MATELECT LTD
ACPD Crack Growth Monitor
TYPE CGM7

INSTRUCTION MANUAL

ACPD CRACK GROWTH MONITOR
TYPE CGM7

Matelect has established itself as the world's foremost designer and manufacturer of stand-alone laboratory ACPD equipment. The CGM7 is the most advanced and highly specified ACPD instrument that Matelect produce. Its upper frequency and current capability have been greatly enhanced over earlier instruments and now make the CGM7 the first choice for demanding scientific and industrial applications. Matelect produce a range of peripherals to support the CGM7 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 CGM7 only. Manuals for earlier instruments can be obtained from Matelect, please contact us.

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 CGM7 system. Never use a solvent cleaner or any fluid. Please note that there are no user serviceable parts within the CGM7. Never attempt to open the instrument case as this will void any warranty. Please contact Matelect should you ever experience any difficulties.

MATELECT LTD

Telephone:	**+44 (0)1895 823 334**
Facsimile:	**+44 (0)1895 824 300**
E-mail:	**info@matelect.com**

MAINS OPERATION

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 CGM7 can be operated on both 110 and 220V supplies by appropriate selection on the input voltage switch (see page 16). 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 CGM7 is fitted with an equipment fuse for protection. The fuse is located in the IEC input socket on the rear panel of the CGM7.

The instrument fuse is rated at 3.15 Ampere (for 220V supplies) or 6.15 Ampere (for 110V supplies) and is of the 20mm "anti-surge" type. Never replace this with a fuse of a different type or rating as the instrument may suffer serious damage.

Ensure that the CGM7 does not come into contact with fluids or corrosive gases and that it is operated within the temperature range of 5-35 degrees C.

MATELECT LTD
ACPD CRACK GROWTH MONITOR
TYPE CGM7

CONTENTS

1. THE ACPD TECHNIQUE (AN OVERVIEW)

The Matelect CGM7 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 the latest and most advanced in Matelect's line of ACPD instruments, which began with the CGM-3, first produced in the early 1980's. The CGM7 was specially designed for demanding applications, such as detecting crack initiation in non-ferritic materials such as aluminium alloys, where much higher excitation currents and operating frequencies are required in order to obtain the required sensitivity.

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, see figure 1 below. If the correct area is chosen, defect initiation can be detected through monitoring the change in the measured ACPD. As a defect enlarges and propagates, the PD measured will increase and the voltage drop will be proportional to the defect depth within the specimen. Additionally, other changes in a material will alter the ACPD reading including the state of stress within the specimen.
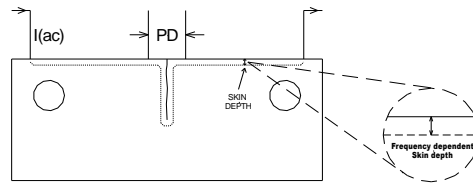

Fig 1. Basic ACPD setup.

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.

1.1 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, see diagram below. 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.
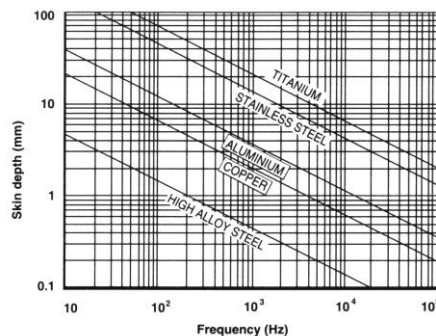

Fig 2. Skin depth v frequency for various materials.

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 improving the signal to noise ratio.

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 plants. 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. See Chapter 10 for further details.

It is usual for the current supply and voltage measurement contacts to be fixed on to 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 undertake the design and manufacture of probes systems for a particular testing need. Please see chapter 10 for further details.

One of the traditional difficulties with the ACPD technique has been the existence of the phenomenon 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. The superposition is a vector addition since AC signals are always treated as having both a phase and a magnitude. Unfortunately PU changes with an alteration of the relative position of the leads, thereby altering the overall measured potential drop. However this limitation can be easily overcome by preventing lead movement during a test.

The CGM7 can source a continuously variable alternating current of up to 5 amperes RMS over a continuously variable frequency range of 0.3 to 500kHz*. The equipment incorporates a very stable current source and a phase sensitive detection system (lock-in amplifier) for the measurement of the real and imaginary components of the ACPD with excellent rejection of extraneous noise. The CGM7 offers two channels of ACPD measurement each with separately adjustable signal offsets for both real and imaginary components as well as separately adjustable gain settings for each channel. Additional signal filtering can be applied, and both analogue and RS232 signal outputs of the signal quantities are provided. All functions and variables are adjusted using a single button and rotary dial control, with data being displayed by a backlit LCD. The CGM7 is micro controller based. Computer control of all functions of the CGM7 is achieved through its serial port and the use of dedicated software running in Microsoft Windows 95 or above.

---

* Dependent on model purchased.

2. A GENERAL DESCRIPTION OF THE CGM7

In essence, the CGM7 comprises a microprocessor based, constant current AC power supply in combination with a two channel sensitive lock-in amplifier. The amplifier incorporates phase sensitive detection circuitry, which permits extraction of the real and imaginary vector components of the ACPD signal. The resultant processed signals are digitised and displayed on the front panel graphics screen of the CGM7. The screen also displays the user set test parameters (current, frequency, gain, filter settings and offsets) and forms the interface through which those parameters are set (in conjunction with the front panel dial and button). The instrument is user friendly and setting parameters is simply a matter of navigating through a menu system.

The CGM7 utilises separate pre-amplifier units to greatly enhance signal sensitivity and immunity from extraneous noise sources. The preamplifiers should ideally be positioned close to the specimen under test.

The diagram below illustrates the basic CGM7 system, connected to a wide plate test specimen. Both channels of the instrument are utilised, one monitors the active defect site, whilst the second is used as a reference channel. In the post analysis of the results, data from the active channel is normalised (for example to remove the effect of temperature or stress) using the data from the reference channel. The system can be extended, by the addition of optional multiplexing modules, to enable multiple defect sites to be monitored.
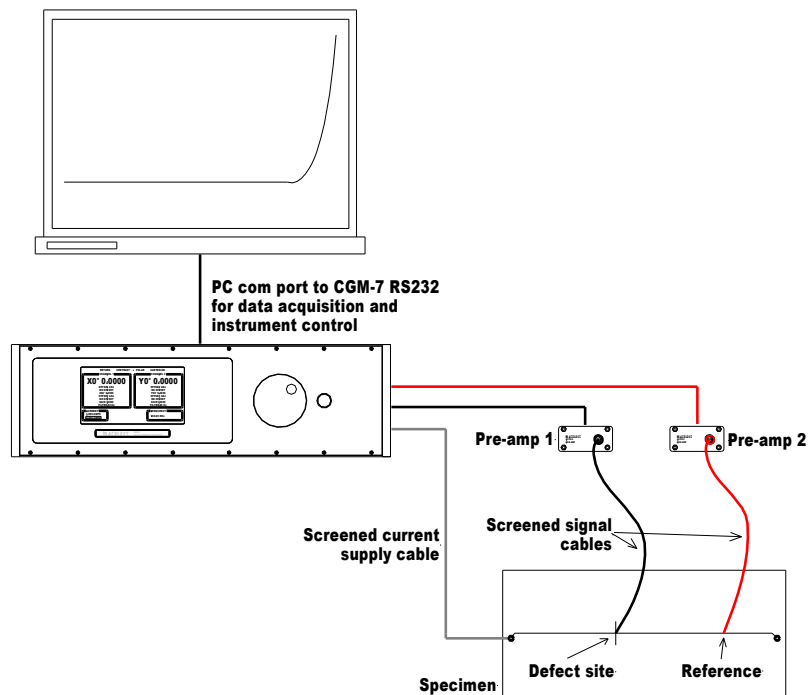
Fig 3. Block diagram of the CGM7 crack growth monitor

The microprocessor core of the CGM7 simplifies its connection to external personal computers for the acquisition and storage of the measured ACPD data. Additionally, the operation of the CGM7 can be controlled from a PC and all the test parameters can be set and adjusted under software control. Software is available as an option if computer control and acquisition is desired.

