Model 129 Quadrupole Power Supply Controller Manual

Version 1.4

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1.0 Packing List

1.1 Packing List for QPS-129 Power Supply

The QPS-129 Power Supply is shipped with the following items:

Table 1. QPS-129 Power Supply Packing List

Quantity	Part Number	Description
1	QPS-129	Quadrupole Power Supply Module
1	PSRF-118-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	CABL_BNC_MXSOCK_BNC_10FT_01	(2) BNC cables to a 4 pin Molex Mini-Fit Jr. connector that connects the DC Offset voltage to the High-Q Head.
1	QPS-129-MAN	QPS Operators Manual
1	CABL_POW_110AC_10FT	Universal AC power cable for US use, 10 feet long.
2	CABL_RG62_36IN_SHV	RG-62 Coaxial Cable with SHV to SHV connectors. Three 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 QPS-129.

Table 2. QPS-129 Optional Components

Quantity	Part Number	Description
1	CABL_RG62_12IN_SHV	RG-62 Coaxial Cable with MHV to SHV connectors. One foot length. Nominal capacitance 15 pF per cable, 7.5 pF for parallel pair.
1	CABL_RG62_24IN_SHV	RG-62 Coaxial Cable with MHV to SHV connectors. Two foot length. Nominal capacitance 30 pF per cable, 15 pF for parallel pair.
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_MHV	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.

2.0 Product Identification

In all communication with Ardara Technologies, please specify the information that is on the nameplate at the right side of the back panel of the electronics module, including the serial number.

3.0 Scope of Manual

This manual applies to the Ardara Technologies Quadrupole power supplies identified as QPS-129 on the right side of the back panel of the box, which includes the products with the front panel labels: 'Quadrupole Power Supply'.

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 Quadrupole 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 output of the Quadrupole Power Supply unit.

In this manual, the terms QPS-129 and Quadrupole Power Supply are used interchangeably.

4.0 Intended Use

The Ardara Technologies QPS-129 series of high frequency RF Quadrupole power supplies were designed to provide an easy-to-install crystal-fixed frequency RF power supply for powering quadrupoles for use in custom mass spectrometer systems.

The QPS-129 is compatible with a wide variety of capacitive loads (20 pF to 360 pF using the standard configuration). This supported capacitance range allows its use for quadrupoles of varying lengths, from centimeters through meters.

Because the design has a crystal to fix the frequency, the QPS-129 has a tuning capacitor that allows for a range of 10 pF to resonate with the desired load.

The QPS-129 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.

5.0 Safety

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

5.1 Input Power

This quadrupole 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 quadrupole 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 7 kV peak-to-peak for RF applications. These connectors are compatible with the full output power of the QPS-129 (4,000 – 4,500 volts-peak-to-peak). The QPS-129 is delivered with SHV to SHV 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 QPS-129 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 Quadrupole Power Supply RF output stages, and re-calibrating the front-panel voltmeter.

5.3 Vacuum Pressure Considerations

While the QPS-129 can be used to power pressurized ion guides, it is not recommended to do so. One challenge if the quadrupole power supply is used in resolving mode in pressurized situations would be that the gas load would cause ion scattering and a significant loss of ion signal would occur. Another 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 quadrupole 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 quadrupole 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 set point. It is recommended that this feature of the quadrupole 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 Quadrupole Power Supply
- Use the product with accessories not listed in the corresponding product documentation

7.0 Product Overview

7.1 Summary

The QPS-129 quadrupole power supply product line was developed to address the need in the marketplace for a stable, easy-to-use quadrupole power supply.

The design is based on a crystal-fixed frequency circuit, which will need to be tuned to the load via adjustable and fixed capacitors.

As such, this Quadrupole 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.

The four front panel potentiometers, control the voltages for resolving RF (Mass), Pole Bias Offset, Low Mass Resolution and High Mass Resolutions. The Pole Bias ranges from -50 to +50 VDC, with 0 VDC being set at 5 on the potentiometer dial.

For the RF outputs, a single 0 to +5 volt command signal results in generation of a pair of high voltage RF outputs which are 180 degrees out of phase with each other, with peak-to-peak voltages as high as 4,500 volts.

