Satellite (LM61) Manual

SP101002 Rev 4.02
January 2002

As part of our continuous product improvement policy, we are always pleased to receive your comments and suggestions about how we should develop our product range. We believe that the manual is an important part of the product and would welcome your feedback particularly relating to any omissions or inaccuracies you may discover.

You can send your comments to: -

MKS Instruments, Spectra Products
Cowley Way
Weston Road
Crewe, Cheshire
CW1 6AG
United Kingdom

+44 (0) 1270 250150 Tel.
+44 (0) 1270 251939 Fax.

In North America send your comments to:-

MKS Instruments, Spectra Products
380 Woodview Ave.
Morgan Hill
CA 95037
USA

(408) 778-6060 Office
(408) 776-8575 Fax
1-800-VAC CHECK

http://www.spectra-rga.com

EC DECLARATION OF CONFORMITY

Spectra SensorTech Ltd.
Cowley Way
Crewe
Cheshire
CW1 6AG
United Kingdom

DECLARES THAT THE FOLLOWING PRODUCTS:

LM62, LM10 VACSCAN 100
LM63, LM10, LM4 VACSCAN PLUS 100, 200
LM61, LM10, LM4, LM9 SATELLITE 100, 200, 300
LM56 MICROVISION
LM70, LM76 MICROVISION PLUS
LM77 VISION 1000P
LM79 VISION 1000I
LM89 VISION 1000B
LM90 VISION 1000 C / E
LM78 VAC CHECK
LM80 MINILAB

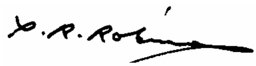
ARE IN CONFORMITY WITH THE FOLLOWING EUROPEAN DIRECTIVES:

89/336/EEC ELECTROMAGNETIC COMPATIBILITY DIRECTIVE
73/23/EEC LOW VOLTAGE DIRECTIVE AS AMMENDED 93/68 EEC

THE APPLICABLE STANDARDS ARE:

EN 61326:1998 ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL & LABORATORY USE.
EN 61010-1:1993 SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL & LABORATRY USE.

SIGNED:



T.R.ROBINSON
MANAGER OF EUROPEAN OPERATIONS
DATE: 1ST JULY 2001

Additional Installation Maintenance and Operating Instructions

In order to comply with European regulations, the following procedures must be followed: -

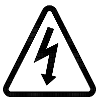
A) INSTALLATION

1) The installation procedures given in the operating and technical manuals must be followed, in addition to these instructions.
2) The mains power cable must conform to local regulations and must have a protective earth (PE) conductor securely connected to the power plug protective earth contact.
3) The short earthing braid supplied with some products must be fitted between the terminal on the RF head and one of the CF40 vacuum flange bolts.
4) Only cables supplied with the equipment may be used for interconnections. If extension cables are required to obtain a greater separation between control unit and RF head, or if longer serial communications cables are required, they must be supplied by Spectra SensorTech Ltd.
5) Cables attached to all other ancillary signal and control ports must have a length of less than 3 metres. If greater length is required, Spectra SensorTech Ltd must be contacted for technical guidance on possible EMC and safety issues.
6) The vacuum system on which the analyser/RF head is mounted must be earthed, to a protective earth, preferably to the same protective earth as the control unit.

B) OPERATION

1) The equipment is not authorised for use as a critical component in a life support or safety critical system without the express written approval of Spectra SensorTech Ltd.
2) All instructions given in the operating manual must be followed.
3) Adjustments are strictly limited to those accessible from the control panel and computer keyboard and only when running software supplied by Spectra SensorTech Ltd.

C) MAINTENANCE



WARNING-DANGEROUS VOLTAGES EXIST INSIDE THE EQUIPMENT

1) Maintenance functions must only be carried out by competent persons.
2) During the warranty period, faulty equipment must be returned to Spectra SensorTech Ltd., unless special arrangements are made.
3) There are no user replaceable parts in the electronic equipment. Certain components are EMC and safety critical and must not be substituted. Replacement parts are available from Spectra SensorTech Ltd.
4) Equipment enclosures embody certain special fastening and bonding devices that affect EMC and safety performance. These must be correctly re-fitted after servicing.

Contents

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Errata and addenda

WARNING

The Electron Multiplier (SEM) MUST NOT be operated at temperatures above 50^{o}C.

With dual (faraday and electron multiplier) detector instruments serious damage will be caused to the electron multiplier if it is operated at temperatures above 50^{0}C. Where instruments use a standard RF power supply the RF must be removed to bake out so there is no chance of the multiplier inadvertently being switched on.

It is possible to run instruments using RF power supplies fitted with a bakeable adapter during a bake out. In this case only the faraday detector should be used NOT the multiplier.

No damage is caused to the multiplier by high temperatures provided it is not switched on.

The only remedy when a multiplier has been damaged due to being operated at higher temperatures is to replace it.

THIS IS AN EXPENSIVE REPAIR.

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Section 1.
Specification

1.1. About this manual

This manual was originally written to support the LM61 Satellite, sometimes referred to as the Mark 3 Satellite. Much of the manual is applicable to earlier versions of the Satellite unit and much will probably be of relevance to later versions.

1.2. Mechanical

Size:	2U * 84T
Dimensions:	Front panel height 88.9mm, width 484.5mm inc. carrying handles. Depth, from rear of front panel over rear panel connectors 300mm
Weight:	7kg

1.3. Electrical

Power Inlet: 100 - 120 or 220 - 240V ac 47 - 63 Hz 45VA

Installation Category II

Pollution Category II

Fuses: 5mm * 20mm Ceramic IEC 127
Mains 3.15A (T) 100 - 120V 1.6A (T) 220 - 240V

Fuses: PCB 5mm * 20mm Ceramic IEC 127
FS1 1.6A (T)
FS 2 & 3 3.15A (T)
FS 4 & 5 200mA(T)

1.4. SAFETY

Class 1

The Yellow / Green Earth Core Of The Power Cord Must Be
Connected To The Power Source Protective Earth Terminal.

There are no operator serviceable parts within the Satellite unit.

This Unit has an IP rating of 0 for protection against fluids.

1.5. Hazard Warning Labels

External:

Rear Panel.
Exclamation Mark label on the rear panel refers to the following:

a) The voltage on the EXT TRIP jack plug must not exceed 60V d.c. and be current limited to less than 2mA

b) The RF Head connector has Hazardous voltages on it, and should only be disconnected with the unit isolated from the mains supply.

Voltage Flash label on the rear panel refers to:
the SEM supply output, and the possibility of non-hazardous electric shock if the connector is removed.

Top Cover. (Exclamation Mark)
Disconnect from mains supply before removing covers

Internal:

Exclamation Mark label on Power Supply Cover refers to:
Risk of Electric shock if cover removed.

Exclamation Mark labels on PCB next to Lithium Battery refers to:
Replacement type and method of disposal of spent battery i.e. Replacement type is, Varta Lithium CRAA or UL approved equivalent

Note: The Lithium Cell installed in this equipment should be discarded in accordance with applicable National statutory regulations

Section 2.
Introduction to the Satellite

This manual was originally written to support the LM61 Satellite. There have been a number of different versions of Satellites all looking very similar. Fortunately, it is quite easy to distinguish between them by looking at the serial number. The first part of the serial number describes the version, it will be either; LM5, LM27, LM46, LM61 or LM65. The first shipments of the current Satellites, LM61, were made towards the end of 1996. The original LM5 Satellite control units were shipped from about mid 1988 to mid 1993 when they were replaced by LM46 units. The LM27 and LM65 Satellites are special instruments designed for a large research establishment. The serial number can be found on the serial number label attached to the outside of the Satellite's rear panel.

2.1. Getting help

We are always pleased to provide assistance where we can. If you are experiencing any difficulties or need help please feel free to call your local Spectra facility and ask for the service department. Please have the following information ready so that our technical staff may help you quickly and efficiently:

1. The serial numbers of the analyser, RF head and control unit; each of these numbers begins with the letters "LM"

2. The type of software operating with the Satellite e.g. RGA for Windows, Multi-Quad etc. together with the software version number (refer to the manual for the operating software if you are un-sure how to find this)

3. The information displayed in the diagnostics screen for the Satellite control unit (refer to the manual for the operating software if you are un-sure how to find this).

2.2. System architecture

The Satellite control unit is a complete Quadrupole Mass Spectrometer controlled from a master control unit via a serial link. The master control unit will probably be an IBM compatible PC running one of Spectra's Windows based software packages; RGA for Windows or Process Eye. In older systems the master control unit maybe a

Multi-Quad or a PC running the DOS based Black Box Multi-Quad software. Alternatively, Satellites may be controlled from a host computer running a custom application package.

Multi-Quad and Black Box Multi-Quad instruments are not longer manufactured and have been replaced by RGA for Windows and Process Eye systems. Existing Multi-Quad and Black Box Multi-Quad instruments continue to be supported in respect of spares and service. The current Satellite units have a high degree of backwards compatible and can usually be integrated into older systems.

2.2.1. RGA for Windows systems

In this type of system up to four Satellite control units may be run from an IBM compatible PC running Microsoft Windows or Windows95 and RGA for Windows software. Refer to the RGA for Windows manual for PC requirements.

2.2.2. Process Eye systems

In this type of system up to eight Satellite control units may be run from an IBM compatible PC running Microsoft Windows or Windows95 and Process Eye software. Refer to the Process Eye manual for PC requirements. Please note that Satellites in Process Eye systems must be specifically supplied to operate with Process Eye software. Check with your local Spectra facility if you are unsure.

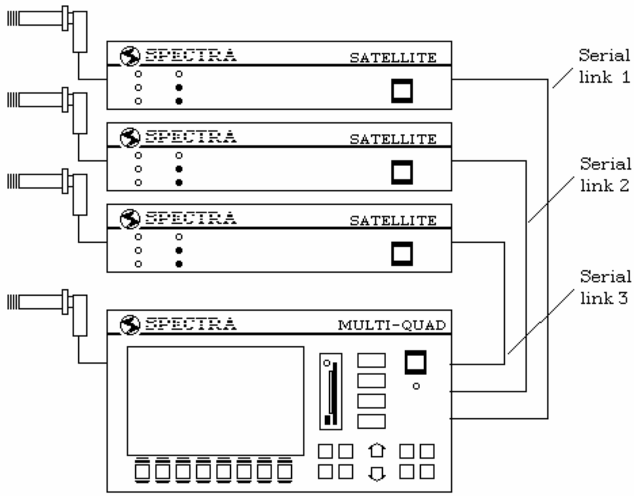

Figure 1 Multi-quad system

2.2.3. Multi-Quad systems

In addition to the "Internal" Satellite contained in a Multi-Quad up to three additional Satellites may be connected if a Satellite communications card has been fitted to the Multi-Quad. This configuration is shown in Figure 1.
A further four Satellites may be connected if a second Satellite communications card is fitted in to the Multi-Quad.

2.2.4. Black Box Multi-Quad system

This configuration allows up to eight Satellites to be connected to an IBM compatible PC, see Figure 2. The Black Box Multi-Quad software package can be run on the PC providing similar features to the Multi-Quad.

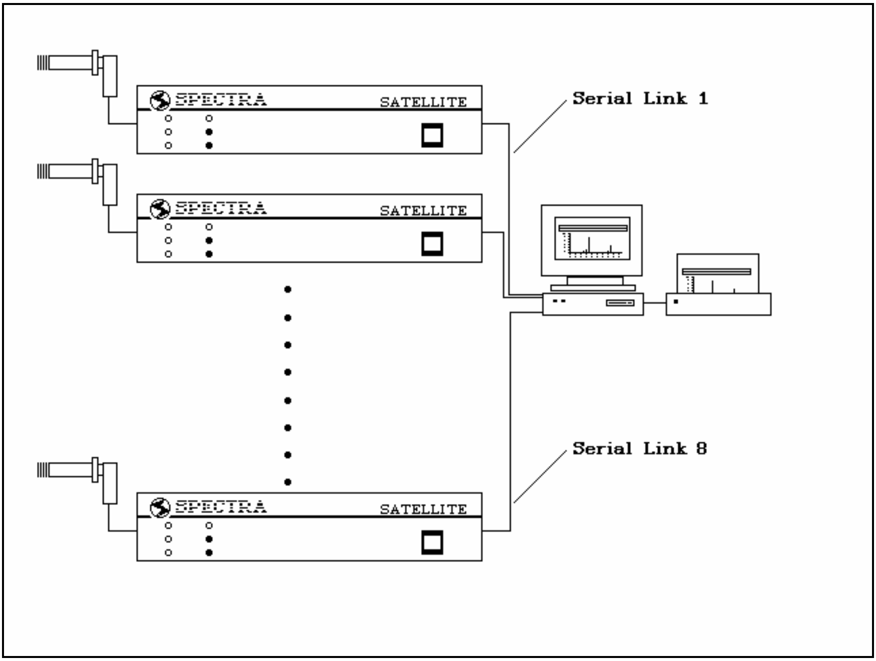

Figure 2 Black Box Multi-quad system

In order to run multiple Satellites it is necessary to use a PC of the appropriate power. The following is a general guide to the number of Satellites that may be connected to a PC of the given power: -

No. of Satellites	Recommended PC
1 to 2	IBM PC/XT or compatible
1 to 4	IBM PC/XT or compatible
1 to 8	IBM compatible 80386sx

The PC should be fitted with a minimum of:-

512K bytes of RAM.
CGA or compatible Display Adapter and Monitor.
one Floppy Disk Drive.
appropriate serial ports.

It is possible to multi-task Black Box Multi-Quad under a multi-tasking operating system.

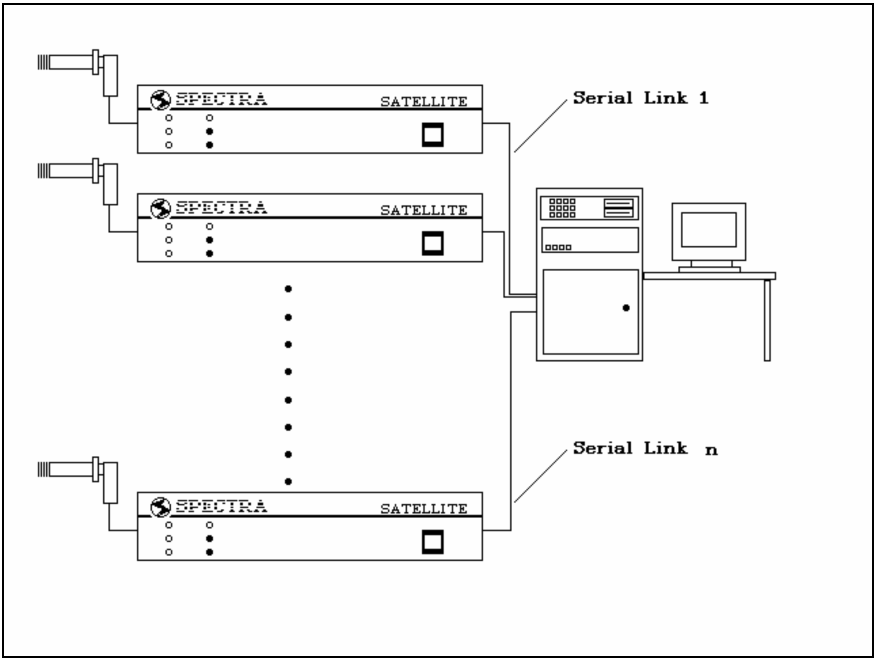

Figure 3 Custom systems

2.2.5. Custom systems

Any number of Satellites may be connected to a custom system limited only by the number of serial ports and the power of your computer, see Figure 3. Your application program should use the ASCII communications protocol described in section 6.

2.3. Satellite interface

The communication between the Satellite and the master control unit is via a serial link. The standard interface is RS232 but an RS422 option is available if required. If you are connecting the Satellite using the standard cable supplied you can skip sections **2.3.1. RS232 interface** and **2.3.2. RS422 interface**.

Caution

You must only use RS232 cables supplied with the equipment. We cannot guarantee that other manufacturers cables will work correctly in Spectra RGA systems.

If you must use an RS232 cable not supplied with the equipment then use the cable supplied as an extension to your cable **ENSURING THE CABLE SUPPLIED WITH THE EQUIPMENT IS PLUGGED INTO THE PC.**

Satellite units are normally supplied with a 3 metre (approx. 10 feet), 9 way D-Type plug to 9 way D-Type socket RS232 cable. If the RS422 option has been fitted a 3 metre RS422 cable will be supplied. 9 way D-Type plug to 25 way D-Type socket RS232 cables are also available as are longer cables. Please contact your local Spectra facility for further information.

2.3.1. RS232 interface

This interface meets the electrical specification of the EIA RS232C interface standard.
The connector used is a 9 pin D-Type socket compatible with that used on IBM AT compatible PCs.

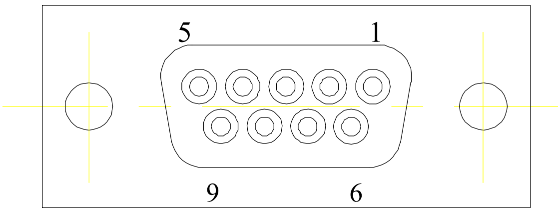

Figure 4 RS232 connector (9 way D-Type socket)

Pin #	Name	Signal	Signal Direction
1	not used	No connection	
2	TxD	Transmit data	OUTPUT
3	RxD	Receive data	INPUT
4	DSR	Data Set Ready	INPUT note 1
5	GND	Ground	
6	DTR	Data Terminal Ready	OUTPUT
7	CTS	Clear to Send	INPUT note 1
8	RTS	Request to Send	OUTPUT
9	not used	No connection	

Note 1 These handshake lines are factory disabled i.e. DSR and CTS are always assumed to be true by the Satellite.

The default baud rate is 9600. This enables cables of up to 30 metres (100 feet) to be used.

It may be necessary to hard wire the DSR and CTS inputs to your computer to the true state to enable it to transmit to the Satellite.

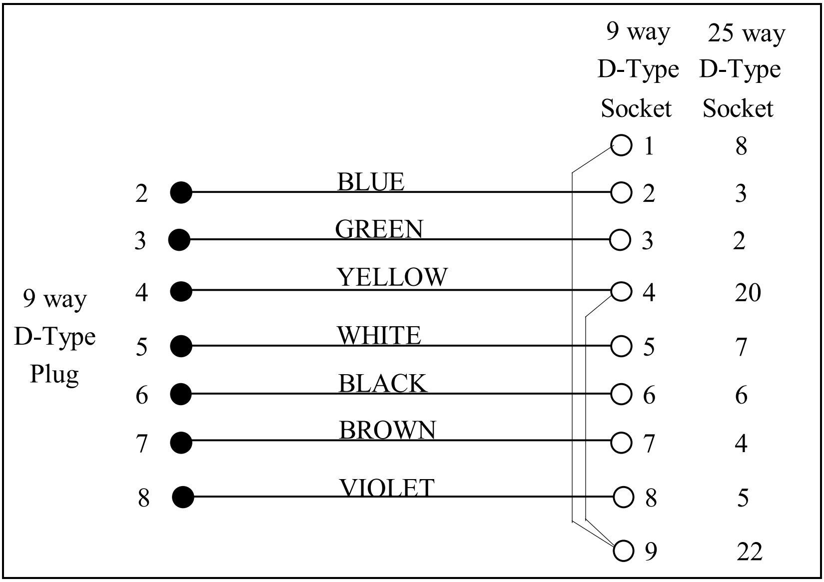

Figure 5 RS232 cable connections

2.3.2. RS422 interface

The RS422 interface meets the electrical specification for the EIA RS422 interface using differential signals within a 5 Volt range.

The 9-pin D-Type female connector used for the serial link has the following connections: -

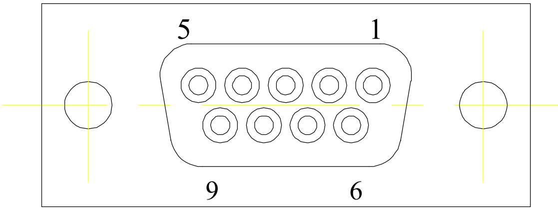

Figure 6 RS422 connector (9 way D-Type socket)

Pin #	Signal Name	Signal Direction
1	Protective ground	
2	No connection	
3	No connection	
4	No connection	
5	Signal Ground	
6	Receive data +	INPUT
7	Receive data -	INPUT
8	Transmit data +	OUTPUT
9	Transmit data -	OUTPUT

The maximum cable length using 24 AWG, copper conductor, twisted-pair telephone cable with a shunt capacitance of 52.5 pF/metre is 1.2Km (4000 feet)

It may be necessary to hard wire the DSR and CTS inputs to your computer to the true state to enable it to transmit to the Satellite.

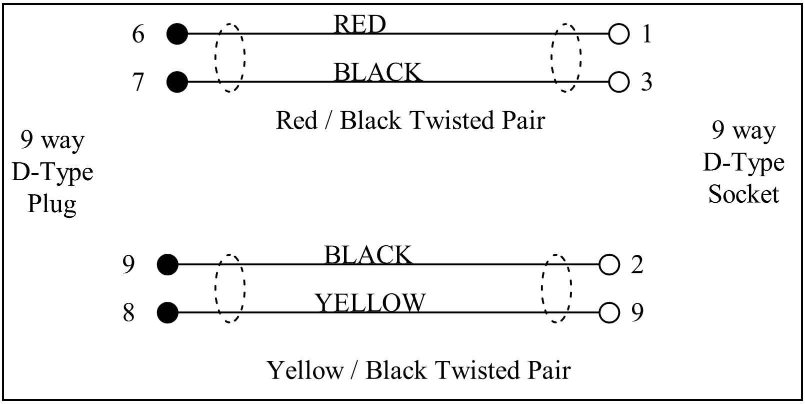

Figure 7 RS422 cable connections

2.4. Satellite features

2.4.1. External trip

The External Trip input is designed to allow independent protection of the Filaments and hence the Multiplier. The 1/4" jack socket allows either a TTL level or relay contacts signal to input into the Satellite. Typically, an Ion or Pirani Gauge would provide this signal. The maximum allowable voltage across the pins of the jack socket is 60 V d.c.

2.4.2. Alarm outputs

In the Peak Jump mode and Leak Check mode (optional) it is possible to program both high and low alarm level limits for a single decade range. Alarm outputs are available on the AUX I/O connector on the rear of the instrument. These outputs operate at TTL levels, a logic 1 indicates that a peak is out of range.

In the Peak Jump mode there are 12 outputs, one for each channel. In the optional Leak Check alarm mode the alarm output of channel 1 is used.

The exact operation of the Alarms may depend on the operating software, RGA for Windows, Process Eye etc.. Please consult the appropriate manual for further details. Also, the Alarm outputs may be further enhanced by the use of a Valve Actuator unit, see section **2.4.6. Valve actuator**.

2.4.3. Analogue inputs

Two analogue input channels are available on the AUX I/O connector. The inputs can be monitored in one of the channels in the Peak Jump and Multi Channel Trend modes. The input range for these inputs is 0 to +5V.

