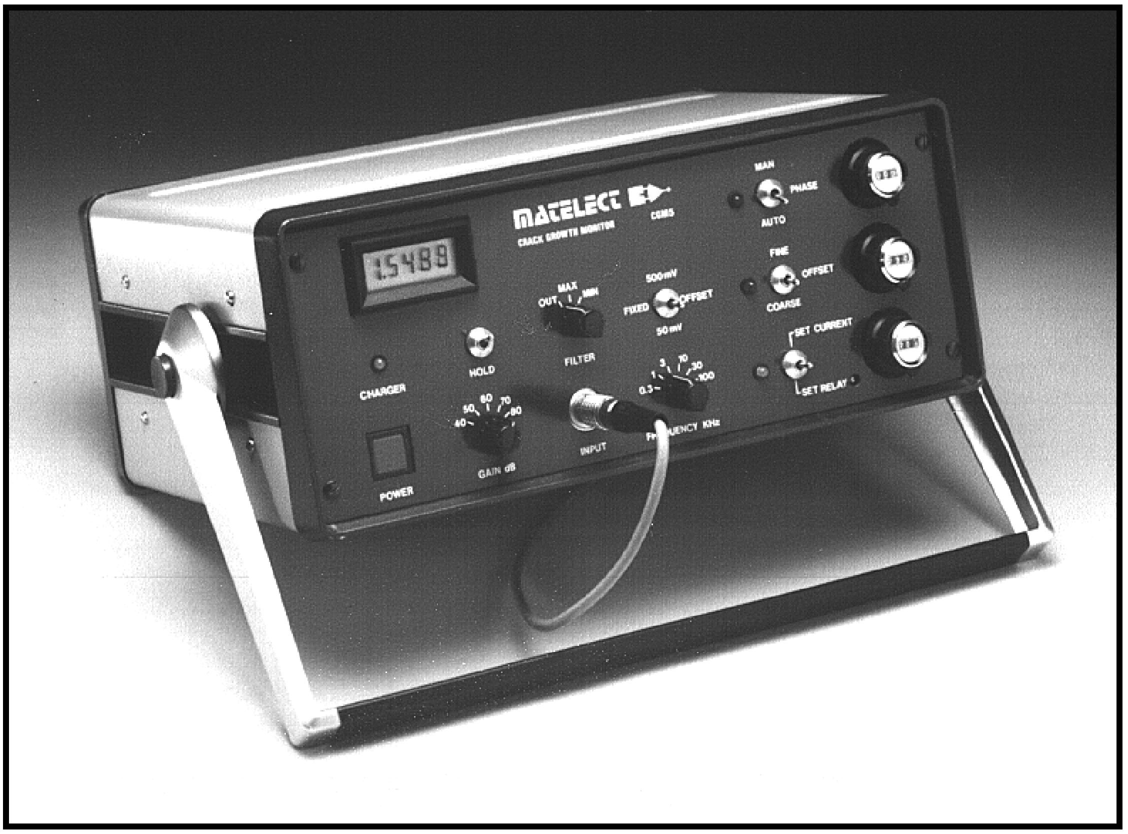
MATELECT ACPD
CRACK GROWTH MONITOR

Type CGM-5R



INSTRUCTION MANUAL

MATELECT LIMITED

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MATELECT ACPD CRACK GROWTH MONITOR

TYPE CGM-5R

Thank you for your interest in our product, we hope that it will serve your needs and prove a reliable tool.

This product has been designed to the highest standard in both electronic and mechanical design, with careful attention to stability, reliability and electrical safety.

The CGM-5 has established itself as the world's best selling laboratory ACPD equipment by far. The CGM-5R is the latest version of this instrument and incorporates several new features and refinements. Matelect produce a range of peripherals to support the CGM-5R and have also built up many years of experience in the ACPD technique. Please contact us should you ever require further information or assistance.

This manual applies to the CGM-5R. Manuals for earlier versions can be obtained from Matelect at the address given below.

IMPORTANT

Please read these instructions carefully before you use the instrument. Please pay particular attention to the section that follows on mains operation. For your reference please also read our terms and conditions of sale printed at the rear of this manual.

Use only a slightly dampened cloth and mild detergent to clean the CGM system. Never use a solvent cleaner or any fluid.

Please note that there are no user serviceable parts within the CGM-5R. Never attempt to open the instrument case as this will void any warranty. Please contact Matelect should you ever experience any difficulties.

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2. MAINS OPERATION

This section applies to all mains operated instruments
PLEASE READ BEFORE OPERATION

Before use, please make sure that the instrument's supply rating is correct for the location it will be used in. The CGM-5R can be operated on both 110 and 220V supplies by appropriate selection on the input voltage switch (see page 19). Before shipment, your instrument will have been set for the commonly used voltage in your locality.

The instrument must be connected to the mains supply using an IEC mains lead terminated with the appropriate local mains plug. The unit is supplied with a suitable lead for this purpose.

The instrument is housed in a metal case for strength and electromagnetic screening purposes. Therefore, PLEASE ENSURE that the instrument is earthed to the mains earth via the IEC connector.

In addition to the fuse that may be present in the mains plug (e.g. UK versions), the CGM-5R is fitted with two equipment fuses for protection. These fuses are located in the IEC input socket on the rear panel of the CGM-5R. Both fuses need to be functional if the equipment is to be operated.

The instrument fuses are rated at 1 ampere and are of the 20mm "anti-surge" type. Never replace these with fuses of a different type or rating as the instrument can be seriously damaged.

Ensure that the CGM-5R does not come into contact with fluids or corrosive gases and that it is operated within the temperature range of 0-40 Deg C

60 Hz mains supplies

In order to avoid harmonic frequencies affecting the operation of the CGM-5R when using mains inputs of 60Hz, the 300Hz current setting is actually set at 270Hz. This does not affect the operation of the unit or the interpretation of results.

3. CONTENTS

4. OVERVIEW

The Matelect CGM-5R has been designed for the accurate and sensitive determination of crack growth in conductive materials using the alternating current potential drop (ACPD) technique. The instrument is based on the original CGM-5 developed and sold by Matelect but with a number of refinements including true resistive measurement.

The ACPD technique is well established as a method for crack growth measurement. Originally a laboratory technique, it is now used in several other areas of research and industry. The technique involves the supply and passage of an alternating current (AC) through the test specimen and the simultaneous measurement of the resultant potential drop (PD) across an area of the specimen. If the correct area is chosen, the voltage drop will be proportional to the defect depth within the specimen. As the defect propagates, the PD measured will increase.

ACPD initially appears to differ little from its direct current equivalent, DCPD. There are however a number of important phenomena which significantly alter the interpretation of the results and the mode of use of the technique. The most important of these is known as the skin effect.

Skin effect is the term used to describe the effective confinement of an alternating current to the surface of a conductor. The skin depth is defined as a depth measured from the specimen surface within which the majority of the current supplied actually flows. The skin effect becomes more pronounced as the frequency of the AC current is increased (thus reducing the skin depth). The strength of the skin effect depends upon the material being tested, being weaker for non-magnetic materials such as titanium and aluminium. The phenomenon is used to great advantage in the ACPD technique as it confers linearity to the voltage-crack depth relationship. Such linearity minimises the calibration required for accurate crack depth measurement and is therefore to be welcomed.

The skin effect also ensures that relatively low specimen currents can be employed to obtain reasonable signal levels. Currents of an ampere or below generate signals comparable to those obtained in DCPD testing at current levels well in excess of 50A. This high signal to current ratio effectively increases the resolution of the AC technique. Additionally the use of alternating currents permits electronic lock-in methods to be employed, which further increase depth resolution by greatly minimising signal noise.

ACPD can be used to detect crack initiation in laboratory specimens, for example, during a fatigue test. Once a crack has been initiated its progress can then be followed using the same technique. If an appropriate calibration is available, a measure of the crack depth can also be obtained. In this way it is possible to measure such materials parameters as fracture toughness and fatigue life.

ACPD can also be used in the field to monitor the initiation and growth of cracks in industrial plant. In such circumstances it is usual to use one CGM unit to monitor several crack sites. Matelect produces a range of signal and current multiplexers for this purpose.

It is usual for the current supply and voltage measurement contacts to be fixed onto the specimen (e.g. by spot welding) to ensure a good electrical contact. However, ACPD can be used to size cracks in the field by the use of hand held probes which incorporate spring loaded contact pins. Matelect manufacture a number of different probe types and can also undertake the design and manufacture of specific probes systems for a particular testing need.

One of the traditional difficulties with the ACPD technique has been the existence of inductive pick-up (PU). This is simply an additional voltage that is superimposed upon the ACPD from the defect, due to the interaction between the voltage measurement leads and the current supply leads. Unfortunately PU changes with an alteration of the relative position of the leads, thereby altering the overall measured potential drop. This limitation is effectively overcome by preventing lead movement during a test. It is possible, however, to electronically reduce the pick up effect.

The CGM-5R can source an infinitely variable alternating current of up to 2 amperes RMS. Seven different frequencies are available to maintain effective use with materials of widely differing magnetic properties. The system incorporates a very stable current source and a lock-in amplifier/phase sensitive detection system for the measurement of the resultant ACPD with excellent rejection of extraneous noise.

Adjustable signal offsets, analogue and RS232 signal outputs, variable amplifier gain and a 3 position filter are additional features of the system. The unit can be used in a number of signal lock-in modes, among which the Resistive mode provides effective immunity to induced pick-up voltages.

This manual applies to the CGM-5R ACPD monitor. Users who experience any difficulty in operation of the equipment are advised to contact Matelect at the address given at the beginning of this manual.

5. GENERAL DESCRIPTION

The CGM-5R comprises a bench mounted constant current AC power supply in combination with a sensitive voltage amplifier. The amplifier incorporates phase sensitive detection circuitry to remove the noise from the ACPD signal. The resultant processed signal is a DC voltage which is displayed on the integral LCD front panel meter.

The block diagram reproduced below illustrates the operation of the CGM-5R.

