BUILD A TIME BASE CALIBRATOR

CLEAN SQUARE WAVES FROM 1 HZ TO 1 MHZ

This is a laboratory-style electronic construction project that would have been impossible to build without integrated circuits. With IC's, it becomes relatively simple and easy to duplicate. Uses for this project are deceptively varied and range from research to short-wave listening.

A SQUARE WAVE of known frequency is one of the most useful waveforms that the serious electronics experimenter, audiophile, or engineer can have in his workshop. It can be used to check out audio systems, align probes and check attenuators of oscilloscopes. When it is differentiated, a square wave can be used to generate accurate time markers on a scope trace for making precise measurements. It can also be used to keep tabs on the accuracy of a triggered sweep scope. In experimenting with logic circuits, a square wave makes an ideal trigger.

The time base, square-wave generator or calibrator described here is crystal controlled and can deliver any of 13 selected timing periods from 1 microsecond to 1 second. Other specifications are given in the Table.

Theory of Circuit Design. The circuit of the calibrator is shown in Fig. 1. Field-effect transistor *Q1*, with *XTAL1* and other components, forms a 1000-kHz oscillator. The signal generated at the junction of *L1* and *R2* feeds a shaper (*Q2*) which is biased to operate in the saturation region. The shaper provides the necessary square-edged signal for driving the DTL (diode-transistor logic) frequency divider chain.

The divider chain, consisting of 12 dual-JK flip-flops, is arranged to divide in a series of 2 and 5. The basic logic circuit for such division is shown in Fig. 2, which is similar to the actual division using the IC's.

The output of each divider is fed to one position of a 13-position rotary switch (*S1*). The selected signal from the switch is coupled to an output buffer (*Q3*), which also operates in the saturation region. The output is split by *R5* and *R6* to provide an output termination of 50 ohms.

Construction. Because of the high fre-

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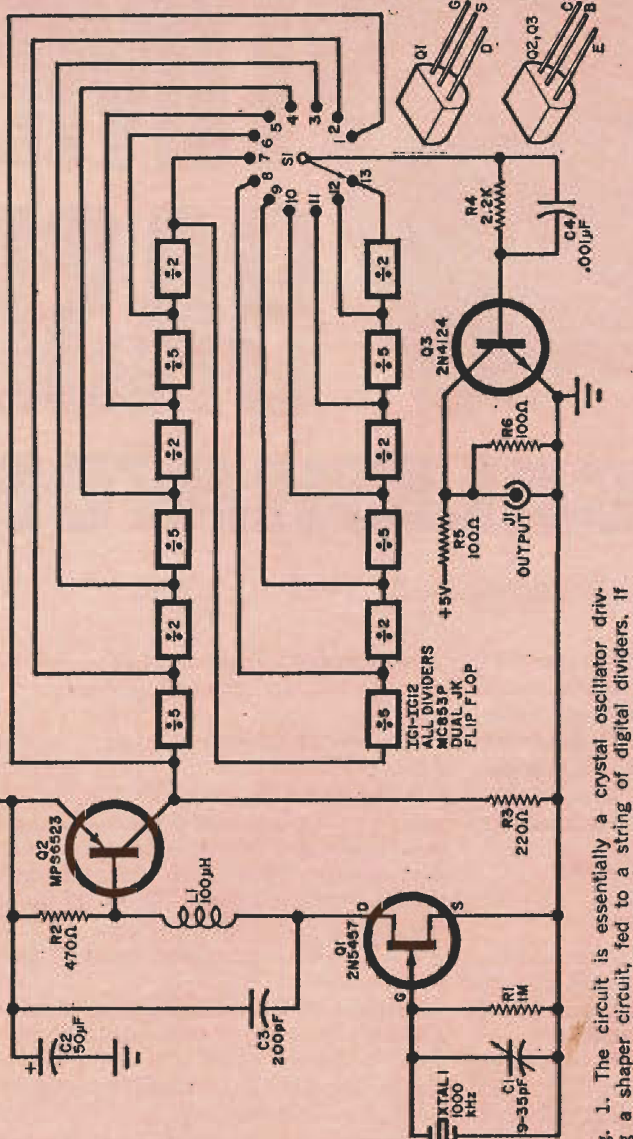


Fig. 1. The circuit is essentially a crystal oscillator driving a shaper circuit, fed to a string of digital dividers. If desired, other frequencies can be obtained either by changing the crystal frequency, the divider chain arrangement, or both.

