

THIN FILM DEPOSITION MONITOR AND CONTROLLER USER'S MANUAL

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1. INTRODUCTION

The **Thin Film Deposition Monitor and Controller** is a modular system, designed to measure the resistivity and the optical transmission of thin films (usually but not necessarily metallic), by using either a light source or Radio Frequencies (RF). No contact between the sensing probes and film is involved. It is a non-contact method.

Various application cards and options are available, which include:

RF probes interface card - for measuring the resistivity of the film.

Optical probes interface card - for measuring the optical transmission and optical density of the film.

Bar Chart Display - Shows a four colour graphical display of the readings with user definable set points and tolerances (displayed in green, excursions from these displayed in red). This output is a standard VGA display

External output interface card -either analogue or digital, with fibre optics options, suitable for interfacing to a PLC.

Printer interface card - to provide a hard copy output of the readings.

Controller interface card - to interface to clutch drivers or similar providing an automatic deposition control.

The standard system includes a high resolution VGA monitor. The monitor displays probe readings, allows easy data entry and has an extensive and intelligent on-line HELP facility.

The system is housed either in a 6U high 19 inch rack or it may be used as a free standing unit.

NB. This manual covers all the available options. If an option is not fitted to your system, the relevant instructions and options will not appear on the display.

2. SYSTEM OVERVIEW

2.1 BRIEF DESCRIPTION OF THE SYSTEM

The Thin Film Deposition Monitor is based on an IBM compatible PC. Various interface cards may then be mounted in the rack as required by the system. The system is modular - comprising a hard disk, a floppy disk and an integral keyboard. An external key board may be also connected.

The following optional interface cards are available:

- Resistivity (RF) probe interface
- Optical probe interface.

- External analogue output.
- External digital output RS 232 or RS422 (for interfacing to PLC).
- External fibre optics output (for interfacing to PLC),
- Controller board for driving clutch motors.

The software for the system realises the full potential of this modularity, allowing any set of probe readings to be displayed or sent to any outputs designated by the user. Thus the optics probes readings may be used as the input to the controller, while the Bar Chart displays the reading from RF probes. These and other options may be changed by the user at will from the keyboard. The selection of option settings may be saved on the hard disk, so that on the subsequent power up the system restores the previously saved settings.

The system is supplied with a high resolution monitor (VGA) as standard. This, apart from displaying the probe readings, is used to select options and for an extensive HELP facility accessed by pressing the HELP key.

2.2 THE RESISTIVITY (RF) PROBES

2.2.1 Principle of operation

Each probe produces a radio-frequency (RF) field, typically at a frequency of 3 MHz. If the film is conductive, it absorbs some of the RF power, leading to a power loss from the probe. The more conductive the film, the greater power loss from the probes; it is this power loss that is measured to infer the film resistivity. The probes cover a range of around 1 to 10 ohms per square. Values outside this range may be measured by using different probes - if this is required, please consult the manufacturer. The use of this method of measurement is not limited to metals, but will work with any conduct substance.

2.2.2 One and two RF beam operation

The probes are mounted on support beams in the vacuum chamber. There are two options available with the RF probes - one and two beam systems. A one beam system may be used where there is a roller which has at least 30 mm of insulation on the outside. The probes are mounted then 1.5-2.5mm from the film - this distance is critical for satisfactory operation of the system. The probes must be re-calibrated if for any reason the support beam is moved. If no such roller is available, then two a beam system should be used. The transmitter probes are then mounted on one beam and the receiver probes on the other which faces the first beam. The receiver probes detect the RF field. A conductive film interposed between the two beams attenuates, by absorption, the detected RF field. The film should be located within ± 2 mm of the line equidistant from the two beams.

The operation of the system with one or two beam systems is almost identical - any exceptions are explicitly noted in the ensuing discussion.

2.2.3 Description of beam and probes

Each probe is housed in a small plastic box, which is then mounted in an extruded aluminium beam. The probes are connected together by a ribbon cable. This ribbon cable (cables in the

case of a two beam system) is/are connected to the Interface Box, a die cast metal box mounted on the beam. The cable from this Interface Box is then connected, through a through vacuum connector, to the main rack containing the PC.

2.2.4 Mounting the beam - one beam system

The beam should be mounted so that during the run, the probe faces are 1.5 to 2.5 mm away from the metallic surface of the film. This distance should be held constant as the probe readings are dependent on the distance between the probe and the film. Because the system is sensitive to the presence of conducting substances, there should be no fixed metal (other than that evaporated on to the web) nearer than 30mm of the probe faces. Also, the beam should be out of line of sight of any hot evaporating boats for thermal reasons, and quite obviously, no metal should be deposited on the probes.

2.2.5 Mounting the beams - two probe system

The beams should be mounted so that their edges are 53mm (+/-1mm) apart - this distance is critical, and should not be varied without discussion with the manufacturer. The film should pass through the centre line between the two beams. Moving the film more than 2mm either way from this position only affects the resistivity readings by 2 or 3 percent.

2.2.6 Calibration

The Resistivity (RF) probes require a two step calibrations procedure, known as with-web and no-web. The no-web calibration is used to establish the power levels in detected by the probe with no film present. The with-web calibration a film sample with a known resistivity is used. This step determines the probes' response to a film of known resistivity. Details are provided in section 6 (calibration). It is very important to note that the RF probes calibration is **relative** to the film sample used. It is only as accurate as the known value of the calibration sample.

2.2.7 Limitations

The method used here for measuring the film resistivity has two limitations of which the user should be aware:

- 1) There is a very small crosstalk between the probes. Because the RF fields have quite a large width, there is some overlap of the field generated by neighbouring probes. This effect is not large, and is normally totally irrelevant, as under normal running conditions the probes have nearly equal load. For this reason, however, when calibrating with-web, the known film sample should be presented to the probe under calibrated and its neighbours.
- 2) The objective is to measure the DC resistance of the film, as determined by, for example, an AVO meter. The RF probes measure the AC resistance (at the RF frequency, typically 3 MHz). Under normal circumstances these are the same. However, for very thin films (above 10 ohms per square), the metal coating may not be even, but "agglomerated" (i.e. lumpy). This will give a lower AC resistance than DC resistance, since the lumps of metal are capacitively joined. In extreme examples, there may be a high, but measurable, AC reading, while the film conducts no DC current.

2.3 THE OPTICAL PROBES

2.3.1 Principle of operation

There are two types of optical probes used in the system: fibre optics and probes on the beams. The principle of operation is the same although the light path and electronic implementation is somewhat different. The fibre optic probes work as described below.

Fibre Optic Probes

The light from Light Emitting Diodes (LEDs), mounted on the back of the rack, is collected by optical fibres, which go to one half of the optical beam. This received light is then collimated and shines through the film, which absorbs a proportion of it. The light is collected by the second lens focused on to another fibre which transmits all the light to the photo diodes, located in the rack. The received light is then measured. To prevent stray light from outside interfering, the LEDs are turned on and off 1200 times per second thus only the light modulated at this frequency is detected.

Note that because there is no electronics of any sort inside the vacuum chamber (not even a wire!), this system is immune to electrical and RF noise. Alternatively, LEDs and Detectors may be mounted inside the chamber on the optical beams if fibre optics cables are not acceptable.

2.3.2 On Beam Probes

The Light Emitting Diodes (LEDs) are mounted inside a small box containing the probe electronics. The light output, as before, is collimated by a similar lens. The light, after passing through the film, is collected by another lens and focused on to a PIN detector, housed in a similar box, mounted on the other beam. The voltage proportional to the detected light is transmitted by a ribbon cable to the optical Interface Box mounted on one beam. To prevent stray light interference the LEDs are modulated at 1200 Hz. The signals are digitised in the Interface Box and then transmitted to the rack.

2.3.3 Description of the beam and probes

In the fibre optics system the rack and the beam are connected by two Kopex armoured fibre optic bundles, with a vacuum penetration plate mounted part-way. The fibre optic connections at both ends are of the 9mm SMA type, with O-rings to preserve vacuum integrity. The probes on the beam have alignment adjustment screws which should not be touched by the user. Alignment may only be performed by the manufacturer.

