PR-*E 3* -SMA

Super Low Noise Preamplifier
40MHz Version

- Datasheet –

Version 3.21, January 2023

Features:

- **Low Voltage Noise (0.85nV/√Hz, @ 1MHz)**
- **Low Current Noise (20fA/√Hz @ 10kHz)**
- **f = 1.5kHz to 40MHz (customizable)**

 All Rights Reserved

Introduction

The PR-E 3 - SMA is a highly sensitive voltage preamplifier, which is intended for low-noise and high-impedance applications like FT-ICR cells, Schottky pickups or charge detectors. This data sheet refers to the 40MHz version. The frequency range comprises approx. 1.5 kHz to 40MHz and features a nominal voltage amplification factor of 250 V/V (high-Z load), or 125 V/V at 50Ω load respectively.

The small size makes upgrade of existing systems easy, improving sensitivity and in most cases delivering a better signal-to-noise ratio. The PR-E 3 - SMA is implemented as solid box of an aluminium alloy with gold plated input/output SMA terminals, offering very high ruggedness and immunity to external noise interference.

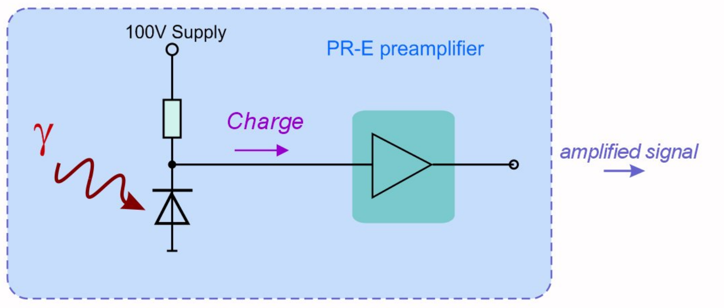


Fig. 1: Photon Counting Application with Avalanche Photo Detectors

Case Outline

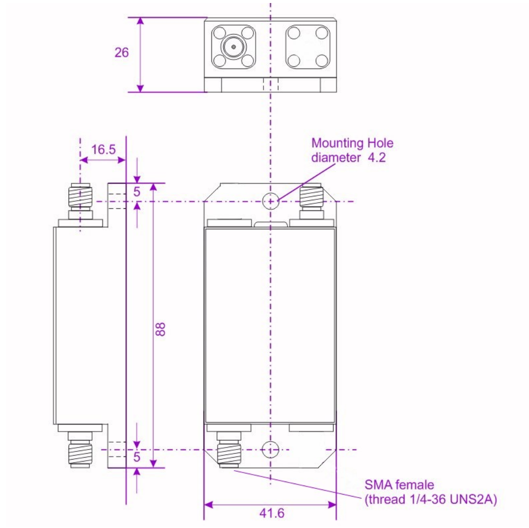
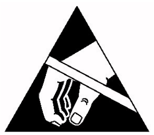


Fig. 10: Housing outline dimensions (millimeter)

Electrostatic Sensitivity



This device can be damaged by ESD (Electrostatic Discharge). It is strongly recommended to handle the device with appropriate pre-cautions.
Failure to observe proper handling and installation procedures can easily cause serious damage. This ESD damage can range from subtle performance degradation to complete device failure.

© 2022 Stahl-Electronics

Contents may be changed without further notice.

Top/Side Views

Fig. 2: Top view, front view (inputs), side view and rear view

Functional Description

The following diagram illustrates the internal structure. The input stage is formed by pre-selected low noise FET transistors, followed by amplification and buffer circuitry. Independent feedback loops guarantee a well-balanced biasing point, also at low temperatures in a cooled operation.

The main target application is the amplification of small signals from high-impedance sources, like FT-ICR cells, Photomultipliers or other sensors. The input signal will appear after amplification on the corresponding output with opposite polarity (i.e. 180° phase shifted) with respect to the input, providing improved stability compared to non-inverting designs.

