Instruction Manual
Extorr XT Series RGA

Models XT100(M), XT200(M), XT300(M)

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1. Safety Information

Limitation on use of Compression Mounts

WARNING!

Do not use a compression mount (quick-connect) for attaching the Analyzer probe to the vacuum system in applications that may develop positive pressures. Positive pressures may cause the probe to be blown out of a compression fitting and damage equipment and injure personnel.

2. Overview

2.1 General Description

The Extorr XT Series instruments are quadrupole residual gas analyzers which also include an enhanced Pirani gauge as well as a hot cathode ion gauge. The Pirani gauge makes vacuum measurements based on thermal conductivity of the gas environment. The ion gauge uses electron impact ionization of residual gases to measure ion currents related to pressure. The quadrupole gas analyzer uses precision mechanics and electronics to measure ion currents due to the partial pressures of the residual gases in the vacuum chamber. The Pirani starts operation at atmospheric pressure, the ion gauge at a nominal 10^{-2} torr and the quadrupole starts at a nominal 10^{-4} torr pressure. The ion gauge will measure total pressures to its x-ray limit of $2x10^{-9}$ torr and the quadrupole can measure partial pressures well below 10^{-11} torr.

There are three XT models. The XT100 operates from 1 to 100 amu. The XT200 operates from 1 to 200 amu. The XT300 operates from 1 to 300 amu. With the inclusion of an electron multiplier detection option, an M is attached to each of these model numbers i.e. XT100M, XT200M and XT300M.

All of the pressure gauging is done under the control of the communications and control unit (CCU) which is powered by the included 24 volt 2.5 amp supply. The CCU is the interface between what is happening in the vacuum probe and the VacuumPlus Software which runs on your Windows computer.

3. Dimensions and Specifications

3.1. Dimensions

The dimensions of the probe and the CCU box are given below in both metric and American Standard units. The mounting flange is a metal sealed DN 40 CF (2 ¾ Inch CF).

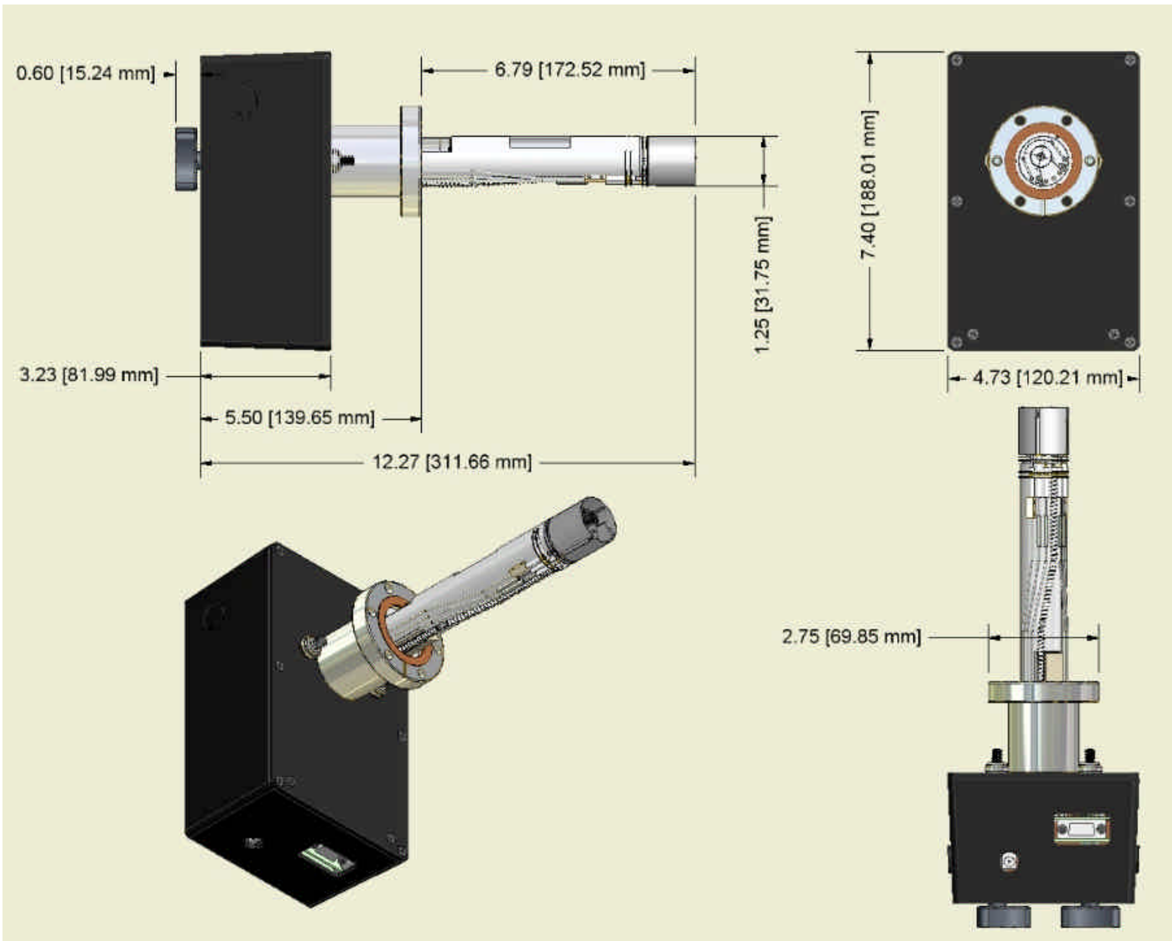


Figure 1: XT dimensions

3.2. Specifications

Mass range	
XT100(M)	1 to 100 amu
XT200(M)	1 to 200 amu
XT300(M)	1 to 300 amu
Mass filter type	Quadrupole
Detector type	Faraday cup (FC), Electron Multiplier (EM) Optional
Resolution	Greater than 0.5 amu @ 10% peak height (per AVS std. 2.3). Adjustable to constant peak width throughout the mass range.
Sensitivity (A/Torr)	$5x10^{-4}$ into Faraday cup. Measured with N2 @ 28 amu with 1 amu full peak width, 10% height, 70 eV electron energy, 6 eV ion energy and 2 mA electron emission current.
Minimum detectable partial pressure	10^{-11} torr. Measured with N2 @ 28 amu with 1 amu full peak width, 10% height, 70 eV electron energy, 6 eV ion energy, and 1 mA electron emission current. Below 10^{-14} torr possible with electron multiplier option.
Operating pressure	Atmosphere to UHV (Recommendations for ion gauge is below 10^{-2}, for the RGA below 10^{-3} torr, for the multiplier below 10^{-6} torr)
Max. operating temp.	40°C
Bakeout temperature	300°C (without CCU)
Total pressure meas.	Available in Pirani, BA and RGA modes
Ionizer	
Design	Open ion source , electron impact ionization.
Dual Filament	Thoria coated Iridium with firmware protection. Built-in 1 to 30 W degas ramp-up. Field replaceable.
Electron energy	11 to 150 V, programmable
Ion energy	3 to 10 V, programmable
Focus voltage	0 to 150 V, programmable
Electron emission current	0.1 to 4 mA, programmable
General	
Materials of Probe Construction	304SS, Kovar, Tungsten, Alumina, Iridium, Copper, Nickel construction
Probe dimension	6.6" from flange face to top of ionizer
CCU Extension	5.5" from flange face
Minimum tube I.D.	1.375"
Probe mounting flange	2.75" CF
CCU dimensions	3.3" x 4.8"x 7.5". Easily separated from the probe for bake-out.
Warm-up time	Mass stability ±0.1 amu after 30 minutes.
Computer interface	RS-232C, 115,200 Baud
Software	Windows® 2000 or XT based application. Requires Pentium or better.
Power requirement	24 VDC @ 2.5 Amps. Standard 120/240 VAC adapter supplied.
Weight	Probe and CCU total 5 lbs.

See Appendix D for options and spare parts. Latest prices and spare parts are on the Extorr web site at www.extorr.com.

4. Installation

4.1. Unpack the XT Shipment

Carefully unpack your XT Unit. The shipment includes these components:

1. quadrupole probe and copper gasket
2. command and control unit
3. mounting bolts
4. RS232 cable (not shown)
5. power supply and power cord
6. VacuumPlus Software on CD
7. plastic screw driver and Allen wrench
8. any spare parts or accessories included with this order

Figure 2: Items Included in XT Package

If your unit does not have all of these items, call Extorr Inc at 724-337-3000. If anything appears to have been damaged in shipment, contact the shipper as well.

The probe is mounted in a transparent, plastic, shipping tube. To remove, Unscrew the two container side screws and, touching only the non-vacuum side of the flange, carefully slip the probe from the plastic tube.

4.2. Factors to Consider before Mounting the Probe

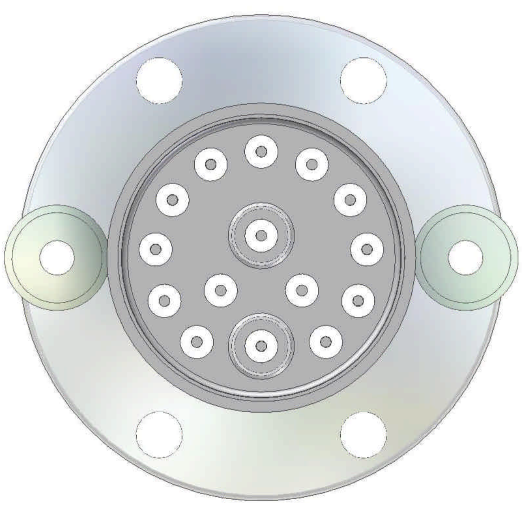


Figure 3. Outside View of Flange

Find a DN 40 CF (2 ¾ inch) flange on your vacuum system. Carefully measure for the 6.75 inch (170.5 mm) clearance required for probe insertion. The port inside dimensions must be greater than 1.375 inches. The port flange must also be a true 90 degrees from the center line of the port tubing. If you require a smaller insertion length or need to convert to a different type of vacuum flange, place the appropriate extension/conversion nipple on the probe at this time. Typically, the CCU hangs in a vertical position with the communications and power connections below the flange position (the orientation as seen in figure 2). Although orientation of the CCU is not a strict requirement for the quadrupole and ion gauge, the Pirani gauge works best in this orientation. You may wish to apply this hanging orientation by rotating the flange so that the shielded pin, which is closest to the outside edge of the flange, is at the bottom. This is shown in figure 3.

4.3. Mount the Probe

Now carefully attach the probe to your system making sure you do not bend or twist the probe as it is inserted into the port. Use the new copper gasket shipped with the unit. Take care in tightening the flange so that the gasket is evenly compressed. The probe is perpendicularly mounted on its flange with great precision but an unevenly compressed gasket could cause improper alignment within a long inlet tube.

As a check on probe integrity after being mounted, use an Ohm meter to check for shorts and filament breakage. Figure 3a shows the feed-through connections on the Extorr flange.

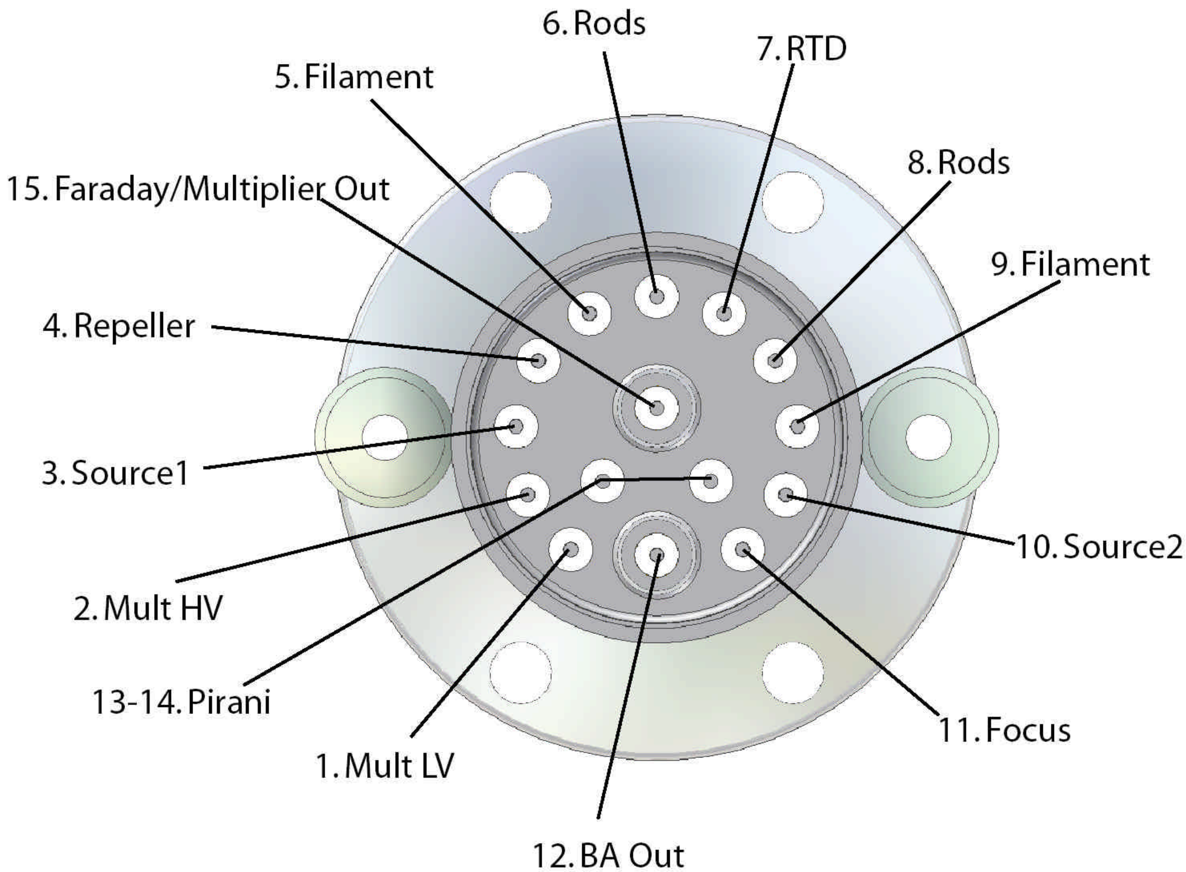


Figure 3a. Flange Pin-outs

Use an Ohm meter to check the probe for shorts by measuring the resistance to ground of all pins. They should all have very high resistance (Mega ohms) to ground except for the RTD (pin7) which should be on the order of 1000 ohms to ground and the daisy chained Pirani Pins (13 & 14) which should be on the order of 5 ohms to ground. The resistance between filament leads should be low, perhaps half an ohm. If this checks out, your probe installation is most likely OK. If not, recheck the port inside diameter and port flange trueness to 90 degrees. The probe requires a port and/or nipple with an inside diameter of at least 1.375 inches. If the filaments are open, this will require a new filament assembly.

