 must be powered from a CED-approved power supply if it is to meet the BS 5724 (IEC 601-1) isolation requirements. The model marked “Power supply type A for the 1902 Mk III” is a suitable supply.

It is important to check that the power supply is rated for the local mains supply voltage and frequency. In the UK this will be 220 - 240 Volts, 50 Hz AC, from which the 1902 power supply draws typically 30 VA.

For applications that do not need BS 5724 (IEC 601-1) isolation, the 1902 can draw power from the rear socket of the CED 1401 Intelligent Laboratory Interface, or any other suitable source of stable power. The 1902 requires approximately 220mA on the +5V, 75mA on the +15V and 20mA on the –15V power rails.

Connectors

The standard connector set supplied with the 1902 comprises:

one 8-pin DIN for transducers
one 4-pin mini DIN for the trigger
one 6-pin DIN for electrode signals (if specified).

Further connectors can be obtained from a variety of suppliers, but for reference, we have obtained ours here:

Component	Part number	Supplier	UK tel. no.
Trigger, 4-pin mini DIN	152-208	Farnell	0113 2636311
Transducer, 8-pin DIN	431-898	"	"

To meet the requirements of IEC 601-1 only the following parts can be used:

Component	Part number	Supplier	UK tel. no.
Electrode, DIN body	1798091	Farnell	0113 2636311
Electrode, plug contacts	1797839	"	"
Electrode, cover *	1797815	"	"

* It is important that the electrode DIN cover is fully pushed onto the plug body at all times.

Components

The 1902 main circuit card carries one or more daughter boards. The main board components are shown below. The picture shows the filter and isolated front end module (ECG in this case) in place.

