

RF Quad Generator

for Ion Guide Applications in Mass Spectrometry

Model RF100

Installation, Operation and Maintenance Manual

November 1, 2006



1kV peak to peak per channel

For maintenance or repair please contact your sales agent or the manufacturer directly:

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Table of Contents

PREFACE	III
1 INTRODUCTION	1
2 BASIC PRINCIPLES OF RF GENERATOR OPERATION	2
3 SAFETY PROCEDURES WHILE USING RF GENERATOR.....	4
3.1 SAFETY PRECAUTIONS	4
3.2 OPERATOR CONTROLS AND INDICATORS	6
4 RF GENERATOR INSTALLATION.....	7
4.1 CHECKING THAT ALL COMPONENTS HAVE BEEN RECEIVED	7
4.2 INSTALLATION OF THE RF GENERATOR	7
4.3 INSTALLING THE SOFTWARE AND USB DRIVERS	8
5 RF GENERATOR OPERATION	10
5.1 RUNNING THE SOFTWARE AND CHANGING THE AMPLITUDE AND FREQUENCY OF THE OUTPUT VOLTAGE.....	10
5.2 TUNING THE RF GENERATOR TO THE RESONANCE	11
6 MAINTENANCE —TROUBLESHOOTING THE SOURCE.....	14
6.1 PROBLEM: INSUFFICIENT AMPLITUDE OF THE OUTPUT RF VOLTAGE.	14
6.2 PROBLEM: NO OUTPUT RF VOLTAGE	14
6.3 PROBLEM: UNCONTROLLED OUTPUT RF VOLTAGE.....	15
6.4 PROBLEM: HIGH CONSUMED ENERGY.	15
6.5 PROBLEM: THE RESONANT FREQUENCY IS NOT IN A DESIRED RANGE.....	15
7 WARRANTY INFORMATION – SIX MONTH LIMITED WARRANTY	18

PREFACE

The following symbols are used in this manual to indicate material that should especially be noted because it relates to safety issues.



This symbol in the manual margin is used to emphasize the presence of very important operating instructions related to safety especially during installation, un-installation, maintenance and troubleshooting.



Operators are strongly encouraged to read this manual before installation, un-installation, operation, maintenance, or troubleshooting. Operators should pay special attention to paragraphs marked by  .



DO NOT ATTEMPT services or repairs that are not covered in the Troubleshooting section, Section 6, of this Manual. For services and repairs beyond those specifically provided in the Troubleshooting section, contact the manufacturer:

MassTech, Inc.
6992 Columbia Gateway Dr.
Columbia, MD 21046
tel. 443-539-1758
fax 443-539-1759.

1 INTRODUCTION

Quadrupole and multipole RF ion guides are common parts of virtually every mass spectrometer. Their basic function is a transportation and storage in ions in vacuum (normally at lower than 100 mTorr pressure). RF ion guides may have different design but all of them require application of the RF voltage of opposite polarities to electrodes. As a result a quadrupole or multipole electric field is created by the ion guide electrodes than makes a spatial trapping field for the ions to be transported or stored.

There is a growing demand in the research and industry for the RF generators that can be used for applying the RF voltages to the RF ion guide electrodes and creating the RF trapping fields. MassTech RF generators were design to satisfy this demand to facilitate planning and conducting ion guide experiments in industry and research labs.

Advantages of MassTech RF Generators are:

- A product specifically designed for mass spectrometry applications.
- Operation in a wide range of output RF voltages and frequencies.
- Software frequency tune-up to a load resonance with quartz accuracy.
- High precision RF voltage control either by an external (0-10 VDC) voltage or from PC (via an USB port).
- Possibility of ion guide floating at DC voltage (using an external DC power supply).

MassTech RF Generators have an USB port to control the RF voltage amplitude and the output frequency via the software supplied with the RF Generator.

2 BASIC PRINCIPLES OF RF GENERATOR OPERATION

Understanding the basic principles of the RF Generator is not strictly necessary for successful practical use of the generator. However, a brief summary of the apparatus and the operating method are provided here for completeness.

A simplified scheme of the RF Generator is presented in Fig. 2-1 below.

