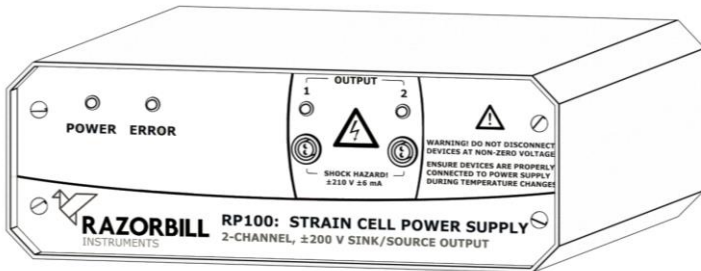


# RP100 Power Supply Manual



The RP100 is a two channel, sink-source power supply designed to drive all of Razorbill Instruments' piezo-actuated series stress and strain cells. This power supply can be used in conjunction with these products to tune the electronic properties of materials by applying controlled strains and stresses.

The two channels of this power supply can output voltages between -200V and +200V and can be used under typical operation to drive a single Razorbill Instruments product. It is also compatible with a wide range of other piezoelectric actuators and similar products from other manufacturers.

## How to use this document

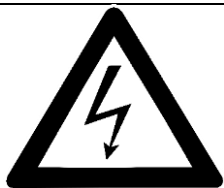
### Scope of use

This document is designed to allow the end-users to safely and efficiently set-up and operate the RP100 power supply and use it in conjunction with other Razorbill Instruments products. The document is also designed to draw attention to any risks and hazards involved in operating the RP100 and the steps necessary to minimise them.

It is not designed to be used to supply power to other manufacturer's products and is also designed to be used by research scientists and trained laboratory users, not household consumers. Consequently, some basic understanding of the conventions regarding the use of sensitive laboratory equipment is assumed.

## Warning indicators

The following signs and symbols are used to convey the described meanings in this document.



**Danger!** Risk of potentially dangerous electric shock. Failure to follow the instructions regarding the described hazard may result in damage to equipment, injury or death.



**Warning!** Hazard risk (as described in more detail in the text). Failure to follow the instructions regarding the described hazard may result in damage to equipment, injury or death.



**Caution!** This symbol is used when failure to abide the given instructions may result in equipment damage.



**Attention!** Please read the appropriate user literature for the Razorbill Instruments equipment that you intend to use the RP100 to power.

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## Specifications

<b>Size</b>	Length	180 mm
	Width	185 mm
	Height	65 mm
	Weight (including cables)	approx. 2.5kg

<b>Output Voltage</b>	Specified Performance range		± 200 V
	Maximum range		± 210 V
	Resolution		2 mV
	Zero offset*	typ.	10 mV
	Gain error*	typ.	0.1 %
	Nonlinearity	typ.	100 mV
	Noise (no load)		< 2 mVrms
<b>Output current</b>	Maximum		± 6 mA
<b>Output Bandwidth</b>	No load		200 Hz
	0.1uF load		100 Hz
	10uF load		1 Hz
<b>Stability</b>	The output is stable into any load		
<b>Output measurement</b>	Current resolution		15 uA
	Current noise		< 1 LSB
	Voltage resolution		0.5V
	Voltage noise		< 1 LSB
<b>Materials</b>	Enclosure		Powder coated aluminium
	Front and rear panels		Printed aluminium
<b>Output Connectors</b>			2 × LEMO 0B.302 Mating connectors supplied on request
<b>Input Connectors</b>	Signal		USB Type-B
	Power		IEC 60320 C14
<b>Mains Power</b>	Voltage		90 - 264 V rms
	Frequency		47 - 63 Hz
	Power requirement		< 70 VA

\*These figures require firmware version 1.0.2 or greater and factory calibration.

## EU declaration of conformity

<b>Product Name</b>	Strain Cell Power Supply
<b>Model Number</b>	RP100
<b>Manufacturer</b>	Razorbill Instruments Ltd
<b>Manufacturer's Address</b>	Unit 8, Castlebrae Business centre Peffer Place, Edinburgh EH16 4BB, UK
<b>Authorised Representative in the European Union</b>	24hour-AR Van Nelleweg 1 3044 BC Rotterdam The Netherlands

This declaration of conformity is issued under the sole responsibility of the manufacturer. The object of the declaration (described above) is in conformity with the following European directives:

2014/35/EU	Low-voltage directive
2014/30/EU	EMC directive
2011/65/EU	RoHS directive

And has been tested according to the following standards:

EN61326-1:2013
EN61010-1:2010 +A1:2019

Signed for and on behalf of Razorbill Instruments:


*Alex Ward*

Dr Alex Ward  
Managing Director

Issued on 13<sup>th</sup> January 2023 in Edinburgh, UK.



