(Draft 07/20/2022)

MODEL SR446

DC to 400 MHz PROGRAMMABLE GAIN PREAMPLIFIER

1290-D Reamwood Avenue
Sunnyvale, California 94089
Phone: (408) 744-9040 • Fax: (408) 744-9049
email: info@thinkSRS.com • www.thinkSRS.com

Revision 1.0 (05/2022)

Certification
Stanford Research Systems certifies that this product met its published specifications at the time of shipment.

Warranty
This Stanford Research Systems product is warranted against defects in materials and workmanship for a period of one (1) year from the date of shipment.

Service
For warranty service or repair, this product must be returned to a Stanford Research Systems authorized service facility. Contact Stanford Research Systems or an authorized representative before returning this product for repair.

Information in this document is subject to change without notice.

Stanford Research Systems, Inc.
1290-C Reamwood Avenue
Sunnyvale, California 94089
Phone: (408) 744-9040 • Fax: (408) 744-9049
www.thinkSRS.com • e-mail: info@thinkSRS.com

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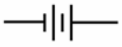
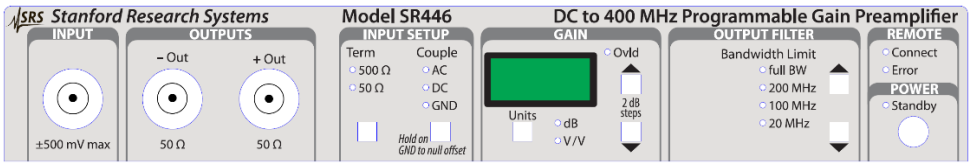
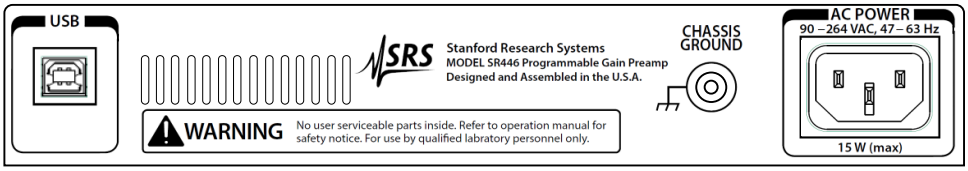
Symbols you may find on SRS products.

Symbol	Description
	Alternating current
	Caution - risk of electric shock
	Frame or chassis terminal
	Caution - refer to accompanying documents
	Earth (ground) terminal
	Battery
	Fuse
	On (supply)
	Off (supply)

SR446 Front Panel



SR446 Rear Panel



SR446 Programmable Amplifier

Description

The SR446 is a single-channel, 400 MHz bandwidth voltage preamplifier with 21 programmable gains from ×1 to ×100 (+0 dB to +40 dB with 2 dB steps). It also includes four programmable low-pass filters, with settings of full bandwidth, 200 MHz, 100 MHz and 20 MHz. There are two output channels which offer complimentary outputs (inverting and non-inverting) that can be used separately, or together as a differential output.

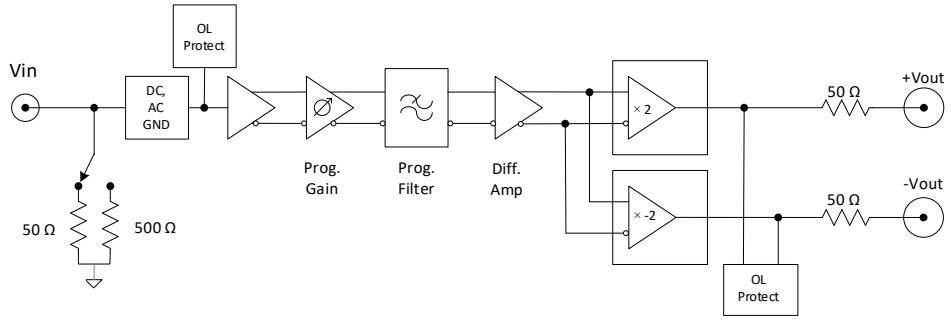
The front panel displays all the setup and the state of the instrument. Users can perform all the configurations from the front panel or remotely through the USB interface (in serial port emulation). A connect indicator shows that a remote serial device is ready for communication. An error indicator illuminates if any remote command errors or system errors have occurred. The error indicator will persist for about 5 seconds. Power standby indicator shows that live AC main is connected and ready to power up the unit.

