

**Product Description**

Peregrine’s PE97022 is a high-performance integer-N PLL capable of frequency synthesis up to 3.5 GHz. The device is designed for superior phase noise performance while providing an order of magnitude reduction in current consumption, when compared with existing commercial space PLLs.

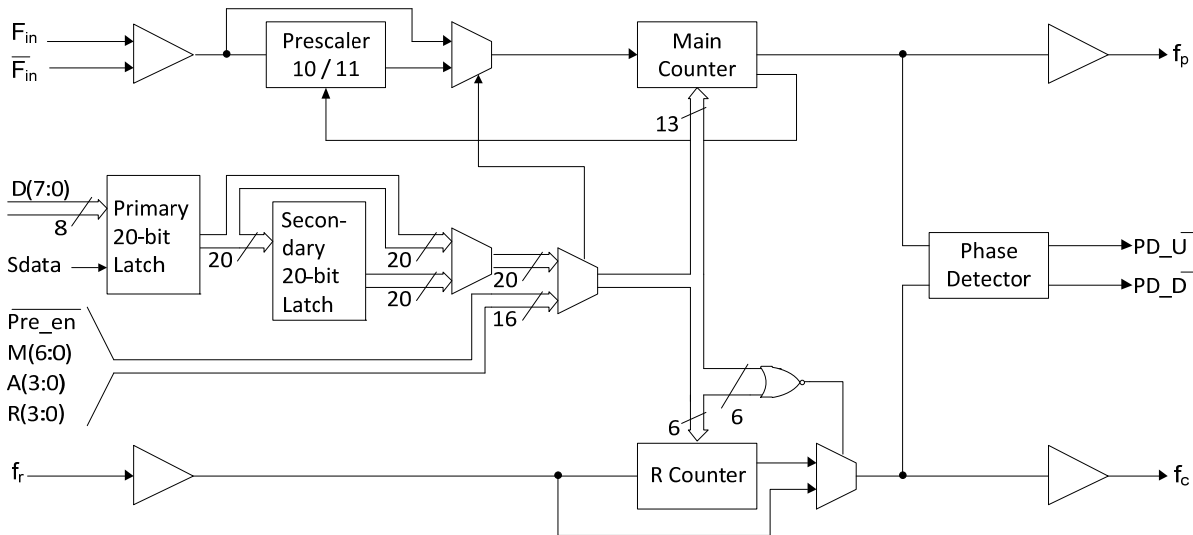
The PE97022 features a ÷10/11 dual modulus prescaler, counters and a phase comparator as shown in *Figure 1*. Counter values are programmable through either a serial or parallel interface and can also be directly hardwired.

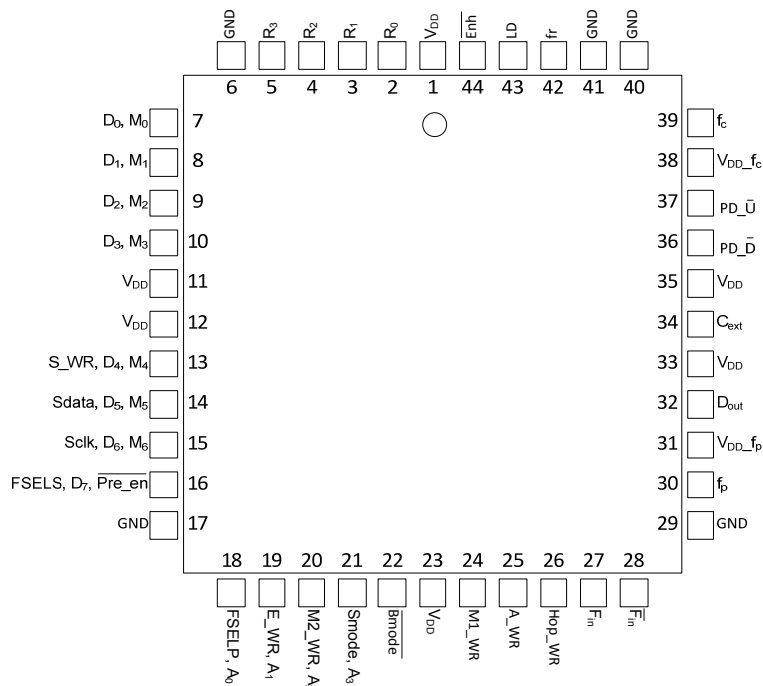
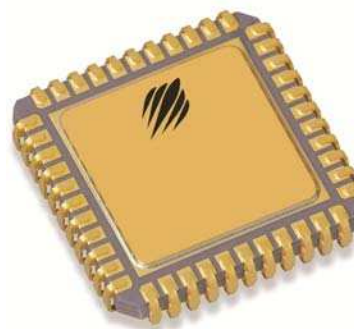
The PE97022 is optimized for commercial space applications. Single Event Latch up (SEL) is physically impossible and Single Event Upset (SEU) is better than  $10^9$  errors per bit / day. It is manufactured on Peregrine’s UltraCMOS™ process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate, offering excellent RF performance and intrinsic radiation tolerance.

**Features**

- Low Power - 45 mA at 3.3 V
- 3.5 GHz operation
- ÷10/11 dual modulus prescaler
- Internal phase detector
- Serial, parallel, or direct hardwired mode
- Ultra-Low Phase Noise: -216 dBc/Hz
- SEU <  $10^9$  errors / bit-day
- 100 Krad (Si) total dose
- Pin compatible with the PE9702, packaged in a 44-lead CQFJ (*reference application note AN22 at [www.psemi.com](http://www.psemi.com)*)

**Figure 1. Block Diagram**



**Figure 2. Pin Configurations (Top View)**

**Figure 3. Package Type**  
 44-lead CQFJ

**Table 1. Pin Descriptions**

Pin No.	Pin Name	Interface Mode	Type	Description
1	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
2	R <sub>0</sub>	Direct	Input	R Counter bit0 (LSB).
3	R <sub>1</sub>	Direct	Input	R Counter bit1.
4	R <sub>2</sub>	Direct	Input	R Counter bit2.
5	R <sub>3</sub>	Direct	Input	R Counter bit3.
6	GND	ALL		Ground.
7	D <sub>0</sub>	Parallel	Input	Parallel data bus bit0 (LSB).
	M <sub>0</sub>	Direct	Input	M Counter bit0 (LSB).
8	D <sub>1</sub>	Parallel	Input	Parallel data bus bit1.
	M <sub>1</sub>	Direct	Input	M Counter bit1.
9	D <sub>2</sub>	Parallel	Input	Parallel data bus bit2.
	M <sub>2</sub>	Direct	Input	M Counter bit2.
10	D <sub>3</sub>	Parallel	Input	Parallel data bus bit3.
	M <sub>3</sub>	Direct	Input	M Counter bit3.
11	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
12	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
13	S_WR	Serial	Input	Serial load enable input. While S_WR is "low", Sdata can be serially clocked. Primary register data is transferred to the secondary register on S_WR or Hop_WR rising edge.
	D <sub>4</sub>	Parallel	Input	Parallel data bus bit4
	M <sub>4</sub>	Direct	Input	M Counter bit4

