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MODEL SR570

Low-Noise Current Preamplifier



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Revision 1.7
(08/2015)

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Safety and Preparation for Use

WARNING: Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution whenever the instrument covers are removed.

********** CAUTION **********

This instrument may be damaged if operated with the LINE VOLTAGE SELECTOR set for the wrong ac line voltage or if the wrong fuse is installed.

LINE VOLTAGE SELECTION

When the AC power cord is connected to the unit and plugged into an AC outlet, the unit automatically switches the amplifier power source from internal battery operation to line operation. The internal batteries are charged as long as AC power is connected.

The SR570 operates from a 100V, 120V, 220V, or 240V nominal AC power source having a line frequency of 50 or 60 Hz. Before connecting the power cord to a power source, verify that the LINE VOLTAGE SELECTOR card, located in the rear panel fuse holder, is set so that the correct AC input voltage value is visible.

Conversion to other AC input voltages requires a change in the fuse holder voltage card position and fuse value. Disconnect the power cord, open the fuse holder cover door and rotate the fuse-pull lever to remove the fuse. Remove the small printed circuit board and select the operating voltage by orienting the printed circuit board so the desired voltage is visible. Push the card firmly into its slot. Rotate the fuse-pull lever back to its normal position and insert the correct fuse into the fuse holder.

LINE FUSE

Verify that the correct line fuse is installed before connecting the line cord. For 100V/120V, use a 1 Amp fuse and for 220V/240V, use a 1/2 Amp fuse.

LINE CORD

The SR570 has a detachable, three-wire power cord for connection to an AC power source and to a protective ground. The exposed metal parts of the instrument are connected to the outlet ground to protect against electrical shock. Always use an outlet which has a properly connected protective ground.

CONNECTION TO OTHER INSTRUMENTS

All front panel BNC shields are isolated from the chassis ground and the power outlet ground via a 1MΩ resistor. Do not apply any voltage to either the shields or to the outputs. The outputs are not protected against connection to any potential other than circuit ground.

VENTILATION

Always ensure adequate ventilation when operating the SR570. The unit will generate heat while charging batteries.

POWER-UP

All instrument settings are stored in nonvolatile memory (battery backed-up RAM) and are retained when the power is turned off. They are not affected by the removal of the line cord. If the power-on self test passes, the unit will return the settings that were in effect when the power was last turned off. If an error is detected or if the backup battery is exhausted, the default settings will be used. Additionally, if the FILTER RESET key is held down when the power is turned on, the instrument settings will be set to the defaults shown below:

Sensitivity = 1 μA/V, calibrated
Invert = off
Input Offset = +1 pA, calibrated, off
Bias = 0 V, off
Filters = none
Hi Pass Freq = 0.03 Hz
Lo Pass Freq = 1 MHz
Gain Mode = Low Noise

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REPACKAGING FOR SHIPMENT

The original packing materials should be saved for reshipment of the SR570. If the original packing materials are not available, wrap the instrument in polyethylene sheeting or equivalent and place in a strong box, cushioning it on all sides by at least three inches of high-density foam or other filler material.

USE IN BIOMEDICAL APPLICATIONS

Under certain conditions, the SR570 may prove to be unsafe for applications involving human subjects. Incorrect grounding, component failure, and excessive common-mode input voltages are examples of conditions in which the instrument may expose the subject to large input currents. Therefore, Stanford Research Systems does not recommend or approve the SR570 for such applications.

WARNING REGARDING USE WITH PHOTOMULTIPLIERS

The front-end amplifier of this instrument is easily damaged if a photomultiplier is used improperly with the amplifier. When left completely unterminated, a cable connected to a PMT can charge to several hundred volts in a relatively short time. If this cable is connected to the inputs of the SR570, the stored charge may damage the front-end op amps. To avoid this problem, always connect the PMT output to the SR570 input before turning the PMT on.

ACCESSORIES FURNISHED

- Power Cable
- Operating Manual

ENVIRONMENTAL CONDITIONS

OPERATING
Temperature: 10° C to 40° C
Relative Humidity: < 90% Non-condensing

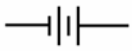
NON-OPERATING
Temperature: -25° C to +65° C Non-condensing

WARNING REGARDING BATTERY MAINTENANCE.

Batteries used in this instrument are sealed lead acid batteries. With usage and time these batteries can leak. Always use and store this instrument in the feet-down position. To prevent possible damage to the circuitboard, it is recommended that the batteries be periodically inspected for any signs of leakage.

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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)

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Specifications

Input

Input	Virtual null or user set bias voltage (-5V to +5V).
Input Impedance	See Table 1
Input Offset	±1 pA to ±5 mA full scale adjustable dc offset current.
Maximum Input	±5 mA.
Noise	See graphs on next page.
Sensitivity	1 pA/V to 1 mA/V in a 1-2-5 sequence. Vernier sensitivity in 1% steps.
Frequency Response	Flat to ±0.5 dB up to 1 MHz (1 mA/V sensitivity). Frequency response can be adjusted from the front panel to compensate for the effects of source capacitance at the input.
Grounding	Amplifier ground is fully floating. Amplifier and chassis grounds may be connected together at rear panel banana plug connectors.

Filters

Signal Filters	Two configurable (low or high pass) filters: 6 or 12 dB/octave. The -3 dB point of each filter is settable in a 1-3-10 sequence from 0.03 Hz to 1 MHz for lowpass filters and 0.03 Hz to 10 kHz for highpass filters.
Filter Reset	Long time constant filters may be reset with a front panel button.

Gain Allocation

Low Noise	Most of the gain is allocated in the front end of the instrument to decrease the magnitude of Johnson noise at the output.
High Bandwidth	Front-end gain is reduced to increase the amplifier's frequency response.
Low Drift	A very low input bias current amplifier is used for more accurate measurements on the higher sensitivity ranges.

Output

Gain Accuracy	±(0.5 % of output + 10 mV [50 mV High BW]) @ 25°C [100 pA/V - 1 mA/V sensitivities]
DC Drift	See Table 1
Maximum Output	±5 V into a high impedance load (50W output impedance).
Slew Rate Limit	2 V peak to peak at 1 MHz.
Rear Panel	±12 VDC @200 mA, referenced to amplifier ground.

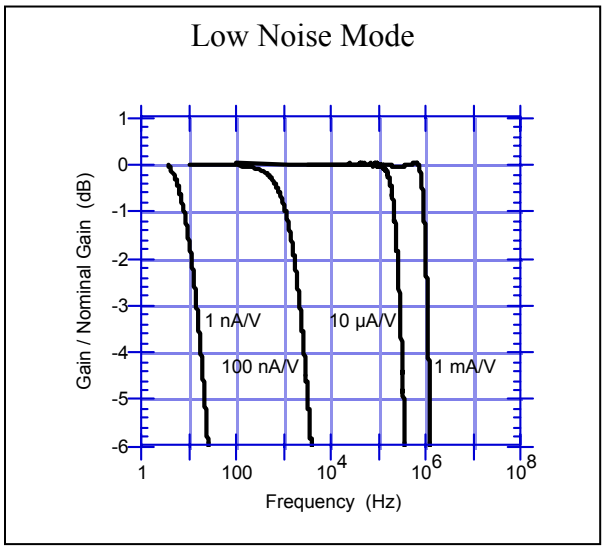
Interface

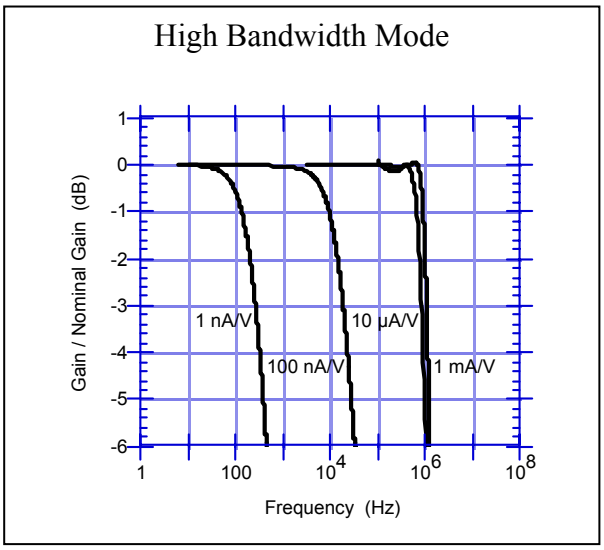
RS-232	Listen only, 9600 Baud DCE, 8 bit, no parity, 2 stop bits. All instrument functions may be controlled. PC compatible serial connector. Optically isolated.
External Gating	TTL inputs to set gain to zero (blanking) or to invert gain polarity (toggling).

General

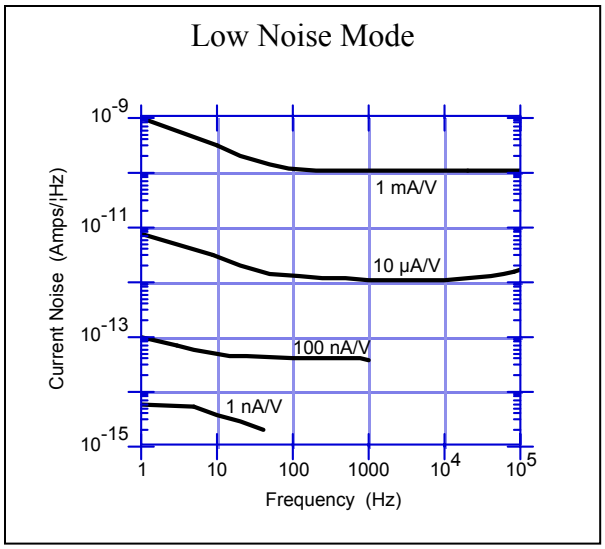
Operating Temperatures	0 to 50° C
Power	100, 120, 220 or 240 VAC, 50/60 Hz from line. Internal batteries provide up to 15 hours between charges. Batteries are charged while connected to the line. Line power required is 30 watts while batteries are charging and 6 watts once fully charged.
Dimensions	8.3" x 3.5" x 13.0". Rack mounting hardware available.
Weight	15 lbs. (including batteries).
Warranty	1 year.

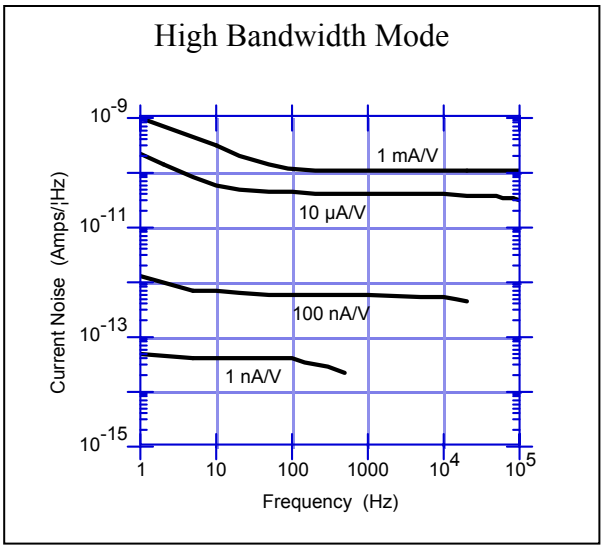
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Amplifier Bandwidth for several sensitivity settings (typical).





Current Noise as a function of Frequency for several sensitivity settings (typical).

Note: The amplifier bandwidth and noise data were taken with the front panel frequency compensation adjusted for flat frequency response over the widest frequency range, with an input capacitance of 100 pF. Either the bandwidth or the noise specification can be improved at the expense of response flatness.

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Specifications

Table 1

Sensitivity (A/V)	Bandwidth (3 dB) [1] High BW	Bandwidth (3 dB) [1] Low Noise	Noise/√Hz[2] Low Noise	Noise/√Hz[2] High BW	Temperature Coefficient Low Drift (11 ° - 28 °C) ±(%input + offset) /°C	DC Input Impedance
10-3	1.0 MHz	1.0 MHz	150 pA	150 pA	0.01 % + 20 nA	1 Ω
10-4	1.0 MHz	500 kHz	60 pA	100 pA	0.01 % + 2 nA	1 Ω
10-5	800 kHz	200 kHz	2 pA	60 pA	0.01 % + 200 pA	100 Ω
10-6	200 kHz	20 kHz	600 fA	2 pA	0.01 % + 20 pA	100 Ω
10-7	20 kHz	2 kHz	100 fA	600 fA	0.01 % + 2 pA	10 kΩ
10-8	2 kHz	200 Hz	60 fA	100 fA	0.01 % + 400 fA	10 kΩ
10-9	200 Hz	15 Hz	10 fA	60 fA	0.025 % + 40 fA	1 MΩ
10-10	100 Hz	10 Hz	5 fA	10 fA	0.025 % + 20 fA	1 MΩ
10-11	20 Hz	10 Hz	5 fA	10 fA	0.040 % + 20 fA	1 MΩ
10-12	10 Hz	10 Hz	5 fA	5 fA	0.040 % + 20 fA	1 MΩ

[1]Frequency Compensation adjusted for flat frequency response (typical values).

[2]Average noise in the freq. range below the 3 dB point but above the frequency where 1/f noise is significant.

Note: The values listed above are typical for a 100 pF source capacitance and an infinite source resistance. Significantly higher values of source capacitance or finite source resistance can degrade these specifications. Proper use of the "FREQ COMP" adjustment and signal filters allows the user to alter the rated noise or bandwidth values. The LOW DRIFT mode has a much lower bandwidth than the LOW NOISE and HIGH BW modes, and should only be used for low frequency measurements.

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Verifying Specifications

To verify the specifications given for the SR570 current amplifier, a few straightforward procedures should be followed. First, the unit must be warmed up for about 60 minutes. Second, for best performance, the input current should produce an output voltage of about 1 V or less. This eliminates problems with slew rate limiting in the various amplifier stages. Finally, care must be taken in selection of a current source for any measurement. Since an ideal current source has infinite impedance, any source used for measurements should have an impedance greater than the inverse of the sensitivity in ohms. Most specifications listed above were measured with an input capacitance of 100 pF. Higher input capacitance will lead to a decrease in performance.

