Craig Kendrick Sellen
Birch Hills Residence
25 Reservoir St.
Simpson PA 18407-1300

Portable Pulse Generator

Build this pocket-size test instrument that's useful in a wide variety of lab and service tasks.

As new laboratory techniques are worked out and new circuits developed, the need for specialized test equipment rapidly changes. "Special" equipment often becomes "standard." For example, pulse generators, once found only in the larger laboratories, are gradually coming to be considered as "standard" pieces of test equipment for all labs. In some cases, pulse generators are used as much as oscilloscopes and VTVMs — "standard" equipment items of long standing.

Most pulse generators are characterized by their large physical size and their voracious appetite for electrical power. Not so, the instrument shown here. Although it delivers either positive- or negative-going pulses over a wide frequency range (100 to 6000 pulses per second), other ranges are easily obtained. With good output amplitude (12–18 volts peak across a 10,000 ohm load), the overall case size is only 3 x 4 x 5 inches and the power requirements are so small that it is practical to power it with two self-contained 9 V batteries.

In addition to its small size and low power requirements, the instrument shown has many other advantages. Highly efficient, it doesn't generate large quantities of surplus heat to increase the discomfort in a crowded lab or workshop. Light in weight and quite rugged, the instrument is ideally suited for portable and field work. It may, literally, be "slipped in an overcoat pocket."

The instrument shown also has the advantage of requiring neither "warm-up" time nor stand-by power. It is ready to use as soon as the power switch is thrown "on."

All these features have been made possible by designing the unit around the highly efficient 2N2222A. Standard, commercially available components are used throughout, and the circuit is sufficiently simple so that the average technician should have little or no difficulty in building a similar or duplicate unit in one or two days.

Circuit description

Basically, this pocket-size pulse generator consists of one transistor connected as a blocking oscillator, followed by a second transistor serving both as a clipper and as a buffer-amplifier.

Referring to the schematic diagram of **Fig. 1**, the first 2N2222A transistor is connected in a grounded emitter blocking oscillator circuit, with transformer T1 providing the necessary energy feedback to start and sustain oscillation.

A step-down turns ratio is provided to match the high collector circuit impedance to the low input impedance of the base-emitter circuit.

In operation, the "blocking" action occurs through the rapid charge of capacitor C1 through the base emitter circuit of the transistor and the secondary of transformer T1, and the gradual discharge of this capacitor through resistors R1 and R2. The blocking rate is determined essentially by the RC time constant of the circuit made up of components C1, R1, and R2.

By making R1 adjustable, the circuit time constant and hence the blocking rate can be changed. Resistor R1 thus serves as the "pulse rate" control.

Resistor R2 is provided to limit the maximum blocking frequency and to protect the transistor from overload.

A signal is obtained from the blocking oscillator stage by means of a tap on T1 and is applied, through coupling capacitor C2, to the base of the second transistor, which serves to shape and amplify it.

An SPDT toggle switch, S1, is provided to change the bias current of the second 2N2222A stage, and thus its mode of operation. When this switch is open, the stage operates with zero bias, since the base resistor R4 is returned directly to the emitter of the transistor.

Under these conditions the stage acts to limit or clip the positive-going transition and to amplify and shape the negative-going portions of the applied signal. The amplified signal appears

