Crystals and Oscillators for Next Generation Timing Solutions

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.

Table of Contents

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 1 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	10	280	2000	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

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.

No list in this revision of the document.

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	ROX2522S (STP2846LF (±10ppb); 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-1080-20M0000000, OX-2211-EAE-3090-20M000, OX-4033-EAE-1080-20M000*, 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	NDK	NH25M22TA-ENA4431A
A2	20MHz	OCXO	3.3V	SE	Taitien	NF-20M-011, NA-20M-012, NJ-20M-002

Table 2 - Class A2 Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
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	ROX2522S (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, OX-2211-EAE-3090-24M576, OX-4033-EAE-1080-24M576*, 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	Raltron	OX2180A-D3-0.8-24.576-3.3, OX2150A-D3-0.6-24.576-3.3
A2	24.576MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4432A
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
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	49.152MHz	OCXO	3.3V	SE	Vectron	OX-2211-EAE-3090-49M152

Table 3 - Class A2 Oscillators (continued)

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 compliant 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	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
C2	20MHz	OCXO	3.3V	SE	CTS	1370100-XXX, 150GREN20M000
C2	20MHz	TCXO	3.3V	SE	CTS	579L200ITT, 581L200X2ITT
C2	20MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A20000KAW33TAD
C2	20MHz	TCXO	3.3V	SE	NDK	NT7050BC 20M ENA3864A, NT7050BC 20M ENA3863A
C2	20MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4433A
C2	20MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4427A
C2	20Mhz	TCXO	3.3V	SE	Rakon	RPT7050J (E6341LF)
C2	20Mhz	OCXO	3.3V	SE	Rakon	RFPO45 (M5627LF), RFPO55 (M6056LF)
C2	20MHz	TCXO	3.3V	SE	Vectron	TX-502-0038-20M0, VT-803, VT-804
C2	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	20MHz	TCXO	3.3V	SE	Epson	TG-5500CA-09N 20.000MHz, TG-5500CA-31N 20.000MHz
C2	20MHz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-020.0M
C2	20MHz	TCXO	3.3V	SE	Connor-Winfield	TL602-020.0M
C2	20MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-20.000-3-TR
C2	20MHz	OCXO	3.3V	SE	Raltron	OX2014A-D3-2-20.000-3.3
C2	20MHz	TCXO	3.3V	SE	TXC	7N20070002, 7P20071004
C2	20MHz	TCXO	3.3V	SE	Taitien	M0135-T-001-3, MT0135-T-002-3
C2	24.576MHz	OCXO	3.3V	SE	CTS	1370300-XXX, 150GREN24M576
C2	24.576MHz	TCXO	3.3V	SE	CTS	579L24CITT, 581L24CX2ITT
C2	24.576MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A24576KAW33TAD
C2	24.576MHz	TCXO	3.3V	SE	NDK	NT7050BC 24M576 NEA3708A
C2	24.576MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4434A
C2	24.576MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4428A
C2	24.576MHz	TCXO	3.3V	SE	Rakon	RPT7050J (E6177LF)
C2	24.576MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5834LF), RFPO55 (M6057LF)

Table 4 - Class C2 Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
C2	24.576MHz	TCXO	3.3V	SE	TXC	7N24570001, 7P245721001
C2	24.576MHz	TCXO	3.3V	SE	Vectron	VT-803, VT-804
C2	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-8010-EAE-1070-24M576
C2	24.576MHz	TCXO	3.3V	SE	Epson	TG-5500CA-27N 24.576MHz
C2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-024.576M
C2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	TL602-024.576M
C2	24.576MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-24.576-3-TR
C2	24.576MHz	OCXO	3.3V	SE	Raltron	OX2114A-HZ-1-24.576-3.3
C2	49.152MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-49.152-3-TR
C2	49.152MHz	OCXO	3.3V	SE	Raltron	OX2014A-LZ-1-49.152-3.3
C2	49.152MHz	TCXO	3.3V	SE	Epson	TG-5500CA-28N-49.152MHz
C2	49.152MHz	TCXO	3.3V	SE	Rakon	RPT1490J (E6698LF)
C2	49.152MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M6348LF), RFPO55 (M5990LF)
C2	49.152MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4435A
C2	49.152MHz	OCXO	3.3V	SE	CTS	150GREN49M152
C2	49.152MHz	TCXO	3.3V	SE	CTS	579L491ITT, 581L491X2ITT
C2	49.152MHz	TCXO	3.3V	SE	TXC	7N4917001
C2	98.304MHz	TCXO	3.3V	SE	CTS	VF901583-98.304MHz
C2	98.304MHz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-098.304M
C2	98.304MHz	TCXO	3.3V	SE	Connor-Winfield	TL602-098.304M
C2	98.304MHz	TCXO	3.3V	Diff	Epson	TG7050EAN 98.30400M
C2	98.304MHz	TCXO	3.3V	SE	Vectron	TX-500-0083-98M30400

Table 5 - Class C2 Oscillators (Continued)

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 1 EEC.

