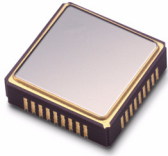




GENERAL DESCRIPTION

The M2006-02A is a VCISO (Voltage Controlled SAW Oscillator) based clock generator PLL designed for clock frequency translation and jitter attenuation. The device supports both forward and inverse FEC (Forward Error Correction) clock multiplication ratios. Multiplication ratios are pin-selected from pre-programming look-up tables.



FEATURES

- ◆ **Reduced intrinsic output jitter and improved power supply noise rejection** compared to [M2006-02](#)
- ◆ **Low phase jitter of 0.25 ps rms typical** (12kHz to 20MHz or 50kHz to 80MHz)
- ◆ **Pin-selectable PLL divider ratios support forward and inverse FEC ratio translation, including:**
 - 255/238 (OTU1) Mapping and 238/255 De-mapping
 - 255/237 (OTU2) Mapping and 237/255 De-mapping
 - 255/236 (OTU3) Mapping and 236/255 De-mapping
- ◆ **Input reference and VCISO frequencies up to 700MHz, supports loop timing modes** (Specify VCISO frequency at time of order)
- ◆ **Supports active switching between inverse-FEC and non-FEC clock ratios (same VCISO center frequency)**
- ◆ **Ideal for complex ratio FEC ratio translation and for use with an unstable reference (i.e., similar to the [M2006-12A](#) - and pin-compatible - but without the Hitless Switching and Phase Build-out functions)**
- ◆ **Single 3.3V power supply**
- ◆ **Small 9 x 9 mm SMT (surface mount) package**

PIN ASSIGNMENT (9 x 9 mm SMT)

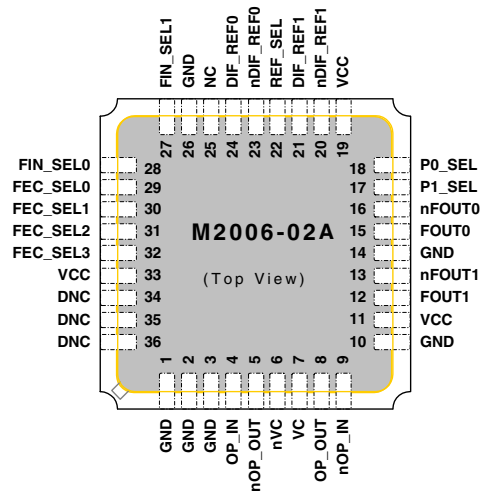


Figure 1: Pin Assignment

Example I/O Clock Combinations Using M2006-02A-622.0800

PLL Ratio	Input Clock (MHz)	Output Clock (MHz)
1/1	622.08, 155.52, 77.76, or 19.44	622.08 or 155.52
237/255 (inverse FEC)	669.3266, 167.3316, 83.6658, or 20.9165	155.52

Table 1: Example I/O Clock Combinations Using M2006-02A-622.0800

Using M2006-02A-669.3266

PLL Ratio	Input Clock (MHz)	Output Clock (MHz)
237/255 (FEC rate)	622.08, 155.52, 77.76, or 19.44	669.3266 or 167.3316
1/1	669.3266, 167.3316, 83.6658, or 20.9165	167.3316