Lets look at a simple example to illustrate some of these principles. To test the gain and frequency response of the instrument at 1 nA/V sensitivity, we might use a 1 V RMS sine wave across a 1 GΩ resistor and through 1 meter of coax cable into the amplifier front-end. The cable itself has about 100 pF of input capacitance to ground. Any other sources of capacitance will only increase this value, and degrade the noise performance of the instrument. The 1 GΩ resistor, while a good current source at DC, will be less accurate at higher frequencies due to capacitance of the resistor. A typical resistor will have about 0.1 pF capacitance, which will provide a parallel impedance of 1 GΩ at about 1.6 kHz. Since this effect provides an alternate path for current, the actual current to the amplifier will be increased and may be misinterpreted as a peaking in the frequency response of the amplifier near 1 kHz. These are only a few examples of what can go wrong when making a measurement. It is very important that the current source be completely characterized before performing specification verification.

Keep in mind the following items when trying to verify specifications or when making sensitive measurements:

1. Make sure the source impedance is greater than the inverse of the sensitivity (e.g. with a sensitivity of 1 nA/V use a source impedance greater than 1 GΩ).

2. If using a voltage source and a big resistor to source the current, use several smaller resistors in series instead of one larger value to reduce the shunting capacitance.

3. Adjust the FREQ COMP pot on the front panel to optimize frequency response for the source character- istics and for the sensitivity selected.

4. Use short lengths of high quality coaxial cable to connect to the amplifier input.

5. Keep the amplifier output below 1 VRMS to avoid slew rate limiting at high frequencies.

6. Ground the chassis (green connector on back) but do not connect the chassis to the amplifier ground (white connector).

7. For low level measurements, disconnect the power cord and use the internal batteries.

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Abridged RS-232 Command List

Command Syntax

All RS232 commands consist of four letter codes, followed in most cases, by an integer value (n). Commands must end with a carriage return and linefeed <CR><LF>.

The SR570 RS232 interface is configured as listen only, 9600 baud DCE, 8 data bits, no parity, 2 stop bits, and is optically isolated to prevent any noise or grounding problems.

Sensitivity control commands

SENS n	Sets the sensitivity of the amplifier. n ranges from 0 (1 pA/V) to 27 (1 mA/V).
SUCM n	Sets the sensitivity cal mode. 0 = cal, 1 = uncal.
SUCV n	Sets the uncalibrated sensitivity vernier. [$0 \le n \le 100$] (percent of full scale).

Input Offset Current control commands

IOON n	Turns the input offset current on (n=1) or off (n=0).
IOLV n	Sets the calibrated input offset current level. n ranges from 0 (1 pA) to 29 (5 mA).
IOSN n	Sets the input offset current sign. 0 = neg, 1 = pos.
IOUC n	Sets the input offset cal mode. 0 = cal, 1 = uncal.
IOUV n	Sets the uncalibrated input offset vernier. [$-1000 \le n \le +1000$] (0 - ±100.0% of full scale).

Bias Voltage control commands

BSON n	Turns the bias voltage on (n=1) or off (n=0).
BSLV n	Sets the bias voltage level in the range. [$-5000 \le n \le +5000$] (-5.000 V to +5.000 V).

Filter control commands

FLTT n	Sets the filter type. 0=6 HP, 1=12 HP, 2=6 BP, 3=6 LP, 4=12 LP, and 5=none.
LFRQ n	Sets the value of the lowpass filter 3dB point. n ranges from 0 (0.03Hz) to 15 (1 MHz).
HFRQ n	Sets the value of the highpass filter 3dB point. n ranges from 0 (0.03Hz) to 11 (10 kHz).
ROLD	Resets the filter capacitors to clear an overload condition.

Other commands

GNMD n	Sets the gain mode of the amplifier. 0=low noise, 1=high bw, 2=low drift.
INVT n	Sets the signal invert sense. 0=non-inverted, 1=inverted.
BLNK n	Blanks the front end output of the amplifier. 0=no blank, 1=blank.
***RST**	Resets the amplifier to the default settings.

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INTRODUCTION

Why use a Current Amplifier?

Many people wonder why current amplifiers are necessary. Why not simply terminate a current source with a resistor and amplify the resulting voltage with a voltage preamplifier? The answer is twofold. First, to get a large voltage from a small current, large resistors are necessary. In combination with cable capacitance and other stray capacitance, this can lead to unacceptable penalties in frequency response and phase accuracy. Current amplifiers have much better amplitude and phase accuracy in the presence of stray capacitance. Secondly, using resistive terminations forces the current source to operate into possibly large bias voltages–a situation that is unacceptable for many sources and detectors. Current amplifiers can sink current directly into a virtual null, or to a selected DC bias voltage.

Overview

The SR570 is a low-noise current preamplifier, providing a voltage output proportional to the input current. Sensitivities range from 1 mA/V down to 1 pA/V. The general architecture is diagrammed in figure 1 on the following page.

The DC voltage at the input can be set as a virtual null or biased from -5V to +5V. An input offset current from 1pA to 1 mA may also be introduced. The user can choose between low noise, high bandwidth, and low drift settings, and can invert the output relative to the input. Two configurable R-C filters are provided to selectively condition signals in the frequency range from DC to 1 MHz.

The SR570 normally operates with a fully floating ground with the amplifier ground isolated from the chassis and the AC power supply. Input blanking, output toggling and listen-only RS-232 interface lines are provided for remote instrument control. These lines are optically isolated to reduce signal interference. Digital noise is eliminated by shutting down the processor clock when not executing a front-panel button press or an RS-232 command.

Internal sealed lead-acid batteries provide up to 15 hours of line-independent operation. Rear panel banana jacks provide access to the internal regulated power supplies (or batteries) for use as a voltage source.

Use this procedure as a quick orientation to the instrument's features and capabilities. If you encounter problems, read the detailed discussions on operation.

1) Make sure that the correct line voltage has been selected on the rear panel power entry module.

2) With the unit's power switch "OFF", hold the "FILTER RESET" key down and turn the unit "ON". This will return all instrument settings to their default state.

3) Select a filter from the "FILTER TYPE" menu. Then use the up/down arrows of the "FILTER FREQ" menu to choose the filter 3 dB points.

4) If an input offset current is desired, choose a current level from the "INPUT OFFSET" menu with the up/down arrow keys. The current will be applied when the "ON" led is lit.

5) When the bias voltage is off, the amplifier input is a virtual null. To set a bias voltage, use the up/down arrow keys of the "BIAS VOLTAGE" menu. The test point will always reflect the selected bias voltage, but the bias will only be applied when the "ON" led is lit.

6) Set the sensitivity and gain mode to the desired settings for the the amplitude of the signal to be measured.

7) Adjust the "FREQ COMP" pot near the input BNC to compensate the amplifier's frequency response for any input capacitance. An external square wave signal from the source under test can be used for precise calibration.

8) Connect the signal to be measured to the "INPUT" BNC. The signal will be converted to a voltage, filtered and amplified. The amplifier output voltage can be accessed from the "OUTPUT" BNC connector.

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Operation and Controls

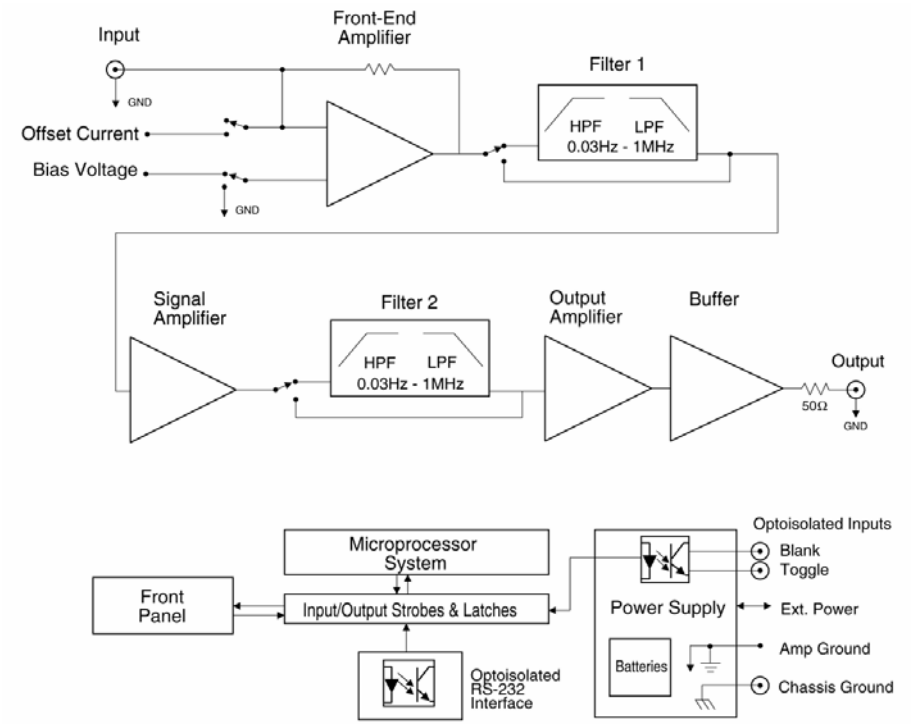


Figure 1: SR570 Block Diagram

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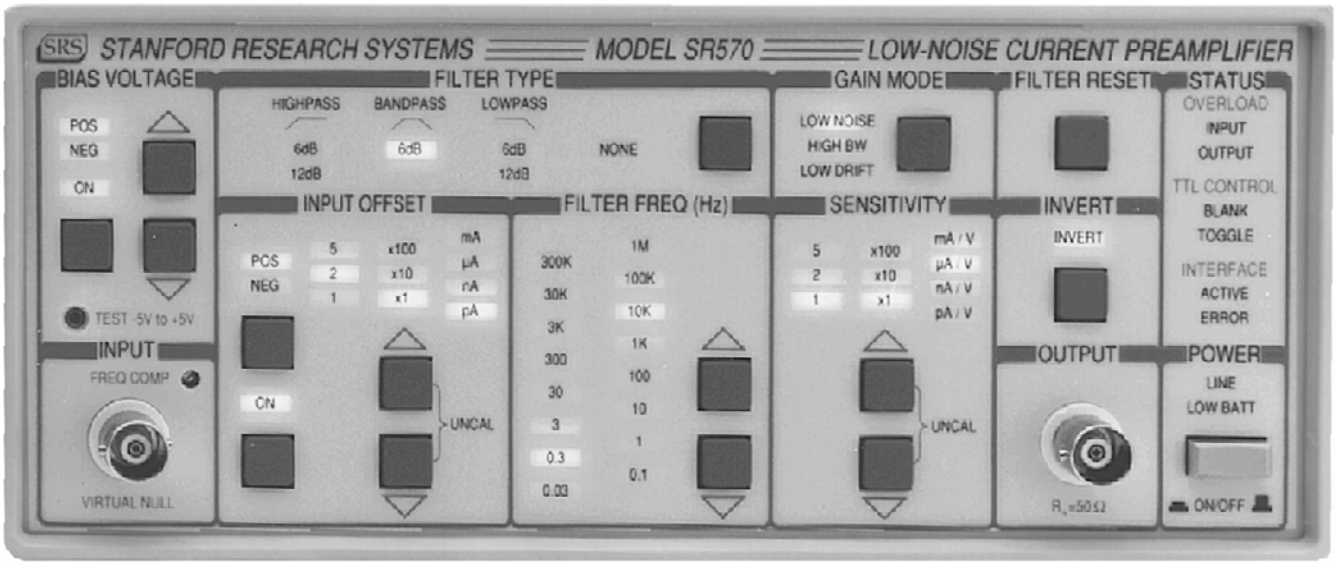


Figure 2: SR570 Front Panel

FRONT PANEL OPERATING SUMMARY

The operation of the SR570 Low-Noise Preamplifier has been designed to be as simple and intuitive as possible. The effect of each keypress on the front panel is reflected in the change of a nearby LED. All front panel functions, except power, can be controlled through the rear-panel RS-232 interface.

Power

The SR570 is turned on by depressing the POWER switch. When disconnected from AC power, the unit will operate for approximately 15 hours on internal sealed lead-acid batteries. Up to 200 mA of unregulated battery power is available at the rear panel banana jacks as long as the power switch is in the ON position. Battery life will be reduced when the unit is providing external power through the rear panel jacks. When operating on batteries, the front panel LINE indicator will not be lit. As the batteries near depletion, the LOW BATT LED will light, indicating that the unit should be connected to AC power to charge the batteries. When connected to an AC power source, amplifier power is derived from regulated line power, and the internal batteries are automatically charged. When operating on AC power, the front panel LINE indicator is on to indicate the source of amplifier power. Charging status is indicated on the rear panel by the CHARGE and MAINTAIN LED indicators.

Input

An insulated BNC is provided to connect the signal of interest to the amplifier. Care should be taken in choosing a cable to connect to the amplifier input. Both cable capacitance and dielectric quality will affect sensitive measurements. Whenever possible, use low noise coaxial cable and always use the shortest possible cable length. Above the input BNC is the FREQ COMP adjustment potentiometer. This feature allows the user to compensate for any input capacitance by varying the capacitance across the front-end amplifier feedback resistor. In this way, the amplifier bandwidth can be easily adjusted to compensate for source capacitance by measuring a square wave signal from the source of interest and using FREQ COMP to optimize the output waveform. See Appendix C for further discussion of the effects of source capacitance.

Defaults

Any changes made to the front panel settings of the SR570 will be stored even when power is turned off, as long as the batteries are hooked up. To reset the SR570 to its default settings, simply turn the power off, and while depressing the FILTER RESET button, turn the power on. Alternatively, removing

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the batteries from an SR570 with no AC power connected will reset the unit to the default state. The default settings are:

Sensitivity = 1 μA/V, calibrated
Invert = off
Input Offset = +1 pA, calibrated, off
Bias = 0 V, off
Filters = none
Hi Freq = 0.03 Hz
Lo Freq = 1 MHz
Gain Mode = Low Noise

Bias Voltage

In the default configuration, the SR570 is a virtual null at the input BNC. The bias voltage provides a variable -5V to +5V voltage (12 bit, 1.22 mV resolution) at the input. This voltage can be used to bias a photodiode or similar device. The voltage level is set by the up/down arrows in the bias voltage section of the front panel. The up arrow increases the voltage towards +5V, and the down arrow decreases the voltage towards -5V. To enable the bias voltage, simply push the button directly below the bias ON LED. The selected voltage can be monitored at the TEST point with a DC voltmeter whether the bias voltage is turned on or not.

