RF Power Supply

Version 5.0

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1.0 Packing List

1.1 Packing List for PSRF-128 RF Power Supply

The PSRF-128 RF Power Supply is shipped with the following items:

Table 1. PSRF-128 RF Power Supply Packing List

Quantity	Part Number	Description
1	PSRF_128_SING	RF Power Supply Controller.
1	PSRF_128_High-Q_Head	RF Power Supply Module with single pair of RF outputs
1	CABL_DB25_22AWG	DB25 cable to connect the controller to the High-Q Head
1	PSRF_128_MAN	PSRF-128 Operators Manual.
1	CABL_POW_110AC_10FT	Universal AC power cable for US use, 10 feet long.
2	CABL_RG62_36IN_MHV	RG-62 Coaxial Cable with two MHV connectors, 3 foot length. Nominal capacitance 44 pF per cable, 22 pF for parallel pair.

1.2 Optional Cables and Components

The following list of optional cables and components are compatible with the PSRF-128.

Table 2. PSRF-128 Optional Components

Quantity	Part Number	Description
1	CABL_RG62_12IN_MHV	RG-62 Coaxial Cable with two MHV connectors. One foot length. Nominal capacitance 15 pF per cable, 7.5 pF for parallel pair.
1	CABL_RG62_24IN_MHV	RG-62 Coaxial Cable with two MHV connectors. Two foot length. Nominal capacitance 30 pF per cable, 15 pF for parallel pair.
1	CABL_RG62_36IN_MB	RG-62 Coaxial Cable with one MHV connector and one BNC connector, 3 foot length. Nominal capacitance 44 pF per cable, 22 pF for parallel pair.
1	CABL_RG62_36IN_SHV	RG-62 Coaxial Cable with two SHV connectors, 3 foot length. Nominal capacitance 44 pF per cable, 22 pF for parallel pair.

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2.0 Product Identification

In all communication with Ardara Technologies, please specify the information that is in the nameplate at the upper left hand corner of the back panel of the electronics module, including the serial number.

3.0 Scope of Manual

This manual applies to the Ardara Technologies RF power supplies identified as PSRF-128 in the upper left hand corner of the box.

This document is valid as of the date of publication. We reserve the right to make technical changes to the design.

As this design of RF power supply is customizable, please refer to the markings on the left hand side of the back panel for specific frequencies, voltage outputs, and capacitance loads for a given RF Power Supply unit.

In this manual, the terms PSRF-128 and RF Power Supply are used interchangeably.

4.0 Intended Use

The Ardara Technologies PSRF-128 series of high frequency RF power supplies were designed to provide an easy-to-install self-oscillating RF power supply for powering RF-only ion guides for use in custom mass spectrometer systems.

The PSRF-128 is compatible with a wide variety of capacitive loads (20 pF to 360 pF using the standard configuration, but extendable to over 1000 pF with minor factory modifications).

This supported capacitance range allows its use for rf-only quadrupoles, hexapoles, and octopoles, of varying lengths, from centimeters through meters.

Because the design is self-oscillating (i.e. there is no crystal to fix the frequency), the PSRF-128 can self-resonate on a variety of loads, with no user intervention required, no matching networks, no tuning procedures.

The PSRF-128 features an available vacuum interlock input on its back panel, which is designed to disable the RF voltage output under conditions where the vacuum pressure is too high for safe operation.

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5.0 Safety

This RF power supply is capable of generating lethal voltages. Care must be taken to ensure safety in use.

5.1 Input Power

This RF power supply is equipped with a universal input AC power connection, which requires that the power cord ground connection be connected to earth ground through a properly wired AC outlet to ensure safe operation. The use of a 'ground isolator' or similar device is prohibited for safe operation.

The AC power input is compatible with worldwide AC power, from 100 to 240 VAC, and 50-60 Hz.

5.2 Custom Output Connections

Use only approved high voltage cables and connectors, which are rated to the voltages in use.

It is often the case that this RF power supply is used to replace another in an existing application. Be sure to review the voltage ratings of the cables and vacuum feedthrus in use to verify compatibility with high voltages possible from this RF supply.

