

**PLL FREQUENCY SYNTHESIZER FOR PAGER**

**S5T8809**

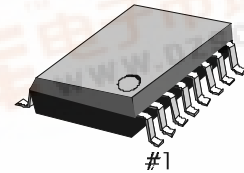
**INTRODUCTION**

S5T8809 is a superior low-power-programmable PLL frequency synthesizer which can be used in high performance / Simple application for a Wide Area Pager system.

S5T8809 consists of 2 kinds of divider block including a 19-bit Shift register, 16/18-bit Latch, 13/15bits R-counter and 16/18-bit N-Counter, 32/33 Prescaler, and a phase detector block including a Phase detector, Lock detector and a Charge pump.

S5T8809 also has a battery saving mode which can control each register block by serial control data from the  $\mu$ -controller (MICOM) and it also has boost up signal output for fast locking.

16-TSSOP-0044



( Magnification = 1 : 4 )

**FEATURES**

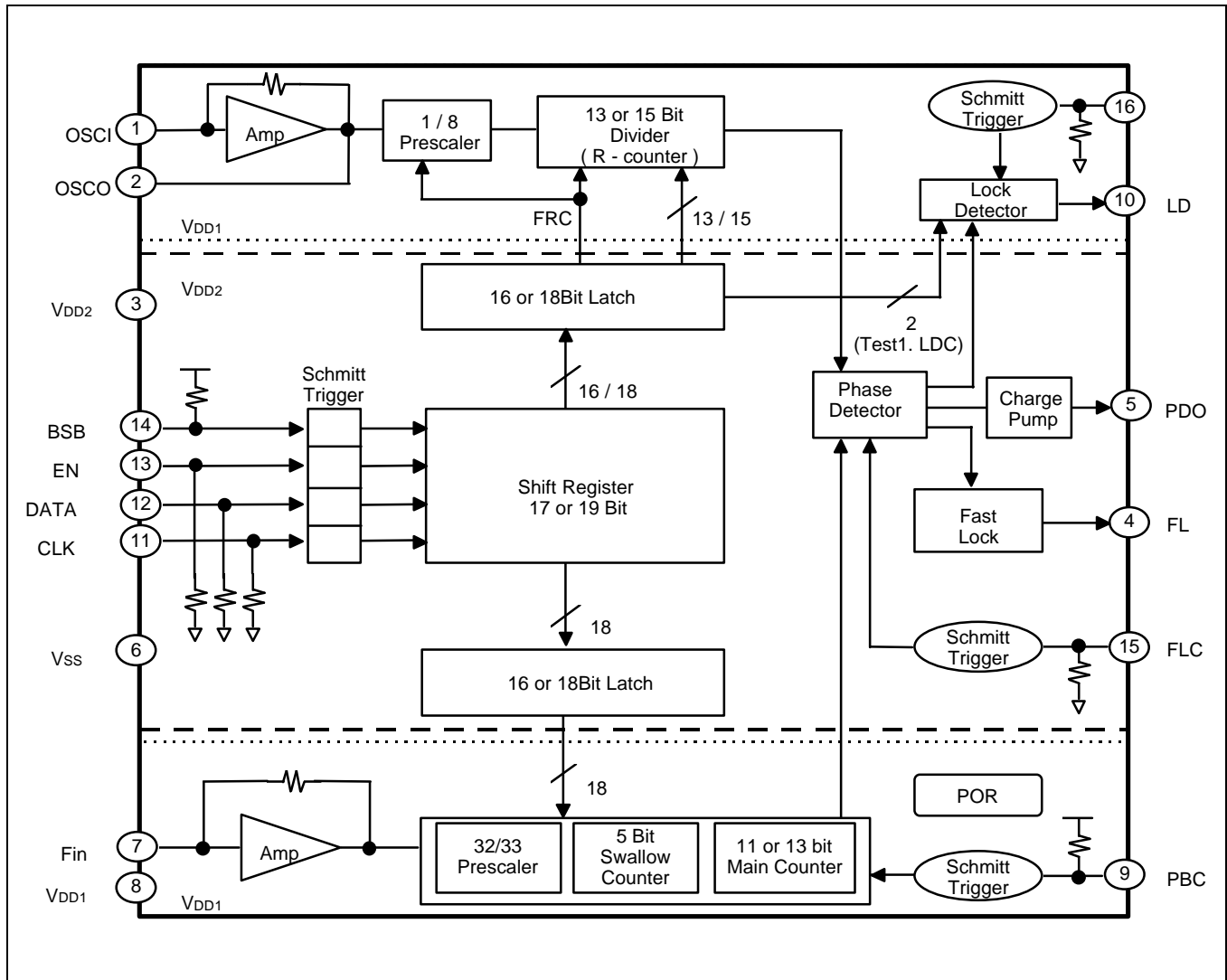
- Maximum operating frequency: 330MHz @ 300mV<sub>P-P</sub>, V<sub>DD1</sub> = 1.0V, V<sub>DD2</sub> = 3.0V
- On-chip reference oscillator supports external crystal which oscillates up to 23MHz
- Superior supply current:
  - F<sub>FIN</sub> = 310MHz, I<sub>DD1</sub> = 0.8mA (Typ.) @ V<sub>DD1</sub> = 1.0V, V<sub>DD2</sub> = 3.0V
- Operating voltage: V<sub>DD1</sub> = 0.95 to 1.5V and V<sub>DD2</sub> = 2.0 to 3.3V
- Excellent Divider range:
  - Ref. Divider:
    - FRC (0): 1 / 40 to 1 / 65528 (Multiple): Default
    - FRC (1): 1 / 5 to 1 / 32767
  - Rx Divider:
    - PBC (0): 1 / 1056 ~ 1 / 65535: Default
    - PBC (1): 1 / 1056 ~ 1 / 262143
- Boost-up signal output for Fast Locking
- In the Standby mode, VDD1 block can be controlled by BSB Pin status
  - Standby current consumption: 10 $\mu$ A (Max.)
- Programmable control the output of LD to reduce internal noise
- Programmable 17 / 19-bit shift register value controlled by PBC
- Charge pump output circuitry for passive filter
- Package type: 16-TSSOP (0.65mm)

