MODEL SR445A

350 MHz PREAMPLIFIER

SRS Stanford Research Systems

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350 MHz PREAMPLIFIER

Stanford Research Systems

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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.

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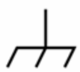
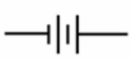
Symbols you may find on SRS products.

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)

SR445A Quad Fast Amplifier

Description

The SR445A is a four-channel, 350MHz bandwidth, dc coupled, 50Ω amplifier with a gain of 5× (or +14dB) in a half-width 1U chassis. Two, three or four channels may be cascaded for gains of 25×, 125×, or 625×, (+28dB, +42dB, or +56dB.) The unit uses BNC connectors for inputs and outputs. The unit is powered from the ac mains by a universal input power supply.

The full scale input is ±200mV. The input noise is typically 5.2nV/√Hz. The output is linear over ±1V and should be terminated into a 50Ω load. Output rise and fall times are 1.3ns. The output will recover from a 10× full scale overload in 3ns. The unit is protected from ±50V, 1µs input overloads.

There are five LEDs on the front panel; one indicates that the unit is powered and "on" and four indicate when the output signal for the corresponding channel is outside its linear range, typically ±1.3Vdc. Brief overloads (<5ns) trigger a 10ms flash.

Operation

The input impedance for each channel is 50Ω. (There is a front panel switch that allows the input resistance of Channel 1 to be set to either 500Ω or 50Ω. The 500Ω setting provides high transimpedance gain for current source—such as photomultiplier tubes—that may be useful when the amplifier is located close to the signal source.) The dc input voltage must be limited to ±4V to avoid damaging the amplifier front-end. The amplifier is internally protected from 50V transients of 1µS duration. The 50Ω input impedance is intended to terminate 50Ω coaxial cable such as RG-58.

The amplifiers perform well when cascaded due to their high input return loss and flat frequency response characteristics. Referenced to the input, the broadband noise (1Hz to 300MHz) is $80\mu V_{rms}$. Peak-to-peak noise is typically 5× the RMS value and so one would expect to see about $10mV_{pp}$ at the output of two cascaded amplifiers, $50mV_{pp}$ at the output of three cascaded amplifiers, and $250mV_{pp}$ at the output of four cascaded amplifiers.

SR445A Specifications

Specification	Min	Typ	Max	Units
Inputs (driven by 50Ω source)				
Input signal level	-200		+200	mV
Impedance	49.5	50	50.5	Ω
Return loss		32		dB
Offset	-500	0	+500	μV
Offset drift	-10		+10	μV/°C
Bias current (note 1)		3	10	μA
Protection (dc)	-4		+4	Vdc
Protection (1μS transient)	-50		+50	V
Recovery time (10×FS overload)		3		nS
Noise (10Hz)		22		nV/√Hz
Noise (100Hz)		8.6		nV/√Hz
Noise (> 1kHz)		5.2		nV/√Hz
Noise (1Hz to 300MHz BW)		80		μVrms
Crosstalk (CH1 out to CH2 in)		-61		dB
Crosstalk (CH2 out to CH1 in)		-82		dB
Amplifier				
Gain (note 2)	4.95	5.00	5.05	V/V
Bandwidth (-3dB)		350		MHz
Rise/fall time		1.3		nS
Propagation delay		2.7		nS
Outputs (driving 50Ω)				
Source impedance (note 3)	49.5	50	50.5	Ω
Linear operation	-1.0		+1.0	V
Overload level	-1.3		+1.3	V
Limit level	-1.6		+1.6	V
General				
Number of Channels		4		
Operating temperature	0		40	ºC
Mains voltage	90-132		175-264	Vac
Mains power		15		Watts
Mains frequency	47		63	Hz
Dimensions	8.35”	1.70”	8.10”	W×H×D

Notes:

1. The input bias current flows out of the unit, creating a positive offset of about 150μV on the 50Ω input termination. This offset will be affected by the dc impedance of the source that is connected to the input.
2. Amplifier gain is calibrated by applying a known current to the input and measuring the voltage into a high impedance load. The gain is adjusted so that a 1mA source applied to the input produces a 500mV voltage at the unloaded output.
3. Channel 1 may be set to either 500Ω or 50.5Ω via a front panel switch.

