Fast Gated Integrators and Boxcar Averagers

SR 250
255
245
235
200
280
275
240

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Fast Gated Integrators and Boxcar Averagers

Model SR250 - Gated Integrator and Boxcar Averager Module

Model SR255 - Fast Sampler Module

Model SR245 - Computer Interface Module

Model SR235 - Analog Processor Module

Model SR200 - Gate Scanner Module

Model SR280 - System Mainframe

Model SR275 - Display Module

Model SR240 - Fast Preamp

Version 2.1

STANFORD RESEARCH SYSTEMS
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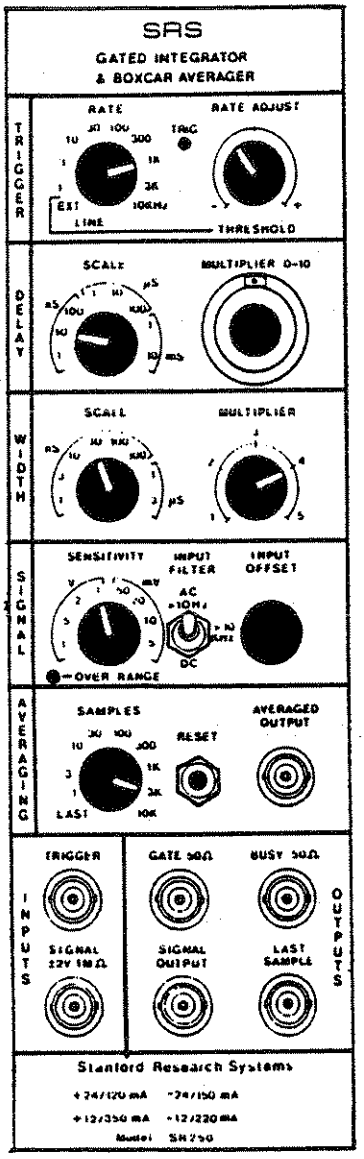
INTRODUCTION

The model SR250 Gated Integrator is a versatile, high speed, low cost NIM module designed to recover fast analog signals from noisy backgrounds.

The SR250 consists of a gate generator, a fast gated integrator, and exponential averaging circuitry. The gate generator, triggered internally or externally, provides an adjustable delay from a few nanoseconds to 100 milliseconds, before it generates a continuously adjustable gate of 2 nanoseconds to 15 microseconds. The delay may be set by a front panel potentiometer, or automatically scanned by a rear panel input voltage in order to record entire waveforms.

The fast gated integrator integrates the input signal during the gate. The output from the



TRIGGER

The unit may be triggered internally or externally. The internal rate generator is continuously variable from 0.5Hz to 20KHz in 9 ranges. The external trigger pulse may be as short as 5nS. A green LED blinks with each trigger.

DELAY

The delay of the sample gate from the trigger is set by these controls. The delay scale is multiplied by the setting on the 10-turn dial, allowing continuously adjustable delays from a few nanoseconds to 100mS. The delay multiplier may also be controlled by a rear panel input voltage for scanning gate applications.

WIDTH

The width of the sampling gate may be continuously adjusted from 2nS to 15μS over 8 width ranges.

SIGNAL

The sensitivity of the instrument (volts out/volts in) may be set from 1V/1V to 1V/5mV. An input filter rejects unwanted signal before it is sampled by the integrator. A 10-turn INPUT OFFSET control may be used to compensate for an unwanted input offset.

AVERAGING

An AVERAGE OUTPUT provides a moving average over 1 to 10K samples. The reset button is used to reset the average to zero. The average may also be reset by a rear panel logic input.

INPUTS

Both the TRIGGER and the SIGNAL inputs have a 1MΩ input impedance and may safely handle 100 volt inputs without damage.

OUTPUTS

The SIGNAL INPUT is passed out to the SIGNAL OUTPUT for termination and for gate timing: The GATE output shows exactly which portion of the input signal is being sampled. The BUSY output provides a TTL synchronizing pulse when the unit is triggered. The LAST SAMPLE output provides a voltage proportional to the latest input signal averaged over the gate.

Figure 1 - SR250 Front Panel

SPECIFICATIONS

TRIGGER

Internal Trigger	The rate generator is continuously adjustable from .5Hz to 20KHz in 9 ranges.
Line Trigger	The gate generator may be triggered from the power mains with adjustable phase.
External Trigger	The gate generator may be triggered by the EXTERNAL TRIGGER INPUT. 1 MΩ input impedance. Trigger threshold adjustable from 0.5 to 2V. The input is protected to +/- 100 VDC. The trigger pulse must be over threshold for at least 5nS and have a rise time shorter than 1 μS.
Manual Trigger	The unit will trigger once if the trigger threshold is scanned through 0 VDC.
Trigger LED	The Trigger LED blinks with each trigger.

DELAY

Delay Scale	Delay scales from 1 nS to 10 mS may be selected.
Delay Multiplier	A 10-turn dial is used to select a delay multiplier from 0 to 10.
Accuracy	2 nS or 5% of the full scale delay, whichever is larger.
Jitter	Less than 20 pS or 0.01% of the full scale delay, whichever is larger.
External Delay Control	Rear panel input voltage from 0 to 10 VDC overrides the front panel delay multiplier. This input is used by the SR200 Gate Scanner Module to scan the sample gate in order to record entire waveforms.
Note:	A trigger discriminator delay of about 25 nS must be added to the gate delay when external triggers are used.

WIDTH

Width Scale	1, 3, 10, 30, 100, 300nS, 1, 3μS.
Width Multiplier	Continuously adjustable from x1 to x5.
Width Accuracy	2nS or 20% of full scale, whichever is greater.
Minimum Width	2nS, FWHM.

SIGNAL

Sensitivity	The sensitivity, volts out/volts in, may be set from 1V/1V to 1V/5mV in a 1, 2, 5 sequence. The sensitivity calibration is accurate to 3% for gate widths longer than 10 nS. The sensitivity decreases to about 50% of nominal at a gate width of 2 nS.
Filter	An input filter allows coupling of DC, AC above 10 Hz, or AC above 10 KHz.
Offset Control	A 10-turn potentiometer adds an input offset of ±0.4VDC. When using very narrow gates, the offset may need adjustment if the gate width is changed.
Over Range LED	A red LED indicates if the signal is greater than 2 VDC or if the LAST SAMPLE output is greater than 10VDC.

LAST SAMPLE

Output	A ±10VDC full scale output with an output impedance of less than 1Ω and a 10mA drive capability. The short circuit output current is limited to about 20mA. The droop rate at this output is less than 0.2% of full scale per second.
Polarity	The polarity of the LAST SAMPLE output may be inverted by a rear panel switch.
Responsivity	95% (no more than 5% of the previous last sample remains.)

AVERAGING

Samples	An exponential moving average may be taken over 1, 3, 10, 30,... to 10,000 samples or LAST may be selected for no averaging.
Reset	Front panel push button resets the moving average to zero.
Remote Reset	Rear panel BNC input resets the moving average with TTL low or switch closure.
Average Output	BNC output, ±10 VDC full scale, with an output impedance of less than 1Ω, and a 10mA drive capability. Short circuit current limits at about 20mA. When there are no triggers the droop rate is less than 1% per minute on 1 to 30 samples, and less than 0.01% per minute for 100 to 10K samples in the average. This implies a droop error of less than 1% of full scale for trigger rates >1Hz.
Average Polarity and Baseline Subtraction	A rear panel switch selects the polarity of the LAST SAMPLE before it is added to the moving average. This may be used to invert the polarity of the AVERAGE OUTPUT. The switch may also be set to the TOGGLE position, in order to subtract every other sample from the moving average. By triggering the unit at twice the experiment's repetition rate, so as to sample only the baseline on alternate triggers, the baseline will be subtracted from the moving average.
Toggle Output	A rear panel BNC provides a TTL signal that changes state with each trigger. This output is used with the Active Baseline Subtraction feature to indicate if the next sample will be added to, or subtracted from, the moving average. The toggle output is capable of driving 50Ω lines to +2 VDC.

SIGNAL INPUT AND OUTPUT

Signal Input	1MΩ input impedance, ±2 VDC usable range, protected to 100 VDC. The input offset drift is less than 0.5mV per hour after a 20 minute warm-up. Shot noise at the input is less than 0.5mV. Coherent pickup is less than 5mV, which may be cancelled with the input offset control in fixed gate applications.
Signal Output	The SIGNAL OUTPUT is the input signal delayed by 3.5nS. This output is used to terminate the input signal, and to precisely time the sample gate with respect to the output signal.

GATE AND BUSY OUTPUTS

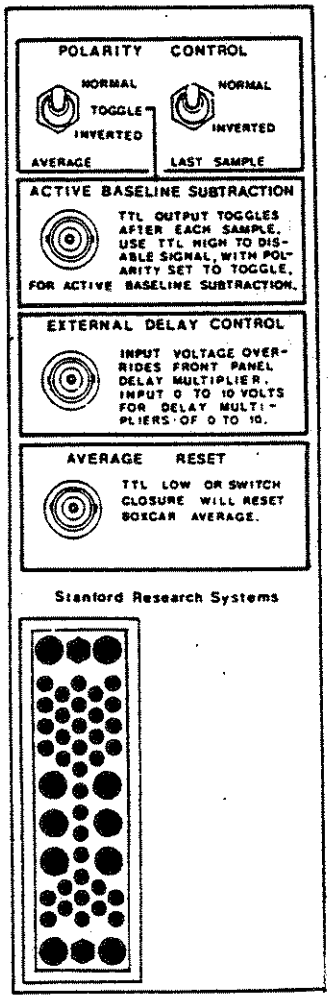
Gate Output	A 200mV output pulse marks the exact position of the sample gate with respect to the output signal. Position accuracy is ±1nS. This output must be terminated into a 50Ω load.
Busy Output	This TTL output is used to synchronize the experiment to the internal rate generator (if it is used) or to signal the data acquisition computer that the unit has been triggered. The output will drive 50Ω lines to 2 VDC, and is logic 1 from the time of the trigger until the unit is ready to accept another trigger input. (A minimum of 45μS, longer for long delays or gate widths.)

GENERAL SPECIFICATIONS

Power Supplies	+24V/135mA, +12V/380mA, -12V/230mA, -24V/150mA. Approximately 14 Watts. Power from a NIM standard crate or from Stanford Research Systems mainframe model SR280.
Mechanical	Dual width NIM standard enclosure per TID-20893. Dimensions 2.7"x8.714"x11.5".
Warranty	1 year parts and labor on defects in materials or workmanship.

integrator is then normalized by the gate width to provide a voltage which is proportional to the average of the input signal during the sampling gate. This signal is further amplified according to the front panel sensitivity setting. Then it is sampled by a low droop sample and hold amplifier, and output via a front panel BNC connector. This LAST SAMPLE output allows the experimenter to do a shot-by-shot analysis of the signal being studied, and makes the instrument a particularly useful component in a computer data acquisition system.

A moving exponential average over 1 to 10,000 samples is available at the AVERAGED OUTPUT. This traditional averaging technique is useful for pulling small signals from noisy backgrounds. As one averages many noisy samples of a signal, the average will converge to the mean value of the signal, and the noise will average to zero. In the case of a random white noise background, the signal-to-noise ratio increases as the square root of the number of samples in the average. This allows a S/N improvement of a factor of 100 using this technique alone.



POLARITY CONTROL AND ACTIVE BASELINE SUBTRACTION

The Polarity of the Last Sample and Averaged Outputs is controlled by rear panel toggle switches. If the Average switch is in the Toggle position the polarity of the last sample is inverted on every other shot before being added to the moving average. This feature is used to subtract the baseline from the Average Output. For this feature to operate, you must use the Active Baseline Subtraction logic output to disable the experiment on alternate triggers. The Last Sample Polarity control provides a simple way to interface the device to unipolar ADC's.

EXTERNAL DELAY CONTROL

The External Delay Control Input allows the user to control the Gate Delay with a voltage. The voltage applied to this input overrides the front panel delay multiplier.

AVERAGE RESET

The Average Reset input will accept a TTL low level or a switch closure to ground to reset the moving average output. If the input is held low for at least 1μS, a 2mS reset pulse is generated internally, resetting the moving average.

Figure 2 - SR250 Rear Panel

In addition to this traditional technique, the averaging circuitry may be used to actively subtract a baseline drift or background from the signal of interest. This is accomplished by taking input samples at twice the repetition rate of the experiment, inverting the baseline sample acquired when the signal is not present, and adding it to the moving average. This method of cancelling baseline drift is analogous to phase sensitive detection which is used in frequency domain measurements.

OPERATION

This section will describe the operation of the SR250 Gated Integrator and Boxcar Averager Module. The instrument's controls and input and output characteristics will be discussed.

While there are several modes of operation, by far the most common application of the SR250 is to sample an input voltage at a fixed time from an input trigger. The time delay from the input trigger to the start of the sample gate is set by the front panel delay controls: the width of the sample gate is set by front panel delay controls.

EXTERNAL TRIGGER INPUT

The gate generator is usually triggered externally. The external trigger input should be a clean signal: if the trigger is marginal or noisy, then the gate will jitter in time. You should avoid excessive high frequency noise on this or on any other input or output to the Boxcar (such as may be created by laser Q-switches, discharges, or spark gaps). Other important characteristics of the trigger signal are:

Amplitude: The trigger pulse must be at least 0.5 volts, preferably should not exceed 5 volts, and in no case is to exceed 100 volts. Positive or negative trigger inputs are okay. The trigger threshold is set between 0.5 volts and 2 volts by the threshold knob. The unit will trigger when the trigger input exceeds the set threshold.

Duration: For reliable triggering, the trigger must remain over threshold for at least 5 nanoseconds.

Risetime: The trigger input is AC coupled to the trigger discriminator. The time constant of this circuit is about 10μS, therefore, external trigger inputs must have a risetime of less than 10μS. This AC coupling makes the trigger circuit immune to DC shifts at the trigger input, and allows the unit to trigger on the falling edge of a long positive logic pulse. If the logic pulse is high for at least a few milliseconds, then the unit may be triggered on the differentiated falling edge of the pulse by setting the trigger threshold to a small negative value.

Frequency: The maximum external trigger rate is 20KHz. This maximum is reduced if long gate widths or delays are used. The external trigger source should not try to trigger the unit while the BUSY output is high, otherwise the trigger may be missed or the unit may trigger erratically.

DELAY

When triggered, the unit will generate a gate, and the input signal will be sampled while the gate is on. The delay from the input trigger to the start of the sample gate is set by the front panel delay controls. A DELAY SCALE of 1nS to 10μS may be selected. The DELAY MULTIPLIER, a 10-turn dial, may be set from 0 to 10.0. The actual delay is equal to the DELAY SCALE times the DELAY MULTIPLIER, plus a nominal 25nS trigger discriminator delay.

WIDTH

The width of the sample gate is set by the front panel width controls. Gate widths from 2nS to 15μS may be set by selecting the appropriate WIDTH SCALE and WIDTH MULTIPLIER. Do not select gate widths shorter than 2nS, since the sensitivity of the instrument reduces dramatically under these conditions.

SIGNAL INPUT

The signal to be sampled is applied to the signal input. This input has a 1 MΩ input impedance, and is passed to the SIGNAL OUTPUT via 3.5nS of internal coax delay line. In many applications, the signal cable should be terminated into 50Ω. If it is necessary to terminate the input signal this should be done at the SIGNAL OUTPUT BNC connector, and not at the SIGNAL input. The input signal should not exceed ± 2 volts, otherwise the instrument's input buffer amplifier may saturate. If this happens, the OVER RANGE LED will turn on.

Input signals with a DC component of up to 50 VDC are okay if the INPUT FILTER is on either the 10Hz or 10KHz range. The SIGNAL input is protected against damage for input signals up to 100 VDC.

GATE OUTPUT AND SIGNAL OUTPUT

The GATE and SIGNAL OUTPUT show the exact timing relation of the sample gate with respect to the signal. The sample gate position is marked by a +200mV output pulse. To overlap the sample gate onto a particular portion of the signal, use equal lengths of coax cable to bring the GATE and SIGNAL OUTPUT to the inputs of a dual channel oscilloscope. The GATE output cable should be terminated into a 50Ω load. You may also need to terminate the SIGNAL OUTPUT cable into 50Ω. Trigger the oscilloscope with the Boxcar's BUSY output, and adjust the DELAY MULTIPLIER to position the gate output with respect to the signal output. The timing accuracy of the gate and signal outputs is 1nS.

SENSITIVITY

The SENSITIVITY switch selects the gain of the instrument in volts out/volts in. The sensitivity may be set from 1V/V up to 1V/5mV. The OVER RANGE LED will turn on if the sum of the input signal and the input offset, averaged over the sample gate, exceeds ten times the sensitivity (i.e. the LAST SAMPLE output exceeds 10VDC). You can make the OVER RANGE LED go off by (1) reducing the SENSITIVITY setting, (2) adjusting the INPUT OFFSET control, (3) reducing the signal amplitude, or (4) by changing the INPUT FILTER.

INPUT OFFSET

This 10-turn knob is used to add a DC offset to the input signal. The offset may be set from +0.4 to -0.4 VDC. Note that this is an offset control, as opposed to a position control, and behaves accordingly when the SENSITIVITY switch is changed. Also, this input offset is not affected by the position of the INPUT FILTER switch.

INPUT FILTER

The INPUT FILTER switch allows you to reject unwanted signal components before they get to the gated integrator. DC drifts are eliminated on either AC range. The AC filters have a 6 dB/octave roll-off, and so the 10KHz filter will reject 99.6% of an unwanted 60Hz noise signal. On either AC range the input is capacitively coupled, allowing photomultiplier anodes to float up unless an external resistance to ground is provided.

LAST SAMPLE OUTPUT

The LAST SAMPLE output has a full scale range of ±10VDC. The output is able to drive any load greater than 2KΩ to full scale. The output impedance is less than 1Ω, and has a short circuit current limit of 20mA. The analog voltage, V, at the LAST SAMPLE output, valid after the BUSY output returns to its low state, is given by:

$$V = \frac{\text{Average of Input during Last Gate}}{\text{Sensitivity Setting}}$$

The polarity of the LAST SAMPLE output may be inverted by a rear panel switch. You may wish to invert the LAST SAMPLE output in order to obtain a positive output from a negative photomultiplier input.

AVERAGING

The AVERAGED OUTPUT provides an exponential moving average over the number of samples specified by the SAMPLES selector. If 300 samples are selected for the moving average, the AVERAGED OUTPUT will come to 67% of its final value after 300 triggers. The RESET button may be used to reset the moving average to zero. A rear panel BNC input may also be used to reset the moving average. The AVERAGED OUTPUT has an output impedance of less than 1Ω and a short circuit current limit of about 20mA. The polarity of the AVERAGED OUTPUT may be inverted by a rear panel switch. This switch also allows the polarity of the current sample to be inverted on alternate triggers, a feature that is used in the ACTIVE BASELINE SUBTRACTION mode, which will be described later.

The averaging circuits use a sample and hold amplifier which has a very small drift that can be neglected in most applications. When triggering stops, the AVERAGED OUTPUT drifts less than 1% per minute on 1 to 30 sample averages and less than .01% per minute for 100 to 10K sample averages. This implies an error of less than 1% of

full scale in any moving average for which the trigger rate is greater than 1Hz.

BUSY OUTPUT

The BUSY output is a TTL output, capable of driving 50Ω loads to 2VDC, which goes high from the time the unit is triggered until the unit is ready for another trigger. The BUSY output goes high for a minimum of 45μS, but will stay high longer if long gate delays or widths are selected. The BUSY output has several uses, including: (1) indicates when the unit is busy, and so when external triggers should not be applied, (2) may be used to trigger other Boxcars, (3) may be used to synchronize an experiment to the Boxcar's internal rate generator, (4) may be used to tell the data acquisition computer that the unit has been triggered and that a new sample is available, and (5) may be used to trigger an oscilloscope to help time the sample gate with respect to the signal of interest. Although it is not necessary to terminate the BUSY output to 50Ω, it is advisable. The BUSY output has a 1nS risetime and so a substantial reflection will occur if the it is not terminated.

ACTIVE BASELINE SUBTRACTION

In addition to the passive baseline subtraction described in the examples, there is another method of eliminating baseline drift called Active Baseline Subtraction. This feature allows the Boxcar Module to subtract baseline drift from the AVERAGED OUTPUT signal. The baseline is removed by taking samples at twice the repetition rate of the experiment, inverting the sample taken with no signal present (only baseline), and adding it to the moving average. This technique is similar to phase sensitive detection in that the baseline, which is not synchronous with the signal, is cancelled from the output. To use this feature the AVERAGE POLARITY CONTROL switch on the rear panel must be set to the TOGGLE position, which will automatically invert the LAST SAMPLE on every other trigger before it is added to the moving average. Of course, the signal must be present only on every other sample, so that only the baseline is subtracted from the moving average. To facilitate this, a rear panel output, ACTIVE BASELINE SUBTRACTION, will toggle with each trigger to tell the experiment when to allow and when to inhibit the signal. The INPUT OFFSET control may appear not to work when in this mode, however this input offset is actually being cancelled from the moving average. When using Active Baseline Subtraction you should average over 30 or more pulses in order to avoid a choppy AVERAGED OUTPUT signal. Proper adjustment of the INPUT OFFSET control will also help reduce this effect.

EXTERNAL DELAY CONTROL

A control voltage applied to this rear panel BNC input overrides the front panel DELAY MULTIPLIER dial. The delay control voltage may be set from 0 to 10.0 VDC. This control input may be used to scan the sample gate in order to record entire waveforms. The input impedance varies from 10KΩ to 16.6KΩ depending on the DELAY MULTIPLIER dial setting; this impedance terminates to a voltage equal to the DELAY MULTIPLIER setting. There are two consequences of these input characteristics: (1) control signals applied to this input should come from a low impedance source (such as the SR200 Gate Scanner Module), and (2) you may use the EXTERNAL DELAY CONTROL input as an output in order to read the DELAY MULTIPLIER dial setting. The output impedance also depends on the delay setting, from 10KΩ at 0.0V to 16.6KΩ at 10.0V. Beware that if you draw current from this 'input' the DELAY MULTIPLIER will be affected, and may appear to be malfunctioning.

AVERAGE RESET

As previously described, the AVERAGE RESET input may be used to reset the voltage at the AVERAGED OUTPUT to zero. This input has an internal 10KΩ pull-up to +5VDC. A TTL low or switch closure to ground will reset the moving average. The input must be held low for at least 1μS, which will trigger an internal 2mS reset pulse which clears the averaging capacitors.

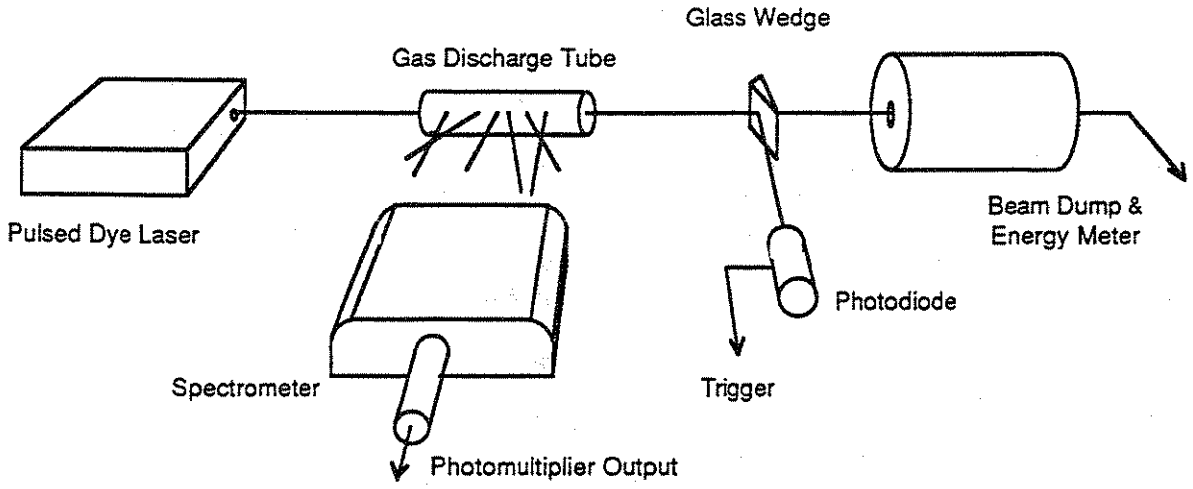


Figure 3 - Experiment For Application Examples

APPLICATIONS

This section will illustrate some specific operating examples using the SR250 Gated Integrator, together with other Boxcar System components. Although the specific examples involve data acquisition in pulsed laser experiments, many of the concepts and techniques introduced in these examples are applicable in other areas of research.

PULSED LASER DATA ACQUISITION

In this example, excited state atoms in a gas discharge are to be transferred to a different excited state by a pulsed dye laser. Figure 3 shows the experimental arrangement for this and the other examples. The transfer will be inferred by the increased fluorescence from the final state as the dye laser frequency is tuned through the transition frequency. The experiment is difficult because the background fluorescence signal from final state atoms excited by the discharge is larger than the laser induced signal. The desired result is shown in Figure 4.

Other details of the experiment, are shown in Figure 5, and summarized here:

1) The laser pulse width is 8nS.
2) There is a 40nS delay in the photomultiplier, from the time photons strike the photo-cathode until the anode signal is seen.
3) Decays from the final state are very fast; the lifetime is less than the laser pulse length.
4) The laser induced signal is expected to be only 25% of the background and is only present during the laser pulse. The experimenter wants a final Signal/Noise ratio of 5:1.

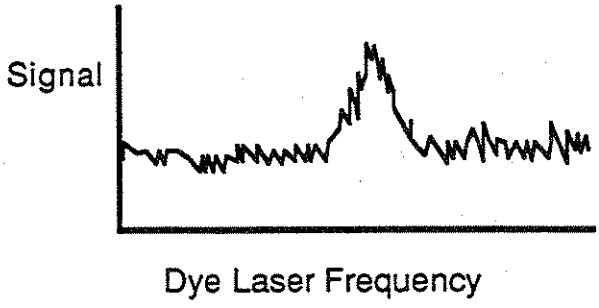


Figure 4 - Desired Result for Example 1

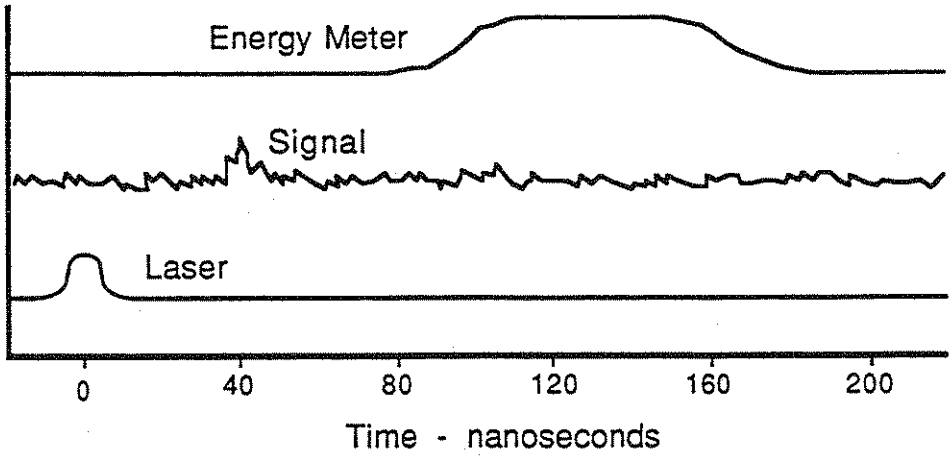


Figure 5 - Experimental Timing Details

The Boxcar Averager system for this experiment is shown in Figure 6. The SR280 Mainframe bar-graph display is used to show shot-by-shot data, while the digital and analog panel meters are used to display the Boxcar outputs. The timing of the sample gate with respect to the laser induced signal is a very important aspect of this signal recovery problem. To maximize the S/N of the result it is important to gate the integrator open only while the S/N is favorable: we must be certain to look only during the 8nS laser pulse. To simplify this timing, the SR250 has signal and gate outputs; the signal output is the same as the signal input, but internally delayed by 3.5nS of coax cable. This delay is added to provide an exact coincidence between the signal and gate outputs. Using a dual channel oscilloscope, usually in the ADD mode, the gate can be accurately positioned over the portion of the signal for which the laser is on.

As shown in Figure 3, a reflection of the laser off a glass wedge is used to trigger the unit via a fast photodiode. The BUSY output from the SR250 is used to trigger the oscilloscope, and equal lengths of cable are brought to the oscilloscope's A and B inputs from the GATE and SIGNAL OUTPUT for the gate timing. The gate can now be accurately positioned over the signal by adjusting the DELAY MULTIPLIER. (If the laser induced signal is too small to be seen for timing purposes, one could tune the spectrometer to the laser frequency and rely on scattered laser light to time the gate to the signal.) Because the photomultiplier delay (about 40nS for a 12 stage PMT) is greater than the 25nS minimum gate delay of the SR250, no cable delay is required to slow the signal from the PMT. And, since the unit is triggered by the laser light, there will be virtually no jitter of the gate with respect to the signal. Low timing jitter is important, as we will be using an 8 to 10nS gate in this experiment. If, because of a long trigger delay, we were forced to use a less stable trigger, the S/N of the experiment would be adversely affected.

In this hypothetical experiment, the S/N of each sample is 1:4. To achieve the desired 5:1 S/N an enhancement of 20 is needed, requiring that about 400 shots be averaged. Knowing this, we select the closest averaging interval, 300 samples, which will give a S/N enhancement of a factor of 17. If the laser is operating at 10 Hz, the effective time constant is 30 seconds: we must be sure not to scan the laser through the transition too quickly.

Data is recorded by displaying the average output on the y-axis of a strip chart recorder as the laser is slowly scanned over the frequency region of interest.

THE BASELINE PROBLEM

In the preceding experiment, we would have used the 10KHz input filter on the signal input: there are no signal components of interest below 10KHz, and so this measure will reduce low frequency noise (i.e. 60Hz and baseline drift).

You may wish to reject even higher frequencies. There are at least two good ways of doing this. The first is to insert a small capacitor in series with the signal input. If the signal line remains terminated into 50Ω at the oscilloscope, and we use a 470pF capacitor, then frequencies below 6.7MHz will be rejected with a 6dB per octave low frequency roll-off.

The second method is actually a very effective method of baseline subtraction. To use this method, after completing the fast timing of the signal and the gate, terminate the SIGNAL OUTPUT into a short circuit. (Make sure that this will not damage your detector.) This probably seems like a very bad idea at first, but recall that there is 3.5nS of coax cable between the SIGNAL input and SIGNAL OUTPUT. The 100% (inverted) reflection from the short will not be seen at the input for 2x3.5 = 7nS. The inverted reflection (which is the baseline at a time 7nS prior to the signal) is superimposed on the input when it is sampled by the gated integrator. If you want to sample the baseline more than 7nS before the signal, just add some additional coax to the SIGNAL OUTPUT before terminating it into a short.

You may want to subtract the baseline just following your signal (rather than the baseline just before). To do this, we are going to sample the reflected signal, superimposed on the baseline (which follows the signal in time). When you do this, you must, of course, move the gate later in time, by an amount equal to 2 x(3.5nS + length of your shorted coax). Since you're sampling the reflected signal pulse, it will be inverted--you may fix this with the output polarity controls on the back panel of the SR250.

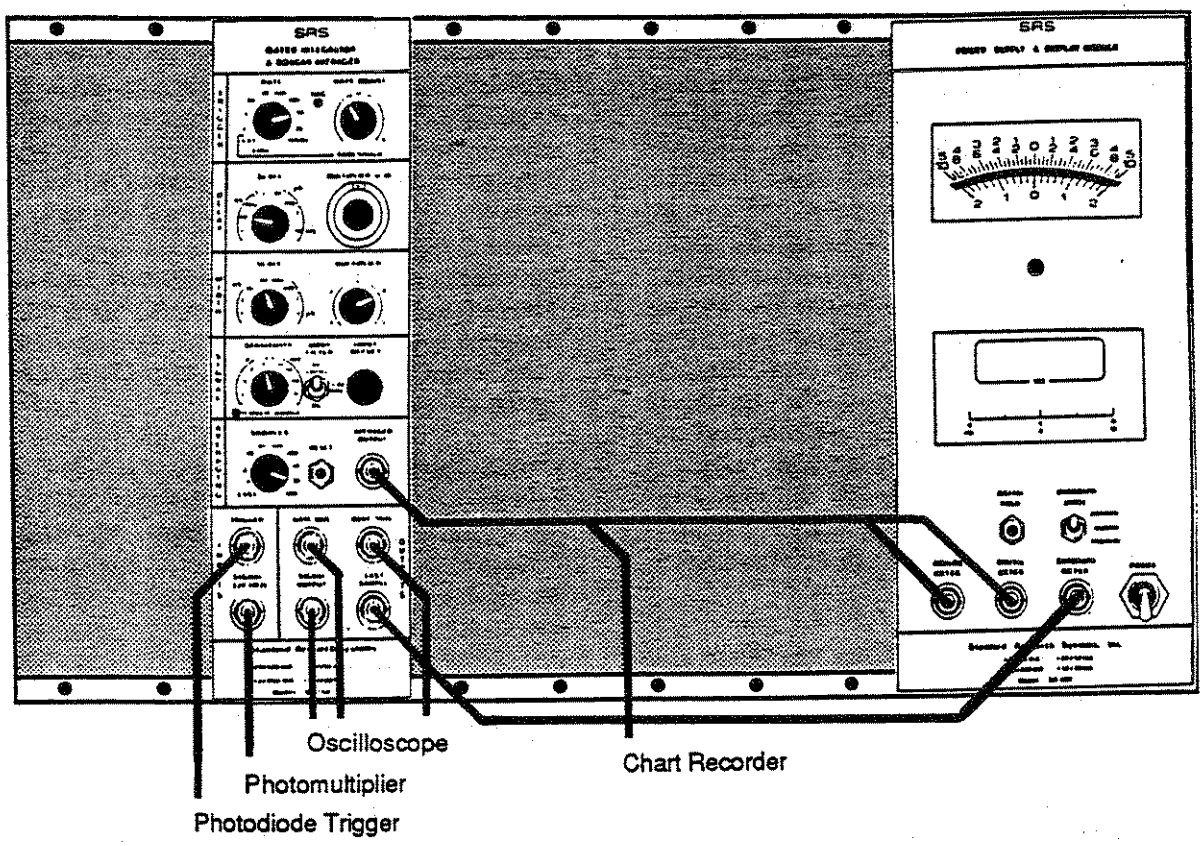


Figure 6 - Boxcar System for Example 1

EXAMPLE 2

Essentially the same as Example 1, only this time we want to normalize the fluorescence signal to the laser intensity. The Boxcar Averager System for this experiment is shown in Figure 7. In this instance, the Mainframe display meters are used to show the signal intensity shot by shot, the averaged signal intensity, and the averaged laser intensity. The fast timing of the signal is done as before, and Passive Baseline Subtraction done with a shorted coax cable attached to the Signal Output. A second SR250 is used to integrate the output of an energy meter. The time response from the energy meter is much slower than from the PMT, and so we will use a much longer gate at a later time to sample its output. This is possible because all the boxcar modules have entirely independent gates. Both boxcar units are set up to average over 300 samples, and the second Boxcar is triggered from the BUSY output of the first Boxcar. The average outputs are ratioed in an SR235 Analog Processor, and the result, Signal Intensity vs. Laser Energy, is displayed on a strip chart recorder.

In order to extend the dynamic range of this experiment, we could select F(x)=ln(a/b) from the Analog Processor. This would display signal changes between 10mV and 100mV as predominantly as changes between 1V and 10V.

EXAMPLE 3

In this example, we want to record the lifetime of the excited state by observing the exponential decay of the population from that state. To do this, we will tune the laser in order to promote atoms to the state of interest, and slowly scan the gate delay, recording the normalized signal intensity versus gate delay. The Boxcar Averager System for this experiment is shown in Figure 8. Here, the Mainframe display meters are used to show the laser intensity (shot by shot as well as the moving average) and the averaged signal intensity. For an excited state with a lifetime of 50nS the expected

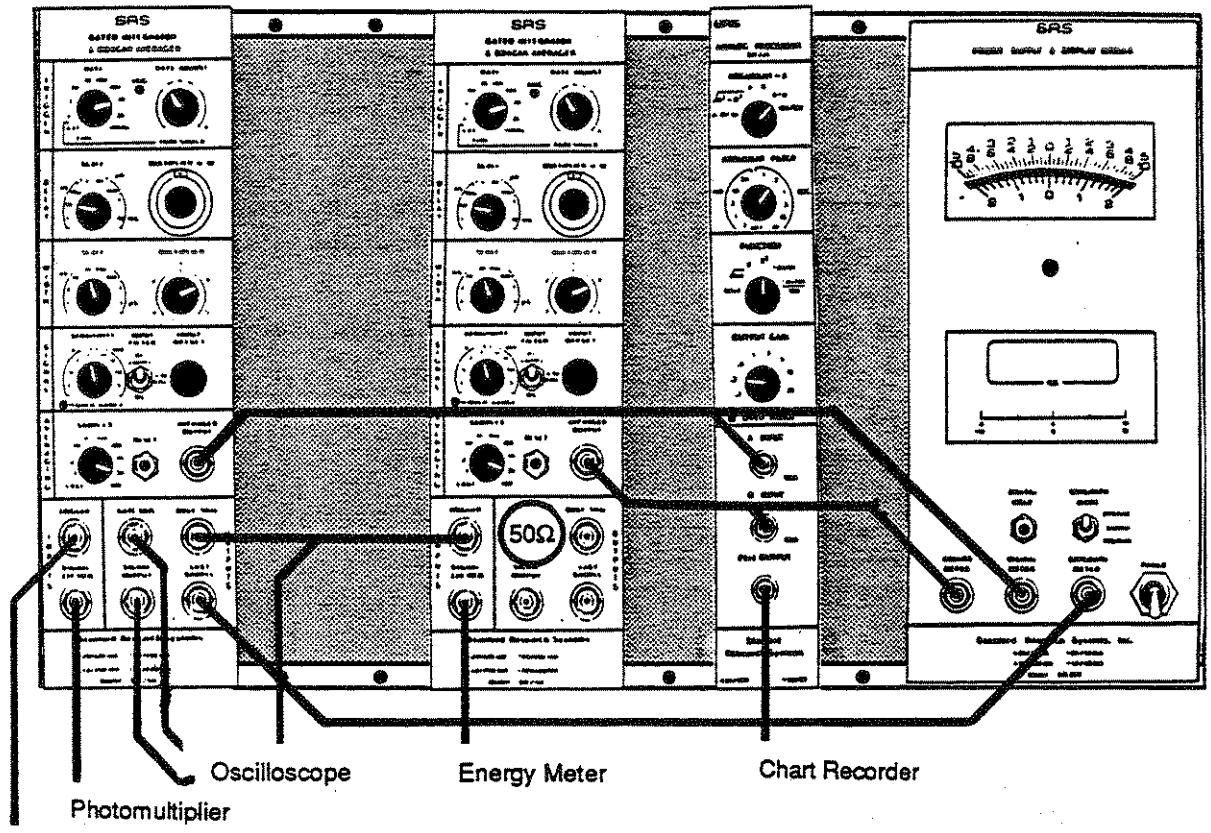


Figure 7 - Boxcar System for Example 2

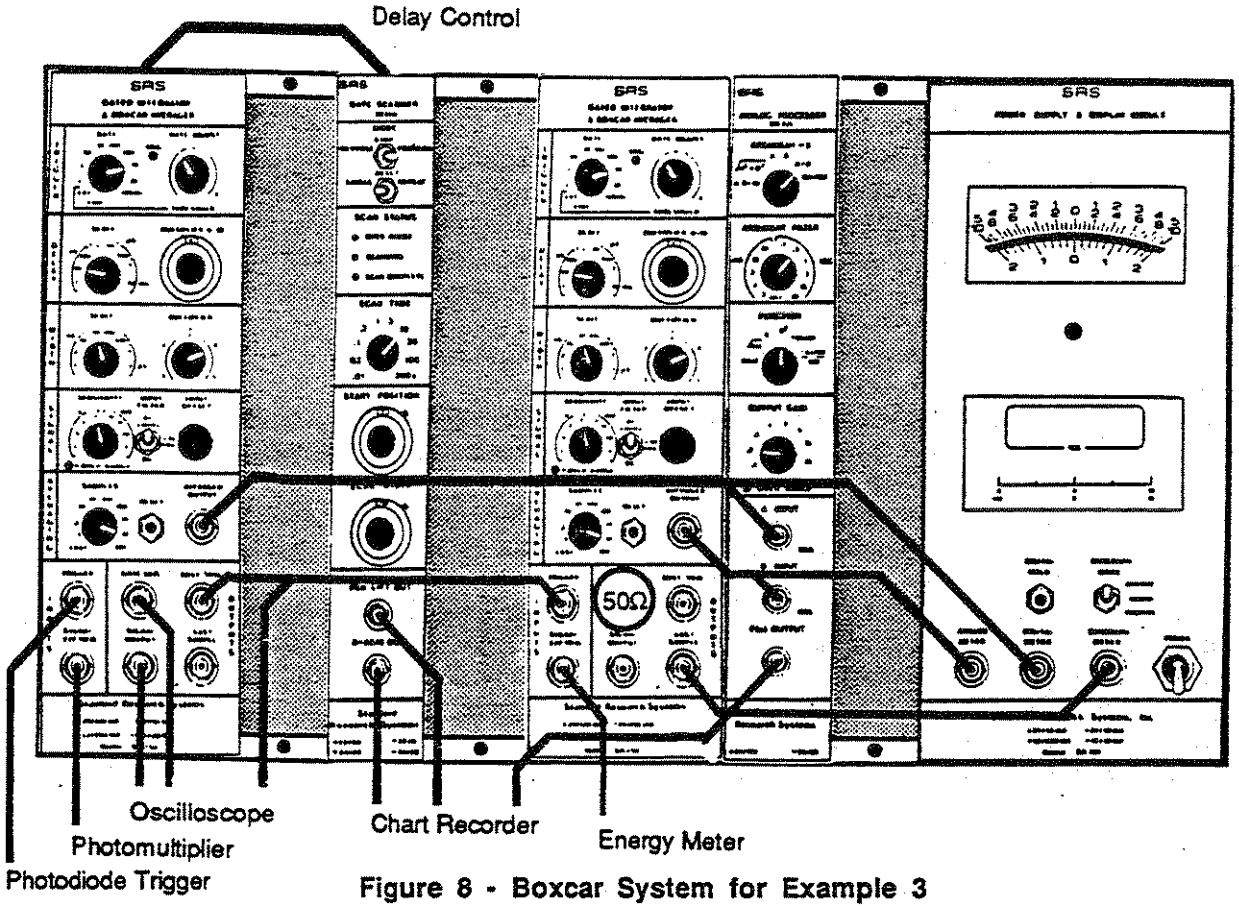


Figure 8 - Boxcar System for Example 3

result is shown in Figure 9. The SR200 Gate Scanner Module is used to slowly scan the gate, and to provide x-axis and pen-lift controls to the chart recorder. This module provides a control voltage to the Boxcar which overrides the front panel delay multiplier. (Electronically turning the delay multiplier knob, if you will.)

Depending on the number of samples being averaged, it is possible to scan the gate too fast. Scanning too fast will distort the shape of the decay curve, a bad thing as we are trying to measure the lifetime of the excited state from this curve. A very simple way to judge if this distortion is occurring is to compare the scan with one taken backwards, i.e.. from long delays to short delays. The SR200 allows scans in either direction, controlling the chart recorder motion properly in either case.

An obvious extension of Example 3 would be to display the log of the intensity normalized signal on the chart recorder. Doing so will remove any laser intensity fluctuations, allow direct measurement of the state's lifetime (now a straight line on the chart recorder), and extend the dynamic range of the experiment.

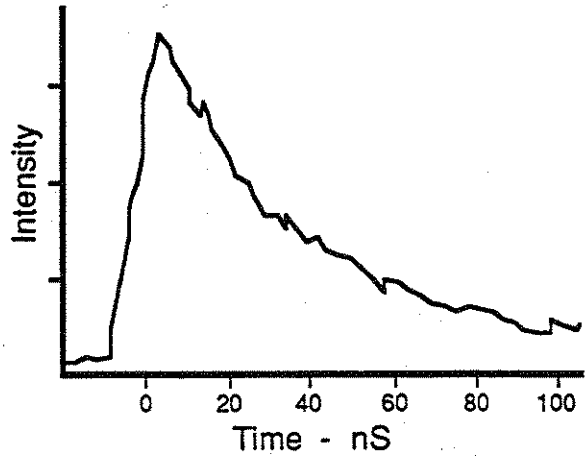


Figure 9 - Desired Result for Example 3

NOTES ON COMPUTER INTERFACE

Several improvements in the operation of these experiments can be achieved by controlling the experiment and the data acquisition by a laboratory computer. The unique ability of the Gated Integrator Module to provide shot-by-shot data dramatically increases the instrument's utility. The LAST SAMPLE output (or AVERAGED OUTPUT) can be digitized by the SR245 Computer Interface Module and sent to the lab computer via RS232 or GPIB. As an example of how a small computer could be used, consider Example 1. In this case, the effects of long term drift can be virtually eliminated by having the computer average the results of many short scans, rather than suffering the consequences of the long term drift in a single long scan.

INTERNAL TRIGGERING

In all of the preceding examples, the unit has been externally triggered. The trigger section of the SR250 also contains a rate generator which is able to trigger the unit at any frequency between 0.5Hz and 20KHz. When internally triggered, you will want to use the BUSY output as a trigger for your experiment. The BUSY output has a fast rising edge (about 1nS) which precedes the earliest possible gate by about 10nS.

TIMING SPECIFICATIONS

SYMBOL	DESCRIPTION	MIN	TYPICAL	MAX	UNIT
Trigger (See note 1)					
T_{tr}	Trigger rise time			1	µS
T_{th}	Trigger high time	5			nS
T_{tl}	Trigger low time	$3xT_{th}$			nS
T_{bnt}	Time from busy to next trigger	5			µS
Busy Output (See notes 2 and 3)					
T_{bd}	Busy delay from trigger	15	25		nS
T_{br}	Busy output rise time	1	1.5		nS
T_{bh}	Busy output high time	45	50		µS
Gate Output (See note 2)					
$T_{gd,min}$	Minimum gate delay from trigger		25	30	nS
$T_{gd,set}$	Range of settable gate delays	0		100	mS
T_{gr}	Gate rise (opening) time 20-80%		.8	1.2	nS
T_{gh}	Gate high (opened) time	2		15K	nS
T_{gf}	Gate fall (closing) time 20-80%		.8	1.2	nS
Toggle, Last Sample, and Averaged Outputs					
T_{gct}	Time from gate close to toggle out	9	10	11	µS
T_{gcsv}	Time from gate close to sample valid		10	12	µS
T_{gcac}	Time from gate close to average change	10	12		µS
T_{blav}	Time from busy low to average valid			0	µS

Note1: The trigger may be positive or negative. In this specification, 'High' refers to the time over threshold, and 'Low' refers to the time below threshold.
Note 2: The output should be terminated into 50Ω.
Note 3: The Busy output high time is specified for sub-microsecond gate delays and widths. This time will be extended if longer gate widths or delays are used.

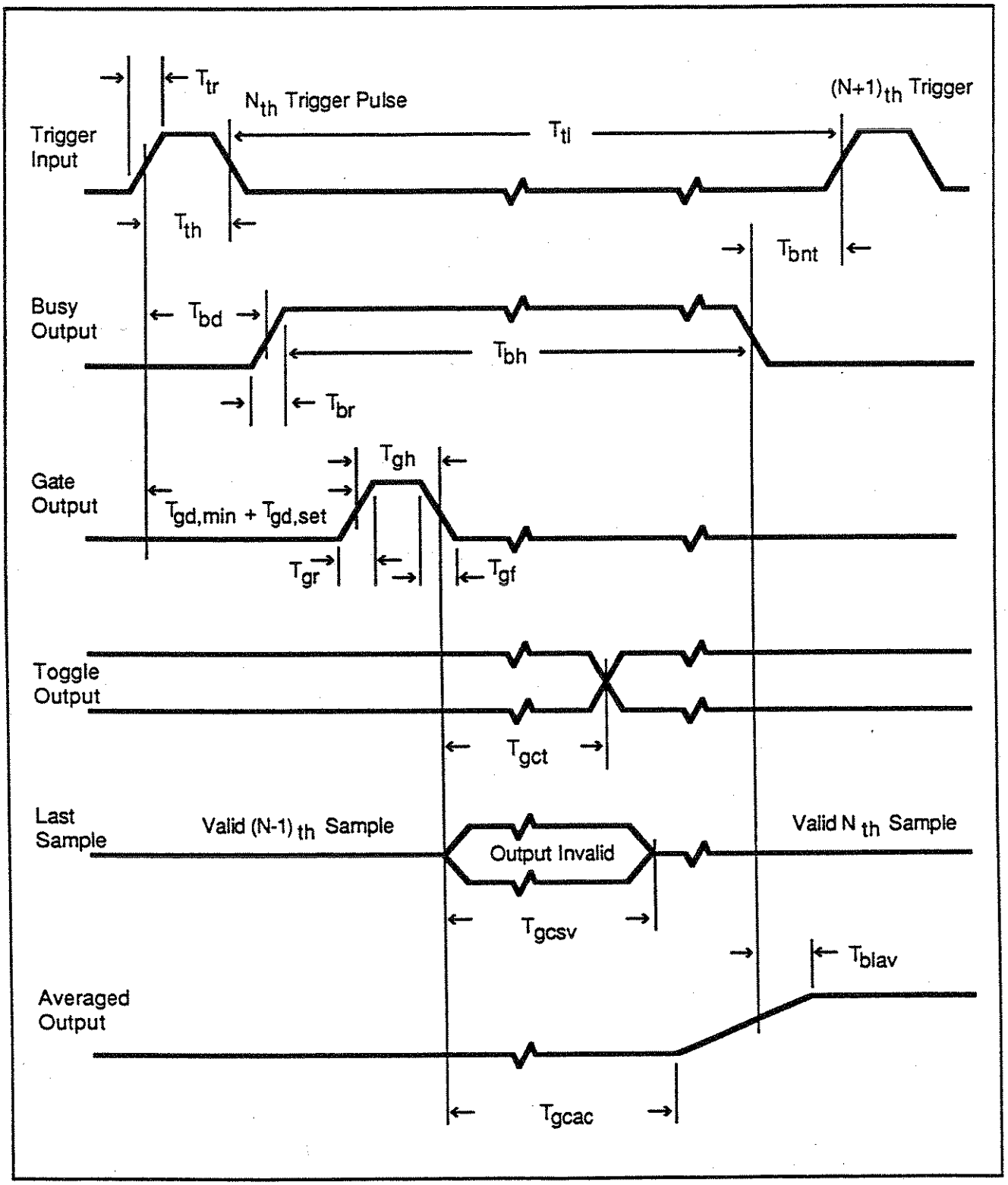


Figure 10 - SR250 Timing Diagram

TROUBLESHOOTING

Although the SR250 is relatively straightforward to operate, there are a few common problems that users encounter. The troubleshooting suggestions given here are not intended to diagnose a unit failure, rather, they are intended to help the user be sure that the apparent malfunction is not an 'operator error'.

Troubleshooting at the component level is not recommended as there are several pitfalls for the untrained. Factory service is available.

To start, be certain that the unit is screwed into the mainframe, that all four power supplies are okay (±12 and ±24 VDC). When measuring the bin supplies, beware of the 110 VAC on the pins at the bottom of the NIM connector block.

PROBLEM	PROBABLE CAUSE
No trigger LED on internal trigger ranges	The NIM Bin power supply is off, unplugged, or defective. The Boxcar Module is not plugged in all the way. Bad trigger LED.
External trigger does not work	The trigger threshold is set too high or the external trigger pulse is too small (<.5VDC) or too fast (<5nS). Also, Q1 or Q2 may be damaged from excessive inputs (>100 VDC).
Line trigger does not work	The THRESHOLD knob needs to be adjusted, or the NIM neutral is floating (operating off an isolation transformer).
Erratic triggering	Threshold is too high or triggered during the Busy period. If a long delay scale is selected, the unit allows itself more time to reset the delay one-shot which will extend the Busy pulse and reduce the maximum repetition rate.
Gate delay multiplier does not work	Something (such as the Gate Scanner Module) was left plugged into the rear panel EXTERNAL DELAY CONTROL which overrides the delay multiplier.
Cannot see the gate	GATE output not terminated into 50Ω, oscilloscope improperly triggered, or gate width set below 2nS.

PROBLEM	PROBABLE CAUSE
Overrange LED on	Input Signal > 2VDC or the LAST SAMPLE output is greater than 10VDC. The later may be corrected by adjusting the input offset control or by reducing the sensitivity. If the unit is not triggered, the LAST SAMPLE output drifts at 0.1% per second. Eventually the LAST SAMPLE output may drift to ±10VDC and turn on the Overrange LED.
AVERAGED OUTPUT does not work	Check if the rear panel switch AVERAGE POLARITY CONTROL is in the toggle position. Reread the Active Baseline Subtraction explanation. Check if something was left plugged into the rear panel AVERAGE RESET.
Wrong Polarity at LAST SAMPLE or AVERAGED OUTPUT	Check the positions of the rear panel POLARITY CONTROL switches.
Input offset control does not move AVERAGED OUTPUT	In the Active Baseline Subtraction Mode it is not supposed to. All input offsets (and Baselines) are cancelled by the Active Baseline Subtraction circuits.
Choppy output at the AVERAGED OUTPUT	This can happen in the Active Baseline Subtraction mode when averaging just a few shots. The chop can be reduced by averaging over more shots or by adjustment of the input offset control.
Excessive gate jitter	External trigger amplitude is too small or the rise time is too slow. Also, gate jitter is reduced by using the shortest delay scale that will work. Triggering too close to the Busy period (within a few µS) may also cause the gate to jitter.
LAST SAMPLE erratic	Input signal noisy or overrange. Sensitivity too high. Excessive trigger amplitude or high frequency noise.

CALIBRATION

The procedure for recalibrating the SR250 is given in this section. Normally, recalibration is not needed or recommended, however, if the unit has been repaired and components replaced, then this procedure may be required. This procedure should be undertaken only by qualified persons. Factory recalibration is available: please call Stanford Research Systems for details.

This prodecure may also be used to carefully verify that a unit is working properly: just follow the procedure without making any adjustments. If any adjustments are made, it is necessary to complete the entire recalibration procedure.

POWER SUPPLY CHECK

Internally trigger the unit at 3+KHz, and trigger the oscilloscope with the BUSY output. To check for supply oscillation and response, look at each supply on AC 5mV/Div, 50µS/div. Record supply spike amplitudes. Record supply levels using a DVM.

NIM Supplies [±1%]

Supply VDC	VDC	AC Spike [<30mV]	Osc? Y/N
+24	_____	_____	___
+12	_____	_____	___
-12	_____	_____	___
-24	_____	_____	___

Internal Supplies [±5%]

Supply VDC	VDC	AC Spike [<20mV]	Osc? Y/N
+15	_____	_____	___
+5	_____	_____	___
-5	_____	_____	___
-15	_____	_____	___

INTERNAL TRIGGER OPERATION

Set-up: Delay= 10nS x 1.0
Width= 30nS x 3
Signal= 1V, DC, centered offset
Average= 300 Samples
Polarity= Both Switches up

[ ] Trigger LED Working?
[ ] Line Trigger at 60Hz?
[ ] Visual Trigger 1-30Hz?
[ ] Manual Trigger Working?

Internally Trigger the unit at 1+ KHz. Trigger the scope on the rising edge of the BUSY output. Look at the BUSY output into a 50Ω load.

____ V Busy Output Amplitude [1.9V to 2.3V]
____ µS Busy Output Duration [43µS to 48µS]
[ ] Trigger Rate Generator from 100Hz to 20KHz?

GATE WIDTH CHECK

Internally trigger the unit at 10+ KHz. Trigger the scope on the rising edge of the BUSY output, and observe the GATE output terminated into 50Ω.

_____ mV GATE output amplitude [180 - 230mv]

Width Scale	Gate Width (mult=5)	
3µS	____ µS	[±30%]
1µS	____ nS	[±30%]
300nS	____ nS	[±30%]
100nS	____ nS	[±30%]
30 nS	____ nS	[±30%]
10 nS	____ nS	[±30%]
3 nS	____ nS	[±30%]
1 nS	____ nS	[±30%]

GATE DELAY CALIBRATION

[ ] Adjust P13 at location B7 for 10.00VDC at CW mark of P14 @ A7.
[ ] Adjust P12 at location B5 for 10.1VDC across R54 at location B5.
[ ] With the delay scale set to 1µS and the delay multiplier at 1.00, adjust P4 at location C5 for 1.00µS from BUSY to GATE.

Measure and record the time from the rising edge of the BUSY output to the start of the GATEoutput.

Trig	DelayScale	Mult=10.0	Mult=0.0
10K	1 nS	_____ nS	_____ nS
10K	10 nS	_____ nS	_____ nS
10K	100nS	_____ nS	_____ uS
1 K	1 µS	_____ µS	_____ µS
1 K	10 µS	_____ µS	_____ µS
100	100µS	_____ µS	_____ mS
100	1 mS	_____ mS	
10	10 mS	_____ mS	

LAST SAMPLE OUTPUT

Setup: Internal Trigger at 100 Hz
Width= 3µS x 3
Delay=10nS x 10.0
Sensitivity =20 mV

[ ] Adjust the offset pot to read 0.0 VDC at the LAST SAMPLE output.
____VDC Measurement of voltage on offset pot rear-most lug, V(sw). [<2 VDC]
____VDC Adjust Offset Pot for 5.0VDC at LAST SAMPLE output. Invert last sample output and record last sample output voltage. [-5.00VDC]
+___VDC Last Sample output for positive over-range indicator.[+10 VDC]
-___VDC Last Sample Output for negative over-range indicator. [-10 VDC]

AVERAGED OUTPUT TESTS

Setup: Adjust offset for LAST SAMPLE=5.00VDC.
Average over 300 samples.
Trigger at 1+ KHz.

____VDC Non-inverted [5.00VDC] AVERAGED OUTPUT
____VDC Inverted [-5.00VDC] AVERAGED OUTPUT
____VDC Toggle [0.0VDC] AVERAGED OUTPUT

[ ] Place AVERAGED OUTPUT on scope, display 0-10VDC. Select normal polarity, and using the front panel reset button, verify an approximate 1 second time constant for 9 Trigger Rate/Sample Average pairs (from 1Hz & 1 Sample to 10KHz and 10K Samples)
[ ] Verify rear panel reset operation by shorting the input to ground.
[ ] Trigger at 1+ KHz. Average over 3K samples. Adjust input offset for last sample = 0.0VDC. Select TOGGLE for average polarity then adjust P6 at location E5 (3K sample null) so that AVERAGED OUTPUT is 0.0VDC.

RESET NULL ADJUST

Setup: 1KHz Trigger
Delay = 10nS x 1.0
20mV Sensitivity
Width = 3ns x 3
Adjust Input Offset for Last Sample = 0V

[ ] Viewing Pin 6 on the LM318 (U18 at location D2) adjust P8 at location D7 (Reset Null) for the best return to its baseline at a time 50µS after reset.