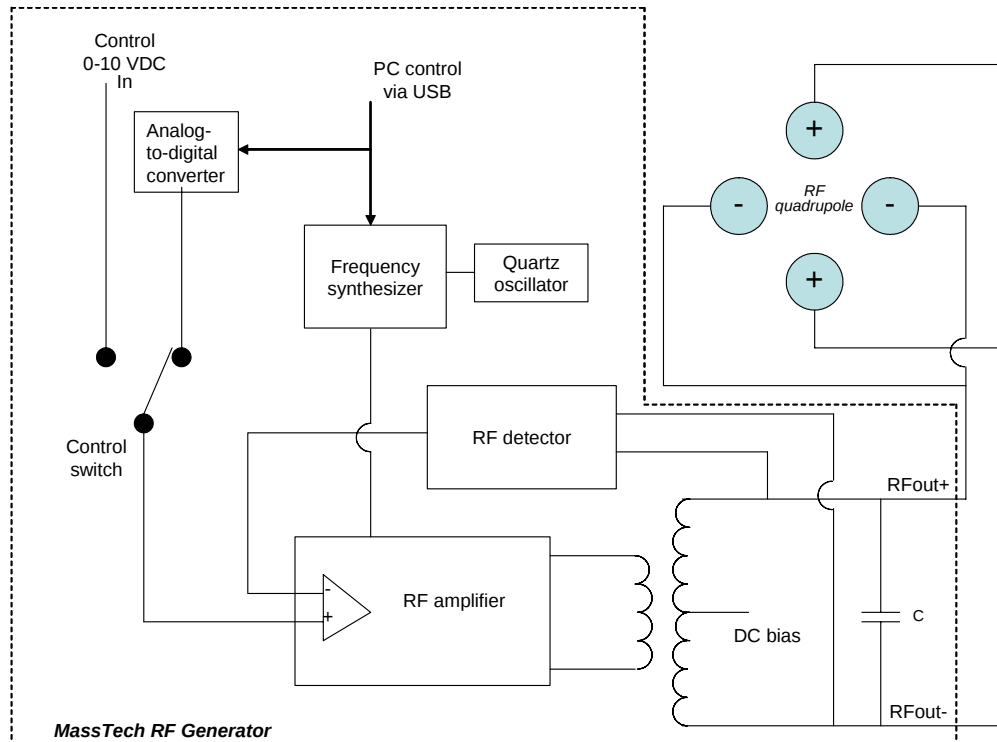


Fig. 2-1. Simplified schematic diagram of the MassTech RF Generator.

The lowest power consumption is observed at the resonance frequency of the output LC contour. The output resonance frequency is determined by the output transformer inductance and the output capacitance. According to the diagram above the internal capacitor C should be added to the intrinsic capacitance of the quadrupole rods (the so-called load capacitance) to determine the output contour capacitance and, thus, the resonance frequency. If the resonance frequency is out of the desired range it can be adjusted by replacing the output capacitor C as described in the “Maintenance – Troubleshooting the RF Generator” section (Section 6 of this manual).

Using the USB port and the computer software supplied with the RF Generator the user can monitor and control the output RF voltage amplitude and frequency and monitor the electric power consumed. Usually, the frequency is tuned to the resonance so the power consumed is minimal. The frequency range for the resonant conditions is determined by the Q value of the resonant contour which is typically in the 50-100 range. The output RF voltage amplitude can also be controlled by the external DC signal which should be in the 0-10 VDC range. The switching between two modes of the output RF voltage control is done by a switch at the rear panel of the RF Generator.

3 SAFETY PROCEDURES WHILE USING RF GENERATOR

If operated properly, the RF Generator is safe. No special knowledge of electrical safety is necessary to operate the source. There is one potentially hazardous factor connected with the RF Generator installation, operation and maintenance/troubleshooting, namely:

High Voltage up to 3 kV

To provide the necessary safety, the manufacturer of this product has provided careful protection to users by shielding (housing) and reliable interlocking of the source components from High Voltage, provided that the RF Generator Power is TURNED OFF during installation and uninstallation.

