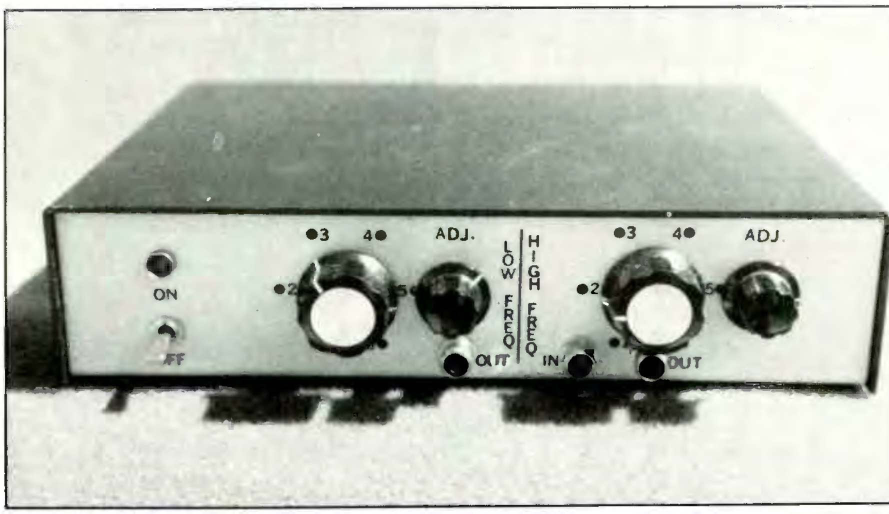
A High-Frequency Dual-Pulse Generator

Easy-to-build project generates high-speed square-wave pulses at frequencies up to 75 MHz

By Desi Stelling



To be able to do meaningful work in modern digital electronic circuits, you often need a source of square-wave pulses with a minimum range of from 1 MHz to 20 MHz. Most current high-speed pulse generators are quite expensive, especially if you need an instrument capable of operating beyond 20 MHz. A very practical alternative is to build such a pulse generator, using readily available parts.

In this article, we will discuss construction of a very reliable High-Frequency Dual-Pulse Generator whose output is capable of exceeding even 75 MHz. Component count for the project is minimal since the Generator is built around an integrated-circuit device that requires very few external parts.

At the heart of the Generator is a voltage-controlled oscillator (vco) chip that can be implemented for FM modulation and/or gate input for precision gating of a pulse train. The IC is an LS124 high-speed, low-power or simply an S124 high-speed but not low-power device containing two independent vcos in a 16-pin package. You can use either the 74 or 54 series of this device in this application. The output frequency of each vco is determined by either a capacitor or a crystal and two voltage-controlled inputs. Since it is rarely necessary for the output frequency of such an oscillator to be right on the head, in our Generator, a series of capacitors are switched into the circuit as needed for selecting a particular frequency range.

Even if you were to buy all the components needed for this project at single-unit prices, they should not cost more than about $50.

About the Circuit

Shown in Fig. 1 is the pinout diagram of the dual vco integrated circuit used in this project. Pin designations and internal details of this IC are identical for the LS and S versions of the 54 and 74 series of the 126 dual-vco integrated circuit.

Note that there are two sets of V_{CC} and GND pins provided for the dc supply voltage for the enable, gate and output sections, the other for the oscillator and associated frequency-control circuits for isolation purposes. The latter are indicated by the circled sine-wave symbols at pins 15 and 8, respectively. The enable input starts and stops output pulses when it is low and high, respectively. Duty cycle of the output signal is fixed at approximately 50%.

Figure 2 illustrates the schematic diagram of the two voltage-controlled oscillators that make up the High-Frequency Dual-Pulse Generator. Observe that the oscillator system is divided into two high-frequency (*IC2A*) and low-frequency (*IC2B*) oscillators. The frequency-determining capacitors that control the range of the high-frequency oscillator are switched in via rotary switch *S2*, while *S3* performs the same task for the low-frequency oscillator.

