QUARTZ CRYSTALS FAQ

Timing Application Engineering

What is quartz crystal?

Quartz is silicon dioxide SiO2 which is naturally chemical very stable material on temperature and ageing. The crystal is a resonator component that is made by quartz's piezoelectric of mechanical electric transformation property. All precision clocks are made by quartz crystal in oscillator such as quartz clock which uses 32.768kHz crystal. Wireless application has stricter requirement on crystal.

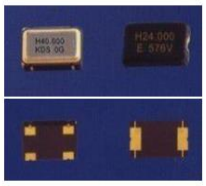
Natural quartz

32.768kHz fork crystal

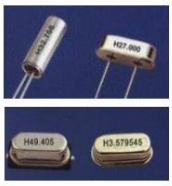
Quartz clock

How many crystal products?

Crystal products are classified by package (Through Hole, SMD, Metal or glass sealing), and size (5x7, 5x3.2, 3225, 2520, 2016 etc. in mm) and frequency accuracy (+/-50ppm, +/-30ppm, +/-20ppm and more). 4 pin SMD crystal has two pins are GND pins.



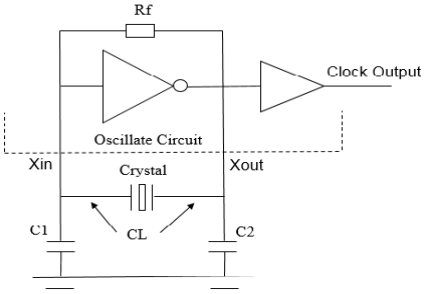
SMD crystal



TH and SMD crystal

How to use crystal?

Crystal self is passive resonator component. It must work together with OSC (Oscillate Circuit) to generate stable clock as the following diagram. The OSC must have enough electric gain to maintain the reliable clock in all condition and millions manufacture.



How to select crystal for application?

Choose crystal size for PCB planning and ppm grade to meet application first. Then choose crystal datasheet CL =8, 16 or 18pF that crystal sees to get "0" ppm frequency oscillation. Last design is the external load cap. C1 and C2, -Cstray that total external load cap. is equivalently equals to CL. Always check datasheet for the recommended external load capacitor value since some IC OSC has integrated portion on-chip cap. to be subtracted. On chip programmable cap. load for wireless ASIC is a trend.

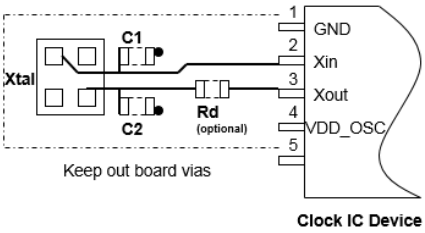
How to design crystal load cap. (C1/C2)?

Design goal: C1=C2=2 *CL – Cstray to be equal to crystal datasheet CL
Typical PCB Cstray = 4 ~ 6pF

For crystal frequency =>20MHz, C1=C2=2*(CL-4) is a good formula to start with, but always check datasheet recommendation. The C1 and C2 value can be fine tune (6ppm/1pF) for more accurate ppm (<+/-20ppm) during board bring up.

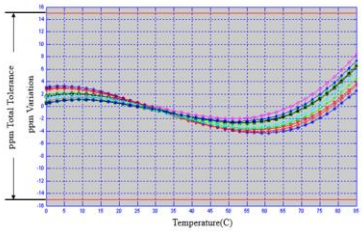
Why is important on crystal PCB layout?

Since good PCB layout can eliminate the most Cstray and OSC IC Xin pin is the most sensitive pin as crystal amplifier input, so make Xin and Xout pins to crystal on trace routing in narrow loop with load cap. (C1/C2) close to crystal pins on top layer. The 2nd layer GND plane must be continuously underneath them with mini. keep-out (>200mil) of any board vias around the crystal area to get rid of board noises.



How to order generic crystal in datasheet?

1)Size ___ It is package. Smart phone/watch need small size, while factory high volume package (3225) has best price.
2)ESR ___Smaller size crystal has higher ESR (Equivalent Series Resistance 26~80 ohm) which requires OSC to have better gain (Negative Resistance) to compensate loss in oscillation. Smaller size crystal has smaller drive level.
3)CL ___Load capacitor (pF) that crystal datasheet provides.
4)ppm Tolerance
___ It is Crystal frequency accuracy grade in ppm includes crystal temperature range, factory tolerance, The following is crystal temperature curve has higher +ppm at >60C. Smaller ppm tolerance crystal is more expensive.



How to order pulling crystal?

To make VCXO PLL needs pulling crystal. Crystal works as inductive with external CL(C1/C2) to get corresponding output frequency in pulling curve as the following plot. To order pulling crystal must specify pulling range: CL_min for > upper limit +ppm and CL_max for < low -ppm limit. +/-100ppm is typical requirement. It is worth to note that generic crystal has <+/-50ppm pulling range can not replace the pulling crystal.