## UK declaration of conformity

<b>Product Name</b>	Strain Cell Power Supply
<b>Model Number</b>	RP100
<b>Manufacturer</b>	Razorbill Instruments Ltd
<b>Manufacturer's Address</b>	Unit 8, Castlebrae Business centre Peffer Place, Edinburgh EH16 4BB, UK
<b>UKCA Mark</b>	

This declaration of conformity is issued under the sole responsibility of the manufacturer. The object of the declaration described above is in conformity with relevant statutory requirements:

Electrical Equipment (Safety) Regulations 2016
Electromagnetic Compatibility Regulations 2016
Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012

And has been tested according to the following standards:

BS61326-1:2013
BS61010-1:2010 +A1:2019

Signed for and on behalf of Razorbill Instruments:



Dr Alex Ward

Managing Director

Issued on 13<sup>th</sup> January 2023 in Edinburgh, UK.



## Compliance information for North America

Razorbill instruments has arranged for the RP100 to be independently tested to ensure compliance with regulations applying to North American markets. This has two parts:

### Electromagnetic interference

The RP100 has been verified as complying with the FCC's requirements. The FCC logo is shown on the rear of the product, alongside other compliance information. The following statement is provided as part of this verification:

*This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

### Electrical safety

The RP100 has been independently tested to allow certification by a Nationally Recognized Testing Laboratory (NRTL). The NRTL used was MET Labs, and their logo appears on the rear of the device alongside other compliance information. The MET listing number is E114523. The listing applies in both the USA and Canada.

## Warnings



**Danger! Risk of Shock.** This power supply is capable of generating bipolar voltages of up to  $\pm 200$  V during operation and thus capable of delivering a serious electrical shock. Only to be used by users with adequate training. Ensure that connected equipment has appropriate grounding or insulation. Some Razorbill products will need to be placed in an insulating or grounded conductive container or cryostat when powered by this supply. **Never touch potentially live outputs unless the power is off and any connected capacitive loads are fully discharged (wait 5 minutes from power off before touching).**



**Danger! Risk of Shock.** To avoid danger of electric shock, and/or equipment damage, do not plug or unplug any cabling if the output indicators are illuminated or flashing.



**Danger! Risk of shock!** Do not open the enclosure as this exposes the user to a danger of direct contact with high voltage components. If a malfunction is experienced contact the manufacturer to allow a trained specialist to make repairs.



**Danger! Risk of shock!** Do not use in an environment where liquids may be spilt on the device – do not drink liquids near the power supply.



**Danger! Risk of shock!** Use of the power supply in ways other than those described in this manual could lead to an electric shock.



**Read Appropriate Instructions!** It is possible to damage your other Razorbill Instruments products if they are not used correctly in conjunction with the RP100. Refer to the documentation for those products for a complete list of precautions. For most stress and strain cells:

- Always ensure your devices are connected to the power supply or a suitable resistor when they are exposed to changing temperatures (the RP100 power supply does not need to be switched on).
- Do not use if your strain cell is damp, icy or visibly damaged.
- Do not apply voltages in excess of the voltages recommended in the documentation for the temperature of the cell.



**Hazard!** Proper safety precautions should be taken if using the RP100 with third party products. Always use in accordance with manufacturer's instructions. Incorrect use with third party products may result in damage to the power supply or third-party product and/or risk of electric shocks.

## Disposing of your RP100

As an electrical good, the RP100 must not be thrown away in normal waste disposal for environmental and ecological reasons.



For products sold to and owned by institutions based within the EU, Razorbill Instruments will be happy to arrange for this product to be picked up and disposed of properly at the end of this products life. This is providing that the product has not been disassembled or contaminated. This is part of Razorbills commitment to the Waste Electrical and Electronic Equipment (WEEE) Directive of the European Community and the corresponding national laws.

For products outside the EU, please dispose of the product using a specialised waste recovery, not in ordinary commercial or household waste.

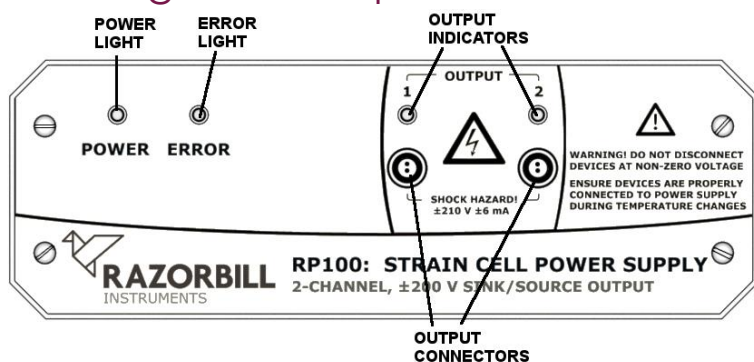
## Suitable operating environments

The RP100 power supply must only be used under the following operating conditions

- ✦ Indoor use only
- ✦ Altitudes up to 2000m above sea level
- ✦ Ambient temperature 5°C to 40°C
- ✦ Relative humidity 80% for temperatures up to 31 °C decreasing linearly to 50% relative humidity at 40 °C
- ✦ Line voltage fluctuations up to  $\pm 10\%$  of the line voltage
- ✦ Transient overvoltages up to overvoltage category II. Category II is typical for building wiring in a home, office, or lab.
- ✦ Pollution Degree 2. Pollution degree 2 means a dry and generally clean home, office, or lab environment with no conductive dust, and no water spills or condensation expected.