The frequency-determining capacitors connect to *IC2* via the vco's

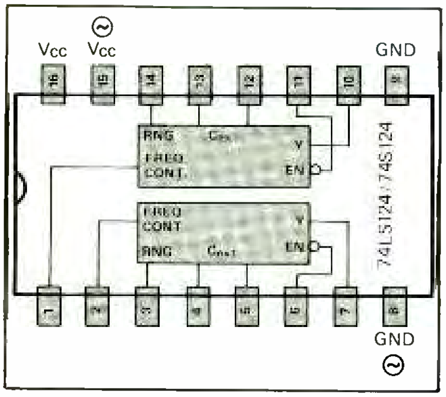


Fig. 1. Shown here are internal details of 54LS124, 54S124, 74LS124 and 74S124 series voltage-controlled oscillators (vcos).

C_{ext} inputs. The output frequency of each vco can be approximated in a single formula as follows:

$$F_O = \frac{1 \times 10^{-4}}{C_{ext}} \quad \text{(for LS124)}$$

$$F_O = \frac{5 \times 10^{-4}}{C_{ext}} \quad \text{(for S124)}$$

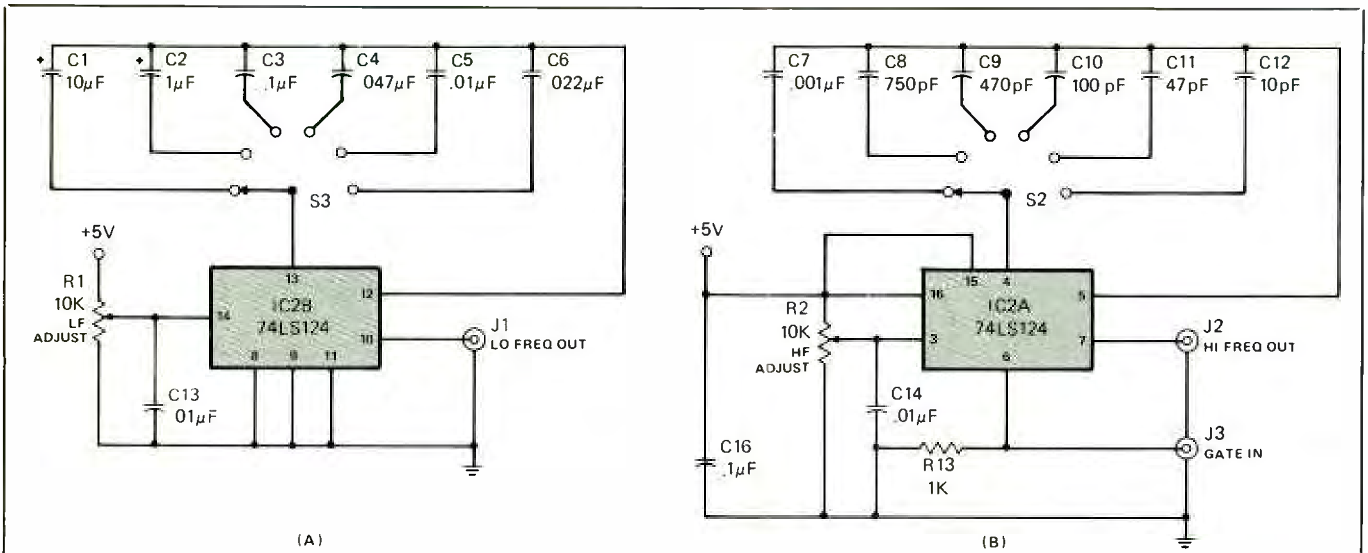
where F is frequency in Hz and C_{ext} is in farads.

Each oscillator has its own separate output—*J1* is the LO FREQ OUTPUT, while *J2* is the HI FREQ OUTPUT. Additionally, the high-frequency oscillator has a GATE input at *J3*.

High and low oscillator frequencies are available simultaneously, since the circuits are completely independent of each other. A rough frequency range is selected via *C1* through *C6* for the low-frequency oscillator and *C7* through *C12* for the high-frequency oscillator. Once a range is selected, you can zero in on a more exact frequency with LF ADJUST control *R1* or HF ADJUST control *R2*.

A very stable 5-volt dc power supply is required for the Generator to assure accurate operation of the os-

Fig. 2. Independent low- (left) and high-frequency (right) oscillators are obtained from a single vco IC.