Operation

The input impedance can be switched between 50 Ω or 500 Ω. The 500 Ω setting provides high transimpedance gain for charge and current sources—such as photomultiplier tubes—that may be useful when the amplifier is located close to the signal source. Thought input is protected, the voltage must be limited to ±4 V to avoid damaging the amplifier front-end. The 50 Ω input impedance is intended to terminate 50 Ω coaxial cable such as RG-58.

The amplifier performs best when both outputs are terminated with 50 Ω. Do not leave unterminated cables connected to the outputs, as this can cause unwanted oscillation of the amplifier. By selecting proper output band-limiting filter, un-wanted high frequency noise can be reduced. To protect external equipment, each output has overload detector and limiter. The overload indicator shows if any output signal is over the limits and beyond linear operating range.

Functional Block Diagram

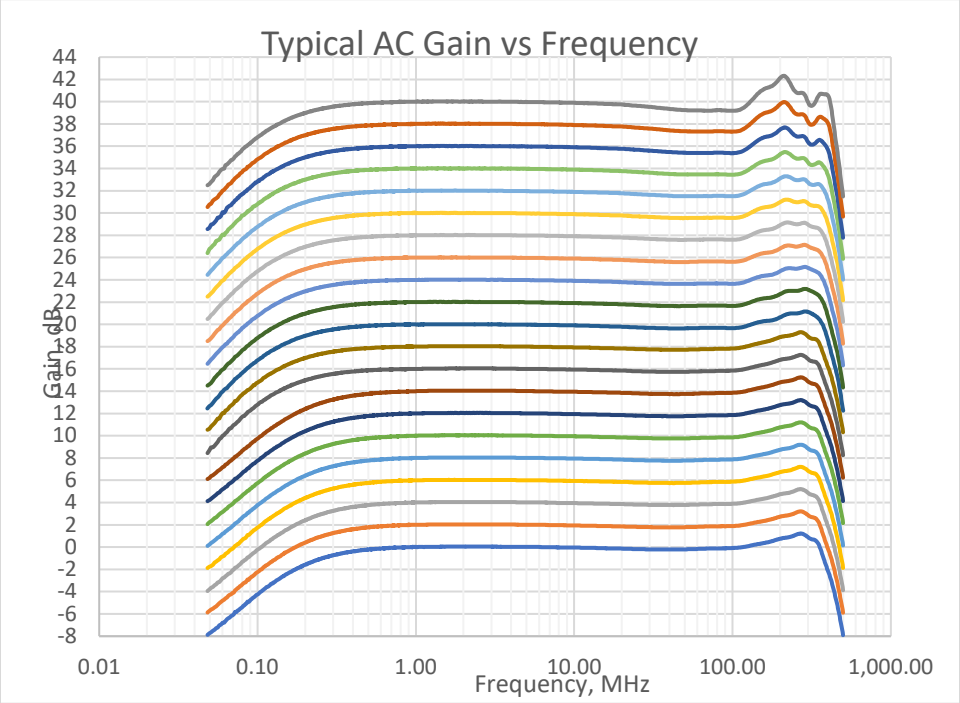


SR446 Specifications

Specification	Min	Typ	Max	Units
Inputs (driven by 50-Ω source)				
Input signal level	-500		+500	mV
AC mode cutoff (-3 dB) 50 Ω 500 Ω		 200 20		 kHz kHz
Impedance (at DC) 50 Ω 500 Ω	 49 497		 51 508	 Ω Ω
Input clamp levels	-1.5		+1.5	V
Protection (DC)	-4		+4	Vdc
Input-referred noise (@1 MHz, Maximum gain)		3.3		nV/$\sqrt{Hz}$
Noise (1 Hz to 400 MHz)		40		µVrms
Amplifier				
Gain	1 (0)		100 (40)	V/V (dB)
Gain accuracy (at 1 MHz)	-0.5		+0.5	dB
Gain flatness (DC to 100 MHz)		0.3		dB
Bandwidth (-3 dB)		400		MHz
Rise/fall time		1		ns
Propagation delay		4.5		ns
Gain drift Gain = 1 Gain = 100		 0.07 0.1		 %/°C %/°C
Outputs (driving 50-Ω load)				
Source impedance	49	50	51	Ω
Offset*	-1		+1	mV
Offset drift Gain = 1 Gain = 100		 0.4 0.8		 mV/°C mV/°C
Linear operation per channel Differential	-0.65 -1.3		+0.65 +1.3	V V
Overload level detect	-0.7		+0.7	V
Limit level	-0.9		+0.9	V
Skew between +Out and -Out		20		ps
Overload recovery time		12		ns
General				
Number of input channel		1		
Number of output channels		2		
USB port type B		1		
Operating temperature (non-condensing)	+5		+40	ºC
Mains voltage	85		264	VAC
Mains power	0.36	5	15	Watt
Mains frequency	47		63	Hz
Weight		1.1 (2.3)		kg (lb)
Dimensions (W × H × D)	213 mm × 45 mm × 230 mm (8.4” × 1.8” × 9.1”)			

*After DC calibration.