The cables required to connect the CGM7 to the specimen are supplied with the instrument and are illustrated opposite in Fig 4.

PC COM port to CGM7 RS232 socket

2 pin current output (CGM-7 to specimen)

mini 2 pin signal input (CGM-7 preamplifier to specimen connection) (2off)

8 pin preamp output to 8 pin CGM-7 input (2 off)

IEC mains input (CGM-7 to local mains plug)

Fig 4. Cables supplied with the CGM7

3. FRONT PANEL DESCRIPTION

The front panel layout of the CGM7 is shown below in Figure 5. The controls and menu functions of the unit are described fully on the next pages.
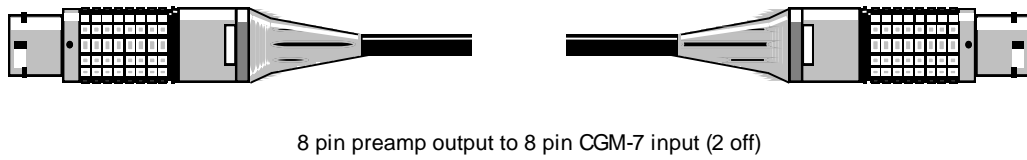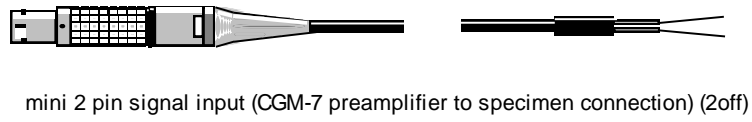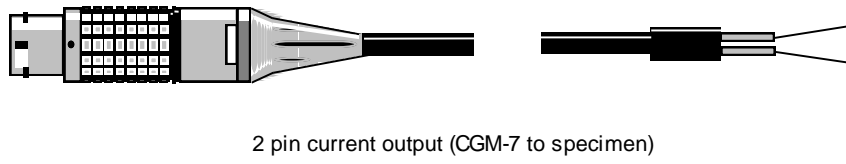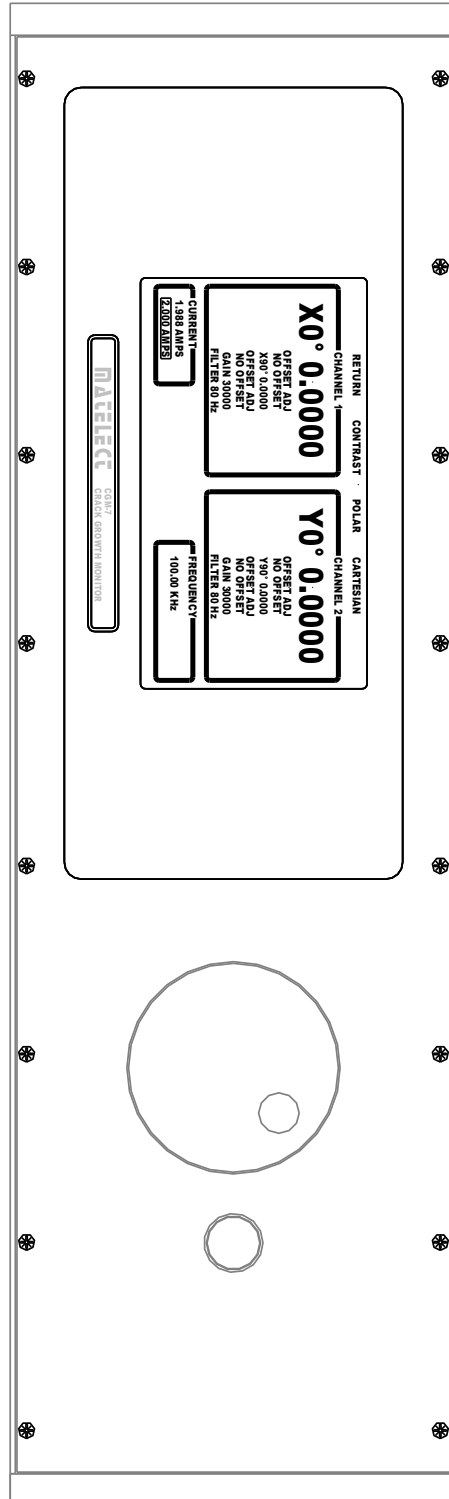

Fig 5. The front panel of the CGM7

3.1 Front panel display

The CGM7 utilises a backlit LCD graphics screen to display the measured ACPD values and indicate the levels of the set parameters such as excitation current and frequency. The Screen, as shown below in greater detail, is split into four windows along with a menu bar across the top, which is only displayed when the select button has been pressed.
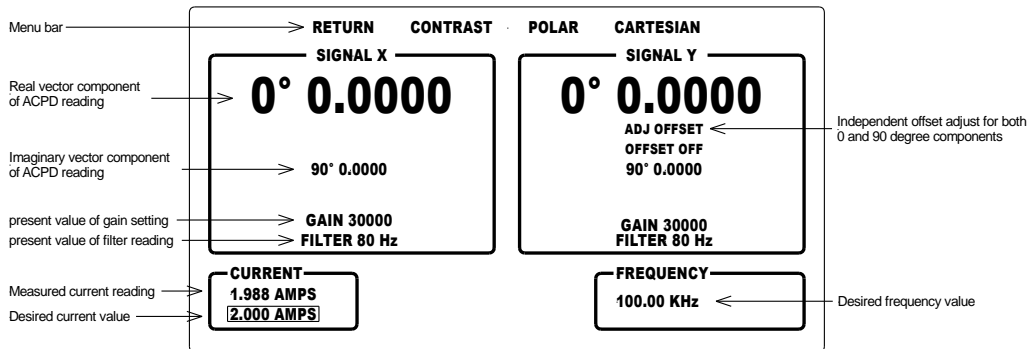
The current and frequency windows allow the user to set the excitation parameters of the specimen connected to the instrument. The remaining two windows channel x and channel y adjust the signal reading parameters from the specimen.

In order to adjust any of the parameters the following actions will need to be performed.

- Press the SELECT button once. The above window will be displayed with the menu bar shown above. (Remember this is not shown if the button has not been pressed.)
- Using the dial scroll to the desired parameter.
- Press the SELECT button again
- Adjust the parameter as required using the dial.
- Press the Select button once more, the menu bar should now have disappeared.

If either of the signals reaches saturation then the respective window will flash informing the user of a problem. Should the current compliance limit be reached, ie the unit is unable to pass the requested current then the current window will also flash.

3.2 Menu bar

The Menu bar has the following settings,

- Return – This returns the user to RUN mode. Although the instrument is always in run mode even when parameters are being set up. However the instrument does not maintain the same data O/P rate during parameter set-up.
- Contrast – This allows the user to adjust the screen contrast. Please note that if the units temperature changes drastically over time then the contrast may need to be readjusted.
- Polar – The unit defaults to display readings in Cartesian, however should the user wish to view the readings in polar simply select this option. This will change both Channel X and Channel Y at the same time.
- Cartesian – This will cause the unit to display the results in Cartesian.

