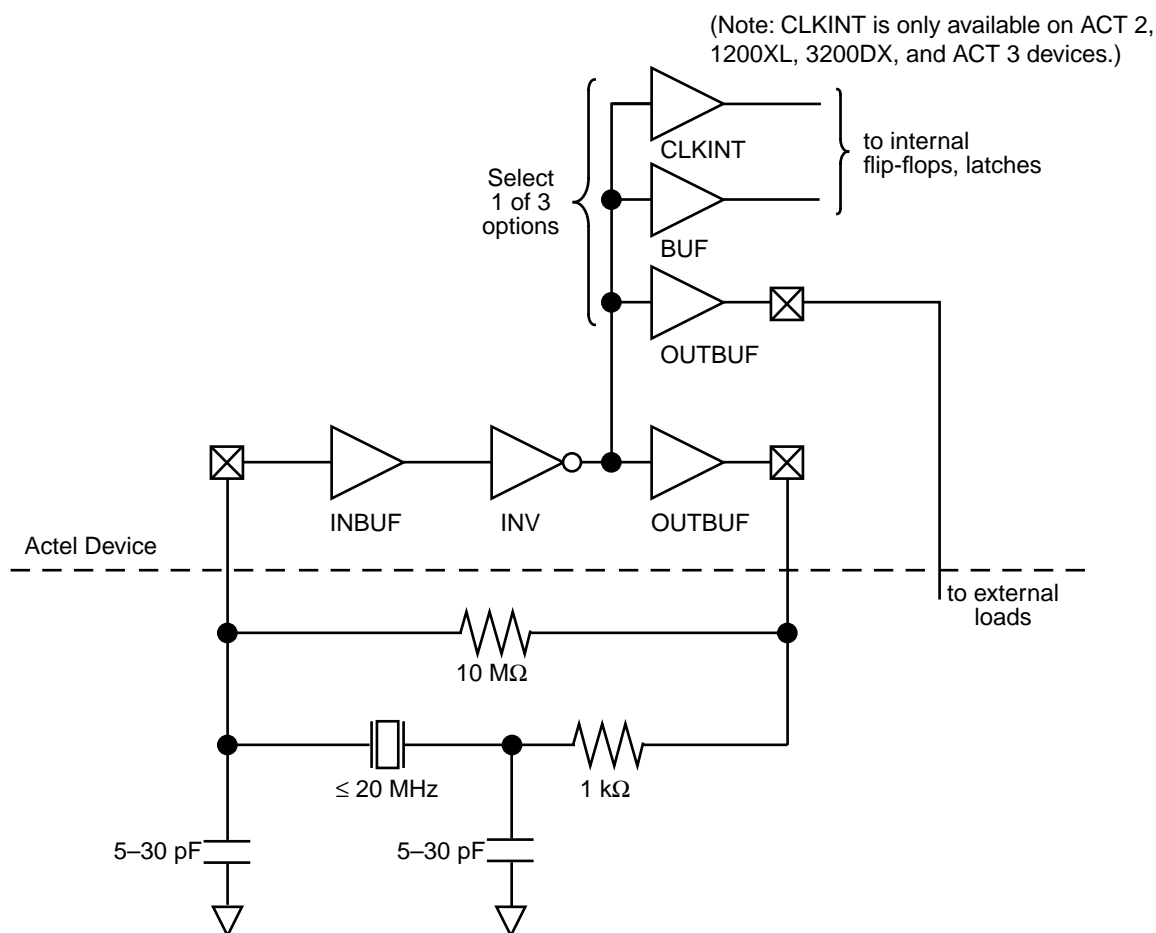


# Oscillators for Actel FPGAs

## Crystal Oscillator

Oscillators are fundamental design circuits used to provide a reference clock signal essential for digital designs. Crystal oscillators provide a simple solution for precise, stable, and calibration-free clocks. An on-chip crystal oscillator can be implemented with Actel devices using the traditional configuration shown in Figure 1. This oscillator has been tested up to 20 MHz and is used in Actel programmers. The 10 M $\Omega$  resistor provides a negative feedback path for the inverter, which makes it behave like a high-gain amplifier. The remaining passive elements, including the crystal, form a pi network that provides a 180 degree phase inversion. The

inverter will lock on to the parallel resonant frequency of the crystal, thus providing a very stable output. The RC network also acts as a low-pass filter to ensure that the crystal operates at the fundamental frequency and not a harmonic frequency. The capacitor values range from 5 to 30 picofarads and depend on the crystal frequency. Some experimentation is suggested to get an optimal value for a specific design. Generally, the two capacitors will have the same value, although the capacitor connected to the input of the inverter can be varied independently to alter the output frequency by  $\pm 0.1$  percent.



