CIRCUIT CIRCUS

By Charles D. Rakes

Plenty Of Oscillators

In this month's Circus, we're going to present several simple but interesting circuits, all of which are based on a single chip—the 4093 CMOS quad 2-input NAND Schmitt trigger, a special NAND gate that is ideally suited for use with slow-changing or noisy input signals.

ASTABLE OSCILLATOR

Our first circuit (see Fig. 1) uses two gates from the quad 4093 package to form a simple astable squarewave oscillator. Actually, the first gate functions as the oscillator and the second serves to buffer the output signal. When power is applied to the circuit and S1 is placed in the RUN position, pin 1 of U1-a is high and pin 2 is low. That combination of inputs causes U1-a's output to go high, causing C_X to begin charging through R_X.

As C_X charges, the voltage across C_X continues to rise until the charge reaches U1-a's high input-trigger voltage, causing its output to swing low. The capacitor discharges until the gate's low-input threshold level is reached. That causes U1-a's output to change states, causing the sequence to repeat. That cycling effect (oscillation) is caused by the difference in the IC's high- and low-gate threshold points.

The circuit's operating frequency (which can range up to about 1 MHz) is determined by the values of C_X and R_X. The value of C_X can be varied from a few picofarads to several microfarads as long as its internal leakage current is very low. The value of R_X can range anywhere from a few thousand ohms to more than several megohms. More information on selecting values for C_X and R_X for a given frequency range is covered in the following oscillator circuits.

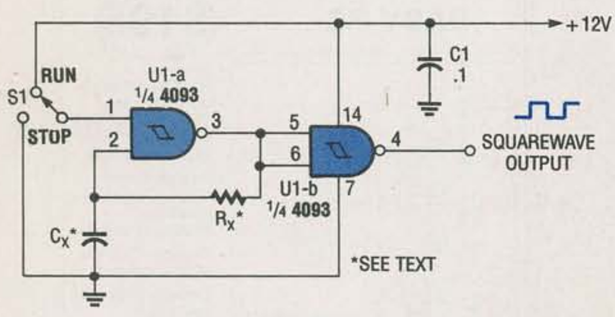


Fig. 1. In this circuit, two gates from the quad 4093 package are used to form a simple astable squarewave oscillator.

VFO

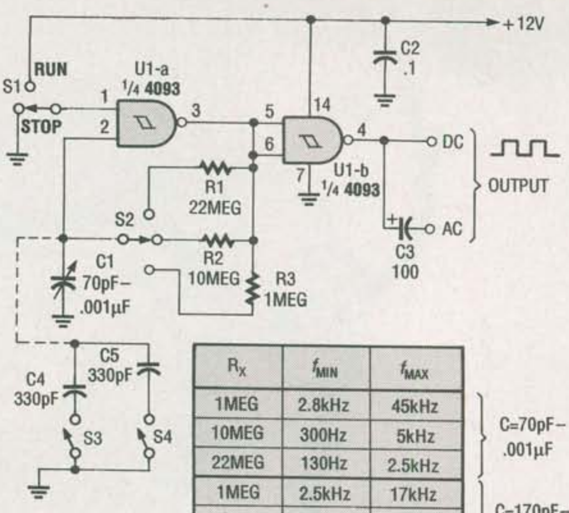
The variable-frequency oscillator (VFO) shown in Fig. 2 is an offshoot of the previous circuit; here, however, the operating frequency is controlled by C1 (a variable tuning capacitor). The circuit can provide an output frequency ranging from 115 Hz to over 40 kHz. The lowest frequency range (see the chart in Fig. 2) is obtained with the largest resistance value. The lowest frequency in all frequency ranges is obtained when C1 is set to its maximum capacitance value. The oscillator's frequency stability is excellent.

The tuning capacitor may be kind of hard to come by from conventional sources, however it can usually be obtained from local hamfests or scrounged from an old tube-type AM radio. If all else fails, check with some of the old timers at local ham clubs. Tuning capacitors are out there if you look hard enough. The one I used was an old 3-gang type that provided a total capacitance of about 1000 pF (0.001-µF) when all of its sections were paralleled. If you can't locate a 2- or 3-gang unit, you can get by with a single 365-pF variable capacitor and two 330-pF fixed units.

The two switches (S3 and S4) are used to switch additional capacitance (C4 and C5, a pair of 330-pF units) into and out of the circuit. The lower three frequency ranges shown in the chart were obtained by adding a fixed 100-pF capacitor across C1. Adding that fixed capacitor to the circuit reduced C1's tuning range, but offers the advantage of making it easier to set the oscillator to the desired frequency.

PARTS LIST FOR THE ASTABLE OSCILLATOR

C1—0.1-µF, ceramic-disc capacitor
C_X—See text
R_X—See text
U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
S1—SPDT switch
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.