GATE RATIO ADJUST

Setup: Trigger at 1KHz
Delay = 10nS x 1.0
Average over 300 Samples
Width = 300nS Scale
Sensitivity = 50mV
Input offset for Last Sample= 0.0VDC
DC couple
Average Output Polarity = Toggle

Use the Toggle output, terminated into 50Ω, and Via a 220Ω resistor to the Signal input as the signal source. The Signal Output must be terminated into 50Ω. Now the Average output is a Baseline Corrected measurement of the instrument's sensitivity.

[ ] Verify that the signal output is a 320mV square wave.
[ ] Carefully adjust P5 at location C3 (Gate Ratio) for the smallest change in the AVERAGED output as the Width Multiplier is scanned from 1 to 5. (This adjusts the Gate Width Ratios to 5:1 and so assures that the sensitivity is independent to the Width Multiplier.

AC AND DC GAIN CALIBRATION

Setup: Trigger External
Delay = 1μs scale
Sensitivity = .1VDC

Use the SR200 Gate Scanner to scan the delay multipliers from 0 to 10. Use a 10μS, 500mV fast pulse (@3KHz) as the signal input. Place the scope in the XY mode to display the input waveform. The Gate Output from another SR250 will do.

[ ] Adjust the P9 at location F5 (DC gain)to get a flat top on the observed voltage waveform. This matches the AC and DC gains.
[ ] Observe about 40% droop of the flat-top when the input filter switch selects 10KHz.
[ ] Observe a baseline shift when coupling changes from DC to AC.

SENSITIVITY CALIBRATION

The instrumment's sensitivity is calibrated in this section. With the sensitivity set at 0.2V, a 1.00VDC input should produce a 5.00VDC output.

Setup: Trigger 1KHz
Delay = 1μS x 1.0
Sensitivity = .2VDC
Width Multiplier = 3.0
Terminate Gate Output in 50Ω

Set the width scale to 3μS. Input0.00VDC and adjust the input offset to give 0.0VDC at the Last Sample Output. Input 1.00VDC and adjust P7 (Gain) at location F5 to read 5.00VDC at the Last Sample Output.

For each Width Scale in the table below, input 0.00VDC and Adjust the input Offset for Last Sample = 0.0. Then input 1.00VDC and record the voltage at the LAST SAMPLE output.

Width Range	LAST SAMPLE Output
3 μS	5.00 VDC [by adjustment]
1 μS	____VDC [5.0V ±.25V]
300 nS	____VDC [5.0V ±.25V]
100 nS	____VDC [5.0V ±.25V]
30 nS	____VDC [5.0V ±.25V]
10 nS	____VDC [5.0V ±.25V]

[ ] Be certain to terminate the GATE output
[ ] Adjust C121 at location C1 to calibrate 3nS Width Scale Sensitivity.
[ ] Adjust P11 at location D2 to calibrate1nS Width Scale Sensitivity.
[ ] Adjust P10 at location E3 for maximum flatness of Average Out vs Width Multiplier.

With the Width Multiplier returned to x 3, repeat these adjustments:

[ ] Adjust C121 at location C1 to calibrate the 3nS Width Scale Sensitivity.
[ ] Adjust P11 at location D2 to calibrate 1nS Width Scale Sensitivity.

HIGH SPEED PERFORMANCE

Return to the X-Y mode to display the Fast input waveform on the scope.

____ nS Record the gate width setting for which the sensitivity falls to 50% of its nominal value [about 2 x 1nS].

____nS Record the 20% to 80% rise time of the displayed waveform. [3nS].

____nS Record the 20% to 80% fall time of the displayed waveform. [3nS]

MODIFICATIONS

INCREASING THE SENSITIVITY

In situations where pre-amplifiers are not available, the sensitivity of the SR250 may be increased by an approximate factor of 10 by replacing the integrating capacitors with smaller values. The required changes are listed below in Figure 11.

EXTENDING THE GATE WIDTH

The SR250 gate width can be extended to 150 µs with the addition of a 0.33 µf capacitor. This capacitor is placed in parallel with C127, which controls the width of the gate pulse on the 3 µs width scale. The capacitor should be soldered to the solder side of the printed circuit board, between the right pad of C126 and the left pad of C127 (as viewed from the component side.) A poly or mylar film capacitor with a 5% tolerance should be used. With this modification, only the 30 µs width scale is affected, and on this scale:

1) The 3 µs width scale is changed to 30 µs, allowing gate widths from 30 µs to 150 µs.
2) The sensitivity is increased by a factor of 10. This is because the gate width was made 10 times longer while the integrating capacitor was left the same. It is not possible to increase the integrating capacitor due to limitations on the reset circuitry.
3) The actual gate width depends somewhat on the repetition rate. See Figure 12 for details.

Width Range	Integrating Capacitor	Board Location	Factory Value (pf)	Action to Increase Sensitivity by x10
1 nS	C212	F4	56	Not recommended
3 nS	C219	D1	150	Not recommended
10 nS	C220	D1	1000	Remove C220
30 nS	C221	D2	3300	Replace C221 w/ 220 pf
100 nS	C222	D2	10,000	Replace C222 w/ 1000 pf
300 nS	C223	D2	33,000	Replace C223 w/ 3300 pf
1 µS	C224	D2	100,000	Replace C224 w/ 10,000 pf
3 µS	C225	C2	330,000	Replace C225 w/ 33,000 pf

Notes:
1) Use only silver mica, poly or mylar film capacitors.
2) Be careful not to damage the PCB with excessive heat.
3) We suggest removing only one lead of the capacitor to be replaced and attaching the new component to the non-component side of the printed circuit board.
4) The overload light will not function properly on the 1V/V sensitivity scale.

Figure 11 - Increasing The Sensitivity By A Factor Of 10

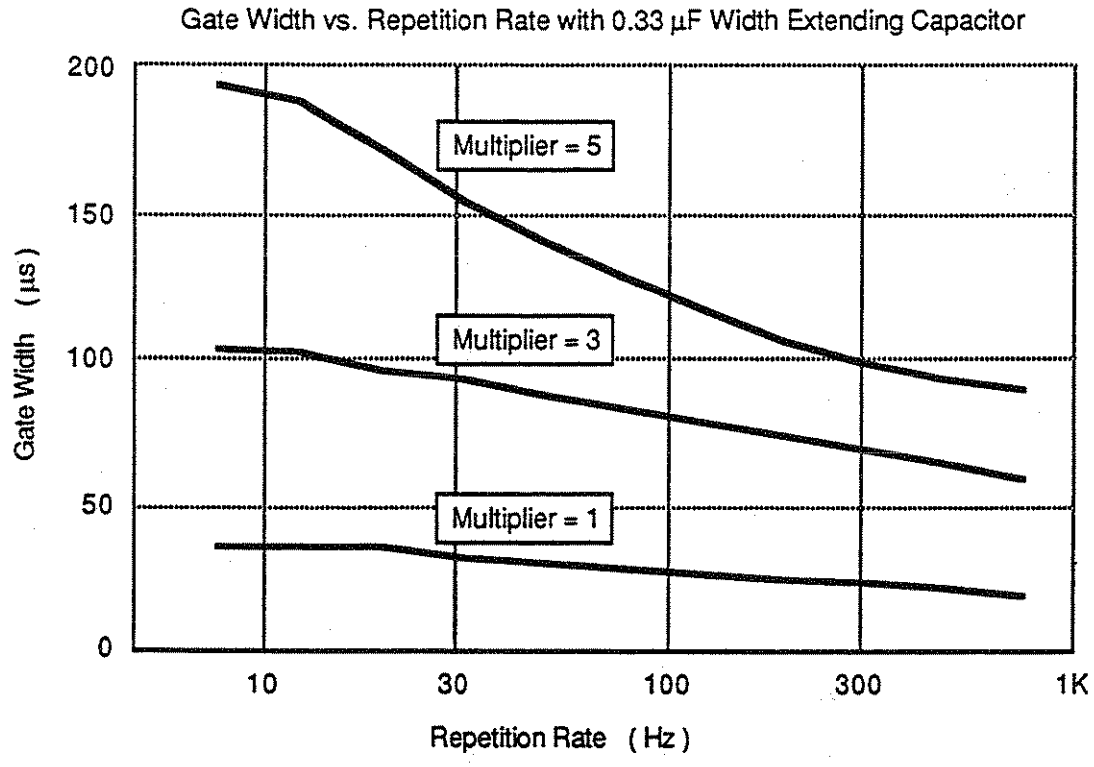


Figure 12 - Gate Width vs. Repetion Rate After Gate Width Modification

4) The gate marker output will have some droop. This does not affect the operation of the device: its response is flat during the gate.
5) Beware of using the 10KHz input filter. This filter AC couples input signals with a 15 µs time constant.

REPLACING FRONT END TRANSISTOR

Symptoms: The red OVER RANGE LED stays on and the LAST SAMPLE output cannot be zeroed.

Supporting Evidence: Your photomultiplier anode does not have a leakage resistor, and so is prone to charging up the signal cable to a few hundred volts. The last time you saw the red light off was just before you plugged the cable into the signal input.

Conclusion: The front end transistor, Q20, a J310 N-Channel JFET, is damaged.

Replacement: Q20 is at location G2 on the printed circuit board. Before removing the damaged Q20, note its orientation: the silk screen legend on the circuit board is wrong. The new J310 must go in opposite to the legend, the same as the old J310. No recalibration is required when replacing Q20.

CIRCUIT DESCRIPTION

The SR250 Gated Integrator and Boxcar Averager Module is constructed on a single printed circuit board, mounted in a NIM compatible module. The unit uses about 12 Watts of power from the 12 and 24 volt NIM supplies. All critical circuits use doubly regulated supplies: the NIM ±24V supplies are regulated to ±15V and the ±12V supplies are regulated to ±5V. RF performance is enhanced by use of PCB mounted rotary switches, careful design of the PCB, and by the use of some very fast transistors in emitter coupled configurations. Reliability is assured by careful design and manufacturing, and by comprehensive testing and burn-in of every unit.

TRIGGER CIRCUIT

The trigger input has a 1MΩ input impedance. The trigger input is buffered by transistors Q1 and Q2 which drive a 100Ω stripline going to the trigger discriminator, U1. If the trigger exceeds the trigger threshold, U1 clocks the trigger latch Q3-Q6, turning on the constant current source for the delay one-shot. The trigger latch will be reset after the sample gate is finished, and is disabled until the unit is ready to receive another trigger.

DELAY ONE-SHOT

The delay capacitor, which was precharged to a specific voltage by the Delay Precharge circuit, is discharged by the constant current source, 1/2 U4. The value of the delay capacitor increases by 10. The precharge voltage depends on the delay multiplier setting (or on the External Delay Control Voltage, if used). When the delay capacitor is discharged to about 5V, the End Of Delay discriminator sets the End of Delay latch. The latch output is buffered by Q12 and Q13 and delayed by two coax delay lines. The delayed signal is received by Q14 and Q15 which start the gate. The delay lines delay the start of the gate by a few nS, cancelling the insertion delay of the width one-shot, allowing the generation of very short gates.

WIDTH ONE-SHOT

The width one-shot is similar to the delay one-shot. A constant current source, 1/2 U5, is turned on at the end of the delay one-shot. A width capacitor, selected by the WIDTH SCALE selector, is precharged to a voltage determined by the Width Multiplier control pot. When the width capacitor is discharged to about 5V Q16, Q17, and 2/2 U5 latch-up, indicating the End Of Gate. This End Of Gate is used to turn off the gate at U6.

GATE BUFFER

U6 consists of two emitter coupled pairs with constant current sources, which are configured as an exclusive-or gate. The output of U6 is used to drive the bases of Q29 and Q30, very fast (4GHz) transistors, which gate open the high speed analog gated integrator. Part of the collector current of transistor Q29 is passed out via the GATE front panel connector. This output must always be terminated into a 50Ω load for proper operation of the instrument.

SIGNAL INPUT AND OUTPUT

The SIGNAL input is passed to the SIGNAL OUTPUT via 3.5nS of coax cable. This delay is inserted so that there will be an exact coincidence between the SIGNAL OUTPUT and the GATE output to allow simple, accurate set up of the instrument. The SIGNAL input is coupled directly, or via a .01μF capacitor, to a 1 MΩ input impedance unity gain buffer amplifier, Q20 and Q21. The input signal is also passed to an IC op amp circuit. The op amp output will be used in a feedback loop to eliminate DC drifts associated with the fast buffer amplifier and gated integrator.

GATED INTEGRATOR

The Fast Gated Integrator consists of transistors Q23-Q28 and their associated bias circuits. Q23 and Q28 are constant current sources that are 'programmed' by the input signal: for a positive input signal the current in Q23 is reduced and the

current in Q28 is increased. This current imbalance is integrated on the integrating capacitor when the gate is opened. A difference amplifier, 3/4 of U16, compares the imbalance to the input signal and makes minor adjustments to the current sources to eliminate drift. The low frequency gain of the gated integrator is set by P9 to match the high frequency gain (determined by the emitter resistors of Q23 and Q28) to produce a flat response from DC to over 100MHz. The analog current gate, Q24-Q27, normally channels the current imbalance to ground. When the gate drive is applied to the gated integrator, Q24 and Q27 turn off, and Q25 and Q26 turn on, channelling the current imbalance to the integrating capacitor. The integrating capacitor, which was reset prior to the unit being triggered, integrates the current imbalance while the gate is open. The value of the integrating capacitor changes with the WIDTH SCALE: bigger integrating capacitors are needed for longer gates in order to avoid saturation. When the gate turns off, the voltage on the integrating capacitor is proportional to the integral of the input signal during the gate.

GATE WIDTH NORMALIZATION

We want a result from the gated integrator which is proportional to the average of the input signal during the gate, not to the integral of the input signal. To accomplish this, we must divide the integral of the signal by the gate width. This is done in two ways. First, as the WIDTH SCALE is changed, the width selector switch changes both the width one-shot capacitor and the integrating capacitor. The ratio of these capacitors is carefully matched on all width ranges by selecting width compensating capacitors after the unit is burned in at the factory. Secondly, the gated integrator output is normallized for the width multipliers within a particular range. This is done by using a dual pot for the width multiplier: one of the pot elements is used to change the width of the gate, while the other is used to scale the gain of 3/4 U17. By decreasing the gain for wider gates the integral is normallized becoming an average.

SENSITIVITY

The sensitivity of the unit is changed by changing the gain of U18 which amplifies the output of the gated integrator. This amplifier has a switch selectable gain from 0.5 to 100. The Offset Control is injected before U18, so that the offset is also amplified, making it appear as an input offset (as opposed to a position) control.

SLOW LOGIC TIMING

At the end of a sample gate, a TTL signal, 'END', is generated to start a 10μS one-shot, 1/2 U15. This 10μS signal is used to sample the gated integrator output. When finished, the 10μS SAMPLE pulse re-triggers the 10mS one-shot, 2/2 U15, to blink the TRIG LED, and toggles the flip-flop that is used for active baseline subtraction. 'END' is also used to reset the trigger latch. Upon reset, the trigger latch clocks the one-shot 1/2 U8, initiating a pulse which is at least 12μS long in order to reset the Gate Delay Circuit. This pulse, 'R-DELAY', is extended in order to allow the delay capacitor time to precharge if the unit is using a delay range greater than 100nS. When 'R-DELAY' ends, 2/2 U8 is triggerred, starting a 33μS pulse which is used to (1) Precharge the width one-shot timing capacitors, (2) reset the Gated Integrator capacitors, and (3), add the Last Sample to the Boxcar Average. After the 33μS one-shot times out, the cycle is complete, and the BUSY output, which has been high during the entire cycle, is released. When the BUSY is released, the trigger inhibit is also removed, allowing the next trigger to occur.

OVER RANGE LED

The OVER RANGE LED is turned on when the input signal exceeds +/-2VDC, or, if the LAST SAMPLE output exceeds 10VDC. In the first case, the input signal must be reduced, or the coupling changed to an AC range. In the second case, the overrange error may be eliminated by either reducing the SENSITIVITY or by adjusting the INPUT OFFSET control.

INTRODUCTION

The model SR255 Fast Sampler is a high speed, sample and hold module designed to measure signals of very short time duration.

The SR255 consists of a trigger discriminator, delay generator, gating circuit, sampling bridge, and digital linearization circuit. A voltage applied to the rear panel BNC controls the delay between the trigger and the sample gate. The gating circuit activates the sampling bridge with a pulse generated by a step recovery diode and a shorted transmission line. The line's round trip delay is set internally to provide a gate width of 100 psec, 200 psec, 500 psec or 1 nsec. The sampled voltage is amplified according to the front panel SENSITIVITY switch, and digitized by an 8 bit A/D converter. The digitized signal is adjusted by a PROM which is customized for each unit to linearize the response

SPECIFICATIONS

GATE WIDTH	
	100 psec, 200 psec, 500 psec, and 1 nsec. Front panel LED indicates selection.
CONTROLS	
Sensitivity	100mV/V, 250 mV/V, and 1 V/V (Vin/Vout). Overrange LED indicates signal is too large.
Trigger Level	-0.5 V for negative trigger (NIM standard). +0.1 V for low level positive triggers. +1.0 V for TTL compatibility. LED blinks with each trigger. 50 KHz max rate.
INPUTS	
Signal Input	Protected to +5 VDC. $Z_o = 50\ \Omega$. Full Scale input equals the sensitivity setting.
Trigger Input	Protected to +5 VDC. $Z_o = 50\ \Omega$.
Gate Delay	1 nsec/V, 10 nsec/V, 100 nsec/V, or 1 µsec/V. Input at rear panel. Minimum insertion delay is 20 nS. Jitter less than 10 psec +.01% of full scale delay.
OUTPUTS	
Signal Output	SIGNAL IN is passed to SIGNAL OUT for termination, signal timing and special applications.
Gate View	The leading edge shows precise timing of the sample gate with respect to SIGNAL OUT
Sample Output	Provides an analog output (without droop) of the sampled signal. Output resolution is 1/4% of full scale.
Digital Output	8-Bit digital interface for the SR245 or a computer. Data Byte - 8 bits give the amplitude of the signal sample including PROM linearity correction. Status Byte - provides status of gate width, sensitivity, data ready, data sign, data missed, and overload error.
GENERAL	
Power	+24V / 100 mA, -24V / 110 mA, +12V / 150 mA, -12V / 35 mA , 7.5 Watts total. Power from Model SR280 Mainframe or from a NIM Standard Crate .
Mechanical	Single width NIM Standard per TID-20893. Dimensions 1.35" x 8.714" x 11.5".
Warranty	One year parts and labor. This warranty does not cover damage to the sampling bridge by excessive input.

Figure 13 - SR255 Front Panel

of the sampling bridge. The adjusted digital signal is output via a rear panel connector. A D/A converter provides a droopless analog output signal at the front panel SAMPLE OUT BNC.

OPERATION

This section describes the operation of the SR255 Fast Sampler including the controls and input/output characteristics.

TRIGGER

The module is triggered by a signal at the 50 Ω, DC coupled, trigger input . The trigger threshold may be set to -0.5 V, +0.1 V, or +1 V by the TRIGGER LEVEL switch on the front panel . For reliable triggering, the trigger must remain over threshold for at least 5 nsec, and not exceed 5 volts. The maximum trigger rate is 50 kHz (reduced when operating on the 1 µsec delay scale.) A green LED on the front panel flashes with each trigger.

DELAY

The delay from trigger to sample is controlled by an analog voltage which is applied at the rear of the unit. Apply 0 to 10 VDC to move the sample gate from 0 to x10 the selected time base scale. The time base is selected by a bank of four switches on the PCB. You may select 1, 10, 100, or 1000 nS/V. These switches may be accessed through the right side panel. In addition to the controlled delay, there is a fixed insertion delay of about 20 µS.

WIDTH

The width of the sample gate is set by three items on two circuit boards:

1) The shorting screw on the RF circuit board's transmission line.
2) A switch bank on the RF circuit board.
3) A switch bank on the main board adjacent to the switch bank on the RF circuit board.

The unit is shipped configured for a 100 psec gate width. To change the gate width:

1) Move the transmission shorting screw from its position closest to the input to the hole corresponding to the desired gate width.
2) Move the RF board switch for 100 psec to OFF and move the RF board switch corresponding to the desired gate width to ON.
3) Move the main board switch for 100 psec to OFF and move the main board switch corresponding to the desired gate width to ON.

Both switches and the screw must be in their correct positions for proper operation of the module. When power is applied, the LED corresponding to the desired gate width will light up.

SIGNAL IN

The signal to be sampled is applied to the signal input. The system is designed to be used with RG58A cable. To achieve an optimally flat response, use two meters of RG58A cable with a BNC connector, and a BNC to N-Type converter (part #UG 201A/U, provided with each SR255.) The frequency response of the SR255's front end has been peaked above 2 GHz to compensate for the losses in 2 meters of RG58A cable, and so you will get the best results when using this length of cable on the signal input line. This input is passed to SIGNAL OUT via an internal 300 psec delay line. The signal output should be terminated in 50Ω with a high quality terminator to minimize reflections and pulse distortion. If one is not available, an N-type to BNC converter plus a few meters of RG58-A cable terminated with a barrel and a 50 Ω BNC terminator will work fairly well. The signal output aids in synchronizing the sample with the gate and can be used for special applications such as time domain reflectometry or shorted-cable baseline subtraction. The input signal should not exceed the SENSITIVITY selection on the front panel. Above this value, the output saturates and the red OVER LED will come on. The input is protected to +5 VDC. Do NOT exceed these voltage limits as repair of the front end is expensive.

GATE VIEW AND FAST TIMING

To time the Sample Gate with respect to the Signal use equal length cables to bring the GATE VIEW and SIGNAL OUT to the 50Ω inputs of a 300 MHz oscilloscope. The GATE VIEW must always see a 50Ω termination, so when you complete this operation, do not leave the GATE VIEW

unterminated. The oscilloscope's finite bandwidth will make accurate timing more difficult than is necessary: the leading edge of the GATE VIEW output indicates when the sample gate is being opened. The GATE VIEW output is a pulse of approximately 3 Volt amplitude, 50pS rise time, with an exponential decay of about 4 nsec.

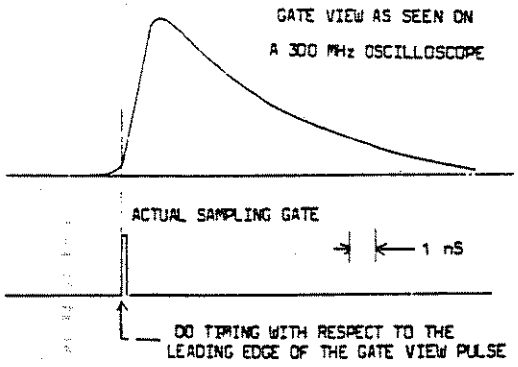


Figure 14 - Gate View

SENSITIVITY

The SENSITIVITY switch selects the gain of the module, volts in / volts out. It can be set to 1 V/V, 0.25 V/V, or 0.1 V/V. For example, a 100 mV input will cause a 1 V output when 0.1 V/V sensitivity is selected. The red OVER LED will come on when the output exceeds approximately 1 volt.

SAMPLE OUT

The analog sample output is derived from the 8 bit digital word representing the amplified sampled signal. Its full range scale is +1 VDC and can drive loads greater than 1 KΩ. The output impedance is less than 1Ω and has a short circuit current limit of 20 mA. The output is available 20 µsec after the signal is sampled. Each unit is custom linearized with a PROM to insure excellent linearity and full dynamic range.

BANDWIDTH

The Fast Sampler can be used as a sampling oscilloscope by slowly scanning the gate delay in order to recover a repetitive waveform. The apparent rise time of a infinitely fast step is approximately equal to the selected gate width. The -3 dB bandwidth of the unit is approximately equal to 0.35 divided by the selected gate width. The table below gives the available gate widths and their corresponding bandwidths.

Gate Width	Bandwidth
1000 pS	359 MHz
500 pS	700 MHz
200 pS	1.7 GHz
100 pS	3.5 GHz

Figure 15 shows an apparent risetime of 150 pS. This curve was taken with a 100pS risetime input step, so the indicated gate width is 110pS. (The apparent risetime is the convolution of the fast sampler gate width with the input signal's rise time.)

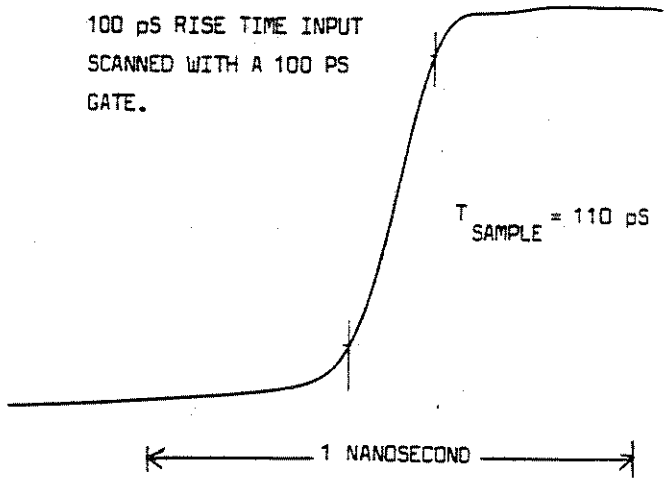


Figure 15 - 100 pS Risetime Input

NOISE

The penalty paid for using narrow gate widths is increased noise. Narrow gates have more noise because of their reduced sampling efficiency and wider bandwidth. Typical noise characteristics are given in the table below:

Gate Width	Peak to Peak Noise	RMSNoise
1000 pS	1.0 mV	200 µV
500 pS	1.8 mV	350 µV
200 pS	3.0 mV	600 µV
100 pS	4.0 mV	800 µV

Figure 16 shows base line noise over a 30 minute period for the four different gate widths. The unit was triggered at 1 Hz. The top curve, taken with a 1 nS gate, shows a noise which is approximately equal to the unit's resolution. The noise increases as the gate width is narrowed.

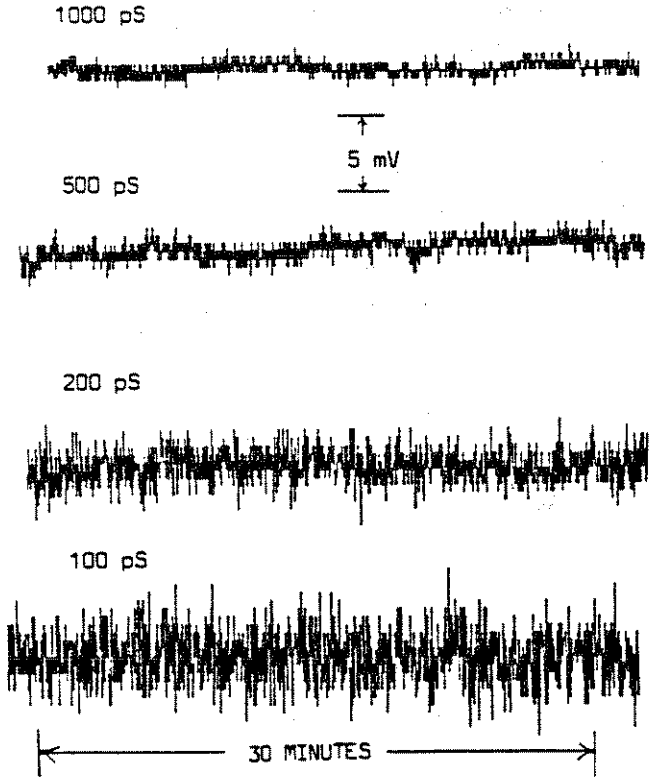


Figure 16 - Noise Characteristics

REPETITION RATE LIMITATIONS

The unit requires about 19 µS to trigger, sample, convert, linearize, and rearm. Some additional time after rearming is required to allow the delay circuit to recharge. This additional time depends on the selected time base delay range. The table below lists the maximum repetition rate before a 1% time base error occurs. Note that for applications which do not require an accurately calibrated time delay that the unit may be triggered at higher rates than are indicated in the table.

Delay Base Range	Maximum Repetition Rate
1 nS/V	50 KHz
10 nS/V	30 KHz
100 nS/V	8 KHz
1000 nS/V	1 KHz

TEMPERATURE EFFECTS

Both the input offset voltage drift and the gain drift will cause less than a one bit (1/4%) error over ambient temperatures of 20 to 60 degrees centigrade.

LINEARITY AND RESOLUTION

The unit uses an A/D converter with 9 bits of resolution (8 bits plus sign bit). About 400 of the A/D's 512 output codes are used to cover the full scale input range. This implies a resolution of 1/4 of one percent. The linearity is held to within 1/2 of one percent by the unit's PROM lookup table. The linearization requires that some of the output codes from the PROM be used twice (to compress a signal) or be skipped (to expand a signal). Generally, fewer than 5% of the output codes are skipped or duplicated. Since the input noise usually exceeds the resolution, these missing codes do not degrade the instrument's performance.

Figure 17 shows the high linearity of the instrument's transfer function. The input was scanned over 120% of the full scale input range.

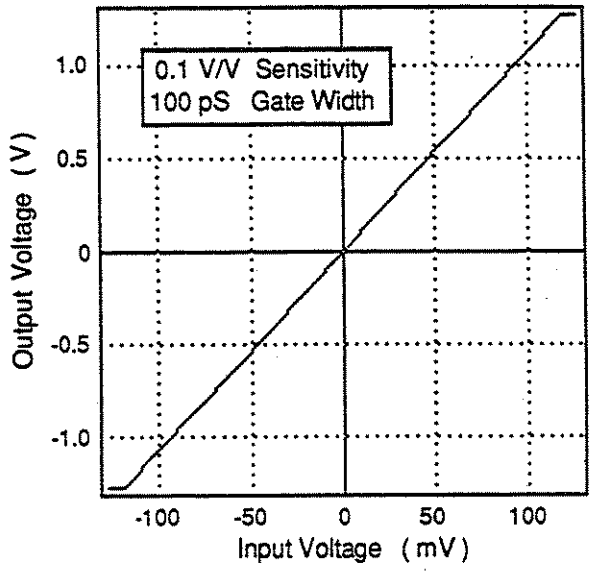


Figure 17 - Linearity

COMPUTER INTERFACE

The recommended way to interface the Fast Sampler to computers is by connecting the SR255's to an analog I/O port of the SR245 Computer Interface Module. The Fast Sampler is also designed to connect directly to the SR245 through a 15 pin connector on the rear panel of the SR255 and a 20 pin connector on the circuit board of the SR245 (Figure 19). Each Fast Sampler in your system is assigned an address by setting four address switches which may be accessed through the right side panel. Even addresses from 0 to 30 may be selected.

The Status byte and Data byte may be read by the SC<Fn>:x and SS<Fn>:x commands where n is the set address divided by two and x is the number of points to be retrieved. An example SR245 command is SC1,3,F2:100. This command scans ports 1 and 3 and a Fast Sampler with address 4 (see the SR245 manual for definitions of the SC, and SS commands.) A single Fast Sampler Status byte can be retrieved by addressing the module with SD=<y> where y is the set address. Then a ?D will return the status byte. Similarly, a Data byte can be retrieved with y equal to the set address plus 1. Now a ?D will return the data byte.

There is a 15 pin connector on the rear of the SR255 which provides a digital interface to the SR245. This connector has 6 digital inputs, 8 digital outputs, and a common ground line (Figure 18.) The incoming lines serve as module address lines and the out-going lines are tri-state outputs and so several modules may be daisy-chained together over the same digital bus.

The interface is a parallel binary interface which may be connected to either an SR245 computer interface module or to an 8 bit digital I/O port of a computer.

To interrogate the SR255 through the digital interface you must supply the 5 bits of address (A0 to A4) and assert the RD strobe. The least significant address bit selects the Status Byte when low, or selects the Date Byte when high. The Status or Data bytes are placed on the 8 output lines (B0 to B7) when the module is addressed and the RD strobe is asserted low.

The Status Byte is placed on the digital I/O bus by U408 when (1) the module is addressed (A1 to A4 match the switch settings) and (2) both A0 and the RD strobe are low.

Designation	Description	Pin	I/O
B7	Bit 7 of Digital Output (MSB)	13	O
B6	Bit 6 of Digital Output	5	O
B5	Bit 5 of Digital Output	12	O
B4	Bit 4 of Digital Output	4	O
B3	Bit 3 of Digital Output	11	O
B2	Bit 2 of Digital Output	3	O
B1	Bit 1 of Digital Output	10	O
B0	Bit 0 of Digital Output (LSB)	2	O
A4	Bit 4 of Module Address (MSB)	8	I
A3	Bit 3 of Module Address	15	I
A2	Bit 2 of Module Address	7	I
A1	Bit 1 of Module Address	14	I
A0	Bit 0 of Module Address (LSB)	6	I
RD	Read Strobe, Active Low	9	I
GND	Common Ground	1	n/a

Figure 18 - Digital I/O Connector Pin Assignment Table

The MSB of the Status byte, the Data Ready Flag, is set on the trailing edge of the module's END strobe. The Data Ready Flag is reset when the data byte is read. If a second END strobe is detected before or during the reading of the data byte, then the Data Missed Flag, S6, will be set. The Data Missed Flag is reset after the status byte is read.

STATUS BYTE DEFINITION

Bit	Definition	(positive logic)
S7	Data Ready Flag	(cleared by a Data read)
S6	Data Missed Flag	(cleared by a Status read)
S5	Overrange Error	
S4	Sign bit	(1=positive input signal)

S3	Width	S3	S2
S2	1000 pS	1	1
	500 pS	1	0
	200 pS	0	1
	100 pS	0	0

S1	Sensitivity	S1	S0
S0	1.0 V/V	0	1
	0.25 V/V	1	1
	0.10 V/V	1	0

The six least significant bits of the Status Byte are latched on the rising edge of the Data Ready Flag. These bits represent the state of the module at the completion of the conversion cycle which first set the Data Ready Flag. Because this data is latched, another trigger will only set the Missed Data Flag, and will have no affect on the other status bits or the data byte. The status and data bytes must be read before a trigger if data and status from that trigger event will be needed.

The data Byte is placed on the digital I/O bus by U409 when (1) the module is addressed (A1 to A4 match the switch settings), (2) A0, the LSB of the address is high, and (3) the RD strobe is asserted to its active low state.

DATE BYTE DEFINITION

Bit	Description
D7	MSB of the unsigned Data
D6	
D5	(The sign of the data is bit
D4	S4 of the Status Byte.)
D3	
D2	
D1	
D0	LSB of the unsigned Data

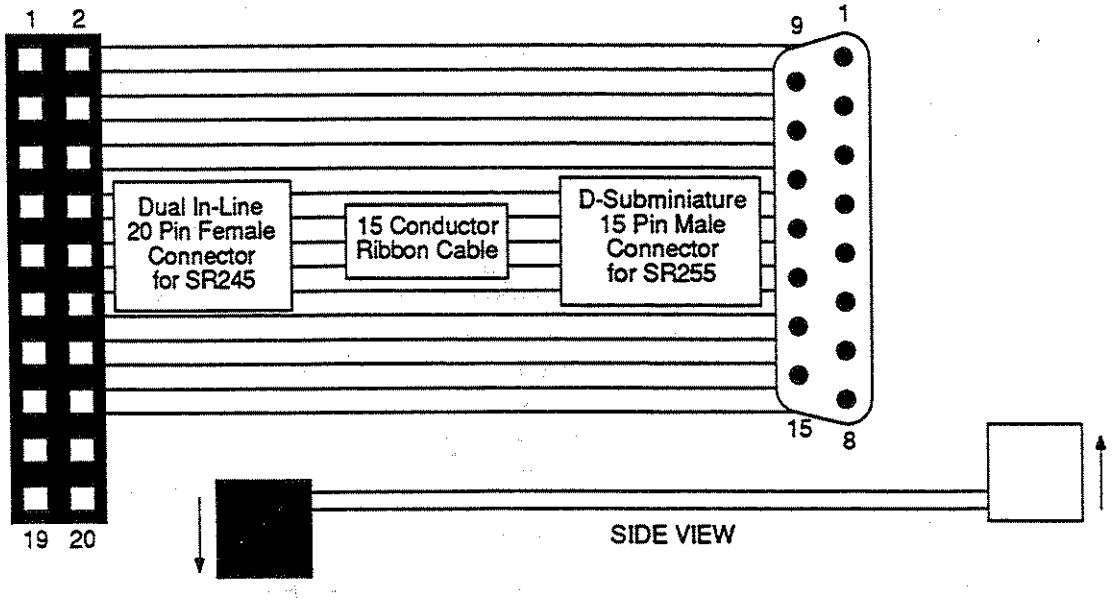


Figure 19 - Connector Assembly For SR245/SR255 Digital Interface

SAMPLING SCOPE EXAMPLE

The SR255 Fast Sampler can be used in conjunction with the SR200 Gate Scanner and an X-Y oscilloscope to provide sampling scope operation. Resolution of 100 psec can be achieved with sample rates up to 50,000 samples per second.

An interconnect diagram is shown in Figure 20. The SR200 Gate Scanner is used to scan the gate delay over 0 to x10 of the selected delay scale. This scale is set on the SR255 circuit board at 1 nsec, 10 nsec, 100 nsec, or 1 µsec to provide time-bases with delays of up to 10 µsec. The maximum delay can be extended by the user by increasing capacitor C115 of the 1 µsec delay scale. The X-AXIS OUT of the SR200 is used to drive the horizontal X-axis of the oscilloscope. The PEN LIFT OUT may be connected to the oscilloscope to blank the CRT during retrace.

Finally, the SAMPLE OUT of the SR255 Fast Sampler connects to the vertical Y-axis of the oscilloscope to display the sampled signal. The resolution can be changed by changing the Gate Width of the SR255 (100 psec, 200 psec, 500 psec, 1 nsec.)

An alternative approach is to substitute the SR245 Computer Interface for the SR200 in the above example. The A command will generate a ramp on port 8 which can scan any portion of the delay range. The sampled output may be read through the digital ribbon cable between the SR245 and the SR255, and the sampling scope data may be displayed on your computer screen.

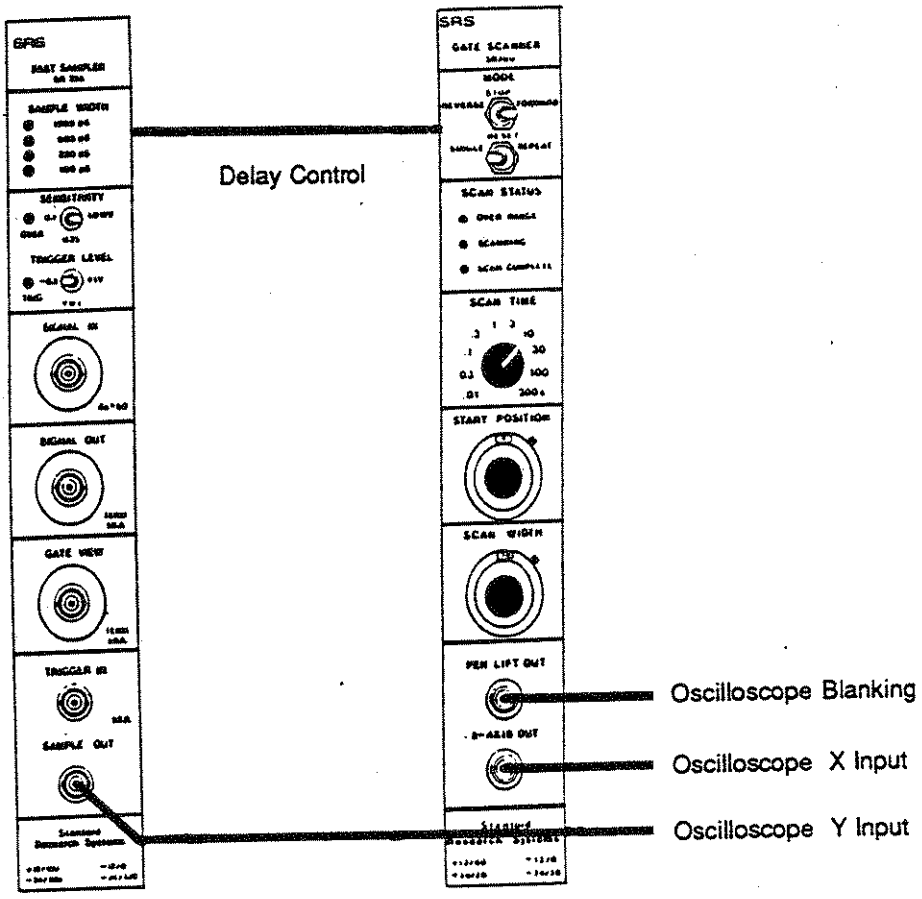


Figure 20 - Setup For Sampling Scope Example

TROUBLESHOOTING

First, make sure that the module is plugged all the way into the NIM crate with both side panels screwed down, and the NIM crate turned on. Check to make sure that the crate is providing +/-12 and +/-24 VDC, +/-2%, with a ripple of less than 20 mV.

SAMPLING BRIDGE CHECK-OUT

To check if the front end sampling bridge has been damaged, unplug all cables and terminators from the SIGNAL IN, SIGNAL OUT, and TRIGGER IN front panel connectors. Use a battery operated, hand-held digital multimeter to measure the voltage present on the center conductor of the SIGNAL IN front panel connector. Be certain that the DVM is set to measure volts. If you set the DVM to measure Ω, the DC bias supplied by the meter may damage the front end of the SR255. You should measure less than 10 mV on the SIGNAL IN connector. The unterminated DC input impedance of the SR255 is 10 KΩ, so 10 mV would indicate 1 μA of leakage current from the sampling bridge, which is excessive. The sampling diodes become leaky when subjected to an excessive input signal.

A damaged front end must be repaired at the factory. The sampling bridge must be replaced, the GAIN and OFFSET pots and blow-by compensation circuits must be re-calibrated, and new linearization tables must be entered into the unit's PROM. Contact the factory for details.

Problem	Possible Cause
Overrange LED Stays ON	-Unit is not being triggered. -Input voltage exceeds full scale sensitivity. -OFFSET pot for selected gate is not adjusted. -Switches and screw for selected gate width are not set consistently. -Sampling bridge is damaged (see above.)
No Trigger LED	-Trigger rate is too fast. -Trigger signal is too small, or wrong polarity. -Trigger signal duty cycle is too high (Time over threshold > time beneath threshold.) -External Delay Control Voltage is negative. -Intercept pot, P101, is far out of calibration. -Trigger discriminator, U105, has been damaged.
Sample Output Is Out Of Calibration	- GAIN or OFFSET pot for selected gate width needs adjustment (see calibration procedure.) -Load too heavy. SAMPLE OUT should not be terminated into 50Ω. -Switches and screw for gate width selection are not set consistently, or screw is not tight. -Sampling bridge is damaged (see above.)

CALIBRATION

SENSITIVITY AND OFFSET

The object is to calibrate the gain and null the offset for each of the four gate width settings. When very precise measurements are required, the offset may be adjusted each time the gate width is changed. You may also wish to periodically re-calibrate all of the gains. These adjustments must be made with the side panels in place and screwed down. Throughout this procedure, be sure that there is at least one meter of cable attached to both the SIGNAL IN and the SIGNAL OUT front panel connectors. These cables do not have to be terminated into 50Ω, however the GATE VIEW output must be terminated into 50Ω. Failing to do this will cause the instrument to see a reflected portion of the sampling bridge's kickout signal and so degrade the calibration.

First, select the gate width to be calibrated by moving the shorting screw to the desired gate width, and set both sets of SAMPLE WIDTH switches to the correct positions. (Only 1 of the four switches in each switch bank is set to on). Install the side panels and their retaining screws. Apply a 1 KHz external trigger and adjust the OFFSET pot corresponding to the selected gate width to null the Sample Output on the 0.1 V/V sensitivity scale. If this cannot be done, see the troubleshooting section for a test to check for damage of the sampling bridge.

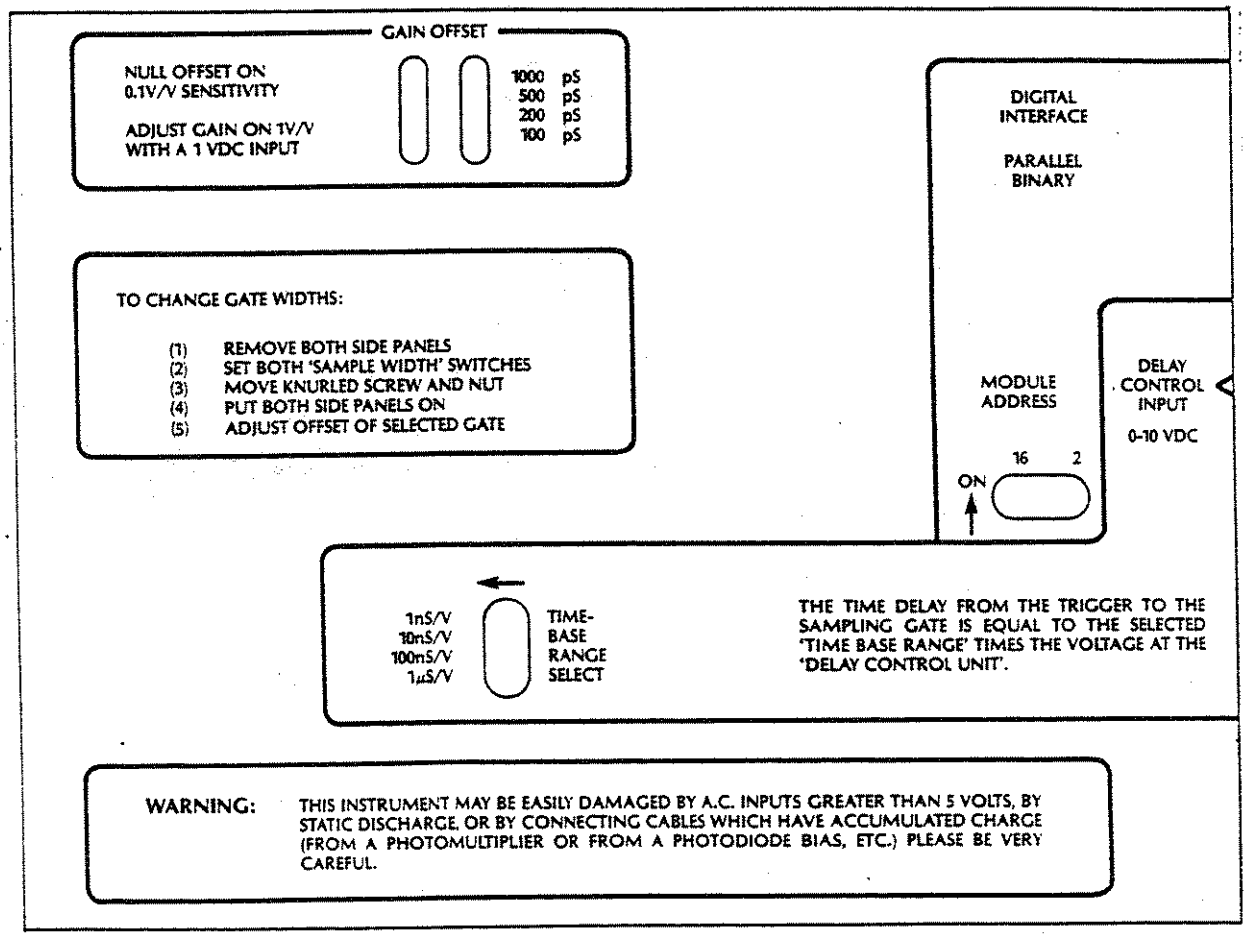


Figure 21 - SR255 Side Panel

To calibrate the gain, select the 1V/V sensitivity scale and apply 1.00 VDC to the signal input. Adjust the GAIN pot for the selected gate width to measure 1.00 VDC at SAMPLE OUT. Repeat this procedure for each of the four gate width settings.

DELAY CIRCUITS

To re-calibrate the delay circuits remove the right side panel of the module before plugging into the NIM crate. Select the 100 nS/V timebase range by turning on the third switch in the Delay Select switch bank. The three other switches in this bank should be off. With no input connected to the DELAY CONTROL INPUT, observe the position of the Gate View pulse with respect to a 1 KHz external trigger. Adjust P101, the Intercept pot, so that the Gate View pulse is about 10nS from its minimum delay position. This sets the intercept of the Time Delay vs. Delay Control Voltage.

Now select the 10 nS/V timebase range and adjust P102, the Slope pot, so that the Gate View pulse moves by 100 nS when the Delay Control Voltage is scanned from 0 to 10 VDC.

BLOW-BY CALIBRATION

To compensate the unit for sampling bridge blow-by you will need a signal source to provide a 1 volt 500 nS pulse into 50Ω. The signal should have a -0.5 VDC offset, so that the pulse goes from -.5 V to +.5 V. The source must also have a sync output to trigger the SR255 a few hundred nanoseconds before its output pulse.

The object of the blow-by compensation is to use the SR255 in a sampling scope mode of operation in order to get the best representation of the input signal. To set up, see section 5 of this manual which uses an SR200 Gate Scanner to scan the gate over a 1000 nS range. The SR200 will provide a voltage ramp from 0 to 10 V to scan the SR255 delay on the 100 nS/V timebase scale. The SR200 will provide the X-axis and blanking inputs to the a scope used in the X-Y mode of operation, and the SR255 SAMPLE OUT will provide the Y-axis voltage.

The blow-by compensation can be done on any width scale. Once set up in the sampling scope mode of operation, you need only adjust C213 and C214. These are the variable capacitors found on the teflon PCB at the front of the module. Remember the position of these trimmers before you start: the two adjustments are not orthogonal and you may wish to return to the starting point. To compensate the blow-by signal, simply adjust C213 and C214 for the best pulse shape display of your input signal. If you are unable to adjust the blow-by compensation refer to the troubleshooting section to check for a damaged sampling bridge.

A/D INPUT OFFSET CALIBRATION

To calibrate the analog to digital converter's input offset, the SR255 will need to be configured as a "sampling scope". Set the gate width to the 100 ps scale, and the delay select to the 1 ns/V range. Use the SR200 Gate Scanner Module to provide a 5 volt ramp at the delay input. Using the SR255 to look at the leading edge of a fast 1 volt pulse (risetime: 1 ns) adjust the 100 ps OFFSET pot so that the rising edge of your signal is crossing zero volts on the oscilloscope. Adjust P401 until there is a smooth and continuous crossing at zero volts.

CIRCUIT DESCRIPTION

The SR255 Fast Sampler is a single width NIM module which is used to sample voltage waveforms with a sampling gate of 100 pS to 1nS. The module contains all the sub-systems necessary to discriminate a trigger, insert a controllable delay, sample an input voltage, do an A/D conversion, linearize the acquired sample, and output the result in both analog and digital forms.

In the circuit descriptions which follow, please refer to sheets 1 through 4 of the schematic diagrams which are at the back of this manual.

MODULE POWER SUPPLY

The module is powered by the +/- 12 and +/- 24 VDC supplies of the NIM crate. Each supply line is filtered by a two pole RC filter to reduce noise from other modules in the crate. These filtered lines are then regulated to +/- 5 and +/- 15 VDC for use throughout the module. The approximate current consumption for each of the NIM supplies is given here:

+24VDC	100 mA
+12 VDC	150 mA
-12 VDC	35 mA
-24 VDC	110 mA

The module uses approximately 7.5 Watts of DC power from the NIM crate.

TRIGGER CIRCUITS

The Trigger Input, J101, is a direct coupled 50Ω input. U105, a CA3102 dual differential pair, is used to compare the input with the threshold selected by SW101, the TRIGGER LEVEL switch. Trigger levels of -0.5, +0.1, or +1.0 VDC may be selected.

Q101 and Q102, together with 1/2 of U106, form a fast regenerative latch and a constant current source. Once latched, this circuit will stay latched until both the trigger goes below threshold and the HOLDOFF signal is asserted and released. HOLDOFF is asserted from the time that the unit is triggered until the unit completes the sample acquisition and A/D and D/A conversion, a process which requires about 20 µS. While latched, 1/2 of U106 provides a constant current sink of 11 mA, which is used to discharge a delay one-shot capacitor in order to provide an accurate and very low jitter time delay with respect to the external trigger.

TIME DELAY CIRCUIT

The PCB mounted Delay Range Select switch is used to select one of four delay ranges: 1,10,100 or 1000 nS/V. For example, if the 10 nS/V range is selected, C113, a 200 pF capacitor, is switched into the circuit. Before the trigger occurs, C113 will be precharged to a voltage between 5 and 10 VDC, depending on the input to the External Delay Control. The delay from trigger to gate may be set or scanned by a voltage at this input. Once triggered, the selected capacitor will be linearly discharged by the constant current source 1/2 of U106. When the capacitor has been discharged so that the voltage at the base of Q103 is equal to the voltage at the base of Q104, then the regenerative latch formed by Q103, Q104 and 2/2 of U106 will latch up. There are two outputs from this latch circuit. The TRIGGER signal from the collector of Q104 (active low) is used to start the A/D conversion process, and the positive output from the collector of Q105 is used to trigger the ultra-fast step generator to initiate the sampling of the input waveform.

STEP GENERATOR

Sheet 2 shows the schematic diagram of the circuit used to sample the signal waveform. All of the components on this page of the schematic are located on the small PCB mounted at the front of the module. This PCB is fabricated on a Teflon substrate to reduce the dispersion which would occur on a conventional glass-epoxy PCB.

The trigger from Q105 on the main PCB is brought to the base of Q201 by a twisted pair. The trigger pulse causes Q201 to go into saturation, thereby injecting a current of about 50 mA into the base of Q202 via the 1:1 transformer, T1-1. Q202, which is normally off, quickly goes into saturation, shorting its emitter and collector together, creating a differential output pulse of +/- 15 Volts with a 1 nS risetime. These pulses are then coupled into the Step Recovery Diode circuit via C202 and C203.

The SRD, D201, is normally forward-biased with about 25 mA via R205, R206, R230, and R231. The 1 nS risetime differential pulses from Q202 are applied so as to reverse-bias the SRD. Even though the SRD is now reverse-biased, it will continue to conduct for a few nanoseconds until all the carriers are cleared from the diode's junction. Once all the carriers are cleared, the SRD will stop conducting very abruptly, injecting a 10V, 50 pS risetime differential pulse on the 40Ω transmission line via C204 and C205. The pulse will propagate in both directions on the transmission line: part of the pulse is used to provide a Gate View marker pulse out the front panel connector, J203, and part of the pulse is used to generate a gate to turn on the sampling diodes, D202. The step output from the SRD is turned into a pulse by shorting the transmission line. The pulse width may be set to 100, 200, 500 or 1000 pS by moving the shorting screw to different locations along the transmission line.

SAMPLING GATE

The charge sample that is stored on the sampling capacitors is a.c. coupled to a video pre-amplifier U201, an LM733, via C210 and C211. The gain of the pre-amplifier is set by the four switches, SW201, which are adjacent to the pre-amplifier. The gain is set higher on narrow gate widths in order to compensate for the reduced sampling efficiency of shorter gates.

BLOW-BY COMPENSATION

Whether or not the sampling diodes have been gated ON, the package and junction capacitance of the sampling diodes always provide a path from the signal input line to the pre-amplifier. The signal which couples to the pre-amplifier in this way is called the blow-by signal. In order to eliminate the artifacts caused by this parasitic path, the Blow-by Compensation circuit produces a signal which mimics the blow-by signal, and is applied to the inverting input of the pre-amplifier to cancel the original blow-by signal.

The blow-by circuit consists of C212 to C218 and R218 to R224. C213 and C214 are adjusted to compensate for the unit's particular blow-by characteristics.

GATED INTEGRATOR AND SAMPLE AND HOLD CIRCUIT

The differential output of the pre-amplifier, U201, is brought to the main PCB and a.c. coupled to the gated integrator via C301 and C302. The pre-amplifier's output pulse is only a few hundred nanoseconds long and so it must be sampled and held for the A/D converter. By using an integrator before the sample and hold amplifier, high frequency noise components are reduced: low frequency noise components have already been filtered by a.c. coupling between stages.

The gated integrator is formed from the transistors Q301 to Q307, and their associated bias resistors, R301 to R321. Q301 and Q302 form a differential input amplifier which takes the pre-amplifier's differential outputs and produces a differential current source. Q302's current is mirrored by Q307 and R319 to R321. In this way the pre-amplifier may adjust the current sources to the gated integrator. The current switching gate is formed by Q303 to Q306. Normally, Q303 and Q306 are on, while Q304 and Q305 are off. When the module is triggered, the one-shot, 1/2 of U301, produces a 300 nS gate which is applied to the current switch. Capacitor C304 integrates the difference in the currents from Q301 and Q307 during the 300 nS gate.

Before the current switch directs the current imbalance to the integrating capacitor, the current sources Q301 and Q307 are balanced and the common collector output of Q303 and Q306 is at zero volts. This balance is maintained by 4/4 of U304 which adjusts the bias on the base of Q301. An offset may be injected via R328 and 1/2 of U306. U306 selects one of the four OFFSET pots corresponding to the selected SAMPLE WIDTH.

The voltage on the integrating capacitor is amplified by U302, an LM318 high speed op amp. The op amp's gain is controlled by SW301 which is the front panel SENSITIVITY switch. Since the integrating capacitor is passively reset by R322 with a time constant of 5 µS, the output of the LM318 is sampled and held by C306 and 1/4 of U303.

The S/H amplifier has a gain which may be adjusted by one of the four gain pots, P302. There is a different gain pot for each gate width, and the correct pot is selected by 2/2 of U306. These pots are adjusted to produce a full scale output when a full scale input is applied at the Signal Input. Linearization, and a more accurate gain calibration, is done by computer at the factory, and the results of the calibration are stored in the module's PROM.

The output of the sample and hold is passed to a comparator (U305, an LM311) to generate a sign bit. The sign bit is (1) used to select a PROM lookup table for linearization, (2) used to select the polarity of the Last Sample output buffer, and (3) latched into the digital interface latch. The output of the S&H amplifier is also passed to an absolute value circuit to rectify the signal before the A/D conversion.

TIMING LOGIC

As previously described, a TTL logic level signal, TRIGGER, (active low, source at Q104 onSheet 1) is generated when the programmable delay times out. The falling edge of this signal is coincident with the sampling of the input signal. TRIGGER is used to trigger 1/2 of U301, a 300 nS one-shot, used to switch the gated integrator, and to trigger the 2/2 of U303, a 1 µsec one-shot. This one-shot turns on the switch, 1/4 of U303, in order to sample and hold the output of the gated integrator. The trailing edge of this signal is delayed by R405 and C401 before triggering the A/D converter, U404. After 14 µS, the conversion is complete, and the A/D triggers 1/2 of U405 to generate a 1 µS END strobe. The trailing edge of the END strobe will trigger 2/2 of U405, a 10 mS one-shot, which turns on the TRIG LED on the front panel of the instrument.

A/D AND PROM LINEARIZATION

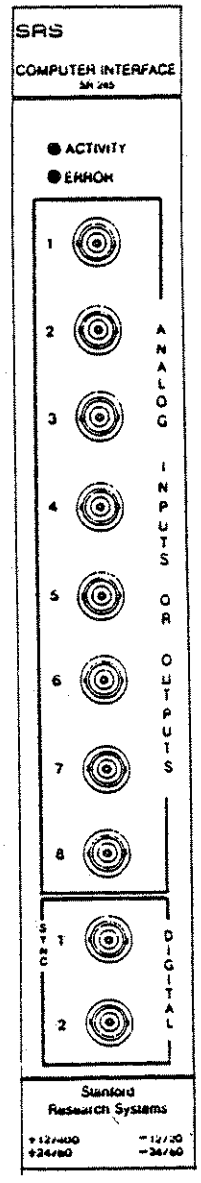
The absolute value of the sample and hold integrator signal is converted by U404, an 8 bit A/D converter. When the conversion is complete, the 8 bits of data serve as an address to U406, an 8 KByte UVEPROM. The PROM contains the linearization tables for converting the raw 8 bits of data from the converter into 8 bits of linearized and gain corrected data. There are 24 different tables of 256 bytes each burned into the PROM. The tables are addressed by the other address bits presented to U406, i.e. by the width, sensitivity and sign bits.