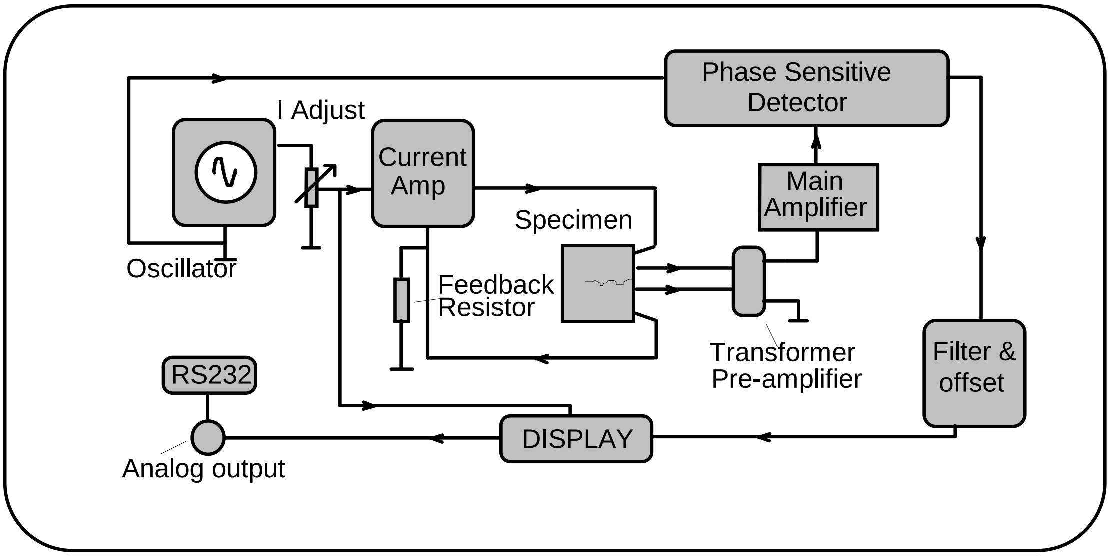


Fig 1. Block diagram of the CGM-5R crack growth monitor

The following description applies to the block diagram.

A low distortion Wien bridge oscillator with six switchable frequency settings (0.3, 1, 3, 10, 30 and 100kHz) supplies a power amplifier whose current output is adjustable via a front panel 10 turn potentiometer and maintained at a constant level by a feedback resistor. The value of the current can be read on the front panel LCD meter. The current supply develops a potential drop across the specimen and leads, sufficient to sustain the value of the current chosen by the user. Part of this potential drop constitutes the signal across the crack site and this small signal (ca. micro volts) is carried via separate signal connections to the amplification stages.

The ACPD signal from the specimen is amplified in two stages, firstly by a low noise transformer and subsequently by an amplifier with switchable gains. Combined gains of 316, 1000, 3162, 10000 and 31622 are provided. The signal then passes through the phase sensitive detector which extracts only signals of the same frequency as the current waveform, thus dramatically reducing the noise level. Although the frequencies are the same, there will be a phase difference between the current waveform and that of the signal. This is because metallic specimens are never truly resistive. Any inductive or in certain cases, capacitive, nature will lead to a phase difference. Pick-up, by virtue of the fact that it is induced, will exhibit a 90 degree phase shift with respect to the current supply.

When in auto mode, the detector adjusts itself to this phase difference in order that the maximum possible signal level is always being measured. In the manual mode, the user can adjust the phase that the detector is most sensitive to, thereby allowing measurement of the ACPD at that particular phase. In the Resistive mode, the detector is sensitive only to the resistive component, i.e. that which is in-phase with the current supply. Since this is 90 degrees out of phase with respect to the induced PU signal, the latter is theoretically removed from the amplified signal.

A three position filter is then used to enhance the rejection of noise. This is most useful when performing a long term continuous test. An adjustable offset can be used to zero the resulting ACPD signal before a test to enable a greater resolution to be achieved. The processed ACPD signal is then displayed on the 4½ digit LCD meter (DVM) and is also available at the rear of the CGM-5R as an analogue output and a serial RS232 digital output.

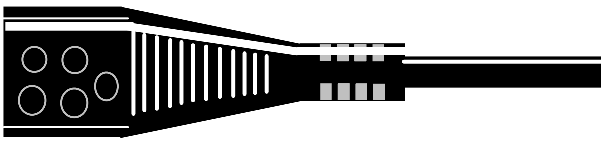
The cables required to connect the CGM-5R to the specimen and to an external recording device such as a chart recorder are supplied with the instrument and are illustrated overleaf in Fig 2.

Further operational advice is given throughout this manual and detailed topics are covered in the section entitled General Usage Advice.

Analogue Output (CGM-5R) to chart recorder

Current output (CGM-5R) to specimen

Signal input (CGM-5R) to specimen connection



IEC mains input (CGM-5R) to local mains plug

Fig 2. Cables supplied with the CGM-5R

6 FRONT PANEL DESCRIPTION

The front panel of the CGM-5R is shown below in Fig.3. The controls are described fully in this section. For further technical information please refer to the sections entitled General Usage Advice and Specifications.

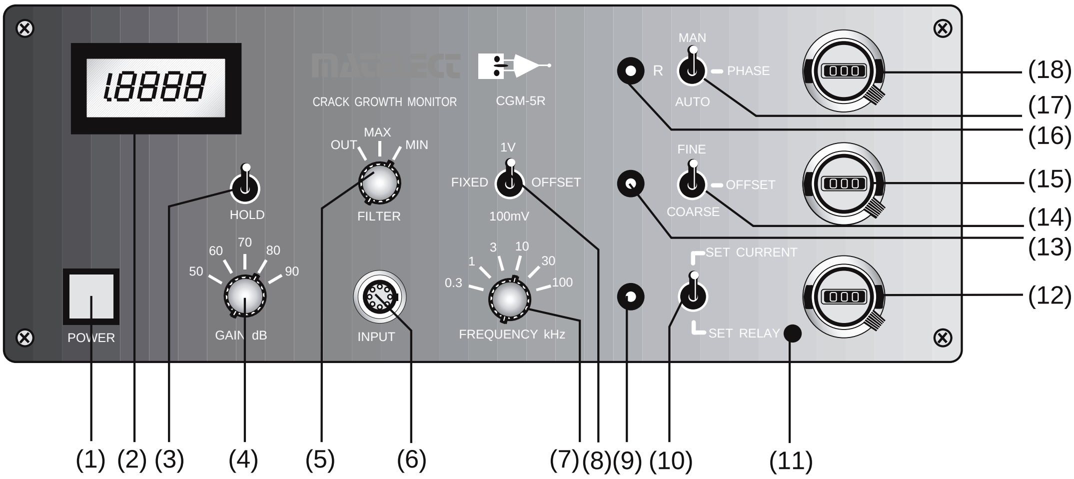


Fig 3. The front panel of the CGM-5R

1. Power Indicator

The power switch for the instrument is located on the rear panel. The red front panel indicator illuminates when power is applied to the unit.

2. Panel Meter

The panel meter displays the value of the processed ACPD and can also display the specimen current value as set by the user. The meter uses a non-backlit liquid crystal display of 4½ digit resolution. The meter autoranges at 1.9999V and then reverts to 3 decimal place accuracy. Users should always try to stay within the maximum 4 decimal point range in order to attain the maximum possible measurement resolution. This can be achieved by reducing the value of the applied current or signal gain.

The display determines the active operating range of the CGM-5R since too high an ambient temperature will cause the display to darken and too low a temperature will result in a slow response to changes in the displayed characters. In both cases the display will return to normal when the ambient temperature is within an operating range of 10 to 35 degrees Celsius.

The value displayed on the LCD panel meter is refreshed every 660 milliseconds which corresponds to a refresh rate of 1.5 Hz. If no ACPD signal input lead is connected to the CGM-5R, the LCD display may indicate random numbers.

3. HOLD Switch

This switch is normally left in the UP position. When depressed the value on the LCD panel meter is stored and retained on the display. In this mode the reading will not change and will flash to indicate that the hold facility has been selected.

4. Signal GAIN

This rotary knob allows the user to select an appropriate gain setting from the following values;

50dB	equivalent to a multiplication factor of	316
60dB	"	1000
70dB	"	3162
80dB	"	10000
90dB	"	31620

It is always advisable to use the minimum gain possible commensurate with obtaining a adequate signal level. Many factors such as the frequency and magnitude of the applied current, together with geometric considerations with respect to the specimen, can affect the signal level. These factors should be considered before increasing the gain setting.

5. FILTER Switch

Although the signal displayed on the panel meter is only refreshed at 1.5 times per second, the actual ACPD level is available as an analogue signal at the rear of the CGM-5R. This signal can be filtered to remove some of its components by use of the front panel filter switch. The switch has 3 positions as follows.

***OUT** position:* No filtering is applied to the ACPD signal. The analogue output will consist of the unsmoothed ACPD value. Details of the nature and shape of this waveform are given in the description of the **RECORDER** output in the next section (Rear Panel Description). The LCD panel meter will indicate changes at its maximum response. The **OUT** position should be selected when user wishes to record ACPD during dynamic or fast materials testing.

***MAX** position:* Maximum filtering is applied to the processed analogue output signal. The filter removes all frequencies above 0.67Hz. This effectively smoothes the **RECORDER** output and removes all traces of the original AC waveform. It also acts to remove any medium to high frequency noise that has otherwise not been removed by the phase sensitive detection circuitry. The response of the LCD panel meter will be slowed by use of this filter. The **MAX** position should ideally be used during slow strain rate experiments or long term continuous testing of specimens and structures.

***MIN** position:* In this position a low pass filter with a cut-off at 80Hz is selected. This acts to remove noise and the AC frequency whilst still permitting the recording of lower frequency phenomenon such as the changes in ACPD during a fatigue testing machine cycle.

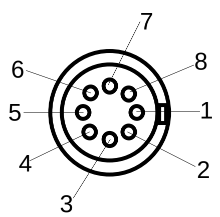
6. Signal INPUT socket.