**ORDERING INFORMATION**

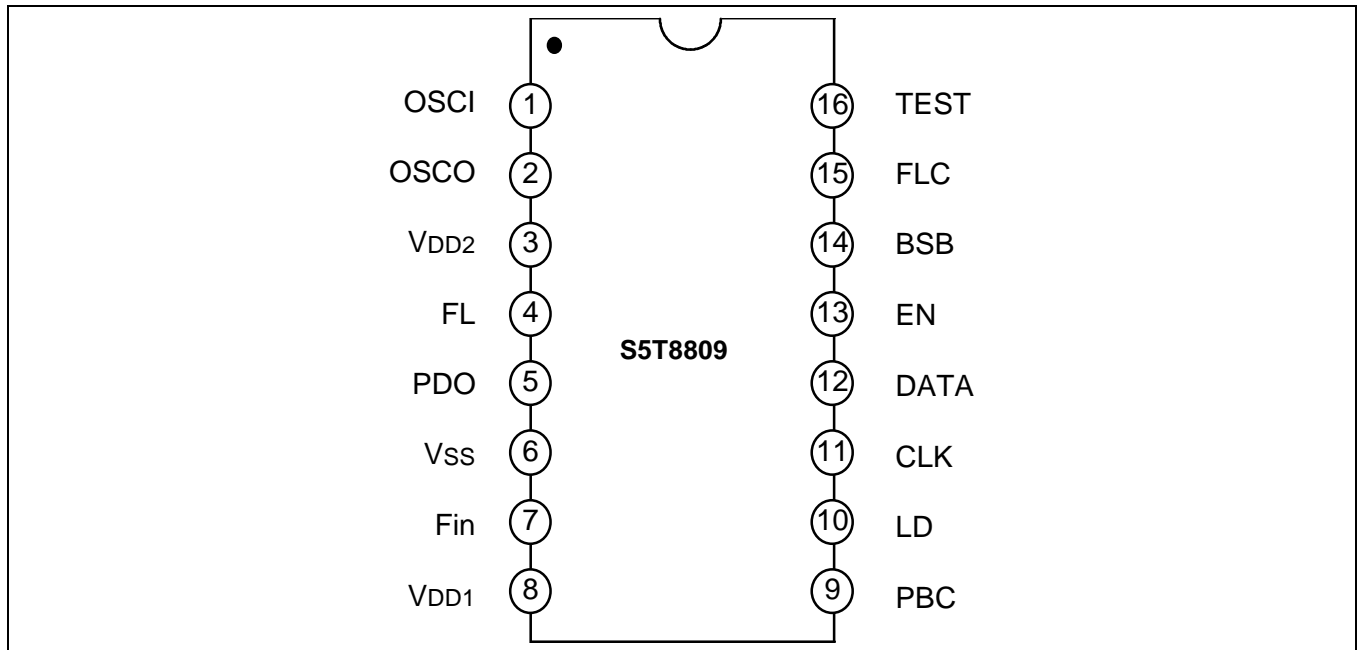
Device	Package	Operating Temperature
+S5T8809X01-R0B0	16-TSSOP-0044	-25°C to +75°C