The PROM's output is passed to U409, an eight bit latch and tri-state buffer IC, to be latched for access via the digital I/O port. The PROM data is also passed to U412, an 8 bit D/A converter. The current output from the D/A converter is converted to a voltage by 2/4 of U411. This voltage is scaled and buffered by 3/4 of U411 before going to the front panel Sample Output. The Sample Output is inverted if the SIGN bit for the latest conversion is positive. The SIGN bit is latched by 1/2 of U415 which drives 3/4 and 4/4 of the analog switch U303 in order to configure the output buffer as an inverting or non-inverting output driver.

The four most significant bits from the PROM go to 2/2 of U403. If all four bits are high, the output of 2/2 of U403 will be high, and an overrange condition will be indicated. 2/2 of U415, a D-type flip flop, will latch this overrange condition and drive the front panel OVER LED. The voltage reference for the A/D and the D/A conversion is U410, a precision 10.240 VDC reference. This reference is inverted and attenuated to -5.12 VDC for the A/D reference input.

INTRODUCTION

The SR245 Computer Interface is a versatile module capable of providing a variety of the scanning, counting, and communications functions typically required in the laboratory. It is remotely programmable via both RS232 and GPIB rear panel connectors and can be used with laboratory computers or simply with a terminal. Eight front panel analog ports can be programmed as inputs or outputs with a range of ±10.24 volts. Two front panel digital input/output bits are provided for general use as well as an eight-bit digital input/output port accessible via an internal 20 pin dual in-line connector. The digital ports can be used to interface the SR245 with the SR255 Fast Sampler module. A variety of simple, easily understood commands eliminate the need for extensive software development to integrate the SR245 into existing experiments.



SPECIFICATIONS

ANALOG PORTS	
Inputs	1 MΩ input impedance, +10.24 VDC range, protected to 40 VDC. 13-bit resolution (2.5mV). Accuracy: 0.05%. Input offset less than 2.5 mV. Maximum A/D rate is 2 KHz.
Outputs	Output impedance less than 1Ω. Short circuit current limit is 20 mA. 13-bit resolution (2.5mV). Accuracy: 0.05%. Output offset less than 2.5mV.
DIGITAL PORTS	
Input Bits	Input impedance greater than 100KΩ. Minimum pulse width is 200nS. Maximum count rate is 4MHz. Logic one > 3 VDC. Logic zero < 0.7 VDC. Inputs protected to +10 VDC.
Output Bits	Can drive loads up to 50Ω to TTL logic levels.
Internal 20 Pin Connector	8 latched TTL output bits with strobe bit. 8-bit TTL input port with strobe bit.
INTERFACES	Both IEEE-488 Std Port and RS232-C(300 to 19.2Kbaud).
SYSTEM COMPONENTS	Z80-A µP @ 4 MHz. 8K ROM, 8K RAM. VLSI counters, UART, and IEEE-488 adapter.
GENERAL	
Power	+24 / 60mA, -24 / 60 mA, +12 / 500 mA, -12 / 20 mA, 8 Watts total. Power from Model SR280 Mainframe or a NIM standard crate.
Mechanical	Single width NIM module per TID-20893. Dimensions 1.35"x8.714"x11.5".
Warranty	One year parts and labor on materials and workmanship.

Figure 22 - SR245 Front Panel

SETUP & OPERATION

TRYING OUT THE SR245

Before attempting any detailed programming with the SR245 it is best to get a feel for the type of functions the module provides by using it with a terminal. If one is available, connect a terminal with an RS232 port to the RS232 port on the rear of the SR245. The unit is shipped with its internal configuration switch set for 9.6 kbaud operation. If your terminal requires a different baud rate it will be necessary to open the side panel and readjust the configuration switch according to the values in Figure 23. After setting the correct baud rate and connecting the terminal, turn the unit on. The green ACTIVITY light will flash for a second or two indicating that the SR245 is performing its internal hardware test routines and the sign-on message will appear at the terminal giving the version number of the ROM supplied with the unit. The red ERROR LED may also momentarily flash when the power is turned on; this does not indicate any problem with the unit. If the sign-on message is not displayed, consult Appendix A, Example1 for more detailed instructions. The last characters displayed will be the prompt 'OK->'. This indicates that the SR245 is ready to accept commands.

Now type the command ?1 followed by a carriage return. The SR245 responds by sending to the terminal the characters 0.000 indicating that the voltage at port 1 is 0 volts. In general, the command ?n causes the the SR245 to send back the value at the nth analog port. Now we will use the unit to output a voltage we can read with the ? command. Type the command I4<cr>. This causes the SR245 to configure the first 4 analog ports as inputs, with the remainder becoming analog output ports. For instance, if we wish to set the voltage at port 8 equal to 5.0 volts type S8=5.0<cr> (Set port 8 equal to five volts). We can read the voltage just set by typing ?8<cr> which will return with the value 5.000. Note that the ?<n> can be used to read the voltage at a port regardless of whether it is configured as an input or an output. The ability to use the eight analog ports as either inputs or outputs gives the SR245 tremendous flexibility in laboratory situations. At this point, the user should review Figure 24 containing the complete command list for the SR245, and experiment with a few of the commands.

COMMUNICATING WITH THE SR245

The SR245 is programmed by sending it strings of ASCII characters via the RS232 or GPIB connectors. The choice of RS232 or GPIB, as well as the details of the actual communications interface used (parity bits, GPIB address, baud rate, etc.) is made by setting the 8 configuration switches inside the unit according to the table in Figure 23. The configuration switch is read only when the unit is turned on or after a GPIB 'device clear' message is received. Thus, changing the value of the switch without clearing the unit or turning it off and on again has no effect. Once the SR245 receives characters over either bus, it looks for the ASCII carriage return character, which signals the end of a line of commands, and processes the commands. Within a given line, there may be many individual commands; these must be delimited by the semicolon (;) character. For instance if we wanted to know the voltages on all of the analog ports we could send the command string:

?1;?2;?3;?4;?5;?6;?7;?8<cr>

and the unit would respond by returning all the port values. It is not necessary in most cases to wait until the SR245 has finished processing a given line of commands before sending the next: the unit automatically queues the commands and executes each as it is ready. (An exception to this occurs when the unit is operated in synchronous mode.)

The various commands cause the unit to either alter its internal state or send various values back over the bus. Values which are sent by the SR245 are also in the form of strings of ASCII characters followed by a string of terminating characters, usually carriage returns and line feeds. For instance, in responding to the ?1 command the unit might send the string 2.357<cr> to indicate the value 2.357 volts. The choice of terminating characters is determined by whether the SR245 is used in the RS232 or GPIB mode and whether the 'echo' feature is in use. In addition, special terminating sequences may be specified by using the Z command. The default terminating sequences for each of the various modes is shown below. Note that in the GPIB mode the final terminating character is accompanied by the EOI (End or Identify) message.

Setting The Configuration Switch

RS232 Operation

Bit	Setting	Explanation
8	OFF	Set RS232 operation
7	ON	Echo mode (terminal operation)
	OFF	Disables echo (computer operation)
6	ON	Two stop bits
	OFF	One stop bit
5	ON	Enable parity (8 data bits and 1 parity bit)
	OFF	Disables parity (8 data bits and no parity bit)
4	ON	Even parity
	OFF	Odd parity
3, 2, 1		RS232 Baud Rate (see below)

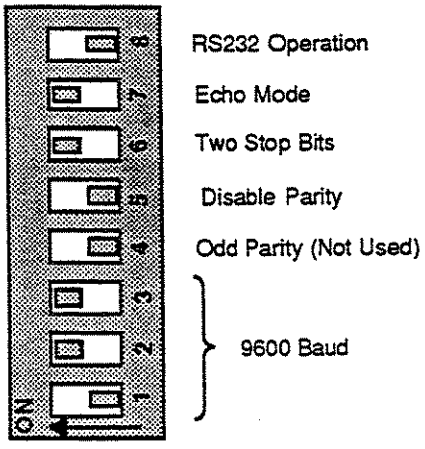
Baud Rate	Bit 3	Bit 2	Bit 1
300 Baud	OFF	OFF	ON
600 Baud	OFF	ON	OFF
1200 Baud	OFF	ON	ON
2400 Baud	ON	OFF	OFF
9600 Baud	ON	ON	OFF
19.2 Kbaud	ON	ON	ON

GPIB Operation

Bit	Setting	Explanation
8	ON	Set GPIB Operation
7	ON	RS232 Echo mode for GPIB
	OFF	GPIB operation without Echo
6	ON	2 stop bits for RS232 echo.
	OFF	1 stop bit for RS232 echo.
5, 4, 3, 2, 1		GPIB address for module (see below)

GPIB Address	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
0	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	ON	OFF
.			.		
.			.		
.			.		
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF

RS232 Example



GPIB Example

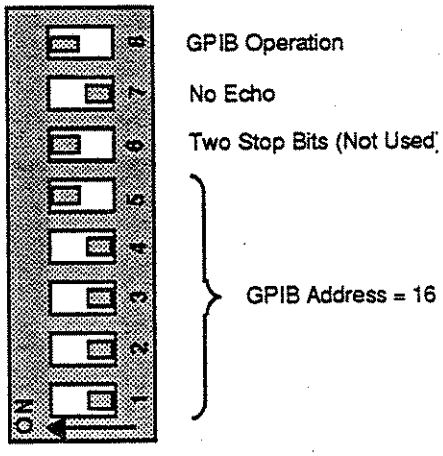


Figure 23 - The Configuration Switch

DEFAULT TERMINATION CHARACTERS

Interface	Echo	No Echo
RS232	CR, LF	CR
GPIB	CR,LF (EOI)	CR,LF (EOI)

Note that the terminating characters are sent with each value returned by the SR245. Thus, in responding to the command string ?1;?B1;?3<cr> while in the RS232 non-echo mode, the unit would send a string such as 2.000<cr>1<cr> 4.875<cr>.

Some commands deal with byte quantities, such as the internal 8-bit digital input/output ports. These values are both sent and received as ASCII coded decimal quantities. For instance, if the user wished to set the value of the digital output port to:

Bit: 7 6 5 4 3 2 1 0
Setting: 0 0 0 1 0 1 1 0

he would send the command SD=22<cr> because 00010110 binary is equal to 22 decimal. Likewise, if the same binary value were present at the digital input port and the command ?D was sent, the unit would respond by sending the string 22<cr>.

FRONT PANEL LEDS

The green front panel LED flashes when the SR245 is sending or receiving information over the RS232 or GPIB interfaces. If the green light remains on while the SR245 is not receiving commands, it indicates that the SR245 is trying to send data over the bus but cannot. This will occur, for instance, if the RS232 'clear to send' line is never asserted, or in the GPIB mode if the unit is never made a talker after requesting data. The red front panel LED flashes whenever an error has occurred, such as an undefined or illegal command string, an A/D overflow, or missed data.

ECHO AND NO ECHO OPERATION

In order to allow the SR245 to be operated from a terminal, an echo feature has been added which causes the unit to echo back commands received over the RS232 port. This feature is enabled by setting bit 7 of the internal configuration switch ON. In this mode the SR245 will send linefeeds in addition to carriage returns with each value and will also send the prompts 'OK->' and 'ERR->' to indicate that the previous command was either processed or contained an error. When the unit is controlled by a computer, the echo feature should be turned off to prevent the sending of spurious characters. The echo feature can also be used with the GPIB as explained in the section on GPIB operation.

DTE AND DCE OPERATION

The SR245 contains an internal jumper plug which allows it to emulate either a DTE (terminal) or a DCE (modem) while operating in the RS232 mode. The unit is shipped as a DCE so that it may immediately be connected to a terminal for check out. If it is desired to configure the unit as DTE (connection to many computers will require this) simply pull out the jumper plug from the socket marked 'DCE' on the circuit board and plug it into the socket marked 'DTE'. The plug is located at the rear of the board directly behind the RS232 connector.

PROGRAMMING

In this section, each of the SR245 commands will be discussed in detail. Commands are denoted by boldface characters. The brackets < > indicate that the item named inside the brackets is to be sent with the command. The brackets are never sent as part of an actual command string. Figure 24 provides a brief summary of all the SR245 commands. The symbol <cr> denotes an ASCII carriage return character.

INPUT / OUTPUT COMMANDS

The SR245 contains three types of input/output ports accessible to the user: the eight analog input/output ports which are referred to simply by their number, 1 through 8; the two front panel bit input/output ports, referred to as B1 and B2; and the 8 bit digital input/output port which is referred to as D. The basic format for interrogating and setting the value of each of these types of ports is the same. To interrogate a port, the command ?<port name> is sent. For instance, to interrogate the value of B2 the user would send ?B2<cr> and the SR245 would respond by sending back either '1' or '0' depending on whether the value at B2 was TTL high or low. To set the value of a port, the command S<port name>=<value><cr> is sent. Thus, to set port 6 to 3.456 volts, we would send the command S6=3.456<cr>. The analog ports may have any value between -10.237 volts and +10.237 volts, the digital bits B1 and B2 are either TTL low or high, and the value of the digital port D may range from 0 to 255.

Certain commands allocate the ports as either inputs or outputs. When the unit is turned on, or after a MR (master reset) command is received, analog ports 1 through 8 and both B1 and B2 are configured as inputs. To configure only the first n analog ports as inputs, with the remainder becoming outputs, the command I<n><cr> is sent. The two front panel digital bits are configured as outputs simply by setting them equal to the desired value, e.g. SB2=1<cr> configures B2 as an output and sets its value to TTL high. To reconfigure the bits as inputs, the command SB<n>=I<cr> is used. Note that certain commands automatically reconfigure the input/output status of B1 and B2 regardless of their previous value. For instance if the PB1 command is sent (Pulse Bit 1), B1 is reconfigured as an output even if SB1=I had been previously sent.

SYNCHRONOUS AND ASYNCHRONOUS MODES

The SR245 can operate in one of two modes, called the synchronous and asynchronous modes, which dictate when the unit will send back the requested values in response to a ? command. In the asynchronous mode, the power on default mode, the unit returns each value immediately after it is requested. Setting synchronous mode operation allows the SR245 to respond to certain commands only in response to an external trigger signal. When the synchronous mode is set using the MS command, front panel bit 1 (B1) is automatically configured as an input and reserved for use as a trigger. In this mode, when a ? command is sent, the SR245 will wait until a trigger is received at B1, at which time it will sample the requested values and send them back over the bus. A 'trigger' consists of the falling edge of a standard TTL pulse. Note that all the commands on a given line are processed after the first trigger following the carriage return which delimits that line of commands. In other words, if the string ?1;?2;?3<cr> is sent in the synchronous mode the unit will wait for a trigger and then send the values of ports one, two, and three.

While the SR245 is waiting for a trigger, commands may be sent to it normally. If operating in the RS232 echo mode, the next 'OK->' prompt will not be displayed until a trigger is received and the previously requested values are sent. Note that if another string containing ? commands is received while the unit is still waiting for a trigger to send back the result from a previous ? command, the first command is flushed and the next trigger will cause the unit to respond only to the latest ? command.

TRIGGER COMMANDS

Certain commands modify the properties of the trigger input. For instance, if the user wishes every nth pulse at B1 to trigger the unit, he can give the command T<n><cr> while in the synchronous mode. The value of n can range from 1 to 32767.

A trigger can be induced without externally pulsing B1 by sending the PB1 command (Note that this will leave B1 configured as an output.) The trigger can be masked by sending the command DT (disable trigger). To re-enable the trigger after this command has been sent, the command ET (enable trigger) is used.

PULSING COMMANDS

Both B1 and B2 can be used as general purpose TTL pulse sources using the P command. Sending PB1<cr> or PB2<cr> configures the appropriate bit as an output and outputs a 10µsec positive TTL pulse. The SR245 may be programmed to act as a 'divide by n' counter by sending the command P/<n><cr> when the unit is in the synchronous mode. This command causes the SR245 to output a 10µsec pulse on B2 every nth trigger. Note that the effects of the T command and the P/<n> commands are cumulative. Thus, if the user had set T10 and then gave the command P/5, a pulse would be output at B2 for every 50th input pulse at B1.

COUNTING COMMANDS

The SR245 may be used as a general purpose counter using the C and ?C commands. Sending the C command configures B2 as an input and initializes the counter. Sending ?C<cr> causes the SR245 to return the number of pulses counted at B2 and clears the counter in preparation for a new count. Note that the C command does not have to be sent before each ?C , but if B2 is ever reconfigured as an output the C command must be sent to reinitialize the counter before using ?C again. The maximum count rate is 4MHz. The maximum count is 65,535. The counter 'wraps around' to 0 and continues counting after the maximum count is reached.

SCAN COMMANDS

One of the most useful features of the SR245 is its ability to independently read the input ports and store a series of data points. The scan command format is:

SC<port 1>,<port 2>,...<port n>:<num of triggers>

A maximum of 8 ports may be specified. This command causes the unit to sample and store the values of specified input ports each time a trigger is received. This process is repeated for the number of triggers specified in the command. For instance if we wanted to scan the values of ports 1 and 3 as well as the digital port for 100 triggers we would give the command:

SC1,3,D:100

The eight analog ports and the 8-bit digital port may be scanned in this manner. The two bits B1 and B2 may not be included in the scan command. When the required number of triggers has been received, the SR245 stops scanning and sets the 'scan finished' bit (bit 4) in the status byte. To stop the scan prematurely, the command ES (end scan) may be used. The number of triggers received since the scan started is returned by the ?N command which may be sent any time during the scan. Other commands may be sent while a scan is in progress, but, since processing these commands takes time, this practice is not recommended, especially at scan rates close to the maximum. The maximum scan rates, as well as the maximum number of points in a scan is shown in the table below.

Maximum Scan Parameters (SC Command)

# of ports	Max trig rate	Max # of triggers
1	2.1 KHz	3711
2	1.3 KHz	1855
3	910 Hz	1237
4	740 Hz	927
5	600 Hz	742
6	510 Hz	618
7	440 Hz	530
8	390 Hz	463

Once a scan has been completed the user may read the stored values with the N (next point) command. Each time the N command is sent, the SR245 returns the next value in the scan. The value of the ports are sent in the same order as they were specified in the scan command. Thus if SC4,6,1:50 were sent, the scan points would be sent in the following order:

Command List

Input/Output Commands

I<n> n=0-8 Designates the first n analog ports as inputs, the remainder become outputs. Default is I8.

?<n> n=1-8 [?3;?5] Returns the value of the designated analog port.

?B<n> n=1,2 [?B1] Returns the value (0 or 1) of the designated digital bit port.

?D Returns the value of the internal 8 bit digital input port.

?S Returns the value of the status byte, and clears the status byte.

C Configures B2 as an input and resets the B2 counter.

?C Returns the number of pulses occur ring at B2 since the previous ?C.

S<n>=<x> n=1-8; x=-10.237 to +10.237 [S8=6 or S2=-41.5E-2] Sets the analog port n (which must be designated as an output) to the value x Volts. x may also be expressed in exponential format with a two digit exponent preceded by an E.

SB<n>=<m> n=1,2; m=0,1 [SB1=1] Designates digital bit n as output and sets its value to TTL low if m=0 or high if m=1 .

SB<n>=I n=1,2 [SB2=I] Designates the selected bit as an input.

SD=<n> n=0-255 [SD=128] Sets the 8-bit digital output port to the value n.

SM=<n> n=0-255 [SM=16] Sets the GPIB SRQ mask to the value n (See GPIB discussion).

Trigger Commands

MS Sets the synchronous mode. Responses to ? commands are returned immediately after the next trigger.

MA Sets the asynchronous mode (default). Responses to ? commands are returned right after command is received.

T<n> n=1 to 32,767 [T3] Designates every nth pulse at B1 as a trigger.

DT Masks the trigger input so that no triggers are recognized.

ET Unmasks the trigger input.

PB<n> n=1,2 [PB2] Outputs a 10µsec TTL pulse at bit port n.

P/<n> n=1-255 [P/3] Outputs a 10µsec TTL pulse at B2 each nth trigger.

Scan Commands

SC<i>,<k>:<n> i..k=1-8,D [SC1;3,D:500] Scans the list i..k of analog ports or digital port for n triggers. Total # of samples may not exceed 3711.

ES End the current scan immediately and reset the point sending counter.

N Send the next point of stored scan.

?N Returns # of points scanned.

A<n>,<i> n=1-255; i=1-255 [A16,2] Adds n x 2.5mV to the value of analog port 8 (must be a positive output) on every ith trigger.

SS<i>,<k>:<n> i..k=1-8,D [SS1:10] Scans the list i..k of analog ports or digital port for n triggers. Data is sent in a 2 byte binary format while the scan is in progress.

X Sends the data of a stored scan in 2 byte binary format.

Miscellaneous Commands

MR Master Reset. Returns the SR245 command settings to their default values.

W<n> n=0-255 Introduces a delay of approximately n x 400µsec before sending each character over the RS232. Default is W255. Allows slow peripherals to keep up.

Z<i>,<k> [Z13,13] Changes the end-of-record characters sent by the SR245 to those specified by the ASCII codes, i...k.

Figure 24 - The SR245 Command List

port 4 at 1st trigger
port 6 at 1st trigger
port 1 at 1st trigger
port 4 at 2nd trigger
.
.
.
port 1 at 50th trigger

The N command may not be sent while a scan is in progress. If N is sent after the entire scan has already been read, a 'command parameter out of range' error is generated setting bit 2 in the status byte and blinking the red LED, and no value is returned. The 'next point' pointer can be made to point to the beginning of the scan at any time by using the ES command. The pointer is automatically reset to the beginning of the scan following completion of a scan.

The SR245 has a limited capacity to ramp one of its analog output ports during a scan. The command A<n>,<m> causes the unit to add n x 2.5 mV to the value of port 8 (port 8 must be configured as output) at each mth trigger. Using the A command reduces the maximum trigger rate by about 20%. The starting value of port 8 should be set using the S8= command and port 8 must have been set as an output with the I command. Both m and n may range from 1 to 255. When the output reaches its maximum value of +10.237 volts it 'wraps around' and begins ramping at 0. The A command may not be sent when the value of port 8 is negative. This ramping output may be used to drive, for instance, the 'external delay' input of the SR250 boxcar integrator.

RECEIVING DATA WHILE SCANNING: THE SS COMMAND

It may sometimes be desirable to receive scan data from the SR245 while a scan is in progress. This can be accomplished with the SS command;

SS<port 1>,<port 2>,...,<port n>:<num of triggers>

When this command is received the SR245 begins scanning the designated ports as in a normal scan. Instead of storing the data so that it may be read back later the SR245 sends each scan point over the bus as it is read. The values of the ports are not sent as ASCII characters in this case. Analog ports are sent as 2 binary bytes which represent a sign bit and 12 data bits. The first byte sent contains the sign bit (1=negative, 0=positive) in the bit 4 position and the high 4 data bits in bits 3 through 0. The second byte sent contains data bits 7 through 0. The analog voltage may be reconstructed by multiplying the signed integer by 0.0025 volts. The digital port value is sent as a single byte preceded by a dummy identifier byte with a value of 0FFH (11111111 binary). At the conclusion of the scan, two dummy bytes with the value 0FFH are sent when in the RS232 mode. In the GPIB mode, the last byte is sent with the End-or Identify message (EOI).

When the SS command is given, the user should be prepared to read the data which is being sent by the SR245 as fast as it is being accumulated. Untransmitted data bytes are temporarily buffered up to a maximum number of 7420. If the number of unread data bytes exceeds 7420, the scan is stopped and a 'missed data' error is generated. Note that the normal restrictions on the number of points scanned do not hold for the SS type of scan. The only restriction in this case is that the total number of bytes sent during the scan must be less than 65535. The number of bytes may be calculated simply by multiplying the number of points in the scan by the number of ports scanned at each point times 2 bytes per port. Thus, SS1:25000 is a legitimate command since it only requires sending 50,000 bytes.

Because the SS command may require that the user be able to acquire unformatted binary data at high data rates, it will not be usable with all languages or with all computers. Special I/O drivers may be necessary to take advantage of this feature. Examples of how this is done are provided in Appendix A. If the additional power provided by the SS command is not required, the user may acquire data in a much simpler manner using the SC and N commands.

FAST TRANSFER OF SCAN DATA: THE X COMMAND

When many data points are acquired during a scan, the amount of time necessary to transfer the scan data to the user's computer using the N command may become significant. To allow for faster transfer of scan data, the X command can be used to cause the SR245 to send the entire scan over the

RS232 or GPIB lines in binary format. When the X command is received, the SR245 first waits for approximately 37*W mS to allow the user's computer time to prepare for the incoming data. W here is the 'wait' value that is set using the W command. After waiting for this time period, the SR245 begins sending the stored scan data, byte by byte, in the same format used in the SS command; i.e. the first byte contains the sign bit and the 4 high data bits, and the second byte contains the low 8 data bits. The digital port value is sent as a single byte preceded by an 'identifier byte' equal to 0FFH (11111111 binary).

If, at any point during the scan dump, the SR245 has to wait for more than 9 mS for the 'clear to send' signal in the RS232 mode or for 'ready for data' (RFD) from all listeners in the GPIB mode, the scan dump is abandoned and the remainder of the data is not sent. Thus, using the X command requires the user's computer to become a dedicated listener while the data is being transferred. When all the data has been sent, the SR245 finishes the dump by sending two terminating 'FF (hex)' bytes in RS232 or a single 'FF (hex) byte with the EOI message in GPIB. Note that these terminating characters are always sent when the X command is used and are not affected by the choice of terminating characters made with the Z command.

INTERFACING WITH THE FAST SAMPLER

Commands are provided which allow the SR245 to scan the SR255 Fast Sampler module. Consult the SR255 section of this manual for information.

MASTER RESET

The MR (master reset) command resets the unit to its default state. All ports are configured as inputs. Any data which is waiting to be sent is lost. Therefore it is bad practice to place a MR command on the same line following a ? command as the unit will send an indeterminate number of characters in response to the ? command before processing the MR command and flush the remainder of the response.

WAIT COMMAND

The SR245 normally waits until the 'Clear to Send' line on the RS232 bus is asserted before sending characters over the bus. However, as some peripherals may not bother to set and reset the CTS line, it is possible for the SR245 to send data out at a rate too fast for some computers and terminals to handle. The SR245 may be 'slowed down' using the W command. Sending W<n><cr> (0<n<255) causes the unit to wait about n x 400 usec before sending each character over the RS232 bus. Note that the default setting for the wait parameter is W255. Thus, to operate at the fastest data rate over the RS232, it is necessary to set the wait parameter to some lower value each time the unit is powered on.

SETTING THE TERMINATION SEQUENCE: THE Z COMMAND

Although the default terminating characters described above will suffice for interfacing the SR245 with a wide variety of hardware and software, it will occasionally be necessary to send special terminating sequences to fit the requirements of some computers. This can be done with the Z command. The format for the command is:

Z<n1>,<n2>,<n3>,<n4>

where n1, n2, n3, and n4 are decimal values between 0 and 255 corresponding the the ASCII codes of the desired termination characters. For instance, if we wanted to send each value followed by the "*" character (ASCII 42), two carriage returns, (ASCII 13) and a line feed (ASCII 10) we would send:

Z42,13,13,10

If a ?1 command was received after this command had been sent and the voltage at port 1 was 2 volts, the string of characters sent back by the SR245 would be 2.000*<cr><cr><lf>. Up to 4 terminating characters may be sent with the command. Note that the Z command only affects the characters sent by the SR245. Command lines received by the SR245 must always be terminated by the carriage return character regardless of the Z command.

For GPIB, the 'E' character (ASCII 69) has special significance. Requesting 'E' as part of a terminating sequence causes the character preceding the 'E' to be sent with the end or

identify (EOI) message (an ASCII 'E' will not be sent.) The 'E' character should always be the last character in the terminating sequence when using the GPIB; when not using the GPIB-RS232 echo mode, the 'E' character must be the last character in the terminating string.

STATUS BYTE

The SR245 contains an 8-bit status register which the user may read to obtain information on the unit's status. The status byte may be read in two ways: by sending the ?S command, which returns the value of the byte in ASCII coded decimal, or when using the GPIB, by performing a serial poll. The status byte returned by the unit reflects all of the status conditions which have occurred since the last time the byte was read After the status byte has been read, it is cleared by the SR245. Thus, in situations where it is critical to monitor a status condition, the status byte should be read initially to clear all previous conditions. The status bits are described in detail in Figure 25.

ERRORS

Whenever a 'parameter out of range' or an 'unrecognized command' error occurs, the appropriate status bits are set and the red LED flashes. In addition, the command queue is reset so that any commands which were pending at the time the error occurred are not executed. Note that an 'A/D overflow' or a 'missed data' error do not reset the command queue or interrupt the processing of commands. In the former case, the overflow value is stored as 10.237 volts and in the latter, the scan is continued even though triggers are being missed. It is the user's responsibility to check for these errors.

The Status Byte

Bit	Value	Explanation
b7	128	**Busy**. When this bit is set it indicates the SR245 has one or more unprocessed commands pending on its command queue. For RS232, this bit is always high as the ?S command will itself be an unprocessed command.
b6	64	**SRQ**. This bit indicates that the SR245 has requested service from the GPIB controller. This occurs when one of the status bits which the user has 'unmasked' with the SM= command is set. The SRQ bit is reset when the controller performs a serial poll and reads the status condition which generated the SRQ.
b5	32	**Trigger received**. Indicates that the SR245 has been triggered.
b4	16	**Scan finished**. This bit is set at the completion of a scan.
b3	8	**Missed data**. This bit is set when the trigger rate in the synchronous mode exceeds the allowed maximum (see Note 1.)
b2	4	**Command parameter out of range**. This bit is set if a parameter associated with a command is not in the allowed range. For instance, S8=45 or SC1:10000 will both generate out of range errors (see Note 2.)
b1	2	**A/D overflow**. This bit is set whenever the unit reads a value at one of the input ports which exceeds +10.237 volts.
b0	1	**Unrecognized command**. Indicates that the unit has received an illegal command string (see Note 3.)

Note 1: Missed Data

1) External trigger rate is too fast.
2) Command queue overflow.
3) Transmission buffer overflow.
4) Available buffer space exceeded in SS command.

Note 2: Parameter Out of Range

1) Scan command designates more than 8 ports to be scanned.
2) Number of scan points specified in the SC command is 0 or greater than the maximum allowed.
3) SS command requires sending greater than 64k bytes.
4) The A command is sent when port 8 is <0.
5) Either parameter in A command is >255 or second parameter =0.
6) Any parameter in Z command is >255.
7) ?C command is sent when B2 is an output.
8) S command specifies an analog port configured as an input.
9) Parameter in I command is >8 or <0.
10) Analog value in S command is >10.2375 volts or <-10.2375.
11) Parameter in SD command is >255 or <0.
12) Parameter in SM command is >255 of <0.
13) Try to set nonexistent port or bit with S command.
14) Parameter in SB command is <0 or >1.
15) Time out on X command.
16) N command received during a scan.
17) X command received during a scan.

Note 3: Unrecognized Command

1) Illegal character in a command string.
2) <cr> or ';' not detected at end of command.
3) Non numeric value detected in a numeric string.
4) '=' character missing in S command.

Figure 25 - The Status Byte

COMMUNICATIONS

INTRODUCTION TO RS232

The RS232 is a standard for bit serial asynchronous data communication. The standard defines the format for data transmission, electrical specifications for signal levels, and mechanical dimensions of connectors.

Despite the existence of a definition of a standard, there are so many permutations of control lines, data formats, and transmission speeds, that getting two RS232 devices to communicate usually requires some work. In this section, we will provide some basic information to aid you in connecting your RS232 device to the SR245 Computer Interface.

Case 1 - The Simplest Configuration

In this case, one wire is used to send data from device A to device B and another wire is used to send data from device B to device A (Figure 26.) Notice that pin 2 is an output on device A and an input on device B. The RS232 defines two types of devices; DTE (Data Terminal Equipment) and DCE (Data Communications Equipment). An RS232 port on a computer may be either a DTE or DCE but nearly every terminal with an RS232 port is a DTE. The SR245 may be configured as either a DTE or a DCE by placing the 16 pin header on the circuit board in either the DTE or DCE socket.

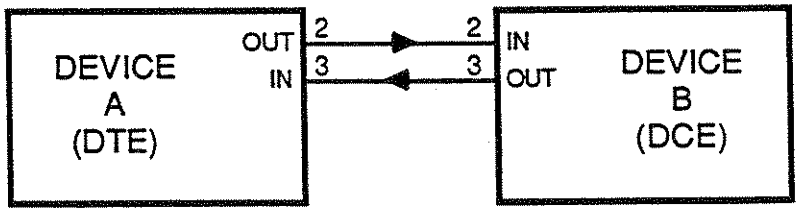
As an example, consider connecting an RS232 ASCII computer terminal to the SR245 (specific details are contained in Example 1 of Appendix A.) The terminal will be DTE and so the SR245 header must be in the DCE socket. To operate correctly, the SR245 and the terminal must have the same settings for baud rate, parity, and number of stop bits. Even set correctly, it may not work as there are other lines in the RS232 Standard which are used to indicate that a device is ready to accept data. If the terminal responds to this line, it will believe that the SR245 is not ready to accept data and will therefore not send any data.

Case 2 - RS232 With Control Lines

The data lines are the same as in Case 1. In addition, two control lines are used:

CTS (Pin 5)	'Clear To Send' is a signal asserted by the DCE to tell the DTE that the DCE is ready to receive data.
DTR (Pin 20)	'Data Terminal Ready' is a signal asserted by the DTE to tell the DCE that the DTE is ready to receive data.

Case 1
The Simplest Configuration



Case 2
RS232 With Control Lines

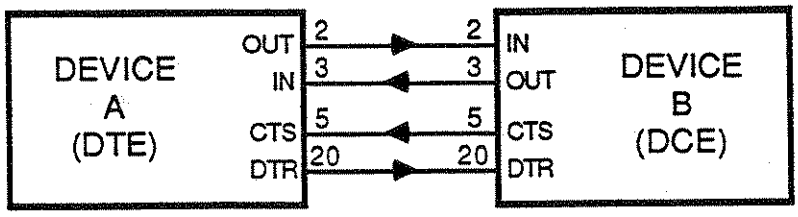


Figure 26 - RS232 Communication

The SR245 responds to the control lines as follows:

1) If the lines are not connected, the SR245 assumes that you are ready to receive data.

2) Data will not be transmitted from the SR245 if the DTR line (pin 20) is low (SR245 configured as a DCE) or the CTS line (pin 5) is low (SR245 configured as a DTE). This is useful in the case when your program has asked for data but is not yet ready to receive it. If data transmission is not suspended, then data can be overwritten in the UART (it is not being retrieved by the program) and therefore lost. When this happens, the 'over-run' flag will be set in your computer's UART and it may be recognized by the operating system generating an error message such as "I/O Device Error". See the "W" command in the Command List (Figure 24.)

Baud Rates

The RS232 baud rate of the SR245 is switch selectable from 300 to 19.2K baud (see configuration switch setting Figure 23.) 19.2K baud means that data is transmitted at 19,200 bits/second. With one start bit, 2 stop bits, 8 data bits, and no parity bits, each ASCII character requires 573 µsec to be transmitted (11bit/19.2K baud.) A typical data string 5.127 <cr> has 6 characters, requiring 3.4 msec to be sent, resulting in a maximum data transfer rate of 290 samples/sec. If the SS or X command is used, then the transfer rate is increased to about 1000 samples/sec.

Stop Bits

Generally, selection of 2 stop bits will result in fewer data transmission errors.

Parity

The Parity bit provides a check against data loss. They are not commonly used in a local data transmission environment. If the parity option is selected, the SR245 will transmit 8 data bits and a parity bit, however, no parity check of incoming data is done.

Voltage Levels

The RS232 uses bipolar voltage levels (Figure 27.) The control lines use positive logic. For example, the DCE tells the DTE that it is clear to send (CTS) by placing >+3 VDC on pin 5 of the interface. Similarly, the DTE can tell the DCE that it is not

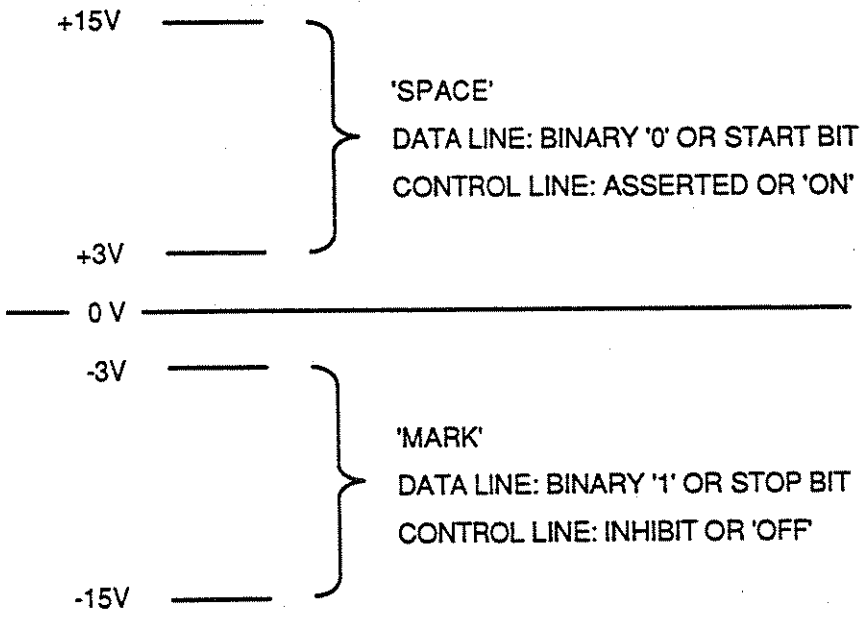


Figure 27 - RS232 Voltage Levels

ready by placing -3 VDC on pin 20 (DTR) of the interface. The data lines, pins 2 and 3, use negative logic. A 'zero' bit is represented by a positive voltage and a 'one' bit is represented by a negative voltage. A start bit is a positive voltage and a stop bit is a negative voltage. Data is transmitted with the least significant bit first. The letter 'A', which has the ASCII code 41H (0100 0001), would appear as in Figure 28. If a parity option was selected, the parity bit would be sent after the 8th data bit, but before the first stop bit.

'Eavesdropping'

When you are trying to get the RS232 to work with your computer, it is helpful to be able to 'eavesdrop' on the RS232 data lines going between the SR245 and the computer. This can be done with an ASCII RS232 computer terminal and the connector shown in Figure 29. To test the connector, place the hook clip on pin 2 of the same connector (shorting pin 2 to pin 3). Now, when you type at the terminal keyboard, data transmitted from pin 2 is received at pin 3 and displayed on the terminal screen. To use as a debugging tool, attach the hook clip to either pin 2

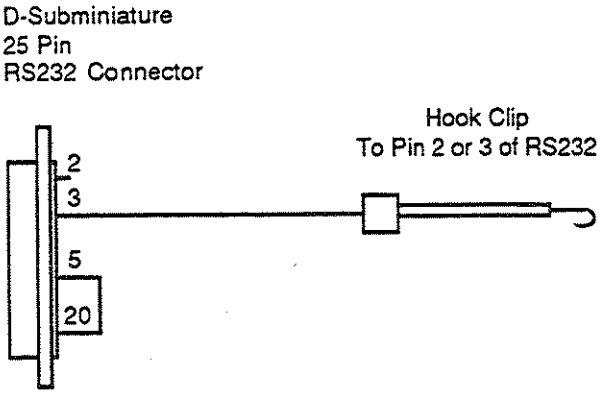


Figure 29 - Eavesdropper

or pin 3 of the RS232 data lines to show either data sent from the DTE or DCE (The hook clip may be placed on one of the top 2 lines in the DTE/DCE Header in the SR245). The baud rate, parity, and stop bits of the terminal must match those of the SR245 and the computer. If your terminal has a mode which will display control characters (such as carriage returns and line feeds) it is helpful to operate in that mode.

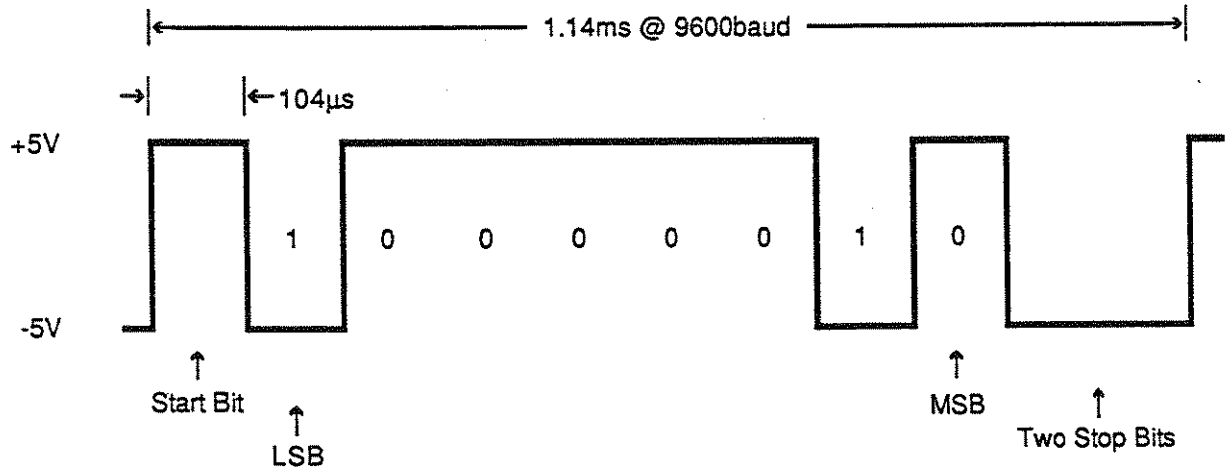


Figure 28 - The Letter 'A'

INTRODUCTION TO GPIB

The IEEE-488 Standard specifies the voltage levels, handshake requirements, timing and hardware details, including pinout and connector dimensions, for a 16 line byte serial bit parallel bus configuration. One major characteristic of this interface is that many instruments may communicate over the same cable and through the same port. Also, because the bits are passed in parallel, it offers speed advantages over the RS232 (about 20 μS per byte).

The controller (generally your computer) coordinates data transfer on the bus by designating all participating instruments (including itself) as either a talker or a listener. Listeners can receive data placed on the bus by the Talker. Devices can have the capacity to operate in either mode. The address of each device is set by switches in the device and must be between 0 and 30.

BUS DESCRIPTION

BYTE TRANSFER CONTROL GROUP. This consists of 3 negative logic lines that implement the GPIB handshaking. The NRFD (Not Ready For Data) line is held low by any designated listener who is not ready to accept data. When every listener is ready, the line goes high and the talker may release data to the bus. After data is on the bus, the talker pulls the DAV (Data Valid) line down. At this point, each listener retrieves the data. Before and during the retrieval of the data, the listener holds the NDAC (No Data Accepted) line down. When every listener has received the data, the NDAC line goes high, allowing the talker to release the DAV line high. Finally, the listener pulls down the NDAC line until another transfer is initiated.

DATA BUS: There are eight data lines which use negative logic and pass the bits of each byte in parallel.

GENERAL INTERFACE LINES: These five lines operate independently of the handshake lines and use negative logic.

1) The EOI (End or Identify) line is used by the talker to designate the end of message.
2) The SRQ (Service Request) line is used by any device to ask for service. The controller can serial poll each device (each device returns an 8 bit status byte) to determine who needs attention. It can also do a parallel poll using the EOI and ATN lines where each device is assigned a single data line.
3) The ATN (Attention) line makes both talkers and listeners accept information and passes control of the DAV line to the controller. This line is used by the controller to identify talkers and listeners through their addresses.
4) The REN (Remote Enable) line changes the status of an instrument from local to remote.
5) The IFC (Interface Clear) line clears the bus of all data and activity.

A complete description of the General Purpose Interface Bus is beyond the scope of this manual. The user should consult the manual for the particular GPIB controller he is using for specific information on how to send and receive characters over the bus, how to perform serial polls, etc. Instead, we will look at those features and commands of the SR245 which relate specifically to the GPIB.

GPIB CAPABILITIES OF THE SR245

The GPIB capabilities of the SR245 consistent with IEEE-488 standard (1978) are shown in Figure 30. Note that the unit has no parallel poll capability. The responses of the SR245 to some of the IEEE-488 standard commands are shown in Figure 31.

Code	Function
SH1	Source handshake capability
AH1	Acceptor handshake capability
T5	Basic Talker, Serial Poll, Unaddressed to talk if addressed to listen
L4	Basic Listener, Unaddressed to listen if addressed to talk
SR1	Service request capability
RL0	No remote-local capability
PP0	No parallel poll capability
DC1	Device Clear capability
DT1	Device Trigger capability

Figure 30 - SR245 GPIB Capabilities

Mnemonic	Command	SR245 response
DCL	Device Clear	Equivalent to Power On
SDC	Selected Device Clear	Equivalent to Power On
GET	Group Execute Trigger	None in Asynchronous Mode In Synchronous, same as a trigger at B1
SPE	Serial Poll Enable	Places status byte on bus and clears status byte

Figure 31 - SR245 Response To Standard GPIB Commands

SETTING THE ADDRESS

The GPIB address of the SR245 is set using bits 5 through 1 of the configuration switch. Bit 5 is the most significant bit, and setting a given switch 'ON' is equivalent to making it a binary 1. The unit is shipped configured for RS232 operation so the configuration switch must be set the first time the unit is used with the GPIB.

SERIAL POLLS AND SERVICE REQUESTS

The status byte sent by the unit when it is serial polled is the same status byte which is read using the ?S command. Of course, when the SR245 is serial polled, it does not encode the status byte as a decimal number. The user can program the SR245 to generate a service request (SRQ) to the controller every time a given status condition occurs. This is done using the SM=<n> command. The mask byte M which is set with this command is periodically logically anded with the status byte. If the result is nonzero, the SR245 generates a service request and leaves the status byte unchanged until the controller performs a serial poll to determine the cause of the service request. When the unit has been serial polled, it loads a new status byte which reflects all of the status conditions which have occurred since the service request was generated. For instance, suppose we wanted to generate a service request each time a scan was finished or the SR245 missed data. We would send the command SM=24 since 24 decimal is 00011000 binary which corresponds to the 'missed data' and 'scan finished' bits in the status byte. If, during the course of a scan, the unit was triggered too fast and missed data, a service request would be generated. If the unit serial polled the SR245 before the scan finished, then the first serial poll would reveal only the 'missed data' condition, after which the SR245 would load the new status byte reflecting the 'scan finished' condition and generate a new service request. It is particularly useful to use the SM command to unmask the 'Scan Finished' bit. This eliminates the need to use the ?N command to detect the completion of a scan, increases the maximum data rate and leaves your computer free for other tasks during the scan.

GPIB RS232 ECHO MODE

It is sometimes useful when debugging a GPIB system to have some way of monitoring exactly what is going back and forth over the bus. The SR245 has the capability to echo all characters sent and received over the GPIB to its RS232 port. This mode of operation is set by turning bits 8 and 7 of the configuration switch ON. This will automatically configure the RS232 port for 9600 baud, no parity operation. The number of stop bits is still user selectable with configuration switch bit 6. Of course, since the RS232 port operates at much lower speeds than the GPIB is capable of, the GPIB cannot be operated at high data rates in this mode. It is useful, however, for determining if what is actually being sent to the SR245 corresponds to what is supposed to be sent to the SR245.

TROUBLESHOOTING

1) SR245 Problem. If, when the power is initially applied, both the RED and GREEN LED's come on and stay on, then the SR245 memory is defective and the unit should be returned for service.

2) RS232 Eavesdropping. This is described in the communications section at the end of the RS232 description..

3) Emulating the SR245 with a Terminal. When trying to debug RS232 interfaces, it can be useful to substitute an RS232 terminal for the SR245. This will allow you to both see what is being sent to the SR245 by the program, and supply responses to the computer via the terminal's keyboard (responses normally sent by the SR245).
For a computer with an RS232 port configured as a DCE, simply substitute the terminal (a DTE device) for the SR245. For a computer with an RS232 port configured as a DTE (i.e. the ASYNC port on the IBM PC) a "null modem" cable is necessary to connect the computer terminal to the DTE port. This cable is made by swapping lines on the RS232 to allow two DTE devices to be connected together (Figure 32).

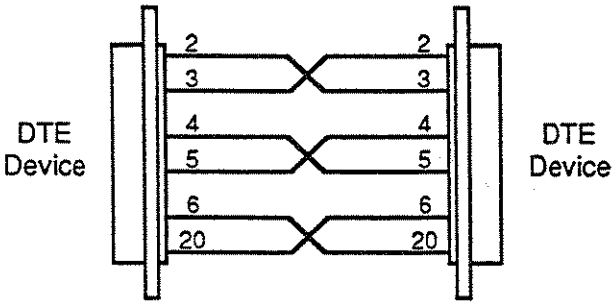


Figure 32 - Null Modem Cable

4) GPIB Eavesdropper. When debugging an IEEE-488 (GPIB) interface, an ASCII terminal (9600 baud only) may be used to view the GPIB transaction on the RS232 connector of the SR245 when the Echo switch (switch 6) is on. A GPIB extender is helpful in allowing the simultaneous connection of GPIB and RS232. When using this technique, the W0 command should be sent to the SR245 so that the GPIB will not be unnecessarily slowed by the terminal. The SR245 must be configured as a DCE so that it may talk to the terminal, a DTE device.

5) Program 'hanging' due to hardware problems. When your computer and the SR245 are talking, it is very easy for the system to "hang." This may occur because the computer is waiting for a response from the SR245 which does not come because:
a) The RS232 or GPIB cable was not attached or has come loose.
b) The configuration switches are not set properly (Baud rate, parity, stop bits, GPIB address conflict). Also, the switches can be set correctly, but the power must be turned off and then on again before the SR245 will read them.
c) The 16 pin Header to select DCE or DTE is not in the correct socket.
d) Your computer requires a control line of the RS232 to be asserted, but you are only using two wires for your cable.

6) Program 'hanging' due to software problems:
a) The SR245 is in the "Mode Synchronous" and is waiting for a trigger input before sending data.
b) The command from the program asking for data was invalid, or a transmission error occurred (ex. we have observed Microsoft's interpreted BASIC on the IBM PC occasionally send a curly bracket (ASCII 0FDH) instead of a carriage return (ASCII 0DH). When this happens, the SR245 sends no response as it is waiting for the carriage return to end the command.
c) The initial command was invalid because of a "garbage character" which was sent by the computer when it was turned on.. It is good practice to send several carriage returns and a ?S when the program starts to clear out bad characters and any resulting errors.
d) The SR245 is not sending the correct 'end-of-record' marker for your computer. For example, it appears that Microsoft's Rev 3.2 FORTRAN on the IBM PC under DOS 2.0 requires two carriage returns for an end-of-record marker. The Z command can be used to set the SR245 end-of-record marker to 2 carriage returns. [The end-of-record marker is that sequence which indicates that the response is complete. From the keyboard, a single carriage return is the end-of-record marker.]
e) Answers are coming back from the SR245 too fast, overwriting the end-of-record markers, and causing the computer to hang waiting for a complete response. In this case, the W command can be used to slow down the response time of the SR245 preventing overwriting.

f) The command, though formatted correctly, was invalid due to incorrect initializing of the SR245 relative to the command: for example, S8=2 is an invalid command if port 8 has not been designated an output port. Note that a previous program or user can leave the SR245 initialized in a variety of configurations incompatible with your program. Including a MR in your program is good protection against this situation.
g) The command, though formatted correctly, was invalid due to parameter limitations such as: SC1:4000 overruns the memory; "S8=",A where the program has set A = 11 and is out-of-range; and A6,1 when port 8 was left at -1 volt.
h) A command was sent too early, as in asking for N prior to completing the scan.
i) The command was invalid due to syntax errors. These errors can occur simply, as in using "," instead of ";" to separate commands, or more obscurely, such as "S",A,"=5" where A is a variable which produces an error because it is sent with leading blanks. Leading blanks are allowed for variable settings, but not in command codes.

7) Incorrect Data. Finally, your program may successfully run but produce invalid data. This can occur through A/D overflows or missed data due to the trigger rate being to fast. In these cases, the red 'error' LED will flash but program execution will not be interrupted.

CALIBRATION

There are only two pots which are used to calibrate the SR245. These pots control the gain of the unit's DAC for negative and positive outputs. To calibrate the unit you will need a 4 1/2 digit voltmeter with a dc accuracy equal to or better than 0.02%, and an ASCII RS232 computer terminal.

Before starting, record the switch settings and the DCE/DTE jumper location so that the unit may be easily returned to service following calibration. To start, establish communications between the SR245 and the computer terminal by selecting the same baud rates, parity bits and stop bits. For a 9600 baud terminal with no parity bit, 8 bit data word and 2 stop bits, set the SR245 switches as in the RS232 example of Figure 2. Also, make sure that the jumper header is in the DCE position (bottom socket, near the back panel RS232 connector). Connect the terminal to the SR245's RS232 connector with a cable that has (at least) pins 2, 3, 5, 6 and 7. When the unit is plugged into the NIM crate and the crate's power turned on, the SR245 sign on message should appear on the terminal screen.

The object of the calibration is to set the gain of the DAC output for negative and then positive outputs. The calibration must be done in that order--negative first, then positive.

Connect the 4-1/2 digit voltmeter to analog output #1. Select the 20 VDC full scale range. Enter the commands as shown below (use the return key at the end of each line). In this procedure, the minus signs are important. [Comments are in square brackets]

```
OK->  I0          [No inputs, all outputs]
OK->  S1 = -0.1   [Set output #1 to -0.1 VDC]
```

Now, place the voltmeter in the relative position to null any offset which may be present (if your DVM does not have a relative button, you must remember the offset voltage: the object is to make the difference in the two readings equal to 10.000 VDC). Then send the command to set the output to -10.100V.

```
OK->  S1 = -10.1
```

Now, adjust P1, the top pot near the channel 3 input, so that the difference between the outputs reads -10.000 +/- .002 VDC.
Then send the command to set the output to +0.100V.

```
OK->  S1 = 0.1
```

Again, toggle the DVM's 'relative' button in order to null any offset. Then send the command to set the output to +10.100V.

```
OK->  S1 = 10.1
```

Now, adjust P2, the lower pot near channel #6 input BNC, so that the difference between the two output values is 10.000 +/- .002 VDC.

When the calibration is completed, return the switch settings and the DCE/DTE jumper to their original positions.

CIRCUIT DESCRIPTION

The SR245 is a microprocessor based instrument which may be used to input and output analog and digital voltages. The analog I/O is via front panel BNC connectors (8 channels); digital I/O is via front panel BNC connectors (two bits) and by a printed circuit board mounted 20 pin dual in-line connector (8 bits of input and 8 bits of output with strobes). The SR245 may be interfaced to computers by either the IEEE-488 (also known as the GPIB or HPIB) or by the RS232. The communication interface is defined by setting the configuration switch on the circuit board.

Analog voltages may be read or set over ±10.2375 VDC with a resolution of 2.5 mV, and an accuracy of +0.05%. Digital bits may be set, reset, tested and counted. One front panel bit is also used to synchronize data acquisition when the unit is programmed to acquire scans.

MICROPROCESSOR AND DIGITAL I/O

SR245 Schematic Page 1

The instrument uses a Z80-A CPU, U1. An 8K byte ROM, U2, is used for program storage and an 8K byte RAM, U3, is used for buffer memory. A power-on-reset circuit, C3 and U36, will restart the program whenever the unit is plugged into the NIM bin, or when the bin is turned on. The CPU is clocked at 4 MHz by a crystal control oscillator, U17. This clock is also divided down to generate other frequencies that are used by the communications circuits.

All of the I/O ports and VLSI devices are I/O mapped. U11, U18 and U19 serve as an I/O port decoder to select one device during I/O operations by the processor.

The 8 configuration switches are read through the octal buffer U12. (There are other hardware consequences of reading this port: the 12 bit DAC is cleared and the 8 bit offset DAC is loaded. More about this in the analog description.)

The 8253-5 programmable timer, U5, may be read, set and programmed by the Z80-A. This IC has three programmable counters: two are used to count digital pulses at the front panel BNC inputs, and the third is used to generate the x16 baud rate clock for the RS232 UART. This baud rate is derived from the 4MHz clock input.

The front panel digital bits may be read through part of U13, an octal tristate buffer. U13 also reads the "compare" bit (used in A/D conversion) and the DCE/DTE bit (from the RS232 interface).

The 8 bit digital I/O port, whose connector may be accessed by a ribbon cable from the rear of the module, is read through U14, an octal buffer. The separate 8 bit output port is set by an output to U16, an octal latch and driver. An input from U14 will generate a 600 nS, active low strobe signal which indicates that the input port is being read. This signal, "RD I/O", appears on pin 2 of the 20 pin connector. An output to U16 will generate a 600 nS, active low strobe signal, "WR I/O", which appears on pin 19 of the 20 pin connector. This signal indicates that the new data has been written to the 8 bit output port.

An 8 bit output latch, U15, is used to set the front panel digital bits high, low or off. When off, the bit may be used as an input. To see how this works, notice that when both bits Q0 and Q1 of U15 are low, transistors Q3 and Q4 are both off, so digital input #1 is a high impedance input which may be read by U13 or counted by U5. If bit Q0 is set high, transistor Q4 will be forced into saturation, grounding the digital output #1 through the current limiting 50 ohm resistor, R7. If bit Q0 is set low, and bit Q1 set high, then digital output #1 is pulled high by the emitter of Q3. The output current is limited by R6 to provide short circuit protection.

Other output bits of U15 are used to control the green ACTIVITY LED, D2, the red ERROR LED, D3, and to control certain aspects of A/D and D/A conversion (the 'POLARITY' and 'SAMPLE' bits).

ANALOG I/O

SR245 Schematic Page 2

A single 12 bit digital-to-analog converter, U20, is used in all of the analog input and output operations. A precision 10.240 VDC reference, U38, is used as a voltage reference for the 12 bit DAC. The DAC is loaded by the Z80, 4 bits at a time. A final write operation is used to transfer the 12 bit input to the DAC's internal control register.

An op amp (the first 1/4 of U26) is used to convert the DAC's output current to a voltage. In addition to the current from the 12 bit DAC, current from an eight bit DAC, U32, is summed at U26. This eight bit DAC is used to correct for offset errors which can accumulate as analog voltages pass through buffers, inverters, S/H amps and comparators. These offsets are carefully measured after the unit is manufactured, and values to compensate for these offsets are placed in the unit's ROM. At the start of any A/D or D/A conversion, the 12 bit DAC is cleared and the appropriate offset byte is loaded into U32 to eliminate the unwanted offset.

The DAC voltage may be inverted or not inverted by the 2/4 of U26 under the control of the POLARITY bit. If the polarity bit is low, the 2/4 of U26 is a precision inverter; if the polarity bit is high, it is a precision unity follower.

The DAC voltage may be multiplexed to one of eight sample and hold output amplifiers [U27, U28] which can provide analog outputs to the front panel. The processor refreshes these S/H amplifiers every few mS.

For a channel to become an output, the appropriate switch in U24 or U25 must be closed. When the switch is closed, current from the particular S/H amp will pull the front panel output to the programmed level. The analog switch's channel resistance (a few hundred Ω) is effectively eliminated by the high open loop gain of the S/H amp. Analog outputs have a measured resistance of less than 1Ω. The processor can select zero to eight of the channels as outputs.

