



APPLICATION NOTE 616

Considerations for Maxim Real-Time Clock Crystal Selection

Abstract: This application note describes crystal selection criteria and proper layout techniques for connecting a 32kHz crystal to a real-time clock (RTC). Following these guidelines will prevent time errors and incorrect time due to crosstalk and improper crystal selection.

All Maxim real-time-clock (RTC) products require an external 32.768kHz watch crystal for use on their on-board crystal oscillator circuit. Except for this crystal, no other external components are required. Selection of the external crystal varies depending on the end application. Considerations are operating temperature range, package style/size, crystal load capacitance, and cost.

Crystal Manufacturers

There are many crystal manufacturers for 32.768kHz "watch crystals." A few of them are listed below, along with their web addresses for quick access to technical details regarding crystals.

Manufacturer	Website
Raltron	http://www.raltron.com
ECS INC International	http://www.ecsxtal.com
SaRonix	http://www.saronix.com
Abracon Corporation	http://www.abracon.com
Fox Electronics	http://www.foxonline.com
M-tron	http://www.mtron.com
Caliber Electronics	http://www.caliberelectronincs.com

Common Watch-Crystal Specifications

Watch crystals at 32.768kHz are optimized for either 6pF or 12.5pF loads (refer to specific Maxim RTC data sheets for which crystal is required). There are common electrical characteristics for both, and these specifications are listed below. In addition, there is a common parabolic temperature curve for watch crystals, shown in Figure 1. Above or below +25°C, the frequency becomes lower with changes in temperature as determined by the frequency stability constant K, which has a maximum value of $-0.040 \text{ PPM}/(\Delta^\circ\text{C})^2$.

Parameter	Symbol	Min	Typ	Max	Units
Frequency	f		32.768		kHz
Equivalent Series Resistance (ESR)	R _s	35		60	KΩ
Frequency Stability	K	-0.028		0.040	PPM/(Δ°C) ²
Turnover Temperature	T _o	+20		+30	°C
Drive Level				1.0	μW
Aging (first year @ 25 °C)		-3.0		+3.0	PPM
Load Capacitance			6pF or 12.5pF		
Q Factor	Q	40,000		60,000	

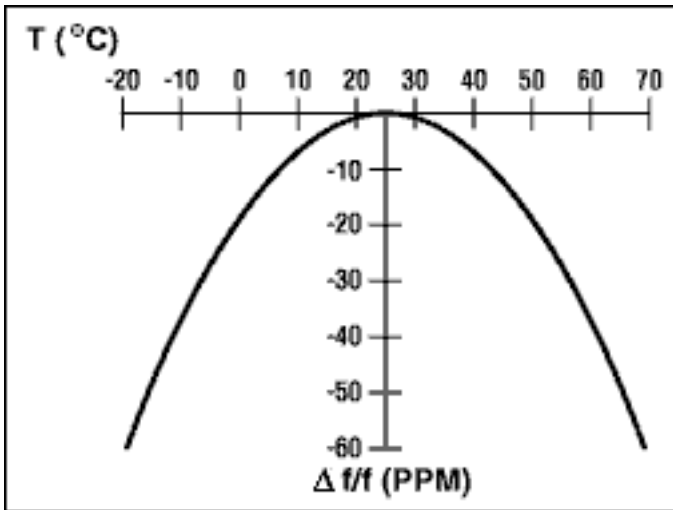


Figure 1. Parabolic temperature curve.

In general, an RTC that uses a 12.5pF crystal will have a timekeeping current of 1.7X more than an RTC that uses a 6pF crystal (that is, 6pF RTC current = 300nA @2V whereas 12.5pF RTC current = 500nA@2V). Timekeeping current is that measured when there is no serial bus activity and the RTC is only using current to run its 32.768kHz oscillator and count real time. A standard, low-cost, 50ma-hr, lithium, backup battery powers an RTC with timekeeping current of less than 570nA for up to 10 years.

A 12.5pF load crystal oscillator is somewhat more stable and less susceptible to noise and PCB layout stray capacitance than a 6pF load crystal oscillator. This is partly due to the capacitance from each crystal pin to ground, internal to the RTC, which is 25pF per pin for the 12.5pF crystal RTC and 12pF for the 6pF crystal RTC.