Table 2: Example I/O Clock Combinations Using M2006-02A-669.3266

SIMPLIFIED BLOCK DIAGRAM

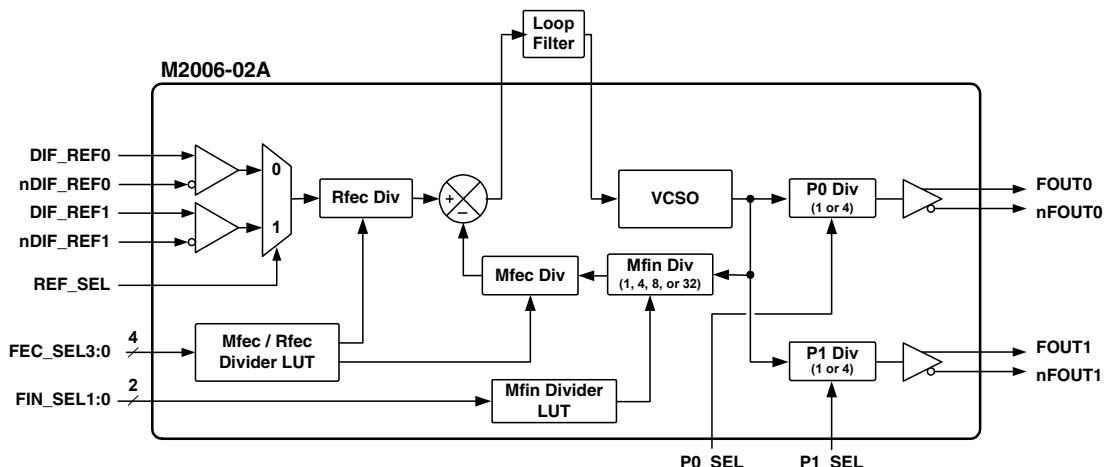


Figure 2: Simplified Block Diagram



DETAILED BLOCK DIAGRAM

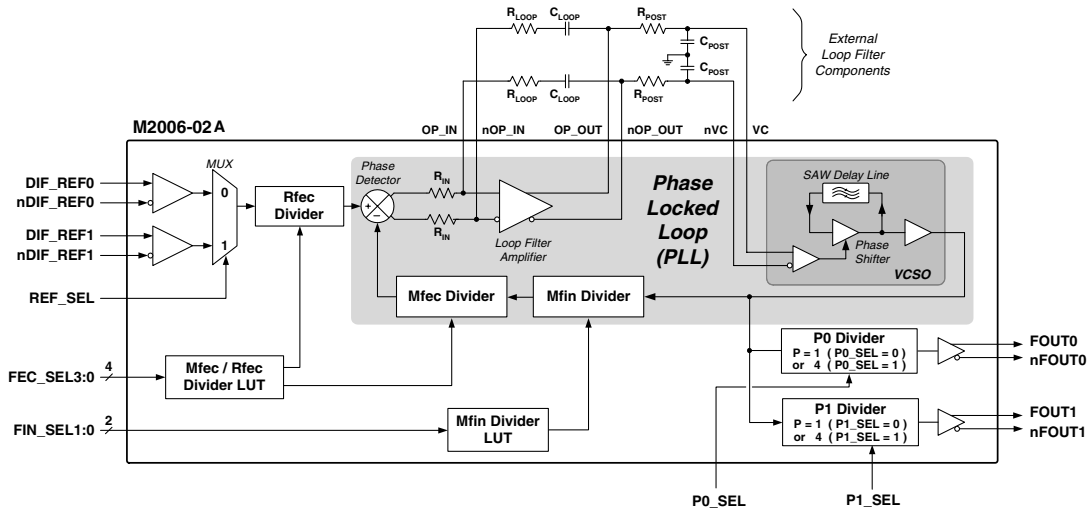


Figure 3: Detailed Block Diagram

PIN DESCRIPTIONS

Number	Name	I/O	Configuration	Description
1, 2, 3, 10, 14, 26	GND	Ground		Power supply ground connections.
4	OP_IN	Input		
9	nOP_IN	Input		
5	nOP_OUT	Output		External loop filter connections. See Figure 4.
8	OP_OUT	Output		
6	nVC	Input		
7	VC	Input		
11, 19, 33	VCC	Power		Power supply connection, connect to +3.3V.
12, 13	FOUT1, nFOUT1	Output	No internal terminator	Clock output pairs. Differential LVPECL.
15, 16	FOUT0, nFOUT0	Output	No internal terminator	
17	P1_SEL	Input	Internal pull-down resistor ¹	P Divider controls. LVCMOS/LVTTL. (For P0_SEL, P1_SEL, see Table 6 on pg. 3.)
18	P0_SEL	Input	Internal pull-down resistor ¹	
20	nDIF_REF1	Input	Internal pull-UP resistor ¹	Reference clock input pair 1. Differential LVPECL or LVDS.
21	DIF_REF1	Input	Internal pull-down resistor ¹	
22	REF_SEL	Input	Internal pull-down resistor ¹	Reference clock input selection. LVCMOS/LVTTL: Logic 1 selects DIF_REF1, nDIF_REF1. Logic 0 selects DIF_REF0, nDIF_REF0.
23	nDIF_REF0	Input	Internal pull-UP resistor ¹	Reference clock input pair 0. Differential LVPECL or LVDS.
24	DIF_REF0	Input	Internal pull-down resistor ¹	
25	NC			No internal connection.
27	FIN_SEL1	Input	Internal pull-down resistor ¹	Input clock frequency selection. LVCMOS/LVTTL. (For FIN_SEL1:0, see Table 4 on pg. 3.)
28	FIN_SEL0	Input	Internal pull-down resistor ¹	
29	FEC_SEL0	Input	Internal pull-UP resistor ¹	FEC PLL divider ratio selection. LVCMOS/ LVTTL. (For FEC_SEL3:0, see Table 5 on pg. 3.)
30	FEC_SEL1	Input	Internal pull-UP resistor ¹	
31	FEC_SEL2	Input	Internal pull-UP resistor ¹	
32	FEC_SEL3	Input	Internal pull-UP resistor ¹	
34, 35, 36	DNC		Do Not Connect.	Internal nodes. Connection to these pins can cause erratic device operation.