## Getting started

### Reading the front panel

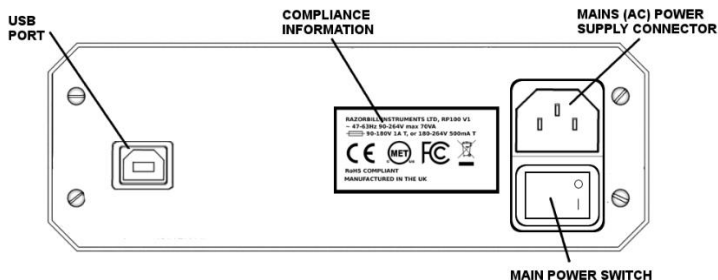


*Figure 1: The front panel of the RP100*

As the primary mode of control of the power supply is using serial commands over a USB connection the front panel does not feature any input controls and relays information only through 4 LED indicators.

- ✦ **Power Light.** This will show a continuous green light when the RP100 is powered on. If this LED is not illuminated please check the power switch on the rear panel of the RP100 is set to the on position and the wall power switch is also on. If this light still does not illuminate please change the fuse.
- ✦ **Error Light.** This light will illuminate red to indicate that an unrecognised SCPI command was sent to the power supply. It will go out once that error has been cleared by the PC. It will also illuminate briefly during boot up.
- ✦ **Output Indicators.** When there is a constant voltage present at an output the corresponding output indicator will display a solid green light. If the output voltage is changing, e.g. it is ramping from one voltage to another, the indicator will be flashing green. When the indicator is off, the output is shorted via a 14.7 kΩ resistor, which will discharge any connected capacitive load.
- ✦ **Output connectors.** The Razorbill Instruments stress/strain cell can be attached to the output connectors using cabling terminated with LEMO 0B.302 family connectors. For example, LEMO connectors FGG.0B.302.CLADxxZ will be suitable where **xx** depends on the thickness of the cable. Each power supply comes with two cables, with FGG.0B.302.CLAD52Z connectors on both ends, suitable for connecting the RP100 to the vacuum feedthrough. In most cases it will be up to the customer to provide a vacuum feedthrough and cabling from there to the cryogenic cell. The top pin on each output (indicated with a red dot on the rim of the connector) is the negative terminal the bottom pin is the positive terminal. More information about cabling is available in application notes AP002 and AP004.

## Back panel layout



*Figure 2: Back panel layout*

**USB Port.** A type B USB port. Connect the control PC to the power supply using USB cable here. The power supply acts as a bus-powered USB2.0 Full Speed device with <100mA draw.

**Compliance Information.** This label displays the statutory compliance information required for sale, including the correct fuses to use in locations with different mains voltages.

**Mains Power Supply Connector.** Insert the supplied power cable that connects the power supply with the mains (wall socket) power supply. The power supply uses an IEC60320 C13 standard cable.

**Mains Power Switch.** This is the main power switch for the device. Ensure this switch is set to the on position before use and set to the off position afterwards.

## First time set-up

- Check that the available mains power is appropriate for the RP100 power supply. The power supply can operate with mains frequencies between 47 and 63Hz, and voltages between 90 and 264V.

- ✦ Check that the correct fuses for the supply voltage are installed. See “changing the fuses” on page 37 for more information.
- ✦ Place the power supply on a flat clean, dry surface. Plug the power lead into the mains (AC) power supply connector. You should locate the power supply so that you can reach the main power switch or the power lead in order to disconnect the power supply in an emergency.
- ✦ Install the correct drivers onto an available computer terminal to be used as the control PC. The drivers are available on the Razorbill Instruments website.
- ✦ Connect the RP100 using the supplied USB cable by plugging into the power supply USB port and any available control PC USB port.
- ✦ Connect the output connectors to the Razorbill device using cabling appropriate for 200 V and terminated in LEMO connectors to mate with the output connectors. See *Correct Wiring Set-up* on the following page for details on how to wire appropriately with a Razorbill Instruments stress or strain cell.



**Danger! Risk of Shock.** Only use suitable high voltage cabling to connect the output of the power supply to a suitable device. This will usually require appropriate vacuum feedthroughs and will require cabling with appropriate insulation and connections for the 200 V outputs.





**Danger! Risk of Shock.** Razorbill Instruments research instruments are designed to be used within research cryostats. Do not connect these Razorbill instruments devices to high voltages unless they are enclosed in a suitable insulating or grounded metal container. Refer to the documentation which came with the cell for details.