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
D2	20MHz	OCXO	3.3V	SE	CTS	1370100-XXX, 150GREN20M000
D2	20MHz	TCXO	3.3V	SE	CTS	579L200ITT, 581L200X2ITT
D2	20MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A20000KAW33TAD
D2	20MHz	TCXO	3.3V	SE	NDK	NT7050BC 20M ENA3864A, NT7050BC 20M ENA3863A
D2	20MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4433A
D2	20MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4427A
D2	20Mhz	TCXO	3.3V	SE	Rakon	RPT7050J (E6341LF)
D2	20Mhz	OCXO	3.3V	SE	Rakon	RFPO45 (M5627LF), RFPO55 (M6056LF)
D2	20MHz	TCXO	3.3V	SE	Vectron	VT-803, VT-804
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
D2	20MHz	TCXO	3.3V	SE	Epson	TG-5500CA-09N 20.000MHz, TG-5500CA-31N 20.000MHz
D2	20Mhz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-020.0M
D2	20MHz	TCXO	3.3V	SE	Connor-Winfield	T200F-020.0M
D2	20MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-20.000-3-TR
D2	20MHz	OCXO	3.3V	SE	Raltron	OX2014A-D3-2-20.000-3.3
D2	20MHz	TCXO	3.3V	SE	TXC	7N20070002, 7P20071004
D2	20MHz	TCXO	3.3V	SE	Taitien	M0135-T-001-3, MT0135-T-002-3
D2	24.576MHz	TCXO	3.3V	SE	CTS	579L24CITT, 581L24CX2ITT
D2	24.576MHz	TCXO	3.3V	SE	AVX/Kyocera	KT7050A24576KAW33TAD
D2	24.576MHz	TCXO	3.3V	SE	NDK	NT7050BC 24M576 NEA3708A
D2	24.576MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4434A
D2	24.576MHz	TCXO	3.3V	SE	NDK	NT5032UA-ENA4428A
D2	24.576MHz	TCXO	3.3V	SE	Rakon	RPT7050J (E6177LF)
D2	24.576MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M5834LF), RFPO55 (M6057LF)

Table 6 - Class D2 Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
D2	24.576MHz	TCXO	3.3V	SE	TXC	7N24570001, 7P245721001
D2	24.576MHz	TCXO	3.3V	SE	Vectron	VT-803, VT-804
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
D2	24.576MHZ	TCXO	3.3V	SE	Epson	TG-5500CA-27N 24.576MHz
D2	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-024.576M
D2	24.576MHz	TCXO	3.3V	SE	Connor-Winfield	T200F-024.576M
D2	24.576MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-24.576-3-TR
D2	24.576MHz	OCXO	3.3V	SE	Raltron	OX2114A-HZ-1-24.576-3.3
D2	49.152MHz	TCXO	3.3V	SE	Raltron	TX257A-D3-0.28-49.152-3-TR
D2	49.152MHz	OCXO	3.3V	SE	Raltron	OX2014A-LZ-1-49.152-3.3
D2	49.152MHz	TCXO	3.3V	SE	Epson	TG-5500CA-28N 49.152MHz
D2	49.152MHz	TCXO	3.3V	SE	Rakon	RPT1490J (E6698LF)
D2	49.152MHz	OCXO	3.3V	SE	Rakon	RFPO45 (M6384LF), RFPO55 (M5990LF)
D2	49.152MHz	OCXO	3.3V	SE	Connor-Winfield	DOC102F-049.152M
D2	49.152MHz	TCXO	3.3V	SE	Connor-Winfield	TB602-049.152M
D2	49.152MHz	OCXO	3.3V	SE	NDK	NH14M09WA-ENA4435A
D2	49.152MHz	OCXO	3.3V	SE	CTS	150GREN49M152
D2	49.152MHz	TCXO	3.3V	SE	CTS	579L491ITT, 581L491X2ITT
D2	49.152MHz	TCXO	3.3V	SE	TXC	7N4917001
D2	98.304Mhz	TCXO	3.3V	SE	CTS	VF901583-98.304MHz
D2	98.304MHz	TCXO	3.3V	SE	Connor-Winfield	TB622-098.304M
D2	98.304MHz	TCXO	3.3V	Diff	Epson	TG7050EAN 98.30400M
D2	98.304MHz	TCXO	3.3V	SE	Vectron	TX-500-0083-98M30400

