MATELECT
DCPD Crack Growth Monitor
TYPE DCM-2

INSTRUCTION MANUAL

Version 35, June 2024

Thank you for your purchase of the Matelect DCM-2 second generation pulsed DCPD apparatus. A standard DCM-2 unit is shipped with the following additional parts:

- An IEC mains cable, fitted with a local mains plug
- A set of current leads consisting of 3 cables
- A set of signal pickup leads consisting of 2 cables
- A serial communications lead

Optional items, which may have accompanied the instrument, include software and signal/current scanning units, and their associated leads.

The DCM-2 is an advanced DCPD crack growth monitor that utilises the pulsed direct current technique to monitor the propagation of cracks within metal specimens undergoing mechanical testing. Pulsed DCPD is generally regarded as preferable to continuous DCPD, and has largely replaced the latter in modern laboratory testing. The DCM-2 is a microprocessor based design and its pulsed current facility has resulted in a compact and lightweight DC system for use in the laboratory. The DCM-2 current supply is fully isolated, as are all other inputs and outputs to the system.

The DCM-2 is a modular instrument and the precise configuration of the unit as supplied, depends on the optional modules purchased by the end-user. Modules available include one for enabling synchronization of the current supply pulses to an external waveform (for example, that derived from a load cycle of a universal testing machine), and a module which delivers a reversing-current capability to the DCM-2 .

Like most digital instruments, the DCM-2 has built-in “firmware” which controls its available functions. The firmware version is displayed upon initial start up of the unit. The firmware is user upgradeable and new firmware can be provided on CD, or by email from Matelect and “flashed” into the DCM-2 by the end-user simply by using a PC and a serial cable. Matelect issues firmware updates rarely for its standard instruments, but has sometimes done so in response to a request from an end-user for a particular facility to be incorporated into the instrument. If an optional upgrade module is retro-fitted to the DCM-2 then a firmware update may also be needed, although this will usually be performed by Matelect at its factory facility.

This manual applies to the DCM-2 only. Replacement manuals as well as manuals for earlier instruments can be obtained from Matelect.

Use only a slightly damp cloth and mild detergent to clean the DCM-2 system. Never use a solvent cleaner or any fluid. **Please note that there are no user serviceable parts within the DCM-2 . Never attempt to open the instrument case, as this will void any warranty**. Please contact Matelect should you ever experience any difficulties.

IMPORTANT

Please read these instructions carefully before you use the instrument. Please pay particular attention to the section that follows on mains operation. The DCM-2 and associated peripheral use mains voltage and improper operation/use can cause injury or death. For your reference please also read our terms and conditions of sale printed at the rear of this manual.

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 DCM-2 can be operated on both 110 and 220V supplies by appropriate selection on the input voltage switch on the mains input socket (see page 21). 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 DCM-2 is fitted with an equipment fuse for protection. The fuse is located in the IEC input socket on the rear panel of the DCM-2 . The fuse needs to be functional if the equipment is to be operated.

The instrument fuse is rated at 4 Ampere (for 100-240V AC operation) and is of the 20mm "time delay" (slow blow) type. Never replace this with a fuse of a different type or rating as the instrument can be seriously damaged.

When replacing the instrument's fuse or altering the mains input voltage setting, users **must** ensure that the unit is disconnected from the mains supply.

Ensure that the DCM-2 does not come into contact with fluids or corrosive gases and that it is operated within the temperature range of 5-35 degrees C.

This manual applies to the DCM-2 pulsed DCPD unit Running Firmware versions up to v300E. Users who experience any difficulty in operation of the equipment are advised to contact Matelect.

MATELECT LTD

DCPD CRACK GROWTH MONITOR
TYPE DCM-2

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THE DCPD TECHNIQUE AND THE DCM-2 : AN OVERVIEW

The Matelect DCM-2 system has been designed to allow measurement of crack growth in metals using the pulsed direct current technique.

The predecessor to the DCM-2 , the DCM-1, was produced to replace the ageing DC systems that were and are still common in laboratories throughout the world, with a modern, sophisticated yet easy to use instrument. The DCM-2 builds on the success of this unit, adding many more features. Although the general operation of the unit remains simple it now allows PC control and thus an ability to offer high degrees of user customisation. It is microprocessor based and all major functions are controllable from the front panel utilising the large dial and button along with the sophisticated menu system, or the optional software. The functions selected and the measurement values are displayed on a backlit LCD graphics screen.

In DCPD work, crack growth is measured by simply passing a stable direct current through the test specimen and measuring the voltage drop developed across an area of that specimen. In effect, DCPD measures specimen resistance. As a crack propagates the specimen resistance will increase in a way that can normally be related to actual values of the crack depth.

Given that metallic specimens are effectively “short circuits”, of finite, but low resistance the currents that are required in DCPD, in order to obtain a measurable voltage, are of the order of tens of amperes. This requirement made first generation DCPD systems large and bulky. Also the high currents were traditionally passed continuously, and this can usually lead to a gradual (but perceptible) rise in the specimen temperature. Such a rise will alter the measured DCPD value, given that most metals exhibit a finite temperature dependency of their resistivity. Additionally “continuous” DCPD suffers from problems due to the generation of thermoelectric EMFs which are of a similar magnitude to the true DCPD signals.

The DCM-2 both sources a stable (or “constant”) current and amplifies the minute voltages generated across the specimen, however, the disadvantages cited above, that traditional DCPD suffers from, have largely been eliminated by the use of a pulsed DC measurement method. Here, the current supply to the specimen is interrupted and pulses of “constant” current are passed, instead of a continuous flow. Measurements are taken both during and in between pulses. These are then compared in order to reduce noise and remove thermoelectric effects. Independent control of the “off” current periods, also ensures that specimen heating effects can be all but eliminated.

As standard, the DCM-2 supplies current pulses of a monopolar nature, (in other words zero to +volts and back to zero) but optionally, a bipolar facility can be specified at the time of purchase. Here the pulses are reversed in polarity in sequence. This facility fulfils the needs of some researchers who prefer to utilize a variant of the continuous DCPD method, known as Reversing-DCPD.

Originally Reversing-DCPD offered an elegant way to eliminate the thermoelectric EMFs that could seriously affect the results of a conventional monopolar DCPD set-up. With the advent of pulsed DCPD, however, this advantage was lost. Reversing-DCPD is sometimes also regarded as offering twice the signal magnitudes over monopolar DCPD – and hence twice the ultimate crack depth resolution, but in reality, this is fallacious, given that each polarity of signal has to be separately measured and any errors are therefore likely to be compounded (although perhaps not always doubled).

Reversing DCPD, however, does offer a hypothetical advantage in testing scenarios where unwanted electrochemical effects could occur. Contentiously, some researchers believe that the application of a direct current to a metallic specimen in a corrosive aqueous environment can generate voltage drops large enough to influence the electrochemistry in the vicinity of the specimen. This could generate effects such as premature embrittlement or stress corrosion, or simply alter the conditions of a specimen held at a particular electrochemical potential.

In order to overcome this latter concern, some workers prefer to employ reversing DCPD – where the continuous current is reversed in polarity at regular intervals during the crack monitoring process, hence reversing and/or preventing electrochemical reactions. The scientific literature on this perceived advantage is sparse. Furthermore it is unlikely that the potential drops that are developed across

metallic specimens would be sufficiently high enough to effect the local electrochemistry and even if they were, the reactions occurring may not be fully reversible in any case.

For now, the matter remains unresolved but for those researchers that prefer the concept of reversing-DCPD, the DCM-2 can be specified at the time of purchase (or retrofitted) with a reversing module. This works in harmony with the pulsed DCPD operation of the DCM-2 to produce the World's first pulsed-reversing-DCPD instrument. In this way, the thermoelectric, specimen heating and possible electrochemical effects are all countered.

The DCM-2 acts as a stable current source but also must amplify the resultant voltages that the current generates across a crack, or between two points on a specimen. Even with large currents, these voltages are never usually more than micro-volts in magnitude, and demand final digit resolutions that are in the nano-volt regime. For sensitive work, carefully designed voltage amplifiers are thus required. These need to be highly stable and as immune to noise as possible.

Highly specified pre-amplifiers, of novel design, are built into the DCM-2 and these have the effect of greatly reducing the electrical noise that superimposes on the processed signal. Noise can be generated in a variety of ways – it can appear at the signal inputs as a result of the interaction with the test environment, and it can be generated within the very circuitry that is used to measure the signal.

If unchecked, external noise will be amplified by an instrument and simply appear at the output. By employing advanced analogue circuit design methods, such noise can be reduced early on in the amplification process. This does not simply constitute application of a filter, as these cannot be employed with any great success on signals that change rapidly (as a pulsed voltage would be expected to). Once analogue noise reduction has been carried out, signal averaging methods are further used to reduce noise. Signal averaging can be thought of as a form of digital filtering – and the DCM-2 offers end-users considerable flexibility in setting the "filter" parameters for this process.

As standard, the DCM-2 houses its analogue pre-amplifiers within its chassis. Optionally these can be specified as external units and supplied as mini-preamp modules in rugged, shielded metallic enclosures. These can then be mounted close to the specimen and are particularly effective where long cable runs are anticipated. The preamplifiers can also be specified to be used in environments where the main unit (and its operator) would not normally wish to be located (e.g. radiation "hot" zones).