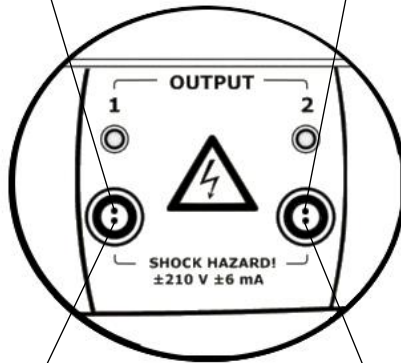
- ✦ Turn on the power supply.
- ✦ The control PC should register the RP100 as a connected device. It will appear as a serial port.
- ✦ The RP100 is now ready to use. It will receive and execute any of the SCPI commands defined in this document.

## Correct wiring set-up

The RP100 is designed to be used with a Razorbill Instruments strain cell. **If incorrect voltages are applied to the strain cell it could be permanently damaged.** Consequently, great care must be taken to ensure the correct pins of the power supply are attached to the correct wires from the strain cell.

The top pin (closest to the red spot) is the negative terminal. When connecting to the CS100 or FC100 series stress/strain cells this will be connected to the tension stacks negative terminal which is the **white** wire.

The top pin (closest to the red spot) is the negative terminal. When connecting to the CS100 or FC100 series stress/strain cells this will be connected to the compression stacks negative terminal which is the **blue** wire.



The bottom pin is the positive terminal. When connecting to the CS100 or FC100 series stress/strain cells this will be connected to the tension stacks positive terminal which is the **red** wire.

The bottom pin is the positive terminal. When connecting to the CS100 or FC100 series stress/strain cells this will be connected to the compression stacks negative terminal which is the **brown** wire.



Ensure that when the cell is at room temperature, the voltages **do not go below - 20 V or above + 120 V**. The more extreme voltages the RP100 can supply should only be applied at cryogenic temperature in accordance with the strain cell datasheet. Exceeding these limits will damage the piezoelectric stacks.

## Wiring channels together to get higher voltages

It is possible to connect the two channels together to make a  $\pm 400\text{ V}$  single channel power supply. The channels should be connected as a bridge, **not in series**. Contact Razorbill Instruments for advice on how to do this safely.

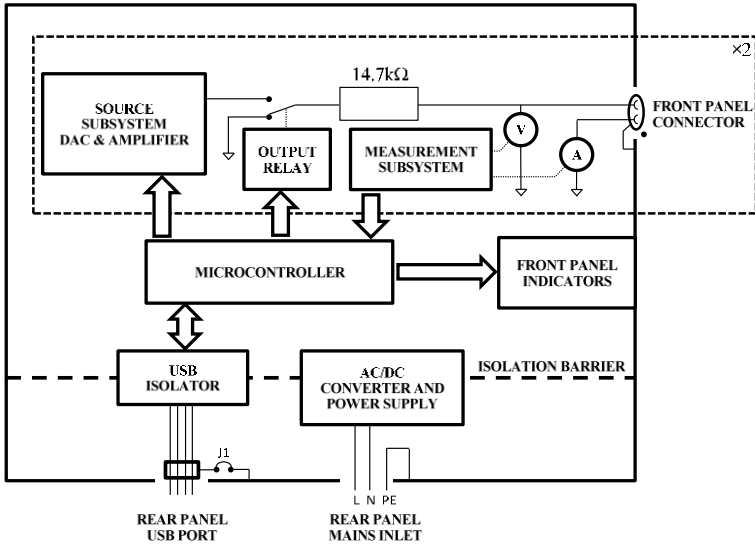
## Using the RP100 power supply

The power supply contains two identical channels, these are intended to power tension and compression stacks on a Razorbill Instruments strain or stress cell. Each of these channels consists of a source, an output relay, and a measurement subsystem. The general internal design is shown in figure 3.

## Source subsystems

Each channel contains a source subsystem. The subsystem consists of an 18-bit digital to analog converter, and an amplifier. Each source can be configured with an output and a slew rate. When a new output is set by the control PC, the source will immediately start slewing from its current output to the target output at the set slew rate. If the slew rate is changed before the target voltage is reached, it will take effect immediately. Assuming the output relay is closed (see below) the green LED on the front panel will be illuminated constantly when the output is at the set voltage, and flashing when it is slewing. It is generally advisable

to keep slew rates below 100V/s for piezoelectric devices which are not designed for high frequency operation, and if the device is in a cryostat, slower rates will reduce unwanted heating.



*Figure 3: A block diagram showing the organisation of the power supply sub-systems.*

The microcontroller controls the slew rate by updating the DAC every millisecond. Combined with the output filters, this gives a smooth ramp for any rate over 0.5 mV/second. For rates below that, the output can take on a staircase shape, as the output changes by one least significant bit at a time. The actual rate at which this becomes noticeable will depend on the capacitance of the load, and the resulting bandwidth.

The power supply is designed to operate over the range  $\pm 200$  V. The noise, accuracy, linearity and other specifications will be met over that range, and that range matches the cryogenic voltage range of most Razorbill products. The power supply also allows some over-range capability, of no less than  $\pm 210$  volts, and

typically around  $\pm 225$  V depending on the load characteristics and small variations from supply to supply. When using this over-range, the noise performance is reduced, and at the ends of the range, the accuracy and linearity will be poor. Using this over-range capability with a Razorbill Instruments cell will probably reduce its service life considerably and should be done with caution. Refer to the cell documentation or contact the manufacturer for more information.