2.4.4. Remote audio

Each Satellite has a speaker, which can produce a variable frequency tone proportional to the peak height in the Leak Check mode. A volume control is fitted to the rear of the instrument.

A 3.5mm Jack Socket is provided on the rear of the instrument enabling a remote speaker or Leak Detector Headset to be connected if necessary.

2.4.5. Analogue output module

This is an optional plug-in module, which provides 6 or 12 analogue output signals. The peak heights for each of the Peak Jump and Multi Trend Channels are converted into signals to drive a Multi Pen Chart Recorder. This enables a Multi Channel trend type output to be produced on the chart recorder.

The analogue output module is connected to the AUX I/O connector. It is not possible to use the analogue output module when the alarm output mode is enabled or when the Satellite is being controlled from a host computer. If an analogue output module if fitted it is not possible to use the AUX I/O connector for any other functions such as Alarm Outputs or connecting a Remote Vacuum Controller.

2.4.6. Valve actuator

The Valve Actuator allows solenoids, actuators, valves and relays to be operated from the Aux. I/O (alarm) port of the Satellite. The Valve Actuator is a self-contained, mains powered, accessory unit capable of driving 24V DC solenoids.

The alarm output signals are TTL levels only capable of driving TTL gates or very low power relays. The Valve Actuator buffers and amplifies these signals to provide 12 identical channels capable of driving 24V DC solenoids.

No additional software is required in the RGA control unit and the Valve Actuator is supplied with a comprehensive operating manual.

2.4.7. Chart recorder output

The optional chart recorder output is available when the Satellite is scanning in Bar Chart, Analogue and Leak Check modes. The voltage (0- 10V) on the output represents the signal acquired as the scan progresses.

In Analogue modes a trace will be produced that is similar to that displayed on the screen. In the Bar Chart mode a trace showing the analogue peaks will be produced for the current scan range.

In Leak Check mode the output represents the current peak height measured. In this mode it is possible to produce a very fast trend for the selected mass.

2.4.8. External reset input

This is a factory fitted option. This input enables an external device to physically reset the Satellite to its power up state. The input is configured to accept either a TTL level or relay contact input.

2.5. Front panel display

2.5.1. Power On LED

This LED is connected to the 5V supply in the Satellite. It should always be ON when mains power is connected to the instrument and the front panel mains switch is in the ON position.

2.5.2. Comms Ok LED

When the Satellite is switched ON the COMMS OK LED will remain OFF until the link has been established with the Master Control Unit. This occurs when the first character of an ASCII command is received from the host computer or during the Satellite polling sequence when either Multi-Quad or Black Box Multi-Quad are run up.

If the Satellite is connected in an RGA for Windows or Process Eye system or to a Multi-Quad or Black Box Multi-Quad this LED continues to indicate the status of the serial link. It will be turned off by the Satellite if the link is lost. This could be caused by: -

i) Physical disconnection of the serial link.
ii) RGA for Windows, Process Eye or Black Box Multi-Quad application being terminated or suspended OR Multi-Quad being turned OFF.

If the Satellite is controlled by a host computer using the ASCII COMMAND

PROTOCOL the COMMS OK LED remains ON unless the Satellite is RESET using the Hardware Reset facility or the RESET command.

With some versions of Multi-Quad and Black Box Multi-Quad the COMMS OK LED will flash on and off. This is due to the master control unit software and is intentional not a fault.

2.5.3. Filament LED's

The FILAMENT LED's indicate the status of the filaments. Only one filament may be turned on at once and the appropriate LED will only be ON when the filament supply is turned ON and the filament supply current is within acceptable limits.

It is therefore possible under certain circumstances (e.g. if a filament has blown) for the filament supply to be on without either FILAMENT LED being lit.

2.5.4. Faraday and SEM LED's

When the faraday detector is selected the FARADAY LED will be ON and the SEM LED OFF. This state is reversed when the SEM (Multiplier) is switched on.

These LED's indicate the actual setting of the hardware, which is not necessarily the state "Requested" or reported. This is due to the built in protection for the Multiplier, which will not allow it to be switched ON if the filaments are OFF. The Satellite records the requested Multiplier setting and will act upon it when a Filament is turned ON.

If a scan has the Total Pressure measurement enabled and is using the Multiplier to measure Partial Pressure, then you will see the Faraday detector being selected during the Total Pressure measurement.

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Section 3.
Installation

This section deals with getting the equipment you have just bought out of its box and installing it on your system. If you have any questions or experience any difficulties, contact your local Spectra facility where help is available.

3.1. Unpacking and inspecting

3.1.1. Unpacking

When you receive the Satellite carefully check each item before removing the foam packaging and plastic wrapping to ensure that no physical damage has occurred during shipment. Also make sure all items have been received by checking against the enclosed packing slip.

WARNING

Do not open the vac-formed envelope at this stage

If there has been obvious damage during shipment or if there are items listed on the packing slip as shipped which are not in the box, immediately contact your local sale/service representative.

WARNING

Most insurance claims for shipment damage must be placed within 7 days from the date of delivery - in WRITING. So don't let your Satellite get buried in its box.

CHECK IT OUT !!

3.1.2. Removing the analyser cover

WARNING

The analyser is both fragile and very easily contaminated by the slightest touch from your fingers or undesirable surfaces.

THE WARRANTY DOES NOT COVER CLEANING OF THE ANALYSER

The analyser is shipped in a vac-formed plastic envelope for protection Carefully remove the tape and unfold the envelope to allow access to the analyser.

Hold the analyser ONLY at the flange.

If you have to set the analyser down for a moment, carefully return it back to the plastic envelope for protection.

DO NOT LEAVE THE ANALYSER IN THIS CONDITION.

The rules of gravity are known to deviate from the norm around unattended analysers and it can easily fall off and smash if the work surface is bumped. It will also collect dust, which will give a very strange mass spectrum!

3.1.3. Inspecting the analyser

Hold the analyser with the quadrupole and ioniser structure vertically up. Carefully inspect all the observable insulators for damage.

Look at each lead from the flange to its termination point to ensure that it does not touch any other element of the analyser.

But note, the less you adjust or change, the lower the possibility of breaking something.

3.1.4. Replacing the analyser cover

To avoid possible damage to the analyser now is the time to put it back in its aluminium shipping cover. Simply reverse the instructions in section **3.1.2. Removing the analyser cover.**

3.2. Installing the analyser

3.2.1. Checking the vacuum chamber dimensions

The vacuum chamber in which you intend to mount the analyser must have a 2.75 inch UHV Conflat® flange fitted with a tube of 35.0mm (1.375 ") minimum inner diameter inclusive of a good welded joint.

The distance from the end of the analyser to its mounting flange depends on the type of analyser. Refer to the table below:

Analyser Type	Length
100 amu	155mm (6.1")
200 amu single filter	155mm (6.1")
200 amu double filter	180mm (7.1")
300 amu double filter	180mm (7.1")
300 amu triple filter	230mm (9.1")

The table above assumes the analyser is fitted with a standard ion source and is not fitted with a Single Channel Electron Multiplier.

There must be at least the distance given above free of obstructions inside the vacuum chamber. If your chamber does not have that much room or only a small flange you should use a specially designed adapter so that the analyser can be mounted outside the chamber. Please contact your local Spectra facility.

3.2.2. Checking the system pressure

Quadrupole analysers cannot be operated at pressures higher than 1×10^{-4} torr and for dual (faraday and electron multiplier detectors) the multiplier should not be used at pressures above 2×10^{-6} torr. If you intend to monitor a sputtering or plasma etching process, remember that, if the analyser is mounted directly in the chamber, you will not be able to switch on the unit while at sputtering pressures.

CAUTION - A worse problem is that sputtering is meant to 'throw' materials around corners. If the analyser extends into the 'throw area' of the sputtering deposition, it will rapidly become coated and cease to function properly. Turning off the power to the Quad during sputtering or etching will not prevent this contamination. It is most important to ensure that the analyser is shielded from his type of contamination.

Remember the warranty does not cover cleaning of the analyser.

We do, however, supply High Pressure Adapter Kits (HPA's) for just these types of applications.

3.2.3. Mounting the analyser

The standard 2-3/4" Conflat® flange on the analyser can be sealed to the vacuum chamber with either a copper gasket or a Viton gasket with a square cross section. Which one you choose depends on the ultimate pressure you expect in your system.

If it is not already clean then clean the gasket with suitable solvent, dry and slip it over the quadrupole structure. Set it in the grooves of the flange surface.

Remove the analyser from its shipping cover. See section **3.1.2. Removing the analyser cover**.

Carefully insert the analyser into the vacuum chamber ensuring that you do not allow the leads to touch the walls of the vacuum chamber. Make sure the gasket does not slip part way out of its slot as you push the two flanges together.

Rotate the flange until the locating key on the feedthrough housing tube is as close to 11 o'clock as the bolt holes will allow. This will ensure that the cable on the RF generator will hang vertically and, therefore put little stress on the connector.

Bolt the feedthrough flange to the vacuum chamber flange using the torque appropriate for the gasket material used. Fit one end of the short, heavy earth strap under the head of the lowermost bolt.

3.3. Connecting up the system

3.3.1. Installing the RF power supply

Rotate the locking ring on the RF/analyser connector so that the slot lines up with the keyway on the connector tube.

If you hold the RF power supply such that the cable hangs downwards, you will be able to slide the power supply onto the analyser. The locating key on the analyser will ensure correct alignment. <u>TAKE GREAT CARE</u> as the vacuum feedthrough pins are easily damaged. <u>DO NOT</u> force the RF power supply onto the analyser.

When all of the pins are engaged, push the power supply firmly onto the analyser to ensure electrical continuity. The last 1/8 th of an inch (3mm) is important.

Finally, rotate the locking ring to lock the power supply in place. You will not be able to do this if the power supply is not pushed fully onto the analyser. Connect the free end of the earth strap to the binding post on the RF power supply.

3.3.2. Installing the adapter box

THIS IS A NON STANDARD ITEM, WHICH IS ONLY SUPPLIED WHEN SPECIALLY REQUESTED AND REQUIRED.

In some instances, customers who wish to use RF and analyser pairs from other manufacturers can be accommodated by means of an adapter box. This box is inserted 'in line' between the control unit and the RF power supply.

Attach the 37 way connector on the flying lead on the adapter box to the socket marked RF Head on the rear of the Satellite control unit. The cable from your own RF head should then be connected to the available socket on the adapter box.

3.3.3. Electrical connections

If you are using another manufacturers RF power supply and analyser read section **3.3.2. Installing the adapter box** before continuing.

Ensure the POWER switch is in the OFF position (top of the switch OUT on US and Japanese models, top of switch IN on European versions).

If the standard 37 way "D" type fittings have been supplied then insert the 37 way connector on the cable from the RF power supply into the socket marked RF HEAD on the rear of the Satellite control unit.

If the 48 way fittings have been supplied then ensure that the 37 way "D" type to 48 way adapter cable is firmly inserted into the 37 way socket . Using a 48 way to 48 way cable connect the socket marked RF HEAD on the rear of the control unit to the 48 way socket on the RF HEAD.

If you have a Multiplier detector version, attach the high voltage cable supplied to the BNC connector on the RF power supply and the connector marked MULTIPLIER on the rear of the control unit.

WARNING

The Electron Multiplier (SEM) MUST NOT be operated at temperatures above 50°C.

With dual (faraday and electron multiplier) detector instruments serious damage will be caused to the electron multiplier if it is operated at temperatures above 50°C. Where instruments use a standard RF power supply the RF must be removed to bake out so there is no chance of the multiplier inadvertently being switched on.

It is possible to run instruments using RF power supplies fitted with a bakeable adapter during a bake out. In this case only the faraday detector should be used NOT the multiplier.

No damage is caused to the multiplier by high temperatures provided it is not switched on.

The only remedy when a multiplier has been damaged due to being operated at higher temperatures is to replace it.

THIS IS AN EXPENSIVE REPAIR.

If the Satellite is being driven by either a Multi-Quad or a PC then connect the 9 way RS232/RS422 cable between the 9 way "D" type socket on the Satellite and the appropriate connector on the interface board in the control unit or the appropriate connector on the PC.
<u>MAKE SURE THE SATELLITE IS NOT PLUGGED INTO THE USER RS232 SOCKET ON THE MULTI-QUAD / BLACK BOX MULTI-QUAD</u>.

If the Satellite is being driven by a host computer you will need to wire your own cable. See sections **2.3.1. RS232 interface** and **2.3.2. RS422 interface.**

Attach the line cord supplied to the plug on the rear panel of the Satellite. The unit will be set to operate on the local line voltage. This can be verified by checking the indicator above the line connector.

You are now ready to power up the Satellite and should refer to the manual for the particular RGA system you have; RGA for Windows, Black Box Multi-Quad, Multi-Quad, RGA Process etc.

Section 4.
Analyser maintenance

4.1. General overview

The quadrupole analyser is the front end of your mass-spectrometer, it produces electrical signals which when presented to your electronics enable them to display in a meaningful fashion the content of either your vacuum system or of some other "interesting" gasses introduced via an inlet.

Spectra provide a range of analyser configurations, utilising various ion source, filter and detector designs as appropriate for particular applications. Before embarking on any analyser maintenance you are advised to ensure you know exactly which analyser options you have. If you are in any doubt please contact your local Spectra facility, ask for the service department and have the serial number of the analyser ready. The serial number is engraved on the analyser flange and will begin with the letters “LM”.

The analyser can be broken down into four separate areas by virtue of their function.

4.1.1. The ion source or ioniser

This is located at the top (furthest from the flange) of your analyser and its function is to take a representative sample of molecules and atoms from your vacuum chamber, convert them into ions and present them to the quadrupole filter. The exact construction will depend upon which source option is fitted.

4.1.2. The quadrupole filter

This is the centre section of your analyser. Its function is to take the ion beam generated in the source and separate the various ions by their mass to charge ratio (m/e) and present the single selected m/e to the collector. Again the exact construction will depend on which type of filter is fitted.

4.1.3. The collector

This area of your quadrupole analyser is "hidden" inside the flanged housing. Its function is simply to convert the filtered ion beam presented by the quadrupole filter into a small electrical current, which can be passed to the electronics for amplification and subsequent display to the outside world.

4.1.4. The flanged housing

This is the only part of your analyser that you will see under normal operating conditions. Comprising of an industry standard 2.75" Conflat® flange with an electrical feedthrough which carries the various supplies and signals to and from the quadrupole analyser.

Figure 9 later in this section shows an exploded view of a typical analyser where you can see all the above-mentioned parts. Remember, though, due to the variety of analyser options your particular model may not be exactly the same as this.

4.1.5. Maintenance of your analyser

Most, if not all, quadrupole analysers have areas of inherent weakness requiring periodic maintenance. This should be viewed as similar to automobiles, which from time to time require oil changes etc. to protect the performance of the engine. Just like the automobile the frequency with which this work has to be carried out depends upon many factors such as the number of miles driven, the climate, the average length of journey and the speed at which the vehicle is usually driven.

Similarly with quadrupole analysers the type and cleanliness of the vacuum system, the hours of operation and the type and size of sample being analysed play a large part in determining the maintenance frequency. Apart from these considerations there are times when the analyser will require maintenance and these are when "accidents" happen i.e. when someone vents the vacuum system to air when the filament is still switched on or when someone forgets to turn on the water cooling for the oil diffusion pump etc. These occurrences only vary in the magnitude of the disaster that ensues.

Routinely there is only one area of the analyser that requires any maintenance. This is the ion source. The ion source contains two filaments, only one of which will be in use at any one time. The filament is heated to approximately 2000 deg K at which temperature it emits electrons, which are used to produce the ions, required by the quadrupole filter. At this high temperature there are two deleterious effects.

The filament material slowly evaporates and condenses upon the surrounding surfaces. This effect is extremely slow but would require from time to time the cleaning of the surrounding source plates and ceramics and the replacement of the filaments.

The second effect is similar to the first except that the vacuum under which the source is operating has either a high oxygen or water content. Then instead of metal being deposited upon the surrounding source plates a layer of metal oxides is deposited. These, being insulators, have a far more noticeable effect upon the performance of the source and therefore a more frequent cleaning program should be undertaken.

WARNING

THE QUADRUPOLE FILTER IS VERY ACCURATELY ALIGNED BY SKILLED PERSONNEL USING SPECIALIST TOOLS AND JIGS. <u>UNDER NO CIRCUMSTANCES SHOULD ANY OF THE SCREWS HOLDING THE RODS IN POSITION BE LOOSENED. IF THEY ARE, WE GUARANTEE THAT THE ANALYSER WILL NOT WORK.</u>
THE ONLY REMEDY WOULD BE A FACTORY RE-BUILD. IF YOU ARE IN ANY DOUBT PLEASE CONTACT YOUR LOCAL SERVICE CENTRE BEFORE PROCEEDING ANY FURTHER.

4.2. Failed filaments

The filament status is constantly monitored by the power supply electronics and the operating software. This is done by measuring the flow of electrons emitted by the hot filament, referred to as the emission current, and flowing to the ion source cage. This is normally maintained at a fixed value of 1mA. The current flow through the filament is increased until the value of emission current is reached. If, however, the control electronics reaches the limit of its filament current supply capability and the emission current has still not reached 1mA a filament fail condition will exist. In the vast majority of cases this will be due to a blown filament, more correctly described as an open circuit filament. There are conditions such as a heavily contaminated ion source, which will result in a filament fail when the filament is not open circuit. So, checking that the filament is open circuit is worth doing before going to the trouble of removing the analyser from your vacuum system.

4.3. Ohm meter analyser checks

There are a number of circumstances when carrying out some simple checks with an ohmmeter can be well worthwhile. If you suspect a failed filament or want to check for shorts following some maintenance, a lot of time can be saved by performing some simple checks.

In carrying out these checks we can legitimately accept two ranges of meter readings as possibly acceptable and anything outside these ranges as being a definite fail. Any readings less than 1 ohm we can take as a short and any reading above 5 Meg Ohm ($5x10^6$ ohms) as being open circuit. The following assumes that the analyser is still on the vacuum system and goes through all the possible tests.

Tools required:-

Ohmmeter with leads

Please refer to Figure 8 for the analyser pin numbers.

4.3.1. Checking for shorts

1. Attach the first meter lead to pin 1 of the analyser feedthrough.

2. Connect the second meter lead to the analyser flange, you should have a short circuit. If not you have a serious problem or more likely a faulty meter/meter leads.

3. Connect the second meter lead to pins 2 to 12 on the analyser feedthrough in turn.
   Each one should give an open circuit. If not you have a short to earth.

   There are basically two types of short to earth; an internal short between one part of the analyser and an earthed part of the analyser, or more commonly a short between part of the analyser and the vacuum chamber. In either case remove the analyser from the vacuum chamber and repeat the test. If the result is the same then you have an internal short and should contact your local Spectra facility and tell them which pins are shorting together. Otherwise you have a short to the vacuum chamber, check the dimensions of the vacuum chamber around the quadrupole analyser or try refitting the analyser in a slightly different orientation. Repeat the ohmmeter test before pumping down the vacuum chamber. Remember that the ion source gets very hot during operation and the stainless steel components will expand slightly. Sometimes a short will only develop when the analyser has been run for a while and is up to temperature.

4. Attach the first meter lead to pin 2 of the analyser feedthrough. Connect the second meter lead to pins 3 to 12 on the analyser feedthrough in turn. Each one should give an open circuit. Now attach the first meter lead to pin 3 and check to pins 4 to 12. Proceed around the feedthrough until all possible connections have been checked. All pins should show open circuit to all other pins EXCEPT pin 4 to pin 8 and pin 8 to pin 10, which should show short, see the next section. If any of the pins do show short to another pin contact your local service centre with the results of your testing and they will advise you how to proceed.

4.3.2. Checking filaments

If you suspect a blown filament, for instance the control unit shows filament fail, carry out the following test before removing the analyser from the vacuum system.

Connect meter lead one to analyser feedthrough pin 8 which is the common

connection to both the filaments.
Connect the second meter lead to pin 4 (Filament 1). You should have a short circuit, the resistance of the filament is about 0.5 ohms when it is cold.
Now connect the second meter lead to pin 10 (Filament 2) again your meter should indicate a short circuit.

If either or both filaments are blown the meter will indicate an open circuit and the filaments should be replaced.

If the meter reading suggests that the filament is good but the control unit shows a filament fail the most likely cause would be a break down in electrical continuity. Examine the RF/analyser connector on the front of the RF power supply, check that none of the gold sockets are pushed out of place.

4.4. Changing filaments

Analysers are fitted with dual, independently replaceable, self-aligning filaments. Each filament consists of a semi-circular plate into which is fitted two small insulated feedthroughs. The filament wire is attached between these feedthroughs on the underside of the filament plate. The filaments are identical eliminating the need to maintain any particular orientation. The assembly consisting of filament plate, two feedthroughs and the filament wire form what we refer to as the “filament”. Changing filaments is probably the most common maintenance procedure that has to be undertaken with quadrupole analysers but the analyser has been designed to make the task as quick and easy as possible.

The basic procedure for changing filaments is the same for all types of ion source. The procedure describe below relates to a standard radial ion source. The procedure for the enclosed ion source is outlined later in this section.

4.4.1. Tools required

Here is a list of the tools and equipment you will require. We recommend that you assemble the following items before you start. Remember that the instrument was supplied with a tool kit, which contained some of the things you will need.

A small jewellers screwdriver (2mm)
A pair of tweezers
A small pair of smooth jawed needle nosed pliers
A pair of clean cotton gloves
A clean bench on which to work
An Ohmmeter
A clean container in which to put small parts
Replacement filament(s)

The RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

4.4.2. Removal of the filaments, general

This relates to all ion sources except the enclosed ion source.

1. Place the RF head onto the clean bench with the cable coiled and placed out of the way.

2. Remove the analyser from the vacuum system making sure that you do not touch the exposed internal surfaces and place in the upturned RF head. Make sure that everything is stable and not likely to fall over. The filaments are located on the very top of the analyser and are retained by two M2x6 pan head screws. The electrical connections are made via two barrel connectors, one to each filament.

3. Hold one of the barrel connectors firmly with your pliers slacken the outermost screw undoing it 4 or 5 turns.

4. Now hold the threaded part of this screw lightly with your tweezers just behind the head of the screw. Undo the screw fully and lift it away (with the washer if fitted) and place it into your container.

5. Loosen but do not remove the screw at the other end of the barrel connector. Remove the barrel connector and place it in your container.

6. Repeat the above for the other filament.

7. Loosen the two M2x6 pan head screws that hold the filaments in place so that 3-4mm of thread is showing and remove the filaments.

It is worthwhile at this stage checking to see if the source requires any attention especially if the filament(s) have broken because of an over pressure situation in your vacuum system. With the filaments removed you have a clear view of the source cage where the signs to look for are powdery deposits of tungsten oxides. These will vary in colour but may be brown, blue, canary yellow or white depending upon the precise circumstances which led to their formation. If these oxides are present it is recommended that you refer to the section on source removal and cleaning before proceeding any further.