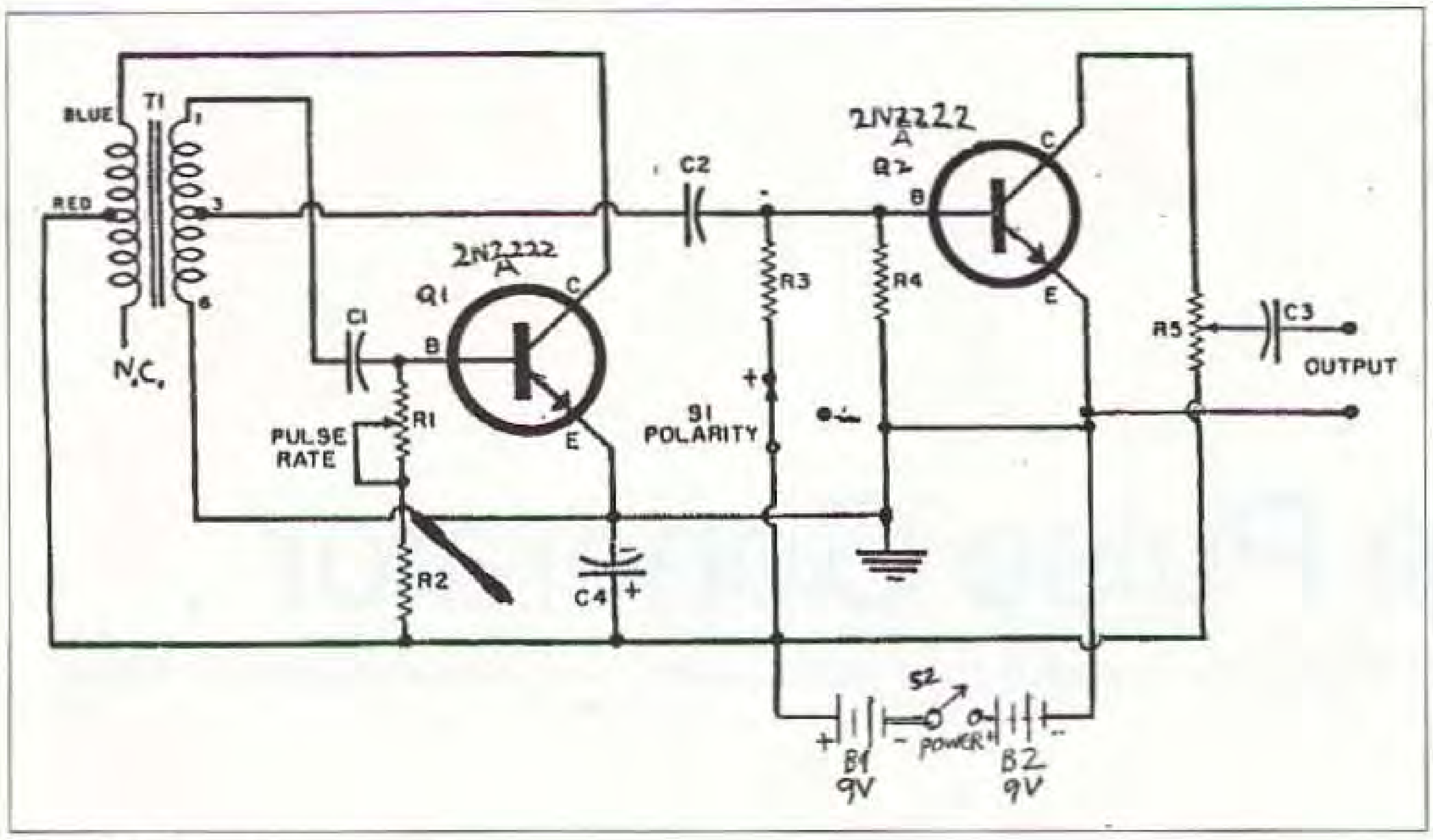

Fig. 1. Schematic.

across load resistor R5, but with positive polarity, due to the phase reversal of the stage.

By using a potentiometer for resistor R5, this resistor serves not only as the load resistor for the output clipper-amplifier but also as the output level control. The output signal is obtained through blocking capacitor C3, with its amplitude dependent on the setting of R5.

When switch S1 is thrown to its closed position, resistor R3 is connected between the base of the transistor and the negative side of the power source, thus permitting a heavy base bias current to flow. This radical shift in bias, in turn, modifies the operating characteristics of the stage so that the negative-going portions of the applied signal are clipped and the positive-going portions are shaped and amplified. This results in pulses of negative polarity appearing across load resistor R5; S1 thus serves as the pulse polarity switch.

Power is supplied by two 9 V transistor-type batteries. B1 and B2 is controlled by an SPST toggle switch, S2 serving as the power switch. Capacitor C4 is provided to ensure a low impedance across the power source.