For example, MHV and SHV connectors are rated to 5kV DC, and can generally be used beyond 2 kV peak-to-peak for RF applications. These connectors are compatible with the full output power of the PSRF-128 (2,500 volts-peak-to-peak). The PSRF-128 is delivered with MHV cables and connectors.

However, often, end users intend to use an existing multi-pin connector, which are typically rated to 700-800 volts DC. Connection of the PSRF-128 to such a connector at full power output will lead to unsafe operation, with potential for discharge.

If it is determined that the rating of the connector to be used is less than the potential RF output voltage, then it is recommended that the unit be returned to Ardara Technologies for de-rating or the RF amplitude limit dial to be set accordingly, to limit the output voltage to a safe level.

The de-rating of the power supply involves reducing the gain of the RF output stages, and re-calibrating the front-panel voltmeter.

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5.3 Vacuum Pressure Considerations

The PSRF-128 is often used to power pressurized RF-only ion guides. One challenge to operating pressurized high voltage devices is the impact of gas pressure on the voltage discharge limit.

At high vacuum (10^{-5} torr and below) and at atmospheric pressure and above, devices can tolerate quite high voltage gradients with very small electrode gaps.

However, for intermediate pressures (10^{-2} torr to 1 torr), the tolerance to high voltage gradients is dramatically reduced, resulting in discharges (i.e. glow discharge) which can damage the device as well as damage the power supplies driving it. This phenomenon is described in the literature using the Paschen Curve.

If the intended use for this RF power supply is to drive devices at or near this glow discharge limit, please contact the factory for de-rating of the power supply to limit its output voltage to a safe level.

The vacuum interlock feature of this RF power supply was designed to be utilized in conjunction with a vacuum gauge that features a contact closure output when the measured pressure is below a given setpoint. It is recommended that this feature of the RF power supply be implemented to ensure safe operation.

6.0 Liability and Warranty

Ardara Technologies assumes no liability and the warranty becomes null and void if the end user or third parties:

- Disregard the information in this manual
- Use the product in a non-conforming manner
- Make any kind of changes (modifications, alterations, etc.) to the RF Power Supply
- Use the product with accessories not listed in the corresponding product documentation

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7.0 Product Overview

7.1 Summary

The PSRF-128 RF power supply product line was developed to address the need in the marketplace for a stable, easy-to-use single polarity RF power supply for use with ion trap.

The design is based on a self-oscillating circuit, which automatically adjusts the output frequency to the capacitive load presented to the RF output connectors.

As such, this RF power supply design is compatible with a wide range of capacitive loads (20 pF to 360 pF with standard configuration, >1000 pF with a custom modified version), resulting in a corresponding frequency range from 1.8 MHz to 700 kHz. See the last section of this manual for typical capacitance-frequency performance.

An optional configuration allows for stable operation to frequencies as high as 4.0 MHz with a 50 pF capacitive load.

A single 0 to +10 volt command signal results in generation of a high voltage RF output, with peak-to-peak voltages as high as 4,000 volts.

A BNC connector on the back panel to provide the pole bias offset. This BNC connector has an internal 10k pull down resistor to ground to ensure safe operation even when there is no external pole bias offset connected. This pole bias offset can be pulsed, although the response of the circuit will be adversely affected by the additional time constant from this pull down resistor.

The unit has a vacuum interlock connector on the back panel, which allows an external contact closure to enable or disable the RF high voltage. This feature is compatible with ionization gauge pressure transducers with vacuum interlock outputs, and allows the RF power supply to be put into a safe state if there is not adequate vacuum. This feature can also be used to turn RF on and off remotely, by applying a 5 volt signal to pin 2 of this connector.

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7.2 Front Panel Controls

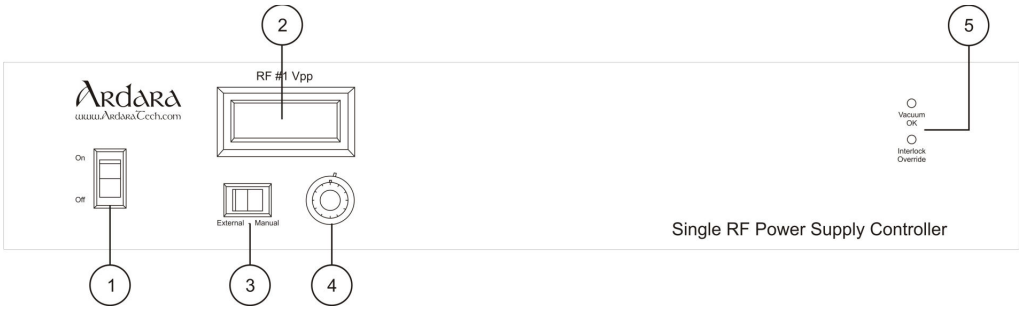

Figure 1. Front Panel controls for RF Power Supply.