Calibration

The purpose of the calibration is to verify operation of the unit and:

1. Adjust the high frequency compensation for best pulse response.
2. Adjust the offset to null the dc voltage at the output with no input.
3. Adjust the gain to 10× for an unloaded output so that the nominal gain for an amplifier driving a 50Ω load will be 5× (or +14dB.)

Since the adjustments are interdependent, it is important that the adjustments be done in the prescribed order, and that all of the adjustments be done. For example, adjusting the high frequency compensation will affect the output offset. Calibration pots are accessible from the underside of the unit.

Required equipment:

1. Pulse generator, splitter and attenuator to produce two ±100mV square waves with a rise time of less than 1nS. (ECL reference output from SR620 Time Interval Counter into an unmatched tee driving two 50Ω cables with a 20dB attenuator on the one that goes to the SR445A.)
2. Digital voltmeter with 4-wire ohm measurement capability (Agilent 34401)
3. Digital oscilloscope with at least 300MHz bandwidth.

High Frequency Compensation

The SR445A uses an AD8009 current feedback amplifier in the output stage. The gain of the amplifier is controlled by the ratio of resistors in the feedback network and the bandwidth is controlled by the Thevenin equivalent source impedance of the feedback network. The ratio is fixed (by R115 & R116, R215 & R216, R315 & R316, R415 & R416) to provide a gain of 5× and the source impedance may be adjusted (by P102, P202, P302 and P402.)

The bandwidth is set to optimize the pulse response of the amplifier. This is done by applying a fast pulse at the input and adjusting P102 (or P202, P302 or P402 for channels 2, 3 & 4) so that the output rise time and overshoot most closely match the rise time and overshoot of the fast input pulse as observed on a 300MHz oscilloscope with 50Ω input impedance.

Note that adjusting P102 will affect the offset for channel 1, as there is a large input bias current (150μA, max) to the inverting input of the AD8009. The offset will need to be adjusted after the HF compensation is adjusted.

1. Split the ECL reference output from SR620 with a coax tee. Take one cable from the tee to channel 1 of the oscilloscope (set to 50Ω input termination) and the other to the top channel of the SR445A via a 20dB coaxial attenuator.

2. Adjust P102 (Channel 1 HF compensation pot) to match the output rise time and overshoot to the input rise time and overshoot.
3. Repeat for the remaining three channels, adjusting the pulse response with P202, P302 or P402.

Offset Calibration

The output offset is affected by the HF compensation and so the offset should be nulled after the HF compensation is adjusted. The offset may also be affected by the amplifier gain adjustment if there is a large input offset voltage.

1. Leave the inputs unconnected.
2. Connect the output (without a 50Ω load) to the DVM on the mV dc range.
3. Adjust the offset pot (P101 for channel 1) to null the output voltage.
4. Verify that the output voltage shifts down by less than 2.5mV when a 50Ω terminator is placed on the input. (The voltage shift will be 10×[the input bias current]×[the change of input resistance=25Ω] hence this measurement confirms that the input bias current is less than 10μA.)
5. Repeat the procedure to null the output of channels 2, 3 and 4 by adjusting P201, P301 and P401.

Gain Calibration

The overall gain of the amplifier is 5× when driving a 50Ω load and 10× when driving a high impedance load. The input source to the amplifier is typically a current source (such as the output from a photomultiplier) and so the magnitude of the input resistance is included in the gain calibration by calibrating the amplifier's transconductance. (Calibration is done with a current source as an input while measuring the voltage at the output.)

A DVM used in the 4-wire resistance mode is convenient for performing the calibration. Typically a DVM will measure small resistances by measuring the voltage across the resistor while passing a 1mA dc current through the resistor. We measure the gain of the amplifier by measuring the voltage at the output while applying test current to input. When the gain is properly adjusted, 1mA applied to the 50Ω input generates 50mV at the input and 500mV at the (unterminated) output causing the DVM to indicate a "resistance" of 500Ω. (To avoid auto ranging "confusion" by the DVM, a 453Ω resistor is placed in series with the current source.)