Table 7 - Class D2 Oscillators (Continued)

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	632L3I020M0000, 625L3I020M0000
E	20MHz	XO	3.3V	SE	Rakon	RX05032M (509410)
E	20Mhz	XO	3.3V	SE	Vectron	VCC4, VC-801
E	20MHz	Crystal	NA	NA	Epson	TSX-3225 20.0000M F
E	20MHz	XO	3.3V	SE	Epson	SG-210STF 20.000M S
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	Crystal	NA	NA	TXC	7M20072001
E	20MHz	XO	3.3V	SE	TXC	8W20072001
E	24.576MHz	Crystal	NA	NA	CTS	406I35B24M57600, 403I33C24M57600, 405I33C24M57600
E	24.576MHz	XO	3.3V	SE	CTS	636L3I024M57600, 632L3I024M57600, 625L31024M57600
E	24.576MHz	Crystal	NA	SE	Epson	FA-238V-24576MB-C
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	Rakon	RX05032M (509401)
E	24.576MHz	XO	3.3V	SE	Vectron	VCC4, VC-801
E	24.576MHz	XO	3.3V	SE	AVX/Kyocera	KC2520C24.5760CSLEXA
E	24.576MHz	Crystal	NA	NA	Epson	TSX-3225 24.5760 F
E	24.576MHz	XO	3.3V	SE	Connor-Winfield	HSM613-024.576M
E	24.576MHz	XO	3.3V	SE	Epson	SG-210STF 24.576M S
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
E	24.576MHz	XO	3.3V	SE	Taitien	M0135-L-002-3, M0135-L-004-3, M0135-L-006-5
E	24.576MHz	Crystal	NA	NA	TXC	7M24572001
E	24.576MHz	XO	3.3V	SE	TXC	8W24572001

Table 8 - Class E Crystals and Oscillators

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
E	39.0625MHz	Crystal	NA	NA	Vectron	VXM7-1150-39M062500
E	39.0625MHz	Crystal	NA	NA	NDK	NC3225SA-EXS00A-CS08881
E	39.0625MHz	Crystal	NA	NA	CTS	40355028
E	39.0625MHz	Crystal	NA	NA	TXC	7M39072001
E	49.152MHz	XO	3.3V	SE	CTS	632L3I049M15200, 625L31049M15200
E	49.152MHz	XO	3.3V	SE	CTS	CB3LV10012
E	49.152MHz	XO	3.3V	SE	Rakon	RX05032M (509402)
E	49.152MHz	XO	3.3V	SE	Vectron	VCC4, VC-801, VCC1-1545-49M1520000
E	49.152MHz	XO	3.3V	SE	AVX/Kyocera	KC2520C49.1520C2LEXA
E	49.152MHz	XO	3.3V	SE	TXC	7X49172001, 8W49172001
E	49.152MHz	Crystal	NA	NA	TXC	7M49170001
E	49.152MHz	Crystal	NA	NA	Vectron	VXM7-1149-49M152000
E	49.152MHz	Crystal	NA	NA	CTS	40355029
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	Connor-Winfield	HSM613-049.152M
E	49.152MHz	Crystal	NA	NA	Raltron	RH100-49.152-18-F-2050-TR
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	50MHz	XO	3.3V	SE	Vectron	VCC1-1544-50M0000000
E	50MHz	XO	3.3V	SE	TXC	7X50072003, 8W50072001
E	50MHz	Crystal	NA	NA	TXC	7M50070021
E	50MHz	Crystal	NA	NA	Vectron	VXM7-1148-50M000000
E	50MHz	Crystal	NA	NA	CTS	40355030
E	50MHz	XO	3.3V	SE	CTS	632L31050M00000, 625L31050M00000
E	50MHz	XO	3.3V	SE	CTS	CB3LV10011
E	50MHz	Crystal	NA	NA	Epson	FA-238 50.0000MB30X-K
E	50MHz	XO	3.3V	SE	Epson	SG-210STF 50.000M S
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	XO	3.3V	SE	Connor-Winfield	HSM613-50MHz
E	50MHz	Crystal	NA	NA	NDK	NX3225SA-EXS00A-CS08883
E	57.1425MHz	Crystal	NA	NA	TXC	7M57172001
E	57.1425MHz	Crystal	NA	NA	NDK	NX3225SA-EXS00A-CS08884