Table 3: Pin Descriptions



PLL DIVIDER LOOK-UP TABLES

Mfin Divider Look-Up Table (LUT)

The FIN_SEL1:0 pins select the feedback divider value “Mfin” (for Frequency Input).

FIN_SEL1:0		Mfin Value	M2006-02A-622.0800 Sample Ref. Freq. (MHz) †
1	1	1 *	622.08
1	0	4	155.52
0	1	8	77.76
0	0	32	19.44

Table 4: Mfin Divider Look-Up Table (LUT)

Note *: Do not use with FEC_SEL3:0=1100 or 1101 or an excessive phase detector frequency will result.

Note †: Example with M2006-02A-622.0800 and “Non-FEC ratio” selection made from Table 5 (FEC_SEL2=1).

FEC PLL Ratio Dividers Look-up Table (LUT)

The FEC_SEL3:0 pins select the FEC feedback and reference divider values Mfec and Rfec.

FEC_SEL3:0	Mfec	Rfec ¹	Description
0 0 0 0	236	255	Inverse FEC ratio
0 0 0 1	79	85	Inverse FEC ratio, equivalent to 237/255
0 0 1 0	14	15	Inverse FEC ratio, equivalent to 238/255
0 0 1 1	239	255	Inverse FEC ratio
0 1 0 0	236	236	Non-FEC ratio, complements 0000 or 1000 ²
0 1 0 1	79	79	Non-FEC ratio, complements 0001 or 1001 ²
0 1 1 0	14	14	Non-FEC ratio, complements 0010 or 1010 ²
0 1 1 1	239	239	Non-FEC ratio, complements 0011 or 1011 ²
1 0 0 0	255	236	FEC ratio (OTU3)
1 0 0 1	85	79	FEC ratio, equivalent to 255/237 (OTU2)
1 0 1 0	15	14	FEC ratio, equivalent to 255/238 (OTU1)
1 0 1 1	255	239	FEC ratio
1 1 0 0	1	1	Non-FEC ratio ³ Do not use these two settings with FIN_SEL1:0=11
1 1 0 1	2	2	
1 1 1 0	4	4	Non-FEC ratio ³
1 1 1 1	8	8	

Table 5: FEC PLL Ratio Dividers Look-up Table (LUT)

Note 1: The phase detector frequency (Fpd, which is calculated as Fref/Rfec) should be above 1.5 MHz to prevent spurs on the output clock. To ensure the PLL remains locked when using a recovered clock (such as in loop timing mode), the phase detector frequency should ideally be about 20MHz, or at least less than 50 MHz.

Note 2: These table selections use the same or similar Mfec divider values as the complementary selections noted. This allows the use of the same loop filter component values and yields the same PLL loop bandwidth and damping factor values for complementary selections. Complementary selections can be actively switched in a given application.

Note 3: In non-FEC applications, these settings can be used to optimize phase detector frequency or to actively change PLL loop bandwidth.

Post-PLL Dividers

The M2006-02A also features two post-PLL dividers, one for each output pair. The “P1” divider is for FOUT1 and nFOUT1; the “P0” divider is for FOUT0 and nFOUT0.

Each divides the VCSO frequency to produce one of two output frequencies (1/4 or 1/1 of the VCSO frequency). The P1_SEL and P0_SEL pins each select the value for their corresponding divider.

P1_SEL, P0_SEL	P Value	M2006-02A-622.0800 Sample Output Frequency (MHz)
1	4	155.52
0	1	622.08

Table 6: P Divider Selector, Values, and Frequencies

FUNCTIONAL DESCRIPTION

The M2006-02A is a PLL (Phase Locked Loop) based clock generator that generates output clocks synchronized to one of two selectable input reference clocks.

