

# Build a Function Generator

*An inexpensive way to generate useful waveforms.*

by J. Frank Brumbaugh KB4ZGC

**F**unction generators provide a number of different waveforms over the audio frequency range and, if you pay enough, up to about 2 MHz or more. Commercial units are priced well over \$100, a very high price for what can be a very simple instrument.

Hams do not need a broad frequency range, nor do they have to spend big bucks for a perfectly adequate function generator covering the most important audio frequencies, at least 300 to 3,000 Hz or a bit higher. But they may need a number of different waveforms, depending on the tests they require.

The function generator described in this article covers from below 300 Hz to above 7,500 Hz in two ranges. It provides positive pulses, negative pulses, square waves, triangle waves, and sine waves at all frequencies within its two ranges. Best of all, it requires only a single inexpensive IC and a general purpose NPN transistor. It can be constructed for less than \$5, not including an enclosure, even if all parts must be purchased new (surplus).

## The Circuit

Figure 1 shows the schematic diagram. U1 is a TL-084 quad FET op amp that is connected with external components to generate square, triangle and sine waves at frequencies controlled by *frequency* potentiometer R4. Positive and negative pulses are derived from the square waves.

There is a minor drawback resulting from trying to do so much with so little, but this is eliminated by adding Q1, a 2N3904. Triangle and sine waves generated by U1 vary inversely in amplitude as frequency is changed. Q1 amplifies sine and triangle waves with the input level controlled by *gain* potentiometer R18. Lowering the frequency reduces their amplitude; raising the frequency provides more gain. This allows you to keep these waveforms at a constant amplitude and eliminates distortion at low frequencies.

Although this circuit requires both positive and negative voltages, the total current drain is so low—a few milliamperes—that a simple voltage doubler consisting of diodes D3 and D4, electrolytic capacitors C7 and C8, and voltage equalizing resistors R16 and R17, does the job. A small wall transformer, or any small low voltage transformer with a secondary voltage between 6 and 12 volts AC, is used to power the function generator. One side of the secondary is the center tap of the voltage doubler circuit and is grounded, thus both positive and negative DC voltages referred to ground (common) are provided, eliminating the need for a complex positive and negative power supply.

## Construction

I recommend a small printed circuit board, such as Radio Shack 276-150. All parts except jacks and