Table 3. PSRF-128 RF Power Supply Front Panel Controls

Balloon Number	Function	Description
1	On / Off Power Switch	Lighted power switch that enables AC power for the RF power supply.
2	Front Panel Meter	Displays actual peak-to-peak or zero-to-peak RF voltage in volts. See details in upper left corner of the back panel to determine whether the system is configured to display peak-to-peak or zero-to-peak voltage.
3	External / Manual Switch	Selects which zero-to-plus-five volt command controls RF amplitude. When 'External' command is selected, the RF amplitude is controlled via the voltage applied to pin 1 of the External Command DB9 connector on the back panel. When Manual command is selected, the potentiometer (balloon #3 in the figure above) controls the RF amplitude.
4	Manual Command Potentiometer	Ten turn potentiometer that controls the RF amplitude when the External / Manual switch is set to 'Manual'.
5	Vacuum OK and Interlock Override LEDs	Lit LEDs indicate if Vacuum OK has a contact closure through the Vacuum Interlock DB9 and if the Vacuum Interlock switch is set to Interlock Override.

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7.3 Back Panel Controls

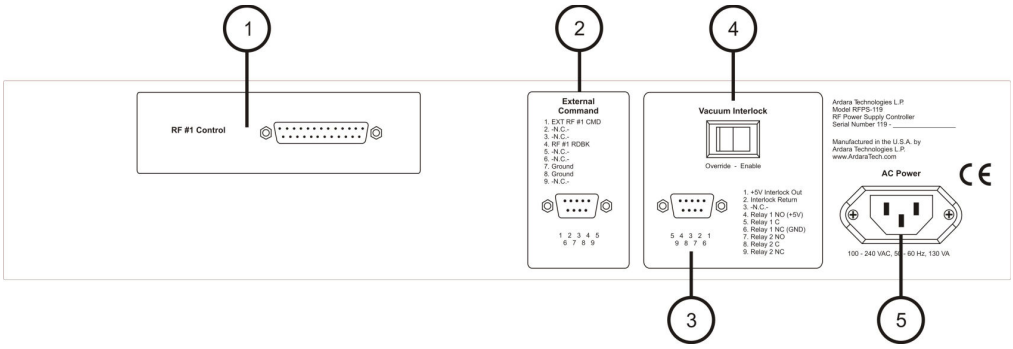

Figure 3. Back Panel controls for RF Power Supply.

Table 4. PSRF-128 RF Power Supply Back Panel Controls

Balloon Number	Function	Description
1	RF #1 Control Connector	Female DB-25 connector which will be needed to connect to the High-Q Head for RF #1 via a DB-25 Male-Female cable.
2	External Control Input	Male DB9 connector which allows external RF amplitude commands, as well as RF amplitude readbacks. To command RF amplitude, an externally generated zero-to-plus-5 voltage is applied to pin 1. RF amplitude can be read back on pin 4. Typical: 2.0 volts = 2,000 Vpp. Pins 7 and 8 are ground.
3	Vacuum Interlock Connector	Female DB-9 connector to allow control of the vacuum interlock. See Vacuum Interlock Control below for pinout.
4	Vacuum Interlock Control	Controls the vacuum interlock feature. When set to 'Override', the RF voltage is always enabled when AC power is turned on. When set to 'Enable', RF voltage is enabled only when +5 volts from an outside source is presented to pin 2 of the Vacuum Interlock Connector (female DB-9). For convenience, a plus-five-volt source is provided on pin 1, suitable for use with an ion gauge controller which has a contact closure output when a suitable pressure is established. A +5V signal present at pin 2 energizes two relays (#1 and #2) The RF supply utilizes relay #1 internally, with pins 4, 5, and 6 available for diagnostics purposes. Relay #2 is available to echo the contact closure status, allowing the unit to daisy chain the vacuum interlock contact closure to other devices. The vacuum interlock relays used in this device support DC operation to 24 volts.
5	Universal AC Power Input	100 to 240 VAC, 50-60 Hz universal power input.
*	RF Output A & B	MHV connectors which supply the RF output.