3.3 Current window

The excitation current can be adjusted from 0.040 Amps to 5* Amps in 1mA increments. There are two values shown in this window. The bottom value is set by the user in 1mA increments and displays the current set by the user. The Value shown above is the actual

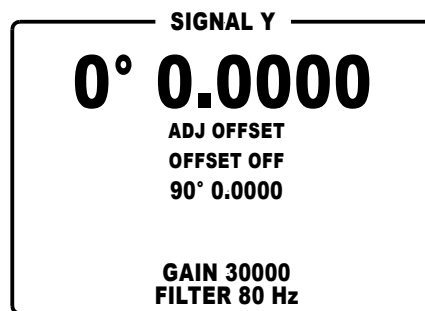---

* Dependent on model purchased.

value being driven across the specimen. It normally takes 1 to 2 seconds to reach the desired value on standard CGM7 models, however on some CGM7 models it may take longer especially on the ultra low frequency model which can go to as low as 8 Hz.

3.4 Frequency window

The frequency window allows the user to adjust the excitation current frequency in 1 Hz increments. The frequency can be adjusted between 300Hz and 500kHz*. Matelect also produce an ultra low frequency model capable of 8Hz, when using this particular model adjustment of the frequency may sometimes momentarily affect the current readings especially at the lower frequency range, this is normal and due to the very sensitive power amplifier used in this model.

3.5 Channel X and Channel Y windows

Each signal window displays the following parameters and readings.

```
┌──────── SIGNAL Y ────────┐
│                          │
│   0°  0.0000             │
│        ADJ OFFSET        │
│        OFFSET OFF        │
│        90˚ 0.0000        │
│                          │
│                          │
│       GAIN 30000         │
│       FILTER 80 Hz       │
└──────────────────────────┘
```

- **0° Reading** (Real vector component). If the user has chosen polar co-ordinates then this will display the magnitude reading.
- **Offset adjust.** To add an offset to the real vector signal, highlight ADJ OFFSET this will allow you to add an offset within the range of +/- 4v, If the user exceeds the signal range of the unit (+/- 4v) then the outline of the box will flash. When an offset has been set this will be displayed just under the signal reading.
- **90° Reading** (Imaginary vector component). If the user has chosen polar co-ordinates then this will display the phase angle reading.
- **Offset adjust.** To add an offset to the imaginary vector signal highlight ADJ OFFSET this will allow you to add an offset within the range of +/- 4v, If the user exceeds the signal range of the unit (+/- 4v) then the outline of the box will flash. When an offset has been set this will be displayed just under the signal reading.
- **Gain setting** [1000,1500,2000,3000,5000,7500,10000,15000,20000,30000]
  The gain can be set to any of the above values. Please note that the gain applies to both the 0° and 90° readings.
- **Filter setting** [None,0.1Hz,80Hz,1kHz]
  The filter settings apply to both the 0° and 90° readings.

12

4. REAR PANEL DESCRIPTION

The rear panel of the CGM7 is shown below in Figure 6. The various functions provided via the rear panel are described fully in this section. For further technical information please refer to the sections entitled General Usage Advice and Specifications.
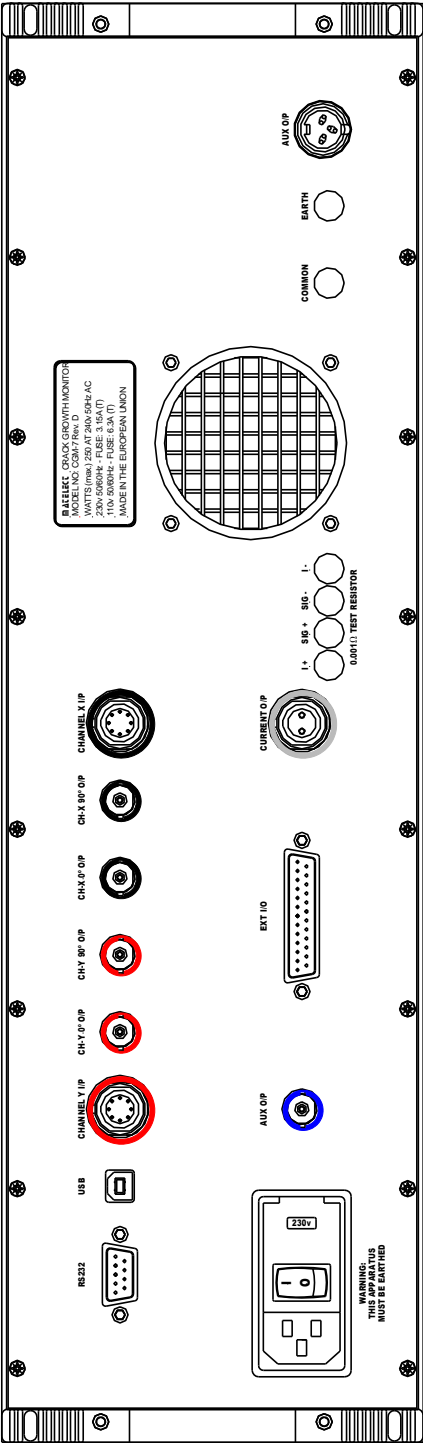

Fig 6. Rear Panel of the CGM7

4.1 RS232 Interface socket

This is a 9 way D connector with male (pin) contacts. It provides a serial digital output of all the various ACPD voltages (as indicated on the front panel graphics screen), together with information regarding the status and value of all the set parameters. 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 can be interpreted and then displayed, stored or manipulated by the program as appropriate. The serial interface also permits the remote control of all CGM7 parameters.

A standard RS232 communication protocol is implemented on the interface but the instrumental interrogation and control protocols are specific to the instrument. Matelect can supply these protocols to end-users who wish to write their own communication software. Matelect also supply dedicated software for instrument control and data acquisition please see chapter 10.

4.2 USB Interface Socket

In order to use the USB connection in place of the RS232, first install the Matelect CGM-7 USB drivers before connecting the CGM-7 to your computer. A CD will have been sent out with your unit, follow the instructions on the face of the CD to install the drivers. If you receive a warning that the drivers have not been 'Signed' or 'Windows validated' please ignore the warning and proceed. Once installed you will see that a com port has been added to your system, please make a note of this com port number as you will need to select the correct com port when using 'PDsoft'. If you need to find the com port number in the future simply go to 'Control panel' then 'Device manager', looking under the 'Ports' section you will find the unit marked as 'Matelect Ltd CGM-7' with a COM port number in brackets.

Once the drivers have been installed you may connect the CGM-7 to the computer.

4.3 Pre-amplifier (ACPR-3) signal input sockets

These are 8 way LEMO type sockets, which accept the corresponding LEMO plug of the pre-amplifier cable. Each socket is polarised to prevent incorrect insertion of its plug. Users should 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 sockets are wired as follows:
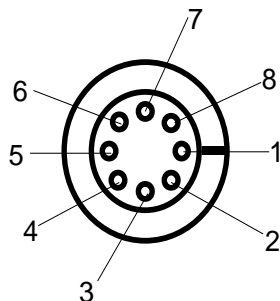

```
pin 1.  -12 V
pin 2.  Power supply common
pin 3.  NC.
pin 4.  Signal out
pin 5.  Signal common
pin 6.  +12 V
pin 7.  NC
pin 8.  NC
CASE.  Earth
```

Fig 7. Connections to the CGM7 pre-amplifier signal input socket

Two contacts (pin 4 and 5) serve to carry the pre-amplified input signals from the relevant ACPR-2 pre-amplifier, whilst the other contacts are used to power the pre-amplifier itself. Only ACPR-2 units (or other approved Matelect peripherals) should be connected to these sockets - do not attempt to feed ACPD signals directly into the pre-amplifier input socket.