3.1 Safety Precautions

This section describes important precautions that must be observed during the RF Generator **installation, operation, and maintenance**. Appropriate precautions can be divided into the following stages:

- **Installing/Uninstalling:** Before the RF Generator is installed, uninstalled, or replaced, make sure that the Power switch on the rear panel is in OFF position and the vent holes of the RF Generator housing are not blocked by external objects. Installation requires connecting the “RFout+” and “RFout-” connectors to a quadrupole/multipole load as shown in Figure 2-1 using proper high voltage cables (make sure that the cables are rated for at least 3 kV). The length of the RF cables should be as small as possible since they add their own capacitance to the load. The “DC bias” connector should be connected to a proper DC voltage source, not exceeding ± 200 VDC. If the Generator output RF voltage is intended to control using an external DC signal the source of the signal (from 0-10 VDC) should be connected to the “Control 0-10 V In” connector and the “Amplitude Control” switch on the rear panel should be in the “External” position. If the RF Generator output voltage is to be controlled via a computer the switch should be in the “USB” position. Connect the RF generator to the computer using the USB cable provided.

Never switch the power ON at the rear panel of the RF Generator before the RF Generator is **completely installed**.

RF Generator

The RF Generator safety interlocks safeguard the user from accidental application of High Voltage when the RF Generator is covered in their housing.

- **Operation:** The RF Generator is turned ON after the Installation by the power switch at the rear panel. Please refer to the RF Generator Operation section for the frequency tune-up procedure and the RF voltage control and monitoring.



Never disconnect or connect any cables to the RF Generator when the power switch is in the ON position.

- **Maintenance and troubleshooting:** The RF Generator does not require any special maintenance. It is strongly recommended that you follow the maintenance and troubleshooting procedures that are described in the “Troubleshooting” section (Section 6) of the present manual.



DO NOT ATTEMPT services or repairs that are not covered in the Troubleshooting section, Section 6, of this Manual. For services and repairs beyond those specifically provided in Section 8, contact the manufacturer, MassTech, Inc. 6992 Columbia Gateway Dr, Columbia, MD 21046; tel. (443) 539 1758

Remember: Only personnel specifically qualified for high voltage jobs can ignore the following safety rules:



- **Never defeat or bypass interlocks**
- **Never switch the Power ON at the rear panel unless the RF Generator is properly installed**

3.2 Operator Controls and Indicators

The two figures below illustrate the front and back plate of the RF Generator.