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*	Test Load A & B	MHV connectors which supply the RF outputs a test load to allow internal testing of the power supply. See Technical Data (page 16) for test procedure.
*	DC Offset Bias Input	With the use of a High-Q Head this feature resides on the High-Q Head. Molex Mini-fit Jr. 4-pin connector to allow externally generated –500 to +500 volt pole bias offset voltage to drive the DC offset of the RF power supply output.
*	Bias Test Point	With the use of a High-Q Head this feature resides on the High-Q Head. Test Point to measure the power supply's Bias setting.
*	RF Amplitude Limit	With the use of a High-Q Head this feature resides on the High-Q Head. Ten turn potentiometer that controls the maximum RF amplitude provided by the RF power supply. Full counter-clockwise will provide maximum voltage with a 5V command.

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7.4 High-Q Head Controls

The High-Q Head has six potentiometers (RF Gain, RF Bias, RF Clamp, RF Offset, and RF RDBK Gain) on its top panel. These are set at the factory and should not be changed unless as a last resort to troubleshoot the RF power supply.

The RF Gain potentiometer allows control of the output gain of the RF Drive circuit, optimizing the RF supply for stable operation. The RF Gain potentiometer is a factory adjustment only, as improper adjustment can lead to instabilities in RF amplitude.

In the event that the power supply is not functioning throughout the whole desired range or at all, the RF Bias can be adjusted. Turning the potentiometer counter-clockwise will increase the Bias voltage. The RF Bias voltage can be read from the Bias Test Point. Typically the RF Bias voltage is between 3.8 and 4.5 volts. If the RF Bias is too small the RF supply will not turn on, however if the RF Bias is too large the RF output amplitude might become unstable.

The RF Clamp potentiometer is factory set to limit the RF output capability of the RF supply transistors, and should not be modified in the field.

The RF Offset potentiometer scales the zero point of the RF power supply. It is set at the factory to yield a zero volt output when no signal is measured at the RF output cables.

The RF RDBK Gain potentiometer scales the RF readback output signal. It is typically set at the factory to yield a two volt output with a 2,000 volt peak-to-peak signal at the RF output cables, as measured using a pair of 100X oscilloscope probes and an oscilloscope.

7.5 Test Load Procedure

The Test Load is provided to allow the RF power supply to be tested without anything else attached. With the RF power supply turned off, connect the RF Output to the Test Load with the RF cables. Switch the front panel External / Manual switch to Manual mode and make sure that the RF command is set to 10.0 and the RF Amplitude Limit is set to full counter-clockwise. Turn on the RF power supply and the RF Output front panel meter should read about the +5 VDC Command voltage that is stated on the High-Q Head.

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8.0 Installation

8.1 Installing the RF Power Supply

Installation of the PSRF-128 RF power supply is fairly straightforward, as long as the following conditions are followed:

- Do not obstruct the airflow to the back panel cooling fan which blows air across the internal DC power supplies.
- Do not operate the RF power supply in an environment that is subject to dust, high humidity, or mechanical vibrations.
- The RF power supply can be mounted onto almost any surface, although it is recommended that the distance to the RF vacuum flange be minimized to minimize the cable length and hence its capacitive load.

8.2 Electrical Connections

8.2.1 AC Power Input

The RF power supply box is connected to ground via the ground connection in the three-pronged AC power cable.

- It is not safe to operate the RF power supply using a 'ground isolator' or three-prong to two-prong converter.
- Use only approved high voltage cables and connectors, which are rated to the maximum output voltage of the RF power supply.

8.2.2 High-Q Head Conntections

All RF connections typically MHV on the RF power supply should be made with the power supply turned off. The DB25 cable connects the controller to the head.

8.2.3 Pole Bias Offset Input on the High-Q Head

The pole bias offset input connection is rated to +/- 500 volts. This input controls the centerline DC offset potential of the RF-only ion guide. This input is compatible with most DC optics supplies, and can also be pulsed.

