Qualcomm Technologies, Inc.

Qualcomm® Snapdragon™ 600E Processor (APQ8064E)

GPS Quality, 19.2 MHz 2520 Package Size, Crystal and TH+Xtal

Mini Specification

September 2016

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Qualcomm Technologies, Inc.
5775 Morehouse Drive
San Diego, CA 92121
U.S.A.

LM80-P0598-8 Rev B

Revision history

Revision	Date	Description
B	September 2016	Update for ‘E’ part
A	June 1, 2015	Initial release

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Figures

Tables

1 Approval Definition

An approved part indicates that the vendor has agreed to the specifications in this document, they have included the specifications in their datasheet, and they have supplied supporting data to show they meet these specifications.

NOTE: This document provides a description of chipset capabilities. Not all features are available, nor are all features supported in the software.

NOTE: Enabling some features may require additional licensing fees.

2 19.2 MHz Crystal Specifications

Standard 4-pin crystal footprint with the crystal connected between pins 1 and 3.

Table 2-1 19.2 MHz 2520 package size crystal specifications table

Parameter	Min	Nom	Max	Units	Notes
Operating frequency		19.2		MHz	
Mode of vibration		AT-cut fundamental			
Initial frequency tolerance			±10	ppm	
Tolerance over temperature			±12	ppm	-30 to +85°C; above 85°C tolerance over temperature bound by third-order coefficient range in Section A.5
Aging			±0.7	ppm/year	
Frequency drift after reflow			±2	ppm	After two reflows
Operating temperature	-30		+105	°C	
Storage temperature	-40		+105	°C	
Equivalent series resistance			80	Ω	New for 2520 crystals
Quality factor (Q)	75,000				The minimum Q value calculated from ESR and L is smaller than this specification.
Spurious mode series resistance	1100			Ω	±1 MHz
Motional capacitance	1.80		3.10	fF	New for 2520 crystals
Shunt capacitance	0.3		1.3	pF	
Load capacitance		7		pF	The load capacitance is measured according to IEC Standard #60444-7.
First-order curve fitting parameter (see Appendix A).	-0.40		-0.10	ppm/°C	The curve fitting parameter is obtained from the crystal curve fitting algorithm (Appendix A, calculation order C0, C1, C3, and C2) using temperature inflection point t_0 = 30°C.
Second-order curve fitting parameter (see Appendix A).	-4.5	0	4.5	$\times 10^{-4}$ ppm/°C^2	The curve fitting parameter is obtained from the crystal curve fitting algorithm (Appendix A, calculation order C0, C1, C3, and C2) using temperature inflection point t_0 = 30°C.

Parameter	Min	Nom	Max	Units	Notes
Third-order curve fitting parameter (see Appendix A).	8.5	10	11.5	$x10^{-5}$ ppm/°C^3	The curve fitting parameter is obtained from the crystal curve fitting algorithm (Appendix A, calculation order C0, C1, C3, and C2) using temperature inflection point t_0 = 30°C.
Drive level	10		100	µW	
Insulation resistance	500			MΩ	
Package		2.5 × 2.0		mm^2	

3 GPS Quality Specifications

Table 3-1 Crystal perturbation specification 1 (residual frequency stability slope)

Item	Condition	Specification	Unit
Residual frequency stability slope (residual = difference from fifth-order curve fit)*	Ta = -30 to +85°C	±50 (max)	ppb/°C
5°C small orbit hysteresis 1*	Ta = -30 to +85°C	±50 (max)	ppb/°C

* Must meet the 1A and 1B conditions:

- Condition 1A – Test condition (continuous temperature rate change of ~1.0°C/min):
  - Measure FT points every 1°C, heating up from -30 to +85°C, subtract a fifth-order polynomial best fit and then calculate the slope of the residual.
  - The residual slope should be within ±50 ppb/°C.
- Condition 1B – Hysteresis 1 test condition (continuous temperature rate change of ~1.0°C/min):
  - Measure FT points every 0.5°C while cycling temperature over a 5°C small temperature orbit; an example 5°C small orbit temperature cycle is +30°C to +35°C to +30°C.
  - During every individual heating/cooling cycle there should be 11 points; discard the first point of each heating and cooling cycle; this leaves 10 points for each heating and cooling cycle. Subtract the fifth-order polynomial best fit from 1A for each of the 10 points, and then calculate the slope of the residual for each of these heating and cooling 10 point curves.
  - The residual slope should be within ±50 ppb/°C.