4.4. Connect the Command and Control Unit (CCU)

Now attach the CCU to the back of the probe being careful to match up the flange pins to the socket on the CCU. The CCU should slip fairly easily onto the flange unless flange pins have been bent. Improper alignment may cause pins to bend further so do not use excessive force. Hand tighten the CCU mounting bolts and the CCU will be firmly attached to the probe. These hand tightened mounting bolts give electrical, mechanical and thermal stability to the unit.

4.5 Attach the RS232 Cable and Power the Unit

Attach the RS232 cable to the CCU and to any unused COM port of your windows operated computer. A single computer can run multiple CCUs. We require the operating system to be Windows 2000, or XP. The power supply may now be attached to the CCU and plugged into a wall socket. Some computers no longer support the nine pin COM port standard. In these cases, the USB port may be used in conjunction with a USB to Serial adaptor. These adapters are now inexpensive and readily available.

4.6 Install the VacuumPlus Software

Take the VacuumPlus software CD from its case and place it into the computer's CD drive. If multiple systems are being used, it is important to match individual units with CD ROMs. The CCU serial number is written on the CD label. Each electronics unit has its own factory configuration file on its own CD. Read the readme.txt file on the software disk for latest instructions concerning installation. Follow these readme instructions carefully. Run the VacuumPlusInstall.exe to install VacuumPlus. Follow any further instructions given by the installation program. Make note of any messages from the installation program. Most of these messages are benign and may be ignored but they may give a clue if the software does not run on your computer.

4.7 Resonating RF Coil

Each Extorr probe and each Extorr electronics unit (CCU) is unique. When a CCU is moved from one probe to another, the CCU RF coil may be tuned for that particular probe. When an Extorr system is delivered, it is tuned for maximum performance, in the factory test chambers, as a matched set. When placed in a new vacuum system environment, the RF coil may be slightly off resonance. This is usually not a problem, especially for the 100 amu models, but to return to maximum performance, the coil may be tuned for the new environment. This may be done when the system is at atmosphere (the filament must be turned off manually) or at a pressure far below where glow discharge is possible, such as 10^{-4} torr or below. Use the purple plastic screwdriver supplied for tuning. Remove the two plastic plugs from the sides of the CCU. Start the software and go to "Operating Parameters" then "Mode" and select "Calibrate". You will then be presented by a horizontal line on the graph. Using the plastic screw driver, slightly turn the tuning slug in one direction and note if the graph goes up or down. If it goes up, turn in the other direction to make the line go down. After the line has gone down do the same thing with the tuning slug on the other side of the CCU. Go back and forth between slugs until the line is at its lowest position and all other turning just makes the line go up. The system is now RF tuned. Replace the plugs in the box. You must do this when placing a CCU on a new probe. Even if CCU and probe remain as a set, you may wish to repeat this anytime the probe is moved or if the unit is not getting up to the full mass range.

4.8. Start Pump Down

After software installation, you may start the VacuumPlus.exe program. The unit immediately starts making Pirani gauge measurements and knows not to supply power to elements which may be harmed by the power application. You may now start your pump down procedure. If VacuumPlus.exe is running, the output screen shows the Pirani reading near the top of the window, just right of the ion gauge output. The Pirani reading is not displayed until the unit has finished one complete sweep.

When the pressure falls below $3x10^{-2}$ torr, the ion gauge will start to operate and finally, when the pressure falls below $3x10^{-3}$ torr, the quadrupole will begin to operate. The factory default VacuumPlus output screen is a mass sweep between masses 1 and maximum amu. Although pressure readings are made by the system for instrument control, pressure outputs on the screen will not be displayed until the end of the first sweep. And will update after every sweep.

The user may change configurations at any time. A new configuration file may be saved at any time. The last saved configuration becomes the new default configuration. The unit will always come up to the configuration it was last using upon shut-down.

Upon exiting the program the user is prompted to save the current configuration in a file. If the user does not want to save this configuration, he must answer “no” twice.

5. Operation

5.1. General theory of Operation

Vacuum measurement requires that some device, be it mechanical, thermal, or electrical, interact with the gases of the vacuum system to produce a voltage or a current which may be related to pressure. For the Extorr XT systems, the highest pressure measuring device is the Pirani gauge. A thin, gold coated, wire with a precisely regulated current passing through it is located on the flange end of the probe. A precise measurement of the wire's temperature yields a reproducible function of gas pressure. This gauge is calibrated for nitrogen but is roughly the same for air. Other gases, such as pure argon, may cause misleading readouts. These may be corrected using a Pirani conversion chart.

At about 10^{-2} torr, the hot cathode ion gauge starts into operation at a reduced emission level. Dual thoria coated iridium filaments produce electrons which are directed into a well defined volume. Within this volume, ions are produced and collected by a high voltage wire. The magnitude of this current is directly proportional to the pressure of the gas in the volume. Again this device is factory calibrated for nitrogen but the user may change the sensitivity factor for other vacuum gases as is given in Appendix B for ion gauge readings.

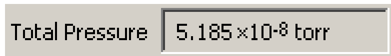
Finally after the ion gauge measures a pressure below 10^{-3} torr, the quadrupole analyzer may be turned on. Now ions are extracted from a second volume. These ions are directed along the axis of a set of four parallel rods, precisely separated and aligned, to produce a nearly perfect hyperbolic field. With just the right combination of radio frequency (RF) potential and direct current (DC) potential, an ion, with just the right mass to charge ratio, will be directed through the rods to a Faraday cup ion collector. All other mass to charge ratios will be rejected long before the ion is collected. By carefully scanning the RF and DC potentials, a mass spectrum, consisting of a number of ion current peaks, may be generated. If the electron multiplier option was chosen, then the ion current may be converted to an amplified electron current. The amplified current will allow mass spectra to be generated at a far greater speed. The multiplier may also increase the ultimate detection sensitivity by a factor of over 1000.

All molecules have their own unique mass spectrum. Those familiar with residual gas analyzers will immediately recognize the mass spectral signatures of those gases frequently encountered. These people will immediately tell you that the cascading intensity of peaks from 18 to 17 to 16 is due to the presence of water. A four to one ratio of peak heights at 28 and 32 indicates that you have an air leak (or the residual air has not yet been pumped down). They would expect peak 44 in even a well sealed stainless chamber. A surprise peak or set of peaks may take longer to identify but commonly available data bases, and the information available on the World Wide Web, make the solutions to many of these puzzles available to non-specialists. Often all that is required is to type "mass XXX peak" into an internet search engine.

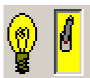
Of course, in residual gas analysis, you must expect that a number of different gases will produce peaks at the same time. The residual gas spectra will be a combination of pure spectra. In fact, the user may see the mass spectrum of a pure compound only when he backfills the chamber with that gas.

5.2 Pirani Readout

After installation, the VacuumPlus Software is started by double clicking on the Extorr icon on the user's Windows desktop. The Pirani gauge is factory calibrated. In the future, when the probe is up to atmosphere, an atmospheric calibration point may be reestablished by pushing the Pirani "1 Atm Recalibrate" button found under the “Calibration Parameter” tab and then pushing the Apply button. The “Zero Recalibrate” button may be pushed when the system is below 10^{-4} torr to reestablish the low calibration point. Again remember to push the Apply button. The Pirani readouts are the first measurements made immediately upon starting to pump down but this value is displayed only after the first sweep. Your factory configuration file includes the factory Pirani calibration parameters.

5.3 Ion Gauge Readout 

The ion gauge readouts start when the pressure is below the Pirani measurement limits (about 10^{-2} torr). Once on, the ion gauge reads continually protecting the system from over pressure. The ion gauge pressure is reported to the host computer for total pressure display update, at the end of each mass scan.

5.4  Filament Activation Switch

The filaments, which produce electrons for both the ion gauge and the quadrupole analyzer ion source, are turned off and on by manually activating the switch icon or automatically, under computer control. If the pressure is too high for ion gauge operation when the switch is turned on, the bulb is displayed as red. If the ion gauge may be used but not the quadrupole, the bulb will be orange. Finally the bulb will become yellow when the quadrupole is operational. When the switch is turned off, the bulb will appear gray. If the configuration file in use has the filament “on” the filament turn-on sequence is automatically activated.

5.5 Reading Mass Peak Heights

Operating voltages are applied to the quadrupole mass analyzer at the proper ion gauge pressure. After the filaments are turned on, the partial pressure readouts are available. The factory default partial pressure operation is an analog scan from mass 1 to the unit’s highest mass. In the default mode, only one scan is stored in an XML file at a time. The streaming XML feature allows for real time data transfer to other programs supporting streaming XML. Depending on the operational mode, a number of different XML data files may be produced. If it is not already obvious to the reader, this device can produce tremendous amounts of data. Care should be taken not to store too much or too little. Only the user can answer what is too much. Single or multiple ion measurements may also be stored in an XML file and/or be streamed into another program. The user sets the time interval between measurements recorded in the Mass Table discussed in section 6.9.

An alternate method of taking ASCII data out of the program is given in section 6.13.

6. VacuumPlus Software

The VacuumPlus Software uses the latest Microsoft Foundation Class techniques to support the most current Windows and Internet functionality. This includes XML data structures and streaming XML. This allows the Extorr system to offer the greatest possible compatibility with modern software programs and the World Wide Web.

The basic VacuumPlus window consists of pressure readouts, a graph, and a file of operational folders which allows the user to setup the Extorr, make measurements, and to customize both look and operation of the system.

6.1 Starting-up

By default the software comes up displaying the Pirani and ion gauge measurements, the filament status, and a graph of either an analog mass spectrum or a trend line of single ion measurements. A push of the graphics button, , on the upper left of the screen will split the screen so that the graph, as well as the

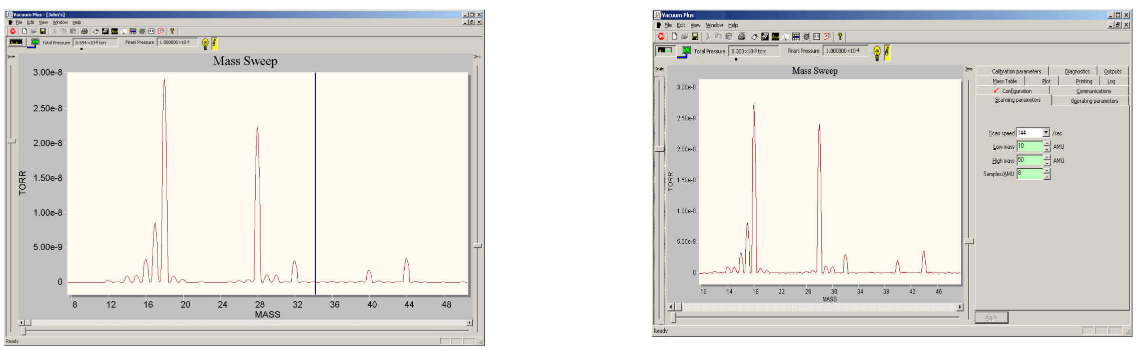


Figure 4. Toggle the Graph Icon (below the stop icon) to go from Pure Graph to Tabs plus Graph

operational file folder tabs, become visible. When in the split mode the graphic button becomes, . The VacuumPlus window and these two sub-windows may be resized to the user's preferences using the usual pull the mouse on the edge of the window technique.