This is an 8 way LEMO type socket which accepts the corresponding LEMO plug. *This socket differs from the two pin version used on the earlier CGM-5 and CGM-5A models as it is able to accept an optional signal preamplifier unit. Users of existing 2 pin Matelect products such as the Matprobe hand held probes can obtain an adapter cable to enable them to use these products with the CGM-5R.*

The socket is polarised to prevent incorrect insertion of the signal plug. Insert the signal plug into this socket only when the red dots on both the plug and socket are aligned. If correct alignment of the plug and socket has been achieved, the insertion force is minimal. Users *must not* force the plug into the socket, nor rotate the plug once inserted. The plug can be removed by grasping the knurled outer collar and squarely pulling the plug from the socket. Minimal force is required.

The input signal is transformer decoupled to the main amplifier within the CGM-5R. This gives a high common mode rejection ratio and reduces signal noise. The input signal should always be fed via low impedance cables and contacts.

The input socket is wired as follows:

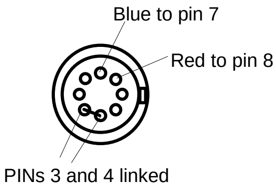


pin 1.	-12 V to optional preamplifier
pin 2.	Ground to optional preamplifier
pin 3.	shorted to pin 4 inside plug when pre-amplifier not being used.
pin 4.	Signal high for optional preamplifier
pin 5.	Signal ground for optional preamplifier
pin 6.	+12 V to optional preamplifier
pin 7.	Standard input high
pin 8.	Standard input low

Fig 4. Connections to the CGM-5R signal input socket

Two contacts (pin 7 and 8) serve to carry the input signal whilst the other contacts are used to power and communicate with the optional pre-amplifier unit (available from Matelect). This unit is only required when long signal cables lengths are being employed (e.g. 10 metres or more) or when the signal is to be routed through a noisy environment such as an industrial plant location.

For the standard case of a CGM-5R without preamplifier, the input cable must be wired as shown overleaf in Fig 5. Any deviation from this regime may cause serious damage to the internal circuitry of the instrument. Always use the cables supplied with the CGM-5R to prevent such damage.



Drawing indicates solder bucket view
Connector is LEMO FGG2B308CNAD62Z
Cable is twisted pair and screen (7/0.2mm)

Fig 5. Pin connections on a standard LEMO type input plug

Users should contact Matelect for further information on cabling or if longer cable lengths are required.

7. FREQUENCY Selector.

This rotary switch is used to select the frequency of the alternating current supplied to the specimen. It has 6 positions corresponding to frequencies of 0.3, 1, 3, 10, 30 and 100kHz. The choice of frequency will depend on the material under investigation. The frequency determines the skin depth with higher values corresponding to smaller skin depths. The smaller the skin depth, the larger the corresponding ACPD (for a particular value of applied specimen current). The magnetic properties of the material will also influence the skin depth and hence the choice of frequency. Ferritic materials such as the steels exhibit small skin depths at relatively low frequencies (e.g. 0.3-1kHz) whereas non magnetic materials such as aluminium require 30 or 100kHz in order to obtain sensible ACPD readings.

Raising the frequency in order to increase the ACPD is not always recommended since the magnitude of the inductive pick up (PU) also increases with frequency. Users should thus consider raising the current through the specimen and then the gain as alternatives.

Because of its effect on the skin depth, frequency is one of the fundamental variables in ACPD work. Careful choice of the frequency is required in order to obtain the optimum results from the technique.

8. FIXED OFFSET toggle switch

This selects the value of a preset and constant DC offset applied to the processed ACPD signal. Three positions are provided: Zero offset (i.e. no offset) is applied when the toggle switch is set to its centre position. 1 Volt is applied in the up position and 100mV in the lower position.

This switch is normally left in the centre (zero) position. The fixed offsets are normally used in conjunction with the Matprobe series of hand held probes which are available from Matelect.

The Matprobe is used as a quick method of sizing cracks in components and plants outside the laboratory. Further details are given in the corresponding Matprobe manual and in the section on General Usage Advice within this manual.

Users wishing to offset their ACPD readings during standard laboratory testing should use the variable offset facility on the CGM-5R (see later).

9. Current LED indicator

A summary of the operation of this and the two other LED indicators is given in Table 1. at the end of this chapter. The LED illuminates RED when the LCD panel meter displays the specimen current. This mode is selectable using the **SET CURRENT** mode switch (10). Additionally if at any time the current supply connections to the specimen are broken, the LED will flash RED. The LED will also flash if the voltage compliance of the current source has been exceeded. This occurs when the overall AC resistance (impedance) of the specimen, current contacts and current leads exceeds the maximum load level that can be supported at the desired current setting.

The most likely cause of exceeding the compliance limit is the use of long current supply leads, for example during long term monitoring of large structures. In such cases users should attempt to reduce the load on the current source. This is most readily accomplished by reducing the resistance of the leads by minimising their length and/or increasing the cross sectional area of the conductors. The capacitance of the cables strongly affects the impedance value, especially at the higher AC frequencies. It is therefore recommended that low capacitance cable types (e.g. coaxial cables) are employed for long cable runs.

The LED indicator illuminates GREEN when the amplified and processed ACPD value exceeds the threshold value set using the **SET RELAY** facility (accessed using switch 10).

The indicator will display combinations of RED/FLASHING RED and GREEN depending on what function or limit is applicable at the time. A combination of red and green will appear as ORANGE/FLASHING ORANGE.

10. Display mode switch.

This toggle switch has three positions which govern what quantity is displayed on the front panel LCD meter. It permits the user to view the RMS specimen supply current, or the threshold voltage at which the internal alarm relay operates, or the processed value of the ACPD signal.

In the CENTRE position, the switch selects the processed ACPD signal. In the UP position the **SET CURRENT** (adjustable using control 12) is displayed and the current LED (9) illuminates. In the DOWN position the **SET RELAY** value (adjustable using control 11) is displayed.

11. SET RELAY control

This facility consists of an internal relay whose contacts are accessible from the rear panel I/O socket (see section entitled Rear Panel Description) and which operates upon attainment of a threshold ACPD signal voltage. The threshold value is adjustable using the **SET RELAY** control potentiometer. This is positioned behind the front panel and is accessible through a small hole. The potentiometer should be adjusted using a suitable slotted blade screwdriver. The potentiometer is of the ten turn variety and care should be taken not to unduly rotate it beyond its limits (faint clicks can be heard at the limits of travel).

Users should simultaneously depress control switch (10) whilst adjusting the potentiometer. This permits them to see the value of the threshold voltage on the front panel LCD meter as the adjustment is being made.

12. SET CURRENT adjustment.

This ten turn potentiometer permits the user to select the magnitude of the alternating current supplied to the test specimen. The current is continuously variable from zero to 2 Amperes (RMS).

When adjusting this potentiometer, the current flowing through the specimen should be monitored on the front panel LCD meter by positioning switch (10) in the up position. Please note that a specimen must be connected (or the ends of the current supply lead shorted) in order for current to flow and thus be displayed and adjusted.

If, whilst adjusting the potentiometer, LED (9) flashes RED, users should check the integrity of their connections and/or the resistance of their cables (see section on LED (9) earlier).

The value of the current determines the resultant ACPD signal and should therefore be adjusted in combination with the **FREQUENCY** and **GAIN** controls in order to obtain a satisfactory signal level. For most materials a level of 0.5 Amperes, at the frequency appropriate for the material, will prove adequate. Currents below 250mA are not usually employed.

The position of the potentiometer and hence the value of the current can be locked using the lever mounted on its underside. Slide this down to lock and up to unlock. Do not apply excessive force to the lever. The potentiometer is also equipped with a dial gauge to assist any adjustments although it is recommended that the LCD panel meter be used to record the actual values.

The LCD meter displays the current set to a resolution of 1 milliampere. Although the current source is extremely stable (better than 0.1%) it is important to note that the potentiometer position will correspond to currents that will differ slightly between frequency settings. Thus, if the frequency is altered, users should readjust the position of the current potentiometer in order to maintain the same current supply conditions.

13. OFFSET LED indicator.

The operation of this indicator is summarised in Table 1. The indicator illuminates RED if an offset has been selected. This occurs when switch (14) and/or (8) is in the UP or DOWN position. The indicator should remain unlit when switches (14) and/or (8) are in the CENTRE position.

If at any time this indicator FLASHES RED, the user is warned that the processed ACPD signal is being clipped. Clipping describes the effect of reaching a threshold signal level beyond which any increase in gain or current will have no effect on the signal level. This limiting condition is due to the electronic constraints within the CGM-5R. Users should never operate at or close to the clipping level (which corresponds to approximately 3.8 volts as displayed on the front panel LCD meter).

If clipping is indicated by the LED, the signal gain and/or current supply should be reduced. Alternatively a lower frequency can be selected if appropriate.

14. Variable OFFSET switch.

This toggle switch has three positions and enables the user to offset (using control 15) the processed ACPD voltage. An offset is normally employed to zero (remove) the initial ACPD present when a specimen is connected to the CGM-5R. Any change in the ACPD will then be easily visualised. This facility is not of great importance as most ACPD work relies upon the recording of changes in the potential drop readings rather than the actual magnitude of the readings themselves.

By using the offset it is possible to ensure that the ACPD is displayed to the maximum 4½ digit resolution since voltages over 1.9999 V are displayed to 3 decimal places. The offset can also be used to reduce the initial signal level, thereby permitting the user to increase the signal gain. This allows smaller variations in the ACPD to be detected.

Users should note that the offset is applied to the processed ACPD voltage and therefore it cannot be used to remove signal clipping should this occur (see above section on **OFFSET** LED).

When the **OFFSET** switch is in the UP (**FINE**) position, the ACPD output can be offset by a maximum of 110mV using control (15). When the switch is in the DOWN (**COARSE**) position the ACPD can be offset by a maximum of 4.4V using control (15). In the CENTRE position, no offset is applied to the ACPD signal and control (15) does not affect the displayed reading.

15. OFFSET control.

This ten turn potentiometer should be used in conjunction with control (14) to vary the offset applied to the processed ACPD signal. The applied offset is continuously variable throughout the range selected by control (14). The position of the potentiometer can be locked to prevent accidental movement during a test (see control (12) for further details. A digital scale within the potentiometer body can be used as an aid to accessing the level of offset applied.