Table 3-2 Crystal perturbation specification 2 (small orbit hysteresis 2)

Item	Condition	Specification	Unit
5°C small orbit hysteresis 2**	Ta = -30 to +85°C	100 (magnitude)	ppb pk-pk

** Must meet condition 2:

- Condition 2 – Hysteresis 2 test condition (continuous temperature rate change of ~1.0°C/min):
  - Measure FT points every 0.5°C while cycling temperature over a 5°C small temperature orbit; an example 5°C small orbit temperature cycle is +30°C to +35°C to +30°C.
  - During every individual heating/cooling cycle there should be 11 points; discard the first and last point of each heating and cooling cycle, which results in 9 temperature points. Calculate the average measured peak-to-peak frequency difference for these 9 temperature points.
  - The average difference is the magnitude of the small orbit hysteresis 2.

Table 3-3 Specification for DLD

	Item	Max - min	Repeatability	Condition
Drive level dependency	Freq	< 3 ppm	< 0.7 ppm	0.01 uW to 100 uW to 0.01 uW
	ESR	< 20%	< 10%	

NOTE: **Number of points:** 15 points up and 15 points down = 29 total data points.
Max–Min: Difference between maximum and minimum in two-way measurement.
In case of ESR, the change rate is (max - min)/min < 20%.
Repeatability: Repeatability of two-way measurement in the above condition.
In case of ESR, the change rate is (ESR2 - ESR1)/ESR1 < 10%.
ESR1: First measurement on each drive levels.
ESR2: Second measurement on each drive levels.
(Example) How to specify each parameter:

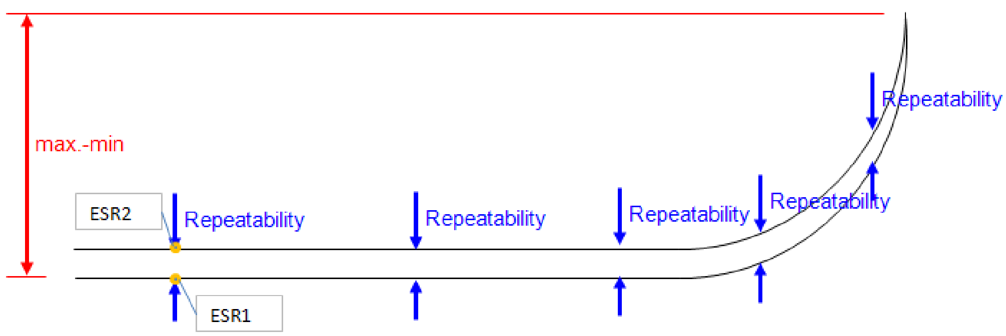

Figure 3-1 Crystal perturbation specification 3 (DLD testing requirements)

3.1 Comments/notes

1. Testing:
   - DLD testing should be done on every device to detect fabrication issues such as contamination, particles of dust, etc., and to verify proper crystal functionality.
   - Specifications 1A, 1B, and 2 process control confirmation testing is recommended to be done at a minimum on a sampling basis for every LOT.
2. The purpose of the specifications:
   - Specification 1A:
     - Verify that the FT curve can fit with a fifth-order polynomial.
     - Verify that there are no package resonances and no micro-jumps that exceed the residual frequency stability slope specification.
     - See Figure 3-2.
   - Specification 1B:
     - Verify that the small orbit hysteresis 1 is controlled to less than 50 ppb/°C residual slope in the crystal (departure from FT curve over small orbits).
     - See Figure 3-3.

- Specification 2:
  - Verify that hysteresis 2 (the gap between the cooling and heating FT curves) over small orbits is of a reasonable value.
  - These are the rapid shifts that occur when changing from cooling-to-heating or heating-to-cooling.
  - See Figure 3-4.