A/D CONVERSION

The processor uses the offset-corrected 12 bit DAC to do analog-to-digital conversions on the inputs by programmed successive approximations. The processor selects 1 of 8 channels by the analog multiplexer, U23. The selected voltage is buffered by the 3/4 of U26 and sampled by the S/H amplifier (U21 and 4/4 U26.) This analog sample is passed to the comparator, U31, to be compared with outputs from the DAC. The processor will cause the DAC output to converge to the analog sample with 13 tests of the COMPARE bit (sign plus 12 bits) by the method of successive approximations. The A/D conversion process takes about 300μS.

The ADC may be done on a channel whether it has been set as an input or an output. As inputs, the channel impedance is 1Mμ (RN4). The input buffer amplifiers are protected from excessive inputs by the 10Kμ resistors of RN3.

COMMUNICATIONS INTERFACES

SR245 Schematic Page 3

RS232 INTERFACE

The RS232 interface uses an 8251 UART (U4) to send and receive bytes in a bit serial fashion. Any standard rate between 300 and 19,200 baud may be selected with the configuration switches. The x16 baud rate clock to the UART comes from the 8253 programmable counter/timer. A 2 MHz clock to the UART is derived from the 4 MHz CPU clock by U9. The number of stop bits and parity format can also be specified by the configuration switches. The RS232 interface can be configured as either DTE (Data Terminal Equipment) or DCE (Data Communications Equipment) by moving a 16 pin jumper assembly between two sockets on the circuit board. When a data byte is received by the UART, the RxRDY output is set high, which interrupts the Z80A in order to remove the character from the UART's receiver data register.

GPIB INTERFACE

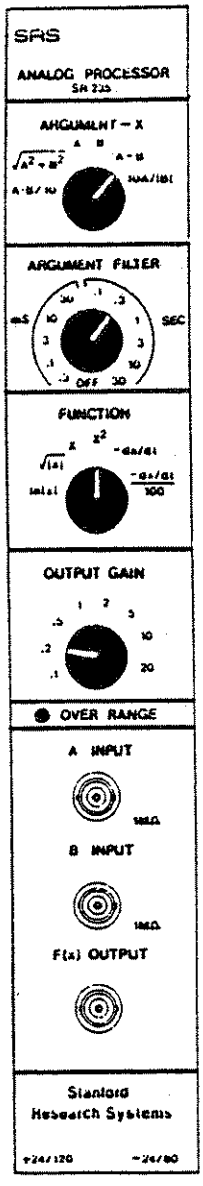
The interface between the SR245 and the GPIB is provided by the GPIB controller chip, U6, an MC68488. GPIB data and control lines are buffered by the bus drivers U7 and U8. The controller chip uses a 1MHz enable clock which is derived from the 4MHz CPU clock by U9. I/O transaction between the CPU and the controller chip must be synchronized to this 1MHz clock: U10 causes this synchronization to occur by making the CPU wait for up to 1μS whenever the controller chip is selected by the CPU.

The controller chip will interrupt the CPU whenever a transaction occurs on the GPIB which requires the CPU's intervention (such as the GPIB requesting data from the SR245). Most GPIB transactions, including transactions with other instruments, do not require the CPU's intervention. The SR245's address on the GPIB is set by the configuration switch when power is applied to the SR245.

INTRODUCTION

The SR235 Analog Processor module provides an analog output, F(x), which is formed from its analog inputs, A and B. The argument, x, is selected from A, B, A-B, AxB/10, 10xA/|B|, or $\sqrt{(A^2+B^2)}$. This argument may be filtered with a time constant from 0.3 ms to 30 s, or left unfiltered. The function may be any of x, x^2, $\sqrt{x}$, ln|x|, -dx/dt or (-dx/dt)/100. Finally, an output gain from 0.1 to 20 may be selected. 5ln(10A/B) for example, is available at the output.

The instrument provides many of the analog processing functions which are needed in an analog data acquisition system. The module may be used to ratio analog voltages, find peaks in experimental scans, linearize exponential decay curves, compress analog signals in order to increase dynamic range, or simply to amplify a signal.



SPECIFICATIONS

A and B Inputs	Input impedance of 1MΩ. Operating range of ± 10 Volts, protected to 100 Volts. Input offset voltage is less than 2mV.
Argument X	Select A, B, $\sqrt{(A^2+B^2)}$, A-B, AxB/10, or 10A/|B|.
Gain	Selectable gain from 0.1 to 20 in a 1, 2, 5, sequence.
F(x) Output	± 10 Volts linear range. Output impedance is less than 1Ω. Short circuit limits at 20 mA.
Over Range Indicator	Lights when input, output, or any intermediate signal is greater than ± 10 Volts.
Frequency Range	-dx/dt to 10 Hz, (-dx/dt)/100 to 1 KHz, $\sqrt{(A^2+B^2)}$ to 20 KHz, and all others from dc to 50 KHz.
Accuracy	Gain 2%, rms sum 3%, difference 1%, multiplication 2% of full scale, division (with denominator >0.1) 3% of full scale; ln|x|, x^2, $\sqrt{x}$ are accurate to ± 20 mV referenced to the input or at the output, whichever is less; -dx/dt and (-dx/dt)/100 5%.
Power	+24 V / 120mA, -24 V / 80mA. 5 watts total. Power from a NIM standard crate or from the Model SR280 mainframe.
Mechanical	Single width NIM Standard per TID-20893. Dimensions 1.35" x 8.71" x 11.5".
Warranty	One year parts and labor on materials and workmanship.

Figure 33 - SR235 Front Panel

OPERATION

The SR235 Analog Processor performs a wide variety of operations on one or both of the two analog inputs labeled 'A' and 'B'. The functions 'F(x)' available at the output are: x, x squared, log of the absolute value of x, square root of x, the time derivative of x, and the derivative of x divided by 100. The argument 'x' is chosen from A only, B only, the rms sum of A and B, the difference of A and B, the product of A and B divided by 10, and the quotient of A and the absolute value of B multiplied by 10. This argument may be filtered with a time constant from 0.3 ms to 30 s, or it may be left unfiltered. In addition, the output may be multiplied by a gain factor ranging from 0.1 to 20. Thus many complex operations may be performed simply by selecting among the various functions, arguments, and gains available at the front panel (Figure 33).

FUNCTION OF CONTROLS AND INDICATOR

ARGUMENT-X: a six position switch for selecting the argument of the function provided to the F(X) OUTPUT. The arguments which may be chosen are: A, B, √(A2+B2), A-B, AxB/10, and 10A/|B|.

ARGUMENT FILTER: a twelve position switch for selecting time constants from .3 ms to 30 s in a1, 3, 10 sequence. When the selector is placed in the 'OFF' position the argument is left unfiltered.

FUNCTION: a six position switch for selecting the function provided to the F(X) OUTPUT. The functions which may be chosen are: x, x2, √x, ln|x|, -dx/dt, and -(dx/dt)/100.

OUTPUT GAIN: an eight position switch which allows a gain factor of .1, .2, .5, 1, 2, 5, 10, or 20 to be applied to the output.

OVER RANGE: a red LED which lights whenever the input, output, or any intermediate signal exceeds ± 10 V.

OUTPUT CHARACTERISTICS

LOAD

The Analog Processor output can drive loads as small as 1 KΩ to full scale, and its output impedance is less than 1 Ω.

FREQUENCY RESPONSE

Most functions of the Analog Processor are capable of processing signals with frequencies up to at least 50 KHz. The frequency response of the rms adder rolls off at about 20 KHz. Bode plots for a few other functions are given in Figures 34-39. Figure 34 gives frequency response verses gain for arguments A, B, and A-B. The frequency response of the derivative circuits is plotted in Figure 35. A differentiator has a gain which is proportional to frequency, and so is sensitive to noise at high frequencies. In order to reduce this noise, the maximum gain of the differentiator circuits is limited to 100. For this reason -dx/dt acts as a differentiator only for frequencies below 10 Hz. Similarly, -(dx/dt)/100 acts as a differentiator only for frequencies below 1 KHz. A INPUT frequency response versus B INPUT dc bias for the multiply and divide circuits are graphed in Figures 36 and 37 respectively. In Figure 37 we see that the divider's frequency response is diminished for small denominators. In Figure 38, small signal gain with a 1 V dc bias is plotted for the square and square root functions. Frequency response curves versus input bias are given for the log function in Figure 39.

SOURCES OF ERROR

The linear range of inputs is ± 10 V. Input signals outside of this range will produce incorrect results, even if a gain is selected which would bring the output voltage within this range. The linear range for outputs is also ± 10 V. Thus output voltages outside of this range are probably incorrect, and it is up to the user to choose input signals or gains which bring the output within its linear range. The 'Over Range' indicator will light whenever the input, output, or any intermediate signal is outside of this linear range. On the high gain range, the input offset voltage is ± 2 mV, so that errors caused by this effect are less than 4% for inputs greater than 50 mV.

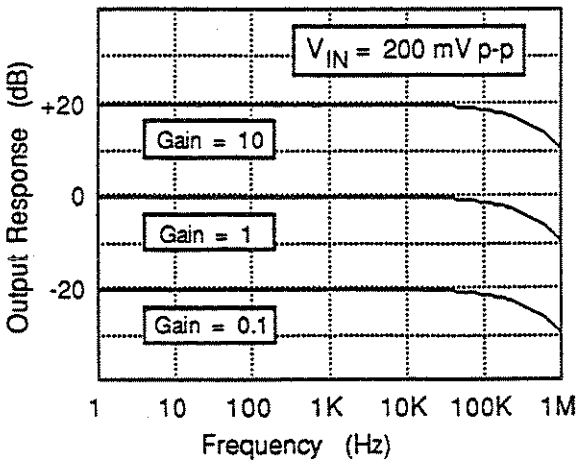


Figure 34 - Response of A, B, A-B

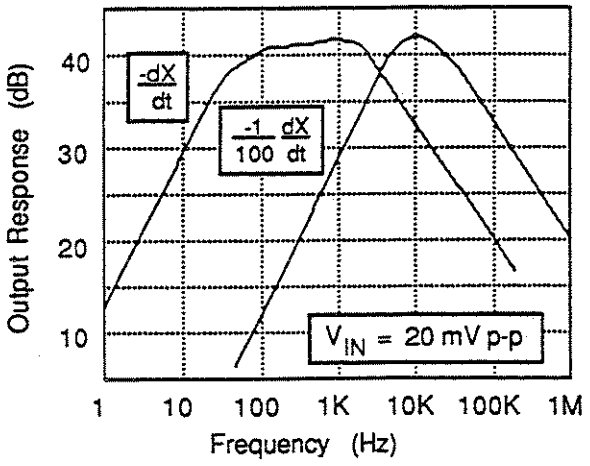


Figure 35 - Response of Derivatives

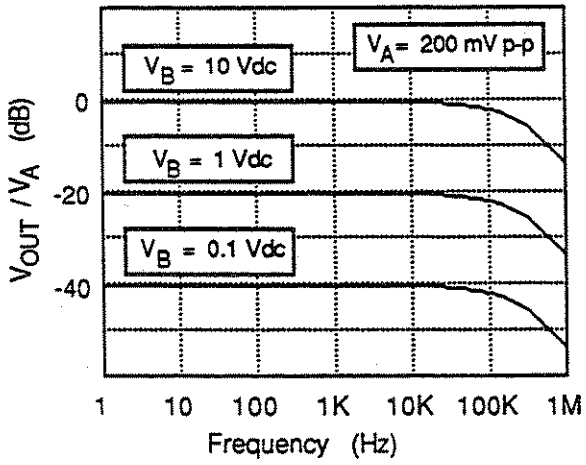


Figure 36 - Response of AxB/10

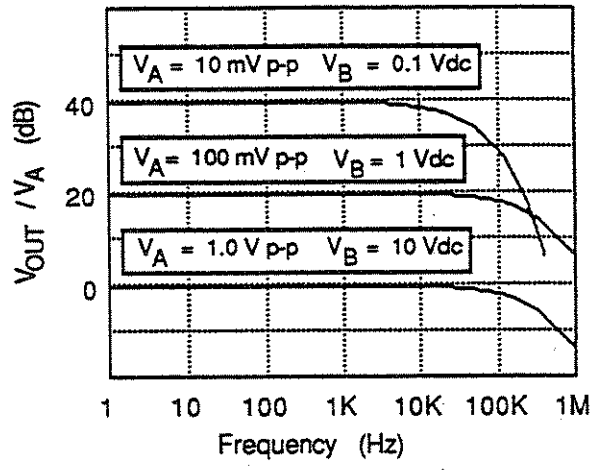


Figure 37 - Response of 10A/|B|

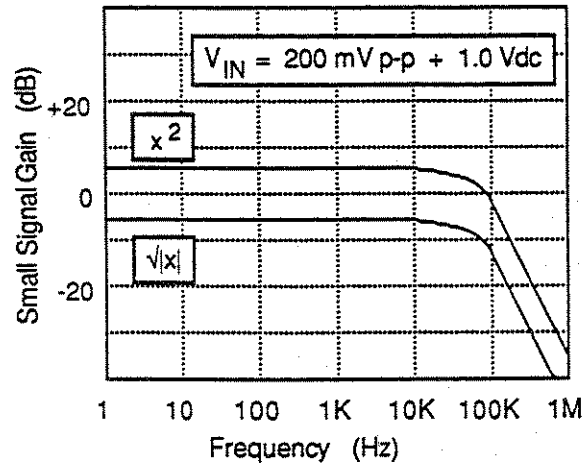


Figure 38 - Response of √x and x^2

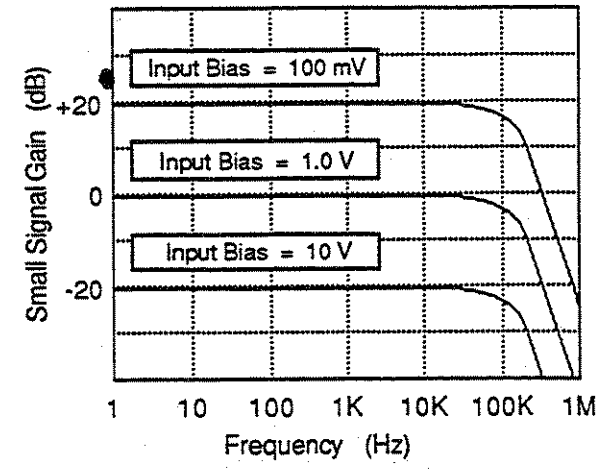


Figure 39 - Response of ln|x|

TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing +24 V and -24 V. Also check that the SR235 is firmly in place with mounting bolts screwed in.

CALIBRATION

The SR235 Analog Processor is calibrated by adjusting the six internal trim pots which are labeled P1 through P6. To make these adjustments a regulated variable dc power supply and voltmeter are required, and the right side panel of the NIM module must be removed to access the trim pots. The output gain should be set to '1', and the argument filter should be off.

P1 is the multiplier input offset trim. Leaving 'B INPUT' open, apply 10 V to 'A INPUT', and connect 'F(X) OUTPUT' to the V meter. Place the argument switch to 'AxB/10' and adjust P1 until 'F(X) OUTPUT' reads 0.00 V.

The rms adder is calibrated by adjusting P2 and P3. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the function switch to 'X' and adjust the input voltage until 500 mV is read at the output. Place the function switch to A2+B2, and adjust P2 until 500 mV is read at the output. Now connect the power supply to 'B INPUT', leaving 'A INPUT' open, and adjust P3 until 500 mV is read at the output.

The log function is calibrated by adjusting the log offset, P4, and the log scale, P5. Place the argument switch to 'A' and the function switch to 'X'. Connect the power supply to 'A INPUT' and the V meter to 'F(X) OUTPUT'. Adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'ln(X)' and adjust P4 until the meter reads 0.00 V. Place the function switch to 'X' and adjust the input voltage until the meter reads 10.00 V. Place the function switch to 'ln(X)' and adjust P5 until the meter at the output reads 2.30 V.

P6 is used to calibrate the square function. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the function switch to 'X' and adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'X2' and adjust P6 until 1.00 V is read at the output.

P7 is used to calibrate the square root function. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the function switch to '$\sqrt{|X|}$' and adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'X2' and adjust P7 until 1.00 V is read at the output.

CIRCUIT DESCRIPTION

Circuit descriptions for the SR235 will be given in terms of the elements which appear on the block diagram (Figure 40). Frequent references will also be made to the schematic diagram, given at the end of this manual.

A AND B INPUT BUFFERS

These circuits consist of dual op amp U1 and resistors R1 - R4. 2/2 U1 is a unity follower that buffers A INPUT, R2 sets the input impedance to 1 MΩ, and R1 protects the op amp by limiting the input current. The B INPUT buffer circuit is identical to the A INPUT buffer circuit.

A AND B ABSOLUTE VALUE

The absolute value of A is generated by dual op amp U2, diodes U19,5 - U19,8 and resistors R5, R6, and R19. The node where R5 and R6 are joined is the output. For A less than zero, the second half of U2 acts as an inverting amplifier with R19 and R6 setting the gain to unity. For A greater than zero, the first half of U2 acts as a unity follower. The absolute value of B is generated by dual op amp U3, diodes U19,1 - U19,4 and resistors R7, R8, and R20.

A MINUS B

1/2 U4 and resistors R9-R12 form the difference circuit. To see how this circuit works, notice that 1/2 U4 is a non-inverting, times 2 amplifier for the signal, A/2, provided to pin 3. 1/2 U4 is also an inverting, unity gain amplifier for the signal B. Thus the output of 1/2 U4 is A-B.

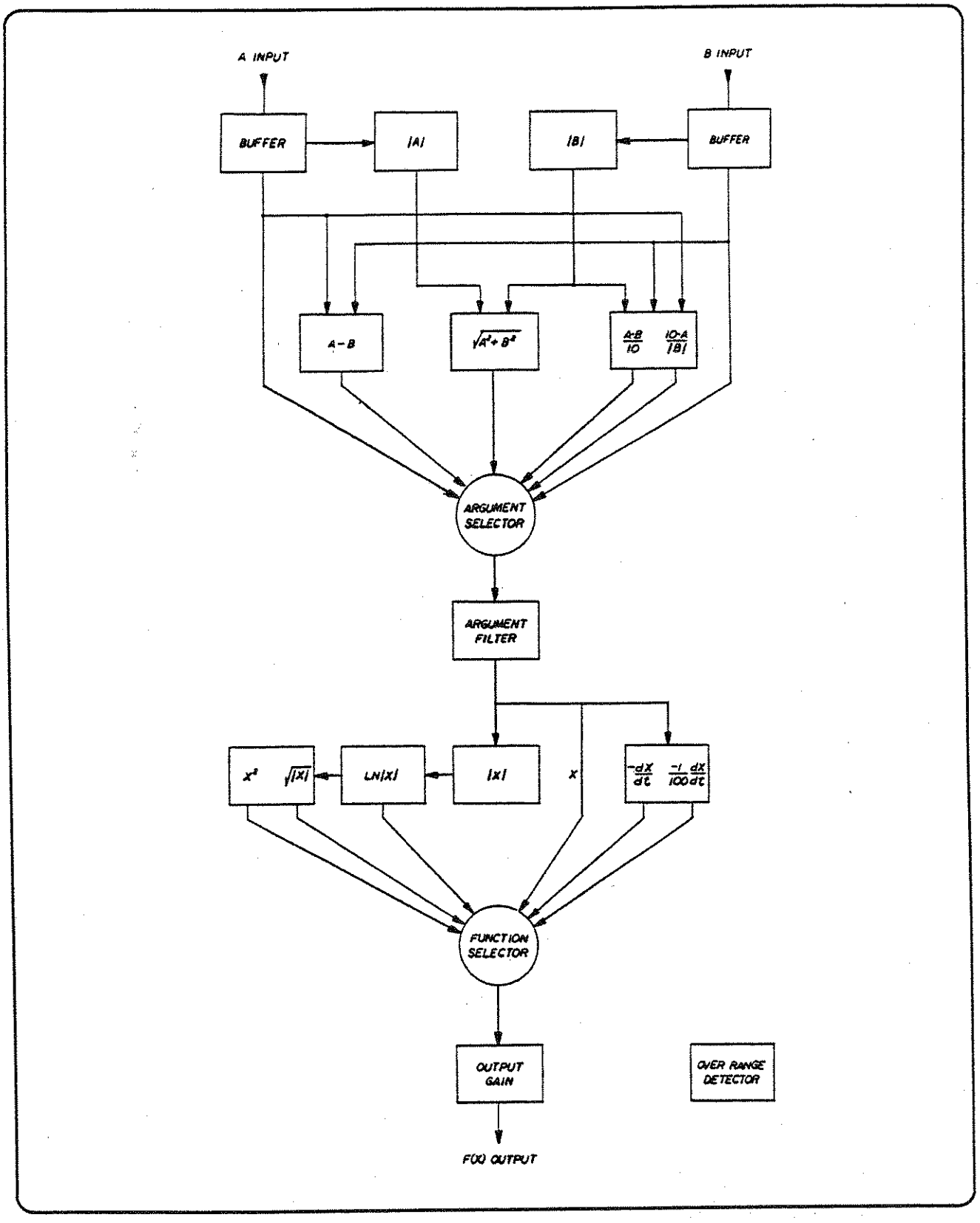


Figure 40 - SR235 Block Diagram

RMS SUM OF A AND B

The following components form the rms adder circuit: op amps 1/2 U5, 2/2 U5, 1/2 U6, 2/2 U6, 1/2 U11, and 1/4 U13; resistors R21-R33; capacitors C1, C2, and C25; diodes U20,6 and U20,7; pots P2 and P3; and transistor array U15. 1/4 U13, R25, and R26 generate a -5 V reference for the circuit. R21 and P2 convert the A input voltage to a current which equals the feedback current of op amp 1/2 U5. Due to the base-emitter characteristic of a transistor the voltage at U15 pin 10 is proportional to the log of the input voltage. 2/2 U5 and resistors R23 and R24 multiply the log of the input voltage by two, which is the square of the input. The current through U15 pin 1 is proportional to the exponential of one half this voltage when the B input is zero. The above description also holds for the B side of the rms adder circuit. The current through R27 is the sum of the currents through pins 1 and 5 of U15. 1/2 U11 and R27 convert this summed current into a voltage which equals the rms sum of the A and B input voltages.

MULTIPLICATION AND DIVISION

Both the multiply and divide functions are provided by U16 which is an AD534 precision IC multiplier. Besides A and B inputs, this circuit also requires the inverse of the absolute value of B. Op amp 2/2 U4, R13, and R14 invert the output of the absolute value of B circuit for this purpose. The switch configuration and resistors R15 and R16 provide necessary feedback paths. R17, R18, and potentiometer P1 provide the input offset trim. Instructions for making this adjustment are given in the calibration section.

ABSOLUTE VALUE OF X

The absolute value of X is used by the log, square, and square root functions allowing these functions to be defined for negative arguments. The dual op amp U8, diodes U20,1 - U20,4 and resistors R40-R42 belong to this circuit. The circuitry is identical to that of the absolute value of A.

LOGARITHM

The first two transistors of U14 form the core of the log circuit, which makes use of the log relationship between Vbe and Ic for a transistor. The first half of U9 and resistor R43 convert the input voltage into an input current Iin which becomes the collector current in the first transistor of U14. R45 and P4 determine the reference current, Iref, which becomes the collector current in the second transistor of U14. The voltage at the base of this transistor, pin 4, is then given by,

$$V_t * \ln(I_{REF}/I_{IN})$$

where Vt depends on temperature and is nominally 26 mV at room temperature. Changing P4 changes the reference current, thus changing the log offset. The second half of dual op amp U9 changes the log scale by factors of two and will be discussed in the following paragraph. R49, R50, R51, P5, and the second half of dual op amp U11 take care of the final scale factor adjustment. Changing P4 changes this scale, and instructions for making this adjustment, as well as for P4, are given in the calibration section. R49 is a thermistor which compensates the scale factor for the temperature dependence of Vt. Diode U20,5 prevents positive voltages, caused by small values of the argument, from heating the thermistor thus preventing erroneous temperature compensation.

SQUARE AND SQUARE ROOT

An antilog circuit is used in conjunction with the log circuit to provide square and square root functions. The following relationships are used:

$$x^2 = \exp(2*\ln(x)) \quad \text{and} \quad \sqrt{x} = \exp(\ln(x)/2)$$

The third and fourth transistors of U14, dual op amp U10, resistors R52-R54, and P6 comprise the antilog circuit. Its theory of operation is the same as that of the log circuit. P6 changes the reference current and therefore the antilog offset. The adjustment of P6 is explained in the calibration section. The gain of two required for the squaring operation is provided by the output of the second half of U10. The factor of one half required for the square root calculation is provided by R47 and R48. Temperature compensation is not required for the square and square root functions because the transistors are on the same monolithic chip and all thermal effects cancel.

DERIVATIVES

The differentiation circuit consists of resistors R55-R58, capacitor C7, and the first half of dual op amp U7. These components are connected to form a differentiator whose time constant varies with the position of switch SW3. Ignoring for the moment the presence of R55 and R56, the gain of this amplifier is -wRC where w is the frequency of the input, R is either R57 or R58, and C is C7. Because its gain is proportional to frequency, this circuit is a differentiator. For '-dX/dt' we have RC=1S, and for '-(dX/dt)/100' we have RC=.01S. In order to reduce high frequency noise, resistors R55 and R56 limit the maximum gain to 100. The transition frequency, above which the gain is limited to 100, is given by the product, RC, where R is either R55 or R56 and C isC7. For '-dX/dt' this frequency is 16 Hz, and for'-(dX/dt)/100' this frequency is 1.6 KHz.

OUTPUT GAIN

This circuit provides a gain factor, ranging from .1 to 20, to the signal at the output of the function selector. Op amp 2/2 U12, switch SW4, and resistors R59-R67 comprise this circuit. The op amp is in an inverting amplifier configuration with SW4 selecting the gain resistor.

OUTPUT BUFFER

Op amp 1/2 U12, capacitor C8, and resistors R68 and R69 comprise the output buffer which is designed to keep the output stable regardless of the output load. This buffer can drive loads as small as 1kΩ to full scale.

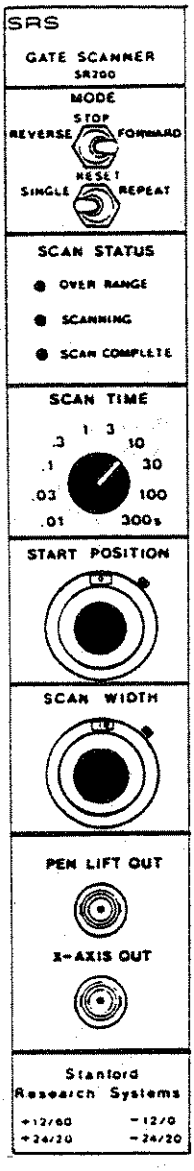
OVER RANGE DETECTOR

The following components are found in the over range detector circuit: diodes D22, U21,1 - U21,8 and U20,8; resistors R70-R80; op amps 2/4 U13, 3/4 U13, and 4/4 U13; capacitors C9 and C10; and LED D24. The five diodes U21,1 - U21,5 detect positive over ranges. The voltage at the common cathode of these diodes is .7 V less than the highest anode voltage. Op amp 4/4 U13 acts as a comparator which goes high whenever the diode common cathode voltage gets too high. Op amp 3/4 U13 is the comparator for negative over ranges. The time constant of R78 and C9 is the ignore time for the over range detector. Signals faster than 50 ms will not light the over range LED. The time constant of R79 and C10 determines the minimum time that the LED will remain lit.

INTRODUCTION

The SR250 Gated Integrator may be used to recover entire signal waveforms. A waveform is recorded by plotting the 'Average Output' vs. the 'Delay Multiplier' setting as the Delay Multiplier is slowly scanned. The SR200 Gate Scanner Module was designed to automate this procedure. This module provides the signals needed to scan the SR250's delay multiplier (to scan the sample gate through the waveform) and to control an X-Y chart recorder or strip chart recorder or oscilloscope.

When connected, the SR200 over-rides the delay multiplier dial on the SR250. The SR200 electronically scans the delay multiplier over a range specified by 10-turn dials on the SR200's front panel. Single or repeated scans may be done in the forward or reverse direction over any portion of the waveform. Scan times from 10 ms to 6 minutes may be selected. The X-axis output always ramps between 0 and 10 Vdc, regardless of the dial settings, providing a convenient interface to pen recorders and oscilloscopes.



SPECIFICATIONS

CONTROLS	
Reverse/Stop/Forward	Selects the scan direction or stops the scan.
Single/Reset/Repeat	Selects single or repeated scans or resets to start.
Scan Time	Selects time to complete one scan.
Start Position	Specifies the smallest Delay Multiplier in the scan.
Scan Width	Specifies the range of Delay Multipliers in the scan.
INDICATORS	
Over Range LED	Indicates that the delay multiplier exceeds 10.0.
Scanning LED	Indicates that a scan is in progress.
Scan Complete LED	Indicates that a single scan has been completed.
OUTPUTS	
Control Voltage	Rear panel output connects to the SR250 External Delay Multiplier Input. This output has an impedance of less than 1 Ω and current limits at 20 mA.
Pen Lift	Logic Signal to lift chart recorder pen or blank an oscilloscope trace.
X-Axis	Analog voltage output scans between 0 and 10.0 Vdc regardless of the start position and scan width dial settings.
GENERAL SPECIFICATIONS	
Power Supplies	+24V/20mA, +12V/80mA, 112V/0mA, 124V/20mA. 2 Watts total. Power from a NIM standard crate or from the SRS mainframe Model SR280.
Mechanical	Single Width NIM standard module per TID-20893. Dimensions 1.35"x8.714"x11.5".
Warranty	1 year parts and labor on materials and workmanship.

Figure 41 - SR200 Front Panel

OPERATION

The SR200 Gate Scanner gives the SR250 Gated Integrator and Boxcar Averager the capability ofoperating in a scanning gate mode. Sampled waveforms may be viewed on either a chart recorder or an oscilliscope. Sample averaging may be used to reduce background noise.

FUNCTION OF CONNECTORS

CONTROL VOLTAGE OUT: provides a ramp or saw-tooth waveform to the SR250's 'External Delay Control'. The 'Start Position', 'Scan Width', and 'Scan Time' controls determine the shape of this waveform, hence the details of how the gate delay is scanned. This connector is located on the rear panel of the SR200.

X-AXIS OUT: a 0 to 10 Volt ramp which connects to the x-axis of a chart recorder or oscilliscope.

PEN-LIFT OUT: connects to a chart recorder pen-lift or to an oscilliscope blanking input. A +3.6 Volt pulse indicates a retrace in progress. Removing internal jumper J1 allows the complement of this signal to be output.

FUNCTION OF CONTROLS

REVERSE/STOP/FORWARD: determines the direction of the scan, or stops a scan in progress, holding the gate in place.

SINGLE/RESET/REPEAT: determines whether a single scan or a repeat scan will be performed, or whether the gate should be reset to its start position.

SCAN TIME: a ten position switch for selection of a scan duration which ranges from 10 milliseconds to 300 seconds.

START POSITION: a ten-turn potentiometer for determining the starting delay of a forward scan, or the final delay of a reverse scan. The reading on the ten-turn dial may be multiplied by the delay range selected on the SR250 to give the actual starting delay.

SCAN WIDTH: a ten-turn potentiometer for determining the range of delays over which the scan will be taken. The reading on the ten-turn dial may be multiplied by the delay range selected on the SR250 to give the actual scan width.

FUNCTION OF INDICATORS

OVER RANGE: a red LED which indicates when the sum of 'Start Position' and 'Scan Width' total to a delay multiplier greater than 10.

SCANNING: an amber LED which indicates that a single or repeat scan is in progress.

SCAN COMPLETE: a green LED which indicates that a single scan is finished.

SET-UP

The 'Control Voltage' output on the rear panel of the Gate Scanner must be connected to the 'External Delay Control' on the rear of the Gated Integrator. This is the only connection between these two devices. The'Delay Multiplier' on the front of the Gated Integrator is now inactive, its function being assumed by the Gate Scanner. 'X-Axis Out' on the Gate Scanner is connected to the x-axis of a chart recorder or to the 'X' input of an oscilliscope in 'X-Y' mode. 'Averaged Output' on the Gated Integrator is connected to the y-axis of a chart recorder or to the 'Y' input of an oscilliscope in 'X-Y' mode. Finally, 'Pen Lift Out' on the Gate Scanner is connected to the pen lift input of a chart recorder or to the blanking input of an oscilliscope.

OPERATING INSTRUCTIONS

Set the Gate Scanner toggle switches to 'Stop' and 'Reset'. Adjust 'Start Position' to the delay multiplier that corresponds to the beginning of the desired scan. Adjust 'Scan Width' to the delay multiplier that corresponds to the width of the desired scan. Select a scan time. Select a 'Forward' or 'Reverse' scan. Select a 'Single' or 'Repeat' scan. An alternative way to adjust the 'Start Position' and 'Scan Width' is to view the signal to be scanned and the gate simultaneously on an oscilliscope. Set the toggle switches to 'Forward' and 'Reset', and adjust 'Start Position' until the gate overlaps the portion of the signal where the scan is to begin. Then set the toggle switches to 'Reverse' and 'Reset', and adjust 'Scan Width' until the gate overlaps the portion of the signal where the scan is to end.

TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing ±24 Volts and ±12 Volts. Also check that the SR200 is firmly in place with mounting bolts screwed in.

CALIBRATION

The SR200 Gate Scanner is calibrated by adjusting a single internal trim pot. Measure the voltage at pin 8 of U1 and adjust the trim pot until 10.00 volts is read.

CIRCUIT DESCRIPTION

ANALOG CIRCUITRY

The 'Control Voltage' output of the gate scanner is a ramp with variable offset, height, and slope. Ramps are generated by integrating a constant voltage, Vin,according to the following relation:

$$V_{out} = -(V_{in}/RC)*t$$

The integrator is the first op amp of quad op amp U1. The output of this op amp is a ramp between 0 and +10 Volts. Offsets and variations in height are added to this ramp later. An analog multiplexer, U9, selects among four constant voltages, Vin, to be integated, and the 'Scan Time' selector switch determines which resistors and capacitors will be used for this integration.

U9 is a dual 4 channel multiplexer. Inputs to the second half of this multiplexer are ±5 Volts with signs being determined by the upper and lower limit sense circuits. The output is fed to R10 to form the retrace ramp. Inputs to the first half of U9 are ±0.44 Volts. Resistive dividers composed of R1, R2, R3, and R4 provide these levels to the multiplexer. The output is fed to resistors R5, R6, R7, R8, and R9 to form the main ramp.

The upper and lower limit sense circuits determine when the output of the integrator is outside of the 0 to 10 Volt range. The lower limit sense circuit is comprised of the first op amp of quad op amp U2, resistors R12, R14, R16, and capacitor C4. The output of this circuit is +5 Volts unless the ramp voltage goes below zero, after which the output is -5 Volts. The upper limit sense circuit is comprised of the second op amp of U2, resistors R11, R13, R15, and capacitor C3. This circuit compares the ramp voltage with a 10 volt reference. It outputs +5 Volts if the ramp is above 10 Volts and -5 Volts otherwise.

The logic level translation circuitry converts these ±5 Volt signals to 5/0 Volt signals which are then compatible with the logic circuits. The upper limit translation circuit consists of the second op amp of U1, and resistors R17, R19, R21, R23, and R25. Its output is 5 Volts when the upper limit is sensed and 0 otherwise. The lower limit translation circuit consists of the fourth op amp of U1, R18, R20, R22, R24, and R26. Its output is 5 Volts when the lower limit is sensed and 0 otherwise.

The 10 Volt reference consists of the third op amp of U1, trim pot P3, resistors R29, R30, and capacitor C8. P3 is adjusted to make the output equal to 10.00 Volts.

The 0 to 10 Volt ramp becomes the 'X-Axis' output after passing through an output buffer consisting of the first op amp of quad op amp U3, resistors R38, R39, and capacitor C6. This buffer keeps the output stable for loads greater than 2KΩ.

Offset and height modifications are made to the 0 to 10 Volt ramp which then becames the 'Control Voltage' output. The 0 to 10 Volt ramp is reduced in height by the 'Scan Width' potentiometer, P2, and buffered by the fourth op amp of U2 which is a unity follower. The 'Start Position' potentiometer, P1, provides a dc level between 0 and 10 Volts, which is buffered by the third op amp of U2. These 'Start Position' and 'Scan Width' signals are then added together by the second op amp of U3 and R31-R34. The output of this adder becomes the 'Control Voltage' after it passes through an output buffer consisting of the fourth op amp of U3, resistors R40, R41, and capacitor C7.

The 'Over Range' indicator lights up when the output of the adder exceeds 10 Volts. The third op amp of U3 compares the output of the adder with the 10 volt reference and outputs +13 Volts if the adder is greater than 10 Volts, and -13 Volts otherwise. R35 and R36 reduce these levels to

±5 Volts. The voltage at the cathode of D1 is +5 Volts when there is an over range and zero otherwise. These +5 Volt signals charge up C5 which is bled off by R37 with a time constant of .1 seconds, thus stretching the duration of short pulses. The fourth gate of quad exclusive OR U7 acts as an impedance buffer to prevent current into the base of Q4 from bleeding C5 too fast. A 5 volt level at the base of Q4 turns this transistor on and lights up the 'Over Range' LED.

DIGITAL CIRCUITRY

The inputs to the digital circuitry are the 'Reverse/Stop/Forward' & 'Single/Reset/Repeat' toggle switches on the front panel, and the upper and lower limit signals from the analog circuitry: UPPER and LOWER. Outputs from the digital circuitry are the 'Scanning' and 'Scan Complete' indicators, the 'Pen Up' output, and the control signals for the analog multiplexer: HOLD, SEEK, and DIRECTION. Figure 42 gives the state of each control signal when the 'Gate Scanner' is performing various functions.

REVERSE SINGLE SCAN

Toggle Switches		Control Lines									Indication	
Rev / Stop / For	Sing / Res / Rep	FOR	SING	UPP	LOW	PEN	END	HOLD	SEEK	DIR	S.	S.C.
x	x	0	Q	1	0	0	0	0	1	1		
x	x	0	1	0	0	0	0	0	0	0	x	
x	x	0	1	0	1	1	1	0	1	1		x

FORWARD SINGLE SCAN WITH STOP

Toggle Switches		Control Lines									Indication	
Rev / Stop / For	Sing / Res / Rep	FOR	SING	UPP	LOW	PEN	END	HOLD	SEEK	DIR	S.	S.C.
x	x	1	Q	0	1	0	0	0	1	0		
x	x	1	1	0	0	0	0	0	0	1	x	
x	x	1	1	0	0	0	0	1	0	1	x	
x	x	1	1	0	0	0	0	0	0	1	x	
x	x	1	1	1	0	1	1	0	1	0		x

FORWARD REPEAT SCAN

Toggle Switches		Control Lines									Indication	
Rev / Stop / For	Sing / Res / Rep	FOR	SING	UPP	LOW	PEN	END	HOLD	SEEK	DIR	S.	S.C.
x	x	1	Q	0	1	0	0	0	1	1		
x	x	1	0	0	0	0	0	0	0	1		
x	x	1	0	1	0	1	0	0	1	1	x	
x	x	1	0	0	0	1	0	0	1	1		
x	x	1	0	0	1	0	0	0	0	1	x	
x	x	1	0	0	0	0	0	0	0	1	x	
x	x	1	0	1	0	1	0	0	1	1		

Figure 42 - Gate Scaner Logic Table

INTRODUCTION

The SR280 System Mainframe provides power to SRS modules and has three displays for monitoring outputs. This mainframe is NIM compatible so that modules from other manufacturers may be used in the SRS system. NIM refers to the nuclear instrument module standard developed by the AEC NIM committee in 1964 and described in report TID-20893. In the SR280 System Mainframe, the three rightmost slots of a standard NIM bin are filled by the display module and unregulated power supply. This leaves 9 slots available for other NIM modules. The dc power supply regulators are mounted on a heat sink on the rear of the mainframe. Regulated + and - 12 Vdc, regulated + and - 24 Vdc , and 120 Vac are bussed to each of the slots. The Mainframe may be mounted on a 19" rack, but also has feet for table top use.

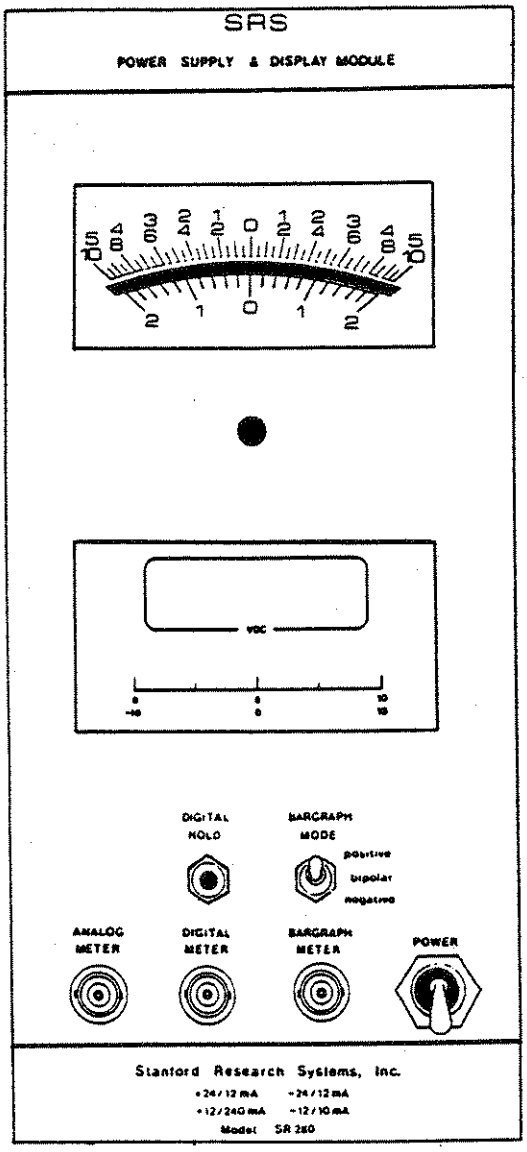


Figure 43 - SR280 Front Panel

SPECIFICATIONS

Input Voltage	120, 220 Vac
Input Voltage Range	120: +8% -8% of nominal 220: +10% -6% of nominal
Input Current	3Amps max. at 120 Vac
Output Voltages	±12 Vdc, ±24 Vdc,120 Vac
Output Currents	2 Amps ±12 Vdc 1 Amp ±24 Vdc 1 Amp 120 Vac
Output Voltage Adjustment	1%
Adjustment Accuracy	.05%
Load Regulation	.1% (±12 Vdc) .3% (±24 Vdc)
Line Regulation	.1%
Output Impedance	< .3 Ω
Combined Noise and Ripple	< 3 mV peak to peak
Temperature Coefficient	< 200 ppm/°C
Display Inputs	1 MΩ input impedance ±10 Volt operating range 100 Volt protection
Analog Meter	zero center, 2% accuracy
Digital Meter	3-1/2 digit, .25% accuracy
Bargraph Meter	20 segments, 2% accuracy, 5% resolution
Mechanical	16.875" x 8.714" x 13.0"
Warranty	1 year parts and labor on materials and workmanship.

The display module features three types of display meters. The analog meter has a high torque, 100°, taut band d'Arsonval movement. It is a zero center, ±10 dc Voltmeter with 2% accuracy. The digital meter uses dual slope integration to provide readings accurate to .25%. This meter samples dc voltages between + and - 10 Volts at a rate of 3 readings per second, and has a 3-1/2 digit seven segment LED display. The 'Digital Hold' button may be used to hold the digital meter's reading. The bargraph meter is best suited for displaying rapidly changing data. It has a bandwidth of 50 KHz, 2% accuracy, and 5% resolution. The bargraph has three display modes: 'positive' for 0 to 10 Volts, 'bipolar' for -10 to +10 Volts, and 'negative' for 0 to -10 Volts. In the 'positive' and 'negative' modes, the display is a bargraph so that all LED's from the reading to zero light up. In the 'bipolar' mode, a dot display is used so that only the LED corresponding to the voltage reading lights up.

TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. Check that the line cord is in place, the display module is firmly attached to the chassis, the fuses are intact, and the power switch is in the up position.

CALIBRATION

SUPPLY VOLTAGES

The dc output voltages should be calibrated with a load about equal to half of full load, and only after the supply has warmed up. Each supply may be calibrated individually by turning the appropriate trim pot and measuring the output voltage with a Voltmeter. The trim pots can be accessed by removing the four mounting screws on the back of the heatsink.

DISPLAYS

The analog meter can be zeroed by turning the front panel adjust screw until the needle is lined up with zero, pointing straight up. This adjustment must be made when there is no voltage connected to the input. The digital meter is calibrated by applying 10 Volts to the input and adjusting the internal trim pot until 10.00 Volts is read on the display. The trim pot may be accessed by sliding open the right side panel of the Display Module. The bargraph meter cannot be calibrated.

CIRCUIT DESCRIPTION

POWER SUPPLY

The unregulated power supply consists of two dual complementary full wave center-tapped rectifier circuits. The transformer has a dual primary which can be wired in parallel or series for 120 or 220 Vac respectively. In some models the primary has a tap for 100 Vac. In all cases, 120 Vac is wired to the bin supplies through its own 1 Amp fuse. The transformer has two center-tapped secondaries of 28 and 48 Vac to provide unregulated 20 and 32 Vdc to the regulator circuit.

The regulator circuits for +12, +24, and -24 V are essentially the same, so only the +24 V supply will be described. The output of U1 is 1.25 V between pins 1 and 3. R1, R2, and P1 bring the voltage between the output and ground to about 24 V. Adjusting P1 changes this output voltage. C1 and C3 are bypass capacitors which improve output stability. C2 improves the ripple rejection of the circuit. D1 protects the regulator from discharge of C3 when the input is shorted, and D2 protects the regulator from discharge of C2 when either the input or the output is shorted.

The circuit for the -12 V supply is the same as for the other supplies except that op amp U5 has been added to improve stability. Its presence assures that variations in current at pin 1 of U4 will not affect the output voltage.

DISPLAY MODULE

The analog meter circuit consists of the meter movement, an op amp, and two resistors. Op amp 2/4 U4 acts as a buffer, R22 sets the input impedance to 1 MΩ, and R21 protects the op amp by limiting its input current.

The digital meter circuit consists of an ICL7117 analog to digital converter connected to a 3-1/2 digit display. Resistors R4 and R5 scale down the

input by a factor of ten and provide 1 MΩ of input impedance. P1 is a 20-turn trim pot used to calibrate the output. SW1 is the digital hold button. R9 turns on the decimal point LED.

The twenty LED segments of the bargraph meter are controlled by two dot/bar display driver IC's. These two IC's are configured to read voltages ranging from 0 to 2.5 V. A set of op amps is used to convert the three front panel modes to this range. The mode is selected at switch SW2-1. Resistors R10 and R11 divide the input by 4 and insure a 1MΩ input impedance. Op amp 3/4 U4 buffers the input and provides the proper voltage for the positive mode to position 1 of SW2-1. Op amp 4/4 U4 inverts the previous voltage for the negative mode at position 3 of SW2-1. Op amp 1/4 U4 amplifies the reference voltage of U2 to 2.5 V, so that the voltage at the node between R14 and R15 is in the correct range for the bipolar mode. The outputs of 3/4 U4 and 4/4 U4 override this voltage unless the center position of SW2-1 is selected. Switches SW2-2 and SW2-3 select whether a dot or bargraph display will be used in each mode. If jumpers J1 and J2 are cut, all three modes will have a dot display.

INTRODUCTION

The display module features three types of display meters. The analog meter has a high torque, 100°, taut band d'Arsonval movement. It is a zero center, ±10 dc voltmeter with 2% accuracy. The digital meter uses dual slope integration to provide readings accurate to .25%. This meter samples dc voltages between + and - 10 Volts at a rate of 3 readings per second, and has a 3-1/2 digit seven segment LED display. The 'Digital Hold' button may be used to hold the digital meter's reading.

The bargraph meter is best suited for displaying rapidly changing data. It has a bandwidth of 50 KHz, 2% accuracy, and 5% resolution. The bargraph has three display modes: 'positive' for 0 to 10 Volts, 'bipolar' for -10 to +10 Volts, and 'negative' for 0 to -10 Volts. In the 'positive' and 'negative' modes, the display is a bargraph so that all LED's from the reading to zero light up. In the 'bipolar' mode, a dot display is used so that only the LED corresponding to the voltage reading lights up.

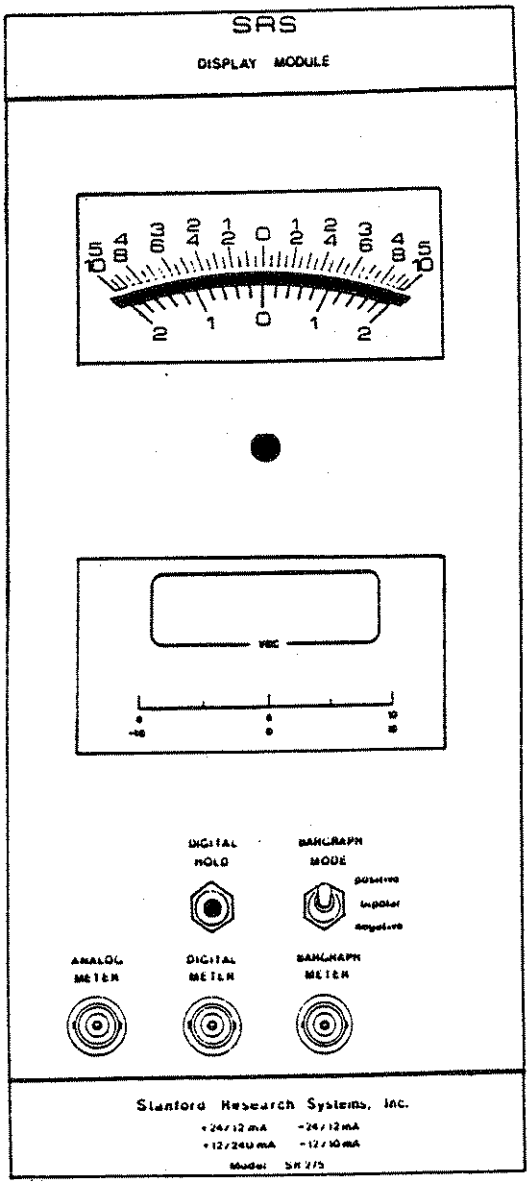


Figure 44 - SR275 Front Panel

SPECIFICATIONS

Input Impedance	1 MΩ
Operating Range	-10 to +10 Volts
Protection	100 Volts
Analog Meter	zero center, 2% accuracy
Digital Meter	3-1/2 digit, .25% accuracy
Bargraph Meter	20 segments, 2% accuracy, 5% resolution
Power	NIM standard crate +24 / 12 mA, -24 / 12 mA +12 / 240 mA, -12 / 10 mA 3.6 Watts total
Mechanical	4.05" x 8.714" x 11.5"
Warranty	1 year parts and labor on materials and workmanship.

TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing ±24 Volts and ±12 Volts. Also check that the SR275 is firmly in place with mounting bolts screwed in.

CALIBRATION

The analog meter can be zeroed by turning the front panel adjust screw until the needle is lined up with zero, pointing straight up. This adjustment must be made when there is no voltage connected to the input. The digital meter is calibrated by applying 10 Volts to the input and adjusting the internal trim pot until 10.00 Volts is read on the display. The trim pot may be accessed by sliding open the right side panel of the Display Module. The bargraph meter cannot be calibrated.

CIRCUIT DESCRIPTION

The analog meter circuit consists of the meter movement, an op amp, and two resistors. Op amp 2/4 U4 acts as a buffer, R22 sets the input impedance to 1 MΩ, and R21 protects the op amp by limiting its input current.

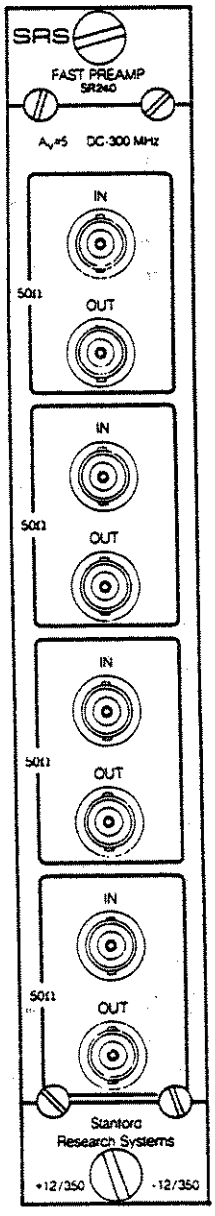
The digital meter circuit consists of an ICL7117 analog to digital converter connected to a 3-1/2 digit display. Resistors R4 and R5 scale down the input by a factor of ten and provide 1 MΩ of input impedance. P1 is a 20-turn trim pot used to calibrate the output. SW1 is the digital hold button. R9 turns on the decimal point LED.

The twenty LED segments of the bargraph meter are controlled by two dot/bar display driver IC's. These two IC's are configured to read voltages ranging from 0 to 2.5 V. A set of op amps is used to convert the three front panel modes to this range. The mode is selected at switch SW2-1. Resistors R10 and R11 divide the input by 4 and insure a 1 MΩ input impedance. Op amp 3/4 U4 buffers the input and provides the proper voltage for the positive mode to position 1 of SW2-1. Op amp 4/4 U4 inverts the previous voltage for the negative mode at position 3 of SW2-1. Op amp 1/4 U4 amplifies the reference voltage of U2 to 2.5 V, so that the voltage at the node between R14 and R15 is in the correct range for the bipolar mode. The outputs of 3/4 U4 and 4/4 U4 override this voltage unless the center position of SW2-1 is selected. Switches SW2-2 and SW2-3 select whether a dot or bargraph display will be used in each mode. If jumpers J1 and J2 are cut, all three modes will have a dot display.

INTRODUCTION

The Model SR240 Fast Preamp contains four wide bandwidth, DC coupled amplifiers designed to be used independently or cascaded to provide gains of 5, 25, and 125.

The fast rise time, low noise, and DC accuracy of the SR240 make it the ideal instrument for amplifying outputs of fast photomultiplier tubes and photodiodes.



SPECIFICATIONS

INPUTS	50 Ω impedance, DC coupled, BNC connectors.
OUTPUTS	DC coupled, BNC connectors (terminate into 50 Ω).
VOLTAGE GAIN	5.0 per channel (up to 3 channels can be cascaded).
BANDWIDTH	DC to 300 MHz (-3 dB).
RISE/FALL TIME	1.2 ns.
PROPAGATION DELAY	2.2 ns.
RECOVERY TIME	< 4 ns for a times 20 overload.
OPERATING RANGE	inputs ± 200 mV, outputs ± 1.0 V.
OVERSHOOT	± 5%.
NOISE	< 50 μV rms referenced to the input, (2.2 nV/√Hz).
STABILITY	10 μV/°C referenced to the inputs (0 - 50°C).
OFFSET	input ± 50 μV (adjustable).
PROTECTION	± 3.5 V DC, ± 50 V transient.
MECHANICAL	Single width NIM module per TID-20893.
POWER	+12V/200 mA, -12V/200 mA. Power from a NIM crate or the SR280 Mainframe.
WARRANTY	One year parts and labor on materials and workmanship.

Figure 45
SR240 FRONT PANEL

OPERATION

The SR240 Fast Preamplifier is useful for amplifying small signals to levels that allow processing by other instruments such as the SR430 Multichannel Scaler, or the SR400 Gated Photon Counter. The four channels may be used independently or cascaded. The following table shows the maximum input voltage for linear operation as a function of amplitude gain.

Number of Channels	Gain	Maximum Input
1	5	200 mV
2	25	40 mV
3	125	8 mV

TROUBLESHOOTING

The diodes in the overload protection circuit can be damaged by excessive voltages at the input of any stage. To check for damage, measure for 0.6 Volts across diodes D1 through D4. Recalibration is necessary if any of the diodes are changed.

CALIBRATION

There are two rows of 4 holes in the cover which access the offset calibration pots. The first row is the input offset adjust, and the second row the output offset adjust.

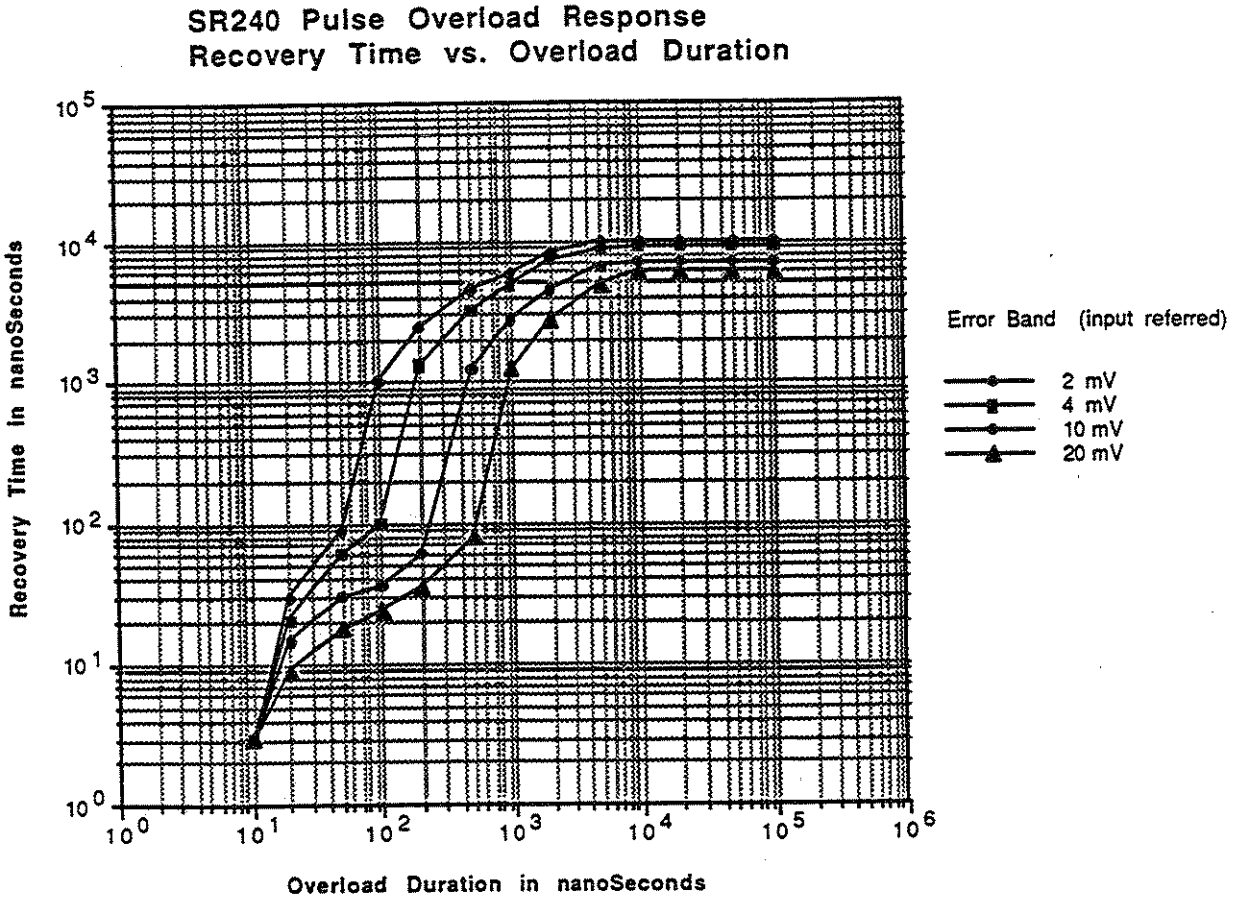
Allow at least 30 minutes for the unit to warm up before calibrating. To calibrate the input offset, connect a voltmeter to the input and adjust the pot at the front hole in line with that channel to 0.0 V ±10 μV. To calibrate the output offset, connect a voltmeter to the output and adjust the pot at the back hole in line with that channel to 0.0 V ±50 μV.