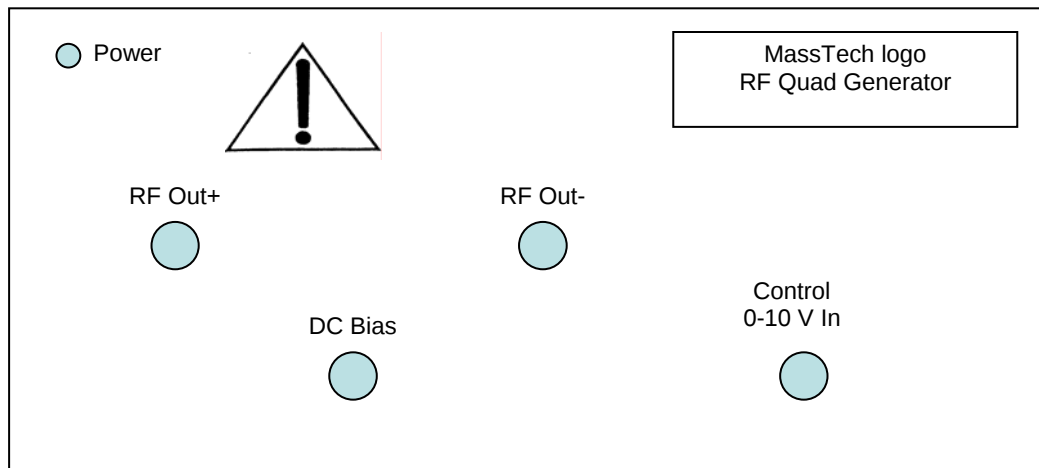


Fig. 3-1 The RF Generator Front Plate

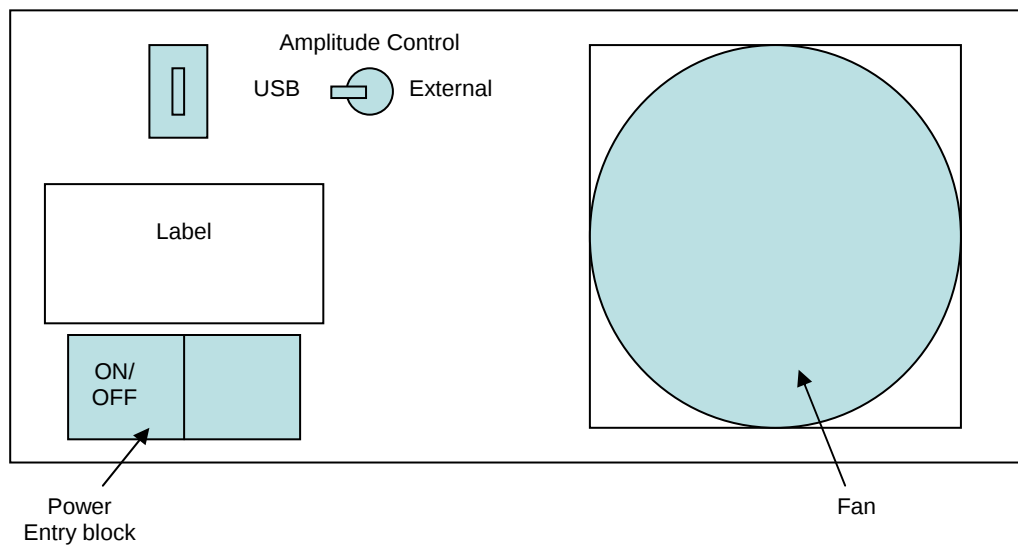


Fig. 3-2 The RF Generator Back Plate

4 RF GENERATOR INSTALLATION

4.1 *Checking that all components have been received*

Before you start installing your source, ensure that all necessary parts and accessories have been delivered. Usually they include (in addition to the RF Generator) a power cord, a USB cable, and installation CD with software. Make sure that the power cord plug corresponds to your AC socket type and rating.

Other cables required for the RF Generator operation can be ordered from any other vendors and:

1. The RF cables must have MHV plug connectors and rated for at least 3 kV.
2. The DC bias cable must have BNC plug connector and rated for at least 500 V.
3. The “Control 0-10 V In” cable should have a BNC plug connector.

Also, the voltage source for the DC bias is required not exceeding ± 200 VDC. If the output RF voltage amplitude of the RF Generator is intended to be controlled using an external 0-10 V signal then it should be prepared for use and should not exceed the 0-10 V range.

4.2 *Installation of the RF Generator*

Before the RF Generator is installed, uninstalled, or replaced, make sure that the Power switch on the rear panel is in OFF position and the vent holes of the RF Generator housing are not blocked by any external objects.



Installation requires connecting the “RFout+” and “RFout-” connectors to a quadrupole/multipole load as shown in Figure 2-1 using proper high voltage cables (make sure that the cables are rated for at least 3 kV). The length of the RF cables should be as small as possible since they add their own capacitance to the load.

The “DC bias” connector should be connected to a proper DC voltage source, not exceeding ± 200 VDC. If the Generator output RF voltage is intended to control using an external DC signal the source of the signal (from 0-10 VDC) should be connected to the “Control 0-10 V In” connector and the “Amplitude Control” switch on the rear panel should be in the “External” position. If the RF Generator output voltage is to be controlled via a computer the switch should be in the “USB” position. Go to the next section 4.3 for software and USB driver installation. Connect the RF generator to the computer using the USB cable provided.



Never switch the power ON at the rear panel of the RF Generator before the RF Generator is ***completely installed***.

The RF Generator safety interlocks safeguard the user from accidental application of High Voltage when the RF Generator is covered in their housing.

Connect the black power cord to the AC socket. **No adjustment is necessary for ~110/~127/~220/~240 VAC.**

4.3 Installing the software and USB drivers

RFquad software is used to control the RF Generator output amplitude and frequency and monitor the power consumed by the RF Generator.

To install the RFquad software for the RF Generator, follow these steps:
(under Windows XP or 2000 you will need Administrator access)

1. With USB cable between the Generator and computer NOT CONNECTED, insert the installation CD and run the Setup.exe program from your CD drive.
2. Chose the desirable location and folder name for the software. By default, the folder is: C:\Program Files\MassTech\RFquad\
3. Follow the next few dialog boxes to completion.

After the software installation process is completed, you can create a shortcut on your desktop to run the software from the desktop.