**Table 1. Pin Descriptions (continued)**

Pin No.	Pin Name	Interface Mode	Type	Description
14	Sdata	Serial	Input	Binary serial data input. Input data entered MSB first.
	D <sub>5</sub>	Parallel	Input	Parallel data bus bit5.
	M <sub>5</sub>	Direct	Input	M Counter bit5.
15	Sclk	Serial	Input	Serial clock input. Sdata is clocked serially into the 20-bit primary register (E_WR “low”) or the 8-bit enhancement register (E_WR “high”) on the rising edge of Sclk.
	D <sub>6</sub>	Parallel	Input	Parallel data bus bit6.
	M <sub>6</sub>	Direct	Input	M Counter bit6.
16	FSELS	Serial	Input	Selects contents of primary register (FSELS = 1) or secondary register (FSELS = 0) for programming of internal counters while in Serial Interface Mode.
	D <sub>7</sub>	Parallel	Input	Parallel data bus bit7 (MSB).
	$\overline{\text{Pre\_en}}$	Direct	Input	Prescaler enable, active “low”. When “high”, F <sub>in</sub> bypasses the prescaler.
17	GND	ALL		Ground.
18	FSELP	Parallel	Input	Selects contents of primary register (FSELP=1) or secondary register (FSELP = 0) for programming of internal counters while in Parallel Interface Mode.
	A <sub>0</sub>	Direct	Input	A Counter bit0 (LSB).
19	E_WR	Serial	Input	Enhancement register write enable. While E_WR is “high”, Sdata can be serially clocked into the enhancement register on the rising edge of Sclk.
		Parallel	Input	Enhancement register write. D[7:0] are latched into the enhancement register on the rising edge of E_WR.
	A <sub>1</sub>	Direct	Input	A Counter bit1.
20	M2_WR	Parallel	Input	M2 write. D[3:0] are latched into the primary register (R[5:4], M[8:7]) on the rising edge of M2_WR.
	A <sub>2</sub>	Direct	Input	A Counter bit2.
21	Smode	Serial, Parallel	Input	Selects serial bus interface mode ( $\overline{\text{Bmode}} = 0$ , Smode = 1) or Parallel Interface Mode (Bmode = 0, Smode = 0).
	A <sub>3</sub>	Direct	Input	A Counter bit3 (MSB).
22	$\overline{\text{Bmode}}$	ALL	Input	Selects direct interface mode ( $\overline{\text{Bmode}} = 1$ ).
23	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
24	M1_WR	Parallel	Input	M1 write. D[7:0] are latched into the primary register ( $\overline{\text{Pre\_en}}$ , M[6:0]) on the rising edge of M1_WR.
25	A_WR	Parallel	Input	A write. D[7:0] are latched into the primary register (R[3:0], A[3:0]) on the rising edge of A_WR.
26	Hop_WR	Serial, Parallel	Input	Hop write. The contents of the primary register are latched into the secondary register on the rising edge of Hop_WR.
27	F <sub>in</sub>	ALL	Input	Prescaler input from the VCO, 3.5 GHz max frequency. A 22 pF coupling capacitor should be placed as close as possible to this pin and terminated with a 50 Ω resistor to ground.
28	$\overline{\text{F}}_{\text{in}}$	ALL	Input	Prescaler complementary input. A 22 pF bypass capacitor should be placed as close as possible to this pin and be connected in series with a 50 Ω resistor to ground.
29	GND	ALL		Ground.
30	f <sub>p</sub>	ALL	Output	Monitor pin for main divider output. Switching activity can be disabled through enhancement register programming or by floating or grounding V <sub>DD</sub> pin 31.

**Table 1. Pin Descriptions (continued)**

Pin No.	Pin Name	Interface Mode	Type	Description
31	V <sub>DD-f<sub>p</sub></sub>	ALL	(Note 1)	V <sub>DD</sub> for f <sub>p</sub> . Can be left floating or connected to GND to disable the f <sub>p</sub> output.
32	Dout	Serial, Parallel	Output	Data Out. The MSEL signal and the raw prescaler output are available on Dout through enhancement register programming.
33	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
34	C <sub>EXT</sub>	ALL	Output	Logical “NAND” of PD <sub>U</sub> and PD <sub>D</sub> terminated through an on chip, 2 kΩ series resistor. Connecting C <sub>EXT</sub> to an external capacitor will low pass filter the input to the inverting amplifier used for driving LD.
35	V <sub>DD</sub>	ALL	(Note 1)	Power supply input. Input may range from 2.85 V to 3.45 V. Bypassing recommended.
36	PD <sub>U</sub>	ALL	Output	PD <sub>D</sub> is pulse down when f <sub>p</sub> leads f <sub>c</sub> .
37	PD <sub>U</sub>	ALL		PD <sub>U</sub> is pulse down when f <sub>c</sub> leads f <sub>p</sub> .
38	V <sub>DD-f<sub>c</sub></sub>	ALL	(Note 1)	V <sub>DD</sub> for f <sub>c</sub> . Can be left floating or connected to GND to disable the f <sub>c</sub> output.
39	f <sub>c</sub>	ALL	Output	Monitor pin for reference divider output. Switching activity can be disabled through enhancement register programming or by floating or grounding V <sub>DD</sub> pin 38.
40	GND	ALL		Ground.
41	GND	ALL		Ground.
42	f <sub>r</sub>	ALL	Input	Reference frequency input.
43	LD	ALL	Output	Lock detect and open drain logical inversion of C <sub>EXT</sub> . When the loop is in lock, LD is high impedance, otherwise LD is a logic low (“0”).
44	$\overline{\text{Enh}}$	Serial, Parallel	Input	Enhancement mode. When asserted low (“0”), enhancement register bits are functional.

Notes: 1. V<sub>DD</sub> pins 1, 11, 12, 23, 31, 33, 35, and 38 are connected by diodes and must be supplied with the same positive voltage level.

V<sub>DD</sub> pins 31 and 38 are used to enable test modes and should be left floating.

2. All digital input pins have 70 kΩ pull-down resistors to ground.

**Table 2. Absolute Maximum Ratings**

Symbol	Parameter/Conditions	Min	Max	Units
$V_{DD}$	Supply voltage	-0.3	4.0	V
$V_I$	Voltage on any input	-0.3	$V_{DD} + 0.3$	V
$I_I$	DC into any input	-10	+10	mA
$I_O$	DC into any output	-10	+10	mA
$T_{stg}$	Storage temperature range	-65	150	°C

**Table 3. Operating Ratings**

Symbol	Parameter/Conditions	Min	Max	Units
$V_{DD}$	Supply voltage	2.85	3.45	V
$T_A$	Operating ambient temperature range	-40	85	°C

**Table 4. ESD Ratings**

Symbol	Parameter/Conditions	Level	Units
$V_{ESD}$	ESD voltage (Human Body Model) <sup>1</sup>	1000	V

Note: 1. Periodically sampled, not 100% tested. Tested per MIL-STD-883, M3015 C2

### Electrostatic Discharge (ESD) Precautions

When handling this UltraCMOS™ device, observe the same precautions that you would use with other ESD-sensitive devices. Although this device contains circuitry to protect it from damage due to ESD, precautions should be taken to avoid exceeding the specified rating in *Table 4*.

### Latch-Up Avoidance

Unlike conventional CMOS devices, UltraCMOS™ devices are immune to latch-up.

