

# Crystals and Oscillators for Next Generation Timing Solutions

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## Introduction

This Application Note provides a list of oscillators available in compatible frequencies for use with Microsemi's PLLs, in various timing & synchronization applications that include clock synthesis, frequency conversion, numerically controlled oscillators, PDH, SONET/SDH, SyncE (Synchronous Ethernet) and IEEE 1588-2008. This list has been categorized based on applicable standards.

**These oscillators have been recommended by the oscillator manufacturer and have NOT been reviewed by Microsemi for compliance to the relevant requirements.**

As changes in system hardware, software or configuration may affect the overall performance of the oscillator in any customer system, designers should consult with their oscillator suppliers to satisfy themselves that the oscillator they select will be suitable for their requirements and follow supplier recommendations for support components and layout.

Reference to non-Microsemi supplied products is for convenience and information only and is not an endorsement or recommendation by Microsemi of such products. Microsemi makes no representation or warranty regarding such products and accepts no responsibility for the selection and use of such products.

The oscillators in this document support both physical layer and protocol layer synchronization PLLs. Both of these applications have different needs depending on the use case.

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## Physical Layer Synchronization

The oscillator requirements for physical layer synchronization are well defined in a variety of ITU-T and ATIS specifications. Namely

- Freerun accuracy – lifetime
- Holdover stability – drift under constant temperature conditions, which includes ageing
- Holdover stability – frequency variation due to variable temperature
- Wander generation (MTIE & TDEV), for the respective filter cut-off frequency, under constant temperature conditions
- Wander generation (MTIE & TDEV), for the respective filter cut-off frequency, under variable temperature conditions

The following are the general classifications used in this document

- Class A1. Used with 3 MHz filter bandwidth for compliance with E1-based ITU-T G.812 Type I (SSU) requirements.
- Class A2. Used with 1 MHz filter bandwidth for compliance with T1-based Stratum 3E & ITU-T G.812 Type III specifications. Note these oscillators may NOT be compliant with 3 MHz filter bandwidth E1-based ITU-T G.812 Type I (SSU) requirements.
- Class C2. Used with 0.1 Hz and higher filter bandwidths for compliance with T1-based hierarchy specifications such as ITU-T G.813 option 2 SEC, ITU-T G.8262 option 2 EEC, Stratum 3 for SONET, Stratum 3 & SMC. Note these oscillators may NOT be compliance with Class D2 requirements for E1-Based hierarchy specifications such as ITU-T G.813 option 1 SEC and ITU-T G.8262 option 2 EEC (specifically frequency stability at constant temperature).
- Class D2. Used with 1 Hz and higher filter bandwidths for compliance with E1-based hierarchy specifications such as ITU-T G.813 option 1 SEC, ITU-T G.8262 option 2 EEC.
- Class E. Used with 14 Hz and higher filter bandwidths for T1-based, E1-based and OTN line card use cases. Class E also used for Clock Synthesis applications.

Details on the test equipment, procedures and test-setups for qualifying oscillators can be found in ZLAN-472 (covering both Stratum 3 and Stratum 3E).

## Classification

Below list is a summary of the various classifications of oscillator for use in physical layer synchronization and protocol layer synchronization. Some classifications represent the superset requirements of closely related clocks (where an individual clock requirement may be less than that listed for the superset).

Oscillator Class	A1	A2	C2	D2	E
Superset Grouping			Stratum 3, SMC & Option 2 (PDH, SONET, SyncE)	Option 1 (SDH, SyncE)	Line Card
Telcordia Clock	N/A	Stratum 3E	Stratum 3 for SONET	N/A	Stratum 4
ITU-T Clock	Type I	Type III	G.813 Option 2, G.8262 Option 2	G.813 Option 1, G.8262 Option 1	
PLL implied Bandwidth	3mHz	1mHz	0.1Hz	1Hz	14Hz
Free-run Accuracy (ppm)	N/A	± 4.6	± 4.6	± 4.6	± 32
Frequency Stability (pk-pk) at Variable Temperature (ppb)	2 (Note 2)	10 (Note 2)	300 (Note1, 2)	2000 (Note 2)	N/A
Frequency Stability at Constant Temperature (ppb)	± 0.2	± 1	± 40	± 10	N/A
Wander Generation (MTIE, TDEV)	Refer to standard	Refer to standard	Refer to standard	Refer to standard	Refer to standard
Note 1: Telcordia GR-1244-CORE issue 3, revision 2005 specifies 280ppb pk-pk, Telcordia GR-1244-CORE issue 4, revision 2009 specifies 300ppb pk-pk Note 2: Some vendors will accept +/- range for variable temperature frequency stability rather than pk-pk (i.e. +/-300ppb vs. 300ppb pk-pk)					

Table 1 – Physical Layer Summary Table

## Detailed Manufacturer Information

### Class A1

Used with 3 mHz filter bandwidth for compliance with E1-based ITU-T G.812 Type I (SSU) requirements.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
A1	20MHz	OCXO	3.3V	SE	Rakon	STP 3309 LF (ROX2522S3)
A1	24.576MHz	OCXO	3.3V	SE	Rakon	STP 3310 LF (ROX2522S3)

Table 2 – Class A1 Oscillators

### Class A2

Used with 1 mHz filter bandwidth for compliance with T1-based Stratum 3E & ITU-T G.812 Type III specifications. Note these oscillators may NOT be compliant with class A1, used for 3 mHz filter bandwidth E1-based ITU-T G.812 Type I (SSU) requirements.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
A2	20MHz	OCXO	3.3V	SE	CTS	1180026-XXX, 1190100-XXX, 1380100-XXX
A2	20MHz	OCXO	3.3V	SE	CTS	149GVEN20M000
A2	20MHz	OCXO	3.3V	SE	Rakon	ROX2522S4 (STP2846LF ( $\pm 10$ ppb); STP2875LF (10ppb p-p))
A2	20MHz	OCXO	3.3V	SE	Rakon	ROM1490E (U6996LF)
A2	20MHz	OCXO	3.3V	SE	Rakon	RFPO45.G8263 (M6380LF)* RFPO55.G8263 (M6324LF)* *meets Stratum 3E requirements in any +/-20°C window within -40 to 85°C operating range)
A2	20MHz	OCXO	3.3V	SE	Vectron	OX-2022-EAE-1080-20M000000
A2	20MHz	OCXO	3.3V	SE	Vectron	OX-221-9100-20M000
A2	20MHz	OCXO	3.3V	SE	Vectron	OX-4033-EAE-1080-20M000*, *(meets frequency stability over any 40 °C window within -40 to 85°C)