Table 9 - Class E Crystals and Oscillators (Continued)

Class	Oscillator Frequency	Oscillator Type	Oscillator Supply Voltage	Single Ended/ Differential	Manufacturer	Part Number(s)
E	60MHz	Crystal	NA	NA	TXC	7M60070001
E	60MHz	Crystal	NA	NA	NDK	NX3225SA-EXS00A-CS08886
E	60MHz	XO	3.3V	SE	Connor-Winfield	HSM613-60MHz
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	NDK	2725T-ENA4411E
E	78.125MHz	XO	3.3V	SE	NDK	NZ2520SD-ENA4410E
E	78.125MHz	XO	3.3V	SE	Connor-Winfield	HSM613-78.125MHz
E	98.304MHz	XO	3.3V	SE	Rakon	RXO7050M (509595)
E	98.304MHz	XO	3.3V	SE	Vectron	VCC1-1541-98M304000
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	Connor-Winfield	HSM613-98.304MHz
E	98.304MHz	XO	3.3V	SE	TXC	7W98372001
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	Rakon	RXO7050M (512382)
E	114.285MHz	XO	3.3V	SE	TXC	7WA1472001, 7XA1472001
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	Connor-Winfield	HSM613-114.285MHz
E	125MHz	XO	3.3V	SE	Vectron	VCC1-1534-125M000000, VCC1-1535-125M000000, VC-820-0009-125M000000, VC-820-0011-125M000000
E	125MHz	XO	3.3V	SE	Rakon	RXO7050M (509596)
E	125MHz	XO	3.3V	SE	TXC	7WA2572007, 7XA2572002
E	125MHz	XO	3.3V	SE	NDK	NZ2520SB-ENA4410G
E	125MHz	XO	3.3V	SE	NDK	2725T-ENA4411G
E	125MHz	XO	3.3V	SE	Connor-Winfield	HSM613-125MHz
E	190MHz	XO	3.3V	SE	Vectron	VCC1-1546-190M00000
E	190MHz	XO	3.3V	SE	Connor-Winfield	X213-190MHz
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

Table 10 - Class E Crystals and 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 and/or ITU-T G.8261.1 PDV network limits. Used for unaware networks with frequency synchronization, based on ITU-T G.8261 Appendix VI profiles. Note that the first revision on ITU-T G.8263 is published, but additional amendments and revisions are expected to clarify items such as wander tolerance testing. Oscillator requirements are taken from Stratum 3E. Note that Microsemi (API v4) 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 APTSC clocks. This class is under development in ITU-T G.8273.2 and G.8273.4 drafts and will be subject to change. Also may be used for unaware aware 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, but additional amendments and revisions are expected to clarify items such as wander generation (TDEV), wander generation under variable temperature and holdover. 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 wander generation (TDEV), wander generation under variable temperature and holdover. Therefore deviations (tougher requirements) from these requirements may be expected, especially related to holdover performance under variable temperature conditions without SyncE.

Class A2 Temperature Consideration

In general a designer is recommended to use a Stratum 3E oscillator. Microsemi (API v4) has budgeted 5 ppb for the oscillator, from the overall 16 ppb budget, when it is desired to jointly test worse-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 added an informational Appendix VI 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 from ITU-T G.8263 Amd 1 is copied below for information. Note that ITU-T G.8263 remains under development for wander tolerance patterns that may impact the oscillator noise budget.