There is a male DB-15 connector on the back panel to provide external commands for Mass Command, Low Mass Resolution Command, Pole Bias Offset Command, and RF Mode TTL. Mass Commands are given through pin 1, with typical values being 500mV = 100 amu. Mass Read back is taken from pin 15 (typically 2.0 V = 2,000 Vpp). Low Mass Resolution Command can be altered by the voltage (-10 V to 10 V) applied to pin 4. The Pole Bias Offset Command is given through pin 2, 10V = 50 VDC. The Pole Bias Offset Read Back is taken from pin 6 (0.5 V = 50 VDC). This pole bias offset can be pulsed, although the response of the circuit will be adversely affected by the additional time constant from a pull down resistor that is in the circuit. The RF Mode TTL (Pin 3) determines the state that the quadrupole power supply is in. At a low (0V) command the power supply will be in RF only mode, while at a high (5V) command it will run in Resolving mode.

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 quadrupole power supply to be put into a safe state if there is not adequate vacuum. This feature can also be used to turn voltages on and off remotely, by applying a 5 volt signal to pin 2 of this connector.

7.2 Front Panel Controls

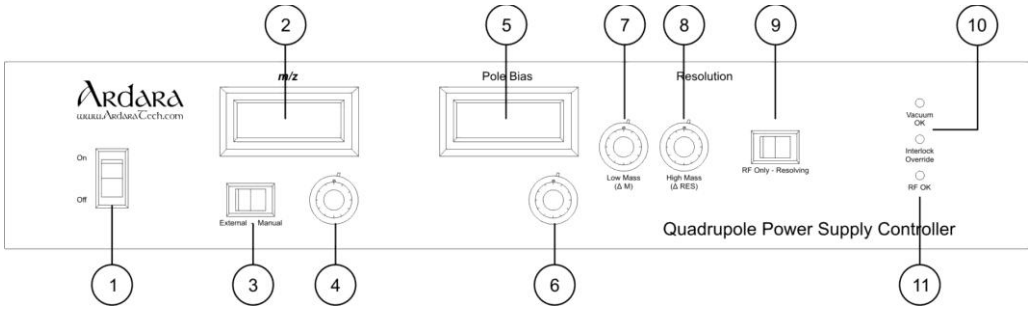

Figure 1. Front Panel controls for Quadrupole Power Supply.

Table 3. Quadrupole Power Supply Front Panel Controls

Balloon Number	Function	Description
1	On / Off Power Switch	Lighted power switch that enables AC power for the Quadrupole Power Supply
2	Mass Front Panel Meter	Displays mass value that the Quadrupole Power Supply is set to allow to pass through the device. This meter has two points for calibration that are located on the inner box.
3	External / Manual Switch	When 'External' command is selected, the Mass Command and RF Mode is controlled via the voltages applied to the External Command DB9 connector on the back panel. When Manual command is selected, the front panel potentiometers and switches can be used to control voltages and modes.
4	Mass Command Potentiometer	Ten turn potentiometer that controls the RF amplitude when the External / Manual switch is set to 'Manual'.
5	Pole Bias Offset Front Panel Meter	Displays the pole bias offset voltage to drive the DC offset of the Quadrupole power supply.
6	Pole Bias Offset Command Potentiometer	Ten turn potentiometer that controls Pole Bias Offset. This value is added to the value that is supplied externally through the External Command DB9 connector.
7	Resolution (Low Mass) Command Potentiometer	Ten turn potentiometer that controls the Low Mass Resolution Command when the Resolving Mode switch is set to 'Resolving'.
8	Resolution (High Mass) Command Potentiometer	Ten turn potentiometer that controls the High Mass Command Resolution when the Resolving Mode switch is set to 'Resolving'.
9	RF-Only and Resolving Mode Switch	Switches between Ion Guiding RF and Resolving DC voltages or only Ion Guiding RF Voltages.
10	Vacuum OK and Interlock Override LEDs	The Vacuum OK LED indicates that the Vacuum Interlock is receiving +5V from an outside source and is presented to pin 2 of the Vacuum Interlock Connector (female DB-9). The Interlock Override LED indicates that the Vacuum Interlock Control is set to 'Override' and the voltages are always enabled when AC power is turned on.
11	RF OK	Indicates that the RF output is stable at the command state.