16. Mode LED indicator

The operation of this indicator is summarised in Table 1. The indicator is used to visually determine what mode the CGM-5R is operating in. Three modes are available and these are selected by use of the adjacent mode switch (17). A description of the modes available is given in this manual (see Overview, page 4) and further information on the **R**esistive mode is given in the section entitled General Usage Advice.

The indicator illuminates GREEN when the instrument is in the **R**esistive mode.

In the **AUTO** mode, the LED is normally unlit to indicate that the phase sensitive detector has locked onto the ACPD signal. When a specimen is first connected to the instrument the LED will flash RED whilst lock-in is being achieved. This process normally takes several seconds but in certain circumstances (e.g. at low signal levels) up to 10 seconds may be required. Once lock-in has been achieved, the LED will extinguish and normally remain so during a test.

If the LED flashes during a test this indicates that a large phase change in the measured ACPD signal has occurred. This could be due to poor electrical contact to the specimen or to a rapid alteration in crack length.

When the CGM-5R is in the **MAN**ual mode, the LED can either indicate a continuous RED or a FLASHING RED. In this mode, the **PHASE** potentiometer (control 18) is used to adjust the phase of the signal to which the instrument is sensitive. This facility is sometimes of use to those who are studying the fundamentals of ACPD theory. In the **MAN**ual mode the LED will remain continuously lit only when the selected phase is that which would have been chosen by the instrument in **AUTO** mode. At all other positions of the **PHASE** adjust potentiometer, the LED will flash red.

17. Mode Selector Switch.

This is a three position toggle switch that allows the user to select the mode of operation of the CGM-5R. It is used in conjunction with controls (16) and (18). See these entries for further information.

In the UP (**MAN**) position the CGM-5R is in **MAN**ual mode. In this mode control (18) is used to adjust the phase of the ACPD signal to which the CGM-5R is sensitive to.

In the CENTRE (**R**) position, the instrument is in the **R**esistive mode (see Overview and General Usage Advice) which effectively reduces the influence of induced pick-up (PU) on the ACPD measurements. This mode is most useful for spot checking of crack depths using Matprobe hand-held probes or in experiments where some lead movement is anticipated.

In the DOWN (**AUTO**) position, the CGM-5R automatically locks into the phase of the measured ACPD signal without user input. This signal will consist of the magnitude of the vectorial summation of both the true ACPD, as developed across a defect, and the pick-up (PU) signal.

18. PHASE adjustment control

This is a ten turn potentiometer that is used in conjunction with controls (17) and (16) which enables the user to adjust the phase that the CGM-5R is sensitive to when operated in **MAN**ual mode. The position of the potentiometer is lockable to prevent accidental movement (see control (12) for further details).

The **MAN**ual mode is normally used for certain fundamental studies of the ACPD technique. It is not normally employed for routine work. Please see the section on General Usage Advice for further details.

Summary of LED indicator functions

The operation of each LED enunciator is described in the main text, however, a summary to assist users in interpreting the various combinations observable, is given below.

	PHASE LED	**OFFSET LED**	**SET CURRENT LED**
LED OFF	Phase correctly adjusted in AUTO mode	Offset OUT All systems OK	Current switch central, all current leads OK
LED FLASHING RED	Phase incorrectly adjusted in both MANual and AUTO modes	Signal clipping is occurring	Compliance limit reached or poor or broken contacts
LED RED	Phase correctly adjusted in MANual mode	Offset IN All systems OK	Current switch held in UP (SET CURRENT) position
LED ORANGE	N/A	N/A	Current switch in UP position AND relay activated (as below)
LED FLASHING ORANGE	N/A	N/A	Compliance limit reached AND relay activated (as below)
LED GREEN	CGM-5R in Resistive mode	N/A	Contacts/limit OK but RELAY limit reached and relay activated

Table 1. LED functions

Please note that if no ACPD signal lead is connected to the CGM-5R, the amplification circuitry may become unstable and a random flashing of the phase LED can occur.

7. REAR PANEL DESCRIPTION

The rear panel of the CGM-5R is shown below in Fig.6. The controls are described fully in this section. For further technical information please refer to the sections entitled General Usage Advice and Specifications. Located on this panel are the analogue, RS232 and current outputs, together with the mains input socket and a large heatsink.

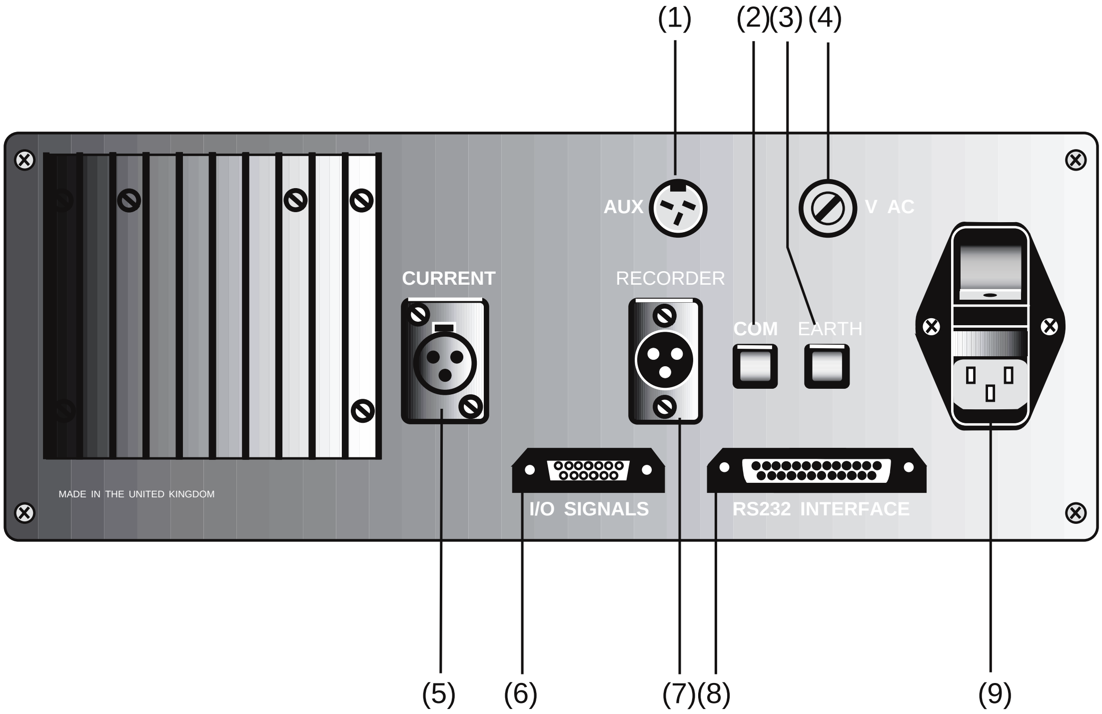
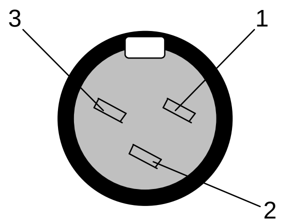


Fig 6. Rear Panel of the CGM-5R

1. Auxiliary output socket.

This socket is used to power peripheral instrumentation that can be connected to the CGM-5R, for example, the SM signal multiplexing system. The socket is wired as follows.



Pin 1. positive 12 V unregulated 100mA max.
Pin 2. circuit common
Pin 3. negative 12 V unregulated 100mA max.

Fig 7 Auxiliary output socket

The auxiliary supply is nominally ±12.5V DC unregulated. Under maximum load this will drop to ±10V. The outputs are current limited to prevent damage to the CGM-5R should a short circuit occur.

2. COMmon terminal.

The circuit common line is available at this terminal. Connection to this is made by depressing the sprung button and inserting a suitable length of equipment wire, then releasing the button. The circuit common of the CGM-5R is electrically isolated from the case Earth. If it is desired to connect common to Earth, a wire link can be used between the **COM**mon terminal and the **EARTH** terminal (item (3) below).

Isolation of the common is useful if external peripherals such as chart recorders are connected to the CGM-5R. If their signal common is connected to Earth, an earth loop could occur, should the CGM-5R's common also be connected to Earth. Such loops are sources of signal instability and should therefore be avoided.

3. EARTH terminal.

Connection to the case (chassis) is available at this terminal (see item (2) above).

4. Voltage selector switch.

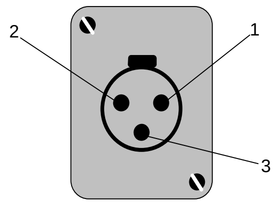
PLEASE READ THE SECTION ON MAINS OPERATION at the beginning of this manual before attempting to alter the position of this switch.

The switch permits the CGM-5R to be used with either 110-120 or 220-240 mains supplies. The CGM-5R is factory adjusted to the correct mains input voltage before shipment but users may wish to alter this depending on the location of the instrument. A wide blade screwdriver should be inserted into the slot within the switch and rotated to the appropriate input voltage (as marked on the switch).

CARE! Disconnect the unit from the mains supply before altering the position of the switch. Operation of the CGM-5R with this switch incorrectly positioned will cause serious permanent damage to the unit.

5. CURRENT output socket.

The alternating current delivered to the specimen is sourced from this 3 pin socket. An appropriate mating lead is supplied with each CGM-5R. The socket is of the latching type. The mating plug is inserted by first aligning the depression on the plug with the locking lever, then firmly pushing the plug home. To remove, depress the locking lever and pull the plug away from the socket. The socket is wired as follows:



Pin 1. Current high output
Pin 2. Current low output
Pin 3. Chassis earth (Com. on pre '94 units)

Fig 8. The current output socket

6. I/O SIGNALS connector

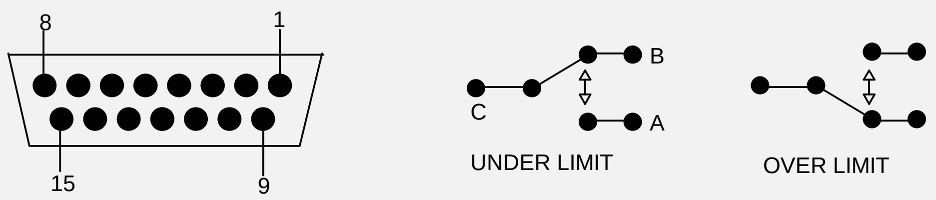
This 15 pin "D" connector supports various input and output functions which are not normally required for operation of the CGM-5R. These signals are sometimes used in advanced ACPD studies.