Temperature can markedly alter the characteristics of the voltage amplification circuitry. It is therefore important to make the pre-amplifiers as temperature insensitive as possible. Some amplifier designs incorporate heaters in order to maintain a constant temperature and hence reduce the drift, however, the advent of modern electronic techniques have made this unnecessary. This results in a simpler and more reliable measurement system. After pre-amplification, concerns about temperature effects become less important, but the DCM-2 is still equipped with extensive design elements to counter thermal effects, including thermally activated forced cooling and ultra low drift voltage references.

A further enhancement of the DCPD technique is to use two specimens. One of these is used as the test specimen, whilst the other is used as a reference so that changes in the DCPD due to environmental changes (e.g. temperature) are eliminated. The specimens are connected in series so that the same current flows through both. Two voltage measurement channels are required in this case. This technique is known as normalisation. The DCM-2 , like its predecessor the DCM-1, is supplied as standard with two entirely separate signal processing and amplification channels, including two electrically independent pre-amplifiers.

Two channel normalisation can still be performed on a single specimen by using specialist formulae (available in published scientific literature). In such cases it is usual for the reference channel to be sited in an area that is not subject to cracking, although formulae have been developed to handle two channels, both of which straddle the crack site. Matelect can advise on some of these methods.

Historically, two channel operation has always been a feature of DCPD apparatus, although in the early years such an implementation was encountered as a means of compensating for the fluctuations in the current supply to the specimen, rather than any thermal compensation. Changes in the supply would thus affect both active and reference channels equally and hence be normalised out. The disadvantage of this was that single channel operation was not feasible. The current supply of the DCM-2 , however, is designed to be inherently stable, and hence it is perfectly possible to use only one of its two channels

and obtain comparable performance to two channel operation. This frees up the second channel to be used to monitor another crack site on the same specimen, or even another specimen altogether.

Overall, by combining the advanced design of the amplification circuitry and the stability of the current supply, with good experimental methods, impressive crack growth resolutions of a few tens of microns or better are possible with the DCM-2 . In many cases, the last digits resolvable on the DCM-2 correspond to distances on the specimen of less than a grain size.

DCM-2 GENERAL DESCRIPTION & SETUP

The DCM-2 unit houses the current sourcing and voltage measurement facilities and the graphics display screen. All functions are controlled by an internal microprocessor. In addition to measuring and displaying the DCPD readings, the main unit also performs a normalisation calculation if the user has selected two-channel operation.

Analogue outputs are provided at the rear of the DCM-2 so that the values of the specimen channel, the reference channel and the normalised DCPD value can be recorded via a computer (suitably equipped with an analogue to digital converter card) or a chart recorder.

The current is pulsed in synchronisation with the mains frequency in order to reduce noise pickup with the ability for the user to set an off period between these readings set in steps of 10th of a second. Optionally, the DCM-2 can be pulsed by an external signal, sourced from the user's testing machine (or other equipment as appropriate). This facility allows the current pulses to be synchronised to a fatigue testing cycle. Such synchronisation is useful in order to measure the DCPD at a particular point on the testing cycle since the DCPD can often change during any one particular cycle. Changes due to crack closure, for example, can be followed by this method.

The DCM-2 sync option permits external synchronisation on both the peak and trough of the fatigue cycle (peak tension or peak compression). Full explanation of the synchronisation modes is given in the Advanced Usage section.

All current and signal gain (amplification) levels together with the pulse synchronisation options are set using a menu system that is displayed on the front panel graphics screen. The menu system is simple to operate and requires little explanation. To assist the user, however, this manual gives an example of how to set up a typical test regime.

The preamplifier module has inputs for two channels and is built into the main unit as standard. It incorporates high stability, low drift amplification circuitry that conditions the minute DCPD voltages, handles any offsets and performs all the basic signal processing functions.

Other circuitry in the main unit further processes the digitized DCPD signals from the preamplifier and displays them on the graphics screen.

In general, the DCPD system should be configured as shown in Fig.1. All the required cables for this set-up are provided with the DCM-2 and are shown overleaf. If the end-user has specified external pre-amplifier units then these will be connected to the DCM-2 main unit by umbilical cables supplied with the pre-amplifiers

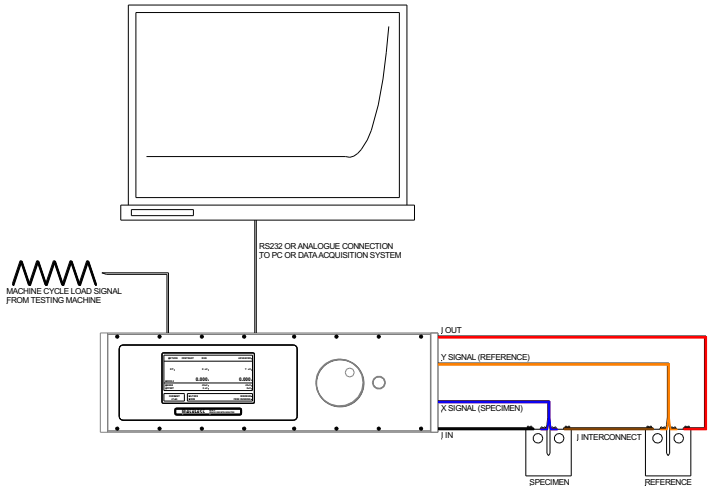
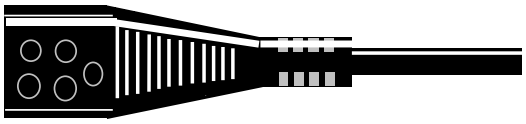


Figure 1 General schematic view of a typical DCM system set-up

In the example shown, two specimens are used, one as the test piece and the second as a reference. As discussed earlier, it is usually advisable to use a reference test piece in DCPD studies, although other configurations are possible. Further operational advice is given throughout this manual and detailed topics are covered in the section entitled, Setting Up and Doing a Test. For users who wish to "just give it a go" it may be wise to turn to this section which can be found on page 30



IEC Mains input to Local mains plug

DCM-2 current I/O to specimen (2off 1 red, 1 black)

Specimen to reference current lead

mini 2 pin signal input DCM-2 preamplifier module to specimen connection (2off 1 blue, 1 orange)

PC COM1 to DCM-2 RS232 socket

Figure 2 Cables supplied with DCM-2

FRONT PANEL DESCRIPTION

The front panel layout of the DCM-2 is shown below in Figure 3. The controls and menu functions of the unit are described fully in this section.

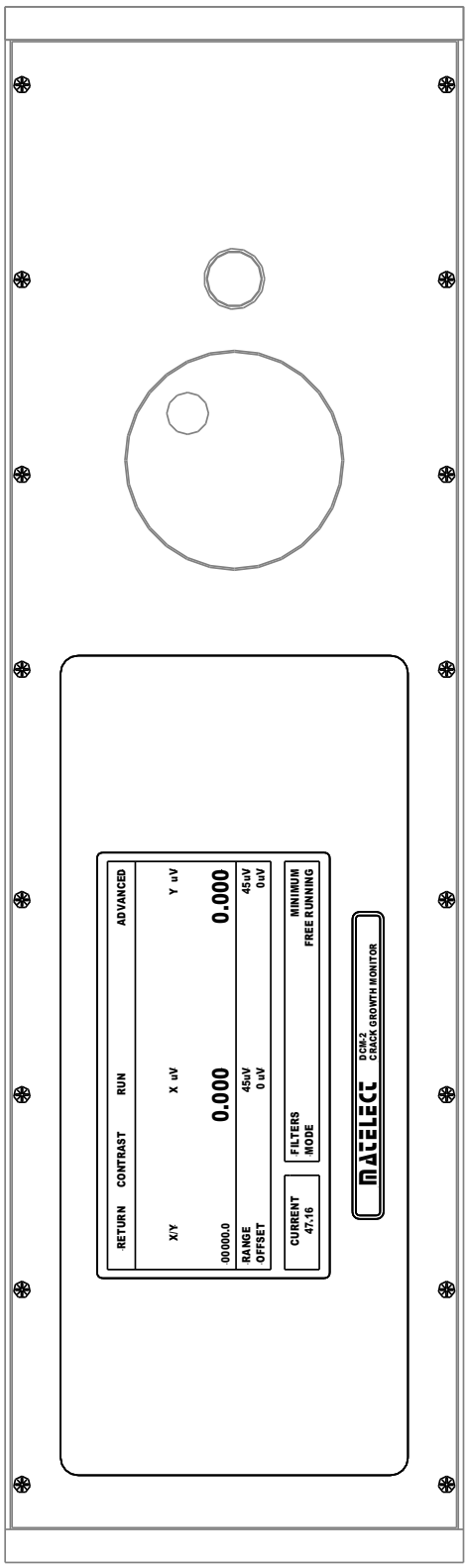


Figure 3 The front panel of the DCM-2

1. Front panel display

The DCM-2 utilises a backlit LCD graphics screen to display the measured DCPD values and indicate the levels of the set parameters such as excitation current and filtering. The Screen, as shown below in Figure 4, is split into four main areas.