If a Interface Box is used for on the beam probes an armoured cable, with 6 twisted pairs, connects the Interface Box to the rack.

2.3.4 Mounting the beam

Despite its being made of thick extruded aluminium material, the beam is in fact quite delicate, due to the requirements of optical alignment. The beam must be mounted to minimise vibration, and to allow a small amount of thermal expansion (less than 0.5mm).

**UNDER NO CIRCUMSTANCES SHOULD ANY WEIGHT OF LOADING
EVER BE APPLIED TO THE BEAM**

If the beam is accidentally stressed the optical probes may go out of alignment. Although this is reversible for small loads, a large load, such as a man standing on it, may produce a permanent deflection, requiring re-alignment by the manufacturer. The beam should also be mounted away from the line of sight of any hot boats and crucibles to avoid thermal effects and, of course, no metal should be allowed to deposit on the lens surfaces.

2.3.5 Calibration

The optical probes measure optical transmission, which are then converts to optical density. The measured transmission (T) is defined as follows:

T (optical transmission), is the amount of light passing through the film, expressed as a fraction, of the amount of light that reached the detector in the absence of a film i.e. when the calibration was carried out.

The user may perform three different sorts of calibration:

- 1) No-web. The calibration is performed with no film in the beam in vacuum or with air present, there is a negligible difference). Readings taken after calibration are then absolute transmissions. Note that film normally considered transparent (and also glass etc.) actually has a transmission of around 90%. This is due to light being reflected from the two surfaces of the film, as well as other losses.
- 2) Transparent web. It is anticipated that this will be the most common form of calibration. The non-metallised web is inserted into the beam at the proper tension, and the calibration performed. Subsequent readings will then give the transmission of the deposited film. The non-metallised web reading corresponds then to 100%. Please note that removing the non-metallised film will give a reading ABOVE 100%, with negative optical densities, as the received light will be grater than the amount of light at time of calibration. This is displayed as an overflow.
- 3) Semi-transparent web. It is possible to perform a calibration on a semi-transparent web. As with the transparent web, subsequent readings will read the transmission of the extra film deposited, and the calibration web will read 100%. Note that overall sensitivity of the system is decreased, and that using nearly opaque web to calibrate will result in noisy readings.

2.3.6 Limitations

Unlike the RF probes, there is little crosstalk between the probes. However, the system should be only calibrated after, at least, 5 minutes after power up.

2.4 THE DISPLAY

The Colour Monitor is used for displaying instructions, HELP text and the probe readings.

2.5 THE BAR CHART DISPLAY

A four colour Bar Chart display is available. This graphically displays the readings from a set of probes, therefore it may be used for monitoring and manually controlling the deposition rates. The chart displays a bar for each probe, together with a set-point and a tolerance. The set point is the ideal probe reading (i.e. the desired film resistivity). The set point corresponds to a horizontal line in the middle of the screen. Each of the probe readings are displayed as a deviation away from this set point. If the deviation is within the specified tolerance, the bar is displayed as green. Readings above the tolerance limits are shown in red. The desired set-point and the tolerance are entered from the keyboard. The displayed range on the screen is 1.5 times the pre-set tolerance limit.

If the controller hardware and software is fitted, the set point corresponds to the reading which the controller tries to maintain. Thus, with a controller working perfectly, the Bar Chart should display only small green bars away from the set-point.

2.6 THE EXTERNAL OUTPUT (ANALOGUE)

The output from optical and resistivity probes may be connected to a PLC by a number of different methods. Described here is the analogue output.

An analogue output, giving between 0 and 10V DC, may be obtained from each probe. This voltage is proportional to either:

- 1) The RF probe reading in ohms per square. 1 volt output per (1 ohm per square).
- 2) The optical transmission in percent. 1 volt output per 10% transmission.

The voltages are brought out to the back of the unit on BNC sockets. They are updated about once every two seconds. The averaging time of the readings may be altered at the customers' request.

To enter a pre-set resistivity value for the analogue card follow the same procedure as used for the Bar Chart Display.

2.7 THE EXTERNAL OUTPUT (DIGITAL)

A digital output to a PLC maybe also provided. The probe readings, with 8 bits resolution are sent sequentially via an RS232 interface.

2.8 THE BACKUP MEMORY

During the normal operation the system uses "Random Access Memory" (RAM) to store set up options and all calibrations. Unfortunately, when power is removed the information is lost. The options may be stored on the hard disk. On the power up, the options last stored on the hard disk, will be used to initialise the system.

There are two backup files resmon.dat, control.dat and resmon.dft, control.dft. As the names indicate the last save parameters for display and control are stored in resmon.dat and

control.dat respectively. The corresponding files ending in *.dft contain the initial data stored when the system was first commissioned.

2.9 THE CONTROLLER

The deposition rate is controlled either by varying current supplied to electron guns or by altering a wire feed rate by engaging or disengaging clutches.

Thus, the Controller Option consists of an interface card providing a suitable output to solenoids operating clutches or a signal which may be used to control the electron gun current. Each boat or electron gun is controlled individually by a probe (either optical or RF) situated in the immediate vicinity.

3. THE SYSTEM REQUIREMENTS AND INSTALLATION

3.1 POWER

The system will operate either from 110 VAC or 240 VAC, at 47-63 Hz, consuming about 90 watts maximum. The system will tolerate mains voltage fluctuations of +/- 15%.

3.2 ENVIRONMENTAL

The electronics rack will operate in a typical factory environment. Operating temperature is between 0°C (32°F) and 40°C (104°F) with relative humidity up to 90% (non condensing).

3.3 RS232 CONNECTOR PIN ASSIGNMENT

PORT 1 and 2 use D9 male connector with the following pin assignments:

Pin number	Signal
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

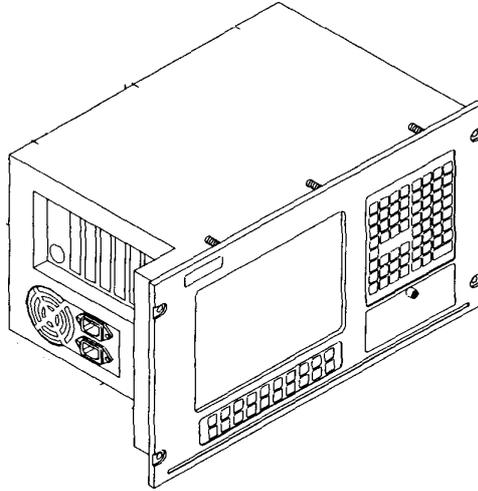
4. USING THE SYSTEM 1 - START UP

4.1 UNPACKING AND CONNECTING THE SYSTEM

The delivered system consists of :

1. An Industrial PC
2. Support Beams with probes and Interface Box.

3. One long cable with a D15 connector at one end and a vacuum through connector at the other end.
4. One short cable with a circular connector at one end and a vacuum through connector at the



other end.

Figure 1. General view of the PC

4.1.1 The Industrial PC

The general view of the PC is shown in figure 1. The dimensions are given in figure 2 below.

The PC may be either free standing, rack or panel mounted. **In order to use both the build in and an external keyboard it is necessary to connect a short cable with circular connectors** (as shown in fig.3) before mounting the PC in the rack. The cable from the vacuum through connector (i.e. from the interface box on the beams) with a D15 connector should be plugged into the driver card positioned at back of the PC. The first connector, after the Driver Card is for the printer. The other two connectors next to the printer connector are the RS232 ports. PORT 2 is above the printer connector, PORT 1 is next to it on the other card.