Table 3 – Class A2 Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
A2	20MHz	OCXO	3.3V	SE	Vectron	OX-4022-EAE-1080-20M000* *(meets frequency stability over any 40 °C window within -40 to 85°C)
A2	20MHz	OCXO	3.3V	SE	Connor-Winfield	OH100-70503CF-020.0M, OH200-61003CF-020.0M, OH300-70503CF-020.0M
A2	20MHz	OCXO	3.3V	SE	Connor-Winfield	OH4610LF-20MHz*, DOCSC012F-20MHz* *meets Stratum 3E requirements in any +/-20°C window within -40 to 85°C operating range
A2	20MHz	OCXO	3.3V	SE	Raltron	OX2180A-D3-0.8-20.000-3.3-SMD
A2	20MHz	OCXO	3.3V	SE	Raltron	OX2180A-D3-1-20.000
A2	20MHz	OCXO	3.3V	SE	Raltron	OX2150A-D3-1-20.000-3.3-STR3E
A2	20MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4431A
A2	20MHz	OCXO	3.3V	SE	Taitien	NA-20M-012, NJ-20M-002, NF-20M-011
A2	20MHz	OCXO	3.3V	SE	Epson	OG2522CAN 20.000000MHz
A2	24.576MHz	OCXO	3.3V	SE	CTS	1380300-XXX, 1190300-XXX
A2	24.576MHz	OCXO	3.3V	SE	CTS	149GVEN24M576
A2	24.576MHz	OCXO	3.3V	SE	Rakon	ROX2522S4 (STP2979LF (±10ppb); STP3040LF (10ppb p-p))
A2	24.576MHz	OCXO	3.3V	SE	Rakon	ROM1490E (U6997LF)
A2	24.576MHz	OCXO	3.3V	SE	Rakon	RFPO45.G8263 (M6150LF)* RFPO55.G8263 * *(meets Stratum 3E requirements in any +/-20°C window within -40 to 85°C operating range)
A2	24.576MHz	OCXO	3.3V	SE	Vectron	OX-2022-EAE-1080-24M576
A2	24.576MHz	OCXO	3.3V	SE	Vectron	OX-221-9101-24M576
A2	24.576MHz	OCXO	3.3V	SE	Vectron	OX-4033-EAE-1080-24M576* *(meets frequency stability over any 40 °C window within -40 to 85°C)
A2	24.576MHz	OCXO	3.3V	SE	Vectron	OX-4022-EAE-1080-24M576* *(meets frequency stability over any 40 °C window within -40 to 85°C)
A2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	OH100-70503CF-024.576M, OH200-61003CF-024.576M, OH300-70503CF-024.576M
A2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	OH100-60503CF-024.576M, OH200-60503CF-024.576M

Table 3 – Class A2 Oscillators (continued)

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
A2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	OH4610LF-24.576MHz*, DOCSC012F-24.576MHz* *meets Stratum 3E requirements in any +/-20°C window within -40 to 85°C operating range
A2	24.576MHz	OCXO	3.3V	SE	Raltron	OX2180A-D3-0.8-24.576-3.3
A2	24.576MHz	OCXO	3.3V	SE	Raltron	OX2150A-D3-0.6-24.576-3.3
A2	24.576MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4432A
A2	49.152MHz	OCXO	3.3V	SE	CTS	149GVEN49M152
A2	49.152MHz	OCXO	3.3V	SE	Rakon	ROM1490E (U6874LF)
A2	49.152MHz	OCXO	3.3V	SE	Vectron	OX-221-9102-49M152
A2	49.152MHz	OCXO	3.3V	SE	Raltron	OX2150A-D3-0.5-49.152
A2	98.304MHz	OCXO	3.3V	SE	Rakon	ROM1490E (U6935LF)

Table 3 – Class A2 Oscillators (continued)

### Class C2 Intro

Used with 0.1 Hz and higher filter bandwidths for compliance with T1-based hierarchy specifications such as ITU-T G.813 option 2 SEC, ITU-T G.8262 option 2 EEC, Stratum 3 for SONET, Stratum 3 & SMC. Note these oscillators may NOT be compliance with Class D2 requirements for E1-Based hierarchy specifications such as ITU-T G.813 option 1 SEC and ITU-T G.8262 option 2 EEC (specifically frequency stability at constant temperature).

### Class D2 Intro

Used with 1 Hz and higher filter bandwidths for compliance with E1-based hierarchy specifications such as ITU-T G.813 option 1 SEC, ITU-T G.8262 option 1 EEC.

### Class C2 & Class D2 Combined

Table 4 shows oscillators suitable for both C2 and D2 applications.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
C2 and D2	20MHz	OCXO	3.3V	SE	CTS	1370100-XXX, 150GREN20M000
C2 and D2	20MHz	TCXO	3.3V	SE	CTS	579L200ITT, 581L200X2ITT
C2 and D2	20MHz	TCXO	3.3V	SE	Rakon	RPT7050J (E6341LF)
C2 and D2	20MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5627LF), RFPO55 (M6056LF)
C2 and D2	20MHz	TCXO	3.3V	SE	Vectron	TX-502-0038-20M0000
C2 and D2	20MHz	TCXO	3.3V	SE	Vectron	VT-803-EAE-2870-20M0000
C2 and D2	20MHz	TCXO	3.3V	SE	Vectron	VT-804-EAE-2870-20M0000
C2 and D2	20MHz	TCXO	3.3V	SE	Vectron	TX-801 (meets frequency stability over any 40 °C window within -40 to 85) TX-8010-EAE-2870-20M0
C2 and D2	20MHz	OCXO	3.3V	SE	Connor-Winfield	DOCAT102F-020.0M
C2 and D2	20MHz	TCXO	3.3V	SE	Connor-Winfield	TL602-020.0M
C2 and D2	20MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-20.000-3-TR
C2 and D2	20MHz	TCXO	3.3V	SE	Raltron	TX035A-HZ-0.1-20.000-3-TR
C2 and D2	20MHz	TCXO	3.3V/5V	SE	Raltron	TX235A-D3-0.28-20.000
C2 and D2	20MHz	OCXO	3.3V	SE	Raltron	OX2014A-D3-2-20.000-3.3
C2 and D2	20MHz	OCXO	3.3V	SE	Raltron	OX2014A-D3-1-20.000-3.3
C2 and D2	20MHz	TCXO	3.3V	SE	NDK	NT7050BC 20M ENA3864A, NT7050BC 20M ENA3863A
C2 and D2	20MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4433A
C2 and D2	20MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4427A
C2 and D2	20MHz	TCXO	3.3V	SE	Taitien	M0135-T-001-3, M0135-T-002-3
C2 and D2	20MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A20000KAW33TAD
C2 and D2	20MHz	TCXO	3.3V	SE	Epson	TG-5500CA-09N 20.000MHz, TG-5500CA-31N 20.000MHz
C2 and D2	20MHz	TCXO	3.3V	SE	Epson	TG5032CGN 20.000000MHz CMGHGA
C2 and D2	24.576MHz	OCXO	3.3V	SE	CTS	1370300-XXX, 150GREN24M576
C2 and D2	24.576MHz	TCXO	3.3V	SE	CTS	579L24CITT, 581L24CX2ITT
C2 and D2	24.576MHz	TCXO	3.3V	SE	Rakon	RPT7050J (E6177LF)
C2 and D2	24.576MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5834LF), RFPO55 (M6057LF)
C2 and D2	24.576MHz	TCXO	3.3V	SE	Vectron	VT-803-EAE-2870-24M5760
C2 and D2	24.576MHz	TCXO	3.3V	SE	Vectron	VT-804-EAE-2870-24M5760
C2 and D2	24.576MHz	TCXO	3.3V	SE	Vectron	TX-801 (meets frequency stability over any 40 °C window within -40 to 85) TX-8010-EAE-2870-24M576 TX-801-0007-24M576 TX-502-0034-24M576