Input Offset Current

The SR570 can provide a DC current offset to suppress any background currents at the input. The offset range can be changed from 1 pA to 5 mA (both positive and negative) in discrete increments. Use the up/down arrow keys in the Input Offset section to change the current level. In addition to these fixed settings, the user may specify arbitrary currents through the UNCAL feature. To set an uncalibrated offset current, the user must press both up and down buttons simultaneously, lighting the UNCAL LED. In this mode, by pressing the up or down pushbuttons, the user may reduce the calibrated current in roughly 0.1% increments from 100% down to 0% of the selected offset value. In contrast to other front-panel functions, when in UNCAL the instrument's key-repeat rate will start slowly and increase to a limit as long as either button is depressed. Simultaneously pressing both Offset buttons once again will restore the unit to the previously calibrated current setting, and turn off the UNCAL LED. The sign of the current is set with the button directly below the POS and NEG LEDs. A positive offset current is defined to be a current that will produce a positive output voltage with no signal connected to the input BNC and INVERT not selected. The button below the input offset ON LED turns the offset on and off. The current level can be adjusted whether the offset current is turned on or not.

Invert

The INVERT pushbutton allows the user to invert the output of the instrument with respect to the input. A positive current will give a negative voltage and visa versa. The INVERT LED displays the output sense relative to the input unless the TOGGLE feature is being used.

Filters

The SR570 contains two identical 1st-order R-C filters whose cutoff frequencies and configuration (high-pass or low-pass) are controlled from the front panel. The maximum bandwidth of the instrument is 1 MHz.

The FILTER CUTOFFS can be configured in the following six ways:

i. high-pass filter at +6 dB / octave
ii. high-pass filter at +12 dB / octave iii. high-pass filter at +6 dB / octave, and low-pass filter at -6 dB / octave (band-pass)
iv. low-pass filter at -6 dB / octave
v. low-pass filter at -12 dB / octave
vi. no filters in the signal path

Filter settings are chosen by the FILTER TYPE pushbutton. Each time the FILTER TYPE pushbutton is pressed, the instrument configures the two R-C filters in the progression shown above. LEDs give a visual indication of the filter configuration.

The filter cutoff frequencies are controlled by the up/down arrows in the FILTER FREQ section. When the FILTER TYPE section is configured solely as high-pass or low-pass (i, ii, iv and v), the cutoff frequency is illuminated by one of sixteen

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LEDs in the range from 0.03 Hz to 1 MHz. High pass filters are not available for the four highest frequency settings. When the filter section is configured as band-pass (iii), the cutoff frequencies are illuminated by two LEDs. The lower frequency setting marks the cutoff for the high-pass filter, and the higher setting is the cutoff for the low-pass filter.

To change the values of the bandpass cutoff frequencies, use the up arrow button to change the lowpass cutoff and the down arrow to change the highpass cutoff. If the displayed frequency is already at the highest or lowest possible choice, then pushing the button again will cause the frequency to "wrap around" to the opposite extreme frequency. In this case the two cutoffs can be set to the same frequency to provide a narrow bandpass. The highpass frequency can never exceed the lowpass frequency. When both filters are removed from the signal path (vi) all FREQ LEDs are extinguished and the NONE LED is lit.

Gain Mode

The allocation of gain throughout the instrument is set using the GAIN MODE pushbutton. The gain mode feature controls the tradeoffs between dynamic reserve, bandwidth, and noise in the amplifier circuits. The Gain Mode is displayed by three indicator LEDs: LOW NOISE, HIGH BW, and LOW DRIFT. For a given gain setting, the LOW NOISE mode allocates gain toward the front-end in order to quickly "lift" low-level signals above the instrument's noise floor. The LOW DRIFT mode allocates the gain just as the LOW NOISE mode, except the front-end op amp is switched to one with a very low input bias current for high sensitivity settings. The HIGH BW setting allocates more gain toward the output stages after the filters. Since smaller values of feedback resistance are needed for the front-end gain, the bandwidth of the amplifier is increased over that of the other two settings. This also prevents signals which are attenuated by the filters from overloading the amplifier. See Appendix B for further details of op amp selection for the different gain modes.

Sensitivity

The instrument's sensitivity is increased or decreased using the SENSITIVITY section pushbuttons. Sensitivity settings from 1 pA/V to 1 mA/V are available and are displayed as the product of a factor 1, 2 or 5 and a multiplier (x1, x10, x100) with the appropriate units. In addition to these fixed settings, the user may specify arbitrary sensitivities through the UNCAL feature.

To set an uncalibrated or arbitrary sensitivity, the user must press both up and down buttons simultaneously, lighting the UNCAL LED. In this mode, by pressing the up or down pushbuttons, the user may reduce the calibrated sensitivity in roughly 1% increments from 100% down to 0% of the selected sensitivity. In contrast to other front-panel functions, when in UNCAL, the instrument's key-repeat rate will start slowly and increase to a limit as long as either sensitivity button is depressed. Simultaneously pressing both sensitivity buttons again will restore the unit to the previously calibrated sensitivity setting, and turn off the UNCAL LED.

Output

The output of the instrument is an insulated BNC with a 50 ohm output impedance. In most applications, the instrument will be used to drive high impedance loads (e.g. voltmeters or oscilloscopes). Therefore, the instrument's gain is calibrated for high impedance loads. When driving a 50 ohm load, the gain of the amplifier is reduced by a factor of two. The shields of the two front-panel BNCs are connected together and form the amplifier's floating ground. In addition, a balun is used at the output to reduce common mode noise. See the end of Appendix A for more details about the output balun.

Filter Reset

If an overload occurs with filter settings of long time constants, the FILTER RESET pushbutton will speed the SR570's recovery from overload. The filters will be discharged by momentarily grounding the filter capacitors.

The FILTER RESET button is also used to return the unit to its default settings. Simply hold down the

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FILTER RESET button while turning on the power and the default settings will be restored.

Status

The INPUT and OUTPUT overload LEDs indicate a signal overload. This condition can occur when a signal is too large or the dynamic reserve is too low. Reducing the sensitivity, reducing the input signal and/or switching to the HIGH BW setting should remedy this condition. An INPUT overload indicates a voltage greater than 7V is present before the filter section, while an OUTPUT overload indicates an overload after the filters.

The ACTIVE LED indicates communication activity via the SR570's optoisolated RS-232 port. The ERROR LED indicates that the SR570 has received an unknown or improperly worded command. The error LED will remain lit until a valid command is issued. Please refer to the Remote Programming section for further details on controlling the instrument via RS-232.

The BLANK LED indicates that the optoisolated BLANK input (on the rear panel of the SR570) is active. The SR570 responds to a blanking input by internally grounding the amplifier signal path after the front end and before the first filter stage. The TOGGLE LED indicates that the optoisolated TOGGLE input (on the rear panel of the SR570) is active. The SR570 responds to a toggle input by toggling the polarity of the INVERT function.

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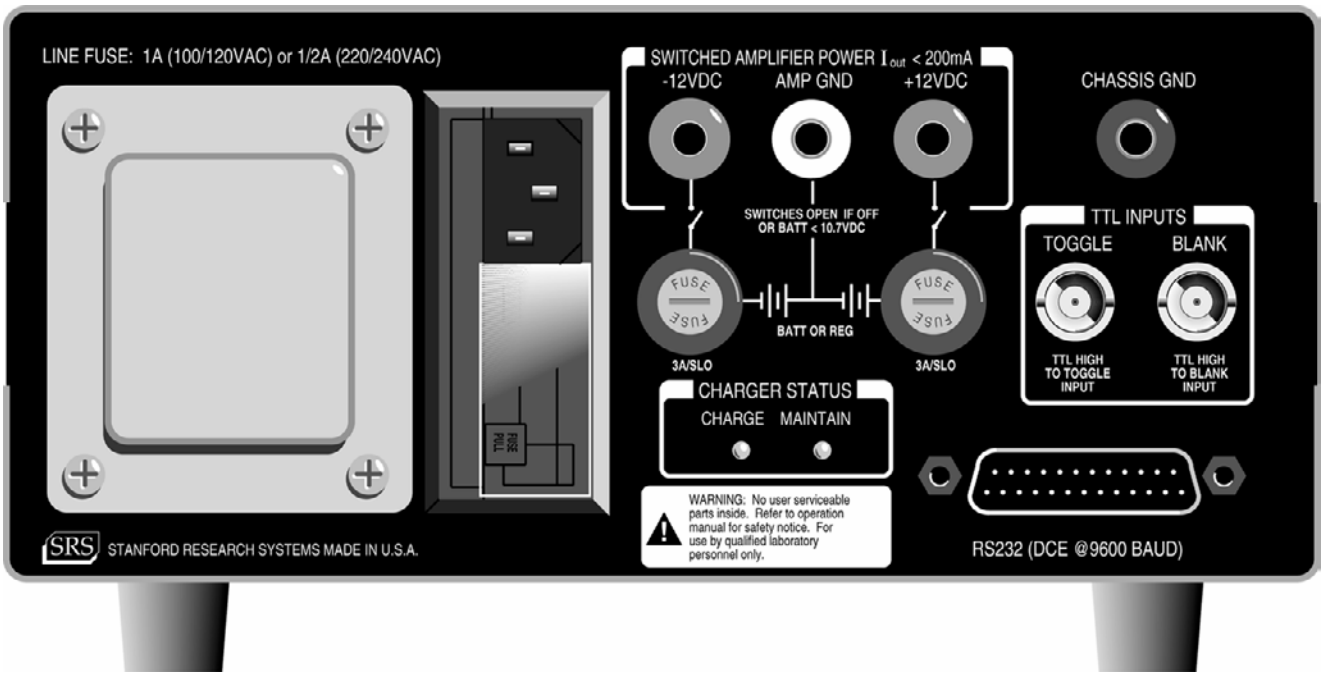


Figure 3: SR570 Rear Panel

REAR PANEL OPERATING SUMMARY

The SR570 rear panel is pictured in Figure 3. Various interface and power connectors are provided, along with fuses and charger status LEDs.

AC Power Input

The power entry module contains the receptacle for the AC line cord and fuse. The line fuse should be a 1 A “slo-blo” for 100/120 VAC operation, or a 1/2 A “slo-blo” for 220/240 VAC operation.

Amplifier Power Output

The -12 V, +12 V, and AMP GROUND banana jacks provide external DC power up to 200 mA for use as a bias source referenced to the amplifier's floating power supplies.

The CHASSIS GROUND banana jack is provided to allow the amplifier's ground to be referenced to the chassis. If the unit is connected to an AC power source via a three prong grounding plug, the chassis ground is connected to the AC line ground conductor.

Battery Charger

Two 3 A “slo-blo” fuses protect the battery supply and charging circuitry. If these fuses are blown, battery power will be unavailable, and charging of the batteries will not be possible.

When both the positive and negative supply batteries are dead, the red CHARGE LED will be on brightly, and the batteries will be charging at a fast rate. When the batteries approach a fully charged condition, the charging current will be reduced to a trickle charge to maintain the batteries. Because the batteries charge at different rates, the indicators on the rear panel can reflect the charge status of the positive and negative batteries independently. When one set of batteries switches to the "MAINTAIN" mode, the red CHARGE LED will be reduced to half brightness, and the yellow MAINTAIN LED will turn on at half brightness. When both batteries switch to "MAINTAIN", the red CHARGE LED will turn off and the yellow MAINTAIN LED will be on full brightness.

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Operation and Controls

Blanking Input

The BLANK input accepts a TTL-level signal and grounds the amplifier signal path after the front end for as long as the input is held high. The response time of the blanking input is typically 5 µs after the rising edge (turn-on) and 10 µs after the falling edge (turn-off).

Toggling Input

The TOGGLE input accepts a TTL-level signal and toggles the invert function as long as the input is held high. The response time of the toggling input is typically 5 µs after the rising edge (turn-on) and 10 µs after the falling edge (turn-off).

The Toggle input can be used for synchronous detection of an AC signal. If the signal is toggled at the frequency of interest, in phase with the signal being measured, with a TTL square wave, then a DC component will be produced that is proportional to the signal amplitude. This is the basic principle of operation of lock-in amplifiers. The modulated signal is then passed through a low pass filter and the DC signal is measured at the output.

RS-232 Interface

The RS-232 interface connector allows listen-only communication with the SR570 at 9600 baud, DCE. Communication parameters should be set to 8 data bits, no parity, 2 stop bits. Data sent must be delimited by <CR> <LF>. All front panel functions, excluding power and toggling, are available over the RS-232 interface. For more information on programming and commands, see Appendix A: Remote Programming.

BATTERY CARE AND USAGE

The SR570 can be powered from either an AC power source or from three 12 V, 1.9 Amp-hour maintenance-free sealed lead-acid rechargeable batteries. Integral to the SR570 is an automatic battery charger, along with battery protection and charge indication circuitry.

Recharging

During battery operation, the front panel LOW BATT LED will light when the batteries are low and require charging. For the longest battery life, the batteries should be immediately charged by plugging the unit into AC power whenever the LOW BATT indicator is lit. Internal protection circuitry will disconnect the batteries from the amplifier if the unit is operated for too long in the low battery condition. This protects the batteries from permanent damage which could occur if they were to remain connected to a load while dead.

The internal battery charging circuitry of the SR570 will automatically charge dead batteries at a quick rate until they are approximately 80% charged. The charge rate is then lowered to a level that is safe for maintaining the batteries. During AC operation, the batteries will be in this "maintain" charge condition indefinitely, and will suffer no degradation from prolonged charging. The sealed lead-acid batteries used in the SR570 differ in this respect from nickel-cadmium batteries, which behave in exactly the opposite manner. The sealed lead-acid batteries will provide the longest service life if they are not allowed to discharge too deeply and if they are charged immediately after use.

Battery Care

WARNING: For safety reasons, as with all rechargeable batteries, the chemical recombination processes within the cells require that the batteries be allowed to vent non-corrosive gases to the atmosphere. Always use the batteries in an area with adequate ventilation.

