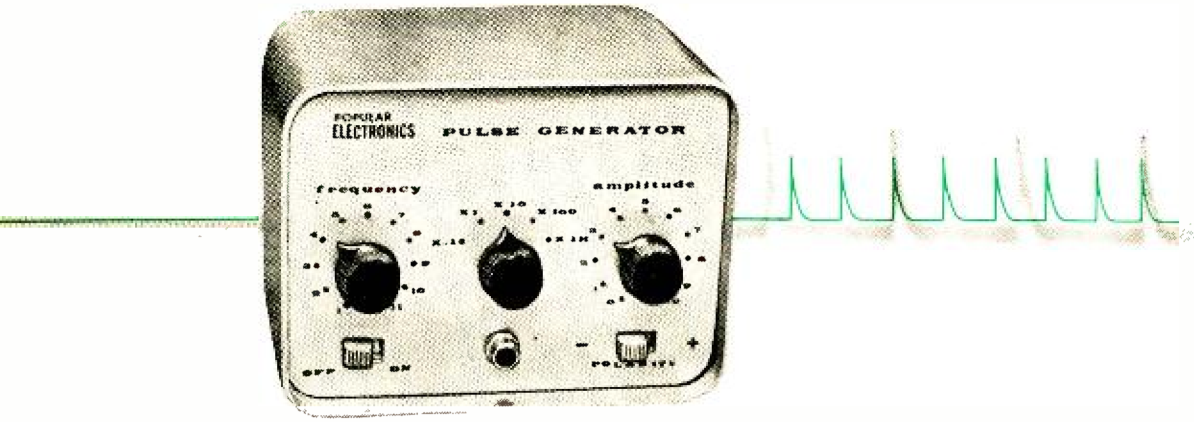
ADVANCED EXPERIMENTER PROJECT

PULSE GENERATOR



Variable amplitude and frequency trigger for counting, testing, and experimenting

By DON LANCASTER

A GOOD commercial pulse generator can sport a $200-and-up price tag. Here is a versatile unit you can build for less than $15 . . . or as little as $2.00. If your workshop is well-stocked, chances are you will only need to buy one $2 part. The circuit is simple, foolproof, and easily built in one or two evenings.

The Pulser produces a free-running series of sharp trigger pulses, variable from 0 to 10 volts in amplitude and with a variable repetition rate of from one pulse every ten seconds to 11,000 pulses per second. It has five overlapping scales and a choice of pulse polarity. It is battery-operated and draws less than 0.0005 ampere, and it puts out almost 8 watts of peak pulse power.

To boot, the Pulser has a low-output impedance and is short-circuit-proof. You can run it all day into a dead short. The rise-time is quite snappy—only 50 nanoseconds. Pulse width varies from scale to scale, but always stays at roughly 1/1000 of the repetition time.

Applications. An important experimental use for the Pulser is as a trigger source for multivibrators and counter circuits. If you have a scope, here is a convenient pulse source for resonance demonstrations, time constant experiments, and "Q" measurements. It is dandy for testing radio control modules and escapements, and doubles as a trigger source for experimental transistor and SCR power inverter circuitry.

The lower repetition rates are tops for timing displays, exhibits and flashers. For example, you can use the Pulser to trigger an SCR lamp controller. Set the Pulser to 58 cycles and the bulb will smoothly oscillate at a 4-cycle rate. Place a photocell and amplifier in front of the light, and you'll wind up with an ultra-low-frequency audio oscillator.

The Pulser easily drives a speaker and produces a series of "pock-pock-pock" sounds to enable you to check out speakers and output transformers. You can also use it as a signal injector for all sorts of audio testing and troubleshooting. And, finally, you can use the "pocks" themselves; the unit will serve as a metronome or as a darkroom timer.

How It Works. It's all made possible by a new semiconductor which sells for $2 . . . a *four-layer diode.* Unlike ordinary diodes, the four-layer diode is a voltage-sensitive switch. It is normally *off*, leakage current is negligible, and it snaps *on* when it "sees" 12 volts. It stays *on* as long as there is significant current (more than 1 ma.) left in the circuit. In the *on* state, the impedance is so low that you must limit the current externally; otherwise the diode will destroy itself. Just like a true diode, the four-layer diode operates only in the forward direction.