4.4 AUX O/P socket
The CGM-7 has an auxiliary output socket which the user may use for any requirement they have, for example, it could be used to give an analogue output proportional to crack length.
It has a voltage range of 0 to 10 volts and a resolution of 0.00015 volts.
The user will need to use PDsoft or develop their own software in order to control this output. The demo version of PDsoft available from our website can be used to control the auxiliary output, see the PDsoft manual for further information.

4.5 Analogue output sockets
Four BNC type analogue output sockets are located on the rear panel of the CGM7. These provide the end user with buffered analogue signals of the in-phase (real) and quadrature (imaginary) components of the ACPD signal (for both channels). The analogue outputs effectively constitute the amplified and processed ACPD signals and mirror the values of the ACPD signals as shown on the front panel graphics screen[*]. If the end-user has implemented the filter functions then the analogue outputs will also be filtered according to the values selected.

Although the analogue outputs from these sockets match those on the LCD front graphics screen, it should be noted that the ACPD readings on the screen are refreshed only a few times a second and those of the RS232 link at about 10 times a second. In contrast, the changes in the analogue outputs are dependent only on the bandwidth of the instrument (and the particular filter setting chosen).

The analogue outputs are suitable for use with data recorders or computer based A-D systems. End-users should choose this method of acquisition if a fast response is required (e.g. if rapid crack growth or impact phenomena are being studied). The RS232 serial link (in conjunction with appropriate software) is used to record the ACPD data if a fast response speed is not a requirement.

Although the front panel graphics screen displays DC voltage components, it must be remembered that true ACPD voltages are alternating in nature (and thus vary in amplitude with respect to time, and also contain phase information). The circuitry within the CGM7 has, in essence, generated a DC representation of the AC signal voltages via a form of rectification. The filter facility (if selected) then smoothes the rectified signal and the slow response of the front panel meter smoothes it further. It is, however, possible to record the un-smoothed (but rectified) signal via the analogue outputs.
If a recording device with suitable bandwidth (e.g. an oscilloscope) is connected to an analogue output then the un-smoothed signal can be observed (if the filters are set to NONE). The output waveforms will generally take on the form shown in Figure 8 below.

If a chart recorder is performing data acquisition then it is unlikely that the device will have sufficient bandwidth to observe the various analogue waveforms, even at the lower AC frequencies permitted by the CGM7. Users of wider bandwidth instrumentation (e.g. oscilloscopes or fast A-D boards) should, however be aware of the waveforms that can be observed.

---

[*] Please note the BNC outputs always output the Cartesian values, even if the user has selected polar coordinates the output of the BNC's will be Cartesian.
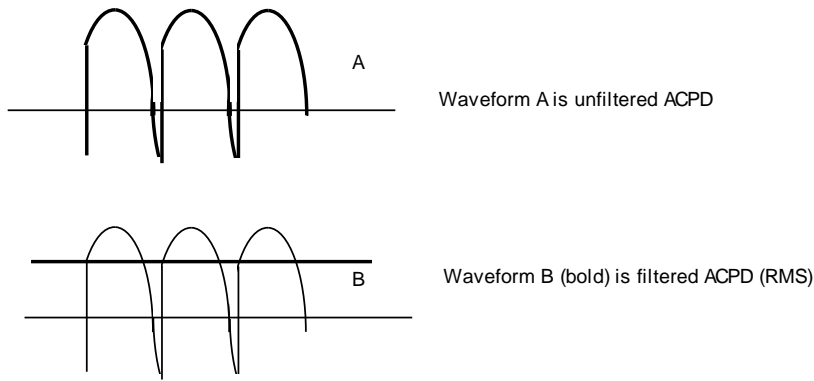
*Fig 8. Typical waveforms from the **analogue** output sockets using an oscilloscope*

The centre pin of each analogue output socket carries the signal whilst the outer case is connected to the circuit common of the CGM7. The outer case of the connectors is isolated from the earth/ground of the instrument.

4.6 Mains input socket & voltage selector switch

The socket is of the standard IEC mains input type with integral line filter, mains switch, mains fuse and voltage selector. A suitable lead, terminated with a local mains plug, will have been supplied with the CGM7. If this is missing, only use an approved mains IEC connector as a replacement.

The instrument is fitted with one 1.5-Ampere anti-surge 20mm fuse (for 220V supplies) or one 3-Ampere anti-surge fuse (for 110V supplies). If this fails, then the equipment should be disconnected from the mains supply, and the fuse replaced with one of the same rating and type. DO NOT use a fuse of a higher rating as permanent damage may result to the CGM7. The fuse is 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 fuse 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.

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

The switch permits the CGM7 to be used with either 110-120 or 220-240 mains supplies. The CGM7 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. The flat blade of a screwdriver should be inserted into the slot on the outside of the mains input socket and used to gently lift up the flap, this exposes a large red block, using the flat blade of the screwdriver gently remove the red block and rotate it 180 degrees and re-insert to change the voltage range. Push down the flap until secure. A cut-out in the flap shows the voltage range selected.

CARE! Disconnect the unit from the mains supply before altering the position of the switch. Operation of the CGM7 with this switch incorrectly positioned will cause serious permanent damage to the unit.

16

4.7 EXT I/O

This is a 25 way D-type connector. It provides parallel digital I/O to the CGM-7's internal microprocessor. This connector is used to control peripheral devices such as the SM1-HF and SM2-HF scanners.
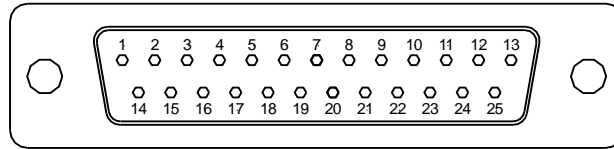
Pin No	Function
1	Voltage address bit 7 (MSB).
14	Voltage address bit 6
2	Voltage address bit 5
15	Voltage address bit 4
3	Voltage address bit 1
16	Voltage address bit 2
4	Voltage address bit 3
17	Voltage address bit 0 (LSB)
5	Current address bit 1
18	Current address bit 3
6	Current address bit 0 (LSB)
19	Current address bit 2
7	+5 Volt system supply
20	EARTH
8	+5 Volt system supply
21	EARTH
9	Current address bit 5
22	Current address bit 6
10	Current address bit 4
23	Current address bit 7 (MSB)
11	MAT-4 Hand held probe reading switch
24	Voltage mux. enable (active high logic)
12	Current mux. enable (active high logic)
25	0 volt
13	0 volt

CARE! Do not connect any non-Matelect equipment to this port or damage may occur.

4.8 Current output socket

The alternating current delivered to the specimen is sourced from this 2 pin latching LEMO socket. An appropriate mating lead is supplied with each CGM7. The socket is polarised to prevent incorrect insertion of the mating plug. The current supply lead should be plugged 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 current socket is wired as follows:
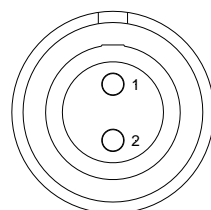
Pin 1. Current output (centre cores of cable)
Pin 2. Current return (screen of cable)
LEMO case is earthed

Fig 9. The current output socket

4.9 0.001 TEST Resistor

The CGM-7 has a built in high precision 0.001 ohm test resistor, this can be accessed from the rear panel and is used by Matelect for testing purposes before the units are sent out. Users should not attempt to connect to this resistor without first seeking guidance from Matelect.