6.2 GUI

The Graphical User Interface (GUI) is shown below. Note the Tool Bars, the pressure readouts, the graphics mode switch, the graph scale slider and zero slider, and the operational folder tabs. The user should take some time moving the mouse from icon to icon to activate pop up labels of their functions

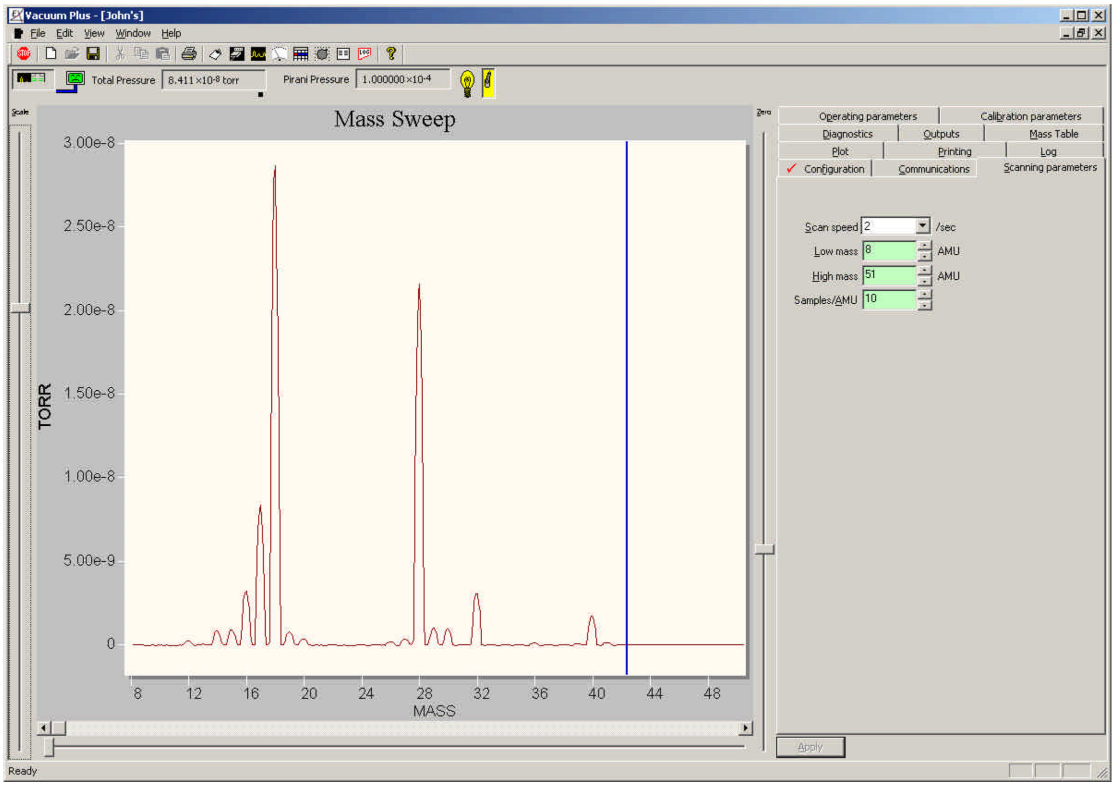


Figure 5. The Graphical User Interface (GUI)

6.3. Operational Settings

Although the system comes up in a default mode, the user has complete control over the configuration of his system. The factory default configuration file, found on the CD, is designated as “snXXXX_factory_cal.cfg”. The XXXX is the four (or three) digit serial number of the CCU. This is a factory configuration which is unique to the unit with which it was shipped and it should only be used with that unit. It is a good idea to give this file another name with the same .cfg extension and save it on the computer hard drive. Even if the factory file is corrupted, it may be recopied to your system from the VacuumPlus installation disk. As seen above, the GUI uses a file tab organization to allow the user to create, edit, and store configurations. The configuration files have an extension .cfg and are in the XML file format. These may then be called up as desired.

The operational file folders tabs give the user control of his system settings. These tabs are shown below.

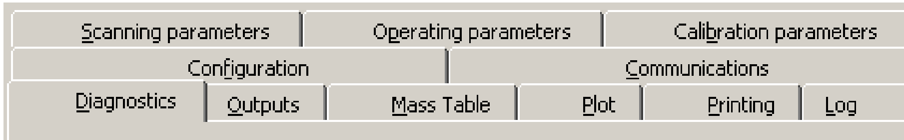


Figure 6. Folder Tabs for operation

As the user changes his system settings, a red check mark appears on the folder tab. These changes only take place after the "Apply" button at the bottom of the folders is clicked. When clicked, the new settings are applied and the red check is cleared.

We will now discuss the contents of each folder tab.

6.4. Communications Tab

If the user has already placed the system on his computer and previously run and saved his configuration, the system will come up in this last saved configuration. If this is the first time the system is run, go to the communications folder and choose the com port to which the Extorr is connected. For ease of selection, all com ports, real and virtual, will be shown in a drop down list. In the same way the baud rate may be selected. The user may also give a data port name for use when taking streaming XML data to an application. To invoke the parameters chosen and to remove the red check mark on the folder, click the Apply button.

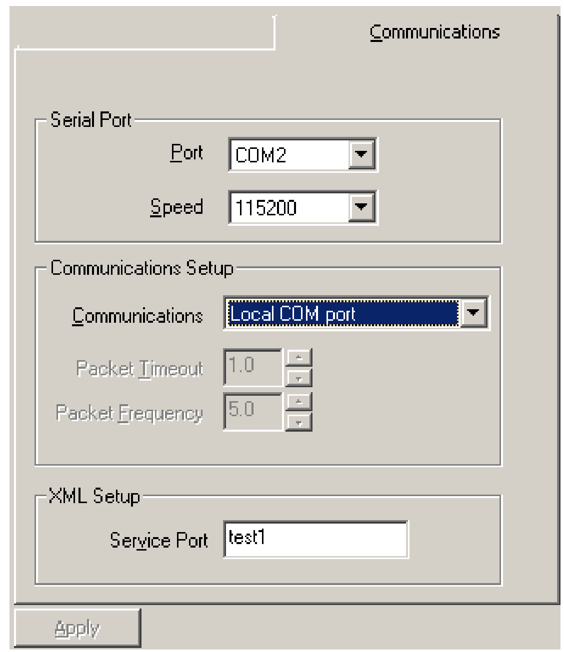


Figure 7. The Communications Tab

A serial server and the appropriate software will allow the system to operate on a Local Area Network (LAN) or a Wide Area Network (WAN).

6.5. Configuration Tab

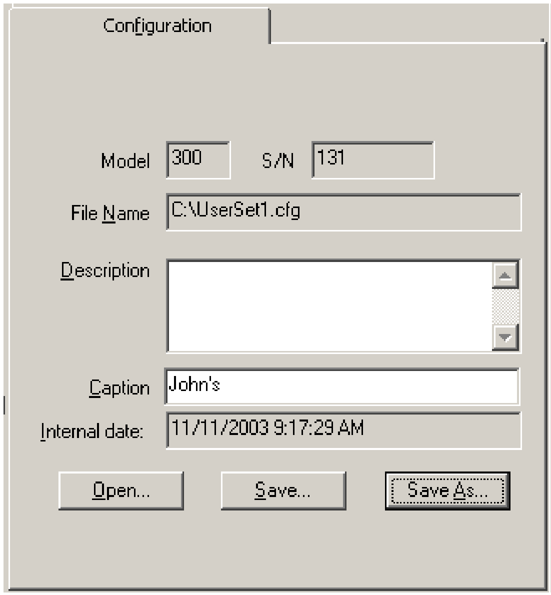


Figure 8. The Configuration Tab

"Configuration" is the folder which allows the user to reestablish the factory settings or to store his own operational settings. The contents of all the .cfg folders are stored in an XML file format. "Save" will call up a dialog box which will allow the user to name this configuration file as desired. The last saved settings will remain in effect by becoming the default settings for the next startup. If, at some later date, the settings are changed again, this previous setting may be called up using the configuration file name under which it was saved.

Note that this folder also gives the option to describe and caption this configuration. This description and caption may then become a label for printouts and data files. Also note that a Model Number, serial Number and date of creation also follows this file.

The .cfg file may be read using any text reader or an internet browser. Changes in the configuration file could be made directly into the text file but the user must do this with caution.

6.6. Scanning Parameters Tab

The most fundamental quadrupole RGA output is the analog mass scan. The graph generated is directly proportional to the ion current generated at each mass to charge ratio. This graph will have mass on the horizontal axis and pressure or ion current on the vertical axis. Under "Scanning Parameters", the High Mass, Low Mass, Samples per amu and scan speed may be set. Numbers may be typed into the appropriate boxes or the up down arrows may be used to change the values. The low mass must be less than the high mass and the low mass may not be set below 1 and the high mass not above the mass range of the system being used. An allowed value will display a green background. A value which is not allowed results in a red background. The Low Mass will start a scan roughly half an amu below the set mass and the High Mass will stop scanning roughly half an amu above that set mass.

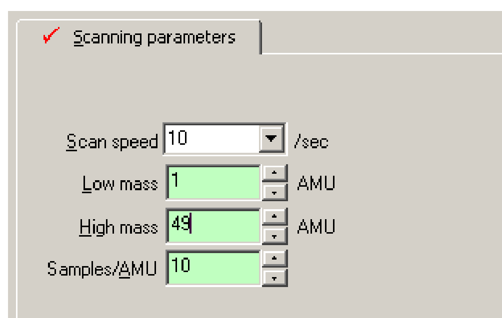


Figure 9. Scanning Parameters Tab

The scan speed is the number of samples measured per second. The user must choose from the values from the drop down menu. The number of samples/amu is the number of evenly spaced samples taken within a one amu mass range. For example, a scan speed of 10/sec and a samples/amu setting of 10 would produce a scan rate of 1 amu/sec.

Click "Apply" and the changes made will take effect. The red check will disappear. The user may wish to save these settings in a new configuration file.

The factory setting has the system scanning rapidly from mass one to the maximum mass for the unit (100, 200 or 300 amu). If the user is looking at the residual gases during pump down, he may wish to concentrate on only the first 50 amu. Do this by setting the low mass to 1 and the high mass to 50.

Since there is always a speed and "signal to noise" tradeoff, the user may wish to reduce the noise by decreasing the Scan speed value.

6.7. Operating Parameters Tab

Under this tab the mode of operation may be changed as well as the Focus Voltage, Electron Energy, the Filament Emission, and the units in which the Pressure is expressed.

The optional electron multiplier is also controlled under this tab.

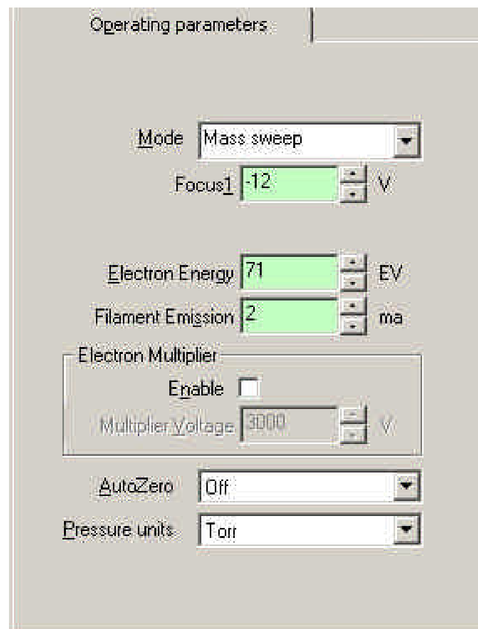


Figure 10. Operating Parameters

6.7.1. Mode

Currently the VacuumPlus Software supports three modes.

These are Mass Sweep, Trend, and Calibration. All may be selected from the drop down menu in the Mode box, as shown below.

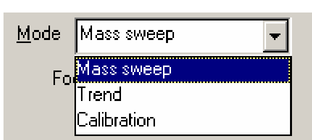


Figure 11. Mode Drop-down Menu

Mass Sweep calls the analog scan, as was discussed in the above section 6.6. Trend is the graphical output of those mass intensities (partial pressures) placed into and activated in the mass table. When Mass Table or Trend is selected, a graph is generated which shows the peak heights, due to the ions selected in the table as a function of time. Each trace is uses the color selected in the Mass Table. The scale and zero functions are the same as for the analog graph. This mode is further described in the section on Mass Table, 6.9.

Calibration is used for RF tune as was described in the RF tune section, 4.7.

6.7.2 Focus

Focus controls the potential which draws the ions out of the ion source grid. It is factory set to give a standard response to a calibration compound at the factory. This may be set to suit the user's tastes especially as the probe ages but is recommended not to deviate too far from the factory setting.

6.7.3 Electron Energy and Emission current

The “electron energy” is the potential placed between the filament and the ion source grid. It is factory set to 70 eV, which is the industry standard for residual gas library spectra. Emission current is the electron current leaving the filament and directed through the source grid. It is set at the factory for high sensitivity when operating with a 70 eV electron energy. The emission current may be set between 0.1 ma and 4 ma. The electron energy may be user set between 11 and 150 volts. However, not all combinations of emission current and electron energy may be set at once. At lower voltages, higher emission currents are not available and the software prompts the user when such a combination will not work. It should be noted that the “Electron Energy” is just the potential difference placed between filament and source grid. The true electron kinetic energy must be corrected for the contact potential difference between the thoria coated filament and the platinum coated source grid. This contact potential difference may place the electron kinetic energy as low as 3.7 eV below the “Electron Energy”. There must also be a correction for the voltage drop across the filament.

6.7.4 Electron Multiplier

If the XT model number ends in an “M”, The unit was shipped with the electron multiplier option. This option may be implemented by checking the multiplier Enable box under the “Operating parameters” tab. The multiplier will then turn on if the pressure is sufficiently low. The multiplier voltage may also be set here. The gain of the multiplier depends on the voltage placed on the multiplier. The gain is determined by measuring the height of a relatively small peak, first when the multiplier is turned off, and then when the multiplier is turned on. The gain is given by dividing the peak height measured using the multiplier by the peak height as measured using the Faraday cup. A gain of 1000 is usually all that is required for most RGA applications. As a general rule, to increase the lifetime of the multiplier, use the lowest multiplier voltage which gives the gain desired.