With all instruments powered by rechargeable batteries, the user must take some precautions to ensure long battery life. Understanding and following the precautions outlined below will result in a long operating life for the batteries in the SR570.

The SR570's internal lead-acid batteries will have a variable service life directly affected by the number of discharge cycles, depth of discharge and ambient temperature. The user should follow these simple guidelines below to ensure longest battery life.

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• AVOID DEEP DISCHARGE

Recharge the batteries after each use. The two-step fast-charge / trickle-charge operation of the SR570 allows the charger to be left on indefinitely. ALWAYS recharge the batteries immediately after the LOW BATT indicator LED on the SR570 comes on. Built-in protection circuitry in the unit removes the batteries from the load once a dead-battery condition is detected. Avoiding deep discharge will provide the longest battery life – upwards of 1,000 charge / discharge cycles.

• DON'T LET THE BATTERIES SIT IDLE

If the batteries are left for an extended period of time without charging, they may become irreparably damaged. An SR570 in storage should be "topped off" every three months with an overnight charge to maintain its batteries in peak condition.

• AVOID TEMPERATURE EXTREMES

When using battery power, operate the SR570 at or near room temperature. Operating at lower temperatures will reduce the capacity of the batteries. At low temperatures more time is required to recharge the batteries to their rated capacity. Higher temperatures accelerate the rate of reactions within the cell, reducing cell life.

• KEEP THE BATTERIES COOL

When not in use, the SR570 should be stored in a cool, dry place with the batteries fully charged. This reduces the self-discharge of the batteries and ensures that the unit will be ready for use when needed.

• INSPECT THE BATTERIES

Batteries used in this instrument are sealed lead acid batteries. With usage and time these batteries can leak. Always use and store this instrument in the feet-down position. To prevent possible damage to the circuitboard, it is recommended that the batteries be periodically inspected for any signs of leakage.

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PROGRAMMING

REMOTE PROGRAMMING

Introduction

The SR570 is equipped with a standard DB-25 RS-232 connector on the rear panel for remote control of all instrument functions. The interface is configured as listen-only, 9600 baud DCE, 8 data bits, no parity, 2 stop bits, and is optically isolated to prevent any noise or grounding problems.

The ERROR LED on the front panel will light if the SR570 receives an unknown or improperly worded command. The LED will remain lit until a proper command is received.

Data are sent to the instrument on pins 2 and 3, which are shorted together. The data flow control pins (5,6,8,20) are shorted to each other. The ground pins (1 & 7) are connected to each other but optically isolated from the amplifier circuit ground and the chassis ground.

Command Syntax

The following is a list of commands used to program the SR570. All RS-232 commands consist of four letter codes followed, in most cases, by an integer value (n). Commands must end with a carriage return and line feed <CR> <LF>.

DETAILED COMMAND LIST

Sensitivity control commands

SENS n Sets the sensitivity of the amplifier according to the following table:

n	scale
0, 1, 2	1, 2, 5 pA/V
3 ,4, 5	10, 20, 50 pA/V
6 ,7, 8	100, 200, 500 pA/V
9, 10, 11	1, 2, 5 nA/V
12, 13, 14	10, 20, 50 nA/V
15, 16, 17	100, 200, 500 nA/V
18, 19, 20	1, 2, 5 µA/V
21, 22, 23	10, 20, 50 µA/V
24, 25, 26	100, 200, 500 µA/V 27 1 mA/V

SUCM n Sets the sensitivity cal mode. 0 = cal, 1 = uncal.

SUCV n Sets the uncalibrated sensitivity vernier. [0 ≤ n ≤ 100] (percent of full scale).

Input Offset Current control commands

IOON n Turn the input offset current on (n=1) or off (n=0).

IOLV n Sets the calibrated input offset current level according to the following table:

n	scale
0, 1, 2	1, 2, 5 pA
3, 4, 5	10, 20, 50 pA
6, 7, 8	100, 200, 500 pA
9, 10, 11	1, 2, 5 nA
12, 13, 14	10, 20, 50 nA
15, 16, 17	100, 200, 500 nA
18, 19, 20	1, 2, 5 µA
21, 22, 23	10, 20, 50 µA
24, 25, 26	100, 200, 500 µA
27, 28, 29	1, 2, 5 mA

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IOSN n Sets the input offset current sign. 0 = neg, 1 = pos.

IOUC n Sets the input offset cal mode. 0 = cal, 1 = uncal.

IOUV n Sets the uncalibrated input offset vernier. [-1000 ≤ n ≤ +1000] (0 - ±100.0% of full scale).

Bias Voltage control commands

BSON n Turn the bias voltage on (n=1) or off (n=0).

BSLV n Sets the bias voltage level in the range. [-5000 ≤ n ≤ +5000] (-5.000 V to +5.000 V).

Filter control commands

FLTT n Sets the filter type according to the following table:

n	filter type
0	6 dB highpass
1	12 dB highpass
2	6 dB bandpass
3	6 dB lowpass
4	12 dB lowpass
5	none

LFRQ n Sets the value of the lowpass filter 3dB point. n ranges from 0 (0.03Hz) to 15 (1 MHz). See table below HFRQ.

HFRQ n Sets the value of the highpass filter 3dB point. n ranges from 0 (0.03Hz) to 11 (10 kHz). See table below.

n	filter frequency
0	0.03 Hz
1, 2	0.1, 0.3 Hz
3, 4	1, 3 Hz
5, 6	10, 30 Hz
7, 8	100, 300 Hz
9, 10	1, 3 kHz
11, 12	10, 30 kHz
13, 14	100, 300 kHz
15	1 Mz

ROLD Resets the filter capacitors to clear an overload condition.

Other commands

GNMD n Sets the gain mode of the amplifier.

n	gain mode
0	Low Noise
1	High Bandwidth
2	Low Drift

INVT n Sets the signal invert sense. 0=non-inverted, 1=inverted.

BLNK n Blanks the front-end output of the amplifier. 0=no blank, 1=blank.

***RST** Resets the amplifier to the default settings.

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PROGRAMMING EXAMPLES

Program Example 1
IBM PC, BASIC, via RS232

In this example, the IBM PC's COM2 serial port is used to communicate with the SR570. The program sets up the SR570 for a typical measurement.

```
10 ' Example program to set up for a measurement.  This
20 ' program uses IBM Basic and communicates via the COM2:RS-232 port.
30 '
40 '
50 ' setup COM2 for 9600 baud, no parity, 8 data bits, 2 stop bits, ignore cts, dsr, and cd
60
70 OPEN "COM2:9600,N,8,2,CS,DS,CD" AS #1
80 '
90 PRINT #1,"    "                          ' clear COM2:
100 '
110 PRINT #1,"*RST"                         ' reset SR570 to the default settings
120 PRINT #1,"SENS22;SUCM0"                 ' set the sensitivity to 20 µA/V (calibrated)
130 PRINT #1,"IOON0;GNMD0"                  ' turn the input offset current off and set LOW NOISE mode
140 PRINT #1,"BSON1;BSLV-2500"              ' turn the bias voltage on and set to -2.500 V
150 PRINT #1,"FLTT2;HFRQ11;LFRQ14"          ' put in a bandpass filter between 10 kHz and 300 kHz
160 END
```


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Program Example 2
IBM PC, Microsoft C, via RS232

In this example, the IBM PC's COM2 serial port is used to communicate with the SR570. The program asks the user to enter an SR570 command to send to the instrument. Before running the program, use the DOS 'MODE' command to set up the serial port parameters, e.g. MODE COM2: 9600,n,8,2

```
/* Program written in Microsoft C to send commands to the SR570 current amplifier */

#include <stdio.h>
#include <conio.h>
#include <string.h>

#define BUFFER 0x2fd                    /* COM2 output status : use 0x3fd for COM1 */
#define OUT 0x2f8                       /* COM2 output port :  use 0x3f8 for COM1 */
#define MASK 0x20                       /* mask to pick out "buffer empty" bit */

void main(void)
{
  int i,j;
  char string[20];

while(1)                                /* Loop forever (use 'control C' to exit) */
      {
      printf("input command string: ");
      gets(string);                     /* Get command from user */
      printf("\n");

           j=strlen(string);            /* Append <CR><LF> to the command */
      string[j]=13;
      string[j+1]=10;

      for ( i=0 ;  i <= (j+1) ;  i++ )  /* Send the command via RS-232 port  */
        {  /*                  one character at a time  */
        while (( inp(BUFFER) & MASK ) == 0 );  /* Wait until transmit buffer is empty      */
        outp( OUT , string[i] );        /* Output the next character to COM2   */
        }
      }
}
```


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CIRCUIT DESCRIPTION

LOW-NOISE Current to Voltage FRONT END

The current signal to be amplified is connected to BNC J104. Relays K103, K104, & K105 choose the sensitivity range. Resistors R132-R135 serve to protect the inputs to the amplifier and to limit the maximum noise gain due to input capacitance. The value of resistance is chosen to produce less than a 0.1% error in the voltage output. Resistors R124-R127 are the feedback resistors that control the gain of the main amplifier circuit. Switch U109 and resistors R121-R123 can multiply the effective feedback resistance by 1 or 10, to double the number of sensitivity ranges. Capacitors C117-C120 can be used to limit the bandwidth of the amplifier circuit. The FREQ COMP pot on the front panel controls the fraction of voltage that is fed back through the capacitors to the amplifier inputs, providing a variable feedback capacitance. Relays K106 & K107 choose between the two main amplifier op amps U107 & U108.

Voltage regulator U101 provides a +5V source for both the bias voltage and input offset current. U111B is used as an inverter to create a -5V source. U102 switches the noninverting input of U107 & U108 between ground and a selected bias voltage, and controls the sign of the bias and offset. The 12-bit DAC U103 allows processor control of both bias and offset levels. U110, U111A, and R136-R143 generate the input offset current by providing a constant voltage, with respect to the bias voltage, across the offset resistors R128-R131. U110, which can switch between x1 and x10 modes, and relays K101 & K102, choose the input offset range. U106A and R104, R105, R108, R109 are part of a differential amplifier circuit that gives an output voltage that is referenced to ground, regardless of the value of bias voltage. Potentiometer P103 can be used to calibrate any offset in the differential amplifier, while P104 balances any offset created by the INVERT function. U105 controls the blank, toggle, & invert features by flipping the polarity of the signal into U106A for inverting (& toggling) and providing open circuits for blanking.

CONFIGURABLE FILTERS AND GAIN

The two filter stages in the SR570 each consist of 16 R-C filters which can be configured as either high pass or low pass by a relay. In the following description, part references in parentheses refer to filter two. Relay K201, (K301) selects either the high-pass or low-pass configuration for all of the sixteen filters. The output of one R-C section is selected by multiplexer U202 or U203, (U301 or U302) and passed on to non-inverting buffer U204, (U303).

Approximately 80 pF input capacitance of the multiplexers is included in the calculation of the R-C time constants of the filters. The four highest frequency stages are not available as high-pass filters because of unacceptable attenuation of the signal that occurs when the filter capacitance forms a divider with the input capacitance of the multiplexers.

DG444 U205D, (U206C) is used to bypass the filter sections entirely and U206A, (U206B) is used to "reset" the filter stages by discharging them through R228, (R329).

U201, (U305) is the second, (third) gain stage with a fixed gain of 5. The input attenuator U205, (U304) allows setting the gain of these stages to 1, 2, or 5 under processor control.

OUTPUT STAGES

The next gain stage consists of op-amp U402 which is configured as a non-inverting amplifier with a gain of 5. U401 is a DG444 that again serves to switch the input attenuation of this stage for overall gains of 1, 2, or 5. Additionally, output offset adjustment is provided by this stage. U405B, half of an AD7528 dual 8-bit DAC is used to provide a ±5 volt offset voltage at the inverting input of U402.

Following amplifier U402 is the other half of the 8-bit DAC U405A, which along with op-amp U404 forms a digital gain vernier. This vernier is used in calibration to compensate for gain variances that occur with configuration changes such as input coupling and filter settings. This DAC also provides the front panel "uncal" gain vernier function.

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The final gain stage consists of U403 and output buffer U406, configured for a gain of 5 and with input attenuator U409 to select overall gains of 1, 2, or 5. The LM6321 (U406) provides the output drive capability for the 50 ohm output.

OVERLOAD DETECTION

The overload detectors constantly monitor the I to V amplifier output, front end output, filter 1 output, U402 (after the second filter) output, and final stage output for excessive signal levels. Comparators U408 and U410 compare both positive and negative signal excursions against a 5 volt reference and light the front panel output or input overload indicators if any levels are excessive.

MICROPROCESSOR

The system processor U503 is a CMOS Z80 processor running at 4 MHz. The system clock consists of Schmitt trigger U506A and an R-C network. The oscillator is designed so that latch U508A can shut down the clock oscillator completely, thereby disabling all digital circuits in the amplifier so that no digital noise will be present. The processor and clock only run when a front panel key is pressed and instrument settings are to be changed, or while there is activity on the RS-232 port.

The SR570 uses a 8 K x 8 CMOS EPROM,(U504) containing system firmware and calibration bytes, along with a 2 K x 8 CMOS RAM, (U505) which is battery backed-up at all times to retain instrument settings.

U507 generates port strobes for system IO, and U510 provides a buffered data bus. The buffered data bus is active only during IO instructions to keep digital noise in the amplifier to a minimum while the processor is running.

U601 through U607 are control latches providing the 56 DC control lines that configure all of the instrument's hardware. U608 is an input buffer that takes data from the front panel and RS-232, and provides a processor input indicating line operation.

BATTERY CHARGER AND PRE-REGULATORS

The 17 volt AC line transformer provides unregulated power for both amplifier operation and battery charging. Diode bridge D706 and filter capacitors C706 and C707 generate unregulated DC voltages that are pre-regulated to ±12 VDC by U706 and U707 to take the place of the batteries when the instrument is operating on AC line power. Relay U705 switches the amplifier from battery to pre-regulated AC whenever the AC line cord is plugged in.

D712, D713 and C709, C710 provide unregulated DC to charge the batteries. U701 and U702 operate as "AC" regulators, limiting peak battery charging voltage. As there are two positive batteries and one negative battery, U701 is a LM350 regulator that provides twice the current of the LM337 negative battery regulator.