R_X	f_{MIN}	f_{MAX}	
1MEG	2.8kHz	45kHz	C=70pF–.001µF
10MEG	300Hz	5kHz	
22MEG	130Hz	2.5kHz	
1MEG	2.5kHz	17kHz	C=170pF–.0011µF
10MEG	270Hz	1.85kHz	
22MEG	115Hz	835Hz	

Fig. 2. This variable-frequency oscillator (VFO) is an offshoot of the previous circuit; however, this circuit has a variable (via C1) operating frequency.

PARTS LIST FOR THE VFO

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—22-megohm
R2—10-megohm
R3—1-megohm

CAPACITORS

C1—70-pF–0.001-µF, variable (see text)
C2—0.1-µF, ceramic-disc
C3—100-µF, 25-WVDC, electrolytic
C4, C5—330-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
S1—SPDT switch
S2—SP3T switch
S3, S4—SPST switch
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.

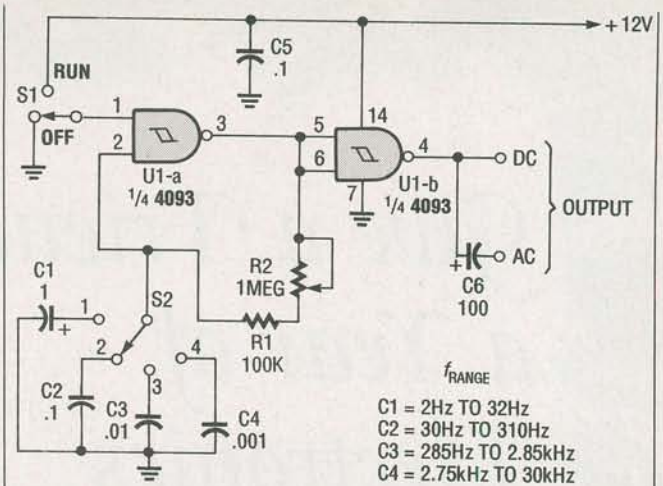


Fig. 3. The circuit shown here (another VFO) reverses the roles of R_X and C_X; e.g., the oscillator's frequency is varied by adjusting R2 and its frequency range is determined by selecting a timing capacitor via S2.

PARTS LIST FOR ANOTHER VFO

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1—100,000-ohm
R2—1-megohm linear potentiometer

CAPACITORS

C1—1.0-µF, Mylar
C2—0.1-µF, Mylar
C3—0.01-µF, Mylar
C4—.001-µF, Mylar
C5—0.1-µF, ceramic-disc
C6—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
S1—SPST switch
S2—SP4T switch
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.

ANOTHER VFO

Our next circuit is another VFO (see Fig 3). That circuit, however, reverses the roles of R_X and C_X; *e.g.*, the oscillator's frequency is varied by adjusting R2 and its frequency range is determined by selecting a timing capacitor via S2. At this juncture, you might be wondering why use a variable capacitor, as in the previous circuit, if it's so easy to obtain similar results with an easy-to-get potentiometer? The main purpose of using the variable capacitor (at least in this column) is to help illustrate the flexibility of the 4093 and to offer another method of frequency control.

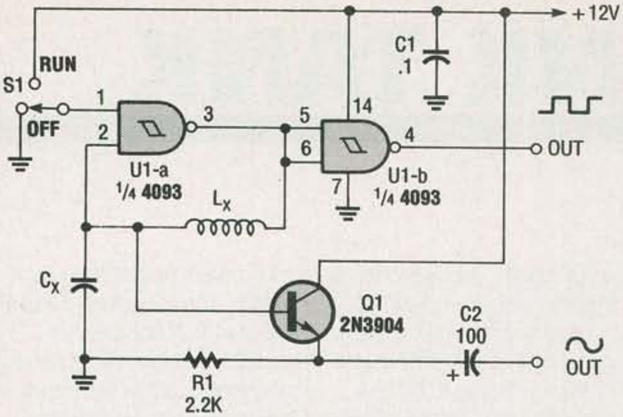
The oscillator circuit in Fig. 3 has four frequency ranges: position 1 has a frequency range of from 2 Hz to 32 Hz; position 2 from 30 Hz to 310 Hz; position 3 from 285 Hz to 2.85 kHz, and position 4 from 2.75 kHz to 30 kHz.

SINEWAVE OSCILLATOR

Squarewaves are nice, but there are times when a sinewave oscillator is useful. The circuit in Fig. 4 shows just how simply that can be accomplished. By replacing R_X of the previous circuit with an inductor, the simple squarewave oscillator turns into a nice little sinewave generator. Several capacitor and inductor values along with their expected frequencies are also given in Fig. 4; those values can be used as a guide in selecting components for a desired frequency.

RANGE SWITCH

Our next circuit (see Fig. 5) shows how easy it can be to electronically switch the oscillator's frequency range. In this circuit, a 2N3904 NPN transistor (Q1) is used as a simple switch that places a second capacitor (C2) in parallel with the circuit's timing capacitor (C1). When S1 is placed in the LOW FREQ. position, a positive voltage is applied to the base of Q1, causing



C_x	L_x	f_{OUT}
.018	50mH	9kHz
.018	2mH	14kHz
.047	5mH	5.5kHz
1	1H	300Hz
1	10H	100Hz

*SEE TEXT

Fig. 4. By substituting an inductor (L_X) for R_X of the previous circuit, the simple squarewave oscillator becomes a sinewave generator.