**Table 5. DC Characteristics:  $V_{DD} = 3.3\text{ V}$ ,  $-40\text{ °C} < T_A < 85\text{ °C}$ , unless otherwise specified**

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{DD}$	Operational supply current; Prescaler disabled	$V_{DD} = 2.85\text{ to }3.45\text{ V}$		15		mA
	Prescaler enabled			45	50	mA
Digital Inputs: All except $f_r$ , $F_{in}$ , $\bar{F}_{in}$						
$V_{IH}$	High level input voltage	$V_{DD} = 2.85\text{ to }3.45\text{ V}$	$0.7 \times V_{DD}$			V
$V_{IL}$	Low level input voltage	$V_{DD} = 2.85\text{ to }3.45\text{ V}$			$0.3 \times V_{DD}$	V
$I_{IH}$	High level input current	$V_{IH} = V_{DD} = 3.45\text{ V}$			70	μA
$I_{IL}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.45\text{ V}$	-1			μA
Reference Divider input: $f_r$						
$I_{IHR}$	High level input current	$V_{IH} = V_{DD} = 3.45\text{ V}$			100	μA
$I_{ILR}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.45\text{ V}$	-100			μA
Counter and phase detector outputs: $f_c$ , $f_p$						
$V_{OLD}$	Output voltage LOW	$I_{out} = 6\text{ mA}$			0.4	V
$V_{OHD}$	Output voltage HIGH	$I_{out} = -3\text{ mA}$	$V_{DD} - 0.4$			V
Lock detect outputs: $C_{EXT}$ , LD						
$V_{OLC}$	Output voltage LOW, $C_{EXT}$	$I_{out} = 100\text{ μA}$			0.4	V
$V_{OHC}$	Output voltage HIGH, $C_{EXT}$	$I_{out} = -100\text{ μA}$	$V_{DD} - 0.4$			V
$V_{OLLD}$	Output voltage LOW, LD	$I_{out} = 1\text{ mA}$			0.4	V

**Table 6. AC Characteristics:  $V_{DD} = 3.3\text{ V}$ ,  $-40\text{ }^{\circ}\text{C} < T_A < 85\text{ }^{\circ}\text{C}$ , unless otherwise specified**

Symbol	Parameter	Conditions	Min	Typical	Max	Units
<b>Control Interface and Latches (see Figures 4, 5, 6)</b>						
$f_{\text{Clk}}$	Serial data clock frequency	(Note 1)			10	MHz
$t_{\text{ClkH}}$	Serial clock HIGH time		30			ns
$t_{\text{ClkL}}$	Serial clock LOW time		30			ns
$t_{\text{DSU}}$	Sdata set-up time after Sclk rising edge, D[7:0] set-up time to M1_WR, M2_WR, A_WR, E_WR rising edge		10			ns
$t_{\text{DHLD}}$	Sdata hold time after Sclk rising edge, D[7:0] hold time to M1_WR, M2_WR, A_WR, E_WR rising edge		10			ns
$t_{\text{PW}}$	S_WR, M1_WR, M2_WR, A_WR, E_WR pulse width		30			ns
$t_{\text{CWR}}$	Sclk rising edge to S_WR rising edge. S_WR, M1_WR, M2_WR, A_WR falling edge to Hop_WR rising edge		30			ns
$t_{\text{CE}}$	Sclk falling edge to E_WR transition		30			ns
$t_{\text{WRC}}$	S_WR falling edge to Sclk rising edge. Hop_WR falling edge to S_WR, M1_WR, M2_WR, A_WR rising edge		30			ns
$t_{\text{EC}}$	E_WR transition to Sclk rising edge		30			ns
$t_{\text{MDO}}$	MSEL data out delay after Fin rising edge	$C_L = 12\text{ pf}$			8	ns
<b>Main Divider (Including Prescaler)<sup>4</sup></b>						
$P_{\text{Fin}}$	Input level range	External AC coupling $275\text{ MHz} \leq \text{Freq} \leq 3200\text{ MHz}$	-5		5	dBm
		External AC coupling $3.2\text{ GHz} < \text{Freq} \leq 3.5\text{ GHz}$ $3.15\text{ V} \leq V_{DD} \leq 3.45\text{ V}$	0		5	dBm
<b>Main Divider (Prescaler Bypassed)<sup>4</sup></b>						
$F_{\text{in}}$	Operating frequency		50		300	MHz
$P_{\text{Fin}}$	Input level range	External AC coupling	-5		5	dBm
<b>Reference Divider</b>						
$f_r$	Operating frequency	(Note 3)			100	MHz
$P_{\text{fr}}$	Reference input power <sup>2</sup>	Single-ended input	-2		10	dBm
<b>Phase Detector</b>						
$f_c$	Comparison frequency	(Note 3)			50	MHz
<b>SSB Phase Noise (<math>F_{\text{in}} = 1.9\text{ GHz}</math>, <math>f_r = 20\text{ MHz}</math>, <math>f_c = 20\text{ MHz}</math>, <math>\text{LBW} = 50\text{ kHz}</math>, <math>V_{DD} = 3.3\text{ V}</math>, <math>\text{Temp} = 25\text{ }^{\circ}\text{C}</math>)<sup>4</sup></b>						
$\Phi_N$	Phase Noise	100 Hz Offset		-89		dBc/Hz
$\Phi_N$	Phase Noise	1 kHz Offset		-95		dBc/Hz
$\Phi_N$	Phase Noise	10 kHz Offset		-102		dBc/Hz
<b>SSB Phase Noise (<math>F_{\text{in}} = 1.9\text{ GHz}</math>, <math>f_r = 20\text{ MHz}</math>, <math>f_c = 20\text{ MHz}</math>, <math>\text{LBW} = 50\text{ kHz}</math>, <math>V_{DD} = 3.0\text{ V}</math>, <math>\text{Temp} = 25\text{ }^{\circ}\text{C}</math>)<sup>4</sup></b>						
$\Phi_N$	Phase Noise	100 Hz Offset		-87		dBc/Hz
$\Phi_N$	Phase Noise	1 kHz Offset		-94		dBc/Hz
$\Phi_N$	Phase Noise	10 kHz Offset		-101		dBc/Hz

- Notes: 1. Fclk is verified during the functional pattern test. Serial programming sections of the functional pattern are clocked at 10 MHz to verify Fclk specification.  
2. CMOS logic levels can be used to drive the reference input. If the  $V_{DD}$  of the CMOS driver matches the  $V_{DD}$  of PLL IC, then the reference input can be DC coupled. Otherwise, the reference input should be AC coupled.  
3. Parameter is guaranteed through characterization only and is not tested.  
4. Parameters below are not tested for die sales. These parameters are verified during the element evaluation.