S1 POSITIONS

1—µS, 1 MHz
2—5 µS, 200 kHz
3—10 µS, 100 kHz
4—50 µS, 20 kHz
5—100 µS, 10 kHz
6—500 µS, 2 kHz
7—1 mS, 1 kHz
8—5 mS, 200 Hz
9—10 mS, 100 Hz
10—50 mS, 20 Hz
11—.1 S, 10 Hz
12—.5 S, 2 Hz
13—1 S, 1 Hz

PARTS LIST CALIBRATOR

C1—9-35-pF miniature trimmer capacitor
C2—50-µF, 6-volt electrolytic capacitor
C3—200-pF disc capacitor
C4—0.001-µF disc capacitor
IC1—IC12—Dual JK flip-flop (Motorola MC853P)
J1—BNC jack and mating plug
L1—100-µH molded choke
Q1—2N5457 transistor
Q2—MPS6523 or HEP57 transistor
Q3—2N4124 or HEP53 transistor
R1—1-megohm
R2—470-ohm
R3—220-ohm } *all resistors ¼-watt*
R4—2200-ohm
R5,R6—100-ohm
S1—13-pole rotary switch
XTAL1—1000-kHz crystal
Misc.—Suitable chassis, knob, stand-offs, wire, solder, etc.

quencies involved, the use of a printed circuit board is recommended. An actual size foil pattern and component installation diagram are shown in Fig. 3.

The power requirements are 5 volts dc at about 220 mA, which can be obtained either from a power supply such as that shown in Fig. 4 or, for a portable unit, from three D cells connected in series. If you build the ac supply, use a 2 sq in. heat sink for *Q1*.

The completed PC board and power supply can be mounted in any type of metal chassis, with the power switch, frequency selector switch and output jack on the front panel.

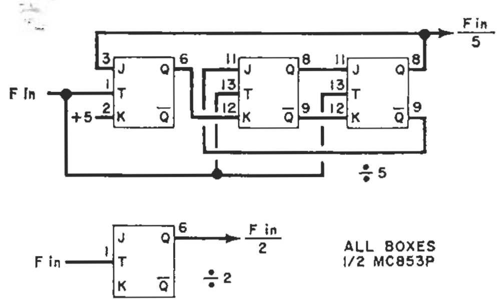
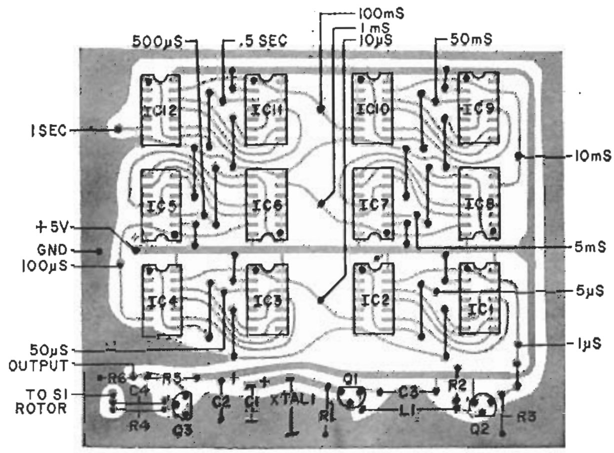
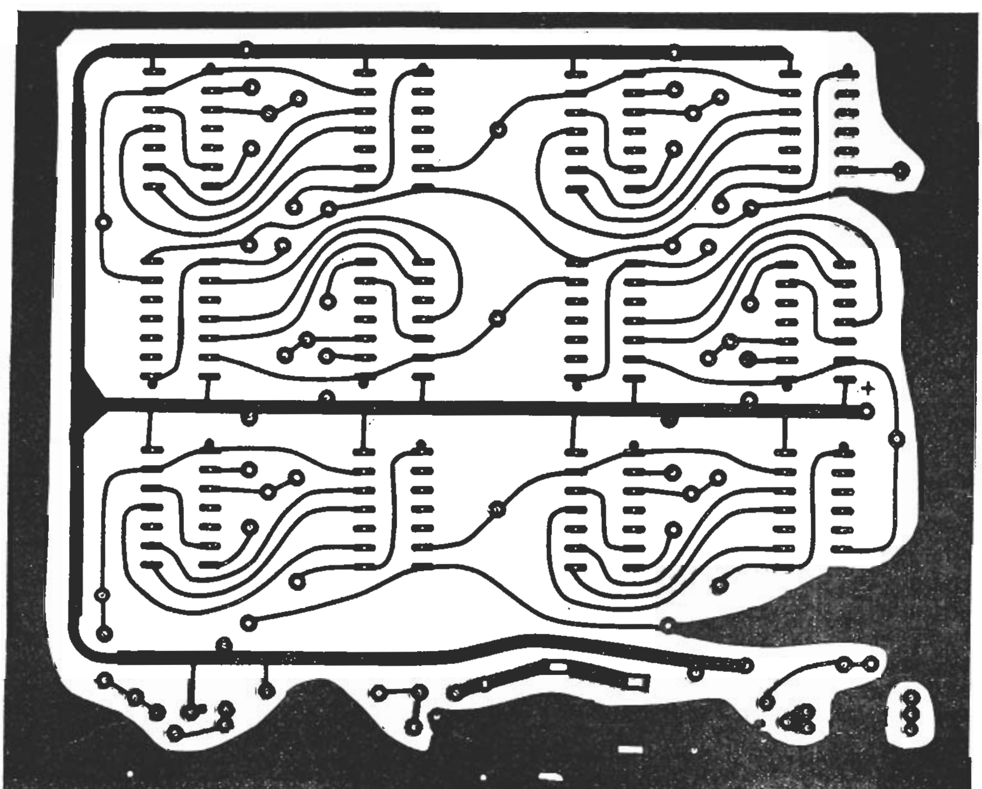