Charging is controlled by changing the set voltage of the regulators based on battery charge status. Flip-flop U703 determines whether the charge regulators will be set to 15.5 volts for a quick charge or 13.8 volts for a trickle or "maintain" charge by grounding the bottom of P701 and P702. C712 and R704 insure that the charger always powers up in the "quick" charge mode. P701 and P702 are provided to adjust the open circuit trickle charge voltage to 13.8 volts. D701 and D703 are blocking diodes for the charging circuits while not charging, and D707 and D708 are clamps to guard against battery polarity reversal.

U708 and U709 are LP365 micropower comparators that monitor the battery voltage. A resistive divider chain sets the four trip points for each comparator. D709 provides a stable 2.5 volt reference against which levels are compared. For each battery, three level indications are provided, and are decoded by multiplexer U704. The "trip" level is 14.5 volts. The trip outputs control the state of U703 and switch the battery charge voltage settings. The "low" level is 11.3 volts and activates the front panel LOW BATT indicator. R730 provides some level hysteresis for the low battery indication to prevent oscillation around the trip point. The "dead" level is 10.7 volts and is used to disconnect the load from the batteries before they are damaged by an excessively deep discharge. Q701 and Q703 are power MOSFET switches used to disconnect battery

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power from the amplifier. Dead level hysteresis is provided by R724. R731 and D711 provide un-interrupted battery power to the system RAM so that stored instrument settings are retained when the power is switched off.

POWER REGULATORS

The +5 V and +10 V supplies are produced with three-terminal regulators U801 and U802, respectively. The -10 V supply is constructed of op-amp U803 and Q801, a N-channel MOSFET, as the pass element. The +10 V supply serves as the reference for the -10 V supply through divider R809 and R810.

The power output banana jacks on the rear panel(J801 and J803) are connected to the pre-regulated voltages after the power switch and before the regulators. This output can provide up to 200 mA of power for use as an external bias source, etc. Under some conditions, these jacks may be used to supply the unit with external DC power.

U506C and U506D generate the TTL level input to the processor to indicate when the unit is operating on the AC line.

Capacitors C801 through C811 are logic supply bypass capacitors distributed throughout the printed circuit board.

REAR PANEL INTERFACES

Three optically isolated rear panel interfaces are provided on the SR570. The blanking input accepts a TTL-level signal and opens the amplifier signal path before the front end differential amplifier for as long as the input is held high. The toggling input also accepts a TTL level signal and toggles the invert status of the I to V amplifier output signal before the front end differential amplifier for as long as the input is held high. The response time of both the blanking and toggling inputs is typically 5 µs after the rising edge (turn-on) and 10 µs after the falling edge (turn-off).

The RS-232 interface allows calibration and control of the instrument at 9600 baud. Data in and out on the connector are tied together, echoing data back to the sender. Hardware handshaking lines CTS, DSR, and CD are tied to DTR. See the Remote Programming section for more info.

BATTERIES AND P.E.M.

The batteries used in the SR570 are of sealed lead-acid construction. There are three 12 volt, 1.9 amp-hour batteries, two of which serve as the positive power supply, and one of which serves as the negative power supply. Powering the SR570 alone, battery life should be 10-15 hours. The batteries should last for more than 1000 charge / discharge cycles, provided the guidelines under the usage section are followed. Two 3A “slo-blo” fuses on the rear panel protect the battery supplies and amplifier against excessive currents.

The power entry module (P.E.M.) contains the AC line fuse, RFI filter, and voltage selection card. To change the operating voltage of the unit, the voltage selector printed circuit card must be pulled out and reinserted into the P.E.M. with the desired operating voltage visible.

FRONT PANEL

The front panel contains the pushbuttons, LED indicators and serial shift registers. The front panel pushbuttons are decoded in a 3 x 5 matrix fashion. The front panel LEDs are controlled by shift registers U1 through U7, which allow the 7 eight-bit control bytes to be serially shifted-in one bit at a time. The red overload LEDs are controlled directly from the output of the overload comparator. The LINE, LOW BATT, BLANK, and TOGGLE LEDs are also controlled directly from their respective main board circuits.

The FREQ COMP pot P1 is mounted on the front panel printed circuit board and is used to control the main amplifier feedback capacitance.

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CALIBRATION AND REPAIR

CALIBRATION

Six pots exist which may be used to calibrate various voltages on the SR570. Two are used to adjust the battery voltages, while the rest are used to null out offsets in the front-end amplifier stage. The bottom panel of the SR570 must be removed to access the pots.

Pots P701 and P702 adjust the battery voltage levels. The batteries must be disconnected to make these adjustments. To adjust the positive supply voltage, adjust P701 while measuring the voltage at U701, pin2. For the negative supply, adjust P702 while measuring U702, pin 3. The recommended voltages are +/- 14.0 V and should have been set at the factory.

Pots P103 and P104 are used to ensure that the applied input bias voltage is completely subtracted from the front-end output.

P104 should be adjusted first. Turn off the SR570. Using an ohmmeter, measure between U107, pin 3, and U105, pin 4, and adjust P104 so that the resistance is equal to that measured across R105.

Turn on the SR570. Select a 1 mA input offset current and 1 mA/V sensitivity from the front panel. The SR570 should otherwise be in its default start-up state (Low Noise, no filters, etc. see p. 4)

Measure the voltage at U106, pin 1.

Now select a 3V bias from the front panel. Adjust P103 until the output at U106, pin 1 is the same as that measured without the bias.

Op amp input offset voltages can be nulled with pots P101 and P102.

To null out the offset for U108 (Low Noise input), attach a “shielded open” to the input of the SR570 and select the 1 mA/V sensitivity. The unit should otherwise be in the default start-up mode. Adjust pot P102 to give 0 volts at U108, pin 6.

To adjust the Low-Drift mode op amp, repeat the procedure as above (with Low Drift mode and 1 µA/V sensitivity selected), adjusting P101 to give 0 volts at U107, pin 6.

FRONT END REPLACEMENT

The most commonly damaged components are the front-end input op amps U107 (Analog Devices AD546) and U108 (Analog Devices AD743). Both are located under the metal shield near the front of the PCB. If the unit is constantly overloaded, or doesn’t amplify any signals, chances are one of these op amps has been damaged. Switching between gain modes while referring to the op amp allocation table in Appendix B should determine which device needs to be replaced.

When replacing an op amp, make sure that all eight pins make firm contact in the socket and that the orientation for pin 1 is observed (match the notch on the IC with the notch on the socket). After replacement, the op amp input offset voltage should be nulled out using either P101 or P102 (cf. Calibration).

BATTERY REPLACEMENT

After three to five years or about 1000 charge/discharge cycles, the sealed lead-acid batteries degrade. When the battery operation time shortens, or if the unit stays very warm for more than a day after it is plugged into the line, the batteries may require replacement.

The three batteries are a standard size which are available from several different distributors. All are 12 VDC with a charge capacity of about 2.0 Amp-hours, and measure 7.02" X 1.33" X 2.38". Two of the batteries are wired in parallel to provide the high current required for the positive supply. Take care to observe battery polarities when replacing!

FUSE REPLACEMENT

There are three fuses on the back panel of the instrument. The fuse located inside the power entry module will blow if the unit draws excessive line current. The replacement should be a standard 1A “slo-blo” fuse.

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The other two fuses are in-line with the batteries and are rated at 3 A. These fuses will blow if the rear panel ±12 VDC supplies are shorted or if excess current flows to or from the batteries.

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APPENDIX A

Amplifier Noise Sources

Input noise

The input noise of the SR570 current amplifier varies depending upon the sensitivity setting. On the 1 mA/V setting, the noise is dominated by the voltage noise of the op amps in the circuit. Typically, this figure is about 100 nV/√Hz, which, when divided by the 1 kΩ feedback resistor, gives a current noise of 100 pA/√Hz. On the other hand, the noise on the higher sensitivity ranges is dominated by the Johnson noise of the feedback resistor. On the 1 nA/V scale, the 1 GΩ resistor alone produces an input current noise of 4 pA/√Hz, while the 100 nV/√Hz of amplifier voltage noise gives an input current noise of about 0.1 fA/√Hz. Therefore, all the possible sources of noise must be considered in order to calculate a noise figure for a current amplifier.

Noise Sources

There are two types of noise we have to worry about in laboratory situations, intrinsic noise and external noise. Intrinsic noise sources like Johnson noise and shot noise are inherent to all physical processes. Though we cannot get rid of intrinsic noise sources, by being aware of their nature their effects can be minimized. External noise sources are those found in the environment, such as power line noise and broadcast stations. The effect of these noise sources can be minimized by careful attention to grounding, shielding and other aspects of experimental design. We will first discuss some sources of intrinsic noise.

Johnson noise

Every resistor generates a noise voltage across its terminals due to thermal fluctuations in the electron density within the resistor itself. These fluctuations give rise to an open-circuit noise voltage:

$$V_{noise}(rms) = (4kTR\Delta f)^{1/2}$$

where k=Boltzmann's constant (1.38×10^{-23} J/°K), T is the temperature in Kelvin (typically 300 K), R is the resistance in Ohms, and Δf is the bandwidth of the measurement in Hz. Using this formula, the Johnson current noise is given by:

$$I_{noise}(rms) = 1.27\times10^{-10} R^{-1/2} \ A/\sqrt{Hz}$$

For example, a 100 MΩ resistor will produce a Johnson current noise of about 13 fA/√Hz. It is important to remember that Johnson voltage noise is proportional to the square root of the measurement bandwidth. Therefore, using signal filters in a measurement will affect the actual value of noise measured in the circuit.

Shot noise

Electric current has noise due to the finite nature of the charge carriers. There is always some non-uniformity in the electron flow which generates noise in the current. This noise is called shot noise. This can appear as voltage noise when current is passed through a resistor, or as noise in a current measurement. The shot noise, or current noise, is given by:

$$I_{noise}(rms) = (2q\,I\Delta f)^{1/2}$$

where *q* is the electron charge (1.6×10^{-19} Coulomb), I is the RMS AC current or DC current depending upon the circuit, and Δf is the bandwidth.

Shot noise is usually not a problem in typical measurement setups. For example, a 1 µA current, measured with a 100 kHz bandwidth, will have only 180 pA of shot noise or 0.02% of the signal amplitude. For very small currents, shot noise will be more appreciable. Take, for instance, a 1 pA current measured with a bandwidth of 100 Hz. The shot noise will be 6 fA or 0.6% of the signal amplitude, which might be important.

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1/f noise

Every 10Ω resistor, no matter what composition, has the same Johnson noise. However, there is excess noise in addition to Johnson noise which arises from fluctuations in resistance due to the current flowing through the resistor. For carbon composition resistors, this is typically 0.1 μV-3 μV of rms noise per Volt of applied across the resistor. Metal film and wire-wound resistors have about one-tenth the noise. This noise has a 1/f spectrum and makes measurements at low frequencies more difficult. Other sources of 1/f noise include vacuum tubes and semiconductors.

Total noise

All intrinsic noise sources are incoherent. The total random noise is the square root of the sum of the squares of all the incoherent noise sources.

External noise sources

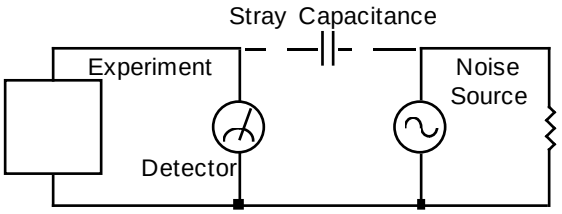
In addition to the intrinsic noise sources discussed previously, there are a variety of external noise sources within the laboratory. Most of these noise sources are asynchronous, i.e. they are not related to the signal frequency. Examples include lighting fixtures, motors, cooling units, radios, computer screens, etc. These noise sources affect the measurement by increasing the required dynamic reserve or lengthening the time constant.

Some noise sources, however, are related to the signal and, if picked up in the measurement, will add or subtract from the actual signal and cause errors in the measurement. Typical sources of synchronous noise are ground loops between the experiment, detector and amplifier, and electronic pick up from the experimental apparatus.

Many of these noise sources can be minimized with good laboratory practice and experiment design. There are several ways in which noise sources are coupled into the signal path.

Capacitive coupling

An AC voltage from a nearby piece of apparatus can couple to a detector via a stray capacitance. Although Cstray may be very small, the coupled noise may still be larger than a weak experimental signal. This is especially damaging if the coupled noise is synchronous (at the signal frequency).



We can estimate the noise current caused by a stray capacitance by:

$$i = C_{stray} \frac{dV}{dt} = \omega C_{stray} V_{noise}$$

where ω is 2π times the noise frequency, Vnoise is the noise amplitude, and Cstray is the stray capacitance.

For example, if the noise source is a power circuit, then f = 60 Hz and V noise = 120 V. Cstray can be estimated using a parallel plate equivalent capacitor. If the capacitance is roughly an area of 1 cm^2 separated by 10 cm, then Cstray is 0.009 pF. The resulting noise current will be 400 pA (at 60 Hz). This small noise current can be thousands of times larger than the signal current. If the noise source is at a higher frequency, the coupled noise will be even greater.

Cures for capacitive noise coupling include:

1) Removing or turning off the noise source.

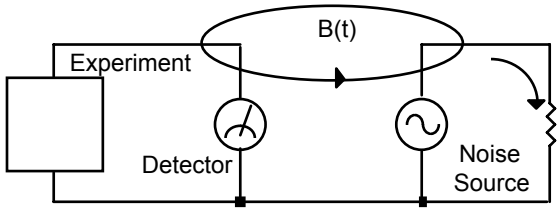
2) Keeping the noise source far from the experiment (reducing Cstray). Do not bring the signal cables close to the noise source.

3) Installing capacitive shielding by placing both the experiment and detector in a metal box.

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Inductive coupling

An AC current in a nearby piece of apparatus can couple to the experiment via a magnetic field. A changing current in a nearby circuit gives rise to a changing magnetic field which induces an emf (dØB/dt) in the loop connecting the detector to the experiment. This is like a transformer with the experiment-detector loop as the secondary winding.



Cures for inductively coupled noise include:

1) Removing or turning off the interfering noise source.