Figure 4. RF Sensitivity versus Frequency (typical device at temperature = 25° C)

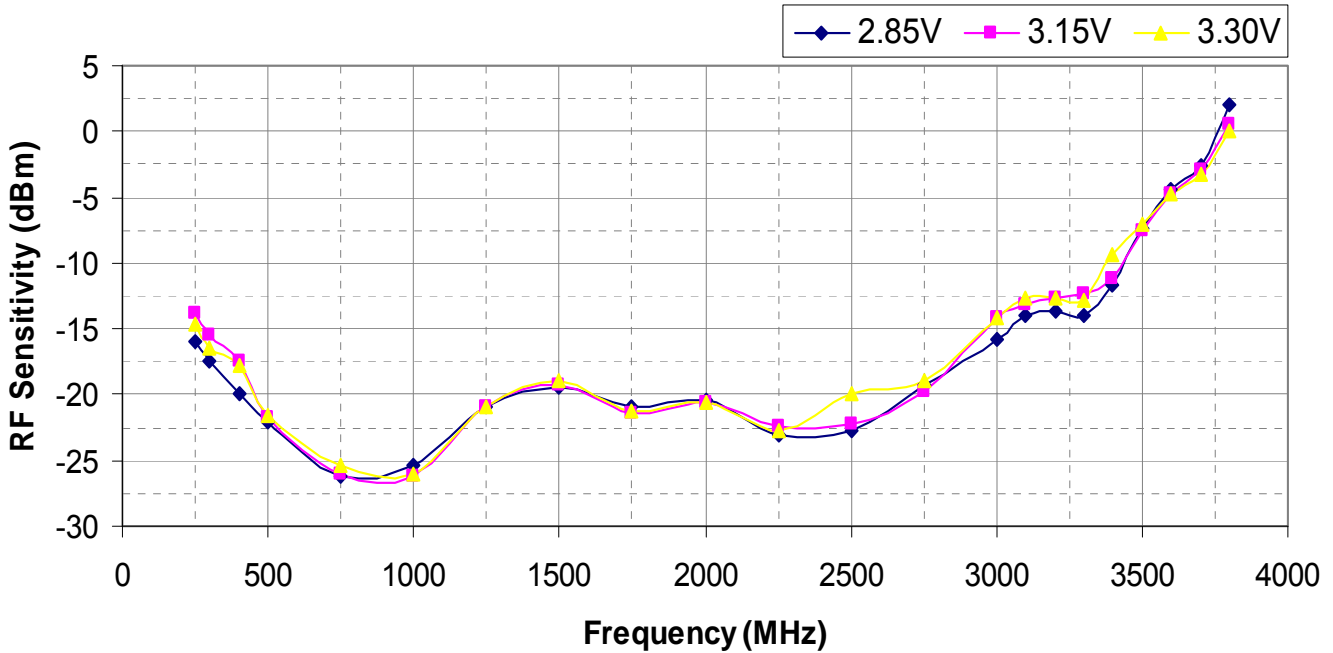
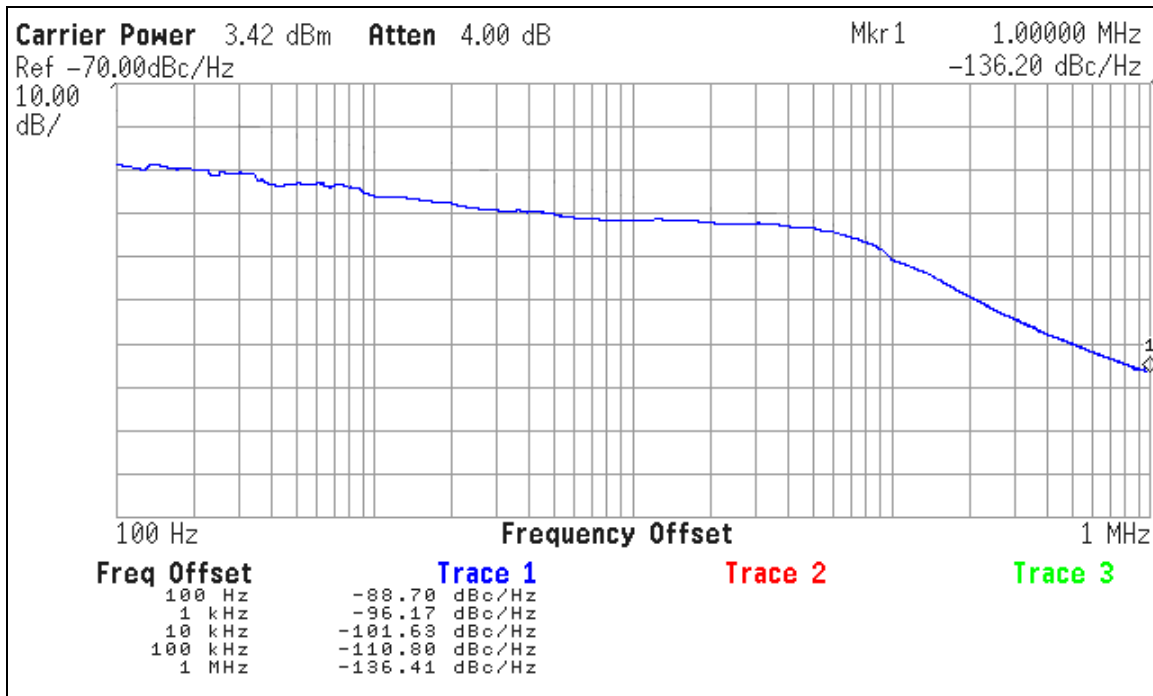


Figure 5. Typical Phase Noise for PE97022,  $V_{DD} = 3.3\text{ V}$ , Temp = 25 C,  $F_{vco} = 1.92\text{ GHz}$ ,  $F_{comp} = 20\text{ MHz}$ , Loop Bandwidth = 50 kHz