3. Measurement technique for specifications 1 and 2:
   - Standard thermocouple should not be used since it has a 0.1°C temperature resolution and therefore can fail a 50 ppb/°C test due to measurement quantization (i.e., which is not part of the real crystal FT performance curve).
   - A preferable technique to measure temperature is to use the internal thermistor (or an external thermistor located near crystal on the PCB board). As an example, voltage measurement is a feature of the 34970A Data Acquisition Unit from Agilent. Frequency can be measured via the 53131A_132A 225 MHz Agilent frequency counter.
   - A continuous temperature rate change of ~1.0°C/min is recommended for all tests.

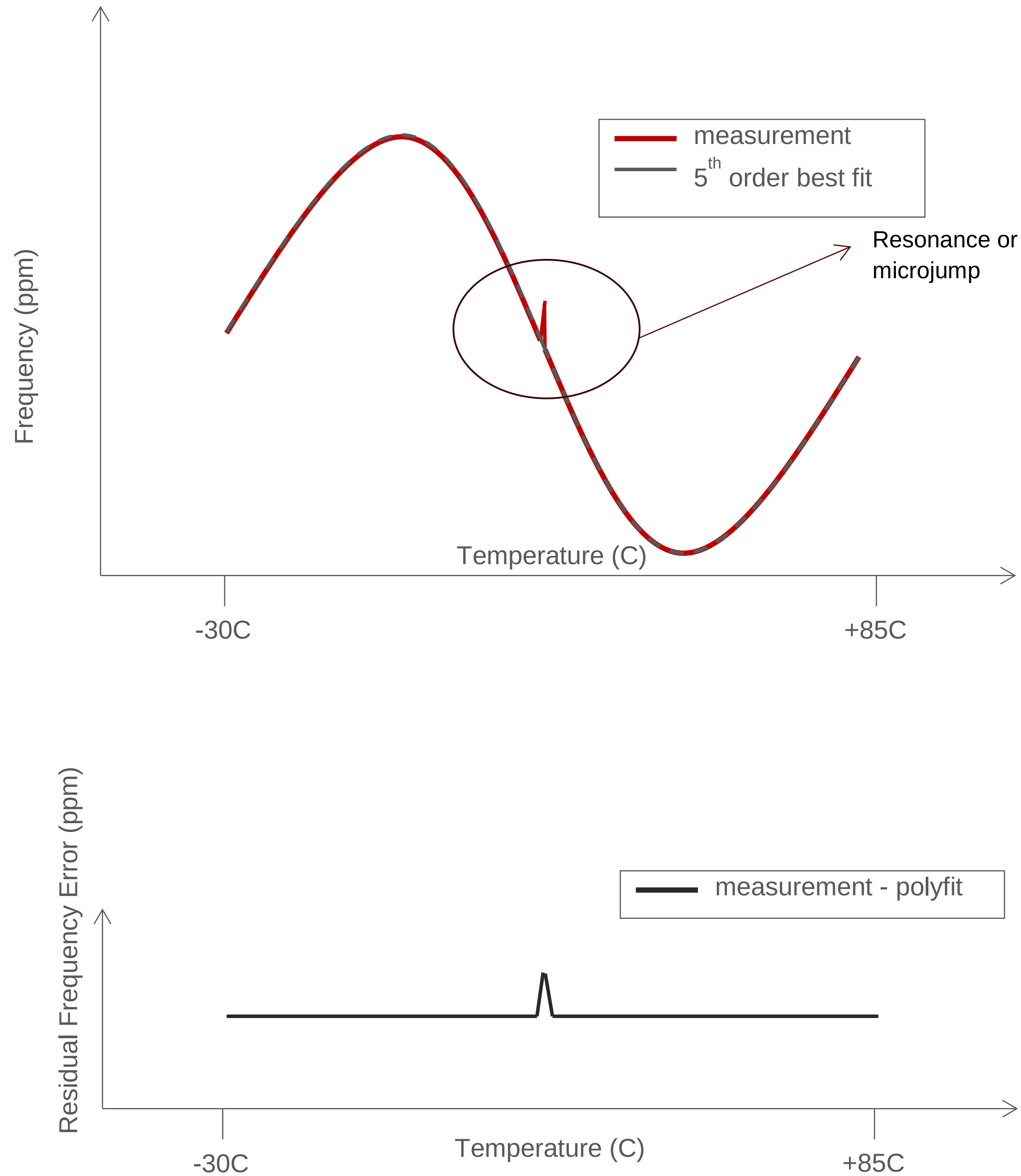

Figure 3-2 Measurement to locate resonances or micro-jumps

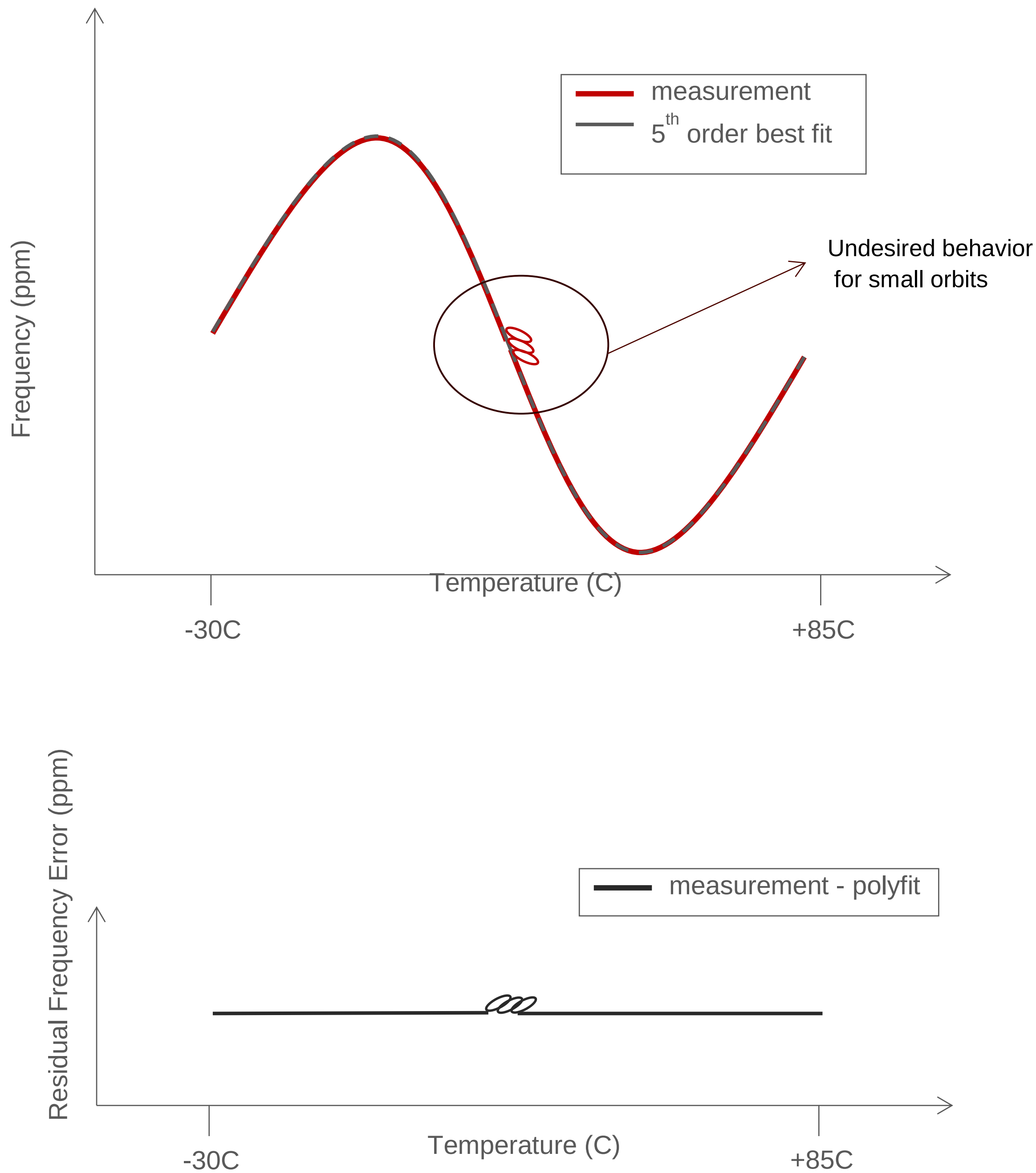

Figure 3-3 Measurement to locate small orbit hysteresis 1