Table 4 – Class C2 and D2 Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
C2 and D2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	DOCAT102F-024.576M
C2 and D2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	TL602-024.576M
C2 and D2	24.576MHz	TCXO	3.3V/5V	SE	Raltron	TX235A-D3-0.1-24.576
C2 and D2	24.576MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-24.576-3-TR
C2 and D2	24.576MHz	OCXO	3.3V	SE	Raltron	OX2114A-HZ-1-24.576-3.3
C2 and D2	24.576MHz	TCXO	3.3V	SE	NDK	NT7050BC 24M576 NEA3708A
C2 and D2	24.576MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4434A
C2 and D2	24.576MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4428A
C2 and D2	24.576MHz	TCXO	3.3V	SE	Taitien	M0135-T-003-3, M0135-T-004-3
C2 and D2	24.576MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A24576KAW33TAD
C2 and D2	24.576MHz	TCXO	3.3V	SE	Epson	TG-5500CA-27N 24.576MHz
C2 and D2	24.576MHz	TCXO	3.3V	SE	Epson	TG5032CGN 24.576000MHz CMGHGA
C2 and D2	49.152MHz	OCXO	3.3V	SE	CTS	150GREN49M152
C2 and D2	49.152MHz	TCXO	3.3V	SE	CTS	579L491ITT, 581L491X2ITT, VF901636-49.152MHz, VF901661-49.152MHz
C2 and D2	49.152MHz	TCXO	3.3V	SE	Rakon	RPT1490J (E6698LF),-RPT7050J (E7350LF)
C2 and D2	49.152MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M6905LF), RFPO55(M5990LF)
C2 and D2	49.152MHz	TCXO	3.3V	SE	Connor-Winfield	DTL602-049.152M
C2 and D2	49.152MHz	OCXO	3.3V	SE	Connor-Winfield	DOCAT102F-049.152M
C2 and D2	49.152MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-49.152-3-TR
C2 and D2	49.152MHz	OCXO	3.3V	SE	Raltron	OX2014A-LZ-1-49.152-3.3
C2 and D2	49.152MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4435A
C2 and D2	49.152MHz	TCXO	3.3V	SE	Epson	TG5032CGN 49.152000MHz CMGHGA
C2 and D2	98.304MHz	TCXO	3.3V	SE	CTS	VF901583-98.304MHz, VF901662- 98.304MHz
C2 and D2	98.304MHz	TCXO	3.3V	SE	Rakon	RHT1490J (E7351LF ±140ppb - 40/85)(E7256LF ±280ppb -40/85)
C2 and D2	98.304MHz	TCXO	3.3V	SE	Vectron	TX-500-0083-98M30400
C2 and D2	98.304MHz	OCXO	3.3V	SE	Connor-Winfield	DOCAT102F-098.304M
C2 and D2	98.304MHz	OCXO	3.3V	SE	Connor-Winfield	OH4650LF-098.304M
C2 and D2	98.304MHz	OCXO	3.3V	SE	Connor-Winfield	OHSM465LF-098.304M
C2 and D2	98.304MHz	TCXO	3.3V	Diff	Epson	TG7050EAN 98.30400MHz
C2 and D2	98.304MHz	TCXO	3.3V	SE	TXC	7K98370001 (14x9mm)
C2 and D2	114.285MHz	TCXO	3.3V	SE	CTS	VF901618-114.285MHz

Table 4 – Class C2 and D2 Oscillators (continued)

### Class C2

Table 5 shows oscillators suitable for Class C2 applications only.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
C2	20MHz	TCXO	3.3V	SE	TXC	7N20070002 (7.0x5.0mm), 7P20071004 (5.0x3.2mm)
C2	24.576MHz	TCXO	3.3V	SE	TXC	7N24570004 (7.0x5.0mm), 7P24571003 (5.0x3.2mm)
C2	49.152MHz	TCXO	3.3V	SE	TXC	7N49170003 (7.0x5.0mm), 7P49171001 (5.0x3.2mm)
C2	98.304MHz	OCXO	3.3V	SE	Vectron	OX-401-9015-98M304

Table 5 – Class C2 Oscillators (only, not meeting class D2)

### Class D2

Table 6 shows oscillators suitable for Class D2 applications only.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
D2	20MHz	TCXO	3.3V	SE	Connor-Winfield	T622-020.0M
D2	20MHz	TCXO	3.3V	SE	Connor-Winfield	T602-020.0M
D2	20MHz	TCXO	3.3V	SE	TXC	7N20070003 (7.0x5.0mm), 7P20071006 (5.0x3.2mm)
D2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	T622-024.576M
D2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	T602-024.576M
D2	24.576MHz	TCXO	3.3V	SE	TXC	7N24570003 (7.0x5.0mm), 7P24571002 (5.0x3.2mm)
D2	49.152MHz	TCXO	3.3V	SE	Connor-Winfield	TB602-049.152M
D2	49.152MHz	TCXO	3.3V	SE	Connor-Winfield	TB622-049.152M
D2	49.152MHz	TCXO	3.3V	SE	TXC	7N49170004 (7.0x5.0mm), 7P49171002 (5.0x3.2mm)
D2	98.304MHz	TCXO	3.3V	SE	Connor-Winfield	TB622-098.304M

Table 6 – Class D2 Oscillators (only, not meeting class C2)

### Class E

Used with 14 Hz and higher filter bandwidths for T1-based, E1-based and OTN line card use cases. Also listed are oscillators/crystals for Clock Synthesis applications