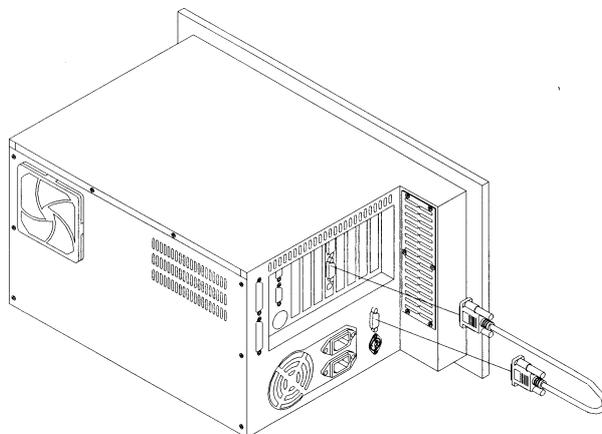


Figure 3. Cable connections

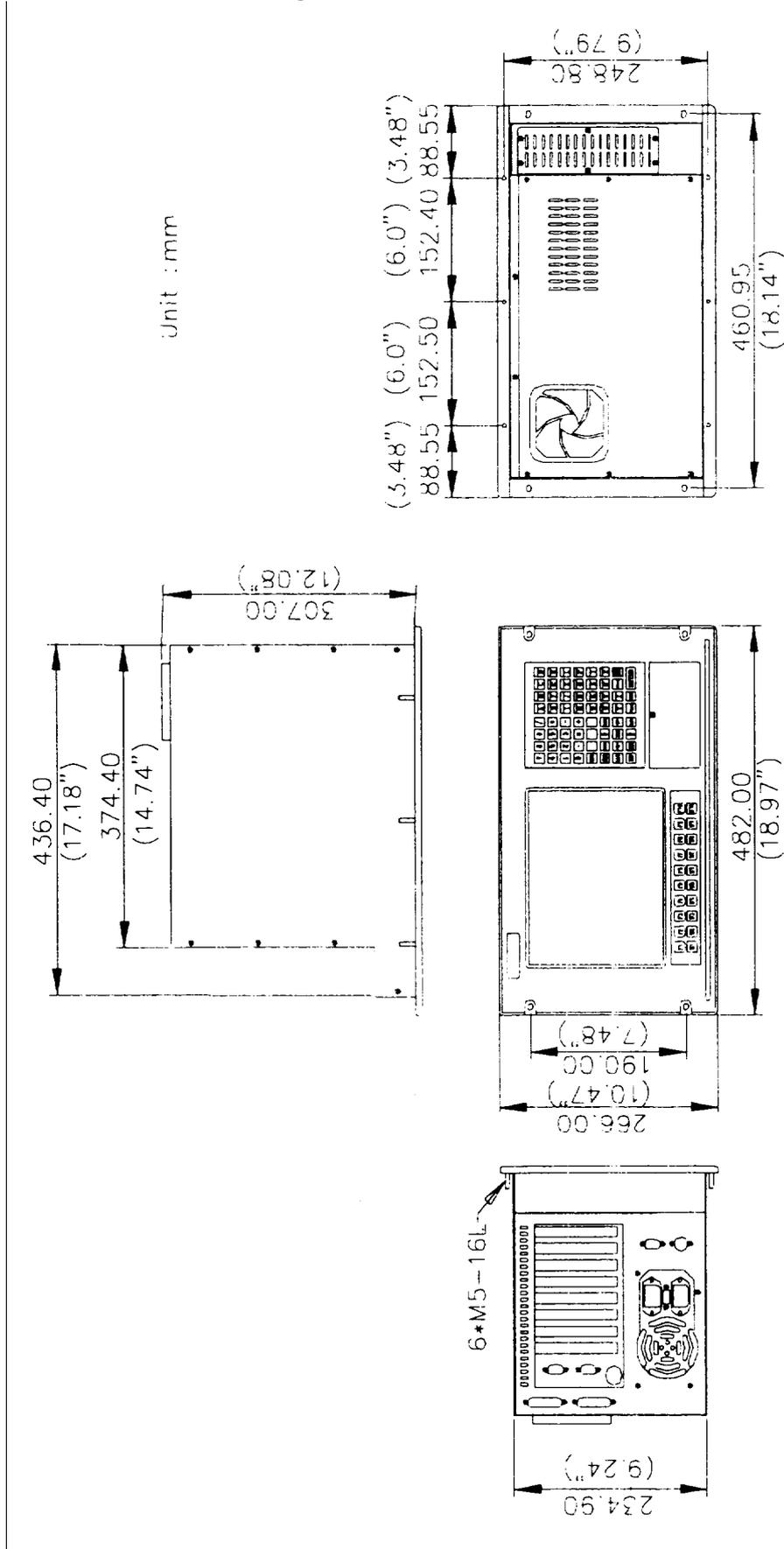


Figure 2 . PC dimensions

The PC should be switched on, before mounting, to ensure that it functions correctly.

Panel Mounting

A panel must have a set of screw holes corresponding to bolts on the PC. See figure 4. Make sure that all the screw holes line up with the bolts.

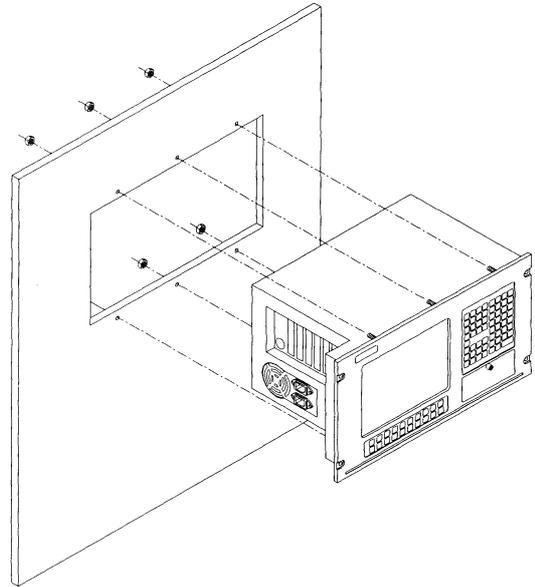


Figure 4. Panel Mounting Method

Rack Mounting

Remove the screw covers on the front panel by pushing them sideways. Unscrew the panel mount brackets and replace them with the rack mount handles as shown in figure 1 above.

Connecting Cables

Once the PC is in the required position other cables may be added (see above) making sure that all the connectors are securely attached to the PC. Then connect the PC cable to the vacuum through connector and then to the interface box using the shorter cable.

Note that with a two beam system one beam carries transmitters the other the receiver probes. It is important to connect cables from the probes to the correct connectors on the interface box. The cables and the outlets are clearly labelled. If these cables are interchanged the system will not function but there will be NO DAMAGE to the equipment.

The system is now ready for power up.

4.2 ON POWER UP....

The power supplies in the system are auto ranging and may be used either with 110VAC or 240VAC. The auto ranging feature sometimes prevents the power supplies from switching on correctly if power up and power down cycles are shorter than about 70 or 90 sec.

On power up, after a short while, the first display screen appears. It shows the relevant information about the system i.e. software version, instrument serial number etc. Once any key is pressed a Bar Chart appears on the monitor. The function assignment of F-keys are shown at the bottom of the screen. For the system to operate correctly the warm up should not be less than about 5 to 10 minutes.

4.3 THE KEYBOARD

A full QWERTY key board is provided for operating the system. The various options are selected by using F-keys from F1 to F9 and keys from 0 to 9. The function of each key is defined on the display screen. Some of the keys are re-defined on different screens. The other ASCII characters are primarily used for entering information to be printed in report.

The following keys always have the same function assigned to them:

F1 HELP F3 SET-UP F5 RUN F7 DEBUG F9 EXIT

Other keys change their function under different options.

F1 HELP this key allows the access to an on-line help menu.
 F3 SET-UP this key opens up the set-up menu from which options listed below may be selected
 F5 RUN this key is used for setting up the Controller
 F7 DEBUG this key displays unprocessed data collected from the probes.
 F9 EXIT this stops the operation of the Monitor.

The following options are available and may be found on the relevant screens:

1. Bar Chart options
2. Active probe selection
3. External Output Select (only if installed)
4. Enter Set Point and Displayed Tolerance for Bar Chart
5. Save current options for start up
6. Printer Time interval
7. Print Report
8. Debug mode which shows unprocessed data received from the probes
9. Manual or automatic control of the deposition rate.(only if installed)

The different options are reached by following instruction on the display screen.

5. USING THE SYSTEM - THE OPTIONS

5.1 THE STANDARD DISPLAY

On power up the Bar Chart Display appears (after the initial screen) with the list of F-keys options at the bottom of the screen.