Since the DVM uses a dc current as the test source, it is important that the amplifier offset be nulled prior to performing the dc gain adjustment.

1. Setup the DVM in the 4-wire resistance measurement mode.
2. Apply the current output to the amplifier input via a 453Ω in-line resistor.
3. Apply the unterminated amplifier output to the DVM's 4-wire sense input.

4. Adjust the gain pot (P100 for channel 1, P200 for channel 2, P300 for channel 3, and P400 for channel 4) so that the DVM indicates a "resistance" of 500Ω.
5. Verify that the offset was nulled by connecting the current source from the DVM to the input of the other channel and measuring a resistance of less than 1Ω.
6. Repeat the gain adjustment for the second channel.

Circuit Description

(The four amplifier channels are identical. This description uses reference designators for the top channel.)

The input is terminated into 50Ω by the parallel combination of R100 & R101. The input signal is coupled via a 47Ω resistor to the high speed “clamp-amp”, U100. U100 is configured as a non-inverting gain of 2× amplifier. Pins 8 & 5 on U100 define input clamping thresholds of ±0.31Vdc. If the input signal exceeds these thresholds then U100 will use the clamping thresholds as inputs thereby limiting its output to ±0.62Vdc. This prevents the output of U100 from overdriving the next gain stage.

Input signals in excess of ±1.4Vdc are shunted to ground via the input protection diodes D100 & D101. Normally both the diodes in D100 are reversed biased and so they do not interfere with the signal. The diodes in D101 are forward biased by R103 & R104. When the input signal exceeds ±1.4Vdc (7× the full scale input), one of the diodes in D100 will turn “on” thereby limiting the input to U100 to a safe level.

The gain of U100 can be adjusted by ±10% by P100, which is calibrated at the factory to set the overall gain of the channel to 5× when terminated into a 50Ω load. The output of U100 is passed to the next gain stage via R112, a 47Ω resistor.

The next stage has a fixed gain of 5× with an adjustable offset and adjustable high frequency response. The gain of U101 is set by R115 & R116. The offset, adjusted by P101 and injected by R117, is nulled during calibration. The high frequency response of U101 is affected by the source impedance of its input signal and its feedback network. Turning P102 clockwise decreases the source impedance of the feedback signal and increases the high frequency response of the gain stage. P102 is adjusted during calibration for an optimum pulse response providing a typical -3dB bandwidth of 350MHz.

The output from U101 is passed to the front panel output BNC via the parallel resistors R118 & R119, providing a 50Ω output impedance. These resistors, in combination with the 50Ω load resistor (provided by the user), attenuate the signal by 2× so that the overall gain is 5×.

Overloads are detected at the output of the second gain stage, U101. A positive overload is rectified by D102 and charges C107. A negative overload is rectified by D102 and discharges C106. One of the comparators in U102 will be driven low when the voltage on C106 or C107 exceeds ±1.7V. The driven comparator discharges C108 from +5V to -5V. C108 will be slowly recharged to +5V by R128, a 1MΩ resistor, thereby stretching the overload signal to about 10ms. One of the comparators in U504 (sheet 3 of the schematics) drives the front panel overload LED until the voltage on C108 recharges above ground. This overload detection will detect overloads as short as 3ns.

Power Supplies

The unit operates from a universal input/single floating output power supply. The power supply can operate from AC mains with 90-132Vac or 175-264Vac between 47 & 63Hz and outputs 18Vdc. An "active ground" is generated by the op amp U501 together with Q500 & Q501 to generate ±9V. The op amp amplifies the midpoint voltage of the dc power supply, which is at its non-inverting input, and either sources current (via Q501) into the negative rail or draws current (via Q500) from the positive rail so that the midpoint is at ground.