## Outputs

The power supply contains two identical channels. Each one has an output relay controlling it.

When the relay is closed, the output is connected to the source subsystem via a 14.7 k $\Omega$  resistor, and the green indicator on the front panel is lit or flashing. The capacitance of the cell and the resistor together form an RC filter, typically rolling off between 1 and 100Hz. This filter prevents excessively abrupt voltage changes which could damage the cell, and also reduces the voltage noise measured at the cell. There is also an internal RC filter, which limits the bandwidth to approximately 100 Hz, even without any capacitive load.

When the output relay is open, the output is instead shorted out by the resistor. This allows any capacitive load to safely discharge, and this works even if the power supply is switched off and disconnected from mains power. A typical Razorbill Instruments strain cell will fully discharge in less than 10 seconds, but some cells can recharge themselves with time or temperature changes, so it is generally advisable to leave them plugged in at all times. Refer to the documentation for the cell for more details.

## Low side current measurement

Each channel also has a measurement subsystem. This can measure the voltage and current at the load with 10-bit precision.

It provides a cross check that everything is functioning correctly, and may also be used, in conjunction with carefully selected voltages and slew rates, to estimate the impedance of the load. The linearity, accuracy, and drift of the measurement system is much poorer than the output system, and it should not be relied upon for gathering experimental data. It is intended to be used to diagnose problems with the cell or supply.

For reasons of simplicity and reliability, the output current is measured using a low-side sensing technique, i.e. the return current is measured. As the power supply outputs are floating, all current which flows out of the supply must flow back in again, and low side measurement is generally sufficient. The one exception is if the two output channels are connected together, in which case current sourced by one channel can return by the other. In which case, the current measurement may not reflect the current provided by the corresponding source, but the sum of the two current measurements will still be the sum of the two output currents.

## Grounding notes

The case is connected to the earth pin of the mains inlet connector. It forms a protective earth around the power supply, and for safety and EMC reasons it must not be disconnected. The two outputs, and all of the analog and digital circuits within the power supply share a separate common ground, which is isolated from the protective earth. The USB port is also isolated from the digital circuitry, but for EMC reasons is connected to the protective earth. In particularly sensitive measurements, this could introduce an undesirable ground loop involving the PC, USB cable, power supply, and mains wiring. If this is a problem, contact Razorbill Instruments to discuss modification options.

## USB serial communication

The RP100 power supply uses a USB virtual serial port to communicate with a computer. The power supply acts as a bus-powered USB2.0 full speed device, and requires less than 10 mA from the computer or USB hub to which it is connected. This means it is compatible with any standard hub, including ones without separate supplies. You can also use standards-compliant USB extenders. The standard allows for one “dumb” 5 m cable, and up to five “active” extenders or hubs, each adding 5 m of cable.

Before using your power supply, you will need to install the necessary drivers for your operating system; these are available on the Razorbill Instruments website. When these are installed and the power supply is plugged in, a new serial port will appear on your system. Your operating system will normally allow you to set baud rate, stop bits, parity etc. for this port, but as there is no physical serial connection within the power supply, these settings have no effect and should be left at the defaults.

Once the serial port has been created, it can be accessed directly as a serial port, or indirectly using, e.g. VISA. Whichever way it is used, you will also need either a terminal emulator to type commands and receive responses, or a program or script to integrate the supply with your measurement system. Alternatively, Razorbill Instruments may be able to provide a software tool with a graphical user interface.

## SCPI command reference

The power supply accepts a variety of simple commands, and is designed to comply with the Standard Commands for Programmable Instruments (SCPI) standard. The power supply implements most of the DCPSUPPLY base functionality, along with

the MEASURE additional functionality. The commands will be described using the following notation:

<b>KEYword</b>	A keyword, which may be written in full or abbreviated to only the letters in capitals. The actual command may use upper or lower case. e.g. the keyword <code>OUTPut</code> means that the commands <code>OUTP</code> , <code>OUTPUT</code> , <code>output</code> and <code>outp</code> can be used and have the same meaning.
<b>[...]</b>	The section enclosed in square brackets is optional
<b>#</b>	The channel to operate on, which may be 1 or 2. If omitted, the command will act on channel 1, this is to provide compatibility with single channel power supplies.
<b>&lt;\n&gt;</b>	A terminator. When sending commands to the instrument, CR, LF or CRLF may be used. Responses from the instrument will always end with CRLF.
<b>&lt;bool&gt;</b>	A Boolean option, either 0 or 1. A 1 means true, or enabled, and 0 means false or disabled.
<b>&lt;int&gt;</b>	An integer number, the minimum and maximum will be given in the command description
<b>&lt;float&gt;</b>	A floating point number, the minimum, maximum, and actual resolution will be given in the command description. When sending the number to the instrument, the following formats are recognised: 1, 1.23, 1.23E0, 1.23E+00 and many others. The responses from the instrument will always be in the form 1.23456789E+00.
<b>&lt;other&gt;</b>	Other tokens will be explained in the command description.

