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## Phase-locked loop system

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### SPECIFICATION

#### 1 FEATURES

- SMIC CMOS 0.18 $\mu$ m
- Wide frequency range (2.8...3.3 GHz)
- Built-in switched capacitors sections for VCO frequency adjustment
- Low noise figure
- High lock detector accuracy
- Charge pump low output current disbalance
- Low current consumption
- Low power consumption
- No external components required
- Small area
- Supported foundries: TSMC, UMC, Global Foundries, SMIC, iHP, AMS, Vanguard, SilTerra

#### 2 APPLICATION

- Portable transmitters
- Portable transceiver

#### 3 OVERVIEW

PLL is an automatic control system adjusting controlled oscillator frequency to be equal to reference oscillator frequency multiplied by a given integer. Frequency adjustment is carried out by using negative feedback. A phase detector compares a controlled oscillator output with a reference signal. The result is a charge pump current output that supplies external feedback filter and converted to a voltage for controlled oscillator adjustment.

Clock divider is used to generate signals with specified frequency. Delta-sigma modulator makes it possible to operate with reference oscillator of different frequency.

The block is fabricated on SMIC CMOS 0.18 $\mu$ m technology.

## 4 STRUCTURE

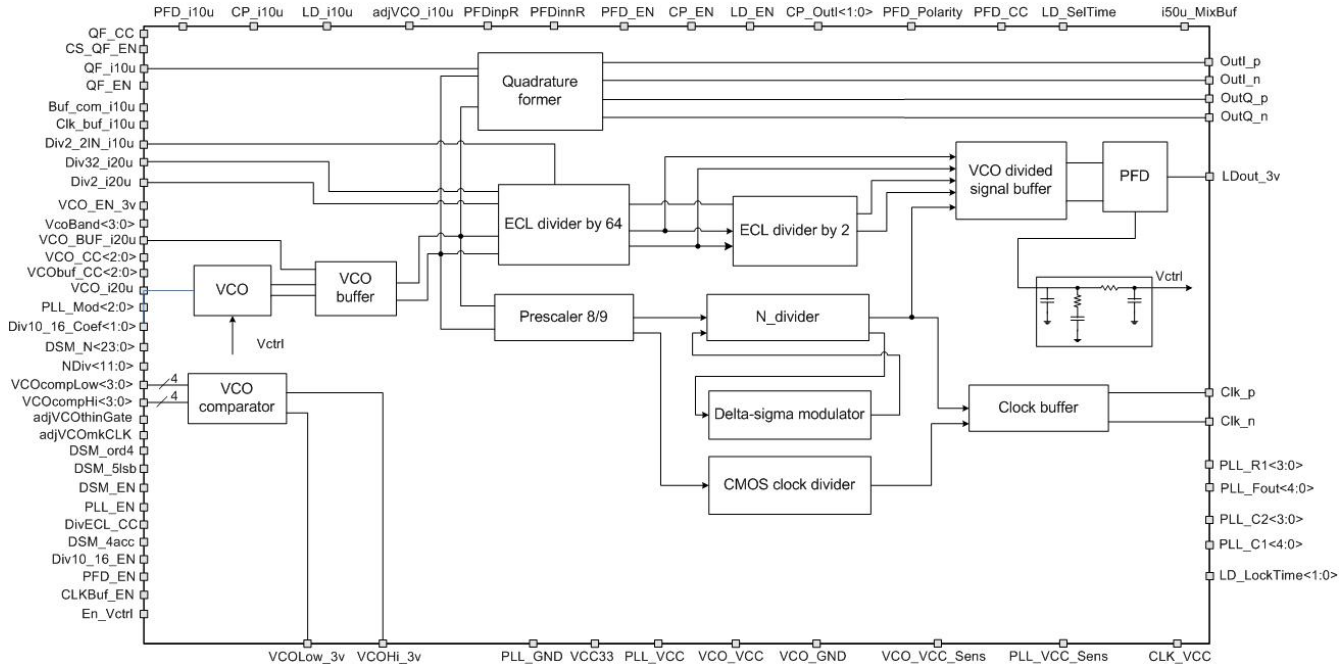


Figure 1: Phase-locked loop system structure.