There are also inventory issues for 32.768kHz watch crystals. Load crystals at 12.5pF are readily available through many distributors. Load crystals at 6pF are not as readily available and can require a minimum-quantity order to procure. Check with your local supplier for availability and price.

It is important to use the correct specified crystal with an RTC, for the wrong crystal can cause as much as a 100ppm error in the 32.768kHz oscillator frequency, which translates to a 4.3-minute error over a one-month period. In addition, the wrong crystal can cause excessive timekeeping current or failure of the oscillator to start properly.

Through-Hole Leaded Crystals

There are three common packages for through-hole leaded crystals. They are available in both 6pF and 12.5pF crystal loads. These package styles are shown below, along with manufacturers who offer such packages.

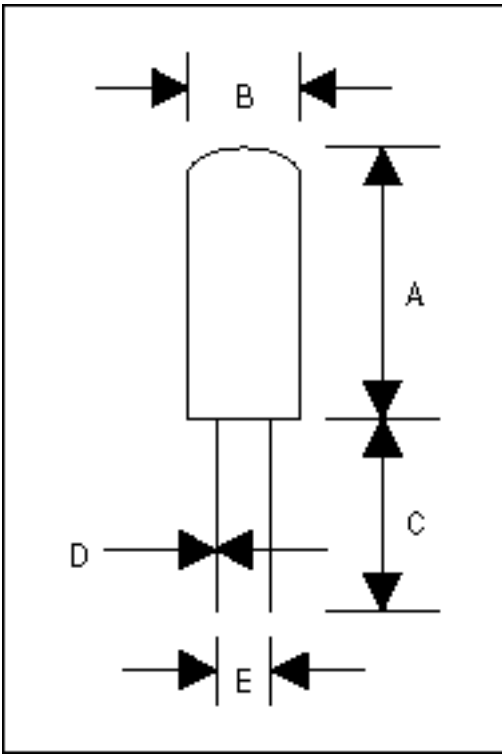


Figure 2. Package for through-hole leaded crystals.

REF	TH1	TH2	TH3
A	5.0 max	6.0 max	8.3 max
B	1.5 max	2.0 max	3.2 max
C	4.3 min	4.0 min	9.0 min
D	0.17 +/-0.05	0.2 +/-0.15	0.3 +/-0.07
E	0.45	0.7 +/-0.15	1.1 +/-0.2

Note: Dimensions in mm

Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	12.5pF optional; 6pF optional	-10 to +60	+/-20PPM	R145	TH1
ECS INC International	12.5pF optional; 6pF optional	-10 to +60	+/-20PPM	ECS-1X5	TH1
SaRonix					TH1
Abracon Corporation					TH1
Fox Electronics	12.5pF	-20 to +60	+/-20PPM	NC15	TH1
M-tron	12.5pF optional; 6pF optional	-20 to +70	+/-30PPM +/-20PPM	MMCC-3	TH1
Caliber Electronics	12.5pF	-10 to +60	+/-20PPM	AWT3	TH1

Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	12.5pF standard; 6pF optional	-10 to +60	+/-20PPM	R26	TH2
ECS INC International	12.5pF	-40 to +85	+/-20PPM	ECS-2X6-FL	TH2
SaRonix	6pF optional; 12.5pF optional	-10 to +60	+/-20PPM	NTF3226	TH2
Abracon Corporation	12.5pF standard; 6pF optional	-10 to +60 -40 to +85 optional	+/-20PPM +/-10PPM +/-5PPM	AB26T	TH2
Fox Electronics	12.5pF	-20 to +60	+/-20PPM	NC26	TH2
M-tron	12.5pF	-20 to +70	+/-30PPM +/-20PPM	MMCC-2	TH2
Caliber Electronics	12.5pF	-10 to +60	+/-20PPM	AWT2	TH2