8.2.4 External Control Input

The RF amplitude can be controlled via external command connected to pin 1 on the back panel male DB9 External Control Input, with RF readback measured from pin 4 of this connector.

8.2.5 Vacuum Interlock Input

The vacuum interlock feature of this power supply should be implemented by constructing a cable that brings the +5 V command from pin 1 of the back panel female DB9 vacuum interlock connector out to the vacuum interlock contact closure from an ionization gauge controller, bringing the contact closure output back to pin 2 of the back panel vacuum interlock connector.

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9.0 Commissioning

The PSRF-128 RF power supply will self-resonate with a wide variety of capacitive loads (typically 20 pF to 360 pF). Once the RF power supply is powered on, it will automatically adjust its operating frequency to match the capacitive load.

For initial operation, it is recommended that the following procedure be followed:

- Set the front panel switch to manual mode
- Set the front panel potentiometer control to full counter-clockwise (zero reading on the dial).
- Set the back panel Vacuum Interlock switch to Override.
- Making sure that there is suitably low vacuum, slowly turn the front panel potentiometer clockwise, and observe the voltage readout on the front panel voltmeter. The front panel meter will indicate peak-to-peak RF output voltage. The customized settings for a given RF supply are identified in the upper left hand corner of the back panel.
- As the front panel command voltage is increased, verify that the resulting output voltage indicated on the front panel meter increases linearly (i.e. 1.0 on the dial should yield 1/10 the maximum voltage on the meter, 5.0 on the dial should yield 1/2 the maximum voltage on the meter).
- Contact the Ardara Technologies Technical Support if the power supply fails to reach the appropriate maximum voltage.
- If the displayed power supply output voltage appears erratic at higher voltage commands, then there may be some discharging happening external to the power supply, likely due to operation at too high a pressure, with too high a voltage, for electrodes which are too close to each other or to ground. Verify that the RF power supply can reach its full voltage stably with no connection to the vacuum flange.
- Note that the voltage display is designed to be linear with the command, but is reproducibly non-linear with peak-to-peak output voltage. Each unit has its display voltage calibrated to match the peak-to-peak voltage output as measured using an oscilloscope with a 100 X probe on the output. The last section of this manual illustrates typical measured voltages for various voltage commands.

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10.0 Maintenance and Care

Under normal operating conditions, the RF power supply does not require maintenance.

10.1 External Cleaning

Use a slightly moist cloth to clean the outside of the RF power supply. Aggressive scouring or cleaning agents might damage the painted surfaces.

10.2 Internal Cleaning

Under normal operating conditions, there should be no need to clean the inside of the RF power supply.

11.0 Technical Data

11.1 Dimensions

Table 8. PSRF-128 Dimensions

Description	Dimension
Box dimensions (WxHxD)	Rack mount front panel
	19 x 3.5 x 15 inches
Power Cable length	10 feet (removable)
RF output Cable Length	3 feet (removable)
DB25 Cable Length	10 feet (removable)
Weight (with cables)	13 lbs.
Shipping Weight	15 lbs.

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12.0 Typical Performance Data

The following tables illustrate typical measured performance for a few different PSRF-128 RF power supplies operated under a variety of capacitive loads. This data is provided as an example of typical performance.

Note that the front panel voltage display follows the command voltage linearly, but the actual peak-to-peak voltage (as measured using an analog oscilloscope with a 100X probe) has a reproducible non-linear response to the command voltage, but is calibrated to match the display voltage at the peak voltage output.

Table 10. Typical PSRF-128 performance at different capacitive loads at the end of three foot cables set at maximum command where +5V command = 1570 Vpp, with Standard Coil. All values are in peak-to-peak voltage.

Capacitive Load	Output Voltage MAX	Frequency
10 pf	1.57 kV	2.02 MHz
20 pf	1.57 kV	1.86 MHz
30 pf	1.57 kV	1.72 MHz
40 pf	1.57 kV	1.62 MHz
50 pf	1.57 kV	1.53 MHz
60 pf	1.57 kV	1.45 MHz
70 pf	1.57 kV	1.39 MHz
80 pf	1.57 kV	1.33 MHz
90 pf	1.57 kV	1.28 MHz
100 pf	1.57 kV	1.24 MHz

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