The socket permits access to the internal relay facility. This can be used to sound external alarms or stop external equipment upon attainment of a particular ACPD signal level.

The relay contacts are rated at 250mA, 200V DC, 3W maximum. Users should not exceed these ratings. If higher powers are to be switched then a second relay of the appropriate rating should be controlled by the internal CGM-5R relay.

Further details of this facility are given in the section entitled Front Panel Description (paragraph 11).

The socket and relay are wired as follows.



Contact No.	Function
1	-8 V Logic level only, 1mA max.
2	+8 V Logic level only, 1mA max.
3	Aux. DVM input
4	Aux DVM Input enable - Active low (0V)
5	External DVM ref. enable - Active low (0V)
6	External DVM ref. input
7	DVM Common (Analog 0V)
8	Q (the in-phase switching signal of CGM-5R)
9	Common (Analog 0V)
10	RELAY CONTACT A
11	RELAY CONTACT B
12	RELAY CONTACT C
13	Relay disable (connect to -5V)
14	-5V (relay disable signal)
15	Q90 (switching signal 90 degrees to Q)

Fig 9. I/O socket functions

7. RECORDER output

The is a three pin, latching socket that is used to output the processed ACPD signal to a chart recorder or other suitable recording device such as a computer based acquisition system. This permits unattended and continuous recording of data from the CGM-5R.

A suitable cable to mate with this socket is supplied with each CGM-5R. The cable is terminated at the opposite end with two 4mm banana type plugs for use with standard chart recorders. Insertion of the mating cable into the **RECORDER** socket should be done by first aligning the pins and latch and then pushing the connector home. Depress the latch and pull the plug away from the socket in order to remove the cable.

The analogue output from this socket matches that on the LCD front panel meter. The value on the panel meter is refreshed at a maximum rate of 1.5 times a second whereas changes in the analogue **RECORDER** output are dependent only on the bandwidth of the instrument and the setting of the front panel **FILTER** switch.

Although the LCD meter displays a DC voltage, it must be remembered that the true ACPD voltage is alternating in nature. The circuitry within the CGM-5R has, in essence, rectified the AC voltage. The filter facility then smoothes the rectified signal and the slow response of the front panel meter smoothes it further (see Front Panel Description item 5).

It is, however, possible to record the unsmoothed (but rectified) signal via the **RECORDER** analogue output.

In addition to its dependency upon the position of the front panel **FILTER** switch, the nature of the analogue output will also depend upon the lock-in mode of the CGM-5R (see also item (17) Front Panel Description) as follows.

If a recording device with suitable bandwidth (e.g. an oscilloscope) is connected to the analogue output then the unsmoothed signal can be observed. This will appear as a full wave rectified sine wave when the CGM-5R is used in the **AUTO** mode. In the **MAN**ual mode the output waveform will be modulated depending on the setting of the **PHASE** potentiometer. In the **R**esistive mode the output will also appear modulated but the **PHASE** potentiometer will no longer affect the waveform.

If data acquisition is being performed by a chart recorder then it is unlikely that the device will have sufficient bandwidth to observe the various analogue waveforms, even at the lower AC frequencies.

Users of wider bandwidth instrumentation should, however be aware of the waveforms that can be observed. A selection of sample waveforms is shown overleaf in Fig. 10.

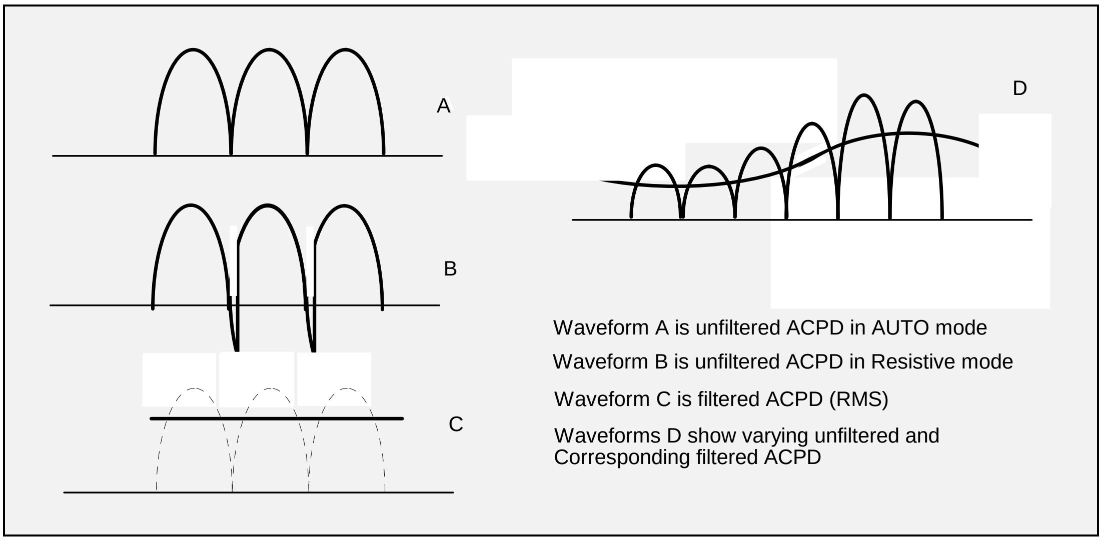
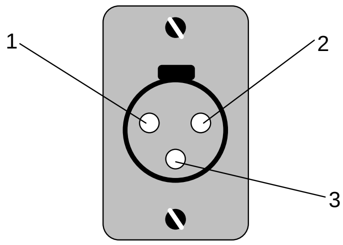


*Fig 10. Typical waveforms from the **RECORDER** output using an oscilloscope*

The recorder socket is wired as follows:



Pin 1. Signal high
Pin 2. Signal Common
Pin 3. Not connected

*Fig 11. The **RECORDER** output socket*

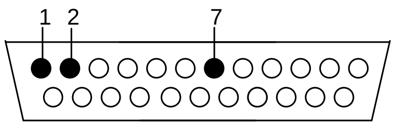
8. RS232 INTERFACE socket

This is a 25 way D connector with male (pin) contacts. It provides a serial digital output of the ACPD voltage (as indicated on the front panel meter). A serial (RS232) link is the most common means of interfacing to a personal computer (PC) or data logging system. With a suitably written computer program, the data format can be interpreted and then displayed, stored or manipulated by the program as appropriate.

The serial link is uni-directional and data is continuously output from the CGM-5R. No control functions are provided. Only three connections are required for serial data transmission. These are of the standard RS232 format.

Matelect can supply a suitable serial cable, terminated in either a nine or 25 way connector (at the PC end). Standard graphical software is also available for data logging, display and storage.

The connector is wired as follows:



Pin 1. Ground (cable shield)
Pin 2. Transmitted data (Tx)
Pin 7. Signal ground

Fig 12. RS232 Serial data interface connector

The serial data is derived from the front panel LCD meter and is therefore subject to the same refresh rate. The data is transmitted during a 10 millisecond period at the end of each measurement cycle of the front panel meter (i.e. every 400mSec). The ACPD signal is represented by five characters each comprising 1 start bit, 8 data bits and 2 stop bits. It is possible to select one stop bit if required although this is an internal adjustment and as such should only be performed by Matelect. The data format is illustrated below.

1 start bit, followed by 8 data bits as given in table below, then two stop bits.
Data rate = 9600 Baud:

QUANTITY				POSITION CODE				
MSB							**LSB**	
X	Y	Z	*	0	0	0	0	Digit 5 (MSD)
*	*	*	*	1	0	0	0	Digit 4
*	*	*	*	0	1	0	0	Digit 3
*	*	*	*	0	0	1	0	Digit 2
*	*	*	*	0	0	0	1	Digit 1 (LSD)

Where * * * * represents binary 8, binary 4, binary 2 and binary units as appropriate for the quantity being transmitted.

X = Over range flag X = 0 for OK and X= 1 for over range condition
Y = Dec. point position Y = 0 for 1.9999 and Y = 1 for 2.000 position
Z = Signal polarity Z = 0 for minus value and X = 1 for plus values

NB MSB = most significant bit (on serial link), LSB = least significant bit
MSD = most significant digit (on panel meter), LSD = least significant.

e.g. a front panel meter reading of +1.2345 volts would be encoded as:

0	0	1	1	0	0	0	0
0	0	1	0	1	0	0	0
0	0	1	1	0	1	0	0
0	1	0	0	0	0	1	0
0	1	0	1	0	0	0	1

Fig 13. Data format for the RS232 serial data link

9. Mains input socket

PLEASE READ THE SECTION ON MAINS OPERATION before attempting connection to this socket.

The socket is of the standard IEC mains input type with integral line filter, mains switch and mains fuse. A suitable lead, terminated with a local mains plug, will have been supplied with the CGM-5R. If this is missing, only use an approved mains IEC connector as a replacement.

The instrument is fitted with two 1 Ampere anti-surge 20mm fuses. If any of these fail, then the equipment should be disconnected from the mains supply, and the fuses replaced with ones of the same rating and type. DO NOT use a fuse of a higher rating as permanent damage may result to the CGM-5R. The fuses are accessible via a sliding carrier tray. This can be levered out using the blade of a slotted screwdriver placed in the recess within the carrier.

If the local mains plug also incorporates a fuse (e.g. UK versions) then this should be of a similar rating to the fuses within the IEC socket.

Always ensure that the mains input lead has an Earth connection and that this is in good order. This is necessary both for safety purposes and in order to obtain sensible results.

8. CONNECTIONS TO THE SPECIMEN

Specimen connection in ACPD work is not a trivial subject and will therefore only be dealt with briefly in this operating manual. It is also assumed that the user is reasonably familiar with the ACPD technique. For further information please contact Matelect who will be pleased to offer applications advice and more detailed assistance.