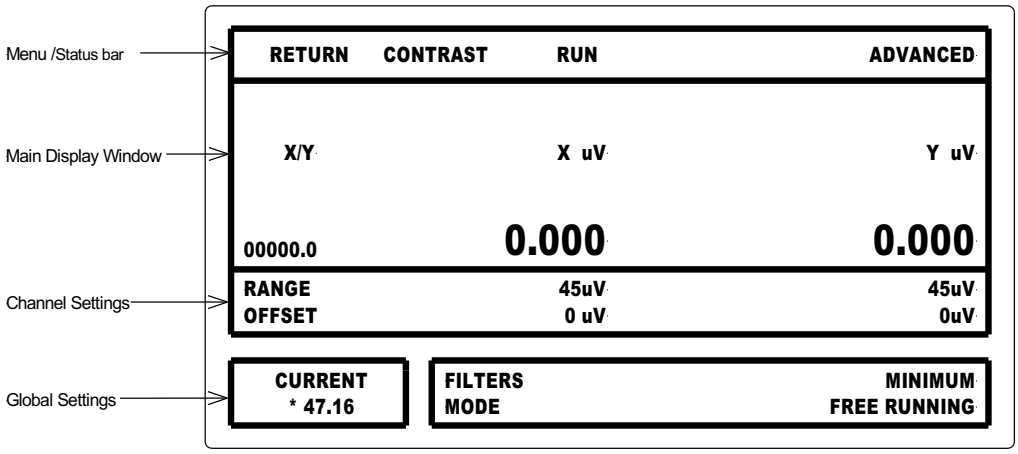


Figure 4. Front panel display

When the DCM-2 is switched on a message window is momentarily displayed indicating the unit's serial number and installed options, after which the unit enters its idle mode. To enter local control mode the user must press the SELECT button, at which point the user can use the dial to sequentially highlight all the selectable options. Pressing the SELECT button will activate the highlighted option. After this it can be adjusted using the dial to the required setting; pressing the SELECT button will save the data and exit that option. Users should note that the dial is not *speed* sensitive however turning it continually in one direction will increase the effect it has.

2. Menu bar

The Menu bar as shown above is only shown when the DCM-2 is in local control mode. At all other times it is used as an information bar. This will display exactly what the unit is doing at that point in time, or report a resent error in its operation.

When the DCM-2 has been placed in local control mode, if the user activates one of the menu bar functions the DCM-2 will respond as described below.

Return – This will return the DCM-2 , to idle mode. In this state the DCM-2 is waiting for instructions from the front panel or an attached computer.

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.

Run – this will initiate run mode. The unit will start to gather data, using the parameters, as displayed on screen. Please note that the DCM-2 will take a few cycles to stabilize; and it is best practice to allow the unit to stabilize for 15 minutes.

Advanced – This takes the user to another menu screen where further more advanced options are available. These are described on page 18.

3. Main display window.

The X and Y signals are displayed in microvolts, the calculated signal X/Y is displayed to 3 decimal places or 5 significant figures. However it should be noted that values that exceed the stated range

are not to be classed as calibrated. The rate these figures are updated is dependent on many factors including filtering, mode of operation, and the synchronizing signal if one is supplied.

4. Channel Settings.

In this area the setting of a particular channel can be changed. The DCM-2 is normally supplied with 2 channels but can be expanded up to 10 channels if required.

Range

The range parameter has three settings. These are shown below. End users should select the correct setting for the signals required. It may be difficult to initially judge the correct range setting, so it is often better to begin using a coarse range (e.g. 4.5mV) and then adjust down to finer ranges once the signal magnitude is known.

4.5 mV – This is the default setting.
450 uV
45 uV

To change the range settings simply highlight it and press the button once. You may now select the desired setting by using the dial to scroll through the three options. Once the desired range is shown press the button again to select it.

The analogue gain from specimen to analogue output is as follow for the following ranges. 4.5mV has a gain of 1,000; 450uV has a gain of 10,000; 450uV has a gain of 100,000

Offset

The offset parameter has a range of ± 4500uV in 1uV steps. To adjust this simply highlight the channel required and press the button once, now using the dial adjust the offset to the required value and press the button once more to set it. Again, it is often better to leave the offset at zero until the signal magnitude has been determined. Note that it is possible to offset a signal so that it can be fed to a lower range. The sensitivity of the DCM-2 to small changes in signal magnitude is thus maximised in this way. Such operation is analogous to suppressing an input signal on a chart recorder so that a higher gain can be selected.

5. Global Setting

In this area changes to the parameters affects all channels.

Current

Once highlighted press the button once, turning the dial clockwise will increase the current and turning it counter clockwise will decrease the current. Once the desired current level has been reached press the button again to set the current. The current is set in 10mA steps up to the maximum for the unit. Note that the DCM-2 can be shipped with different maximum current capabilities of 10, 20 or 50 Amperes, depending on the end-user specification.

The current control on the DCM-2 operates by first reading the desired set-current and then ramping the output up and comparing the set value to the actual value. This ramp up takes only a short time and once the set value is reached, it is maintained by the constant current circuitry. Users should note that the value displayed once the DCM-2 unit is pulsing is the *actual* current being supplied at that time, and not simply a digital indication of the desired set level. In this way, the user can always confirm the correct operation of the DCM-2.

In the unlikely event that after a few pulses the DCM-2 is still indicating a current less than that set by the user. It has most likely reached maximum drive capability; this is often referred to as voltage compliance.

The voltage compliance is in essence the maximum voltage that can be developed across the current output terminals of the DCM-2. This will thus define the limit of the resistance through which a current can be delivered. The compliance limit is close to 5 volts DC, hence for a full 50 amp capability, a total resistance of more than 0.1 Ohms will begin to limit the unit's output current capability.

If voltage compliance has been reached there are two likely causes; poorly made connections, and highly resistive specimens or cables. Please make sure all connections are mechanically sound, free from grease and oxide layers. If cables which were not supplied with the unit have been used please insure that they are of a resistance significantly low as not to cause an issue with the output current source. Highly resistive leads are often necessary to supply specimens in furnaces; these leads should be as short as possible. If the user can not acquire the current they require they should contact Matelect for advice.

When the current level is set, activated, and the DCM-2 unit is correctly pulsing, the front panel graphics screen will indicate each pulse with a small asterix (*) adjacent to the displayed value of the current. If a reversing module has been fitted, a minus signs (-) will appear next to the asterix, when the current is reversed with respect to its initial polarity.

Filter

DCPD signals can become contaminated with noise from many sources. The DCM-2 filters are designed to remove noise from the following sources; inducted mains, thermal, mechanical, and random electronic noise.

Signal filtering on the DCM-2 works in a fundamentally different manner to analogue filters, which are usually described in terms of frequency, pass bands, and are constructed around passive components such as capacitors and inductors. The Filter setting of the DCM-2 controls the operation of a digital (DSP) based filter that functions on the principle of signal averaging – taking many readings, and digitally calculating the average. Superimposed noise, with a theoretically random distribution of magnitudes and polarities thus sums to an average of zero.

In a similar manner to an analogue frequency based filter, a digital filter set to a "high" level, will take longer to respond to a genuinely changing signal. However, whereas when analogue filters respond slowly, the result is a time lag (i.e. a phase shift) between the signal and the reading, digital filters will respond in quantized jumps (i.e. the signal magnitudes remain fixed, until a new signal level is calculated and displayed). Once these nuances are accepted, the filter setting and its effect on the signal can be better understood.

The filter parameter has three settings. These are minimum, medium and max. The settings are explained below.

Minimum – This takes two sets (samples) of 64 on and off current readings and takes an average. This is quick but may be more susceptible to noise.
Medium – This takes four sets (samples) of 64 on and off current readings and takes an average.
Max – This takes eight (samples) sets of 64 on and off current readings and takes an average. Although this takes much more time than the minimum setting it is much quieter.

To change the filter settings simply highlight it and press the button once. You may now select the desired setting by using the dial to scroll through the three options. Once the desired filter is shown press the button again to select it.

Mode

The mode parameter relates to the optional pulse synchronization module that permits the pulsing, and hence acquisition of a specimen signal, at specific points on a user defined input waveform (such as that derived from the load cycle of a testing machine). This might be useful, for example, where readings are desired at the peak loads during a fatigue test, given that at these points, any crack that has developed is fully opened and hence errors in the potential drop readings that could occur if the crack is partially closed and hence electrically shorted, can be eliminated. Taking the reading at the same point on a test waveform is also beneficial because crack shorting effects could give the impression of noise on a PD output trace, if an unsynchronized approach is taken to current pulsing and signal acquisition. In the latter case, readings could be taken anywhere along the load waveform, and each reading would not necessarily correspond in position, along the load cycle, to the next or subsequent ones. For non-fatigue type tests, (e.g. constant strain rate testing), the synchronization mode is not required.

If the synchronization option is fitted the mode can be altered to one of seven settings. These are shown below. The frequency figures relate to the frequency of the input waveform. There are two frequency ranges that apply – and end-users should select the one in which their test waveform falls, if it falls outside of both please consult the table below and use the advance menu to adjust settings.

Free running – This takes continuous readings, with no reference to an external signal.
Peaks 0.6 Hz – 5.5 Hz – This takes a reading in sync with an external signal such as that from a loading machine on the peak of the waveform.
Midpoint 0.6 Hz – 5.5 Hz– This takes a reading in sync with an external signal at the point where the signal from a loading machine goes from less than the set midpoint to great than this.
Trough 0.6 Hz – 5.5 Hz – This takes a reading in sync with an external signal such as that from a loading machine on the trough of the waveform.
Peak 130 Hz – 500 Hz – This takes a reading in sync with an external signal such as that from a loading machine on the peak of the waveform.
Midpoint 130 Hz – 500 Hz – This takes a reading in sync with an external signal at the point where the signal from a loading machine goes from less than the set midpoint to great than this.
Trough 130 Hz – 500 Hz– This takes a reading in sync with an external signal such as that from a loading machine on the trough of the waveform.