F1 HELP F3 SET-UP F5 RUN F7 DEBUG F9 EXIT

To change any parameter it is necessary to enter the SET-UP SCREEN by pressing F3 key. The following display is then obtained:

Please select one of:

- 1: SET-POINT
- 2: Optical probes
- 3: Printing
- 4: Bar Chart Display
- 5: To save these new set-up to file
- 6: To restore the set-up from the file
- 7: To restore the factory settings

ESC: For none of these

5.2 SET-POINT

The set point determines the value at the centre of the Bar Chart Display and control value for the Controller.

By choosing one of the above options another screen display is reached with instructions how to enter all appropriate parameters.

After selecting **1** from the previous screen, the display changes to:

```

Select Set Point and error limits for Resistivity

Upper error limit      2.20 Ohms
SETPOINT              1.20 Ohms
Lower error limit     0.20 Ohms

Please press

  1: to alter the SETPOINT
  2: to alter the error limits

 F8: to confirm these changes
ESC: to abandon these changes

14:38:34   Manual System
F8: Confirm changes
    
```

Note that changing the SET-POINT also alters the error limits

The error limits affect only the Bar Chart Display. The bars below the set error limit are green and above the error limit change to red.

5.3 PROBES

5.3.1 Optical Probes

There are two options on this screen: active probe selection and calibration.

Although the any given vacuum chamber has fixed number of boats and normally would require a monitor with the same number of sensing probes. Quite often, however, coating runs are made with narrow webs, much less than the full width of the coating chamber. This option allows to set and calibrate only the probes covering the web for a given run.

The selection is performed using arrow keys left and right, F2 and F4 keys and observing the change in the display.

5.3.2 RESISTIVITY (RF) Probes

There are two options on this screen: active probe selection and calibration.

Although the any given vacuum chamber has fixed number of boats and normally would require a monitor with the same number of sensing probes. Quite often, however, coating runs are made with narrow webs, much less than the full width of the coating chamber. This option allows to set and calibrate only the probes covering the web for a given run.

The selection is performed using arrow keys left and right, F2 and F4 keys and observing the change in the display.

5.4 REPORT PRINTING

When the printing option is installed the following window appears.

SET-UP PRINTING

Please press :

F2: to enable the printer

F4: to disable the printer

F6: to set the printer interval

F8: to confirm these settings

ESC: to abandon this section

At a pre-selected time intervals the probe readings may be printed. At the end of each run the final report is printed giving the average values over the run. It is also possible to disable the intermediate printout and only print the final report.

5.5 CONFIGURING THE BAR CHART

The Bar Chart allows three types of display when both resistivity and optical probes are used:

- optical transmission
- optical density
- resistivity

NOTE: If optical probes are not connected this option only allows the display of resistivity. After selecting **4** from the previous screen, the display changes to:

BAR CHART DISPLAY

Please select one of:

- 1: To display optical density
- 2: To display percentage optical transmission
- 3: To display resistivity

F8: To confirm the change

ESC: To leave it unchanged

With this option selected, you may control what the Bar Chart displays. You may press the following keys:

- 1: The Bar Chart displays the readings of the optical probes, giving optical density (which has no units).
- 2: The Bar Chart displays the readings of the optical probes, giving transmission in percent.
- 3: The Bar Chart displays the readings of the RF probes, in ohms per square.

5.6 SAVING TO SET-UP FILE

Altered parameters may be saved to a file so that on the next power up the values are restored. When this option is chosen the following widow appears:

SAVE THIS SET-UP ON DISK

If you write these options to disk they will be ready
next time you switch the system on.

You will also erase the previous settings saved
on the disk.

Do you wish to do this? Please press

Y to write to the disk

N to leave this section

ESC will also leave this section

Simply follow the above instruction. These parameters are saved in files RESMON.DAT and CONTROL.DAT in RESMON directory on the hard disk.

5.7 RESTORE FILE SETTINGS

All the parameters previously saved may be restored at any time by using this option and following instruction on the screen shown below:

RESTORE FILE SETTINGS

If you run this section the changes to the set-up that you have made will be lost and those saved to disk will be restored.

Do you wish to do this? Please press

Y to restore the saved settings

N to leave this section

ESC will also leave this section

5.8 RESTORE FACTORY SETTINGS

Factory settings are also stored on the software back up floppy disk. This disk or a copy of it should be kept in a safe place. Sometimes the files on the hard disk may be corrupted resulting in a system crash. There are several possible causes: very severe power fluctuations during saving of options, a nearby lighting strike etc. In the case of such an event the factory settings should be restored and the system re-calibrated.

In the event of problems restore the factory settings from the hard disk. If this fails copy, using DOS instruction files RESMON.DFT and CONTROL.DFT from the back up disk to RESMON directory the hard disk and repeat the procedure below.

RESTORE FACTORY SETTINGS

If you run this section the factory settings will be restored and the existing ones forgotten.

Do you wish to do this? Please press

Y to restore the factory settings

N to leave this section

ESC will also leave this section

5.9 RESTORING A CORRUPT FILE

Sometimes a file gets corrupted on the hard disk and on power up the system reports a file error. To remedy the problem start the machine in DOS mode and copy the relevant file to

hard disk. If its not clear which file is corrupted copy all the files from the back up disk to the hard disk ensuring that they are placed in the correct directories as shown below:

C:\	autoexec.bat config.sys command.com note.txt			DOS files
C:\	RESMON\ resmon.exe resmon.dat resmon.dft control.dat control.dft help.txt			Serial No. of the system Resistivity Monitor System files. Essential for the system.
C:\	RESMON\ FONTS\ Coure.fon Sariff.fon Ssariff.fon			Font files used by the display
C:\	GALDEBUG\ Plc_simu.exe Test0u.exe Test1u.exe Test2u.exe Versions.txt			Files used for debugging only. They are not needed for the operation of the system.

5.9.1 Hard Disk Failure.

On very rare occasions the hard disk may fail completely. When this happens either power down the PC or press the RESET button or press simultaneously the three keys: Ctrl Alt Del to re-start the system. When a message saying “Hit DEL key to change settings” appears press Del key. A BIOS screen is displayed. Go to Advance settings and change boot order from C: to A:. Then save and exit this set-up. The system will start from the drive A:. It may be possible to correct corrupted files either by copying files from the disk in drive A: .If not a DOS operating system, DOS 6.0 or higher, must be re-installed.

5.10 DEBUG MODE

When the F7 key is pressed the Bar chart display disappears and a set of readings is displayed. The three numbers on each line represent: the probe number, the raw data collected from the probe and a percentage reading indicating the ratio between the current probe reading and the original reading after the initial set-up. This feature is particularly useful for observing the collection of deposited material on optical lenses. The decrease of this last number indicates that some metal has been deposited on the probe lenses. When it drops below about 10% it is recommended that the lenses of the optical probes should be cleaned. . Before the Monitor is used for the first time a note of all the readings should be taken for future reference. A suitable form is provided in the appendix.

By pressing F2 key and then up/down arrow keys it is possible to display, in enlarged letters the percentage transmission of each probe. This feature is used for aligning the optical probes.

6. SYSTEM CALIBRATION

The calibration menu for each type of probes is reached, as described above, through probes set up menu. Here suitable calibration methods will be described.

6.1 INTRODUCTION

The two types of probes, optical and RF, operate independently. They measure optical transmission and resistivity respectively. Unfortunately, there is no simple relationship between the two measurements. The conversion involves the properties of thin metal films, such as the bulk resistivity, Fresnel Reflection coefficients, skin effects etc.

RF probes measure a parameter, absorbed energy, which is related to the resistivity of the film. However, the exact function is rather difficult to calculate, and depends on the distance between the probes and the film, therefore a suitable calibration is required.

Optical probes measure the relative change in light level, therefore they also should be calibrated to establish the reference level i.e. 100% transmission. This 100% transmission level may be chosen as the amount of light transmitted through either a transparent or semi-transparent web or through the free space.

The calibration routines are accessed by selecting probes from the set up menu. The calibration is held in random access memory. If the calibration is to be used again after the power is turned off and on, it must be saved to backup memory. After each successful calibration, the user is invited to do so.

