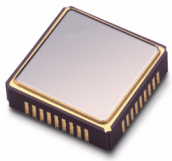
GENERAL DESCRIPTION

The M902-01 is a PLL (Phase Locked Loop) based clock generator that uses an internal VCSO (Voltage Controlled SAW Oscillator) to produce a very low jitter output clock. It is ideal for Gigabit Ethernet. The output clock (frequency of 156.25 or 187.50MHz for example) is provided from two LVPECL clock output pairs. (Specify frequency at time of order.) The accuracy of the output frequency is assured by the internal PLL, which phase-locks the internal VCSO to the reference input frequency (25 or 30MHz for example). The input reference can either be an external crystal, utilizing the internal crystal oscillator, or a stable external clock source such as a packaged crystal oscillator.



FEATURES

- **Output clock frequency from 125MHz to 190MHz (Consult factory for frequency availability)**
- **Two identical LVPECL output pairs**
- **Integrated SAW (surface acoustic wave) delay line**
- **Low jitter 0.5ps rms (over 12kHz-20MHz)**
- **Ideal for Gigabit Ethernet clock reference**
- **Output-to-output skew < 100ps**
- **External XTAL or LVCMOS reference input**
- **Selectable external feed-through clock input**
- **STOP clock control (Logic 1 stops output clocks)**
- **Industrial temperature grade available**
- **Single 3.3V power supply**
- **Small 9 x 9 mm SMT (surface mount) package**

PIN ASSIGNMENT (9 x 9 mm SMT)

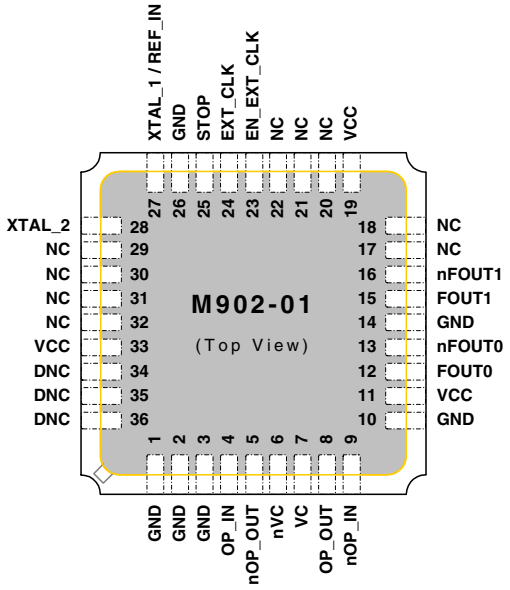


Figure 1: Pin Assignment

Example Output Frequency Configurations

Ref Clock Frequency (MHz)	PLL Ratio	Output Frequency [1] (MHz)	Application
20	25/4	125.00	GbE
25		156.25	10GbE
30		187.50	12GbE