PARTS LIST

Semiconductors
D1 thru D4—1N4001 rectifier diode
IC1—LM317T +5-volt regulator
IC2—54LS124, 54S124, 74LS124 or 74S124 (see text)
LED1—Panel-mount type light-emitting diode

Capacitors
C1—10 µF, 20-volt nonpolarized
C2—1-µF, 20-volt nonpolarized
C3,C16,C17—0.1-µF disc
C4—0.47-µF disc
C5,C13,C14—0.1-µF disc
C6—0.0022-µF disc
C7—0.001-µF disc
C8—750-pF disc
C9—470-pF disc
C10—100-pF disc
C11—47-pF disc
C12—10-pF disc
C15—150-µF, 20-volt electrolytic

Resistors (½-watt, 10% tolerance)
R3—1000 ohms
R4—240 ohms
R5—760 ohms
R6—300 ohms
R1,R2—10,000-ohm potentiometer

Miscellaneous
F1—0.5-ampere slow-blow fuse
J1,J2,J3—Phono jack
S1—Spst slide or toggle switch
S2,S3—6-position, nonshorting rotary switch
T1—12.6-volt, 300-mA transformer
Printed-circuit board; suitable metal enclosure; socket for IC1 (optional); ac line cord; fuseholder; control knobs (4); line-cord strain relief or rubber grommet; shielded cable; dry-transfer lettering kit; clear acrylic spray; heat-shrinkable tubing or electrical tape; ac line cord with plug; hookup wire; machine hardware; spacers (4); solder; etc.

Note: The following are available from DDS Systems, P.O. Box 5715, Glendale, AZ 85023: pc board for $4.95; complete kit of parts, excluding S2 and S3, for $29.95 plus $3.50 S&H.

cillators. An ac line-powered supply is shown in Fig. 3. Incoming 117 volts ac is stepped down to 12.6 volts ac by *T1*, rectified by *D1* through *D4* and smoothed by *C15*. The resulting dc is then regulated by *IC1* and then fed out to the oscillator circuits.

Construction

Due to the high frequencies involved in this project, the only way of obtaining reliable operation is by wiring it on a printed-circuit board. You can fabricate your own pc board, using the actual-size etching-and-drilling guide given in Fig. 4 or purchase one ready to wire from the source given in the Parts List. You will note from the components-placement guide, also in Fig. 4, that all components, except frequency-determining capacitors *C1* through *C12*, the switches and controls, POWER LED, fuse holder and power transformer mount directly on the pc board.

Wire the board exactly as shown in the components-placement diagram. Make sure you observe proper component orientations and polarities before soldering them into place. A socket for *IC2* is optional.

Remove ¼″ of insulation from both ends of 13 6″ lengths of hookup wire. Plug in and solder one end of these wires at the holes labeled C_X on both sides of *IC2* (accounts for four wires), R1 and R2 (six wires), LED1 (two wires) and GATE (one wire). Then remove ¾″ of outer insulation from both ends of two 5″ lengths of shielded cable. Separate the shields all the way back to the remaining insulation, twist together the fine wires and lightly tin with solder. Strip ¼″ of insulation from the inner conductors from all four ends. Then install and solder one end of these cables in the holes labeled LF OUT and HF OUT. Make sure the shields plug into the indicated holes.

Drill the mounting holes for the various items that make up the project. You need nine holes in the front panel for the jacks, controls, LED and switches; six holes in the floor for the circuit-board assembly and power transformer; and two holes in the rear panel for the fuse holder and ac line cord.

Temporarily mount *S2* and *S3* in their respective holes on the front panel and place a control knob on the shaft of each. Rotate the knobs and mark the positions of the stops on the panel. Remove the knobs and controls. Then use a dry-transfer lettering kit to label the switch positions and jack, control, and power switch/LED legends. Spray two or three *light* coats of clear acrylic, allowing each coat to dry before spraying on the next, over the entire surface of the front panel.

When the acrylic spray has completely dried, mount the controls, jacks, LED and switches in their respective holes. Strip ¼″ of insulation from all four leads of the power transformer. Mount the transformer on the floor of the box with machine hardware. Plug the secondary wires of the transformer into the holes labeled 12.6V AC on the circuit board and solder them to the copper pads. Mount the assembly to the floor of the box with ¼″ or ½″ spacers and