Fig. 2. Minimum hardware divide-by-5 and divide-by-2 circuits used in the calibrator. Because each IC contains a pair of JK flip-flops, a pair of IC's contains the two divide circuits shown at the left.

Fig. 3. The actual size PC board foil pattern shown below simplifies the wiring of the calibrator. Once fabricated, the components are installed as shown at the right. Observe the coding of all components, and make sure that all jumpers are placed properly. Due to the delicacy of this PC pattern all of the drill holes for installing the IC's may not show in this reproduction. Drill holes in each of the 14 contact points for all 12 IC's.





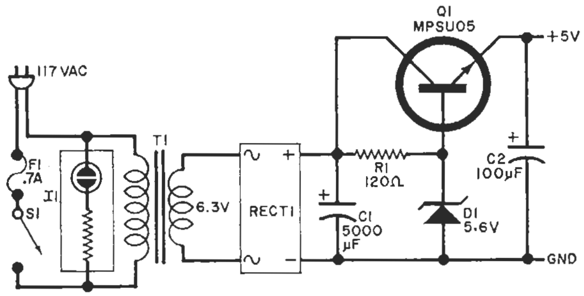


Fig. 4. This regulated power supply can easily handle the calibrator. If you want portability, use three 1½-volt D cells in series for the power supply. The slightly reduced voltage will not affect operation.

PARTS LIST
POWER SUPPLY

C1—5000-μF, 10-volt electrolytic capacitor
C2—100-μF, 6-volt electrolytic capacitor
D1—1N5232 diode
F1—0.7A fuse and holder
I1—120-volt neon lamp indicator assembly
Q1—MPSU05 transistor
R1—120-ohm, ½-watt resistor
RECT1—MDA920-1 or HEP175 25-volt, 1A bridge
S1—Spst switch
T1—Filament transformer, secondary 6.3 volts at 600 mA
Misc.—optional power-on indicator, heat sink, terminal strip, mounting hardware, line cord, grommet, etc.

Operation. To calibrate the generator accurately, put *S1* in the 1 MHz position and connect a short length of wire to the output jack. With the wire and the calibrator near a shortwave receiver tuned to WWV (5, 10, or 15 MHz), adjust capacitor *C1* to obtain a zerobeat between the generator and WWV. If you have a frequency meter, adjust *C1* to obtain an exact 1-MHz indication on the meter. However, if you have neither a WWV receiver nor a frequency meter, the inherent accuracy of the 1-MHz crystal will be sufficient for most purposes.

In using the calibrator, the output connection should be made through a 50-ohm coaxial cable terminated in a 50-ohm load.

Spiker. If you need a sharp spike signal of known frequency, use the circuit shown in Fig. 5 to develop the required signal. The input impedance is 50 ohms; the output is 1000 ohms. The switch is used to select the proper capacitor for each group of frequencies.

Applications. Although primarily designed for the calibration of oscilloscopes with triggered sweeps, this square-wave generator and spiker combination has a number of other important laboratory and experimental applications.