An internal high "Q" SAW filter provides low jitter signal performance and controls the output frequency of the VCSO (Voltage Controlled SAW Oscillator).

Configurable FEC feedback and reference dividers (the “Mfec Divider” and “Rfec Divider”) provide the multiplication ratios necessary to accommodate clock translation for both forward and inverse Forward Error Correction.

In addition, a configurable feedback divider (labeled “Mfin Divider”) provides the broader division options needed to accommodate various reference clock frequencies.

For example, the M2006-02A-622.0800 (see “Ordering Information” on pg. 8) has a 622.08MHz VCSO frequency:

- The inverse FEC PLL ratios (at top of Table 5) enable the M2006-02A-622.0800 to accept “base” input reference frequencies of: 663.7255, 666.5143, 669.3266, 672.1627, and 622.08MHz.
- The Mfin feedback divider enables the actual input reference clock to be the “base” input frequency divided by 1, 4, 8, or 32. Therefore, for the base input frequency of 622.08MHz, the actual input reference clock frequencies can be: 622.08, 155.52, 77.76, and 19.44MHz. (See Table 4 on pg. 3.)



The PLL

The PLL uses a phase detector and configurable dividers to synchronize the output of the VCSO with selected reference clock.

The “Mfin Divider” and “Mfec Divider” divide the VCSO frequency, feeding the result into the phase detector.

The selected input reference clock is divided by the “Rfec Divider”. The result is fed into the other input of the phase detector.

The phase detector compares its two inputs. It then outputs pulses to the loop filter as needed to increase or decrease the VCSO frequency and thereby match and lock the divider output’s frequency and phase to those of the input reference clock.

Due to the narrow tuning range of the VCSO ($\pm 200\text{ppm}$), appropriate selection of all of the following are required for the PLL be able to lock: VCSO center frequency, input frequency, and divider selections.

Maintaining PLL Lock:

The narrow tuning range of the VCSO requires that the input reference frequency must remain suitable for the current look-up table selection. For example, when switching between “Inverse FEC ratio” and “Non-FEC ratio” look-up table selections (see Table 5 on pg. 3), the input reference frequency must change accordingly in order for the PLL to lock.

An out-of-lock condition due to an inappropriate configuration will typically result in the VCSO operating at its lower or upper frequency rail, which is approximately 200ppm above or below the nominal VCSO center frequency.

Relationship Among Frequencies and Dividers

The VCSO center frequency must be specified at time of order. The relationship between the VCSO (Fvcso) frequency, the Mfin divider, the Mfec divider, the Rfec divider, and the input reference frequency (Fin) is:

$$F_{vcso} = F_{in} \times M_{fin} \times \frac{M_{fec}}{R_{fec}}$$

As an example, for the M2006-02A-622.0800, the non-FEC and inverse-FEC PLL ratios in Table 5 enable use with these corresponding input reference frequencies:

M2006-02A-622.0800 VCSO Clock Frequency (MHz) ÷	FEC Ratio	M2006-02A-622.0800 Base Input Ref. Frequency (MHz) ¹
	1 / 1	622.0800
622.08	238 / 255	666.5143
	237 / 255	669.3266
	236 / 255	672.1627

Table 7: Example FEC PLL Ratios and Input Reference Frequencies
 Note 1: Input reference clock (“Fin”) can be the base frequency shown divided by “Mfin” (as shown in Table 4 on pg. 3).

Outputs

The M2006-02A provides a total of two differential LVPECL output pairs: FOUT1 and FOUT0. Because each output pair has its own P divider, the FOUT1 pair and the FOUT0 can output the two different frequencies at the same time. For example, FOUT1 can output 155.52MHz while FOUT0 outputs 622.08MHz.

Any unused output should be left unconnected (floating) in the system application. This will minimize output switching current and therefore minimize noise modulation of the VCSO.



External Loop Filter

To provide stable PLL operation, and thereby a low jitter output clock, the M2006-02A requires the use of an external loop filter. This is provided via the provided filter pins (see Figure 4).

Due to the differential signal path design, the implementation requires two identical complementary RC filters as shown here.