4.4.3. Filament plate design

The following does not apply to enclosed ion sources.

Due to new ion source designs and a desire to kept the filaments interchangeable between the different ion source types the design of the filament plate was changed at the beginning of 1995. The modification increased the diameter of the central hole formed when the two filament plates are placed together on the repeller assembly of the ion source.

With the older type of filament plate this central hole is approximately 3.5mm (1/8inch) in diameter. On the newer type the central hole is approximately 6mm (1/4inch) in diameter.

These newer filaments may be used as direct replacements for all types of ion source. However, for the UHV/radial open ion source and the cross beam ion source an additional filament screening plate needs to be fitted. This is supplied with the replacement filaments. If you are removing older type filaments and replacing them with the newer type you will have to fit the filament screening plate. To do this:

1. remove the two M2x6 pan head screws that hold the filaments in place

2. position the screening plate centrally on the ion source with the two fixing tabs over the holes which take the M2x6 screws which hold the filaments in position

3. refit the two M2x6 pan head screws that hold the filaments in place leaving 3 to 4mm of thread exposed.

Fitting the filament screening plate in this way means that in future the filaments can be removed and the screening plate will remain in position.

4.4.4. Fitting of new filaments, general

The fitting of new filaments is simply the reversal of the procedure for removing them. Care should be exercised at all stages to ensure that no shorts are introduced and that the analyser is kept clean.

1. Place the filaments into the top of the source ensuring that the filament wire does not touch any part of the source and thus potentially causing damage.

2. With a gloved hand gentle hold the two filament plates together and tighten the two M2x6 pan head screws that retain the filaments.

3. Place the barrel connector over the filament leg adjacent to the wire connection but do not tighten the screw at this stage.

4. Replace the small screw (and washer if needed) through the wire connection and screw into the barrel connector to locate the barrel connector in the right orientation.

5. Holding the barrel connector firmly with your pliers tighten both screws.

6. Repeat the above for the second filament.

7. Check with your ohmmeter for shorts.

8. Replace the analyser into your vacuum housing and again check for shorts or grounding to the outer vacuum housing see section **4.3. Ohm meter analyser** checks.

You are now ready to pump down and continue operation of your quadrupole.

4.5. In-situ source cleaning

Sometimes it is possible to clean the ion source without removing it from the analyser. For the user who has the necessary equipment available it is usually worth trying this method before removing/replacing the ion source. However, it is only likely to be successful where the source is contaminated with loose or alcohol soluble deposits.

4.5.1. Tools required

A small jewellers screwdriver (2mm)
A pair of tweezers
A small pair of smooth jawed needle nosed pliers
A pair of clean cotton gloves
A clean bench on which to work
An Ohm meter
A clean container in which to put small parts
Replacement filament(s)
Ultra-sonic bath
Measuring cylinder (see text below)
Iso-propyl-alcohol
Heat gun
The RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

4.5.2. Cleaning the source

Remove the analyser from the vacuum chamber, place it into the RF head and remove the filaments as described in section **4.4.2. Removal of the filaments**.

Insert the analyser into the measuring cylinder so that the knife edge side of the

flange rests on the lip of the cylinder. Note the level which the ion source comes to on the measuring cylinder before removing the analyser and filling the measuring cylinder with sufficient iso-propyl-alcohol to cover the ion source.
Note: the measuring cylinder should be of a diameter and length to accommodate the analyser. The exact size will vary depending on the analyser type.

Put the measuring cylinder into the ultra-sonic bath for 10 to 15 minutes.

Remove the analyser and allow any excess alcohol to drain off. Keep the analyser inverted (feedthrough upper most) until it is dry. Do not let any alcohol run down the analyser into the flange assembly, it will get onto the multiplier and seriously damage it. Check the condition of the ion source. A second or third wash may be required.

Note: the ultra sonic bath may loosen some of the screws in the ion source take care note to throw these away when discarding the alcohol.

After the final wash remove the analyser and dry it using the heat gun.

Fit into the RF head on the bench and check all the screws in the ion source are tight, re-fit any which may have come out.

Re-fit the analyser in the vacuum chamber.

4.6. Cleaning or replacing the ion source

Generally the analyser design permits the removal of the ion source as one complete assembly, which can be replaced or dismantled for cleaning. The ion source automatically aligns on the main analyser assembly allowing it to be easily replaced without the need for any special jigs. The following description relates to the standard radial ion source any deviations from this due to other ion source design are described in later sections. The differential ion source cannot be removed in the manner described below, instead you should contact your local Spectra facility.

4.6.1. Tools required

Once again you are advised to get the necessary tools together before you start this job. It really does make life simpler.

A small jewellers screwdriver (2mm)
A pair of tweezers
A small pair of smooth jawed needle nosed pliers
A 0.89mm (0.035") Allen key
A pair of clean cotton gloves

A clean bench on which to work
A source alignment jig
4 pieces of straight clean wire (NOT tinned or insulated) 1mm (0.04") dia. 25mm (1") long
An Ohmmeter
A clean container in which to put small parts
Replacement filament(s)
Replacement source parts if necessary
A set of replacement ceramics is highly desirable if none are cracked and essential if any are broken
The RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

4.6.2. Removing the ion source

1. Remove the analyser from the vacuum system, place it into the RF head and remove the filaments as described above.

2. Locate and remove the three very small socket set (Allen) screws that clamp the focus/extraction, source and repeller supply leads to their respective plates.

3. Locate and remove the two very small socket set screws that are positioned at the base of the source assembly.

The source is now free from the rest of the assembly and can be removed and placed onto the bench. Before proceeding any further you should make a sketch that defines the positions of the barrel connectors for the source and focus/extraction plates and the position of the repeller and source mounting plate relative to these so that when you come to reassemble the source you will have a clear idea of how the various plates fit together.

4.6.3. Standard radial source dismantle

The following section applies to the dismantling of the Standard Radial ion source with a mesh repeller. As each of the plates is removed note its orientation and place it on the bench in the same orientation, it makes life much easier when you come to re-assemble the source.

1. Place the source assembly onto the source alignment jig making sure that the three cut-outs are aligned and taking care not to damage any of the source plates on the spigot in the centre of the jig.

2. Remove the four M1.6x10 screws, the M1.6 stainless steel washers and the 1mm thick ceramic washers that are equi-spaced around the repeller plate (topmost

plate).

3. Remove the repeller plate, which includes the repeller cage.

4. Remove the four exposed 1mm thick ceramic washers and lift away the source plate which includes the source cage.

5. Remove the 1mm thick ceramic washers then remove the focus/extraction plate.

6. Remove the four remaining ceramic washers and remove the 2mm diameter insulator tubes to leave just the source collar on the jig.

You now have a completely disassembled source ready for cleaning.

4.6.4. Solid repeller source dismantle

The following section only applies to the dismantling of the Standard Radial ion source with a solid repeller, which was used on older types of analyser.

1. Place the source assembly onto the source alignment jig making sure that the three cut-outs are aligned and taking care not to damage any of the source plates on the spigot in the centre of the jig. Undo the four screws that are recessed into the top of the repeller.

2. Remove the repeller block complete with the repeller base plate, four screws, washers and ceramic washers.

3. Remove the four exposed ceramic washers and the source plate.

4. Remove the four exposed ceramic tubes and washers and the focus/extraction plate.

5. Remove the four remaining ceramic washers and take the source mounting plate off of the jig.

6. Finally remove the two barrel connectors from the source and focus/extraction plates.

You now have a completely disassembled source ready for cleaning.

4.6.5. Standard source re-assemble

1. Place the source alignment jig flat on the bench and put the source collar on top making sure all the cut-outs are aligned properly. Insert into the four tapped holes the 25mm long pieces of wire, these will help to line up the ceramics as

you build up the source.

2. Place the four 2mm diameter ceramic tubes over the wires followed by four 1 mm thick ceramic spacers, one to each wire.

3. Place the focus/extraction plate over the ceramic tubes making sure the barrel connector is in the right place.

4. Place four 1mm thick ceramic spacers over the top of the focus/extraction plate.

5. Place the source plate over the ceramic tubes, again making sure the barrel connector is in the right place, followed by four more ceramic spacers.

6. Fit the repeller plate and four 1mm thick ceramic washers.

7. Carefully remove one of the wires and replace with a M1.6x10 pan head screw and the M1.6 stainless steel washer which should be screwed down but not tightened, repeat this for the remaining three wires.

8. Check that all the plates and ceramics are seated properly before tightening the screws fully. Be careful not to over-tighten because you will break the ceramic spacers.

9. Remove the source assembly from the jig and place on a non-conducting surface. Check with your Ohmmeter that there are no shorts between any of the plates. If you do have any shorts correct them before continuing any further.

You are now ready to fit the filaments and fit the ion source on to the analyser.

4.6.6. Solid repeller source re-assemble

1. Place the source alignment jig flat on the bench and put the source mounting plate on top making sure all the cut-outs are aligned properly. Insert into the four tapped holes the 25mm long pieces of wire, these will help to line up the ceramics as you build up the source.

2. Place the four 9mm ceramic tubes over the wires followed by four ceramic spacers, one to each wire.

3. Attach a barrel connector to the focus/extraction plate and the source plate so that the tapped hole in the side is furthest away from the plate and facing outward.

4. Place the focus/extraction plate over the ceramic tubes making sure the barrel connector is in the right place.

5. Place four ceramic spacers over the top of the focus/extraction plate.

6. Place the source plate over the ceramic tubes, again making sure the barrel connector is in the right place, followed by four more ceramic spacers and the repeller base plate.

7. Insert a ceramic spacer followed by a washer into each of the counterbores in the repeller block.

8. Carefully remove one of the wires and replace with a M1.6x12 pan head screw which should be screwed down but not tightened, repeat this for the other three wires.

9. Check that all the plates and ceramics are seated properly before tightening the screws fully. Be careful not to over-tighten because you will break the ceramic spacers.

You are now ready to fit the filaments and the source on to the analyser.

4.7. Enclosed ion source

The enclosed ion source is obsolete and was replaced by the PVD Ion Source in 1996.
The enclosed ion source comprises a source ionisation region, which has restricted pumping between it and the main filter assembly. This allows the analysis of gasses at higher pressures than are allowed with a standard open ion source. Typically the enclosed ion source will operate in the 10^{-4} mBar region. This means that the partial pressure of the background gases are reduced by two orders of magnitude when compared to the inlet gas signal relative to the background measured with an analyser fitted with an open ion source. This reduction gives an enhanced signal to background and therefore allows measurements to be made to lower levels of detection than is possible with a standard open ion source.

Another feature of the enclosed ion source is that the filaments are now outside the ionisation region thus minimising interactions between incoming gas and the hot filament.

4.7.1. Construction

Construction of the enclosed ion source is very similar to the standard source, indeed they share many common components. Gas sample is introduced directly into the ionisation region from the inlet assembly via a small diameter pipe, which leads to the most noticeable difference between the enclosed source and a standard source.

Mounted on top of the filament plates is an inlet guide which directs the gas coupling onto the small pipe at the top of the ion source.

The other noticeable difference is the two permanent magnets on opposite sides of the ion source which help focus the electrons emitted from the filaments.

4.7.2. Removal of the filaments, enclosed ion source

This only relates to enclosed ion sources.

1. Place the RF head onto the clean bench with the cable coiled and placed out of the way.

2. Remove the analyser from the vacuum system making sure that you do not touch the exposed internal surfaces and place in the upturned RF head. Make sure that everything is stable and not likely to fall over. The filaments are located on the top of the analyser and are retained by two M2x6 pan head screws which also hold the inlet guide in place on top of the filament plates. The electrical connections are made via two barrel connectors, one to each filament.

3. Remove the two M2x6 pan head screws which hold the inlet guide in place. Now remove the inlet guide.

4. Hold one of the barrel connectors firmly with your pliers, slacken the outermost screw undoing it 4 or 5 turns.

5. Now hold the threaded part of this screw lightly with your tweezers just behind the head of the screw. Undo the screw fully and lift it away (with the washer if fitted) and place it into your container.

6. Loosen but do not remove the screw at the other end of the barrel connector. Remove the barrel connector and place it in your container.

7. Repeat the above for the other filament. Then lift the filaments off the analyser.

4.7.3. Fitting of new filaments, enclosed source

The fitting of new filaments is simply the reversal of the procedure for removing them. Care should be exercised at all stages to ensure that no shorts are introduced and that the analyser is kept clean.

1. Place the filaments into the top of the source ensuring that the filament wire does not touch any part of the source and thus potentially causing damage. Make sure that the hole in the filament plate locates over the pin on the top of the magnet holder.

2. Place the barrel connector over the filament leg adjacent to the wire connection but do not tighten the screw at this stage. Repeat for the other barrel connector.

3. Replace the small screw (and washer if needed) through the wire connection and screw into the barrel connector to locate the barrel connector in the right orientation. Repeat for the other barrel connector.

4. Holding the barrel connector firmly with your pliers tighten both screws. Repeat for the other barrel connector. Take care not to move the filament plate out of position.

5. Fit the inlet guide and the two M2x6 screws.

6. Check with your ohmmeter for shorts.

7. Replace the analyser into your vacuum housing and again check for shorts or grounding to the outer vacuum housing see section **4.3. Ohm meter analyser** checks.

You are now ready to pump down and continue operation of your quadrupole.

4.7.4. Removing an enclosed source

Once the filaments have been removed removing an enclosed ion source from the analyser is the same as removing a standard ion source.

1. Remove the analyser from the vacuum system, place it into the RF head and remove the filaments as described above.

2. Locate and remove the three very small socket set screws that clamp the focus/extraction, source and repeller supply leads to their respective plates.

3. Locate and remove the two very small socket set screws that are positioned at the base of the source assembly.

The source is now free from the rest of the assembly and can be removed and placed onto the bench. Before proceeding any further you should make a sketch that defines the positions of the two barrel connectors for the source and focus/extraction plates and the position of the repeller block and source mounting plate relative to these so that when you come to reassemble the source you will have a clear idea of how the various plates fit together.

4.7.5. Enclosed source dismantle

As each of the plates is removed note its orientation and place it on the bench in the same orientation, it makes life much easier when you come to re-assemble the source. A source alignment jig is not required for the enclosed ion source.

1. Remove the four M1.6x8 screws, the M1.6 stainless steel washers and the 1mm thick ceramic washers that are equi-spaced around the repeller plate (topmost plate).

2. Remove the repeller plate which includes the magnets and magnet holders.

3. Remove the four exposed 1mm thick ceramic washers and lift away the source plate which includes the source ionisation chamber.

4. Remove the four 0.5mm thick ceramic washers and the 1mm thick 11mm diameter central ceramic washer.

5. Remove the focus/extraction plate.

6. Remove the four remaining ceramic washers and remove the 2mm diameter insulator tubes to leave just the source collar.

4.7.6. Enclosed source re-assemble

1. Place the source collar on the bench and insert into the four tapped holes the 25mm long pieces of wire, these will help to line up the ceramics as you build up the source.

2. Place the four 2mm diameter ceramic tubes over the wires followed by four 1 mm thick ceramic spacers, one to each wire.

3. Place the focus/extraction plate over the ceramic tubes making sure the barrel connector is in the right place.

4. Place the four 0.5mm thick ceramic spacers over the top of the focus/extraction plate. Place the large 11mm diameter ceramic centrally on the focus/extraction plate.

5. Place the source plate over the ceramic tubes, again making sure the barrel connector is in the right place and the large ceramic washer sits squarely in the counterbore. Fit four more 1mm thick ceramic spacers.

6. Fit the repeller plate and four 1mm thick ceramic washers.

7. Carefully remove one of the wires and replace with a M1.6x8 pan head screw

and the M1.6 stainless steel washer which should be screwed down but not tightened, repeat this for all four wires.

8. Check that all the plates and ceramics are seated properly before tightening the screws fully. Be careful not to over-tighten because you will break the ceramic spacers.

9. Hold the source up to the light and check that the large ceramic washer is seated correctly by checking that the source plate is parallel to the source collar, rotate the source and check again. Check with your Ohmmeter that there are no shorts between any of the plates. If you do have any shorts correct them before continuing any further.

You are now ready to fit the filaments and fit the ion source on to the analyser.

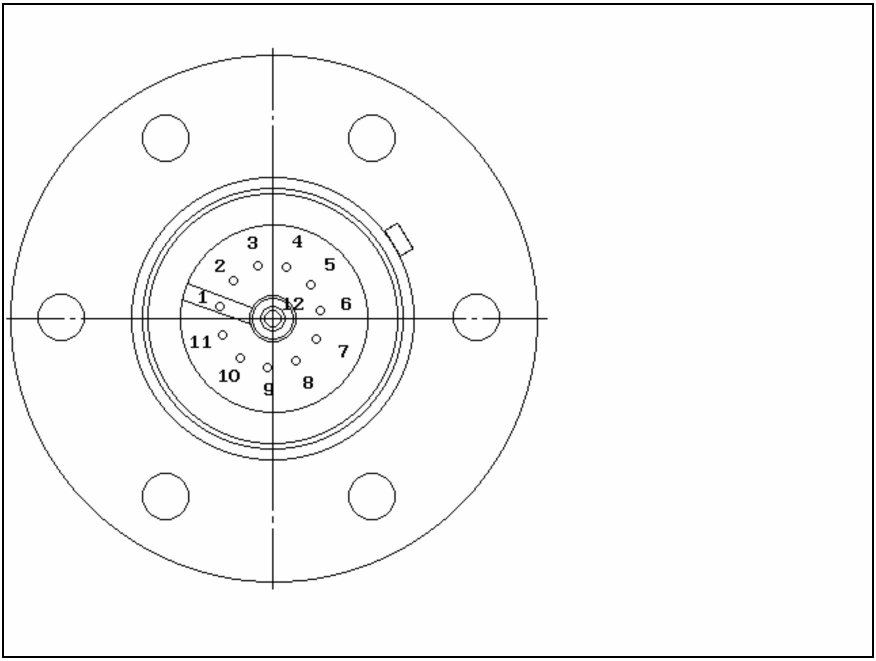

Figure 8 Analyser pin configuration

Figure 8 Pin Descriptions	
Pin	Connection

1	Earth
2	Source plate
3	Electron Multiplier
4	Filament 1
5	Extraction plate
6	Suppressor plate
7	R.F.1
8	Repeller plate / filament common
9	no connection
10	Filament 2
11	R.F.2
12	Collector

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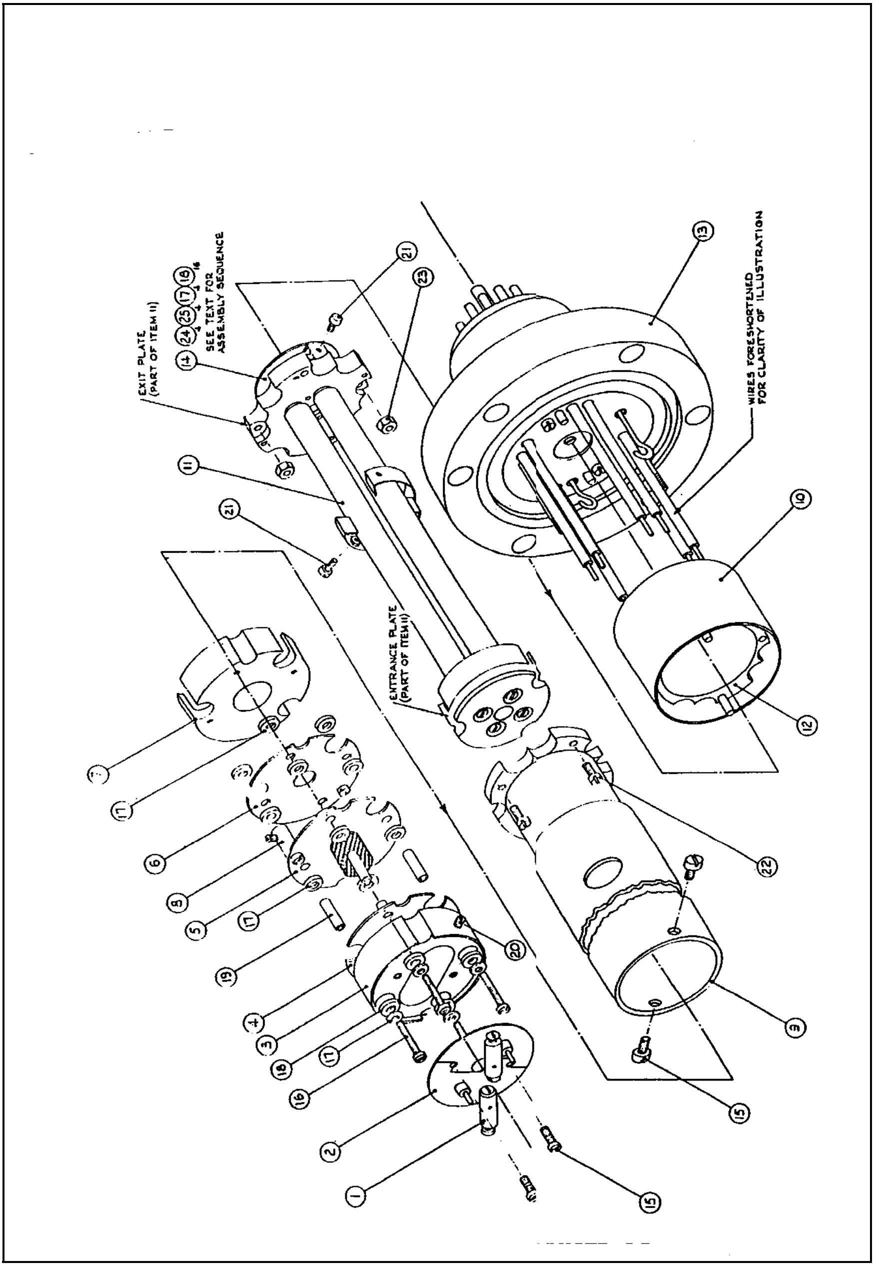

Figure 9   Exploded analyser assembly

Figure 9 Item Descriptions	
Item	Description
1	Barrel connector (Filament)
2	Filament plate
3	Source repeller block
4	Repeller plate
5	Source plate inc. source cage
6	Focus/extraction plate
7	Exit plate
8	Barrel connector
9	Support tube
10	Suppressor screen
11	Quadrupole filter assembly
12	Collector housing
13	Conflat® flange assembly
14	Multiplier assy.
15	Screw (M2x4)
16	Source screw (M1.6x12)
17	Washer (M1.6 flat)
18	Ceramic washer (source)
19	Ceramic tube (source)
20	Grub screw (M2)
21	Screw (M1.6x4)
22	Screw (M1.6x10)
23	Nut (M1.6)