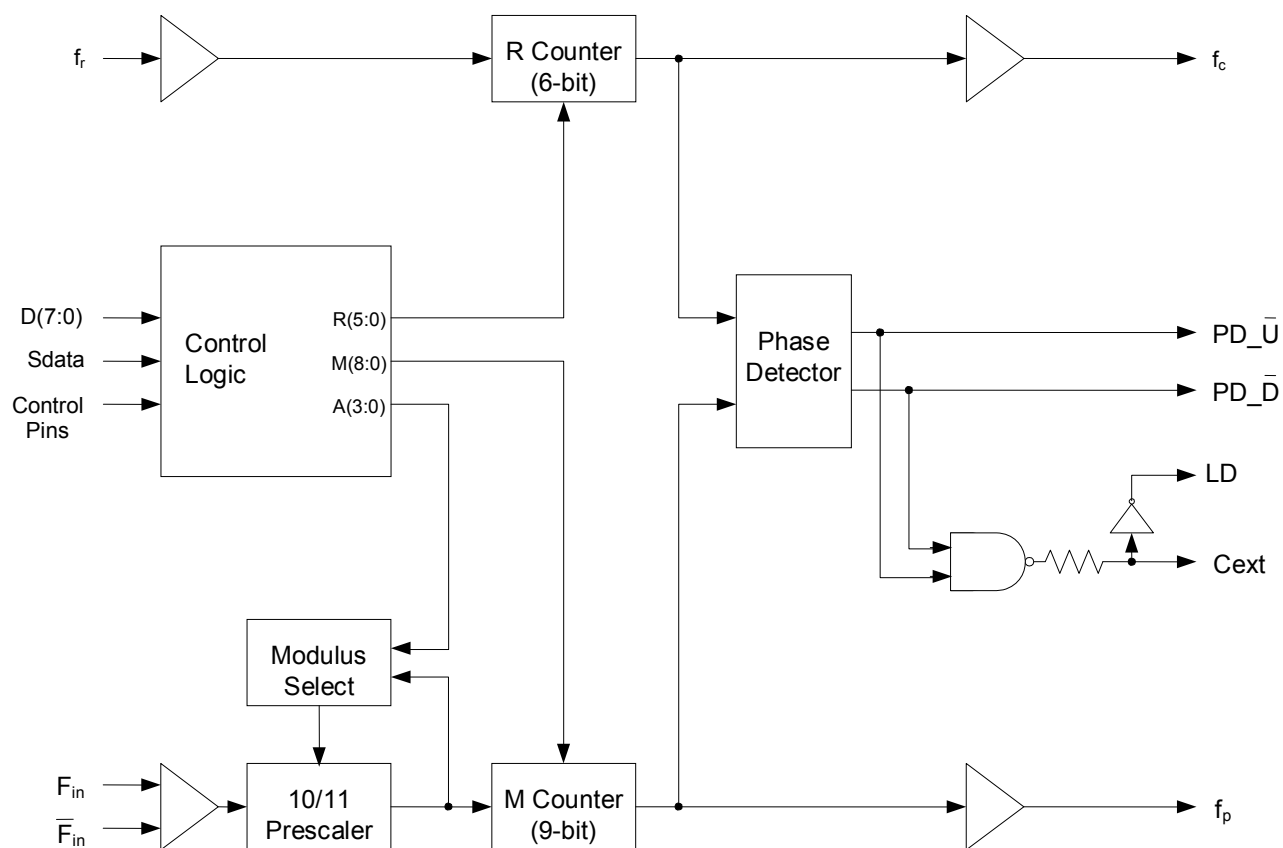


### Functional Description

The PE97022 consists of a prescaler, counters, a phase detector, and control logic. The dual modulus prescaler divides the VCO frequency by either 10 or 11, depending on the value of the modulus select. Counters “R” and “M” divide the reference and prescaler output, respectively, by integer values stored in a 20-bit register. An additional counter (“A”) is used in the modulus select logic. The phase-frequency detector

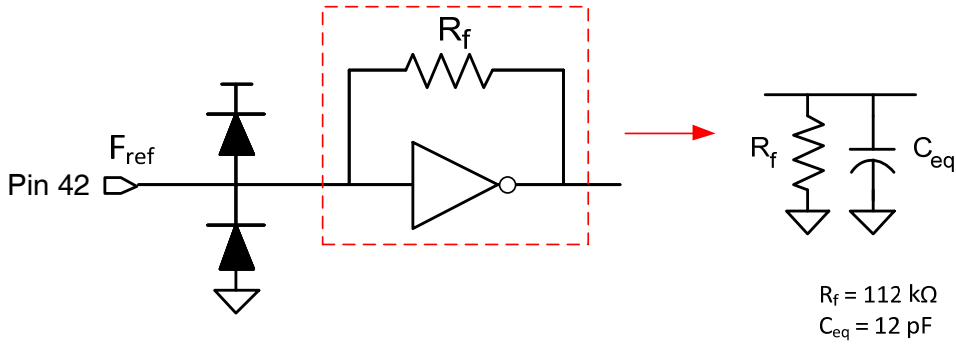
generates up and down frequency control signals. The control logic includes a selectable chip interface. Data can be written via serial bus, parallel bus, or hardwired directly to the pins. There are also various operational and test modes and a lock detect output.

Figure 6. Functional Block Diagram



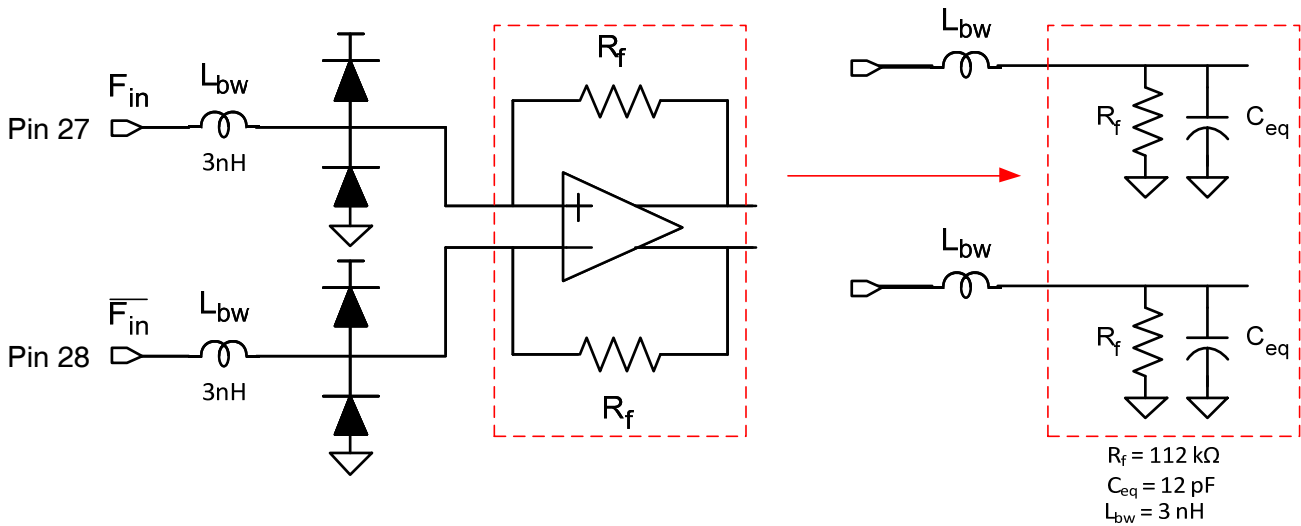
**Figure 7. Equivalent Input Diagram: Reference Input**

Peregrine Specification 71/0032



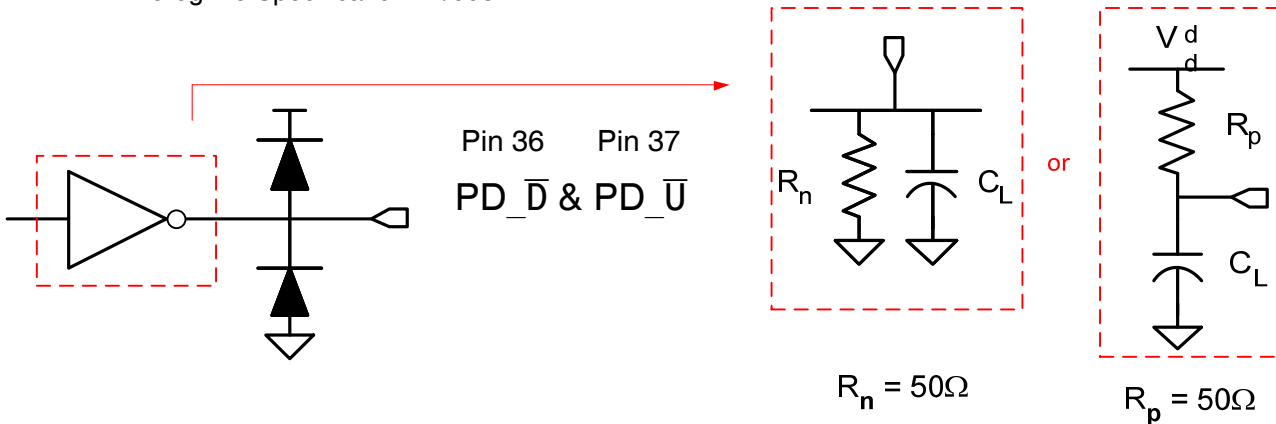
**Figure 8. Equivalent Input Diagram: Main Input**