## 5 PIN DESCRIPTION

Name	Direction	Description
QF_i10u	I	Quadrature former reference current (10 $\mu$ A)
Clk_buf_i10u	I	Reference current of reference frequency buffer (10 $\mu$ A)
Buf_com_i10u	I	Reference current of VCO divided signal buffer (10 $\mu$ A)
CP_i10u	I	Charge pump reference current (10 $\mu$ A)
PFD_i10u	I	PFD reference current (10 $\mu$ A)
VCO_i20u	I	VCO core reference current (20 $\mu$ A)
VCO_BUF_i20u	I	VCO buffer reference current (20 $\mu$ A)
adjVCO_i10u	I	Reference current VCO comparator
Div2_2IN_i10u	I	ECL divider by 2 reference current (10 $\mu$ A)
Div32_i20u	I	ECL divider by 64 reference current (20 $\mu$ A)
Div2_i20u	I	
LD_i10u	I	Lock detector reference current (10 $\mu$ A)
Vctrl	I	VCO control voltage input
PFDinpR	I	PFD differential input
PFDinnR	I	
VCO_EN_3v	I	VCO enable/disable
PFD_EN	I	VCO divided signal buffer enable/disable
PLL_EN	I	PLL enable/disable
QF_EN	I	Quadrature former enable/disable
Div_10_16_EN	I	CMOS clock divider enable/disable

Table “Pin Description” (continue).

Name	Direction	Description
DSM_EN	I	Delta-sigma modulator enable/disable
LD_EN	I	Lock detector enable/disable
CLKBuf_EN	I	Clock buffer enable/disable
PFD_Polarity	I	PFD polarity
En_Vctrl	I	VCO control voltage
VCO_CC<2:0>	I	VCO core current selection
VCObuf_CC<1:0>	I	Buffer current selection
DivECL_CC	I	ECL frequency divider by 64 current control
CP_OutI<1:0>	I	Charge pump output current control
PFD_CC	I	PFD current control
QF_CC	I	Quadrature former current control
VCOcompHi<3:0>	I	Voltage detector upper bound (VCO subband autoselect system)
VCOcompLow<3:0>	I	Voltage detector lower bound (VCO subband autoselect system)
VcoBand<3:0>	I	Switching capacitor sections
QF_CS_TD	I	Quadrature former temperature dependent source enable
NDiv<11:0>	I	Delta-sigma modulator integer dividing ratio
Div10_16_Coef<1:0>	I	Dividing ratio of CMOS clock divider
LD_LockTime<1:0>	I	Detection period adjustment
LD_SelTime	I	Detection accuracy adjustment
PLL_Mod_3v<2:0>	I	PLL mode select
adjVCOmkCLK	I	Voltage detector bounds type (VCO subband autoselect system)
adjVCOthinGate	I	Fixed bounds mode control
DSM_ord4	I	Selection of 4th order delta-sigma modulator signal
DSM_4acc	I	All four accumulators are set to non-zero value
DSM_5lsb	I	First 5 bits of first accumulator are set “1”
DSM_N<23:0>	I	DSM fractional dividing ratio
PLL_C1<4:0>	I	PLL feedback filter adjustment
PLL_C2<3:0>	I	
PLL_R1<3:0>	I	
PLL_Fcut<4:0>	I	
VcoHi_3v	O	VCO maximum required control voltage indicator
VcoLow_3v	O	VCO minimum allowable control voltage indicator
LDout_3v	O	Lock detector output
CLK_n	O	Clock buffer differential output
CLK_p	O	
i50u_MixBuf	O	Mixer buffer reference current
OutI_p	O	Quadrature former differential outputs
OutI_n	O	
OutQ_p	O	
OutQ_n	O	
VCC33	IO	High level supply voltage

Table "Pin Description" (continue).

<b>Name</b>	<b>Direction</b>	<b>Description</b>
CLK_VCC	IO	Clock former supply voltage
VCO_VCC	IO	VCO supply voltage
VCO_VCC_Sens	IO	VCO supply voltage feedback
PLL_VCC	IO	PLL supply voltage
PLL_VCC_Sens	IO	PLL supply voltage feedback
VCO_GND	IO	VCO ground
PLL_GND	IO	PLL ground

## 6 LAYOUT DESCRIPTION

The block dimensions are given in the table 1.

Table 1: Block dimensions.