6.7.5 AutoZero

When invoked, AutoZero makes a baseline measurement during a time when the quadrupole does not allow ions to pass through its length. This measurement is then subtracted from true ion measurements thereby eliminating baseline offsets. Since extremely low current measurements can suffer from baseline drift due to thermal or other environmental factors, this function is used to reduce the effect as much as possible. The drop-down menu for AutoZero is

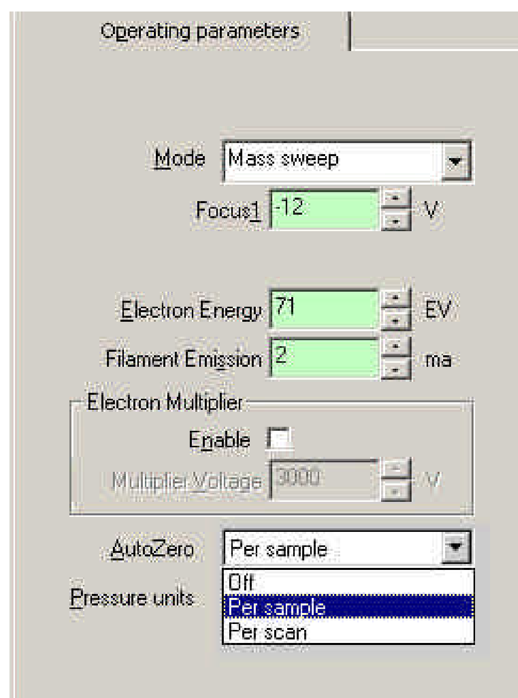


Figure 11A. AutoZero Drop-down Menu

shown in figure 11a. The user may choose to turn AutoZero off, invoke it before each sample measurement, or invoke it only once per scan.

AutoZero is important only when attempting to measure very small peaks. The price paid, in the case of using “per sample”, is a doubling of acquisition time.

6.7.6 Pressure Units

The system may display pressures and partial pressures using a number of different units. The units chosen may be selected from this drop down menu.

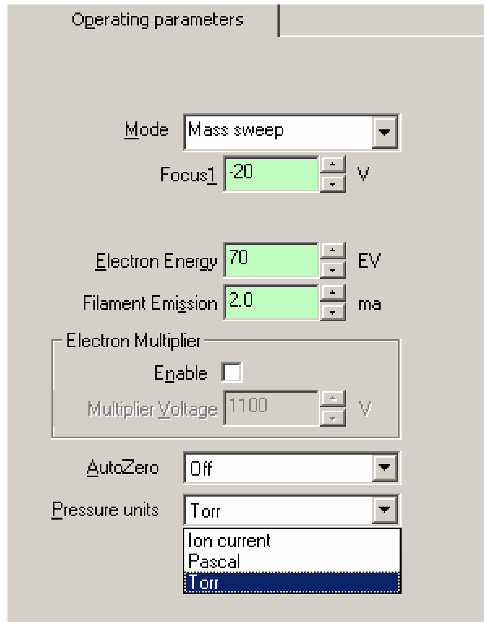


Figure 11B. Pressure Units drop down menu

6.8 Calibration Parameters Tab

The Extorr system comes with a factory tuning which can always be reestablished by loading the factory configuration file. None of the tuning parameters should be changed greatly from the factory settings. The system worked best with the factory set parameters but these may require slight changes over time.

There are, however, times when a special tune may be helpful. An example of this may be when a very weak signal requires less than unit resolution or a fractional mass must be resolved from a peak next to it.
The calibration parameters allow for the changing of system resolution and sensitivity. This is also the place where the Pirani gauge may be calibrated and the ion gauge can convert ion current to pressure.

6.8.1 Low Cal and High Cal

Because of the linearity and stability of the Extorr system, the resolution and sensitivity requires calibration at only two points within the mass range. These are the Low Cal and High Cal points along the mass axis. We designate their location by placing values in the Low Cal Mass and the High Cal Mass. All mass positions are linearly placed between these two points or extrapolated beyond these points. The Low Cal Position allows for an offset so that a known low mass peak may be placed in the correct mass scale position. Similarly, the high Cal Position can be used to place a known mass peak at its correct position. The mass scale will then be calibrated. Again, to actually make the changes, the “Apply” button must be pushed.

Residual gas analyzers are usually run with “unit resolution”. This means that, throughout the system’s mass range, the peaks are set so that the valley between two equal height adjacent peaks is about 10 % of the peak heights. Setting a low cal resolution, at the low mass position and a high cal resolution at the high mass position allows the user to adjust for this “unit resolution”. The user may explore the resolution function by changing the values and observing the width and sensitivity of the resulting peaks. Remember to “Apply” changes. The user may choose to save the resulting configuration, or not, but he can always return to any other saved configuration by reopening it.

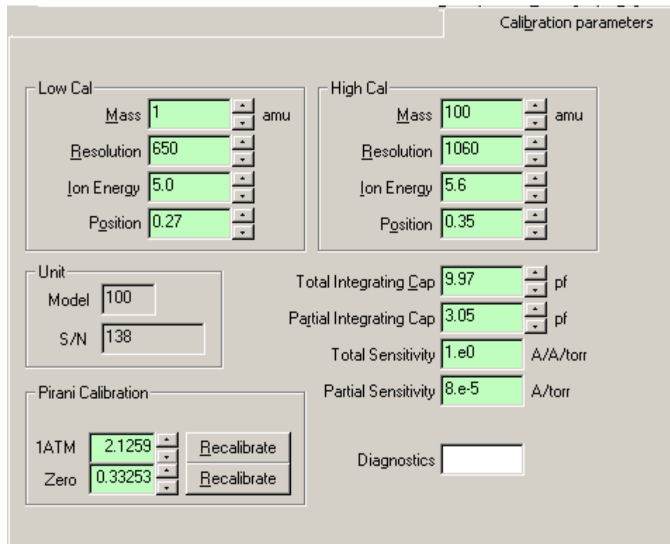


Figure 12. Calibration Parameters Tab

The intensity of the peaks may be changed by changing the ion energy. Greater sensitivity may be gained by increasing the ion energy. Unfortunately, the quality of the peak shapes tend to suffer when the ion energy becomes too high. Again, the ion energy is interpolated between and extrapolated beyond the two mass cal points.

A description of this tuning procedure is given in Appendix C of the manual.

6.8.2 Unit Information

The information under Unit is the model and serial number of the user’s CCU. These are useful when using multiple CCUs or when model or serial number specific information is requested.

6.8.3 Pirani Calibration

The Pirani probe, located in the base of the Extorr probe, is factory calibrated. After a period of use, the user may perform a two point calibration. The first is done by pushing the “1ATM Recalibrate” when the unit is at atmospheric pressure. The other is done by pushing the “Zero Recalibrate” and then when the probe is at a pressure below 10^{-3} torr. Remember to press Apply after each of these recalibrations.

6.8.4 Total and Partial Integrating Caps

The total and partial integrating capacitor values for the ultra-sensitive electrometer are set at the factory for optimum performance and should not be changed without consulting with the factory.

6.8.5 Total and Partial Sensitivity

The total and partial pressure sensitivities are factory set and should only be reset if trusted secondary pressure standards are presented to the probe. In general the sum of the partial pressure peaks should roughly equal the total pressure. When adjusting these calibration numbers remember that total pressure is only displayed at the end of a scan. It is therefore important to setup for a scan which completes about once per second.

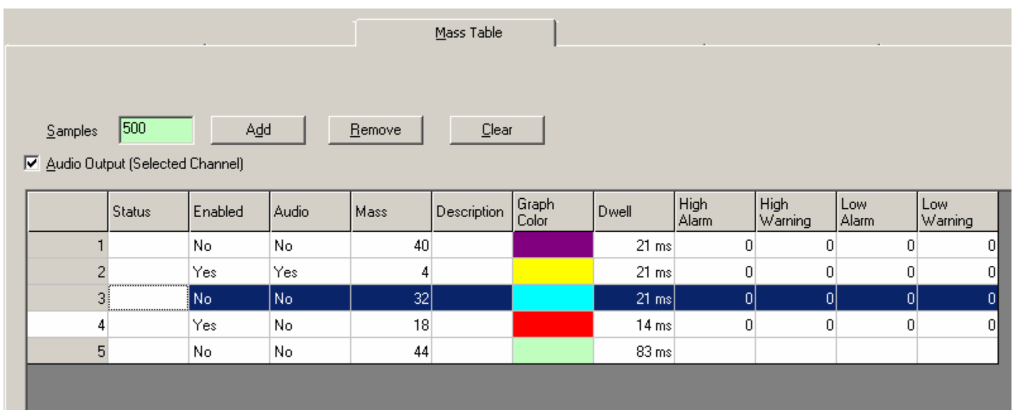
6.8.6 Diagnostics

The Diagnostics box allows the user to place a password to unlock the information contained in the Diagnostics Tab. See 6.14.

6.9 Mass Table Tab

The system may also be setup in a single or multiple ion monitoring mode for use in leak detection or process monitoring. This is done by placing ion information into the Mass Table folder tab.

Just fill in the mass to charge ratio of the ion to be monitored in the mass column. A description may be used such as "Hydrogen" for mass 2. A graph color for each mass may be selected from a drop down menu invoked by double clicking the left mouse button on the cell. Dwell times may be set with the drop down menu from each cell in the dwell column. The actual time taken for a measurement at one mass is five times

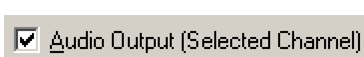


	Status	Enabled	Audio	Mass	Description	Graph Color	Dwell	High Alarm	High Warning	Low Alarm	Low Warning
1		No	No	40			21 ms	0	0	0	0
2		Yes	Yes	4			21 ms	0	0	0	0
3		No	No	32			21 ms	0	0	0	0
4		Yes	No	18			14 ms	0	0	0	0
5		No	No	44			83 ms				

Figure 13. The Mass Table

this dwell time. Five measurements are taken across the peak and the largest measurement is the one reported. All of these settings may be saved in a .cfg file as described in section 6.5.

Again, the "Apply" button must be pushed before these settings will take effect. The table may be edited and saved in a configuration file at any time. Actual operation requires the operational mode to be set to Trend. This mode selection is explained in section 6.7.1.

6.9.1 

Mass Table Setup for Leak Detection

When in the Trend mode, audio leak detection may be setup by choosing a leak detect gas from those mass peaks placed in the mass table. This is done, in the mass table, by checking Audio box of the selected mass in the table. Helium at mass 4 is usually the gas chosen. However, any other leak detection gases may be used. An audio output will be heard if the user's computer supports sound. If no audio is heard, first check to see that the system is in the trend mode and the audio box is checked. Use the sensitivity and offset gliders, located to the sides of the graph, along with the dwell time to get a smooth baseline tone. When the trace is near the bottom of the trend graph the sound has a low frequency. As the signal increases the sound frequency increases. A leak will be indicated by a rapid increase in frequency as the leak detect gas is applied to the location of the leak. Since the sound is tied to the intensity level on the screen, it is best to be in the linear plot mode. If a multiplier unit is being used and the pressure is below 10^{-6} torr, a leak is best detected with the multiplier option turned on.

6.10. Outputs Tab

The outputs tab gives information on system operation. They are updated at the end of every scan. The user will find this information very useful, especially if trouble shooting is required. The factory support personnel will ask for the values on this page when trouble shooting. The top parameters reported here are "Degas current", "Electronics Temperature" within the electronics box (CCU), the voltage placed on the electronics by the power supply, the voltage placed across the filaments, the resistance of the filaments, and the temperature at the base of the probe. The degas current is also the total emission current from the filaments when the system is not in the degas mode. The total current through the filaments is given by the voltage across the filaments divided by the resistance.

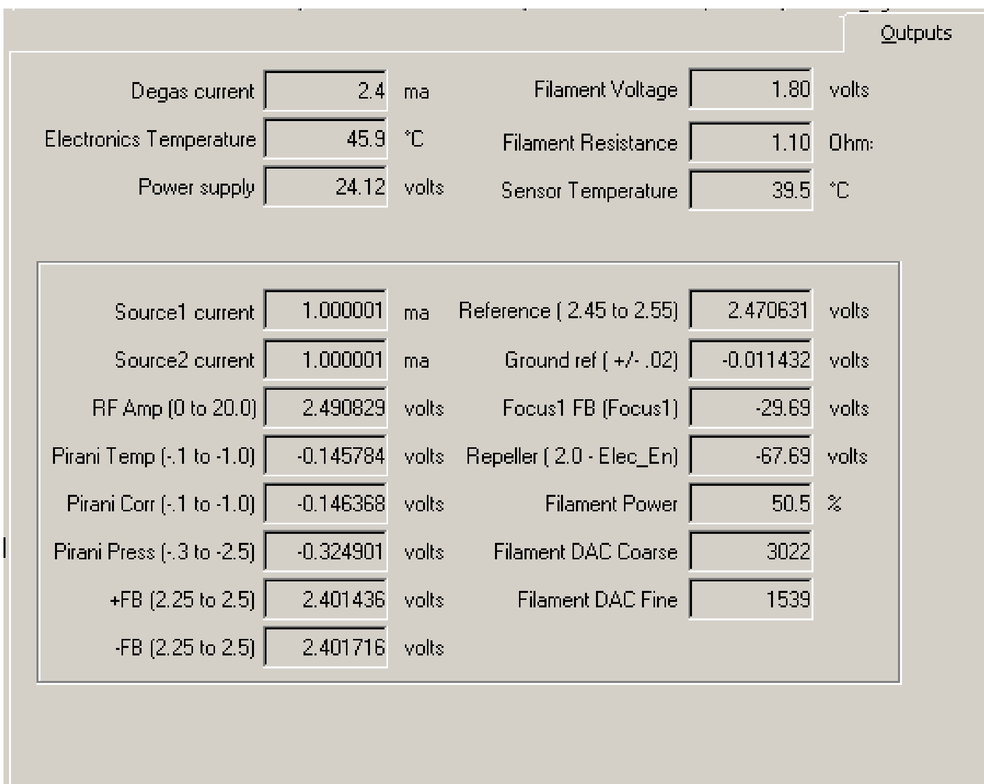


Figure 14. The Outputs Tab

Below these readings are further operational readings labeled with the acceptable ranges for these readings. "Source 1 current" is electron current to the source grid. "Source 2 current" is electron current to the B/A section of the ionizer. "RF Amp" is from the RF section of the electronics and is roughly proportional to the high mass value in sweep. The “Pirani Corr” and “Pirani Temp” are proportional to the Pirani wire temperature and, when added should be roughly equal to Pirani Press. “+FB” and “–FB” are proportional to the DC voltages on the rods. Reference and Ground ref are voltage references which test the operation of the analog to digital converter and should be within the ranges given. The “Focus 1” reading should be about equal to the value entered into the focus box under the Operating parameters tab. The “Repeller” reading should be about equal to the value entered into the Electron Energy box under the Operating parameters tab, less 2 volts. If these readings are not as described, a short circuit may be present in the probe. “Filament Power” indicates how much of the available filament power is currently used. “Filament DAC” Coarse and Fine give information about the regulation of the filament.