4.8. Standard ion source drawings

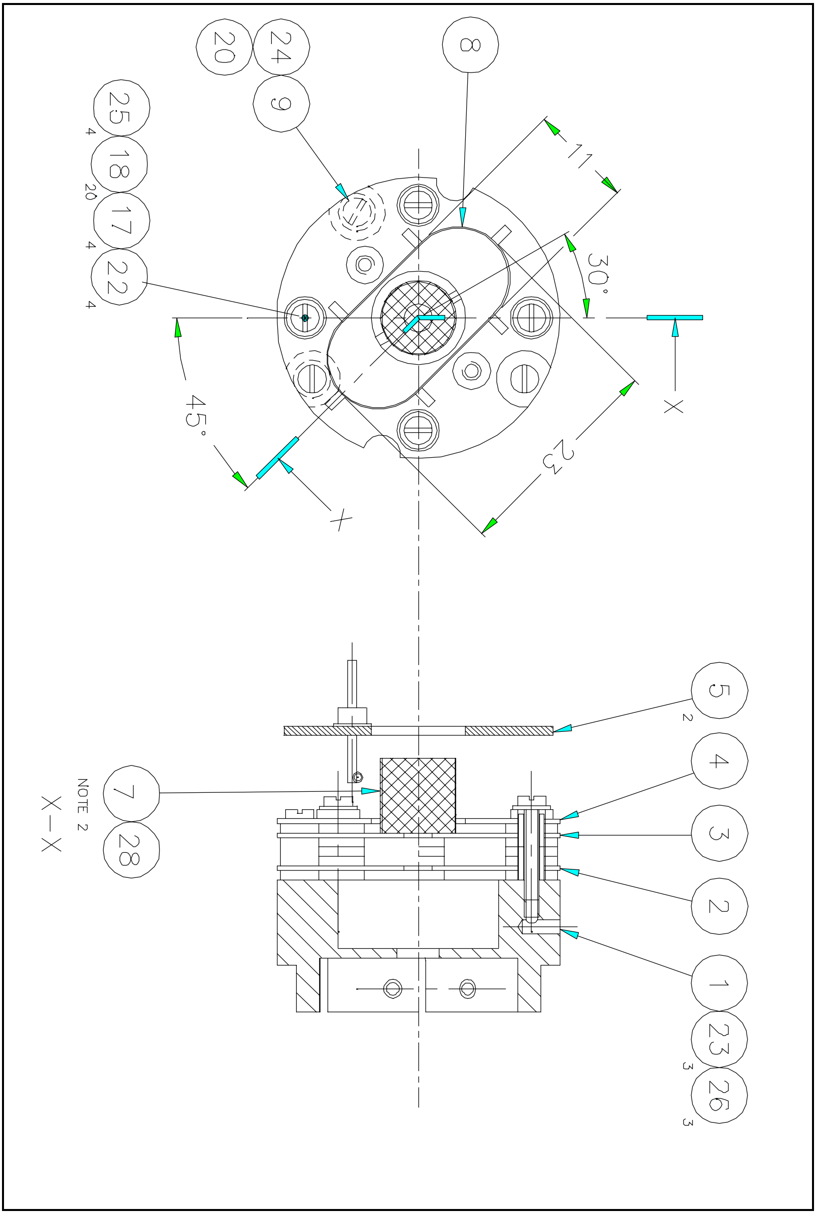

Figure 10 Standard open ion source (1)

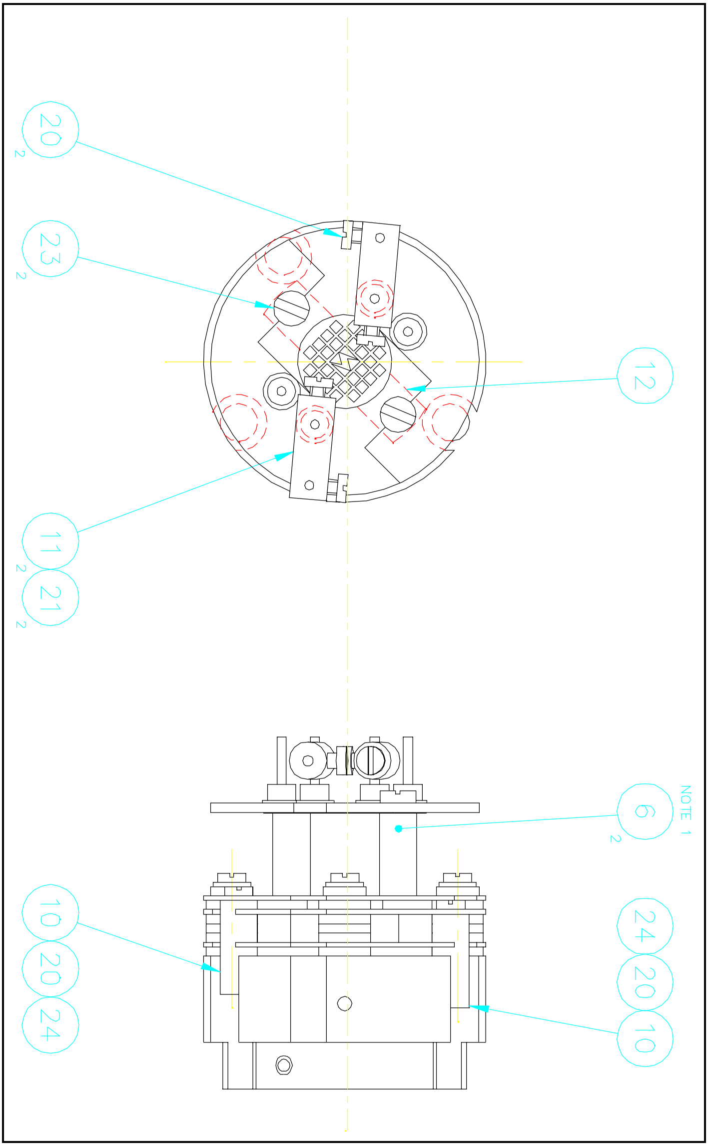

Figure 11 Standard open ion source (2)

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Standard Ion Source Item Descriptions	
Item	Description
1	Source Mounting Ring
2	Focus/Extraction Plate
3	Source Plate
4	Repeller Plate
5	Filament
6	Filament Support Spacer
7	Source Cage Support
8	Repeller Grid
9	Connector
10	Connector
11	Filament Connector
12	Filament Screen
17	Ceramic Spacer 1mm Pink
18	Ceramic Spacer 1mm White
19	Ceramic Tube 2.8mm Diameter
20	Screw M1.6 x 3
21	Screw M1.6 x 4
22	Screw M1.6 x 10
23	Screw M2 x 4
24	Screw M2 x 3 Socket Head
25	Washer M1.6 Plain
28	Stainless Steel Mesh

4.9. Enclosed ion source drawings

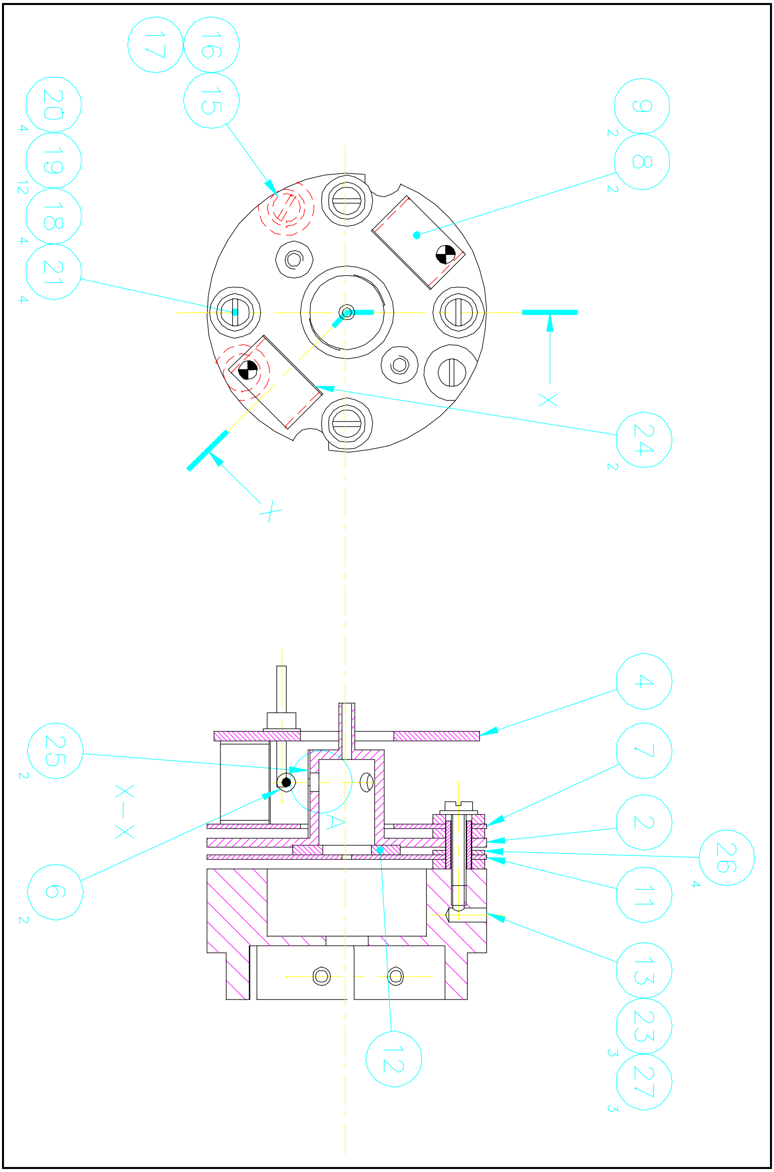

Figure 12 Enclosed ion source (1)

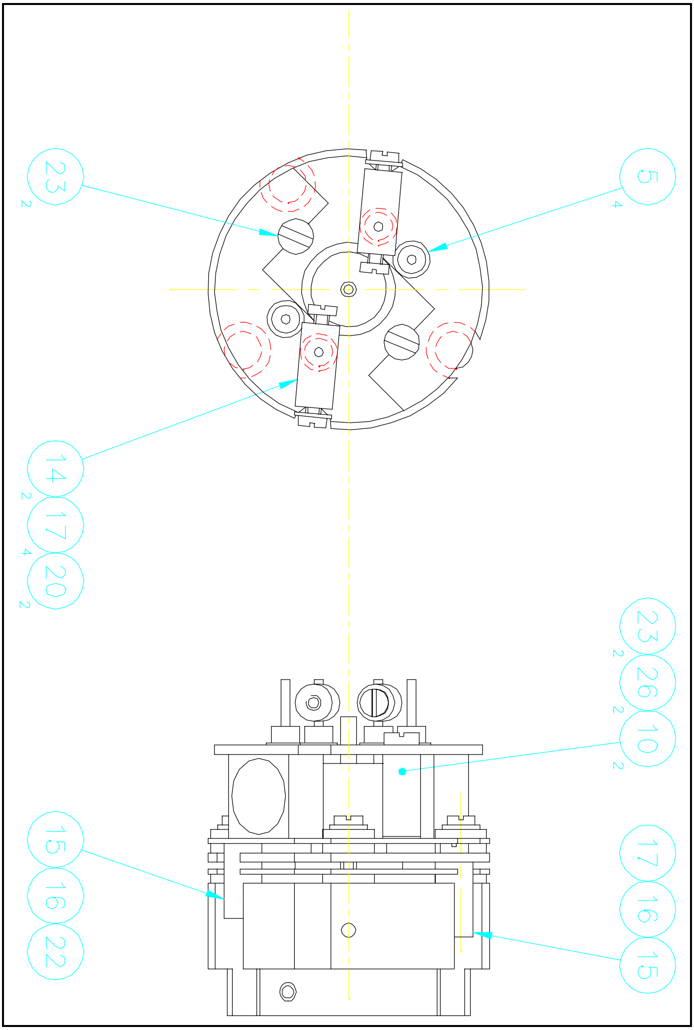

Figure 13 Enclosed ion source (2)

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Enclosed Ion Source Item Descriptions	
Item	Description
2	Source Plate
4	Filament Plate
5	Glass to Metal Seals
6	Tungsten Wire
7	Repeller Plate
8	Magnet Retainer
9	Magnet
10	Filament Support Spacer
11	Extraction Plate
12	Large Ceramic Washer
13	Source Mounting Ring
14	Filament Connector
15	Connector
16	Screw M2 x 3 Socket
17	Screw M1.6 x 4
18	Ceramic Tube
19	Ceramic Washer 1mm
20	Washer M1.6 Plain
21	Screw M1.6 x 8
22	Screw M1.6 x 4
23	Screw M2 x 4
24	Shim Stainless Steel
25	Source Slit
26	Ceramic Washer 0.5mm

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Section 5.
PVD ion source

This section of the manual describes the PVD Ion Source so it will only be applicable if your instrument is fitted with such a source.
This section of the manual was previously released as the manual supplement LP103020.

5.1. Overview

The PVD ion source has an enclosed ionisation region which has restricted pumping between it and the main filter assembly. Gas sample is introduced directly into the ionisation chamber and is analysed at a higher pressure than is allowed with a standard open ion source. Typically the PVD ion source will operate in the 10^{-3} mbar region. This means that the partial pressure of the background gases are reduced by two orders of magnitude when compared to the inlet gas signal relative to the background measured with an analyser fitted with an open ion source. This reduction gives an enhanced signal to background and therefore allows measurements to be made to lower levels of detection than is possible with a standard open ion source.

Another feature of the PVD ion source is that the filaments are now outside the ionisation region thus minimising interactions between incoming gas and the hot filament.

Quadrupoles fitted with a PVD ion source can only be used as part of a differentially pumped system, the quadrupole analyser is fitted into its own vacuum chamber which is evacuated by its own pumping system.

5.1.1. Construction

Construction of the PVD ion source is very similar to the standard source, indeed they share many common components. Gas sample is introduced directly into the ionisation region from the inlet assembly via a 6.25mm (1/4 inch) internal diameter pipe which stands about 12mm (1/2 inch) proud of the source. This leads to the most noticeable difference between the PVD source and any other Spectra ion source.
If your source does not have the inlet pipe the chances are that it is not a PVD source and you should not need this manual supplement.
The inlet pipe mates with a ceramic gas coupling, which is built into the inlet assembly. Without the coupling the PVD source and hence the quadrupole will not operate satisfactorily.

5.2. Installation

5.2.1. Removing the analyser cover

CAUTION

The analyser is both fragile and very easily contaminated by the slightest touch from your fingers or undesirable surfaces.

THE WARRANTY DOES NOT COVER CLEANING OF THE ANALYSER

The analyser is shipped in a vac-formed envelope for protection. Carefully remove the tape and unfold the envelope to allow access to the analyser.

Hold the analyser ONLY at the vacuum flange.

If you have to set the analyser down for a moment, carefully return it back to the plastic envelope for protection

DO NOT LEAVE THE ANALYSER IN THIS CONDITION.

The rules of gravity are known to deviate from the norm around unattended analysers and it can easily fall off and smash if the work surface is bumped. It will also collect dust, which will give a very strange mass spectrum!

5.2.2. Inspecting the analyser

Hold the analyser with the quadrupole and ion source structure vertically up. Carefully inspect all the observable insulators for damage.

Look at each lead from the flange to its termination point to ensure that it does not touch any other element of the analyser.

But note, the less you adjust or change, the lower the possibility of breaking something.

Notice the gas inlet tube on the top of the analyser. This must mate with the ceramic coupling which is part of the inlet built into the analyser vacuum chamber.

5.2.3. Installing a PVD source analyser

Tools required:
    One pair of 10mm spanners

OR
One pair of 7/16 inch spanners if you are in North America

Parts required:
One CF35 copper gasket
M6 bolt set
see section **5.9. Spares list**

The standard 2-3/4" Conflat® flange on the analyser should be sealed to the vacuum chamber with a copper gasket.

If it is not already clean then clean the gasket with suitable solvent, dry and slip it over the quadrupole structure. Set it in the grooves of the flange surface.

Carefully insert the analyser into the vacuum chamber ensuring that you do not allow the leads to touch the walls of the vacuum chamber. Make sure the gasket does not slip part way out of its slot. Make sure that the gas inlet tube on the top of the analyser engages with the ceramic coupling on the inlet.

Rotate the flange until the locating key on the feedthrough housing tube is as close to 11 o'clock as the bolt holes will allow. This will ensure that the cable on the RF generator will hang vertically and, therefore put little stress on the connector or the control electronics will be in the correct orientation.

Bolt the feedthrough flange to the vacuum chamber flange. If one has been supplied as part of the system fit one end of the short, heavy earth strap under the head of the lowermost bolt.

We recommend you to check for shorts using an ohmmeter see section **5.3.1. Checking for shorts.**

Refer to the instrument manual for details on connecting the RF head and control unit.

5.2.4. Removing a PVD source analyser

Before removing the analyser you may want to make a mark on the vacuum chamber in line with the locating pip on the analyser so that you can easily re-fit it in the same orientation.

Tools required:
One pair of 10mm spanners
OR
One pair of 7/16 inch spanners if you are in North America

Parts required:

None, but you will be removing the analyser for a reason and that may require some parts.

1. Switch off the RGA control unit and wait for 15 minutes to ensure that the filaments are cold.

2. Switch off then vent the quadrupole vacuum system.

3. Remove the six bolts which fasten the analyser to the vacuum chamber.

4. Carefully withdraw the analyser trying not to touch the sidewalls of the chamber with the analyser.

5. Leave the old copper gasket in place until you are ready to fit a new one, this will help to protect the knife-edge.

5.3. Meter checks

There are a number of circumstances when carrying out some simple checks with an ohmmeter can be well worthwhile. If you suspect a failed filament or want to check for shorts following some maintenance, a lot of time can be saved by performing some simple checks.

In carrying out these checks we can legitimately accept two ranges of meter readings as possibly acceptable and anything outside these ranges as being a definite fail. Any readings less than 1 ohm we can take as a short and any reading above 5 Meg Ohm ($5x10^6$ ohms) as being open circuit. The following assumes that the analyser is still on the vacuum system and goes through all the possible tests.

Tools required:-

Ohmmeter with leads

Please refer to **4.8. Standard ion source drawings** for the analyser pin numbers.

5.3.1. Checking for shorts

1. Attach the first meter lead to pin 1 of the analyser feedthrough.

2. Connect the second meter lead to the analyser flange, you should have a short circuit. If not you have a serious problem or more likely a faulty meter/meter leads.

3. Connect the second meter lead to pins 2 to 12 on the analyser feedthrough in

turn.
Each one should give an open circuit. If not you have a short to earth, refer to section **5.3.2. Short to earth**.

4. Attach the first meter lead to pin 2 of the analyser feedthrough. Connect the second meter lead to pins 3 to 12 on the analyser feedthrough in turn. Each one should give an open circuit. Now attach the first meter lead to pin 3 and check to pins 4 to 12. Proceed around the feedthrough until all possible connections have been checked. All pins should show open circuit to all other pins EXCEPT pin 4 to pin 8, pin 8 to pin 10 and pin 4 to pin 10 which should show short, see **section 5.3.3. Checking filaments**. If any of the pins do show short to another pin contact your local Spectra facility with the results of your testing and they will advise you how to proceed.

5.3.2. Short to earth

There are basically two types of short to earth; an internal short between one part of the analyser and an earthed part of the analyser, or more commonly a short between part of the analyser and the vacuum chamber. In either case remove the analyser from the vacuum chamber and repeat the test. If the result is the same then you have an internal short and should contact your local Spectra facility and tell them which pins are shorting together. Otherwise you have a short to the vacuum chamber, check the dimensions of the vacuum chamber around the quadrupole analyser or try refitting the analyser in a slightly different orientation. Repeat the ohmmeter test before pumping down the vacuum chamber. Remember that the ion source gets very hot during operation and the stainless steel components will expand slightly. Sometimes a short will only develop when the analyser has been run for a while and is up to temperature.

5.3.3. Checking filaments

If you suspect a blown filament, for instance the control unit shows filament fail, carry out the following test before removing the analyser from the vacuum system.

1. Connect meter lead one to analyser feedthrough pin 8 which is the common connection to both the filaments.

2. Connect the second meter lead to pin 4 (Filament 1). You should have a short circuit, the resistance of the filament is about 0.5 ohms when it is cold.

3. Now connect the second meter lead to pin 10 (Filament 2) again your meter should indicate a short circuit.

If either or both filaments are blown the meter will indicate an open circuit and the filaments should be replaced.

If the meter reading suggests that the filament is good but the control unit shows a filament fail the most likely cause would be a break down in electrical continuity. Examine the RF/analyser connector on the front of the RF power supply, check that none of the gold sockets are pushed out of place.

5.3.4. Failed filaments

The filament status is constantly monitored by the power supply electronics and the operating software. This is done by measuring the flow of electrons emitted by the hot filament, referred to as the emission current, and flowing to the ion source chamber. This is normally maintained at a fixed value of 1mA. The current flow through the filament is increased until the value of emission current is reached. If, however, the control electronics reaches the limit of its filament current supply capability and the emission current has still not reached 1mA a filament fail condition will exist. In the vast majority of cases this will be due to a blown filament, more correctly described as an open circuit filament. There are conditions such as a heavily contaminated ion source which will result in a filament fail when the filament is not open circuit. So, checking that the filament is open circuit is worth doing before going to the trouble of removing the analyser from your vacuum system.

5.4. Replacing the filaments

The PVD ion source is fitted with dual, independently replaceable, self-aligning filaments. Each filament consists of a semi-circular plate into which is fitted two small insulated feedthroughs. The filament wire is attached between these feedthroughs on the underside of the filament plate. The filaments are identical eliminating the need to maintain any particular orientation. The assembly consisting of filament plate, two feedthroughs and the filament wire form what we refer to as the "filament". Changing filaments is probably the most common maintenance procedure that has to be undertaken with quadrupole analysers but the analyser has been designed to make the task as quick and easy as possible.

Before you can replace the filaments you must remove the analyser from its vacuum chamber, to do this follow the instructions in section **5.2.4. Removing a PVD source analyser**.

We strongly advise you to collect together all the tools and spare parts you may need before you begin. The quicker you can complete the job and return the analyser to its vacuum chamber the less chance there is of it being damaged.

Tools:

One pair of 10mm spanners

OR
One pair of 7/16 inch spanners if you are in North America
A small jewellers screwdriver (2mm)
A pair of tweezers
Clean rubber gloves or finger stalls
An Ohmmeter
A clean container in which to put small parts
An analyser stand, the RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

Parts:

One CF35 copper gasket
Replacement filaments
Ceramics kit (routinely not needed but it will be if you drop and loose one of the screws or connectors)
see section **5.9. Spares list**

Numbers in [] (square brackets) refer to items on the PVD ion source drawings found in section **5.7.1. PVD ion source assembly**.

5.4.1. Removing the filaments

1. Make sure the analyser is held firmly in an upright position by placing it in an analyser stand, fitting it into its upturned RF head or by holding it in a small vice.

2. Hold one of the filament barrel connectors [5] with your tweezers and slacken each of the two M1.6 x 3 slotted cheese head screws [22] 1 to 1½ turns.
3. Lift away the filament barrel connector.