Table 1: Example Output Frequency Configurations

Note 1: Specify output clock frequency at time of order

SIMPLIFIED BLOCK DIAGRAM

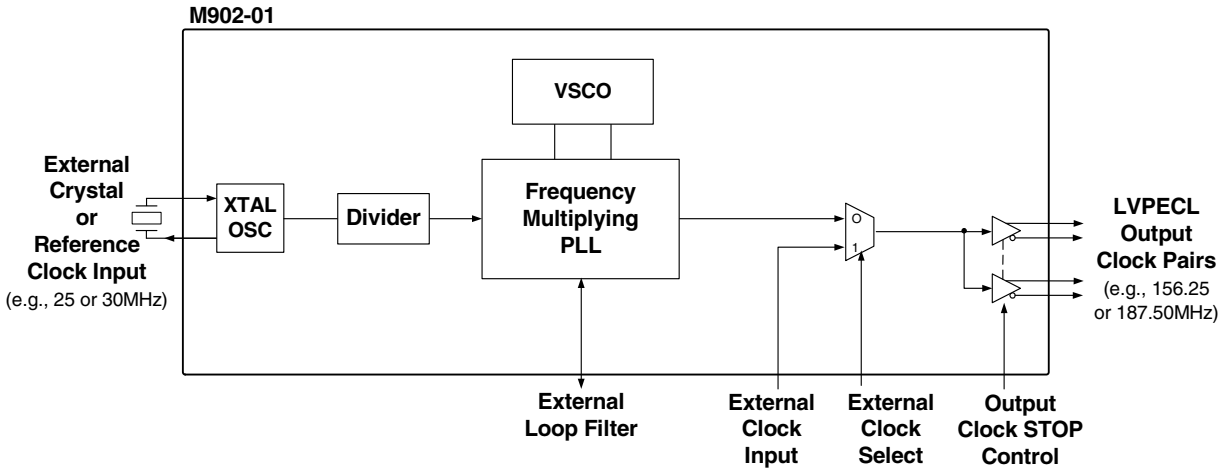


Figure 2: Simplified Block Diagram

DETAILED BLOCK DIAGRAM

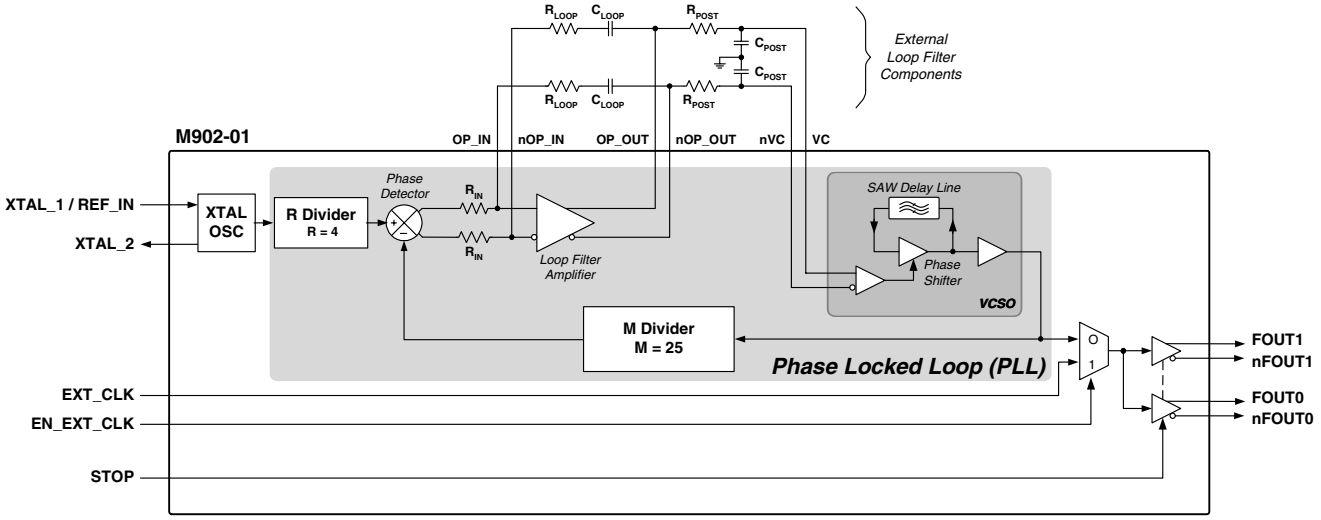


Figure 3: Detailed Block Diagram

PIN DESCRIPTIONS

Number	Name	I/O	Configuration	Description
1, 2, 3, 10, 14, 26	GND	Ground		Power supply ground connections.
4 9	OP_IN nOP_IN	Input		External loop filter connections. See Figure 5, External Loop Filter, on pg. 4.
5 8	nOP_OUT OP_OUT	Output		
6 7	nVC VC	Input		
11, 19, 33	VCC	Power		Power supply connection, connect to +3.3V.
12 13	FOUT0 nFOUT0	Output	No internal terminator	Clock output pairs, differential LVPECL output (156.25 MHz for the **M902-01-156.2500**)
15 16	FOUT1 nFOUT1			
17, 18 20, 21, 22 29, 30, 31, 32	NC			No internal connection
23	EN_EXT_CLK	Input	Internal pull-down resistor[1]	Logic 1 enables the EXT_CLK input. Use Logic 0 for normal operation.
24	EXT_CLK	Input		External clock feed-through: 0 to 200 MHz
25	STOP	Input	Internal pull-down resistor[1]	Logic 1 stops clock outputs. Use Logic 0 for normal operation.
27	XTAL_1 / REF_IN	Input		External crystal connection. Also accepts LVCMOS/LVTTL compatible clock source.
28	XTAL_2	Input		External crystal connection. Leave unconnected when driving pin 27 with external clock reference.
34, 35, 36	DNC			Do Not Connect.

Table 2: Pin Descriptions

Note 1: For typical value of internal pull-down resistor, see DC Characteristics, Pull-down on pg. 6.

FUNCTIONAL DESCRIPTION

The M902-01 is a PLL (Phase Locked Loop) based clock generator that generates output clocks synchronized to an input reference clock.

The M902-01 combines the flexibility of a VCSO (Voltage Controlled SAW Oscillator) with the stability of a crystal oscillator.

Input Reference

The input reference can either be an external, discrete crystal or a stable external clock source such as a packaged (temperature-compensated) crystal oscillator.

- If an external crystal is used with the on-chip crystal oscillator circuit (XTAL OSC), the external crystal should be a parallel-resonant, fundamental mode crystal. Apply it to the XTAL_1 / REF_IN and XTAL_2 input pins. External crystal load trim capacitors are also required. (See "Crystal Specifications" on pg. 4.)