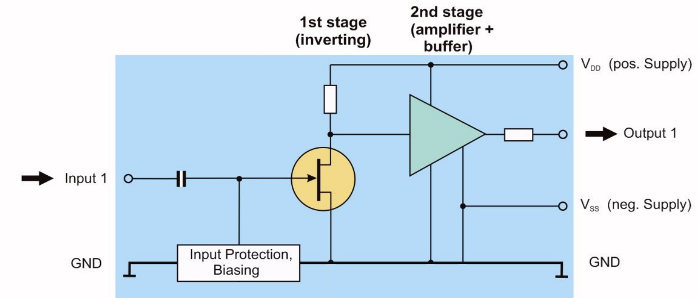


Fig. 3: Simplified Diagram of Internal Structure

Mains Supply and Connections

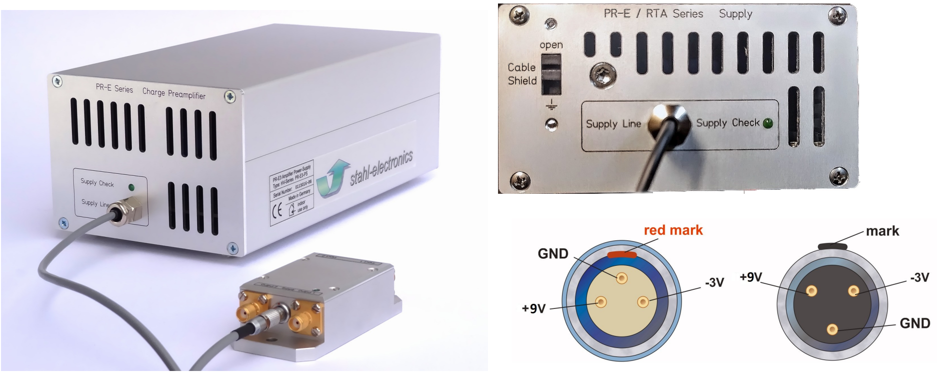


Fig. 4: Mains Supply, connection to amplifier module. Lower right picture: The Pin orientation as seen in the PR-E case outside, Lemo and XLR versions

The manufacturers mains adapter delivers +9V and -3V as V_{DD}, V_{SS} on a 3pole cable and feeds the PR-E 3 - SMA via a Lemo "type 0B" or ITT-XLR plug/socket. When connecting the supply cable to the PR-E 3

Typical Performance Characteristics

Voltage Amplification Factor vs. Frequency (*unless customized*)

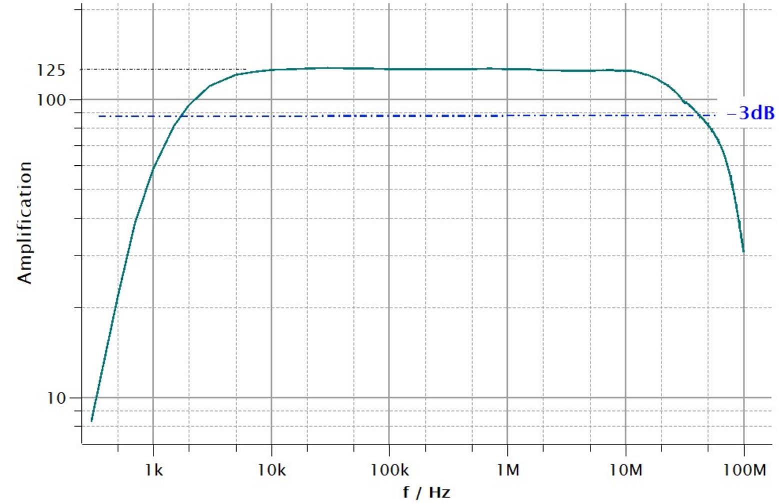


Fig. 8: Linear Voltage Amplification Factor vs. Frequency, T = 297 K, with 50 Ohm load