4.10 Common terminal

The circuit common line is available at this terminal. Connection to this terminal can be made using 4mm banana plugs or by unscrewing the terminals and trapping a suitable wire underneath. The circuit common of the CGM7 is electrically isolated from the case Earth. If it is desired to connect common to Earth, a wire link can be used between the terminal and the adjoining **EARTH** terminal (item (3) below).

Isolation of the common is useful if external peripherals such as chart recorders are connected to the CGM7. If their signal common is connected to Earth, an earth loop could occur, should the CGM7's common also be connected to Earth. Such loops are sources of signal instability and should therefore be avoided.

4.11 EARTH terminal

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

4.12 Auxiliary output socket

This socket is used to power peripheral instrumentation that can be connected to the CGM7, for example, the SM signal multiplexing system. The socket is wired as follows.

Pin 1. positive 12 V regulated 400mA max.
Pin 2. circuit common
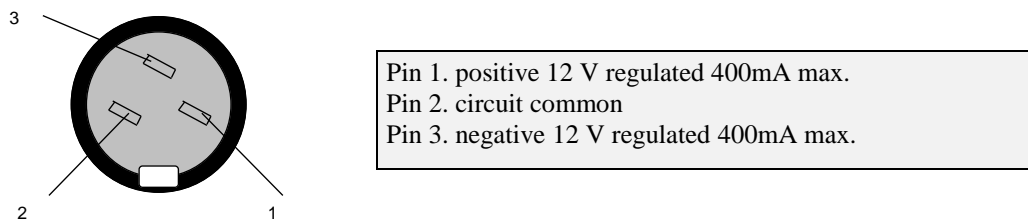Pin 3. negative 12 V regulated 400mA max.

Fig 10 Auxiliary output socket

The auxiliary supply is at 12V DC and is regulated. The outputs are current limited to prevent damage to the CGM7 should a short circuit occur.

18

5. EXTERNAL PRE-AMPLIFIERS

The Matelect CGM7 is supplied with two ACPR-3 external pre-amplifier units. These are semiconductor-based pre-amplifiers with a fixed gain of 500. A separate pre-amplifier based system is especially useful in noisy testing environments, or when long signal cable runs are employed. The units are equipped with a high input impedance which improves the ability of the ACPD system to deal with poor, or oxidised signal contacts and very fine signal wires (such as often employed in high temperature testing applications).

The preamplifiers have colour-coded sockets. Although they are interchangeable, the colour coding should be followed as this enables the end-user to quickly identify the signal sources. Only the supplied Matelect lead should be used to connect the ACPR-3 to the CGM7. End-users should contact Matelect if longer interconnecting lead lengths are required. The front panel of the ACPR-3 is shown below in Figure 11.
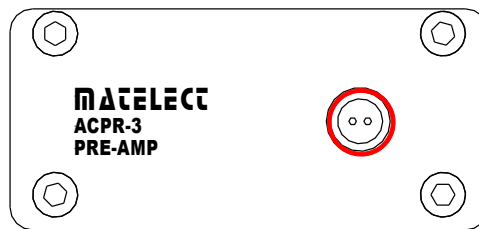
Fig 11. Front panel of the ACPR-3 preamplifier unit

5.1 Input socket
The signal input socket is a 2 way LEMO type which accepts the corresponding LEMO plug on the specimen connections leads (supplied with the CGM7).

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. Wiring is as follows:

Fig 12 Preamp signal input socket

The rear panel of the ACPR-3 is shown below in Figure 13.
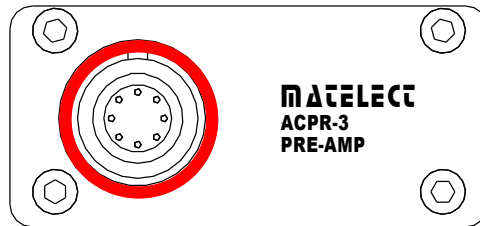
Fig. 13 Rear panel of the ACPR-3 preamplifier unit

The rear panel is fitted with either one or two connectors depending on the model:

5.2 Earth terminal (depending on model)

In order to help reduce electrical noise and prevent oscillations within the amplification circuitry, the pre-amplifier's circuit common ideally needs to be connected to the specimen. This connection can be made anywhere on the specimen, but ideally close to one of t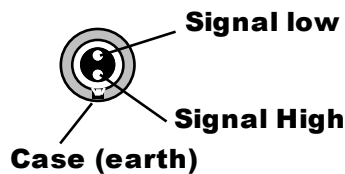he current supply connections (see the system schematic in Fig 1). A 4mm banana plug and a short length of multi-strand wire forms an ideal earthing lead.

5.3 Output socket

This is an 8 way LEMO type socket which accepts the corresponding LEMO plug on the ACPR-2 to CGM7 interconnecting lead. It 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):
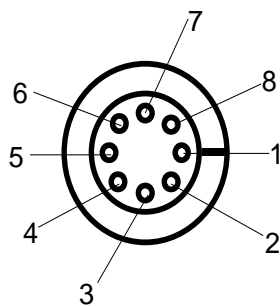
pin 1. -12 V
pin 2. Power supply common
pin 3. NC.
pin 4. Signal out
pin 5. Signal common
pin 6. +12 V
pin 7. NC
pin 8. NC
CASE - Earth

Fig 14. preamp output socket

6. MAKING 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 normally required to a specimen for ACPD testing, 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. 15 below.
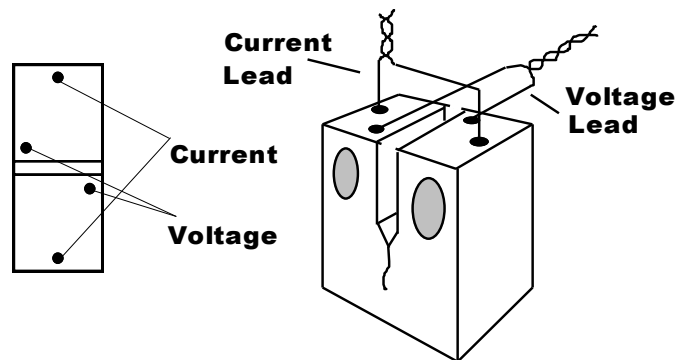

Fig 15. General ACPD connection locations

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 lead should be positioned such that the current path encloses the crack or defect site. 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. If a reference channel (e.g. for post-test normalisation of temperature and stress effects) is required, then this should be sited on the specimen so that the current flow past the defect site also passes largely through the reference site. This will help set the initial ratio of signal levels (of active wrt reference) close to 1 so that the normalisable effects are similar in magnitude. It is, of course, possible to adjust the relative ratio between active and reference channels by utilising the individual gain control (see later), however it is always preferable to minimise the discrepancy between gain settings in order to prevent one channel from becoming over-sensitive to signal noise.

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.

To reduce the actual magnitude of the pick-up voltage it is important to tightly twist the leads (as shown above). 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.
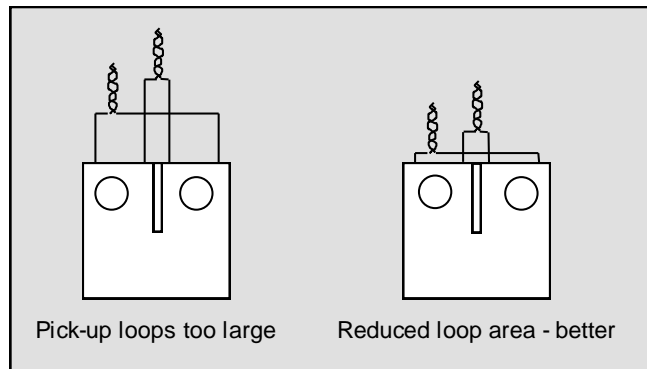

Pick-up loops too large   Reduced loop area - better

Fig 16. 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 if inadvertently implemented. Further details of this advanced technique can be obtained from Matelect but the general concept behind current focusing can be seen in Figure 1 above, where the return current lead passes *across* the crack and reference site.

