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Preproduction Tests for Crystal Oscillators

Crystal oscillators are among the more critical electronic circuits and, as such, often experience difficulty in production. Certain tests can be run on the engineering models of an oscillator to assist in assuring that the circuit will not encounter trouble in production or, at least, that it will not require a major redesign.

Perhaps the most important test is to build three to five engineering models and make certain that none of them is marginal. Secondly, it is important that the oscillator circuit will have adequate reserve gain to function with maximum-resistance crystals. This test can be run conveniently by adding resistance in series with the crystal until the circuit will just oscillate. The total resistance (crystal plus the external resistor) must be higher than the maximum permissible resistance for the crystal type being used. In order to allow for variations in transistors and other components, it usually is desirable to have the circuit oscillate with two or three times the maximum crystal resistance.

A number of other factors should be considered in the evaluation of an oscillator. Several of these are obvious but are included here for completeness.

a. *Frequency stability*. The required frequency tolerance of the oscillator must be larger than the temperature variation of the crystal and oscillator plus the aging rate of the crystal. If no tuning adjustment is used, allowances must be made for unit-to-unit variation also.
b. *Output power*. The output power must be adequate even with a high-resistance crystal and a low-gain transistor.
c. *Crystal dissipation*. The crystal dissipation should be consistent with the discussion in section 5.4.

d. *Spurious oscillations.* The circuit should have a reasonable safety factor with respect to free-running and spurious oscillation. As a rule of thumb, the oscillator should be capable of being detuned to pull the crystal frequency at least ±10 ppm without spurious or free-running oscillations becoming evident. Switching the crystals and turning the oscillator off and on repeatedly in the detuned condition also may aid in discovering spurious oscillations. These procedures are inadequate, however. The only way to determine a spurious safety factor with any degree of certainty is with the aid of very low-spurious-ratio crystals for which spurious oscillation actually can be induced.

e. *Component tolerance.* The critical components of the circuit should be checked for permissible tolerance. This can be done conveniently by substituting components of the next size smaller and larger. In the case of gate oscillators, it is particularly important to obtain limit-active devices to check for spurious and free-running oscillations.

f. *Stray capacitance variation.* The circuit must be capable of functioning properly even if the stray capacitance or inductance configuration changes somewhat. This usually is unimportant for oscillators below 10 MHz. It can be checked by adding a 1- or 2-pF capacitor to ground at every critical point of the circuit.

g. *Crystal load capacitance.* The oscillator should be designed so that the crystal looks into the specified load capacitance (32 pF, 20 pF, or series resonance). This can be determined easily by having the frequency of a crystal measured at the desired load capacitance and then adjusting it to that frequency in the actual circuit.

h. *Supply voltage.* The oscillator should be checked to make certain that it will function properly with the minimum and maximum supply voltages.

i. *Temperature.* The oscillator should be checked over the entire temperature range with all conditions exactly the same as they will be in the final unit.