Commands fall into two categories. Ones which end in a question mark, and ones which do not. The former are referred to as *queries*. Queries will always generate a response from the



instrument, and will never have any other effect. Commands which are not queries will never generate a response from the instrument, and generally do have an effect on it.

Normally, individual commands will be sent, each followed by a terminator. However, it is also possible to chain commands with semicolons, e.g.

```
SOUR1:VOLT 20;SOUR2:VOLT -10<\n>
```

in which case commands will be executed in order from left to right. When chaining commands, care must be taken that the complete chain, including terminator, is no longer than 255 characters. Otherwise the input buffer will overflow and some of the commands will be lost.

A command which is not recognised by the instrument, is followed by a parameter of the wrong type, or otherwise can't be understood by the instrument will generate an error. Errors are stored in a queue, first in, first out, and as long as there is something in the queue the error LED on the front panel will be lit. The `SYSTem:ERRor?` command will fetch to error at the top of the queue, and the `SYSTem:ERRor:COUnT?` command will return the number of errors present. Note that in some cases, one malformed command can generate several errors.

## Command list

The commands listed here are supported by the 1.0.0 to 1.0.2 firmware versions. Future firmware versions may add more commands and functionality. An up-to-date manual will be made available on the Razorbill Instruments website with each firmware update.

<b>command</b>	<b>description</b>	<b>see page</b>
*CLS	System clear	27
*ESE[?]	Error status exe	27
*ESR?	Error status	27
*IDN?	Identification request	28
*OPC[?]	Operation complete?	28
*RST	Reset device	29
*SRE[?]	Service request enable	29
*STB?	Get status byte	30
*TST?	Self test	30
*WAI	Wait for operation	31
SYSTem:ERRor[:NEXT]?	Get last error	31
SYSTem:ERRor:COUNT?	Get number of errors	32
OUTPut#[:STATe][?]	Set output on or off	32
SOURce#:VOLTage[:LEVel] [:IMMediate][:AMPlitude][?]	Change output voltage	33
SOURce#:VOLTage:SLEW[?]	Set voltage slew rate	34
SOURce#:VOLTage:NOW?	Query output voltage	34
MEASure#[:SCALar]:VOLTage[:DC]?	Measure output voltage	35
MEASure#[:SCALar]:CURRent[:DC]?	Measure output current	36

## SCPI core commands

The commands in this section are in the SCPI standard, and many are included just for compatibility with other power supplies.

<b>*CLS</b>	No response
Description	Clears all status data structures in the device, including all status registers and the error queue.
Example	*CLS

<b>*ESE</b>	No response
<b>*ESE?</b>	<int>
Description	Set or query the Standard Event Status Enable register. This command is required for SCPI compatibility, and is only minimally supported. Refer to the SCPI standard for more information.
Example	*ESE?

<b>*ESR?</b>	<int>
Description	Query the Standard Event Status Register. This command is required for SCPI compatibility, and is only minimally supported. Refer to the SCPI standard for more information.
Example	*ESR?

<b>*IDN?</b>	<str1>,<str2>,<str3>,<str4>
parameter <str1>	The device manufacturer. Always Razorbill
parameter <str2>	The device model. Always RP100
parameter <str3>	The six-digit serial number, as a string, e.g. 000001
parameter <str4>	The firmware version number, e.g. 1.0.2
Description	Query the device identity information. The response is four strings, separated by commas. Almost every SCPI-like instrument supports this command, so it can be used by software to identify the instrument. The firmware number uses the major,minor,release format. Changes to the release version are small bugfixes or changes in packaging and distribution. Changes to the minor version may add features, but will always maintain backwards compatibility. Changes to the major version number may break compatibility.
Example	*IDN?

<b>*OPC</b>	No response
<b>*OPC?</b>	1
Description	The command form sets the operation complete flag. This command is required by the SCPI standard, but has no effect as the flag is always set. The query form queries the operation complete flag, and will always return 1.
Example	*OPC

<b>*RST</b>	No Response
Description	On receipt of this command, the device resets to power-on settings. Both outputs are set to zero and disabled, and all status registers and the error queue are cleared. The USB serial connection is not reset.
Example	*RST

<b>*SRE</b>	No Response
<b>*SRE?</b>	<bool>
Description	Set or query the service request enable flag. This command is required for SCPI compliance, but even with service requests enabled, the power supply will never raise them. So this command has no effect.
Example	*SRE?

<b>*STB?</b> <int>	
Parameter <int>	The status byte expressed as an integer between 0 and 255.
Description	Read the Status Byte from the instrument. Although the response is an integer, it represents 8 individual bits/flags. Only bit 2 is used in the power supply, and indicates an error is in the error queue. In general, it is easier to use SYST:ERR:COUNT? To check for errors, but this command is provided for compatibility with the SCPI standard.
Example	*STB?

