

Crystal terms and application notes

It has an input port (normally called XIN, XTALL) and an output port (XOUT, XTALO) for crystal connections between those two ports. Most chips are designed with an option either driven by an external clock oscillator fed to the crystal input port, or with an external crystal. Depending on frequency, crystals can be selected as fundamental or an overtone mode. Normally, frequencies above 24 MHz requires the third overtone mode for price advantage and delivery. Higher fundamental frequencies, up to 40 MHz can be bought as a BT-cut with a lower price compared to an AT-cut. In parallel mode, where the crystal reactance is inductive, two external capacitors C_1 and C_2 are required for a necessary phase shift in oscillation. C_1 and C_2 are needed whether the crystal is in fundamental mode or overtone mode. Values of C_1 and C_2 are specified by the chip manufacturer and vary from 6pF to 47pF. C_1 and C_2 may not be balanced, i.e., equal in value, but sometimes are offset in a particular ratio (C_1/C_2) for best performance, depending on crystal and amplifier characteristics and board layout. Figure 10 shows a typical configuration for a fundamental mode operation.

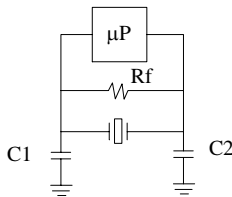


Figure 10

In an overtone mode, an additional inductor L_1 and capacitance C_c is required to select the third-overtone mode while suppressing or rejecting the fundamental mode. Choose L_1 and C_c component values in the third overtone crystal circuit to satisfy the following conditions:

- The L_1/C_c components form a series resonant circuit at a frequency below the fundamental frequency, which makes the circuit look inductive at fundamental frequency. This condition does not favor to oscillation at fundamental mode.

- The L_1/C_c and C_2 components form a parallel resonant circuit at a frequency about half-way between the fundamental and third-overtone frequency. This condition makes the circuit capacitive at the third-overtone frequency, which favors the oscillation at the desired overtone mode. See figure 11.

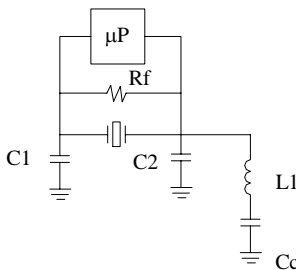


Figure 11

- In a standard overtone mode, C_2 value varies from 10pF to 30pF. C_c value should be chosen at least 10 times the value of C_2 , so its equivalent C_{equiv} will be approximately the value of C_2 .

- Typical values of L_1 for different crystal frequencies:

25 MHz	4.7uH, 6.8uH, 8.2uH, 10uH
32 MHz	2.7uH, 3.9uH, 4.7uH, 5.6uH
40 MHz	1.5uH, 1.8uH, 2.2uH, 2.7uH, 3.3uH

Figure 12 shows a typical circuit configuration for a 40.3200MHz, third-overtone mode operation.

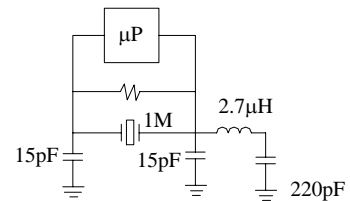


Figure 12

DIFFERENCE BETWEEN AT CUT AND BT CUT CRYSTALS

As described, AT cut crystals and BT cut crystals possess different angle cut (35 degrees on AT fundamental vs. 49 degrees on BT cut). Both types have the same vibration mode (thick-ness-shear). However, the BT cut crystal on the 50MHz fundamental is slightly thicker (2mils) compared to its AT cut (1.3mils), thus offers a better yield and unit cost. AT cut and BT cut have different temperature vs. frequency curves, but they are made to meet all specifications.

$$\text{AT Fundamental } F = \frac{1670}{t}$$

$$\text{AT Overtone } F = \frac{1670 \times n}{t} \begin{cases} F \text{ in KHz} \\ t \text{ in mm} \\ n = \text{overtone mode} \end{cases}$$

$$\text{BT Fundamental } F = \frac{2560}{t}$$

Unless chemical etching is used (which increases the unit cost), standard fundamental crystal 50 MHz was lapped to the frequency. Due to its thin and delicate plate, the control process is so difficult in handling and processing, thus results in a much lower yield. In contrast with a 50 MHz fundamental, the blank thickness of the 3rd overtone crystal is approximately 4 mils (in AT-cut).

Besides mechanical lapping required on fundamental 50 MHz, special material finishing process is added (polishing and sometimes use aluminum or silver material).