To use the USB port to communicate between the RF Generator and computer, you will need to install the USB Driver for this communication method.

To enable USB communication with the RF Generator, follow these steps:
(under Windows XP or 2000 you will need Administrator access)

1. Ensure that the one end of USB cable is properly connected to the RF Generator while the other end of the cable IS NOT connected to the computer.
2. Turn ON the power of the RF Generator.
3. Plug the USB cable into the computer.
4. The computer should detect “New Hardware Found”
5. In the Hardware Wizard dialog, answer the question: “Can Windows connect to Windows Update...” as “No, not this time.” Click Next button.

6. In the next dialog, choose “Install from the list of specific location (Advanced)” option. Click Next.
7. In the next dialog, choose “Search for the best drivers in these locations” and “Include this location in the search” options. Use Browse button to open “USB Driver” directory of the Installation CD into the search field.
8. Answer “Continue Anyway” to the Windows compatibility warning message. Wait till the driver installation is completed and press “Finish” button. Wait for some time.
9. If “New Hardware Found” message has appeared again, repeat steps 5-8. Finally, the message “Your new hardware is installed and ready to use” will indicate that USB driver setup is finished successfully. After that, you can run RFquad software to control the RF generator.

5 RF GENERATOR OPERATION

5.1 *Running the software and changing the amplitude and frequency of the output voltage*

Make sure that the software and USB drivers are properly installed (see Section 4.3). Install the RF Generator and connect it to the load as described in Section 4.2.

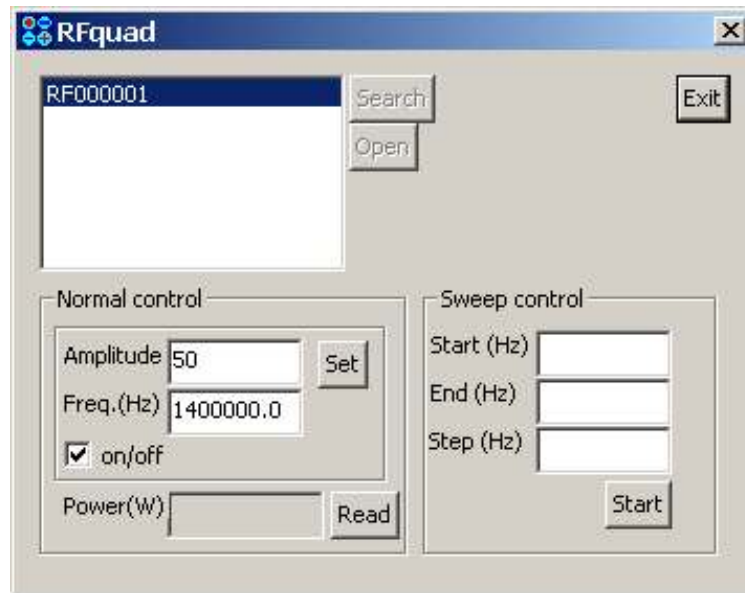
Switch the “Amplitude Control” switch at the rear panel to the “USB” position if you want control the output RF voltage using the software.

Switch the “Amplitude Control” switch at the rear panel to the “External” position if you want control the output RF voltage using the external 0-10 V signal.

Turn on the RF Generator.

Wait approximately 1 minute while Windows locate and connect a new USB device.

Run the RF quad software.



Press “search” button in the main window to find all RF generators connected to PC. The list of all available RF generators will appear in upper left box. Choose one of them and press “open” button. Now the software takes of this RF generator.

There are two modes of operation for the RF quad software: Normal and Sweep modes. The ON/OFF check box is used to turn on/off the output voltage. The sweep mode is used only for the resonant frequency search.

To set the frequency, click on the FREQUENCY field in the “Normal mode” window and type a desired value in Hertz.

To apply the new frequency value, check “ON/OFF” box and press the “SET” button.

To set the amplitude:

- a) if the “Amplitude Control” switch is in the “USB” position, click on the AMPLITUDE field in the “Normal mode” window and type a desired value expressed in arbitrary units (typically from 0-200 although the software will accept the value up to 1023). To apply the new amplitude value, check “ON/OFF” box, and press the “SET” button.
- b) if the “Amplitude Control” switch is in the “External” position, apply a DC voltage (0-10V) to the BNC input at the front panel. The output RF amplitude will be changed immediately.