Dimension	Value	Unit
Height	730.68	$\mu\text{m}$
Width	1022.34	$\mu\text{m}$

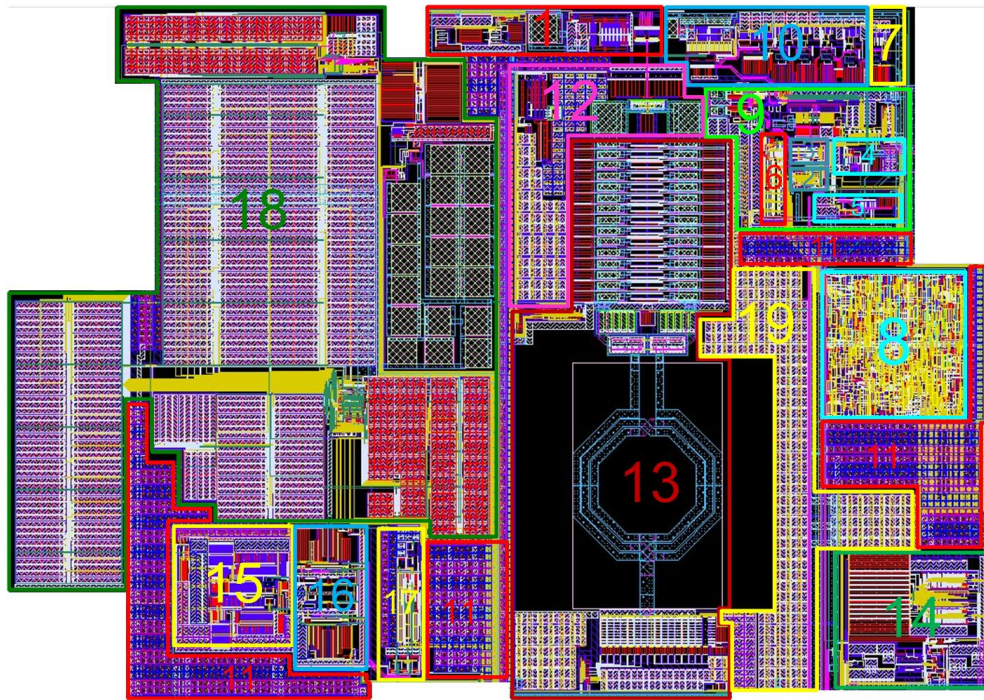


Figure 2: Device layout view.

1. Quadrature former
2. CMOS commutator
3. CMOS clock divider
4. Clock buffer
5. Buffer of VCO divided signal
6. N-divider
7. ECL frequency divider by 2
8. Delta-sigma modulator
9. Prescaler 8/9
10. ECL frequency divider by 64
11. Filtering capacitors
12. VCO buffer
13. VCO
14. VCO comparator
15. Charge pump
16. ECL PFD
17. Lock detector
18. Feedback filter
19. VCO filtering capacitors

## 7 OPERATING CHARACTERISTICS

### 7.1 TECHNICAL CHARACTERISTICS

Technology \_\_\_\_\_ SMIC CMOS 0.18  $\mu\text{m}$   
 Status \_\_\_\_\_ silicon proven  
 Area \_\_\_\_\_ 0.67  $\text{mm}^2$

### 7.2 ELECTRICAL CHARACTERISTICS

The values of electrical characteristics are specified for  $V_{cc} = 1.7 \div 1.9 \text{ V}$  and  $T = -45 \div +85 \text{ }^\circ\text{C}$ . Typical values are at  $V_{cc} = 1.8 \text{ V}$  and  $T = +27^\circ \text{C}$ , unless otherwise specified.

Parameter	Symbol	Condition	Value			Unit
			min	typ	max	
Supply voltage	$V_{cc}$	-	1.7	1.8	1.9	V
Operating temperature range	T	-	-45	27	85	$^\circ\text{C}$
PLL dividing ratio	$N_{PLL}$	-	56	-	16383	-
Clock frequency	$F_{clk}$	-	-	49.68	-	MHz
Reference frequency	$F_r$	-	-	24.84	-	MHz
Oscillation frequency range	$F_{Osc}$	-	2.8	-	3.3	GHz
Peak-to-peak output voltage	$A_{VCO}$	Differential output	742	-	-	mV
Peak-to-peak at clock frequency differential outputs	$A_{cmos}$	CMOS	1.7	1.8	1.9	V
		Differential output	0.3	0.32	0.45	
R divider programmable values	$R_{PLL}$	-	1	-	32	-
Comparison frequency range	$F_{PFD}$	-	-	24.84	-	MHz
Lock monitoring time	Sel_time	-	2.58	-	20.6	$\mu\text{s}$
Lock accuracy	Prec_lock	Preset 1	6.5	7	7.5	ns
		Preset 2	13	14	15	
Current consumption in an active mode	$I_{cc}$	-	4.3	5.9	7.5	mA
Current consumption in a standby mode	$I_{stb}$	-	-	70	-	nA
Oscillator phase noise spectral concentration	$I_s$	at 10kHz offset	-	-83	-80	dBHz
Input logic-high level	$V_{IH}$	For digital inputs	$0.7 V_{cc}$	-	3.6	V
Input logic-low level	$V_{IL}$		-0.25	-	0.3	V

Table 2: Preset description.

Preset	Control signal
Preset 1	LD_SelErr="0"
Preset 2	LD_SelErr="1"

## 8 DELIVERABLES

IP contents:

- Schematic or NetList
- Layout or blackbox
- Extracted view (optional)
- GDSII
- DRC, LVS, antenna report
- Test bench with saved configurations (optional)
- Documentation

## REVISION HISTORY

1. From version 1.0:
  - Table “Electrical characteristic” (refer to [page 6](#)).