Frequency	Mode	No. reading	No. samples for min filtering	Approximate Update Rate
0.6 Hz-5.5 Hz	0.6 Hz – 5.5 Hz	64	2	3 sec
5.5 Hz-10 Hz	0.6 Hz – 5.5 Hz	32	4	5 sec
10 Hz-20 Hz	0.6 Hz – 5.5 Hz	16	8	8 sec
20 Hz-30 Hz	0.6 Hz – 5.5 Hz	8	16	12 sec
30 Hz-65 Hz	130 Hz – 500 Hz	15	9	12 sec
65 Hz-130 Hz	130 Hz – 500 Hz	32	4	5 sec
130 Hz-500 Hz	130 Hz – 500 Hz	64	2	3 sec

To change the mode settings simply highlight it and press the button once. You may now select the desired setting by using the dial to scroll through the options. Once the desired mode is shown press the button again to select it.

When a synchronization mode has been selected then, on completion of setting-up the DCM-2, the test machine should be started before the DCM-2 is placed in run mode.

Further details of the relationship between the test waveform and the PD signal during synchronization are given in the Advanced Usage section of this manual.

6. Advanced Menu.

When the user selects 'Advanced' from the menu bar the advanced menu as show in Figure 5 will be displayed.

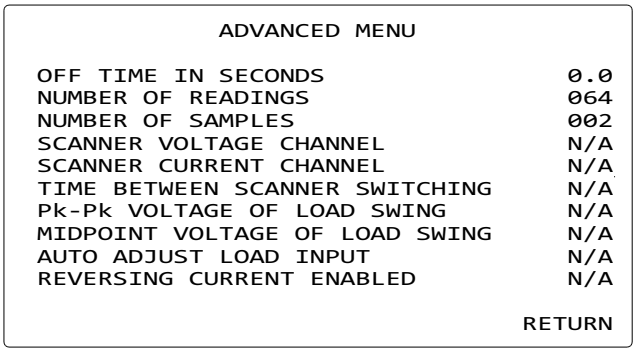


Figure 5 Advanced Menu

Off Time In Seconds

This defines the time the DCM-2 waits before starting to take the next set of readings. This is useful when a slow crack growth is being monitored, and the readings are like to be affected by the heating effects of the current. A long off time will reduce the apparent effects of the heating by allowing the specimen to cool.

Number of readings

This defines the number of data points used in the DCM-2 filtering system to form a sample. How the filtering works is explained in greater detail on page 24.

Number of samples

This defines the number of samples (as defined above) used in the DCM-2 filtering system to form the displayed signal. This is also explained in greater detail on page 24.

Scanner Voltage Channel

When the SC1 module is fitted to the DCM-2 this menu option is user to adjust the selected channel on the voltage scanner during setup.

Scanner Current Channel

When the SC1 module is fitted to the DCM-2 this menu option is used to adjust the selected channel on the current scanner during setup.

Time between scanner switching

This defines the time the DCM-2 will read a particular scanner channel before switching to the next scanner channel. This is a bespoke option as in normal use the scanner channel is controlled by PC software which also records the signals.

Pk-Pk voltage of load swing

This defines the peek to peek voltage of the external load waveform that the DCM-2 is to synchronize to. The auto adjust load input feature will normally adjust this setting to the optimum value; please make sure it is enabled if you are not setting this value manually. The midpoint

voltage of the load swing should be used with the Pk-Pk voltage of load swing feature to specify the voltage into the DCM-2 when it is synchronizing to more random loads. The maximum permissible voltage at the load input is defined as half the Pk-Pk voltage of the load swing plus the midpoint voltage of the load swing. The minimum permissible voltage at the load input is defined as the midpoint voltage of the load swing less half the Pk-Pk voltage of the load swing.

Midpoint voltage of load swing

This defines the midpoint of the load waveform the DCM-2 is expected to synchronize with, in volts. This is the point equal distance in potential between the maximum and minimum values and should not be confused with the mean load although in symmetrical waveforms this is true. The synchronize waveform must cross this value for each peek or trough. Setting this value disables the auto adjust load input and is normally used when synchronizing to more random wave forms. The auto adjust load input feature will normally adjust this setting to the optimum value; please make sure it is enabled if you are not setting this value manually.

Auto adjust load input

This feature when enabled is used to define the best values for the peek to peek swing and midpoint of the load waveform. It can be disabled so that the user can define these manually.

Reversing current enabled

If a reversing current module is fitted, this menu option offers end-users the ability to activate it. It will NOT be activated by default, and the DCM-2 will remain in a monopolar mode. The usage of this is described in greater details on page 24

REAR PANEL DESCRIPTION

The rear panel of the DCM-2 is shown below. Located on this panel are the IEC mains inlet socket, the fan outlet grill, the current I/O sockets, the external I/O socket, RS232 socket, Load input, analogue outputs, and preamplifier inputs.

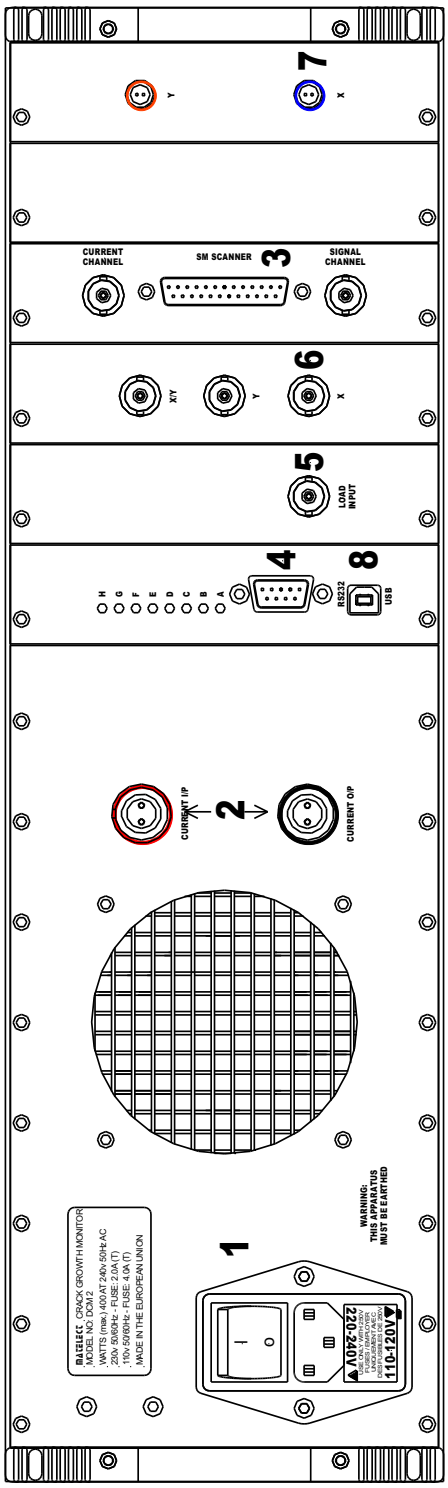


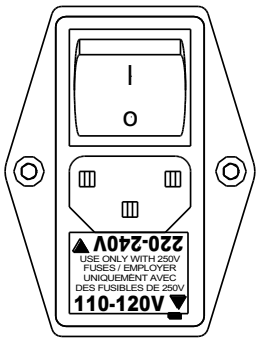
Figure 6 The rear panel of the DCM-2

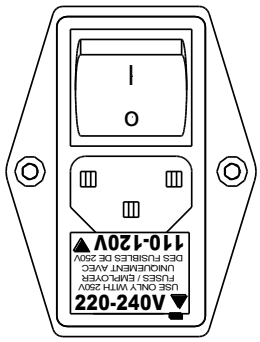
1. IEC Inlet socket

This is a standard IEC mains input socket 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 DCM-2 . If this is missing, only use an approved mains connector lead in the IEC socket.

The instrument is fused with a 4 ampere time delay (slow blow) 20mm fuse for operation in the 100-240V AC range. If the fuse fails for whatever reason, disconnect the equipment from the mains supply and replace the fuse with one of the same rating and type. DO NOT use a fuse of a higher rating as permanent damage may result to the DCM-2 . If the local mains plug also incorporates a fuse, then this should be of a similar rating to the fuse within the IEC socket.

The IEC socket is configurable for either 240-220 or 120-110 volt operation, and will have been shipped with the appropriate configuration for the country it is supplied into. Selection of the voltage is achieved by rotation of the integral fuse holder. BEFORE OPERATION, END-USERS SHOULD ENSURE THAT THE CONFIGURATION IS CORRECT FOR THE LOCAL MAINS SUPLY. If the unit is moved to a location that uses a different mains voltage to the one it has been supplied into, then users can simply extract, rotate and reinsert the fuse holder (disconnect the unit from the mains supply before doing so). The casing of the fuse holder indicates both 110v and 220v and this should be aligned with the arrow on the IEC inlet case for the correct voltage. As shown to the left and right. On the 110V range, the unit will function down to 100V as applicable to some countries such as Japan.





