

# TECHNICAL NOTE 24

## Comparison of Low Frequency Oscillator Designs

### Oscillator Types

Crystal-controlled oscillators can be divided into two basic groups: positive reactance or negative reactance. The positive reactance mode is commonly called a “parallel resonant” or “anti-resonant” oscillator. A *pierce* oscillator is one commonly-known positive reactance oscillator. The negative reactance mode is usually referred to as a *series* oscillator. Statek crystals are designed and tuned for a specific mode of operation (Table 1).

### Pierce Oscillators

The pierce oscillator (Figure 1) utilizes a single inverter, with two phase-shift capacitors and the crystal providing 180°C phase shift in the feedback loop. The crystal behaves electrically as though it were an inductor. The frequency of oscillation is 30ppm to 300ppm above the series resonant frequency of the crystal. If the crystal is removed from the circuit, the oscillator will usually stop oscillation. Compared to a series oscillator, the pierce oscillator generally starts slower and draws less current. Miniaturized portable equipment (battery powered), including hand held data entry terminals, utilizes the pierce oscillator.

### Series Oscillators

Generally a series oscillator (Figure 2) consists of two cascaded inverters with the crystal connected between the second inverter output and the first inverter input. The crystal behaves electrically as though it were a capacitor. The oscillator will usually free-run at a higher frequency if the crystal is removed. Compared to the pierce oscillator, it starts faster (typically 100 milliseconds) and draws higher current.

### Pierce or Series??

The choice of crystal or oscillator types depends primarily on performance requirements. Table 2 summarizes the performance characteristics of pierce and series oscillators. The CX-1V crystal has a higher Q than the CX-1H because it is sealed in an evacuated package. The CX-1H crystal has approximately 3 to 5 times higher motional resistance (lower Q) because it is hermetically sealed close to atmospheric pressure

TABLE 1. Recommended Statek Crystals for Basic Oscillator Circuits

Mode	Oscillator	Recommended Crystals	Remarks
Positive reactance	Pierce or parallel	CX-1V or CX-2V	Uses single inverter
Negative reactance	Series	CX-1H or CX-2H	Uses two inverters

FIGURE 1. – Pierce Oscillator

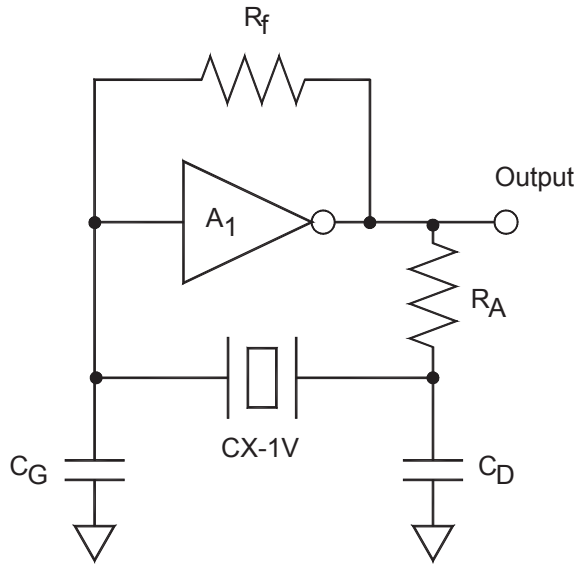


FIGURE 2. –Series Oscillator

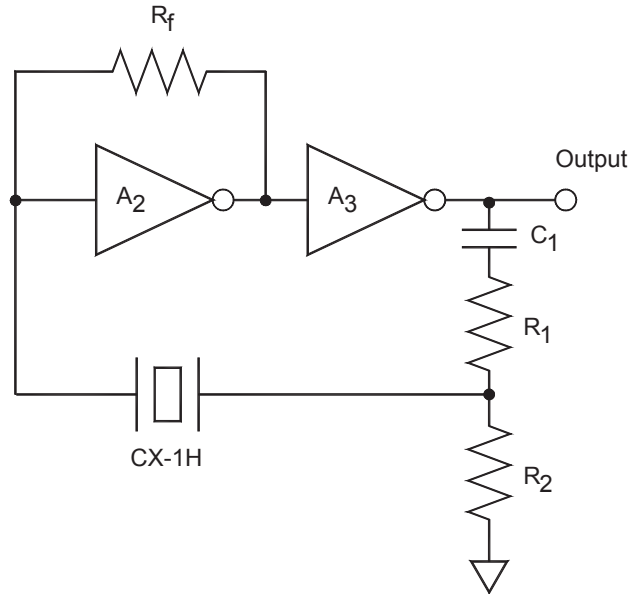


TABLE 2. Characteristics of Pierce and Series Oscillators

Oscillator Characteristics	Series Oscillator CX-1H, CX-2H	Pierce Oscillator CX-1V, CX-2V
Oscillator Current	0.1 – 5 mA	10 – 600 $\mu$ A
Start Time	Less than ¼ second	Less than 1 second
Long-Term Stability	Determined by crystal aging	Determined by crystal aging
Temperature Stability	Determined by crystal	Determined by crystal
Crystal Failure (open)	Usually free-runs 1.5-2x crystal frequency	Stops oscillation
Package Seal Failure	Frequency shifts down	Oscillation stops or frequency shifts down
Adjustment of Frequency	More difficult than pierce	Easily trimmed by trimmer capacitor

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