Clocking Your Circuits. Many digital logic and microprocessor circuit designs require a fixed frequency pulse source for timing. The circuits supplying these signals, essentially simple oscillators, generally are called *clocks,* since their primary function is to provide a timing signal. A number of sim-

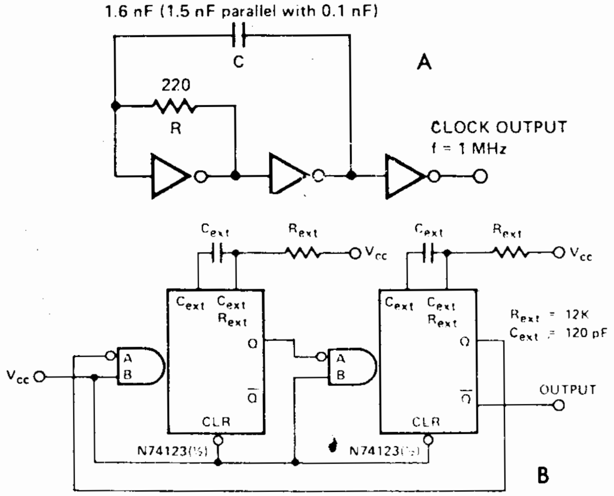

Fig. 1. RC clock circuits.

ple and inexpensive clock generator circuits are illustrated in Figs. 1 through 3. Designed specifically for use with the Signetics 2650 Microprocessor, the circuits are suitable for use with *any* microprocessor or logic circuit requiring single-phase, TTL-level signals. They may be used, too, as general-purpose signal sources for various other projects, such as signal generators, electronic musical instruments, function generators, or signal injectors if their operating frequencies are changed to meet the needs of the specific application. All of the circuits were abstracted from Application Memo MP52, published by the Signetics Corporation (811 East Arques Ave., Sunnyvale, CA 94086).

A pair of simple RC oscillators is shown in Fig. 1. The first, Fig 1A, uses three standard 7400 inverters. Resistor *R* biases the first inverter into its linear region while capacitor *C* pro-

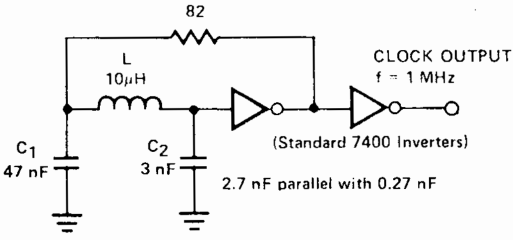

Fig. 2. LC clock circuit.

vides the feedback signal from the second stage needed to start and sustain oscillation. The third inverter serves as a simple buffer/driver. The circuit's oscillation period is approximately 3RC or, with the component values specified, about 1 μs, resulting in an output frequency of 1 MHz. In test measurements with a breadboarded circuit, the output signal had a 10-ns rise time and a 7-ns fall time. While the circuit is reasonably stable, its output frequency will vary with changes in both temperature and dc source voltage (V_{CC}).

In a typical circuit, the output frequency dropped from 1043.20 kHz at 0°C to 990.45 kHz at 70°c with V_{CC} held constant at 5.0 volts. When the temperature was held constant at 25°C, the output frequency dropped from 1028.95 kHz with a 4.75-volt source to 1013.63 kHz with a 5.25-volt V_{CC}. The second RC oscillator, Fig. 1B, uses a type N74123 monostable multivibrator and is somewhat more stable with respect to temperature variations than the inverter circuit. Here, the fre-

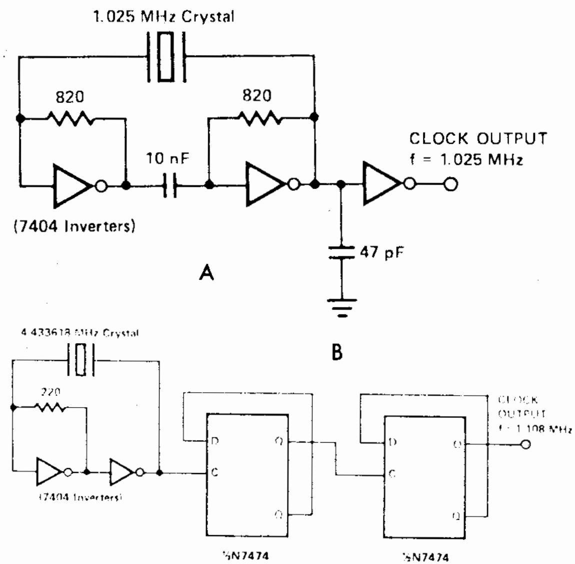

Fig. 3. Crystal clock circuits.

quency of oscillation is determined by the relative pulse width of each monostable circuit and hence by the external R and C values. Again, with the values indicated, the operating frequency is approximately 1MHz. As in the first circuit, the output frequency drops slightly with increasing temperature and/or dc supply voltage.

Having even greater stability with respect to temperature and voltage variations than the two RC oscillators, the LC clock generator circuit shown in Fig. 2 uses a pair of 7400 type inverters, an 82-ohm feedback resistor which also biases the first inverter into its linear region, and a simple LC resonant circuit made up of inductance *L* and capacitors *C1* and *C2*. In operation, the LC circuit forms a basic Colpitts oscillator in conjunction with the first inverter, while the second inverter acts as a buffer amplifier to minimize oscillator loading. The operating frequency is determined by the *L, C1* and *C2* values, and can be calculated using the following equation:

$$f_{osc} = \frac{1}{2\pi\sqrt{LC}},$$

where "C" is the effective series capacity of *C1* and *C2*, or . . .

$$C = C1C2/C1+C2.$$

With the values specified, the f_{osc} as in the previous circuits, is approximately 1 MHz. In experimental tests, the actual output frequency of a breadboarded circuit varied from 1017.75 kHz to 1016.30 kHz as the dc source voltage was raised from 4.75 to 5.25 volts at 25°C. When the dc voltage was held constant at 5 volts, the output frequency dropped from 1026.62 kHz to 1004.11 kHz as the ambient temperature was raised from 0°C to 70°C.

In applications where maximum frequency stability is required, crystal-controlled clock circuits should be used. A pair of suitable circuits is given in Fig. 3. The first, Fig. 3A, employs two inverters in a crystal stabilized cross-coupled multivibrator. In operation, the 820-ohm resistors bias each inverter into its linear region, while cross-coupling is provided by the crystal and by a 10-nF capacitor. A third inverter serves as a waveform squarer and output buffer. All three are type 7404 (i.e., half of a hex inverter IC). The circuit's output frequency is determined by the crystal and a suitable type must be used to obtain a 1-MHz output signal. The second circuit, Fig. 3B, employs an inexpensive 4.433618-MHz crystal of the type used in many European color-TV sets. Again, the crystal is used with cross-coupled inverters to form an oscillator; but, in this case, the oscillator's output frequency is divided by four by the cascaded N7474 flip-flops to develop an (approximate) 1-

MHz output signal. In both circuits, overall frequency stability with respect to temperature and source voltage is determined by the crystals' characteristics.

When duplicating the clock generator circuits for specific projects, remember that the series 7400 IC's specified require a well-filtered, reasonably well-regulated 5-volt dc source, and that the power (V_{CC}) and GND connections must be made to the specified pins of each device, as indicated by the appropriate terminal diagrams. All resistors are ¼- or ½-watt types, while the capacitors can be either ceramic, mica, or plastic film units. Neither lead dress nor layout should be overly critical but, of course, good wiring practice should be observed, with signal-carrying leads kept short and direct.