Add two resistors, a capacitor, and a battery to the diode, and you have a pulse generator, as shown in the simplified circuit of Fig. 1. Capacitor *C* takes on a charge from *B1* through *R1*. When the charge reaches 12 volts, the diode snaps *on*, producing a sharp spike across current limiting resistor *R3*. This spike is the output pulse and is almost 10 volts high; its width is *R3* x *C*.

As the capacitor discharges (very rapidly, since *R3* is much smaller than *R1*), less and less current flows through the diode, and it finally turns *off* when the capacitor voltage drops close to zero.

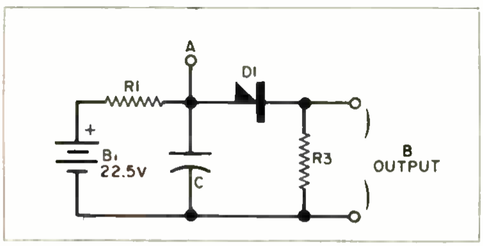


Fig. 1. Four-layer diode conducts when the capacitor charges up to about 12 volts, and stays "on" as long as there is more than 1 ma. of current flow.

As battery current through *R1* in this circuit is held to about 0.5 ma., it cannot hold the diode *on*; the capacitor recharges, and repeats the cycle.

One output pulse is produced for each charge and discharge cycle. The waveforms in Fig. 2 show the exponential charge-discharge waveform at point *A* in the simplified circuit, the sharp output pulse at point *B*, and their relationship to the *on-off* time of the diode.

Figure 3 shows the entire circuit of the Pulser. You can change the frequency by varying *R2* or by switching in different capacitors. Potentiometer *R2* provides a continuously variable frequency range, on the order of 11 to 1. Each of the five capacitors is ten times

PARTS LIST

(Diagram on page 62)

B1—22½-volt battery
C1—30-µf., 15-volt electrolytic capacitor
C2—3-µf., 15-volt electrolytic capacitor
C3—0.3-µf., 200-volt Mylar capacitor
C4—0.03-µf., 200-volt Mylar capacitor
C5—0.003-µf. mica capacitor
D1—Four-layer diode (Motorola M4L3054)
J1—Phono jack
R1—47,000-ohm, ½-watt resistor
R2—500,000-ohm, 2-watt potentiometer (linear taper)
R3—250-ohm, 2-watt potentiometer (linear taper)
R4—3.3-ohm, ½-watt resistor
S1—S.p.s.t. slide switch
S2—Single-pole, five-position wafer switch (Mallory 3215J or equivalent)
S3—D.p.d.t. slide switch
1—3" x 4" x 5" case, approx. (Zero Z58-78-52 or Bud CU-2105A or equivalent)
1—4" x 5" dialplate (an anodized hard aluminum Metalphoto dialplate with POPULAR ELECTRONICS on it is available from Reill's Photo Finishing, 4627 North 11th St., Phoenix, Ariz. 85014; in silver color for $3.50, or in blue, red, or copper for $4, postpaid in U.S.A.)
Misc.—Battery holder; #10 nylon countersunk washers (4); nuts and bolts; knobs (3); wire; solder; etc.

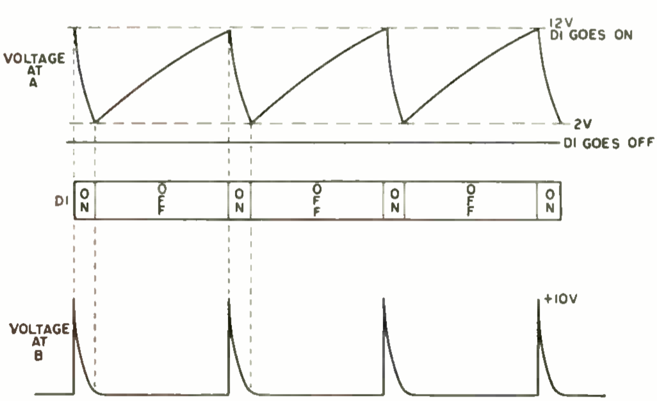


Fig. 2. Typical capacitor charge-discharge waveform is present at point "A" in Fig. 1. At output "B," the rise time is so fast that you'll need a fairly good scope to see it. When the diode is "off," the capacitor has a chance to build up a charge until it is large enough to trigger the diode into conduction. Current flow through the diode is relatively so very large that the capacitor discharges and cannot take on a new charge until the diode stops conducting.