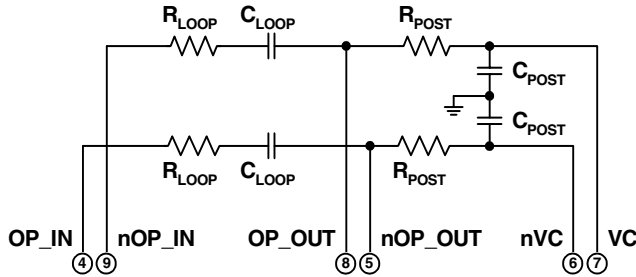


Figure 4: External Loop Filter

PLL bandwidth is affected by loop filter component values, “Mfec” and “Mfin” values, and the “PLL Loop Constants” listed in AC Characteristics on pg. 7.

The various “Non-FEC ratio” settings can be used to actively change PLL loop bandwidth in a given application. See “FEC PLL Ratio Dividers Look-up Table (LUT)” on pg. 3.

See Example External Loop Filter Component Values table.

PLL Simulator Tool Available

A free PC software utility is available on the ICS website (www.icst.com). The M2000 Timing Modules PLL Simulator is a downloadable application that simulates PLL jitter and wander transfer characteristics. This enables the user to set appropriate external loop component values in a given application.

Go to the SAW PLL Simulator Software web page at www.icst.com/products/calculators/m2000filterSWdesc.htm

Example External Loop Filter Component Values¹

VCSO Parameters: $K_{VCO} = 800\text{kHz/V}$, $R_{IN} = 50\text{k}\Omega$, VCSO Bandwidth = 700kHz.

Device Configuration				Example External Loop Filter Component Values				Nominal Performance Using These Values			
F _{Ref} (MHz)	F _{VCSO} (MHz)	FIN_SEL1:0 pins	FEC_SEL3:0 pins	R loop	C loop	R post	C post	PLL Loop Bandwidth	Damping Factor	Passband Peaking (dB)	
19.44	622.08	0 0	1 1 0 0	11.5kΩ	2.2μF	34kΩ	470pF	1kHz	6.0	0.05	
77.76		0 1	1 1 1 0								
155.52		1 0	1 1 1 1								
622.08	669.3266	1 1	0 1 1 0	5.11kΩ	4.7μF	121.0kΩ	0.22μF	6.0	0.06		
167.3317		1 0	0 0 0 1	113.0kΩ	0.22μF						
669.3266		1 1		28.0kΩ	1.0μF					6.3	0.05
155.52		1 0	1 0 0 1	121.0kΩ	0.22μF					6.0	0.05
622.08		1 1		30.1kΩ	1.0μF			6.5	0.05		

Table 8: Example External Loop Filter Component Values

Note 1: K_{VCO} , VCSO Bandwidth, M Divider Value, and External Loop Filter Component Values determine Loop Bandwidth, Damping Factor, and Passband Peaking. For PLL Simulator software, go to www.icst.com.

ABSOLUTE MAXIMUM RATINGS¹

Symbol	Parameter	Rating	Unit
V _I	Inputs	-0.5 to V _{CC} +0.5	V
V _O	Outputs	-0.5 to V _{CC} +0.5	V
V _{CC}	Power Supply Voltage	4.6	V
T _S	Storage Temperature	-45 to +100	°C

Table 9: Absolute Maximum Ratings

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in Recommended Conditions of Operation, DC Characteristics, or AC Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.



RECOMMENDED CONDITIONS OF OPERATION

Symbol	Parameter	Min	Typ	Max	Unit
V _{CC}	Positive Supply Voltage	3.135	3.3	3.465	V
T _A	Ambient Operating Temperature	Commercial	0	+70	°C
		Industrial	-40	+85	°C

Table 10: Recommended Conditions of Operation

ELECTRICAL SPECIFICATIONS

DC Characteristics

Unless stated otherwise, V_{CC} = 3.3V ±5%, T_A = 0 °C to +70 °C (commercial), T_A = -40 °C to +85 °C (industrial), F_{VCSO} = F_{OUT} = 622-675MHz, LVPECL outputs terminated with 50Ω to V_{CC} - 2V