Typical Voltage Noise Density at room temperature

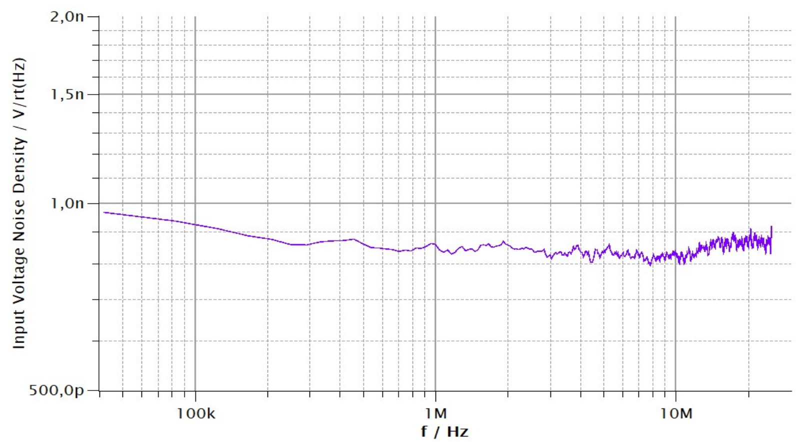


Fig. 9: Voltage Noise Density at room temperature

finally at a cable length above 6m a termination is recommended to avoid unwanted cable reflections.

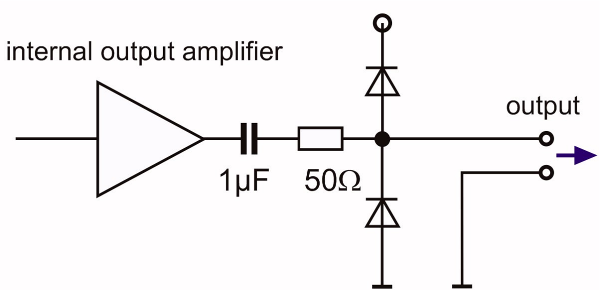


Fig. 7: Output circuit scheme

In case a 50 Ohm resistive load is attached to the amplifier's output, the attenuation of signal amplitude by a factor of 2 should be kept in mind. The nominal voltage amplification will be x 125 V/V with 50 Ohm termination, or x 250V/V otherwise (high-Z or open-ended).

- SMA please make sure that the red marks match on plug and socket. The plug can be detached by carefully pulling the handle ring.

The mains supply requires 230V$_{ac}$ supply voltage, 50Hz nominally. It should be connected by a standard IEC power cord to the power grid. Conncection to the PR-E 3 - SMA module is established by a 3-pole connector cable with Lemo or Mini-XLR (ITT-Canon) connectors. Pinout is shown above. Note that devices with production date Feb. 2021 and later feature a shield GND switch, which allows for connecting the PR-E case GND and supply cable shield to the mains GND of the suppl, in favor of avoidance of external RF noise intrusion.

Please observe that different PR-E versions have individual power supply requirements. Never apply wrong supply voltage, preferably use the factory mains supply. A wrong supply voltage may damage this device.

Absolute Maximum Ratings

Note: Stress above these ratings may cause permanent damage or degradation of device performance. Exposure to absolute maximum conditions for extended periods may also degrade device parameters or reliability.

Parameter	min.	max.	
pos. Supply Voltage V_{DD}	-0.3V	+9.6V	avoid connecting the voltage supply lines with wrong polarity.
neg. Supply Voltage V_{SS}	+0.3V	-3.2V	
V_{DD} - V_{SS}		12.3V	**Never exceed this rating**
Input Voltage absolute value (AC+DC) AC DC		25 V_{pk} vs. GND, 5V_{pp}, f = 0 ... 40MHz 400V	derating inversely proportional with frequency above 5MHz
Admissible Input Current		80 mA_{eff}	permanent current through

(see remarks)		1A$_{pk}$	protection circuitry maximum peak current for less than 10ms, at max. 1 Hz repetition rate
Storage Temperature	-55°C	125°C	baking is possible up to 125°C, max. for 48 hours