Peregrine Specification 71/0033



**Figure 9. Equivalent Input Diagram: PD<sub>D</sub> & PD<sub>U</sub> Outputs**

Peregrine Specification 71/0034



## Main Counter Chain

### Normal Operating Mode

The main counter chain divides the RF input frequency,  $F_{in}$ , by an integer derived from the user-defined values in the “M” and “A” counters. It is composed of the 10/11 dual modulus prescaler, modulus select logic, and 9-bit M counter. Setting  $\overline{\text{Pre\_en}}$  “low” enables the 10/11 prescaler. Setting  $\overline{\text{Pre\_en}}$  “high” allows  $F_{in}$  to bypass the prescaler and powers down the prescaler.

The output from the main counter chain,  $f_p$ , is related to the VCO frequency,  $F_{in}$ , by the following equation:

$$f_p = F_{in} / [10 \times (M + 1) + A] \quad (1)$$

where  $A \leq M + 1$ ,  $1 \leq M \leq 511$

When the loop is locked,  $F_{in}$  is related to the reference frequency,  $f_r$ , by the following equation:

$$F_{in} = [10 \times (M + 1) + A] \times (f_r / (R+1)) \quad (2)$$

where  $A \leq M + 1$ ,  $1 \leq M \leq 511$

A consequence of the upper limit on A is that  $F_{in}$  must be greater than or equal to  $90 \times (f_r / (R+1))$  to obtain contiguous channels. Programming the M Counter with the minimum value of “1” will result in a minimum M Counter divide ratio of “2”.

In Direct Interface Mode, main counter inputs  $M_7$  and  $M_8$  are internally forced low. In this mode, the M value is limited to  $1 \leq M \leq 127$ .

### Prescaler Bypass Mode

Setting  $\overline{\text{Pre\_en}}$  “high” allows  $F_{in}$  to bypass and power down the prescaler. In this mode, the 10/11 prescaler and A register are not active, and the input VCO frequency is divided by the M counter directly. The following equation relates  $F_{in}$  to the reference frequency,  $f_r$ :

$$F_{in} = (M + 1) \times (f_r / (R+1)) \quad (3)$$

where  $1 \leq M \leq 511$

In Direct Interface Mode, main counter inputs  $M_7$  and  $M_8$  are internally forced low. In this mode, the M value is limited to  $1 \leq M \leq 127$ .

## Reference Counter

The reference counter chain divides the reference frequency,  $f_r$ , down to the phase detector comparison frequency,  $f_c$ .

The output frequency of the 6-bit R Counter is related to the reference frequency by the following equation:

$$f_c = f_r / (R + 1) \quad (4)$$

where  $0 \leq R \leq 63$

Note that programming R with “0” will pass the reference frequency,  $f_r$ , directly to the phase detector.

In Direct Interface Mode, R Counter inputs  $R_4$  and  $R_5$  are internally forced low (“0”). In this mode, the R value is limited to  $0 \leq R \leq 15$ .

## Register Programming

### Parallel Interface Mode

Parallel Interface Mode is selected by setting the  $\overline{\text{Bmode}}$  input “low” and the  $\overline{\text{Smode}}$  input “low”.

Parallel input data,  $D[7:0]$ , are latched in a parallel fashion into one of three 8-bit primary register sections on the rising edge of  $M1\_WR$ ,  $M2\_WR$ , or  $A\_WR$  per the mapping shown in *Table 7* on page 11. The contents of the primary register are transferred into a secondary register on the rising edge of  $\overline{\text{Hop\_WR}}$  according to the timing diagram shown in *Figure 10*. Data is transferred to the counters as shown in *Table 7* on page 11.

The secondary register acts as a buffer to allow rapid changes to the VCO frequency. This double buffering for “ping-pong” counter control is programmed via the  $\overline{\text{FSELP}}$  input. When  $\overline{\text{FSELP}}$  is “high”, the primary register contents set the counter inputs. When  $\overline{\text{FSELP}}$  is “low”, the secondary register contents are utilized.

Parallel input data,  $D[7:0]$ , are latched into the enhancement register on the rising edge of  $\overline{\text{E\_WR}}$  according to the timing diagram shown in *Figure 10*. This data provides control bits as shown in *Table 8* on page 11 with bit functionality enabled by asserting the  $\overline{\text{Enh}}$  input “low”.

### Serial Interface Mode

Serial Interface Mode is selected by setting the  $\overline{\text{Bmode}}$  input “low” and the  $\text{Smode}$  input “high”. While the  $\text{E\_WR}$  input is “low” and the  $\text{S\_WR}$  input is “low”, serial input data ( $\text{Sdata}$  input),  $\text{B}_0$  to  $\text{B}_{19}$ , is clocked serially into the primary register on the rising edge of  $\text{Sclk}$ , MSB ( $\text{B}_0$ ) first. The contents from the primary register are transferred into the secondary register on the rising edge of either  $\text{S\_WR}$  or  $\text{Hop\_WR}$  according to the timing diagram shown in *Figure 11*. Data is transferred to the counters as shown in *Table 7*.

The double buffering provided by the primary and secondary registers allows for “ping-pong” counter control using the  $\text{FSELS}$  input. When  $\text{FSELS}$  is “high”, the primary register contents set the counter inputs. When  $\text{FSELS}$  is “low”, the secondary register contents are utilized. While the  $\text{E\_WR}$  input is “high” and the  $\text{S\_WR}$  input is “low”, serial input data ( $\text{Sdata}$  input),  $\text{B}_0$  to

$\text{B}_7$ , is clocked serially into the enhancement register on the rising edge of  $\text{Sclk}$ , MSB ( $\text{B}_0$ ) first. The enhancement register is double buffered to prevent inadvertent control changes during serial loading, with buffer capture of the serially-entered data performed on the falling edge of  $\text{E\_WR}$  according to the timing diagram shown in *Figure 11*. After the falling edge of  $\text{E\_WR}$ , the data provides control bits as shown in *Table 8* with bit functionality enabled by asserting the  $\overline{\text{Enh}}$  input “low”.

### Direct Interface Mode

Direct Interface Mode is selected by setting the  $\overline{\text{Bmode}}$  input “high”.

Counter control bits are set directly at the pins as shown in *Table 7*. In Direct Interface Mode, main counter inputs  $\text{M}_7$  and  $\text{M}_8$ , and R Counter inputs  $\text{R}_4$  and  $\text{R}_5$  are internally forced low (“0”).