Excessive length to the current supply cable can seriously degrade the performance of the ACPD system. If it is found necessary to extend the factory supplied cable or substitute different cable 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 rated maximum.

These considerations are especially important for high frequency operation (e.g. above 10 kHz). The impedance will be a function of the resistance, capacitance and inductance of the cable. It will be necessary to optimise 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. The ACPR-2 preamplifiers largely minimise this problem but it is still important to site the pre-amplifiers themselves close to the specimen or their advantage will be lost.

22

7. 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. The CGM7 offers extensive opportunities for end-user configuration and the section that follows is aimed at indicating how the instrument can be set up, rather than providing the definitive guide to all menu options. Once familiar with the basic operating interface of the machine, end-users should feel free to experiment with the menu options at will. No damage can be done to the instrument through incorrect or inappropriate menu selections. As will be seen from the following section, navigation is straightforward and intuitive and parameter setting is simplicity itself.

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 CGM7, users will be able to select and optimise their own settings as appropriate to the particular specimen configuration employed.

The user should consult the Specifications section in this manual to determine the limits of the parameter setting on the CGM7. Some parameters (e.g. excitation current) are adjustable in fine increments and appear essentially as continuously variable, whereas others (e.g. signal gain and filter cut-off frequency) are fixed menu options of quantised levels.

1. Connect the specimen using the method most suitable to the specimen and testing regime (see preceding section and also refer to Figure 3). Connection is probably the single most critical item to the success of an ACPD test (apart from the choice of instrument!). A poor connection regime can easily make the difference between success an failure. In recognition of this, end-users are encouraged to spend time on this aspect of their work and also to contact Matelect to discuss their particular application.

2. Connect the CGM7 to the mains supply and switch on using at the rear panel IEC socket. 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.

3. If employing a testing machine, it is sometimes a good idea to perform bench testing and 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.

4. Select the test parameters as follows:
From the initial power-up screen press the SELECT button once. The graphics display will then switch from TEST mode to SET mode and hence allow parameter adjustment. Rotation of the SCROLL knob will allow navigation between the various set-able parameters. The upper row of controls, for example, relate to the display options - for example the contrast setting of the display itself. To change the contrast, use the SCROLL knob to highlight the CONTRAST menu item. Once highlighted, the SELECT button should be depressed to enter the adjustment mode. The SCROLL knob can then be rotated to the desired contrast setting. Once chosen, the setting is stored by a final push on the SELECT button.

In this way all the test parameters can be set up quickly.

The following diagram illustrates the significance of the various display-able parameters:
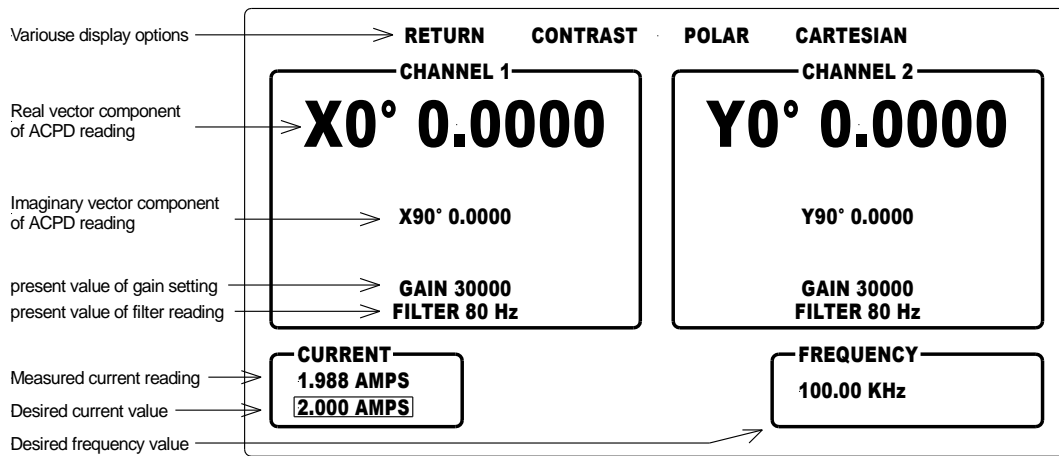
Variouse display options → RETURN   CONTRAST   POLAR   CARTESIAN

CHANNEL 1 —
Real vector component of ACPD reading → **X0° 0.0000**

CHANNEL 2 —
Y0° 0.0000

Imaginary vector component of ACPD reading → X90° 0.0000   Y90° 0.0000

present value of gain setting → **GAIN 30000**   **GAIN 30000**
present value of filter reading → **FILTER 80 Hz**   **FILTER 80 Hz**

CURRENT ———
Measured current reading → 1.988 AMPS
Desired current value → 2.000 AMPS

FREQUENCY ———
100.00 KHz

Desired frequency value —

Fig 17. System screens

The signal magnitudes that are obtained from a specimen during ACPD studies are strongly dependant upon the chosen levels of the set-able parameters. Frequency of the AC excitation current has a strong effect and it perhaps the frequency that the end user should set first.

The level chosen will be influenced by the type of material being tested and sensitivity to surface defects required. As an example choose 0.3 kHz 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 low cycle fatigue or impact testing, higher frequencies can also assist in capturing the crack growth. The choice is not trivial and inexperienced end-users are invited to contact Matelect for further advice.

Adjustment of the frequency is performed in the same way as for the display options described above - the SELECT button is pushed once to enter SET mode, and the FREQUENCY window is highlighted by use of the SCROLL control. One push on the SELECT button then allows editing of the frequency value. Clockwise rotation of the SCROLL control raises the value and anticlockwise rotation lowers it. The SCROLL knob has and acceleration facility which responds to the speed of rotation of the knob itself. This facility allows rapid changes in the decade value of the frequency to be achieved whilst also permitting fine adjustments. Impatient users should note that too rapid a rotation will actually slow the machine's response!

Once a frequency is chosen, a suitable excitation current value can be selected. The choice of current also influences the ACPD signal levels obtained, but in a linear fashion (unlike changes in frequency). Generally, the current should be adjusted so that the signal levels of interest are of a reasonable magnitude, e.g. 0.5000 to 1.0000 volts. Too high an initial value will cause the CGM7 to saturate (this will occur even if the initial voltage has been offset as described below). About 0.5 Amperes is adequate for a typically instrumented steel CT specimen at 0.3 kHz, but aluminium alloy specimens may require 3-4 amperes at higher frequencies. Further information is given in the following chapter on General Usage Advice.

Select a value of the GAIN setting. The CGM7 offers separate signal gains on each channel. The signal gain on a particular channel will be applied equally to both the real (in-phase) and imaginary (quadrature) ACPD components. The effect of adjusting the gain setting is similar to that of changing the excitation current. Higher gains obviously generate larger signal magnitudes but also amplify the noise in the system. In this respect it is usually better to

increase signal levels by first raising the current and then raising the gain if further amplification is required.

It is important to note that the signal gain, excitation current magnitude and frequency setting all define the ultimate ACPD signal level. The CGM7 offers considerable dynamic ranges of these quantities and whilst this can ensure decent signal levels from non-ferrous, highly conductive metals, it is perfectly possible, however, for the end-user to overdo the settings and saturate the amplification stages of the instrument. If this is done, a warning flag will appear in the centre of the graphics screen for the appropriate channel. The signal gain, current or frequency (in that order) should then be dropped to remove this flag. Users should also note that this flag could appear during a test (see General Usage section). The flag signifies that the ACPD signal has exceeded about 2.5 Volts.