6.2 CALIBRATION OF THE OPTICAL PROBES

After the selecting probes from the set up menu the optical calibration mode is reached. The bottom half of the screen shows the following display :

CALIBRATE OPTICAL PROBES

Install the web which is to be calibrated as being transparent

Press ESC to EXIT

If an absolute transmission is required, then the space between the optical beams should be empty, otherwise the transparent or semi-transparent web should be inserted between the optical beams. Any web should be correctly tensioned. When this is done, pressing F6 key initiates the calibration, and displays the following message.

***** SYSTEM CALIBRATING - PLEASE WAIT *****

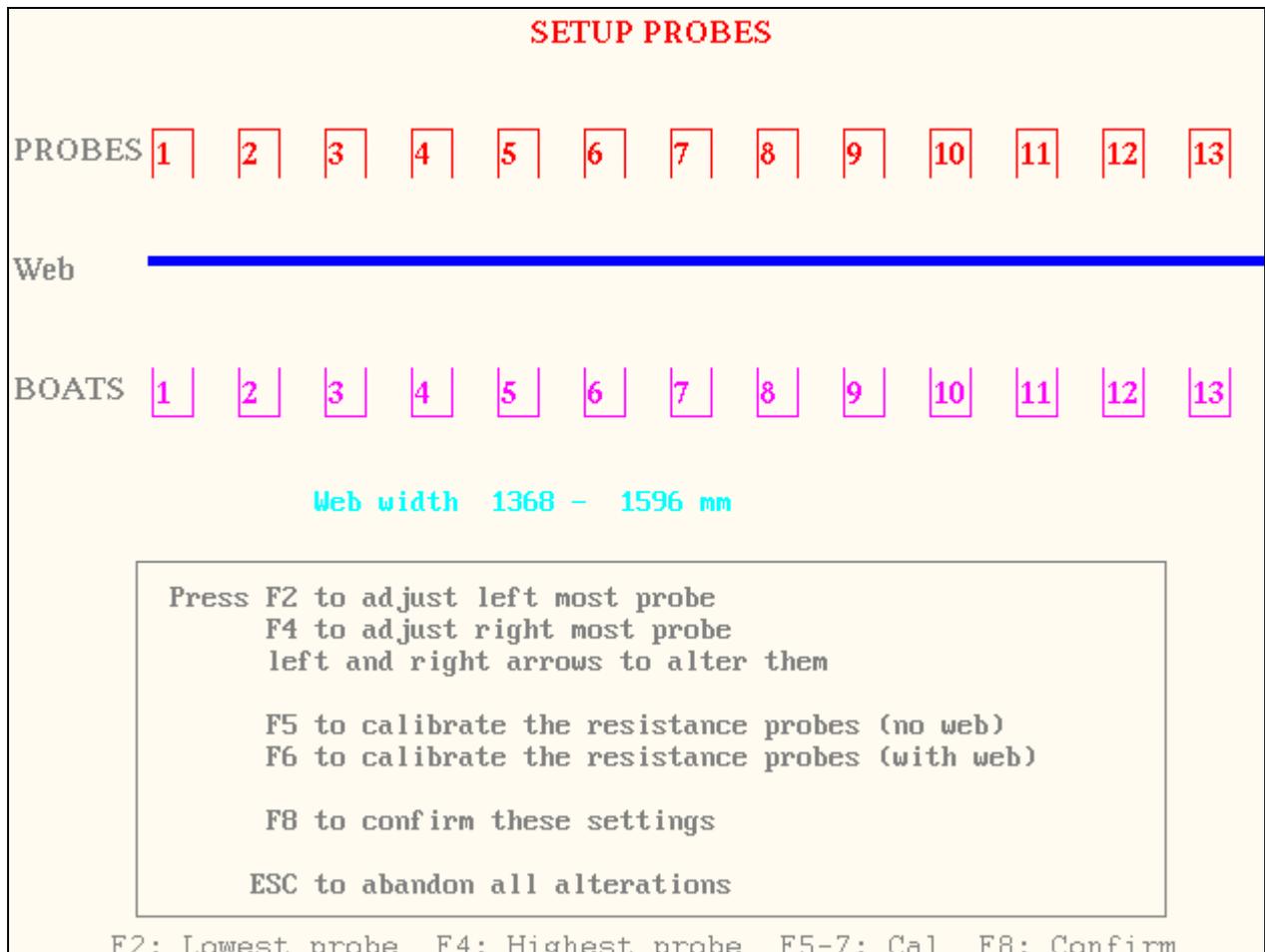
Calibration takes only a few seconds.

If the web used is too opaque, the system will refuse to use that web as a calibration standard. Severe damage or severe optical misalignment will also result in calibration difficulties. In this case, consult the manufacturer.

How often? The optical system takes a few minutes to warm up and stabilise after the power is turned on, therefore a calibration should not be attempted within 5 minutes of power being applied. Because the calibration is very easy to perform, and because the transmission of different webs (even transparent ones) is liable to be different, it is recommended that an optical calibration should be done before each run.

6.3 CALIBRATION OF THE RF PROBES

As mentioned above a two stage calibration of RF probes is required. Each type is selected from the following menu appearing in the bottom half of the screen:



6.3.1 No Web calibration

This calibration establishes the RF probe power levels when there is no loading.

F5 key is used to calibrate the probes without the film present. RF calibration without the web is selected. The following message appears below the probes display:

```

Press F2 to adjust left most probe
    F4 to adjust right most probe
    left and right arrows to alter them

F5 to calibrate the resistance probes (no web)
F6 to calibrate the resistance probes (with web)

F8 to confirm these settings

ESC to abandon all alterations

F2: Lowest probe  F4: Highest probe  F5-7: Cal  F8: Confir
    
```

The user should ensure that there is no metal or metallic film near the probes. Unlike the optical beam, where a part metallised film may be used as a reference, only uncoated, insulating film should be presented to the RF probes.

After pressing the F5 key the calibration starts and lasts for a few seconds with the following message displayed:

****** PLEASE WAIT CALIBRATING ******

How often? Because the power levels in the RF beam drift a little, and because this calibration is very easy to perform, it is recommended that this calibration be made before every run.

6.3.2 With Web

It is also necessary to determine the response of the RF probes to a film of known resistivity. To do this a strip of uniform resistivity equal to the width of the web should be used. Failing that, a strip of film covering, at least three probes at a time, should be used. The calibration instructions below assume the latter case. However, the same instructions should be followed if a film covering all the probes is available. Then of course, it will not be necessary to move the film strip between each pressing of F6 key. Choose a film strip with a resistivity near the proposed metallisation value.

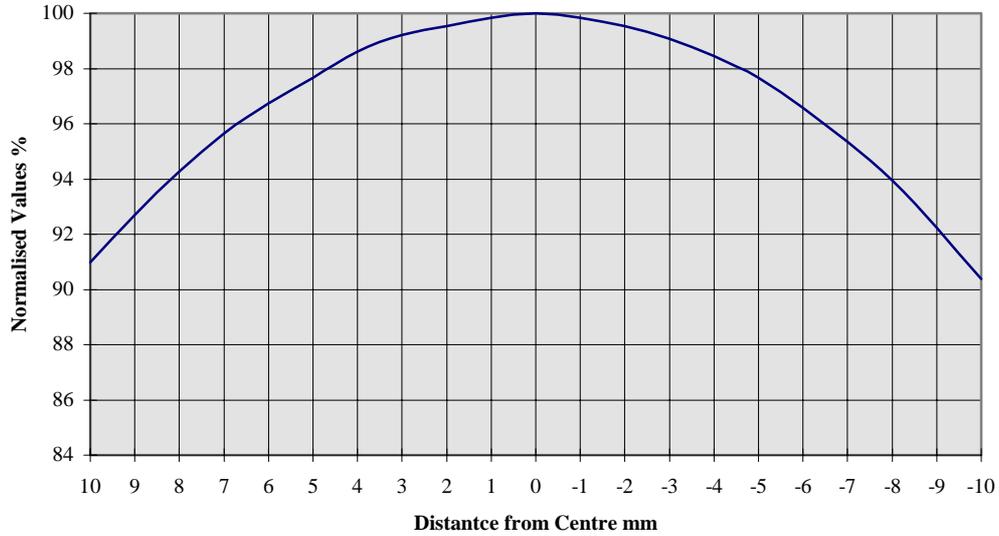
When calibrating with a one beam system, the film should be placed against the insulated roller. With a two beam system, it should be placed midway between the two beams, as close as possible to the position of the web position during the actual coating run.