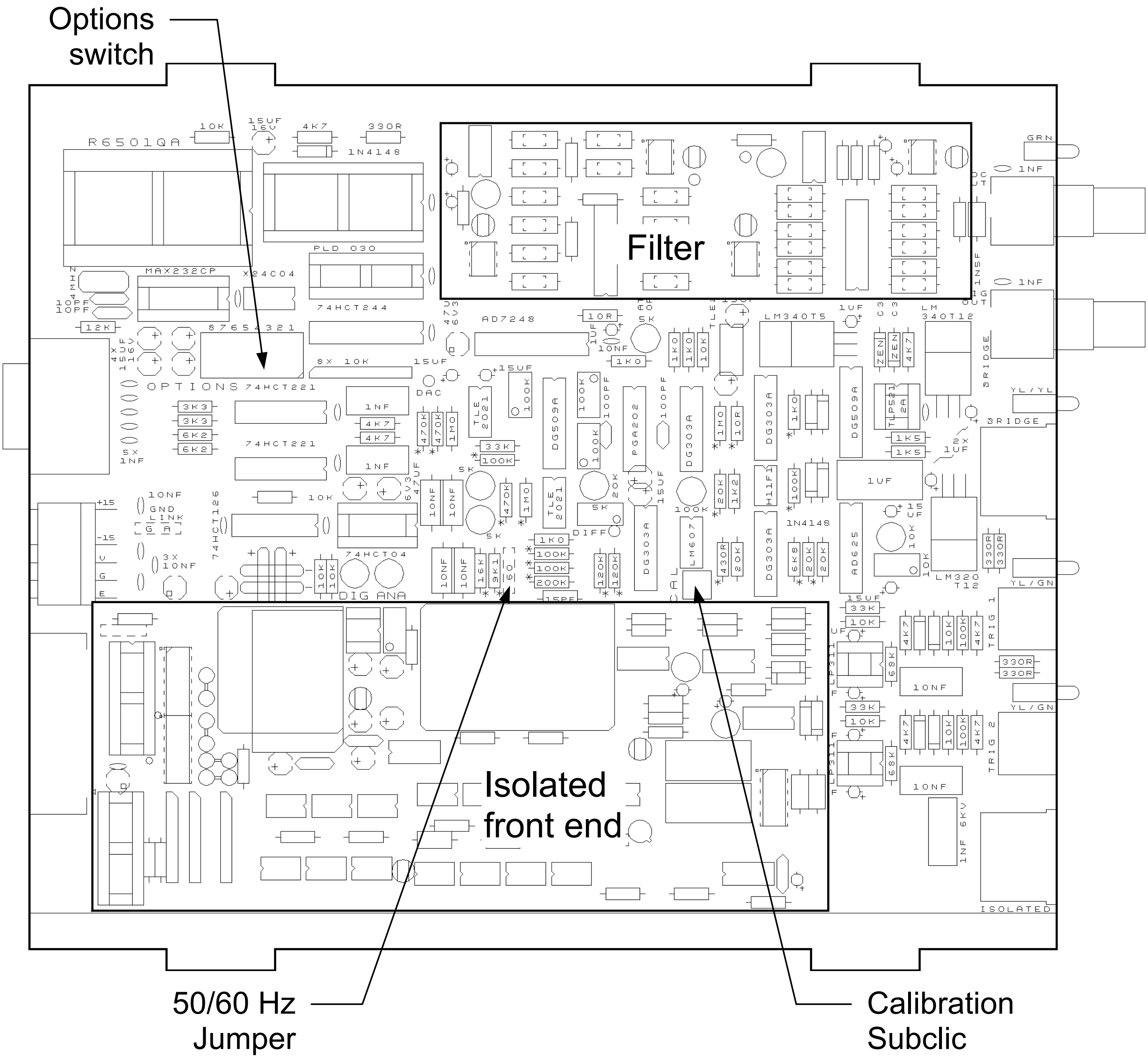

Figure 20: Arrangement of circuit boards

Component list

IC1	TLP521-2A	IC9	TLE2021CP	IC16	TLE2021CP	IC23	X2402
IC2	DG509A	IC10	ADG528A	IC17	AD7248JN	IC24-25	74HCT221
IC3	AD625JN	IC11	DG303A	IC18	TLE2021CP	IC26	74HCT126
IC4-5	LP311N	IC12	LM607CN	IC19	HN27C64G-15	IC27	R6501QA
IC6	DG303A	IC13	PGA202KP	IC20	PLD-030	IC28	MAX232CP
IC7	H11F1	IC14	DG303A	IC21	74HCT244		
IC8	DG303A	IC15	DG509A	IC22	74HCT04		
C1-2	1n0F	C17-18	15µF,16V	C28-31	10nF 1%	C45-47	15µF,16V
C3	1n5F	C19	1µF,35V	C32-34	10nF	C48	47µF,6V3
C4	10nF	C20	10nF	C35-36	1n0F	C49-50	15µF,16V
C5-6	1µF,35V	C21-22	100pF	C37-38	47µF,6V3	C51-55	1n0F
C7-8	10nF	C23-24	15µF,16V	C39-41	10nF	C56-59	10nF
C9	1µ0F	C25	47µF,6V3	C42	15µF,16V	C60-62	10pF
C10-16	1µF,35V	C26-27	1µF,35V	C43-44	10nF	C63	1nF,6KV
R1-4	330R	R22	10K	R37-38	1K0	R54	100K,HiStab
R5	1K0	R23	1K0,HiStab	R39-40	10K	R55	9K1,HiStab
R6	4K7	R24	100K,HiStab	R41	1K0	R56	16K,HiStab
R7	100K	R25	20K	R42	10R	R57	1M0
R8	10K	R26	20K,HiStab	R43	200K 1%	R58-59	470K,HiStab
R9-10	4K7	R27	6K8,HiStab	R44	1K0	R60	330R
R11	100K	R28-29	10K	R45	100K 1%	R61-63	4K7
R12	10K	R30	10R,HiStab	R46	120K,HiStab	R64-67	10K
R13-14	4K7	R31	1M0,HiStab	R47	100K 1%	R68-69	3K3
R15-16	1K5	R32	1K2	R48	120K,HiStab	R70-71	6K2
R17-18	68K	R33	20K,HiStab	R49	1M0,HiStab	R72	12K
R19	33K	R34	20K	R50	470K,HiStab		
R20	10K	R35	430R,HiStab	R51-52	10K		
R21	33K	R36	10K	R53	33K		
XT1	4MHz	RP1	8x 10K SIL	VR1-2	10K		
				VR3	100K		
D1	LED Green	SW1	8way	VR4-5	5K		
D2	Dual LED Y/Y		DIL switch	VR6-7	100K		
D3-4	Dual LED Y/G			VR8	20K		
D5-8	1N4148	Q1	LM340T12	VR9	100K		
D9-10	Zener C3V9	Q2	LM320T12	VR10-			
D11-15	1N4148	Q3	LM340T5	VR11	5K		

Serial line protocols

The 1902 operates on a standard PC serial line with an internal cable to allow a multi-drop configuration. The serial line parameters are fixed at 9600 baud, 7 data bits, even parity and 1 stop bit. Parity errors are not recognised, and the parity bit will not be generated by the 1902, so it would be equally correct to use 8 data bits and no parity. The eighth (parity) data bit will be ignored by the 1902 in either case. An internal DIL switch has sections reserved to allow selection of another baud rate if required at some future date.