Adjoining the IEC socket is the main airflow outlet of the DCM-2. The instrument is fitted with a temperature controlled fan system that automatically activates whenever the temperature of the main heatsink (which cools the current output power transistors) rises above 30 degrees Celsius. This fan outlet must not be blocked and free flow of air around the inlets of the instrument case, (mostly located under the instrument), must be provided. When the DCM-2 is pulsing anything above a few amperes of current, the fans operate continuously, but when the unit is in set-up mode or not pulsing, the fans will usually turn off.

2. Current output connectors

These Lemo connectors are colour coded Red and Black. The current connectors are fully isolated as are all other connections on the DCM-2 .

The appropriate cables (supplied) should be used between these connectors and the specimen/reference. It is advisable to attach the cables and specimen to the current terminals before attempting to supply a current. Making a connection to the supply whilst the DCM-2 is pulsing a current will cause sparking at the point of connection. This is not good practice since sparks are sources of electrical noise, which can often upset or destroy sensitive electronic equipment. The current output of the DCM-2 is protected against damage from such unexpected disconnections, but it is not recommend that this be relied upon as an alternative to good experimental practice.

As described earlier, if the current connections are not properly made or the specimen and lead resistance is too high then the unit will indicate a current less than the user set current.

3. External I/O

The external I/O socket is used to control the SM1-HC and SM2-HC scanner modules. These modules are used to multiplex both current source and signal pickup from the DCM-2 allowing multiple crack regions to be monitored by one unit.

4. Serial Data (RS232) output socket.

This is a 9 way D type male socket. The pins are configured as a standard RS232 9 way null modem connector. The data format and pin out details can be obtained from Matelect. Software for data acquisition via the serial data link is also available from Matelect. With the addition of the usb port to the DCM-2 the RS232 input to the DCM-2 is disabled while a "live" usb cable is connected to the DCM-2.

5. Load input

Also referred to as the machine cycle input this BNC style connector allows the DCM-2 to be synchronised with an external signal as found on most testing machines. The external signal must be in the following range ±50V to ±150mV. The input to this socket is processed by the DCM-2 and an automatic gain facility (AGC) is applied so that input signal magnitudes can vary throughout the range quoted above. Advanced analogue circuitry and digital algorithms are used to determine the peak, trough, DC offset and any crossover, of the input signal, so that reliable synchronization can be applied to the appropriate position on the waveform.

6. Analogue Outputs.

The DCM-2 provides three analogue outputs; these are labelled as X, Y, and X/Y. The maximum voltage range of these outputs is ± 10 Volts. These signals are derived from 16 bit digitals representations of the signal values, and therefore quantized in steps of $1/(2^{16})$ of the total output range. The analogue outputs can be configured to be proportional to any signal within the DCM-2 and to have an output voltage range as low as ± 3 volts, however this requires bespoke firmware.

The standard configuration of the DCM-2 is to have the X, Y, and X/Y analogue outputs proportional to their front panel namesakes. There output ranges are set to ± 9 volts as this is seen as the best compromise between the requirements of X/Y and X, Y.

The relationship of the analogue outputs to the front panel namesake's is as follows for X, and Y. Maximum signal for that range is equal to 4.5 volts. For example, when channel X is in the 4.5mV range and has a reading of 4482.3uV displayed on the front panel this is represented by 4.482 volts (± it quantization error) on the X analogue output. Likewise if the Y channel is in the 450uV range and the Y reading of 442.38uV is displayed on the front panel this is represented by 4.4238 volts (± it quantization error) on the Y analogue output.

The relationship of the X/Y signal is much simpler. The analogue output is directly proportional to the signal being displayed on the front screen within the range of ± 9 volts. I.e. X/Y = 1.323 on the front panel is represented by 1.323 volts (± it quantization error) on the X/Y analogue output.

For DCM-2s operating firmware version V003D and earlier the relationship is scaled down by a factor of 10. I.e. X/Y = 1.323 on the front panel is represented by 0.1323 volts (± it quantization error) on the X/Y analogue output.

When an internal signal is driven beyond its output range the signal will be limited by this. I.e. if X/Y = 12.534 is represented by 9.0 volts (± it quantization error) on the X/Y analogue output.

The analogue gain from specimen to analogue output is as follow for the following ranges. 4.5mV has a gain of 1,000; 450uV has a gain of 10,000; 450uV has a gain of 100,000

All outputs are buffered and are suitable for connection to a chart recorder or computer data acquisition system. Please ensure that the correct polarity is maintained - the Common of the output is always the outer portion of the BNC connector.

7. Pre-amplifier I/P's

Both the specimen and reference signals must be in the range of ± 4.5mV.

8. **Serial Data (USB) output socket.**

In order to use the USB connection a 'Virtual COM Port' needs to be installed on your host system before the DCM-2 is connected. Follow the instructions on the face of the CD to install the windows drivers.

Once the drivers have been installed you may connect the DCM-2 which should be switched on before plugging the USB connector.

The 'COM port' number can be found in windows 'Device manager', under the 'Ports' section you will find the port marked as 'CP210x USB to UART' with a COM port number in brackets. It should be noted that connecting a "live" usb cable to the DCM-2 will disable any input from the RS232 port until the cable is removed.

ADVANCED USAGE AND ADVANCED MENU

The DCM-2 has many advanced user settings, allowing the user full control of the way the unit's current and sampling is synchronised with the machine cycle input. The unit also has many features implemented in both hardware and firmware in order to reduce noise pickup and permit selection of various sampling options.
One of the most important features of the DCM-2 is the synchronisation of the unit and the mains frequency. Mains frequency can be a cause of electrical noise. In order to reduce this effect the DCM-2 always takes both the ON and OFF readings at the same point in the mains cycle independent of which mode the user has selected, by employing simple techniques any mains noise is automatically removed.
Below is an explanation of the various advanced modes available to the user. If further explanation is required please contact Matelect Ltd. Some of these modes are accessed through the Advanced Menu within the DCM-2 firmware, whereas others are selectable through the Main setup screen.

1. Free running mode

When using the instrument without an external synchronisation module or, when fitted, synchronization is not required; the free running mode should be selected. In this mode the following internal operation routine is enabled,

The current is switched on and set to the user setting.
The DCM-2 then waits 20mS in order to allow the current to settle.
The unit then waits for a negative-to-positive zero crossover point in the mains cycle. At this point, it proceeds to take 64 continuous readings, with each reading taking on average approximately 582µS.
The current is then switched off and allowed to settle again for 20mS.
The DCM-2 as before waits for a negative to positive zero crossover point in the mains cycle and takes 64 continuous readings again.

As both the on and off readings were taken at the same point in the mains cycle any noise can now be easily cancelled out by the DCM-2 and the readings averaged. This is one complete sample cycle. Both the settling time between on, off current states and the number of readings taken are user adjustable under the advanced user settings menu. Dependent on the filter setting chosen the DCM-2 will take two, four or eight sample cycles before pausing for the user set off time, again set under the advanced user settings menu.

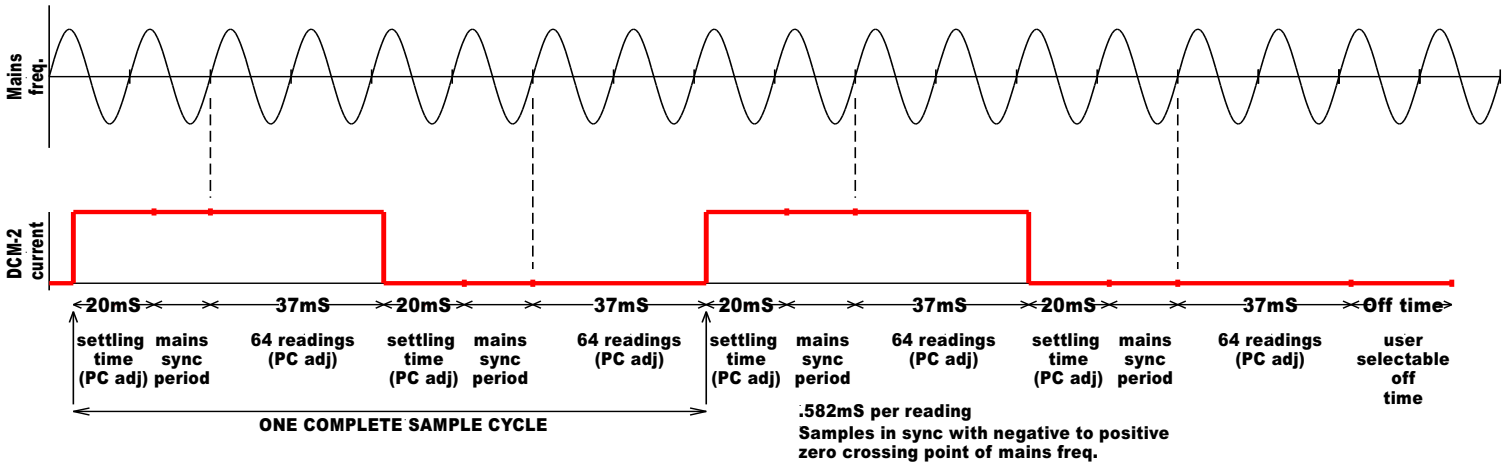


Figure 7 Free running mode.