CIRCUIT DESCRIPTION

Input signal coupling is provided by D1, D2, D3, and D4 which are biased by R14, R8, R9, and R27. Positive overload protection is supplied by the action of Q6 and D10. When the output reaches +1.25 volts, Q6 begins to conduct, stealing bias current from D1 and D3. Thus, the input voltage is effectively clamped at ±0.25 volts. Similarly, Q5 and D8 provide negative overload protection. Input offsets are nulled out with P1. SW1 allows the channel 1 input impedance to be increased to 500 ohms by the use of bootstrapping. Q1 and Q2 comprise a fully symmetrical push-pull output stage that is driven by the complimentary pair of Q3 and Q4. U1 uses feedback to maintain DC accuracy and P2 adjusts the output offset voltage of the amplifier.

OVERLOAD BEHAVIOR

The SR240 accurately amplifies input signals from -200 mV to +200 mV. Transient overloads to ±50 volts can be safely accommodated, and DC inputs up to ±3.5 volts will not damage the unit. The time required for the amplifier output to return from an overload condition is a function of the duration of the overload and the error allowance of the application. A graph of recovery time versus overload duration is shown on page 78a. The input referred error bands are defined as the voltage difference between the input signal and the output voltage divided by the amplifier gain (5 volts/volt). For example, after a 100 nanosecond overload, 1 microsecond is required to reach 2 mV accuracy (input referred). However, if 20 mV accuracy is sufficient, then the amplifier will recover from the same overload in 20 nanoseconds.

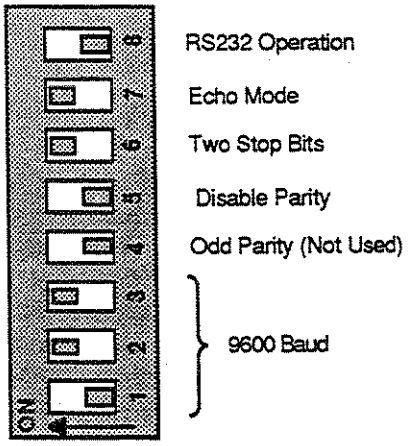

SR240 Pulse Overload Response
Recovery Time vs. Overload Duration
Recovery Time in nanoSeconds
10^5
10^4
10^3
10^2
10^1
10^0
10^0 10^1 10^2 10^3 10^4 10^5 10^6
Overload Duration in nanoSeconds
Error Band (input referred)
2 mV
4 mV
10 mV
20 mV

EXAMPLE 1 - RS232 COMPUTER TERMINAL

This example will allow you to communicate with the SR245 from a standard RS232 computer terminal.

1. Configure an ASCII terminal for 9600 baud, two stop bits, no parity bits, and 8 data bits.

2. Set the SR245 configuration switch as follows:



3. Place the 16 pin header in the socket marked 'DCE' (the lower socket of two, located near the RS232 connector on the inside of the SR245.)

4. Turn the NIM bin off, then on, to reset the SR245. The copyright sign-on message should appear on the screen along with the prompt 'OK->'.

5. Set voltages at the outputs and check them with a voltmeter as follows:

```
OK-> I0
OK-> S1=8
OK-> S2=7
OK-> S3=6
OK-> S4=5
OK-> S5=4
OK-> S6=3
OK-> S7=2
OK-> S8=1
OK-> ?1;?2;?3;?4;?5;?6;?7;?8
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
OK-> W0;?1;?2;?3;?4;?5;?6;?7;?8
```

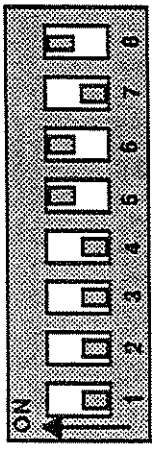
EXAMPLE 2 - HP85 VIA GPIB (HPIB, IEEE-488)

This program provides an example of an HP85 program using the HPIB interface which could be used to control a Boxcar Averager gate delay and retrieve and print the integrated outputs. The program self-triggers 100 times, provides an output ramp on port 8 from 1 to 5.5 volts (delay control voltage), and measures the the voltage at port one for each trigger (Boxcar Output.) The following hardware connections and settings must be made.

Connection:

ports B1 to B2	provide trigger (connect to Boxcar trig. also if desired)
port 8 to voltmeter	view voltage ramp (connect to Boxcar delay if desired)
port 1 to a voltage	measure output (connect to Boxcar last sample if desired)

Configuration Switch:



GPIB Operation

No Echo

Two Stop Bits (Not Used)

GPIB Address = 16

Note:

When using the SR245 and the GPIB with certain computers, notably the HP 98XX series, a few precautions are necessary when sending the SR245 several commands on a single line. With these computers the following piece of BASIC code will not work:

```
10 OUTPUT 716; "?1; ?2"
20 ENTER 716; A, B
```

(assuming the SR245 address is 716)

This is because of a conflict in the terminating sequence expected by the computer and the one sent by the SR245. The SR245 provides (normally) a CR LF at the end of each answer it sends. The computers in question expect a CR separating each value on a CR LF at the end of a complete line. The problem can be easily solved by using the following alternate piece of code:

```
10 OUTPUT 716; "?1; ?2"
20 ENTER 716; A
30 ENTER 716; B
```

Note that this is not necessary on all computers, and is only an issue when using the GPIB. If any doubt exists, try both methods and see which one works.

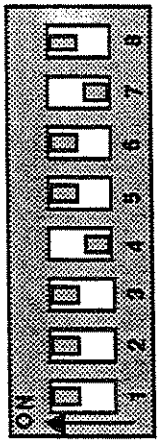
Program:

```
100 OUTPUT 716 ; "MR"
110 OUTPUT 716; "I4; MS; A18,1; T1; ET; W0"
130 OUTPUT 716; "S8=1"
135 OUTPUT 716; "SC1,8:100"
136 FOR I = 1 TO 100
137 OUTPUT 716; "PB2"
138 NEXT I
140 FOR I = 1 TO 100
150 OUTPUT 716; "N; N"
170 ENTER 716; A, D
180 PRINT A, D
270 NEXT I
400 END
```

EXAMPLE 3 - IBM PC VIA GPIB (INTERPRETED BASIC)

This program requires the Capital Equipment Corporation GPIB card which is a short card for the IBM PC or XT and has firmware in ROM to interface high level languages to the GPIB. In this program, the CEC card's ROM starts at OC0000H, the system controller's address is 21 and the SR245 has been assigned as GPIB address 23.

The configuration switch on the SR245 should be set as follows:



GPIB Operation

No Echo

Two Stop Bits (Not Used)

GPIB Address = 23

Calls in Microsoft's BASIC for the PC are done to memory locations specified by the name of the subroutine. The address is relative to the segment address specified by the DEF SEG statement preceding CALL.

To monitor the GPIB activity with an RS232 terminal, switch 7 should be set to ON, the SR245 configured as a DCE, and the ASCII terminal attached to the appropriate pin of the RS232. The terminal should be set for 9600 Baud, 8 data bits, 2 stop bits, and no parity.

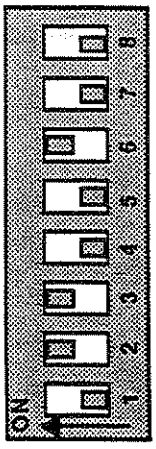
Program:

```
10   'GPIB TEST ROUTINE
20   'SENDS ?1 CONTINUALLY AND PRINTS RESPONSE
30   '
40   CLS
50   DEF SEG =&HC000              'ADDRESS OF CONTROLLER CARD
60   S$=SPACE$(80)                'USED TO ERASE INPUT LINE
70   INIT=0: TRANSMIT=3: RECV=6: ADDR%=21: SYS.CONT%=0
80   CALL INIT(ADDR%, SYS.CONT%)
90   A$= "IFC MTA LISTEN 23 DATA '?1' 13"
100  B$= "UNL MLA TALK 23"
110  ANS$=SPACE$(10)
120  CALL TRANSMIT(A$, STATUS%)
130  IF STATUS%<>0 GOTO 200
140  CALL TRANSMIT(B$, STATUS%)
150  IF STATUS%<>0 GOTO 200
160  CALL RECV(ANS$, LENGTH%, STAUS%)
170  IF STATUS%<>0 GOTO 200
180  PRINT USING "##.###"; VAL(ANS$)
190  GOTO 120
200  PRINT "STATUS CODE ="; STATUS%
210  STOP
220  END
```

EXAMPLE 4 - IBM PC VIA RS232 (BASIC)

In this example, the IBM PC's "ASYNC" port (known as COM1: or AUX: to DOS users) will be used to communicate with the SR245. Only two wires between the IBM PC ASYNC port and the SR245 are required (pins #2 and #3 of RS232), but pins # 5,6,8,and 20 should be connected together on the connector at the IBM end.

Set the switches of the SR245 as follows:



RS232 Operation

Disable Echo

Two Stop Bits

Disable Parity

Odd Parity (Not Used)

9600 Baud

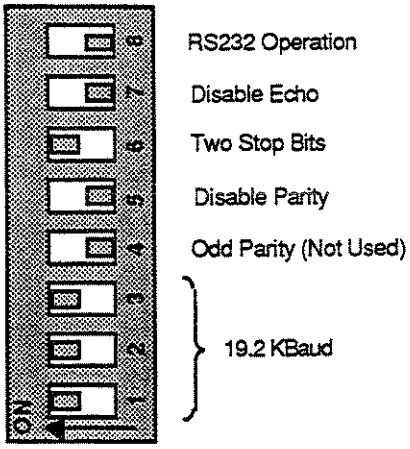
After resetting the SR245 (toggle the Bin power switch), run the program. The eight values displayed on the screen are values read at the eight inputs of the SR245. Apply voltages at the 8 inputs to test for yourself. The values will be updated at about 1 Hz (Interpreted BASIC is slow).

Program:

```
10    REM     Connect the Async port of the IBM to the SR245.  You only
20    REM     need to connect pins 2 and 3 in this sample program.
30    REM
40    CLS
50    OPEN "COM1:9600,N,8,2,CS,DS,CD" AS #1
60    PRINT #1, "           "
70    PRINT #1, "MR; I8; W25"
80    LOCATE 1,1
90    FOR I = 1 TO 8
100   PRINT #1, USING "?#"; I
110   PRINT #1,
120   INPUT #1, V
130   PRINT USING "##.###";V
140   NEXT I
150   PRINT "loop count=", J
160   J = J + 1
170   GOTO 80
```

EXAMPLE 5 - IBM PC VIA RS232 (FORTRAN)

This program makes use of assembly language drivers to communicate with the SR245 via RS232. The SR245's internal 16 pin header should be in the socket marked DCE, and the configuration switch should be set as follows.



The program sets the first four ports of theSR245 as inputs. It then reads those four ports continuously, displaying its readings to a scrolling screen. The program may be paused and resumed by typing control S, and program execution is halted by typing control C. ftst.for is written in Microsoft FORTRAN v3.3. It makes calls to procedures in rs232.asm which is written in Microsoft MACRO Assembler v1.25.

To compile ftst.for:	for1 ftst; pas2
To assemble rs232.asm:	masm rs232;
To link:	link ftst rs232/NOD;
To execute:	ftst

```
c       ftst.for
c
c       A FORTRAN program that uses assembly language drivers
c       to communicate with the SR245 via RS232.
c
c       S. Lindgren     12/11/86
c
c
        program ftst

        character       io*40
        real            v(4)

c       Initialize computer's RS232 port COM1:
        call bgn232

c       Initialize the SR245
        call snd232 ('W0;I4$')

c       The '$' is required by snd232 to mark the end of the string.
c       It is not sent to the SR245.

100     do 200 i=1,4

c       Request an input voltage
        write (io, 1000) i
1000    format (BN, '?', I1, '$')
        call snd232 (io)

c       Receive an input voltage
```

```
        call rcv232 (io)
        read (io, 1100) v(i)
1100    format (BN, F8.3)

200     continue

c       Write the four voltages to the screen.
        write (*, 1200) v(1), v(2), v(3), v(4)
1200    format (2X, F8.3, 2X, F8.3, 2X, F8.3, 2X, F8.3)

        goto 100

        end
```

```
;rs232.asm

;rs232 interface procedures: bgn232, snd232, rcv232

                page    60,132

data            segment         public  'data'

data            ends

dgroup          group   data
code            segment         'code'
                assumecs:code,ds:dgroup,ss:dgroup

public  bgn232
bgn232          proc    far

status          equ     3fdh            ;UART status port address
modcon          equ     3fch            ;modem status reg
rxdata          equ     3f8h            ;UART data port address
intreg          equ     3f9h            ;UART interrupt register
lnctl           equ     3fbh            ;UART line control register
divreg          equ     3f9h            ;UART divisor register

keybrd          equ     16h             ;Int for rom bios call for keyboard
rs232           equ     14h             ;Int for rom bios service of rs232
cr              equ     0dh             ;carriage return
lf              equ     0ah             ;line feed


                push    bp              ;save the frame pointer
                mov     bp,sp           ;get the pointer to the function code
```

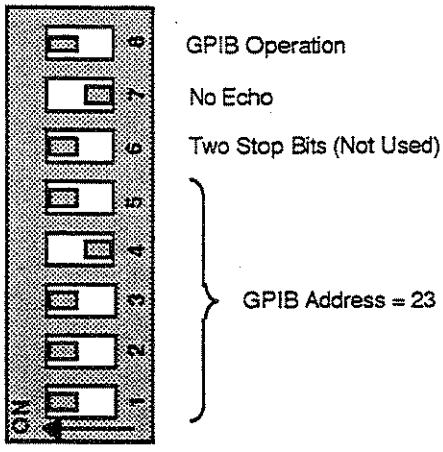
```
;               Initiallize the RS232 port.

init:           mov     ah,0            ;initialize request
                mov     dx,0            ;point to the first card
                mov     al,11100111b    ;9600 baud, no parity, 2 stop bits
                int     rs232           ;off to rom bios

;               now set 19.2 Kbaud operation

                mov     dx,lnctl        ;point to line control register
                in      al,dx           ;get it
                mov     ah,al           ;save it
                or      al,10000000b    ;turn on divisor access bit
                out     dx,al

                mov     dx,divreg       ;point to msb of divisor
                sub     al,al           ;this is 0
                out     dx,al
                mov     al,6h           ;19.2 kbaud
                dec     dx              ;point to lsb of divisor
                out     dx,al

                mov     dx,lnctl        ;point to line control reg
                mov     al,ah           ;restore divisor latch to 0
                out     dx,al

;               end of 19.2 set

                mov     dx,intreg       ;turn off UART interrupts
                sub     al,al
                out     dx,al
                mov     al,00000111b    ;set clear to send
                mov     dx,modcon       ;modem control reg
                out     dx,al
                mov     dx,status       ;point to the status port
                in      al,dx           ;clear errors
                mov     dx,rxdata       ;point to data port
                in      al,dx           ;clear pending data

                pop     bp
                ret

bgn232          endp


public          snd232
snd232          proc    far

;               Send a string via the COM1: port. Stop sending when a '$' is
;               found in the string. Do not send the '$'.

send:           push    bp
                mov     bp,sp
```

```
                push    ds
                lds     si,dword ptr [bp+6]     ;point to the first character to go
                sub     cx,cx                   ;will flag end of string when <>0
                cld

gtnxt:          lodsb                           ;get the character
                mov     ah,al                   ;save it
                cmp     al,'$'                  ;test for end of string
                jnz     arnd                    ;jump if not at end of string

last:           mov     al,cr                   ;substitute a CR
                mov     ah,al
                mov     cx,1                    ;flag done

arnd:           cmp     al,' '                  ;check for a superflous blank
                jz      short gtnxt

xhold1:         mov     dx,status               ;get transmitter status
                in      al,dx                   ;get status
                test    al,20h
                jz      xhold1                  ;if not ready wait

                mov     dx,rxdata               ;output the character
                mov     al,ah
                out     dx,al

                jcxz    short gtnxt

                pop     ds
                pop     bp
                ret     04

snd232          endp


public          rcv232
rcv232          proc    far


                push    bp
                mov     bp,sp

                les     di,dword ptr [bp+6] ;point to the start of the string

;               get the character

                mov     cx,15                   ;counter for blanks
                mov     bx,0ffffh               ;counter for timout loop
                cld

statlp:         mov     dx,status               ;point to the status port
                dec     bx
                jz      timout
```

```
                in      al,dx           ;get the status byte
                test    al,1            ;check for rececived data
                jz      statlp          ;wait for data

                mov     dx,rxdata       ;point to the data port
                in      al,dx           ;get the data byte

                stosb                   ;place the character in the string
                dec     cx              ;decrement number of blanks to place

                cmp     al,0dh          ;was it a <cr>?
                jnz     statlp          ;go back for more characters

                dec     di
                mov     al,' '          ;clear remainder of buffer
rep             stosb                   ;fill with spaces

timout:         mov     sp,bp
                pop     bp
                ret     04

rcv232          endp


code            ends
                end
```

EXAMPLE 6 - IBM PC VIA GPIB USING C

This program is the same as the one in Example 5 except that it is written in C and communicates via GPIB. The SR245's configuration switch should be set as follows.



The program sets the first four ports of theSR245 as inputs. It then reads those four ports continuously, displaying its readings to a scrolling screen. The program may be paused and resumed by typing control S, and program execution is halted by typing control C. ctst.c is written in Microsoft C v3.0. It makes calls to procedures in GPIB-L which is included with the Capital Equipment Corp. GPIB card. Similar software is provided with other GPIB cards.

To compile ctst.c: msc ctst/Ze/AL;

To link: link ctst GPIB-L;

To execute: ctst

```
/* ****************************** ctst.c ********************************** */

/*      C program that communicates with the SR245 via GPIB.
        The functions initialize(), transmit(), and receive()
        are defined in GPIB-L.

        S. Lindgren     12/15/86
*/

#include <ms-c488.h>  /* provided with CEC gpib card */
#define sr245  23     /* gpib address */

int status, length;


main ()
        {
        int i;
        float v[4];
        char cmd[20], *recv, *get_gpib (int);

        /* Initialize the computer's GPIB card and the SR245 */
        setup();
```

```
        while (1)
                {
                for (i=1 ; i<=4 ; i++)
                        {
                        /* Request an input voltage */
                        sprintf (cmd, " '?%d' 13", i);
                        tx_gpib (sr245, cmd);

                        /* Receive an input voltage */
                        recv = get_gpib (sr245);
                        sscanf (recv, "%f", &v[i-1]);
                        }

                /* Write the four voltages to the screen */
                printf ("%7.3f %7.3f %7.3f %7.3f\n", v[0], v[1], v[2], v[3]);
                }
        }

/* ************************************************************************** */


setup ()
        {
        int my_address=21, system_controller=0;

        initialize (&system_controller, &my_address);
        transmit (&status, "IFC UNT UNL DCL");
        wait(2);
        transmit (&status, "IFC UNT UNL MTA REN");
        wait(2);
        tx_gpib (sr245, " 'W0;I4' 13");
        }

/* ************************************************************************** */


tx_gpib (address,command)

int address;
char *command;
        {
        char t_string[100];

        sprintf (t_string,"UNT MTA LISTEN %d DATA %s", address, command);
        transmit (&status, t_string);
        statcheck (address);
        }
```

```
/* ********************************************************************** */


char *get_gpib (address)

int address;
        {
        char r_string[40], recv[80];

        sprintf (r_string, "UNL MLA TALK %d", address);
        transmit (&status, r_string);
        statcheck (address);

        strcpy (recv, "                    ");
        receive (&status, &length, recv);
        statcheck (address);
        return (recv);
        }

/* ********************************************************************** */


/* check the gpib status and exit if error */

statcheck (address)
int address;
        {
        if (status != 0)
                {
                printf ("Error at device %d, status = %d\n", address, status);
                exit ();
                }
        }

/* ********************************************************************** */


wait (n)  /* wait n seconds */
int n;
        {
        int i,j,dum;
        for (j=n ; j>=1 ; j--)
                {
                for (i=0 ; i<=32000 ; i++)
                        dum = 10*10;
                }
        }
```

MODEL SR200 PARTS LIST

Ref	Value	Description
C 1	.015U	Capacitor, Mylar/Poly, 50V, 10%, Radial
C 2	4.7U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 3	100P	Capacitor, Ceramic Disc,250V, 10%, Y5P
C 4	100P	Capacitor, Ceramic Disc,250V, 10%, Y5P
C 5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 6	100P	Capacitor, Ceramic Disc,250V, 10%, Y5P
C 7	100P	Capacitor, Ceramic Disc,250V, 10%, Y5P
C 8	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 9	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 10	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 11	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 12	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 13	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 14	1U	Capacitor, Tantalum, 35V, 20%, Radial
C 15	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 16	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 17	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 18	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 19	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 20	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
D 1	1N4148	Diodes
D 2	1N746A	Diodes
D 3	HLMP-1503	LED, T1 Package, Green
D 4	HLMP-1400	LED, T1 Package, Amber
D 5	HLMP-1300	LED, T1 Package, Red
P 1	20K	Pot, 10-turn Panel
P 2	20K	Pot, 10-turn Panel
P 3	20K	PCB mount trim pot, inline leads
PC1	SR200	PCB Board
Q 1	2N3904	Transistor, TO-92 Package
Q 2	2N3904	Transistor, TO-92 Package
Q 3	2N3904	Transistor, TO-92 Package
Q 4	2N3904	Transistor, TO-92 Package
R 1	33K	Resistor, Carbon Film, 1/4W, 5%
R 2	33K	Resistor, Carbon Film, 1/4W, 5%
R 3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 5	30K	Resistor, Carbon Film, 1/4W, 5%
R 6	91K	Resistor, Carbon Film, 1/4W, 5%
R 7	300K	Resistor, Carbon Film, 1/4W, 5%
R 8	910K	Resistor, Carbon Film, 1/4W, 5%
R 9	3.0M	Resistor, Carbon Film, 1/4W, 5%
R 10	91K	Resistor, Carbon Film, 1/4W, 5%
R 11	10K	Resistor, Carbon Film, 1/4W, 5%
R 12	10K	Resistor, Carbon Film, 1/4W, 5%
R 13	22K	Resistor, Carbon Film, 1/4W, 5%
R 14	22K	Resistor, Carbon Film, 1/4W, 5%
R 15	10K	Resistor, Carbon Film, 1/4W, 5%
R 16	10K	Resistor, Carbon Film, 1/4W, 5%
R 17	22K	Resistor, Carbon Film, 1/4W, 5%
R 18	22K	Resistor, Carbon Film, 1/4W, 5%
R 19	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 20	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 21	10K	Resistor, Carbon Film, 1/4W, 5%
R 22	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 24	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 25	10K	Resistor, Carbon Film, 1/4W, 5%
R 26	10K	Resistor, Carbon Film, 1/4W, 5%
R 27	10K	Resistor, Carbon Film, 1/4W, 5%
R 28	22K	Resistor, Carbon Film, 1/4W, 5%
R 29	22K	Resistor, Carbon Film, 1/4W, 5%
R 30	56K	Resistor, Carbon Film, 1/4W, 5%
R 31	10.0K	Resistor, Metal Film, 1/8W, 1%
R 32	10.0K	Resistor, Metal Film, 1/8W, 1%
R 33	10.0K	Resistor, Metal Film, 1/8W, 1%
R 34	10.0K	Resistor, Metal Film, 1/8W, 1%
R 35	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 36	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 37	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 38	470	Resistor, Carbon Film, 1/4W, 5%
R 39	47K	Resistor, Carbon Film, 1/4W, 5%
R 40	470	Resistor, Carbon Film, 1/4W, 5%
R 41	47K	Resistor, Carbon Film, 1/4W, 5%
R 42	10K	Resistor, Carbon Film, 1/4W, 5%
R 43	10K	Resistor, Carbon Film, 1/4W, 5%
R 44	10K	Resistor, Carbon Film, 1/4W, 5%
R 45	10K	Resistor, Carbon Film, 1/4W, 5%
R 46	180	Resistor, Carbon Film, 1/4W, 5%
R 47	180	Resistor, Carbon Film, 1/4W, 5%
R 48	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 49	220	Resistor, Carbon Comp, 1/2W, 5%
R 50	180	Resistor, Carbon Film, 1/4W, 5%
SW1	SPDT	Switch, Miniature Bat Toggle
SW2	SPDT	Switch, Miniature Bat Toggle
SW3	2P12T	Switch, Rotary, PCB Mounted
U 1	LF347	Integrated Circuit
U 2	LM324	Integrated Circuit
U 3	LM324	Integrated Circuit
U 4	CD4013	Integrated Circuit
U 5	CD4013	Integrated Circuit
U 6	CD4025	Integrated Circuit
U 7	CD4030	Integrated Circuit
U 8	CD4019	Integrated Circuit
U 9	CD4052	Integrated Circuit
U 10	MC7805	Integrated Circuit
U 11	MC7815	Integrated Circuit
U 12	MC7915	Integrated Circuit
Z 0	2607	Dial
Z 0	KLN500B1/8	Knobs
Z 0	09-011	NIM Parts
Z 0	200833-4	NIM Parts
Z 0	202394-2	NIM Parts
Z 0	202514-1	NIM Parts
Z 0	203964-6	NIM Parts
Z 0	204186-5	NIM Parts
Z 0	66103-4	NIM Parts
Z 0	6-32 HEX	Nut, Hex
Z 0	4-40X1/4P	Screw, Panhead
Z 0	6-32X1/4P	Screw, Panhead
Z 0	#6 LOCK	Washer, lock
Z 0	1/4X1/16	Washer
Z 0	1/4X1/32	Washer
Z 0	1" #26	Wire #26
Z 0	12" #24	Wire #24
Z 0	6-1/2" #24	Wire #24
Z 0	7-1/2" #22	Wire #22
Z 0	7-1/4" #24	Wire #24
Z 0	8-1/2" #24	Wire #24
Z 0	SHEET	Mylar Sheet
Z 0	BNC	BNC Connector
Z 0	SR200	Front Panel
Z 0	SR200	Rear Panel
Z 0	BLANK	NIM Parts
Z 0	23-001	NIM Parts
Z 0	24-001	NIM Parts
Z 0	25-001	NIM Parts
Z 0	26-001	NIM Parts
Z 0	26-003	NIM Parts

MODEL SR235 PARTS LIST

Ref	Value	Description
C 1	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 4	3.3U	Capacitor, Mylar/Poly, 50V, 10%, RADIA
C 5	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 6	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 7	.1U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 8	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 9	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 10	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 11	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 12	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 13	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 14	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 15	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 16	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 17	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 18	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 19	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 20	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 21	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 22	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 23	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 24	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 25	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 22	1N4148	Diodes
D 24	HLMP-1300	LED, T1 Package, Red
P 1	50K	PCB mount trim pot, inline leads
P 2	50K	PCB mount trim pot, inline leads
P 3	50K	PCB mount trim pot, inline leads
P 4	500K	PCB mount trim pot, inline leads
P 5	100K	PCB mount trim pot, inline leads
P 6	500K	PCB mount trim pot, inline leads
P 7	20	PCB mount trim pot, inline leads
PC1	SR235	Printed Circuit Board
R 1	10K	Resistor, Carbon Film, 1/4W, 5%
R 2	1.00M	Resistor, Metal Film, 1/8W, 1%
R 3	10K	Resistor, Carbon Film, 1/4W, 5%
R 4	1.00M	Resistor, Metal Film, 1/8W, 1%
R 5	10K	Resistor, Carbon Film, 1/4W, 5%
R 6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 7	10K	Resistor, Carbon Film, 1/4W, 5%
R 8	10.0K	Resistor, Metal Film, 1/8W, 1%
R 9	10.0K	Resistor, Metal Film, 1/8W, 1%
R 10	10.0K	Resistor, Metal Film, 1/8W, 1%
R 11	10.0K	Resistor, Metal Film, 1/8W, 1%
R 12	10.0K	Resistor, Metal Film, 1/8W, 1%
R 13	10.0K	Resistor, Metal Film, 1/8W, 1%
R 14	10.0K	Resistor, Metal Film, 1/8W, 1%
R 15	10K	Resistor, Carbon Film, 1/4W, 5%
R 16	10K	Resistor, Carbon Film, 1/4W, 5%
R 17	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 18	470K	Resistor, Carbon Film, 1/4W, 5%
R 19	10.0K	Resistor, Metal Film, 1/8W, 1%
R 20	10.0K	Resistor, Metal Film, 1/8W, 1%
R 21	75K	Resistor, Carbon Film, 1/4W, 5%
R 22	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	10.00K	Resistor, Metal Film, 1/8W, 0.1%
R 24	20.00K	Resistor, Metal Film, 1/8W, 0.1%
R 25	10K	Resistor, Carbon Film, 1/4W, 5%
R 26	20K	Resistor, Carbon Film, 1/4W, 5%
R 27	100K	Resistor, Carbon Film, 1/4W, 5%
R 28	20.00K	Resistor, Metal Film, 1/8W, 0.1%
R 29	10.00K	Resistor, Metal Film, 1/8W, 0.1%
R 30	20.00K	Resistor, Metal Film, 1/8W, 0.1%
R 31	10.00K	Resistor, Metal Film, 1/8W, 0.1%
R 32	10K	Resistor, Carbon Film, 1/4W, 5%
R 33	75K	Resistor, Carbon Film, 1/4W, 5%
R 34	30K	Resistor, Carbon Film, 1/4W, 5%
R 35	10M	Resistor, Carbon Film, 1/4W, 5%
R 36	3.0M	Resistor, Carbon Film, 1/4W, 5%
R 37	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 38	300K	Resistor, Carbon Film, 1/4W, 5%
R 39	100K	Resistor, Carbon Film, 1/4W, 5%
R 40	10.0K	Resistor, Metal Film, 1/8W, 1%
R 41	10K	Resistor, Carbon Film, 1/4W, 5%
R 42	10.0K	Resistor, Metal Film, 1/8W, 1%
R 43	47K	Resistor, Carbon Film, 1/4W, 5%
R 44	10K	Resistor, Carbon Film, 1/4W, 5%
R 45	560K	Resistor, Carbon Film, 1/4W, 5%
R 46	200	Resistor, Metal Film, 1/8W, 1%
R 47	90.9	Resistor, Metal Film, 1/8W, 1%
R 48	82.5	Resistor, Metal Film, 1/8W, 1%
R 49	10K	Thermistor -7%/Degree Cent
R 50	10K	Resistor, Carbon Film, 1/4W, 5%
R 51	330K	Resistor, Carbon Film, 1/4W, 5%
R 52	560K	Resistor, Carbon Film, 1/4W, 5%
R 53	10K	Resistor, Carbon Film, 1/4W, 5%
R 54	47K	Resistor, Carbon Film, 1/4W, 5%
R 55	100K	Resistor, Carbon Film, 1/4W, 5%
R 56	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 57	10M	Resistor, Carbon Film, 1/4W, 5%
R 58	100K	Resistor, Carbon Film, 1/4W, 5%
R 59	100K	Resistor, Metal Film, 1/8W, 1%
R 60	49.9K	Resistor, Metal Film, 1/8W, 1%
R 61	20.0K	Resistor, Metal Film, 1/8W, 1%
R 62	10.0K	Resistor, Metal Film, 1/8W, 1%
R 63	4.99K	Resistor, Metal Film, 1/8W, 1%
R 64	2.00K	Resistor, Metal Film, 1/8W, 1%
R 65	1.00K	Resistor, Metal Film, 1/8W, 1%
R 66	499	Resistor, Metal Film, 1/8W, 1%
R 67	10.0K	Resistor, Metal Film, 1/8W, 1%
R 68	10.0K	Resistor, Metal Film, 1/8W, 1%
R 69	10.0K	Resistor, Metal Film, 1/8W, 1%
R 70	11K	Resistor, Carbon Film, 1/4W, 5%
R 71	15K	Resistor, Carbon Film, 1/4W, 5%
R 72	10K	Resistor, Carbon Film, 1/4W, 5%
R 73	15K	Resistor, Carbon Film, 1/4W, 5%
R 74	11K	Resistor, Carbon Film, 1/4W, 5%
R 75	10K	Resistor, Carbon Film, 1/4W, 5%
R 76	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 77	100K	Resistor, Carbon Film, 1/4W, 5%
R 78	100K	Resistor, Carbon Film, 1/4W, 5%
R 79	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 80	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 81	220	Resistor, Carbon Film, 1/4W, 5%
SW1	4P6T	Switch, Rotary, PCB Mounted
SW2	2P12T	Switch, Rotary, PCB Mounted
SW3	4P6T	Switch, Rotary, PCB Mounted
SW4	1P12T	Switch, Rotary, PCB Mounted
U 1	LF412	Integrated Circuit
U 2	LF412	Integrated Circuit
U 3	LF412	Integrated Circuit
U 4	LF412	Integrated Circuit
U 5	LF412	Integrated Circuit
U 6	LF412	Integrated Circuit
U 7	LF412	Integrated Circuit
U 8	LF412	Integrated Circuit
U 9	LF412	Integrated Circuit
U 10	LF412	Integrated Circuit
U 11	LF412	Integrated Circuit
U 12	LF412	Integrated Circuit
U 13	LF347	Integrated Circuit
U 14	CA3046	Integrated Circuit
U 15	CA3046	Integrated Circuit
U 16	AD534	Integrated Circuit
U 17	MC7915	Integrated Circuit
U 18	MC7815	Integrated Circuit
U 19	TND903	Integrated Circuit
U 20	TND903	Integrated Circuit
U 21	TND903	Integrated Circuit
Z 0	KLN500B1/8	Knobs
Z 0	09-011	NIM Parts
Z 0	200833-4	NIM Parts
Z 0	202394-2	NIM Parts
Z 0	202514-1	NIM Parts
Z 0	203964-6	NIM Parts
Z 0	204186-5	NIM Parts
Z 0	66103-4	NIM Parts
Z 0	6-32 HEX	Nut, Hex
Z 0	4-40X1/4P	Screw, Panhead
Z 0	6-32X1/4P	Screw, Panhead
Z 0	4"	Tie
Z 0	#6 LOCK	Washer, lock
Z 0	1/4X1/16	Washer
Z 0	1/4X1/32	Washer
Z 0	1" #26	Wire #26
Z 0	4" #24	Wire #24
Z 0	SHEET	Mylar Sheet
Z 0	BNC	BNC Connector
Z 0	SR235	Front Panel
Z 0	SR235	Rear Panel
Z 0	23-001	NIM Parts
Z 0	24-001	NIM Parts
Z 0	25-001	NIM Parts
Z 0	26-001	NIM Parts

MODEL SR240 PARTS LIST

Ref	Value	Description
C1A	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C1B	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C1C	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C1D	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C2A	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C2B	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C2C	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C2D	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C3A	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C3B	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C3C	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C3D	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C4A	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C4B	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C4C	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C4D	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C5A	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C5B	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C5C	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C5D	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C6A	50P	Capacitor, Variable, 250V, 5mm
C6B	50P	Capacitor, Variable, 250V, 5mm
C6C	50P	Capacitor, Variable, 250V, 5mm
C6D	50P	Capacitor, Variable, 250V, 5mm
C8A	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C8B	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C8C	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C8D	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C9A	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C9B	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C9C	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C9D	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C10A	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C10B	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C10C	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C10D	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C11A	56P	Capacitor, Ceramic Disc, 50V, 10%, SL
C11B	56P	Capacitor, Ceramic Disc, 50V, 10%, SL
C11C	56P	Capacitor, Ceramic Disc, 50V, 10%, SL
C11D	56P	Capacitor, Ceramic Disc, 50V, 10%, SL
C12A	56P	Capacitor, Ceramic Disc, 50V, 10%, SL
C12B	75P	Capacitor, Ceramic Disc, 50V, 10%, SL
C12C	75P	Capacitor, Ceramic Disc, 50V, 10%, SL
C12D	75P	Capacitor, Ceramic Disc, 50V, 10%, SL
C13A	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C13B	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C13C	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C13D	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C14A	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C14B	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C14C	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C14D	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C15A	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C15B	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C15C	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C15D	47U	Capacitor, Electrolytic, 16V, 20%, Rad
C16A	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C16B	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C16C	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C16D	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C17A	18P	Capacitor, Ceramic Disc, 50V, 10%, SL
C17B	18P	Capacitor, Ceramic Disc, 50V, 10%, SL
C17C	18P	Capacitor, Ceramic Disc, 50V, 10%, SL
C17D	18P	Capacitor, Ceramic Disc, 50V, 10%, SL
C18A	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C18B	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C18C	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C18D	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C19A	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C19B	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C19C	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C19D	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C20A	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C20B	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C20C	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C20D	680P	Capacitor, Ceramic Disc, 50V, 10%, SL
C23	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C24	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C25	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C29	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C30	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C31	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
D1A	1N4148	Diode
D1B	1N4148	Diode
D1C	1N4148	Diode
D1D	1N4148	Diode
D2A	1N4148	Diode
D2B	1N4148	Diode
D2C	1N4148	Diode
D2D	1N4148	Diode
D3A	1N4148	Diode
D3B	1N4148	Diode
D3C	1N4148	Diode
D3D	1N4148	Diode
D4A	1N4148	Diode
D4B	1N4148	Diode
D4C	1N4148	Diode
D4D	1N4148	Diode
D5A	1N4148	Diode
D5B	1N4148	Diode
D5C	1N4148	Diode
D5D	1N4148	Diode
D6A	1N4148	Diode
D6B	1N4148	Diode
D6C	1N4148	Diode
D6D	1N4148	Diode

Ref	Value	Description
D 7A	1N4148	Diode
D 7B	1N4148	Diode
D 7C	1N4148	Diode
D 7D	1N4148	Diode
D 8A	1N4148	Diode
D 8B	1N4148	Diode
D 8C	1N4148	Diode
D 8D	1N4148	Diode
D 9A	1N4148	Diode
D 9B	1N4148	Diode
D 9C	1N4148	Diode
D 9D	1N4148	Diode
D 10A	1N4148	Diode
D 10B	1N4148	Diode
D 10C	1N4148	Diode
D 10D	1N4148	Diode
J 1A	BNC	Connector, BNC, Panel Mount
J 1B	BNC	Connector, BNC, Panel Mount
J 1C	BNC	Connector, BNC, Panel Mount
J 1D	BNC	Connector, BNC, Panel Mount
J 2A	BNC	Connector, BNC, Panel Mount
J 2B	BNC	Connector, BNC, Panel Mount
J 2C	BNC	Connector, BNC, Panel Mount
J 2D	BNC	Connector, BNC, Panel Mount
L 1A	FB43-301	Ferrite Beads
L 1B	FB43-301	Ferrite Beads
L 1C	FB43-301	Ferrite Beads
L 1D	FB43-301	Ferrite Beads
L 2A	FB43-301	Ferrite Beads
L 2B	FB43-301	Ferrite Beads
L 2C	FB43-301	Ferrite Beads
L 2D	FB43-301	Ferrite Beads
L 3A	FB43-301	Ferrite Beads
L 3B	FB43-301	Ferrite Beads
L 3C	FB43-301	Ferrite Beads
L 3D	FB43-301	Ferrite Beads
L 4A	FB43-301	Ferrite Beads
L 4B	FB43-301	Ferrite Beads
L 4C	FB43-301	Ferrite Beads
L 4D	FB43-301	Ferrite Beads
L 5A	FB43-301	Ferrite Beads
L 5B	FB43-301	Ferrite Beads
L 5C	FB43-301	Ferrite Beads
L 5D	FB43-301	Ferrite Beads
L 6A	FB43-301	Ferrite Beads
L 6B	FB43-301	Ferrite Beads
L 6C	FB43-301	Ferrite Beads
L 6D	FB43-301	Ferrite Beads
P 1A	10K	Pot, Multi-Turn Trim
P 1B	10K	Pot, Multi-Turn Trim
P 1C	10K	Pot, Multi-Turn Trim
P 1D	10K	Pot, Multi-Turn Trim
P 2A	10K	Pot, Multi-Turn Trim
P 2B	10K	Pot, Multi-Turn Trim
P 2C	10K	Pot, Multi-Turn Trim
P 2D	10K	Pot, Multi-Turn Trim

Ref	Value	Description
Q 1A	MRF914	Transistor, TO-72 Package
Q 1B	MRF914	Transistor, TO-72 Package
Q 1C	MRF914	Transistor, TO-72 Package
Q 1D	MRF914	Transistor, TO-72 Package
Q 2A	MM4049	Transistor, TO-72 Package
Q 2B	MM4049	Transistor, TO-72 Package
Q 2C	MM4049	Transistor, TO-72 Package
Q 2D	MM4049	Transistor, TO-72 Package
Q 3A	MM4049	Transistor, TO-72 Package
Q 3B	MM4049	Transistor, TO-72 Package
Q 3C	MM4049	Transistor, TO-72 Package
Q 3D	MM4049	Transistor, TO-72 Package
Q 4A	MRF914	Transistor, TO-72 Package
Q 4B	MRF914	Transistor, TO-72 Package
Q 4C	MRF914	Transistor, TO-72 Package
Q 4D	MRF914	Transistor, TO-72 Package
Q 5A	2N5771	Transistor, TO-92 Package
Q 5B	2N5771	Transistor, TO-92 Package
Q 5C	2N5771	Transistor, TO-92 Package
Q 5D	2N5771	Transistor, TO-92 Package
Q 6A	2N5770	Transistor, TO-92 Package
Q6B	2N5770	Transistor, TO-92 Package
Q 6C	2N5770	Transistor, TO-92 Package
Q 6D	2N5770	Transistor, TO-92 Package
R 1A	73.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 1B	73.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 1C	73.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 1D	73.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 2A	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 2B	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 2C	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 2D	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3A	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3B	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3C	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3D	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 4A	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 4B	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 4C	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 4D	20.0	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5A	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5B	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5C	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5D	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6A	51.1	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6B	51.1	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6C	51.1	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6D	51.1	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7A	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7B	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7C	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7D	82.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 8A	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 8B	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 8C	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 8D	909	Resistor, Metal Film, 1/8W, 1%, 50PPM

Ref	Value	Description
R 9A	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 9B	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 9C	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 9D	909	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 10A	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 10B	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 10C	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 10D	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11A	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11B	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11C	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11D	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12A	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12B	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12C	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12D	49.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13A	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13B	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13C	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13D	21.5	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14A	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14B	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14C	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14D	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15A	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15B	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15C	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15D	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16A	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16B	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16C	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16D	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 17A	75	Resistor, Carbon Film, 1/4W, 5%
R 17B	75	Resistor, Carbon Film, 1/4W, 5%
R 17C	75	Resistor, Carbon Film, 1/4W, 5%
R 17D	75	Resistor, Carbon Film, 1/4W, 5%
R 18A	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 18B	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 18C	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 18D	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 19A	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 19B	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 19C	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 19D	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 20A	75	Resistor, Carbon Film, 1/4W, 5%
R 20B	75	Resistor, Carbon Film, 1/4W, 5%
R 20C	75	Resistor, Carbon Film, 1/4W, 5%
R 20D	75	Resistor, Carbon Film, 1/4W, 5%
R 21A	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 21B	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 21C	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 21D	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 22A	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 22B	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 22C	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 22D	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 23A	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 23B	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 23C	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 23D	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 24A	10K	Resistor, Carbon Film, 1/4W, 5%
R 24B	10K	Resistor, Carbon Film, 1/4W, 5%
R 24C	10K	Resistor, Carbon Film, 1/4W, 5%
R 24D	10K	Resistor, Carbon Film, 1/4W, 5%
R 26A	2.21K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 26B	2.21K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 26C	2.21K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 26D	2.21K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 27A	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 27B	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 27C	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 27D	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 28A	10K	Resistor, Carbon Film, 1/4W, 5%
R 28B	10K	Resistor, Carbon Film, 1/4W, 5%
R 28C	10K	Resistor, Carbon Film, 1/4W, 5%
R 28D	10K	Resistor, Carbon Film, 1/4W, 5%
R 31	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 32	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 34	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 35	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 36	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 37A	2.74K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 37B	2.74K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 37C	2.74K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 37D	2.74K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 38A	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 38B	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 38C	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 38D	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
U 1A	LT1007	Integrated Circuit
U 1B	LT1007	Integrated Circuit
U 1C	LT1007	Integrated Circuit
U 1D	LT1007	Integrated Circuit
U2	MC7905	Integrated Circuit
U3	LT1007	Integrated Circuit
U4	LM336-2.5V	Integrated Circuit
U5	MC78L05	Transistor, TO-92 Package
U6	LT1007	Integrated Circuit
U7	LM340T-5	Transistor, TO-220 (TAB) Package
Z0	NYLON	Washer, nylon, Shoulder

MODEL SR245 PARTS LIST

Ref	Loc	Value	Description
C 1	F7	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	F7	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	C7	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 4	C3	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 5	F3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 6	G3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 7	G3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 8	F3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 9	F3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 10	G3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 11	G3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 12	F3	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 13	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 14	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 15	G2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 16	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 17	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 18	G2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 19	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 20	F2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 21	E3	.0047U	Capacitor, Polystyrene, 50V, 5%, RADIA
C 22	B3	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 23	B3	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 24	B4	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 25	B4	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 26	B5	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 27	B5	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 28	G1	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 29	A7	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 30	G6	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 31	D8	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 32	F1	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 33	C4	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 34	B4	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 35	C5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 36	D8	Deleted	Misc. Components
C 37	F9	220U	Capacitor, Electrolytic, 50V, 20%,RADI
C 38	F9	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 39	F9	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 40	F9	22U	Capacitor, Electrolytic, 50V, 20%,RADI
D 1	D8	1N4001	Diodes
D 2	A1	HLMP-1503	LED, T1 Package, Green
D 3	A1	HLMP-1300	LED, T1 Package, Red
D 4	A4	1N5820	Diodes
H 1	D9	16 DIP	CNCTR, Header
J 1	A6	20 PIN DI	CNCTR, Male
J 2	D9	RS232 F PC	CNCTR, Male
J 3	A9	IEEE488 PC	CNCTR, Male
P 1	C3	100	PCB mount trim pot, inline leads
P 2	E3	100	PCB mount trim pot, inline leads
PC1		SR245	Printed Circuit Board
Q 1	F4	PN2222	Transistor, TO-92 Package
Q 2	G4	PN2222	Transistor, TO-92 Package
Q 3	G4	PN2222	Transistor, TO-92 Package
Q 4	G4	PN2222	Transistor, TO-92 Package
R 1	F7	10K	Resistor, Carbon Film, 1/4W, 5%
R 2	F7	10K	Resistor, Carbon Film, 1/4W, 5%
R 3	E7	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 4	F4	47	Resistor, Carbon Comp, 1/2W, 5%
R 5	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 6	G4	47	Resistor, Carbon Comp, 1/2W, 5%
R 7	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 8	C3	47	Resistor, Carbon Film, 1/4W, 5%
R 9	E3	47	Resistor, Carbon Film, 1/4W, 5%
R 10	E3	10.00K	Resistor, Metal Film, 1/8W, 0.1%
R 11	E3	10.00K	Resistor, Metal Film, 1/8W, 0.1%
R 12	D3	39K	Resistor, Carbon Film, 1/4W, 5%
R 13	D3	22K	Resistor, Carbon Film, 1/4W, 5%
R 14	D3	100K	Resistor, Carbon Film, 1/4W, 5%
R 15	D3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 16	C4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 17	C4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 18	C4	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 19	C8	10K	Resistor, Carbon Film, 1/4W, 5%
R 20	D8	10K	Resistor, Carbon Film, 1/4W, 5%
R 21	D8	10K	Resistor, Carbon Film, 1/4W, 5%
R 22	C6	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	C8	10K	Resistor, Carbon Film, 1/4W, 5%
R 24	B4	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 25	F4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 26	G4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 27	G4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 28	G4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 29	G5	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 30	G5	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 31	A1	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 32	A1	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 33	B8	10K	Resistor, Carbon Film, 1/4W, 5%
R 34	F8	1.0	Resistor, Carbon Comp, 1W,10%
R 35	F9	1.0	Resistor, Carbon Comp, 1W, 10%
R 36	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 37	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 38	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 39	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 40	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 41	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 43	B4	1.5M	Resistor, Carbon Film, 1/4W, 5%
RN1	B5	9X100K	Resistor Network SIP 1/4W 2% Common
RN3	G2	8X10K	Resistor Network, DIP, 1/4W,2%,8 ind
RN4	C2	9X1.0M	Resistor Network SIP 1/4W 2% Common
RN5	E2	8X10K	Resistor Network, DIP, 1/4W,2%,8 ind
SO1	D5	40	DIP Socket
SO2	E5	28	DIP Socket
SO3	F5	28	DIP Socket
SO4	D7	28	DIP Socket
SO5	E7	24	DIP Socket
SO6	B7	40	DIP Socket
SO24	D2	16	DIP Socket
SO25	E2	16	DIP Socket
SO40	C9	16	DIP Socket
SO41	D9	16	DIP Socket
SW1	C8	Deleted	Misc. Components
SW2	B5	SPSTX8	Switch, Miniature Bat Toggle
U 1	D5	Z80A-CPU	Integrated Circuit
U 2	E5	2764-250	Integrated Circuit
U 3	F5	HM6264LP-15	Integrated Circuit
U 4	D7	UPD8251A	Integrated Circuit
U 5	E7	UPD8253-5	Integrated Circuit
U 6	B7	MC68488	Integrated Circuit
U 7	B8	DS75160A	Integrated Circuit
U 8	B9	DS75161A	Integrated Circuit
U 9	F9	74HC73	Integrated Circuit
U 10	G7	74HC73	Integrated Circuit
U 11	C5	74HC138	Integrated Circuit
U 12	B5	74HC244	Integrated Circuit
U 13	C7	74HC244	Integrated Circuit
U 14	A6	74HC244	Integrated Circuit
U 15	F5	74HC374	Integrated Circuit
U 16	B6	74HC374	Integrated Circuit
U 17	F6	74HCU04	Integrated Circuit
U 18	C6	74HC32	Integrated Circuit
U 19	C4	74HC32	Integrated Circuit
U 20	C3	AD7542JN	Integrated Circuit
U 21	E3	DG211	Integrated Circuit
U 22	F3	DG528	Integrated Circuit
U 23	B3	DG528	Integrated Circuit
U 24	D2	AD7591	Integrated Circuit
U 25	E2	AD7591	Integrated Circuit
U 26	E3	LF347	Integrated Circuit
U 27	F2	LF347	Integrated Circuit
U 28	G2	LF347	Integrated Circuit
U 29	A2	LF347	Integrated Circuit
U 30	B2	LF347	Integrated Circuit
U 31	B4	LM311	Integrated Circuit
U 32	D3	AD7524	Integrated Circuit
U 33	A3	MC7815	Integrated Circuit
U 34	A4	MC7915	Integrated Circuit
U 35	A5	MC7805	Integrated Circuit
U 36	D8	MC1489	Integrated Circuit
U 37	C8	MC1488	Integrated Circuit
U 38	C3	LH0071	Integrated Circuit
X 1	F6	4M	Crystal
Z 0		09-011	NIM Parts
Z 0		200833-4	NIM Parts
Z 0		202394-2	NIM Parts
Z 0		202514-1	NIM Parts
Z 0		203964-6	NIM Parts
Z 0		204186-5	NIM Parts
Z 0		66103-4	NIM Parts
Z 0		4-40 KEP	Nut, Kep
Z 0		6-32 HEX	Nut, Hex
Z 0		4-40X1/4P	Screw, Panhead
Z 0		6-32X1/4P	Screw, Panhead
Z 0		M/F 3/16"	Standoff

MODEL SR250 PARTS LIST

Ref	Loc	Value	Description
C 1	F1	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	F1	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	F1	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 4	A3	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 5	A5	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 6	A6	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 7	B5	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 8	B8	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 9	A3	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 10	A6	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 11	B8	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 12	B4	24P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 100	B2	Deleted	Misc. Components
C 101	B1	180P	Capacitor, Silver Mica, 250V, 5%, DM15
C 102	B1	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 103	B1	.022U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 104	B2	.22U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 105	B1	Selected	Misc. Components
C 106	A2	Deleted	Misc. Components
C 107	A2	Selected	Misc. Components
C 108	A2	Selected	Misc. Components
C 109	A2	Selected	Misc. Components
C 110	C3	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 111	D5	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 112	B7	Deleted	Misc. Components
C 113	C6	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 114	B2	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 115	B2	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 116	B2	.015U	Capacitor, Mylar/Poly, 50V, 10%, Radial
C 117	B2	.15U	Capacitor, Tantalum, 35V, 20%, Radial
C 118	B2	1.5U	Capacitor, Tantalum, 35V, 20%, Radial
C 119	A8	100P	Capacitor, Silver Mica, 250V, 5%, DM15
C 120	B8	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 121	C1	20P	Max, Variable Capacitor, 250V, 5mm
C 122	C1	82P	Capacitor, Silver Mica, 250V, 5%, DM15
C 123	C1	300P	Capacitor, Silver Mica, 250V, 5%, DM15
C 124	C1	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 125	C1	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 126	C1	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 127	C1	.033U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 128	C2	Selected	Misc. Components
C 129	C2	Selected	Misc. Components
C 130	C2	Selected	Misc. Components
C 131	B2	Selected	Misc. Components
C 132	C1	Selected	Misc. Components
C 133	C1	Selected	Misc. Components
C 134	F6	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 135	D3	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 136	E5	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 137	D5	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 138	E3	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 139	D3	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 140	D4	24P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 141	C4	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 201	G1	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 202	.001U		Capacitor, Mylar/Poly, 50V, 5%, Radial
C 203	G1	470P	Capacitor, Silver Mica, 250V, 5%, DM15
C 204	G2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 205	F2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 206	G2	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 207	G3	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 208	F2	Deleted	Misc. Components
C 209	G3	39P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 210	G4	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 211	G3	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 212	F4	56P	Capacitor, Silver Mica, 250V, 5%, DM15
C 213	F4	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 214	F3	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 215	F3	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 216	E3	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 217	F2	Deleted	Misc. Components
C 218	F2	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 219	D1	150P	Capacitor, Silver Mica, 250V, 5%, DM15
C 220	D1	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 221	D2	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 222	D2	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 223	D2	.033U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 224	D2	.1U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 225	C2	.33U	Capacitor, Stacked Metal Film
C 226	E7	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 227	E7	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 228	G7	330P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 229	E2	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 230	E2	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 231	E2	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 232	G4	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 233	G1	15P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 234	D7	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 235	G4	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 300	F6	.0047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 301	E6	.047U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 302	G8	4.7U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 303	F6	.01U	Capacitor, Ceramic Disc, 100V, 20%, Z5
C 304	C6	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 305	F8	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 306	F8	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 307	E8	.001U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 308	E8	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 309	F7	Deleted	Misc. Components
C 400	F2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 401	C3	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 402	D6	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 403	B3	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 404	D3	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 405	B3	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 406	E2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 407	C7	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 408	D6	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 409	D2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 410	A5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 411	C5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 412	G5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 413	A5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 414	D5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 415	G2	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 416	D5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 417	B5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 418	C6	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 419	B9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 420	B9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 421	C9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 422	C9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 423	E9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 424	E9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 425	G9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 426	G9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 427	E5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 428	A7	10U	Capacitor, Tantalum, 35V, 20%, Radial
D 1	B2	1N4148	Diodes
D 2	D2	1N4148	Diodes
D 3	D5	1N746A	Diodes
D 4	B7	1N4148	Diodes
D 6	G5	1N4148	Diodes
D 7	G5	1N4148	Diodes
D 8	F6	1N4148	Diodes
D 9	E6	1N4148	Diodes
D 10		HLMP-1503	LED, T1 Package, Green
D 11		HLMP-1300	LED, T1 Package, Red
D 12	F7	1N4148	Diodes
DL1	C4	CoAxial	RG174 Coaxial Cable
DL2	D5	CoAxial	RG174 Coaxial Cable
DL3		CoAxial	RG174 Coaxial Cable
L 1	C3	33U	Inductor, Radial Lead
L 2	D2	33U	Inductor, Radial Lead
P 1		50K	Pot, Dual Control
P 2		50K	Pot, Dual Control
P 3		20K	Pot, 10-turn Panel
P 4	C5	10K	PCB mount trim pot, inline leads
P 5	C3	10K	PCB mount trim pot, inline leads
P 6	E5	100K	PCB mount trim pot, inline leads
P 7	F5	2.0K	PCB mount trim pot, inline leads
P 8	D7	10K	PCB mount trim pot, inline leads
P 9	F5	500	PCB mount trim pot, inline leads
P 10	E3	10K	PCB mount trim pot, inline leads
P 11	D2	100K	PCB mount trim pot, inline leads
P 12	B5	500	PCB mount trim pot, inline leads
P 13	B7	2.0K	PCB mount trim pot, inline leads
P 14		20K	Pot, 10-turn Panel
PC1		SR250	Printed Circuit Board
Q 1	F1	2N5951	Transistor, TO-92 Package
Q 2	F2	2N5771	Transistor, TO-92 Package
Q 3	B3	2N5771	Transistor, TO-92 Package
Q 4	A3	2N5771	Transistor, TO-92 Package
Q 5	B4	2N5770	Transistor, TO-92 Package