Table 1: Absolute Maximum Ratings

Typical Operating Parameters, unless customized

Parameter	**typical Value**	**Remarks/Conditions**
Standard Freq. Range for ±3dB deviation (customizable)	1.5 kHz....45 MHz	50Ω –Load T = 300K
Gain Voltage gain @300K	x 250 ± 5% x 125 ± 5%	medium impedance load, C_{Load} < 125pF, f = 100kHz 50Ω –Load
Input Impedance DC AC resistive impedance and input capacitance	> 300 MΩ 30MΩ capacitively coupled 30pF ± 6 pF	
Output Impedance @ 300 K Output Power	50Ω ± 4% vs. GND max. 30mW	@ f = 200kHz … 10MHz
Input Noise *noise figure* voltage noise density current noise density	0.2dB @ 1kΩ$_{Source}$ 2.7dB @ 50Ω$_{Source}$ 0.85nV / √Hz 25 fA / √Hz	@ f = 1MHz, T = 300K @ f = 1MHz, T = 300K @ f = 1MHz, T = 300K @ f = 100kHz, T = 300K
Operating voltages		

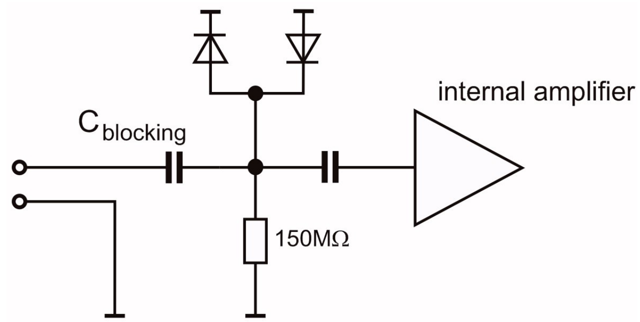


Fig. 6: Input protection scheme (each channel)

After the blocking capacitor, the input features a 150MOhm resistor to the input GND. The ESD-protection diodes limit the maximum voltage at this point to about +/-725mV.Behind this protection circuitry the subsequent amplifier stage follows capacitively (AC) coupled.

Output Circuitry

The subsequent figure shows the output configuration. ESD protection diodes provide a certain degree of protection against electrostatic discharge effects. The output impedance equals 50 Ohms nominally. Normally, in case the amplifier output is connected to subsequent signal processing circuitry (analog or digital), a 50 Ohms termination at the other end of the line is not required. In cases when cable length to the next stage exceeds approx. 3m, a termination with 50 Ohms may help to keep the flatness of amplifiers over-all frequency response, pickups) or inductive (e.g. NMR probes). However, stability problems (problem of self-oscillation) may occur, if a non-terminated cable (e.g. RG58) from a high-impedance signal source (e.g. a photo detector or electrostatic pickup electrode) is used, and if at the same time the cable length is excessively long (>6m). In this range, an open-ended coaxial cable represents a resonator, which can be easily excited at a frequency of several MHz, if not damped by a termination at one end. If this happens, one should terminate the cable with appropriate termination (e.g. 50 Ohms), or, if this is not convenient because of signal loss, add a small resistor, e.g. 10 Ohms in the signal path, e.g. between signal source and amplifier. This will reliably cease oscillation, even though it comes with a slightly affected noise figure (typ. 1dB).

Input Circuitry

The subsequent figure shows the input protection circuitry for each input. DC blocking capacitors are provided in order to maintain a reasonable amount of admissible DC voltage being applied to the inputs. The maximum allowed DC voltage at input is +/-400V_{DC}.
Even though this relatively high voltage may be applied (DC-wise), the limited pulse capability of maximum 1A_{pk} for less than 10ms duration has to be kept in mind, which is restricted by the maximum possible current through antiparallel protection diodes (see fig. 6). This matters especially if the attached electrode or signal source is run in a switched or pulsed mode, or exposed to radio frequency bursts.