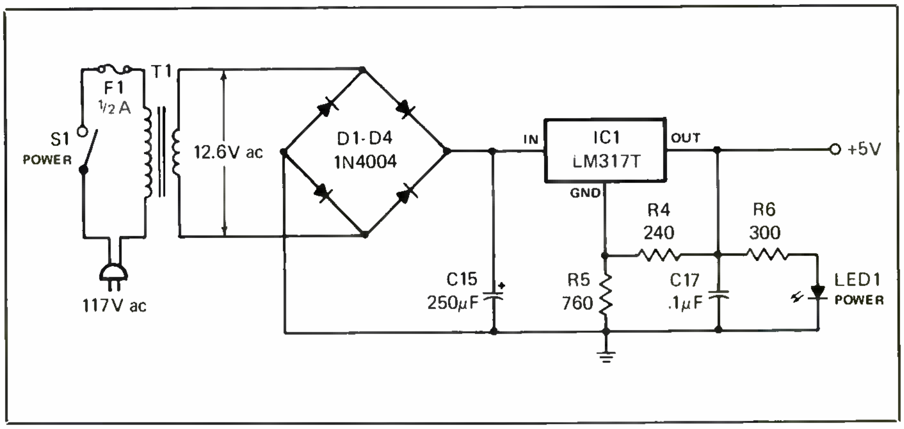
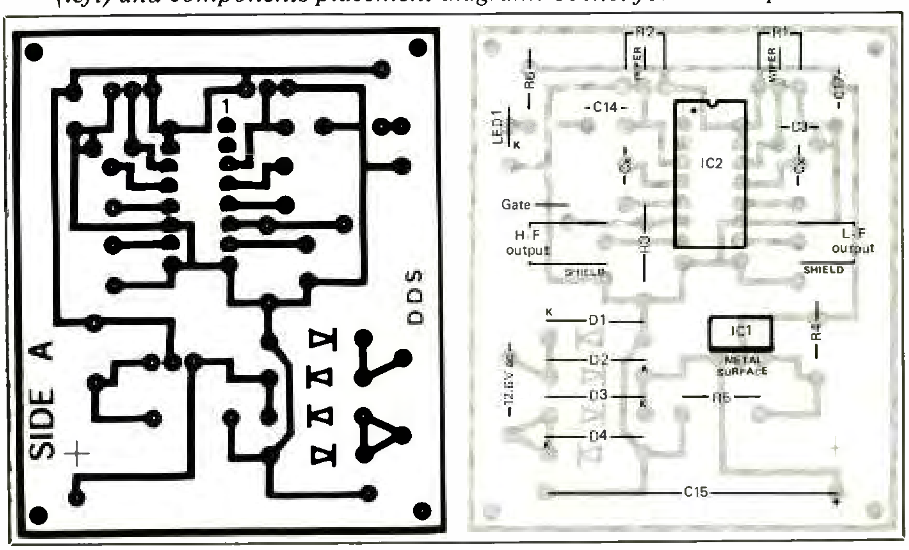
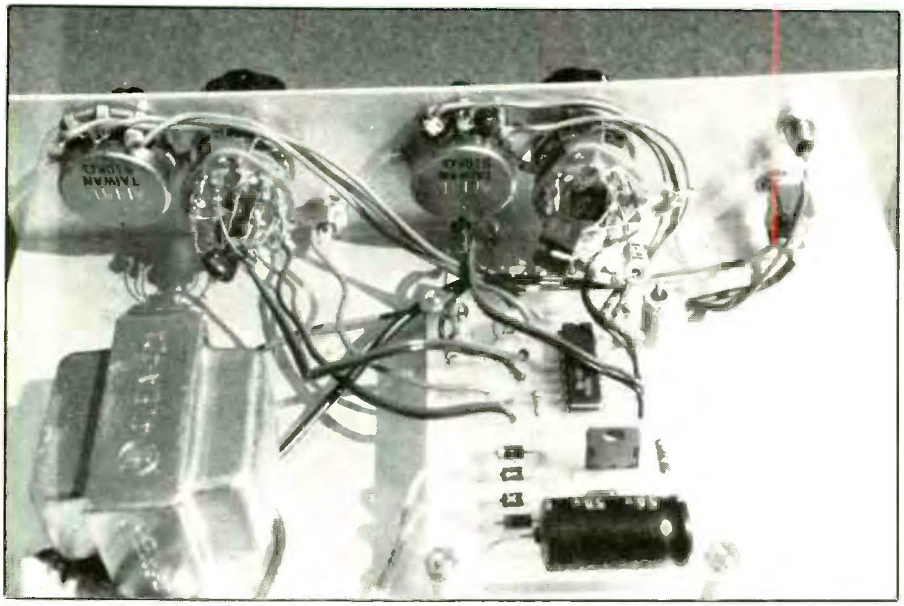


Fig. 3. Generator's ac-line-driven power supply.