Four electrical connections are required to be made to the specimen, two current and two voltage. As far as is practical, the leads, as supplied with the instrument, should be employed for connection purposes. It is important to obtain a good electrical contact between lead and specimen and it is usual to use spot welded, soldered or screwed connections in this respect.

For a typical compact tension specimen (CT) the connections should be made as shown in Fig. 14. below.

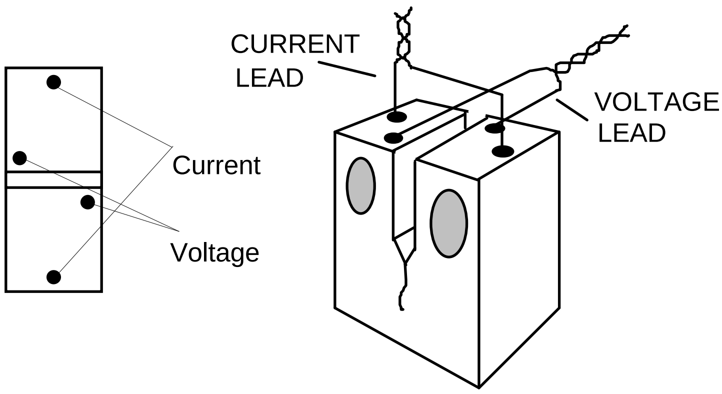


Fig 14. General ACPD connection locations

This is a general arrangement that can be adapted to other configurations such as three point bend and wide plate specimens. Long term monitoring of large components may involve a more complex arrangement of contacts, especially if multiple sensing points are required and if temperature variations are likely to occur during a test. Further information is available from Matelect.

The current leads should be positioned such that the current path encloses the crack. In this manner, the propagation of a defect will cause a perturbation in the current flow that will lead to a change in the measured ACPD.

The voltage sensing leads should be positioned symmetrically about the crack site and between the current connections. By locating the voltage connections as shown in the above diagram, the average depth across the advancing crack front is registered.

It is highly advantageous to make the connections to the specimens as rigid as possible. This minimises possible lead movement during a test and hence reduces any errors due to changes in the pick-up (PU) signal. This unwanted signal is derived from the interaction of the voltage leads with the magnetic field generated by the passage of the alternating current through the supply leads and specimen. (see also General Usage Advice).

Rigid connections can be made using thick gauge copper wires. The relevant cables can then be attached to these conductors as close to the specimen as the testing configuration allows. Use adhesive tape to secure the cables themselves to prevent any possible lead movement during a test. If the CGM-5R is operated in Resistive mode some lead movement can be tolerated without causing gross errors.

To reduce the actual magnitude of the pick-up voltage it is important to tightly twist the leads (as shown in Figure 15). It is important to note that the magnitude of the PU can be reduced by minimising the area enclosed by both the current and voltage leads. This is illustrated in the following diagram. If large loops are unavoidable, it is best to position them perpendicular to each other.

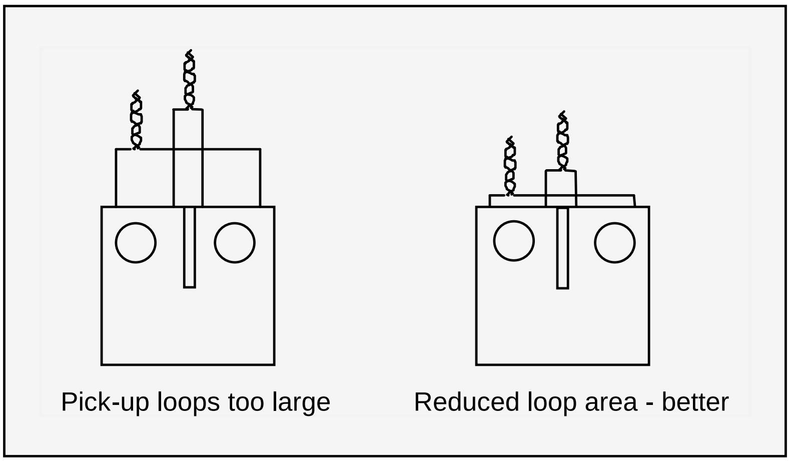


Fig 15. Loop area considerations

It is not usually necessary to isolate the specimen from the testing machine since the specimen presents a far lower impedance to the flow of current than does the alternative path via the grips and body of the machine. Care must be taken, however, if a clip gauge is used in conjunction with ACPD measurements. The gauge can easily short out the signal from the specimen, so it is important to provide some form of electrical isolation in such cases.

A phenomenon known as current focusing can occur in ACPD experimentation. This effect causes the specimen current to closely follow a path defined by one of the current leads. It is especially prevalent when the current lead is close to the specimen's surface. Current focusing is used to great effect to increase ACPD sensitivity but it can lead to errors in interpretation of results. Further details of this advanced technique can be obtained from Matelect.

Excessive cable length can seriously degrade the performance of the ACPD system. If it is found necessary to extend the factory supplied cables or substitute different cables types then users must always try to minimise cable impedance. If the impedance is excessive, the voltage compliance limit will be reached and the maximum specimen current available will drop from its 2 ampere maximum. (see Front Panel Description item (9) for further details).

These considerations are especially important for high frequency operation (30/100 kHz). The impedance will be a function of resistance, capacitance and inductance. It will be necessary to minimise all these variables if it is desired to utilise the instrument over the full range of current.

Long signal cables can also lead to problems, especially with regard to induced pick-up and external sources of noise. An optional signal pre-amplifier is available from Matelect to counter this problem. All signal and power supply lines for the pre-amplifier are already present in the factory fitted front panel LEMO connector.

9. SETTING UP A TEST

This section is intended as a brief "getting started" procedure. No attempt has been made to cover detailed aspects of ACPD testing as further advice is readily available from Matelect and published literature.

It is assumed that users have first read, and become familiar with, the preceding sections of this manual before commencing a test. The settings suggested below are generalisations. Once experienced in the operation of the CGM-5R, users will be able to select and optimise their own settings as appropriate to the particular specimen configuration employed.

1. Connect the specimen using the method most suitable to the specimen and testing regime (see preceding section) and switch on the CGM-5R. If possible allow the instrument to warm up for a least 20 minutes. This is especially important if sensitive work is to be carried out and if the unit has been moved between areas differing in ambient temperature.

2. If employing a testing machine, it is sometimes a good idea to select the appropriate current, gain and frequency levels with the specimen away from the rig. Once this is done, the specimen can be positioned as appropriate and the settings reassessed.

3. Select the frequency of the alternating current. This choice will be influenced by the type of materials being tested. As an example choose 300 Hz for a mild steel. In general the higher frequencies are more suitable for observing surface phenomena such as crack initiation. For dynamic testing such as high cycle fatigue or impact testing, higher frequencies can assist in capturing the crack growth.

4. Choose a suitable current value. Begin at about 0.5 Amperes, and raise if required.

5. Choose the mode of operation - initially it is best to experiment in **AUTO** mode. **R**esistive mode (see General Usage Advice) is used in situations were lead movement can be a problem and were substantial amounts of induced pick up are present (e.g. long leads). **MAN**ual mode is not normally employed unless users are engaged in fundamental ACPD studies.

6. Wait for the CGM-5R to lock-in and note the value of the amplified ACPD signal on the front panel meter. Check that all fixed and variable offsets are switched out. Adjust the gain control until a signal of about 0.5 volts is observed. The current can also be adjusted in order to obtain this approximate signal level.

7. Use the variable offset control to zero the ACPD output if desired. This is not absolutely necessary but can aid the setting up of recording devices such as chart recorders. Note that if a scanning system is being used, the offset should not be employed as the value that has to be offset will invariably vary between signal channels.

8. Use the filter facility if engaged in long term testing or low cycle fatigue work.

9. Connect a suitable recording device (chart recorder, PC based acquisition card) to the **RECORDER** output, or use the **RS232** serial data facility. The choice of device will depend on the data acquisition rate and the type of signal that is being recorded. For long term monitoring, the RS232 link is ideal, whereas for fatigue studies, a chart recorder would be appropriate. For rapid crack growth (e.g. during impact studies) a transient recorder should be employed.

10. Begin the test, but assume that it will be necessary to modify the settings in light of your results!

10. GENERAL USAGE ADVICE

This section covers a number of topics mentioned earlier in the manual in greater detail together with other points of relevance. Users should note that further information is available from Matelect and from the published literature. It is assumed that the user has read and become familiar with the preceding chapters.

SIGNAL NOISE, GAIN, DRIFT AND RESOLUTION

In common with all measurement techniques, the minimisation of noise is important in ACPD work. The advanced design of the CGM-5R endows it with excellent noise immunity, but this can only be appreciated if sensible precautions have been taken to complement this feature. In particular, the gain of the amplification circuitry should be minimised. Always use the lowest gain setting possible by raising the supply current in preference to increasing the gain. A signal level of about 0.5 volts is a good starting point as it allows for a substantial increase in the ACPD before reaching the 2 volt autoranging point (which would otherwise lower the resolution by one decimal point).

Increasing the frequency will also raise the signal level, but this option can also lead to a greater susceptibility to pick-up and hence lead movement. Indeed it is possible that much of the increase in signal level that occurs with a rise in frequency is due to a larger induced pick-up component. The **R**esistive mode may then be preferable in order to remove much of the pick-up (see below).

The use of the filter facility can improve the noise performance somewhat and it should always be employed during long term testing or low cycle fatigue work.

In general, the measured noise on the analogue output signal with the filter applied is less than 200µV (at 70dB gain). When referred to the input (i.e. the gain is used to calculate the noise at the specimen), this figure amounts to less than 100nV. The long term drift of the CGM-5R has been measured at ±500µV in a 1V output, over a period of 200 hours (or 0.05%).

For a typical mild steel specimen, a change of approximately 1 volt can be expected for very 10mm change in crack depth (current = 2 amperes @ 3kHz, gain = 70dB). This, when combined with the drift figures, gives a crack growth sensitivity of 2E-8 mm/second over the long term. Over a few hours, however, the drift is lower and even this performance is improved.