	Symbol	Parameter		Min	Typ	Max	Unit	Conditions
Power Supply	V _{CC}	Positive Supply Voltage		3.135	3.3	3.465	V	
	I _{CC}	Power Supply Current			175	225	mA	
All Differential Inputs	V _{P-P}	Peak to Peak Input Voltage		0.15			V	
	V _{CMR}	Common Mode Input	DIF_REF0, nDIF_REF0, DIF_REF1, nDIF_REF1	0.5		V _{CC} - .85	V	
	C _{IN}	Input Capacitance				4	pF	
Differential Inputs with Pull-down	I _{IH}	Input High Current (Pull-down)				150	μA	V _{CC} = V _{IN} = 3.456V
	I _{IL}	Input Low Current (Pull-down)	DIF_REF0, DIF_REF1	-5			μA	
	R _{pulldown}	Internal Pull-down Resistance			50		kΩ	
Differential Inputs with Pull-up	I _{IH}	Input High Current (Pull-up)				5	μA	V _{IN} = 0 to 3.456V
	I _{IL}	Input Low Current (Pull-up)	nDIF_REF0, nDIF_REF1	-150			μA	
	R _{pullup}	Internal Pull-up Resistance			50		kΩ	
All LVCMOS / LVTTTL Inputs	V _{IH}	Input High Voltage	REF_SEL, FIN_SEL1, FIN_SEL0, FEC_SEL3, FEC_SEL2,	2		V _{CC} + 0.3	V	
	V _{IL}	Input Low Voltage	FEC_SEL1, FEC_SEL0,	-0.3		0.8	V	
	C _{IN}	Input Capacitance	P1_SEL, P0_SEL			4	pF	
LVCMOS / LVTTTL Inputs with Pull-down	I _{IH}	Input High Current (Pull-down)				150	μA	V _{CC} = V _{IN} = 3.456V
	I _{IL}	Input Low Current (Pull-down)	REF_SEL, FIN_SEL1, FIN_SEL0, P1_SEL, P0_SEL	-5			μA	
	R _{pulldown}	Internal Pull-down Resistance			50		kΩ	
LVCMOS / LVTTTL Inputs with Pull-up	I _{IH}	Input High Current (Pull-up)				5	μA	V _{CC} = 3.456V V _{IN} = 0 V
	I _{IL}	Input Low Current (Pull-up)	FEC_SEL3, FEC_SEL2, FEC_SEL1, FEC_SEL0	-150			μA	
	R _{pullup}	Internal Pull-up Resistance			50		kΩ	
Differential Outputs	V _{OH}	Output High Voltage	FOUT0, nFOUT0,	V _{CC} - 1.4		V _{CC} - 1.0	V	
	V _{OL}	Output Low Voltage	FOUT1, nFOUT1	V _{CC} - 2.0		V _{CC} - 1.7	V	
	V _{P-P}	Peak to Peak Output Voltage ¹		0.4		0.85	V	

Note 1: Single-ended measurement. See Figure 5, Output Rise and Fall Time, on pg. 7.

Table 11: DC Characteristics



ELECTRICAL SPECIFICATIONS (CONTINUED)

AC Characteristics

Unless stated otherwise, $V_{CC} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ to $+70^\circ C$ (commercial), $T_A = -40^\circ C$ to $+85^\circ C$ (industrial), $F_{VCSO} = F_{OUT} = 622\text{-}675\text{MHz}$, LVPECL outputs terminated with 50Ω to $V_{CC} - 2V$

	Symbol	Parameter		Min	Typ	Max	Unit	Test Conditions
Input Frequency Range	F_{IN}	Input Frequency	DIF_REF0, nDIF_REF0, DIF_REF1, nDIF_REF1	10		700	MHz	
Output Frequency	F_{FOUT}	Output Frequency Range	FOUT0, nFOUT0, FOUT1, nFOUT1	100		700	MHz	
	APR	VCSO Pull-Range	Commercial	± 120	± 200		ppm	
			Industrial	± 50	± 150		ppm	
PLL Loop Constants ¹	K_{VCO}	VCO Gain			800		kHz/V	
	R_{IN}	Internal Loop Resistor			50		k Ω	
	BW_{VCSO}	VCSO Bandwidth			700		kHz	
Phase Noise and Jitter	Φ_n	Single Side Band Phase Noise @ 622.08MHz	1kHz Offset		-73		dBc/Hz	$F_{in}=19.44\text{ MHz}$ $M_{fin}=32, M_{fec}=1, R_{fec}=1$
			10kHz Offset		-103		dBc/Hz	
			100kHz Offset		-126		dBc/Hz	
	$J(t)$	Jitter (rms) @ 622.08MHz	12kHz to 20MHz		0.25	0.5	ps rms	
			50kHz to 80MHz		0.25	0.5	ps rms	
	t_{PW}	Output Duty Cycle ² FOUT0, nFOUT0, FOUT1, nFOUT1	P0, P1 = 1	40	50	60	%	
			P0, P1 = 4	45	50	55	%	
	t_R	Output Rise Time ²	FOUT0, nFOUT0, FOUT1, nFOUT1	200	450	500	ps	20% to 80%
	t_F	Output Fall Time ²	FOUT0, nFOUT0, FOUT1, nFOUT1	200	450	500	ps	20% to 80%

Table 12: AC Characteristics

Note 1: Parameters needed for PLL Simulator software; see Table 8, Example External Loop Filter Component Values, on pg. 5.
Note 2: See Parameter Measurement Information on pg. 7.