Flow control between the 1902 and the host is by means of the CTS/DTR lines. The standard PC BIOS routines can be used to send data to the 1902 and to read the results. A turn-round delay of 5 ms and a per-character delay of 1 ms is provided by the 1902 to avoid errors in BIOS reads of the data sent by the 1902.

Using the commands

The 1902 command groups associated with input selection, signal gains, signal offsetting and filters all provide one or more commands to allow the application program to read the possible options. Typically, one command will return a list of possible options, while another will provide general information and another will be used to select an option.

In many cases, the range of offset and gain settings available will vary with the input selected. The application program should always read the currently allowable options after changing the input and make what adjustments are necessary.

Command format

1902 commands are ASCII strings terminated by a carriage return or semicolon. If line feed, space, or tab characters occur they are ignored. Each command starts with a pair of identifying characters followed, where necessary, by a single command parameter. The commands are not case-sensitive.

1902 command specification

Wherever appropriate, a query command can be made up by a question-mark character followed by the command identifying characters. The 1902 will respond to a query command by returning the appropriate data in the same form as used when the command is sent to the 1902. Other query commands read values not controlled by the host, principally the EEPROM information on the two add-on boards: the front-end module, and the high- and low-pass filter module. Where a command also has a query form, this is shown in brackets, with the returned result after the semi-colon. All strings returned to the host are terminated by a carriage return. Numbers returned to the host may be in simple integer, or floating-point format.

The optional command parameter is a single number in decimal or hex format; both signed and unsigned numbers may be used where appropriate. The parameter values will be checked by the 1902, and must lie within the range specified.

Command summary

Set up & input control

Initialise	IN	Set channel number	CHn (?CH;n)
Read input selection	?IS	Input control	IPn (?IP;n)
Read front end data	?IF		

Gain

Read gain selection	?GS	Set gain	GNn (?GN;n)

Filter

Read low pass filter	?LF ?LS	Low pass filter setting	LPn (?LP;n)
Read high pass filter	?HF ?HS	High pass filter setting	HPn (?HP;n)
Notch filter enable	NFn (?NF;n)	Read notch filter data	?NT
Set AC/DC coupling	ACn (?AC;n)		

Offset

Read offset ranges	?OS	Select offset range	ORn (?OR;n)
Set offset value	OFn (?OF;n)		

Miscellaneous control

Select trigger	TGn (?TG;n)	Set control byte	X0n X1n (?X0;n)
Set debug address	ADn (?AD;n)	Poke to debug address	PKn
Peek at debug address	?PK;n	Character echo	ECn (?EC;n)
Multiplexer control	MXn (?MX;n)		

Miscellaneous data

Read revision level	?RV;1902xxx	Read serial number	?SN;n
Read over-range flag	?OV;n	Read error	?ER;xxx

Initialise

IN

This command initialises the 1902 hardware to a known state: the same state as after power-up. The 1902 will behave as near as possible like a piece of wire (unity gain, no filters, DC coupling, no offset). The signal source is set to the single ended transducer input, and the trigger source is set to trigger 1. Character reflection is turned off and the error and over-range information is cleared.

Set channel number

CHn (?CH;n)

This command is used to select a channel for set-up, from 0 to 31. Only the 1902 with the correct channel will respond to commands after this command is sent; the host software should use timeouts to detect if no 1902 is set to that channel. The 1902 channel number is set using the Options DIL switches 0 to 4, with 5 reserved for future channel expansion. If channel –1 is selected, commands will be accepted by all 1902 units, but only the unit on channel 0 will reply to the host computer.

Read input selection

?IS

This command returns information on the inputs available. The first line returned holds the number of possible inputs, from 1 to 20. This is followed by one line for each input containing up to 16 characters describing the input.

Input control

IPn (?IP;n)

This command is used to select the input used from the selection provided by the ?IS command. A value of ‘1’ selects the first item in the list, and so forth.

Selections 1 to 4 will normally be the standard 1902 instrumentation amplifier inputs, while selections 5 and upwards will vary with the front-end module fitted. Information on the front-end module is returned by:

Read front end data

?IF

This command returns a string of from 2 to 18 characters in length. The first character holds the front end identification code, between 0 and 7, which is read from the front-end hardware. The second character is a ‘0’ if the front-end cannot be offset, and a ‘1’ if it can. This character is modified by adding 2 if the front end AC/DC control via the AC command is available. The rest of the string, up to 16 characters in length, describes the front-end module fitted.