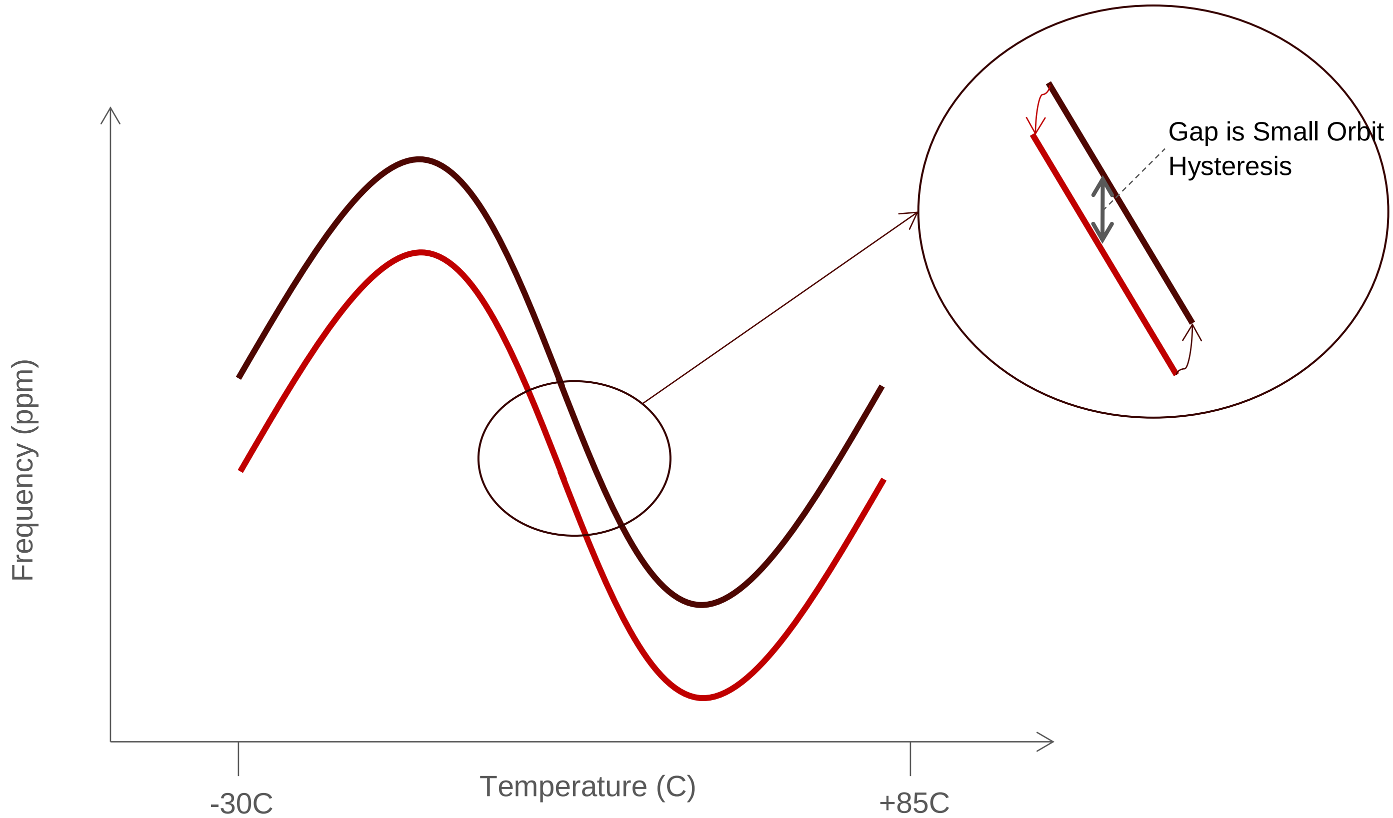

Figure 3-4 Measurement to locate hysteresis 2

4 Thermistor Specifications

- The thermistor can be discrete on the CCA next to the crystal or collocated within the crystal package.
- If the thermistor is located in the crystal package, the connection of the crystal and thermistor should be as shown in Figure 4-1. Pin 1 and pin 3 are the two terminals of the crystal; pin 2 is the ground and provides ground reference to the lid of the package. The thermistor is connected between pin 4 and terminated on pin 2. This integrated thermistor and crystal device is referred to as TH+Xtal. The crystal must meet 100% of the crystal specifications in Table 2-1 , and the thermistor must meet 100% of the thermistor specifications in Table 4-1.

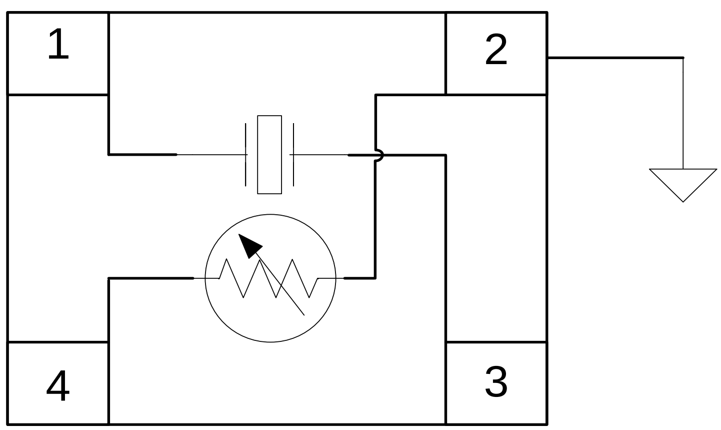

Figure 4-1 TH+Xtal connection diagram

Table 4-1 Thermistor specifications table