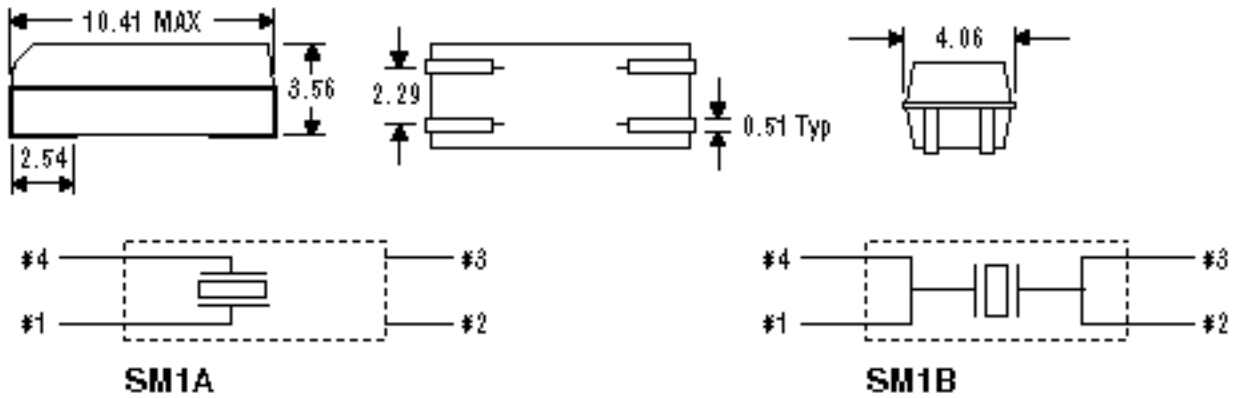
Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	12.5pF standard; 6pF optional	-10 to +60	+/-20PPM	R38	TH3
ECS INC International					TH3
SaRonix	12.5pF	-10 to +60	+/-20PPM	NTF3238	TH3
Abracon Corporation	12.5pF standard; 6pF optional	-10 to +60 -40 to +85 optional	+/-20PPM +/-10PPM +/-5PPM	AB38T	TH3
Fox Electronics	12.5pF	-20 to +60	+/-20PPM	NC38	TH3
M-tron	12.5pF	-20 to +70	+/-30PPM +/-20PPM	MMCC-1	TH3
Caliber Electronics	12.5pF	-10 to +60	+/-20PPM	AWT	TH3

Surface-Mount Crystals

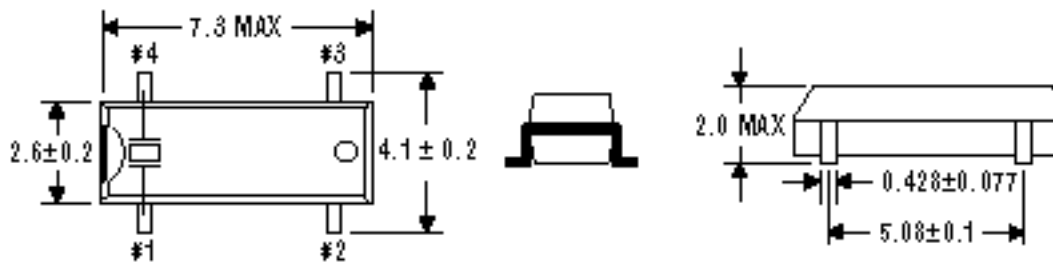
There are three common packages for surface-mount crystals. They are available in both 6pF and 12.5pF crystal loads. These package styles are shown below, along with manufacturers who offer such packages.

Surface-Mount Crystals
 (all dimensions are in mm)