Read gain selection

?GS

This command returns information on the gains available with the currently selected input. The gain information is returned as a series of numbers, one per line. The first line specifies the number of gain values available, from 1 to 20. The n following lines hold the gain values 1 to n. Each gain value is a positive floating point number, indicating attenuation when less than unity.

Quasi-continuous gain ranges are also supported, as long as they are linear. For this type of system (currently not implemented), the gain information returned would be as follows: the first line would hold '–1' to indicate quasi-continuous gain, the second would hold the number of possible gain values, the third would hold the minimum gain possible while the fourth and final line would hold the maximum gain possible. Intermediate gain values would be calculated by the application software using linear interpolation, with a value of '1' selecting the first, minimum, value and the maximum value selecting the maximum gain setting.

Set gain

GNn (?GN;n)

This command is used to set the gain of the 1902 from the selection available. The data value can run from 1 to the maximum possible. The selection used is determined by the input currently selected.

Read low pass filter data

?LF and **?LS**

These two commands return information on the low pass filter module and the cut-off frequencies available. The ?LF command returns a string, of up to 16 characters, describing the filter. The ?LS command returns information on the filter settings available in the same manner as the ?GS command; the first line holds the number of filter settings, while the following lines (up to 20) return the cut-off frequencies in Hz for each setting as floating point numbers. If zero filter ranges are specified, the filter is not fitted. A quasi-continuous range specifier, while not used at present, may be implemented in the future.

Low pass filter settings

LPn (?LP;n)

This commands sets the 1902 low pass filter settings from the range provided by the ?LS command. A value of ‘1’ selects the first setting in the list, as usual. In addition, a value of ‘0’ will cause the filter to be disabled.

Read high pass filter data

?HF and **?HS**

These two commands return information on the high pass filter module and the cut-off frequencies available. The ?HF command returns a string, of up to 16 characters, describing the filter. The ?HS command returns information on the filter settings available in the same manner as the ?GS command; the first line holds the number of filter settings, while the following lines (up to 20) return the cut-off frequencies in Hz for each setting as floating point numbers. If zero filter ranges are specified, the filter is not fitted. Again, a quasi-continuous range specifier, while not used at present, may be implemented in the future.

High pass filter settings

HPn (?HP;n)

This commands sets the 1902 high pass filter settings from the range provided by the ?HS command. A value of ‘1’ selects the first setting in the list, as usual. In addition, a value of ‘0’ will cause the filter to be disabled.

Notch filter enable

NFn (?NF;n)

This command is used to enable and disable the mains frequency notch filter. A parameter value of ‘0’ disables the filter, while a value of ‘1’ enables it. The default state has the notch filter disabled. The notch filter set-up can be determined by:

Read notch filter information

?NT

This command returns information on the notch filter 50/60 Hz build option. It returns an integer code; either ‘50’ or ‘60’ as appropriate or ‘0’ if the notch filter is not fitted.

AC/DC coupling

ACn (?AC;n)

This command is used to select AC or DC coupling of the input signal. A data value of ‘0’ sets DC coupling, while ‘1’ sets AC coupling.

The offsetting system of 1902 is slightly different from the simple 1-of-n selections used elsewhere. The offset control is provided using a signed 16-bit control value, and the information commands give details of the ranges available and the offsets that these ranges allow.

Read offset ranges available

?OS

This command returns information on the offset ranges available, like the gain range information supplied by ?GS. The first number returned is the number of offset ranges available, from 0 to 8. Succeeding lines give the full-scale offset available from that range in volts; specifically the signed offset value that would be obtained using an offset control value of 32768 (note that the actual offset values available run from –32768 to 32767). Offsets unavailable are indicated by zero ranges. It is assumed that an offset control value of zero will always give zero offset. The availability of offsets, as well as the ranges available, may change with the input selection.

Select offset range

ORn (?OR;n)

This commands sets the offset range from the ranges provided by the ?OS command. A value of ‘1’ selects the first setting in the list, as usual.

Set offset value

OFn (?OF;n)

This command is used to write an offset value to the DAC. The command data is a sixteen bit signed (2’s complement) number.

Select trigger **TGn (?TG;n)**

This command is used to select which trigger input drives the trigger output. A data value of ‘1’ selects trigger 1, while ‘2’ selects trigger 2. The default state is trigger 1.

Set control byte **X0n** and **X1n (?X0;n** and **?X1;n)**

These two commands are used to write to the two control bytes of the front-end module. The function of these bytes is entirely determined by the front-end module fitted.

Set debug address **ADn (?AD;n)**

This command sets the address to be used for the poke and peek commands (below). It is a sixteen-bit number specifying an absolute 6501 address.