Ref	Loc	Value	Description
Q 6	A4	2N5770	Transistor, TO-92 Package
Q 7	C8	2N5771	Transistor, TO-92 Package
Q 8	C8	2N5771	Transistor, TO-92 Package
Q 10	C3	2N5771	Transistor, TO-92 Package
Q 11	B3	2N5771	Transistor, TO-92 Package
Q 12	D4	2N5770	Transistor, TO-92 Package
Q 13	C4	2N5770	Transistor, TO-92 Package
Q 14	E4	2N5771	Transistor, TO-92 Package
Q 15	E4	2N5771	Transistor, TO-92 Package
Q 16	D3	2N5771	Transistor, TO-92 Package
Q 17	C3	2N5771	Transistor, TO-92 Package
Q 20	G2	J310	Transistor, TO-92 Package
Q 21	G1	2N5771	Transistor, TO-92 Package
Q 22	G3	2N5770	Transistor, TO-92 Package
Q 23	G3	MM4049	Transistor, TO-72 Package
Q 24	G4	MM4049	Transistor, TO-72 Package
Q 25	G3	MM4049	Transistor, TO-72 Package
Q 26	F4	MRF904	Transistor, TO-72 Package
Q 27	F3	MRF904	Transistor, TO-72 Package
Q 28	F3	MRF904	Transistor, TO-72 Package
Q 29	F4	MRF901	Transistor, Micro Strip Package
Q 30	F3	MRF901	Transistor, Micro Strip Package
Q 31	E8	2N3904	Transistor, TO-92 Package
Q 32	C8	2N3906	Transistor, TO-92 Package
Q 33	C8	2N3906	Transistor, TO-92 Package
R 1	F1	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 2	F1	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 3	F2	220	Resistor, Carbon Film, 1/4W, 5%
R 4	F2	47	Resistor, Carbon Film, 1/4W, 5%
R 5	F2	47	Resistor, Carbon Film, 1/4W, 5%
R 6	F1	47	Resistor, Carbon Film, 1/4W, 5%
R 7	F2	560	Resistor, Carbon Film, 1/4W, 5%
R 8	A3	56	Resistor, Carbon Film, 1/4W, 5%
R 9	B3	56	Resistor, Carbon Film, 1/4W, 5%
R 10	B4	47	Resistor, Carbon Film, 1/4W, 5%
R 11	A4	100	Resistor, Carbon Film, 1/4W, 5%
R 12	A4	47	Resistor, Carbon Film, 1/4W, 5%
R 13	B5	100	Resistor, Carbon Film, 1/4W, 5%
R 14	B5	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 15	A5	100	Resistor, Carbon Film, 1/4W, 5%
R 16	A5	470	Resistor, Carbon Film, 1/4W, 5%
R 17	A5	47	Resistor, Carbon Film, 1/4W, 5%
R 18	A4	47	Resistor, Carbon Film, 1/4W, 5%
R 19	B5	560	Resistor, Carbon Film, 1/4W, 5%
R 20	A6	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 21	B6	330K	Resistor, Carbon Film, 1/4W, 5%
R 22	A6	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 23	B1	10M	Resistor, Carbon Film, 1/4W, 5%
R 24	A1	3.3M	Resistor, Carbon Film, 1/4W, 5%
R 25	A1	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 26	A1	330K	Resistor, Carbon Film, 1/4W, 5%
R 27	A1	100K	Resistor, Carbon Film, 1/4W, 5%
R 28	A1	33K	Resistor, Carbon Film, 1/4W, 5%
R 29	A1	10K	Resistor, Carbon Film, 1/4W, 5%
R 30	A1	3.3K	Resistor, Carbon Film, 1/4W, 5%
R 31	A1	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 32	A6	22K	Resistor, Carbon Film, 1/4W, 5%
R 33	A6	22K	Resistor, Carbon Film, 1/4W, 5%
R 34	A3	470	Resistor, Carbon Film, 1/4W, 5%
R 35	A3	47	Resistor, Carbon Film, 1/4W, 5%
R 36	B3	560	Resistor, Carbon Film, 1/4W, 5%
R 37	B3	56	Resistor, Carbon Film, 1/4W, 5%
R 38	A3	47	Resistor, Carbon Film, 1/4W, 5%
R 39	B3	470	Resistor, Carbon Film, 1/4W, 5%
R 40	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 41	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 42	A3	47	Resistor, Carbon Film, 1/4W, 5%
R 43	A3	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 44	A3	47	Resistor, Carbon Film, 1/4W, 5%
R 45	B4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 46	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 47	C3	47	Resistor, Carbon Film, 1/8W, 5%
R 48	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 49	B4	47	Resistor, Carbon Film, 1/4W, 5%
R 50	B4	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 51	B4	150	Resistor, Carbon Film, 1/4W, 5%
R 52	B4	47	Resistor, Carbon Film, 1/4W, 5%
R 53	B5	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 54	B5	887	Resistor, Metal Film, 1/8W, 1%
R 55	B8	150	Resistor, Carbon Film, 1/4W, 5%
R 56	B8	100	Resistor, Carbon Film, 1/4W, 5%
R 57	C8	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 58	C8	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 59	C8	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 60	C8	150	Resistor, Carbon Comp, 1/2W, 5%
R 61	C8	220	Resistor, Carbon Film, 1/4W, 5%
R 62	C8	1.2K	Resistor, Carbon Film, 1/4W, 5%
R 63	C8	56	Resistor, Carbon Film, 1/4W, 5%
R 64	C8	330	Resistor, Carbon Film, 1/4W, 5%
R 65	A3	47	Resistor, Carbon Film, 1/4W, 5%
R 66	F2	56	Resistor, Carbon Film, 1/4W, 5%
R 67	A2	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 68		100K	Resistor, Carbon Comp, 1/4W, 5%
R 69		100K	Resistor, Carbon Comp, 1/4W, 5%
R 100	B3	56	Resistor, Carbon Film, 1/4W, 5%
R 101	C3	470	Resistor, Carbon Film, 1/4W, 5%
R 102	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 103	B3	47	Resistor, Carbon Film, 1/4W, 5%
R 104	C4	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 105	C3	47	Resistor, Carbon Film, 1/4W, 5%
R 106	B3	47	Resistor, Carbon Film, 1/8W, 5%
R 107	C4	47	Resistor, Carbon Film, 1/4W, 5%
R 108	C4	47	Resistor, Carbon Film, 1/4W, 5%
R 109	B4	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 110	C5	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 111	C5	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 112	C5	390	Resistor, Carbon Film, 1/4W, 5%
R 113	D3	47	Resistor, Carbon Film, 1/4W, 5%
R 114	D3	47	Resistor, Carbon Film, 1/8W, 5%
R 115	D4	47	Resistor, Carbon Film, 1/4W, 5%
R 116	D4	47	Resistor, Carbon Film, 1/4W, 5%
R 117	D4	47	Resistor, Carbon Film, 1/4W, 5%
R 118	D4	820	Resistor, Carbon Film, 1/4W, 5%
R 119	C5	47	Resistor, Carbon Film, 1/4W, 5%
R 120	C5	56	Resistor, Carbon Film, 1/4W, 5%
R 121	C4	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 122	C5	47	Resistor, Carbon Film, 1/4W, 5%
R 123	C5	56	Resistor, Carbon Film, 1/4W, 5%
R 124	D5	47	Resistor, Carbon Film, 1/4W, 5%
R 125	D5	560	Resistor, Carbon Film, 1/4W, 5%
R 126	B6	9.09K	Resistor, Metal Film, 1/8W, 1%
R 127	A7	10K	Resistor, Carbon Film, 1/4W, 5%
R 128	A7	100K	Resistor, Carbon Film, 1/4W, 5%
R 129	B6	20.0K	Resistor, Metal Film, 1/8W, 1%
R 130	C6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 131	B6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 132	C6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 133	C6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 134	C6	47K	Resistor, Carbon Film, 1/4W, 5%
R 135	F6	49.9K	Resistor, Metal Film, 1/8W, 1%
R 136	F6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 137	D6	47K	Resistor, Carbon Film, 1/4W, 5%
R 138	D3	47	Resistor, Carbon Film, 1/4W, 5%
R 139	D3	390	Resistor, Carbon Film, 1/4W, 5%
R 140	D3	47	Resistor, Carbon Film, 1/4W, 5%
R 142	C3	56	Resistor, Carbon Film, 1/4W, 5%
R 143	B7	560	Resistor, Carbon Film, 1/4W, 5%
R 144	C4	47	Resistor, Carbon Film, 1/4W, 5%
R 145	C3	750	Resistor, Carbon Film, 1/4W, 5%
R 146	D3	39	Resistor, Carbon Film, 1/4W, 5%
R 147	D4	470	Resistor, Carbon Film, 1/4W, 5%
R 148	C3	39	Resistor, Carbon Film, 1/4W, 5%
R 149	D3	47	Resistor, Carbon Film, 1/4W, 5%
R 150	D4	200	Resistor, Carbon Film, 1/4W, 5%
R 151	E3	47	Resistor, Carbon Film, 1/4W, 5%
R 152	E3	47	Resistor, Carbon Film, 1/4W, 5%
R 153	E5	680	Resistor, Carbon Film, 1/4W, 5%
R 154	E5	47	Resistor, Carbon Film, 1/4W, 5%
R 155	E4	22	Resistor, Carbon Film, 1/4W, 5%
R 156	E4	56	Resistor, Carbon Film, 1/4W, 5%
R 157	D4	22	Resistor, Carbon Film, 1/4W, 5%
R 158	D4	56	Resistor, Carbon Film, 1/4W, 5%
R 159	E5	47	Resistor, Carbon Film, 1/4W, 5%
R 160	D5	47	Resistor, Carbon Film, 1/4W, 5%
R 161	E3	1.3K	Resistor, Carbon Film, 1/4W, 5%
R 162	D4	10	Resistor, Carbon Film, 1/4W, 5%
R 163	E3	10	Resistor, Carbon Film, 1/4W, 5%
R 164	E3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 165	E4	47	Resistor, Carbon Film, 1/4W, 5%
R 166	E4	47	Resistor, Carbon Film, 1/4W, 5%
R 167	E5	220	Resistor, Carbon Film, 1/4W, 5%
R 168	E4	10	Resistor, Carbon Film, 1/4W, 5%
R 169	E3	10	Resistor, Carbon Film, 1/4W, 5%
R 170	D3	220	Resistor, Carbon Film, 1/4W, 5%
R 171	D4	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 172	A8	220K	Resistor, Carbon Film, 1/4W, 5%

Ref	Loc	Value	Description
R 173	B8	75K	Resistor, Carbon Film, 1/4W, 5%
R 174	D7	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 175	D7	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 176	C3	56	Resistor, Carbon Film, 1/4W, 5%
R 177	C4	120	Resistor, Carbon Film, 1/4W, 5%
R 200	G1	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 201	G1	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 202	G2	1.00M	Resistor, Metal Film, 1/8W, 1%
R 203	G1	100K	Resistor, Carbon Film, 1/4W, 5%
R 204	G2	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 205	G2	68	Resistor, Carbon Film, 1/4W, 5%
R 206	F1	56	Resistor, Carbon Film, 1/4W, 5%
R 207	G1	470	Resistor, Carbon Film, 1/4W, 5%
R 208	G2	56	Resistor, Carbon Film, 1/4W, 5%
R 209	G2	220	Resistor, Carbon Film, 1/4W, 5%
R 210	G3	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 211	G3	100	Resistor, Carbon Film, 1/4W, 5%
R 212	G5	10.0K	Resistor, Metal Film, 1/8W, 1%
R 213	G5	15.0K	Resistor, Metal Film, 1/8W, 1%
R 214	F5	47K	Resistor, Carbon Film, 1/4W, 5%
R 215	F5	47K	Resistor, Carbon Film, 1/4W, 5%
R 216	G2	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 217	F2	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 218	F5	10.0K	Resistor, Metal Film, 1/8W, 1%
R 219	F5	1.82K	Resistor, Metal Film, 1/8W, 1%
R 220	G2	150	Resistor, Metal Film, 1/8W, 1%
R 221	F2	47	Resistor, Carbon Film, 1/4W, 5%
R 222	G2	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 223	G2	33	Resistor, Carbon Film, 1/4W, 5%
R 224	F3	33.2	Resistor, Metal Film, 1/8W, 1%
R 225	G3	10.0K	Resistor, Metal Film, 1/8W, 1%
R 226	G4	10.0K	Resistor, Metal Film, 1/8W, 1%
R 227	G4	68	Resistor, Carbon Film, 1/8W, 5%
R 228	G4	39	Resistor, Carbon Film, 1/4W, 5%
R 229	G4	22	Resistor, Carbon Film, 1/8W, 5%
R 230	G3	39	Resistor, Carbon Film, 1/4W, 5%
R 231	G3	22	Resistor, Carbon Film, 1/8W, 5%
R 232	G4	47	Resistor, Carbon Film, 1/8W, 5%
R 233	G3	47	Resistor, Carbon Film, 1/8W, 5%
R 234	F4	47	Resistor, Carbon Film, 1/8W, 5%
R 235	F3	47	Resistor, Carbon Film, 1/8W, 5%
R 236	F4	47	Resistor, Carbon Film, 1/8W, 5%
R 237	F4	220	Resistor, Carbon Film, 1/4W, 5%
R 238	F3	47	Resistor, Carbon Film, 1/8W, 5%
R 239	F3	220	Resistor, Carbon Film, 1/4W, 5%
R 240	F3	1.2K	Resistor, Carbon Film, 1/4W, 5%
R 241	F3	470	Resistor, Carbon Film, 1/4W, 5%
R 242	F4	30	Resistor, Carbon Film, 1/8W, 5%
R 243	E4	39	Resistor, Carbon Film, 1/4W, 5%
R 244	E4	56	Resistor, Carbon Film, 1/4W, 5%
R 245	E3	39	Resistor, Carbon Film, 1/4W, 5%
R 246	E3	56	Resistor, Carbon Film, 1/4W, 5%
R 247	F3	56	Resistor, Carbon Film, 1/8W, 5%
R 248	F5	390	Resistor, Carbon Comp, 1/2W, 5%
R 249	F3	10.0K	Resistor, Metal Film, 1/8W, 1%
R 250	F3	33.2	Resistor, Metal Film, 1/8W, 1%
R 251	F3	10.0K	Resistor, Metal Film, 1/8W, 1%
R 252	F2	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 253	F3	33	Resistor, Carbon Film, 1/4W, 5%
R 254	F2	47	Resistor, Carbon Film, 1/4W, 5%
R 255	F2	150	Resistor, Metal Film, 1/8W, 1%
R 256	F4	10.0K	Resistor, Metal Film, 1/8W, 1%
R 257	F4	10.0K	Resistor, Metal Film, 1/8W, 1%
R 258	F3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 259	E3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 260	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 261	E7	10K	Resistor, Carbon Film, 1/4W, 5%
R 262	E6	22M	Resistor, Carbon Comp, 1/4W, 5%
R 263	F5	10.0K	Resistor, Metal Film, 1/8W, 1%
R 264	G5	21.0K	Resistor, Metal Film, 1/8W, 1%
R 265	G6	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 266	G7	10.0K	Resistor, Metal Film, 1/8W, 1%
R 267	E1	100K	Resistor, Metal Film, 1/8W, 1%
R 268	E1	49.9K	Resistor, Metal Film, 1/8W, 1%
R 269	E1	20.0K	Resistor, Metal Film, 1/8W, 1%
R 270	D1	10.0K	Resistor, Metal Film, 1/8W, 1%
R 271	E1	4.99K	Resistor, Metal Film, 1/8W, 1%
R 272	D1	2.00K	Resistor, Metal Film, 1/8W, 1%
R 273	D1	1.00K	Resistor, Metal Film, 1/8W, 1%
R 274	D1	499	Resistor, Metal Film, 1/8W, 1%
R 275	D2	49.9K	Resistor, Metal Film, 1/8W, 1%
R 276	E2	100K	Resistor, Metal Film, 1/8W, 1%
R 277	E2	4.99K	Resistor, Metal Film, 1/8W, 1%
R 279	G7	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 280	G3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 281	G4	470	Resistor, Carbon Film, 1/4W, 5%
R 282	G1	56	Resistor, Carbon Film, 1/4W, 5%
R 283	D7	10K	Resistor, Carbon Film, 1/4W, 5%
R 284		150	Resistor, Carbon Film, 1/8W, 5%
R 300	F6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 301	F6	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 302	F7	10.0K	Resistor, Metal Film, 1/8W, 1%
R 303	F6	10K	Resistor, Carbon Film, 1/4W, 5%
R 304	F6	10K	Resistor, Carbon Film, 1/4W, 5%
R 305	D9	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 307	E6	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 308	E1	560	Resistor, Carbon Film, 1/4W, 5%
R 309	E1	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 310	E1	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 311	E1	22K	Resistor, Carbon Film, 1/4W, 5%
R 312	E1	68K	Resistor, Carbon Film, 1/4W, 5%
R 313	E5	1.5M	Resistor, Carbon Film, 1/4W, 5%
R 314	F8	470	Resistor, Carbon Film, 1/4W, 5%
R 315	F8	10K	Resistor, Carbon Film, 1/4W, 5%
R 316	F8	470	Resistor, Carbon Film, 1/4W, 5%
R 317	F8	10K	Resistor, Carbon Film, 1/4W, 5%
R 318	E8	22K	Resistor, Carbon Film, 1/4W, 5%
R 319	E8	220K	Resistor, Carbon Film, 1/4W, 5%
R 320	D9	390	Resistor, Carbon Film, 1/4W, 5%
R 321	G7	10K	Resistor, Carbon Film, 1/4W, 5%
R 322	F8	10K	Resistor, Carbon Film, 1/4W, 5%
R 323	D8	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 324	D8	220	Resistor, Carbon Film, 1/4W, 5%
R 325	C8	150	Resistor, Carbon Comp, 1/2W, 5%
R 326	D8	220	Resistor, Carbon Film, 1/4W, 5%
R 327	D8	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 328	C8	330	Resistor, Carbon Film, 1/4W, 5%
R 329	D8	56	Resistor, Carbon Film, 1/4W, 5%
R 330	D6	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 331	C6	10K	Resistor, Carbon Film, 1/4W, 5%
R 332	C5	10K	Resistor, Carbon Film, 1/4W, 5%
R 333	E8	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 334	F8	390K	Resistor, Carbon Film, 1/4W, 5%
SW1	A1	1P12T	Switch, Rotary, PCB Mounted
SW2	B1	2P12T	Switch, Rotary, PCB Mounted
SW3	C1	2P12T	Switch, Rotary, PCB Mounted
SW4	D1	1P12T	Switch, Rotary, PCB Mounted
SW5	F1	2P12T	Switch, Rotary, PCB Mounted
SW6	SPST		Switch, Momentary Push Button
SW7	SPDT		Switch, On-Off-On, Locking Toggle
SW8	DPDT		Switch, Miniature Bat Toggle
SW9	SPDT		Switch, On-None-On, Locking Toggle
U 1	A4	CA3102	Integrated Circuit
U 2	A6	LF347	Integrated Circuit
U 3	B8	74S15	Integrated Circuit
U 4	C4	CA3102	Integrated Circuit
U 5	D4	CA3102	Integrated Circuit
U 6	E3	CA3102	Integrated Circuit
U 7	B6	LF347	Integrated Circuit
U 8	A8	74LS123	Integrated Circuit
U 9	C6	DG211	Integrated Circuit
U 10	D6	DG211	Integrated Circuit
U 11	F6	LF347	Integrated Circuit
U 12	E6	DG211	Integrated Circuit
U 13	F8	LF412	Integrated Circuit
U 14	D8	74LS74	Integrated Circuit
U 15	E8	74LS123	Integrated Circuit
U 16	F4	LF347	Integrated Circuit
U 17	G6	LF347	Integrated Circuit
U 18	D2	LM318	Integrated Circuit
U 19	A9	MC7815	Integrated Circuit
U 20	C9	MC7805	Integrated Circuit
U 21	D9	MC7905	Integrated Circuit
U 22	F9	MC7915	Integrated Circuit
Z 0		2607	Dial
Z 0		KLN500B	1/4 Knobs
Z 0		KLN500B	1/8 Knobs
Z 0		KN500B	1/4 Knobs
Z 0		3/8"	Lugs
Z 0		11"	Wire, Other
Z 0		09-011	NIM Parts
Z 0		200833-4	NIM Parts
Z 0		202394-2	NIM Parts
Z 0		202514-1	NIM Parts
Z 0		203964-6	NIM Parts
Z 0		204186-5	NIM Parts

MODEL SR255 PARTS LIST

Ref	Loc	Value	Description
C 101	G8	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 102	G8	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 103	E8	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 104	E8	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 105	E9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 106	E9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 107	G9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 108	G9	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 109	A8	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 110	G5	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 111	F4	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 112	E6	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 113	F5	200P	Capacitor, Silver Mica, 250V, 5%, DM15
C 114	E5	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 115	E5	.022U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 116	G8	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 117	F8	47U	Capacitor, Electrolytic, 50V, 20%,RADI
C 118	F9	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 119	G9	22U	Capacitor, Electrolytic, 50V, 20%,RADI
C 120	E5	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 201	TF	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 202	TF	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 203	TF	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 204	TF	100P	Capacitor, Ceramic, 50V, 10%, NPO, CHI
C 205	TF	100P	Capacitor, Ceramic, 50V, 10%, NPO, CHI
C 206	TF	22P	Capacitor, Ceramic, 50V, 10%, NPO, CHI
C 207	TF	22P	Capacitor, Ceramic, 50V, 10%, NPO, CHI
C 208	TF	10U	Capacitor, Electrolytic, 50V, 20%,RADI
C 209	TF	10U	Capacitor, Electrolytic, 50V, 20%,RADI
C 210	TF	47P	Capacitor, Silver Mica, 250V, 5%, DM15
C 211	TF	47P	Capacitor, Silver Mica, 250V, 5%, DM15
C 212	TF	1P	Capacitor Silver Mica for SR255
C 213	TF	6P	Max, Variable Capacitor, 250V, 5mm
C 214	TF	50P	Max, Variable Capacitor, 250V, 5mm
C 215	TF	100P	Capacitor, Silver Mica, 250V, 5%, DM15
C 216	TF	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 217	TF	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 218	TF	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 301	B3	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 302	B2	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 303	A5	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 304	B2	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 305	B2	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 306	B5	.0047U	Capacitor, Polystyrene, 50V, 5%, RADIA
C 307	D5	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 308	C5	100P	Capacitor, Silver Mica, 250V, 5%, DM15
C 309	C5	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 310	A7	1000P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 311	C5	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 401	B7	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 402	B6	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 403	A7	.001U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 404	A7	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 405	B6	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 406	B6	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 407	C6	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 408	C6	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 101	G2	1N4148	Diodes
D 102	F5	1N4148	Diodes
D 201	TF	MMD835	Diode, Step Recovery
D 202	TF	MSS50	Diodes, Dual Schottky
D 301	A6	1N4148	Diodes
D 302	A6	1N4148	Diodes
D 303	A5	1N4148	Diodes
D 304	A5	1N4148	Diodes
D 401	A1	HLMP-1503	LED, T1 Package, Green
D 402	A1	HLMP-1503	LED, T1 Package, Green
D 403	A1	HLMP-1503	LED, T1 Package, Green
D 404	A1	HLMP-1503	LED, T1 Package, Green
D 405	B1	HLMP-1503	LED, T1 Package, Green
D 406	B1	HLMP-1300	LED, T1 Package, Red
J 401	A9	15 PIN D	CNCTR, Male
P 101	G7	2.0K	PCB mount trim pot, inline leads
P 102	F7	10K	PCB mount trim pot, inline leads
P 301	A4	4X10K	Quad Trim Pot, DIP package
P 302	A4	4X10K	Quad Trim Pot, DIP package
P 401	C4	10K	PCB mount trim pot, inline leads
PC1		SR255	Printed Circuit Board
PC2		SR255DUR	Printed Circuit Board
Q 101	G4	2N5771	Transistor, TO-92 Package
Q 102	G4	2N5771	Transistor, TO-92 Package
Q 103	F6	2N5771	Transistor, TO-92 Package
Q 104	F6	2N5771	Transistor, TO-92 Package
Q 105	G5	2N5771	Transistor, TO-92 Package
Q 201	TF	MRF914	Transistor, TO-72 Package
Q 202	TF	2N5583	Transistor, TO-39 Package
Q 301	B3	2N5086	Transistor, TO-92 Package
Q 302	B2	2N5086	Transistor, TO-92 Package
Q 303	A3	2N5086	Transistor, TO-92 Package
Q 304	A2	2N5086	Transistor, TO-92 Package
Q 305	A3	2N5088	Transistor, TO-92 Package
Q 306	A2	2N5088	Transistor, TO-92 Package
Q 307	A2	2N5088	Transistor, TO-92 Package
R 101	G2	51	Resistor, Carbon Film, 1/4W, 5%
R 102	G2	47	Resistor, Carbon Film, 1/4W, 5%
R 103	G3	47	Resistor, Carbon Film, 1/4W, 5%
R 104	G3	100	Resistor, Carbon Film, 1/4W, 5%
R 105	G2	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 106	G2	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 107	G2	100	Resistor, Carbon Film, 1/4W, 5%
R 108	G3	47	Resistor, Carbon Film, 1/4W, 5%
R 109	G3	47	Resistor, Carbon Film, 1/4W, 5%
R 110	G3	2.4K	Resistor, Carbon Film, 1/4W, 5%
R 111	G3	47	Resistor, Carbon Film, 1/4W, 5%
R 112	G2	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 113	G4	390	Resistor, Carbon Film, 1/4W, 5%
R 114	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 115	G3	56	Resistor, Carbon Film, 1/4W, 5%
R 116	G4	560	Resistor, Carbon Film, 1/4W, 5%
R 117	G3	56	Resistor, Carbon Film, 1/4W, 5%
R 118	G4	56	Resistor, Carbon Film, 1/4W, 5%
R 119	G4	390	Resistor, Carbon Film, 1/4W, 5%
R 120	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 121	F5	47	Resistor, Carbon Film, 1/4W, 5%
R 122	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 123	G4	47	Resistor, Carbon Film, 1/4W, 5%
R 124	G5	47	Resistor, Carbon Film, 1/4W, 5%
R 125	G5	825	Resistor, Metal Film, 1/8W, 1%
R 126	G4	56	Resistor, Carbon Film, 1/4W, 5%
R 127	G4	56	Resistor, Carbon Film, 1/4W, 5%
R 128	F5	47	Resistor, Carbon Film, 1/4W, 5%
R 129	F6	390	Resistor, Carbon Film, 1/4W, 5%
R 130	F6	47	Resistor, Carbon Film, 1/4W, 5%
R 131	F5	47	Resistor, Carbon Film, 1/4W, 5%
R 132	G6	47	Resistor, Carbon Film, 1/4W, 5%
R 133	G5	100	Resistor, Carbon Film, 1/4W, 5%
R 134	G4	100	Resistor, Carbon Film, 1/4W, 5%
R 135	G6	100	Resistor, Carbon Film, 1/4W, 5%
R 136	G6	47	Resistor, Carbon Film, 1/4W, 5%
R 137	G6	47	Resistor, Carbon Film, 1/4W, 5%
R 138	F5	47	Resistor, Carbon Film, 1/4W, 5%
R 139	G5	47	Resistor, Carbon Film, 1/4W, 5%
R 140	G5	820	Resistor, Carbon Film, 1/4W, 5%
R 141	G6	9.09K	Resistor, Metal Film, 1/8W, 1%
R 142	F6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 143	G6	15.0K	Resistor, Metal Film, 1/8W, 1%
R 144	F6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 145	F6	10.0K	Resistor, Metal Film, 1/8W, 1%
R 146	F5	10K	Resistor, Carbon Film, 1/4W, 5%
R 147	E5	20K	Resistor, Carbon Film, 1/4W, 5%
R 148	E5	20K	Resistor, Carbon Film, 1/4W, 5%
R 150	G3	510	Resistor, Carbon Film, 1/4W, 5%
R 151	G8	10	Resistor, Carbon Film, 1/4W, 5%
R 152	G8	10	Resistor, Carbon Film, 1/4W, 5%
R 153	F8	2.2	Resistor, Carbon Film, 1/4W, 5%
R 154	F8	2.2	Resistor, Carbon Film, 1/4W, 5%
R 155	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 156	F9	10	Resistor, Carbon Film, 1/4W, 5%
R 157	G9	10	Resistor, Carbon Film, 1/4W, 5%
R 158	G8	10	Resistor, Carbon Film, 1/4W, 5%
R 201	TF	150	Resistor, Carbon Film, 1/4W, 5%
R 202	TF	270	Resistor, Carbon Film, 1/4W, 5%
R 203	TF	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 204	TF	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 205	TF	270	Resistor, Carbon Film, 1/4W, 5%
R 206	TF	270	Resistor, Carbon Film, 1/4W, 5%
R 207	TF	47	Resistor, Carbon Film, 1/8W, 5%
R 208	TF	33	Resistor, Flat Chip, 1/8W, 5%
R 209	TF	51	Resistor, Flat Chip, 1/8W, 5%
R 210	TF	100K	Resistor, Carbon Film, 1/4W, 5%
R 211	TF	10K	Resistor, Carbon Film, 1/4W, 5%
R 212	TF	100K	Resistor, Carbon Film, 1/4W, 5%
R 213	TF	1.0K	Resistor, Carbon Film, 1/8W, 5%
R 214	TF	1.0K	Resistor, Carbon Film, 1/8W, 5%

Ref	Loc	Value	Description
R 215	TF	100K	Resistor, Carbon Film, 1/4W, 5%
R 216	TF	100K	Resistor, Carbon Film, 1/4W, 5%
R 217	TF	10K	Resistor, Carbon Film, 1/4W, 5%
R 218	TF	10K	Resistor, Carbon Film, 1/4W, 5%
R 219	TF	11K	Resistor, Carbon Film, 1/4W, 5%
R 220	TF	470	Resistor, Carbon Film, 1/4W, 5%
R 221	TF	100	Resistor, Carbon Film, 1/4W, 5%
R 222	TF	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 223	TF	10K	Resistor, Carbon Film, 1/4W, 5%
R 224	TF	10K	Resistor, Carbon Film, 1/4W, 5%
R 225	TF	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 226	TF	Deleted	Misc. Components
R 227	TF	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 228	TF	220	Resistor, Carbon Film, 1/4W, 5%
R 229	TF	33	Resistor, Carbon Film, 1/4W, 5%
R 230	TF	10	Resistor, Carbon Film, 1/8W, 5%
R 231	TF	10	Resistor, Carbon Film, 1/8W, 5%
R 232	TF	150	Resistor, Carbon Film, 1/8W, 5%
R 233		15	Resistor, Flat Chip, 1/8W, 5%
R 234		15	Resistor, Flat Chip, 1/8W, 5%
R 235		15	Resistor, Flat Chip, 1/8W, 5%
R 236		15	Resistor, Flat Chip, 1/8W, 5%
R 301	B3	180	Resistor, Carbon Film, 1/4W, 5%
R 302	B3	220	Resistor, Carbon Film, 1/4W, 5%
R 303	B3	220	Resistor, Carbon Film, 1/4W, 5%
R 305	B3	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 306	B3	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 307	B2	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 308	B2	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 309	B5	330	Resistor, Carbon Film, 1/4W, 5%
R 310	A3	330	Resistor, Carbon Film, 1/4W, 5%
R 311	A3	220	Resistor, Carbon Film, 1/4W, 5%
R 312	A2	220	Resistor, Carbon Film, 1/4W, 5%
R 313	A3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 314	A3	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 315	A2	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 316	A2	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 317	A3	220	Resistor, Carbon Film, 1/4W, 5%
R 318	A2	220	Resistor, Carbon Film, 1/4W, 5%
R 319	A2	560	Resistor, Carbon Film, 1/4W, 5%
R 320	A2	330	Resistor, Carbon Film, 1/4W, 5%
R 321	A2	270	Resistor, Carbon Film, 1/4W, 5%
R 322	B2	10K	Resistor, Carbon Film, 1/4W, 5%
R 323	B2	39K	Resistor, Carbon Film, 1/4W, 5%
R 324	B1	10K	Resistor, Carbon Film, 1/4W, 5%
R 325	B1	5.1K	Resistor, Carbon Film, 1/4W, 5%
R 326	A5	10K	Resistor, Carbon Film, 1/4W, 5%
R 327	A5	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 328	A3	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 329	D6	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 330	D6	100	Resistor, Carbon Film, 1/4W, 5%
R 331	D5	100K	Resistor, Carbon Film, 1/4W, 5%
R 332	D6	10K	Resistor, Carbon Film, 1/4W, 5%
R 333	A6	10K	Resistor, Carbon Film, 1/4W, 5%
R 334	A5	10K	Resistor, Carbon Film, 1/4W, 5%
R 335	A5	10K	Resistor, Carbon Film, 1/4W, 5%
R 336	C5	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 337	C5	330	Resistor, Carbon Film, 1/4W, 5%
R 338	C5	330	Resistor, Carbon Film, 1/4W, 5%
R 339	C6	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 340	B1	10K	Resistor, Carbon Film, 1/4W, 5%
R 341	B1	10K	Resistor, Carbon Film, 1/4W, 5%
R 342	B5	100	Resistor, Carbon Film, 1/4W, 5%
R 401	A1	330	Resistor, Carbon Film, 1/4W, 5%
R 402	A1	330	Resistor, Carbon Film, 1/4W, 5%
R 403	A1	330	Resistor, Carbon Film, 1/4W, 5%
R 404	A1	330	Resistor, Carbon Film, 1/4W, 5%
R 405	B6	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 406	A6	120K	Resistor, Carbon Film, 1/4W, 5%
R 407	B5	10.0K	Resistor, Metal Film, 1/8W, 1%
R 408	B5	4.99K	Resistor, Metal Film, 1/8W, 1%
R 409	A6	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 410	A7	220K	Resistor, Carbon Film, 1/4W, 5%
R 411	B1	220	Resistor, Carbon Film, 1/4W, 5%
R 412	B6	1.00K	Resistor, Metal Film, 1/8W, 1%
R 413	B6	140	Resistor, Metal Film, 1/8W, 1%
R 414	B6	49.9K	Resistor, Metal Film, 1/8W, 1%
R 415	C6	470	Resistor, Carbon Film, 1/4W, 5%
R 416	C6	49.9K	Resistor, Metal Film, 1/8W, 1%
R 417	B6	100K	Resistor, Carbon Film, 1/4W, 5%
R 418	B1	330	Resistor, Carbon Film, 1/4W, 5%
R 419	C6	470	Resistor, Carbon Film, 1/4W, 5%
R 420	C6	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 421	A9	100K	Resistor, Carbon Film, 1/4W, 5%
R 422	C5	51	Resistor, Carbon Film, 1/4W, 5%
R 423	A5	1.0K	Resistor, Carbon Film, 1/4W, 5%
RN401	D9	9X100K	Resistor Network SIP 1/4W 2% Common
SO1	B8	28	DIP Socket
SW101	B1	SPDT	Switch, On-Off-On, Small Toggle
SW102	E4	SPSTX4	Switch, Miniature Bat Toggle
SW201	TF	SPSTX4	Switch, Miniature Bat Toggle
SW301	B1	DPDT	Switch, On-Off-On, Small Toggle
SW401	D4	SPSTX4	Switch, Miniature Bat Toggle
SW402	D9	SPSTX4	Switch, Miniature Bat Toggle
T1	TF	T1-1	Transformer
U 101	E8	MC7815	Integrated Circuit
U 102	G8	MC7805	Integrated Circuit
U 103	E9	MC7905	Integrated Circuit
U 104	G9	MC7915	Integrated Circuit
U 105	G2	CA3102	Integrated Circuit
U 106	F5	CA3102	Integrated Circuit
U 107	F6	LF412	Integrated Circuit
U 201	TF	LM733	Integrated Circuit
U 301	C5	74LS123	Integrated Circuit
U 302	B2	LM318	Integrated Circuit
U 303	B5	DG211	Integrated Circuit
U 304	A5	LF347	Integrated Circuit
U 305	D5	LM311	Integrated Circuit
U 306	B4	CD4052	Integrated Circuit
U 401	D1	74HC00	Integrated Circuit
U 402	D8	74HC74	Integrated Circuit
U 403	C7	74LS21	Integrated Circuit
U 404	B7	AD7574	Integrated Circuit
U 405	A7	74LS123	Integrated Circuit
U 406	B8	2764-250	Integrated Circuit
U 407	C9	74HC174	Integrated Circuit
U 408	B9	74HC244	Integrated Circuit
U 409	B8	74HC374	Integrated Circuit
U 410	B5	LH0071	Integrated Circuit
U 411	B5	LF347	Integrated Circuit
U 412	B7	AD7524	Integrated Circuit
U 413	D8	74HC00	Integrated Circuit
U 414	D9	74HC85	Integrated Circuit
U 415	D7	74HC74	Integrated Circuit
Z0		3/8"	Lugs
Z0		09-011	NIM Parts
Z0		200833-4	NIM Parts
Z0		202394-2	NIM Parts
Z0		202514-1	NIM Parts
Z0		203964-6	NIM Parts
Z0		204186-5	NIM Parts
Z0		66103-4	NIM Parts
Z0		4-40 KEP	Nut, Kep
Z0		4-40 KNURL	Nut, Knurl
Z0		6-32 KEP	Nut, Kep
Z0		4-40X1/4P	Screw, Panhead
Z0		4-40X3/8P	Screw, Panhead
Z0		4-40X5/16F	Screw, Flathead
Z0		6-32X1/4P	Screw, Panhead
Z0		M/F 3/16"	Standoff
Z0		4"	Tie
Z0		#6X.047"	Washer
Z0		1-1/2" #24	Wire #24
Z0		1-3/4"#24B	Wire #24
Z0		1-3/4"#24R	Wire #24
Z0		2-1/4" #24	Wire #24
Z0		3-1/2" #24	Wire #24
Z0		BNC	BNC Connector
Z0		UG-58A/U	N-type Panel Connector
Z0		UG201A/U	N-type Panel Connector
Z0		SR255	Front Panel
Z0		FAST BRACK	Fabricated Parts
Z0		SR255	Rear Panel
Z0		SR255	Side Panel
Z0		BLANK	NIM Parts
Z0		23-001	NIM Parts
Z0		24-001	NIM Parts
Z0		25-001	NIM Parts
Z0		26-001	NIM Parts
Z0		26-003	NIM Parts

MODEL SR275 PARTS LIST

Ref	Value	Description
C1	.1U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C2	.22U	Capacitor, Mylar/Poly, 50V, 10%, RADIA
C3	.22U	Capacitor, Mylar/Poly, 50V, 10%, RADIA
C4	100P	Capacitor, Silver Mica, 250V, 5%, DM15
C5	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C6	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C7	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C8	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C9	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C10	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C11	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C12	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C13	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
M1	-10/0/10	Analog Meter
P1	20K	PBS Find Out
PC1	SR275	PCB Board
R1	20K	Resistor, Carbon Film, 1/4W, 5%
R2	470K	Resistor, Carbon Film, 1/4W, 5%
R3	110K	Resistor, Carbon Film, 1/4W, 5%
R4	909K	Resistor, Metal Film, 1/8W, 1%
R5	100K	Resistor, Metal Film, 1/8W, 1%
R6	100K	Resistor, Carbon Film, 1/4W, 5%
R7	220	Resistor, Carbon Film, 1/4W, 5%
R8	220	Resistor, Carbon Film, 1/4W, 5%
R9	300	Resistor, Carbon Film, 1/4W, 5%
R10	750K	Resistor, Metal Film, 1/8W, 1%
R11	249K	Resistor, Metal Film, 1/8W, 1%
R12	10.0K	Resistor, Metal Film, 1/8W, 1%
R13	12.1K	Resistor, Metal Film, 1/8W, 1%
R14	10.0K	Resistor, Metal Film, 1/8W, 1%
R15	10.0K	Resistor, Metal Film, 1/8W, 1%
R16	10.0K	Resistor, Metal Film, 1/8W, 1%
R17	10.0K	Resistor, Metal Film, 1/8W, 1%
R18	1.0K	Resistor, Carbon Film, 1/4W, 5%
R19	2.7K	Resistor, Carbon Film, 1/4W, 5%
R20	100K	Resistor, Carbon Film, 1/4W, 5%
R21	100K	Resistor, Carbon Film, 1/4W, 5%
R22	1.0M	Resistor, Carbon Film, 1/4W, 5%
R23	20K	Resistor, Carbon Film, 1/4W, 5%
R24	47	Resistor, Carbon Film, 1/4W, 5%
R25	1.8K	Resistor, Carbon Film, 1/4W, 5%
SO1	40	DIP Socket
SO2	20	DIP Socket
SO3	20	DIP Socket
SO6	14	DIP Socket
SO7	14	DIP Socket
SO8	14	DIP Socket
SO9	14	DIP Socket
SO10	14	DIP Socket
SO11	14	DIP Socket
SO12	14	DIP Socket

Ref	Value	Description
SO13	14	DIP Socket
SO14	14	DIP Socket
SW1	SPST	Switch, Momentary Push Button, NO
SW2	3PDT	Switch, Miniature Bat Toggle
U1	ICL7117	Integrated Circuit
U2	LM3914	Integrated Circuit
U3	LM3914	Integrated Circuit
U4	LF347	Integrated Circuit
U5	MAN72	Integrated Circuit
U6	MAN72	Integrated Circuit
U7	MAN72	Integrated Circuit
U8	MAN73	Integrated Circuit
U9	HDSP-4820	Integrated Circuit
U10	HDSP-4820	Integrated Circuit
U11	MC7805	Integrated Circuit
U12	MC79L05	Integrated Circuit
U13	MC79L15	Integrated Circuit
U14	MC78L15	Integrated Circuit
Z0	HEAT SINK	Heat Sinks
Z0	3/8"	Lugs
Z0	09-011	NIM Parts
Z0	200833-4	NIM Parts
Z0	202394-2	NIM Parts
Z0	202514-1	NIM Parts
Z0	202516-3	NIM Parts
Z0	203964-6	NIM Parts
Z0	66099-4	NIM Parts
Z0	4-40 HEX	Nut, Hex
Z0	4-40 KEP	Nut, Kep
Z0	6-32 KEP	Nut, Kep
Z0	4-40X1/4P	Screw, Panhead
Z0	6-32X3/8P	Screw, Panhead
Z0	36154	Termination
Z0	4"	Tie
Z0	#4	Washer
Z0	1/4X1/16	Washer
Z0	1/4X1/32	Washer
Z0	RED	Window
Z0	1-1/2" #24	Wire #24
Z0	16" #18	Wire #18
Z0	2-1/4" #24	Wire #24
Z0	8-1/4" #18	Wire #18
Z0	BNC	BNC Connector
Z0	SR275	Front Panel
Z0	BRACKET	Fabricated Parts
Z0	22-003	NIM Parts
Z0	23-001	NIM Parts
Z0	24-003	NIM Parts
Z0	25-003	NIM Parts
Z0	26-001	NIM Parts
Z0	26-002	NIM Parts
Z0	26-003	NIM Parts

MODEL SR280 PARTS LIST

Display PC

Ref	Value	Description
C 1	.1U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 2	.22U	Capacitor, Mylar/Poly, 50V, 10%, RADIA
C 3	.22U	Capacitor, Mylar/Poly, 50V, 10%, RADIA
C 4	100P	Capacitor, Silver Mica, 250V, 5%, DM15
C 5	.01U	Capacitor, Mylar/Poly, 50V, 5%, Radial
C 6	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 7	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C 8	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C 9	.33U	Capacitor, Tantalum, 35V, 20%, Radial
C 10	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 11	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 12	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 13	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 101	5800U	Capacitor, Electrolytic, 40V, +80/-20%
C 102	5800U	Capacitor, Electrolytic, 40V, +80/-20%
C 103	2400U	Capacitor, Electrolytic, 50V, +80/-20%
C 104	2400U	Capacitor, Electrolytic, 50V, +80/-20%
F 101	1A SLO-BLO	Fuse
F 102	2A SLO-BLO	Fuse
M 1	-10/0/10	Analog Meter
P 1	20K	PBS Find Out
PC1	SR275	PCB Board
R 1	20K	Resistor, Carbon Film, 1/4W, 5%
R 2	470K	Resistor, Carbon Film, 1/4W, 5%
R 3	110K	Resistor, Carbon Film, 1/4W, 5%
R 4	909K	Resistor, Metal Film, 1/8W, 1%
R 5	100K	Resistor, Metal Film, 1/8W, 1%
R 6	100K	Resistor, Carbon Film, 1/4W, 5%
R 7	220	Resistor, Carbon Film, 1/4W, 5%
R 8	220	Resistor, Carbon Film, 1/4W, 5%
R 9	300	Resistor, Carbon Film, 1/4W, 5%
R 10	750K	Resistor, Metal Film, 1/8W, 1%
R 11	249K	Resistor, Metal Film, 1/8W, 1%
R 12	10.0K	Resistor, Metal Film, 1/8W, 1%
R 13	12.1K	Resistor, Metal Film, 1/8W, 1%
R 14	10.0K	Resistor, Metal Film, 1/8W, 1%
R 15	10.0K	Resistor, Metal Film, 1/8W, 1%
R 16	10.0K	Resistor, Metal Film, 1/8W, 1%
R 17	10.0K	Resistor, Metal Film, 1/8W, 1%
R 18	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 19	2.7K	Resistor, Carbon Film, 1/4W, 5%
R 20	100K	Resistor, Carbon Film, 1/4W, 5%
R 21	100K	Resistor, Carbon Film, 1/4W, 5%
R 22	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 23	20K	Resistor, Carbon Film, 1/4W, 5%
R 24	47	Resistor, Carbon Film, 1/4W, 5%
R 25	1.8K	Resistor, Carbon Film, 1/4W, 5%
SO1	40	DIP Socket
SO2	20	DIP Socket
SO3	20	DIP Socket
SO6	14	DIP Socket
SO7	14	DIP Socket
SO8	14	DIP Socket
SO9	14	DIP Socket
SO10	14	DIP Socket
SO11	14	DIP Socket
SO12	14	DIP Socket
SO13	14	DIP Socket
SO14	14	DIP Socket
SW1	SPDT	Switch, On-None-On, Large Toggle
SW1	SPST	Switch, Momentary Push Button, NO
SW2	3PDT	Switch, Miniature Bat Toggle
T 101	4A48V	Transformer
U 1	ICL7117	Integrated Circuit
U 2	MDA2502	Integrated Circuit
U 3	LM3914	Integrated Circuit
U 4	LF347	Integrated Circuit
U 5	MAN72	Integrated Circuit
U 6	MAN72	Integrated Circuit
U 7	MAN72	Integrated Circuit
U 8	MAN73	Integrated Circuit
U 9	HDSP-4820	Integrated Circuit
U 10	HDSP-4820	Integrated Circuit
U 11	MC7805	Integrated Circuit
U 12	MC79L05	Integrated Circuit
U 13	MC79L15	Integrated Circuit
U 14	MC78L15	Integrated Circuit
U 101	MDA2502	Integrated Circuit
U 102	LM3914	Integrated Circuit
Z0	AC RECPT	Power Entry Hardware
Z0	CAP BRACK	Misc. Hardware
Z0	FUSEHOLDER	Power Entry Hardware
Z0	HEAT SINK	Heat Sinks
Z0	LINE CORD	Power Entry Hardware
Z0	3/8"	Lugs
Z0	09-011	NIM Parts
Z0	200833-4	NIM Parts
Z0	202394-2	NIM Parts
Z0	202514-1	NIM Parts
Z0	202516-3	NIM Parts
Z0	203964-6	NIM Parts
Z0	66099-4	NIM Parts
Z0	66101-4	NIM Parts
Z0	10-32 HEX	Nut, Hex
Z0	4-40 HEX	Nut, Hex
Z0	4-40 KEP	Nut, Kep
Z0	6-32 HEX	Nut, Hex
Z0	6-32 KEP	Nut, Kep
Z0	8-32 HEX	Nut, Hex
Z0	10-32x1F	Screw, Flathead
Z0	10-32X3/8F	Screw, Flathead
Z0	4-40X1/4F	Screw, Flathead
Z0	4-40X1/4P	Screw, Panhead
Z0	4-40X3/8F	Screw, Flathead
Z0	4-40X5/8F	Screw, Flathead
Z0	6-32X3/8P	Screw, Panhead
Z0	8-32X3/4F	Screw, Flathead
Z0	32054	Termination
Z0	36154	Termination
Z0	52422-1	Termination
Z0	640903-1	Termination
Z0	640905-1	Termination
Z0	4"	Tie
Z0	#4	Washer
Z0	1/4X1/16	Washer
Z0	1/4X1/32	Washer
Z0	10-32 LOCK	Washer, lock
Z0	8-32 LOCK	Washer
Z0	RED	Window
Z0	1-1/2" #24	Wire #24
Z0	10-1/8"#18	Wire #18
Z0	11-3/4"#18	Wire #18
Z0	16" #18	Wire #18
Z0	2-1/2" #18	Wire #18
Z0	2-1/4" #24	Wire #24
Z0	3" #18	Wire #18
Z0	4" #18	Wire #18
Z0	5-5/8" #18	Wire #18
Z0	7-5/8" #18	Wire #18
Z0	8-1/4" #18	Wire #18
Z0	9" #18	Wire #18
Z0	BNC	BNC Connector
Z0	SR280	Front Panel
Z0	BRACKET	Fabricated Parts
Z0	PLATE	Fabricated Parts
Z0	SR280-120V	Rear Panel
Z0	SR280-220V	Rear Panel
Z0	23-001	NIM Parts
Z0	24-003	NIM Parts
Z0	25-003	NIM Parts
Z0	26-001	NIM Parts
Z0	26-002	NIM Parts
Z0	26-003	NIM Parts

MODEL SR280 PARTS LIST

Regulator Strip

Ref	Value	Description
C 1	1.0U	Capacitor, Tantalum, 50V, 20%, Radial
C 2	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 3	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 4	2.2U	Capacitor, Tantalum, 35V, 20%, Radial
C 5	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 6	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 7	1.0U	Capacitor, Tantalum, 50V, 20%, Radial
C 8	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 9	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 10	10U	Capacitor, Tantalum, 35V, 20%, Radial
C 11	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 12	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 13	100U	Capacitor, Electrolytic, 50V, 20%, AXI
C 14	.1U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
D 1	1N4007	Diodes
D 2	1N4007	Diodes
D 3	1N4007	Diodes
D 4	1N4007	Diodes
D 5	1N4007	Diodes
D 6	1N4007	Diodes
D 7	1N4007	Diodes
P 1	20	PCB mount trim pot, inline leads
P 2	20	PCB mount trim pot, inline leads
P 3	10	PCB mount trim pot, inline leads
P 4	20	PCB mount trim pot, inline leads
PC1	SR280	PCB Board
R 1	200	Resistor, Metal Film, 1/8W, 1%
R 2	3.83K	Resistor, Metal Film, 1/8W, 1%
R 3	200	Resistor, Metal Film, 1/8W, 1%
R 4	1.82K	Resistor, Metal Film, 1/8W, 1%
R 5	100	Resistor, Metal Film, 1/8W, 1%
R 6	1.91K	Resistor, Metal Film, 1/8W, 1%
R 7	200	Resistor, Metal Film, 1/8W, 1%
R 8	294	Resistor, Metal Film, 1/8W, 1%
R 9	1.0K	Resistor, Carbon Film, 1/4W, 5%
U 1	LM317	Integrated Circuit
U 2	LM350	Integrated Circuit
U 3	LM337	Integrated Circuit
U 4	LM345	Integrated Circuit
U 5	LM741	Integrated Circuit
Z 0	FOOT	Misc. Hardware
Z 0	STANDOFF	Standoff
Z 0	PLASTIC	Insulators
Z 0	03-001	NIM Parts
Z 0	200833-4	NIM Parts
Z 0	202512-1	NIM Parts
Z 0	202516-3	NIM Parts
Z 0	203964-6	NIM Parts
Z 0	66099-4	NIM Parts
Z 0	66101-4	NIM Parts
Z 0	6-32 KEP	Nut, Kep
Z 0	4-40X1/4F	Screw, Flathead
Z 0	6-32X1/2R	Screw, Roundhead
Z 0	6-32X2P	Screw, Panhead
Z 0	6-32X3/4R	Screw, Roundhead
Z 0	6-32X5/8R	Screw, Roundhead
Z 0	4"	Tie
Z 0	#6X.047"	Washer
Z 0	2-1/2" #18	Wire #18
Z 0	5-5/8" #18	Wire #18
Z 0	SHEET	Mylar Sheet
Z 0	1-640387-0	AMP Connector
Z 0	1-640431-0	AMP Connector
Z 0	END CAP	Fabricated Parts
Z 0	U-CHANNEL	Fabricated Parts