6.11. Plot Tab

The Plot tab allows the user to change the graph output. A linear intensity (pressure) output is the default graph but a logarithmic output is available by checking the logarithmic Y axis box. The color of the graph window may also be changed here. Drop down menus give a choice of background color, plot color for the analog mass sweep, and the scan position line.

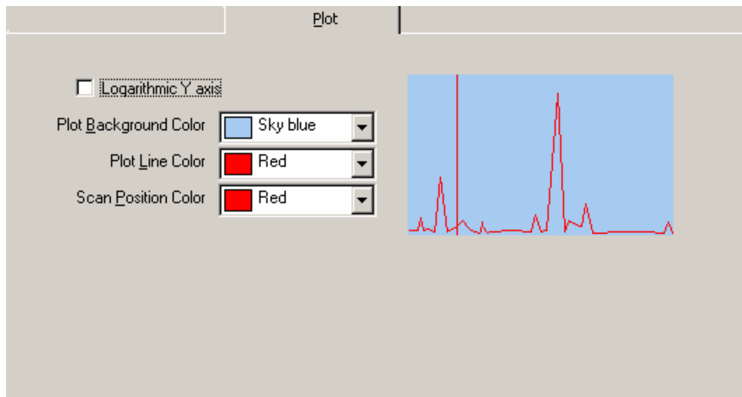


Figure 15. The Plot Tab

6.12. Print Tab

The Printing tab allows for the selection of what will be printed when Print under File is invoked. Instead of printing light on dark, the print output may invert the colors to give dark on light. The configuration file name and a description given in the configuration file may be added. The Pirani and Ion gauge readings may also be included.

Figure 16. The Printing Tab

6.13  Log Tab

A log of CCU to computer communications is shown in this tab. Here you can follow the communications between the VacuumPlus software and the Microprocessors in the CCU. This information may come in handy for trouble shooting. It will clearly tell you when there is no communication in the case of an incorrect port setting, power failure, or cable being unplugged. The user may also use a number of features which are displayed when the “Options” button is pressed. The options pop-up box allows for a scan restart, as well as setting a number of parameters. A more extensive graphics look and functionality, which supports zoom functions and fancy looking skins, is also available here.

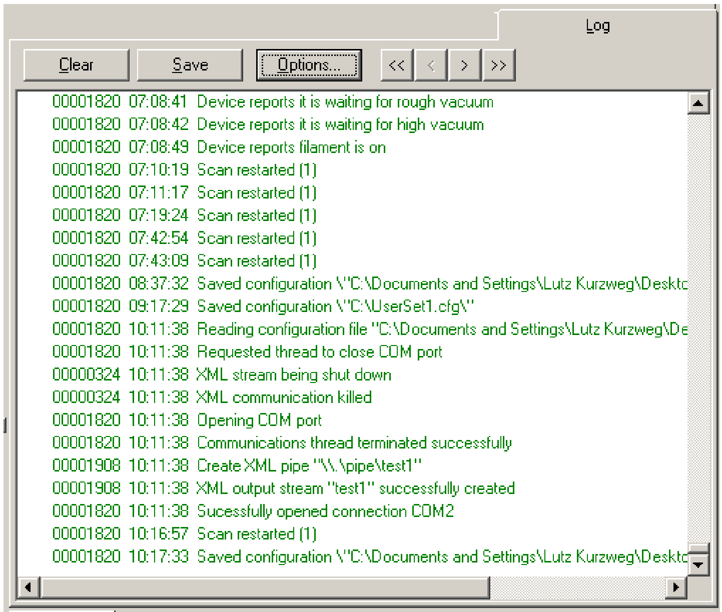


Figure 17. The Log

To apply the advanced graphics functions mark the check box under Log>Options. Once this box is checked, a whole new world of plotting outputs becomes available. For instance, grid lines, graph labels, graphics colors and options are available. Figure 17a shows some of these features. These options may now be applied by right clicking the mouse over the graph. Left double clicking the graph will bring up the mass sweep customization dialog directly.

Data output options including text and graphics formats may also be accessed with a right click on the graph. This may be the preferred method of taking data out of the vacuum plus software for some users.

With a change in mode many of the graphics changes revert to a default but it is still well worth exploring the options found by right clicking over the graph.

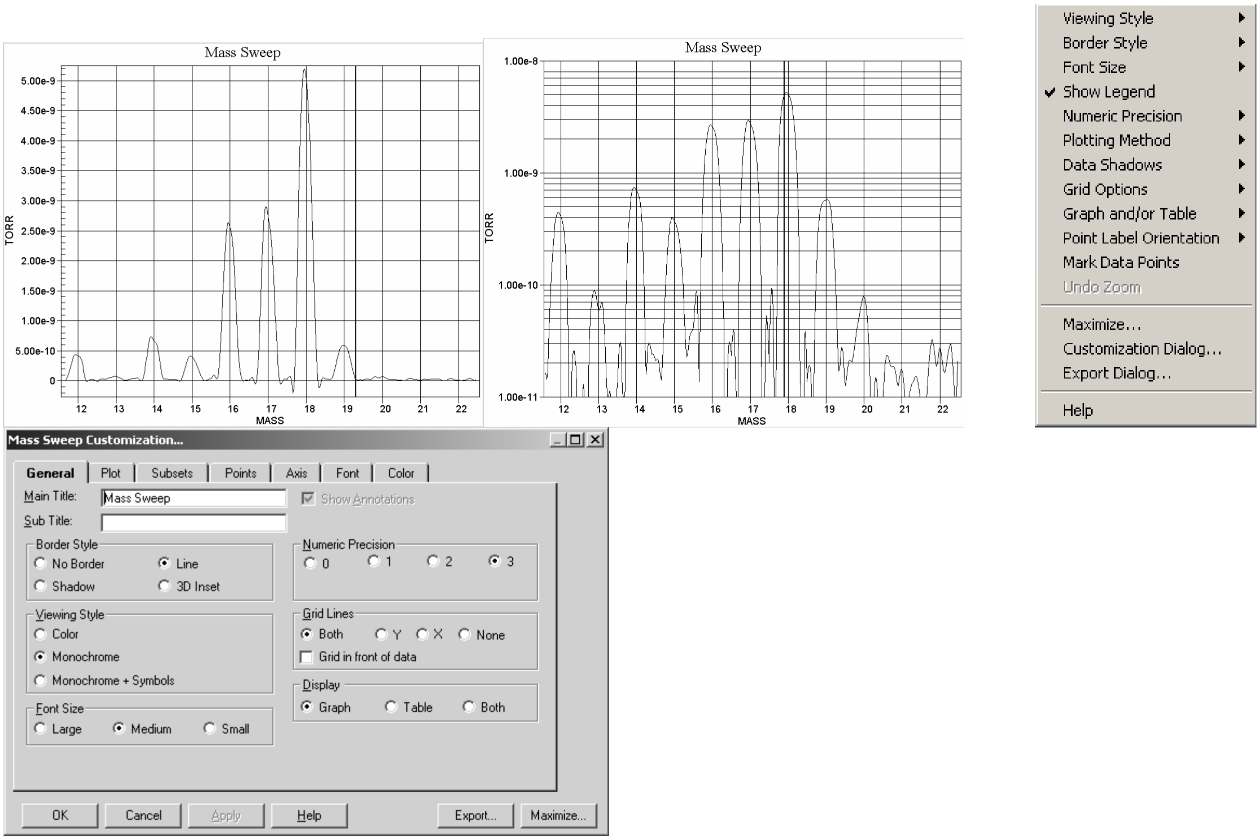
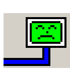


Figure 17A. Customized Graphs and the Customization Dialog Box

6.14. Diagnostics

Diagnostics is a locked function which may be used by the factory for trouble shooting as required. For the curious, this may be unlocked by placing “extorr” into the password in the Calibration Parameters Diagnostics field.

6.15.  XML Use

XML stands for eXtensible Markup Language. Like the famous HTML of internet fame, XML is a subset of SGML. In particular, XML is the text markup language for interchange of structured data. XML has as its goal to enable generic SGML to be served, received, and processed on the Web in the way that is now possible with HTML. XML has been designed for ease of implementation and for interoperability with both SGML and HTML. XML is a trademark of the World Wide Web Consortium.

VacuumPlus produces XML files on command as well as supporting streaming XML data to an XML port of the user’s choosing. XML data files may be saved from the Save XML and Save XML as selections from the File drop down menu.

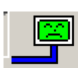
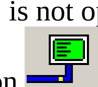
Configurations may be saved, edited in a text file (XML format), renamed and opened at a later time. A representative XML file as read in a browser is given below.


```
<?xml version="1.0" encoding="us-ascii" ?>
- <ConfigurationData>
<CommunicationParameters Port="COM2" Baud="115200" PacketFrequency="5.0" PacketTimeout="1.0"
    CommunicationsType="1" UserFrequency="5.0" UserTimeout="1.0" NamedPort="VacuumPlus" />
<ConfigurationParameters Filename="C:\Documents and Settings\Jack \Desktop\sn132_factory_cal.cfg"
    TimeStamp="07d3000b000300130011002100260203" DateTime="11/19/2003 5:33:38 PM" Caption="" Serial="0"
    Model="0" />
<ScanParameters ScanSpeed="20" LowMass="14" HighMass="19" SamplesPerAMU="8" />
<OperatingParameters Mode="Mass sweep" Focus1="-35" Focus2="-20" ElectronEnergy="68" FilamentEmission="3.0"
    AutoZero="Off" ScanMode="Sweep" Filament="1" PressureUnits="Torr" />
<CalibrationParameters LowCalMass="1" LowCalResolution="672" LowCalPosition="0.21" LowCalIonEnergy="4.2"
    HighCalMass="300" HighCalResolution="1895" HighCalPosition="0.50" HighCalIonEnergy="5.3"
    TotalAmpOffset="0" PartialAmpOffset="0" TotalIntegratingCap="9.97" PartialIntegratingCap="3.05"
    RFSettleTime="50" SWSettleTime="10" Pirani1ATM="2.25670" PiraniZero="0.31365" PiraniAutoRecalibrate="0"
    PartialSensitivity="8.00e-004" TotalSensitivity="1.00e+000" debug="0" />
- <MassTableParameters Samples="100">
<Mass1 Enabled="1" Mass="2" Description="" Color="Black" Dwell="3.5 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass2 Enabled="1" Mass="18" Description="" Color="Navy" Dwell="50 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass3 Enabled="1" Mass="28" Description="" Color="Dk. Gray" Dwell="50 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass4 Enabled="1" Mass="32" Description="" Color="Red" Dwell="100 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass5 Enabled="1" Mass="149" Description="" Color="Fuschia" Dwell="200 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass6 Enabled="1" Mass="69" Description="" Color="Green" Dwell="100 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass7 Enabled="1" Mass="38" Description="" Color="Silver" Dwell="3.5 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass8 Enabled="1" Mass="40" Description="" Color="Pink" Dwell="42 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
<Mass9 Enabled="1" Mass="44" Description="" Color="White" Dwell="21 ms" HighWarning="0" HighAlarm="0"
    LowWarning="0" LowAlarm="0" />
  </MassTableParameters>
<PrintingParameters InvertColors="0" ShowConfigurationFile="1" ShowDescription="1" ShowTotalPressure="1"
    ShowPiraniPressure="1" />
- <GraphParameters>
<Y-Axis FullScale="9.81748e-008" Span="1.05925" />
  </GraphParameters>
- <WindowParameters>
<Frame flags="2" showCmd="3" ptMinPosition.x="0" ptMinPosition.y="726" ptMaxPosition.x="-4" ptMaxPosition.y="-23"
    rcNormalPosition.left="0" rcNormalPosition.top="0" rcNormalPosition.right="667" rcNormalPosition.bottom="438" />
<Setup flags="0" showCmd="1" ptMinPosition.x="-1" ptMinPosition.y="-1" ptMaxPosition.x="-1" ptMaxPosition.y="-1"
    rcNormalPosition.left="958" rcNormalPosition.top="50" rcNormalPosition.right="1349"
    rcNormalPosition.bottom="723" />
  </WindowParameters>
<PlotParameters BkColor="Lt Green" LineColor="Red" ScanColor="Md Blue" MouseWheel="0" />
  </ConfigurationData>
```


A representative data file for a sweep from 13.5 amu to 19.5 amu is given below.


```
<?xml version="1.0" encoding="us-ascii" ?>
- <Data LowMass="14" HighMass="19" SamplesPerAMU="8" Units="Torr" Sample="0">
<Sample Value="-4.80521e-012" />
<Sample Value="4.90272e-012" />
<Sample Value="3.49013e-011" />
<Sample Value="2.13785e-010" />
<Sample Value="2.38185e-010" />
<Sample Value="1.70573e-010" />
<Sample Value="1.16129e-011" />
<Sample Value="1.44788e-012" />
<Sample Value="1.04575e-012" />
<Sample Value="-3.8262e-013" />
```

<Sample Value="1.86295e-011" />
<Sample Value="2.13322e-010" />
<Sample Value="2.52524e-010" />
<Sample Value="1.75088e-010" />
<Sample Value="2.61942e-011" />
<Sample Value="1.25229e-012" />
<Sample Value="-2.86834e-012" />
<Sample Value="2.62114e-012" />
<Sample Value="1.64358e-010" />
<Sample Value="1.00085e-009" />
<Sample Value="1.17773e-009" />
<Sample Value="8.14476e-010" />
<Sample Value="1.09915e-010" />
<Sample Value="7.56115e-012" />
<Sample Value="1.92803e-012" />
<Sample Value="3.37541e-012" />
<Sample Value="5.62092e-010" />
<Sample Value="2.50811e-009" />
<Sample Value="2.8665e-009" />
<Sample Value="1.99793e-009" />
<Sample Value="1.79753e-010" />
<Sample Value="1.34216e-012" />
<Sample Value="1.11096e-011" />
<Sample Value="2.38959e-011" />
<Sample Value="1.86811e-009" />
<Sample Value="7.15505e-009" />
<Sample Value="8.63439e-009" />
<Sample Value="6.02352e-009" />
<Sample Value="4.11353e-010" />
<Sample Value="8.15777e-013" />
<Sample Value="2.86842e-012" />
<Sample Value="-1.2607e-013" />
<Sample Value="5.3608e-011" />
<Sample Value="2.04398e-010" />
<Sample Value="2.53127e-010" />
<Sample Value="1.79202e-010" />
<Sample Value="2.55128e-011" />
<Sample Value="5.37074e-012" />
</Data>

The Icon  indicates that a data pipe for streaming XML is not open. When the pipe is open and data is flowing from the program, this icon changes to a dynamic icon .