First, the generator makes an excellent frequency calibrator for use with general purpose shortwave receivers. For this application,

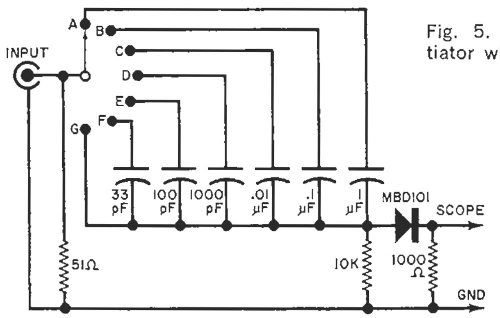


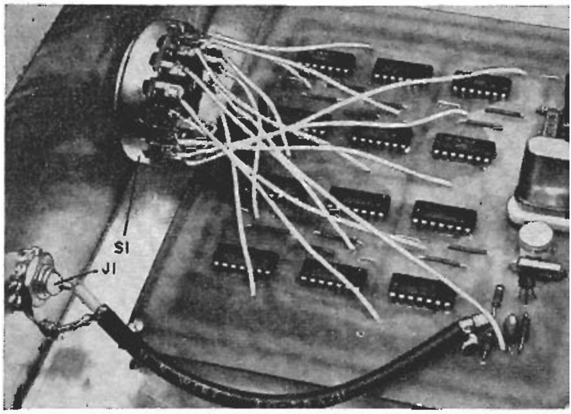
Fig. 5. The spiker is essentially a differentiator whose series capacitor can be selected.

SWITCH POSITIONS

A—1 S-50 mS
B—10 mS-5 mS
C—1 mS-500 μS
D—100 μS-50 μS
E—10-μS-5 μS
F—1 μS
G—direct

TECHNICAL SPECIFICATIONS

Rise and fall times: 25 nanoseconds
Time period: 13 selectable times in 1 and 5 steps from 1 μs to 1 second
Accuracy: 0.005%
Amplitude (output): 1 volt into 50 ohms
DC offset: less than 0.3 volt
Noise and ripple: 20 mV
Power required: 5 volts at 220 mA

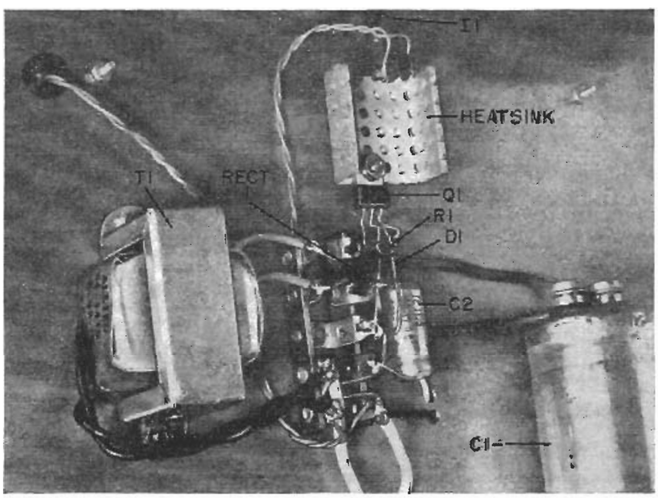


The connections from the PC board to the selector switch should be made as short as possible. A short length of coaxial cable serves as the output lead.

connect the spiker to the generator and attach a short antenna to the spiker output. Set the front panel switch to 1 MHz (1 μS). This will produce a train of "birdies," 1 MHz apart. With the receiver tuned to WWV on 5, 10, or 15 MHz, the crystal oscillator in the generator can be trimmed to the exact frequency. Use other dial positions and the calibrator will generate the frequencies shown in Fig. 1. Suitable selection of frequencies will permit a very accurate determination of the frequency of an incoming signal.

Due to the fact that the square waves generated have very rapid rise and fall times, they can be used as a source of pulses for triggering many types of IC logic, especially RTL, where steep edges are required. Having complete control of the output frequency means that the logic can be triggered at almost any desired rate.

The square waves are also ideal for testing amplifiers—from conventional audio to broad-bandwidth video. High- and low-frequency response, as well as ringing, can be detected when using the square-wave generator in conjunction with a wideband scope. Simply driving the amplifier under test with a square wave of suitable frequency and observing the changes (if any) that the amplifier produces on the square wave will show the characteristics of the amplifier. For example, to provide a clean square-wave output, the amplifier response must be from about 1/10 to 10 times the fundamental frequency of the square wave. Thus, if an amplifier can cleanly reproduce a 10-kHz waveform, then its response is good from about 1 kHz (usually much lower) to about 100 kHz. –30–



Use a 2-square-inch piece of scrap aluminum as the heat sink for Q1. Isolate the heat sink from the chassis using an insulated spacer.