7.3 Back Panel Controls

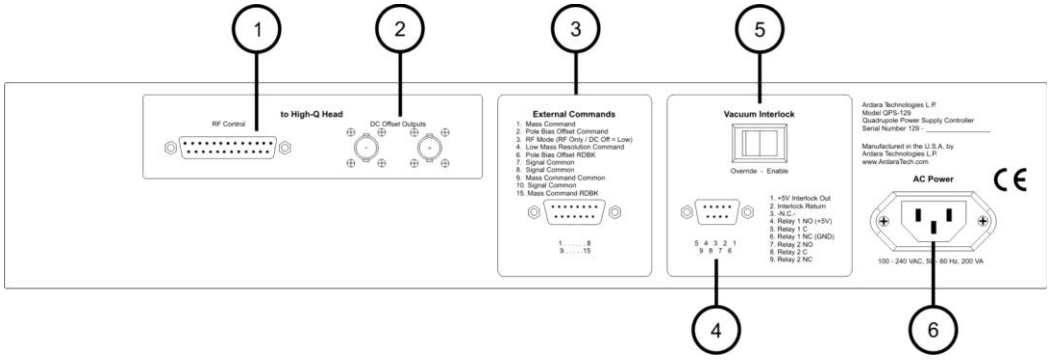

Figure 2. Back Panel controls for Quadrupole Power Supply.

Table 4. Quadrupole Power Supply Back Panel Controls

Balloon Number	Function	Description
1	High-Q Head Control Connector	Female DB-25 connector which will be needed to connect to the High-Q Head via a DB-25 Male-Female cable. It is recommended to only use the provided DB-25 since it is made with 22 gauge wire opposed to the standard 24 gauge wire.
2	DC Offset Outputs	2 BNC connectors designated for the (+) / (-) phases of the RF output. These two BNCs must be connected to the High-Q Head for the resolving DC to be added onto the device.
3	External Control Input	Male DB15 connector which allows external Mass Command, Low Mass Resolution Command, Pole Bias Offset Command, and RF Mode Command. Mass Command is controlled via pin 1. Typical: 500 mV = 100 amu Pole Bias Offset Command is controlled via pin 2. RF Mode is controlled via pin 3. (Low = RF Only; High = Resolving) Low Mass Resolution Command is changed by a voltage applied to pin 4. Pole Bias Readback is measured via pin 6. Typical: 0.5V = 50V Mass Readback is given from pin 15. Typical: 100 mV = 50 amu Pins 7, 8, and 10 are Signal Common. Pin 9 is Mass Command Common.
4	Vacuum Interlock Connector	Female DB-9 connector to allow control of the vacuum interlock. See Vacuum Interlock Control below for pinout.

5	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.
6	Universal AC Power Input	100 to 240 VAC, 50-60 Hz universal power input.
*	Manual Command RF Amplitude Limit Potentiometer	Potentiometer that will allow the manual command voltge to be limited to a safe voltage.
*	RF Output A and B	SHV connectors which supply both phases of the RF output.
*	Test Load Output A and B	SHV connector which supplies a connection to the test load. See Technical Data (page 11) for test procedure.

7.4 High-Q Head Controls

The inner box has five potentiometers (RF Gain, RF Clamp, Zero Correction, RF RDBK, and RF Command Limit) on the left side of the 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.

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 Zero Correction 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 potentiometer scales the RF readback output signal. It is typically set at the factory to yield a two volt output corresponding to m/z 2000. The output will vary according to the configured mass range for the power supply

The potentiometers on the right side of the top panel are to allow the user to linearize the m/z command of the RF power supply via hardware settings. There are two sets in the row of potentiometers. The first five starting at the top are the set points that correspond to certain masses. The last six provide the degree of change at each set point; where the first one is above the first set point and the rest are below the corresponding set points. The potentiometers are arranged from top to bottom to affect the high to low m/z respectively. While these potentiometers will be set at the factory, the user may find that the final setup may cause the command to be non-linear. Adjustments can be made to the potentiometers to correct for any error in the mass range.

Another feature on the top panel is the Tuning Meter. For the power supply to work correctly the correct capacitive load must be attached to the power supply. A variable capacitor is provided on the front panel of the High-Q Head to adjust the load allowing for the RF power supply to be in resonance. The Tuning Meter provides indication of how close to resonance the power supply is with a particular capacitive load. The RF power supply will work best when it is at peak resonance. The Tuning Meter needle will minimize at peak resonance. See the Commissioning section for the proper resonating procedure.

Other features that are on the front panel are the RF Output connectors (typically SHVs), the Test Load connectors (typically SHVs), and the Pole DC input connector (4-pin Molex Mini-Fit Jr. Connector). The RF Output connectors will need to be attached via cables to the device that the power supply is to drive. The Test Load connectors just have a discrete capacitor across the two connectors. This capacitive load can be used to mimic/test if the power supply is working

properly by itself. See section 7.4 Test Load Procedure for directions to perform the self-test. The Pole DC input must be connected to the BNC DC Offset connectors that are on the back panel of the QPS Controller. A dual cable is provided for this function.