Poke to debug address **PKn**

Peek at debug address **?PK;n**

This command writes a byte value to the debug address. The query form of the command reads from the same location. These commands must be used with great care.

Character echo **ECn (?EC;n)**

This command allows you to control whether characters sent to the 1902 are automatically echoed to the host. A data value of ‘0’ sets no echo, while a value of ‘1’ enables the echo; the default state is no echo. Add 2 to the data value to force LF as well as the normal CR.

Multiplexer control

MXn (?MX;n)

This command controls the multiplexer that routes signals to the calibration Subclic connector. The values for n are:

Value	Signal name	Comment
0	Analogue ground	
1	Notch	Notch amplifier output
2	Diff offs	LM607 output
3	Cond	1/3 amplifier output
4	AC/DC input	After source selection
5	Decade	PGA202 output
6	ADC out	Main output from filter card
7	DAC offs	Line to transducer socket

The program `TEST1902` saves the user from needing detailed knowledge of the table above.

Read revision level

?RV;1902xxx

This command returns a seven-character identifying string to the host. The first four characters are '1902' to allow identification of the hardware. The next two characters are the 1902 ROM software version numbers (i.e. version x.x) while the last character is the hardware revision level. The software for the 1902 uses software versions 1.x.

Read overrange flag

?OV;n

This command returns a flag indicating if an over-range signal has been detected. A '1' is returned if an over-range has been detected, otherwise the command returns '0'. The flag is cleared by using this command, or by initialising the 1902.

Read error

?ER;xxx

This command returns three characters giving details of the most recent error detected. The first two characters returned are the command identification characters for the command that caused the error, the third indicates the form of the error. Using this command will clear all error information to the "no error" state; in this state the command will return three zero characters. The currently defined error form characters are:

U	Unknown command
L	Bad command length or form
I	Illegal or invalid parameter
V	Unacceptable parameter value
O	Serial line buffer overflow
F	Serial line framing error

In the case of the two serial line errors, the command identification characters will be 'RS'.

Exchanging 1902 daughter boards

Disconnect all power and signal leads from the 1902 case. Remove the two M3 screws holding the rear panel, and remove the panel. Slide the inner case rearwards about 1 inch until the M3 screw securing the earth bonding strap on the side of the inner case is visible. Remove the earth bonding screw and star washer. Slide out the inner case completely and place on a flat surface. Remove the four vertical M3 screws and star washers towards the side edges (the longer ones) of the inner case. Remove the lid of the inner case.

The filter module is located just behind the output connector. The front-end module is a little way behind the isolated input connector. Using a strong plastic pry tool, gently lever the appropriate circuit board upwards. It may help to use a pair of pliers to pinch the split tops of the nylon stand-offs to allow the board to spring off the stand-offs. Ease the board **vertically** off its connector pins. It is important that these pins are not bent.

Install the replacement board in place of the original. Take care to align the bottom-entry connector sockets correctly with the connector pins on the motherboard. Be patient! Push the board down until it locates firmly on the shoulders of the nylon stand-offs. If any of the stand-offs have come away with the old board, push them out and re-fit them in the motherboard. The larger-diameter end fits into the motherboard.

Re-assembly is the reverse of disassembly. Take extra care to replace the star washers correctly, as they form part of the BS5724/IEC601-1 approval: the four screws holding the lid of the inner case have star washers between the screw heads and the lid, the earth bonding strap has a star washer between the ring tag and the case and not under the screw head, and the rear panel has star washers under the screw heads.

Index

Notes

EC Declaration of Conformity

This is to certify that the:

CED 1902

Manufactured by:

Cambridge Electronic Design Limited
Science Park, Milton Road, Cambridge CB4 0FE, UK
Tel (+44) 01223 420186

Conforms with the protection requirements of Council Directive 89/336/EEC, relating to Electromagnetic Compatibility, by the application of the following EMC standards:

Conducted and radiated emissions:

EN55022 (1987) Class B	-	COMPLIES
Vfg1046/1984	-	COMPLIES
FCC CFR47 Part 15 Subpart J Class A	-	COMPLIES

EN50082-1:1991 Immunity standards:

EN50082-1 (Generic immunity)	-	PASS
EIC801-2 (Electrostatic discharge)	-	PASS (8kV) Criterion A
EIC801-3 (RF field immunity)	-	PASS (3V/m) Criterion B
EIC801-4 (Electrical fast transients)	-	PASS (2kV - Heavy industrial) Criterion A
EN61000-4-11 (1998) (Dips immunity)	-	PASS Criteria A & C

Signature — Peter Rice, Technical Director

Date — 25 December 1995