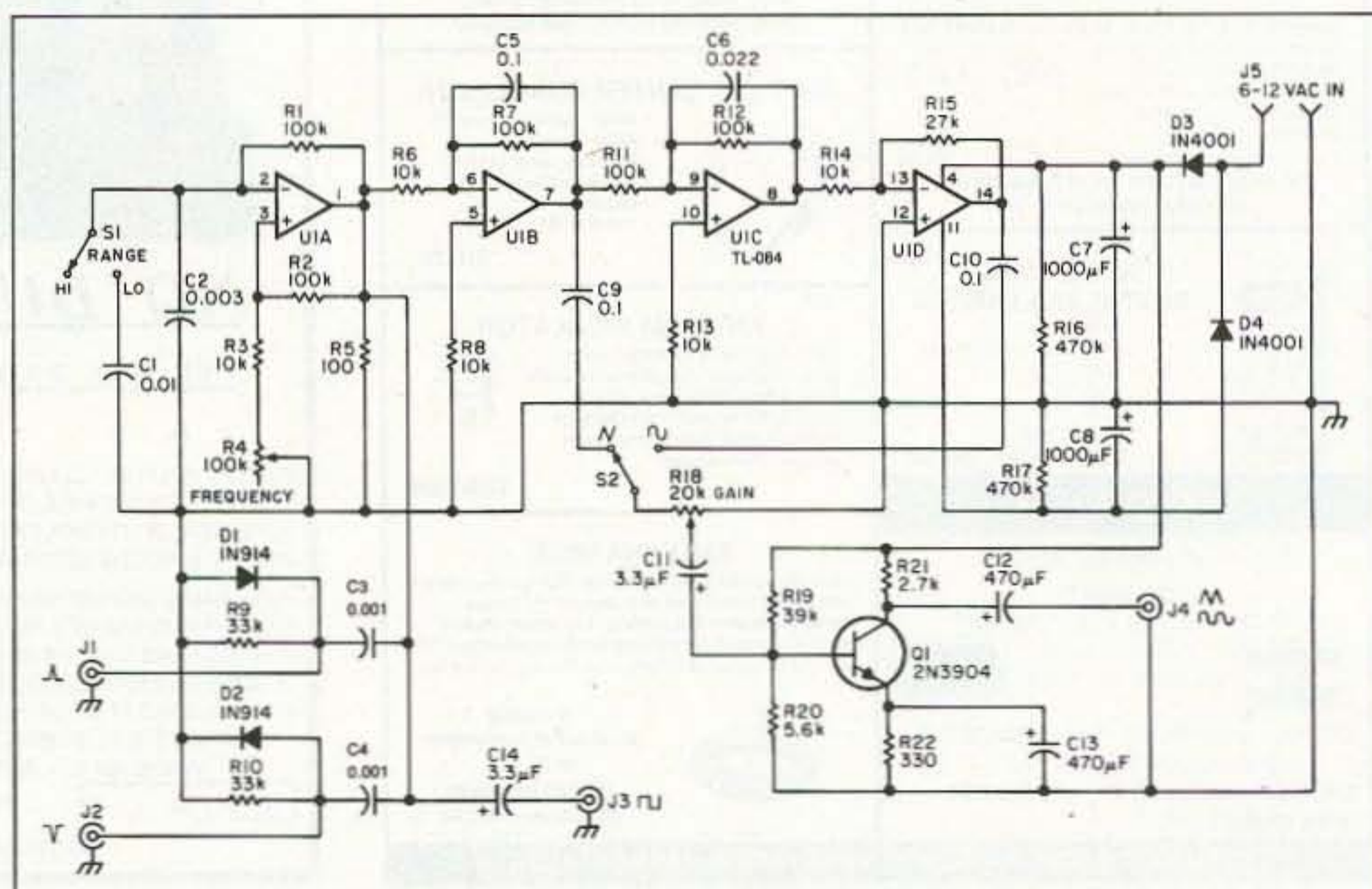


Figure 1. Schematic diagram, function generator.

controls are mounted on the PC board. The layout is not critical, despite the rapid rise and fall times of the square waves. You don't need any shielded wire.

The PC board can be mounted in a small metal or plastic enclosure, or one made from printed circuit board material. Both the potentiometers and the toggle switches can be mounted on the panel, along with the four waveform output jacks. The AC connector can be mounted wherever desired. It must match the low voltage AC connector from the wall transformer.

If desired, a small step-down transformer with a secondary of 6 to 12 VAC can be mounted in the enclosure if a wall transformer is not used. If you do this, an SPST toggle or slide switch should be used in series with the primary to serve as an on/off switch. If you want a pilot light, connect an LED in series with approximately 12,000 ohms, 2 watts, across the transformer primary. Two-watt resistors are scarce today. If you do not have one in your junk box you can use a pair of 27k, 1W resistors; four 47k, 1/2W resistors; or eight 100k, 1/4W resistors, wired in parallel to substitute for the 12k, 2W resistor.

Although calibrations can be marked directly on the panel, it will look better if you use a circular calibrated dial. You can make an excellent dial using an aluminum or steel circle left over from cutting a hole for a meter or small speaker. (You do save these in your junk box, don't you? If not, you'll have to cut one the correct size.)

Paste white card stock to one side of the circular dial. Allow it to dry thoroughly before trimming the excess card even with the dial plate. Enlarge the center hole if necessary so the dial will just clear

the shaft of R4. Fasten the dial plate to a knob, using super glue or epoxy. Place the dial over the shaft and tighten the setscrew(s) in the knob.

All parts except the printed circuit board and transformer are available from Short Circuits, PO Box 285, Barnegat NJ 08005, at unbelievably low prices. Small inexpensive power transformers are available from Micro-Mart, 508 Central Ave., Westfield NJ 07090. (Cat. No. T-11 provides 10.6 VAC at 175 mA for \$1.50.)

## Calibration

A frequency counter is recommended for calibrating the frequency dial. It must be capable of measuring frequencies below 300 Hz. Some of the frequency counters which have very broad measurement ranges require use of a low-pass probe for frequencies below about 20 kHz. Figure 2 shows the schematic for a simple low-pass probe which will work with any frequency counter.