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
E	20MHz	Crystal	NA*	NA*	CTS	405I33C20M0000, 403I33C20M0000
E	20MHz	XO	3.3V	SE	CTS	632L5I020M0000, 625L5I020M0000, CB3LV-5I-20M0000, 632L3I020M0000, 625L3I020M0000
E	20MHz	XO	3.3V	SE	Rakon	RX05032M (509410)
E	20MHz	XO	3.3V	SE	Vectron	VCC4-B3F-20M0000
E	20MHz	XO	3.3V	SE	Vectron	VC-801-EAE-FAAN-20M0000
E	20MHz	XO	3.3V	SE	Connor-Winfield	HSM613-020.0M
E	20MHz	Crystal	NA*	NA*	Raltron	RH100-20.000-18-1030-TR
E	20MHz	XO	3.3V	SE	Raltron	CO43025-20.000-EXT-TR
E	20MHz	Crystal	NA*	NA*	NDK	NX3225SA-EXS00A-CS08878
E	20MHz	XO	3.3V	SE	NDK	2725T-ENA4411A
E	20MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410A
E	20MHz	XO	3.3V	SE	Taitien	M0135-L-001-3, M0135-L-003-3, M0135-L-005-3
E	20MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K20.0000C1HEXC
E	20MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K20.0000C1HEXC
E	20MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K20.0000C1HEXC
E	20MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K20.0000C1HEXC
E	20MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K20.0000C1HEXC
E	20MHz	Crystal	NA*	NA*	Epson	TSX-3225 20.0000M F
E	20MHz	Crystal	NA*	NA*	Epson	FA-20H 20.0000MA 30X-W
E	20MHz	XO	3.3V	SE	Epson	SG-210STF 20.000M S
E	20MHz	Crystal	NA*	NA*	TXC	7M20072001 (3.2x2.5mm)
E	20MHz	XO	3.3V	SE	TXC	8W20072001 (2.5x2.0mm)
E	24.576MHz	Crystal	NA*	NA*	CTS	406I35B24M57600, 403I33C24M57600, 405I33C24M57600
E	24.576MHz	XO	3.3V	SE	CTS	632L5I024M57600, 625L5I024M57600, CB3LV-5I-24M5760, 636L3I024M57600, 632L3I024M57600, 625L3I024M57600
E	24.576MHz	XO	3.3V	SE	Rakon	RX05032M (509401)
E	24.576MHz	XO	3.3V	SE	Vectron	VCC4-B3F-24M576000
E	24.576MHz	XO	3.3V	SE	Vectron	VC-801-EAE-EAAN-24M576000
E	24.576MHz	XO	3.3V	SE	Connor-Winfield	HSM613-024.576M
E	24.576MHz	Crystal	NA*	NA*	Raltron	RH100-24.576-18-F-2050-TR
E	24.576MHz	XO	3.3V	SE	Raltron	CO43025-24.5760-EXT-TR

\* NA = Not Applicable

Table 7 – Class E Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
E	24.576MHz	XO	3.3V	SE	Taitien	M0135-L-002-3, M0135-L-004-3, M0135-L-006-5
E	24.576MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410B
E	24.576MHz	XO	3.3V	SE	NDK	NZ2520SB 24.576M NEA3728A
E	24.576MHz	XO	3.3V	SE	NDK	2725T-ENA4411B,
E	24.576MHz	Crystal	NA*	NA*	NDK	NX32258A-EXS00A-CS08879
E	24.576MHz	XO	3.3V	SE	Taitien	M0135-L-002-3, M0135-L-004-3, M0135-L-006-3
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K24.5760C1HEXC
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K24.5760C1HEXC
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K24.5760C1HEXC
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K24.5760C1HEXC
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K24.5760C1HEXC
E	24.576MHz	Crystal	NA*	NA*	Epson	FA-238V-24576MB-C
E	24.576MHz	Crystal	NA*	NA*	Epson	TSX-3225 24.5760 F
E	24.576MHz	Crystal	NA*	NA*	Epson	FA-20H 24.5760MA 30X-W
E	24.576MHz	XO	3.3V	SE	Epson	SG-210STF 24.576M S
E	24.576MHz	Crystal	NA*	NA*	TXC	7M24572001 (3.2x2.5mm)
E	24.576MHz	XO	3.3V	SE	TXC	8W24572001 (2.5x2.0mm)
E	39.0625MHz	Crystal	NA*	NA*	CTS	40355028
E	39.0625MHz	Crystal	NA*	NA*	Vectron	VXM7-1150-39M062500
E	39.0625MHz	Crystal	NA*	NA*	Raltron	RH100-39.0625-9-1016-F-EXT-TR
E	39.0625MHz	Crystal	NA*	NA*	NDK	NC3225SA-EXS00A-CS08881
E	39.0625MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K39.0625C1HEXC
E	39.0625MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K39.0625C1HEXC
E	39.0625MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K39.0625C1HEXC
E	39.0625MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K39.0625C1HEXC
E	39.0625MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K39.0625C1HEXC
E	39.0625MHz	Crystal	NA*	NA*	TXC	7M39072001 (3.2x2.5mm)
E	49.152MHz	XO	3.3V	SE	CTS	632L5I049M15200, 625L5I049M15200, 632L3I049M15200, 625L3I049M15200
E	49.152MHz	XO	3.3V	SE	CTS	CB3LV10012
E	49.152MHz	Crystal	NA*	NA*	CTS	40355029
E	49.152MHz	XO	3.3V	SE	Rakon	RX05032M (509402)
E	49.152MHz	XO	3.3V	SE	Vectron	VCC4-B3F-49M152000,
E	49.152MHz	XO	3.3V	SE	Vectron	VC-801-EAE-EAAN-49M152000
E	49.152MHz	XO	3.3V	SE	Vectron	VCC1-1545-49M1520000
E	49.152MHz	Crystal	NA*	NA*	Vectron	VXM7-1149-49M152000
E	49.152MHz	XO	3.3V	SE	Connor-Winfield	HSM613-049.152M
E	49.152MHz	Crystal	NA*	NA*	Raltron	RH100-49.152-18-F-2050-TR

\* NA = Not Applicable

Table 7 – Class E Oscillators (continued)

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
E	49.152MHz	XO	3.3V	SE	Raltron	CO43025-49.152-TR
E	49.152MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410C
E	49.152MHz	XO	3.3V	SE	NDK	2725T-ENA4411C
E	49.152MHz	Crystal	NA*	NA*	NDK	NX3225SA-EXS00A-CS08882
E	49.152MHz	XO	3.3V	SE	Taitien	M0135-L-007-3, M0135-L-008-3, M0135-L-009-3
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K49.1520C1HEXC
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K49.1520C1HEXC
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K49.1520C1HEXC
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K49.1520C1HEXC
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K49.1520C1HEXC
E	49.152MHz	Crystal	NA*	NA*	Epson	FA-238-49.1520MB30X
E	49.152MHz	XO	3.3V	SE	Epson	SG-211SCE 49.152M
E	49.152MHz	XO	3.3V	SE	TXC	7X49172001 (3.2x2.5mm), 8W49172001 (2.5x2.0mm)
E	49.152MHz	Crystal	NA*	NA*	TXC	7M49170001 (3.2x2.5mm)
E	50MHz	Crystal	NA*	NA*	CTS	40355030
E	50MHz	XO	3.3V	SE	CTS	632L5I050M00000, 625L5I050M00000, 632L3I050M00000, 625L3I050M00000
E	50MHz	XO	3.3V	SE	CTS	CB3LV10011
E	50MHz	XO	3.3V	SE	Vectron	VCC1-1544-50M0000000
E	50MHz	Crystal	NA*	NA*	Vectron	VXM7-1148-50M000000
E	50MHz	XO	3.3V	SE	Connor-Winfield	HSM613-50MHz
E	50MHz	Crystal	NA*	NA*	Raltron	RH100-50.000-18-F-2050-TR
E	50MHz	XO	3.3V	SE	Raltron	CO46025-50.000-TR
E	50MHz	XO	3.3V	SE	NDK	2725T-ENA4411D
E	50MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410D
E	50MHz	Crystal	NA*	NA*	NDK	NX3225SA-EXS00A-CS08883
E	50MHz	XO	3.3V	SE	Taitien	M0135-L-010-3, M0135-L-012-3, M0135-L-014-3
E	50MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K50.0000C1HEXC
E	50MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K50.0000C1HEXC
E	50MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K50.0000C1HEXC
E	50MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K50.0000C1HEXC
E	50MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K50.0000C1HEXC
E	50MHz	Crystal	NA*	NA*	Epson	FA-238 50.0000MB30X-K
E	50MHz	Crystal	NA*	NA*	Epson	FA-20H 50.0000MA 30X-W
E	50MHz	XO	3.3V	SE	Epson	SG-210STF 50.000M S
E	50MHz	XO	3.3V	SE	TXC	7X50072003 (3.2x2.5mm), 8W50072001 (2.5x2.0mm)
E	50MHz	Crystal	NA*	NA*	TXC	7M50070021 (3.2x2.5mm)