Separate offset control is available on all four ACPD vectors measured by the CGM7. The values of the offsets are set in exactly the same way as for the frequency and the current described above. Highlighting the offset windows below each of the ACPD vector displays, and pressing the SELECT button, will bring up a small menu, with ZERO OFFSET and ADJUST OFFSET options. The SCROLL knob can be used to cycle between these and the SELECT button enters the function chosen. If ADJUST OFFSET is selected, then the SCROLL button can once again be used to change the set parameter's value. A final push on the SELECT button completes the adjustment and returns the user to the TEST mode and screen.

*The need for offset adjustment is a matter of personal taste. Some users will prefer to begin their tests from a near zero position so that changes in the ACPD can be displayed directly. However it is important to note that the signal offsets are implemented **after** the signal has been amplified. The consequences of this are important and are discussed further in the section on General Usage Advice.*

Finally, the FILTER setting should be chosen. Users should employ the filter facility if they are engaged in long term testing or high cycle fatigue work, where rapid changes in crack growth are not expected. Conversely a MIN setting would be required, for example, if the raw, un-smoothed ACPD signal is being recorded on fast data acquisition equipment or transient recorders. Feeding the analogue signal into slow A-D equipment, on the MIN filter setting should be avoided as this will normally generate the appearence of a noisy signal. This is because the A-D sample rate is not syncronized with any particular point on the signal waveform and data points will therefore be sampled at inconsistent points.

5. Once the parameters have been chosen, the instrument should be returned to TEST mode. A suitable recording device (e.g. chart recorder, PC based acquisition card) can then be connected to the desired analogue output(s) and/or the RS232 serial link (with appropriate software) can be employed. The choice of recording device will obviously depend on the data acquisition rate and the type of signal that is being recorded. For long term monitoring, or fatigue studies, the RS232 link or a data recorder would be appropriate. For rapid crack growth (e.g. during impact studies) a transient recorder should be employed.

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

8. 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.

8.1 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 CGM7 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 its attainment usually signifies a suitable choice of frequency, current and gain. It also leaves sufficient headroom for the signal to increase (which is to be expected as a defect propagates) without prematurely reaching the saturation point of the amplification circuitry. If the saturation flag appears mid-test then there is little that can be done except to reduce the signal gain or excitation current level. Be sure to make a careful note of the changes so that algebraic correction can be made in the post processing of the results.

In the previous section it was noted that the signal offsets are applied after the amplification of the signal has been performed. This is significant because it highlights a subtle difference between offsets as applied in other scientific instruments (e.g. chart recorders). In such a case, an offset is used to reduce the signal level so that further amplification can be applied - this process has the effect of boosting instrumental sensitivity so that tiny changes in a large steady signal can be detected (but it also boosts the noise levels by a similar argument). The CGM7 offsets behave differently - they are applied to the signal *after* amplification and therefore *cannot* be used to boost sensitivity. Their only purpose is to provide a convenient zero point from which ACPD changes during a test can be easily seen.

Furthermore, because an offset is applied after amplification, it cannot be used to prevent or delay saturation of the instrument (if the too high a value has been selected for the frequency/current/gain settings). Thus it is perfectly possible to generate a saturated amplifier flag with the signal magnitude *apparently* well below the saturation level (of about 2.5 volts).

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. In theory, the in-phase component of the ACPD signal (signified as 0^0 on the graphics screen) should be independent of the pick-up problem but the limits of this theoretical ideal remain a research topic.

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

For a typical mild steel specimen, a change of approximately 1 volt can be expected for every 10mm change in crack depth (current = 2 amperes @ 3kHz, gain = 3000X). This, when combined with the drift figures of the instrument, gives a crack growth sensitivity of 0.2 microns/second over the long term. Over a few hours, however, the drift is lower and even this performance is improved.

8.2 Thermal Effects

The ACPD 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. The second channel on the CGM7 is ideally suited to the recording of an ACPD reference signal which can be applied during the post processing of the results to correct for temperature variations.

Users should also note that stress can affect the value of the measured ACPD value. It is theoretically possible to use the reference technique to normalise for stress effects. However, normalisation relies upon the fact that changes in one channel equally affect changes in the other and it is likely that a propagating defect will upset this balance by modifying the stress field around itself.

8.3 Calibration

It is important to note that the absolute 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 during a test that is significant. It is therefore usual to perform a 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 (deviations from linearity can, however, be seen at very small defect depths especially if these are comparable to the skin depth) 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. Users should consult the published literature for further information.

8.4 Induced pick-up and in-phase vectors

ACPD signals are by their very nature representable 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 generated by the specimen. This value is not normally displayed by the CGM7 but it can be calculated using Pythagoras' theorem from the two quantities that are the 0 and 90 degree readings (or alternatively it can be displayed when the instrument is set to the POLAR display mode, PLEASE! Remember that the analogue outputs as well as the RS232 always output the Cartesian values no matter what mode you have chosen to display on the LCD).

The vectors are shown in the diagram below. 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 and it is therefore preferable to investigate the changes in the 0 degree/in-phase/real vector as explained below.
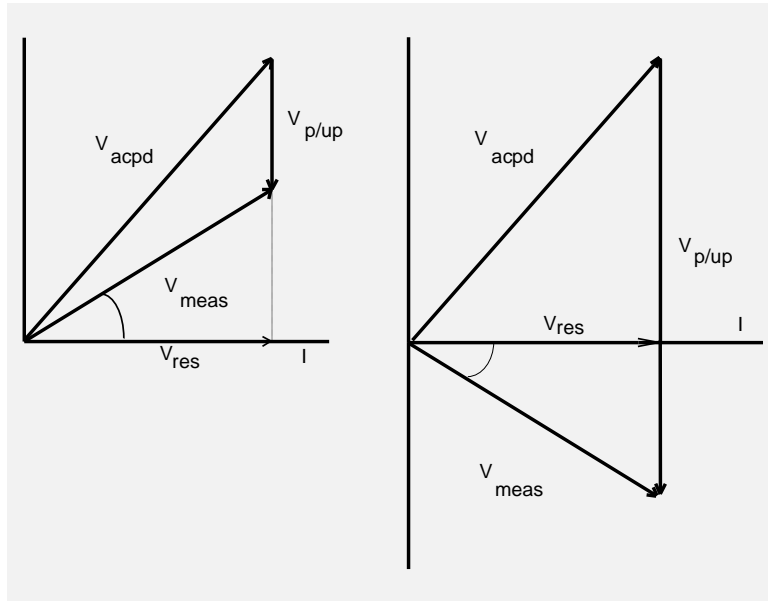
Fig. 18. The relative vectorial positions of signals in ACPD studies.

The in-phase/real portion of the ACPD signal lies along the specimen current vector, (i.e. they share the same phase). It is therefore also known as the "resistive" voltage signal. The magnitude of this does not change with a change in the magnitude of the pick-up. Monitoring the in-phase ACPD will therefore theoretically confer an immunity to errors caused by variation in lead position. This is most marked at the lower operating frequencies (0.3 to 10kHz). At 30kHz and above, the advantage conferred by monitoring the in-phase signal reduces but it nevertheless remains worthwhile. This deterioration indicates that the simple theory given above may not describe the entire situation.

8.5 Crack Depth Measurement
The CGM7 can be used in conjunction with a Matprobe hand held crack depth measuring probe in order to size cracks in the field, however this application can be more appropriately fulfilled by less well specified instruments. Users interested in this application should contact Matelect for further information.