- If an external LVCMOS/LVTTL clock source is used, apply it to the XTAL_1 / REF_IN input pin.

In either case, the reference clock is supplied to the phase detector of the PLL. The M902-01 includes a reference divider that divides the input reference frequency by a fixed value "R" and provides the result to the phase detector.

The EX_CLK *pin is available for a clock feed-through mode for testing. See "External Clock Feed-through" on pg. 3.*

The PLL

The PLL (Phase Locked Loop) includes the phase detector, the VCSO, a feedback divider (labeled "M Divider"), and a reference divider ("R Divider").

The feedback divider divides the VCSO output frequency by a fixed value "M" to match the reference frequency provided to the phase detector by the reference divider.

By controlling the frequency and phase of the VCSO, the phase detector precisely locks the frequency and phase of the feedback divider output to that of the reference divider output.

The relationship between the VCSO output frequency, the M Divider, the R Divider and the input reference frequency is defined as follows:

$$Fvcso = Fxtal \times \frac{M}{R}$$

For the **M902-01-156.2500** *(see "Ordering Information" on pg. 8):*

- VCSO output frequency = 156.25MHz
- Input reference frequency = 25MHz
- M=25
- R= 4

Therefore, for the **M902-01-156.2500**:

$$156.25MHz = 25MHz \times \frac{25}{4}$$

The product of the input crystal frequency and $\frac{M}{R}$ falls within the lock range of the VCSO.

External Clock Feed-through

The EXT_CLK pin provides an input for an external single-ended clock that directly drives the LVPECL clock outputs. This pin is intended for system debugging and performance evaluation..

EN_EXT_CLK	Logic 1 enables the EXT_CLK input. Use Logic 0 for normal operation.
EXT_CLK	Apply an external LVCMOS/LVTTL clock source for 0 to 200 MHz feed-through operation. Leave inactive for normal operation.[1]

Note 1: In applications where EXT_CLK is active while the SAW PLL signal path is enabled, it is necessary to gate the EXT_CLK to minimize jitter in the LVPECL output pairs. See the *PCB Design Guidelines for ICS SAW PLLs* application note at www.icst.com/products/appnotes/M000-AN-001.PCBdesign.pdf

STOP Clock

The STOP pin puts the output clock into a static condition.