4. Repeat steps 2 and 3 for the other filament barrel connector.

5. Remove the four M2 x 4 slotted cheese head screws [23] which hold the two filament plates in place.

Tip
Un-do the screw a few turns then place your tweezers between the screw head and the filament plate, un-do the screw fully then lift it away held in the tweezers.

6. Using your tweezers carefully lift away each filament.

5.4.2. Replacing the filaments

1. Place the first filament on the analyser taking care to locate the dowel [9] on the top of the spacer block [8] in the hole in the filament plate. Be careful not to damage the filament wire by knocking it against part of the ion source.

2. Fit one of the M2 x 4 slotted cheese head screws [23] to secure the filament to the spacer block [8] but do not tighten this screw yet.

3. Repeat step 2 for the other filament.

4. Fit the other two M2 x 4 slotted cheese head screws [23] to secure the filament to the cylindrical support spacers [10].

5. Tighten all four M2 x 4 slotted cheese head screws [23].

6. Re-fit the two filament barrel connectors.

7. Check for shorts then re-fit the analyser in the vacuum chamber.

5.5. Removing the PVD ion source

Once again we advise you to collect together all the tools and spare parts you may need before you begin.

Tools:
One pair of 10mm spanners
OR
One pair of 7/16 inch spanners if you are in North America
A small jewellers screwdriver (2mm)
A pair of tweezers
A 0.89mm (0.035") Allen key
Clean rubber gloves or finger stalls
An Ohmmeter
A clean bench on which to work
A clean container in which to put small parts
An analyser stand, the RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

Parts:
One CF35 copper gasket
Ceramics kit (routinely not needed but it will be if you drop and loose one of the screws or connectors)

1. Remove the quadrupole analyser from its vacuum chamber as described in

section **5.2.4. Removing a PVD source analyser** then remove the filaments as described in **5.4.1. Removing the filaments.**

2. There are three wires, which run up the side of the analyser and connect to the source plate, extraction plate and the repeller plate. They fasten into barrel connectors attached to each plate and are secure by socket head screws [16]. Locate each of these barrel connectors and un-do each socket head screw 2 turns.

3. Remove the three M2 x 4 slotted cheese head screws together with their M2 shakeproof washers that fasten the analyser support tube to the source-mounting ring.

4. Lift away the PVD ion source.

5.5.1. Refitting the PVD ion source

To re-fit the PVD ion source simply follow in reverse the steps for removing it.

1. Make sure you have the ion source in the correct orientation with respect to the analyser. The small slot must line up with the gold wires hooked over the analyser support tube.

2. Slide the ion source into the analyser support tube guiding the three supply wires (source plate, extraction plate and repeller plate) into their respective barrel connectors.

3. Re-fit the three M2 x 4 slotted cheese head screws together with their M2 shakeproof washers, which fasten the analyser support tube to the source-mounting ring.

4. Tighten the three socket head screws [16] which clamp the supply wires in their barrel connectors.

5. Fit the filaments as described in section **5.4.2. Replacing the filaments.**

5.6. Dismantling the PVD ion source

Tools: One pair of 10mm spanners
OR
One pair of 7/16 inch spanners if you are in North America
A small jewellers screwdriver (2mm)
A pair of tweezers
A 0.89mm (0.035") Allen key
Clean rubber gloves or finger stalls

An Ohmmeter
4 lengths of straight clean 1mm dia. wire (not tinned or insulated) 25mm long and 1 length 50mm long, these are included in the ceramics kit
A clean bench on which to work
A clean container in which to put small parts
An analyser stand, the RF Head or some other method of holding the analyser in an upright position.
A pen and paper on which to make notes and sketches

Parts:

One CF35 copper gasket
Ceramics kit, you are bound to find at least one broken ceramic washer

1. Remove the PVD ion source from the analyser as described in section **5.5. Removing the PVD ion source**. Look at the source-mounting ring and notice the three large slots in line with the three barrel connectors. Now, notice the single smaller slot which accommodates the gold wire which you will see hooked over the analyser support tube. It is this small slot which you should use as an alignment reference.

2. Remove the four M1.6 x 8 slotted cheese head screws [21] together with their M1.6 washers [20].

3. Lift off the four white 1mm thick ceramic spacers [19].

4. Remove the repeller plate [7].

5. Lift off the four white 1mm thick ceramic spacers [19].

6. Remove the source plate assembly [2].

7. Lift off the four white 0.5mm thick ceramic spacers [26] and the single large pink ceramic spacer [12].

8. Remove the extraction plate [11].

9. Lift off the four white 1.0mm thick ceramic spacers [19] and the four ceramic tubes [18].

You have now completely disassembled the PVD ion source.

5.6.1. Re-assembling the PVD ion source

1. Place the source-mounting ring [13] on the bench with the small groove in the 9 o'clock position.

2. Into each of the four threaded holes place a 25mm long piece of wire this will help to line up the ceramics as you build up the source.

3. Over each piece of wire place one of the ceramic tubes [18] and one of the 1mm thick ceramic spacers.

4. Fit the extraction plate [11] over the wires and ceramic tubes. The extraction plate's barrel connector will be in the 8 o'clock position.

5. Place the large pink ceramic spacer [12] centrally on the extraction plate and then place the four 0.5mm ceramic washers [26] over the wires and ceramic tubes.

6. Look at the underside of the source plate. The large ceramic spacer [12] must sit in the circular recess machined into the underside of the source plate [2].
   Fit the source plate [2] over the wires and ceramic tubes, it's barrel connector will be in the 1 o'clock position. Make sure the large ceramic washer is located squarely in the recess.

7. Place a 1mm thick ceramic washer [19] over each wire and ceramic tube.

8. Fit the repeller plate, the barrel connector will be in the 5 o'clock position.

9. Over each wire place a 1mm thick ceramic washer [19] and an M1.6 stainless steel washer [20].

10. Carefully withdraw one of the pieces of wire and fit an M1.6 x 8 screw in its place, do not tighten the screw at this stage.

11. Repeat step 10 for the piece of wire opposite to the screw you have just fitted.

12. Repeat step 10 for the other two pieces of wire.

13. Check that the plates are sitting squarely.

14. Take the 50mm long piece of wire and thread it through the oblong cut out in the repeller plate spacer block, through the small holes in the gas inlet tube and then through the cut out in the opposite spacer block. This will aligned the repeller plate with the source plate and gas inlet tube.

15 Carefully tightening the four M1.6 x 8 screws [21] equally but do not overtighten them as you may break the ceramic washers. Then withdraw the 50mm long piece of wire.

14. Hold the source up to the light and check that the large ceramic washer is seated

correctly by checking that the source plate is parallel to the source mounting ring, rotate the source and check again. Check with your Ohmmeter that there are no shorts between any of the plates. If you do have any shorts correct them before continuing any further.

You are now ready to fit the ion source onto the analyser as described in section **5.5.1. Refitting the PVD ion source** and then re-fit the filaments as described in section **5.4.2. Replacing the filaments**.

5.7. Replacing an enclosed source

(Taken from the technical note LP202005 Rev1.00)
The following instructions are a brief guide to replacing an enclosed ion source with a PVD ion source and do assume some knowledge of routine analyser servicing.

1. Remove the two filament connectors on the closed source.

2. Loosen the three M2 x 3 socket set (Allen) screws in the repeller, source and extraction plate barrel connectors.

3. Loosen the two M2 x 3 socket set (Allen) screws in the mounting collar and remove the closed source.

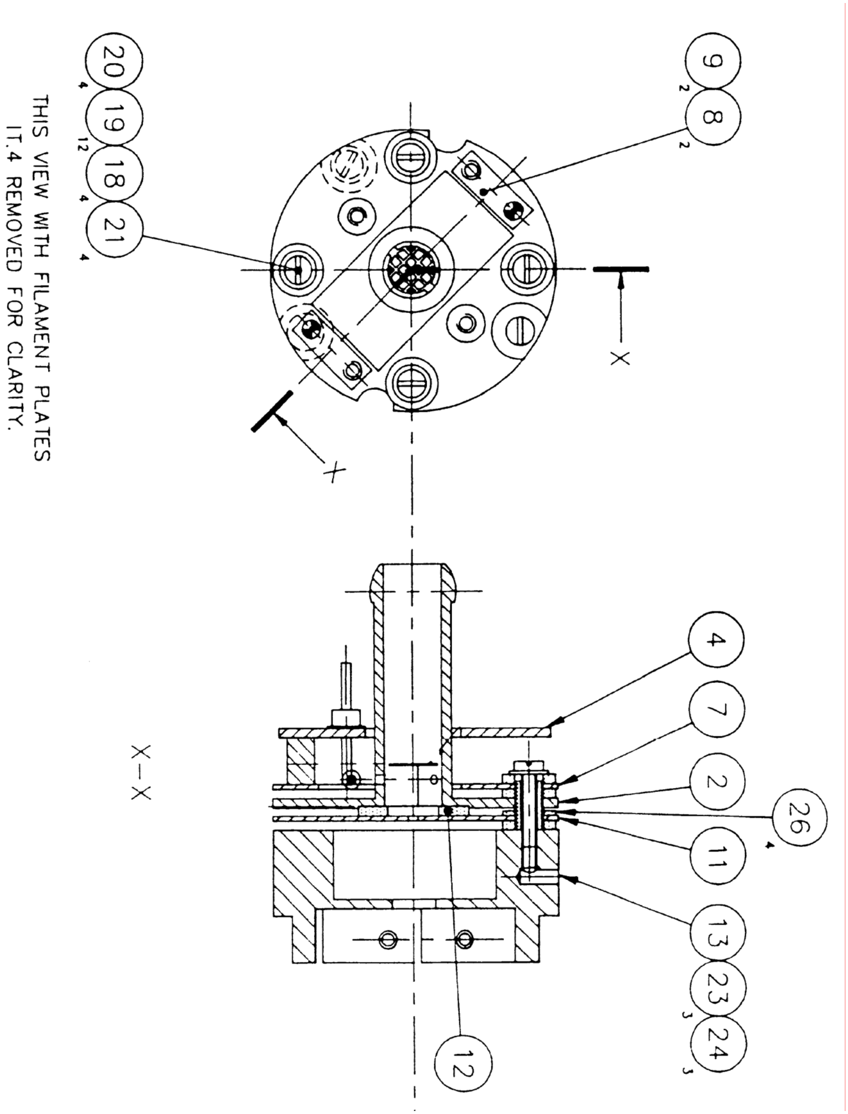
4. Fitting the PVD source is simply the reverse of the above.

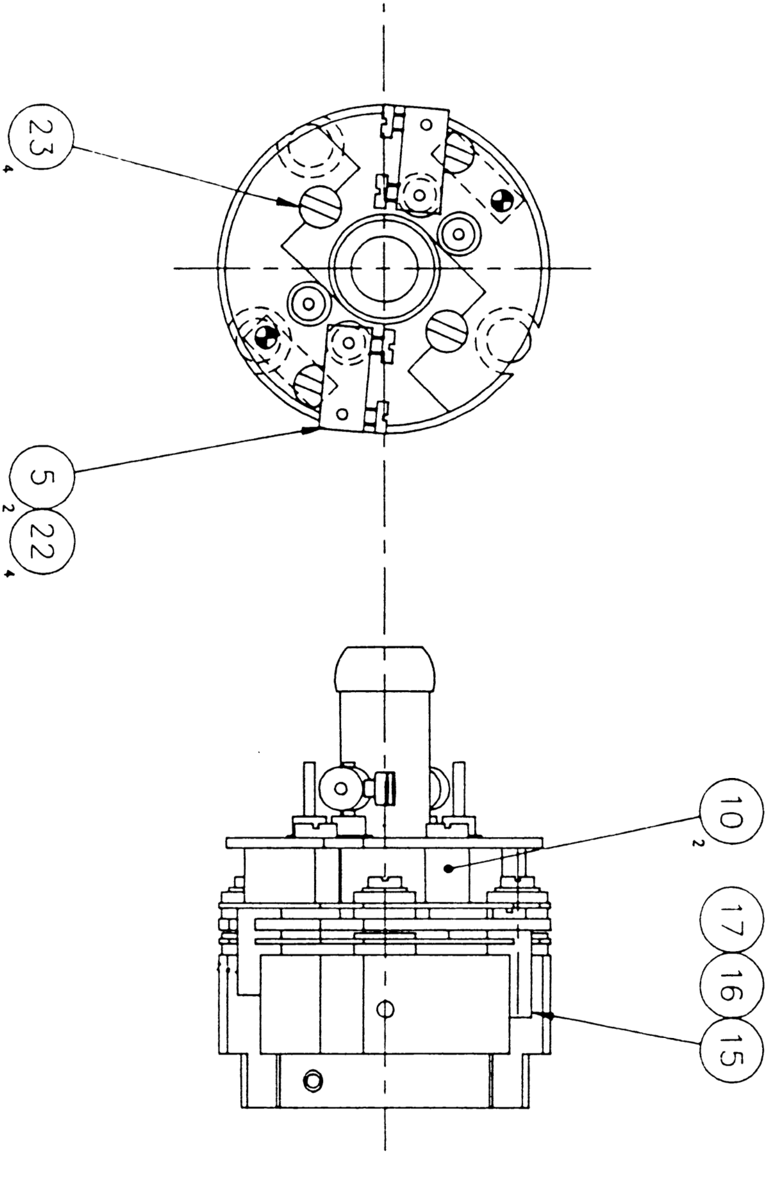
5. Once you have correctly orientated the PVD source onto the analyser and secured the five M2 x 3 socket set (Allen) screws onto the front cap and wiring connectors you will notice that the filament connections are too long. Cut the insulating ceramics level with the filament plate.

6. Fit the new filament connectors provided and cut off the excess wire.

Typical Analyser Item Descriptions	
Item	Description
1	Barrel connector (Filament)
2	Filament plate
3	Source repeller block
4	Repeller plate
5	Source plate inc. source cage
6	Focus/extraction plate
7	Exit plate
8	Barrel connector
9	Support tube
10	Suppressor screen
11	Quadrupole filter assembly
12	Collector housing
13	Conflat® flange assembly
14	Multiplier assy.
15	Screw (M2x4)
16	Source screw (M1.6x12)
17	Washer (M1.6 flat)
18	Ceramic washer (source)
19	Ceramic tube (source)
20	Grub screw (M2)
21	Screw (M1.6x4)
22	Screw (M1.6x10)
23	Nut (M1.6)

5.7.1. PVD ion source assembly




23
4
5
2
22
4
10
2
17
16
15

Item	Description
2	Source Plate and Gas Inlet Tube
4	Filament
5	Filament Barrel Connector
7	Repeller Plate
8	Spacer Block
10	Filament Support Spacer
11	Extraction Plate
12	Large Pink Ceramic Washer
13	Source Mounting Ring
16	Screw M2 x 3 socket head
17	Screw M1.6 x 4 slotted cheese head
18	Ceramic Tube
19	Ceramic Washer 1mm thick
20	M1.6 Plain Washer
21	Screw M1.6 x 8 slotted cheese head
22	Screw M1.6 x 3 slotted cheese head
23	Screw M2 x 4 slotted cheese head
24	Washer M2 shakeproof
26	Washer Ceramic 0.5mm thick

5.8. Electrical parameters

The default settings for the various PVD Ion Source parameters are:

Emission Current	1mA
Electron Energy	40 V
Ion Energy	7.0V
Extractor	-20V

5.9. Spares list

The following is a list of spares parts which may be needed when carrying out maintenance or installation of analysers fitted with a PVD ion source.

Item	Product No.
Complete replacement PVD ion source	842-045
PVD Ion Source Overhaul Kit see note 1	842-014
Replacement Tungsten filaments (pack of 2 filaments)	842-060
Replacement Thoriated Iridium filaments (pack of 2 filaments)	842-002
Analyser stand	802-002
CF35 Copper Gaskets (pack of 10)	300-010
M6 Bolt Set	302-100
Replacement Ceramic Coupling note 2	842-049

note 1
The PVD Ion Source Overhaul Kit consists of:
a full set of ceramic washers and tubes, full set of screws, filament barrel connectors and wires to aid assembly.

note 2
The replacement ceramic coupling includes:
the ceramic coupling, retaining ring, screws and springs.

Section 6.
Circuit descriptions

6.1. General system overview

The Satellite control unit is based on a single, large printed circuit board. The power supplies for the mass spectrometer, the analogue electronics and the logic are all derived from a power supply sub-section, fed from a mains transformer. A high voltage power supply board for the SEM is plugged into the motherboard on instruments fitted with a dual detector.

The microprocessor sub-system, complete with memory and I/O take up the largest single area of the motherboard. The remaining board area is occupied by the analogue electronics.

The front panel carries the mains power switch and power indicator; filament, detector and serial link status indicators.

With the exception of the mains power inlet and RF head connector that are carried on the rear panel, all input/output connectors are arranged along the rear edge of the mother board and appear through openings in the rear panel.

WARNING

DANGEROUS VOLTAGES EXIST INSIDE THIS UNIT. THE FOLLOWING CIRCUIT DESCRIPTIONS ARE FOR INFORMATION ONLY AND DO <u>NOT</u> IMPLY ANY USER SERVICEABILITY.

6.2. Mains distribution system

The mains input connector is located on the rear panel of the instrument. The inlet unit also contains the main fuses, a voltage selector drum, and a mains input filter. Both fuse ratings and voltage setting <u>MUST</u> be correct for the local supply.

Power from the mains input passes firstly through the input filter and main fuses and thence, via pins G and H on the mains inlet unit to the front panel mounted power switch. Switched power from the power switch passes to the mains transformer via the voltage selector section of the mains input connector.

The mains transformer requires tap changing for each of the four voltage ranges of the instrument; this is achieved by the connection of its primary windings to the voltage selector part of the mains inlet unit (pins A,B,C,D,E,F).

6.3. Power supplies

The main function of the power supplies section is to provide the main DC supplies for the logic, analogue electronics and the mass spectrometer. This section receives AC power from the secondary windings of the mains transformer and produces several stabilised rails for the rest of the main board and the remote RF head. There is also provision to plug in a high voltage SEM supply.

6.3.1. +/- 15 volts supply

Power from the 16.2-0-16.2V secondary passes through FS2 and FS3 to bridge rectifier BR2, connected as two bi-phase rectifiers. C22 and C23 provide smoothing to give +/- 24V unstabilised rails. VDR3 and VDR2 protect BR2 against voltage surges. The unstabilised +/- 24V are fed to SKT4, the RF head connector, for local conversion to +/- 15V stabilised rails in the RF head.

The +15 volts stabilised rail is provided by REG5, a self contained regulator IC. This IC features a built in reference, current limiting, and thermal protection. C22 and C23 provide output filtering to reduce output noise and improve transient response. R31 and R32 sample the output voltage for diagnostics purposes.

+15 volts is distributed throughout the main board and fed to the SEM board via PL7, and the RF head through SK4.

The -15 volts supply is similar in operation, consisting of regulator REG3, and capacitors C14 and C15 . The diagnostics path is via R26, the other resistor in this chain being R113 on sheet 2 of the schematic.

6.3.2. +70 volts supply

Power from the 62-0-62v secondary passes through FS4 and FS5 to bridge rectifier BR3, whose positive output, in conjunction with the centre tap of the transformer winding forms a full wave bi-phase rectifier. VDR4 and VDR5 protect BR3 against voltage surges. The DC output is smoothed by C40 and C25 to give an unstabilised output of +87 volts DC.

The stabiliser circuit consists of TR7, TR8, TR10, and TR11. The output of the supply is sampled by R56, R57, R58, and R59 and fed to the base of TR7. TR7 and TR8 are connected as a long tailed pair; a +5 volts reference being fed to the base of TR8. The +5 volts reference is derived from the +87 volts unstabilised supply by

ZN2 in conjunction with R86. This reference is compared to the sampled output voltage at the base-emitter junction of TR7. The error signal is amplified by TR7 and applied through R60 to the base of series pass transistor TR11 to provide the stabilising action. Base drive for TR11 is provided by R88 and R89, with C54 providing additional smoothing.

Current limiting is provided by TR10, R83, R84, and R87. With no load current flowing, current flow through R83 and R87 establishes a bias of -0.69volts on TR10. Load current flowing through R84 produces a positive bias to counteract the negative bias, until, with approximately 80mA of load current flowing, TR10 begins to conduct, diverting base drive away from TR11.
Eventually, the output voltage begins to fall and this reduces the current flowing in R87 due to the output voltage; the effect of which is to reduce the current limit. A cumulative action follows which results in the output voltage reducing to zero, at a current limit of approximately 43mA. This foldback action is designed to limit the dissipation of TR11 to a safe level under all conditions.

6.3.3. -65 volts supply

The -65 volts supply provides the electron energy voltage for the mass spectrometer source during normal operation.

The negative output of BR3, in conjunction with smoothing capacitors C67 and C75, provides an unstabilised supply of -87v DC. D25, R107 and R108 produce a forward bias of 2.7 volts on the base of TR14; C74 providing additional smoothing. This produces a constant voltage of 2.1 volts on the emitter of TR14 with respect to the anode of D25, leading to a constant emitter current of 9.5mA; determined by R106. The collector current of TR14 is thus made constant (neglecting the base drive).

This constant current is shared by D30, which establishes a voltage of -65 volts with respect to 0v, and by the external load. The constant current characteristic gives short circuit protection.

6.3.4. -130 volts supply

Power is taken from one half of the 62-0-62v transformer secondary, through FS5 to a half wave voltage doubler consisting of D17, D18, C61, and C62, to produce -175 volts DC.

D23, R100, and R1021 establish a forward bias of 2.7 volts on the base of TR13; additional smoothing being provided by C60. This produces a constant voltage of 2.1 volts on the emitter of TR13 with respect to the anode of D23, leading to a constant emitter current of 5.4mA; determined by R101. The collector current of TR13 is thus made constant (neglecting the base drive).

This constant current is shared by D21 and D22, which establishes a voltage of -130 volts with respect to 0v, and by the external load. The constant current characteristic gives short circuit protection.

6.3.5. Degas supply

The degas supply provides a high voltage electron energy supply for outgassing the mass spectrometer source.

Power from the 106v transformer secondary is fed through TH1 to a full wave voltage doubler circuit, comprising D31, D38, C76, and C80 to give an unregulated supply of -300 volts DC. TH1 is a positive temperature coefficient thermistor whose purpose is to provide short circuit protection for the transformer secondary.

The output passes through current limiting resistor R120, to the degas relay, RLA.

6.3.6. +/-12 volts supply

The +12 volts supply is fed from the unstabilised +24 volts supply at C16 (described in section **6.3.1. +/- 15 volts supply**) and consists of REG4, C12 and C13.

REG4 is a three terminal regulator with built-in reference and current limit; C12 and C13 providing additional smoothing.

REG2, C10 and C11 provide the -12 volts supply from the unstabilised -24 volts rail at C24.

6.3.7. Filament power supply

The filament power supply measures the emission current in the mass spectrometer source, and regulates the filament current to produce the correct emission.