The ±9Vdc is regulated to ±5Vdc by U502 and U503. The ±5Vdc power supplies are passively filtered by capacitors on the outputs of the regulators and by L/C filters for each amplifier channel. Careful power supply filtering is important to reduce channel crosstalk. The crosstalk from the output of channel 1 to the input of channel 2 is less than -60dB (1:1000 of the amplitude) and peaks around 300MHz. The crosstalk from the output of channel 2 to the input of channel 1 is less than -80dB (1:10,000 of the amplitude) and occurs in a broad band between 180MHz and 360MHz.

SR445A Component parts list

REF. #	SRS P/N	VALUE	DESCRIPTION
C 100	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 101	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 102	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 103	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 104	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 105	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 106	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 107	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 108	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 110	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 111	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 200	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 201	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 202	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 203	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 204	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 205	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 206	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 207	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 208	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 210	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 211	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 300	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 301	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 302	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 303	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 304	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 305	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 306	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 307	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 308	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 310	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 311	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 400	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 401	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 402	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 403	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 404	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 405	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 406	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 407	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 408	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 410	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 411	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)

REF. #	SRS P/N	VALUE	DESCRIPTION
C 501	5-00516-526	330U HIGH RIPPL	Capacitor, Electrolytic, 35V, 20%, Rad
C 502	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 503	5-00516-526	330U HIGH RIPPL	Capacitor, Electrolytic, 35V, 20%, Rad
C 504	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 505	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 506	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 507	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 508	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 509	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 510	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 511	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 512	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
D 100	3-00896-301	BAV99	Diode
D 101	3-00896-301	BAV99	Diode
D 102	3-00896-301	BAV99	Diode
D 200	3-00896-301	BAV99	Diode
D 201	3-00896-301	BAV99	Diode
D 202	3-00896-301	BAV99	Diode
D 300	3-00896-301	BAV99	Diode
D 301	3-00896-301	BAV99	Diode
D 302	3-00896-301	BAV99	Diode
D 400	3-00896-301	BAV99	Diode
D 401	3-00896-301	BAV99	Diode
D 402	3-00896-301	BAV99	Diode
D 600	3-00010-303	GREEN	LED, T1 Package
D 601	3-00011-303	RED	LED, T1 Package
D 602	3-00011-303	RED	LED, T1 Package
D 603	3-00011-303	RED	LED, T1 Package
D 604	3-00011-303	RED	LED, T1 Package
J 100	1-00003-120	BNC	Connector, BNC
J 101	1-00003-120	BNC	Connector, BNC
J 200	1-00003-120	BNC	Connector, BNC
J 201	1-00003-120	BNC	Connector, BNC
J 300	1-00003-120	BNC	Connector, BNC
J 301	1-00003-120	BNC	Connector, BNC
J 400	1-00003-120	BNC	Connector, BNC
J 401	1-00003-120	BNC	Connector, BNC
J 506	1-01043-171	5POS .100 JMPR	Cable Assembly, Ribbon
L 100	6-00236-631	FR47	Ferrite bead, SMT
L 101	6-00236-631	FR47	Ferrite bead, SMT
L 200	6-00236-631	FR47	Ferrite bead, SMT
L 201	6-00236-631	FR47	Ferrite bead, SMT
L 300	6-00236-631	FR47	Ferrite bead, SMT
L 301	6-00236-631	FR47	Ferrite bead, SMT
L 400	6-00236-631	FR47	Ferrite bead, SMT
L 401	6-00236-631	FR47	Ferrite bead, SMT
L 500	6-00174-630	6611 TYPE 43	Ferrite Beads

REF. #	SRS P/N	VALUE	DESCRIPTION
L 501	6-00174-630	6611 TYPE 43	Ferrite Beads
P 100	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 101	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 102	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 200	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 201	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 202	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 300	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 301	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 302	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 400	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 401	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 402	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
PC1	7-01479-701	SR240A/445A	Printed Circuit Board
Q 500	3-01091-360	MJD44H11	Integrated Circuit (Surface Mount Pkg)
Q 501	3-01100-360	MJD45H11	Integrated Circuit (Surface Mount Pkg)
R 1	4-00997-462	56.2	Thin Film, 1%, 50 ppm, MELF Resistor
R 100	4-01117-462	1.00K	Thin Film, 1%, 50 ppm, MELF Resistor
R 101	4-01117-462	1.00K	Thin Film, 1%, 50 ppm, MELF Resistor
R 102	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 103	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 104	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 105	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 106	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 107	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 108	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 109	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 110	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 112	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 115	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 116	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 117	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 118	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 119	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 120	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 121	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 122	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 123	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 124	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 125	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 126	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 127	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 128	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 200	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 201	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 202	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 203	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor

REF. #	**SRS P/N**	**VALUE**	**DESCRIPTION**
R 204	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 205	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 206	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 207	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 208	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 209	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 210	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 212	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 215	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 216	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 217	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 218	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 219	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 220	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 221	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 222	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 223	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 224	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 225	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 226	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 227	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 228	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 300	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 301	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 302	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 303	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 304	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 305	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 306	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 307	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 308	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 309	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 310	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 312	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 315	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 316	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 317	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 318	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 319	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 320	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 321	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 322	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 323	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 324	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 325	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 326	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 327	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor

REF. #	SRS P/N	VALUE	DESCRIPTION
R 328	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 400	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 401	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 402	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 403	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 404	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 405	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 406	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 407	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 408	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 409	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 410	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 412	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 415	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 416	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 417	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 418	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 419	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 420	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 421	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 422	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 423	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 424	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 425	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 426	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 427	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 428	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 500	4-01213-462	10.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 501	4-01213-462	10.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 502	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 503	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 504	4-00320-409	18	Resistor, Wire Wound
R 505	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 506	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 507	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 508	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 509	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 510	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
SW100	2-00025-217	SPDT	Switch, On-None-On, Toggle, Right Angle
U 100	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 101	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 102	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 200	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 201	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 202	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 300	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 301	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)

REF. #	SRS P/N	VALUE	DESCRIPTION
U 302	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 400	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 401	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 402	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 501	3-00729-360	LM741C	Integrated Circuit (Surface Mount Pkg)
U 502	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 503	3-00119-329	7905	Voltage Reg., TO-220 (TAB) Package
U 504	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 505	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00096-041	#4 SPLIT	Washer, Split
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00197-002	3ED8	Power Entry Hardware
Z 0	0-00222-021	6-32X1/4PP	Screw, Panhead Phillips
Z 0	0-00238-026	6-32X1/4PF	Screw, Black, All Types
Z 0	0-00240-026	4-40X3/8PF	Screw, Black, All Types
Z 0	0-00252-057	GROMMET DG532	Grommet
Z 0	0-00267-052	6-1/2" #22 RED	Wire #22 UL1007
Z 0	0-00268-052	6-1/2" #22 BL	Wire #22 UL1007
Z 0	0-00330-050	5-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00415-031	4-40X1/2 M/F	Standoff
Z 0	0-00517-000	BINDING POST	Hardware, Misc.
Z 0	0-00536-032	31894	Termination
Z 0	0-00772-000	1.5" WIRE	Hardware, Misc.
Z 0	0-00907-020	6-32X1/4 PF UC	Screw, Flathead Phillips
Z 0	0-01068-000	SR445A FOOT	Hardware, Misc.
Z 0	1-00033-113	5 PIN, 18AWG/OR	Connector, Amp, MTA-156
Z 0	1-00254-113	2 PIN, 22AWG/RD	Connector, Amp, MTA-156
Z 0	2-00049-211	SPST ON-NONE-OF	Switch, Rocker
Z 0	6-00626-615	18V-15WATT	Power Supply
Z 0	7-00167-720	SR445A	Fabricated Part
Z 0	7-00349-720	SR445A	Fabricated Part
Z 0	7-00380-721	SR445A/SR240A	Machined Part
Z 0	7-01480-720	SR445A, RCK MT	Fabricated Part
Z 0	7-01481-709	SR445A	Lexan Overlay
Z 0	7-01482-720	SR445A	Fabricated Part
Z 0	7-01622-720	SR445A MYLAR	Fabricated Part
Z 0	9-00267-917	GENERIC	Product Labels