THERMAL EFFECTS

The ACPD potential drop technique is sensitive to temperature variations. Temperature affects both the magnetic permeability and the resistivity of materials. Since these are factors determining the skin depth at any particular frequency, it is expected that the measured ACPD will also be a function of temperature. In general ACPD rises with temperature.

During normal room temperature testing it is unlikely that any errors will occur due to temperature changes. However if the ACPD is being measured during anisothermal testing (e.g. thermal fatigue studies) a correction will need to be applied. This is usually accomplished by using a referencing technique and computing a ratio which is independent of temperature. Users wishing to perform such tests should contact Matelect for further applications information (see Optional Equipment Section).

CALIBRATION

It is important to note that the value of the processed ACPD at any one time is of little use in the determination of crack depth except perhaps in carefully calibrated systems where the connection configuration is maintained rigidly between specimens. It is the change in the ACPD signal that is significant. It is therefore usual to perform calibration before testing commences so that a sensitivity to crack depth changes can be defined.

Calibration can be carried out simply by using an artificially introduced defect (e.g. a saw cut) and measuring the resultant changes in the ACPD. The calibration curve should be linear (unlike DCPD studies) and therefore only a small number of readings need be taken. A calibration can also be obtained using the specimen itself if, (for example), optical measurements are related to the ACPD values.

INDUCED PICK-UP AND RESISTIVE MODE

ACPD signals are by their very AC nature represented as vector quantities. Theory predicts that pure ACPD, as generated by passage of an AC current through a metal, will exhibit a phase difference of 45 degrees with respect to the actual current delivered to the specimen.

Unfortunately, the true ACPD is masked by the superposition of a second vector quantity. This vector represents the potential induced in the measurement leads by the current flowing in the supply leads. Theory predicts that this "pick up" vector lies at 90 degrees to the specimen current vector.

The resultant of the two vectors, is the actual ACPD as measured by an automatic phase lock loop detecting circuit within a standard CGM-5R (in **AUTO** mode).

The vectors are shown in the diagram overleaf. Two different pick-up vectors are indicated, for a particular true ACPD vector. It can be seen that these will give widely different ACPD readings. Since the magnitude of the pick-up vector will vary depending on the relative position of the supply and measurement leads, significant errors can occur in ACPD measurements.

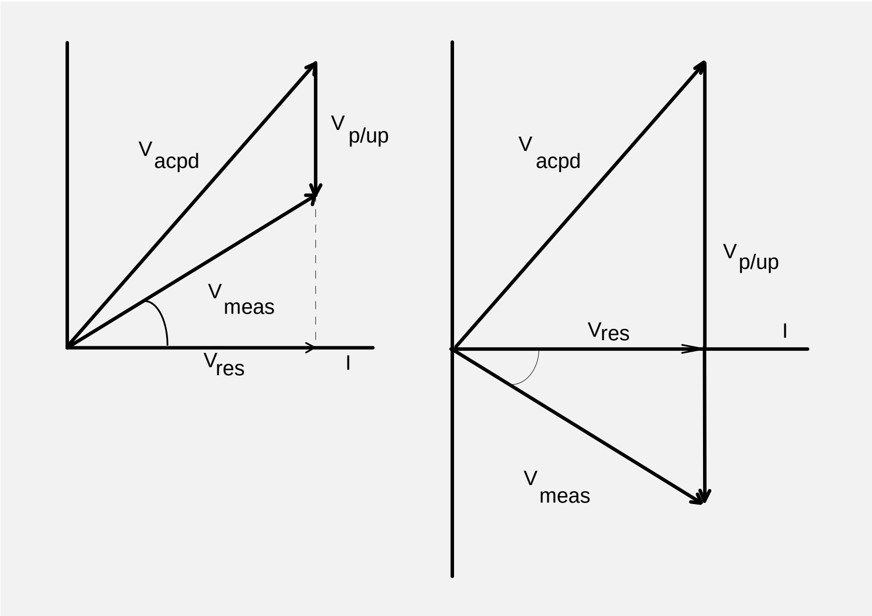


Fig. 15. The relative vectorial positions of signals in ACPD studies

The resistive or real portion of the ACPD signal lies along the specimen current vector, (i.e. they share the same phase). The magnitude of the **R**esistive vector does not change with a change in the magnitude of the pick-up. Monitoring the resistive ACPD will therefore theoretically confer an immunity to errors caused by variation in lead position.

The CGM-5R can be operated in **R**esistive mode, this being a refinement over the original CGM-5 design. In this mode the displayed ACPD value is actually that which is in-phase with the applied current and is therefore purely resistive.

In **R**esistive mode the readings are much less susceptible to lead movement. This is most marked at the lower operating frequencies (0.3 to 10kHz). At 30kHz and above, the advantage conferred by the **R**esistive mode reduces but it nevertheless remains worthwhile. This deterioration indicates that the simple theory given above may not describe the entire situation.

Users should not be surprised if a considerable reduction in signal amplitude is noticed between **AUTO** and **R**esistive modes. This indicates that much of the original processed signal is due to induced pick-up.

It is also possible to adjust a standard CGM-5 to operate under a resistive mode. This involves use of an oscilloscope and further advice can be obtained from Matelect.

CRACK DEPTH MEASUREMENT

The CGM-5R can be used in conjunction with a Matprobe hand held crack depth measuring probe in order to size cracks in the field. Detailed instructions for the operation of the Matprobe are given in its accompanying instruction manual.

Although it is always recommended to use a calibration curve in order to obtain accurate crack depths, users of the Matprobe can employ a rapid technique for the approximate assessment of crack depth. To this end, the CGM-5R is equipped with fixed offsets which are used in order to obtain a direct measure of crack depth on the front panel display meter.

The depth measurement procedure is reproduced below.

BASIC METHOD

1. Power up the CGM-5R and connect the Matprobe 2. Abrade and clean specimen surface
2. Apply Matprobe to surface and set the current to 0.5 Amps, gain to 70dBs and frequency to 10kHz for ferritic and 30kHz for non ferritic materials. Use AUTO mode, with no offsets applied and filter in OUT position
3. Apply Matprobe to surface, near to defect but not across it. Press down firmly until probe is seated flat. Wait for reading to stabilise and record it designate it "B"
4. Apply Matprobe across crack, record reading and designate "A"
5. Perform calculation (A-B)/B to give crack depth in cm.

MODIFIED METHOD

1. As above
2. As above except subsequently adjust the current supply potentiometer until the measured ACPD value reads 1.0000 volt (to the nearest 10 digits).
3. Operate the FIXED OFFSET switch and use the 1V setting
4. Apply Matprobe across crack and the reading obtained will be the depth ***in mm*** (since calculation is now (A-1)/1 and (A-1) is automatically generated by virtue of the fixed 1 volt offset that has been applied)

11. SPECIFICATIONS

GENERAL

The CGM-5R is a multi-frequency single channel alternating current potential drop system. It is housed in a portable enclosure and employs the phase sensitive detection technique to process potential drop signals generated by passage of an internally sourced, high stability alternating current.

ELECTRICAL SPECIFICATIONS

Current: High stability (better than 0.05%) infinitely variable current supply adjustable between Zero and 2 Amperes RMS max. via a ten turn potentiometer. Load regulation is better than 0.05%. The actual applied current can be monitored on the front panel display meter.

Frequency The frequency of the alternating current can be selected from one of 6 preset values of 0.3, 1, 3, 10, 30 and 100kHz, accurate to ±0.1% The stability of the frequency is better than 0.02% and the distortion is less than 0.1%.

Amplification The signal gain is adjustable in 10dB steps form 50 to 90dB, accurate to 0.1dB. The unit can be operated in three mode:

AUTO Automatic lock-in to ACPD signal
MANual Manual adjustment of phase sensitivity
Resistive Amplifiers sensitive to only resistive portion of signal

Lock-in time in **AUTO** mode is less than 10 seconds depending on phase of signal wrt current supply, but typically 3 seconds. Warm up time of amplifier is less than 5 minutes. 20 minutes recommended for gross temperature changes.

OUTPUTS

1. Processed ACPD and set current displayed on 4½ digit LCD meter, non backlit, wide viewing angle.
2. Analogue output of displayed voltage (± 5V) with facility for continuous offset adjustment.
3. Serial digital (RS232) output for computerised data acquisition. 9600 Baud. Mark (logic 1) -6.8V (through 3kOhm load). Space (logic 0) +6.8 V (through 3kOhm load). Short circuit current 21mA, slew rate 100V/µSec. Power consumption 95mW (through 3kOhm load), 77mW no load.
4. Internal switching signals available on rear panel **I/O** connector.

ADDITIONAL FEATURES

3 position filter control, with 3dB points at 80 and 0.67Hz. Fixed offsets of 1V and 100mV for use with hand held depth probes.
AUXilary power output for peripheral devices (e.g. scanner system)
Display **HOLD** facility Optional input pre-amplifier for long cable runs.
Separate **COM**mon and **EARTH** terminals.
Internal relay with user adjustable operating trip levels.

POWER

220-240 and 110-120 AC mains, 50 or 60 Hz line frequency. Input voltage range must be pre-selected by user. Input via earthed and fused IEC connector. Instrument can be specified with optional factory fitted battery power pack for special cases.

LINE FUSES

Two 20mm anti-surge 1 ampere fuses protect both Live and Neutral lines. Fuses located within IEC connector

DIMENSIONS

Without handle,
360 x 310 x 155 mm (W x D x H)

MECHANICAL

Cast aluminium frame with pressed aluminium alloy panels finished in standard RAL epoxy powder coat colours.
Adjustable tilt handle (3 positions). Optional padded aluminium carry case available.

OPERATING TEMPERATURE RANGE

0-40 Degrees Celsius for electronics.
10-35 Degrees Celsius for LCD display.

MASS 10kg
SEALING To IP20
STANDARD Constructed in accordance with CEI/IEC 1010-1 1990

12. PERIPHERAL EQUIPMENT

HARDWARE PERIPHERALS:

The CGM-5R can be expanded into a complete system for ACPD studies by addition of a number of hardware based peripherals.