Logic 1	Output clocks are static
Logic 0	Output clocks enabled for normal operation

APPLICATION INFORMATION

This section includes information on the optional external crystal and on the external loop filter.

The subsections on the loop filter provide example component values and also briefly describe the SAW PLL simulator tool and additional application information available at www.icst.com.

External Crystal Specifications

If an external crystal is used with the on-chip crystal oscillator circuit (XTAL OSC), the external crystal should have the following general specifications:

Crystal Specifications

	Parameter	Min	Typ	Max	Unit
	Crystal Type		AT-cut quartz		
	Mode of Oscillation		Fundamental		
f_0	Nominal Frequency Range	16		40	MHz
$\Delta f/f_0$	Frequency Tolerance @+25 °C [1]		±15		ppm
$\Delta f/f_C$ / T_A	Frequency Stability -40 to +85 °C [1]		±50		ppm
$\Delta f/f_0$ / y	Aging, per year (first) @+25 °C [1]		±5		ppm
ESR	Equivalent Series Resistance			50	Ω
C_S	Shunt Capacitance			7	pF
	Spurious Response (non-harmonic)			-40	dBc
C_L	Load Capacitance, parallel load resonant	16		32	pF
P_0	Drive Level	0.1		1.0	mW

Table 3: External Loop Filter Component Values

Note 1: These frequency tolerance specifications are suitable for a ±100 ppm clock output frequency requirement.

The external crystal will be applied to the XTAL_1 / REF_IN and XTAL_2 input pins. External crystal load capacitors are also required.

Recommended External Crystal Configuration

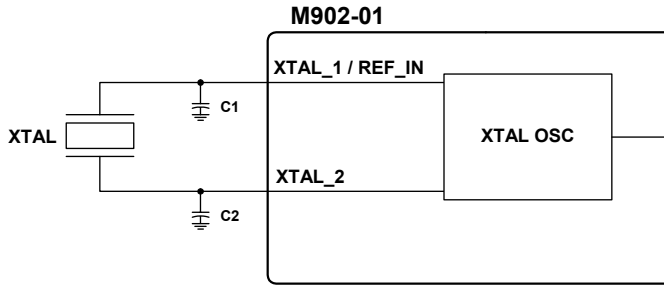


Figure 4: Recommended External Crystal Configuration

XTAL= 25 or 30 MHz, Load Capacitance Specification = 18 pF
C1 = 27 pF
C2 = 33 pF

External load capacitors C1 and C2 present a load of 15 pf to the crystal (they are seen in series by the crystal through the common ground connection). With the additional of PCB trace capacitance and M902-01 input capacitance, the total load to the crystal is about 18 pf.

External Loop Filter

To provide stable PLL operation, and thereby a low jitter output clock, the M902-01 requires the use of an external loop filter. This is provided via the provided filter pins (see Figure 5).

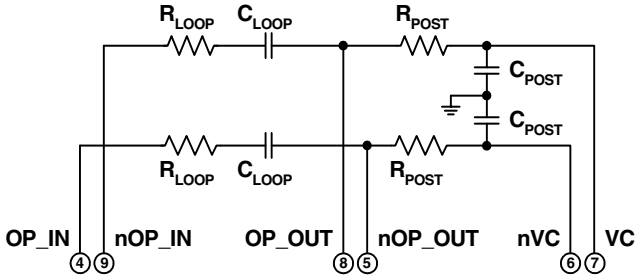


Figure 5: External Loop Filter

The loop filter is implemented as a differential circuit to minimize system noise interference. Due to the differential signal path design, the implementation requires two identical complementary RC filters as shown here. See Table 4, External Loop Filter Component Values, below.