**Table 7. Primary Register Programming**

Interface Mode	Enh	$\overline{\text{Bmode}}$	Smode	R <sub>5</sub>	R <sub>4</sub>	M <sub>8</sub>	M <sub>7</sub>	Pre_en	M <sub>6</sub>	M <sub>5</sub>	M <sub>4</sub>	M <sub>3</sub>	M <sub>2</sub>	M <sub>1</sub>	M <sub>0</sub>	R <sub>3</sub>	R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>
Parallel	1	0	0	M2_WR rising edge load				M1_WR rising edge load								A_WR rising edge load							
				D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
Serial*	1	0	1	B <sub>0</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	B <sub>7</sub>	B <sub>8</sub>	B <sub>9</sub>	B <sub>10</sub>	B <sub>11</sub>	B <sub>12</sub>	B <sub>13</sub>	B <sub>14</sub>	B <sub>15</sub>	B <sub>16</sub>	B <sub>17</sub>	B <sub>18</sub>	B <sub>19</sub>
Direct	1	1	X	0	0	0	0	Pre_en	M <sub>6</sub>	M <sub>5</sub>	M <sub>4</sub>	M <sub>3</sub>	M <sub>2</sub>	M <sub>1</sub>	M <sub>0</sub>	R <sub>3</sub>	R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>	A <sub>0</sub>

\*Serial data clocked serially on  $\text{Sclk}$  rising edge while  $\text{E\_WR}$  “low” and captured in secondary register on  $\text{S\_WR}$  rising edge.



**Table 8. Enhancement Register Programming**

Interface Mode	Enh	$\overline{\text{Bmode}}$	Smode	Reserved	Reserved	Reserved	Power down	Counter load	MSEL output	Prescaler output	f <sub>c</sub> , f <sub>p</sub> OE		
Parallel	0	0	0	E_WR rising edge load									
				D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>		
Serial*	0	0	1	B <sub>0</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	B <sub>7</sub>		

\*Serial data clocked serially on  $\text{Sclk}$  rising edge while  $\text{E\_WR}$  “high” and captured in the double buffer on  $\text{E\_WR}$  falling edge.



Figure 10. Parallel Interface Mode Timing Diagram

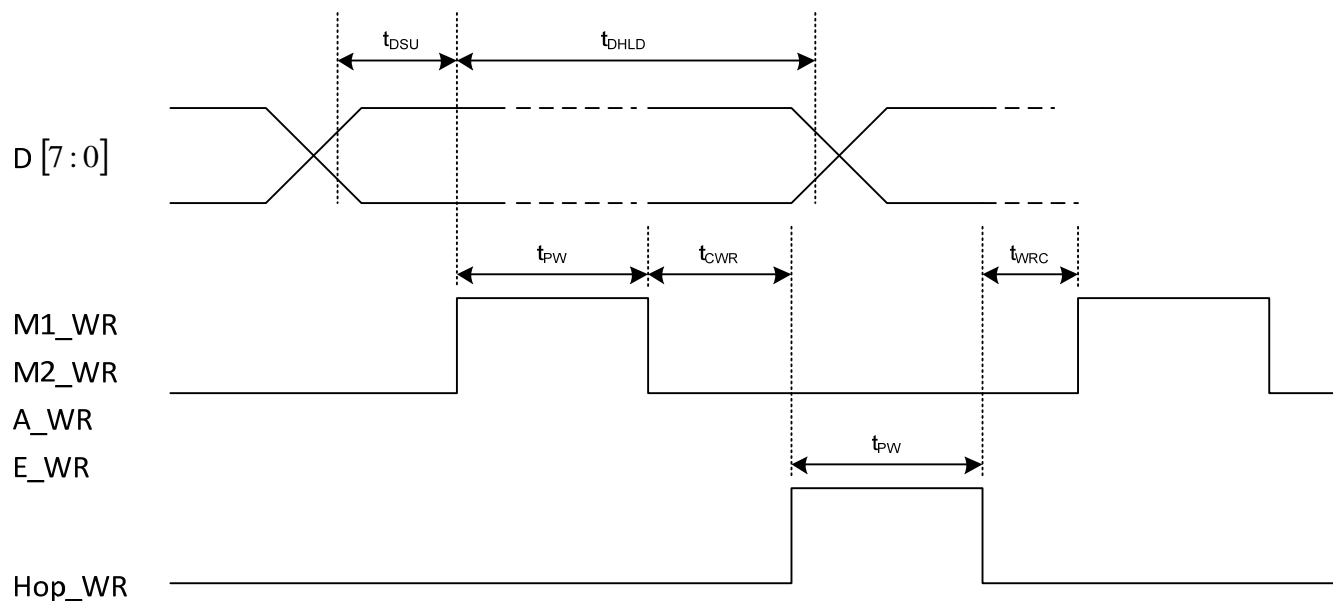
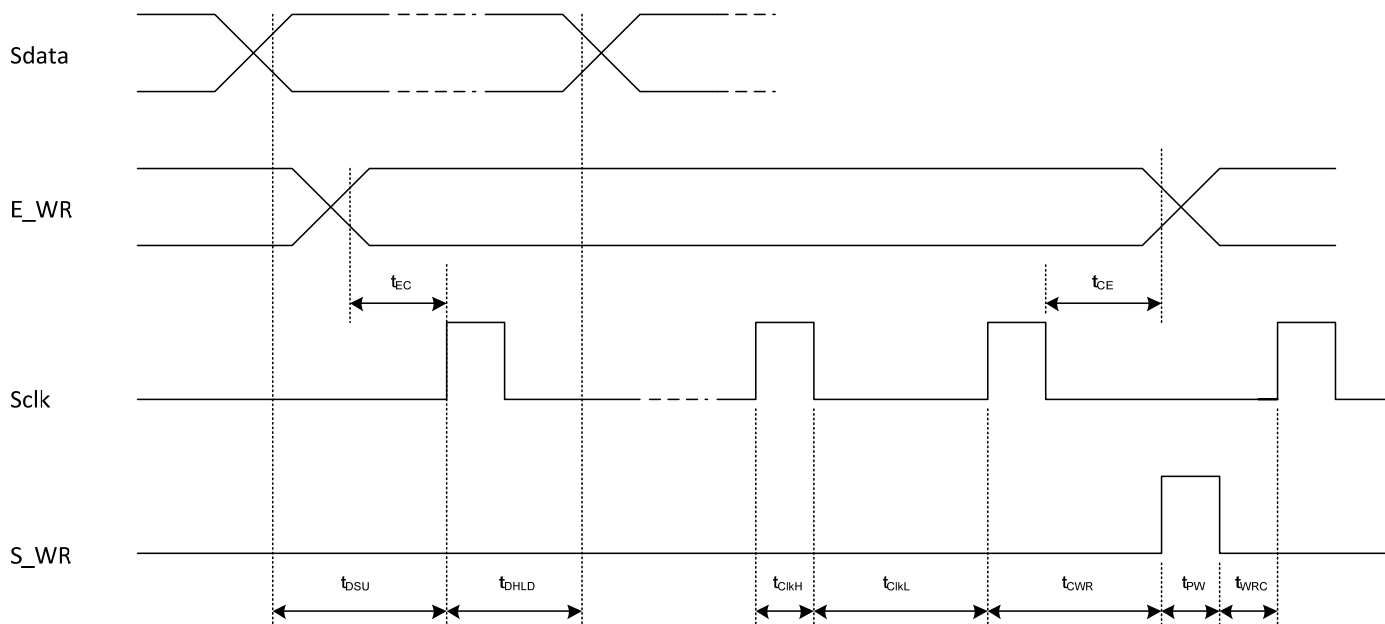


Figure 11. Serial Interface Mode Timing Diagram



## Enhancement Register

The functions of the enhancement register bits are shown below with all bits active “high”.

**Table 9. Enhancement Register Bit Functionality**

Bit Function		Description
Bit 0	Reserved**	
Bit 1	Reserved**	
Bit 2	Reserved**	
Bit 3	Power down	Power down of all functions except programming interface.
Bit 4	Counter load	Immediate and continuous load of counter programming as directed by the $\overline{\text{Bmode}}$ and $\overline{\text{Smode}}$ inputs.
Bit 5	MSEL output	Drives the internal dual modulus prescaler modulus select (MSEL) onto the Dout output.
Bit 6	Prescaler output	Drives the raw internal prescaler output (fmain) onto the Dout output.
Bit 7	$f_p, f_c \overline{\text{OE}}$	$f_p, f_c$ outputs disabled.

\*\* Program to 0

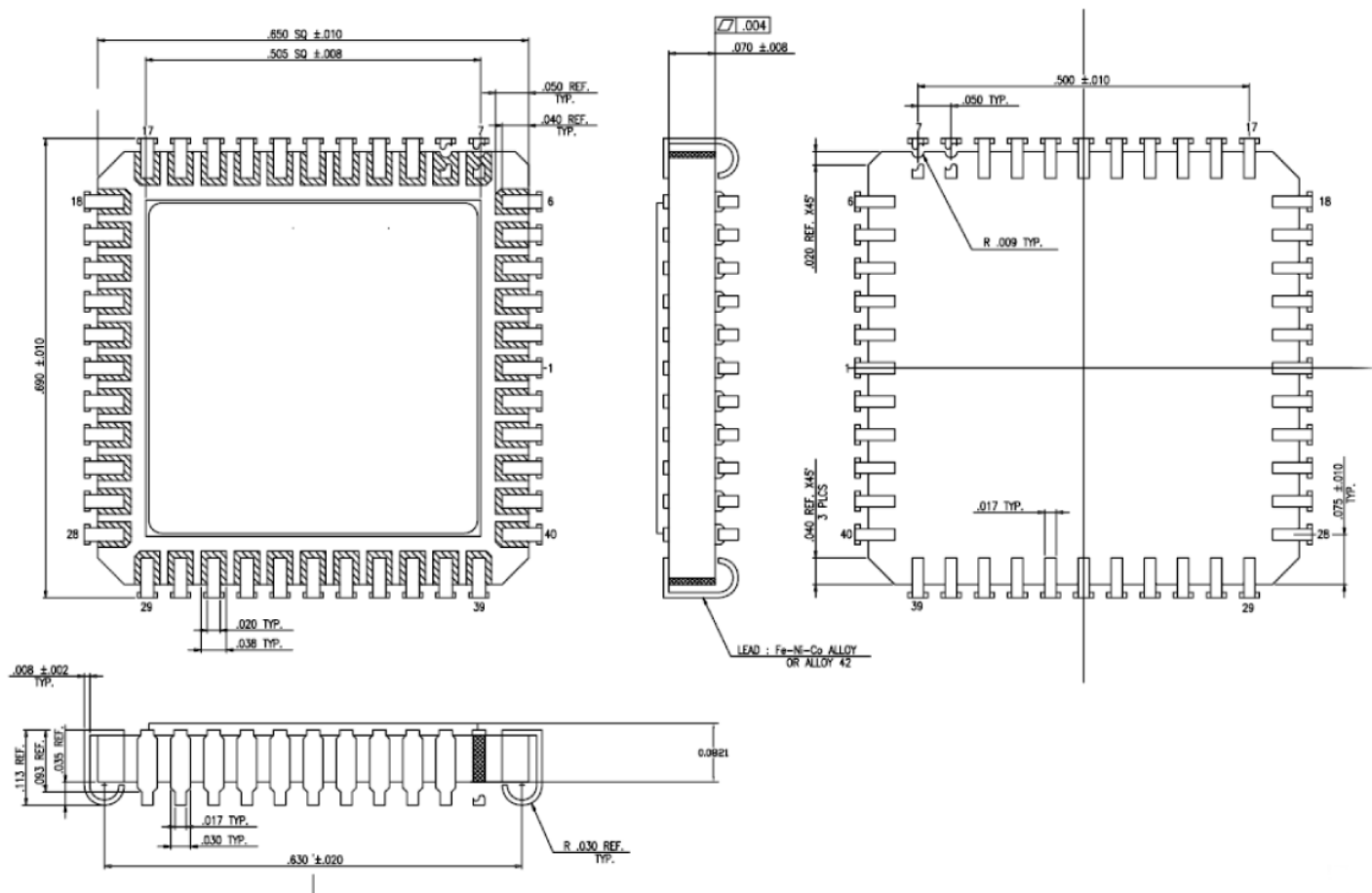
## Phase Detector

The phase detector is triggered by rising edges from the main Counter ( $f_p$ ) and the reference counter ( $f_c$ ). It has two outputs, namely  $\text{PD}_{\overline{\text{U}}}$ , and  $\text{PD}_{\overline{\text{D}}}$ . If the divided VCO leads the divided reference in phase or frequency ( $f_p$  leads  $f_c$ ),  $\text{PD}_{\overline{\text{D}}}$  pulses “low”. If the divided reference leads the divided VCO in phase or frequency ( $f_r$  leads  $f_p$ ),  $\text{PD}_{\overline{\text{U}}}$  pulses “low”. The width of either pulse is directly proportional to phase offset between the two input signals,  $f_p$  and  $f_c$ . The phase detector gain is 430 mV / radian.

$\text{PD}_{\overline{\text{U}}}$  and  $\text{PD}_{\overline{\text{D}}}$  are designed to drive an active loop filter which controls the VCO tune voltage.  $\text{PD}_{\overline{\text{U}}}$  pulses result in an increase in VCO frequency and  $\text{PD}_{\overline{\text{D}}}$  results in a decrease in VCO frequency.

A lock detect output, LD is also provided, via the pin  $\text{C}_{\text{EXT}}$ .  $\text{C}_{\text{EXT}}$  is the logical “NAND” of  $\text{PD}_{\overline{\text{U}}}$  and  $\text{PD}_{\overline{\text{D}}}$  waveforms, which is driven through a series 2k  $\Omega$  resistor. Connecting  $\text{C}_{\text{EXT}}$  to an external shunt capacitor provides integration.  $\text{C}_{\text{EXT}}$  also drives the input of an internal inverting comparator with an open drain output. Thus LD is an “AND” function of  $\text{PD}_{\overline{\text{U}}}$  and  $\text{PD}_{\overline{\text{D}}}$ . See *Figure 6* for a schematic of this circuit.

**Figure 12. Package Drawing**  
44-lead CQFJ



All dimensions are in inches

**Table 10. Ordering Information**

Order Code	Part Marking	Description	Package	Shipping Method
97022-01	PE97022 ES	Engineering Samples	44-pin CQFJ	40 units / Tray
97022-11	PE97022	Flight Units	44-pin CQFJ	40 units / Tray
97022-99	FA97022	Die Production Units	Die	100 units / waffle pack
97022-00	PE97022 EK	Evaluation Kit		1 / Box

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