Parameter	Min	Nom	Max	Units	Notes
Operating temperature	-30		+105	°C	
Storage temperature	-40		+105	°C	
Resistance		100		kΩ	25°C
B-constant		4250		K	25–50°C
Tolerance			1	%	

A How to Find the Curve-Fitting Parameters

The FT curve of an AT-cut crystal can be modeled as a third-order polynomial.

$$f(t) = c_3(\theta)(t - t_0)^3 + c_2(\theta)(t - t_0)^2 + c_1(\theta)(t - t_0) \; + c_0$$

C0, C1, C2, and C3 are coefficients that need to be defined. The C1 and C3 parameter of the crystals must fall into a certain predetermined range for the system to estimate the resonant frequency of the crystal effectively. In the following sections, the details of the coefficient calculations are presented, and a range is listed of acceptable C1 and C3 coefficients.

A.1 FT data

The crystal vendors need to gather the FT data. The FT data should cover a temperature range from -30 to 105°C. The resolution should be 1°C (linear extrapolation can be used), and the frequency value should be in ppm and reflect the deviation from the frequency at 30°C.

A.2 C0

C0 is the frequency offset at 30°C.

A.3 C1

C1 is the average slope of the FT curve between 25°C and 35°C.

A.4 C3 and C2

- To calculate C3, find the difference between the measured FT curve and the first-order estimation from the C1 parameter. Next, find the C3 term using the third-order least square fit method. Use 30°C as t_0.
- To calculate C2, remove the third-order and first-order terms first from the FT curve. Next, find the C2 term using the second-order least square fit method. Use 30°C as t_0.

A.5 Coefficient range

- C0: ±10 ppm
- C1: -0.10 to -0.40 ppm/°C
- C2: -4.5×10^{-4} to 4.5×10^{-4} ppm/°C^2
- C3: 8.5×10^{-5} to 11.5×10^{-5} ppm/°C^3

A.6 Comments

C3 needs to be calculated before C2.

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