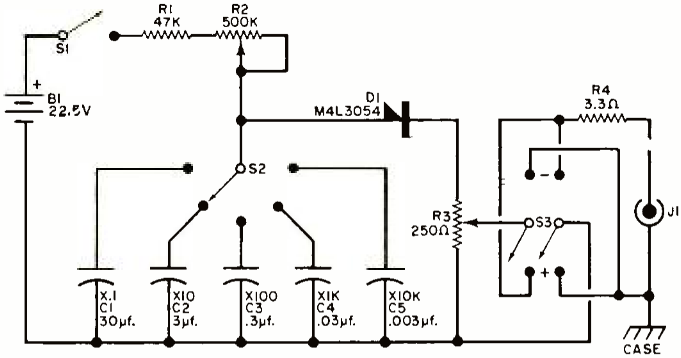
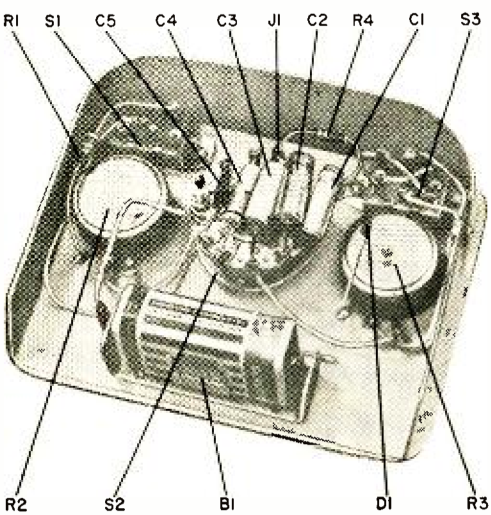


Fig. 3. Frequency depends upon battery voltage and amount of resistance and capacitance in the circuit. Combination of R1 and R2 provides an 11 to 1 spread within each of five decade ranges. Pulse repetition rate can be varied from 1 every 10 seconds to 11,000 each second.

its neighbor, and they provide five frequency ranges in decade steps from x 0.1 to x 10,000.

In spite of its simplicity, this *RC* configuration makes it possible to select any frequency within the Pulser's range. Potentiometer *R3* varies the output pulse amplitude; it works like a volume control. Switch *S3* performs the simple task of reversing output pulse polarity. And to make the whole thing short-circuit-proof, *R4* limits current drain to a safe value.

Construction. You can build the Pulser in a plain-Jane fashion in a 3″ x 4″ x 5″ Minibox, or assemble the unit in a deep drawn aluminum case, as shown in the photos. Any chassis will do; the one shown here was made from a piece of 5″ x 7″ x 1/32″ soft aluminum.



Only electrical connection to the chassis is at J1. The unused side of S2 conveniently serves as a terminal strip for the negative capacitor leads.

The switches, battery bracket, and chassis sides are "pop"-riveted in place, but you can use 6-32 x ¼″ machine screws and nuts if you wish. If you can't find an exact holder for the 22½-volt battery, you can modify an ordinary penlight-cell holder (Keystone 139) by extending the contacts with solder lugs. (Note: no part of the circuit, including even one side of the battery, comes in contact with the case, except for outer portion of *J1*.)

The dialplate is drilled to match the openings in the chassis for the controls and output jack; the nuts on *J1*, *R2*, *R3* and *S2* hold the plate in place. Four feet for the bottom of the case can be made from four #10 nylon countersunk washers and four #6 panhead sheet metal screws. The screws through the front two feet also go through the chassis, and hold it in place.

Wiring is a cinch. All unused terminals on *S2* are tied together and used to secure the negative ends of the capacitors.

Modifications. Any reasonable value can be employed for any of the parts, but the battery supply should be 22½ volts or more. Use linear pots; avoid ordinary volume controls. Audio controls with their log tapers will give you a nonlinear scale.

Larger tantalum capacitors can be used to extend the range on the low end. The high end is limited by *D1* and cannot be increased.

The scales are only accurate to ± 15 percent, and will vary with battery voltage and the exact values of capacitors used. If you need greater accuracy, go to a line-operated, zener-regulated supply and pick your capacitors. —30—