Output signal waveforms

The waveform of the output pulses obtained from my model are given in **Fig. 2**. The signals obtained from another unit should appear similar to these, but may not be exact duplicates.

A low-frequency (approximately 200 pps, pulses-per-second) positive-going pulse is shown in **Fig. 2A** and a high frequency (about 6000 PPS) positive-going pulse in **Fig. 2B**. As can be readily observed by comparing these two illustrations, the pulsewidth remains relatively constant. It appears narrower in **Fig. 2A** because of the lower repetition rate. The pulsewidth depends primarily on the characteristics of transformer T1 in the blocking oscillator stage.

When the polarity switch S1 is thrown so that negative-going output pulses are obtained, the shaping action of the output 2N2222A stage is not quite as good, so that the negative-going pulses are not quite as sharp as the positive-going pulses. Nonetheless, they are quite satisfactory for most practical work.

Typical high-frequency negative-going pulses (about 6000 pps) are illustrated in **Fig. 2C**.

The maximum amplitude of the output pulse is approximately equal to the voltage of the power supply battery B1 and B2, because the output 2N2222A stage is driven over such extremely wide limits. On one peak the collector current is reduced to virtually zero, while on the other peak the collector current reaches the maximum possible with the supply voltage and the load resistor (R5) used.

Construction hints

The exterior and interior of this model are sufficient to indicate the general layout and parts placement. This layout need not be followed exactly, although standard good wiring practice should be used.

Although the model was assembled in a standard 3 x 4 x 5 inch metal box, either a larger or smaller case may be used. If a smaller case is employed, the wiring will require somewhat greater care. Even a plastic case can be used.

All controls and switches in the model were labeled using commercially available black decals protected after application by three coats of clear plastic. The plastic coating is easily applied with a standard spray can.

The battery is held in place by a small "Z" bracket, with its connections made simply by soldering leads to its

Fig. 2. Waveform of output pulses obtained from the author's model. (A) Low-frequency (200 pps) positive-going pulse. (B) High-frequency (6000 pps) positive-going pulse, and (C) high-frequency, negative-going pulse (6000 pps).

Part	Description
R1	2 meg carbon potentiometer ("pulse rate control")
R2	27k 1/2 W
R3	6.8k 1/2 W, see text
R4	18k 1/2 W
R5	10k carbon potentiometer ("output control")
C1	0.1 μF disc
C2	0.05 μF disc
C3	0.5 μF disc
C4	100 μF 25 WVDC electrolytic
S1	SPDT toggle switch ("polarity control")
S2	SPST toggle switch ("power control")
B1, B2	Two 9 V batteries in series
T1	Universal audio output transformer (Stancor #A-3856 or equiv., see text)
Q1, Q2	2N2222A

Table 1. *Parts list.*

tin end terminals; or you may want to use battery clips. A certain amount of care must be exercised when doing this to avoid overheating and shortening the life of the battery.

Scotch electrical tape was used to insulate the exposed battery terminals after the connecting leads were soldered in place.

Another builder might prefer to devise and construct a small clip or socket for the battery, so that it would not be necessary to use a soldering iron to remove or replace the unit.

I installed the transistors in the model by simply soldering them in place. Should the prospective builder decide to follow a similar course, exercise special care to avoid accidentally overheating and damaging these components.

Transistors are especially sensitive to heat damage. Where they are to be soldered in place, the leads should not be cut too short and the actual soldering should be done as quickly as possible using a well-tinned and quite hot iron. An alternative is to provide sockets for the transistors.

The primary connections of transformer T1 are identified by color-coded leads when the secondary connections are identified by numbered terminals. The proper connections for the STANCOR transformer that I used are indicated in **Fig. 1.**

Parts substitutions

A number of parts substitutions are permissible in order to change the operating characteristics of the pulse generator. However, in addition to these component changes, a number of other parts may be changed without modifying the basic circuit.

As mentioned earlier, either a larger or a slightly smaller case may be used without difficulty. In some instances, a builder may wish to wire the pulse generator into an existing piece of equipment.