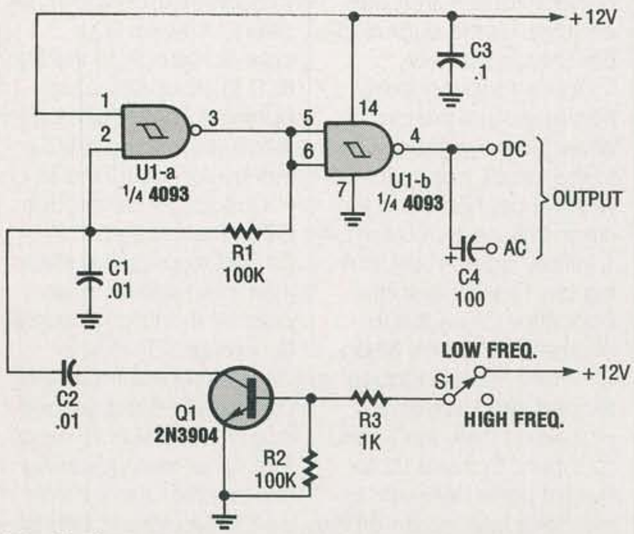


Fig. 5. The operating frequency of our oscillator circuits can be altered by adding the transistor-switch portion (Q1, R2, R3, and S1) of this circuit.

to turn on, pulling its collector to ground. That places C2 in parallel with C1, thereby increasing the effective timing capacitance, which in turn lowers the oscillator's operating-frequency range.

If S1 is flipped to the HIGH FREQ. position, Q1 turns of, removing C2 from the timing circuit. Removing that capacitor decreases the oscillator's effective timing capacitance, thereby raising the oscillator's operating-frequency range.

Although the transistor circuit was designed to be driven by the output of a CMOS gate, a mechanical switch (S1) is shown to illustrate how the circuit operates. The transistor switch can be used with both the squarewave and sinewave oscillators shown earlier.

PARTS LIST FOR THE SINEWAVE OSCILLATOR

SEMICONDUCTORS

U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor

CAPACITORS

C1—0.1-µF, ceramic-disc
C2—100-µF, 25-WVDC, electrolytic
C_X—See text

ADDITIONAL PARTS AND MATERIALS

L_X—See text
S1—SPST switch
R1—2200-ohm, ¼-watt, 5% resistor
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.

PARTS LIST FOR THE RANGE SWITCH

SEMICONDUCTORS

U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R2—100,000-ohm
R3—1000-ohm

CAPACITORS

C1, C2—0.01-µF, ceramic-disc
C3—0.1-µF, 50-WVDC, ceramic-disc
C4—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—SPST switch
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.

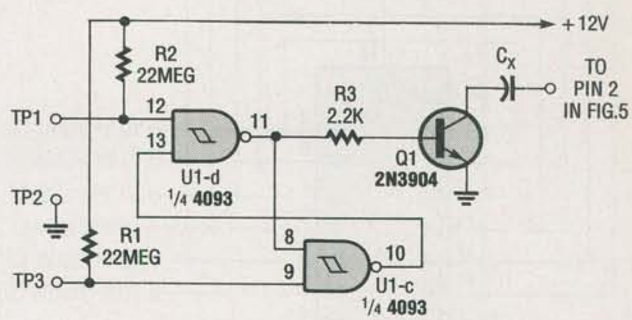


Fig. 6. This circuit uses two NAND Schmitt triggers connected in a flip-flop configuration to produce a bridged touch-activated switch. The switch can replace the range-switching portion (Q1, R2, R3, and S1) of the circuit in Fig. 5.

BRIDGED TOUCH SWITCH

Our next circuit (Fig. 6) uses two NAND Schmitt triggers, connected in a flip-flop configuration, to produce a bridged touch-activated switch, which can replace the range-switching portion (Q1, R2, R3, and S1) of the Fig. 5 circuit.

(Continued on page 90)

CIRCUIT CIRCUS

(Continued from page 71)

PARTS LIST FOR THE BRIDGED TOUCH SWITCH

SEMICONDUCTORS

U1—4093 quad 2-input NAND Schmitt trigger, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R2—22-megohm
R3—2200-ohm

ADDITIONAL PARTS AND MATERIALS

C_X—See text
TP1–TP3—Metal contacts (see text)
Perfboard materials, +12-volt power source, IC socket, wire, solder, hardware, etc.

By bridging the TP1 and TP3 contacts, or the TP2 and TP3 contacts, C_X can be added or removed from the oscillator circuit. A number of similar latching circuits can be added to the oscillator circuit to form a touch-controlled range switch.

That does it for this month. Until we meet next time, have fun experimenting with the 4093. ■