6.16. Use with Multiple XT Systems

The VacuumPlus software allows for the multiplexing of all XT systems run by the host computer. Each unit must be run from an independent com port but as many units, as com ports available, may be run by a single host computer. All that is required is to open a second, third, etc. file using the “File” drop-down menu. For each case designate the port and .cfg file for the unit on that port. The VacuumPlus window can then display embedded windows for each system being run. The various display modes may be selected from those found in “Window” on the menu bar.

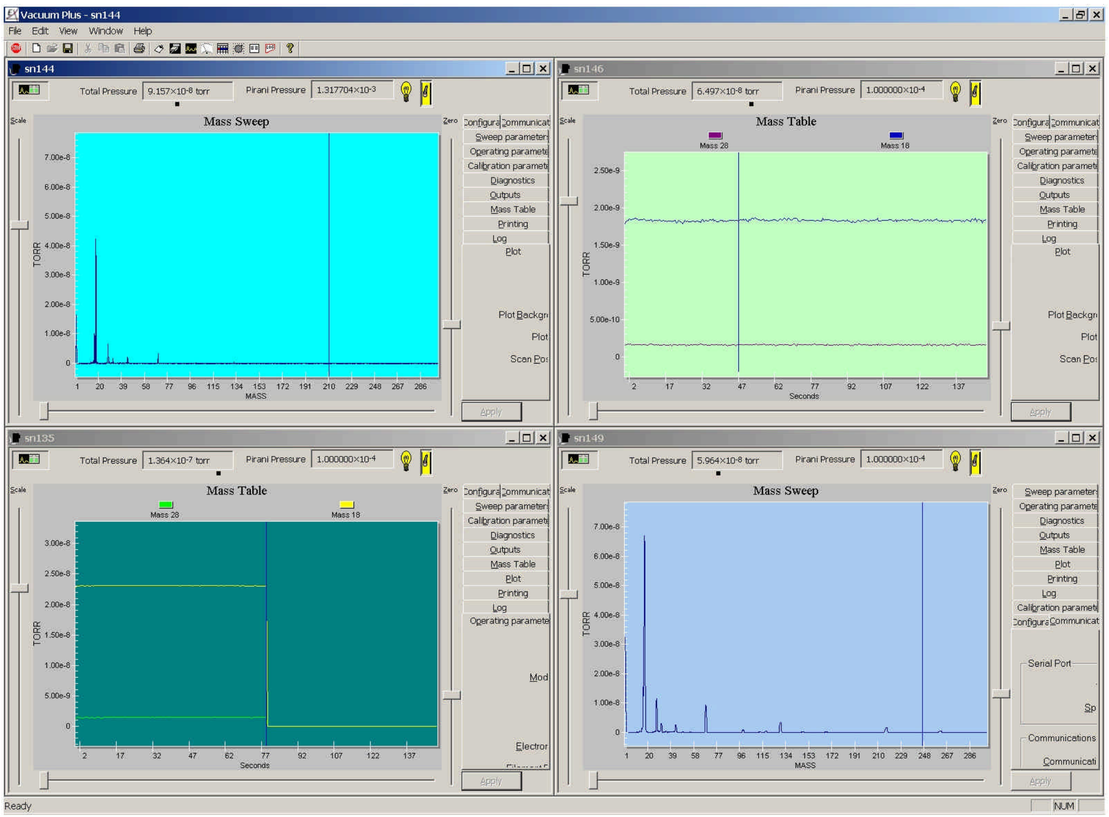
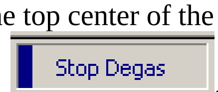


Figure 18. Multiple Units Operated from a Single Computer

6.17.  The Degas Mode

Degas increases the electron energy to nearly 400 volts, the electron emission to nearly 50 ma, and the ion energy to 200 volts. The purpose of degas is to clean the unit. If the unit loses sensitivity due to contamination, a degas of a few minutes duration, often will restore the sensitivity.

To start degas, click on the “Start Degas” button shown above and located to the right of the filament switch at the top center of the graphics interface. After a descriptive message is displayed and agreed to, a Time-out bar, , will be displayed. The user may choose to stop the degas process at any time by clicking on the button again. If not clicked, the bar will continue across the button until it is automatically turned off after ten minutes.

7. Maintenance

7.1 Servicing the RGA probe

7.1.1. Ionizer /Dual Filament Replacement

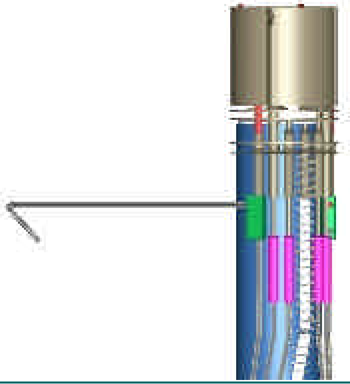
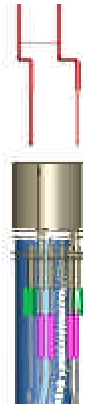
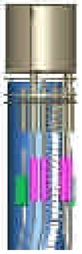
A filament will eventually fail after years of operation even in a clean UHV system due to the thoria coating on it eventually decomposing and evaporating. The Extorr RGA uses two thoria coated iridium filaments that operate in parallel. When one of them burns out, the other will continue to operate the instrument normally, giving a warning so that the user will be able to replace the filament assembly when it is convenient. Unlike what may occur with other residual gas analyzers, the Extorr's filaments will not fail due to exposure to high pressures because they are protected by both ion and Pirani gauge outputs. A complete filament failure can be verified by looking at the DIAGNOSTICS readings on the OUTPUTS page. If there is an open filament, the filament voltage will read > 5 volts and, using the resistance reading and V= IR, there will be < .1 amp filament current. The filament light icon will not stay yellow on the main window. If only one of the filaments is burned out, the instrument will operate normally but there will be <1.5 amp of filament current.

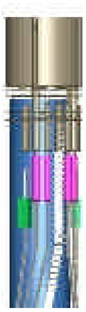
The ionizer normally will last for years without attention in a UHV environment. There is nothing to wear out, but the metal surfaces can become contaminated. The results of contamination could cause low sensitivity for partial pressure readings. It generally take a very severe contamination to cause the total pressure readings to be low because the B/A type gauge uses higher voltages and works with more energetic ions that are less susceptible to stray fields. If you have a total pressure reading of 10^{-7} torr for example, the sum of your partial pressure readings should be roughly the same. A number of factors such as the relative sensitivities of different compounds and the cracking of molecules into ion fragments makes it unlikely that they will add up exactly, but as the ionizer contamination increases, you may see a an order of magnitude or more difference between the total pressure and the sum of partial pressures. Cleaning the ionizer is difficult if not impossible in most cases, so replacement is the remedy. It is also likely that some contamination will make it to the rods of the quadrupole. So, when replacing the ionizer due to low sensitivity, it is a good idea to clean the quadrupole rods as well.

Always handle the probe with clean gloves, or you will see the results of your contamination on the next scan. A fingerprint will outgas and cause peaks at virtually every amu until it is evaporated or turned into low vapor pressure compounds in your vacuum system. Of course other sources of contamination such as diffusion or mechanical pump oil could cause similar problems. Even after the volatiles are gone, the residue may cause the probe to operate improperly by leaving behind either insulating compounds or secondary electron emitting surfaces. This can cause charge from electrons to build up and disturb the electric fields in the ionizer, or the mass filter, leading to low sensitivity.

At the factory, all parts are mechanically cleaned, then vacuum baked, and then plasma cleaned. If you are doing UHV work and demand the best cleanliness, you can send the analyzer to the factory for refurbishment, but many customers have had good success with cleaning in the field. The rods are best cleaned with an abrasive method, such as 1200 grit abrasive paper polishing, followed by an Alconox ultrasonic bath and several rinses with distilled water. The Extorr probe was designed to allow easy cleaning and ionizer/filament replacement. The only tool required is an Allen wrench to loosen the set screws that hold the ionizer to the probe. This tool is supplied with all new ionizers.

The following steps will usually restore the XT system to proper operation:

Step 1			Placing the analyzer onto the CCU without the thumbscrews makes a good stand for the repair. Loosen the top set screws on the 2 barrel connectors that connect the filament wires. Remove and discard the old filament assembly. If you are only replacing the filament, skip to step 7.
Step 2			Loosen the bottom set screws on each barrel connector and slide them down the wires towards the feedthrough. Remove the ionizer by pulling upward, a gentle twisting action may be necessary.
Step 3			Using a hook made from some .062 diameter wire, pull the mass filter.

Step 4			Pull the mass filter out of the frame.
Step 5			Clean the surfaces of the rods with 1200 grit alumina abrasive paper until they are bright. Using a waterproof paper with water works well. Be careful not to bend the electrical contacts. Then clean in Alconox detergent using an ultrasonic cleaner at 40 kHz. Rinse well with distilled water in the ultrasonic bath several times, then dry at 75 degrees C.
Step 6			Next insert the mass filter into the probe, being careful to line up the 2 wires with the two holes in the end of the mass filter that make the electrical contact.
Step 7		Slide the 4 tubular spring connectors completely up onto the ionizer wires.	Using a small pair of needle nose pliers or a strong pair of tweezers, remove the 4 tubular spring connectors from the old ionizer and push them onto the respective pins on the new ionizer. Push the new ionizer down onto the probe, carefully engaging the center pin and BA shield spring until the focus plate is flush with the top of the quadrupole.

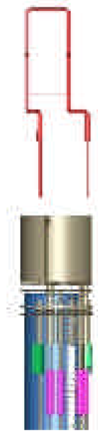
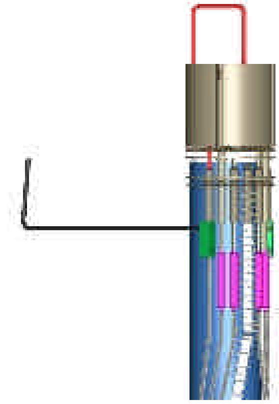
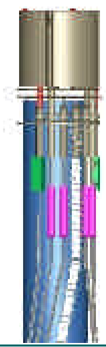
Step 8			Slide the four 4 tubular spring connectors down to engage the respective feedthrough wires. Insert the new filament assembly and while holding down on the filament, slide the barrel connectors into place and tighten both set screws on each barrel connector. Be careful that the wires do not short to each other or the frame. You can bend the wires from the feedthrough easily if necessary, but do not bend the wires from the ionizer or you may crack the ceramics.
Step 9			Finally, break off the top of the filament assembly and discard.

Fig 19. Servicing the Probe

More detailed Photographs are available on the Extorr web site at www.extorr.com.

8. Return Procedure

If, for any reason, you need to return your XT system to Extorr Inc. for service, first call 1-724-337-3000 to obtain a Returned Material Authorization (RMA) number. Then pack the instrument securely, using the original packaging if it is available. Be sure that the RMA number is clearly marked on the outside of the shipping box.

Appendix A. First Mass Spectrum

As the vacuum system is first pumped down, the Pirani gauge output will decrease (hopefully rapidly) to pressures in the 10^{-2} torr range. In the factory configuration file the filaments are in the activated position and the light bulb icon will glow red when only the Pirani is activated. As the pressure drops below 3 x 10^{-2} torr, the ion gauge starts to operate with a reduced electron emission. In this situation the bulb icon shines orange. In this pressure region, the ion gauge yields the more accurate pressure measurement. As the pressure falls below $3x10^{-4}$ torr, the electron emission for the ion gauge and the quadrupole analyzer ion source are increased to the value set in the configuration file (see the filament emission box under the operating parameters tab). At this point, the bulb icon becomes yellow and the quadrupole starts operation.

The factory setting for the quadrupole is a sweep from mass 1 to the highest rated mass of the system. This usually makes for a rather cramped spectrum making the assignment of peaks to masses difficult. The spectrum may be stretched out either by changing the mass range or by using the sliders at the bottom of the graph.

