

# PE3239

## Product Description

Peregrine's PE3239 is a high performance integer-N PLL capable of frequency synthesis up to 2.2 GHz. The superior phase noise performance of the PE3239 is ideal for applications such as wireless local loop basestations, LMDS systems and other demanding terrestrial systems.

The PE3239 features a 10/11 dual modulus prescaler, counters, phase detector and a charge pump as shown in Figure 1. Counter values are programmable through a three wire serial interface.

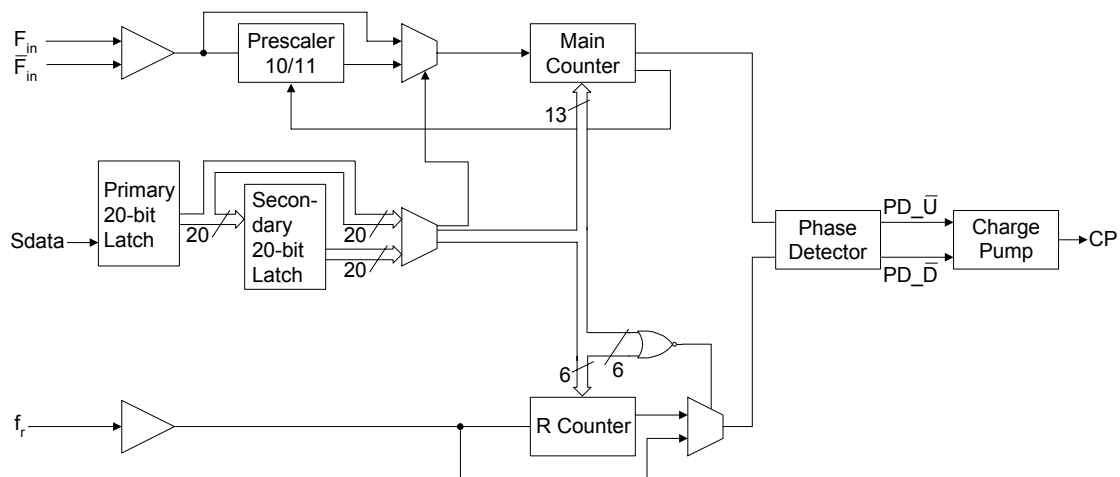
Fabricated in Peregrine's patented UTSi® (Ultra Thin Silicon) CMOS technology, the PE3239 offers excellent RF performance with the economy and integration of conventional CMOS.

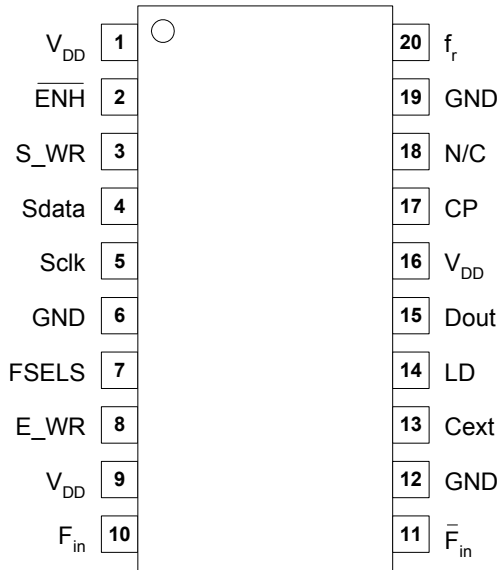
## 2.2 GHz Integer-N PLL for Low Phase Noise Applications

### Features

- 2.2 GHz operation
- 10/11 prescaler
- Internal phase detector with charge pump
- Serial programmable
- Low power — 20 mA at 3 V
- Ultra-low phase noise
- Available in 20-lead TSSOP

Figure 1. Block Diagram



**Figure 2. Pin Configuration**

**Table 1. Pin Descriptions**

Pin No.	Pin Name	Type	Description
1	V <sub>DD</sub>	(Note 1)	Power supply input. Input may range from 2.85 V to 3.15 V. Bypassing required.
2	$\overline{\text{Enh}}$	Input	Enhancement mode. When asserted low ("0"), enhancement register bits are functional. Internal 70 k $\Omega$ pull-up resistor.
3	S_WR	Input	Serial load enable input. While S_WR is "low", Sdata can be serially clocked. Primary register data are transferred to the secondary register on S_WR rising edge.
4	Sdata	Input	Binary serial data input. Input data entered MSB first.
5	Sclk	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.
6	GND		Ground.
7	FSELS	Input	Selects contents of primary register (FSELS=1) or secondary register (FSELS=0) for programming of internal counters. Internal 70 k $\Omega$ pull-down resistor.
8	E_WR	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. Internal 70 k $\Omega$ pull-down resistor.
9	V <sub>DD</sub>	(Note 1)	Same as pin 1.
10	F <sub>in</sub>	Input	Prescaler input from the VCO. Max frequency input is 2.2 GHz.
11	$\overline{\text{F}}_{\text{in}}$	Input	Prescaler complementary input. A bypass capacitor should be placed as close as possible to this pin and be connected in series with a 50 $\Omega$ resistor to the ground plane.
12	GND		Ground.
13	Cext	Output	Logical "NAND" of PD_U and PD_D terminated through an on chip, 2 k $\Omega$ series resistor. Connecting Cext to an external capacitor will low pass filter the input to the inverting amplifier used for driving LD.
14	LD	Output	Lock detect is an open drain logical inversion of CEXT. When the loop is in lock, LD is high impedance, otherwise LD is a logic low ("0").
15	Dout	Output	Data out function, Dout, enabled in enhancement mode.
16	V <sub>DD</sub>	(Note 1)	Same as pin 1.

Pin No.	Pin Name	Type	Description
17	CP	Output	Charge pump current is sourced when $f_c$ leads $f_p$ and sinked when $f_c$ lags $f_p$ .
18	NC	Output	No connection.
19	GND		Ground.
20	$f_r$	Input	Reference frequency input.

**Note 1:**  $V_{DD}$  pins 1, 9, and 16 are connected by diodes and must be supplied with the same positive voltage level.

**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	3.15	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 (Note 1)	1000	V

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

### Electrostatic Discharge (ESD) Precautions

When handling this UTSi 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 rating specified in Table 4.

### Latch-Up Avoidance

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

**Table 5. DC Characteristics**
 $V_{DD} = 3.0\text{ V}$ ,  $-40^\circ\text{ C} < T_A < 85^\circ\text{ C}$ , unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$I_{DD}$	Operational supply current; Prescaler enabled	$V_{DD} = 2.85\text{ to }3.15\text{ V}$		20	26	mA
Digital Inputs: S_WR, Sdata, Sclk						
$V_{IH}$	High level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$	$0.7 \times V_{DD}$			V
$V_{IL}$	Low level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$			$0.3 \times V_{DD}$	V
$I_{IH}$	High level input current	$V_{IH} = V_{DD} = 3.15\text{ V}$			+1	$\mu\text{A}$
$I_{IL}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.15\text{ V}$	-1			$\mu\text{A}$
Digital Inputs: Enh (contains a 70 k $\Omega$ pull-up resistor)						
$V_{IH}$	High level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$	$0.7 \times V_{DD}$			V
$V_{IL}$	Low level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$			$0.3 \times V_{DD}$	V
$I_{IH}$	High level input current	$V_{IH} = V_{DD} = 3.15\text{ V}$			+1	$\mu\text{A}$
$I_{IL}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.15\text{ V}$	-100			$\mu\text{A}$
Digital Inputs: FSELS, E_WR (contains a 70 k $\Omega$ pull-down resistor)						
$V_{IH}$	High level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$	$0.7 \times V_{DD}$			V
$V_{IL}$	Low level input voltage	$V_{DD} = 2.85\text{ to }3.15\text{ V}$			$0.3 \times V_{DD}$	V
$I_{IH}$	High level input current	$V_{IH} = V_{DD} = 3.15\text{ V}$			+100	$\mu\text{A}$
$I_{IL}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.15\text{ V}$	-1			$\mu\text{A}$
Reference Divider input: f <sub>r</sub>						
$I_{IHR}$	High level input current	$V_{IH} = V_{DD} = 3.15\text{ V}$			+100	$\mu\text{A}$
$I_{ILR}$	Low level input current	$V_{IL} = 0, V_{DD} = 3.15\text{ V}$	-100			$\mu\text{A}$
Counter output: Dout						
$V_{OLD}$	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: (Cext, LD)						
$V_{OLC}$	Output voltage LOW, Cext	$I_{out} = 0.1\text{ mA}$			0.4	V
$V_{OHC}$	Output voltage HIGH, Cext	$I_{out} = -0.1\text{ mA}$	$V_{DD} - 0.4$			V
$V_{OLLD}$	Output voltage LOW, LD	$I_{out} = 1\text{ mA}$			0.4	V
Charge Pump output: CP						
$I_{CP} - \text{Source}$	Drive current	$V_{CP} = V_{DD} / 2$	-2.6	-2	-1.4	mA
$I_{CP} - \text{Sink}$	Drive current	$V_{CP} = V_{DD} / 2$	1.4	2	2.6	mA
$I_{CPL}$	Leakage current	$1.0\text{ V} < V_{CP} < V_{DD} - 1.0\text{ V}$	-1		1	$\mu\text{A}$
$I_{CP} - \text{Source}$ vs. $1_{CP} \text{ Sink}$	Sink vs. source mismatch	$V_{CP} = V_{DD} / 2, T_A = 25^\circ\text{ C}$			15	%
$I_{CP} \text{ vs. } V_{CP}$	Output current magnitude variation vs. voltage	$1.0\text{ V} < V_{CP} < V_{DD} - 1.0\text{ V}$ $T_A = 25^\circ\text{ C}$			15	%

**Table 6. AC Characteristics**

$V_{DD} = 3.0\text{ V}$ ,  $-40^\circ\text{ C} < T_A < 85^\circ\text{ C}$ , unless otherwise specified

Symbol	Parameter	Conditions	Min	Max	Units
Control Interface and Latches (see Figures 5, 6, 7)					
$f_{CLK}$	Serial data clock frequency	(Note 1)		10	MHz
$t_{CLKH}$	Serial clock HIGH time		30		ns
$t_{CLKL}$	Serial clock LOW time		30		ns
$t_{DSU}$	Sdata set-up time to Sclk rising edge		10		ns
$t_{DHLD}$	Sdata hold time after Sclk rising edge		10		ns
$t_{PW}$	S_WR pulse width		30		ns
$t_{CWR}$	Sclk rising edge to S_WR rising edge		30		ns
$t_{CE}$	Sclk falling edge to E_WR transition		30		ns
$t_{WRC}$	S_WR falling edge to Sclk rising edge		30		ns
$t_{EC}$	E_WR transition to Sclk rising edge		30		ns
Main Divider (Including Prescaler)					
$F_{in}$	Operating frequency		200	2200	MHz
$P_{Fin}$	Input level range	External AC coupling	-5	5	dBm
Main Divider (Prescaler Bypassed)					
$F_{in}$	Operating frequency		20	220	MHz
$P_{Fin}$	Input level range	External AC coupling	-5	5	dBm
Reference Divider					
$f_r$	Operating frequency	(Note 3)		100	MHz
$P_{fr}$	Reference input power (Note 2)	Single ended input	-2		dBm
Phase Detector					
$f_c$	Comparison frequency	(Note 3)		20	MHz

- Note 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.
- Note 2:** CMOS logic levels can be used to drive reference input if DC coupled. Voltage input needs to be a minimum of 0.5 Vp-p. For optimum phase noise performance, the reference input falling edge rate should be faster than 80mV/ns.
- Note 3:** Parameter is guaranteed through characterization only and is not tested.

Typical Performance Data ( $V_{DD} = 3.00V$ ,  $T_A = 25^\circ C$ )

Figure 3. Typical RF Input Sensitivity

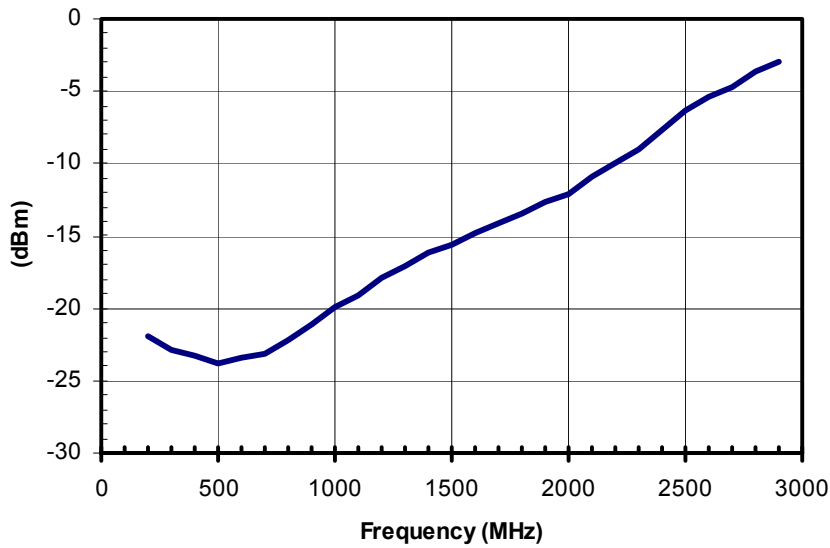
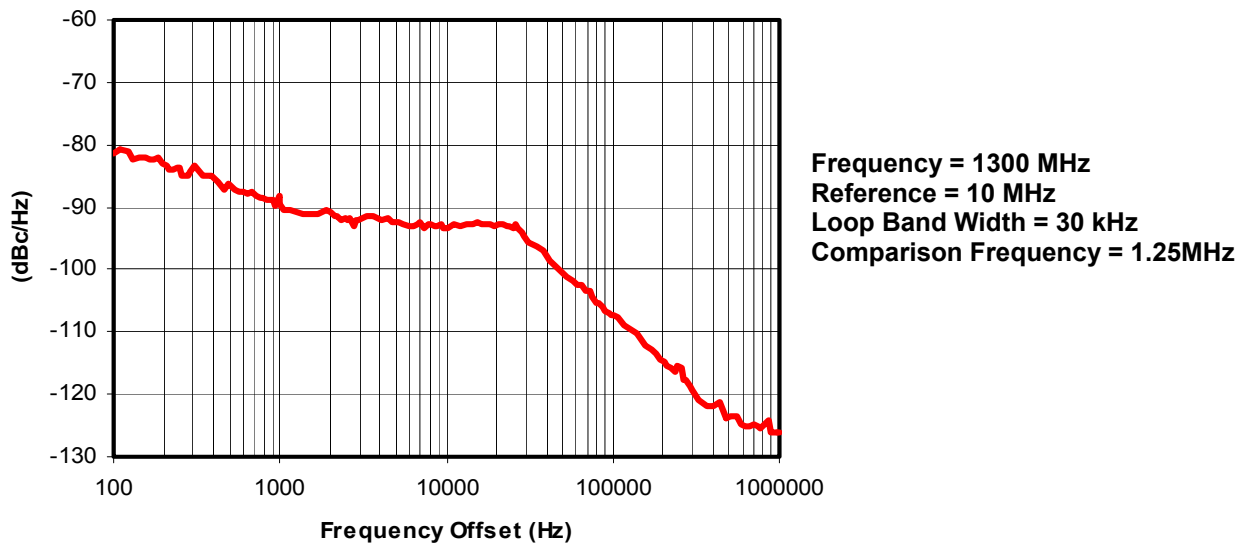


Figure 4. Typical Phase Noise Performance

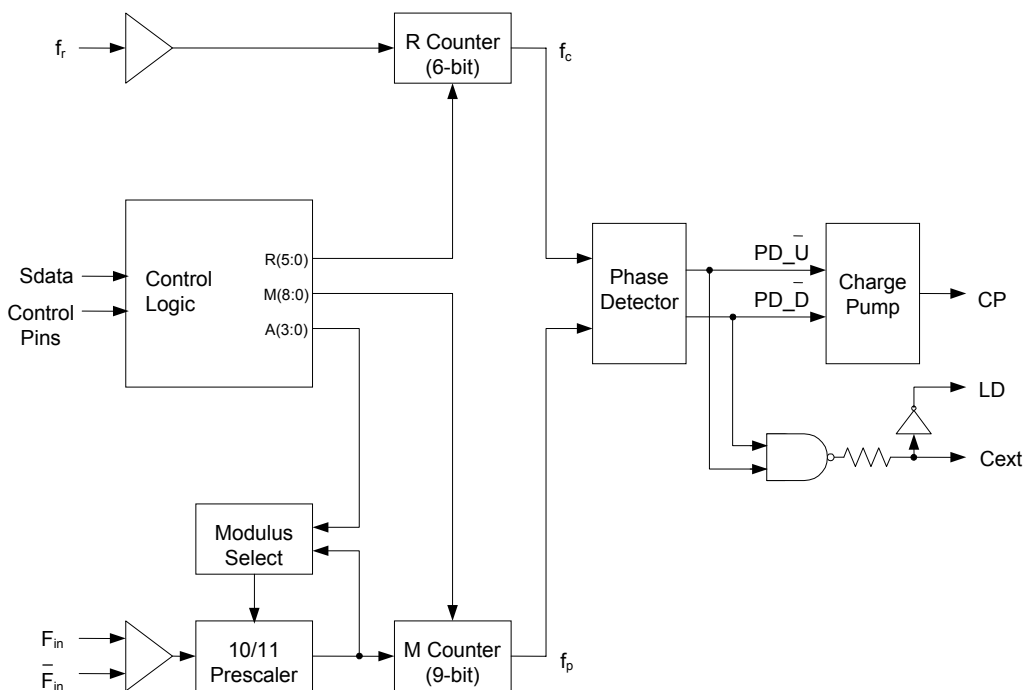


### Functional Description

The PE3239 consists of a prescaler, counters, a phase detector, charge pump 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 which direct the charge pump operation. The control logic includes a selectable chip interface. Data is written into the internal registers via the three wire serial bus. There are also various operational and test modes and a lock detect output.

Figure 5. Functional Block Diagram



## Main Counter Chain

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  $\overline{Pre\_en}$  “low” enables the 10/11 prescaler. Setting  $\overline{Pre\_en}$  “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  $A \leq M + 1$ ,  $M \neq 0$

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  $A \leq M + 1$ ,  $M \neq 0$

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”.

## 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:

$$f_c = f_r / (R + 1) \quad (3)$$

where  $R \geq 0$

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

## Register Programming

### Serial Interface Mode

While the  $E\_WR$  input is “low” and the  $S\_WR$  input is “low”, serial input data (Sdata input),  $B_0$  to  $B_{19}$ , are clocked serially into the primary register on the rising edge of Sclk, MSB ( $B_0$ ) first. The contents from the primary register are transferred into the secondary register on the rising edge of either  $S\_WR$  according to the timing diagrams shown in Figure 6. Data are transferred to the counters as shown in Table 7 on page 9.

The double buffering provided by the primary and secondary registers allows for “ping-pong” counter control using the FSELS input. When FSELS is “high”, the primary register contents set the counter inputs. When FSELS is “low”, the secondary register contents are utilized.

While the  $E\_WR$  input is “high” and the  $S\_WR$  input is “low”, serial input data (Sdata input),  $B_0$  to  $B_7$ , are clocked serially into the enhancement register on the rising edge of Sclk, MSB ( $B_0$ ) 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  $E\_WR$  according to the timing diagram shown in Figure 6. After the falling edge of  $E\_WR$ , the data provide control bits as shown in Table 8 on page 9 will have their bit functionality enabled by asserting the  $\overline{Enh}$  input “low”.



**Table 7. Primary Register Programming**

Interface Mode	$\overline{\text{Enh}}$	R <sub>5</sub>	R <sub>4</sub>	M <sub>8</sub>	M <sub>7</sub>	$\overline{\text{Pre\_en}}$	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*	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>

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



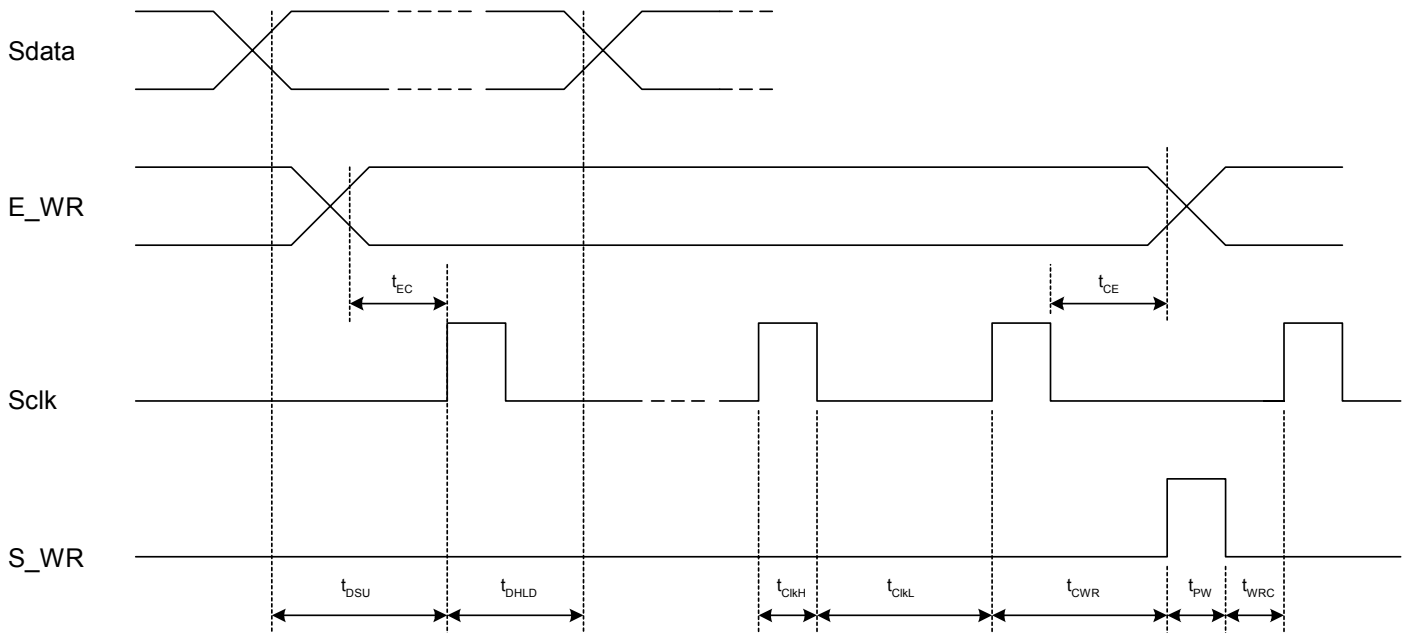
**Table 8. Enhancement Register Programming**

Interface Mode	$\overline{\text{Enh}}$	Reserved	Reserved	f <sub>p</sub> Output	Power down	Counter load	MSEL output	f <sub>c</sub> output	Reserved
Serial*	0	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 Sclk rising edge while E\_WR “high” and captured in the double buffer on E\_WR falling edge.



**Figure 6. 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	$f_p$ output	Drives the M counter output onto the Dout output.
Bit 3	Power down	Power down of all functions except programming interface.
Bit 4	Counter load	Immediate and continuous load of counter programming.
Bit 5	MSEL output	Drives the internal dual modulus prescaler modulus select (MSEL) onto the Dout output.
Bit 6	$f_c$ output	Drives the reference counter output onto the Dout output
Bit 7	Reserved**	

\*\* Program to 0

## Phase Detector

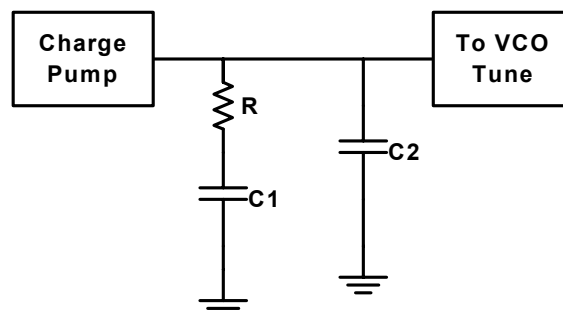
The phase detector is triggered by rising edges from the main Counter ( $f_p$ ) and the reference counter ( $f_c$ ). It has two outputs, namely  $PD_{\bar{U}}$ , and  $PD_{\bar{D}}$ . If the divided VCO leads the divided reference in phase or frequency ( $f_p$  leads  $f_c$ ),  $PD_{\bar{D}}$  pulses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

The signals from the phase detector couple directly to a charge pump.  $PD_{\bar{U}}$  controls a current source at pin CP with constant amplitude and pulse duration approximately the same as  $PD_{\bar{U}}$ .  $PD_{\bar{D}}$  similarly drives a current sink at pin CP. The

current pulses from pin CP are low pass filtered externally and then connected to the VCO tune voltage.  $PD_{\bar{U}}$  pulses result in a current source, which increases the VCO frequency and  $PD_{\bar{D}}$  results in a current sink, which decreases VCO frequency when using a positive  $K_v$  VCO.

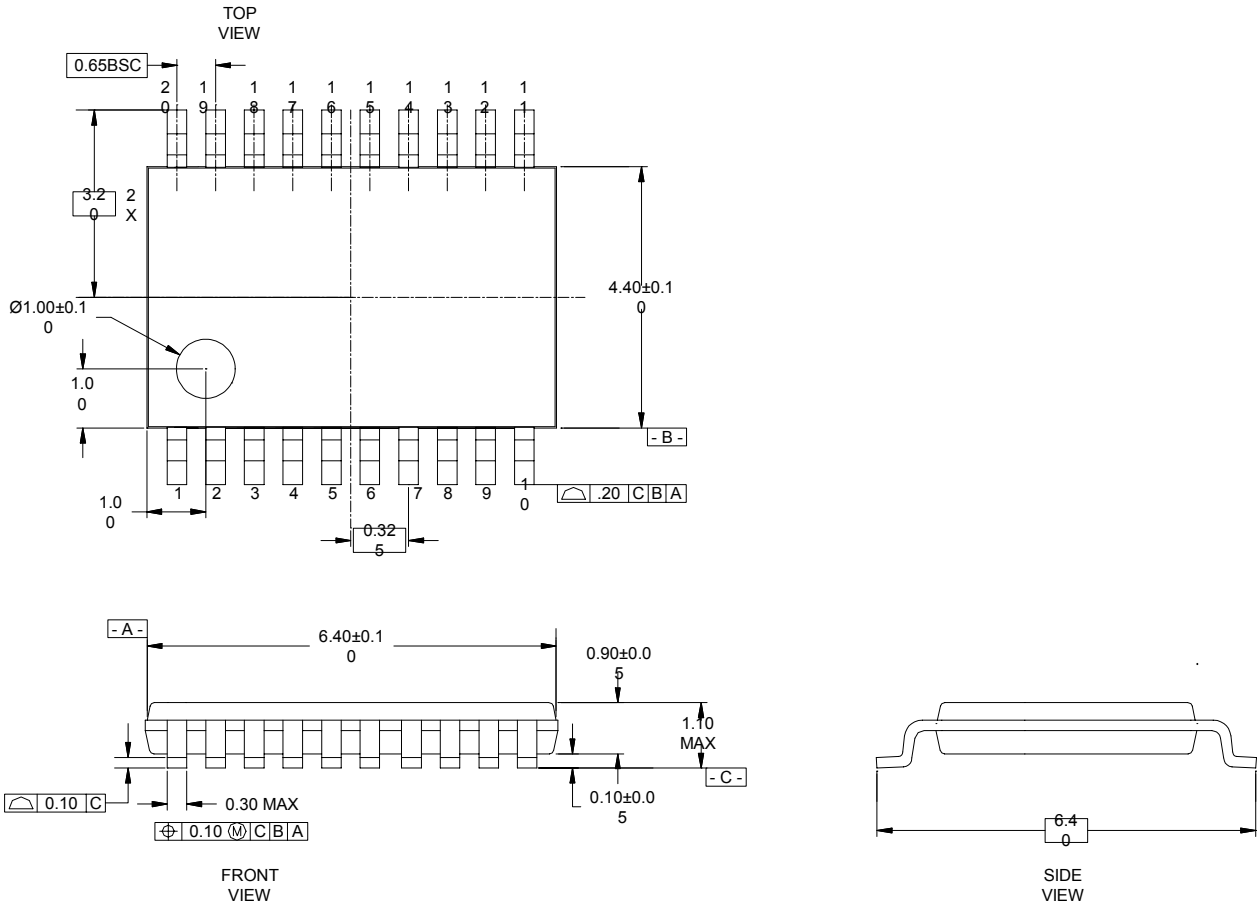
A lock detect output, LD is also provided, via the pin Cext. Cext is the logical “NAND” of  $PD_{\bar{U}}$  and  $PD_{\bar{D}}$  waveforms, which is driven through a series 2 kohm resistor. Connecting Cext to an external shunt capacitor provides low pass filtering of this signal. Cext also drives the input of an internal inverting comparator with an open drain output. Thus LD is an “AND” function of  $PD_{\bar{U}}$  and  $PD_{\bar{D}}$ .

**Figure 7. Typical PE3239 Loop Filter Application Example**



### Figure 8. Package Drawing

20-lead TSSOP (JEDEC MO-153-AC)



**Table 10. Ordering Information**

Order Code	Part Marking	Description	Package	Shipping Method
3239-11	PE3239	PE3239-20TSSOP-74A	20-lead TSSOP	74 units / Tube
3239-12	PE3239	PE3239-20TSSOP-2000C	20-lead TSSOP	2000 units / T&R
3239-00	PE3239EK	PE3239-20TSSOP-EVAL KIT	Evaluation Board	1 / Box

## Sales Offices

### **United States**

#### **Peregrine Semiconductor Corp.**

6175 Nancy Ridge Drive  
San Diego, CA 92121  
Tel 1-858-455-0660  
Fax 1-858-455-0770

### **Europe**

#### **Peregrine Semiconductor Europe**

Aix-En-Provence Office  
Parc Club du Golf, bat 9  
13856 Aix-En-Provence Cedex 3  
France  
Tel 33-0-4-4239-3360  
Fax 33-0-4-4239-7227

### **Japan**

#### **Peregrine Semiconductor K.K.**

The Imperial Tower, 15th floor  
1-1-1 Uchisaiwaicho, Chiyoda-ku  
Tokyo 100-0011 Japan  
Tel: 03-3507-5755  
Fax: 03-3507-5601

### **Australia**

#### **Peregrine Semiconductor Australia**

8 Herb Elliot Ave.  
Homebush, NSW 2140  
Australia  
Tel: 011-61-2-9763-4111  
Fax: 011-61-2-9746-1501

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## Data Sheet Identification

### **Advance Information**

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### **Preliminary Specification**

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### **Product Specification**

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