Lastly on the back panel are the cooling fans and the DB-25 connector. Make sure not to obstruct the cooling fans and to use the provided DB-25 cable to connect the High-Q Head to the controller box.

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 Command Limit is 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.

8.0 Installation

8.1 Installing the Quadrupole Power Supply

Installation of the QPS-129 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 quadrupole power supply in an environment that is subject to dust, high humidity, or mechanical vibrations.
- The quadrupole 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 quadrupole 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 quadrupole 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 quadrupole power supply.
- Make all RF connections with the quadrupole power supply turned off.

8.2.2 External Control Input

The Mass Command can be controlled via external commands connected to pin 1 on the back panel male DB9 External Control Input, with Mass Read Back measured from pin 15. The Pole Bias Offset input connection is rated to +/- 10 volts, where 10 V = 50 VDC. This input controls the centerline DC offset potential of the RF-only ion guide. Pole Bias is controlled by commands connected to pin 2 and has a Read Back on pin 6 of 0.5 V = 50 VDC. The RF Mode is controlled via pin 3 with TTL logic. Low is for RF Only mode and high is for Resolving mode. Low Mass Resolution can be controlled via commands connected to pin 4.

8.2.3 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.

9.0 Commissioning

The QPS-129 quadrupole power supply needs to be resonated to work at maximum efficiency. To achieve the peak resonance the correct capacitive load must be attached to the RF outputs. While the quadrupole power supply was resonated at the factory the final setup may have be different than the one used at the factory. To ensure that the power supply is at the ideal resonance, it is recommended that the following procedure be followed for initial operation:

- Install the power supply at its final location and attach all of the cables.
- Set the front panel switch to manual mode
- Set the front panel potentiometer(s) 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 Mass readout on the front panel voltmeter. The customized settings for a given RF supply are identified in the upper left hand corner of the front panel of the High-Q Head and in the configuration document.
- 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 100 volts on the meter, 5.0 on the dial should yield 500 volts on the meter).
- Once any voltage is applied the Tuning Meter on the High-Q Head should provide feedback on the degree of resonance. The power supply is at peak operation when the Tuning Meter minimizes and the front panel meter is at its maximum. This indicates that the correct capacitance has been added to the device outputs. To adjust the resonance/capacitance, turn the Tuning Capacitor potentiometer on the front panel of the High-Q Head. The Tuning Capacitor has a range of 2 to 10 pF and turning the potentiometer clockwise increases the capacitance. As the potentiometer is turned the Tuning Meter should also change. The position of the potentiometer should be left at the point when the Tuning Meter minimizes. If the Tuning Meter and front panel meter do not coincide in the Tuning Capacitor positioning, use the front panel meter as the indicator.
- For best operation of the power supply the above resonance procedure should be checked at a few m/z commands, starting at a low command and ending at the maximum command. Once the power supply is resonated at the maximum m/z command, the power supply will operate at peak performance.
- Contact the Ardara Technologies Technical Support if the power supply fails to resonate and/or reach the appropriate maximum voltage.

- If the displayed m/z appears erratic at higher voltage commands, then there may be some discharging occuring 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 a connection to the test load.
- Note that the m/z 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 m/z calibrated to match the peak-to-peak voltage output as measured using an oscilloscope with a 100 X probe on the output.
- The Pole Bias meter should read ~0 with a front panel command of 5 on the dial. With the Pole Bias dial set to 10 the meter should provide a ~50.0 V reading and at 0 the meter should read ~-50.0 V.

10.0 Maintenance and Care

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

10.1 External Cleaning

Use a slightly moist cloth to clean the outside of the Quadrupole 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 quadrupole power supply.

11.0 Technical Data

11.1 Dimensions

Table 8. QPS-129 Dimensions

Description	Dimension
Box dimensions (WxHxD)	17.5 x 3.5 x 15.0 inches
	444.5 x 88.9 x 381.0 mm
Front Panel (WxH)	19.0 x 3.5 inches
	482.6 x 88.9 mm
Power Cable length	10 feet (removable)
Control Cable Length	10 feet (removable)
DC Offset Cable Length	10 feet (removable)
RF output Cable Length	3 feet (removable)
Weight (with cables)	17.0 lbs.
Shipping Weight	20.0 lbs.