NOTE IT IS ESSENTIAL THE CALIBRATION FILM IS LOCATED IN A EXATLY THE SAME POSITION AS THE WEB DURING THE COATING RUN.

The film location is very important because the reading will differ if the film is moved. The film should be located in the centre of the two beams. The sensitivity to displacement is shown in the graph below.

To obtain accurate results the film should be placed at ± 2 mm from the centre.

Resistivity Change with Displacement from Centre



Follow the instructions shown on the screen.

To calibrate with a film of known resistivity press F6. Then the system, as shown below requires the entry of the resistivity of the film, for example 2.0. Then there is an option to either calibrate one probe at time (F2) or all the probes simultaneously (F4). This can only be performed if all the probes are covered by the film of the same resistivity.

```

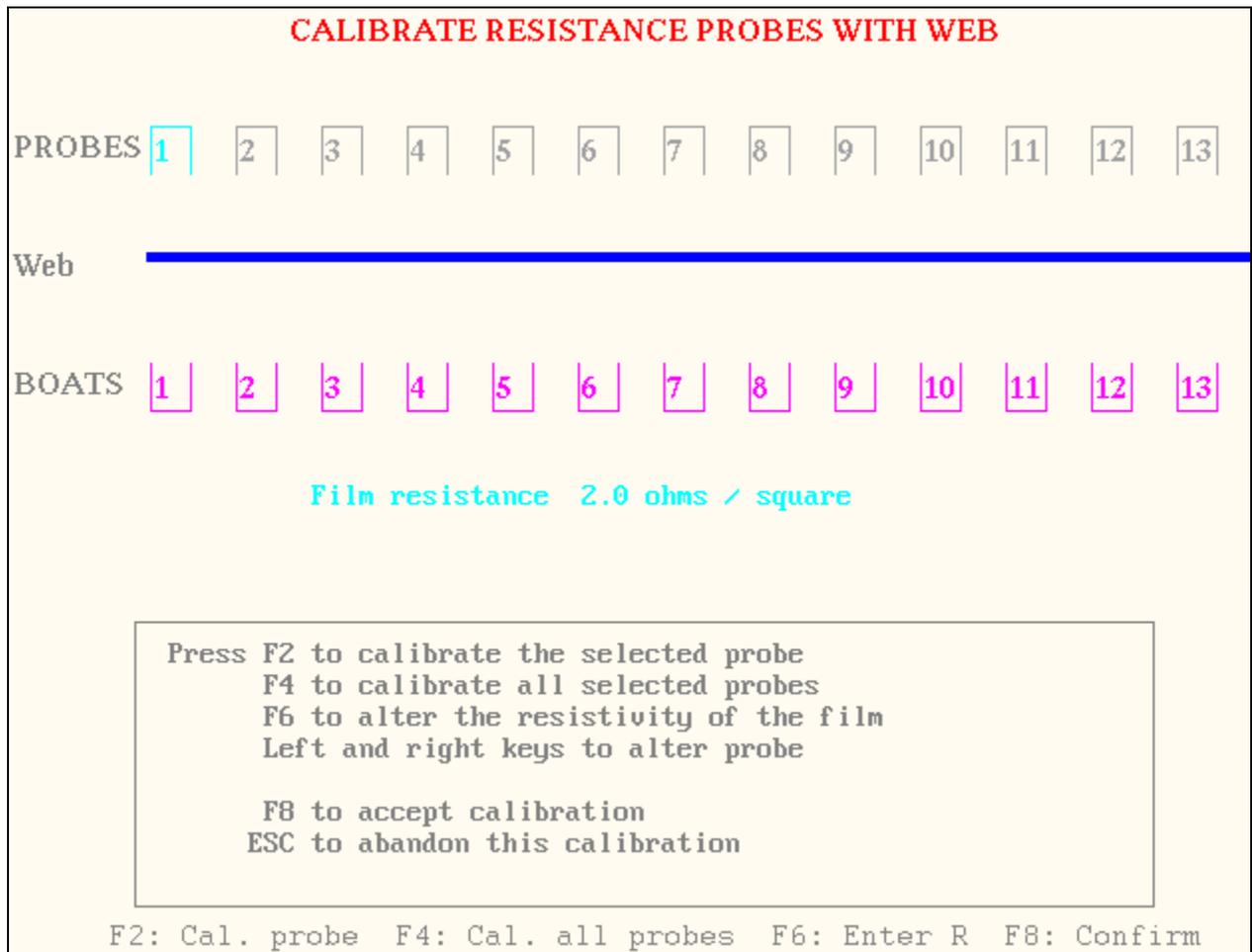
                Film resistance 2.0 ohms / square
Please type in a new value for film resistance
Press ENTER when complete :

    Press F2 to calibrate the selected probe
    F4 to calibrate all selected probes
    F6 to alter the resistivity of the film
    Left and right keys to alter probe

    F8 to accept calibration
    ESC to abandon this calibration

F2: Cal. probe  F4: Cal. all probes  F6: Enter R  F8: Confirm
    
```

On the other hand, when one probe is calibrated at time, the film need to cover only the probe under calibration and the nearest neighbours.



When F2 option is chosen the probe to be calibrated is highlighted as shown above. Once the calibration for the probe is completed the probe number changes by 1 from left to right. Simply follow the instruction on the screen. While the calibration is in progress the message shown below appears.

****** PLEASE WAIT CALIBRATING ******

To accept each successful calibration press key F8.

Very occasionally the following message may appear



If this happens check that the actual value of the film strip being used for calibration is correct and that its position with respect to the probes is within the two mm. If this message appears consistently a hardware fault may have occurred. Contact the manufacturer.

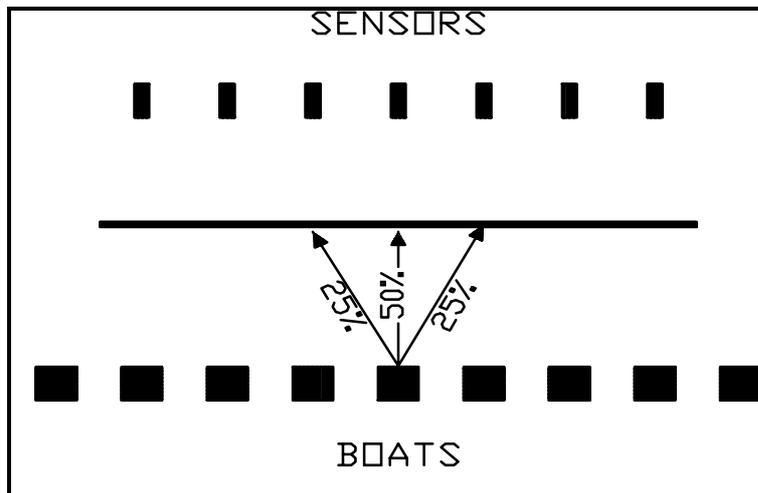
7. THE CONTROLLER

7.1 INTRODUCTION

The metal is deposited by evaporation of metal from boats heated electrically. The rate of deposition is governed by various factors including the boat temperature the amount of molten metal in a boat and the rate of wire feed. In a ideal situation all the parameters should remain constant and hence provide a uniform deposition rate. In practice, however, the parameters mentioned above change. Provided that this change is not too large the alteration of wire feed rate may be used to compensate for boat temperature and resistance changes etc. The Controller has been designed to perform this function by modifying appropriately the mark to space ratio of wire feed clutches.

7.2 PARAMETERS USED IN THE CONTROLLER

Although the boats width is small in comparison to their spacing there is an overlap of deposited material from the adjacent boats. This overlap varies with the boat spacing and from machine to machine. The diagram below illustrates the geometry of a typical system.