The output RF voltage amplitude depends on the attached load and frequency. To determine the output RF voltage amplitude, a high impedance high voltage (HV) probe and an oscilloscope should be used.



You must use a high impedance high voltage (HV) probe for output voltage measurements. Only personnel specifically qualified for high voltage jobs can perform HV measurement procedure.

NOTE: If you have several MassTech RF Generators connected to the same computer you have to run a separate instance of the software to control each RF Generator.

5.2 *Tuning the RF Generator to the resonance*

Switch the “Amplitude Control” switch at the rear panel to the “USB” position.

Turn on the RF Generator, wait approximately 1 minute and run the software.

In sweep mode box set start and end values in Hertz for the frequency range of interest.

RF Generator

In sweep mode box set frequency increment in Hertz. The recommended value for frequency step is 500 Hz.

Set the amplitude level in the Normal mode box to 50 arbitrary units.

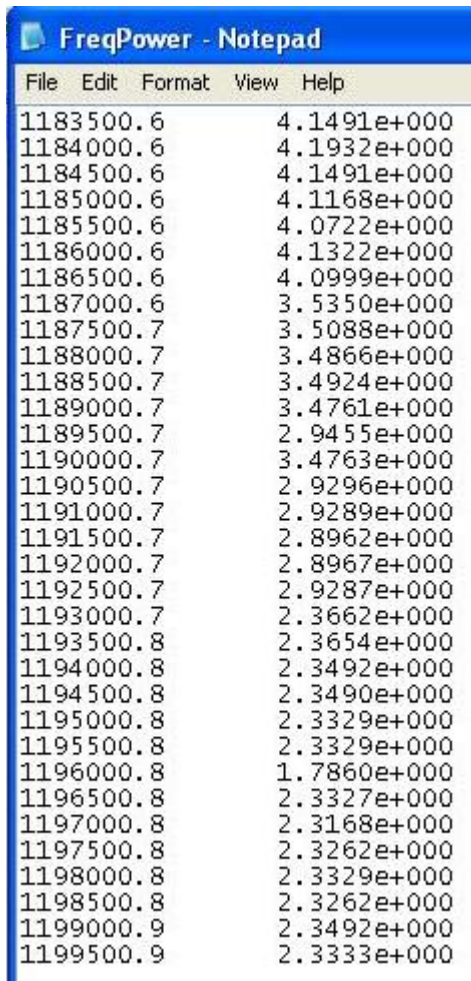
Check “ON/OFF” box in the normal mode box.

Press “SET” button in the normal mode box.

Press “START” button in the sweep mode box.

Now software subsequently changes operating frequency measuring power consumption at each frequency value. The currently used frequency is shown in “Frequency” field in the Normal mode box. The measured power consumption (in Watts) is shown in the “POWER” field.

After software finished tuning procedure, file “FreqPower.txt” will be generated in the same folder where executable file located.



File	Edit	Format	View	Help
1183500.6		4.1491e+000		
1184000.6		4.1932e+000		
1184500.6		4.1491e+000		
1185000.6		4.1168e+000		
1185500.6		4.0722e+000		
1186000.6		4.1322e+000		
1186500.6		4.0999e+000		
1187000.6		3.5350e+000		
1187500.7		3.5088e+000		
1188000.7		3.4866e+000		
1188500.7		3.4924e+000		
1189000.7		3.4761e+000		
1189500.7		2.9455e+000		
1190000.7		3.4763e+000		
1190500.7		2.9296e+000		
1191000.7		2.9289e+000		
1191500.7		2.8962e+000		
1192000.7		2.8967e+000		
1192500.7		2.9287e+000		
1193000.7		2.3662e+000		
1193500.8		2.3654e+000		
1194000.8		2.3492e+000		
1194500.8		2.3490e+000		
1195000.8		2.3329e+000		
1195500.8		2.3329e+000		
1196000.8		1.7860e+000		
1196500.8		2.3327e+000		
1197000.8		2.3168e+000		
1197500.8		2.3262e+000		
1198000.8		2.3329e+000		
1198500.8		2.3262e+000		
1199000.9		2.3492e+000		
1199500.9		2.3333e+000		

Open file “FreqPower.txt” with any text reader, for instance, “Notepad”. This file contains two columns. The frequency (in hertz) is shown in the left column while corresponding power consumption (in Watts) is shown in the right column. The smallest power consumption (usually about 1 W) corresponds to resonant conditions.