\* NA = Not Applicable

Table 7 – Class E Oscillators (continued)

Class	Oscillator Frequency	Oscillat or Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
E	57.1425MHz	Crystal	NA*	NA*	Raltron	RH100-57.1425-1020-F-EXT-TR
E	57.1425MHz	Crystal	NA*	NA*	NDK	NX3225SA-EXS00A-CS08884
E	57.1425MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K57.1425C1HEXC
E	57.1425MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K57.1425C1HEXC
E	57.1425MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K57.1425C1HEXC
E	57.1425MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K57.1425C1HEXC
E	57.1425MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K57.1425C1HEXC
E	57.1425MHz	Crystal	NA*	NA*	TXC	7M57172001 (3.2x2.5mm)
E	60MHz	Crystal	NA*	NA*	CTS	403I33C60M00000
E	60MHz	XO	3.3V	SE	CTS	632L5I060M00000, 625L5I060M00000, CB3LV-5I-60M0000
E	60MHz	XO	3.3V	SE	Connor-Winfield	HSM613-60MHz
E	60MHz	Crystal	NA*	NA*	Raltron	RH100-60.000-18-F-2030-TR
E	60MHz	XO	3.3V	SE	Raltron	CO46025-60.000-EXT-T-TR
E	60MHz	Crystal	NA*	NA*	NDK	NX3225SA-EXS00A-CS08886
E	60MHz	XO	3.3V	SE	Taitien	M0135-L-011-3, M0135-L-013-3, M0135-L-015-3
E	60MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K60.0000C1HEXC
E	60MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K60.0000C1HEXC
E	60MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K60.0000C1HEXC
E	60MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K60.0000C1HEXC
E	60MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K60.0000C1HEXC
E	60MHz	Crystal	NA*	NA*	TXC	7M60070001 (3.2x2.5mm)
E	78.125MHz	XO	3.3V	SE	CTS	632L5I078M12500, 625L5I078M12500, CB3LV-5I-78M1250
E	78.125MHz	XO	3.3V	SE	Rakon	RXO7050M (509594)
E	78.125MHz	XO	3.3V	SE	Vectron	VCC1-1539-78M125000
E	78.125MHz	XO	3.3V	SE	Connor-Winfield	HSM613-78.125MHz
E	78.125MHz	XO	3.3V	SE	Raltron	CO46025-78.125-EXT-T-TR
E	78.125MHz	XO	3.3V	SE	NDK	2725T-ENA4411E
E	78.125MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410E
E	78.125MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K78.1250C1HEXC
E	78.125MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K78.1250C1HEXC
E	78.125MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K78.1250C1HEXC
E	78.125MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K78.1250C1HEXC
E	78.125MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K78.1250C1HEXC
E	98.304MHZ	XO	3.3V	SE	CTS	632L5I098M30400, 625L5I098M30400, CB3LV-5I-98M3040
E	98.304MHz	XO	3.3V	SE	Rakon	RXO7050M (509595)
E	98.304MHz	XO	3.3V	SE	Vectron	VCC1-1541-98M304000

\* NA = Not Applicable

Table 7 – Class E Oscillators (continued)

Class	Oscillator Frequency	Oscillator or Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
E	98.304MHz	XO	3.3V	SE	Connor-Winfield	HSM613-98.304MHz
E	98.304MHz	XO	3.3V	SE	Raltron	CO46025-98.304-EXT-T-TR
E	98.304MHz	XO	3.3V	SE	NDK	2725T-ENA4411F
E	98.304MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410F
E	98.304MHz	XO	3.3V	SE	Taitien	M0135-L-017-3,M0135-L-019-3
E	98.304MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K98.3040C1HEXC
E	98.304MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K98.3040C1HEXC
E	98.304MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K98.3040C1HEXC
E	98.304MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K98.3040C1HEXC
E	98.304MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K98.3040C1HEXC
E	98.304MHz	XO	3.3V	Diff	Epson	SG7050EEN 98.304000MHz CDGA**
E	98.304MHz	XO	3.3V	SE	TXC	7W98372001 (7.0x5.0mm)
E	114.285MHz	XO	3.3V	SE	CTS	632L5I114M28500, CB3LV10063
E	114.285MHz	XO	3.3V	SE	Rakon	RXO7050M (512382)
E	114.285MHz	XO	3.3V	SE	Vectron	VCC1-1536-114M285000, VCC1-1537-114M285000, VC-820-0010-114M285000, VC-820-0012-114M285000
E	114.285MHz	XO	3.3V	SE	Connor-Winfield	HSM613-114.285MHz
E	114.285MHz	XO	3.3V	SE	Raltron	CO46025-114.285-EXT-T-TR
E	114.285MHz	XO	3.3V	SE	Raltron	COM2305-114.285-EXT-T-TR
E	114.285MHz	XO	3.3V	SE	NDK	NZ2520SB-ENA4363A-TC±50ppm over -10 to 70 °C NZ2520SB-ENA4363B-TC±50ppm over -40 to 85 °C NZ2520SB-ENA4363C-TC±25ppm over -40 to 85 °C
E	114.285MHz	XO	3.3V	SE	Taitien	M0135-L-020-3
E	114.285MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K114.285C1HEXC
E	114.285MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K114.285C1HEXC
E	114.285MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K114.285C1HEXC
E	114.285MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K114.285C1HEXC
E	114.285MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K114.285C1HEXC
E	114.285MHz	XO	3.3V	Diff	Epson	SG7050EEN 114.285000MHz CDGA**
E	114.285MHz	XO	3.3V	SE	TXC	7WA1472001 (7.0x5.0mm), 7XA1472001 (3.2x2.5mm)
E	125MHz	XO	3.3V	SE	CTS	632L5I125M00000, CB3LV-5I-125M00000
E	125MHz	XO	3.3V	SE	Rakon	RXO7050M (509596)
E	125MHz	XO	3.3V	SE	Vectron	VCC1-1534-125M000000, VCC1-1535-125M000000, VC-820-0009-125M000000, VC-820-0011-125M000000

Table 7 – Class E Oscillators (continued)