Nonetheless it very important to maintain more accurately THE SPEED than during manual feed in order to obtain the same deposition rates. Initially the overlap value should be established for the correct automatic control of the deposition rate. The other important parameter for the

system is the time constant of the machine i.e. when the wire feed rate is doubled how long does it take to obtain a uniform film deposition corresponding to the new feed rate. As the wire feed rate is controlled by clutches **THEY MUST NOT SLIP!!!!** Any slippage will cause an unsatisfactory operation of the Controller. Furthermore, as the Controller modifies the mark to space ratio of the clutch drive current, the clutch motor **MUST BE CAPABLE** of running **AT DOUBLE** the normal speed. To avoid inductive problems, when switching ON/OFF the clutch solenoid, **A RESISTIVE LOAD IS ADDED** in series with each clutch solenoid. Thus the clutch power supply **MUST PROVIDE A HIGHER VOLTAGE** than just for powering the clutches without the resistive load. For 0.5A clutches the power supply voltage of 35 VDC is required instead of the usual 24 VDC. Due to the presence of the overlap it is not possible to control the uniformity of the film over the end probes. Thus the output of the end boats is not controlled independently. Their output is the same as their nearest neighbour.

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7.3 THE CONTROL ALGORITHM

In order to control satisfactorily the rate of deposition the control algorithm calculates the new wire feed rate for all the boats from the overlap ratio, the machine time constant, the previous wire feed rate, the current and the previous probe readings. In this way the wire feed rate is adjusted twice a second. Furthermore, in order to ensure smooth changes in the wire feed rate the maximum rate of change is also limited. The lock on time is governed by the step size used. Thus, if the Controller is switched over to automatic, with all the wire feed rates set near the optimum, the lock on time is considerably reduced. The final values of the parameters, discussed above are determined during the installation.

7.4 HOW TO USE THE CONTROLLER

The preparation of the plant should be carried out in exactly the same way as for manual operation. Set the BAR CHART display to TRANSMISSION with error limits of either $\pm 10\%$ or $\pm 15\%$. Alternatively OPTICAL DENSITY display may be used. At this stage the Controller should be set to WARMUP. The WARMUP key is reached by first selecting RUN by F5 followed by F4. At this stage the system will not allow any changes to be made to any parameters until the warm-up or the automatic control is switched off, usually just before the end of the run. With the WARMUP position selected the Controller feeds the wire with 50% space ratio. The boats are then warmed up and wetted in the usual manner. When the shutter is opened and the web running the clutch motor speed should be adjusted so that all the probe readings fall within the error limits set above. Once this is achieved, the automatic control may be switched on by pressing F6 key. The switching off of the Controller initiates the printing of the final report.

7.5 MANUAL OPERATION

When the system is in control mode it is also possible to adjust wire feed rate manually. This option is reached by pressing F5 and then "M". After pressing "M" the system reverts to the Bar Chart display. The wire feed rate mark to space ratio, for each selected probe, is also shown at the bottom of the screen. The settings of a given probe may be changed by selecting it by pressing the left and right arrows. The mark to space ratio may be then altered by up and down arrows.

8. TROUBLE SHOOTING

8.1 LCD DISPLAY

In systems with LCD (Liquid Crystal Display) there may be a need to replace back illumination light. To do so:

1. Remove the backplane as shown in figure 5.
2. Pull out the bracket which is located below the backplane.
3. Detach the two brackets behind the front panel. One is bigger than the other. (See figure 6)
4. Remove the LCD.
5. Unscrew the three screws from the LCD. There will be only one backlight for mono displays, but there will be two backlights for TFT displays

Warning: The backlight is small and fragile. Use caution when handling or replacing it.