To set RF generator to the resonance, manually set the found resonant frequency into the “FREQUENCY” field in the Normal mode box as described in the previous section.

6 MAINTENANCE —TROUBLESHOOTING THE SOURCE.

Maintenance and troubleshooting: The RF Generator does not require special maintenance. It is strongly recommended that you follow the troubleshooting procedures that are described below.



DO NOT ATTEMPT services or repairs that are not covered in this Troubleshooting section. For services and repairs beyond those specifically provided in the Troubleshooting section, contact the manufacturer, MassTech, Inc. 6992 Columbia Gateway Dr, Columbia, MD, 21046; tel. (443)539-1758

The RF Generator is supplied ready for installation and operation. Still there are several reasons why the RF output signal might be different from the expected one. The following sections describe possible symptoms with their remedies.



You must use high impedance high voltage (HV) probe for output voltage measurements. Only personnel specifically qualified for high voltage jobs can perform HV measurement procedure.

6.1 **PROBLEM: Insufficient amplitude of the output RF voltage.**

1. Switch the “Amplitude Control” switch at the rear panel to the “USB” position.
2. Run the software and check the power consumed by the RF Generator.
3. If it is too high then the working frequency may be out of the resonance. Please refer to Section 5.2 for the procedure for tuning the RF Generator to the resonance.

If these actions do not help, call MassTech for assistance.

6.2 **PROBLEM: No output RF voltage**

1. If the Power LED is not lit at the front panel then replace the fuse, and check AC voltage. Turn on the RF Generator and check the output again.
2. If the “Amplitude Control” switch at the rear panel is in the “External” position then make sure that the control cable is attached to the “Control 0-10 V In” connector and a positive voltage is applied in the 0-10 V range.

3. If the “Amplitude Control” switch at the rear panel is in the “USB” position then quit and start again the software. Make sure that the output voltage is set at more than 0 (typically from 1-200) and the ON/OFF check box is checked.

If these actions do not help, call MassTech for assistance.

6.3 ***PROBLEM: Uncontrolled output RF voltage.***

1. If the “Amplitude Control” switch at the rear panel is in the “External” position then make sure that the control cable is attached to the “Control 0-10 V In” connector and a positive voltage is applied in the 0-10 V range. Change the control voltage and check whether the RF output voltage changed as well.
2. If the “Amplitude Control” switch at the rear panel is in the “USB” position then quit and start again the software. Make sure that the output voltage is set at more than 0 (typically from 1-200). Change the set voltage and check whether the RF output voltage changed as well.
3. Check the power consumed by the RF Generator. If it is too high then the working frequency may be out of the resonance. Please refer to Section 5.2 for the procedure for tuning the RF Generator to the resonance.

If these actions do not help, call MassTech for assistance.

6.4 ***PROBLEM: High consumed energy.***

Only personnel specifically qualified for high voltage jobs can ignore the following safety rules:

- Never defeat or bypass interlocks
 - Never switch the Power ON at the rear panel unless the RF Generator is properly installed
1. The working frequency may be out of the resonance. Please refer to Section 5.2 for the procedure for tuning the RF Generator to the resonance.

If this action does not help, call MassTech for assistance.

6.5 ***PROBLEM: The resonant frequency is not in a desired range.***



Only personnel specifically qualified for high voltage jobs can do the troubleshooting work below.

- **Never** defeat or bypass interlocks.
- **Never** switch the Power ON at the rear panel unless the cover is replaced back and the RF Generator is properly installed.



1. Replacing the internal load capacitor C (see Figure 2-1) may solve the problem. Note the current frequency. The resonance frequency is determined by the following formula:

$$F_{res} = \frac{1}{2\pi\sqrt{L(C + C_{quad})}}$$

where C_{quad} is a capacitance of the quadrupole/multipole rods which is typically equal to 10-70 pF.