MULTIPLEXING SYSTEMS: When it is desired to detect and record ACPD in multiple specimens or at multiple sites on a single specimen, it is necessary to multiplex (scan) between signal sources. To maintain sensitivity it may also be necessary to switch the current supply to the various locations. Variations in ACPD with temperature can also be compensated for by multiplexing reference and signal channels and subsequently performing a division of the two quantities to normalise for temperature fluctuations.

Automatic scanning systems: SM. series (SM1, SM2 and SC1 units)

Standard systems are assembled from combinations of 8 way signal switching and 8 way current switching modules, together with one overall controller module which permits control of the scanning parameters either under manual, internal (auto) or external (PC) supervision. Most applications require between 8 and 16 channel capability although the SM series of scanners is expandable up to 99 channels. High quality screened construction and locking LEMO connectors are used for all signal inputs and outputs.

Users who wish to monitor in excess of 32 channels are advised to contact Matelect to discuss the possibility of custom systems.

Automatic scanning systems for temperature compensation only (D2M-1 units)

A simple automatic method employing a two channel scanner can be used to compensate for temperature variations in the ACPD via a division normalisation technique. This is especially useful for single specimens undergoing anisothermal testing (e.g. thermal fatigue tests).

The D2M-1 unit can interface to both a PC (with appropriate software) and provide an analogue output of the normalised ACPD signal.

Manual Multiplexing units (M2M-1 and M6M-1)

These provide cost effective signal and current switching via high quality low noise manual switches mounted in metal enclosures. Terminals are provided for connection of the signal and current cables.

CRACK DEPTH MEASUREMENT PROBES

These optional items are used in conjunction with the CGM-5R to measure crack depth without the need to make permanent connection to a specimen. Spring loaded probes are used to form the electrical contact to the specimen. Two types of probe are available.

Matprobe 1 2 pin traditional ACPD depth probe with separate current lead complete with magnetic/toothed grip contacts.

Matprobe 2 Advanced 4 pin probe incorporating both current and voltage contacts in one unit. Probe is designed to enhance depth resolution and position sensitivity whilst minimising sensitivity to lead movement and specimen edge effects.

SOFTWARE OPTIONS:

A number of different software packages can be supplied by Matelect for data acquisition from the CGM series monitors. All the packages utilise the RS232 output socket located on the rear of the monitors. The following programs are available.

CGMlog A simple low cost, text based, single channel acquisition program.

CGMpeek1 A user friendly real time data acquisition and graphical display program with post plot facilities.

Other packages are available for use with our SM scanner system. These are:

CGMscan A text based acquisition and control program for up to 99 channels.

CGMpeek16 A 16 channel version of CGMpeek1 with multiple alarms and an independent random access channel sequencer for both voltage and current. DOS based with Windows 3.1 shell.

D2Msoft A text based program for controlling and reading the D2M-1 thermal compensation unit.

Utilities available to users wishing to perform their own programming include:

CGMSUB BASIC source code to read the CGM front panel.

CGMgraph A simple QuickBasic graph plotting program.

For end users who require bespoke software, Matelect provide a cost effective custom software facility. Existing programs can be modified or fresh code written to solve a particular applications problem.

Please contact Matelect for further details on all hardware and software options.

13. WARRANTY AND SERVICE INFORMATION

The following text is an extract from our standard conditions of sale. It covers the terms of warranty and liability only. Please refer to the full text, supplied upon delivery of the goods or contact Matelect Limited.

Extract 6. WARRANTY

Items sold by the company are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the company agrees to correct, whether by repair or, at it's election, by replacement, any defect of materials or workmanship which develops within twelve months after delivery of the instrument to it's original purchaser by the company or by any authorised representative provided that investigation and factory inspection by the company discloses that such defect developed under normal and proper use (unless covered by a separate agreement or guarantee written by the company).

The exceptions and conditions mentioned above are the following.

a). The company makes no warranty concerning components and accessories not manufactured by it. however, in the event of the failure of such components or accessory, the company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

b). The company shall be released from all obligations under it's warranty in the event of repairs or modifications being made by persons other than it's own or authorised service personnel unless such repairs by others are made with the written consent of the company or unless such repairs are minor or merely the installation of a new Matelect component.

c). The warranty is only valid providing that the terms of payment in clause 4 are strictly adhered to.

d). No product may be returned except with the company's permission in writing. After receiving factory authorisation, goods requiring repair or replacement should be sent prepaid to the factory in the original container properly packed accompanied by a Return Goods Authorisation, purchase order or letter stating as completely as possible the defects and the condition under which it occurred.

Extract 8. CONDITIONS PARAMOUNT

The company expressly disclaims any liability of whatsoever nature and in any circumstances whatsoever, to it's customers, dealers or agents, except as stated in the forgoing terms and conditions.

Extract 9. These terms and conditions of sale may be amended or altered at any time the company feel it necessary to do so.

REPAIR AND RECALIBRATION: Matelect Limited can repair and/or recalibrate instruments manufactured by it, after the warranty period has expired. If this service is required then please contact Matelect and we will be pleased to provide a quotation for the work necessary.

14. External Pre-amp Information ACPA-1 (option)

Features

The Matelect ACPA-1, is an external pre-amplifier unit for use with the Matelect CGM-5R series of crack growth monitors. It offers performance enhancements over the internal pre-amplification circuitry already built into these monitors, but its main use is as a local pre-amplifier unit to be employed for long signal cable runs and/or within electrically “noisy” environments. The principal features of the ACPA-1 are:

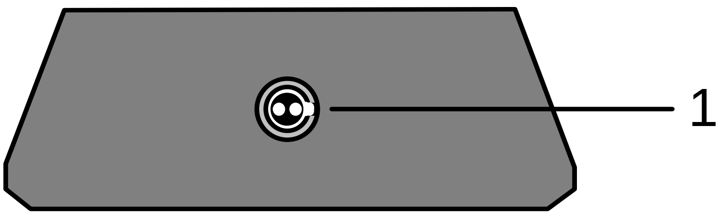
- Wide bandwidth
- High input impedance
- Bypasses internal pre-amplification circuitry

The ACPA-1 does not simply replicate the existing CGM, transformer based, front end pre-amplification circuitry in a self contained enclosure for local use. The bandwidth performance of the pre-amplifier is actually flatter than the pre-amplification circuitry of the CGM itself (which is bypassed automatically as soon as the ACPA unit is attached), but the chief advantage of the unit is its dramatically enhanced input impedance. This is due to the use of semiconductor rather than transformer based amplification techniques. A high input impedance is useful in ACPD studies especially if surface oxide films and poor contact to the specimen (of the signal wires) is likely.

System requirements

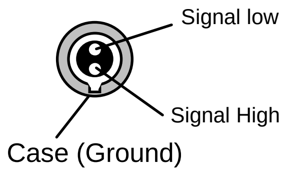
- The ACPA-1 can only be used with a CGM-5R certified for use with the ACPA-1
- The test specimen must be earthed through the socket provided on the front of the ACPA-1
- The ACPA-1 may only be used with MATELECT supplied cables

Front panel description

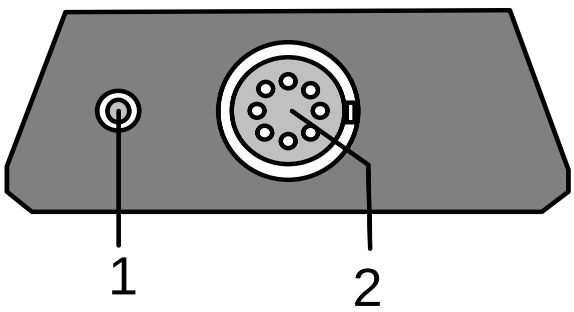


1. Input socket of ACPA-1
This is a 2 way LEMO type socket which accepts the corresponding LEMO plug.
The socket is polarised to prevent incorrect insertion of the signal plug. Insert the signal plug into this socket only when the red dots on both the plug and socket are aligned. If correct alignment of the plug and socket has been achieved, the insertion

force is minimal. Users *must not* force the plug into the socket, nor rotate the plug once inserted. The plug can be removed by grasping the knurled outer collar and squarely pulling the plug from the socket. Minimal force is required.



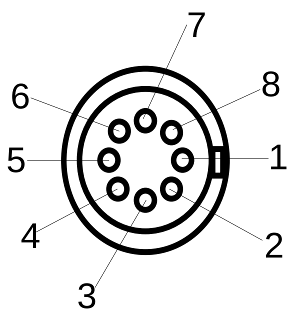
Rear panel description



1. Earth terminal
The specimen should be earthed to this terminal using a 4mm Banana plug and a short length of multi-strand wire. This will help to reduce electrical noise and prevent oscillations within the amplification circuitry.

2. Output socket
This is an 8 way LEMO type socket which accepts a corresponding LEMO plug, and is polarised to prevent incorrect mating. Insert the signal plug into this socket only when the red dots on both the plug and socket are aligned. If correct alignment of the plug and socket has been achieved, the insertion force is minimal. Users *must not* force the plug into the socket, nor rotate the plug once inserted. The plug can be removed by grasping the knurled outer collar and squarely pulling the plug from the socket. Minimal force is required.

The output socket is wired as follows (socket view):



pin 1. -12 V
pin 2. Power supply common
pin 3. NC .
pin 4. Signal out
pin 5. Signal common
pin 6. +12 V
pin 7. NC
pin 8. NC
CASE - Ground

Wiring instructions

Connect the ACPA-1 to the CGM-5R using the supplied ACPA-1 to CGM-5R cable (8 way to 8 way LEMO cable, see below). Next connect the specimen to the ACPA-1 using the supplied ACPA-1 to specimen cable (2 way LEMO connector to tinned copper twin).

Proceed with the set-up instructions as described in Chapters 8 & 9 of this manual.

Pre-amp cables

ACPA-1 to CGM-5R cable

ACPA-1 to specimen

General Information

Use only a slightly dampened cloth and mild detergent to clean the ACPA-1 system. Never use a solvent cleaner or any fluid.

Please note that there are no user serviceable parts within the ACPA-1. Never attempt to open the instrument case as this will void any warranty. Please contact Matelect should you ever experience any difficulties with the unit.