Class	Oscillator Frequency	Oscillator or Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
E	125MHz	XO	3.3V	SE	Connor-Winfield	HSM613-125MHz
E	125MHz	XO	3.3V	SE	Raltron	CO46025-125.000-EXT-T-TR
E	125MHz	XO	3.3V	SE	Raltron	COM23025-125.000-EXT-T-TR
E	125MHz	XO	3.3V	SE	NDK	NZ2520SB-ENA4410G
E	125MHz	XO	3.3V	SE	NDK	2725T-ENA4411G
E	125MHz	XO	3.3V	SE	Taitien	M0135-L-016-3, M0135-L-018-3, M0135-L-021-3
E	125MHz	XO	3.3V	SE	AVX/Kyocera	KC7050K125.000C1HEXC
E	125MHz	XO	3.3V	SE	AVX/Kyocera	KC5032K125.000C1HEXC
E	125MHz	XO	3.3V	SE	AVX/Kyocera	KC3225K125.000C1HEXC
E	125MHz	XO	3.3V	SE	AVX/Kyocera	KC2520K125.000C1HEXC
E	125MHz	XO	3.3V	SE	AVX/Kyocera	KC2016K125.000C1HEXC
E	125MHz	XO	3.3V	Diff	Epson	SG7050EEN 125.000000MHz CDGA**
E	125MHz	XO	3.3V	SE	TXC	7WA2572007 (7.0x5.0mm), 7XA2572002 (3.2x2.5mm)
E	190MHz	XO	3.3V	SE	CTS	CB3LV-5I-190M0000
E	190MHz	XO	3.3V	SE	Vectron	VCC1-1546-190M00000
E	190MHz	XO	3.3V	SE	Connor-Winfield	X213-190MHz
E	190MHz	XO	3.3V	SE	Raltron	CO46025-190.000-EXT-T-TR
E	200MHz	XO	3.3V	SE	CTS	CB3LV-5I-200M0000
E	200MHz	XO	3.3V	SE	Rakon	RXO7050M (508604)
E	200MHz	XO	3.3V	SE	Vectron	VCC1-1538-200M000
E	200MHz	XO	3.3V	SE	Connor-Winfield	X213-200MHz
E	200MHz	XO	3.3V	SE	Raltron	CO46025-200.000-EXT-T-TR
E	200MHz	XO	3.3V	Diff	Epson	SG7050EEN 200.000000MHz CDGA**

Table 7 – Class E Oscillators (continued)



## Protocol Layer Synchronization

The oscillator requirements for protocol layer synchronization are not finalized as most of the ITU-T development work on synchronization over packet networks is still under development (in draft status, or incomplete). The following three classifications are used as a guide

- Class A2. Used for unaware networks with frequency synchronization, suitable for ITU-T G.8263. Also may be used for unaware networks with frequency or phase synchronization, based on ITU-T G.8261 Appendix VI profiles. Oscillator requirements are taken from Stratum 3E. Note that Microsemi has allocated 5 ppb pk-pk for the temperature effects of the Stratum 3E oscillator over a reduced temperature range profile for ITU-T G.8263 testing (see ITU-T G.8263 Amendment 1 Appendix VI).
- Class B. Used for partially aware networks (3-4 nodes) with phase synchronization, such as T-BC-P, T-TSC-P and T-TSC-A clocks. This class is under development in ITU-T G.8273.4 drafts and will be subject to change. Also may be used for unaware networks with relaxed frequency synchronization requirements, based on ITU-T G.8261 Appendix VI profiles.
- Class C1. Used for fully aware BC networks with phase synchronization suitable for ITU-T G.8273.2 T-BC and T-TSC. Note that the first revision of ITU-T G.8273.2 is published based on use of SyncE, but additional amendments and revisions are expected to clarify items such as wander generation and holdover stability when SyncE is not present. Therefore deviations (tougher requirements) from these requirements may be expected, especially related to wander generation (at 0.05 Hz) and holdover stability under variable temperature.
- Class D1. Used for fully aware BC networks when combined with EEC option 1 reference chain, with phase synchronization suitable for ITU-T G.8273.2 T-BC and T-TSC. Note that the first revision of ITU-T G.8273.2 is published, but additional amendments and revisions are expected to clarify items such as operation (possibly holdover) during loss of SyncE. Therefore deviations (tougher requirements) from these requirements may be expected, especially related to holdover performance under variable temperature conditions without SyncE.

## Handling Unknown Deployment Scenarios

When a system is designed to handle a variety of deployment scenarios (unaware networks, partially aware networks, fully aware networks) with differing performance requirements (frequency accuracy, frequency, phase alignment), it is suggested to use a class A2 oscillator or at least dual footprint a class A2 oscillator with a lower cost class oscillator (such as B).

## Classification

Below list is a summary of the various classifications of oscillator for use in physical layer synchronization and protocol layer synchronization. Some classifications represent the superset requirements of closely related clocks (where an individual clock requirement may be less than that listed for the superset).

Oscillator Class	A2	B	C1	D1/D2
Superset Grouping	Unaware Networks	Partially Aware Networks T-BC-P, T-TSC-P, T-TSC-A or Unaware Networks OC	Fully Aware Networks T-BC, T-TSC	Fully Aware Networks, combined with SyncE, T-BC, T-TSC (Note 2)
ITU-T Clock	G.8263 (Note 1)	G.8273.4 (Note 1)	G.8273.2 (Note 1)	G.8273.2 (Note 1)
Non- standardized network profiles	G.8261 Appendix VI	G.8261 Appendix VI		
PLL implied Bandwidth	1mHz	3mHz	TBD (0.05Hz)	1Hz for SyncE 0.05Hz for PTP
Free-run Accuracy (ppm)	± 4.6	± 4.6	± 4.6	± 4.6
Frequency Stability (pk-pk) at Variable Temperature (ppb)	10	TBD	TBD	TBD
Frequency Stability at Constant Temperature (ppb)	± 1	TBD (± 2)	± 10	± 10
Wander Generation (MTIE, TDEV)	Refer to Stratum 3E standard	Use Stratum 3E standard, but at PLL implied bandwidth (Note 3)	Refer to standard (Note 3)	Refer to standard (Note 3)
Estimated Frequency Stability (pk-pk) at Variable Temperature (ppb) to meet Wander Generation (Note 4)	5 (reduced temp range) 10 (full temp range)	TBD (100)	TBD (140 for 30°C/hr 340 for 12°C/hr)	TBD (2000)
<p>Note 1: Specifications under revision, under draft or no yet reached draft.</p> <p>Note 2: Oscillator must comply with both class D1 (G.8273.2) and class D2 (G.8262 option 1 EEC)</p> <p>Note 3: When measurement is performance on a PTP output there is up to 8 ns of additional timestamp noise. Therefore clearance/margin of 8 ns or 25% (whichever is larger) against the wander generation MTIE &amp; TDEV masks may be requested.</p> <p>Note 4: Assumption of linear response of oscillator to temperature ramp</p>				

Table 8 –Protocol Layer Summary

## Detailed Manufacturer Information

### Class A2

Used for unaware networks with frequency synchronization. Suitable for ITU-T G.8263 specification. Also used for unaware networks with frequency or phase synchronization, based on ITU-T G.8261 Appendix VI profiles.