Frequency Response
AC mode, Input impedance = 50 Ω, Full bandwidth, input signal = 130mVpk-pk., sinusoidal wave



Calibration

Users can perform two types of calibrations: DC offset trim and AC gain adjustments.

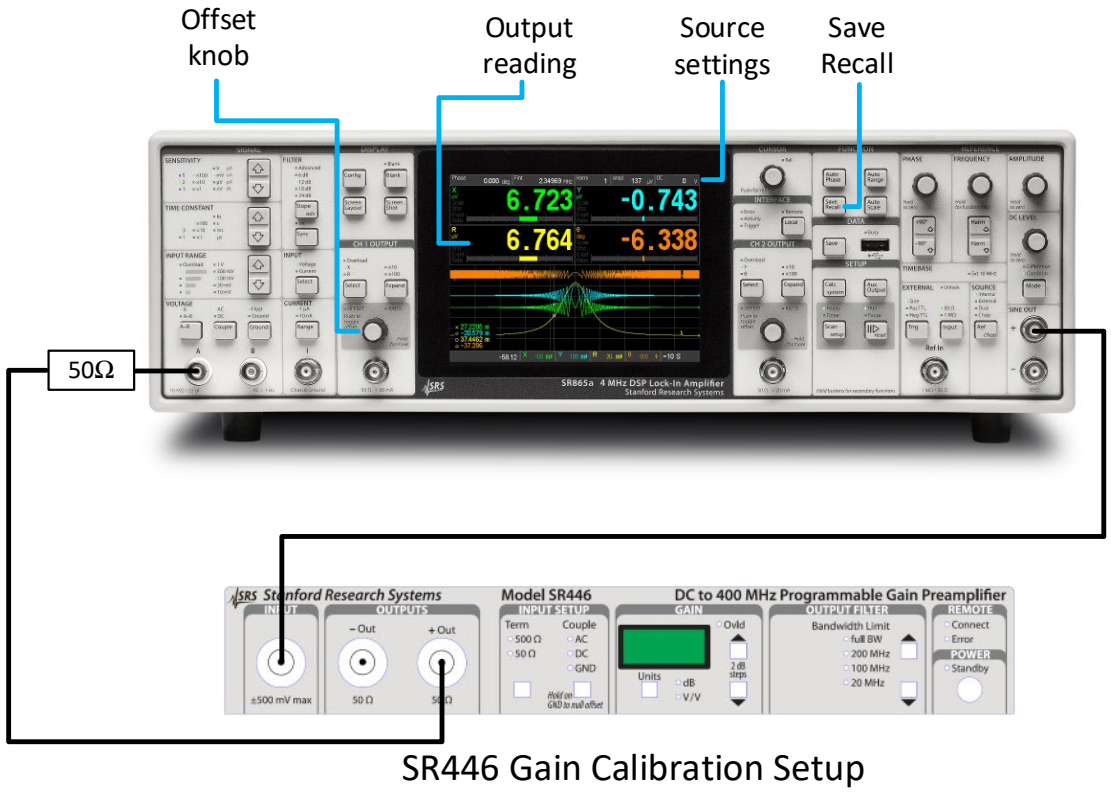
To trim DC offset, all connections must be disconnected from the input and the outputs ports. On the front panel, simply press and hold the input coupling button while at GND. Release the button when calibration starts as display indicates "CAL" and counts down to completion with "End" displayed. DC offset trimming can also be performed through the remote commands. Commands are listed in the remote interface section below.

For accurate calibration, power on the SR446 and wait for least 20 minutes to ensure it is warm up.

AC gain calibration compare output signal with respect to input signal at a given frequency. One recommendation is to use lock-in amplifier like SR865A. (Lock In Amplifier - SR865A (thinksrs.com))

Basic procedures:

1. Set and measure the reference signal source. Derive expected output readings for each channel.
2. Measure the outputs of the SR446
3. Adjust the trim pots in the unit to match the expected readings for each channel.