PARAMETER MEASUREMENT INFORMATION

Output Rise and Fall Time

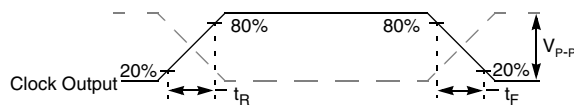


Figure 5: Output Rise and Fall Time

Output Duty Cycle

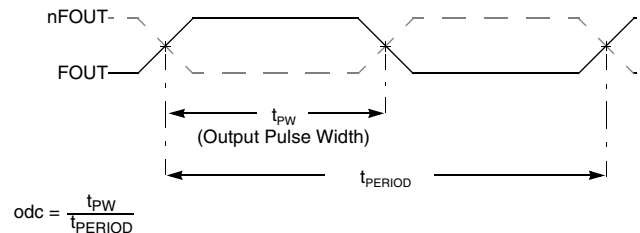
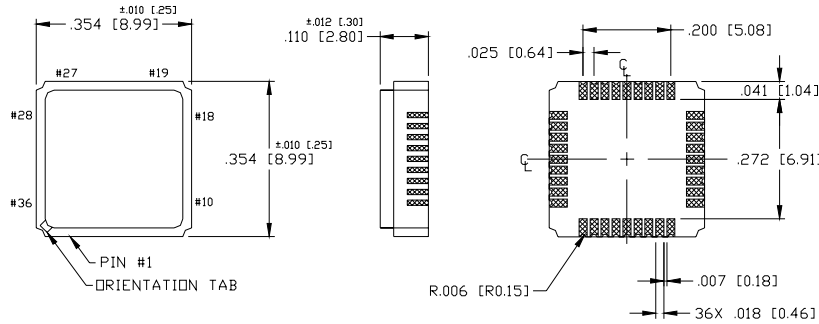


Figure 6: Output Duty Cycle



DEVICE PACKAGE - 9 x 9mm CERAMIC LEADLESS CHIP CARRIER
Mechanical Dimensions:



Refer to the SAW PLL application notes web page at www.icst.com/products/appnotes/SawPLLAppNotes.htm for application notes, including recommended PCB footprint, solder mask, and furnace profile.

- NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [] ARE MM.
2. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE ±.005 [0.13]

Figure 7: Device Package - 9 x 9mm Ceramic Leadless Chip Carrier

ORDERING INFORMATION

Part Numbering Scheme

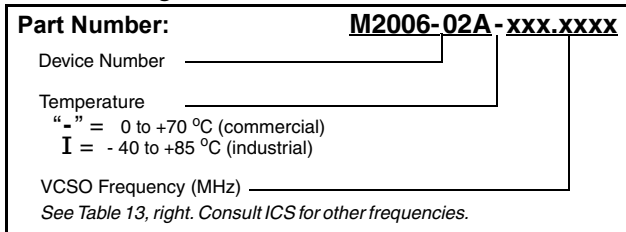


Figure 8: Part Numbering Scheme

Standard VCSO Output Frequencies (MHz)*

Consult ICS for the availability of other VCSO frequencies

622.0800	669.3120
625.0000	669.3266
627.3296	669.6429
644.5313	670.8386
666.5143	672.1600
669.1281	690.5692

Table 13: Standard VCSO Output Frequencies (MHz)

Note *: Fout can equal Fvcs0 divided by: 1 or 4

Consult ICS for the availability of other PLL frequencies.

Example Part Numbers

PLL Frequency (MHz)	Temperature	Order Part Number
622.08	commercial	M2006-02A-622.0800
	industrial	M2006-02AI622.0800
625.00	commercial	M2006-02A-625.0000
	industrial	M2006-02AI625.0000
669.3266	commercial	M2006-02A-669.3266
	industrial	M2006-02AI669.3266
669.6429	commercial	M2006-02A-669.6429
	industrial	M2006-02AI669.6429

Table 14: Example Part Numbers

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