See table in physical layer section above for suitable oscillators.

### Class B

Used for partially aware networks with phase synchronization, such as T-BC-P, T-TSC-P and T-TSC-A clocks. Used for unaware aware networks with relaxed frequency synchronization requirements, based on ITU-T G.8261 Appendix VI profiles.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
B	20MHz	OCXO	3.3V	SE	CTS	1380100-XXX, 1190100-XXX, 1490100-XXX
B	20MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5627LF), RFPO55 (M6056LF)
B	20MHz	OCXO	3.3V	SE	Vectron	OX-5011-EAE-2080-20M00
B	20MHz	OCXO	3.3V	SE	Connor-Winfield	OX400-620LF-020.0M, DOCSC022F-020.0M
B	20MHz	OCXO	3.3V	SE	Raltron	OX2114B-D3-2-20.000-3.3
B	20MHz	OCXO	3.3V	SE	Raltron	OX2120A-D3-2-20.000-3.3-SMD
B	20MHz	OCXO	3.3V	SE	Raltron	OX2150A-D3-1-20.000-3.3-STR3E
B	20MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4431A
B	20MHz	OCXO	3.3V	SE	Taitien	NK-20M-027
B	20MHz	OCXO	3.3V	SE	TXC	OD20070001 (21x13mm), OE20070002 (14x9mm)
B	24.576MHz	OCXO	3.3V	SE	CTS	1380300-XXX, 1190300-XXX, 1490300-XXX
B	24.576MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5834LF), RFPO55 (M6057LF)
B	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	OX400-620LF-024.576M, DOCSC022F-024.576M
B	24.576MHz	OCXO	3.3V	SE	Raltron	OX2114A-D3-3-24.576-3.3
B	24.576MHz	OCXO	3.3V	SE	Raltron	OX2150A-D3-2-24.576-3.3
B	24.576MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4432A
B	24.576MHz	OCXO	3.3V	SE	TXC	OD24570001 (21x13mm), OE24570001 (14x9mm)

Table 9 – Class B Oscillators

**Class C1**

Used for fully aware BC networks with phase synchronization suitable for ITU-T G.8273.2 T-BC and T-TSC.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
C1	20MHz	OCXO	3.3V	SE	CTS	1370100-xxx, 150GREN20M000
C1	20Mhz	TCXO	3.3V/5V	SE	Raltron	TX257A-D3-0.14-20.000
C1	20MHz	TCXO	3.3V	SE	Epson	TG5032CGN 20.000000MHz CMGHGA
C1	20MHz	OCXO	3.3V	SE	TXC	OD20070001 (21x13mm), OE20070002 (14x9mm)
C1	20MHz	TCXO	3.3V	SE	Taitien	M0135-T-005-3, M0135-T-007-3
C1	24.576MHz	OCXO	3.3V	SE	CTS	1370300-xxx, 150GREN24M576
C1	24.576MHz	TCXO	3.3V	SE	Epson	TG5032CGN 24.576000MHz CMGHGA
C1	24.576MHz	OCXO	3.3V	SE	TXC	OD24570001 (21x13mm), OE24570001 (14x9mm)
C1	24.576MHz	TCXO	3.3V	SE	Taitien	M0135-T-006-3, M0135-T-008-3
C1	49.152MHz	OCXO	3.3V	SE	CTS	150GREN49M152MHz
C1	49.152MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-49.152-3-TR
C1	49.152MHz	TCXO	3.3V	SE	Epson	TG5032CGN 49.152000MHz CMGHGA
C1	98.304MHz	TCXO	3.3V	SE	Raltron	TX2045A-LZ-0.28-98.304-3.3
C1	98.304MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-98.304-3.3-GL
C1	98.304MHz	TCXO	3.3V	SE	Epson	TG7050EAN 98.304000MHz

Table 10 – Class C1 Oscillators

### Class D1/D2

Used for fully aware BC networks when combined with EEC option 1 reference chain, with phase synchronization suitable for ITU-T G.8273.2 T-BC and T-TSC.

Class	Oscillator Frequency	Oscillator Type	Oscillator or Supply Voltage	Single Ended/Differential	Manufacturer	Part Number(s)
D1/D2	20MHz	OCXO	3.3V	SE	CTS	1370100-XXX, 150GREN20M000
D1/D2	20MHz	TCXO	3.3V	SE	CTS	579L200ITT, 581L200X2ITT
D1/D2	20MHz	TCXO	3.3V	SE	Connor-Winfield	T622F-020.0M
D1/D2	20MHz	TCXO	3.3V/5V	SE	Raltron	TX235A-D3-0.28-20.000
D1/D2	20MHz	TCXO	3.3V	SE	Epson	TG5032CGN 20.000000MHz CMGHGA
D1/D2	20MHz	TCXO	3.3V	SE	TXC	7N20070003 (7.0x5.0mm), 7P20071006 (5.0x3.2mm)
D1/D2	20MHz	TCXO	3.3V	SE	Taitien	M0135-T-001-3, M0135-T-002-3
D1/D2	24.576MHz	TCXO	3.3V	SE	CTS	579L24CITT, 581L24CX2ITT
D1/D2	24.576MHz	OCXO	3.3V	SE	CTS	1370300-xxx, 150GREN24M576
D1/D2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	T622F-024.576M
D1/D2	24.576MHz	TCXO	3.3V	SE	Epson	TG5032CGN 24.576000MHz CMGHGA
D1/D2	24.576MHz	TCXO	3.3V	SE	TXC	7N24570003 (7.0x5.0mm), 7P24571002 (5.0x3.2mm)
D1/D2	24.576MHz	TCXO	3.3V	SE	Taitien	M0135-T-003-3, M0135-T-004-3
D1/D2	49.152MHz	OCXO	3.3V	SE	CTS	150GREN49M152
D1/D2	49.152MHz	TCXO	3.3V	SE	CTS	579L491ITT, 581L491X2ITT, VF901636-49.152MHz, VF901661- 49.152MHz
D1/D2	49.152MHz	TCXO	3.3V	SE	Connor-Winfield	T622F-49.152M
D1/D2	49.152MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-49.152-3-TR
D1/D2	49.152MHz	TCXO	3.3V	SE	Epson	TG5032CGN 49.152000MHz CMGHGA
D1/D2	49.152MHz	TCXO	3.3V	SE	TXC	7N49170004 (7.0x5.0mm), 7P49171002 (5.0x3.2mm)
D1/D2	98.304MHz	TCXO	3.3V	SE	CTS	VF901583-98.304MHz, VF901662- 98.304MHz
D1/D2	98.304MHz	TCXO	3.3V	SE	Connor-Winfield	T622F-098.304M
D1/D2	98.304MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-98.304-3.3-GL
D1/D2	98.304MHz	TCXO	3.3V	SE	TXC	7K98370001 (14x9mm)
D1/D2	114.285MHz	TCXO	3.3V	SE	CTS	VF901618-114.285MHz

Table 11 – Class D1/D2 Oscillators

## General Notes

### Holdover Stability Parameter

Referencing Stratum 3E, the Telcordia GR-1244-CORE and ITU-T G.812 specifications indicate that upon entry into holdover the system will not drift more than 10 ppb from its current position due to changes in temperature. At the extreme, if the system were to enter holdover at the coldest temperature (say -40 °C) then it cannot move more than 10 ppb even if the temperature changes to the warmest temperature (say +85 °C). Thus the oscillator selected should have a maximum 10 ppb peak-peak variation over the full temperature range expected to be experienced during deployment. This temperature range may be less than industrial temperature range, if that is allowed for the deployment.