V_{DD}, positive supply voltage V_{SS}, negative supply voltage	+9V -3V	ensure V_{DD}-V_{ss} < 12V.3 in any case
Maximum AC Output Voltage	2.2V_{pp} at 1 MHz	medium impedance load, C_{Load} < 125pF
Supply Currents typical values V_{DD} = 9V V_{SS} = -3.0V	+35mA -10mA	No input signal
Operating Temperature	T = -25°C…55°C	
Magnetic Properties	Device consists mostly of non-magnetic materials. small amounts of ferromagnetic substances < 1 x gr. possible	For use with FT-ICR cells, it is recommended to locate the device min. 12cm away from the ion trap/FT-ICR cell structure in order to avoid magnetic disturbance
Geometrical Size and Weight	88mm x 41.6mm x 26mm / 130 gr.	
Mains Supply Unit grid voltage	115V_{ac} or 230V_{ac} +/-10%, 50/60 Hz	Note that required grid voltage depends on country, the supply expects a well-defined voltage.
Power consumption	max. 5W, typ. 2.5W	Fuse in mains supply filter: 100mA medium-slow (230V_{ac}) or 200mA medium-slow (115V_{ac})

Table 2: Operating Parameters

AC connections and Grounding

Grounding and Shielding are general issues of concern, especially in connection with high- impedance charge or voltage amplifiers. A proper grounding and shielding geometry is essential to maintain good device performance and to achieve the low noise characteristics, described in the specifications. The typical RF-(radio-frequency) design rules for proper grounding and shielding apply here. To ensure a “clean” environment, good ground connections around the amplifier have to be provided, avoiding ground loops, keeping lines as short as possible and of low inductance-style. All DC-lines leading to the signal source in front of the amplifier, e.g. a FT-ICR Ion Trap or Photo Detector, should be filtered appropriately by low pass filters. Failure in providing a good grounding, may lead to a considerably increased noise level and can cause self-oscillations of amplifiers.

Signal connections may be implemented as coaxial or twisted-pair lines, to avoid external interference and unwanted feedback from the output to the high-impedance input. The connections from the signal source to the PR-E input may also have a dedicated ground shield to minimize external noise pickup and should be as short as possible. A low-capacitance cable is preferable.

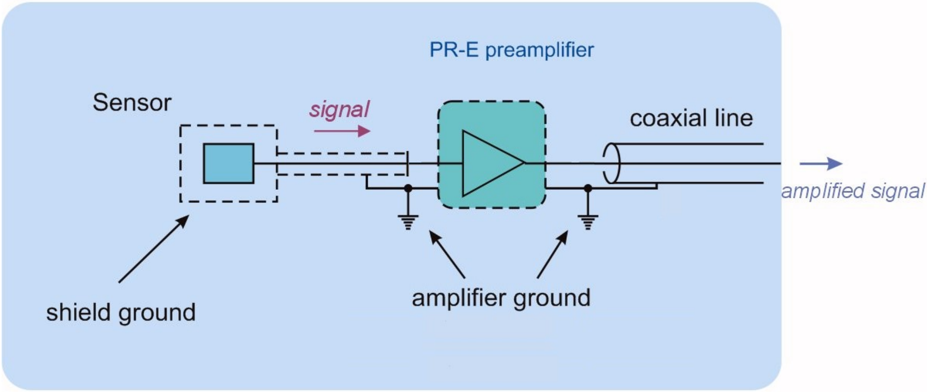


Fig. 5: Example of shielding and ground line

The GND-connection at the input of the amplifier (SMA shield) must be connected appropriately to the signal source, and the supply/output lines respectively. Especially a good low impedance ground is very important at the input. In noisy environments the output line also should be implemented as coaxial line. The rf-impedance of the output cabling is not critical, unless the cable length greatly exceeds ~2m. In that case the PR-E output resistance of 50 Ohms becomes relevant and a 50 Ohms-cable should be used.

Input Impedance and Stability

In general, the PR-E amplifier is highly stable, despite of its high input impedance, over a very wide range of input source impedances. They may be resistive (e.g. a photo sensor), capacitive (e.g. electrostatic