2. External synchronisation mode 0.6 – 5.5Hz

When synchronising the DCM-2 current and reading cycles with an external source such as that from a testing machine, the user must choose the correct frequency range. Currently the DCM-2 offers two ranges these are 0.6Hz to 5.5Hz and 130Hz to 500Hz. When in the 'PEAKS 0.6Hz to 5.5Hz' mode the following routine is enabled,

The DCM-2 waits for a negative to positive midpoint crossover point in the external synchronisation waveform and turns the current on.
The DCM-2 then waits 20mS in order to allow the current to settle.
The DCM-2 then waits for the peak of the external synchronisation waveform and at this point it proceeds to take 64 continuous readings.
The current is then switched off and allowed to settle again for 20mS.
The DCM-2 then waits for the same mains cycle point at which it took the first 64 'current on' readings, and proceeds to take 64 continuous 'off current' readings.

As before in the free running mode both the 'on' and 'off current' readings were taken at the same point in the mains cycle, any noise can now be easily cancelled out by the DCM-2 and the readings averaged. This is one complete sample cycle. Both the settling time between on, off current states and the number of readings taken are user adjustable under the advanced user settings menu. Dependent on the filter setting chosen the DCM-2 will take two, four or eight sample cycles before pausing for the user set off time, again set under the advanced user settings menu.

If the user choose 'MIDPOINTS 0.6Hz to 5.5Hz' mode then the above process is followed in the same way but now the current is switched 'on' when the external synchronisation goes through the trough.
If the user choose 'TROUGHS 0.6Hz to 5.5Hz' mode then the above process is followed in the same way but now the current is switched 'on' when the external synchronisation goes through the positive to negative midpoint crossover.

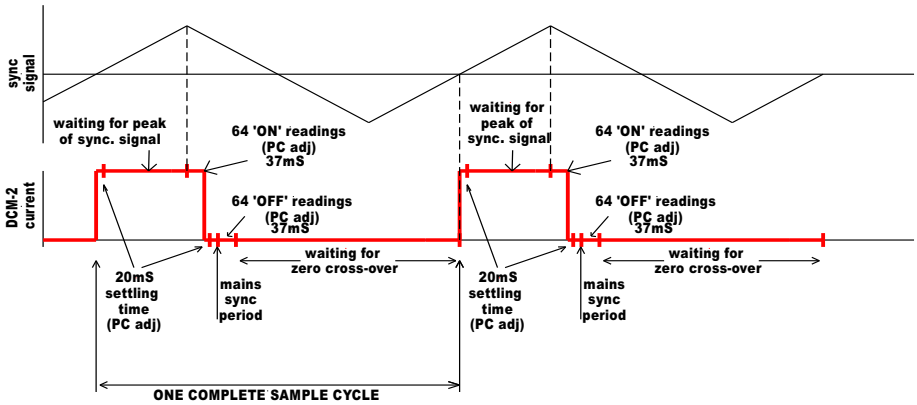


Figure 8 0.6-5.5Hz peak mode.

3. External synchronisation mode 130 – 500Hz

When in the 'PEAKS 130Hz to 500Hz' mode the following routine is enabled,

The DCM-2 waits for a negative to positive midpoint crossover in the external synchronisation waveform and turns the current on.
The DCM-2 then waits 20mS in order to allow the current to settle.
The DCM-2 then waits for the peak of the external synchronisation waveform and at this point proceeds to take a single reading.

The DCM-2 then waits for the next peak of the external synchronisation waveform and takes a second reading, repeating this process until 64 readings have been taken.
The current is then switched off and allowed to settle again for 20mS.
The DCM-2 then waits for the same mains cycle point at which it took the first of the 64 'current on' readings, and proceeds to take a single 'off current' reading.
The DCM-2 then waits for the same point in the mains cycle waveform that the second 'on current' reading was taken and takes the second 'off current' reading, repeating this process until 64 'off current' readings have been taken.

As before in the free running mode both the 'on' and 'off current' readings were taken at the same point in the mains cycle, any noise can now be easily cancelled out by the DCM-2 and the readings averaged. This is one complete sample cycle. Both the settling time between on, off current states and the number of readings taken are user adjustable under the advanced user settings menu. Dependent on the filter setting chosen the DCM-2 will take two, four or eight sample cycles before pausing for the user set off time, again set under the advanced user settings menu.

If the user chooses 'MIDPOINTS 130Hz to 500Hz' mode then the above process is followed in the same way but now the current is switched 'on' when the external synchronisation goes through the trough.
If the user chooses 'TROUGHS 130Hz to 500Hz' mode then the above process is followed in the same way but now the current is switched 'on' when the external synchronisation goes through the positive to negative midpoint crossover.

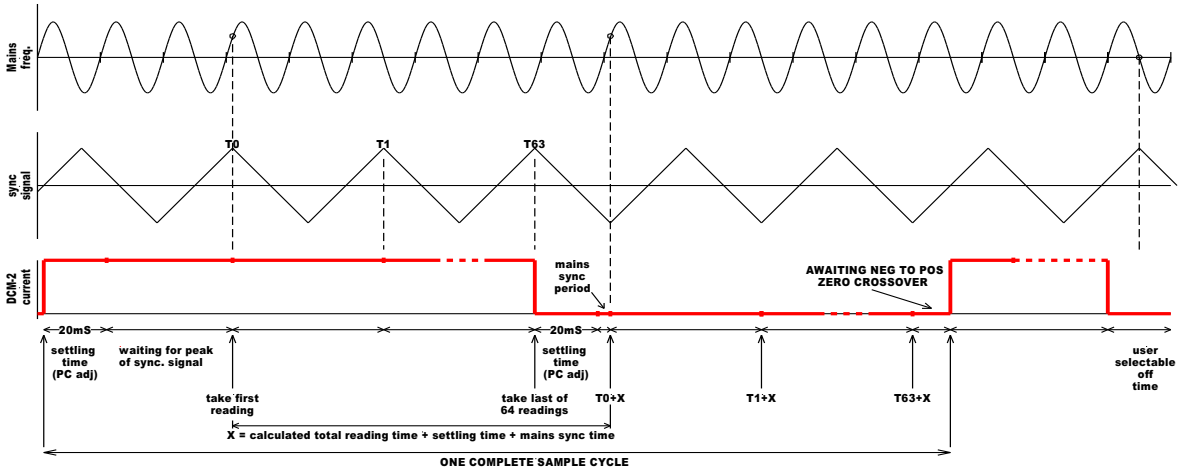


Figure 9 130-500Hz peak mode.

To accurately set-up the DCM-2 for an external signal, the end-user should follow the Synchronization Wizard that accompanies this mode.

4. Other Options

In addition to the previously defined options, the Advanced menu in the DCM-2 firmware also offers end-users, as standard, the ability to modify the number of readings and samples taken by the DCM-2 each time a current pulse is generated. This facility can be regarded much like the Filter setting which is accessed in the basic menu of the DCM-2 . Indeed when these values are adjusted from the Advanced Menu, a return to the Operating screen of the DCM-2 will reveal that the Filter setting is now "User Defined". The Filter settings are simply default sub-sets of the combination of readings and samples that the unit is capable of achieving.

If users are unclear about the way in which this Advanced menu option functions, then they should utilize the default Filter settings in the first instance, and then contact Matelect for further

advice. It should be noted that if large values of the number of readings and samples are selected (the DCM-2 allows a maximum of 255 for each) then the "current on" period can be substantial, hence negating the advantages of reduced specimen heating provide by pulsed operation. Also, users will have to wait long periods of time before readings are taken and subsequently updated.

If a reversing current module is fitted, the Advanced menu offers end-users the ability to activate it. It will NOT be activated by default, and the DCM-2 will remain in a monopolar mode.

To activate the reversing facility, the menu item is highlighted and selected in the conventional manner and the setting can then be cycled between False (reversing OFF) and True (Reversing ON). Confirmation of current reversal will be obtained during pulsed operation of the unit by a minus sign appearing in the Current setting window of the main Operating screen.

The reversing facility has been implemented in the DCM-2 in a manner which allows the end-user to observe and record the voltages measured in both the positive and negative pulse periods. This is an unconventional implementation given that, historically, most reversing DCPD instruments added the two signals together, calculated an average and then displayed the value as the "true" DCPD. This latter method is fundamentally flawed and was usually employed to mask the fact that the two readings were never the same.

Although, in theory at least, the readings should be identical, in practice, it is difficult to design and construct amplifier circuitry to functions in a totally linear bipolar manner. The DCM-2 however was designed to be accurate in both the positive and negative going signal regimes, and this should be apparent to the end-user if observation is made of the signal when the current polarity flag (the minus sign) appears and disappears. Usually only a single digit flicker is observed, if at all.

In experimental tests, however, some specimens have generated inexplicable differences of the order of 10 -100 digits. The mechanism behind this is unknown but could be due to differences in the current flow lines generated in one polarity compared to another.

If end-users experience such shifts in the signal level between the positive and negative pulses, it is important to understand that this is not "noise", but a true phenomenon. However, if large discrepancies are observed, these can confuse the data. If this is the case, then the unit should either be operated in monopolar mode or end-users can request a firmware update to the DCM-2 which will display the calculated average of the two polarities of DCPD, rather than the individual values, thus removing the signal level jumps.

MAKING CONNECTIONS TO A SPECIMEN

1. General

In general, if the user has chosen no specific test regime, the configuration shown in Fig 1, should be employed.