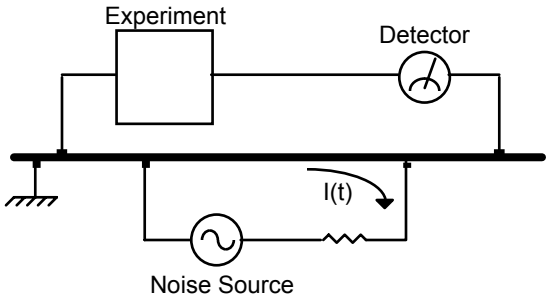
2) Reduce the area of the pick-up loop by using twisted pairs or coaxial cables, or even twisting the 2 coaxial cables used in differential connections.

3) Using magnetic shielding to prevent the magnetic field from crossing the area of the experiment.

4) Measuring currents, not voltages, from high impedance detectors.

Resistive coupling or ground loops

Currents flowing through the ground connections can give rise to noise voltages. This is especially a problem with signal frequency ground currents.



In this illustration, the detector is measuring the signal relative to a ground far from the rest of the experiment. The experiment senses the detector signal plus the voltage due to the noise source's ground return current passing through the finite resistance of the ground between the experiment and the detector. The detector and the experiment are grounded at different places which, in this case, are at different potentials.

Cures for ground loop problems include:

1) Grounding everything to the same physical point.

2) Using a heavy ground bus to reduce the resistance of ground connections.

3) Removing sources of large ground currents from the ground bus used for small signals.

Microphonics

Not all sources of noise are electrical in origin. Mechanical noise can be translated into electrical noise by microphonic effects. Physical changes in the experiment or cables (due to vibrations for example) can result in electrical noise over the entire frequency range of the amplifier.

For example, consider a coaxial cable connecting a detector to a amplifier. The capacitance of the cable is a function of its geometry. Mechanical vibrations in the cable translate into a capacitance that varies in time, typically at the vibration frequency. Since the cable is governed by Q=CV, taking the derivative, we have:

$$C\frac{dV}{dt} \quad V\frac{dC}{dt} \quad \frac{dQ}{dt} \quad i$$

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Mechanical vibrations in the cable which cause a dC/dt will give rise to a current in the cable. This current affects the detector and the measured signal.

Some ways to minimize microphonic signals are:

1) Eliminate mechanical vibrations near the experiment.

2) Tie down cables carrying sensitive signals so they cannot move.

3) Use a low noise cable designed to reduce microphonic effects.

Thermocouple effects

The emf created by junctions between dissimilar metals can give rise to many microvolts of slowly varying potentials. This source of noise is typically at very low frequency since the temperature of the detector and experiment generally changes slowly. This effect is large on the scale of many detector outputs and can be a problem for low frequency measurements, especially in the mHz range. Some ways to minimize thermocouple effects are:

1) Hold the temperature of the experiment or detector constant.

2) Use a compensation junction, i.e. a second junction in reverse polarity which generates an emf to cancel the thermal potential of the first junction (both held at the same temperature).

A few words about Baluns

To reduce the effects of ground loops, the SR570 has a balun (BALanced/UNbalanced common-mode choke) connected to the output stage. This may be thought of as two wires wrapped about a magnetic core, forming a pair of inductors. One wire carries the output signal and the other the return, forming essentially a differential signal which can pass through the balun with little to no attentuation over the SR570's bandwidth.

Non-differential (“common-mode”) signals, like ground-loop pickup, however, are effectively blocked by the balun. The degree of rejection varies with frequency and is determined by the choke inductance and the resistance of the windings.

The presence of the balun effectively breaks the ground loop which would have occurred if the SR570 and the device connected to the output were both connected to ground. However, this also means that the output is “differential” and cannot be used as a ground reference when attempting to trace noise in the SR570 circuitry. Measurements of this type should be referenced to the input ground or the SR570 chassis.

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APPENDIX B

FRONT-END AMPLIFIER

On the high sensitivity scales, since noise is dominated by DC current offset, an op amp with a very low input current is used on all gain modes. On intermediate sensitivity scales, a low noise op amp is switched in for the LOW NOISE and HIGH BW modes to improve the AC response of the front-end. On the less sensitive scales, where DC drift is dominated by drift in the offset voltage, the low noise op amp is used in all gain modes. On all scales, the High BW mode is obtained by shifting some of the gain from the front-end to the output stage.

Op Amp Allocation Table

Scale	Low Noise	High BW	Low Drift
1 mA/V	1	1	1
100 µA/V	1	1	1
10 µA/V	1	1	1
1 µA/V	1	1	2
100 nA/V	1	1	2
10 nA/V	2	1	2
1 nA/V	2	2	2
100 pA/V	2	2	2
10 pA/V	2	2	2
1 pA/V	2	2	2

1 = AD743 (Low Noise)
2 = AD546 (Low Input Current)

DYNAMIC RESERVE

The term “Dynamic Reserve” comes up frequently in discussions about amplifiers. It’s time to discuss this term in a little more detail. Assume the amplifier input consists of a full scale signal at fsig plus noise at some other frequency. The traditional definition of dynamic reserve is the ratio of the largest tolerable noise signal to the full scale signal, expressed in dB. For example, if full scale is 5 µA, then a dynamic reserve of 60 dB means noise as large as 5 mA (60 dB greater than full scale) can be tolerated at the input without overload.

The problem with this definition is the word 'tolerable. Clearly the noise at the dynamic reserve limit should not cause an overload anywhere in the instrument. This is accomplished by adjusting the distribution of the gain. To achieve high reserve, the input signal gain is set very low so the noise is not likely to overload. This means that the signal at the filter section is also very small. The filters then remove the large noise components from the signal which allows the remaining component to be amplified to reach full scale. There is no problem running the input amplifier at low gain. However, large noise signals almost always disturb the measurement in some way.

The most common effect of high dynamic reserve is to generate noise and drift at the output. This comes about because the output amplifier is running at very high gain and front-end noise and offset drift will be amplified and appear large at the output. The noise is more tolerable than the DC drift errors since increasing the time constant of the filters will attenuate the noise.

Lastly, dynamic reserve depends on the noise frequency. Clearly noise at the signal frequency will make its way to the output without attenuation. So the dynamic reserve at fsig is 0 dB. As the noise frequency moves away from the signal frequency, the dynamic reserve increases. Why? Because the filters after the front-end attenuate the noise components. The rate at which the reserve increases depends upon the filter time constant and rolloff. The reserve increases at the rate at which the filter rolls off. When the noise frequency is far away, the reserve is limited by the gain distribution and overload level of each gain element.

In the SR570, decreasing front-end gain to increase dynamic reserve can only be accomplished by decreasing the value of the input op amp’s feedback resistor. Thus, the high dynamic reserve mode is also a high bandwidth mode due to a smaller time constant between the input capacitance and the feedback resistor. On the other hand, a smaller resistor means that even though the Johnson noise is less, the extra gain of 10 at the output makes the

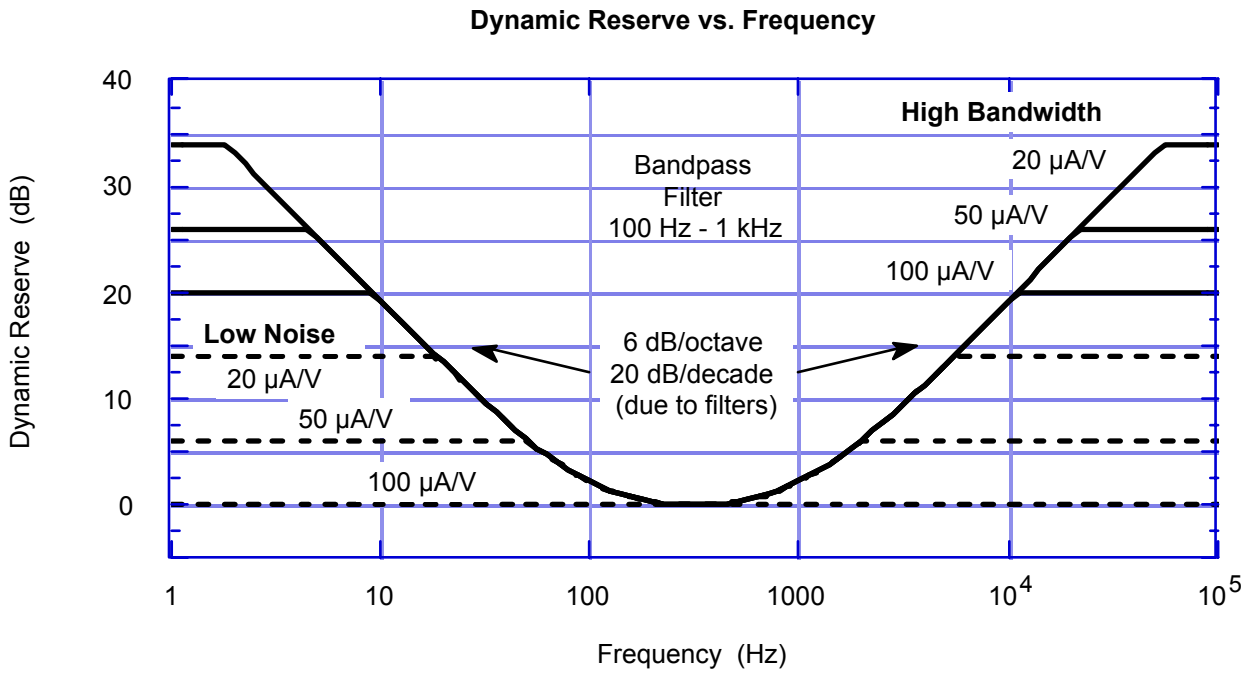
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noise greater. So, when making a measurement, it is important to keep in mind the tradeoff between high dynamic reserve (bandwidth) and low noise performance.

The dynamic reserve is a function of frequency and depends on the amplifier configuration (sensitivity, filters and gain mode setting). The figure below shows the dynamic reserve for a SR570 set to sensitivities of 20 µA/V, 50 µA/V, and 100 µA/V, with the high pass filter set to 100 Hz and the low pass filter set to 1 kHz (for a bandpass from 100 Hz to 1 kHz). The dynamic reserve characteristics are shown for both "High Bandwidth" and "Low Noise" gain modes. The Low Drift mode has the same dynamic reserve as the Low Noise mode.

There are several features to note. In the bandpass region between 100 Hz and 1 kHz the dynamic reserve is near 0 dB. The dynamic reserve is 3 dB at the filter frequencies of 100 Hz and 1 kHz. The dynamic reserve rises by 6 dB/oct (or 20 dB per decade) as the signal moves away from the pole frequency, since each RC filter attenuates the signal. If a faster rolloff for interfering signals was required, a 12 dB/octave HP or LP filter could be used.

The DR rises to a maximum which depends on the gain distribution in the amplifier circuit. The plot gives the DR for a 1-2-5 sequence of sensitivities on two different gain modes. It turns out that between 20 pA/V and 100 µA/V, the curves are exactly the same for any other 1-2-5 sequence. Below 20 pA/V, the maximum DR increases by 20 dB for all gain modes over those in the plot. Above 100 µA/V the Low Noise curves are the same as in the plot and the High Bandwidth curves are the same as the Low Noise. Keep in mind that the amplifier bandwidth may limit the DR at the higher frequencies on some sensitivities.



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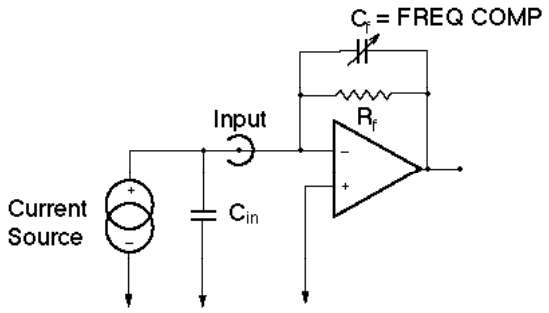
APPENDIX C

CAPACITANCE EFFECTS

Feedback Capacitance

All op amps have some parasitic capacitance associated with their inputs and output. Together with the capacitance of the source being measured and the resistors in the amplifier circuit, the parasitics affect the frequency response of the amplifier. Typically, this effect is manifested as overshoot or "ringing" in the square wave response of an instrument. One way to compensate for these unwanted effects is to put a capacitor in the feedback loop of the op amp. The value of this capacitor is chosen to optimize the frequency response of the circuit.

In the SR570, we have implemented a variable feedback capacitance across the amplifier which can be controlled from the instrument's front panel. To get the best frequency response, the FREQ COMP can be adjusted to give a clean square wave output with a square wave input. It is important that the source resistance and capacitance be the same for the adjustment procedure as it will be for the actual measurement to get the best results.



Input Capacitance

One of the most important differences between using a current amp instead of a voltage amp is the effect that input capacitance has on the noise performance of the instrument. In the figure above, we see that in the traditional configuration of a current amplifier, with a virtual null at the input and an essentially infinite input resistance, any voltage noise that appears at the input to the op amp will also appear at the output without any gain. On the other hand, if we introduce some capacitance from the input to ground – say, coaxial cable capacitance (about 100 pF/m) – then we have gain for the op amp input voltage noise.

Let's look at the effect that input capacitance would have on a typical measurement. If we make a measurement on the 1 nA/V scale, then the feedback resistor in the low noise mode is 1 GW. The bandwidth of this sensitivity range, without any filters in the circuit, is about 20 Hz. If we use one meter of coax cable at the input, then we have about 100 pF of input capacitance , which at 20 Hz is about 80 MW to ground. Therefore, the input voltage noise of the op amp is amplified with a gain of around 13! Even more important is that this gain increases with increasing values of input capacitance.

Incidentally, the FREQ COMP capacitor mentioned above also has the effect of limiting the ultimate value of noise gain in the circuit to the ratio of the input capacitance to the feedback capacitance.

There are a few straightfoward precautions that can be taken to minimize the effects of input capacitance:

1) Place the amplifier as close as possible to the signal being measured and use the shortest cable length necessary to connect them.

2) Use high quality, low noise coaxial cables.

3) Reduce any stray capacitance to ground at the output of the circuit being measured.

4) If the amplifier must be placed a large distance from the circuit under test, then use triaxial cable with both a guard and a shield to reduce the capacitance to ground.