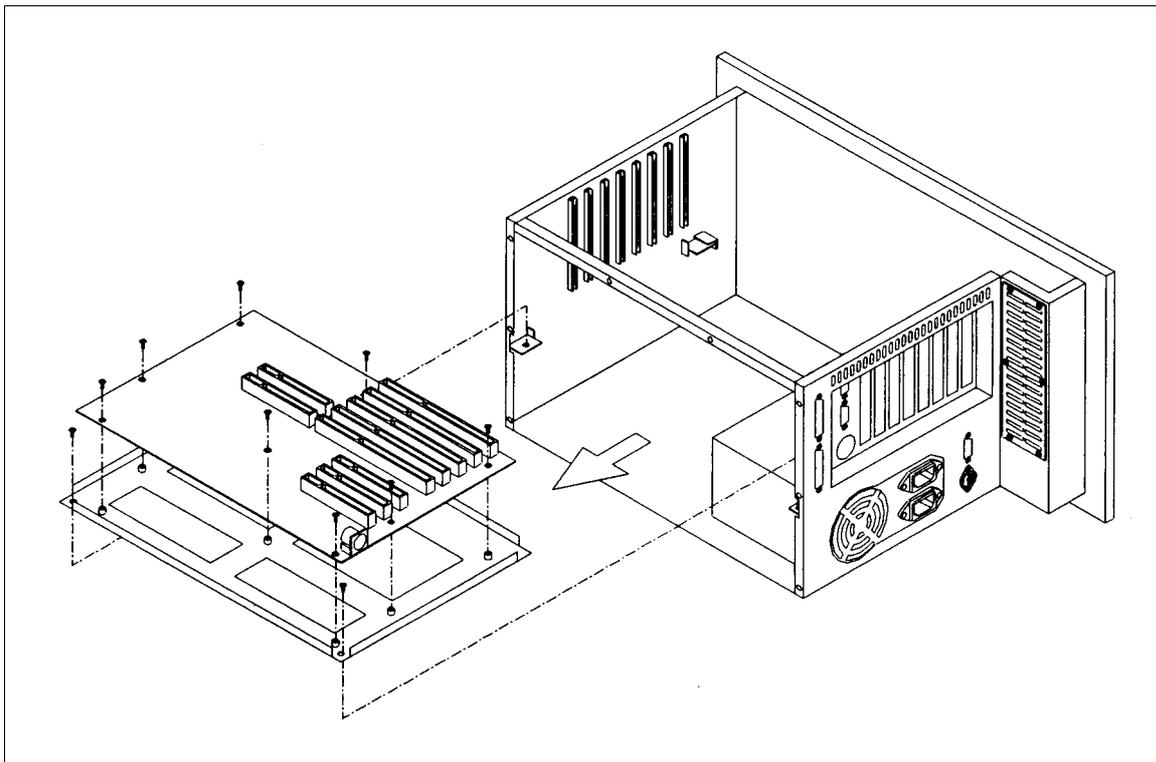


Figure 5. Detaching the backplane and the bracket

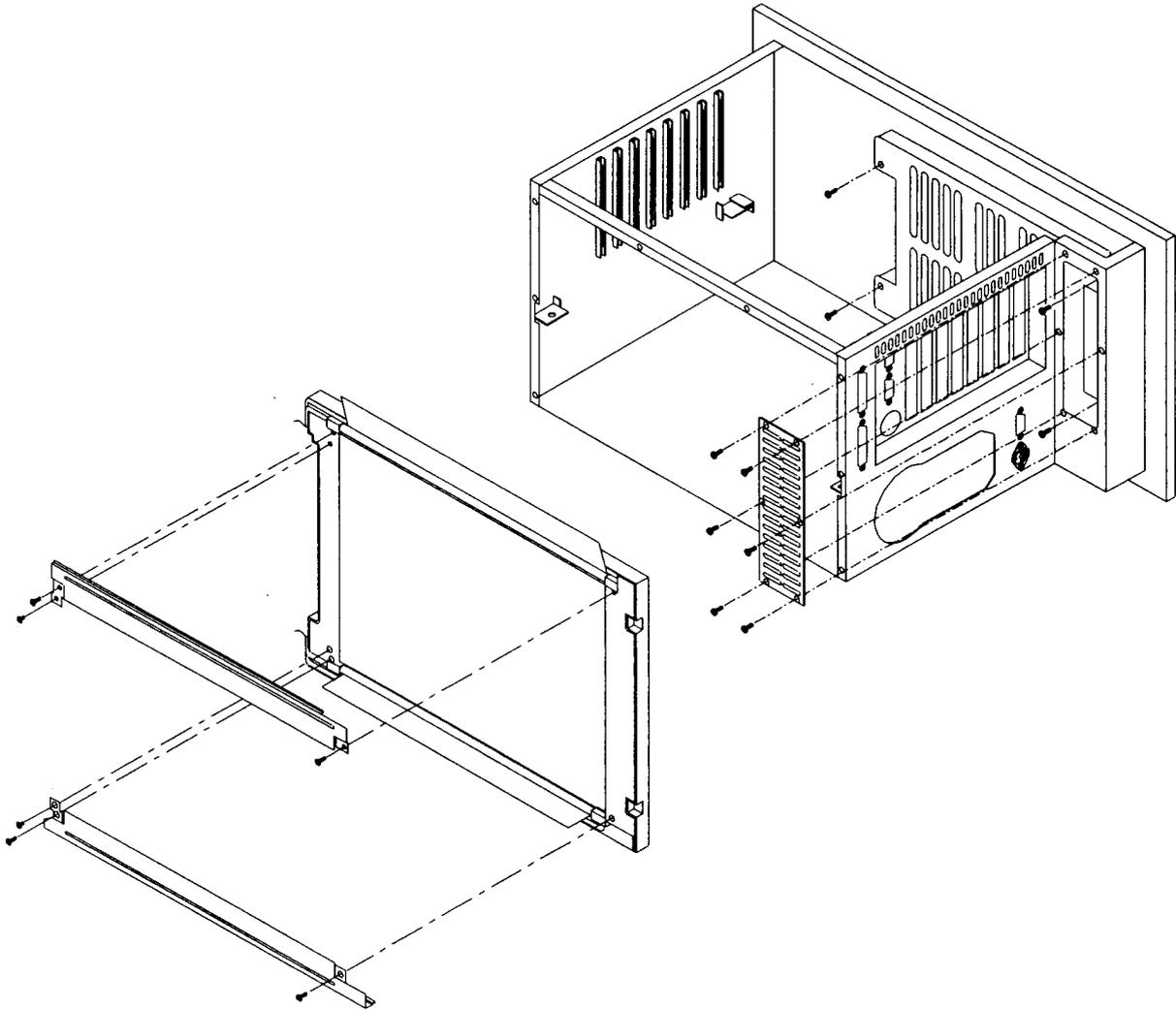


Figure 6. Replacing the LCD backlight.

8.2 OTHER FAILURE PROBLEMS

When the system fails totally to operate the most likely cause is either a bad cable connection or a power failure.

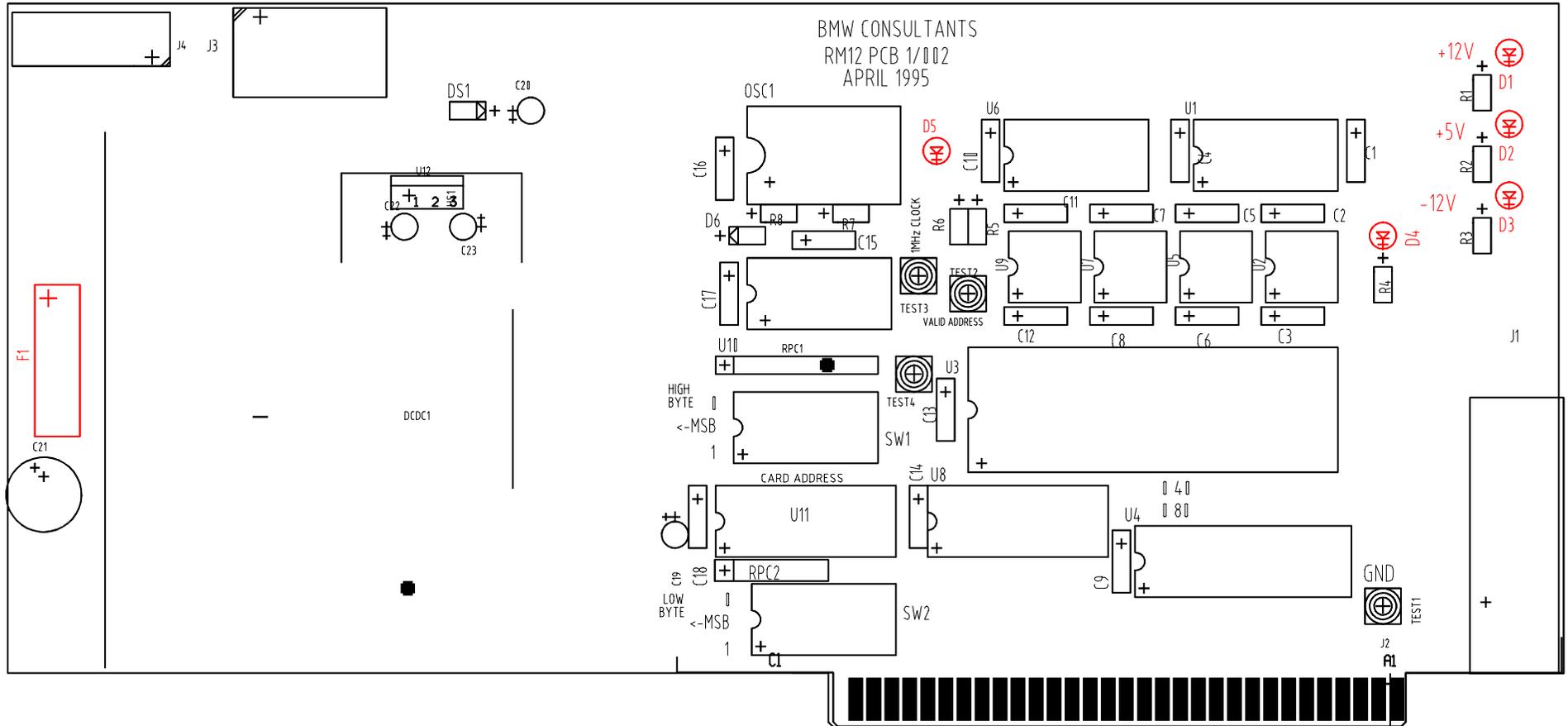
First of all check that all the connectors seated. Also check that the cable is not damaged. If this procedure fails to cure the fault check the power supplies.

The Thin Film Deposition Monitor is powered by the power supply located in the PC. To investigate the problem carry out the following procedure:

1. Switch off the power.
2. Remove the top cover of the PC by undoing all the fixing screws.
3. Once the cover is safely out of the way, turn the power on.

4. Look at the component side of the Printed Circuit Board (PCB) connected to the system by a D15 connector. There are 5 green Light Emitting Diodes (LED) mounted on this PCB, all marked in red in figure 5.
5. All LEDs must be ON. If LED D1 (+12V), D2 (+5V) and D3 (-12V) are off, then the fuse, marked F1, may have failed. Replace the fuse (800mA) if necessary.
6. If D4 (+5V) is off there is no power reaching the PCB from the computer bus.
7. The fifth LED (D5) indicates a valid bus address. It should be ON or flashing whenever the Monitor displays a bar chart.
8. If at least one LED remains off after changing the fuse contact the manufacturer.

BEAM DRIVER CARD



9. SYSTEM SPECIFICATIONS

Resistivity Range with RF Probe	0.5 to 10 ohms/square
Reproducibility	± 5%
Optical Transmission	0.1% to 100%
Reproducibility	± 0.5%
Ranges	1.5%, 20% and 100%
Optical Density	up to 3.0 OD
Number of probes	any up to 32
Display	A colour LCD with Bar Chart display showing one bar per probe. Bars change colour when the present resistive, optical density transmission exceeds pre-set limits.
Interfaces	Digital or analogue to communicate with a PLC or a printer. For long distance communication, or electro-magnetic interference is present, equivalent fibre optic links may be provided.
Dimensions	Units
RF probe	mm 70 x 50 x 35
Separation between probes	mm 0 to 2 (1 beam system)
Separation between beams	mm 52 (2 beam system)
Optical probes	mm 50 x 30 x 70
Separation between optical probes	mm 30 min
Separation of facing probes	mm up to 30
Power Supply	
Input power (typical)	<100watts
Input Voltage	90 to 132VAC or 180 to 264VAC at 47 to 63 Hz autoranging
Fuse on PC card driving the beams	800mA
Driver Rack	19 in rack 460 mm deep 6 U high.

APPENDIX

INITIAL PROBE READINGS

Probe no	RF probes readings	Optical probes readings
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		