<b>*TST?</b> <bool>	
Description	On receipt of this command, the device resets executes an internal self-test. The response will be 1 if an error is detected and 0 if all tests pass.
Example	*TST?

<b>*WAI</b>	No Response
Description	Wait for the current operation to complete. This command is required for SCPI compliance, but all there are no commands which take time to execute, so the instrument will never wait.
Example	*WAI

## SYSTEM commands

These commands are used to obtain information about the error queue. If the power supply detects an internal error, or it cannot parse a command from the PC, it will generate an error. Errors are stored in a queue, first in, first out, and as long as there is something in the queue the error LED on the front panel will be lit. Note that in some cases, one malformed command can generate several errors.

<b>SYSTEM:ERROR[:NEXT]?</b>	<int>,<string>
Parameter <int>	A numerical error code. For a complete list of codes and their meanings, refer to the SCPI standard.
Parameter <string>	A short, human readable description of the error.
Description	Retrieves the error from the top off the error queue. As the queue is first-in first-out, this is the earliest error still in the queue. Once read, the error is removed from the queue. If there are no errors in the queue, it will return 0,No Error.
Example	SYST:ERR?

<b>SYSTem:ERRor:COUNT?</b> <span style="float: right;">&lt;int&gt;</span>	
Parameter <int>	The number of errors in the queue.
Description	Retrieves the number of errors in the error queue. The queue can store at most 16 errors, if that number is exceeded, the last error in the queue becomes a queue overflow error, and the other errors are discarded.
Example	<code>SYST:ERR:COUNT?</code>

## OUTPut Command

Each of the two source subsystems is connected to an output subsystem. Each one contains a relay, which can connect the source to the front panel connector, or can connect the front panel connector to ground.

<b>OUTPut# &lt;bool&gt;</b> <span style="float: right;">No response</span>	
<b>OUTPut#?</b> <span style="float: right;">&lt;bool&gt;</span>	
Parameter <bool>	A Boolean representing the state of the output relay. A 1 means output enabled, 0 means output shorted via resistor.
Description	The command form enables or disables the output relay. The query form checks the status of the output relay. The front panel LED will be on or flashing if the relay is connected, and off otherwise. Note that this will not affect the source subsystem. If the source voltage is set to 100V, then the output is turned off and on again, it will come back on at 100V.
Example	<code>OUTP1 1</code>



## SOURce commands

The power supply has two independent source subsystems. Each is connected to a front panel connector via an output subsystem.

<b>SOURce# :VOLTage[:LEVel][:IMMediate]</b>	No response
<b>[:AMPlitude] &lt;float&gt;</b>	
<b>SOURce# :VOLTage[:LEVel][:IMMediate]</b>	<float>
<b>[:AMPlitude]?</b>	
Parameter <float>	The output voltage. A floating point number between -230 and 230, in volts, with a resolution of approximately 2mV. Values beyond $\pm 210V$ may be clipped to a smaller value.
Description	<p>Sets or queries the output voltage.</p> <p>When the command form is used, the source will start sweeping towards the new value immediately. The front panel LED will flash while the voltage is sweeping, and be lit continuously when it has reached the new set value. If the corresponding OUTPut is disabled, the LED will remain off, and the output will remain grounded, but the voltage at the terminals will jump to the set voltage when the output is enabled.</p> <p>When the query form is used, the value returned is the value the source is sweeping to. For the value it is currently set to, see SOUR# :VOLT :NOW? and for an instant measurement see MEAS# :VOLT?</p>
Example	SOUR1 :VOLT 195.332

<b>SOURce#:VOLTage:SLEW &lt;float&gt;</b>		No response
<b>SOURce#:VOLTage:SLEW?</b>		<float>
Parameter <float>	A floating point number between in volts/sec, between 0.1mV/sec and 100kV/sec. Resolution is approx. 0.1mV/sec, and power on default setting is 100V/sec.	
Description	Sets or queries the source slew rate. When a new voltage is set with SOUR#:VOLT the source will immediately begin slewing to that voltage at this rate. If a new slew rate is set while the source is slewing, it takes effect immediately, and affects the ongoing change.	
Example	SOUR1:VOLT:SLEW 10	

<b>SOURce#:VOLTage:NOW?</b>		<float>
Parameter <float>	The output voltage. A floating point number between -230 and 230, in volts, with a resolution of approximately 2mV.	
Description	Query the instantaneous output of a source. If the source is not changing, this returns the same thing as SOUR#:VOLT?. If the source is slewing, then this returns the output right now, and SOUR#:VOLT? returns the output the source is slewing to. See also MEAS:VOLT? For a measurement of the voltage present at the front panel output.	
Example	SOUR1:VOLT:NOW?	

## MEASure commands

The power supply has a voltage measurement and low-side current measurement at each front panel output. These form the MEASure subsystem.