8.6 Current lead problems
Much can be said about lead placement and the effect on ACPD measurements. The end-user is encouraged to seek advice from Matelect on matters such as the current focusing effect if required (see earlier), please note that the type of leads employed can also influence a test.

One of the core components of the CGM7 is a highly stable and complex constant current supply. All real (as opposed to ideal) current sources have a limited ability to drive current down a cable - this is known as the voltage compliance of the source. The CGM7 has a compliance limit of approximately 5 volts. This means that in a purely DC case, the compliance limit of the instrument will be reached if a specimen+lead resistance of 5V/5A = 1 Ohm is exceeded. However, since the ACPD technique relies upon alternating currents, the specimen+lead *impedance* needs to be considered.

This difference is significant because impedance is affect by the resistance, the capacitance, and the inductance of the current supply cable - PLUS the frequency of the alternating current employed. The higher the frequency, the sooner the compliance limit of the current source is reached and therefore the lower the absolute current that can be delivered into the supply leads/specimen.

28

If the compliance limit is reached, through the unfortunate combination of long leads, high frequency and/or poor cable, a flag will appear in the graphics screen above the set current value. Users have no choice but to lower the level of current or frequency, shorten the cable length or utilise low capacitance cabling (coaxial cable often lends an improvement in the situation - contact Matelect for further information).

9. SPECIFICATIONS

CGM-7 Model range.	
Option1	2A Max current output and up to 100kHz max frequency.
Option2	2A Max current output and up to 240kHz max frequency.
Option3	5A Max current output and up to 100kHz max frequency.
Option4	5A Max current output and up to 240kHz max frequency.
Option5	5A Max current output and up to 500kHz max frequency.
Option6	2A Max current output and 10Hz to 100kHz max frequency.

Please specify option required when placing an order.

Specifications	
Current O/P	High stability (better than 0.1%) continuously variable current supply. Continuously variable up to 5 Amperes* RMS maximum in 1mA increments.
Frequency O/P	Continuously variable from 10Hz to 500kHz*, in 1Hz increments to a stability better than 0.01% and a distortion of less than 0.1%.
Amplification	Independent gain setting of each channel, 1000, 1500, 2000, 3000, 5000, 7500, 10000, 15000, 20000 and 30000.
Offset	Continuous offset adjustment of both resistive and inductive components. Variable from –4v to +4v in 1mV increments.
Filter	Filter with sharp cut-offs at 0.1Hz, 80Hz, and 1KHz, as well as an OUT position.
Display	Large 240*128 back-lit LCD displaying the following; Current set/read, Frequency set, gain set, bias set, filter set, resistive and inductive components of each channel.
Outputs	Separate analogue O/P of resistive and inductive components of each channel (BNC) Digital O/P of all set and displayed values. (Via RS-232)
Connectors	Current O/P 2-way Lemo Pre-Amp Input 8-way Lemo (one per channel) 9-pin D-type for RS232 25-way D-type for SM1-HF and SM2-HF units.
EMC and Safety	Conforms to all relevant European directives.
Power supply	110-120V or 220-240v (Switch selectable) AC Mains, 50 or 60Hz. Mains input via earthed and fused IEC connector.
Line Fuses	Two 20mm anti surge 1Ampere fuse.
Mechanical	Frame made of aluminium extrusions and die-cast pieces, covers made of zinc-plated steel. All finished in a RAL epoxy powder coat. Optional 19" rack mountable handles.
Dimensions / Weight	450mm wide x 340mm deep x 145mm high. Net weight 12Kg. (approx)
Operating Temperature	0˚-35˚C main unit. LCD 10˚-30˚C. 30 minutes warm up time is recommended.

*Total frequency range is dependent on model purchased see reverse for further information.

ACPR-2 Pre-Amplifier specifications	
Pre-set gain	500
Mechanical	Extruded aluminium silver anodised case. With optional mounting brackets available on request.
Dimensions Weight	63mm wide x 84mm deep x 33mm high. Net weight 120g. (approx)
Operating Temperature	0˚-35˚C.

Available accessories and options on all models.	
SM1-HF	4 dual channel signal switching unit. (500KHz compliant)
SM2-HF	4 channel current switching unit. (5A compliant)
Dimensions	110mm wide x 170mm deep x 33mm high.
CGM7scan	16 channel data logging software.
19" rack mounting	Rack mounting kit, please state when ordering.
Mounting brackets	A range of mounting brackets are available for both the pre-amplifiers and scanner modules for directly mounting to any flat surface.*

10. PERIPHERAL EQUIPMENT

10.1 Multiplexing systems (SM1-HF and SM2-HF units)

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 between signal sources. To maintain sensitivity it may also be necessary to switch the current supply to the various locations. For this the SM HF scanner units should be employed.

Standard systems are assembled from combinations of 4 way signal (X and Y signals) switching and 4 way current switching modules, the CGM7 comes with a scan controller built in which permits control of the scanning parameters. 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 and current connections.

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

10.2 Crack depth probes (MAT-3)

These optional items are used in conjunction with the CGM7 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. A standard "Matprobe" is available for this purpose or custom built probes can be fabricated to order. Please contact Matelect for further information.

10.3 Software Options

Matelect can supply software packages for data acquisition and control of the CGM7. All the packages utilise the RS232 output socket located on the rear of the instrument. Software can also be written to order. Please contact Matelect for further information.

11. WARRANTY & 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.

12. LOW FREQUENCY CGM7 (OPTION 6) ADDITIONAL NOTES

This paper contains additional information concerning the new specially modified ultra low frequency CGM-7 unit. As with the other units in the CGM-7 range they all share the same user interface, for more information on this please refer to the main manual. Although controlled in the same way as the other units, the following considerations should be taken into account when using the ultra low frequency CGM-7.

Current start-up.

As with all high precision instrumentation all CGM-7 models should be allowed to warm up for at least 30 minutes before performing any experiments to allow for thermal stabilisation. If the unit has been off for a long time i.e. over night, it may take up to 5 minutes for the current to initialise. This is normal for the unit and is caused by the ultra low frequency current control circuitry.

Current stabilisation.

With all other CGM-7 units current reaches the user set value within 2-3 seconds. However due to the high capacitor values used in the ultra low frequency current control circuitry the settling time can be 30-40 seconds. Special microprocessor control routines have been used in order to reduce this time as much as possible. When performing experiments this should be kept in mind, we therefore suggest that the current be applied continuously to the specimen. You will also note that when adjusting the excitation frequency below 60 Hz that this will have an effect on the current reading and a small amount of time will be taken to re-stabilise the current. Both these behaviours are normal and intrinsic to the ultra low frequency current control circuitry.

Frequency setting.

As with all CGM-7 units the excitation frequency is adjustable in 1 Hz increments. When using the ultra low frequency unit at lower frequencies however care should be taken to avoid harmonic multiples of the mains frequency powering the unit. Although care has been taken to cancel out this form of interference by careful circuitry design, it is impossible to reduce all effects of mains interference especially at sub 200 Hz frequencies. When setting frequencies below this level, multiples of mains frequency should be avoided. When setting up a test care should be taken to observe the amount of mains pickup shown on the screen and the frequency adjusted if necessary.

When using the CGM-7 at low frequencies, certainly below 300Hz, the user should use the 0.1Hz filter, selectable from the front panel.

Taking into account the above considerations very steady readings can be achieved from the ultra low frequency CGM-7. As with all ACPD work great care must be taken with cable placement, and current excitation of the specimen, however with the ultra low unit this becomes of even greater importance. As with all Matelect equipment should you have any queries not answered in this document please get in touch with Matelect.

MATELECT LTD