External Loop Filter Component Values

PLL Bandwidth (kHz)	Damping Factor	R loop (kΩ)	C loop (µF)	R post (kΩ)	C post (pF)
0.5	3.0	1.5	4.70	20	150
1.5 [1]	3.3	4.7	1.00	10	150
2.1 [2]	1.1	4.7	0.10	10	150
6.4	4.5	20.0	0.10	20	270
10.6 [3]	4.2	33.0	0.03	20	120

Table 4: External Loop Filter Component Values

Note 1: Optimum loop bandwidth when using an external reference crystal. Will help to attenuate interference on the crystal's sinusoidal clock waveform and therefore will minimize device output clock jitter.

Note 2: Alternative loop filter setting when using an external reference crystal. Smaller C loop lowers loop damping factor with negligible increase in output jitter.

Note 3: Optimum loop bandwidth when using an external reference crystal oscillator. The square wave clock reference does not require as much jitter attenuation, which allows for a wider loop bandwidth and improved system noise tolerance.

Refer to the M902-01 product web page at www.icst.com/products/summary/m902-01.htm for additional product information.

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.

Refer to the SAW PLL Simulator Software web page at www.icst.com/products/calculators/m2000filterSWdesc.htm for additional information.

SAW PLL Application Notes Available

The ICS web site (www.icst.com) also has application notes on:

- PCB layout guidelines (including special detailed instructions for preventing issues such as external reference crosstalk)
- Any new special device application details that may become available
- Instructions for using PLL simulator software
- Guidelines for PCB fabrication (including recommended PCB footprint, solder mask, and furnace profile)

Refer to the SAW PLL Application Notes web page at www.icst.com/products/appnotes/SawPllAppNotes.htm for application notes and any additional product information that may become available.

ABSOLUTE MAXIMUM RATINGS[1]

Symbol	Parameter	Rating	Unit
V_I	Input Voltage	-0.5 to V_{CC} +0.5	V
V_O	Output Voltage	-0.5 to V_{CC} +0.5	V
I_O	Output Current	25	mA
V_{CC}	Power Supply Voltage	4.6	V
T_S	Storage Temperature	-45 to +100	°C

Table 5: 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 6: Recommended Conditions of Operation

ELECTRICAL SPECIFICATIONS

DC Characteristics

Unless stated otherwise, V_{CC} = 3.3V ±5%, T_A = 0 °C to +70 °C (commercial)[1], T_A = -40 °C to +85 °C (industrial)[1], Output Frequency=156.25MHz[1], LVPECL outputs terminated with 50Ω to V_{CC} - 2V

	Symbol	Parameter		Min	Typ	Max	Unit
Power Supply	V_{CC}	Positive Supply Voltage		3.135	3.3	3.465	V
	I_{CC}	Power Supply Current			300		mA
Logic Inputs	V_{IH}	Input High Voltage	EN_EXT_CLK, EXT_CLK, STOP	2		V_{CC} +0.3	V
	V_{IL}	Input Low Voltage		-0.3		0.8	V
	I_{IH}	Input High Current				150	µA
	I_{IL}	Input Low Current		-5.0			µA
Reference Clock Input	V_{IH}	Input High Voltage	XTAL_1 / REF_IN (XTAL_2 disconnected)	(V_{CC}/2) +0.5		V_{CC} +0.3	V
	V_{IL}	Input Low Voltage		-0.3		(V_{CC}/2) -0.5	V
	I_{IH}	Input High Current				150	µA
	I_{IL}	Input Low Current		-5.0			µA
All Inputs	C_{IN}	Input Capacitance, All Inputs	EN_EXT_CLK, EXT_CLK, STOP, XTAL_1 / REF_IN, XTAL_2			4	pF
Pull-down	$R_{pulldown}$	Internal Pull-down Resistor	EN_EXT_CLK, STOP		51		kΩ
Differential Output	V_{OH}	Output High Voltage	FOUT, nFOUT (0-1)	V_{CC} -1.4		V_{CC} -1.0	V
	V_{OL}	Output Low Voltage		V_{CC} -2.0		V_{CC} -1.7	V
	V_{P-P}	Peak to Peak Output Voltage		0.5		0.85	V