Likewise, referencing Stratum 3, the drift limit due to holdover is 280 ppb (Telcordia GR-1244-CORE, revision 2005) or 300 ppb (Telcordia GR-1244-CORE, revision 2009).

### Constant Temperature

In general constant temperature is taken as  $\pm 2.8^{\circ}\text{C}$  or  $\pm 5^{\circ}\text{F}$ . This therefore includes the drift due to ageing, but additionally some movement of the oscillator due to temperature changes. A maximum rate of change of temperature (under constant temperature conditions) of  $0.1^{\circ}\text{C}/\text{minute}$  may be reasonable.

### Variable Temperature

The total temperature range for which the system is qualified may fall into a variety of classifications (which are not listed here). The largest temperature range allowed should be the one used to select the oscillator. There are a few different specifications that may cover the maximum rate of change of temperature (under variable temperature conditions), notably  $0.5^{\circ}\text{C}/\text{minute}$  or  $20^{\circ}\text{C}/\text{hour}$ . Typically  $12^{\circ}\text{C}/\text{hour}$  may be acceptable.

In general the oscillator manufacturer will specify a temperature range over which the oscillator will meet one of the relevant specifications. The agreed/target temperature range is to be carefully chosen by the system designer in consultation with the oscillator manufacturer.

When the specified temperature range is wider for the same criteria (e.g. 10 ppb pk-pk stability over industrial vs. commercial temperature range) then it will decrease the frequency rate of change seen during a variable temperature test for the same temperature change rate.

### Example Temperature Profile

Microsemi may typically use the following temperature profile during characterization of oscillators, but this is not intended to replace or override industry environmental standards or those specified by individual system vendors or operators. The temperature profile has flat stabilization durations of 1 hour, a ramp rate of 12°C/hour and a peak-peak temperature variation of 125 °C.

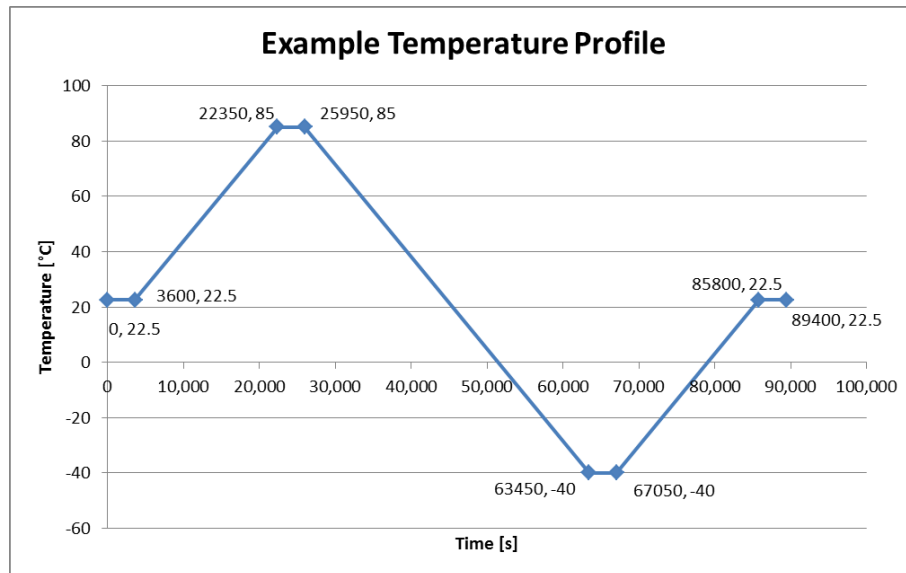


Figure 1 – Example Microsemi Temperature Profile

### Class A2 Temperature Consideration

In general a designer is recommended to use a Stratum 3E oscillator. Related to ITU-T G.8263, Microsemi has budgeted 5 ppb for the oscillator, from the overall 16 ppb budget, when it is desired to jointly test worst-case wander tolerance and variable temperature ramps. The remaining 11 ppb is allocated to the PDV filtering algorithm and some portions of the oscillator ageing.

ITU-T G.8263 Amd 1 (Appendix IV) and G.8273 Amd 1 (Appendix I) have added an informational Appendices to cover variable temperature profile. An example temperature ramp rate was 0.5 °C/min, with a temperature range of 40 °C pk-pk with stable temperature instances occurring at the minimum, mean and maximum temperature values. The temperature profile diagram is copied below for information.

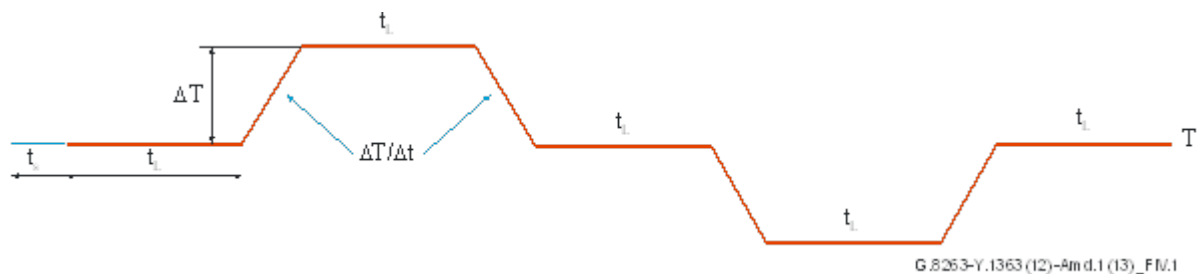


Figure 2 – Example Temperature Profile from ITU-T G.8263 Amd 1 and ITU-T G.8273 Amd 1.

## **Wander Generation Temperature Considerations**

Wander generation is not typically listed in an oscillator datasheet (where normally only frequency-based characteristics are listed). Nevertheless it is a critical parameter that the oscillator must meet in order for the overall system to comply with the relevant specification. Wander generation may be measured both at constant temperature and possibly also under variable temperature conditions.

## **Jitter Generation**

The jitter from the oscillator is an important contributing factor to the output jitter of the PLL. We have evaluated the jitter of our products in the lab with a number of crystals and XOs. Many of these are listed in this application note. There are too many oscillator options for us to evaluate them all. We recommend that you use oscillator vendor phase noise plots and information in ZLAN-442 to guide your selection. Based on the application jitter requirements, example oscillator phase noise plots are available upon request.





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