2. Turn OFF the RF Generator and UNPLUG the power cord from the AC socket.
3. Open the top cover using a screwdriver. Check the value of the capacitor C on the PCB (see Fig. 6-1). Recalculate the new value of C_{new} based on the formula below (followed from the formula above) so the new frequency F_{new} is in the desired range:

$$C_{new} = (C_{old} + C_{quad}) \left(\frac{F_{old}}{F_{new}} \right)^2 - C_{quad}$$

where C_{old} and F_{old} are the “old” capacitor and the resonant frequency, respectively.

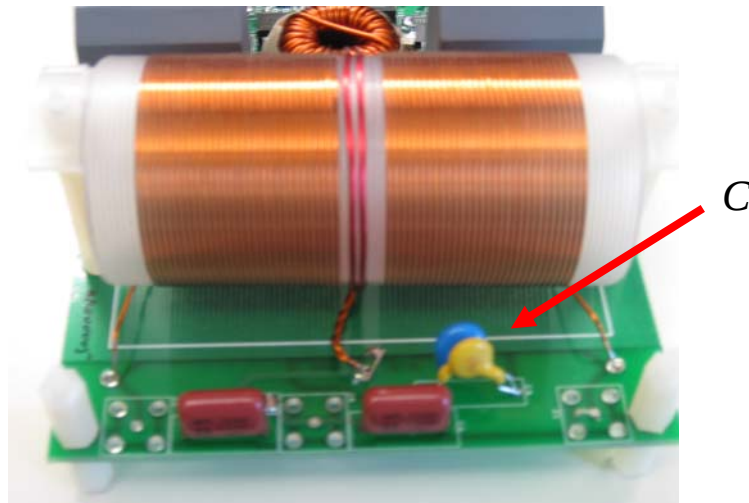


Fig. 6-1. The capacitor C affecting the output resonant frequency (make sure it is rated for at least 3 kV).



4. Using a soldering iron replace the capacitor C for the new one which value is close to that calculated in the previous step 3. **Make sure that the new capacitor is rated for at least 3 kV.**
5. Check that no additional conductors or parts are electrically shorted as a result of replacing/soldering. Replace back the cover securely. Reconnect the power cord.

Never switch the power ON at the rear panel of the RF Generator before the cover of the RF Generator is replaced securely back and it is completely installed.

6. Turn the power ON. Tune the RF Generator to the resonance according to the procedure in section 5.2.

If these actions do not help, call MassTech for assistance.

We are ready to provide you any technical assistance! Call us at (443) 539 1758 or e-mail the problem to: support@apmaldi.com

7 Warranty Information – Six month limited warranty.

MassTech, Inc. provides to the original purchaser the following limited warranty from date of invoice.

MassTech, Inc. warrants each RF Generator instrument and its components to be free from defects in material and workmanship. Liability under this warranty covers servicing of the instrument when returned from the customer's facility within the United States pre-paid to our factory. MassTech, Inc. will repair any component(s) or part(s) that it finds to be defective during the period of this limited warranty, which is six months from the date of invoice. Should a defect become apparent, the original purchaser must first notify MassTech, Inc. at (443) 539-1758 of the suspected defect and request a Return Merchandise Authorization number (RMA#). The instrument (or suspect components) should be carefully packaged in the original container (if the original shipping container has been lost, trashed, or damaged, another one must be purchased from MassTech, Inc. prior to shipping). Then, mark the original container with the RMA#, and ship prepaid to:

MassTech, Inc.
6992 Columbia Gateway Dr
Columbia, MD, 21046
Attn: Service Dept.

The instrument will be repaired in the shortest possible time and returned prepaid by the same shipping method as received by the factory. During the warranty period, no charge will be made to you for parts, service, or labor.

This limited warranty is void if the instrument has been damaged by accident, misuse, negligence, act of God, or serviced by any other person not authorized by MassTech, Inc. The warranty also does not apply to units that have had the serial lot number altered, defaced or removed.

This limited warranty contains the entire obligation of MassTech, Inc. and no other warranties expressed, implied, or statutory are given. No representative or employee of MassTech, Inc. is authorized to assume any further liability or grant any further warranties except as set herein.

MassTech, Inc. disclaims liability for indirect, incidental or consequential damages. Exclusion or limitation of incidental or consequential damages are not permitted by some states and this limitation or exclusion may not apply to you. Warranty rights vary from state to state; and, therefore, you may have other rights in addition to those provided by this warranty.