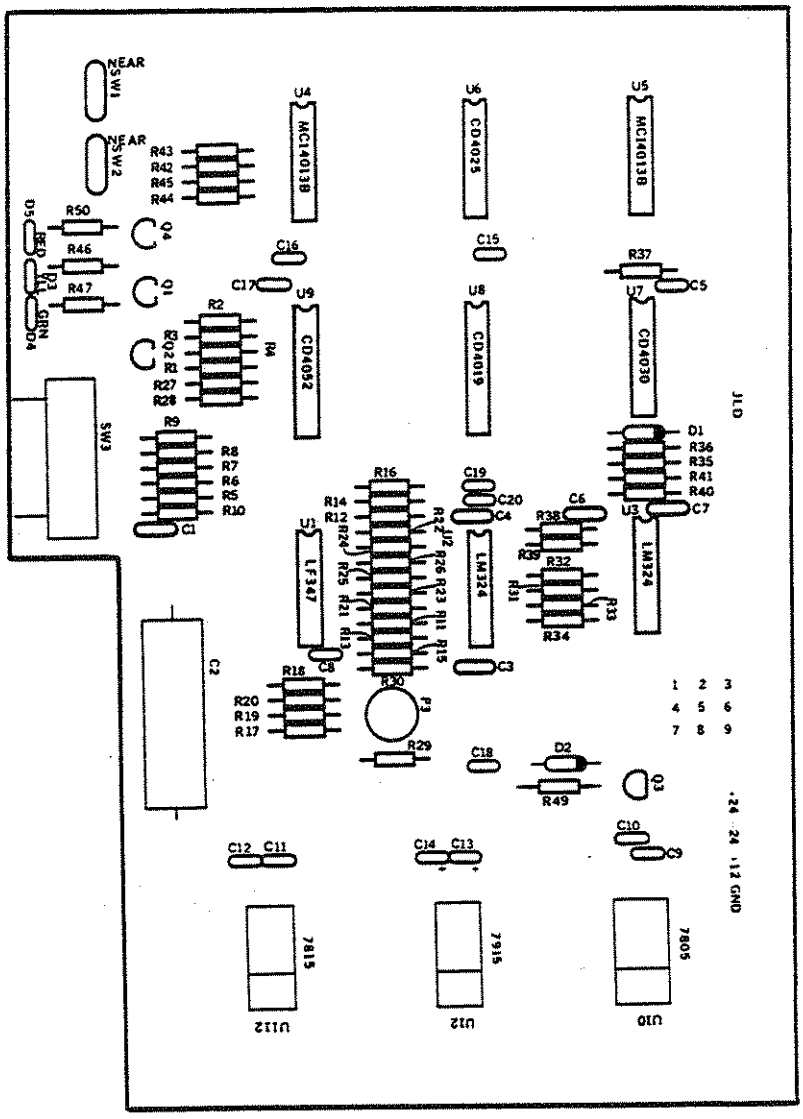


Figure 46 - SR200 Gate Scanner

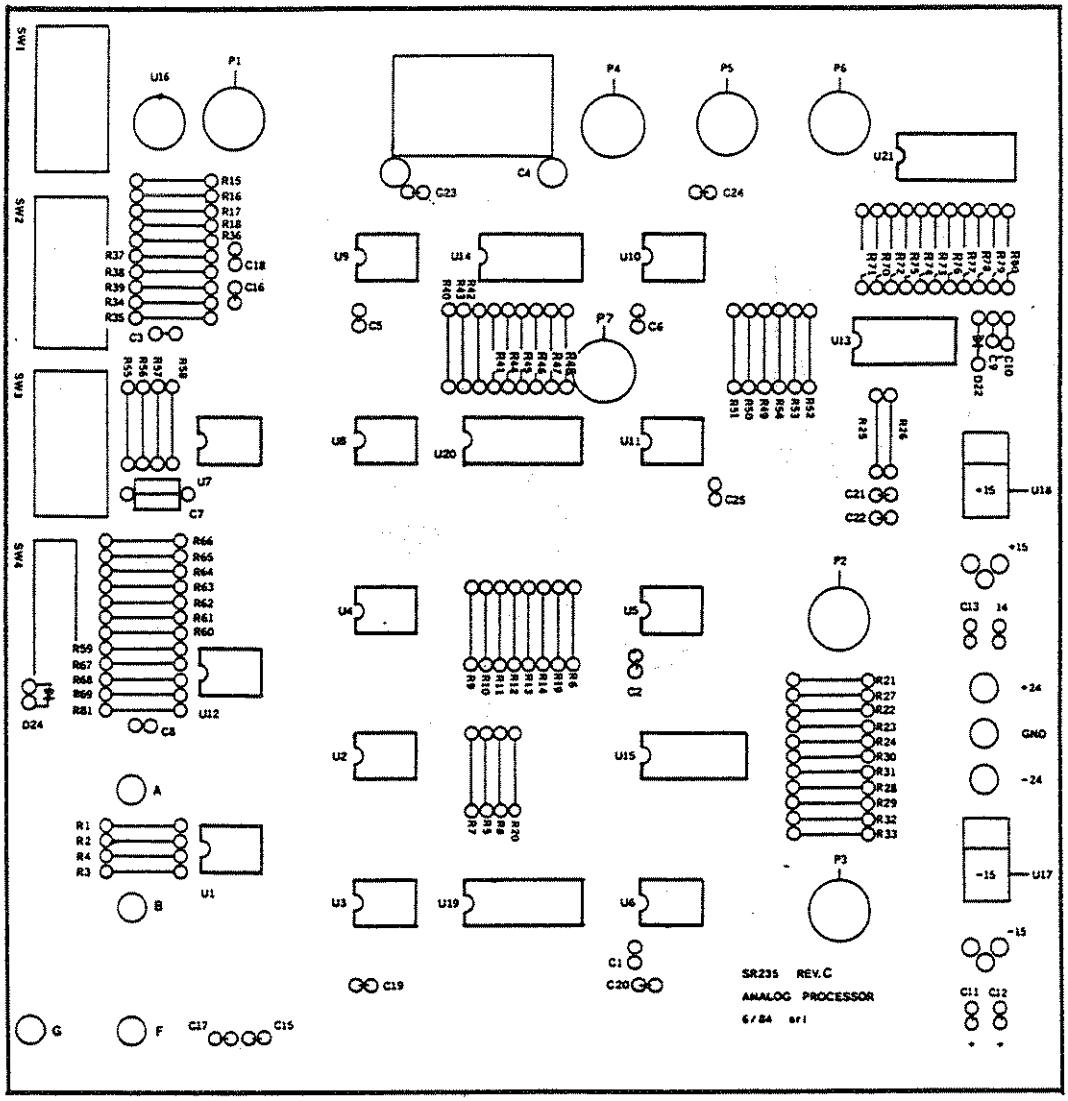


Figure 47 - SR235 Analog Processor

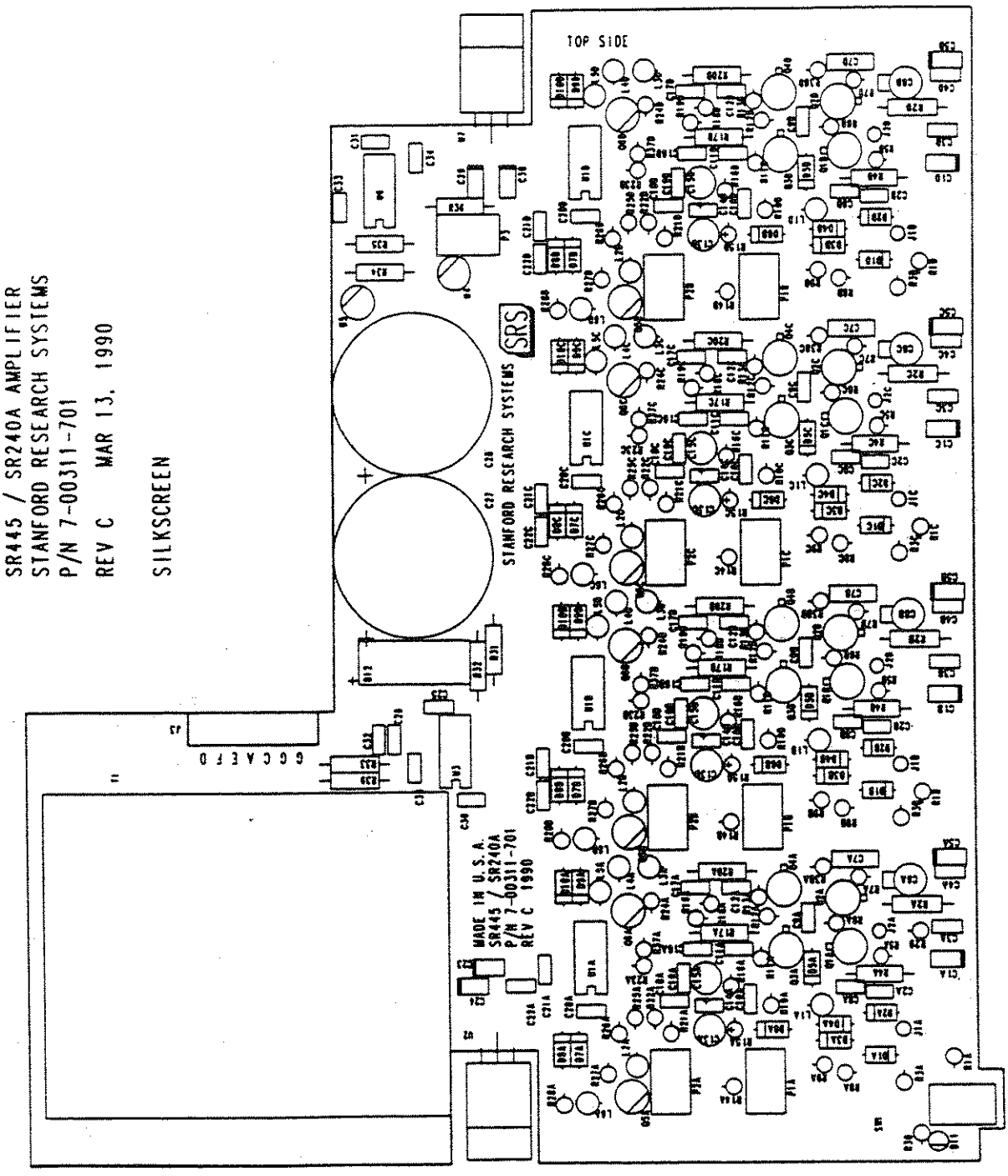


Figure 48 - SR240 Fast Preamp

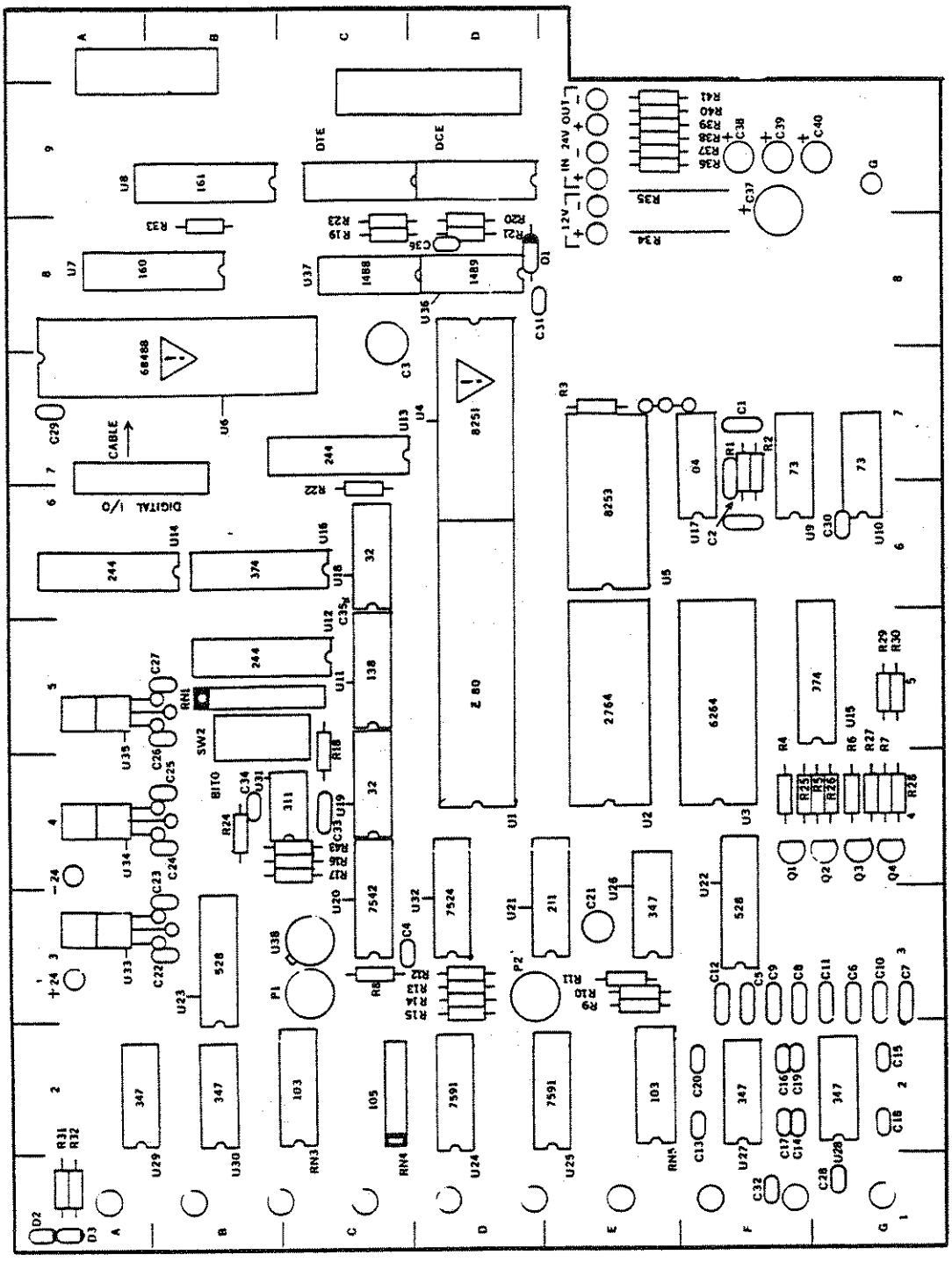


Figure 49 - SR245 Computer Interface

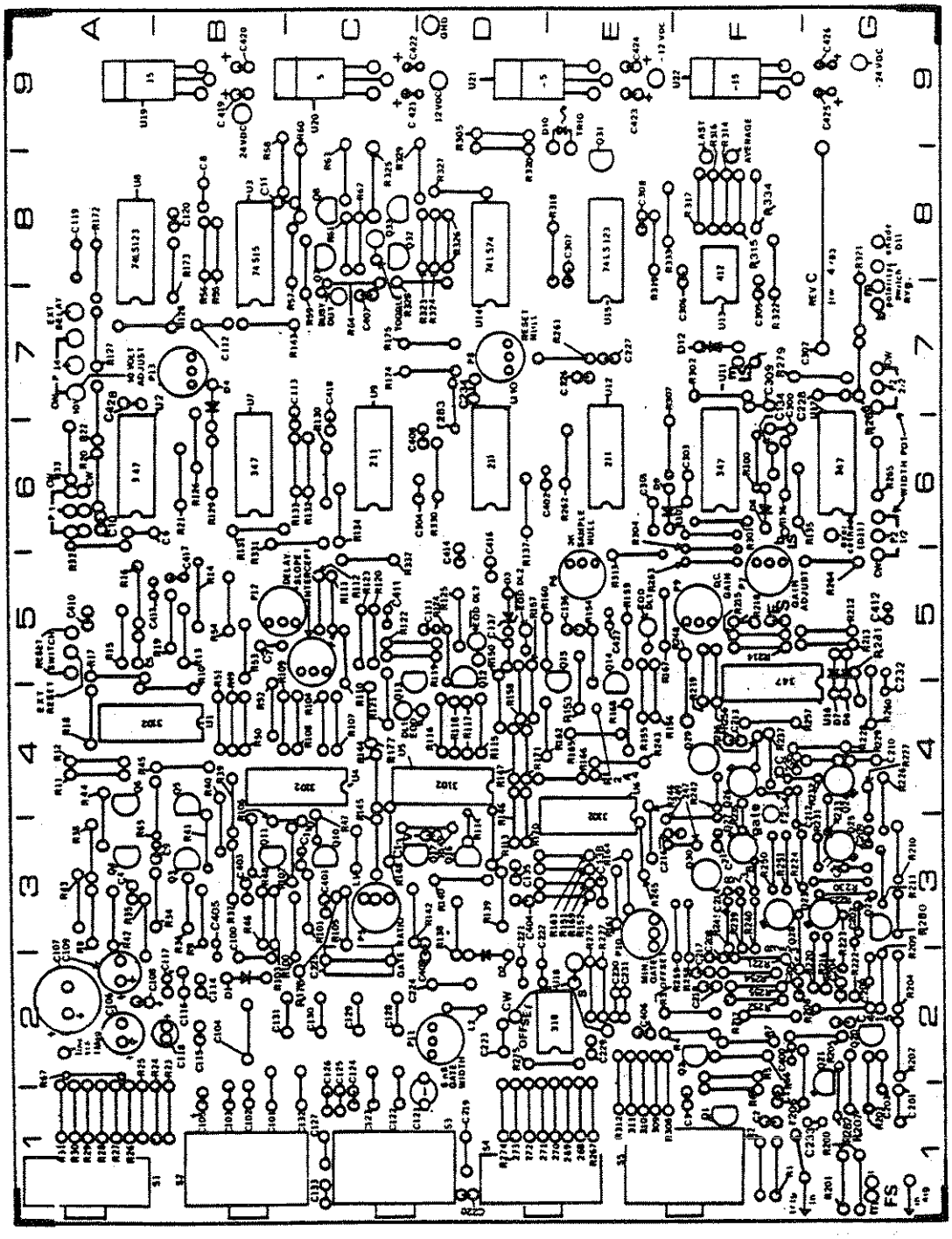


Figure 50 - SR250 Gated Integrator and Boxcar Averager

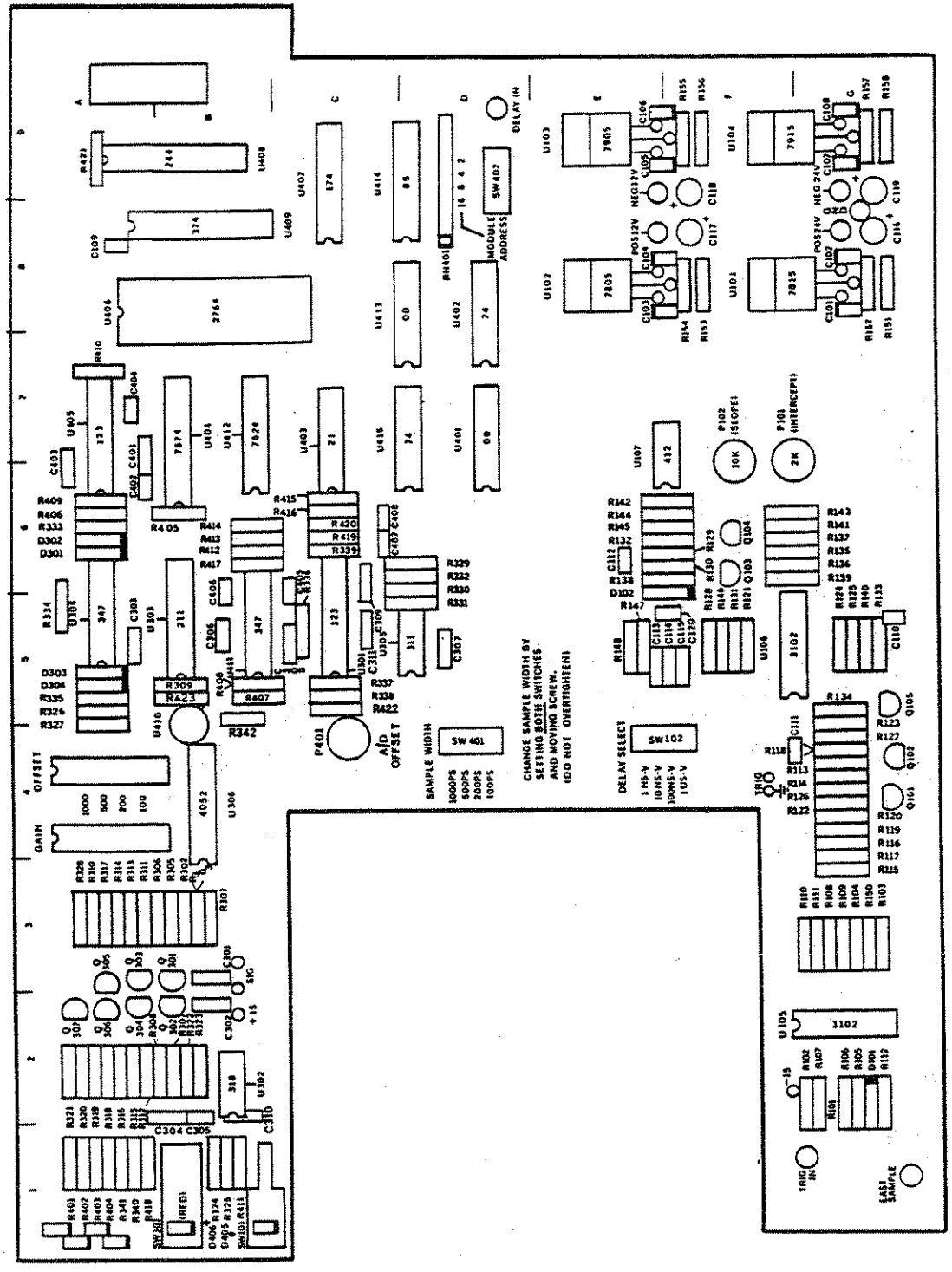


Figure 51 - SR255 Fast Sampler: Main Board

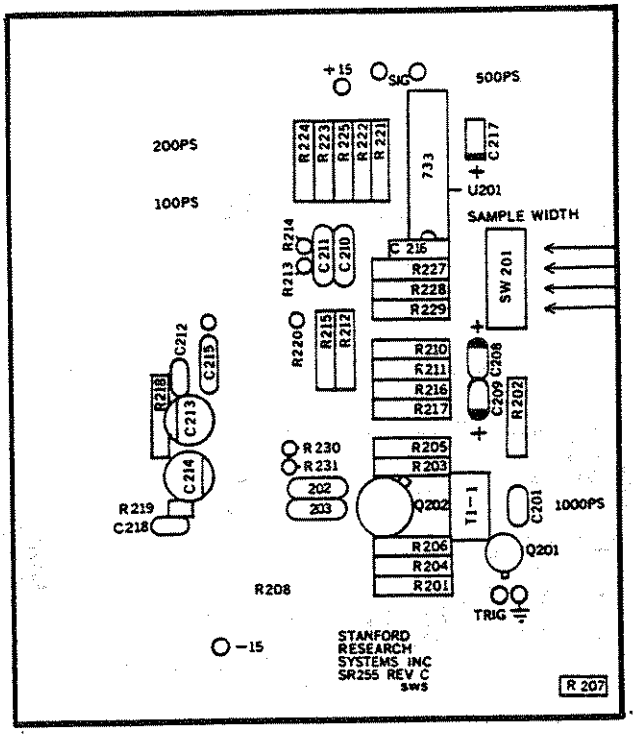


Figure 52 - SR255 Fast Sampler: Fast Board

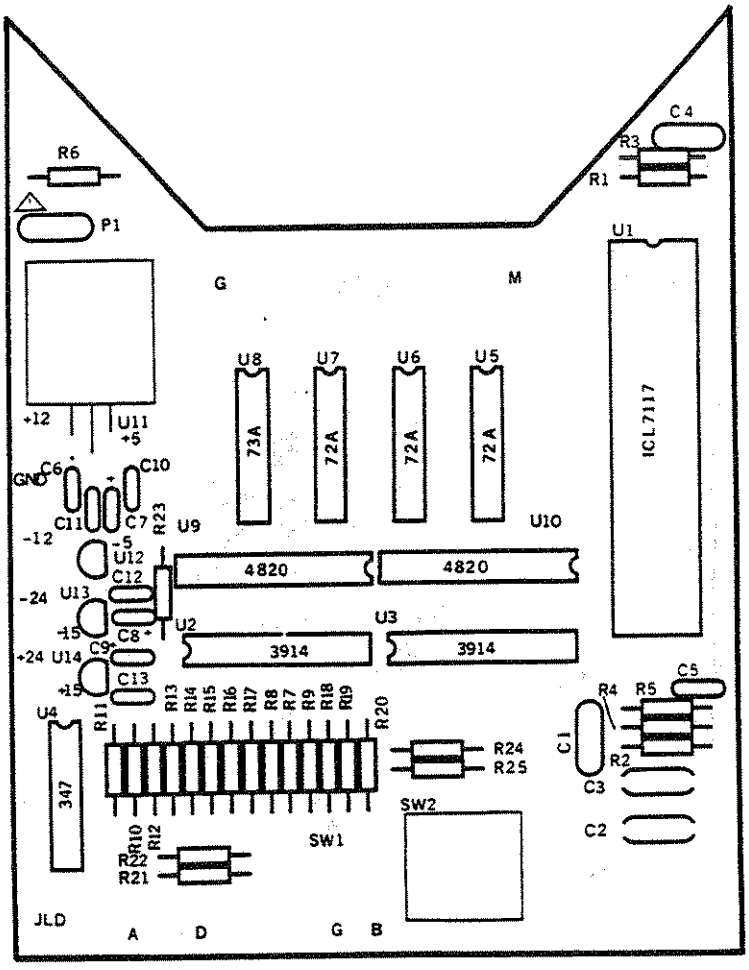


Figure 53 - Display PC

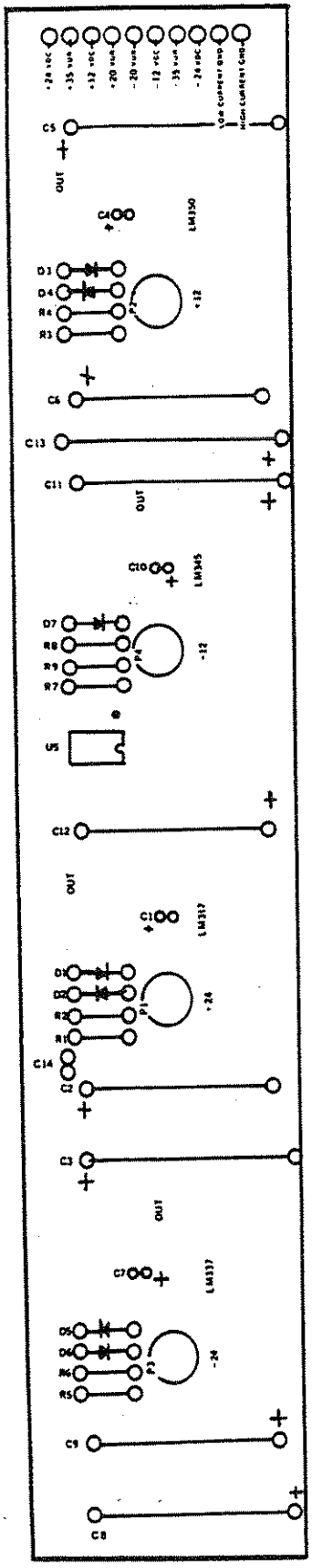
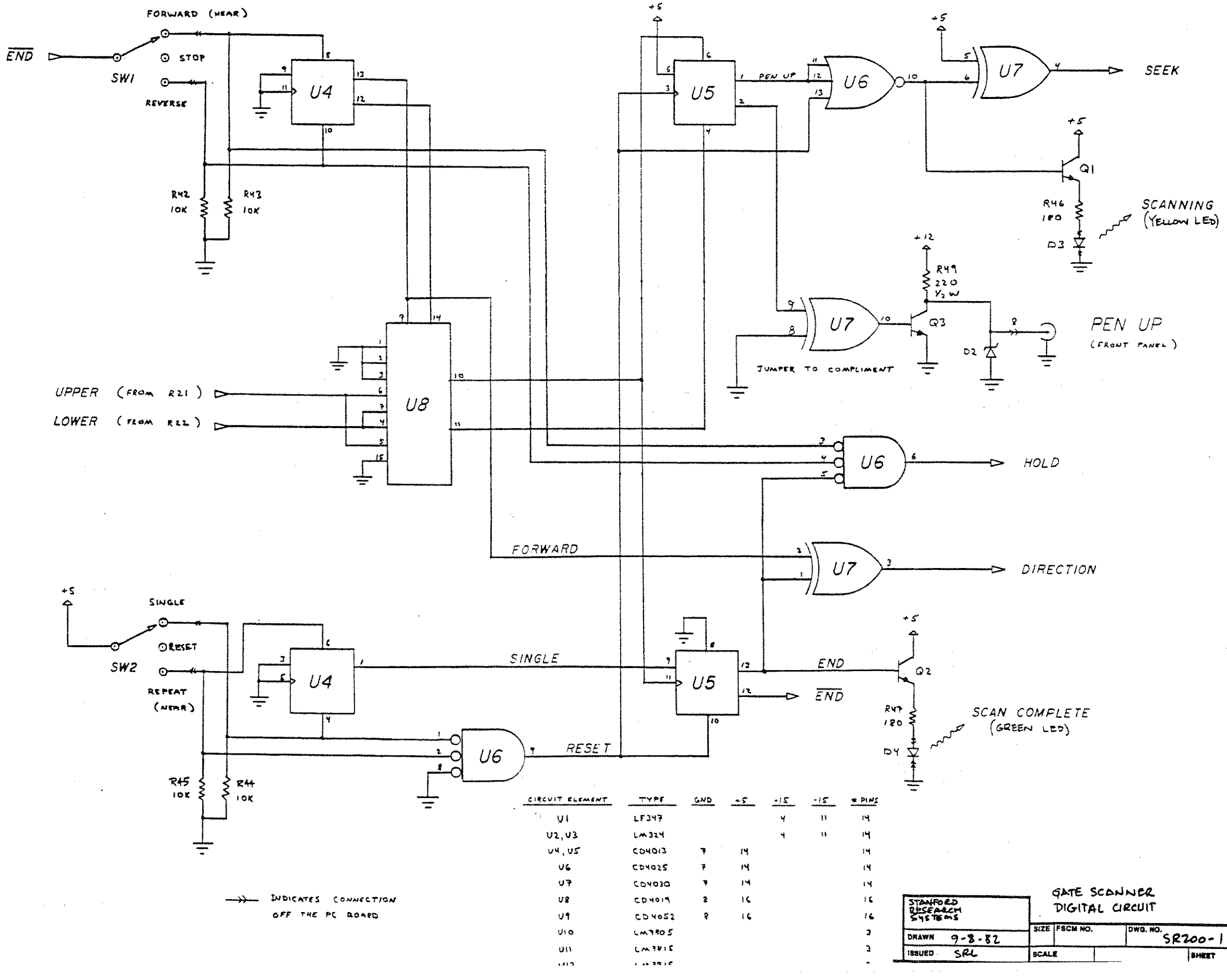
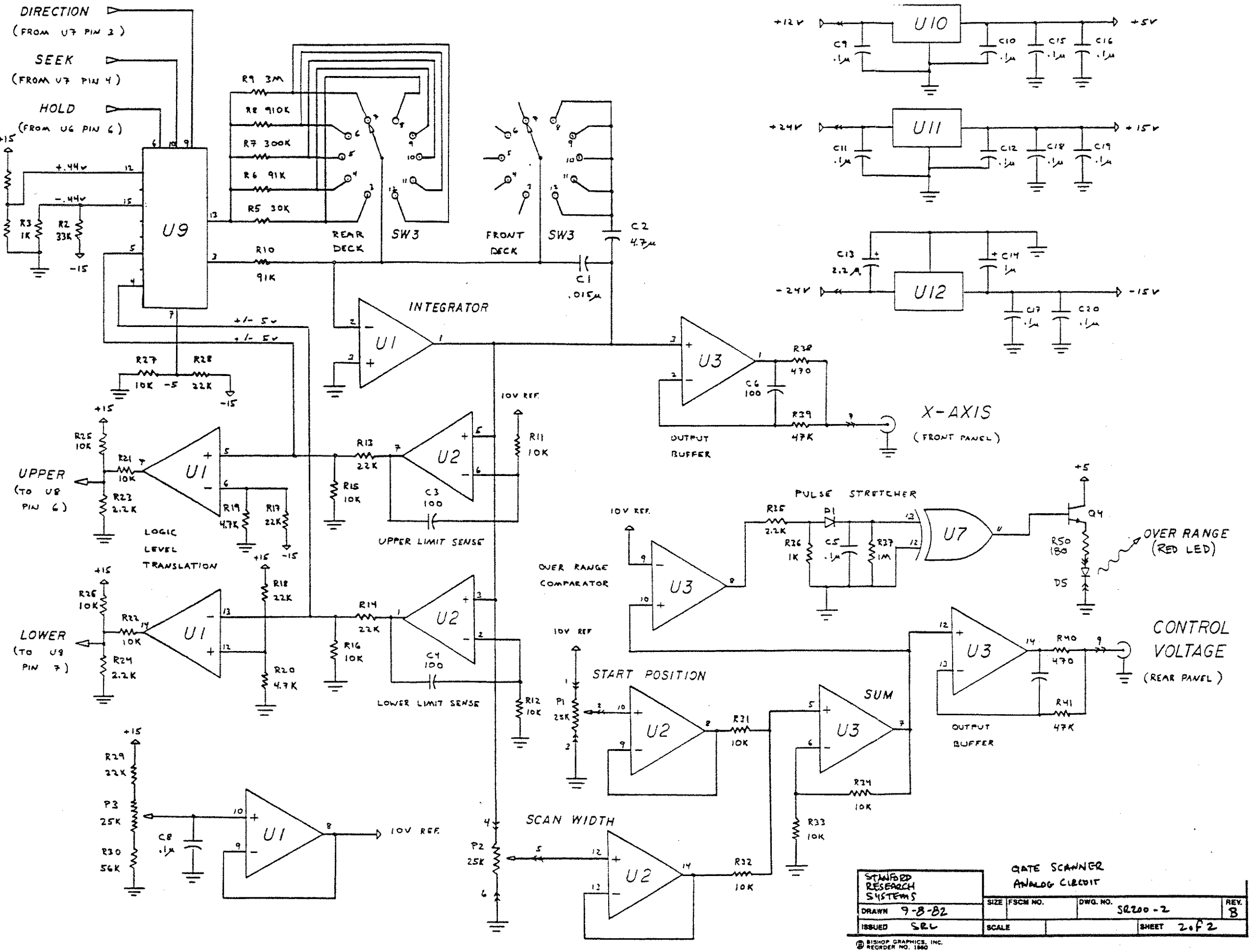


Figure 54 - Regulator Strip



CIRCUIT ELEMENT	TYPE	GND	+5	+15	-15	# PINS
U1	LF347			4	11	14
U2, U3	LM324			4	11	14
U4, U5	CD4013	7	14			14
U6	CD4025	7	14			14
U7	CD4030	7	14			14
U8	CD4019	8	16			16
U9	CD4052	8	16			16
U10	LM7805					3
U11	LM7815					3
U12	LM7915					3

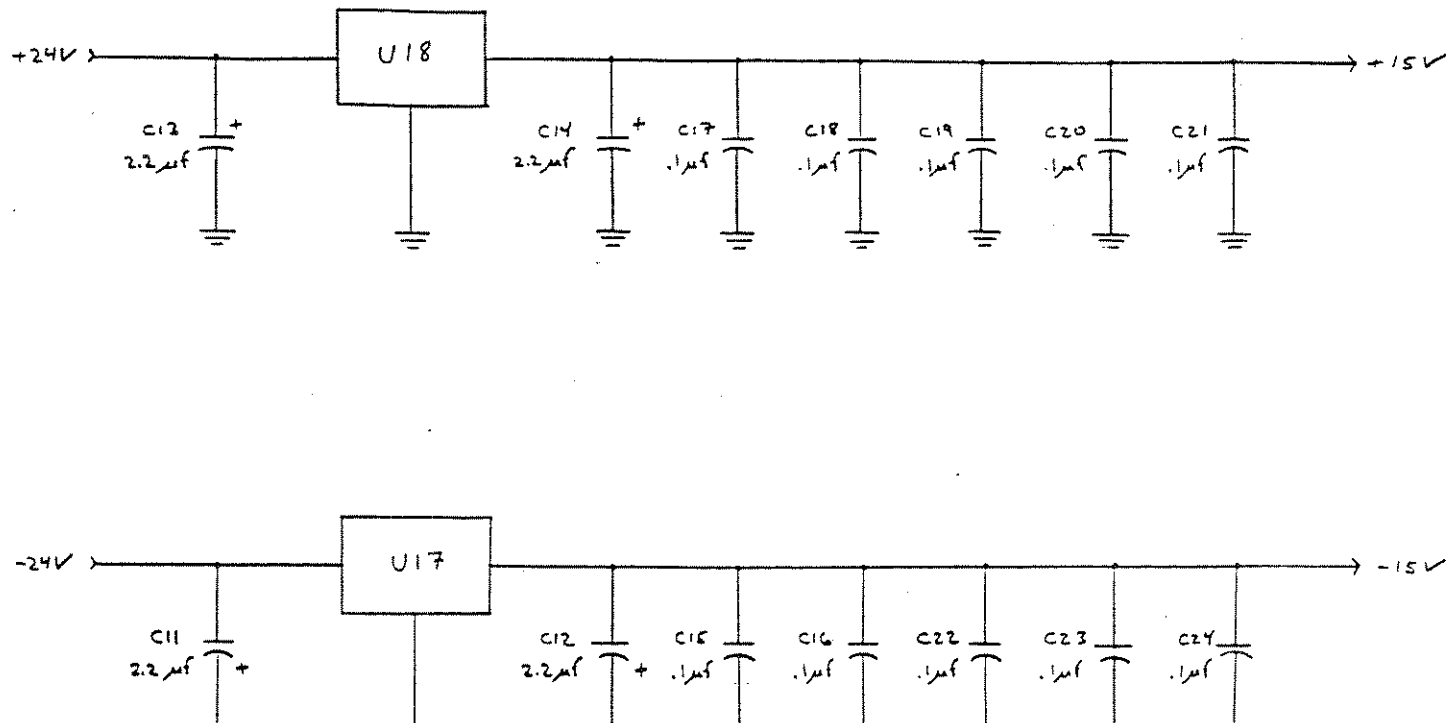
STANFORD RESEARCH SYSTEMS	GATE SCANNER DIGITAL CIRCUIT			
DRAWN 9-8-82	SIZE	FSCM NO.	DWG. NO. SR200-1	REV. B
ISSUED SRL	SCALE		SHEET 1 of 2	



STANFORD RESEARCH SYSTEMS	GATE SCANNER ANALOG CIRCUIT		
DRAWN 9-8-82	SIZE	FSCM NO.	DWG. NO. SR200-2 REV. B
ISSUED SRL	SCALE		SHEET 2 of 2

STANDARD RESONANCE SYSTEMS			
DRAWN 6-27-84	SIZE B	FSCM NO.	DWG. NO. 5E235F-2
ISSUED SBL	SCALE		SHEET 2 OF 3

FUNCTIONS & OUTPUT



SWITCH DESIGNATIONS	SWITCH ABBREVIATIONS
SW1 - ARGUMENT SELECTOR	TF - TOP FRONT GANG
SW2 - ARGUMENT FILTER	TR - TOP REAR GANG
SW3 - FUNCTION SELECTOR	BF - BOTTOM FRONT GANG
SW4 - OUTPUT GAIN	BR - BOTTOM REAR GANG

SW1 POSITIONS
1 - A
2 - B
3 - A-B
4 - 10A/|B|
5 - A·B/10
6 - $\sqrt{A^2+B^2}$

SW2 POSITIONS
1 - 30 Sec
2 - OFF
3 - .3 ms
4 - 1 ms
5 - 3 ms
6 - 10 ms
7 - 30 ms
8 - .1 Sec
9 - .3 Sec
10 - 1 Sec
11 - 3 Sec
12 - 10 Sec

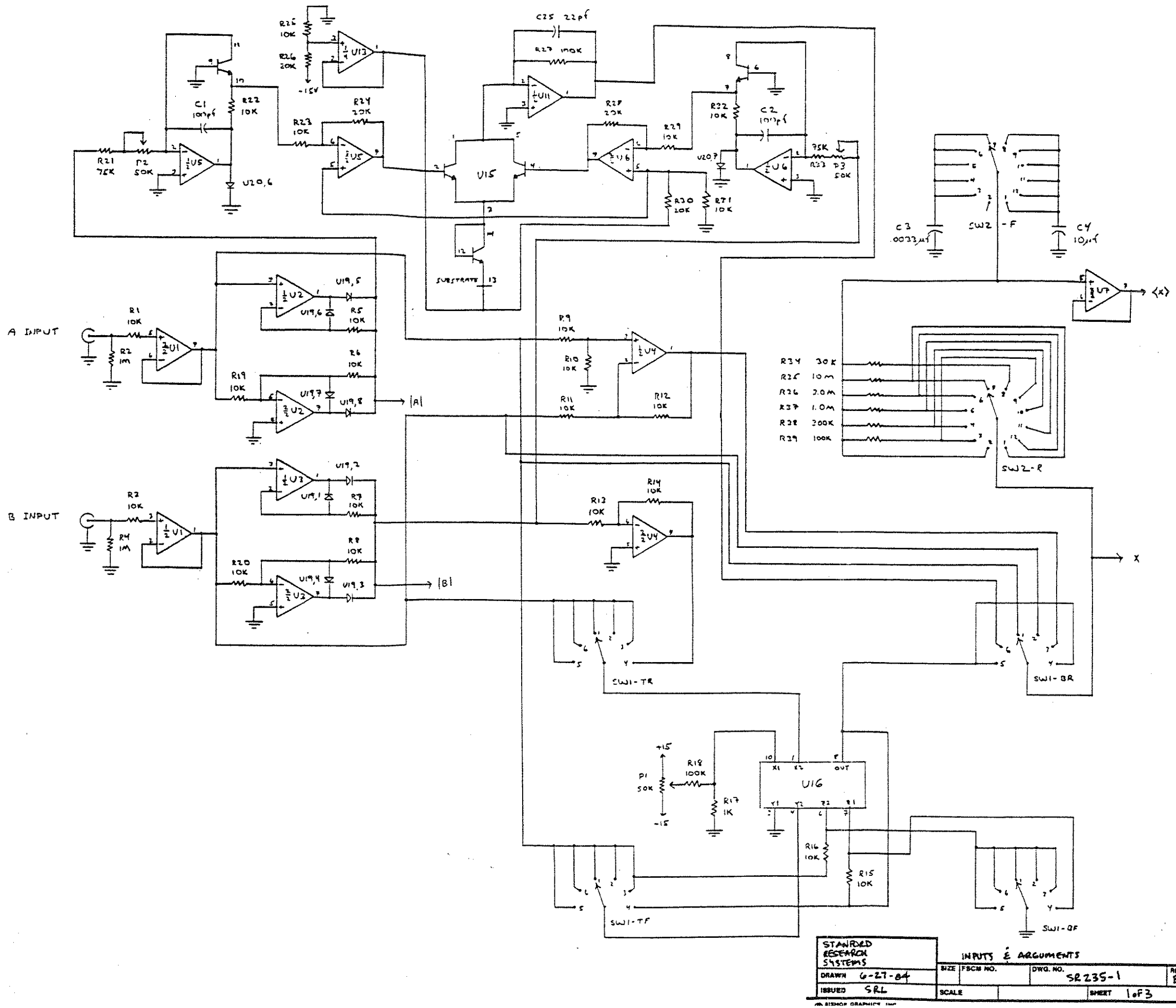
SW3 POSITIONS
1 - X
2 - X^2
3 - -dx/dt
4 - -(dx/dt)/100
5 - ln(x)
6 - $\sqrt{\|x\|}$

SW4 POSITIONS
4 - .1
5 - .2
6 - .5
7 - 1
8 - 2
9 - 5
10 - 10
11 - 20

STANFORD RESEARCH SYSTEMS
REVISED: 6-27-84 S. LINDGREN SHEET 2 OF 3
SR235 ANALOG PROCESSOR
VOLTAGE REGULATION

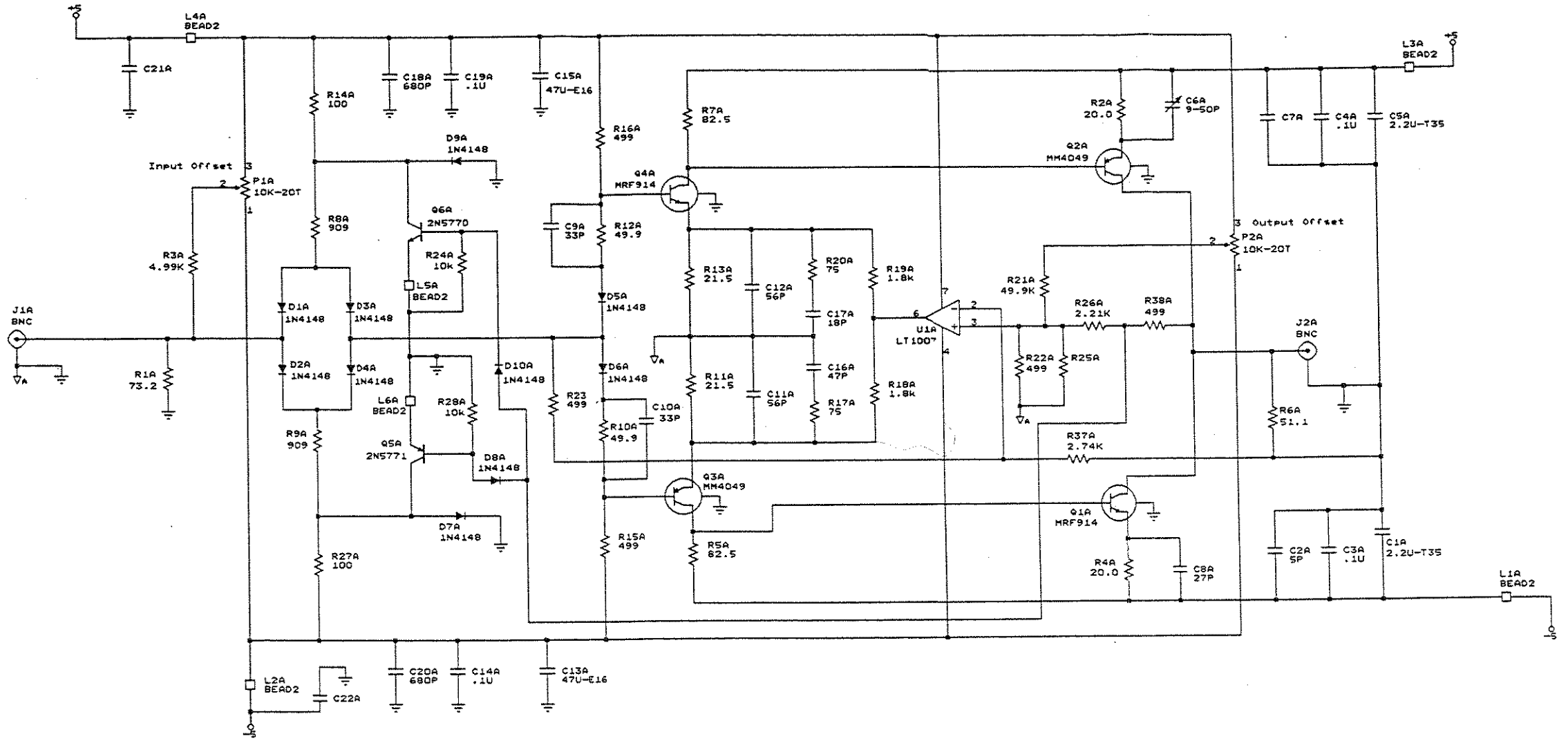
CIRCUIT ELEMENT	TYPE	+15	-15
U1 - U12	LF412	8	4
U13	LF347	4	11
U14	CA3046	-	12, 13, 14
U16	AD534	9	5

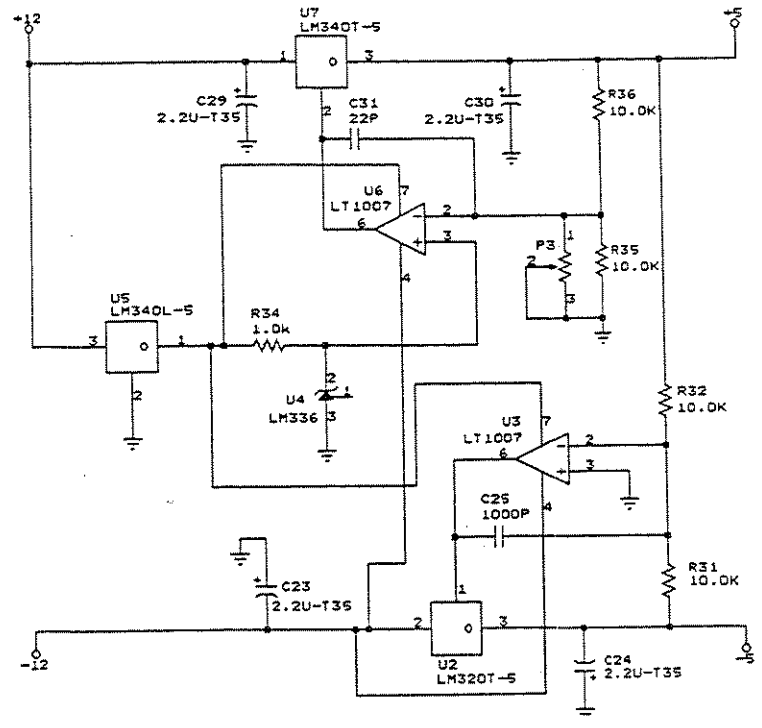
STANFORD RESEARCH SYSTEMS	VOLTAGE REGULATION			
DRAWN 6-27-84	SIZE	FSCM NO.	DWG. NO. SR235-3	REV. B
ISSUED SRL	SCALE		SHEET 3 of 3	


A INPUT
B INPUT
R1 10K
R2 1M
R3 10K
R4 1M
U1
U2
U3
U5
U6
U11
U13
U15
U16
U4
U7
U19,5
U19,6
U19,7
U19,8
U19,2
U19,1
U19,4
U19,3
U20,6
U20,7
R5 10K
R6 10K
R7 10K
R8 10K
R9 10K
R10 10K
R11 10K
R12 10K
R13 10K
R14 10K
R15 10K
R16 10K
R17 1K
R18 100K
R19 10K
R20 10K
R21 75K
P2 50K
R22 10K
R23 10K
R24 20K
R25 10K
R26 20K
-15V
C1 100pf
C25 22pf
R27 100K
R28 20K
R29 10K
R30 20K
R31 10K
R32 10K
C2 100pf
75K
R33
P3 50K
C3 .0033μf
C4 10μf
SW2-F
SW2-R
R34 30K
R35 10M
R36 2.0M
R37 1.0M
R38 200K
R39 100K
P1 50K
+15
-15
X1
X2
OUT
Y1
Y2
Z2
Z1
SUBSTRATE
|A|
|B|
X
SW1-TR
SW1-BR
SW1-TF
SW1-BF
STANFORD RESEARCH SYSTEMS
INPUTS & ARGUMENTS
DRAWN 6-27-84
ISSUED SRL
SIZE
FSCM NO.
DWG. NO. SR235-1
REV. B
SCALE
SHEET 1 OF 3
© BISHOP GRAPHICS INC

SR240 Schematic

SR445 / SR240A AMPLIFIER
REV C MAR 13, 1990



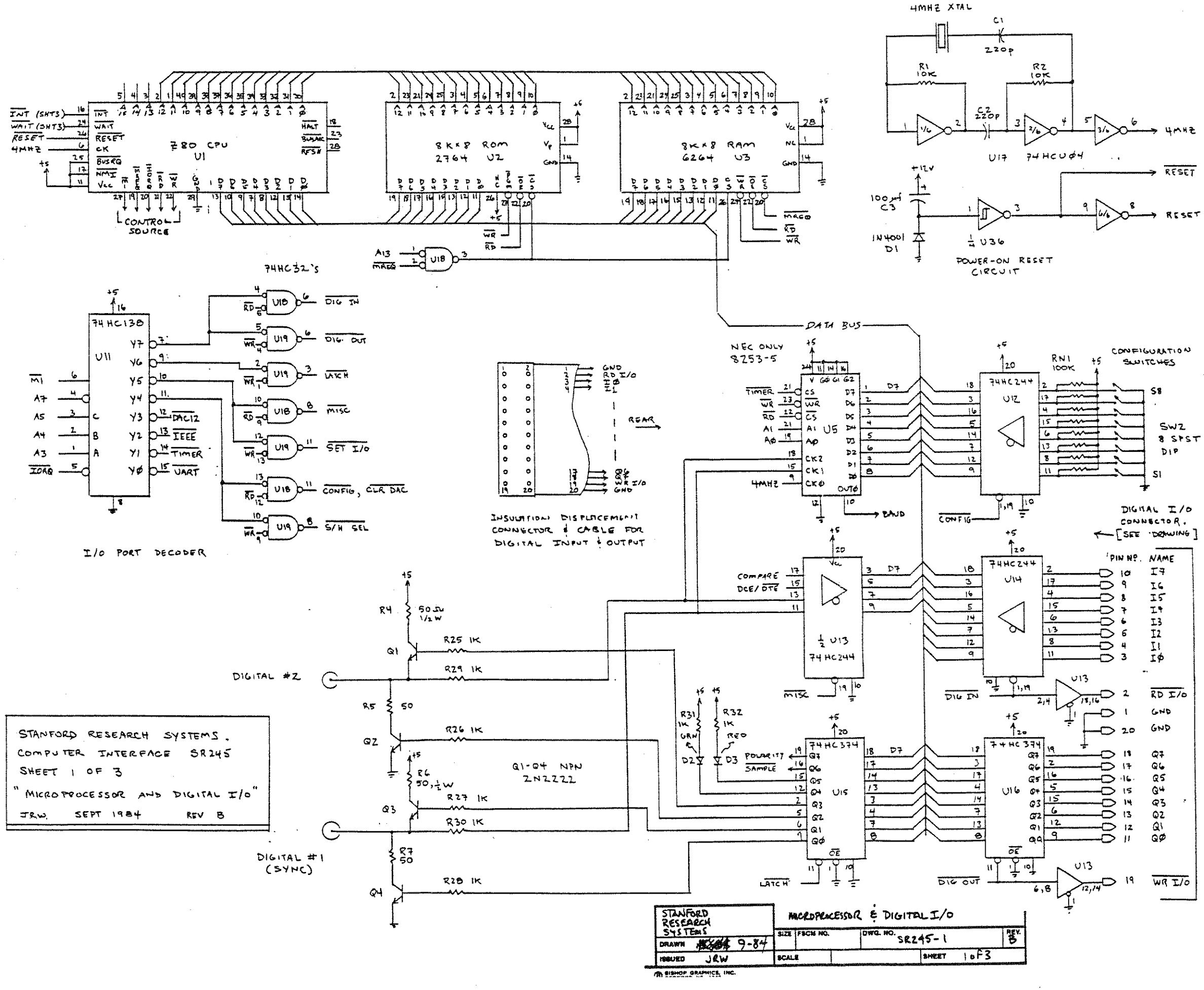


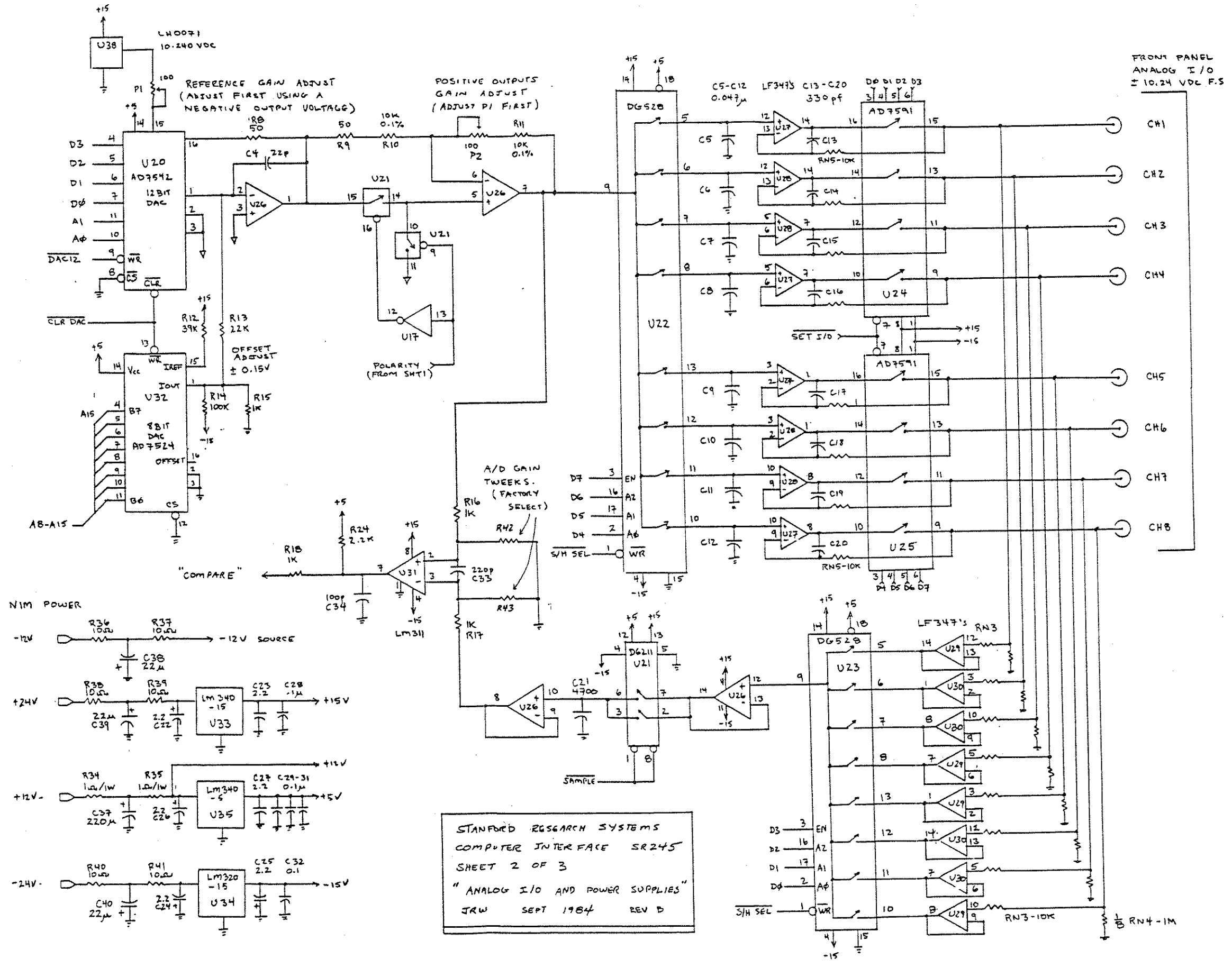
NOTES:

1. A suffix denotes channel 1 components. Channels 2, 3, and 4 will have B, C, and D suffix respectively.
2. R29, R30, D11, and SW1 are channel 1 only.
3. Not Stuffed: C21A through D, C22A through D, C7A through D, P3
4. Adjust C6 for flat frequency response.
5. May select R25 for best DC gain match.
6. C12B, C12C, and C12D are 75P (not shown)

Stanford Research Systems
1290 D Reamwood Ave.
Sunnyvale, CA 94089
(408) 744-9040

Title		
SR445 DC to 300MHz Amplifier		
Size C	Document Number 7-00311	REV C


Z80 CPU U1
8K x 8 ROM 2764 U2
8K x 8 RAM 6264 U3
CONTROL SOURCE
74HC32's
U18
74HC138 U11
I/O PORT DECODER
DIG IN
DIG OUT
LATCH
MISC
SET I/O
DAC12
IEEE
TIMER
UART
CONFIG, CLR DAC
S/H SEL
INSULATION DISPLACEMENT CONNECTOR & CABLE FOR DIGITAL INPUT & OUTPUT
4MHZ XTAL
C1 220P
R1 10K
R2 10K
C2 220P
U17 74HCU04
4MHZ
RESET
100 µf C3
1N4001 D1
POWER-ON RESET CIRCUIT
DATA BUS
NEC ONLY 8253-5
U5
74HC244 U12
RN1 100K
CONFIGURATION SWITCHES
SW2 8 SPST DIP
S8
S1
BAUD
CONFIG
DIGITAL I/O CONNECTOR. [SEE DRAWING]
PIN Nº. NAME
10 I7
9 I6
8 I5
7 I4
6 I3
5 I2
4 I1
3 Iφ
COMPARE
DCE/DTE
½ U13 74HC244
74HC244 U14
MISC
DIG IN
RD I/O
GND
GND
R31 1K GRN D2
R32 1K RED D3
POLARITY SAMPLE
74HC374 U15
74HC374 U16
LATCH
DIG OUT
WR I/O
R4 50Ω 1/2W
R25 1K
R29 1K
R5 50
R26 1K
R6 50, ½W
R27 1K
R30 1K
R7 50
R28 1K
Q1
Q2
Q3
Q4
Q1-Q4 NPN 2N2222
DIGITAL #2
DIGITAL #1 (SYNC)
STANFORD RESEARCH SYSTEMS.
COMPUTER INTERFACE SR245
SHEET 1 OF 3
" MICROPROCESSOR AND DIGITAL I/O"
JRW. SEPT 1984 REV B
STANFORD RESEARCH SYSTEMS
MICROPROCESSOR & DIGITAL I/O
DRAWN 9-84
ISSUED JRW
SIZE FSCM NO. DWG. NO. SR245-1 REV. B
SCALE
SHEET 1 OF 3
BISHOP GRAPHICS, INC.