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Main Circuit Board Parts List

B 401	6-00137-601	15MH	Inductor
C 101	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 102	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 103	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 104	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 105	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 106	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 107	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 108	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 109	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 110	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 111	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 112	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 113	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 114	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 115	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 116	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 117	5-00016-501	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 118	5-00015-501	39P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 119	5-00011-501	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 120	5-00215-501	20P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 201	5-00019-501	68P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 202	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 203	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 204	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 205	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 206	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 208	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 209	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 210	5-00063-513	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 211	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 212	5-00067-513	.033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 213	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 214	5-00194-542	.47U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 215	5-00194-542	.47U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 216	5-00193-542	2.2U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 217	5-00193-542	2.2U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 218	5-00213-546	4.7U	Cap, Mini Electro, 100V, 20%, Rad
C 219	5-00213-546	4.7U	Cap, Mini Electro, 100V, 20%, Rad
C 220	5-00033-520	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C 221	5-00033-520	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C 222	5-00031-520	220U	Capacitor, Electrolytic, 16V, 20%, Rad

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C 223	5-00031-520	220U	Capacitor, Electrolytic, 16V, 20%, Rad
C 224	5-00232-520	470U	Capacitor, Electrolytic, 16V, 20%, Rad
C 225	5-00232-520	470U	Capacitor, Electrolytic, 16V, 20%, Rad
C 226	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 227	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 228	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 230	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 301	5-00159-501	6.8P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 302	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 303	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 304	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 306	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 307	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 308	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 309	5-00063-513	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 310	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 311	5-00067-513	.033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 312	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 313	5-00194-542	.47U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 314	5-00194-542	.47U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 315	5-00193-542	2.2U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 316	5-00193-542	2.2U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 317	5-00213-546	4.7U	Cap, Mini Electro, 100V, 20%, Rad
C 318	5-00213-546	4.7U	Cap, Mini Electro, 100V, 20%, Rad
C 319	5-00033-520	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C 320	5-00033-520	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C 321	5-00031-520	220U	Capacitor, Electrolytic, 16V, 20%, Rad
C 322	5-00031-520	220U	Capacitor, Electrolytic, 16V, 20%, Rad
C 323	5-00232-520	470U	Capacitor, Electrolytic, 16V, 20%, Rad
C 324	5-00232-520	470U	Capacitor, Electrolytic, 16V, 20%, Rad
C 325	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 326	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 327	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 328	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 330	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 401	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 402	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 403	5-00017-501	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 404	5-00107-530	1.8-6P	Capacitor, Variable, Misc.
C 405	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 406	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 407	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 408	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 409	5-00021-501	82P	Capacitor, Ceramic Disc, 50V, 10%, SL

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C 410	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 411	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 412	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 413	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 414	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 415	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 416	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 417	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 419	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 420	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 502	5-00104-530	3.5-20P	Capacitor, Variable, Misc.
C 503	5-00233-532	22P	Capacitor, Ceramic Disc, 50V, 10% NPO
C 703	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 704	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 705	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 706	5-00234-551	1000U	Capacitor, Electrolytic,35V,20%, Ax
C 707	5-00234-551	1000U	Capacitor, Electrolytic,35V,20%, Ax
C 708	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 709	5-00227-526	100U	Capacitor, Electrolytic, 35V, 20%, Rad
C 710	5-00227-526	100U	Capacitor, Electrolytic, 35V, 20%, Rad
C 711	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 712	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 713	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 714	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 715	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 716	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 717	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 718	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 719	5-00297-567	2.2U 50V RAD	Capacitor, Non-polarized Electrolytics
C 720	5-00297-567	2.2U 50V RAD	Capacitor, Non-polarized Electrolytics
C 801	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 802	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 803	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 804	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 805	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 806	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 807	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 808	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 809	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 810	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 811	5-00225-548	.1U AXIAL	Capacitor, Ceramic, 50V,+80/-20% Z5U AX
C 822	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 823	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 824	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad

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C 825	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 826	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 827	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 828	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 829	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 830	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 831	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 832	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
D 201	3-00368-301	1N753A	Diode
D 202	3-00368-301	1N753A	Diode
D 203	3-00203-301	1N5711	Diode
D 204	3-00203-301	1N5711	Diode
D 301	3-00368-301	1N753A	Diode
D 302	3-00368-301	1N753A	Diode
D 303	3-00203-301	1N5711	Diode
D 304	3-00203-301	1N5711	Diode
D 401	3-00004-301	1N4148	Diode
D 402	3-00004-301	1N4148	Diode
D 403	3-00004-301	1N4148	Diode
D 404	3-00004-301	1N4148	Diode
D 405	3-00004-301	1N4148	Diode
D 406	3-00004-301	1N4148	Diode
D 407	3-00004-301	1N4148	Diode
D 408	3-00004-301	1N4148	Diode
D 409	3-00004-301	1N4148	Diode
D 410	3-00004-301	1N4148	Diode
D 501	3-00004-301	1N4148	Diode
D 502	3-00004-301	1N4148	Diode
D 503	3-00004-301	1N4148	Diode
D 505	3-00004-301	1N4148	Diode
D 701	3-00226-301	1N5822	Diode
D 702	3-00004-301	1N4148	Diode
D 703	3-00226-301	1N5822	Diode
D 704	3-00009-303	YELLOW	LED, T1 Package
D 705	3-00011-303	RED	LED, T1 Package
D 706	3-00062-340	KBP201G/BR-81D	Integrated Circuit (Thru-hole Pkg)
D 707	3-00226-301	1N5822	Diode
D 708	3-00226-301	1N5822	Diode
D 709	3-00306-340	LM385BZ-2.5	Integrated Circuit (Thru-hole Pkg)
D 711	3-00198-301	1N5231B	Diode
D 712	3-00391-301	MBR360	Diode
D 713	3-00391-301	MBR360	Diode
D 801	3-00226-301	1N5822	Diode
D 802	3-00004-301	1N4148	Diode

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D 803	3-00004-301	1N4148	Diode
D 804	3-00004-301	1N4148	Diode
DU105A	3-00004-301	1N4148	Diode
DU105B	3-00004-301	1N4148	Diode
K 101	3-00523-335	G6AK-234P-ST-UC	Relay
K 102	3-00523-335	G6AK-234P-ST-UC	Relay
K 103	3-00523-335	G6AK-234P-ST-UC	Relay
K 104	3-00523-335	G6AK-234P-ST-UC	Relay
K 105	3-00523-335	G6AK-234P-ST-UC	Relay
K 106	3-00523-335	G6AK-234P-ST-UC	Relay
K 107	3-00523-335	G6AK-234P-ST-UC	Relay
K 201	3-00523-335	G6AK-234P-ST-UC	Relay
K 301	3-00523-335	G6AK-234P-ST-UC	Relay
N 701	4-00497-421	1.5KX4	Res. Network, SIP, 1/4W,2% (Isolated)
N 702	4-00501-425	1.0MX5	Resistor Network SIP 1/4W 2% (Common)
P 101	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 102	4-00799-441	2M	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 103	4-00370-441	500	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 104	4-00326-441	200	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 701	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 702	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
PC1	7-00468-701	SR570 MAIN	Printed Circuit Board
Q 501	3-00021-325	2N3904	Transistor, TO-92 Package
Q 701	3-00310-329	MTP25N05	Voltage Reg., TO-220 (TAB) Package
Q 702	3-00887-325	MPS2907A	Transistor, TO-92 Package
Q 703	3-00374-329	MTP20P06	Voltage Reg., TO-220 (TAB) Package
Q 801	3-00376-329	MTP5N05	Voltage Reg., TO-220 (TAB) Package
R 101	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 102	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 103	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 104	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 105	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 106	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 107	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 108	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 109	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 110	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 111	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 112	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 113	4-00194-407	5.11K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 114	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 115	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 116	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 117	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%

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R 118	4-00398-407	499K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 119	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 120	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 121	4-00776-407	178	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 122	4-00136-407	1.82K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 123	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 125	4-00139-407	10.0M	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 126	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 127	4-00204-407	750	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 129	4-00449-407	4.99M	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 130	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 131	4-00193-407	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 132	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 133	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 134	4-00141-407	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 135	4-00800-401	1	Resistor, Carbon Film, 1/4W, 5%
R 136	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 137	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 138	4-00132-407	1.10K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 139	4-00801-407	5.49K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 140	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 141	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 142	4-00132-407	1.10K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 143	4-00801-407	5.49K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 144	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 145	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 146	4-00141-407	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 147	4-00329-407	402	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 201	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 202	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 203	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 204	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 205	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 206	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 207	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 208	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 209	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 210	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 211	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 212	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 213	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 214	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 215	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 216	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%

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R 217	4-00325-407	845	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 218	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 219	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 220	4-00296-407	604	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 221	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 222	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 223	4-00148-407	12.1K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 224	4-00519-407	4.75K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 225	4-00135-407	1.50K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 226	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 227	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 228	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 229	4-00305-401	4.3K	Resistor, Carbon Film, 1/4W, 5%
R 301	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 302	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 303	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 304	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 305	4-00516-407	14.3K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 306	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 307	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 308	4-00168-407	22.6K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 309	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 310	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 311	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 312	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 313	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 314	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 315	4-00433-407	931	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 316	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 317	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 318	4-00296-407	604	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 319	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 320	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 321	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 322	4-00600-407	15.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 323	4-00148-407	12.1K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 324	4-00519-407	4.75K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 325	4-00135-407	1.50K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 326	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 327	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 328	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 329	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 330	4-00065-401	3.3K	Resistor, Carbon Film, 1/4W, 5%
R 401	4-00296-407	604	Resistor, Metal Film, 1/8W, 1%, 50PPM

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R 402	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 403	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 404	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 405	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 406	4-00325-407	845	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 407	4-00190-407	42.2K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 408	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 409	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 410	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 411	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 412	4-00296-407	604	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 413	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 414	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 415	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 416	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 417	4-00317-407	422	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 418	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 419	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 420	4-00130-407	1.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 421	4-00272-407	221	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 422	4-00616-453	49.9	Resistor, 2W, 1%
R 423	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 424	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 425	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 426	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 427	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 428	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 429	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 430	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 431	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 432	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 433	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 434	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 435	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 436	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 437	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 440	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 441	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 501	4-00305-401	4.3K	Resistor, Carbon Film, 1/4W, 5%
R 502	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 503	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 701	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 702	4-00088-401	51K	Resistor, Carbon Film, 1/4W, 5%
R 703	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%

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R 704	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 705	4-00169-407	249	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 706	4-00042-401	15K	Resistor, Carbon Film, 1/4W, 5%
R 707	4-00042-401	15K	Resistor, Carbon Film, 1/4W, 5%
R 708	4-00376-407	2.87K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 709	4-00169-407	249	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 710	4-00058-401	220K	Resistor, Carbon Film, 1/4W, 5%
R 711	4-00035-401	10M	Resistor, Carbon Film, 1/4W, 5%
R 712	4-00035-401	10M	Resistor, Carbon Film, 1/4W, 5%
R 713	4-00612-407	768K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 714	4-00278-407	10.7K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 715	4-00576-407	17.8K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 716	4-00386-407	30.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 717	4-00614-407	174K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 718	4-00155-407	150K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 719	4-00363-407	21.5K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 720	4-00383-407	12.7K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 721	4-00615-407	8.25K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 722	4-00207-407	806K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 723	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 724	4-00203-407	75.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 725	4-00169-407	249	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 726	4-00169-407	249	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 727	4-00582-407	2.15K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 728	4-00582-407	2.15K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 729	4-00309-407	3.32K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 730	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 731	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 801	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 802	4-00092-401	56K	Resistor, Carbon Film, 1/4W, 5%
R 803	4-00056-401	22	Resistor, Carbon Film, 1/4W, 5%
R 804	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 805	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 806	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 807	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 808	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 809	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 810	4-00155-407	150K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 811	4-00787-407	768	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 812	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 813	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 814	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 815	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 816	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%

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R 817	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 818	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 819	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
SO504	1-00026-150	28 PIN 600 MIL	Socket, THRU-HOLE
SO708	1-00570-150	16 PIN	Socket, THRU-HOLE
SO709	1-00570-150	16 PIN	Socket, THRU-HOLE
T 1	6-00067-610	SR560	Transformer
U 101	3-00116-325	78L05	Transistor, TO-92 Package
U 102	3-00385-340	74HC4053	Integrated Circuit (Thru-hole Pkg)
U 103	3-00430-340	AD7547JN	Integrated Circuit (Thru-hole Pkg)
U 104	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 105	3-00402-340	74HC4052	Integrated Circuit (Thru-hole Pkg)
U 106	3-00296-340	OPA404	Integrated Circuit (Thru-hole Pkg)
U 107	3-00451-340	AD546	Integrated Circuit (Thru-hole Pkg)
U 108	3-00535-340	AD743JN	Integrated Circuit (Thru-hole Pkg)
U 109	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 110	3-00385-340	74HC4053	Integrated Circuit (Thru-hole Pkg)
U 111	3-00536-340	AD706	Integrated Circuit (Thru-hole Pkg)
U 112	3-00195-340	CA3082	Integrated Circuit (Thru-hole Pkg)
U 113	3-00195-340	CA3082	Integrated Circuit (Thru-hole Pkg)
U 201	3-00382-340	OPA37	Integrated Circuit (Thru-hole Pkg)
U 202	3-00270-340	74HC4051	Integrated Circuit (Thru-hole Pkg)
U 203	3-00270-340	74HC4051	Integrated Circuit (Thru-hole Pkg)
U 204	3-00090-340	LF411	Integrated Circuit (Thru-hole Pkg)
U 205	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 206	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 301	3-00270-340	74HC4051	Integrated Circuit (Thru-hole Pkg)
U 302	3-00270-340	74HC4051	Integrated Circuit (Thru-hole Pkg)
U 303	3-00090-340	LF411	Integrated Circuit (Thru-hole Pkg)
U 304	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 305	3-00382-340	OPA37	Integrated Circuit (Thru-hole Pkg)
U 401	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 402	3-00297-340	LT1028	Integrated Circuit (Thru-hole Pkg)
U 403	3-00382-340	OPA37	Integrated Circuit (Thru-hole Pkg)
U 404	3-00090-340	LF411	Integrated Circuit (Thru-hole Pkg)
U 405	3-01017-340	TLC7528CN	Integrated Circuit (Thru-hole Pkg)
U 406	3-00383-340	LM6321	Integrated Circuit (Thru-hole Pkg)
U 407	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 408	3-00143-340	LM393	Integrated Circuit (Thru-hole Pkg)
U 409	3-00371-340	DG444	Integrated Circuit (Thru-hole Pkg)
U 410	3-00143-340	LM393	Integrated Circuit (Thru-hole Pkg)
U 501	3-00155-340	74HC04	Integrated Circuit (Thru-hole Pkg)
U 502	3-00045-340	74HC32	Integrated Circuit (Thru-hole Pkg)
U 503	3-00298-340	Z84C0008PEC	Integrated Circuit (Thru-hole Pkg)