Emission current flows from the +15 volts rail, through R52 to the source electrode via SK4 pin 6. The voltage at the junction of R52 and D13 is compared with the +5 volts reference by IC10. The amplified error signal appearing at the output of IC10 regulates the filament current so that the source current flowing through R52 produces a voltage of +5 volts at IC10 pin 2; this corresponds to a voltage of +5.5 volts at the junction of R52 and D13. Under these conditions the source current is 1mA.

Filament power is derived from a switch mode power supply.

IC16 is a switch mode controller IC.

The output, at IC16 pin 6, turns on mosfet TR12. The voltage induced in the primary of transformer T1 is coupled to the secondary and forward biases the series diode in D36. Current builds up in inductors L1 and L2, and this is reflected back to the primary of T1 appearing as a current in TR12, R92, and R93. The primary current is related to the current in L1 and L2 by the transformer turns ratio. The current flowing in T1 and TR12 is monitored as a volt-drop across R92 and R93 by IC16 pin 3. When the current reaches a level determined by the error signal at IC16 pin 2, the output goes low turning off TR12. R97, D20, and CM2 reduce the amplitude of the voltage spike produced by the leakage inductance of T1 when TR12 turns off and D19, in conjunction with a tertiary winding on T1, resets the core flux to zero ready for the next switching cycle.

The AC component of the current pulses from the secondary of T1 is routed through C92; the DC component flows through the mass spectrometer filament. The energy stored by the inductance of L1 and L2 maintains filament current flow through the shunt diode of D36 during the period when TR12 is turned off.

The filament circuit is also connected, through RLA to either the -65 volts supply or to the degas supply.

During degas, the voltage on the anode of D14 (pulled to a low value through D24 during normal operation) is allowed to rise. The degas relay, RLA is not energised during degas, therefore the cathode of D24 rises to +15 volts and D24 becomes reverse biased. A ramp voltage, derived from the SEM DAC is conditioned on the SEM PCB (see section **6.3.8. SEM power supply**) and applied to the anode of D14. This causes additional current to flow to the mass spectrometer source, increasing the degas power. The degas power is ramped up under microprocessor control from the initial value of 1mA to a max. value of 9mA over a user set time period. The SEM program can be used since the SEM supply is shut down during degas.

The status of the filament circuit is monitored by IC17, connected as a window comparator. The two reference inputs of IC17 are set to +4.4 and +2.3 volts respectively, by R80, R81, and R79. So long as the input through R65 from IC16 is within these limits, the outputs of IC17 remain high. If the input exceeds these limits, one of the outputs of IC17 goes low signalling the EMISSION OK line false. This signal is passed to the logic section and is also gated by IC1 to give front panel filaments status.

6.3.8. SEM power supply

The SEM power supply is a small printed circuit board that is plugged into the main PCB.

Transistor TR1 and high frequency transformer T1 are connected as a self-oscillating invertor. The voltage developed across the primary winding between pins 2 and 12 of

T1 is stepped up by the secondary winding between pins 3 and 7.

The high voltage AC output is rectified by D1 and D2, connected as a half wave voltage doubler, and smoothed by C1, C2, R2, and R3 to produce high voltage DC for the electron multiplier detector.

The output control program, in the range 0 to -9.94 volts is produced by a digital to analogue converter located on the main board, and passes via PL1 pins 1 and 2 to The first half of IC1, R17, and R19 which invert the control program to cover the range 0 to +9.94 volts. This 0 to +9.94 volts program is also used by the degas circuitry (see section **6.3.7. Filament power supply**); it is connected to the base of TR3, when the Program Volts are zero TR3 is turned on and no current from the +15V supply flows into the emission control circuit, as the base drive voltage increases negatively TR3 conducts less and current from the +15V supply is allowed to flow into the emission control circuit up to a maximum of 8mA, via PL1 pin B.

The program input is mixed with an additional, fixed, input from the +4.98 volts supply via R6 and R114. R114 is located on the main PCB, adjacent to the analogue to digital convertor, IC24. The output voltage is sampled by R1 and is fed back to be mixed with the fixed and variable program inputs at pin 6 of IC1.

The resulting error voltage is amplified by the second half of IC1 whose output controls the conduction current of the inverter transistor, TR1, through control transistor, TR2; thus controlling the output voltage of the inverter in the range -560 to -1500 volts DC.

R11, C5, and C6 provide compensation of the control loop.

The supply is switched on and off by the operating software, through a logic signal FAR/SEM applied from the logic via PL1 pin 4. When this logic level is high (+5v), a positive voltage appears at IC1 pin 5 which forces the output, at pin 7 to go positive irrespective of any input program voltage, turning off TR2 and causing the output voltage to drop to zero. When this logic level goes low, normal operation is restored.

6.4. The logic section

The logic section contains a large proportion of the dedicated mass spectrometer digital hardware, and all of the operating software.

6.4.1. Logic interface

An interface is required between the mass spectrometer control signals generated by the logic and the various control relays and other devices on the mass spectrometer, since the logic generates only logic levels and the mass spectrometer requires that relays and other devices be controlled. IC32 and associated components perform this task.

The TOT RF signal from the logic is inverted by the top section of IC32 and produces an inverted logic signal for the RF head. There is a pull-up resistor to +15 volts in the RF head.

The FIL 1/2 signal is inverted by the second section of IC32 and drives the filament changeover relay in the RF head. The relay is energised from the +15 volts rail. The signal is also used by IC1 to gate the EMISSION OK signal with the filament selected, for front panel indication.

The DEGAS signal controls the degas relay, RLA via the third section of IC32. The relay has two sets of contacts; one set selects either -65volts for normal source operation, or -300 volts in degas mode. The second set of contacts selects either -130 volts or +15 volts for the ion optics. The positive voltage is used to prevent contamination of the analyser during degas. In addition, +15 volts is supplied to the cathode of D24 during degas; this enables the programmed emission increase during degas.

The fourth section of IC32 inverts the SEM signal. The output logic level at IC32 pin10 is determined by pull-up resistor R135 and drive circuitry in the RF head to alter the ion optics when in SEM mode.

The PAG control signal is inverted by the fifth section of IC32 and controls a feedback resistor selection relay in the pre-amplifier, via level changing transistor TR16. When TR16 is turned on, the relay, which is fed from the -15 volts rail is energised.

The B.O. (beam off) signal is used to remove the ion beam when the signal amplifier zero offset is being measured. The signal is inverted by the sixth section of IC32 and converted to a +15 volts logic level by pull-up resistor R137.

6.4.2. The CPU

The processor used is a 65SC02A, a 2MHz CMOS version of the 6502. The processor performs the control and data acquisition tasks on instructions from the operating software, resident in IC26, the processor ROM.

The master clock is derived from a 3.6864 MHz crystal, divided by two in IC7, to give 1.8432 MHz for the serial link controller IC20, and for the CPU IC27. The use of one master clock for all subsystems ensures complete synchronisation.

The power up reset for the CPU and peripheral chips is provided by IC25, a device designed for this purpose. On power up, a current source in IC25 charges up C70, giving a delay of several hundred milliseconds before the reset signal goes high; the active level being low. The device continuously monitors the +5 volts rail and will generate a reset signal if the rail goes outside a +/- 5% tolerance band. This ensures that the +5 volts supply is well established before operation is allowed.

6.4.3. Address decoding

The 64K total address space of the processor is partitioned in the following way:

0000 to 7FFF	Battery backed RAM IC23
8000 to 80FF	input / output
8100 to FFFF	Program ROM IC26

The input / output address space is decoded by IC29 and IC30, which enables IC19. IC19 sub divides the I/O address space into eight smaller block decodes of 32 addresses for the individual peripheral chips. The individual device allocations are as follows:

8000 to 801F	The analogue output DAC.
8020 to 803F	MDAC The mass scale DAC.
8040 to 805F	DDAC The dual SEM / degas program and autozero DAC.
8060 to 807F	ADC The analogue/digital convertor.
8080 to 809F	RTC The real time clock/calendar.
80A0 to 80BF	ACIA The serial link.
80C0 to 80DF	VIA 1 The first digital i/o group.
80E0 to 80FF	VIA 2 The second digital i/o group.

The A15 address line is also used to decode the ROM space, which occupies the top 32K of address space except for the 256 bytes of i/o space at the very bottom of this range. A15 is applied to IC12 pin 12; the I/O enabling signal from IC30 pin 8 going to IC12 pin 13. When both these inputs are high, the output at IC12 pin 11 goes low, enabling the ROM.

6.4.4. Battery backed RAM

The RAM IC23 is supplied from an on board Lithium battery when mains power is removed. The RAM is used to store the mass spectrometer parameters so that, when the machine is switched on again, the previous machine settings are still in place.

The power for the RAM is supplied by IC6 and TR6. IC6 contains a voltage comparator that continuously compares the +3 volts battery voltage to the +5 volts supply. When +5 volts is present on pin 8 of IC6, the voltage on pin 6 goes low, turning on TR6 and applying +5 volts to the RAM. The voltage on pin 3 goes high turning on TR5. This FET is in series with the RAM chip enable.

When the +5 volts rail drops below the battery voltage, the comparator changes state, operating an internal FET switch that connects the battery through pin 1 to the RAM supply rail. The voltage at pin 6 goes high, turning off TR6 so that the battery does not supply the main +5 volts rail. The voltage on pin 3 goes low, switching off TR5; this inhibits any chip enable signals to prevent corruption of the data.

6.4.5. The real time clock

IC18 is a special purpose clock/calendar chip. It contains an on board 32.768KHz oscillator circuit and internal counters that record both date and time. The device is powered from the battery back up system so that it keeps time when the mains power is off.
The clock chip is accessed by the CPU via the address and data busses, which fetch the date and time on demand.

6.5. Digital input/output system

6.5.1. External trip

The purpose of the external trip is to allow the mass spectrometer to be protected by an external vacuum gauge.

A 10 volts secondary winding on the mains transformer is connected through R7 to D2, D3, D4, and D5, configured as a full wave rectifier. The resulting DC voltage is smoothed by C4 and regulated to 4.7 volts by D1. This 4.7 volts supply is isolated from earth and all other supplies.

This supply feeds opto isolator IC35 via R140 and SKT5. SKT5 has a set of normally closed contacts so that IC35 is energised in the absence of a jack plug in SKT5. Under these conditions, current flows through the diode in IC34 and turns on the photo-transistor, producing a logic "0" at the collector of the photo-transistor in IC35.

The normally closed contacts in SKT5 allow normal operation without the need for a link plug.

If vacuum protection is required, a jack plug wired to a set of normally closed contacts, on a vacuum gauge, should be provided. The trip contacts on the vacuum gauge should be closed during normal operation, but should open on vacuum failure and when the unit is turned off.

When a jack plug is inserted, the internal contacts are opened and the energisation of IC35 is governed by the external circuit. If the external circuit is broken, the photo-transistor in IC35 turns off and a logical "1" appears at its collector. This signal passes to the logic section and is used to interrupt the processor, which turns off the filament and the SEM and puts a warning message on the screen of the master control unit.

6.5.2. External reset

External hardware reset is also possible via IC25 pin 2. In normal operation, the photo transistor in opto isolator IC22 is turned off. An external logic "1", applied through the rear panel connector, through R96 and the LED in IC22 turns on the photo transistor, producing a low level at IC25 pin 2. This initiates a full hardware reset. An opto isolator is used to give complete isolation from the external logic signal.

6.5.3. The audio amplifier

A loudspeaker is fitted to the mainframe of the unit. This is used to generate continuous tones when in leak detect mode.

IC34 is the audio amplifier that drives the loudspeaker.

The tone signals from IC33 pin 19 pass through R133 and C91 to the rear panel mounted volume control, VR3. The output from VR3 passes to the input of IC34 at pin 3. The amplifier closed loop gain is determined by C82 and R129. The amplified output passes to the loudspeaker through C87 and the auxiliary contacts of SK1, a rear panel mounted jack socket. An external speaker may be connected via SK1, in which case the internal speaker will be muted. The minimum allowed speaker impedance is 8 Ohms.

6.5.4. Serial interface

An RS232 serial interface is supplied as standard but may optionally be replaced by an RS422 interface.

All commands and data pass between the Satellite and the host computer via the serial link.

IC20 is the UART that manages the serial link. The transmit/receive clock for this link is supplied by the main 1.8432MHz clock. Data for transmission to the host computer is passed from the CPU to IC20 where it is clocked out in serial form. Likewise, incoming serial data is assembled into parallel bytes and an interrupt is generated.

The inputs and outputs of IC20 are interfaced to SK3, the RS422 connector, via a small daughter board plugged into the IC21 socket (see schematic LM27-010-C), which converts the TTL level outputs from IC20 to RS422 levels, and also converts incoming RS422 signals to TTL levels.

An internal divider in IC20 sets the baud rate for transmission and reception on the serial port. The 1.8432 MHz input clock signal is divided down by a programmable divider within IC20.

6.5.5. Digital control lines

There are two programmable interface chips IC31, and IC33. Both devices are identical but are initialised differently at power up.

The main function of IC33 is to produce, from an internal counter, regular interrupts every 200 microseconds. These interrupts are connected to the non-maskable interrupt input on the CPU and control the operation of the analogue to digital convertor.

Control output CB2, on pin 19, generates audio tones for use when the system is in leak detect mode .

The parallel input/output ports A and B are connected directly to SK2 for use with external modules. The external modules can be used to operate relays, generate analogue output voltages, or carry out a variety of other process control functions.

IC31 also contains two eight bit parallel input/output ports and is used to monitor and control the status of the mass spectrometer.

On port A, three lines are configured as outputs, three are configured as inputs, and two are unused.

PA0 is not used.

PA1 passes to the RF head via SK4. This signal, when low, turns off the ion beam by increasing the DC rod voltages so that the amplifier zero level may be measured. Protection against externally induced transients is provided by R125 and D42.

PA2 operates an analogue switch (TR1 and TR3) to change the gain of the amplifier system when in total pressure mode, to cater for the increased analyser sensitivity when in total pressure mode.

PA3 drives a front panel indicator to show that the serial link to the host computer is functioning correctly.

PA4 is not used.

PA5 receives a signal from a monitoring circuit in the RF head. If this signal goes low, it signifies a fault in the RF generator system. This input is also connected to CA2, which is programmed to generate an interrupt. Protection against externally induced transients is given by RM4 and DM1.

PA6 receives a signal from the emission regulator, which is normally high. If the filament in use fails, this signal goes low, generating an interrupt through its connection to CB1.

PA7 monitors the status of the external trip circuitry on the power supply section, and generates an interrupt through CA1 if the trip is operated.

On port B, all eight lines are configured as outputs.

PB0 controls a relay in the pre-amplifier that changes the feedback resistor on the input stage. In conjunction with PB1 and PB2, six decades of amplifier sensitivity may be programmed.

PB1 and PB2 control the gain of the signal amplifier system; with both bits low, the gain is 1. With only PB1 set high, the gain is 10, and with only PB2 set high the gain is 100. The two bits are never set high together.

PB3 is used to turn off the DC rod voltages so that a total pressure measurement can be made. It is used in conjunction with PA2, which changes the signal amplifier gain during total pressure measurement.

PB4, when low, turns on the SEM power supply. It also drives a solid state switch that alters the biasing of the signal amplifier.

PB5 controls the operational mode of the mass spectrometer source. When high, the source is in its normal mode; when low, degas mode is selected.

PB6 controls the filament selection relay, located in the RF head.

PB7 switches the selected filament on and off.

6.6. The analogue input/output system

Four digital to analogue convertors are employed, to generate the mass scanning program, to control the output voltage of the SEM power supply, to generate an amplifier zero error correction voltage and to generate a 0 to +10 volts analogue chart recorder output. Three of the convertors are fed from a precision voltage reference; the chart recorder DAC having its own, self contained reference. The zero DAC and the SEM DAC are both contained within the same IC.

6.6.1. The voltage reference

The reference IC, ZN1 is a precision 5 volts source fed from the +15 volts rail through R42. VR2 is used to set the reference voltage to the exact value required by the mass scale generator.

The reference output takes two routes. A voltage follower comprising a section of IC9 and D12 is used to buffer the reference for application to the ADC and to part of the signal amplifier system. Another section of IC9, in conjunction with R43, R67, and R69 for the digital to analogue convertors.

6.6.2. The mass scale generator DAC

The mass scale program is generated by IC13, a 14 bit digital to analogue convertor. The convertor IC is fitted to a small daughter board that contains the chart recorder DAC and the serial interface drivers. The daughter board plugs in to the IC13 socket merely to pick up address and data signals for the chart recorder DAC. The current output from IC13 is converted to an output voltage in the range 0 to -5.82 volts by IC14. IC15, R68, R70, R71, and R72 amplify and invert this to the range 0 to +9.6 volts at mass 300.

The mass program passes out through R73, and SK4 pin 2 to the RF head.

6.6.3. The zero correction DAC

In order to compensate for long term drift in the signal amplifier, a zero error correction signal is applied to the amplifier.
This signal is generated as a current by section A of IC8 and converted to a voltage in the range 0 to - 9.94 volts by a section of IC9.

6.6.4. The SEM program DAC

The gain of the SEM detector is determined by its applied voltage. The SEM is powered by a programmable supply, as described previously.

The SEM program voltage, in the range 0 to -9.94 volts, is generated by section B of IC8 in conjunction with a section of IC9.

6.6.5. The chart recorder DAC

This is a factory fitted option and will not be fitted in all instruments.

The chart recorder DAC is used to provide analogue peak profile/intensity signals when in analogue peaks, bar chart or leak check mode. The circuitry is contained on a small daughter board that plugs in to the IC13 socket on the main board. The AD7534 device normally resident there is fitted to the daughter board instead, where it picks up its regular signals and power supplies.

The chart recorder DAC, IC1 is a self-contained convertor with on board reference and conditioning amplifier. It picks up power supplies and data lines through the IC13 socket. The device occupies two addresses, 8002 and 8003, which are decoded from A0 and A1 by IC5. IC5 is enabled by the 8000 to 801F block decode at IC19 pin 15, to which it is connected via PL4

The 0 to +10 volts output goes, via PL4 to the rear panel connector.

6.7. The signal measurement system

6.7.1. The signal amplifier system

IC2, IC4, and IC5, and their associated circuitry buffer, amplify, and scale the signals from the pre-amplifier before they are digitised. The gain of the system can be ranged over three decades by the processor.

The signals from the pre-amplifier enter the main board through SK4 pin 3 together with its signal return on pin 21. IC5 is arranged as a differential amplifier to produce signals referred to the local analogue ground. C9 and C21 provide some noise filtering. The output of the zero error correction DAC is connected to the input of this stage via R21 and R30; the effect of R30 being to give a bipolar offset to the DAC signal so that offset errors of either polarity may be nulled. This system can cope with pre-amplifier offset errors of up to +/- 33 millivolts.

IC2 is a programmable gain amplifier. It contains a network of amplifiers and analogue gates arranged to give gains of 1, 10, and 100 under the control of PB1 and PB2 on IC31.

The final amplifier stage, comprising IC4, TR4, and TR5 perform several functions. The normal output range is between 0 and +4.98 volts.

When the Faraday plate detector is in use a standing offset of +3.8 volts is established at the output of this stage by R14 and R15. The signals at TP14 are positive going, leading to negative going signals at the output on pin 6 of IC4. The normal full scale is at +1.2 volts which gives a 1.2 volts noise margin at each end, so that noise, which has both positive and negative excursions about the mean value may be fully digitised. In this way, no signal information is lost.

When the SEM detector is in use, the polarity of the signals is reversed, being negative going at TP14. The SEM control bit, in conjunction with IC11, R16, and TR2 change the standing offset to +1.2 volts. The normal full-scale output is at +3.8 volts, giving a 1.2 volts noise margin as in Faraday mode.

TR4, TR5, R18, D7, and D8 are configured as a clamping circuit to constrain the output in the range 0 to +4.98 volts to suit the input limits of the ADC.

D7, D8, and R18 bias the bases of TR4 and TR5 0.6 volts above 0 volts and 0.6 volts below +4.98 volts, respectively. If the output signal tries to go below 0 volts TR5 turns on and shorts out the feedback resistor R17, so reducing the gain and clamping the signal at 0 volts until it returns within normal range. If the output signal tries to exceed +4.98 volts TR4 turns on, once again shorting out R17 and clamping the output to +4.98V.

When in total pressure measurement mode the sensitivity of the analyser increases, therefore the gain of the amplifier is reduced pro rata to restore calibration. R13 is switched in parallel with feedback resistor R17, by TR1 and TR3, to fulfil this function. R12, switched in with R13, restores the correct standing offset at the output.

Bandwidth limiting is provided on all measurement ranges to give an adequate signal to noise ratio into the analogue to digital convertor in normal operation.

On the lowest gain range, smoothing is provided by C9, and C21. This is used with both pre-amplifier feedback resistors.

When IC2 is set to a gain of 1, CM5 provides additional smoothing in conjunction with R11, and at a gain of 10 CM8, CM7 and R9 are used.

When the larger of the two feedback resistors is selected, the PAG signal activates three sections of IC3, so that further smoothing is provided by CM6 (x1), CM8 (x10)), and CM10 (x100).

6.7.2. The analogue to digital converter

IC24 is a microprocessor bus compatible 10-bit analogue to digital convertor, complete with sixteen input analogue multiplexer and sample/hold control.

One input, AI0 is selected to digitise the amplifier output signals. AI9 to AI15 are used to measure power rails for fault diagnosis, and AI3 and AI4 are available at pins 23 and 25 of SK2 for the measurement of external signals.

During conversion the GAINSEL signal on pin 2 goes high. The level on IC3 pin 16 goes low, opening the connection between the multiplexer output and the ADC input. During the conversion time C28 holds the ADC input at a steady value.

Section 7.
ASCII protocol

An ASCII protocol has been provided for users who wish to control the Satellite control unit computer using their own application software. This may be of use to users who in addition to the normal facilities provided by RGA for Windows need to carry out Residual Gas Analysis as part of a complete process or monitoring system.

7.1. Communicating with the Satellite

7.1.1. Default serial interface parameters

Each time the Satellite is switched on the default parameters are used:-

Baud rate:- 9600
Data bits:- 8
Stop bits:- 1
Parity:- none

7.1.2. Command syntax

All commands to the Satellite consist of printable ASCII characters (range 20H..7FH), XON (11H) or XOFF (13H) characters.

All commands start with a **(** (28H) and are terminated by **)** (29H). Commands are executed on receipt of the **)** and any characters, except XON and XOFF, sent before the next **(** are ignored.

The character following the **(** is the command identifier. The full description of the commands available is given in the following sections. Generally the command identifier is an upper or lower case letter. Upper case letters in the range **A**..**Z** (41H..5AH) are used for commands which set parameters and lower case letters **a**..**z** (61H..7AH) for those which read parameters and data.