STANFORD RESEARCH SYSTEMS
COMPUTER INTERFACE SR245
SHEET 2 OF 3
"ANALOG I/O AND POWER SUPPLIES"
JRW SEPT 1984 REV B

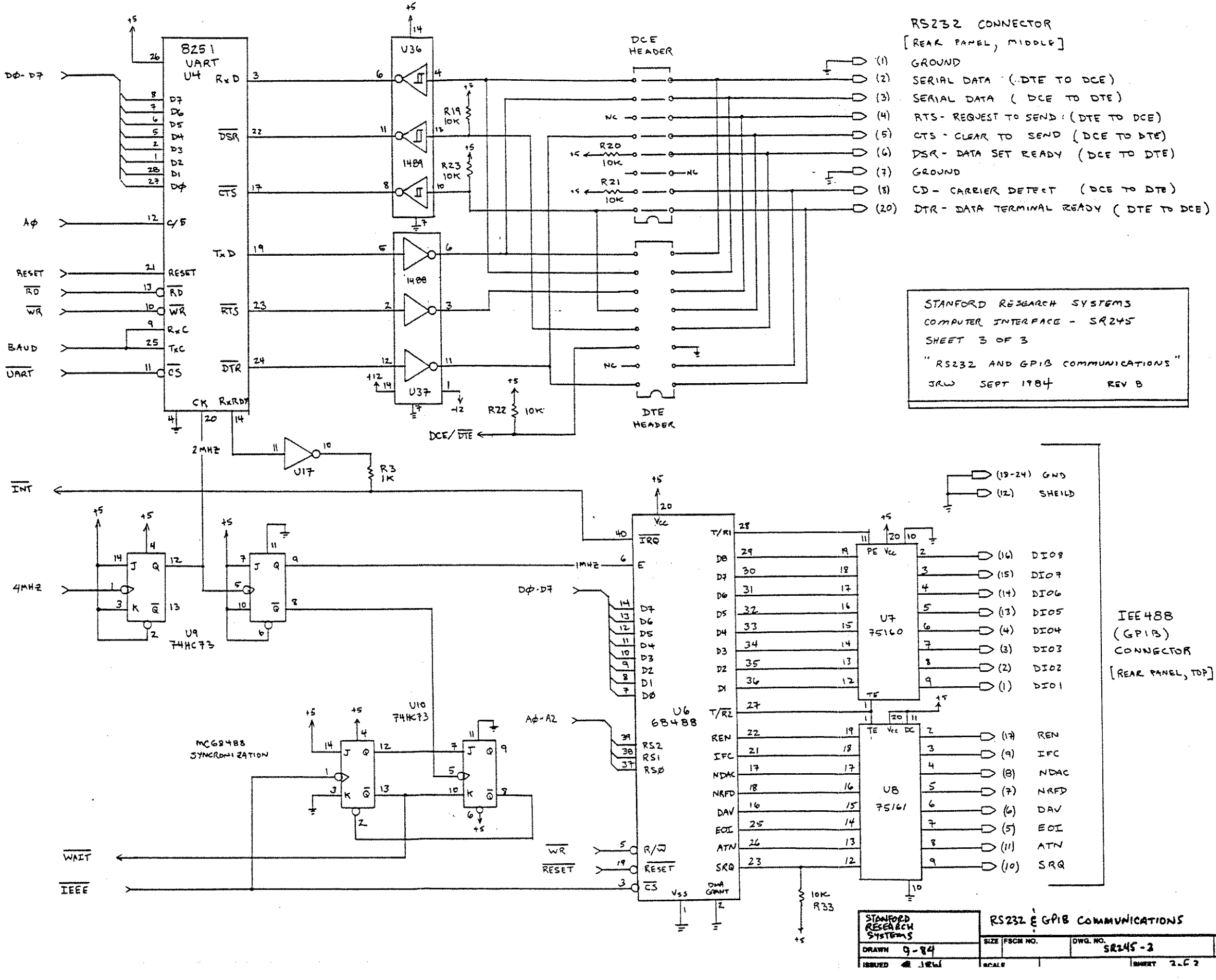
STANFORD RESEARCH SYSTEMS

ANALOG I/O & POWER SUPPLIES

SIZE B | FSCM NO. | DWG. NO. SR245-2 | REV B

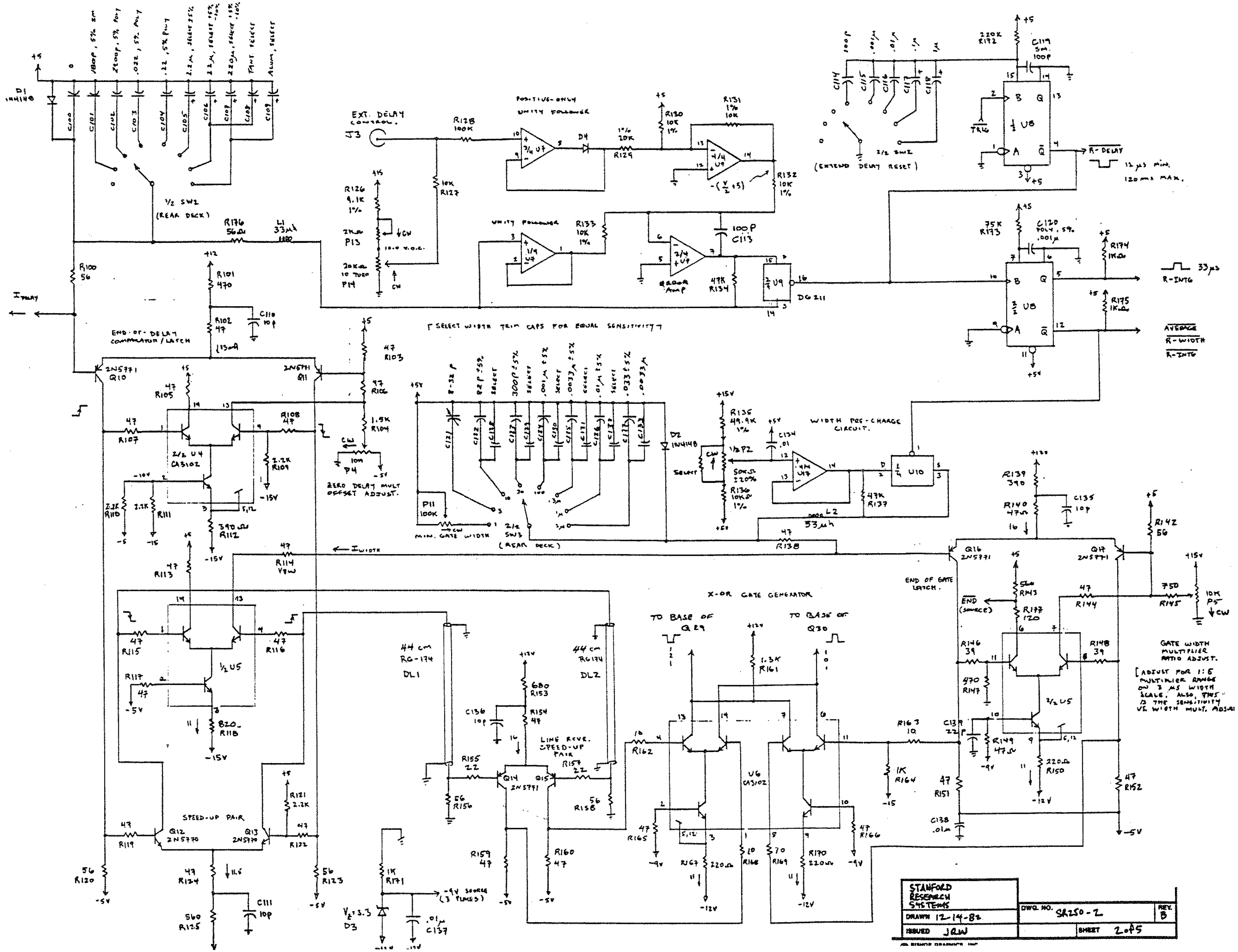
DRAWN 9-84 JRW | SCALE | SHEET 2 of 3

ISSUED JRW


8251
UART
U4
RxD
TxD
DSR
CTS
RTS
DTR
RESET
RD
WR
RxC
TxC
CS
CK
RxRDY
D0-D7
A0
RESET
RD
WR
BAUD
UART
2MHZ
INT
U36
1489
U37
1488
R19 10K
R23 10K
R20 10K
R21 10K
R22 10K
+12
-12
DCE/DTE
DCE HEADER
DTE HEADER
NC
RS232 CONNECTOR
[REAR PANEL, MIDDLE]
(1) GROUND
(2) SERIAL DATA (DTE TO DCE)
(3) SERIAL DATA (DCE TO DTE)
(4) RTS - REQUEST TO SEND (DTE TO DCE)
(5) CTS - CLEAR TO SEND (DCE TO DTE)
(6) DSR - DATA SET READY (DCE TO DTE)
(7) GROUND
(8) CD - CARRIER DETECT (DCE TO DTE)
(20) DTR - DATA TERMINAL READY (DTE TO DCE)
STANFORD RESEARCH SYSTEMS
COMPUTER INTERFACE - SR245
SHEET 3 OF 3
"RS232 AND GPIB COMMUNICATIONS"
JRW SEPT 1984 REV B
U17
R3 1K
4MHZ
U9
74HC73
1MHZ
U10
74HC73
MC68488
SYNCRONIZATION
WAIT
IEEE
WR
RESET
U6
68488
IRQ
E
D0-D7
A0-A2
RS2
RS1
RS0
R/W
CS
DMA GRANT
T/R1
T/R2
REN
IFC
NDAC
NRFD
DAV
EOI
ATN
SRQ
U7
75160
U8
75161
10K R33
(19-24) GND
(12) SHEILD
(16) DIO8
(15) DIO7
(14) DIO6
(13) DIO5
(4) DIO4
(3) DIO3
(2) DIO2
(1) DIO1
(17) REN
(9) IFC
(8) NDAC
(7) NRFD
(6) DAV
(5) EOI
(11) ATN
(10) SRQ
IEE488
(GPIB)
CONNECTOR
[REAR PANEL, TOP]
STANFORD RESEARCH SYSTEMS
RS232 & GPIB COMMUNICATIONS
DRAWN 9-84
ISSUED 1RW
SIZE FSCM NO. DWG. NO. SR245-3 REV. B
SCALE
SHEET 3 OF 3

TRIG INPUT
J1
C1 47p
C2 220p
R66 56Ω
R3 220
R4 47Ω
14mA
Q1 2N5951
47 R5
2N5771 Q2
.1μ C3
47Ω R6
100Ω STRIPLINE
21mA
560Ω R7
TRIGGER DISCRIMINATOR
56Ω R8
56Ω R9
R10 47
100 R11
47 R12
100Ω R13
100Ω R15
U1 CA3102
2.2K R14
47 R17
47 R18
.001μ C5
R16 470
560Ω R19
TRIGGER LATCH
R34 470Ω
R36 560Ω
R37 56Ω
470Ω R39
Q3 PN4258
Q4 PN4258
10p C4
R35 47Ω
R38 47Ω
R41 47
47 R40
Q5 2N5770
Q6 2N5770
R42 47
R43 2.2K
R44 47
R65 49Ω
C9 10pF
1K R45
I DELAY (CONNECTIONS TO +5V DC ONLY)
R47 47Ω
47 R46
47 R48
47 R49
½ U4 CA3102
2.2K R50
150Ω R51
R52 47Ω
1.5K R53
500Ω P12
C7 .01μ
887Ω, 1% R54
11mA, EXACTLY (9.757V)
DELAY CAL. ADJ.
TRIGGER THRESHOLD
50KΩ ½ P1
.01μ C10
½ U2
THRESHOLD COMPARATOR
LINE VOLTAGE (HOT) (NEUTRAL)
4.7K R20
R21 330K
100K R68 100K R69
INSIDE AMP CONNECTOR
60 V.A.C. (NOT ON PCB)
THRESHOLD BUFFER
2.2K R22
R23 10K
R24 3.3K
R25 1K
R26 330K
R27 100K
R28 33K
R29 10K
R30 3.3K
R31 1K
RATE GENERATOR
SW1
RATE SELECT
.047 POLY C6
R32 22K
RATE ADJ. 2/2 P1 50K
R33 22K
PIN 6, U5 = $\overline{END}$
PIN 4, U8 = $\overline{R\text{-DELAY}}$
PIN 12, U8 = $\overline{R\text{-WIDTH}}$
$\overline{R\text{-TRIG}}$
$\overline{TRIG}$ (SOURCE)
150Ω R55
100Ω R56
.001μ C8
1/3 U3
2/3 U3
3/3 U3
74S15
1.5K R58
1K R59
C11 5P
R64 330Ω
Q7 2N5771
Q8 2N5771
BUSY OUT
J2
1N4148
150Ω 1/2 W R60
47 mA
56Ω R63
1.2K R62
R61 220Ω

STANFORD RESEARCH SYSTEMS			
DRAWN 12-14-82	SIZE	FSCM NO.	DWG. NO. SR250-1 REV. B
ISSUED 12-14-82	SCALE		SHEET 1 of 5


EXT. DELAY CONTROL
POSITIVE-ONLY UNITY FOLLOWER
UNITY FOLLOWER
ERROR AMP
1/2 SW2 (REAR DECK)
2/2 SW2 (EXTEND DELAY RESET)
END-OF-DELAY COMPARATOR / LATCH
ZERO DELAY MULT OFFSET ADJUST.
[SELECT WIDTH TRIM CAPS FOR EQUAL SENSITIVITY]
MIN. GATE WIDTH
2/2 SW3 (REAR DECK)
WIDTH PRE-CHARGE CIRCUIT.
END OF GATE LATCH.
GATE WIDTH MULTIPLIER RATIO ADJUST.
[ADJUST FOR 1:5 MULTIPLIER RANGE ON 3 MS WIDTH SCALE. ALSO, THIS IS THE SENSITIVITY VS WIDTH MULT. ADJUST.
X-OR GATE GENERATOR
TO BASE OF Q29
TO BASE OF Q30
LINE RCVR. SPEED-UP PAIR
SPEED-UP PAIR
44 cm RG-174 DL1
44 cm RG174 DL2
-4V SOURCE (3 PLACES)
R-DELAY 12 μs min, 120 ms max.
R-INTG 33 μs
AVERAGE R-WIDTH R-INTG
STANFORD RESEARCH SYSTEMS
DRAWN 12-14-83
ISSUED JRW
DWG. NO. SR250-2
REV. B
SHEET 2 of 5

SIGNAL IN J4
SIGNAL OUT J6
24" RG174 DL3
1/2 SW8
AC 10 HZ
AC 10KHZ
DC
4.7K R200
R201 4.7K
470P C203
C201 .01µ
PDLY
100K R203
R202 1M 1%
R204 1K
C202 .001µF
AC 10HZ
AC 10KHZ
DC
3/5 SW8
+15
60Ω R205
56Ω R206
470 R207
2N5771 Q21
J310 Q20
56 R208
150Ω R209
10
Q22 2N5770
R210 2.2K
.01 C206
R211 100Ω
R280 1K
-12
-15
C204 .1µ
R282 56
15P C233
R218 10K 1%
P9 2KΩ
R219 1820, 1%
CW
DC GAIN ADJUST ±10%
3.9K R222
R220 150Ω 1%
C207 .01µ
R221 47Ω
C208 10P
R223 33
MM4049 Q23
R225 10K 1%
FACTORY SELECT, < 22 pf (WIRE SIDE)
R257 10K, 1%
R224 33Ω 1%
R226 1ok 1%
C209 39P
R227 68 VSW
24mA
C210 .01 µ
R228 39
R229 22 1/8W
Q24 MM4049
Q25 MM4049
R231 22 1/8W
R230 39
C211 .01µ
R232 47Ω VSW
R233 47Ω VSW
GATE VIEW J6
C235 2.2µ
R284 150
C212 56P
C213 2.2µ
R234 47Ω VSW
R235 47Ω VSW
R236 47Ω VSW
Q26 MRF904
Q27 MRF904
R238 VSW 47
C214 2.2µ
R241 470
CW
P10 10K
OFFSET NULL AT MINIMUM GAIN WIDTH
R220 10K
R237 -5
R242 30 VSW
C215 27
R239 1.2Ω 1/8W
R240 -5
R245 39
MRF901 Q30
56 R246
V6 PIN 14
R243 39
MRF901 Q29
56Ω R244
V6 PIN 13
R247 56Ω VSW
C216 10P
R248 390Ω 1/2W
R250 33Ω 1%
C217 OP
R251 10K 1%
R249 10K 1%
Q28, MRF904
33 R253
47Ω, R254
R255 150Ω 1%
C218 .01µ
-15
C205 .1µ
3.9K R252
R216 4.7K
R281 470
C232 .1µ
4.7K R217
X 2.5
1/4 U16
R213 15KΩ 1%
R212 10K 1%
OVERVOLTAGE
1N4148 D6
47K R214
47K R215
D7
1N4148
2/4 U16
ERROR AMP
1/4 U16
1K R258
R259 1K
R256 10K 1%
5% POLY CAPS.
1500P, 5%, 5W
C219 .001
C220 .0033
C221 .01
C222 .033
C223 .1
C224 .33
C225
1/2 SW3 (FRONT DECK)
4.7P
R261 10K
R260 47
C226
470P C227
CW
10K
R263 10K
C234 470P
22M.Ω R262
4/4 U10
U9
PIN 5, U8 R-INTG
PIN 12, U8 R-INTG
ACTIVE INTEGRATOR RESET.
4.7K R279
330pF C228
X3 AMP W/GAIN ADJ.
1/4 U17
4.7K R265
3/4 U17
R264 24.9K 1%
2K P7
CW
R263 10K 1%
R275 49.9K, 1%
C229 33P
LM318 U18
+15V
10 TURN "INPUT OFFSET" 20 KΩ... P6
CW
C231 .01µ
-15
COAX
100K, 1%
R276
.01µ C230
R277 4.99K 1%
ALL 1%
100K R267
49.9K R268
20.0K R269
10.0K R270
4.99K R271
2.00K R272
1.00K R273
499Ω R274
N/C
SW4
1V/5mV
3/4 U17
"WIDTH" 2/L P2 50KΩ ±20%
CW
~200KΩ
5% CARBON FILM: FACTORY SELECT TO TRIM POT TO 40KΩ ± 1%.
R266 10KΩ 1%

STANFORD RESEARCH SYSTEMS	SIZE	FSCM NO.	DWG. NO. SR250 - 3	REV. B
DRAWN 12-14-82				

GATED INTEGRATOR OUTPUT. PIN6, U18

3/4 U10

.0047μ C300

R300 10K 1%

R301 6.8K

C309 OP

R302 10K, 1%

1N4148 D8

1N4148 D9

3/4 U11

1/4 U11

1/4 U12

INVERT

SW9

NORMAL

UNITY FOLLOWER

3/4 U11

R308 580 | R309 1.8K | R310 6.8K | R311 22K | R312 68K

LAST

P6 100K 3K SWP NULL

+15 CW -15

2.2M R313

U10

AVERAGE 33μs

PIN 12, U8

4.7μ C302

.047μ C301

R303 10K

R304 10K

OVERLOAD SIGNAL FROM FRONT-END

1MΩ R307

4/4 U11

R305 1KΩ

D11 RANGE ERROR LED. (RED) ON IF |V_in| > 2V -OR- |LAST SAMPLE OUT| > 10V

.01μ C303

3/4 U12

3/4 U12

SW6 MANUAL RESET.

C304 .002 μF

1M R330

10K R331

1/4 U9

R332 10K

JB REMOTE RESET INPUT

OUTPUT BUFFER $A_v = 1.04$

1/4 U13

R314 470Ω

AVERAGE OUTPUT

100P C305

10K R315

R334 240K

LF412 OUTPUT BUFFER

1/2 U13

R316 470

JIO LAST SAMPLE OUTPUT

100P C306

10K R317

SAMPLE

END PIN 6 U5

22KΩ R318

C307 POLY 1000P 5%

1/2 U15 10μs

SAMPLE ONE-SHOT

220K R319

C308 .1μ

3/2 U16

10mS

R320 390Ω

D10 N-TRIG. LED (GREEN)

R333 2.2K

2N3904 Q31

TRIGGER LAMP

D12 1N4148

POLARITY CONTROL

AVERAGE PIN 5, U8

R321 10K

R322 10K

NORMAL

TOGGLE

INVERTED

SW7

1/2 U14

1/2 U14

1K R323

R324 220Ω 5%/4W

46 mA

R325 150Ω 1/2W

Q32 2N3906

Q33 2N3906

4W/5W

220Ω R326

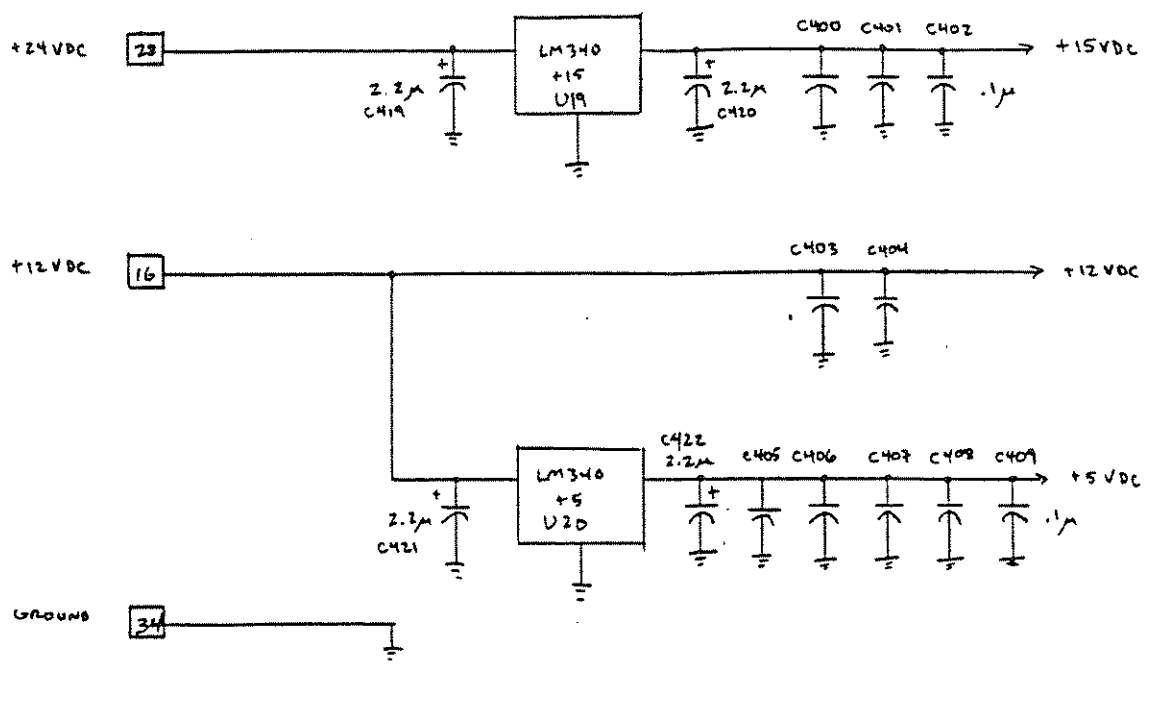
1K R327

JII TOGGLE OUTPUT

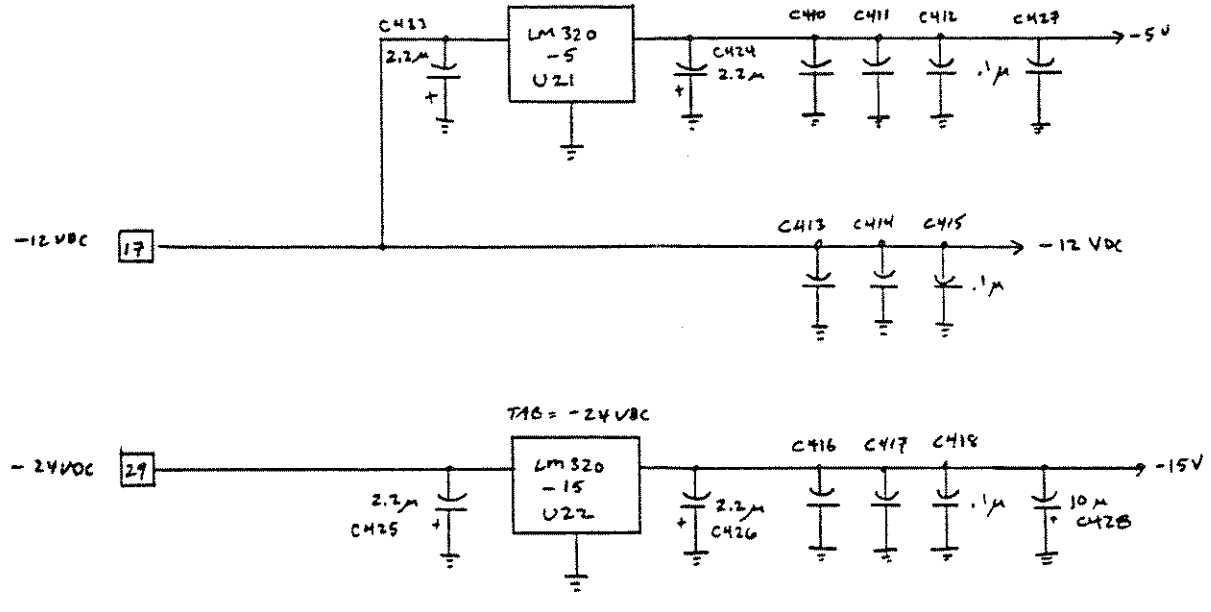
330Ω R328

56 R329

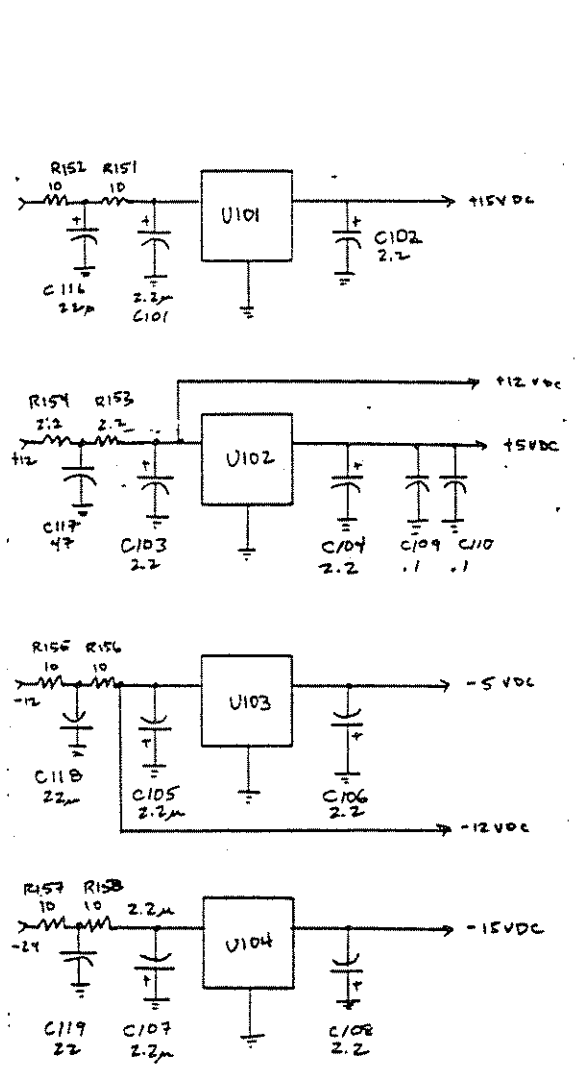
STANFORD RESEARCH SYSTEMS				
DRAWN 12-14-82	SIZE	FSCM NO.	DWG. NO. SR250-4	REV. B
ISSUED JRW	SCALE		SHEET 4 of 5	



TAB = -12VDC



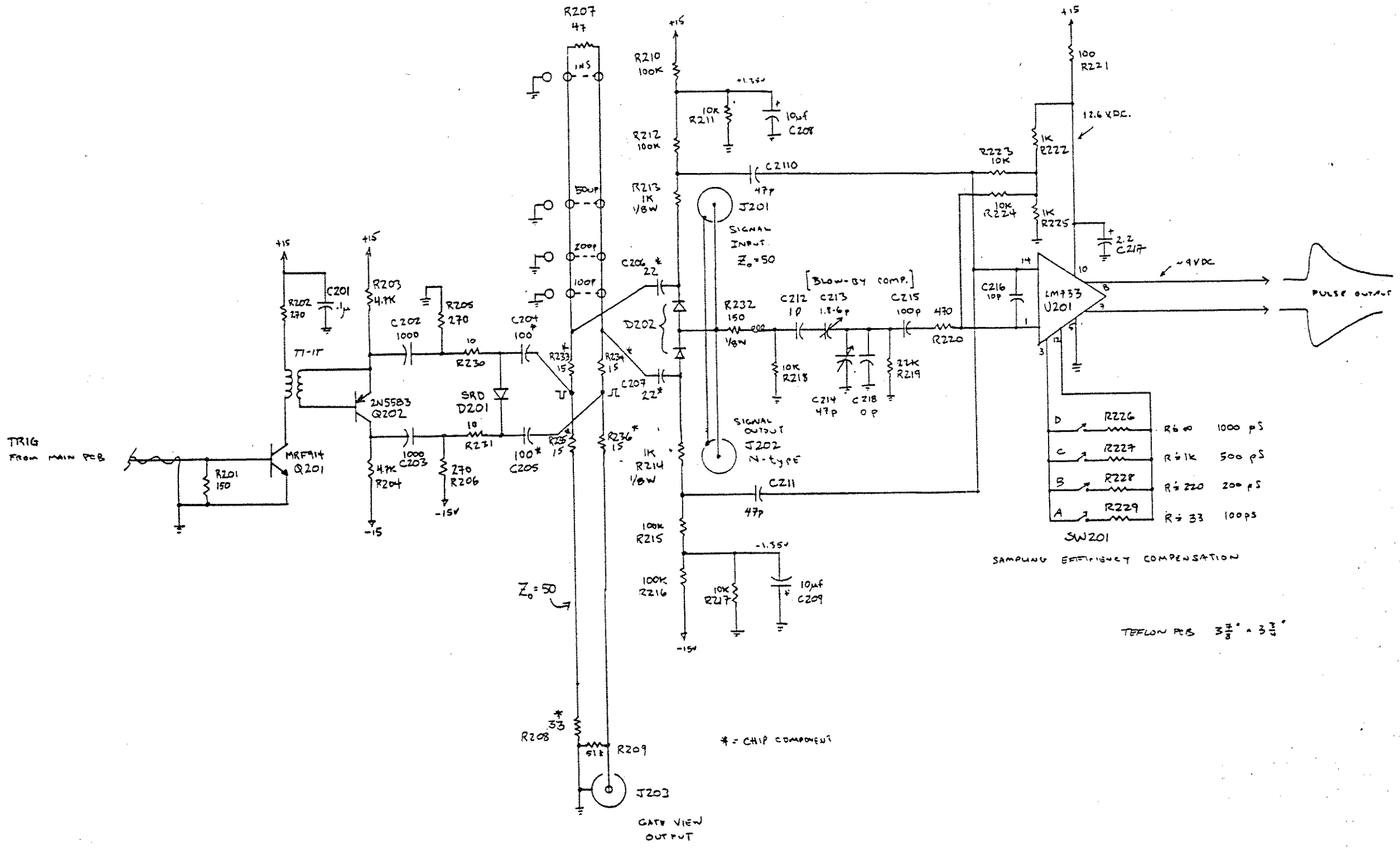
STANFORD RESEARCH SYSTEMS				
DRAWN 12-19-82	SIZE	FSCM NO.	DWG. NO. SR250-5	REV. B
ISSUED JRW	SCALE		SHEET 5 of 5	



EXT DELAY COEFFICIENT

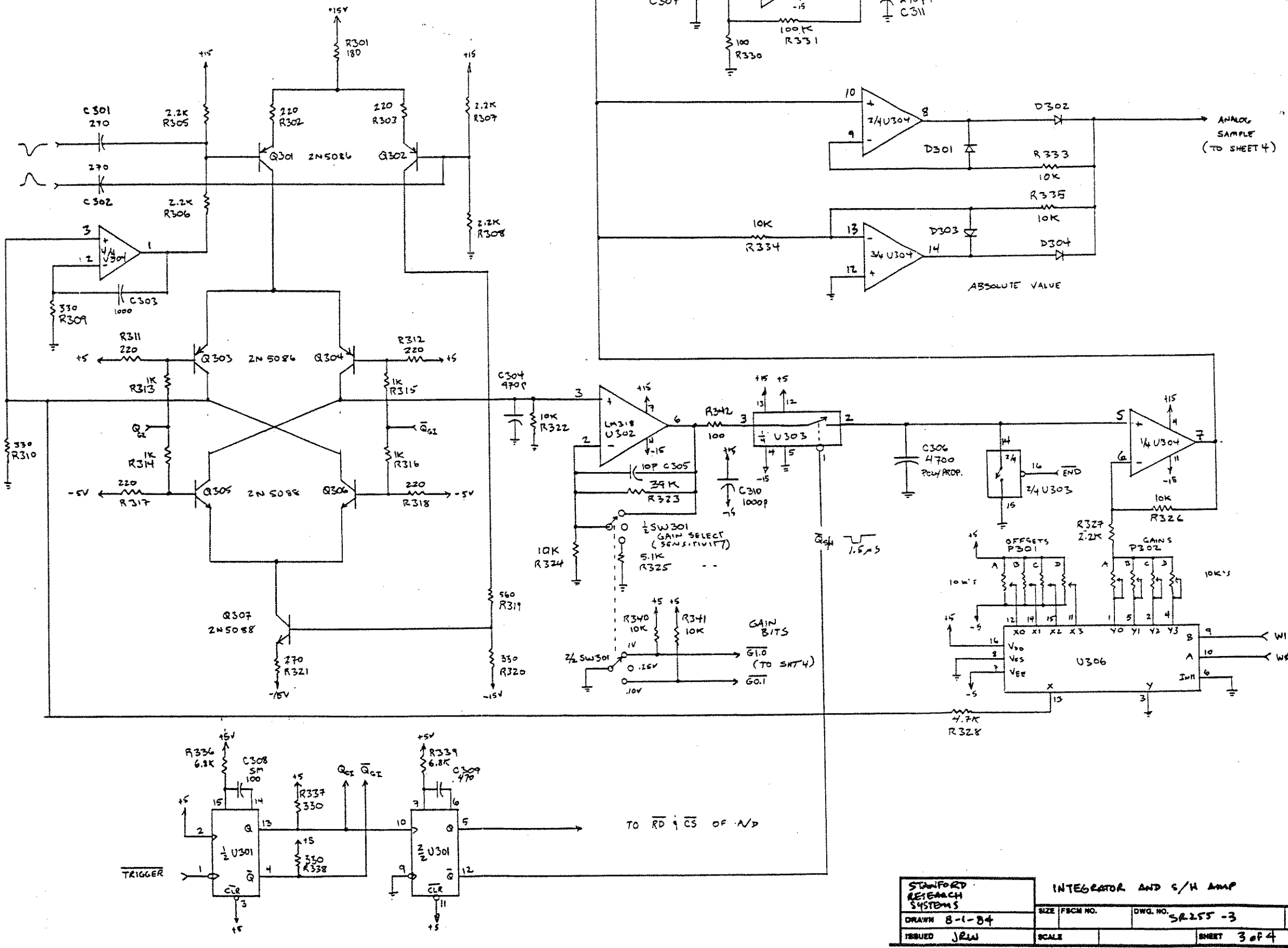
A: 1 NS/V
B: 10nS/V
C: 100nS/V
D: 1000 NS/V

STANFORD RESEARCH SYSTEMS	POWER SUPPLIES & TRIGGER CIRCUITS		
DRAWN 8-1-84	SIZE	FSCM NO.	DWG. NO. SR255-1
ISSUED JRW	SCALE		SHEET 1 of 4



TEFLON PCB $3\frac{3}{8}" \times 3\frac{3}{8}"$

STANFORD RESEARCH SYSTEMS	TEFLON (FAST) PCB		
DRAWN 8-1-84	SIZE	FSCM NO.	DWG. NO. SR255-2
ISSUED JRW	SCALE		SHEET 2 of 4



STANFORD RESEARCH SYSTEMS	INTEGRATOR AND S/H AMP		
DRAWN 8-1-84	SIZE	FSCM NO.	DWG. NO. SR255-3 REV. A
ISSUED JRW	SCALE		SHEET 3 of 4

BISHOP GRAPHICS, INC. REORDER NO. 1880

R401 - R404 (330Ω)
D401 - D404 (GREEN)

WIDTH	100	200	500	1000
W1	0	0	1	1
WΦ	0	1	0	1

SW401

TRIGGER

HOLDOFF

74LS21

END

DATA OE

STATUS OE

V_{cc} = 14
GND = 7

U401 U402 U403 U404 U405 U406 U407 U408 U409 U410 U411 U412 U413 U414 U415 U417

2764 EPROM

HC174

HCZ44

HC 374

A/D

D/A

TRIG LED

TRIG GREEN

D405

ANALOG SAMPLE

+10.24

-5.12V

"OVER"

RED OVER-RANGE D406

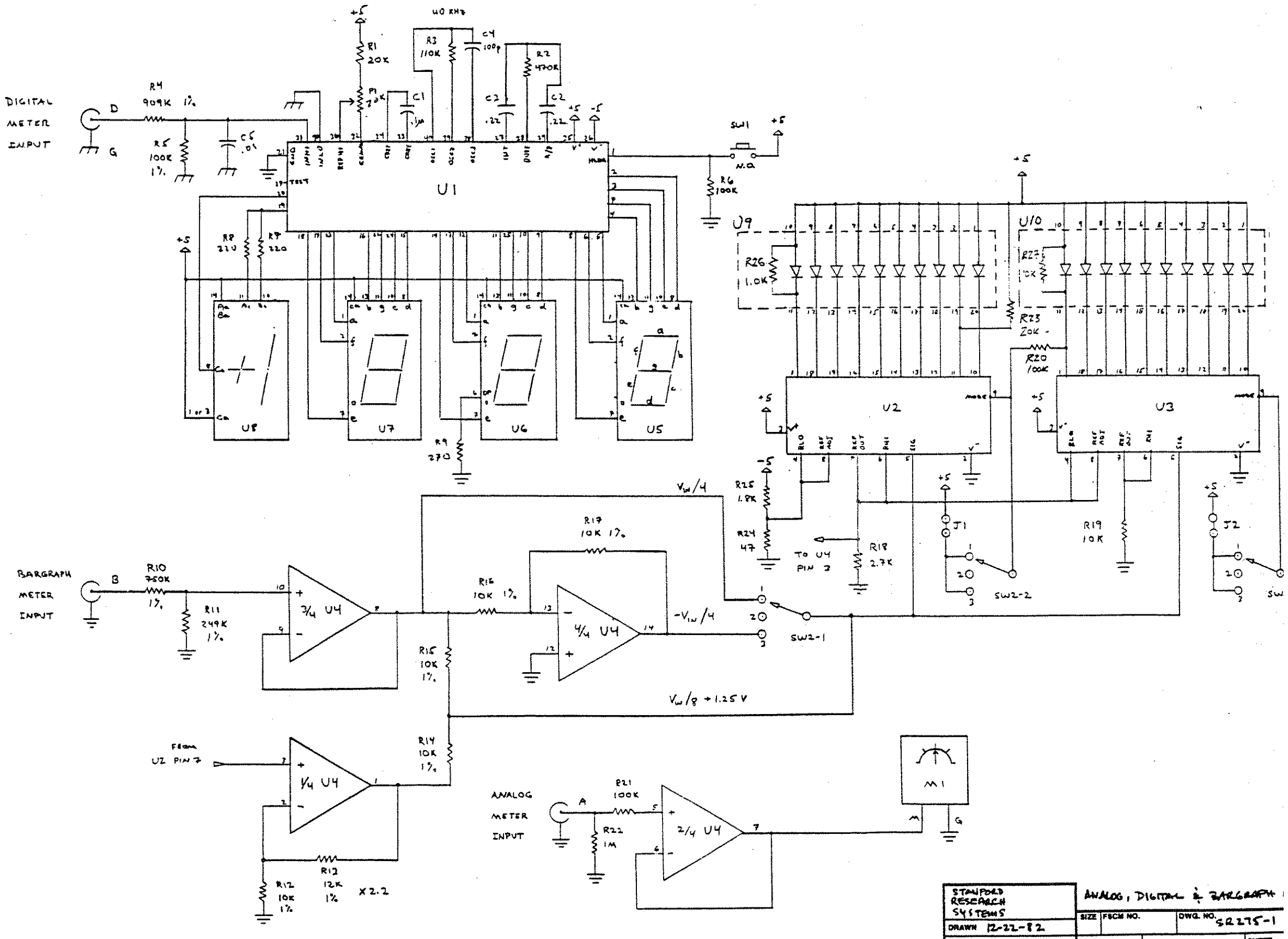
LAST SAMPLE OUTPUT J402

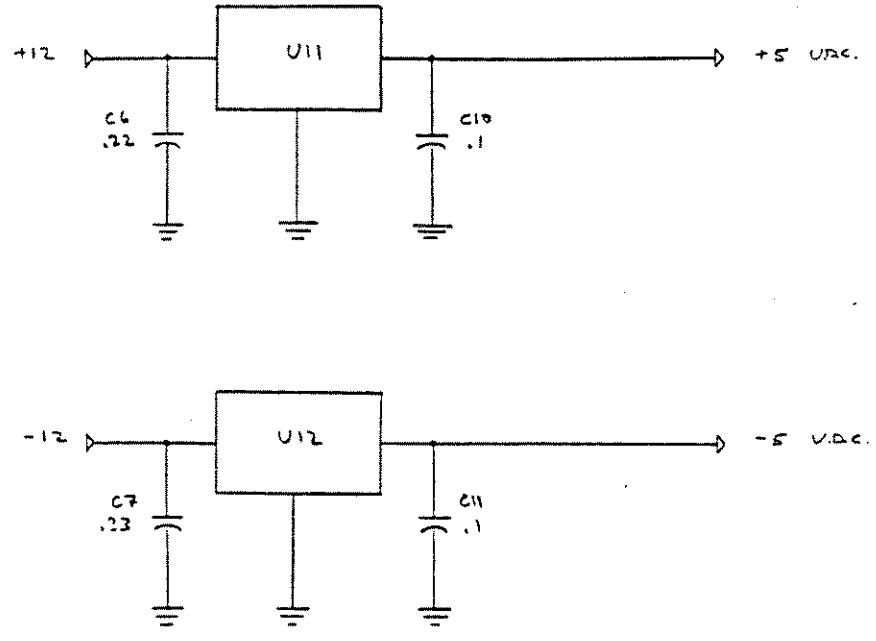
HIGH = POSITIVE

DATA/STATUS

100K RN401

STANFORD RESEARCH SYSTEMS	A/D, D/A, PROM & COMPUTER INTERFACE
DRAWN 8-1-84	SIZE / FSCM NO. / DWG. NO. SR255-4 / REV. A
ISSUED JRW	SCALE / SHEET 4 of 4


DIGITAL METER INPUT
D
G
R4 909K 1%
R5 100K 1%
C5 .01
R1 20K
P1 2.0K
C1 .1µ
40 KHz
R3 110K
C4 100p
R2 470R
C2 .22
C2 .22
+5
-5
U1
SW1
N.O.
R6 100K
R8 220
R7 220
R9 270
U8
U7
U6
U5
U9
U10
R26 1.0K
R27 10K
R23 20K
R20 100K
U2
U3
R25 1.8K
R24 47
To U4 pin 2
R18 2.7K
J1
SW2-2
R19 10K
J2
SW2-1
$V_{in}/4$
R17 10K 1%
BARGRAPH METER INPUT
B
R10 750K 1%
R11 249K 1%
3/4 U4
R16 10K 1%
4/4 U4
$-V_{in}/4$
R15 10K 1%
$V_{in}/8 + 1.25$ V
From U2 pin 7
1/4 U4
R14 10K 1%
R12 10K 1%
R13 12K 1% X2.2
ANALOG METER INPUT
A
R21 100K
R22 1M
2/4 U4
M1
M
G
STANFORD RESEARCH SYSTEMS
DRAWN 12-22-82
ISSUED SRL
ANALOG, DIGITAL & BARGRAPH
SIZE
FSCM NO.
DWG. NO. SR275-1
SCALE
SHEET
BISHOP GRAPHICS, INC. REORDER NO. 1860



CIRCUIT ELEMENT	TYPE	PIN # +5	PIN # -5	PIN # GND	PIN # +15	PIN # -15
U1	ICL7117	35	26	21	-	-
U2, U3	LM3914CN	3	-	2	-	-
U4	LF347N	-	-	-	4	11
U5, U6, U7	MAN72A	14	-	-	-	-
U8	MAN73A	1, 14	-	-	-	-
U9, U10	HLSP-4820	1-10	-	-	-	-
U11	MC7805CT					
U12	MC79L05CP					
U13	MC79L15CP					
U14	MC78L15CP					

NOTES

1. THE ZERO-CENTER MODE OF THE BARGRAPH DISPLAY IS ALWAYS A FLYING DOT. THE OTHER MODES OF THE BARGRAPH DISPLAY MAY BE CONVERTED TO FLYING DOT BY REMOVING JUMPERS J1 AND J2.
2. ⏚ SYMBOL INDICATES GROUNDING TO FRONT PANEL

STANFORD RESEARCH SYSTEMS	VOLTAGE REGULATORS		
DRAWN 12-22-82	SIZE	FSCM NO.	DWG. NO. SR275-2 REV. B
ISSUED SRL	SCALE		SHEET 2 of 2

NIM BIN A.C.

1A SLOW

120 VAC HOT

NEUTRAL

POWER

2A SLOW

120 VAC HOT

NEUTRAL

GROUND

115

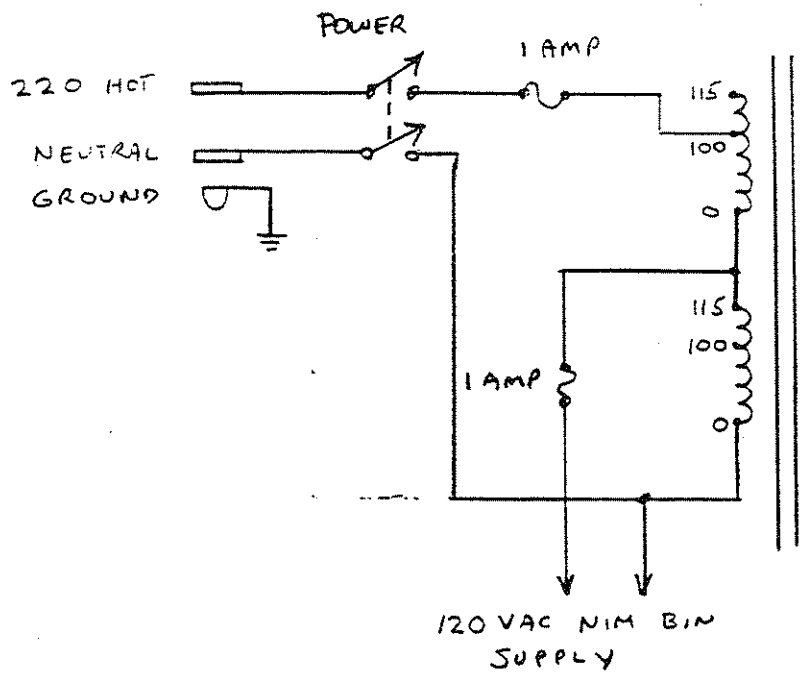
0

115

0

WIRING FOR 120 VAC
POWER MAINS.

WIRING FOR 220VAC
POWER MAINS



28VCT

+ 20 VDC

- 20 VDC

TO REGULATOR
STRIP

5800μF
40V

5800μF
40V

48VCT

+ 35V

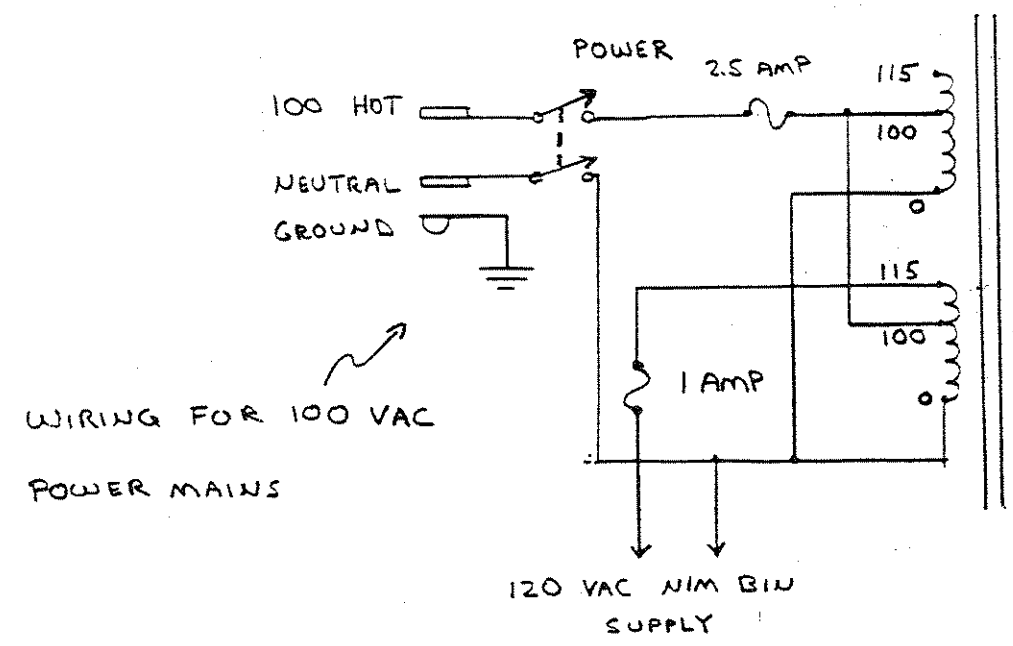
- 35V

TO REGULATOR
STRIP

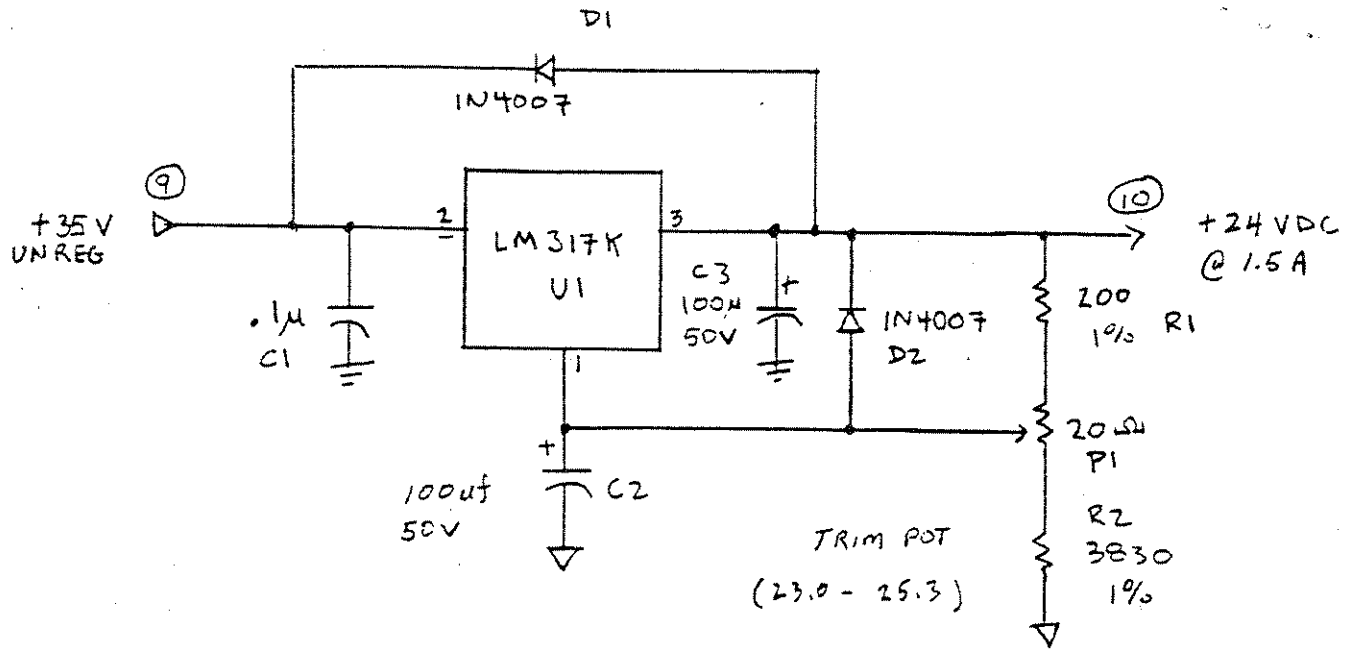
2400μF
50V

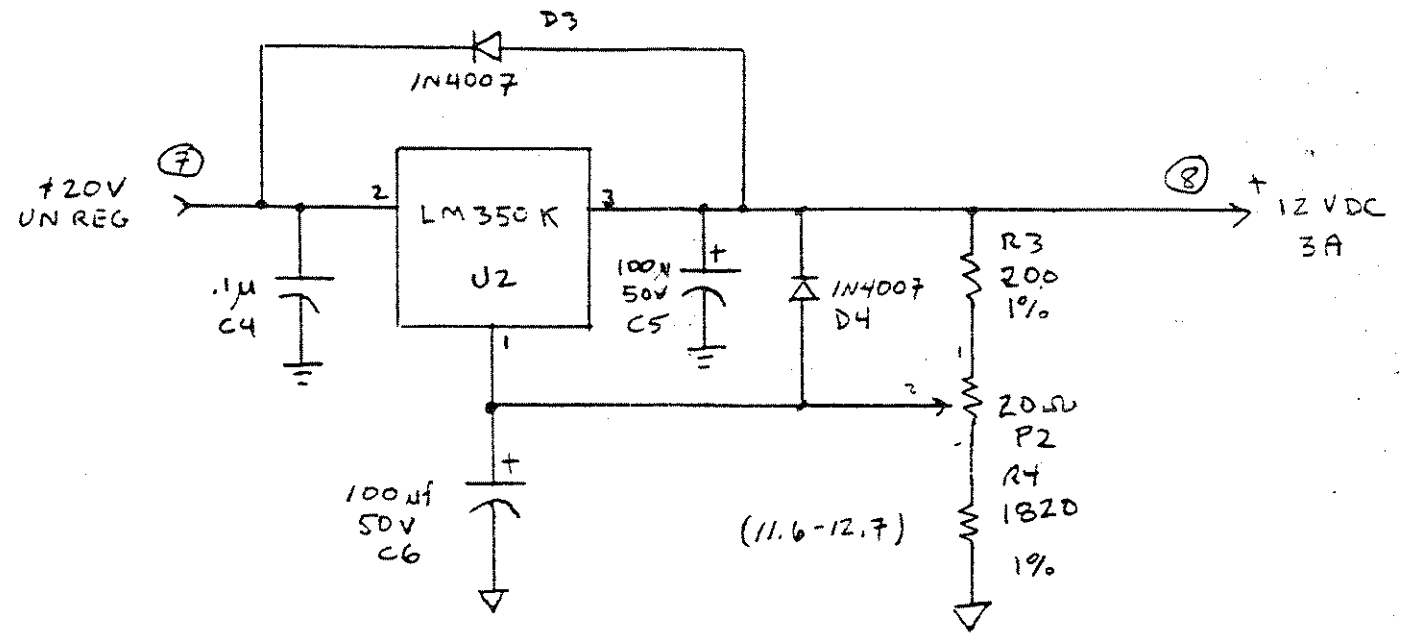
2400μF
50V

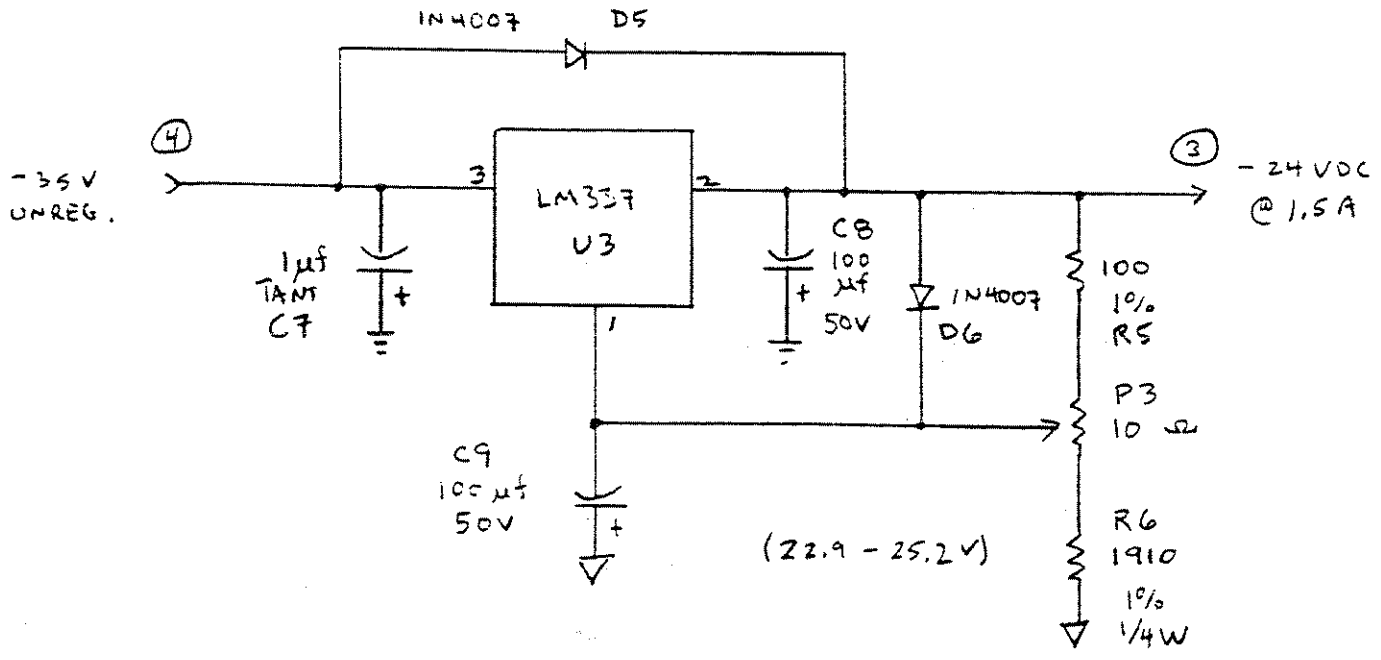
SR280 NIM BIN UNREGULATED
POWER SUPPLY. 8/83

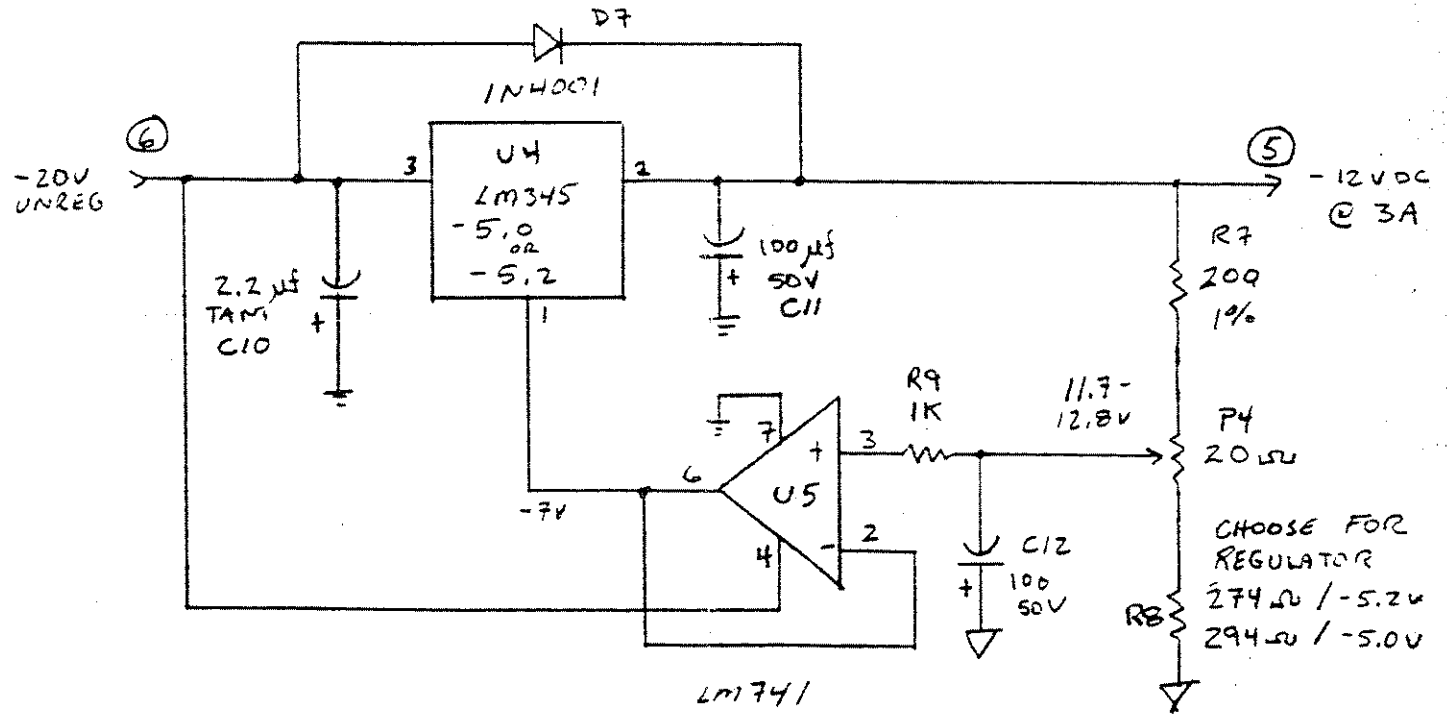


WIRING FOR 100 VAC
POWER MAINS









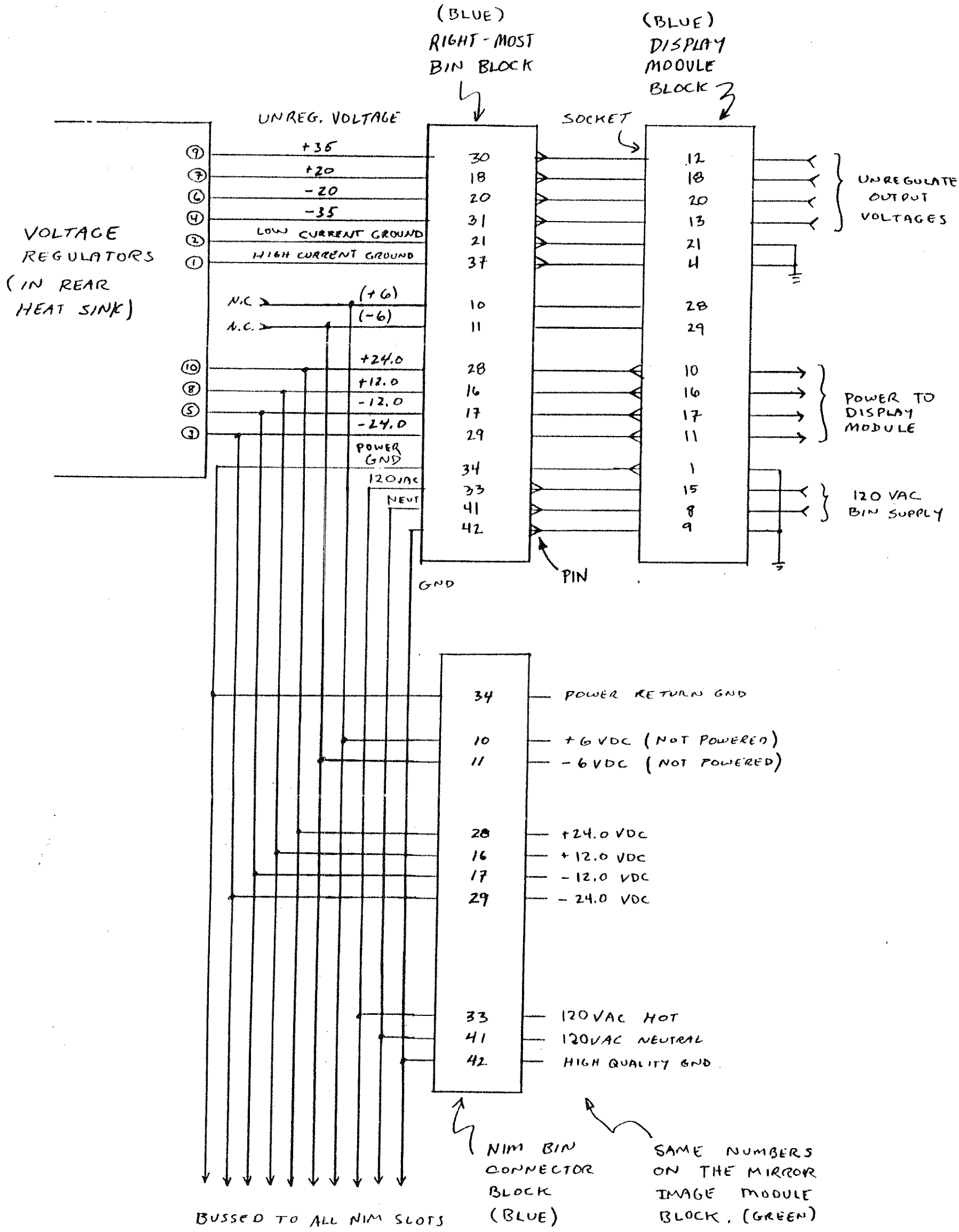
(2) LOW CURRENT, HIGH QUALITY GND

(1) HIGH CURRENT POWER RETURN GND

ALL 1% RESISTORS ARE RN55C

(N) PIN NUMBER ON IN-LINE CONNECTOR

SR280 REGULATOR SCHEMATIC REV-C



SR280 BIN WIRING DIAGRAM