If you are pumping down from atmosphere, the dominant peaks will be the water peaks at masses 18, 17 and 16. The mass spectrum usually consists of a molecular ion, parent peak or M peak. Then there will also be one or more fragments of the molecule. A mass spectrum which includes H_2O is shown in Figure 20. The largest peak is the molecular ion, H_2O^+, with a mass of 18. The next most abundant ion is the fragment OH^+ at mass 17. The next most abundant fragment is O^+ at mass 16. Note that the fragments are formed by the removal of an atom or group of atoms from the molecular ion. The molecular weight of the molecular ion and the particular fragment of the molecule both are used in the identification of the molecule

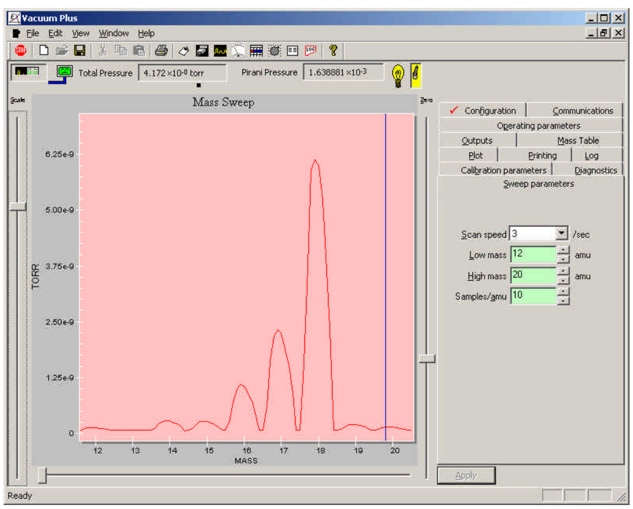


Figure 20. Water Vapor in Mass spectrum

A closer examination of a pure water spectrum would also show peaks at mass 1, mass 19 and mass 20 but these peaks are on the order of 1000 times less than the peak at mass 18.

The peaks at masses 19 and 20 arise because some of the H_2O molecules contain 0-17 and 0-18 isotopes. Ordinary oxygen contains 99.756% of the mass 16 isotope, 0.039% of the mass 17 isotope, and 0.205% of the mass 18 isotope. The peak at mass 18 is called the molecular, or M, peak of water vapor while those at peaks 19 and 20 are called the M + 1 and M + 2 peak respectively.

The other two peaks which are expected to be in these first mass spectra are the peaks due to the other main constituents of air, nitrogen, oxygen, and argon. The molecular peaks of these gases are at 28, 32 and 40. The ratios of these peaks are 4 to 1 to 1/20. If these same ratios persist for a length of time, you most likely have an air leak.

As the pumping continues, these peaks will become smaller until there is virtually no mass 32 peak. The nature of the pumps used and the material of vacuum system construction will determine the mass spectrum at the lowest pressures. There are many sources of mass spectra in libraries on the World Wide Web. NIST maintains a database on the web. Some common residual gases first encountered on pump down are given below. The numbers are rough percentage intensities with respect to the largest peak for each source.

Source ? / Mass ?	Air	Nitrogen	Oxygen	Argon	Water vapor	Hydrocarbon fragment	Carbon dioxide	Carbon monoxide	Hydrogen
1						x			2
2									100
12						x	2	5	
13						x			
14	5	5							
15									
16	1		5		7		5	2	
17					25				
18					100				
20				13					
24						x			
26						x			
28	100	100				x	5	100	
29		1				x			
30						x			
32	25		100						
36						x			
37						x			
38						x			
39						x			
40	1			100		x			
41						x			
42						x			
43						x			
44						x	100		

Figure 20A. Table of Common Mass Peaks

Note that hydrocarbons tend to produce peaks virtually everywhere but they tend to group in bunches which are separated by the CH_2 fragment, a mass of 14. If you look deep enough into every unbaked system you will most likely find hydrocarbon peaks. An example of a hydrocarbon group is shown in Figure 21.

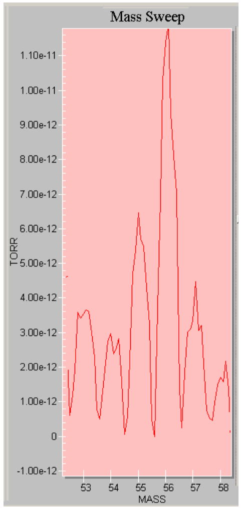


Figure 21. Low level Hydrocarbons

Beyond these first "pump down" peaks, the residual gases which are most likely to be found are those probably best known to the user of the vacuum system. The user knows the processes carried out in his chamber and the chemical species involved.

There are other tricks to help in identification of residual gas peaks. For instance, the intensities of the various isotopic peaks can be used to help identify molecules. For instance, a molecule containing a single Cl atom is going to have an molecular peak (due to ^{35}Cl) and an M + 2 peak (due to ^{37}Cl). The intensity of the M + 2 peak is about 33% of that of the M peak. A molecule containing a single Br atom will have M and M + 2 peaks of about equal intensity.

Armed with a few cracking patterns of common residual gasses, a periodic table and a knowledge of how your chamber is used, the user should have little trouble identifying the gases in his system. If he is stumped, it is amazing what a simple search such as "what is mass spectral peak xxx?" or "peak at m/z XXX" on the world wide web will yield.

Appendix B. Gauge Sensitivity to Differing Gases

B.1. Pirani Gauge

Thermal conductivity of a gas is directly related to both the mass of the gas molecules and the pressure. The Pirani readout is calibrated for air. Pressures in other gases may vary considerably from the results due to air.

The characteristic voltage vs. pressure response curve for the Pirani is shown to the right. The voltage read at atmospheric pressure and that read when pressures are below 10^{-2} torr will establish the voltage pressure relationship between these two points.

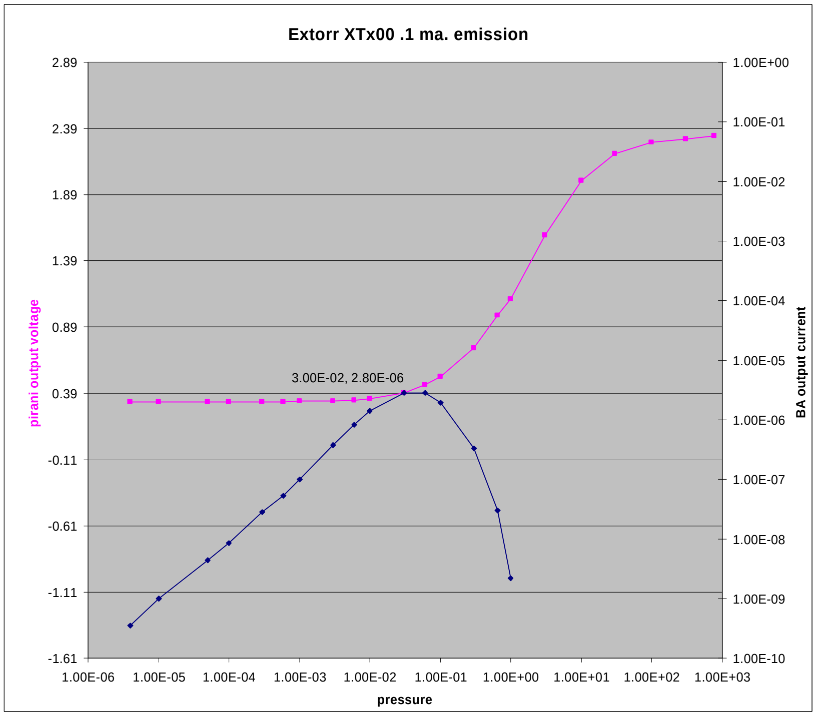


Figure 22. Pirani & Ion Gauge Operation

B.2. Ion Gauge Corrections

The ion gauge is also calibrated for nitrogen. In the ion gauge pressure realm, the ion current depends on the probability that an electron ionizes a molecule to make an ion. This probability (actually a cross section for ionization) is strongly dependent on the molecular structure. The pressure is defined by the ratio of ion current, i, to electron current, e, times a sensitivity number, k. That is P= i/ (k*e). k must have units of inverse pressure. This k can vary widely depending on the molecular make-up of the gas. The table below gives this k value for most common vacuum gases.

The table gives this result in inverse torr, inverse mbar and inverse pascals. A relative sensitivity is also given with respect to nitrogen. This is the number used to convert a nitrogen gauge reading to a reading for the gas in question. This is done by dividing by the relative sensitivity number, k_r.

Gas	k,Sens (mbar^{-1})	k,Sens (torr^{-1})	k,Sens (Pa^{-1})	k_r, Relative Sensitivity
Air	19.0	25.3	0.19	1.00
H_2O	19.0	25.3	0.19	1.00
O_2	21.0	27.9	0.21	1.11
D_2	6.6	8.8	0.07	0.35
H_2	6.2	8.2	0.06	0.33
He	2.4	3.2	0.02	0.13
Ar	21.0	27.9	0.21	1.11
N_2	19.0	25.3	0.19	1.00
NO	22.0	29.3	0.22	1.16
CO	19.0	25.3	0.19	1.00
CO_2	27.0	35.9	0.27	1.42
Ne	5.4	7.2	0.05	0.28
CH_4	27.0	35.9	0.27	1.42
Kr	37.0	49.2	0.37	1.95
Xe	54.0	71.8	0.54	2.84
SF_6	48.0	63.8	0.48	2.53

Figure 22A. Ion Gauge Relative Gas Sensitivities

Here we divide the nitrogen reading by the relative sensitivities above to get the pressure of that pure gas. A gas mixture will give some intermediate result.

B.3. Determination of Partial Pressures

Of all the vacuum measurements, the partial pressure measurements are the most difficult because they depend on so many different things. As in the ion gauge, the residual gas molecules are electron impact ionized. Unlike the ion gauge which just measures total ion current, the quadrupole separates all the ions produced into their mass to charge ratios and measures the current from each of the ions produced. These ions may be molecular fragments or from a mixture of molecules. So not only is the ionization cross section important, so is the “cracking pattern” of each molecule. We can then add to this the mass to charge discrimination inherent to any mass spectrometer system. When used, the response of an electron multiplier to differing ions must also be taken into account.

The system may be calibrated to take most of these factors into account. For most purposes, an extremely accurate partial pressure measurement is not required. If we know the cracking pattern, of the molecule, at a given ion energy, and we have a single peak which is free of interferences, then a measure of the partial pressure of the molecule may be derived by comparing its peak height divided by the fraction of the total current produced by the molecule. The ion gauge sensitivity factor, although measured at a different electron energy, may be used to get a rough idea of the partial pressure. As an example, let's say that we have a peak at mass 20 due to Ar^{++} . We look at the cracking pattern of Argon and find that 17 % of ionized argon becomes Ar^{++}. So we measure the current $i(Ar^{++})$ divide by 0.17. The partial pressure is then given by $i(Ar^{++})/(i_e * k(Ar))$ where i_e is the electron current to the ionizer. Putting numbers into this example, suppose the 20 amu signal was 10^{-11} amps, the ionizer electron current was 10^{-3} amps so P(Ar)= 10^{-13} amps/(10^{-3} amps*0.17*27.9 torr^{-1}) = 2.1 x 10^{-9} torr. Again it should be emphasized that we have made a number of gross assumptions here which add to the uncertainty in this value. Another factor is the relative quadrupole transmission for differing masses. If the simplest tuning provisions are made, a quadrupole has a transmission which falls off in direct proportion to the inverse of the mass. In an RGA such transmission factors are usually normalized to the transmission at mass 28. Mass 20 would therefore have a current 28/20 times more than mass 28 if the same number of ions is produced per unit time in the ionizer. So the 2.1X10^{-9} torr should be multiplied by 20/28 to get 1.5x10^{-9} torr. If exact partial pressures are required, it is still best to calibrate by applying pure gases to your vacuum system.

A few cracking patterns for some common molecules are given in Figure 22B.

Ar		**CO2**		**He**		**H2**		**Kr**		**N2**		**O2**		**H2O**	
Mass	Fract.	Mass	Fract.	Mass	Fract.	Mass	Fract.	Mass	Fract.	Mass	Fract.	Mass	Fract.	Mass	Fract.
40	.83	44	.70	4	1.0	2	1.0	84	.45	28	.93	32	.95	18	.75
20	.17	28	.11					86	.13	14	.06	16	.05	17	.19
		16	.06					82	.1	29	.01			1	.05
		12	.01					83	.1					16	.02

Figure 22B. Cracking Patterns for Some Common Molecules

Appendix C: Manual Tuning of an RGA

The Extorr XT Residual Gas Analyzer (RGA) comes with its default tune. This was set at the factory for a nominal unit mass resolution at the proper mass positions throughout the mass range. This default tune may always be assumed to be either fairly exact or a good starting point for a user calibration.

The user can over-ride this tune by changing the default tuning parameters. He may wish to do this to give special measurement capabilities to certain spectral regions. He may, for instance, want to look at a particular weak spectral region with enhanced sensitivity or look at a portion of the spectrum with higher resolution to look at “half mass” peaks, or peaks which suffer mass defects.

The tuning parameters which may be controlled and their functions are:

1. Electron energy, which controls sensitivity.
2. Filament emission, controls the amount of electrons available for ionization.
3. Ion energy, which controls sensitivity and peak shape.
4. Focus which can affect sensitivity and peak shape.
5. High Cal Mass and Low Cal Mass which control the set points on the mass scale from which extrapolation and interpolation for Ion Energy, Mass Position, and Resolution values are taken.
6. High Cal Position and Low Cal Position which control where peaks are placed on the mass scale and where the High Resolution and Low Resolution settings are applied.
7. High Resolution and Low Resolutions which control spectrum wide resolution, peak shape, and sensitivity.