SR446 Gain Calibration Setup

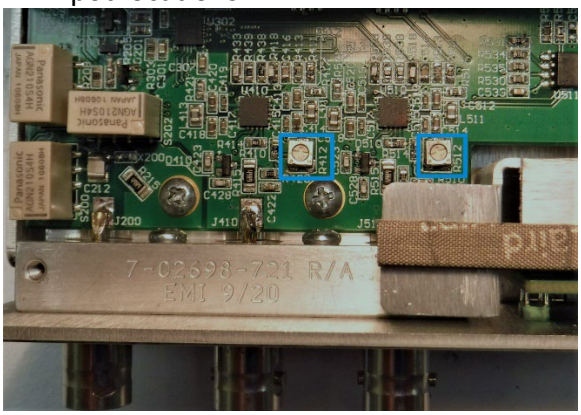
Recommended test equipment:
SR865A (Stanford Research Systems)
50 Ω load (Pomona P/N 4391-50 or equivalent)
Coaxial cables of RG-58 type (Pomona P/N 5697-36 or equivalent)
Trim pot adjustment tool (Aven P/N1322 or equivalent)

SR865A settings:
Refer to SR865A operations manual, configure following parameters:

- Reset the instrument
    - Press “Save Recall” button
    - Press “Recall Default” on the screen
    - Press “Confirm”
- REFERENCE:
    Amplitude = 200 mV
    Frequency = 1.0 MHz
    Phase = 0°
    DC LEVEL = 0 V
    Mode = Common
    Source = Internal
    Note: press “Ampl” on the top row of the screen, and use the on-screen key pad to enter the amplitude. Frequency and phase values can be entered in similar way.
- SIGNAL:
    Sensitivity = 500 mV
    Time constant = 10 ms
    Input range = 300 mV
    Voltage = Enable A, AC, Float
- CH1 OUTPUT:
    Select = R (radius)
    Expand = None
    Offset = Disable

SR446 settings:
Input impedance: 50 Ω
Input couple: DC
Gain: 1 V/V or 0 dB
Bandwidth: Full

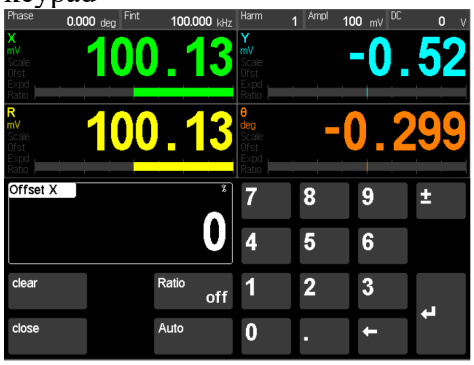
Trim pot locations



R412 is on the left. R512 is on the right.

Test procedures:

1. Remove the top cover of the SR446. Power up and configure the unit as stated above. Wait at least 20 minutes to warm up the device.
2. Power up and configure the SR865A as stated above. Wait at least 20 minutes to warm up the device.
3. Measure the reference signal:
    - Connect the SR865A SINE OUT + to the SIGNAL channel A through a 50 Ω load
    - Verify that the measured value is about one half of the set value, between 48% to 52%.
    - Press and hold the OFFSET knob under <CH1 OUTPUT> to display offset keypad



    - Press the on-screen Auto button (LED, next to the OFFSET, should be energized)
    - Verify that R value is less than +/-0.1 mV
4. Measure and adjust +Out gain:
    - Connect the SR865A SINE OUT + to the input of SR446
    - Connect the SR446 +Out to channel A of the SR865A through a 50 Ω load
    - Adjust the trim pot R512 so that the “R” reading is between +1 mV and -1mV
    - Press "Auto Phase” button under FUNCTION on the SR865A
5. Measure and adjust -Out gain:
    - Connect the SR446 -Out to channel B of the SR865A through a 50 Ω load.
    - Connect channel A of the SR865A with a shorting cap
    - Adjust the trim pot R412 so that the “R” reading is between +1 mV and -1 mV Also verify that the phase is between 179° and 181°
6. Turn off the power and disconnect all cables to the SR446. Replace and secure the top cover.

Power Supplies

The unit operates from a universal input power supply. The power supply can operate from AC mains with 85 ~ 264 VAC and 47 ~ 63 Hz. Typical power consumption is 5 W.