Fig. 4. Actual-size etching-and-drilling guide for fabricating your own pc board (left) and components placement diagram. Socket for IC1 is optional.





Controls, LED and switches mount on front panel as shown. Range capacitors mount directly on S2 and S3—not on pc board—as shown.

machine hardware. Mount the fuse holder on the rear panel.

Place a rubber grommet in the line cord hole (or use a plastic strain relief). Strip ¼" of insulation from both conductors of the line cord. Tightly twist together the fine wires in each conductor and lightly tin with solder. Pass the line cord through its rubber-grommet-lined hole and tie a knot in it about 6" from the prepared end (or secure it in place with the strain relief so that there is 6" of cord inside the box).

Note from the photo that all frequency-determining capacitors are mounted directly to the lugs of *S2* and *S3*, with the free leads of the two sets tied together into separate bundles.

Locate the cable coming from board holes HF OUT and connect and solder the inner conductor to the center lug and shield to the groung lug of *J2*. Do the same with the cable coming from the LF OUT holes to *J1*. Connect and solder the GATE wire from the circuit board to *J3*'s center lug.

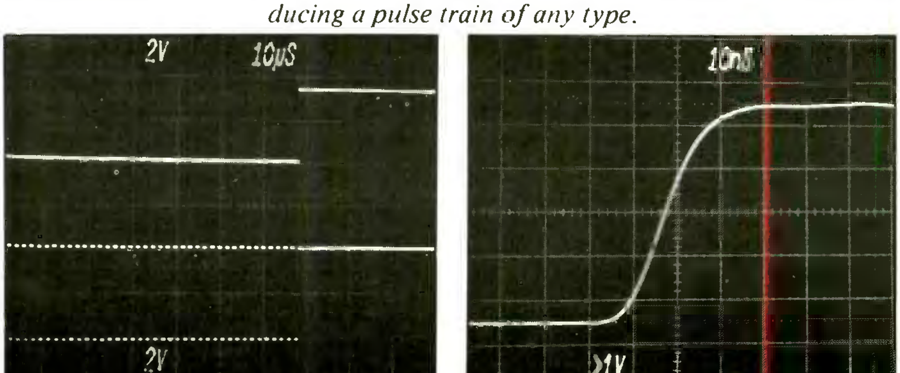
With the circuit board oriented as shown in the components-placement diagram in Fig. 4, the wires from the holes labeled C_X to the left of *IC2* go to the *S2/C7* through *C12* assembly, while those to the right of *IC2* go to the *S3/C1* through *C6* assembly.

Locate the wires connected to the LED1 holes on the circuit board and connect the K wire to the cathode lead of the LED and the other lead to the anode lead. Next, connect and solder the six wires at the top of the board to the lugs of *R1* and *R2*. Make sure the wires indentified as WIPER go to the center lugs of the respective controls.

Slip a 1" length of heat-shrinkable tubing over one of the primary leads of the transformer. Separate the conductors of the line cord for a distance of about 6". Then connect and solder one conductor to the transformer lead that has the tubing on it. When the connection cools, push the tubing over it, making sure no portion of the connection is visible and shrink it into place. (If you wish, you can substitute plastic electrical tape for the tubing.) Connect and solder the other transformer primary to one lug of the fuse holder.

Use a heavy-duty stranded hookup wire to connect the remaining lug on *S1* to the remaining lug on the fuse holder. Install a ½-ampere slow-blow fuse in the fuse holder. Then assemble the box. Install the knobs on the range switches and frequency ADJUST controls. The project is now ready to be put into service.

Fig. 5. The risetime of the oscillator is less than 20 ns (left), demonstrating the speed of the device. Synchronously gated pulses (right) may be desirable for producing a pulse train of any type.



In Closing

From the foregoing, it should be obvious that the High-Frequency Dual-Pulse Generator described here may be relatively simple from a parts-count point of view, but is big on performance. You will find that this instrument will fill virtually any need for a source of square-wave pulses, whether low or high frequency. **ME**