Quadrupole rods act as a mass filter. For a given mass to charge ratio, a large number of combinations of RF and DC voltage will allow that ion through the length of the rods. In fact all combinations of RF and DC below a unique, nearly triangular, graph will allow that ion through. This is called the quadrupole stability diagram. Note that this graph is reflected in the Extorr logo. A second ion, say with half the mass to charge ratio as the first, will have a completely similar stability diagram as shown in figure 23. We can now see how this arrangement can be used to produce a mass spectrometer. Clearly, if we have combinations of RF and DC voltages in the region A, neither of the ions will make it through the rods. In the D region both ions make it through the rods. In the B region only the high mass ion makes it through the rods and in C only the low mass ion makes it through the rods.

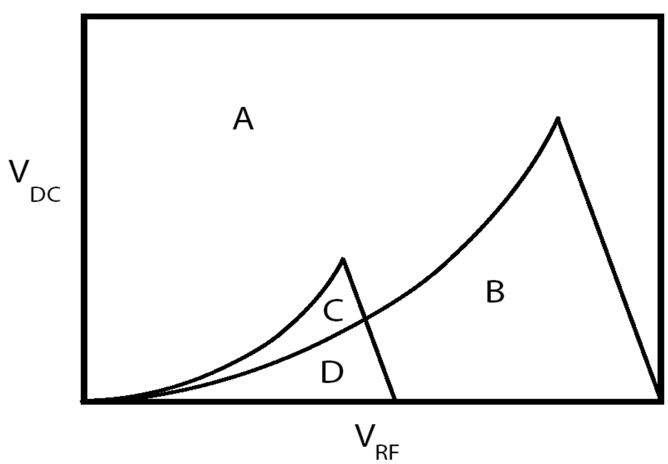


Figure 23. Stability Diagrams

A second example of this concept is of the stability diagrams of the first 5 masses. Note the 5 similar stability diagrams for the first 5 ion masses. If we sweep the RF and DC voltages along line A, we get the mass spectrum shown as a. Note that the peaks are flat topped and thin. I have chosen an ion abundance at each mass such that mass 1 is larger, mass 2, 3 and 5 are about half this size and mass 4 is the largest peak. When we sweep along B we get the spectrum shown as b. The peaks are now uniformly wider. So we can control the peak widths with our sweep line. If we want to change peak widths, we could sweep as in C and get the mass spectrum c. Note that the mass 1 peak is no longer as tall as mass 2. This is the situation when a peak is said to be over-resolved.

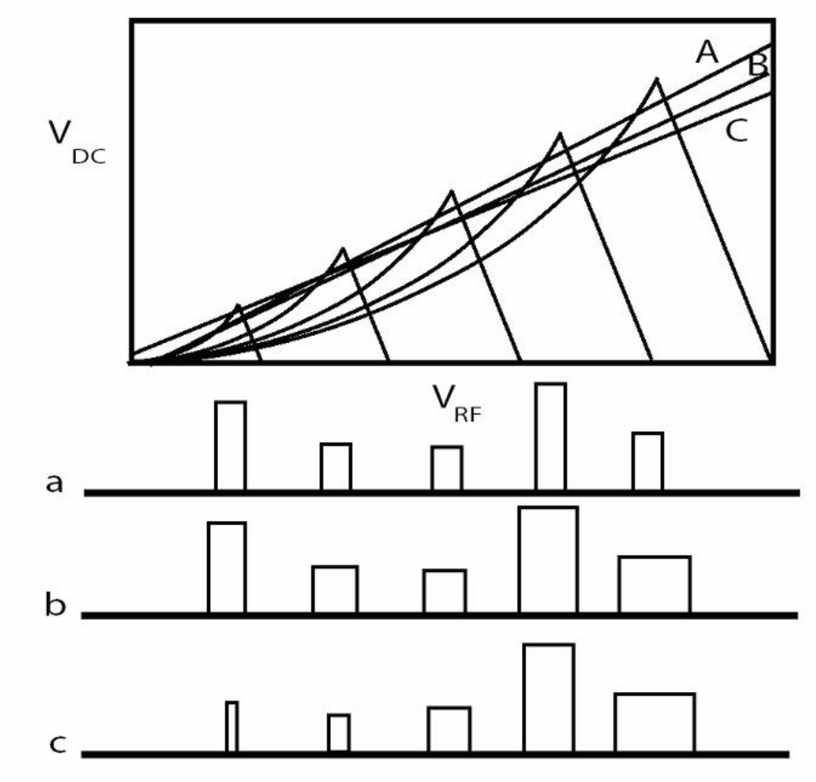


Figure 24: Stability Diagrams and Mass Spectra

You may note that theses peaks do not look like real world peaks. They are indeed idealized. In the real world the corners are smoothed.

Armed with these ideas of how mass sweeps work, we can look at how the parameter settings can change individual peak heights, shapes and widths. Always remember you can go back to the factory settings by reloading the factory configuration file which came with your RGA.

Electron energy, which may be controlled under the Operating Parameters tab, is the energy, in electron volts, that the electrons have as they move through the ionization volume. The probability that the electron produces an ion from a molecule moving within this volume depends on the electron's energy and the nature of the molecule. Ionization depends on the electron energy ionization threshold below which no ionization is produced. After this threshold, ionization probabilities increase to a maximum and then decrease as electron energies are advanced beyond this maximum. This electron impact ionization "cross section" curve is unique to each molecule but, for production of singly charged ions, the maximum is near 70 eV. This is the normal setting for RGA electron energy. If, for some reason, it is desirable to reduce the intensity of doubly charged ions, a reduction of electron energy will usually help.

Filament emission, which may be controlled under the Operating Parameters tab, controls the amount of electrons available for ionization. Peak height can be adjusted using this parameter.

When operating at pressures above 10^{-5} torr, filament and ionizer lifetime will be increased if the filament emission is decreased by a factor of 10. Note that partial pressure readings will read low unless the Partial Sensitivity factor is changed under the Calibration parameters tab.

The mass scale set points are under the Calibration Parameters tab. These set points are usually set to mass 1 and the highest nominal mass for the XT unit. That is, for an XT100 the set points are 1 and 100, for an XT200 the points are 1 and 200, and so on. They may, however, be set anywhere in the mass range of the RGA. These set points control, by extrapolation and interpolation, the values of Ion Energy, Mass Position, and Resolution at each individual point along the mass axis.

Ion energy is controlled under the Calibration Parameters tab. It is controlled by extrapolation and interpolation from the High Cal Ion Energy and Low Cal Ion Energy set points. It is the parameter which controls the speed of the ion through the quadrupole. As the speed is increased so is the probability of the ion making it from the ionization volume to the ion detector. Ion energy is therefore a way of controlling peak height. The lower the ion energy, the lower are the number of ions detected. The higher the energy, the greater are the number of ions detected. Unfortunately, as the ions increase their speed, they are less likely to be properly selected by the RF field of the quadrupole and peak splitting occurs. In the Extorr RGA, an “Electron Energy” between 3 to 6 volts usually gives the best sensitivity without peak shape distortion. Also note that higher masses have less speed than do lower masses at the same energy.

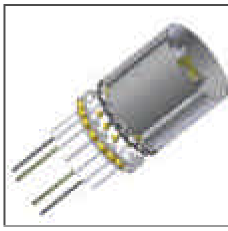
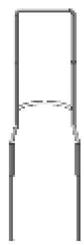
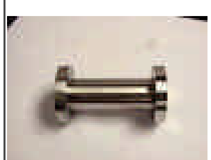
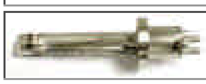
The focus voltage, which may be controlled under the Operating Parameters tab, controls how the ions are extracted from the ionization region. Any particular tune setting may be optimized by a change in this voltage. As ionizers age by contamination, sensitivity may be increased by an increase in magnitude of this negative voltage.

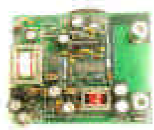
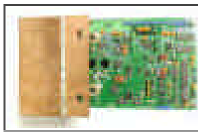
Mass calibration is controlled under the Calibration Parameters tab. It is controlled by extrapolation and interpolation from the High Cal Mass and Low Cal Mass set points. These are the parameters which control the exact position of the mass peak on the mass scale. As resolution is increased (peak width decreased), the mass peak will change width more on the low mass side than the high mass side. The peak maximum will therefore have been shifted. The High Cal Mass and Low Cal Mass set points may be adjusted to place the peak top back at the proper mass position.

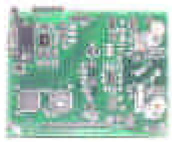
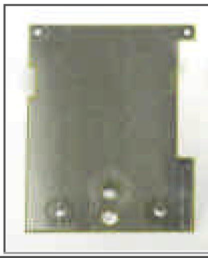
Mass peak resolution is also controlled under the Calibration Parameters tab. It is controlled by extrapolation and interpolation from the High Cal Resolution and Low Cal Resolution set points. These are the parameters which control the width of the mass peak. As resolution is increased the peak widths are decreased. Decreasing the resolution allows more ions through the quadrupole and increasing the resolution allows less. Therefore, peak heights may also be controlled by the resolution settings.

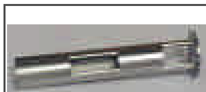
Quadrupole tuning is somewhat an acquired art. The more the user “plays” with different tunes, the more adept he will become at achieving customized purposes. We again emphasize that for 99% of RGA operations, the factory tune is more than adequate. Remember you can go back to this tune by reopening the factory configuration file under the Configuration tab.

Appendix D: Options and Spare Parts

Part Number	Picture	Description	Unit Price
XTFIGI-1		Filament, Ion Gauge, and Ionizer Assembly OBSOLETE, use XTIONIZER+ XTDUALFIL	$200.00
XTIONIZER		Ionizer assembly for use with dual filaments (XTDUALFIL)	$200.00
XTDUALFIL		Dual thoria coated iridium filament, must use with XTIONIZER	$90.00
N500		2 3/4 Inch CF Nipple, 5.0 Inches between Flange Faces Used to install analyzer in a vacuum system where there is insufficient internal clearance	$100.00
XTPR100		XT100 Probe	$1600.00
XTPR100M		XT100M Probe	$2600.00
XTPR200		XT200 Probe	$2100.00
XTPR200M		XT200M Probe	$2900.00
XTPR300		XT300 Probe	$2600.00
XTPR300M		XT300M Probe	$3400.00
XTPR100RF		XT100(M) Probe Refurbish	$500.00
XTPR200RF		XT200(M) Probe Refurbish	$550.00
XTPR300RF		XT300(M) Probe Refurbish	$600.00

XTCCU100		Command and Control Unit for XT100	$2000.00
XTCCU100M		Command and Control Unit for XT100M	$2500.00
XTCCU200		Command and Control Unit for XT200	$2500.00
XTCCU200M		Command and Control Unit for XT200M	$3000.00
XTCCU300		Command and Control Unit for XT300	$3000.00
XTCCU300M		Command and Control Unit for XT300M	$3500.00
XTCCURF		Command and Control Unit for XTx00(M) Refurbish	$400.00
XTPSB000		Power Supply Board for all XT models	$600.00
XTPSB000EX		Power Supply Board for all XT models Exchange Price	$300.00
XTRFB100		RF Board for XT100	$600.00
XTRFB100EX		RF Board for XT100 Exchange Price	$300.00
XTRFB200		RF Board for XT200	$850.00
XTRFB200EX		RF Board for XT200 Exchange Price	$300.00
XTRFB300		RF Board for XT300	$1100.00

XTRFB300EX		RF Board for XT200 Exchange Price	$300.00
XTELB100		Electrometer Board for XT100	$600.00
XTELB100EX		Electrometer Board for XT100 Exchange Price	$300.00
XTELB200		Electrometer Board for XT200	$850.00
XTELB200EX		Electrometer Board for XT200 Exchange Price	$300.00
XTELB300		Electrometer Board for XT300	$1100.00
XTELB300EX		Electrometer Board for XT200 Exchange Price	$300.00
XTSHB001		Power Supply shield board	$25.00
XTSHB002		RF Shield Board	$25.00

XTPS24VDC		24 Volt 50 Watt power supply, Input 100-240 VAC 50-60 Hz	$100.00
XTPC		Power Cord for PS24VDC, North America, User must Install plug end for other Countries	$5.00
XTTS000		Thumb Screws to hold CCU to Analyzer	$10.00
XTFT000		Vacuum Feedthrough, with Pirani Gauge	$600.00
XTMF100		Mass Filter for XT100	$500.00
XTMF200		Mass Filter for XT200	$1000.00
XTMF300		Mass Filter for XT300	$1500.00
XTMF300EX		Mass Filter for XTx00 Exchange	$300.00
XTFRAME		Frame for XTx00 Analyzers	$200.00
XTFAR		Faraday Detector Assembly	$200.00

* prices effective as of 3-8-2006. International prices are 10% higher with a $50 minimum increase per invoice.

Warranty

XT products of Extorr Inc. are warranted to be free of defects in material and workmanship for a period of one year from the date of shipment. At our option, we will repair or replace products which prove to be defective during the warranty period. Liability under this warranty is limited to repair or replacement of the defective items. Shipping damage is excluded from the scope of this warranty.

If this product is returned to Extorr for warranty service, Buyer will prepay shipping charges and will pay all duties and taxes for products returned to Extorr. Extorr will pay for return of products to Buyer, except for products returned to a Buyer from a country other than the United States.

LIMITATION OF WARRANTY: The foregoing warranty does not apply to the defects resulting from unauthorized modification or misuse or operation outside the specifications of the product.

THE WARRANTY SET FORTH ABOVE IS EXCLUSIVE AND NO OTHER WARRANTY, WHETHER WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED. Extorr DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES: The remedies provided herein are Buyer's sole and exclusive remedies. In no event will Extorr be liable for direct, indirect, special, incidental, or consequential damages, including loss of profits, whether based on contract, tort, or any other legal theory.