Rotate the dial (R4) fully counterclockwise to maximum resistance. Set RANGE switch S1 to LOW. Connect the square-wave output (J3), through a low-pass probe if used, to the frequency counter. Set the frequency counter to a one-second gate period. Apply power to the frequency counter and the function generator.

Note the frequency displayed. It should be a bit below 300 Hz. If the frequency displayed is higher than about 500 Hz and you are *not* using a low-pass

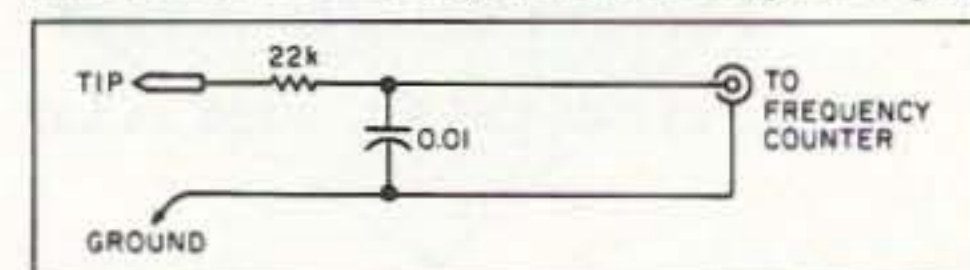


Figure 2. Low-pass probe.