Following the command identifier are one or more parameter fields separated by a **,** (2CH). Each parameter field consists of up to 5 digits **0**..**9** (30H..39H) representing a decimal number. The actual range of valid values for a particular field is given with the description of the commands below.

Note: Leading zeros can be used if required but exceeding a total of 5 characters will cause an error.

Some of the parameter fields are optional. If they are omitted from the command then the previously used value is assumed. <u>MOST</u> of these fields are stored in battery backed memory so the values are maintained even when power is removed from the Satellite. It is possible to reset all the optional fields to their default settings by sending the **(R)** command. A full description of the POWER UP and RESET default settings for all parameters is given in section **7.4. Command reference**.

Option fields can be omitted in the middle of a command by not entering any characters between the field separator e.g. **,,**. A command may be terminated at any time if only optional fields are required. All optional fields will assume the current setting.

XON and XOFF characters may be sent to the Satellite at any time. If a XOFF character is received then any transmission from the Satellite will be suspended until an XON character is received.

Note 1 A Maximum of 9 Characters may be transmitted after the XOFF character is received.

Note 2 When the Satellite has received an XOFF any new commands issued by the host computer are queued up in a 256 character input buffer. When this buffer is full characters will be lost. In general we do not recommend the sending of commands to the Satellite if the host computer has sent an XOFF.

The SPACE character (20H) is always ignored regardless of its position in the command. This is generally useful where the built in string functions of programming language append spaces to integer string conversions etc.

In the description of the commands the following notation is used to express the commands:-

(*f1**,** [f2]**,** ....**,** {fn}**)**

i) All characters shown in **Bold** are the actual ASCII characters that should be sent by the host computer.

ii) The * character represents the position of the command identifier character.

iii) f1 .. fn represent parameter fields.

iv) [ ] around a field indicate that the field is optional and that the previous value is stored in battery backed memory. The default values are reset by using the **(R)** command.

v) { } around a field indicate that the field is optional but the default value is set each time the Satellite is powered up.

Commands that send responses other than the Ack or Nack (**A** or **N**) use the -> symbol to separate the command from the response. The actual response format will be described using the following:-

pn - Peak Height where n = decimal number
sn - Status information n = decimal number
, - The delimiter character (Default)
<CR> - The response terminator (0DH) (Default)

7.1.3. Responses from the Satellite

Peak Heights

Peak Height format = N**.**N**e-**EE

Where E is an ASCII character in the range **0** - **9** and N is an ASCII character in the range **0** - **9** ***** or **>**. The total range of the response is 9.9e-05 to 0.0e-14. A reading of *.*e-EE indicates that the peak is invalid and >.>e-EE indicates that it greater than full scale. In response to some commands more than one peak height value is returned. In these cases each value will be separated by a delimiter. The default delimiter character is **,** (2CH) but a command is available to set this to other printable ASCII characters. See section **7.2.14. Set output terminator and delimiter** for details.

Status information

Status responses from the Satellite consist of a single ASCII string of characters representing one or more DECIMAL numbers separated by the delimiter character.

Response termination

All responses from the Satellite are terminated with a programmable string. This string defaults to the Carriage Return character (0DH) when the **(R)** command is sent.

7.1.4. Command acknowledgement

A command is available which allows a command acknowledgement protocol to be enabled and disabled.

When disabled an invalid command is just ignored. Valid commands are executed and the Satellite will respond with peak height or status information if requested.

Enabling the command Acknowledgement protocol causes the Satellite to respond to every command received. The responses are either **N** (4EH) or **A** (41H). The **N** (Not-Acknowledged) response indicates that the previous command was not valid and has been ignored and could occur as a result of any of the following:-

i)	Invalid command identifier
ii)	Too many parameter fields
iii)	Missing fields when they are not optional
iv)	Field values outside allowable range
v)	Invalid characters in parameter fields
vi)	Invalid field separator
vii)	Attempt to Degas a filament when it is turned off.

If the **A** (Acknowledged) response is received then the command was valid and has been executed. If the command causes the Satellite to respond with peak height or status information then the **A** is sent followed by the normal response.

Note 1 Most commands will be acknowledged within 50mS of receipt of the **)**. The only exception to this is the Filament On command where a delay of approx. 8 seconds will occur.

7.2. Set and read parameter commands

This section will introduce you to the commands available to set and read parameters in the Satellite. It is not a full description of all the commands available, but it will give you a general idea of how to communicate with the Satellite. You may find it useful to refer to the command reference section when you read this section.

7.2.1. Enable/disable command acknowledgement

Enable/disable command acknowledgement **(A**f1**)** turns the command acknowledgement protocol ON or OFF.

Where the value of f1 represents:- **1** = ON
0 = OFF

7.2.2. Channel parameter set

Channel parameter set **(C**f1,f2,f3**)** sets the parameter number f1 of channel f2 for the current mode (3 or 6 only) to the value f3. (Used for Peak Jump and Fast Scan channel parameters). See section **7.4. Command reference** for parameters numbers and ranges.

7.2.3. Read channel parameter

Read channel parameter **(C**f1, f2**)** -> s1 **<CR>** causes the Satellite to report the value or status of parameter f1 of channel f2. See section **7.4. Command reference** for details about parameter numbers and response ranges for s1. Only valid for modes 3 - Peak Jump and 6 - Fast Scan.

7.2.4. Perform diagnostic tests

Perform diagnostics test **(d)** -> s1,s2,s3,s4,s5,s6,s7**<CR>** in response to the **(d)** command the Satellite will measure the output of all the Mass Spectrometer power supplies and test the result against the acceptable limits. The Satellite then responds with the results where sn can be:-

2 = Switched off (See Note 1 below)
1 = Pass
0 = Fail

Each field s1 - s7 refers to one of the supplies:-

s1 - +70 Volt
s2 - +15 Volt
s3 - Multiplier
s4 - -15 Volt
s5 - -130 Volt
s6 - -65 Volt
s7 - Degas

Note 1 Only the Multiplier Supply can return the Switched Off state and will occur when diagnostics are run when the filaments are turned off. If a filament is turned on when diagnostics are run then the Multiplier will be turned on momentarily during the test.

7.2.5. Filament set

Filament set **(F**f1,f2**)** sets filament number f1 (**1**= fil #1, **2** = fil #2) to the state f2 (**1** = on, **0** = off).

7.2.6. Read filament status

Reads the filament status **(f)** -> s1,s2**<CR>** and causes the Satellite to report the filament status:-

s1 = Filament selected (**1**= fil #1, **2**= fil #2)
s2 = Status :- **0** = OFF
1 = ON
2 = FAILED
3 = EXTERNAL TRIP
4 = TOTAL PRESSURE TRIP
5 = PARTIAL PRESSURE TRIP

7.2.7. Select multiplier gain factor

Selects the multiplier gain factor **(G**f1**)**. Within the Satellite two values of Multiplier voltage are stored. These are nominally the voltages required to produce a Multiplier Gain of x100 and x1000. The actual Multiplier Gain will depend on the values set using the **(V**f1**)** command (See section **7.2.17. Set multiplier voltage** for details). To select the value associated with a gain of x100 field f1 should contain **2** i.e. a gain of E2 and **3** for x1000 i.e. E3.

When the Multiplier Gain Factor has been set, the relevant Multiplier voltage will be applied to the Multiplier whenever it is turned on. The **(V**fn**)** command can then be used to adjust the actual gain to match the selected Gain Factor.

7.2.8. Read multiplier gain factor

Reads the multiplier gain factor **(g)** -> s1**<CR>.** The current Multiplier Gain Factor (s1 = **2** or **3**) is returned from the Satellite.

7.2.9. Set serial link parameters

Sets the serial link parameter **(L**{f1},{f2},{f3},{f4}**)**. The Baud Rate {f1}, Parity {f2}, Data Bits {f3} and Stop Bits {f4} used by the serial link can be changed using this command. The ranges available for each of these parameters are listed in section **7.4. Command reference**.

If the command acknowledgement protocol is enabled when you send this command the ack character **A** will be transmitted using the new setting. If you cannot reprogram the receive and transmit parameters in your UART independently, it is recommended that you disable the command acknowledgement protocol before sending this command.

Note 1 Each time the Satellite is powered up the default settings are always used. See section **7.1.1. Default serial interface parameters** for values.

7.2.10. Mode set

The mode set **(M**[f1]**,....,**[fn]**)** will start up a mode enabling the parameters associated with that mode to be changed using the **(P**f1,f2**)** and scan data to be acquired by the host computer using the **(i)** **(s**f1**)** **(o)** and **(e)** commands. The parameters associated with a particular mode can be set using this command if required. See section **7.4. Command reference** for details of mode numbers and related parameters.

e.g. **(M2,1,0,3,10,30,9,0)** will start the Satellite scanning in Bar Chart mode with the following settings:-

Multiplier .... ON
Total Pressure measurement ... OFF
Speed/Accuracy................ 3 (Standard)
First Mass Scanned............ 10
Last Mass Scanned............. 30
Range (Gain).................. E-9
Auto Range.................... OFF

A subsequent command **(M,,,,1,50)** would restart the Bar Chart mode with a First Mass = 1 and a last Mass = 50. All the other parameters would remain the same.

7.2.11. Mode read

Mode read **(m)** -> s1**<CR>** reads the current mode where s1 is current mode number. See section **7.4. Command reference** page97 for mode numbers.

e.g. If the Satellite is scanning in Analogue Mode then the command **(m)** would cause the following response:-

4<CR> i.e. 34H 0DH

7.2.12. Parameter set

Parameter set **(P**f1,f2**)** sets the parameter number f1 for the current mode to the value f2. See section **7.4. Command reference** for valid parameter numbers and value ranges.

7.2.13. Read parameter

Read parameter **(p**f1**)** -> s1**<CR>** causes the Satellite to report the value of parameter number f1 for the current scanning mode. See section **7.4. Command reference** for details of valid parameter numbers for the various scanning modes and nature of the response.

7.2.14. Set output terminator and delimiter

Sets the output terminator and delimiter **(O**{f1}**,**{f2}**)**. The responses from the Satellite can be terminated by the following; either **<CR>** (0DH) or **<CR><LF>** (0DH 0AH) or No terminator. The Delimiter character sent by the Satellite can be either **,** (2CH) **<SPACE>** (20H) or **:** (3AH). In the command, field {f1} = **0** to change the Delimiter and **1** the terminator.

When {f1} = **0** then the value of {f2} is interpreted:-
0 = **,** **1** = **<SPACE>** **2** = **:**
When {f1} = **1** then the value of {f2} is interpreted:-
0 = No terminator **1** = **<CR>** **2** = **<CR><LF>**

7.2.15. Reset

The Reset **(R)** command will reset all parameters to their default states and the Satellite to its power up state i.e. Filaments & Multiplier off, Null Mode with the comms ok light off. See section **7.5. Default settings** for listing of default values. You should allow 500ms before sending another command.

7.2.16. Total/partial pressure trip

The total/partial pressure trip **(T**f1**,** f2**)** if enabled will turn off the Filaments and hence the Multiplier if a Total Pressure reading exceeds 9.9e-05 torr. To Enable/Disable the Total Trip field f1 should be **1** and f2 should be either **1** to Enable or **0** to Disable.

The partial Trip (when enabled) will turn off the filaments and hence the Multiplier if <u>any</u> partial pressure in the scan exceeds full scale on the selected gain range. To Enable/Disable the Partial Pressure Trip f1 should be **2** and f2 a **1** or **0** to Enable/Disable.

7.2.17. Set multiplier voltage

Set multiplier voltage **(V**f1**)** sets the Multiplier Voltage (hence gain) to the Value f1 (Range **0**..**255**) for the selected Gain Factor (see **(G**f1**)** command, section **7.2.7. Select multiplier gain factor**. The actual voltage applied to the Multiplier for a given value of field f1 can be calculated:-

Voltage V = -(f1 * 2.87) - 700 Volts for a 1.5kV SEM supply
Voltage V = -(f1 * 2.91) - 454 Volts for a 1.2kV SEM supply
Voltage V = -(f1 * 9.56) - 611 Volts for a 3kV SEM supply

7.2.18. Read multiplier voltage

Read multiplier voltage **(v)** ->s1**<CR>** allows the multiplier voltage for the current gain factor to be returned as a value in the range **0** - **255**. See **(V**f1**)** command above for conversion to Volts.

7.3. Scanning modes and read spectra commands

The general method for reading the mass spectra is the same for all the scanning modes. Each scanning mode is designed to optimise the performance of the Mass Spectrometer for a particular application. It is therefore important to understand the operation of the scanning modes and when they should be used. The easiest way to become familiar with the different scanning modes is to run up RGA for Windows and use the basic scanning modes (Leak Check, Bar Chart, Peak Jump, Analogue and Fast Scan). The modes accessed using the ASCII protocol are almost identical to the comparable mode in RGA for Windows.

7.3.1. Acquiring a single element from a spectra

When the Satellite is in one of its main scanning modes (Leak Check, Bar Chart, Peak Jump or Analogue) the scan, defined by the relevant parameters, is repeated continually until another mode is selected. As each element of the spectra is acquired the new value is stored in a buffer overwriting the previous value for that element.

eg In Bar Chart the scan elements are 1 AMU. A scan with a First Mass of 10 and a Last Mass of 30 will continually scan masses 10 to 30. Each time Mass 10 is re-scanned the new value will overwrite the previous Mass 10 reading and so on throughout the scan.

Single Element Read Command **(s**f1**)** -> p1**<CR>**

The **(s**f1**)** command is provided to read the current value of any element in the scan. The value of f1 indicates which element is to be returned and its interpretation varies from mode to mode. Details are given for each mode later in this section. If the value of f1 is invalid for the current mode or scan setting the command will be ignored if command acknowledgement is off or the Nack character **N** will be returned if it is on.

Read Scan Index **(i)** -> s1**<CR>**

The scan index indicates which element in the scan is currently being measured by the Satellite. It is useful if you wish to synchronise the reading of data using the **(s**f1**)** command to the internal scan. The value of s1 will indicate the current element being measured. The range of values it may have, depends on the mode and scan characteristics. These are the same as the current valid values for field f1 in the **(sf1)** command.

7.3.2. Acquiring a complete spectra

In addition to the buffer used by the single element read command, a second buffer is available which is updated at the end of each complete scan. A flag is set when a scan is copied into this buffer and is cleared when the data has been read.

Read Complete Spectra Command **(e)** -> p1,p2, ... ,pn**<CR>**

The **(e)** command returns all the elements in the current spectra. The exact number of elements returned will depend on the current mode and scan characteristics.

Read Scan Available Flag **(o) ->** s1**<CR>**

The scan available flag may be read using the **(o)** command. s1 will be **1** when a new scan is available and **0** at all other times.

7.3.3. Leak check mode . Mode 1

Leak check is a fast scanning single point acquisition mode. The sample Mass number may be tuned to within 1/32nd of an AMU allowing rapid monitoring of a single point in the mass spectra.

Since one point is being scanned only the last reading is available to the **(sf1)** command i.e. only **(s1)** is valid. However a pseudo "end of scan" occurs after 150 readings have been taken and all this data is available to the **(e)** command.

7.3.4. Bar chart mode. Mode 2

A complete scan is performed from First Mass - 1/2 AMU to Last Mass + 1/2 AMU. Each AMU is scanned (from -1/2 to +1/2 AMU) and the maximum intensity found is stored as the peak height for that AMU.
The single element in Bar Chart mode is an AMU in the range First Mass to Last Mass. The value of f1 in the **(sf1)** command is the mass number (AMU) and the **(e)** command returns (Last Mass - First Mass) + 1 number of elements.

7.3.5. Peak jump mode. Mode 3

Twelve programmable channels are available each of which may be set to any required mass number (AMU), Gain Range, Detector and Auto Range. This mode is useful where up to twelve specific species are to be monitored. Each mass is scanned over the range -1/2 to +1/2 AMU and the maximum intensity found is stored as the peak height for that AMU.

The single element in Peak Jump mode is the channel number **1**..**12**. The **(e)** command returns the data for all twelve channels.

7.3.6. Analogue mode. Mode 4

This mode scans 256 elements from First Mass -1/2 AMU to First Mass + Mass Zoom -1/2 AMU. The number of elements per AMU varies according to the Mass Zoom:-

Mass Zoom	Elements / amu	AMU / Element
64	4	¼
32	8	1/8
16	16	1/16
8	32	1/32

In the single element read command **(s**f1**)**, f1 corresponds to an offset into a 256 element buffer. The **(e)** command returns all 256 elements of the previous scan.

7.3.7. Single peak read. Mode 5

Unlike the modes described so far, single peak read scans the requested peak once. It scans from -1/2 AMU to +1/2 AMU and stores the maximum intensity ready to be accessed via the **(s1)** or **(e)** commands. The scan available flag is a **1** when the peak has been scanned.

7.3.8. Fast scan. Mode 6

This is the most flexible scanning mode available in the Satellite but it must be carefully tuned to obtain VALID results for the Mass Numbers, Gains and Detector combinations set. Before you try to use this mode we strongly recommend that you familiarise yourself with the Fast Scan Mode using RGA for Windows. If you need to use the Fast Scan mode in your application you are advised to determine the parameter setting using RGA for Windows before using the Satellite in isolation.

The actual mechanism for driving this mode is fairly straightforward. Twelve channels are available, which can be set to a specific mass number, gain range and detector. Unlike the Peak Jump mode only one point is scanned (1/32nd AMU) rather than the complete AMU. A Mass offset parameter is provided to accurately position the 1/32nd AMU scan point within the AMU selected. Two other parameters are also required, the Dwell and the Settle times. The Dwell time is the number of averaged readings taken (at 200us intervals) to produce the result and the Settle Time is the delay between setting the "Hardware" to the required state and starting the reading.

This mode does not scan automatically. The **(S**f1**)** command must be sent to start the reading of channel f1. A Nack **N** will be sent if another **(S**f1**)** command is received by the Satellite before the reading is complete. The host computer can use the "trigger" command for the next channel to indicate when the current reading has finished. The **(s**f1**)** command is used to read the value obtained for channel f1. The **(e)** command will return the values obtained for all twelve channels, even if they have not been scanned. The **(i)** and **(o)** commands can also be used to determine when the reading has finished.

The trigger scan command **(S**f1**)** may also be sent with f1 = **0**. This will cause the Satellite to run a Zeroing Routine, which compensates for the offsets introduced into the detection system due to temperature changes etc. The Zero Routine should be performed before any of the channels are scanned preferably when the Satellite has reached a stable operating temperature.

7.3.9. Degas. Mode 7

Although Degas is not a scanning mode, it operates in a similar manner. When activated the scan index **(i)** command returns the elapsed time in seconds since the start and the scan available **(o)** command indicates when the Degas is complete. A filament must be on before the Degas mode is entered otherwise a Nack will be received.

7.4. Command reference

VARIABLE PARAMETERS		
r	Valid Range	Description
a	1 = On 0 = Off	General indication for on/off parameters
b	Range 1 . . Max. Mass	Represents the mass number. Max. mass will be either 100, 200, 300 depending on the instrument.
c	Range 5 . . 13	Representing the Gain Range. 5 . . 11 are valid when Faraday detector is used 7 . . 13 are valid when the multiplier is used.
d	Range 0 . . 99	Alarm settings. 0 = Off 1 . . 99 represents values 0.1 to 9.9
e	0 . . 5	Scan Speed/Accuracy. 0 = very fast 1 = fast 2 = med 3 = standard 4 = slow 5 = very slow
f	8, 16, 32, 64	Analogue mass zoom factors. (AZ)
g	0 . . 31	Mass offset in 1/16th AMU, 16 = 0 offset
h	1 . . max. mass - 1	Bar Chart Scan First Mass (FM)
i	FM + 1 . . max. mass	Bar Chart Scan Last Mass (see h above)
j	1 . . max. mass - AZ	Analogue scan first mass (see f above)
k	1 . . 9999	Degas time in seconds
l	1 . . 255	Degas seconds/power step
m	0 . . 255	Degas initial power 0 . . 255 = 15% to 100% full power.
n	0 . . 14 = n	Dwell time 2^n x 200 microseconds
o	1 . . 9900	Settle time x 1millisecond
p	1 . . Max. Mass 301 &302	1 . . max. mass = mass numbers amu 301 & 302 = Analogue input 1 &2.
q	0=off, 1=on, 2=Trip (Read only)	Multiplier Status

(af1) -> s1**<CR>** - READ ALARM STATUS

0 = OK **1** = ALERT

CHANNEL NUMBER **1 . . 12**

(Af1**)** - COMMAND ACKNOWLEDGEMENT PROTOCOL ENABLE/DISABLE

0 = DISABLE **1** = ENABLE

(cf1**,** f2**)** -> s1 **<CR>** - READ CHANNEL PARAMETER

(Cf1**,** f2**,** f3**)** - SET CHANNEL PARAMETER

VALUE see page 97 for parameter ranges

CHANNEL NUMBER **1** .. **12**

Mode Dependant Scan Parameters

MODE 3 Peak Jump		
f1	Parameter	r
1	Multiplier	q
2	Channel Enable	a
3	Mass Select	p
4	Range (Gain)	c
5	Auto Range	a
6	High Alarm	d
7	Low Alarm	d

MODE 6 Fast Scan		
f1	Parameter	r
1	Multiplier	q
2	Channel Enable	a
3	Mass Select	p
4	Range (Gain)	c
5	Mass Offset	g
6	Dwell Time	n
7	Settle Time	o

(d) -> s1**,** s2**,** s3**,** s4**,** s5**,** s6**,** s7 **<CR>** DIAGNOSTICS

DEGAS	**2** = SWITCHED OFF *
-65 VOLTS	**1** = PASS
-130 VOLTS	**0** = FAIL
-15 VOLTS	
MULTIPLIER *	
+15 VOLTS	
+70 VOLTS	

(e) -> p1**,** p2**,** . . . **,** pn **<CR>** - READ COMPLETE SPECTRA

Peak Heights Mode dependant

(f) -> s1**,** s2 **<CR>** READ FILAMENT STATUS

s2	STATUS
0	Off
1	On
2	Failed
3	External Trip
4	Total pressure trip
5	Partial pressure trip

Filament Number

1 or **2**

(Ff1**,** f2**)** - FILAMENT CONTROL COMMAND

FILAMENT ON / OFF **1** or **0**

FILAMENT NUMBER **1** or **2**

(g) -> s1 **<CR>** - READ MULTIPLIER GAIN FACTOR
(Gf1**)** - SELECT MULTIPLIER GAIN FACTOR

MULTIPLIER GAIN FACTOR **2** or **3** = x100 or x1000

(I) -> s1 **<CR>** - READ SCAN INDEX

ELEMENT BEING MEASURED (MODE DEPENDANT)

(L{f1}**,** {f2}**,** {f3}**,** {f4}**)** - SERIAL LINK PARAMETER SET

STOP BITS
1 or **2**

DATA BITS
7 or **8**

PARITY		
0 = NONE	**1** = ODD	**2** = EVEN

BAUD RATE				
300	**600**	**1200**	**1800**	**2400**
3600	**4800**	**7200**	**9600**	**19200**

(m) -> s1 **<CR>** READ MODE

s1	MODE
0	Null
1	Leak Check
2	Bar Chart
3	Peak Jump
4	Analogue Peak
5	Single Peak
6	Fast Scan
7	Degas