SM1



SM2



SM3

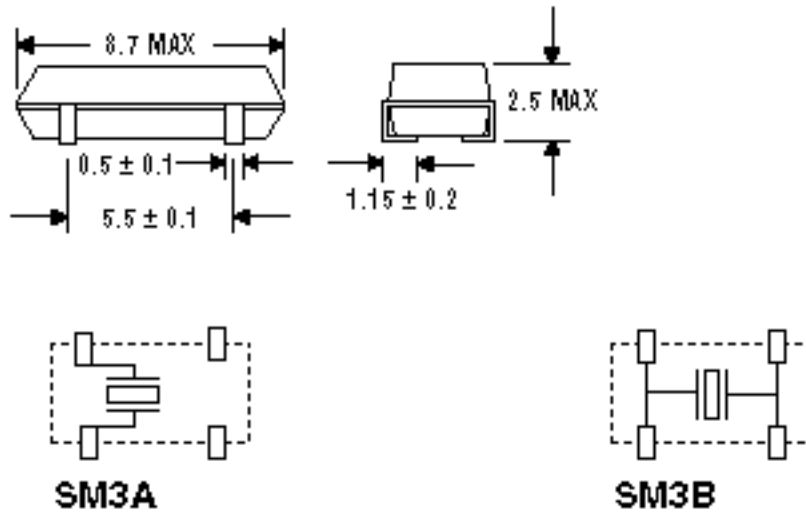


Figure 3. Surface-mount crystals (all dimensions are in mm).

Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	12.5pF	-10 to +60	-10 to +60	RSM200SA RSM200SB	SM1A SM1B
Raltron	6pF 12.5pF	-40 to +85	+/-20PPM +/-50PPM +/-100PPM	RSE B RSE A	SM1B SM1A
ECS INC International	12.5pF standard 6pF optional	-40 to +85	+/-20PPM	ECX-205 ECX-206	SM1B SM1A
SaRonix	12.5pF	-40 to +85	+/-20PPM	32S12B 3212SA	SM1B SM1A
Abracon Corporation	12.5pF standard 6pF optional	-40 to +85	+/-20PPM +/-25PPM +/-30PPM	ABS35A ABS35B	SM1B SM1A
Fox Electronics	12.5pF	-40 to +85	+/-20PPM	FSM327	SM1B
M-tron	12.5pF	-20 to +70	+/-20PPM	SSX2010 SSX2020	SM1B SM1A
Caliber Electronics	12.5pF	-20 to +70	+/-20PPM	AWS2A AWS2B	SM1B SM1A

Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	6pF 12.5pF	-40 to +85	+/-20PPM +/- 50PPM +/- 100PPM	RSE H2	SM2
ECS INC International	6pF 12.5pF	-40 to +85	+/-20PPM	ECX-3TA	SM2
SaRonix					SM2
Abracon Corporation	12.5pF standard 6pF optional	-40 to +85	+/-20PPM +/- 25PPM +/- 30PPM	ABS20G	SM2
Fox Electronics	12.5pF	-40 to +85	+/-20PPM	FSP	SM2

Manufacturer	Crystal Load	Operating Temperature Range (°C)	Frequency Tolerance @ 25°C	Part Series	Package Style
Raltron	12.5pF	-10 to +60	+/-20PPM	RSM200S	SM3A
Raltron	6pF 12.5pF	-40 to +85	+/-20PPM +/- 50PPM +/- 100PPM	RSE C RSE D	SM3A SM3B
ECS INC International	12.5pF standard 6pF optional	-40 to +85	+/-20PPM	ECX-306I	SM3A
SaRonix	12.5pF	-40 to +85	+/-20PPM	32S12C	SM3A
Abracon Corporation	12.5pF standard 6pF optional	-40 to +85	+/-30PPM +/- 20PPM +/- 25PPM	ABS25	SM3A
Fox Electronics	12.5pF	-40 to +85	+/-20PPM	FSR327 FST327	SM3A SM3B
M-tron (SM3 pkg w/2mm height)	12.5pF	-40 to +85	+/-30PPM	SX1575	SM3A
M-tron	12.5pF	-20 to +70	+/-30PPM	SX1555	SM3A

Typical Crystal Prices

Typical distributor pricing (as of early 2001) in 1K quantity is shown below. Regional pricing and availability can vary and should be checked with your local supplier.

Package Style	Price in 1K Qty*
TH1	\$0.62
TH2	\$0.18
TH3	\$0.18
SM1	\$0.62
SM2	\$0.82
SM3	\$0.62

*Catalog distributor pricing in \$US

Application Note 616: <http://www.maxim-ic.com/an616>

More Information

For technical questions and support: <http://www.maxim-ic.com/support>

For samples: <http://www.maxim-ic.com/samples>

Other questions and comments: <http://www.maxim-ic.com/contact>

Related Parts

MAX6900: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6901: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6902: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX6909: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

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