**Figure 1 • Crystal Oscillator Circuit**

A second OUTBUF or CLKBIBUF output buffer is used to provide a sharper clock signal at full amplitude when used outside the FPGA. Alternatively, the output buffer can be replaced with an internal buffer, which will allow a direct connection to internal macros. For ACT 2, 1200XL, 3200DX, and ACT 3 devices, the CLKINT macro can be used allowing high fanout drive capability of internal macros with minimal skew.

Fix the placement of the oscillator I/O macros to adjacent package pins to minimize internal delays. Also, fixing the I/O macros near ground pins and far from other high-speed switching I/O pads minimizes noise effects.

## RC Oscillator

For applications not requiring the accuracy of a crystal, there is an RC oscillator that can be used in an Actel device as shown in Figure 2. As a strong word of caution, this circuit is not recommended for system clocks, since it is heavily

dependent on resistor and capacitor tolerances, process variation, and temperature. Some applications for this lower cost oscillator include LCD backplane and debounce circuits.

The circuit reaches alternate switching thresholds by charging and discharging the capacitor with resistor R2. The R1 resistor provides a better square wave output by minimizing effects of input protection diodes of the input buffer. The approximate formula for output frequency is:

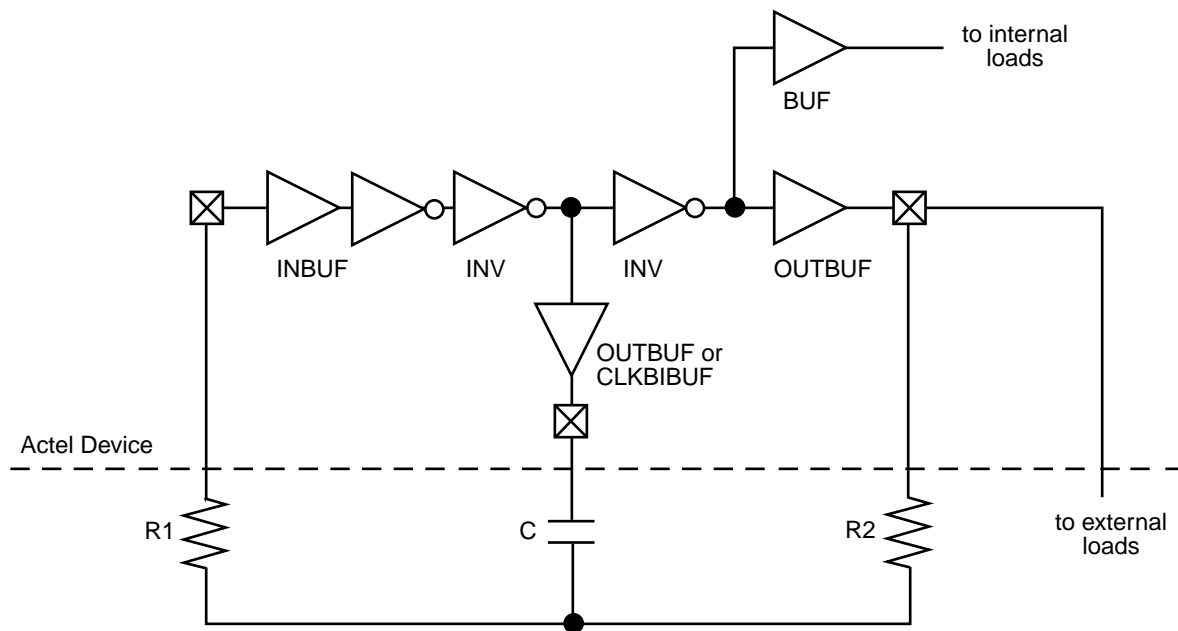
$$frequency \cong \frac{1}{2.2 R_2 C}$$

The formula is most accurate if parameters have the following limitations:

$$R1 > 10R2$$

$$10\text{K} > R2 > 1\text{ M}$$

$$1000 \text{ pF} > C > 10 \text{ }\mu\text{F}$$



**Figure 2 • RC Oscillator**