Table 7: DC Characteristics

Note 1: See Ordering Information on pg. 8

AC Characteristics

Unless stated otherwise, V_{CC} = 3.3V ±5%, T_A = 0 °C to +70 °C (commercial)[1], T_A = -40 °C to +85 °C (industrial)[1], Output Frequency=156.25MHz[1], LVPECL outputs terminated with 50Ω to V_{CC} - 2V

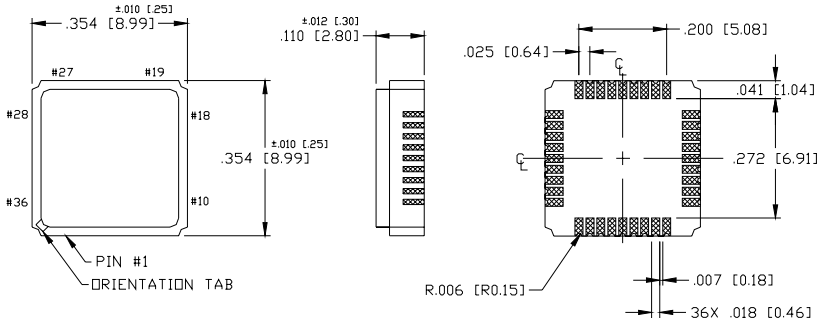
Symbol	Parameter		Min	Typ	Max	Unit	Test Conditions
F_{OUT}	Output Frequency Range		125	156.25	190	MHz	
F_{IN}	Nominal Input Frequency, XTAL_1 / REF_IN			25		MHz	
APR	VCSO Pull-Range		±100	±150		ppm	
Φn	Single Side Band Phase Noise @156.25MHz	1kHz Offset		-90		dBc/Hz	
		10kHz Offset		-110		dBc/Hz	
		100kHz Offset		-135		dBc/Hz	
J(t)	Jitter (rms)			0.5	1.0	ps	12kHz to 20MHz
t_{DC}	Output Duty Cycle, High Time		45	50	55	%	
t_R	Output Rise Time	FOUT, nFOUT (0-1)	350	450	550	ps	20% to 80%
t_F	Output Fall Time	FOUT, nFOUT (0-1)	350	450	550	ps	20% to 80%
t_S	Output Skew	Between Any Pair			100	ps	
	EXT_CLK Frequency	EXT_CLK	0		200	MHz	

Table 8: AC Characteristics

Note 1: See Ordering Information on pg. 8

DEVICE PACKAGE - 9 x 9mm CERAMIC LEADLESS CHIP CARRIER

Mechanical Dimensions:



Refer to the M902-01 product web page at www.icst.com/products/summary/m902-01.htm for recommended PCB footprint, solder mask, furnace profile, and related information.

NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE MM.
2. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE ±.005 [.13]

Figure 6: Device Package - 9 x 9mm Ceramic Leadless Chip Carrier

ORDERING INFORMATION

Part Numbering Scheme

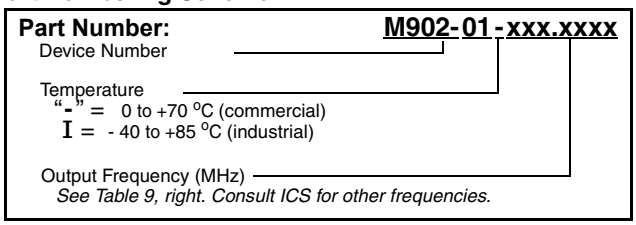


Figure 7: Part Numbering Scheme

Example Part Numbers

Output Freq. (MHz)	Temperature	Order Part Number
125.00	commercial	**M902-01-125.0000**
	industrial	**M902-01I125.0000**
156.25	commercial	**M902-01-156.2500**
	industrial	**M902-01I156.2500**
187.50	commercial	**M902-01-187.5000**
	industrial	**M902-01I187.5000**

Table 9: Example Part Numbers

Consult factory for frequency availability.