Slide or rotary switches may be substituted for the toggle switches used as the polarity and power switches in my model. If preferred, a volume control–type switch could be used for the "power" switch, permitting this unit to be combined with either the pulse rate or output controls.

Although binding post output connectors were employed, tip jacks, banana jacks, or even a coaxial or a BNC connector may be used instead.

An Everready type 411 battery may be used in place of the battery specified in the parts list. This unit is about the same size physically and supplies the same voltage as the battery I used.

Capacitor C4 is not critical, since it is used only for bypass purposes, and a smaller or larger unit may be substituted here without difficulty.

The size of the output blocking capacitor C3 is noncritical, and either a larger or smaller capacity may be used here if desired. The larger capacities are suggested to prevent possible distortion of the output signal waveform.

Circuit modifications

The basic pulse generator may be easily modified to suit the specialized needs or requirements of the individual builder. Let us discuss the more important modifications in order:

Changing pulsewidth. As mentioned earlier, the pulsewidth depends primarily on the characteristics of the transformer used in the blocking oscillator circuit. I used a standard "universal" audio output transformer. Where the prospective builder has access to special transformers, it should be practical to substitute another unit to obtain either a narrower or a wider pulse.

Changing the pulse rate range. My model covers a range from approximately 100 to 6000 pps. Where a different range is desired, it is necessary only to change the value of C1.

Using a larger capacity here will reduce the operating frequency, while a smaller capacity will increase the frequency. If desired, several ranges might easily be provided by using a selector switch to choose different values of C1.

The pulse rate range covered by the pulse rate control may be extended to provide wider coverage or reduced to provide more accurate adjustment. To extend the range covered by the control, use a potentiometer having a larger maximum resistance — a 5 megohm or 10 megohm pot, for example. To reduce the range covered by the control, use a pot of lower maximum resistance (1 megohm, 500,000, or even a 100,000 ohm unit). Where pulses at only a few fixed repetition rates are desired, a selector switch may be substituted for the "pulse rate" potentiometer, and fixed resistance values chosen as the switch is rotated.

Changing the output impedance. Where a lower or slightly higher output impedance is desired, it is only necessary to substitute a potentiometer of the desired impedance (resistance) for R5. When this is done, care should be taken that the output transistor cannot be accidentally overloaded. Do not use a pot of less than 3000 ohms with an 18 volt supply.

Obtaining pulse of fixed amplitude. Where the user will not need an adjustable output amplitude, a fixed resistor may well be substituted for R5. The output pulse amplitude should approximate the battery supply voltage and should remain fairly constant, even at different repetition rates. A fixed amplitude signal with a lower value may be obtained by using two fixed resistors in series in place of R5 to form a simple voltage divider. The output signal is obtained at the junction of the two resistors.

Obtaining pulses of fixed polarity. Should the user not require both positive- and negative-going pulses, the pulse polarity switch may well be omitted and the circuit permanently wired to deliver whichever type of signal the user requires.

Conclusion

The possible applications of a pulse generator are too numerous to more than briefly indicate. New applications are constantly being worked out, and the individual worker often finds that the only limitation on his use of the instrument is his or her ingenuity and skill in applying it.

The pulse generator is particularly valuable for operating many types of "slave" sweep circuits or for synching recurrent sweeps and multivibrators. A simple linear sweep (sawtooth signal) generator may be formed by using the positive-going pulse from a pulse generator to operate a discharge transistor connected across the capacitor in a simple RC series network. The capacitor is charged slowly through the resistor from a DC source, and then discharged rapidly by the transistor when a positive pulse is applied to its base.

Pulse generators are widely used for checking and testing delay lines, for checking the transient response of amplifiers, for testing counter circuits, and for calibrating and testing radiation instruments.

The pulse signals obtained from a pulse generator are also useful for oscilloscope retrace blanking and for use as a marker to divide a scope trace into segments of known duration. In both of these applications the pulse signal is applied to the "Z-axis" or intensity modulation terminal of the scope.

Considering the small amount of time and money required to build this compact unit, it makes a worthwhile project. 73