MEASure#[:SCALar]:VOLTage[:DC]?	<float>
Parameter <float>	The output voltage, in volts. A floating point number between -250 and 250, in volts, with a resolution of approximately 250mV.
Description	Query the instantaneous output of a source. The value returned comes from a 10-bit DAC completely separate from the source subsystem, and is a real measurement of the voltage at the front panel output. As such, it will reflect the state of the output relay, and any voltage drop over the output resistors.
Example	MEAS2 : VOLT?

<b>MEASure#[:SCALar]:CURRent[:DC]? &lt;float&gt;</b>	
Parameter <float>	The output current, in amps. A floating point number between -0.007 and 0.007, in amps, with a resolution of approximately 15uA.
Description	Query the instantaneous output of a source. The value returned comes from a 10-bit DAC completely separate from the source subsystem, and is a real measurement of the current at the front panel output.
Example	MEAS2:CURR?

## Example Code Snippet

The following commands will enable the output of channel 1, set it to 1V, then set the slew rate to 0.1V/sec and slew, at that speed, to 20V:

```
OUTP1 1
```

```
SOUR1:VOLT 1
```

```
SOUR1:VOLT:SLEW 0.1
```

```
SOUR1:VOLT 20
```

And here is an example of how you might achieve that in Python:

```
import serial

import time

with serial.Serial('COM1') as rp100:

    rp100.write(b'OUTP1 1\n')

    rp100.write(b'SOUR1:VOLT 1\n')

    time.sleep(0.1)

    rp100.write(b'SOUR1:VOLT:SLEW 0.1\n')

    rp100.write(b'SOUR1:VOLT 20\n')

    time.sleep(200)
```

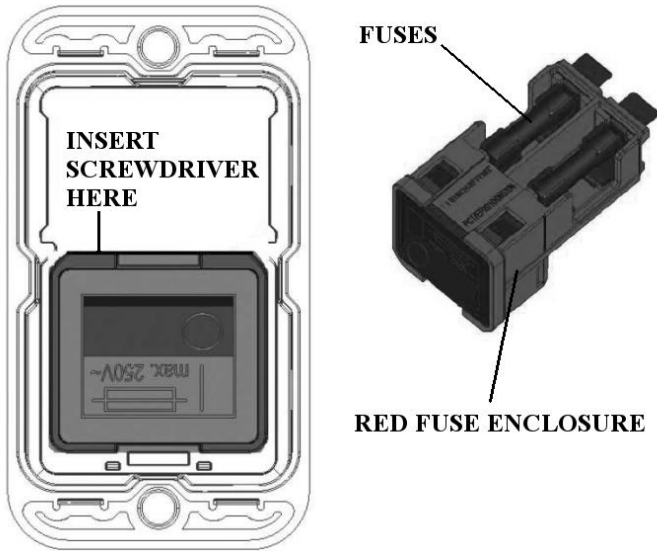
Where the `time.sleep` statements allow time for the power supply to actually carry out the instructions, based on the voltage change requested and the slew rate.

## Caring for your RP100 power supply

### Changing the fuses



**Danger! Risk of shock!** Always ensure that the power supply is turned off and unplugged at least 5 minutes before removing the fuse cartridge from the back of the power supply.



The RP100 power supply is equipped with two fuses. Occasionally these fuses will need to be changed, either because they have blown or because you are changing from a 220 V supply to a 110 V supply or vice versa. To change the fuse(s) follow the following steps:

1. Unplug the power supply from the wall and remove the power cable from the socket on the back of the box.
2. Insert a screwdriver (or similar implement) into one of the notches between the red fuse cartridge and black power entry module. This will be located just inside the rim of where you unplugged the power cable from the back of the control box.
3. Gently lever the red fuse enclosure out of the power entry module.
4. If a fuse has blown, use a multimeter to test which fuse has failed and replace it. If no multimeter is available you

- can just replace both. One spare fuse is located on the reverse of the red fuse enclosure.
5. If you are changing to a different supply voltage, replace *all three* fuses with the correct value for the new supply voltage. Use 0.5 A fuses for a 180 - 264 V supply and 1 A fuses for a 90 – 180 V supply. You do not need to make any other changes.
  6. Reinsert the red fuse enclosure and plug the power cable back in.

## Installing a firmware upgrade

Razorbill Instruments may add additional functionality in the future through firmware updates. This may involve adding support for additional serial commands and/or additional performance monitoring options. Razorbill Instruments will periodically contact you with updates that will be installed through the control PC, or you can check the Razorbill Instruments website.

## Cleaning

The power supply may be cleaned with a cloth dampened with warm soapy water or mild solvents like isopropanol. Avoid using abrasive cleaners, or using large quantities of liquid which could enter the power supply and cause damage.

## Firmware licencing information

The firmware uses two open-source components, scpi-parser and LUFA. The software licences and warranty disclaimers for these projects are reproduced below. Note that the authors of the open-source projects do not give any warranty on the code, but this does not impact the warranty provided by Razorbill Instruments, which covers the complete power supply, including firmware.

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## SCPI-PARSER

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# RP100 Power Supply Manual