Remote Interface
Users can control the SR446 via the serial port emulation provided by the USB interface. Connect a USB cable from the device to a remote terminal or a computer. Start a terminal emulation program and configure it as follows;

Serial port: USB 2.0 type B receptacle.

The serial port settings are:
Speed: 115200 baud
Data: 8 bit
Parity: None
Stop bit: 1 bit
Flow control: None or hardware (RTS/CTS)

Terminal settings are:
Terminal: VT100
Coding: ASCII or UTF-8
Receive: CR or CR/LF
Transmit: CR/LF

Remote command list:
Only the host can initiate a command. The SR446 can only send response to a query and it does not echo back the command sent. The system will clear some error flags after respond to the query. All messages are ASCII strings. The communication format is described below:

1. Every message shall be terminated with <CR> (and optional <LF>).
2. Return messages are ASCII text and end with <CR><LF>.
3. Commands are case insensitive.
4. Separate command and parameter by a space <SP>.
5. No space is allowed between a command and "?" for queries.
6. Hexadecimal number does not allow 0x in front and is defined per command.

*Note that only *IDN?, FLAG? and OCAL? are valid during offset calibration. All other commands are ignored.*

Nomenclatures:
<h>: hexadecimal digit
<n>: decimal digit

Commands	Responses	Remarks
*IDN?	<System message>	System message = "Stanford_Research_Systems,SR446, <Serial Number>, <Revision number>"
*RST	None	Reset configuration to default settings. Copy factory settings to last settings and current settings. EEPROM update might be delayed up to 30 seconds.
ICPL <n>	None	Select input couple mode n: 0 = DC, 1 = AC, 2 = GND
ICPL?	<n>	Query input couple mode n: 0 = DC, 1 = AC, 2 = GND
INPZ <n>	None	Select input impedance [Ω] n: 0 = 500, 1= 50
INPZ?	<n>	Query input impedance [Ω] n: 0 = 500, 1= 50
UNIT <n>	None	Select unit of the gain n: 0 = dB; 1 = V/V
UNIT?	<n>	Query unit of the gain n: 0 = dB; 1 = V/V
GAIN <n>	None	Select voltage gain n: gain index from 0 to 20 Gain = $10^{n/10}$ [V/V] or Gain = 2 × n [dB]
GAIN?	<n>	Query voltage gain n: gain index from 0 to 20 See above
BNDW <n>	None	Select bandwidth index. n: 0 = Full, 1 = 200 MHz, 2 = 100 MHz, & 3 = 20 MHz
BNDW?	<n>	Query bandwidth n: 0 = Full, 1 = 200 MHz, 2 = 100 MHz, & 3 = 20 MHz
OCAL	<CAL in Progress> <CAL done> or <CAL aborted>	Initiate offset calibration. Note that this command is ignored if the calibration is already in progress. Wait ~18 seconds for completion.
OCAL?	<n>	Query status of offset calibration. 0 = Idle 1 = Requested by remote command 2 = Requested by front panel 3 = In progress 4 = Aborted after not able to calibrate 5 = Done after success. This is read to clear command
FLAG?	<hhhhhhhh>	Query system status flags hhhhhhh: 8-digit hexadecimal number including leading '0'. The definitions of each bit are defined below.
RDSN?	<nnnnnnnn>	Read 8-digit serial number.
OUTP <n>	<n>	Both output channels enable: 0 = disable; 1 = enable. After re-boot, the outputs become enable again.

System flags:

The system flag is an 8-digit hexadecimal number. The bits are arranged from MSB to LSB with LSB being bit 0. Example: 000000020 means bit 5 is set. Bit definitions are listed below:

BIT0: Unknow command
BIT1: Invalid parameter
BIT2: Console communication error
BIT3: Front panel communication error
BIT4: Analog board communication error
BIT5: EEPROM error
BIT6: Factory calibration in the EEPROM is invalid
BIT7: Last calibration data in the EEPROM is invalid
BIT8: Not able to set parameter
BIT9: Not able to configure system
BIT10: Invalid serial number
BIT11: Watchdog timer expired and disabled.
BIT12: ADC auto calibration on -Out failed
BIT13: ADC auto calibration on +Out failed
BIT14: DC calibration failed
BIT15: Reserved
BIT16: -Out output overloads
BIT17: +Out output overloads
All other bits are reserved.