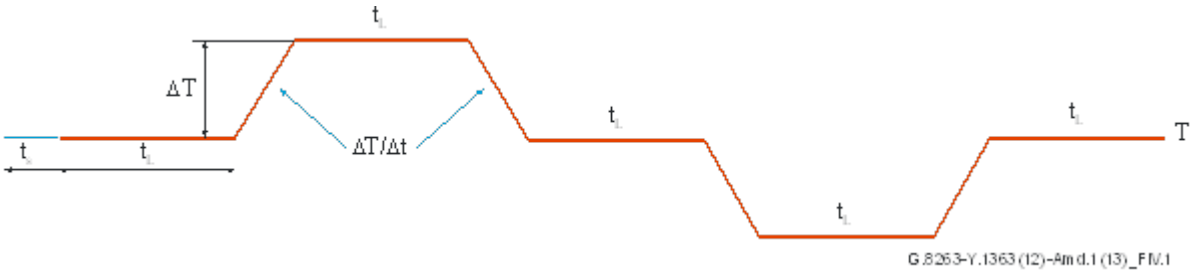

Figure 1 – Example Temperature Profile from ITU-T G.8263 Amd 1

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
Superset Grouping	Unaware Networks	Partially Aware Networks T-BC-P, T-TSC-P, APTSC 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.8273.2, 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	0.05Hz (TBD 0.08 Hz max 0.1 Hz)	1 Hz (TBD 0.8 Hz max 10 Hz)
Free-run Accuracy (ppm)	± 4.6	± 4.6	± 4.6	± 4.6
Frequency Stability (pk-pk) at Variable Temperature (ppb)	5 (reduced temp range) 10 (full temp range)	TBD (100)	TBD (200)	TBD (2000)
Frequency Stability at Constant Temperature (ppb)	± 1	± 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)
Note 1: Specifications under revision, under draft or no yet reached draft. Note 2: Oscillator must comply with both class D1 (G.8273.2) and class D2 (G.8262 option 1 EEC) 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 & TDEV masks may be requested.				

Table 11 – Protocol Layer Summary Table

Detailed Manufacturer Information

Class A2

Used for unaware networks with frequency synchronization, suitable for ITU-T G.8263 and/or ITU-T G.8261.1 PDV network limits. Used for unaware networks with frequency 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 APTSC 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	Taitien	NK-20M-027
B	20MHz	OCXO	3.3V	SE	NDK	NH25M22TA-ENA4431A
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	NDK	NH25M22TA-ENA4432A
B	24.576MHz	OCXO	3.3V	SE	Connor-Winfield	OX400-620LF-024.576M,DOCSC022F-024.576M

Table 12 - 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.

No list in this revision of the document.

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.

No list in this revision of the document.

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, the specifications related to Stratum 3 limit drift due to holdover to 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 ±2.8°C or ±5°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°C/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°C/minute or 20°C/hour. Typically 12°C/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.

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.

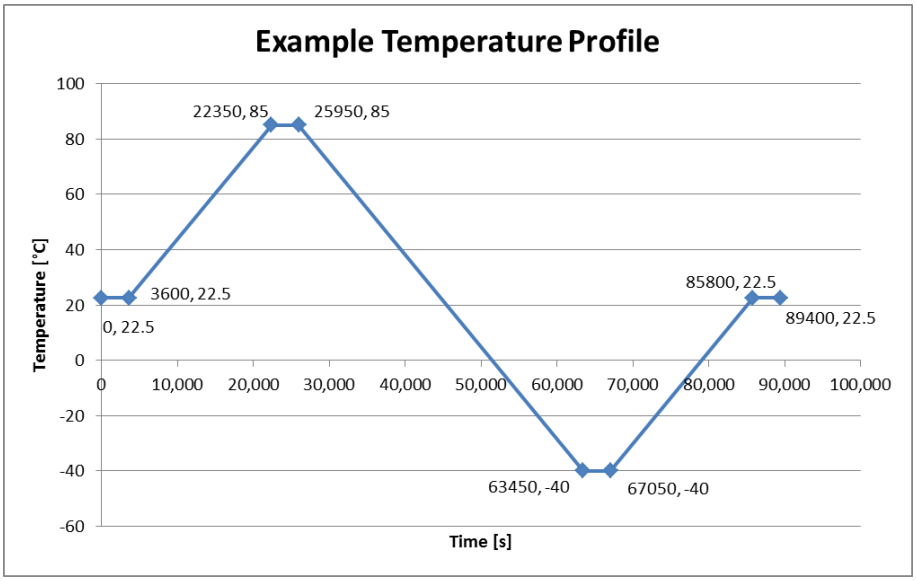

Figure 2 – Example Microsemi Temperature Profile

Wander Generation & Temperature

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

Microsemi Corporate Headquarters
One Enterprise, Aliso Viejo,
CA 92656 USA

Within the USA: +1 (800) 713-4113
Outside the USA: +1 (949) 380-6100
Sales: +1 (949) 380-6136
Fax: +1 (949) 215-4996

E-mail: sales.support@microsemi.com

Microsemi Corporation (MSCC) offers a comprehensive portfolio of semiconductor and system solutions for communications, defense & security, aerospace and industrial markets. Products include high-performance and radiation-hardened analog mixed-signal integrated circuits, FPGAs, SoCs and ASICs; power management products; timing and synchronization devices and precise time solutions, setting the world's standard for time; voice processing devices; RF solutions; discrete components; security technologies and scalable anti-tamper products; Ethernet solutions; Power-over-Ethernet ICs and midspans; as well as custom design capabilities and services. Microsemi is headquartered in Aliso Viejo, Calif., and has approximately 3,600 employees globally. Learn more at **www.microsemi.com**.

ZLAN-442/09-2015