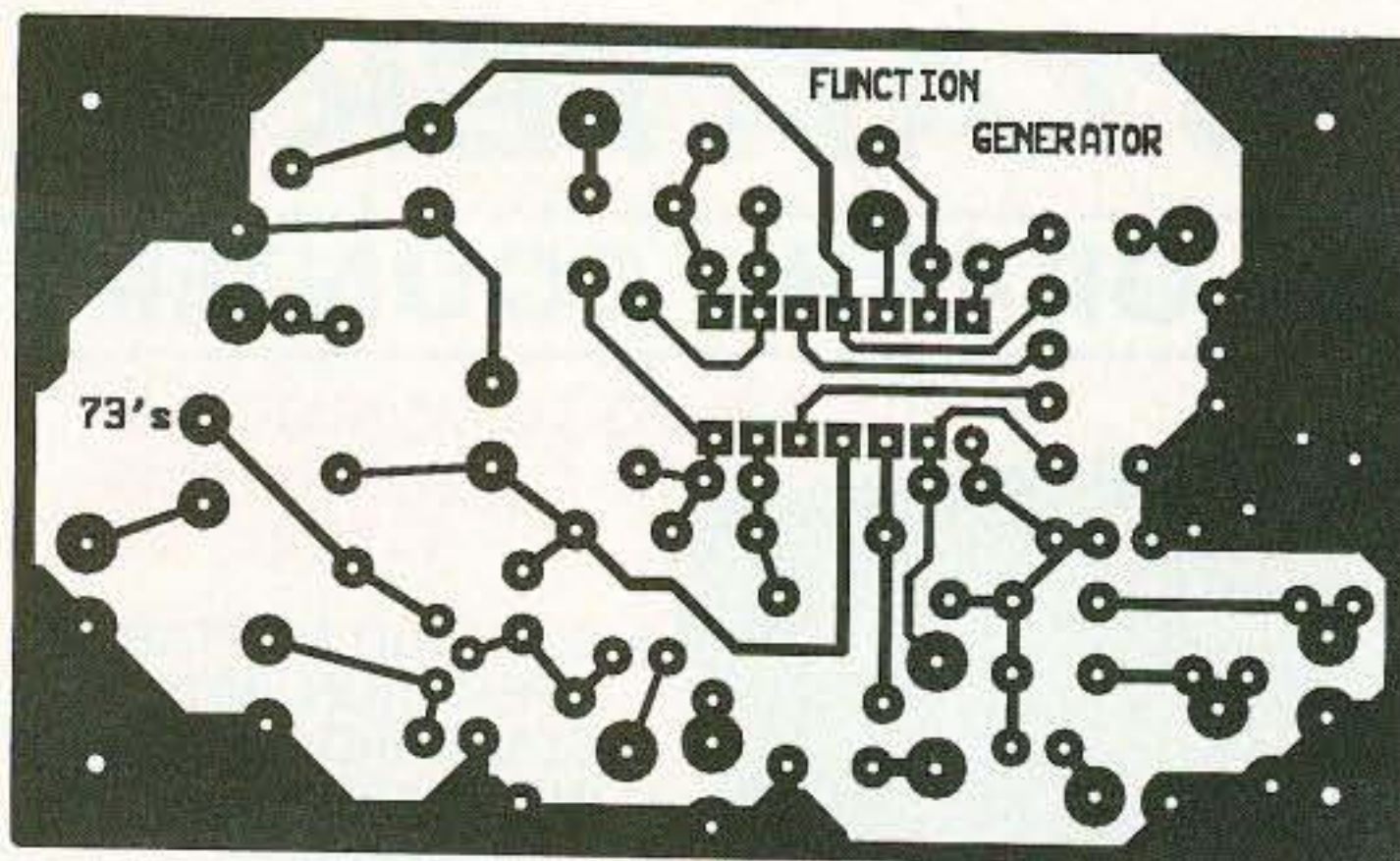


Figure 3. PC board foil pattern.