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U 505	3-00081-341	2KX8-100	STATIC RAM, I.C.
U 506	3-00039-340	74HC14	Integrated Circuit (Thru-hole Pkg)
U 507	3-00158-340	74HC154N	Integrated Circuit (Thru-hole Pkg)
U 508	3-00049-340	74HC74	Integrated Circuit (Thru-hole Pkg)
U 509	3-00277-340	74HC11	Integrated Circuit (Thru-hole Pkg)
U 510	3-00537-340	74HC373	Integrated Circuit (Thru-hole Pkg)
U 601	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 602	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 603	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 604	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 605	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 606	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 607	3-00411-340	74HC273	Integrated Circuit (Thru-hole Pkg)
U 608	3-00044-340	74HC244	Integrated Circuit (Thru-hole Pkg)
U 701	3-00384-329	LM350T	Voltage Reg., TO-220 (TAB) Package
U 702	3-00141-329	LM337T	Voltage Reg., TO-220 (TAB) Package
U 703	3-00067-340	CD4013	Integrated Circuit (Thru-hole Pkg)
U 704	3-00152-340	CD4051	Integrated Circuit (Thru-hole Pkg)
U 705	3-00239-335	HS-212-12	Relay
U 706	3-00149-329	LM317T	Voltage Reg., TO-220 (TAB) Package
U 707	3-00141-329	LM337T	Voltage Reg., TO-220 (TAB) Package
U 708	8-00072-860	SR566 ASSY	SRS sub assemblies
U 709	8-00072-860	SR566 ASSY	SRS sub assemblies
U 801	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 802	3-00307-340	LM2940T-10	Integrated Circuit (Thru-hole Pkg)
U 803	3-00090-340	LF411	Integrated Circuit (Thru-hole Pkg)
U 804	3-00446-340	6N137	Integrated Circuit (Thru-hole Pkg)
U 805	3-00446-340	6N137	Integrated Circuit (Thru-hole Pkg)
U 806	3-00446-340	6N137	Integrated Circuit (Thru-hole Pkg)
U 807	3-00262-340	74HC86	Integrated Circuit (Thru-hole Pkg)

Front and Rear Panel Parts List

D 1	3-00012-306	GREEN	LED, Rectangular
D 2	3-00012-306	GREEN	LED, Rectangular
D 3	3-00012-306	GREEN	LED, Rectangular
D 4	3-00012-306	GREEN	LED, Rectangular
D 5	3-00012-306	GREEN	LED, Rectangular
D 6	3-00012-306	GREEN	LED, Rectangular
D 7	3-00012-306	GREEN	LED, Rectangular
D 8	3-00012-306	GREEN	LED, Rectangular
D 9	3-00012-306	GREEN	LED, Rectangular
D 10	3-00012-306	GREEN	LED, Rectangular
D 11	3-00012-306	GREEN	LED, Rectangular

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D 12	3-00012-306	GREEN	LED, Rectangular
D 13	3-00012-306	GREEN	LED, Rectangular
D 14	3-00012-306	GREEN	LED, Rectangular
D 15	3-00012-306	GREEN	LED, Rectangular
D 16	3-00012-306	GREEN	LED, Rectangular
D 17	3-00012-306	GREEN	LED, Rectangular
D 18	3-00012-306	GREEN	LED, Rectangular
D 19	3-00012-306	GREEN	LED, Rectangular
D 20	3-00012-306	GREEN	LED, Rectangular
D 21	3-00012-306	GREEN	LED, Rectangular
D 22	3-00012-306	GREEN	LED, Rectangular
D 23	3-00885-306	YELLOW	LED, Rectangular
D 24	3-00012-306	GREEN	LED, Rectangular
D 25	3-00012-306	GREEN	LED, Rectangular
D 26	3-00012-306	GREEN	LED, Rectangular
D 27	3-00012-306	GREEN	LED, Rectangular
D 28	3-00012-306	GREEN	LED, Rectangular
D 29	3-00012-306	GREEN	LED, Rectangular
D 30	3-00012-306	GREEN	LED, Rectangular
D 31	3-00012-306	GREEN	LED, Rectangular
D 32	3-00012-306	GREEN	LED, Rectangular
D 33	3-00012-306	GREEN	LED, Rectangular
D 34	3-00012-306	GREEN	LED, Rectangular
D 35	3-00012-306	GREEN	LED, Rectangular
D 36	3-00012-306	GREEN	LED, Rectangular
D 37	3-00012-306	GREEN	LED, Rectangular
D 38	3-00012-306	GREEN	LED, Rectangular
D 39	3-00012-306	GREEN	LED, Rectangular
D 40	3-00012-306	GREEN	LED, Rectangular
D 41	3-00012-306	GREEN	LED, Rectangular
D 42	3-00012-306	GREEN	LED, Rectangular
D 43	3-00012-306	GREEN	LED, Rectangular
D 44	3-00012-306	GREEN	LED, Rectangular
D 45	3-00012-306	GREEN	LED, Rectangular
D 46	3-00885-306	YELLOW	LED, Rectangular
D 47	3-00012-306	GREEN	LED, Rectangular
D 48	3-00012-306	GREEN	LED, Rectangular
D 49	3-00012-306	GREEN	LED, Rectangular
D 50	3-00012-306	GREEN	LED, Rectangular
D 51	3-00012-306	GREEN	LED, Rectangular
D 52	3-00012-306	GREEN	LED, Rectangular
D 53	3-00012-306	GREEN	LED, Rectangular
D 54	3-00012-306	GREEN	LED, Rectangular
D 55	3-00885-306	YELLOW	LED, Rectangular

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D 56	3-00884-306	RED	LED, Rectangular
D 57	3-00885-306	YELLOW	LED, Rectangular
D 58	3-00885-306	YELLOW	LED, Rectangular
D 59	3-00012-306	GREEN	LED, Rectangular
D 60	3-00884-306	RED	LED, Rectangular
D 61	3-00884-306	RED	LED, Rectangular
D 62	3-00884-306	RED	LED, Rectangular
D 63	3-00004-301	1N4148	Diode
D 64	3-00004-301	1N4148	Diode
D 65	3-00004-301	1N4148	Diode
D 66	3-00004-301	1N4148	Diode
D 67	3-00004-301	1N4148	Diode
J 4	1-00139-130	28 PIN DIL	Connector, Male
J 5	1-00197-101	TEFLON TEST JAC	Vertical Test Jack
J 104	1-00073-120	INSL	Connector, BNC
J 401	1-00073-120	INSL	Connector, BNC
J 601	1-00139-130	28 PIN DIL	Connector, Male
J 805	1-00073-120	INSL	Connector, BNC
J 806	1-00073-120	INSL	Connector, BNC
JP801	1-00016-160	RS232 25 PIN D	Connector, D-Sub, Right Angle PC, Female
N 1	4-00288-425	470X9	Resistor Network SIP 1/4W 2% (Common)
N 2	4-00288-425	470X9	Resistor Network SIP 1/4W 2% (Common)
N 3	4-00288-425	470X9	Resistor Network SIP 1/4W 2% (Common)
N 4	4-00298-425	470X5	Resistor Network SIP 1/4W 2% (Common)
N 5	4-00298-425	470X5	Resistor Network SIP 1/4W 2% (Common)
P 1	4-00802-452	2.0K	Pot, Multi Turn Trim, Mini
PC2	7-00469-701	SR570 FP	Printed Circuit Board
Q 1	3-00022-325	2N3906	Transistor, TO-92 Package
Q 2	3-00022-325	2N3906	Transistor, TO-92 Package
Q 3	3-00021-325	2N3904	Transistor, TO-92 Package
R 1	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00026-401	1.3K	Resistor, Carbon Film, 1/4W, 5%
R 5	4-00803-401	910	Resistor, Carbon Film, 1/4W, 5%
SW1	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW2	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW3	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW4	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW5	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW6	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW7	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW8	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW9	2-00031-201	D6-01-05	Switch, Momentary Push Button

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SW10	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW11	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW12	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW13	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW14	2-00031-201	D6-01-05	Switch, Momentary Push Button
SW15	2-00031-201	D6-01-05	Switch, Momentary Push Button
U 1	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 2	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 3	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 4	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 5	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 6	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
U 7	3-00303-340	74HC164	Integrated Circuit (Thru-hole Pkg)
Z 0	0-00014-002	6J4	Power Entry Hardware
Z 0	0-00017-002	TRANSCOVER	Power Entry Hardware
Z 0	0-00042-010	4-40 HEX	Nut, Hex
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00077-030	3/16"X5/16"NYLN	Spacer
Z 0	0-00079-031	4-40X3/16 M/F	Standoff
Z 0	0-00089-033	4"	Tie
Z 0	0-00096-041	#4 SPLIT	Washer, Split
Z 0	0-00109-050	1-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00122-053	2-1/4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00126-053	3-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00128-053	4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00136-053	8-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00153-057	GROMMET2	Grommet
Z 0	0-00194-043	#4 SHOULDER	Washer, nylon
Z 0	0-00195-020	6-32X3/8PF	Screw, Flathead Phillips
Z 0	0-00202-021	4-40X1-1/2PP	Screw, Panhead Phillips
Z 0	0-00231-043	1-32, #4 SHOULD	Washer, nylon
Z 0	0-00237-016	F1404	Power Button
Z 0	0-00240-026	4-40X3/8PF	Screw, Black, All Types
Z 0	0-00243-003	TO-220	Insulators
Z 0	0-00259-021	4-40X1/2"PP	Screw, Panhead Phillips
Z 0	0-00268-052	6-1/2" #22 BL	Wire #22 UL1007
Z 0	0-00277-053	4" #24 BLK	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00299-000	1/8" ADHES TAPE	Hardware, Misc.
Z 0	0-00312-000	FUSEHOLDER	Hardware, Misc.
Z 0	0-00314-040	#8 18-8 SS	Washer, Flat
Z 0	0-00321-035	BLACK	BANANA JACK
Z 0	0-00322-035	RED	BANANA JACK
Z 0	0-00323-035	GREEN	BANANA JACK
Z 0	0-00324-035	WHITE	BANANA JACK

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Z 0	0-00325-032	2-520182-2	Termination
Z 0	0-00327-050	8" #18 WHITE	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00328-050	8" #18 RED	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00329-050	8" #18 BLACK	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00330-050	5-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00333-052	6" #22	Wire #22 UL1007
Z 0	0-00334-052	1-3/4" #22	Wire #22 UL1007
Z 0	0-00350-053	2-1/4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00355-050	20" #18 RED	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00466-050	23" #18 BLACK	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00523-048	5-5/8" #18	Wire, #18 UL1015 Strip 3/8 x 3/8 No Tin
Z 0	0-00524-048	8-1/4" #18	Wire, #18 UL1015 Strip 3/8 x 3/8 No Tin
Z 0	0-00666-050	23" #18 WHITE	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00667-050	20" #18 WHITE	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	1-00124-178	4 PIN	Connector Housing, Plug
Z 0	1-00125-179	4 PIN	Connector Housing, Receptacle
Z 0	1-00126-176	.062" DIAM	Terminal, Male
Z 0	1-00127-177	.062" DIAM	Terminal, Female
Z 0	1-00194-171	28 CON DIL	Cable Assembly, Ribbon
Z 0	4-00541-435	130V/1200A	Varistor, Zinc Oxide Nonlinear Resistor
Z 0	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
Z 0	6-00004-611	1A 3AG	Fuse
Z 0	6-00050-612	GB1219-36	Battery
Z 0	6-00074-611	3A 3AG	Fuse
Z 0	7-00201-720	SR500-32	Fabricated Part
Z 0	7-00460-709	SR570	Lexan Overlay
Z 0	7-00462-709	SR570	Lexan Overlay
Z 0	7-00463-720	SR570-4&5	Fabricated Part
Z 0	7-00464-720	SR570-6	Fabricated Part
Z 0	7-00795-720	BATTERY PAN	Fabricated Part
Z 0	7-00796-720	BATTERY RETAINR	Fabricated Part
Z 0	9-00267-917	GENERIC	Product Labels
Z 0	9-00792-917	EC WARNING	Product Labels

Miscellaneous and Chassis Assembly Parts List

R 124	4-00857-458	1.0G .5W 200PPM	Resistor, Metal Oxide
R 128	4-00864-458	500M 3/4-WATT	Resistor, Metal Oxide
U 504	3-00305-342	27C64-255	EPROM/PROM, I.C.
Z 0	0-00150-026	4-40X1/4PF	Screw, Black, All Types
Z 0	0-00179-000	RIGHT FOOT	Hardware, Misc.
Z 0	0-00180-000	LEFT FOOT	Hardware, Misc.
Z 0	0-00185-021	6-32X3/8PP	Screw, Panhead Phillips
Z 0	0-00204-000	REAR FOOT	Hardware, Misc.

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Z 0	0-00248-026	10-32X3/8TRUSSP	Screw, Black, All Types
Z 0	0-00315-021	6-32X7/16 PP	Screw, Panhead Phillips
Z 0	0-00326-026	8-32X1/4PP	Screw, Black, All Types
Z 0	0-00471-021	4-40X1"PP	Screw, Panhead Phillips
Z 0	7-00122-720	DG535-36	Fabricated Part
Z 0	7-00217-735	PS300-40	Injection Molded Plastic
Z 0	7-00259-720	SR560-28	Fabricated Part
Z 0	7-00260-720	SR560-27	Fabricated Part
Z 0	7-00465-720	SR570-7	Fabricated Part
Z 0	7-00466-720	SR570-8	Fabricated Part

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