

Two inverters and a crystal assure oscillator start

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A crystal-stabilized, transistor-transistor-logic clock source with no start-up problems can be made with two TTL inverters in the arrangement described here. The circuit has two other advantages: it will operate with almost any crystal from any manufacturer, and its stability is dependent on the characteristics of only two components.

TTL circuitry has inherently low impedance at all nodes, necessitating a series-mode oscillator configuration to provide a reasonably high Q. This mode requires a low-impedance path through 360° of phase shift with sufficient gain to overcome the losses in the loop.

In the circuit below, I_1 and I_2 are TTL inverters (or NAND gates with the inputs tied together) that provide the necessary gain and phase inversion. RFC_1 and RFC_2 provide dc feedback at the inverters that forces them into a linear mode. These chokes are chosen to provide enough loop gain to drive a weak crystal, and should have a dc resistance on the order of 100 ohms or less. R_1

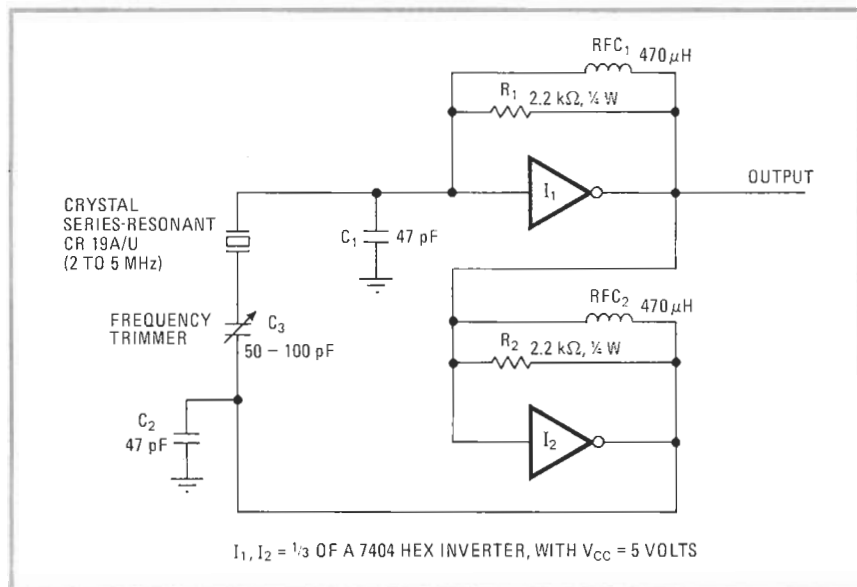
and R_2 are Q-swamping resistors inserted to eliminate oscillation of the circuit at the self-resonant frequency of the chokes. If low-Q chokes are used, these resistors may be eliminated, but it is wise to allow for them in the circuit-board layout to permit choke substitution.

Usually serial-mode crystals have three stable modes of oscillation—the one stamped on the can, one above that frequency, and one below that frequency. The higher- and lower-frequency modes are generally determined by both the crystal and distributed circuit parameters. Capacitors C_1 and C_2 are included in the circuit to eliminate these modes; by lowering the impedance of the loop they ensure that the specified frequency occurs. They have very little effect on the operating frequency, so high-quality capacitors are not required.

C_3 can be a trimmer or a fixed capacitor, depending on the exactness of frequency required. A tuning range of about 100 parts in 10^6 can be obtained by varying C_3 , but temperature stability and long-term stability are dependent on its characteristics.

This circuit with the values shown will operate in the frequency range of 2 to 5 megahertz. Below this range, the values of RFC_1 , RFC_2 , C_1 , and C_2 should be increased. Above this range C_1 and C_2 should be reduced to 22 picofarads or less. □

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Reliable clock source. When power is applied to this series-mode TTL crystal oscillator, it always starts up at the right frequency. It will operate with most crystals; the components shown here are for crystals in the 2-to-5-MHz range.