Two specimens are utilised, one acting as the test specimen and one acting as the reference specimen. As described earlier, a reference specimen is used to counter any thermal effects that occur due to a variation in the ambient temperature. The value of the DCPD from the test specimen is normalised via a division using the DCPD value from the reference specimen. This method will only work if both the test and reference specimens are subjected to the same ambient temperature and also that any temperature variations are uniform in nature. For example, bright sunlight shining only on one side of the test or reference specimen can seriously affect the DCPD values obtained. The DCM-2 performs a simple X/Y normalisation as standard and both displays this on the front panel graphics screen and output's it as an analogue signal through the rear panel analogue output BNC sockets. If the optional computer control software is employed, then this output is also available in the software.

2. Connections

Users must obey the usual sign conventions when connecting the current and signal cables to the test and reference specimens. The signal-high wire on the signal cable (coloured red) should always be connected to the side of the specimen nearest the Red current terminal. The signal-low (black) wires should similarly be situated nearest the connection to the black current terminals (see Fig 1).

Users should always employ the standard cables as supplied by Matelect with the DCM-2 system. If the cables have had to be lengthened, please ensure that the same types of cables are used and that the connections to the DCM-2 are made correctly. Unfortunately Matelect cannot accept responsibility for any damage caused to the DCM-2 by incorrect cable connections.

If a lower rating of current cable is utilised (below ca. 70 amperes continuous) users may find that the voltage compliance of the current source is reached well before it is possible to pass the maximum current. This may especially be applicable for large or high resistivity specimens.

3. Contacts

Securing the current cables to the specimen is best accomplished using a large gauge threaded fastener, such as a machine screw. Ensure that the contact surfaces are free from corrosion and any poorly or non-conducting surface layers, as these can also force a lower maximum current by causing the voltage compliance to be reached.

The signal contacts can be made using finer screw fasteners or they can be spot-welded. Other methods such as conductive glues or soldering can be used for specialist applications.

For test specimens that are to be submerged in an electrolyte (e.g. water) it is important to use fastening materials and methods that are electrochemical compatible. Corrosion of the current contacts can be especially problematic in DCPD studies but the use of pulsed current as opposed to continuous, has reduced these effects dramatically.

4. Thermoelectric EMF's

Thermoelectric EMF's are generated wherever dissimilar metals are in contact with each other. These can be of the same order of magnitude as the value of the actual DC signals due to the specimen resistance. Such EMF's can therefore destroy the integrity of DCPD results. Again the use of pulsed currents has effectively eliminated the thermoelectric effects.

Pulsing allows the EMF's to be measured during the current OFF period. The OFF reading is subtracted from the ON reading thus eliminating the thermoelectric EMF's. This method assumes that no temperature change occurs between the two sets of readings. This is a fair assumption unless abnormally high rates of heating or cooling are occurring.

5. Noise

All cables leading from the specimens to the pre-amplifier should be shielded from stray EM radiation and as short as practicable. Remember that the voltage resolution at the specimen surface ranges from a few hundred nanovolts to a few tens of nanovolts (dependent upon gain) so any noise can seriously affect the integrity of the measurements.

6. Other considerations

DCPD specimens should be electrically isolated from the test machine. A significant portion of the DC current can flow through the testing machine if this rule is not followed. Damage to equipment is unlikely to occur but the voltage readings obtained under such a situation will be non ideal. The ASTM states that if the readings change by more than 0.1% between the bench and initial loading in the testing machine isolation should be fitted. The alternative current paths may not exhibit a constant resistance during a test, and therefore introduce noise. This is why specimens must always be electrically isolated.

Most users have their own method of specimen isolation but in general, any thin strip of an insulator can be used to insulate the specimen surface from the testing machine grips. In the case of standard CT specimens for example, the pins that permit the specimen to be stressed must also be isolated from the specimen. Conventional pins are usually machined to be a tight fit into the specimen locating holes so as to minimise "slack". Smaller pins will therefore have to be machined in order to permit insertion of an isolating layer. Washers should also be used to insulate the side of the CT specimens from the machine.

SETTING UP AND DOING A TEST

Please read all the previous sections within this manual before commencing to set up a test.

The DCM-2's basic operation is relatively easy to understand and therefore does not require elaborate explanation of the setting up options. In this section the various options available to the user are described with the aid of a standard set-up routine.

Once experienced in the operation of the DCM-2, users are not required to rigorously follow the following set-up. Indeed with experience, the DCM-2 user will wish to use his or her own set-up parameters, which have been optimised for a particular specimen or test.

Providing the precautions and recommendations already described in this manual have been followed, no damage can be done to the DCM-2 by a non-standard combination of menu options, so the user should feel free to experiment with the parameters in order to achieve an optimum test result.

1. A basic fatigue test using the DCM-2

This example describes a fatigue test set-up, with current pulse synchronisation and a reference specimen. It is designed as an illustration of the options available and should not be considered a full and exhaustive description of the procedures involved in such a test.

1. If possible, perform a set-up test with the specimens not attached to the testing machine as follows.

2. Connect the system components as shown in Figure 1. Remember to follow the colour code for the connections to the specimen. Use only Matelect cables where specified. Ensure all connections are firm and properly made. Connect the analogue outputs (in this case X/Y) to a chart recorder or acquisition system.

3. Connect the DCM-2 to the main power and switch on using the rear panel mains switch. The front panel display should light and after a short delay, the Main Menu will appear

4. Use the front panel dial and button to travel between each parameter. Start at the beginning of the menu and work around. At any time you can return to a menu option and change it without difficulty.

5. Set the signal **range** value (gain) of the DCM-2 system. The range can be varied between 4.5mV to 45uV. It is best to start at 4.5mV and work your way down.

6. Set the test **current**. This can be set between zero and 50 amperes (depended on unit) in steps of 10mA. For a typical CT specimen try 30 Amps or the maximum current if below this value. In general try to use the maximum current you can with your specimen without making it heat up in the process, this will allow you to achieve the maximum resolution of the system.

7. Select the **filter** parameter. Set this to minimum for now. This will give you the fastest response but may be noisy depending on your set-up increase this if required

8. Set the measurement **mode**. If pulse synchronisation is required, and the optional module fitted, set peak, midpoint or trough at the correct frequency. If the test will be under constant load, select free running mode. For our example select peak mode at 0.6 – 5.5Hz.

   Please note that you will need to pulse the unit from your testing machine or some other source in order to test the set-up. Alternatively you can put the machine into free running mode to test your setup.

9. Begin the test by going to the run setting on the main menu bar. If the readings obtained on channel X and Y are each about 25% of the selected range, then the current and gain settings are ideal. Between 10% and 75% of the selected range is useable.

10. To stop the test, press button at any time and you will be returned to the Main Menu

11. Remove the DCPD connections if required and attach the specimen to the testing machine, and perform your usual test machine set-up. Ensure that the machine cycle input socket has been correctly connected to your testing machine output and that sensible values of the cyclic frequency and amplitude have been set.

12. Check the electrical isolation of the test specimen from the testing machine. Attach the current and signal cables to the specimen, locate the reference close to the specimen but away from sources of noise and uneven heat. Confirm the readings are the same as on the bench if possible.

13. Commence the fatigue test, and the DCPD test by selecting the run setting on the main menu bar.

14. The readings obtained should be similar to those observed during the set-up test. If they are not check the level of noise on the signal by observing the front panel readings. Also check the integrity of the connections and the isolation of the specimen. Contact Matelect for further advice if a problem remains.

Remember that to translate voltage or voltage ratio into crack depth, it is usual to perform a calibration test whereby the readings are related to the crack depth as measured by another technique.

COMMUNICATIONS PROTOCOLS

Please contact Matelect for further information should you require access to the communications (RS232) protocols used to achieve computer control and data logging using the DCM-2 . Matelect can supply dedicated off-the-shelf software to control and read the DCM-2 or we can consider specific requests for modification and bespoke software. The software is also able to control the optional signal and current scanner units that are used to extend a standard two channel DCM-2 into a multi-channel monitoring system (see section on Peripheral Equipment). Labview virtual instrument drivers are also available for most of our products – please contact Matelect head office for more information and prices.

Below is a List of all the DCM-2 Commands.

Command	Description
INF	Send information on unit
HEL	Explains most instructions and their format.
SVR	Set Voltage Range.
SFR	Set Filter number of Readings.
SFS	Set Filter number of samples.
SLG	Set Load Gain *
SLO	Set Load offset *
SCH	Set Number of active channel.
SCR	Set the value of current
SSC	Set scanners Current Channel
SSV	Set scanners Voltage Channel
SSB	Set scanners both voltage and current Channels
SUO	Set the User offset
SST	Set the settling time
RAV	Read all variable
RAD	Read all variable including diagnostic ones *
MON	Puts Machine into Monitor Mode *
SCM	Set the run mode
RES	Puts Machine into RUN Mode without resetting auto offset
RUN	Puts Machine into RUN Mode and resets auto offset
STO	Puts Machine into STOP Mode
SMS	Set Mark Space delay in mill seconds
SRM	Set Reversing mode 0 = off 1 = on
SRS	Set RS232 mode

* For Matelect's internal use only

Please note that not all commands are available for all DCM-2's some are option dependant.