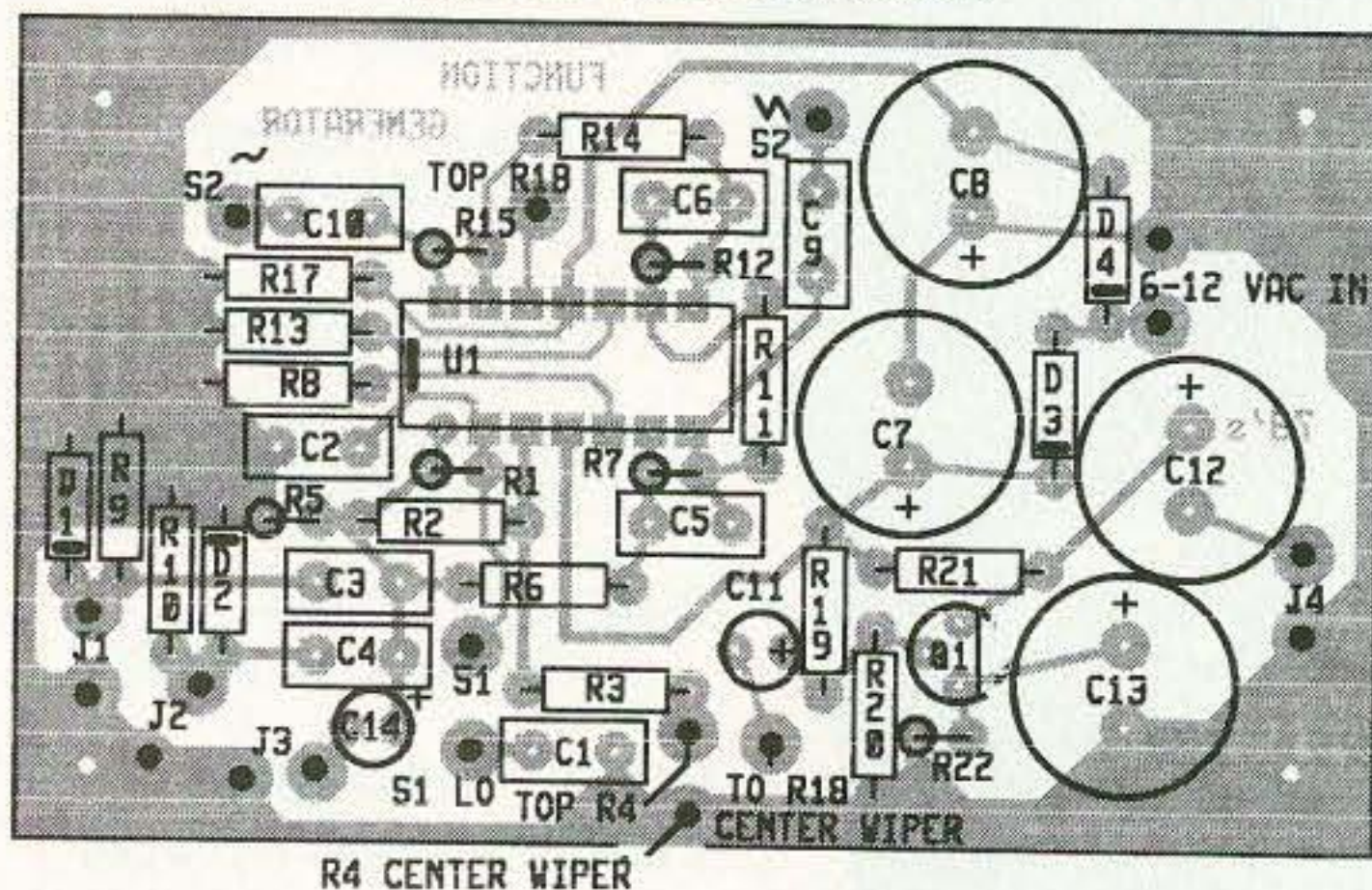


Figure 4. Parts placement.

probe, both the positive and negative edges of the square wave will be counted, displaying double the actual frequency. If this occurs, either divide

their amplitude controlled by gain control R18. Both triangle and sine waves should be observed on an oscilloscope when setting the gain control. Too

by two or use a low-pass probe.

Rotate the dial until a frequency of 300 Hz is displayed. Mark the dial at this point. Continue calibrating the dial as described until the entire low range has been calibrated. Then move the range switch to HIGH and calibrate the high frequency range.

The dial will not be linear with frequency. Lower frequencies on both ranges will be spread out and high frequencies compressed. However, these ranges overlap so the compressed high frequencies on the LOW range are spread out on the low end of the HIGH range.

#### Operation

Apply power to the function generator. Set the dial and RANGE for the desired frequency. Pulses and square waves are available at all times. A choice of triangular or sine waves at J4 is controlled by S2, and

high a gain at low frequencies can result in greatly distorted waveforms.

#### Conclusion

The function generator is a general purpose instrument. A few of the more common uses are:

- Pulses: External triggering of oscilloscope. Checking electrical length of coaxial cables. Measuring carrier lifetimes of diodes.

- Square Waves: Checking low frequency limits of amplifiers. Vertical amplifier voltage calibration of oscilloscope. Output can be keyed into a speaker or headphones for code practice. Signal injector in receiver tests.

- Triangle Waves: Bi-directional sweeping of a voltage controlled oscillator.

- Sine Waves: Checking bandpass or bandstop characteristics of active and passive filters. Measuring frequency limits and insertion losses of active and passive filters. A known modulation source for transmitter testing.

The methods and techniques for using various waveforms for testing and evaluating circuits and equipment are explained in a number of textbooks, and detailing them here is far beyond the scope of this article. When you become familiar with the function generator you will discover many more uses for it in the shack. **73**

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#### Parts List

C1	0.01 $\mu$ F 5% mylar or polycap
C2	0.003 $\mu$ F 5% mylar, polycap or monolithic
C3, C4	0.001 $\mu$ F ceramic disc
C5	0.1 $\mu$ F ceramic, polycap, mylar or monolithic
C6	0.0022 $\mu$ F mylar, polycap or monolithic
C7, C8	1000 $\mu$ F 25 VDC electrolytic
C9, C10	0.1 $\mu$ F disc ceramic or monolithic
C11, C14	3.3 $\mu$ F 16 VDC electrolytic
C12, C13	470 $\mu$ F 25 VDC electrolytic
D1, D2	Silicon switching diode (1N914, IN4148, etc.)
D3, D4	Silicon rectifier diode 1N4001
J1, J2, J3, J4	RCA or phone jack
J5	AC connector to match wall transformer output
Q1	NPN small signal transistor (2N3904, 2N4124, etc.)
R1, R2, R7, R11, R12	100k 5% 1/4W resistor
R3, R6, R8, R13, R14	10k 5% 1/4W resistor
R4	100k potentiometer
R5	100 ohm 5% 1/4W resistor
R9, R10	33k 5% 1/4W resistor
R15	27k 5% 1/4W resistor
R16, R17	470k 5% 1/4W resistor
R18	20k potentiometer
R19	39k 5% 1/4W resistor
R20	5.6k 5% 1/4W resistor
R21	2.7k 5% 1/4W resistor
R22	330 ohm 5% 1/4W resistor
S1	SPST toggle or slide switch
S2	SPDT toggle or slide switch
U1	TL-084 quad FET op-amp

A blank PC board is available for \$6.25 + \$1.50 shipping per order from FAR Circuits, 18N640 Field Court, Dundee IL 60118.