(o) -> s1 **<CR>** - SCAN OVER FLAG

0	NO DATA FOR **(e)** COMMAND
1	SCAN DATA AVAILABLE FOR **(e)** COMMAND

(O {f1}, {f2}**)** - SET OUTPUT DELIMITER AND TERMINATOR

0	DELIMITER
1	TERMINATOR

DELIMITER	
0	,
1	<SPACE>
2	**:**

TERMINATOR	
0	None
1	<CR>
2	<CR><LF>

7.4.1.(M [f1], [f2], . . . , [fn]) - MODE SET COMMAND

f1	MODE
0	Null
1	Leak Check
2	Bar Chart
3	Peak Jump
4	Analogue Peak
5	Single Peak
6	Fast Scan
7	Degas

Mode Dependant Scan Parameters

	MODE 0 Null	r
	No Fields	

	MODE 1 Leak Check	r
f2	Multiplier	q
f3	Response (speed)	e
f4	Probe Gas	b
f5	Mass Tune	g
f6	Range (Gain)	c
f7	Auto Range	a
f8	High Alarm	d
f9	Low Alarm	d
f10	Audio	a

	MODE 2 Bar Chart	r
f2	Multiplier	q
f3	Total Pressure	a
f4	Accuracy / Speed	e
f5	First Mass	h
f6	Last Mass	i
f7	Range (Gain)	c
f8	Auto Range	a

	MODE 3 Peak Jump	r
f2	Total Pressure	a
f3	Accuracy / Speed	e

	MODE 4 Analogue	r
f2	Multiplier	q
f3	Total Pressure	a
f4	Accuracy / Speed	e
f5	First Mass	j
f6	Mass Zoom	f
f7	Range (Gain)	c
f8	Auto Range	a

	MODE 5 Single Peak	r
f2	Multiplier	q
f3	Accuracy / Speed	e
f4	Mass	b
f5	Gain	c

	MODE 6 Fast Scan	r
	No Fields	

	MODE 7 Degas	r
f2	Degas Time	k
f3	Power Ramp	l
f4	Start Power	m

(pf1**)** -> s1 **<CR>** - PARAMETER READ (CURRENT SCAN MODE)
(Pf1, f2**)** - PARAMETER SET (CURRENT SCAN MODE)

VALUE see page 97 for parameter ranges

Mode Dependant Parameter Number

MODE 0 Null		r
	No Parameters	

MODE 1 Leak Check		
f1	Parameter	r
1	Multiplier	q
2	not used	-
3	Response (speed)	e
4	Probe Gas	b
5	Mass Tune	g
6	Range (Gain)	c
7	Auto Range	a
8	High Alarm	d
9	Low Alarm	d
10	Audio	a

MODE 2 Bar Chart		
f1	Parameter	r
1	Multiplier	q
2	Total Pressure	a
3	Accuracy / Speed	e
4	First Mass	h
5	Last Mass	i
6	Range (Gain)	c
7	Auto Range	a

MODE 3 Peak Jump		
f1	Parameter	r
1	not used	-
2	Total Pressure	a
3	Accuracy / Speed	e

MODE 4 Analogue		
f1	Parameter	r
1	Multiplier	q
2	Total Pressure	a
3	Accuracy / Speed	e
4	First Mass	j
5	Mass Zoom	f
6	Range (Gain)	c
7	Auto Range	a

MODE 5 Single Peak
No Parameter Set

MODE 6 Fast Scan
No Parameter Set

MODE 7 Degas
No Parameter Set

r - see page Variable Parameters for description of parameters and ranges.

(R) - RESET SATELLITE
Allow 500ms before sending another command.

(Sf1**)** -> pl **<CR>** - READ SINGLE SCAN ELEMENT

(Sf1**)** - TRIGGER MEASURE FAST SCAN CHANNEL

0	Measure Zero
1 . . .12	Channel Number

(tf1**)** -> s1 **<CR>** - READ PRESSURE TRIP SETTING
(Tf1**,** f2**)** - PRESSURE TRIP ENABLE / DISABLE

Enable / Disable = **1** / **0**

Total = **1**, Partial = **2**

(v) -> s1 **<CR>** - READ MULTIPLIER VOLTAGE
(Vf1**)** - SET MULTIPLIER VOLTAGE

Range **0 . . 255**
Where Voltage V = - ((f1 x 2.87) + 700) volts

7.5. Default settings

MODE 0
No Parameters

MODE 1 Leak Check	
Multiplier	**0** = Off
Response (speed)	**3** = Standard
Probe Gas	**4** = Helium
Mass Tune	**16** = Peak 0 Offset
Range (Gain)	**5** = E-05
Auto Range	**0** = Off
High Alarm	**0** = Off
Low Alarm	**0** = Off
Audio	**1** = On

MODE 2 Bar Chart	
Multiplier	**0** = Off
Total Pressure	**1** = On
Accuracy / Speed	**3** = Standard
First Mass	**1** = First Mass
Last Mass	**50** = Last Mass
Range (Gain)	**5** = E-05
Auto Range	**0** = Off

MODE 3 Peak Jump	
Total Pressure	**1** = On
Accuracy / Speed	**3** = Standard

MODE 4 Analogue	
Multiplier	**0** = Off
Total Pressure	**1** = On
Accuracy / Speed	**3** = Standard
First Mass	**21** = Mass 21
Mass Zoom	**16** = 16 amu
Range (Gain)	**5** = E-05
Auto Range	**0** = Off

MODE 5 Single Peak	
Multiplier	**0** = Off
Accuracy / Speed	**3** = Standard
Mass	**28** = Mass 28
Range (Gain)	**5** = E-05

MODE 6 Fast Scan
No Parameters

MODE 7 Degas	
Degas Time	**300** = 300 seconds
Power Ramp	**1** = 1 second / power step
Start Power	**0** = 15%

MODE 3 Peak Jump Channel Parameters												
Channel	1	2	3	4	5	6	7	8	9	10	11	12

Multiplier	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
On / Off	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off
Mass	2	4	12	14	15	16	17	18	28	32	44	55
Gain	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5
Auto Range	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
High Alarm	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Low Alarm	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off

MODE 6 Fast Scan Channel Parameters												
Channel	1	2	3	4	5	6	7	8	9	10	11	12
Multiplier	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
On / Off	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off
Mass	2	4	12	14	15	16	17	18	28	32	44	55
Gain	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5	E-5
Mass Offset	16	16	16	16	16	16	16	16	16	16	16	16
Dwell Time	3	3	3	3	3	3	3	3	3	3	3	3
Settle Time	10	10	10	10	10	10	10	10	10	10	10	10

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Section 8.
Connector pinouts

This section identifies the connectors on the rear panel of the Satellite control unit and contains connector pinouts which you may need to refer to when connecting peripheral equipment.

8.1. Standard rear panel

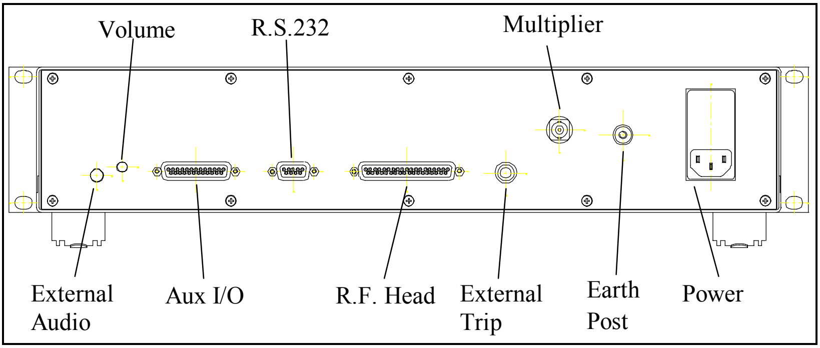

Figure 14 Standard rear panel

8.2. Optional rear panel

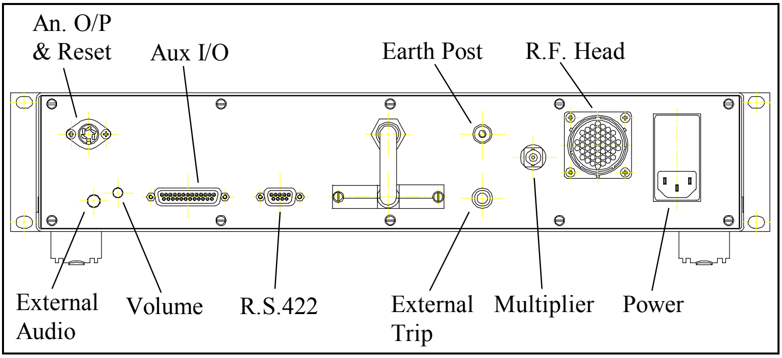

Figure 15 Optional rear panel

8.3. Aux I/O connector

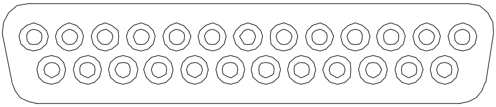

Figure 16 Aux I/O view from rear

Pin	Description
1	Not used
2	Alarm for Peak Jump channel 2. TTL High when alarm is true.
3	Alarm for Peak Jump channel 4. TTL High when alarm is true.
4	Alarm for Peak Jump channel 6. TTL High when alarm is true.
5	Alarm for Peak Jump channel 8. TTL High when alarm is true.
6	Alarm for Peak Jump channel 10. TTL High when alarm is true.
7	Alarm for Peak Jump channel 12. TTL High when alarm is true.
8 and 9	used by analogue output module
10	0v digital (0v for alarms)
11	0v analogue (0v for analogue inputs)
12	-15v
13	+15v
14	Alarm for Peak Jump channel 1. TTL High when alarm is true.
15	Alarm for Peak Jump channel 3. TTL High when alarm is true.
16	Alarm for Peak Jump channel 5. TTL High when alarm is true.
17	Alarm for Peak Jump channel 7. TTL High when alarm is true.
18	Alarm for Peak Jump channel 9. TTL High when alarm is true.
19	Alarm for Peak Jump channel 11. TTL High when alarm is true.
20 and 21	used by analogue output module
22	+5v
23	Vref (4.9v)
24	Analogue input 2
25	Analogue input 1

8.4. External trip socket

The external trip socket is a 1/4 inch mono jack socket. It must be used with a 1/4 inch mono jack plug. The tip is positive, the body is negative. The voltage between the pins must not exceed 60V DC.

8.5. Analogue output / hardware reset

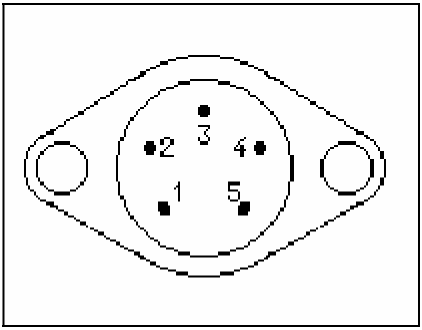

Figure 17 An. o/p & reset (view from rear)

The socket is a 5 pin (240 degree) DIN socket.

Pin	Description
1	Analogue output signal (0 to 10v)
2	Analogue output return (0v)
3	Earth
4	Hardware reset +
5	Hardware reset -

The analogue output signal is 0 to 9.9v representing a peak height in the range 0.0 to 9.9.

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Appendix 1.
Variable electron energy

This appendix was previously available as Tech Note LP207004

Variable Electron Energy

This is a factory built option that may be added to the Satellite control unit.

The option allows the electron energy normally fixed at 70eV to be adjusted in the range 10.2 to greater than 70eV. The value of electron energy is adjusted by means of a 10 turn potentiometer mounted on the front panel of the Satellite control unit. The value of electron energy is displayed on a digital panel meter also mounted on the front panel of the Satellite control unit.

CAUTION

The display reading is only accurate when the filament is switch on.

At low values of electron energy there is insufficient voltage in the ion source to maintain the standard 1mA of emission. At these low values, the filament current rises to levels that will seriously shorten filament life. Therefore, a switch is provided to select an emission setting of 0.33mA, which gives safe levels of filament current and also reduces the filament current surge at switch on. It is strongly recommended that for electron energy settings lower than 25eV the 0.33mA emission setting is used. At 0.33mA emission the sensitivity will be about 1/3 of the normal sensitivity at 1mA.

Variable Emission Control

Units fitted with the Variable Emission option will have an adjustable emission control. This is provided by a 10 turn potentiometer mounted on the front panel of the Satellite control unit.

With the emission switch set to 1mA the emission is variable in the range 0.088mA (dial set to 0.0) to 1mA (dial set to 10.0).

With the emission switch set to 0.33mA the emission is variable in the range 0.074mA (dial set to 0.0) to 0.33mA (dial set to 10.0).

CAUTION

When running diagnostics the –65 volt supply will show fail if the electron energy setting is anything other than 70eV.

Front Panel Layout

Appendix 2
Upgrading satellite software

This appendix was previously available as Tech. Note LP206003.

A number of versions of the Satellite control unit exist each having its own type of case. The earliest type of Satellite had serial numbers beginning LM5 and used an all black case with a one piece front panel. The LM5 units were shipped from about mid 1988 to the middle of 1993. The next generation of Satellite units used a case consisting of a silver anodised aluminium frame and black aluminium panels, serial numbers for these units began LM46. The current Satellite instruments have serial numbers beginning LM61 with the first shipments being made towards the end of 1996. LM61 units have a moulded metal case painted grey.

Two other versions of Satellite have been made these have serial numbers beginning LM27 and LM65. For the purposes of software upgrades LM27 units can be considered the same as LM5 units and LM65 units can be considered the same as LM61 units.

Satellite control units are fitted with one EPROM, IC25 (IC26 on later units). Most software changes will involve replacing this EPROM. However, if your Satellite is fitted with a version of software earlier than V1.50 you will have to make some other modifications, as detailed below, to complete the upgrade. This may include replacing the static RAM chip IC22 (IC23 on newer units).

Please observe the standard precautions for handling static sensitive devices:-

1. Disconnect the power from the **SATELLITE**.

2a. With LM5 units remove the 9 screws securing the top panel and lift off the top panel.

2b. With LM46 units remove the left ear (looking at the Satellite from the rear) by removing the two posi-head screws. Now slide out the left side panel.

2c. With LM61 units remove the three centre most black posi-pan head screws from the top of the rear panel, remove the two grey posi-countersunk screws from each of the two side panels then lift off the top panel which is clipped into place at the front.

3. If you are upgrading from version V1.50 or later then you can skip to step 7. If you have followed 2b or 2c above then you will skip to step 7.

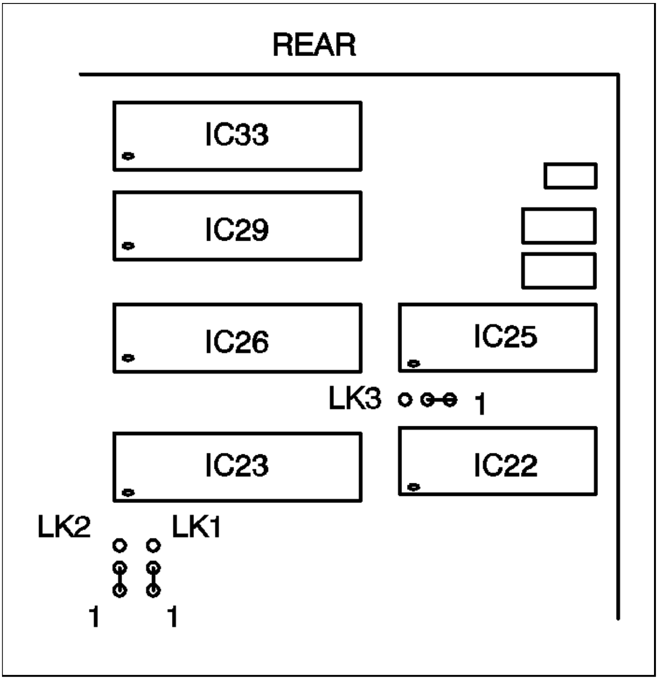


Figure 1.

4. The link between 2 and 3 of LK3 must be removed with a soldering iron and a link made between pins 1 and 2 as shown in figure 1.

5. The link between 2 and 3 of LK1 must be removed with a soldering iron and a link made between pins 1 and 2 as shown in figure 1.

6. The IC22 should be removed and replaced with the static RAM (20256 or equivalent) as supplied.

7. The IC25 (or IC26 on LM61 units) should be removed and replaced with the new ROM supplied.

6. Re-fit the panels.

7. Most important. When powering up the **SATELLITE** for the first time after the upgrade, a power up reset should be performed.

If you need any further assistance please contact your local MKS Spectra facility.

Appendix 3.
Auxiliary RF connections

Detector output

R.F. Power Supplies fitted with this modification allow the output signal from the analyser detector to be sampled directly. The raw signal is taken to a switch before reaching the pre-amplifier stage in the electronics. It can then either be switched to the amplifier or to a B.N.C. type connector fitted to the case of the R.F.

This type of R.F. head may be operated in two modes.

Internal operation

With the switch set in the "INT" position and the B.N.C. output shield fitted the system may be operated in a normal manner.

Note if the shield cap is not fitted the analyser will appear to be noisy as the pre-amplifier will be detecting external noise sources.

External output mode.

Set the switch to the "EXT" position. Remove the shield cap from the B.N.C. connector and connect to a suitable charge/current sensitive pre-amplifier device.

Note due to the very high gains used in the R.F. head pre-amplifier assembly it is still possible to see some leakage current being detected by the system.

The signal connected to the BNC will be from the Faraday detector or the secondary multiplier detector depending which is selected by the operating software.

CAUTION

Because the external pre-amp output and the SEM supply are both B.N.C. type connectors. It is possible to connect the SEM supply to the external output from the pre-amplifier. Doing this will cause serious damage to sensitive circuits inside the R.F. Power Supply.

Mass program

R.F. Power Supplies fitted with this modification allow the instrument to operate under the control of an external mass program signal.

This type of R.F. head may be operated in two modes.

Internal operation

With the switch set in the "INT" position and the B.N.C. output shield fitted the system may be operated in a normal manner.

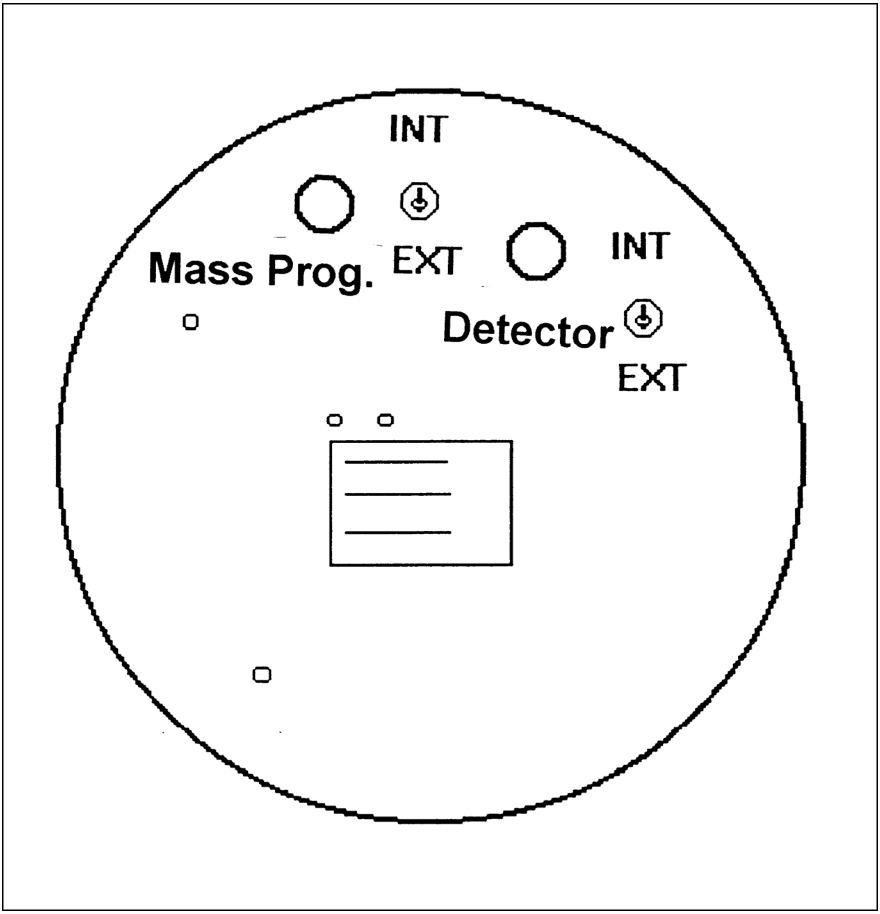
Note if the shield cap is not fitted the instrument will be susceptible to external noise.

External output mode

Set the switch to the "EXT" position. Remove the shield cap from the B.N.C. connector and connect the mass program signal. The mass program voltage should be:
32mV per amu
with 0.0mV corresponding to 0amu and therefore 3.2V corresponding to 100amu.

When using the external mass program feature the RGA instrument should be run in the Leak Check mode.

The figure below shows the approximate positions of the BNC connectors and the switches.


INT
EXT
Mass Prog.
INT
Detector
EXT

Appendix 4.
Health and safety clearance form

1. This form must be used when returning analysers and other equipment for service.

2. A completed copy of this form should be faxed or sent by post to ensure that we have this information before we receive the equipment.

   A further copy should be handed to the carrier with the equipment.

3. Failure to complete the form or comply with the procedure will lead to delays in servicing the equipment.

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RETURNS FORM

1. This form must be completed when returning equipment for service or repair.

2. Please complete the form and fax or send by first class post to the appropriate Spectra facility. Fax numbers and addresses can be found on the inside front page of this manual. Please ensure that we have this information before we receive the equipment. A copy should also be given to the carrier.

FAILURE TO COMPLETE THIS FORM OR COMPLY WITH THE PROCEDURE WILL LEAD TO DELAYS IN SERVICING THE EQUIPMENT

Please Complete The Following

Our RMA number: Customer P.O. No.

Customer Bill To Address:
Company
Department
Address

City
Zip/Postal Code

Customer Return To Address (if different from above):
Company
Department
Address

City
Zip/Postal Code
User's Name: Phone No.:

Equipment Shipped
Item 1: Serial No.:

Item 2: Serial No.:

Item 3: Serial No.:

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Please describe the system fault in detail:

Details of all substances pumped or coming into contact with the returned equipment.
Chemical names:

Precautions to be taken in handling these substances:

Action to be taken in the event of human contact or spillage:

I hereby confirm that the only toxic or hazardous substances that the equipment specified above has been in contact with are named above, that the information given is correct and that the following actions have been taken:
1. The equipment has been securely packaged and labelled.
2. The carrier has been informed of the hazardous nature of the consignment.

Signed: Title:

Date: Phone: