

## General Description

The BW2010P is a Phase-Locked Loop (PLL) frequency synthesizer constructed in CMOS process technology. The PLL macrofunctions provide frequency multiplication capabilities. The output clock frequency,  $F_{out}$ , is related to the reference input clock frequency,  $F_{in}$ , by the following equation:

$$F_{out} = ( m * F_{in} ) / ( p * s )$$

where  $F_{out}$  is the output clock frequency.

$F_{in}$  is the reference input clock frequency.  $m$ ,  $p$  and  $s$  are the values for programmable dividers. BW2010P consists of a Phase/Frequency Detector (PFD), a Charge Pump, an External Loop Filter, a Voltage Controlled Oscillator (VCO), a 6bit Pre-divider, an 8bit Main divider and 2bit Post Scaler as shown in Figure 1.

## Features

- 0.35um CMOS process technology
- 3.3 Volt Single power supply
- Output frequency range: 25~ 250 MHz
- Jitter:  $\pm 100$ ps
- Output Duty ratio: 40% to 60%
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- Frequency changed by programmable divider
- Power down mode

## FUNCTIONAL BLOCK DIAGRAM

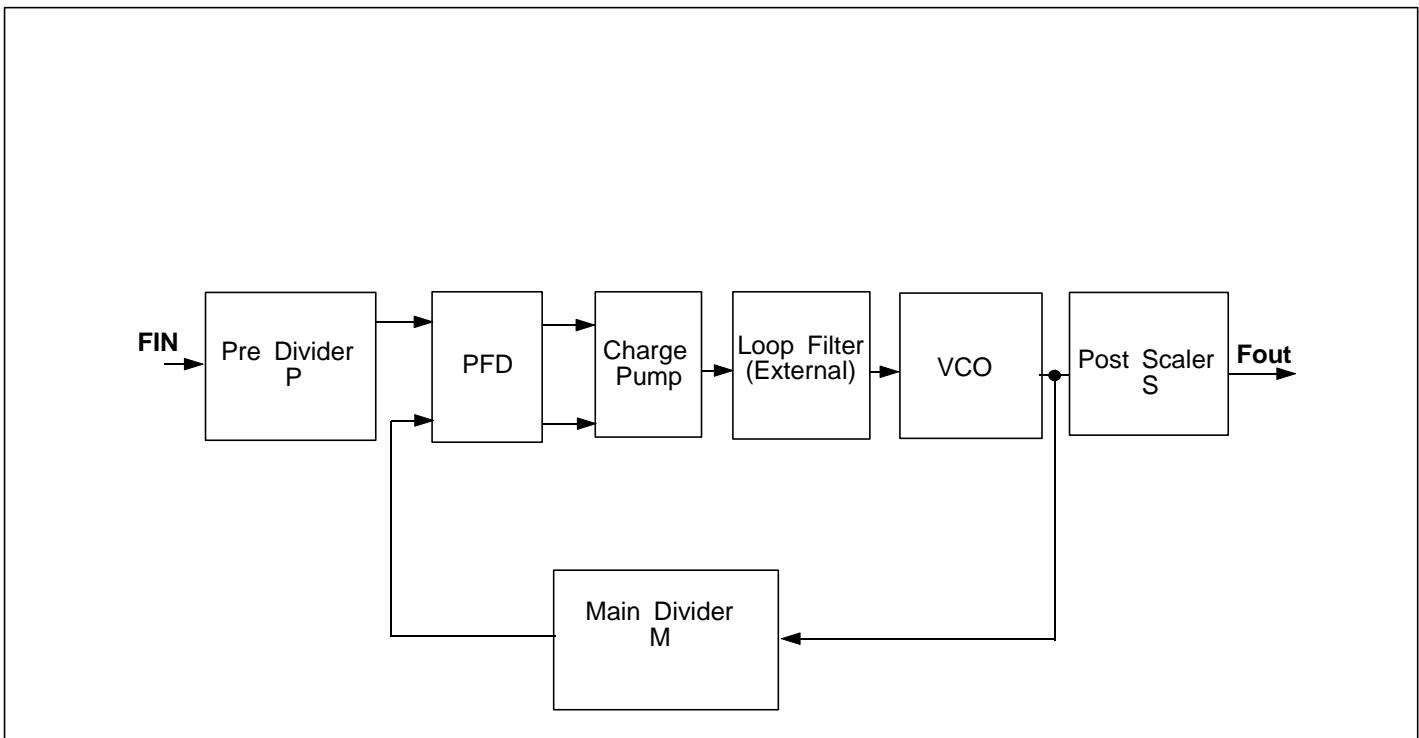


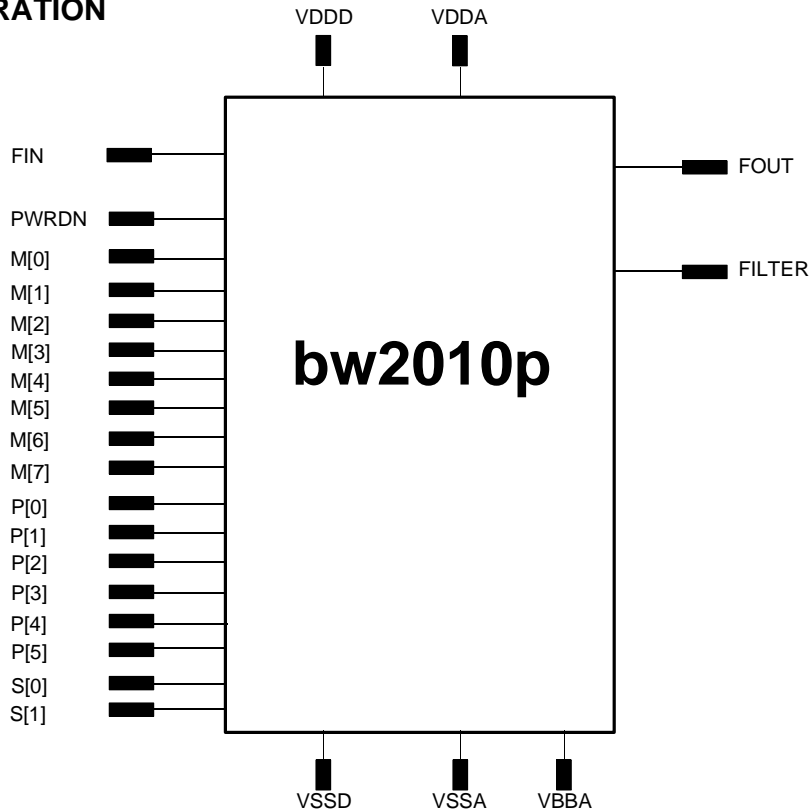
Figure 1. FUNCTIONAL BLOCK DIAGRAM

CORE PIN DESCRIPTION

NAME	I/O TYPE	I/O PAD	PIN DESCRIPTION
VDDD	DP	vddd	Digital power supply
VSSD	DG	vssd	Digital ground
VDDA	AP	vdda	Analog power supply
VSSA	AG	vssa	Analog ground
VBBA	AG	vbba	Substrate ground
FIN	AI	pia_bb	External F <sub>REF</sub> input
FILTER	AO	poar50_bb	Pump out is connected to Filter -A capacitor is connected between the pin and analog ground
FOUT	DO	pot12_bb	25MHz~250MHz clock output
PWRDN	DI	picc_bb	FSPLL clock power down. -If PWRDN is High, PLL does not operate under this condition. -If not used, tie it to VSSA.
P[5:0]	DI	picc_bb	The values for 6bit programmable pre-divider.
M[7:0]	DI	picc_bb	The values for 8bit programmable main divider.
S[1:0]	DI	picc_bb	The values for 2bit programmable post scaler.

I/O TYPE ABBR.
- AI : Analog Input
- DI : Digital Input
- AO : Analog Output
- DO : Analog Output
- AP : Analog Power
- AG : Analog Ground
- AB : Analog Sub Bias
- DP : Digital Power
- DG : Digital Ground
- DB : Digital Sub Vias
- BD : Bidirectional Port

CORE CONFIGURATION



**ABSOLUTE MAXIMUM RATINGS** ( $T_a=25^\circ\text{C}$ )

Characteristics	Symbol	Value	Unit	Applicable pin
DC Supply Voltage	$V_{DD}$ $V_{DDA}$	-0.3 to 3.8	V	VDDD, VDDA, VSSD, VSSA, VBBA
DC Input Voltage	$V_{IN}$	-0.3 to $V_{DD}+0.3$	V	P[5:0], M[7:0], S[1:0], PWRDN
Storage Temperature	$T_{STG}$	-40 to 125	$^\circ\text{C}$	-

## NOTES

1. ABSOLUTE MAXIMUM RATING specifies the values beyond which the device may be damaged permanently. Exposure to ABSOLUTE MAXIMUM RATING conditions for extended periods may affect reliability. Each condition value is applied with the other values kept within the following operating conditions and function operation under any of these conditions is not implied.
2. All voltages are measured with respect to VSSD unless otherwise specified.
3. 100pF capacitor is discharged through a 1.5Kohm resistor (Human body model)

**Recommended Operating Conditions**

Characteristics	Symbol	Min	Typ	Max	Unit
Supply Voltage	$V_{DD}$ $V_{DDA}$	3.14	3.3	3.46	V
Supply Voltage Difference	$V_{DD}-V_{DDA}$	-0.1		0.1	V
Oscillator(=Input) Frequency	Fosc		14.318		MHz
External Loop Filter Capacitor 1	$C_{LF1}$		390		pF
External Loop Filter Capacitor 2	$C_{LF2}$		30		pF
External Loop Filter Resistor	$R_{LF}$		9		Kohm
Operating Temperature	$T_{OPR}$	0		70	$^\circ\text{C}$

## NOTES

1. It is strongly recommended that all the supply pins (VDDA, VDDD) be powered from the same source to avoid power latch-up.

**DC ELECTRICAL CHARACTERISTICS**

Characteristics	Symbol	Min	Typ	Max	Unit
Operating Voltage	$V_{DD}/V_{DDA}$	3.14	3.3	3.46	V
Digital Input Voltage High	$V_{IH}$	2.0			V
Digital Input Voltage Low	$V_{IL}$			0.8	V
Dynamic Current @250MHz	I <sub>dd</sub>		5		mA
Power Down Current	I <sub>pd</sub>			100	uA

**AC ELECTRICAL CHARACTERISTICS**

Characteristics	Symbol	Min	Typ	Max	Unit
Input Frequency	$F_{IN}$	1		40	MHz
Output Clock Frequency	$F_{OUT}$	25		250	MHz
Output Clock Duty Cycle	$T_{OD}$	40	50	60	%
Input Clock Duty Cycle	$T_{ID}$	40		60	%
Lock-in Time	$T_{LT}$		100		us
Cycle to Cycle Jitter	$T_{JCC}$	-100		+100	ps

## Functional Description

A PLL is the circuit synchronizing an output signal (generated by a VCO) with a reference or input signal in frequency as well as in phase.

In this application, it includes the following basic blocks.

- . The voltage-controlled oscillator to generate the output frequency.
- . The divider P to divide the reference frequency by p.
- . The divider M to divide the VCO output frequency by m.
- . The divider S to divide the VCO output frequency by s.
- . The phase frequency detector to detect the phase difference between the reference frequency and the output frequency (after division) and to control the charge pump voltage.
- . The loop filter to filter out high frequency components in charge pump voltage and give smooth and clean control to VCO.

The m, p, s values can be programmed by 16bit digital data from the external source. So the PLL can be locked onto the desired frequency.

$$F_{out} = ( m \cdot F_{in} ) / ( p \cdot s )$$

$F_{in} = 14.318\text{MHz}$ ,  $m=M+8$ ,  $p=P+2$ ,  $s=2^S$

Digital data format:

Main Divider	Pre Divider	Post Scaler
M[7],M[6],M[5],M[4],M[3],M[2],M[1],M[0]	P[5],P[4],P[3],P[2],P[1],P[0]	S[0],S[1]

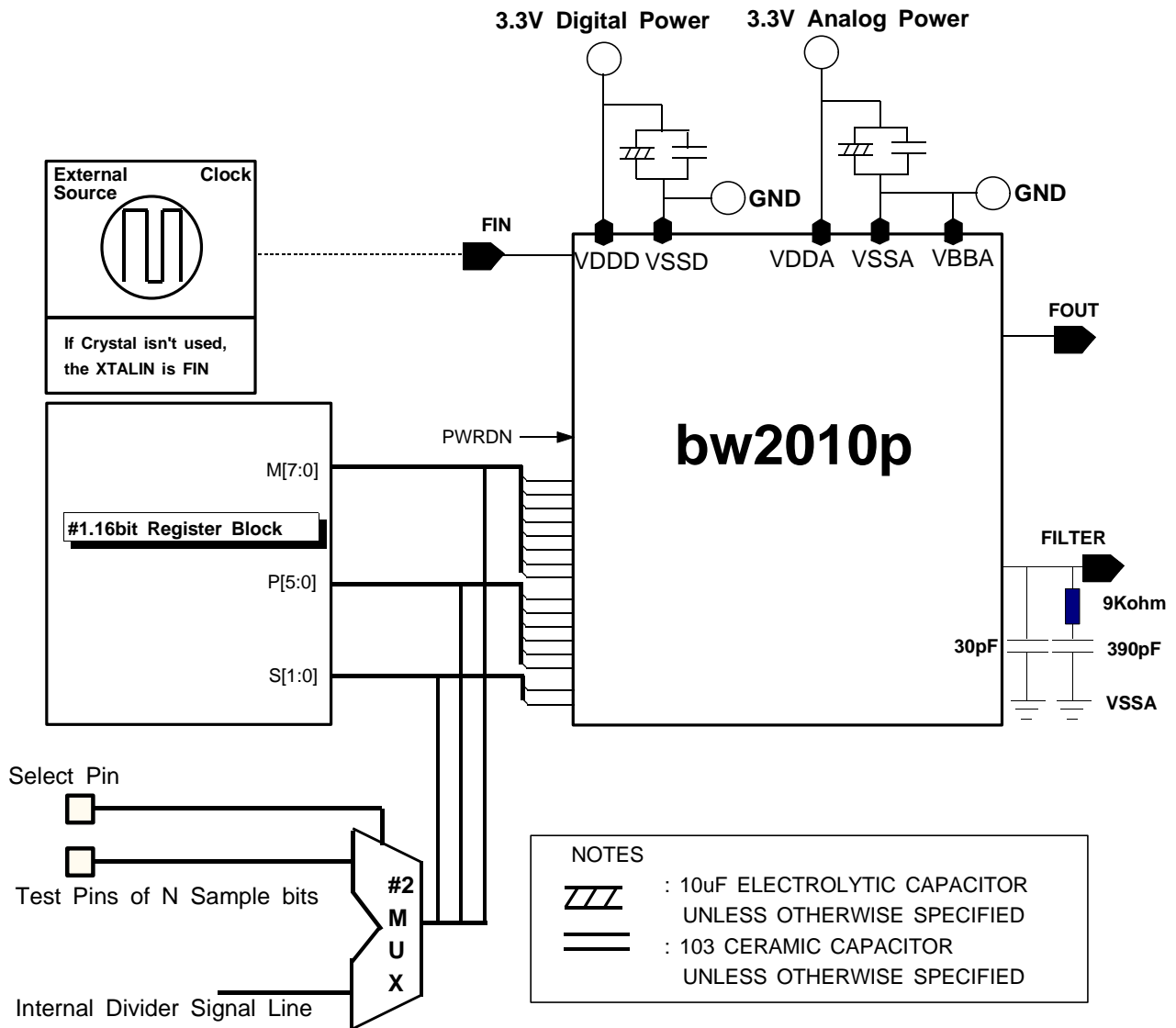
### NOTES

- . S[1] - S[0] : Output Frequency Scaler
- . M[7] - M[0] : VCO Frequency Divider
- . P[5] - P[0] : Reference Frequency Input Divider
- . Every M,P and S values is not available. so your M,P,S values should be checked by bw2010p designer. bw2010p designer can recommend suitable values.

**CORE EVALUATION GUIDE**

For the embedded PLL, we must consider the test circuits for the embedded PLL core in multiple applications. Hence, the following requirements should be satisfied.

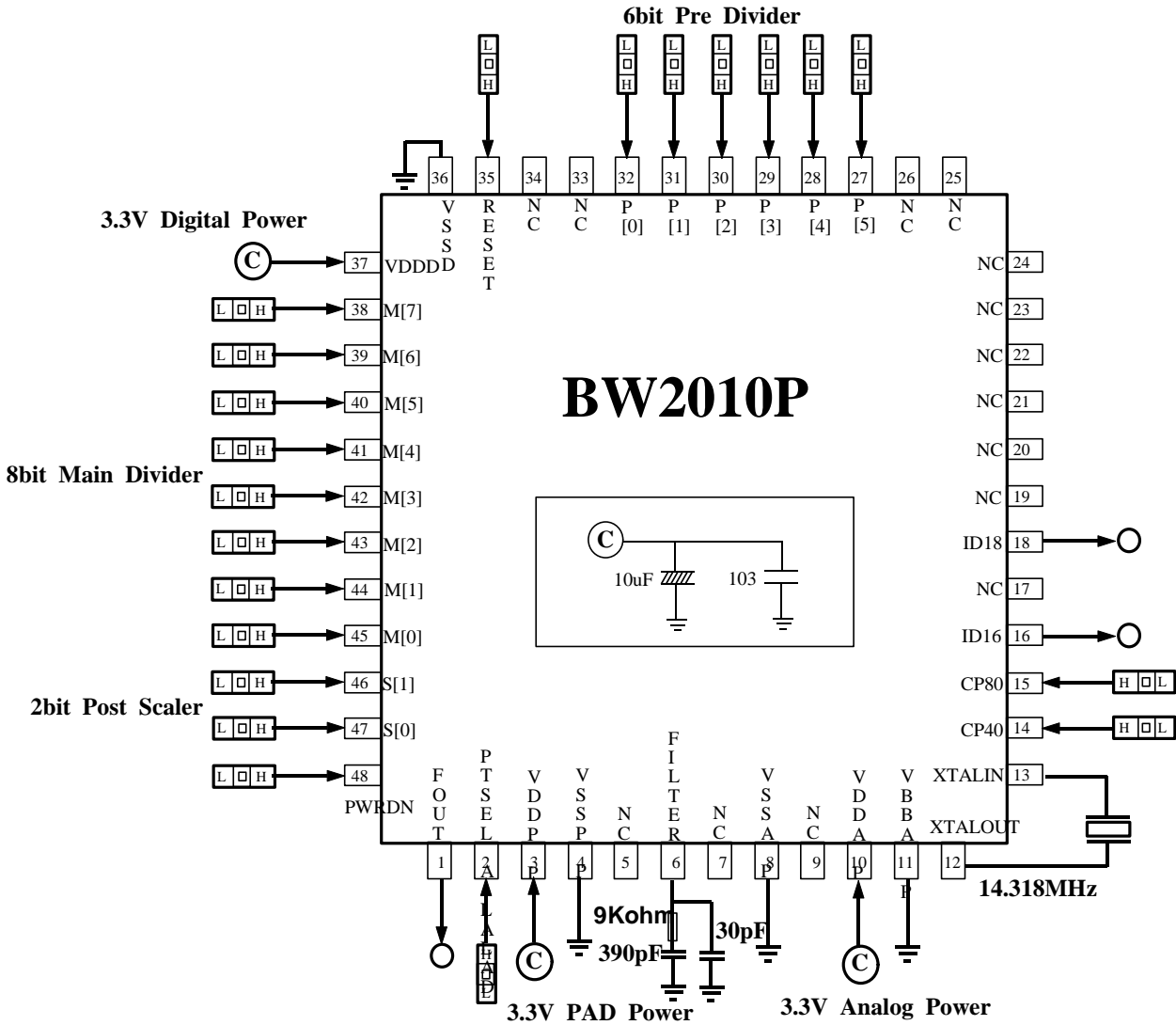
- The FILTER and FOUT pins must be provided for test.
- For PLL test (Below 2 examples), it is needed to control the dividers - M[7:0],P[5:0] and S[1:0] -that generate multiple clocks.
  - #1. Registers can be used for easy control of divider values.
  - #2. N sample bits of 16-bit divider pins can be bypassed for test using MUX.



**CORE LAYOUT GUIDE**

- The digital power(VDDD,VSSD), the analog power(VDDA,VSSA) and the bulk power(VBBA) must be dedicated to the PLL separately. If the dedicated VDDD and VSSD are not allowed, the pins of the smallest power consuming block are shared with the PLL.
- The POA\_BB pad is used as a FILTER pad that contains only ESD protection diodes without any resistors and buffers.
- The FOUT and FILTER pins must be placed away from the internal signals in order to avoid overlapping signal lines.
- The blocks having a large digital switching current must be located away from the PLL core.
- The PLL core must be shielded by guardring.
- For the FOUT pad, you can use a custom drive buffer or POT12\_BB buffer considering the drive current.

PACKAGE CONFIGURATION



NOTES

- 1. CP40, CP80, PTSEL pins are internal dummy block test pins.  
So CP40 and CP80 are tied to VDDA or VSSA, and PTSEL pin is tied to VDDP or VSSP.



## PACKAGE PIN DESCRIPTION

NAME	PIN NO	I/O TYPE	PIN DESCRIPTION
VDDD	37	DP	Digital power supply
VSSD	36	DG	Digital ground
PWRDN	48	DI	FSPLL clock power down -If PWRDN is High, PLL does not operate under this condition. - If not used, tie it to VSSD.
RESET	35	DI	PLL M,P divider block resistor setting reset
P[0]~P[5]	27~32	DI	Pre-Divider Input(LSB)
VDDA	10	AP	Analog power supply
VSSA	8	AG	Analog ground
VBBA	11	AG	Substrate ground
XTALIN/FIN	13	AI	Crystal input or external F <sub>REF</sub> input
XTALOUT	12	AO	Crystal output -If a crystal is used, it is connected to the I/O pins, XTALIN and XTALOUT. If not used, they are floating.
VSSP	4	PG	PAD ground
VDDP	3	PP	PAD supply power
FOUT	1	DO	25MHZ~250MHz clock output
FILTER	6	AO	Pump out is connected to the FILTER.
PTSEL	2	DI	Internal test block(MUX) input Do not float this pin. It must be tied to VDDP or VSSP
CP40	14	AI	Charge pump current switch(20uA)
CP80	15	AI	Charge pump current switch(40uA)
VSSA	8	AG	Analog ground
M[0]~M[7]	38~45	DI	8bit main divider input
S[0]~S[1]	46~47	DI	2bit post divider input
ID16	16	AO	Identification resistor output
ID18	18	AO	Identification resistor output

## NOTES

- I/O TYPE PP and PG denote PAD power and PAD ground respectively.

## PLL Introduction

### De-Skew Function

In semiconductor manufacturing, smaller device geometry facilitate greater on-chip density and higher chip performance. System performance is compromised, however, by clock skew which occurs when the clock on a chip is not synchronized to the system clock. The degree of clock skew varies from chip to chip because of variations in process, temperature, power supply, interconnects, and routing. The PLL tracks the system clock and compares it with the on-chip clock, then adjusts the latter until it matches the former in frequency and phase.

### Frequency Synthesis Function

Frequency synthesis uses the system clock as a base frequency to generate higher/lower frequency clocks for internal logic. For high speed applications in high-end designs, transmission line effects cause problems because of parasitics and impedance mismatch among various on-board components. These problems can be eliminated by moving the high frequency to the chip level. On-chip clocks that are faster than the external system clock can be synthesized by inserting a divider in the feedback path. The divider is placed after voltage controlled oscillator, as illustrated in Figure 1. The signal is running at M times the system clock frequency, so the PLL matches the divider signal output to the system clock. This configuration reduces the problem of interfacing to the system clock on the board, and it reduces the noise generated by the system clock oscillator and driver for all the components in the system.

## PLL Components

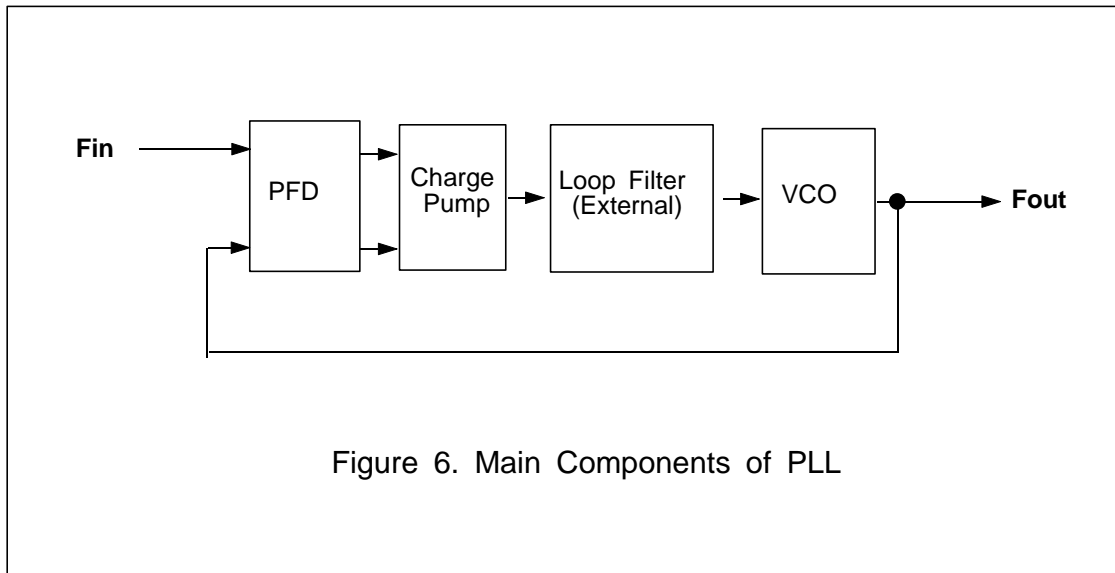
Figure 6 is block diagram of the components of a PLL: phase frequency detector, charge pump, voltage controlled oscillator, and loop filter. In SEC technology, the loop filter is implemented as external components close to chip.

**Phase detector** : The phase detector monitors the phase difference between the  $F_{in}$  and  $F_{out}$ , and generates a control signal when it detects a difference between the two. If the  $F_{in}$  frequency is higher than the  $F_{out}$  frequency, its falling edge occurs before (lead) the falling edge of the  $F_{out}$  output. When this occurs the phase detector signals the VCO to increase the frequency of the on-chip clock. If the falling edge of the  $F_{in}$  occurs after (lag) the falling edge of the  $F_{out}$  output, the detector signals the VCO to decrease on-chip clock frequency. If the frequencies of the  $F_{in}$  and  $F_{out}$  are the same, the detector does not generate a control signal, so the frequencies remain the same.

**Charge Pump** : The charge pump converts the phase detector control signal to a change in voltage across the external filter that drives the VCO. As the Voltage Controlled Oscillator decreases, or increases, if the voltage remains constant, the frequency of the oscillator remains constant.

**Loop Filter** : The control signal that the phase detector generates for the charge pump may generate large excursions (ripples) each time the VCO output is compared to the system clock. To avoid overloading the VCO, a low pass filter samples and filters the high-frequency components out of the control signal. The filter is typically a single-pole RC filter consisting of a resistor and capacitor.

**Voltage Controlled Oscillator(VCO)** : The output voltage from the loop filter drives the VCO, causing its oscillation frequency to increase or decrease as a function of variations in voltage. When the VCO output matches the system clock in frequency and phase, the phase detector stops sending a control signal to the charge pump, which in turn stabilizes the input voltage to the loop filter. The frequency then remains constant, and the PLL remains locked onto the system clock.



## Design Considerations

The following design considerations apply:

- \* Phase tolerance and jitter are independent of the PLL frequency.
- \* Jitter is affected by the noise frequency in the power(VDDD/VSSD,VDDA/VSSA and VBBA). It increases when the noise level increases.
- \* A CMOS-level input reference clock is recommended for signal compatibility with the PLL circuit. Other levels such as TTL may degrade the tolerances.
- \* The use of two, or more PLLs requires special design considerations. Please contact SEC's application engineer for more information.
- \* The following apply to the noise level, which can be minimized by using good analog power and ground isolation techniques in the system:
  - Use wide PCB traces for POWER(VDDD/VSSD, VDDA/VSSA and VBBA) connections to the PLL core. Separate the traces from the chip's VDDD/VSSD,VDDA/VSSA and VBBA supplies.
  - Use proper VDDD/VSSD,VDDA/VSSA and VBBA de-coupling.
  - Use good power and ground sources on the board.
- \* The PLL core should be placed as close as possible to the dedicated loop filter and analog Power and ground pins.
- \* It is inadvisable to locate noise-generating signals, such as data buses and high-current outputs, near the PLL I/O cells.
- \* Other related I/O signals should be placed near the PLL I/O but do not have any pre-defined placement restriction