The standard port settings for the DCM-2 are as follows:

Baud rate = 19200
Parity = none
Start bits =1
Data bits = 8
Stop bits = 1
Handshaking = xon/xoff

There are options to configure the DCM-2 digital output to be the same as a DCM-1 or to be defined by the user.

SPECIFICATIONS

DCM-2 Model range.	
Option1	10A maximum current output.
Option2	10A maximum current output, with Advanced triggering
Option3	10A maximum current output, with Advanced triggering, and 20 volt output supply
Option4	50A maximum current output.
Option5	50A maximum current output, with Advanced triggering
Option6	50A maximum current output, with Advanced triggering and reversing output current
Other Configurations are available please call for a quote	

Specifications	
Current O/P	High stability (better than 0.01%) continuously variable current supply. Continuously variable in 10mA increments. No minimum load required.
Input ranges	±4500µV with a resolution of 0.1µV. ±450µV with a resolution of 0.01µV. ±45µV with a resolution of 1nV.
Offset	± 4.5mV with respect to input signal. Adjustable in 1µV steps.
Filters	User definable filtering with 3 pre-defined settings.
External sync	Input voltage range, Max ±20V Min ±150mV Frequency range, Max 500Hz Min 0.6Hz Unit will trigger on peak, trough or mid-point of load cycle waveform input.
Display	Large 240*128 back-lit LCD displaying all user definable settings. As well as the X, Y and X/Y signals.
Outputs	Separate analogue O/P's of X, Y and X/Y signals. (BNC) Digital O/P of all set and displayed values. (Via RS-232)
Connectors	Current O/P 2-way and 3-way Lemo (2B size) Signal I/P X and Y 2-way Lemo (0B size) Analogue signal out X, Y & X/Y: BNC Ext sync BNC RS232 9-pin male D-type USB Type B
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 4Ampere 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.
Operating Environment	Indoor use only 0°-35°C main unit. LCD 10°-30°C. A 30 minutes warm up time is recommended. Pollution Degree 1 environment (no pollution, or only dry non-conductive pollution) Humidity 20% -80% RH (non-condensing).
All modules are built to the EN61010-1:2001 standard for electrical safety CE	

*Total current output is dependent on model purchased.

Available accessories and options on all models.	
INTERNAL PRE-AMP	Internal Preamplifier providing 2 extra concurrent inputs.

EXTERNAL PRE-AMP	External Preamplifier. (Availability TBA)
INTERNAL SC1-HC	Scanner control with 25-way male D-type for SM system, 2x BNC to give analogue position of current and signal channels.
EXTERNAL SM1-HC	4 dual channel signal switching unit.
EXTERNAL SM2-HC	4 channel current switching unit. (50amp compliant)
19" rack mounting	Rack mounting kit, please state when ordering.

DOCUMENT HISTORY

Modifications to "Advanced Menu" February 2011 Ver 19

To reflect changes with firmware VER30XX to Ver35XX the 'Advanced' menu changed to than now show in section 6.

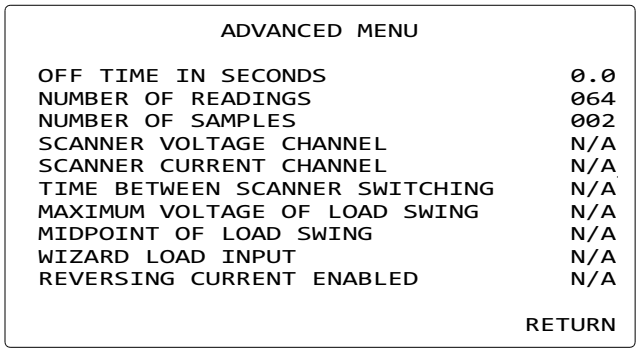


Figure 10 Advanced Menu

Maximum voltage of load swing
This defines the maximum voltage within the external load waveform the DCM-2 is to synchronize with. This is a bespoke option as this is normally done best using the DCM-2s in built optimizer just before a reading rather than a static point as defined by a user.

Midpoint of load swing
This defines the midpoint of the load waveform the DCM-2 is expected to synchronize with, in volts. This is the point equal distance in potential between the maximum and minimum values and should not be confused with the mean load although in symmetrical waveforms this is true. This is a bespoke option as this is normally done best using the DCM-2s in built optimizer just before a reading rather than a static point as defined by a user.

Wizard load input
This option is used to help the user define the best values for the maximum and midpoint of the load waveform. As the DCM-2s in built optimizer is the most efficient way of doing this, this option is not normally activated.

Modifications to "Advanced Menu" March 2011 Ver 20

Changes were made to the manual to reflect the changes in the firmware which changed the label from "*0.6-130Hz peak"* to "*0.6-5.5Hz peak"* and also in the troughs and zero crossing in this frequency range. A table to cover the number of samples and readings suitable for load cycle with frequencies in the range of 5.5Hz to 130Hz was added.

Modifications to "Other considerations" July 2013 Ver 22

Clarification to the explanation of, isolation of the specimen with relation to earth and current supply.

Modifications to "External synchronisation mode 130 – 500Hz" August 2013 Ver 23

Correction to *Figure 9* text changed from "ONE COMPLETE READING CYCLE" to "ONE COMPLETE SAMPLE CYCLE"

Modifications to "Figure 1" November 2013 Ver 24

Correction to *Figure 1* to better describe the real world layout and match *Figure 6* .

Modifications to "Rear panel description" February 2014 Ver 25

Introduction of USB to the DCM-2. The manual was modified in the "Rear panel description" section to reflect this.

Modifications to "Communications protocols" May 2014 Ver 26

Update to include RS232/USB baud rate and setting plus clarification of bespoke protocols.

Modifications to "Rear panel description" August 2015 Ver 27

Update to include RS232 interaction USB and correction of typing errors.

Modifications to "Specifications" November 2015 Ver 28

Update to include USB connector.

Modifications to "Communications protocols" December 2015 Ver 29

Update to reflect the inclusion of the RESume command.

Modifications Throughout the manual March 2016 Ver 30

Update to reflect changes in firmware version 370a where the terms "*0.6-5.5Hz zero"* was replaced with "MIDPOINTS 0.6-5.5Hz" and "*130-500Hz zero"* was replaced with "MIDPOINTS 130-500Hz".
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Modifications to "Communications protocols" December 2017 Ver 31

Correction of Baud Rate from 192000 to 19200

Modifications Throughout the manual February 2018 Ver 32

Correction of Fuse rating to be consistence for the DCM-2 mains fuse at 4 amps

Modifications "ADVANCED USAGE AND ADVANCED MENU" June2024 Ver 35
Correction of timing of a single reading from 667µS to 582µS and other timings associated.

PERIPHERAL EQUIPMENT

SM1-HC & SM2-HC

To increase the versatility of the DCM-2 crack growth monitor, Matelect has developed a new compact, modular signal and current multiplexing system designed to allow multi-point monitoring of specimens undergoing crack growth measurements. In its basic form the system is capable of measuring up to 4 signal points (reference plus specimen) simultaneously.

SM1-HC and SM2-HC FEATURES & APPLICATIONS

- Each signal channel switches both the signal from the crack region as well as the reference signal.
- Multiple monitoring of separate specimens undergoing crack initiation and propagation tests, using a single DCM-2 .
- Current switching module capable of switching up to 50Amps.
- Monitoring of up to 256 areas on a single specimen. This allows the DCPD system to be used in long term monitoring of mechanical structures, such as airframes.

The component parts of the multiplexing system consist of the SM1-HC signal switching module and SM2-HC current switching module. In the case of the DCM-2 the unit directly controls these by the provided control cable.

For those customers without the optional DCM-2 scan controller unit, the SC1-HC standalone may be used, allowing manual or PC control of the SM1-HC and SM2-HC.

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SM1-HC AND SM2-HC SPECIFICATIONS

SC1 MODULE SPECIFICATIONS	
Modes	EXTernal (PC), MANual and AUTOmatic
Capability	256 channels

SM1-HC SPECIFICATIONS	
Type	4 channel DCPD voltage signal switching module
Addresses	000000 to 111111 (Set via an Internal 6 way DIL switch)
Relays	Pickering type double pole changeover dry reed
Rating	0.5A max at 20V, 0.05A at 200V max
Contacts	Rhodium plate
Power	± 5 volts from SC1
Input	2 pin LEMO type X 8(mates with FGG0B302CNAD42Z LEMO plug)
Output	2 pin LEMO to 8 pin DCM-1 input
Case	Epoxy coated steel enclosure to IP20

SM2-HC SPECIFICATIONS	
Type	4 channel DCPD current switching module
Addresses	000000 to 111111 (Set via an Internal 6 way DIL switch)
Rating	50A @ 1/3 duty cycle, max on time 350mS at 6v
Power	± 8 volts from SC1
Input	3 pin LEMO to spade connector of DCM-1 output RED
	2 pin LEMO to spade connector of DCM-1 output BLACK
Output	3 pin LEMO & 2 pin LEMO
Case	Epoxy coated steel enclosure to IP20

PSU-1 SPECIFICATIONS	
Type	Stand alone power supply unit
Input	230V AC 50/60Hz OR 110V AC 50/60Hz
Output	± 8 Volts @ 300mA Regulated
Fuse	Internal short circuit protection and 3A fuse (UK plug)

All modules are built to the EN61010-1:2001 standard for electrical safety CE

WARRANTY

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.

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