+: New Product

**BLOCK DIAGRAM**



PIN CONFIGURATION



## PIN DESCRIPTION

Pin No	Symbol	Description
1	OSCI	These input / output pins generate the reference frequency. In case of OSCI Pin, external reference frequency can be used through the AC coupling.
2	OSCO	
3	V <sub>DD2</sub>	The highest potential supply terminal that can be supplied up to 2.0 ~ 3.3V.
4	FL	Booster signal output for fast locking.
5	PDO	The output of RX phase detector terminal for passive loop filter. There are 3-kinds of output signal states according to Rx loop error.
6	V <sub>SS</sub>	Ground terminal
7	Fin	Input terminal for the frequency from VCO. Output frequency from VCO was inputted through AC coupling
8	V <sub>DD1</sub>	Voltage supply terminal for Oscillator and Fin block. This pin can be supplied up to 0.95 ~ 1.5V from V <sub>SS</sub> .
9	PBC	This is an input for programmable bit control which has Schmitt Trigger architecture, Internally biased pull-up. High = 16 Bits N-Divider (Default: ND0 ~ ND15) Low = 18 Bits N-Divider (ND0 ~ ND7) cf) R-divider bits will be changed by the FRC bit of program
10	LD	The output of phase detector can be controlled by R-counter register. When the LDC bit of R-counter set to Low, the output will be disabled to reduce a noise problem, but if it is set to High, the output will be enabled to show an lock / unlock status that is the error width between to Ref. signal and the VCO output signal.
11	CLK	These pins are controlled by the $\mu$ -controller which has Schmitt Trigger architecture, Internally biased pull-down. The features of these pins are as follows; Clock input for 17 or 19-bit Shift Register, Serial data input (it include TEST1, FRC and LDC), and Latch enable input.
12	DATA	
13	EN	
14	BSB	In the BS mode (set to Low), the VDD1 block will be powered off, but the internal latch data is still valid because the VDD2 is supplied continuously. This input has Schmitt Trigger architecture & internally biased pull-up.
15	FLC	This is the input pin for Fast Locking Control (FLC) which has Schmitt Trigger architecture, Internally biased pull-down. Low = The Current of PDO Charge pump output is Normal (Default: x1) High = The Current of PDO Charge pump output is increase (x 1.5)
16	TEST	This is the input pin for TEST which has Schmitt trigger architecture, Internally biased Pull-down. Low = All block will be operated as normal state (Default) High = LD and FL state will be TES mode

**ABSOLUTE MAXIMUM RATINGS**

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{DD} \sim V_{DD2}$	-0.3 ~ +4.0	V
Input Voltage	$V_I$	$V_{SS} - 0.3 \sim V_{DD} + 0.3$	V
Power Dissipation	$P_D$	350	mW
Operating Temperature	$T_{OPR}$	-25 ~ +75	°C
Storage Temperature	$T_{STG}$	-40 ~ +125	°C

**ELECTRICAL CHARACTERISTICS**(Ta = 25°C, V<sub>DD1</sub> = 1.0V, V<sub>DD2</sub> = 3.0V, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Operating voltage	$V_{DD1}$	-	0.95	1.0	1.5	V
	$V_{DD2}$	-	2.0	3.0	3.3	
Operating current	$I_{DD}$	$F_{OSCI} = 12.8\text{MHz}$ $F_{FIN} = 310\text{MHz @ } 0.3V_{P-P}$ $V_{DD1} = 1.0V, V_{DD2} = 3.0V, BSB=High$	-	0.8	-	mA
Standby current	$I_{SB1}$	$V_{DD1} = 0.0V, V_{DD2} = 3.0V, BSB=Low$	-	0.1	10	μA
Input voltage (DATA, CLK, EN, BS)	$V_{IL}$	-	-	-	0.3	V
	$V_{IH}$	-	$V_{DD2}-0.3$	-	-	
Input voltage (TEST, PBC)	$V_{IL}$	-	-	-	0.2	V
	$V_{IH}$	-	$V_{SS1}-0.2$	-	-	
Input current (Fin, Xin)	$I_{IH}$	$V_{IH} = V_{DD1}, BSB = High$	-	-	20	μA
	$I_{IL}$	$V_{IL} = 0V, BSB = High$	-	-	20	
Input frequency	$F_{FIN}$	$V_{FIN} = 0.3V_{P-P}, V_{DD1} = 1.0V$	40	-	330	MHz
	$F_{OSCI}$	$V_{OSCI} = 0.3V_{P-P}, V_{DD1} = 1.0V$	7	12.8	23	
Output current (PDO, FL)	$I_{OH1}$	$V_{OH} = 0.4V$	1.0	-	-	mA
	$I_{OL1}$	$V_{OL} = V_{DD2} - 0.4V$	1.0	-	-	
Output current (LD)	$I_{OH2}$	$V_{OH} = 0.4V$	0.1	-	-	mA
	$I_{OL2}$	$V_{OL} = V_{DD2} - 0.4V$	0.1	-	-	
Setup-time (DATA-CLK, CLK-EN)	$t_s$	-	2	-	-	μS
Hold time	$t_H$	-	2	-	-	μS

## FUNCTIONAL DESCRIPTION

Table 1. N-Counter Register Program Scheme (19 bit)

Bit	Bit 18 (ND 17) ~ Bit 1 (ND 0)	Bit 0 (LSB)
Name	ND	PMC
Description	N-Counter Data (ND 17 ~ ND 0)	Program Mode Control
Function	18 Bit Program Data PBC = 1 : 16 bits (ND 15 ~ ND 0) will be valid PBC = 0 : 18 bits (ND 17 ~ ND 0) will be valid	0: N-Counter Program 1: Ref. R-Counter Program

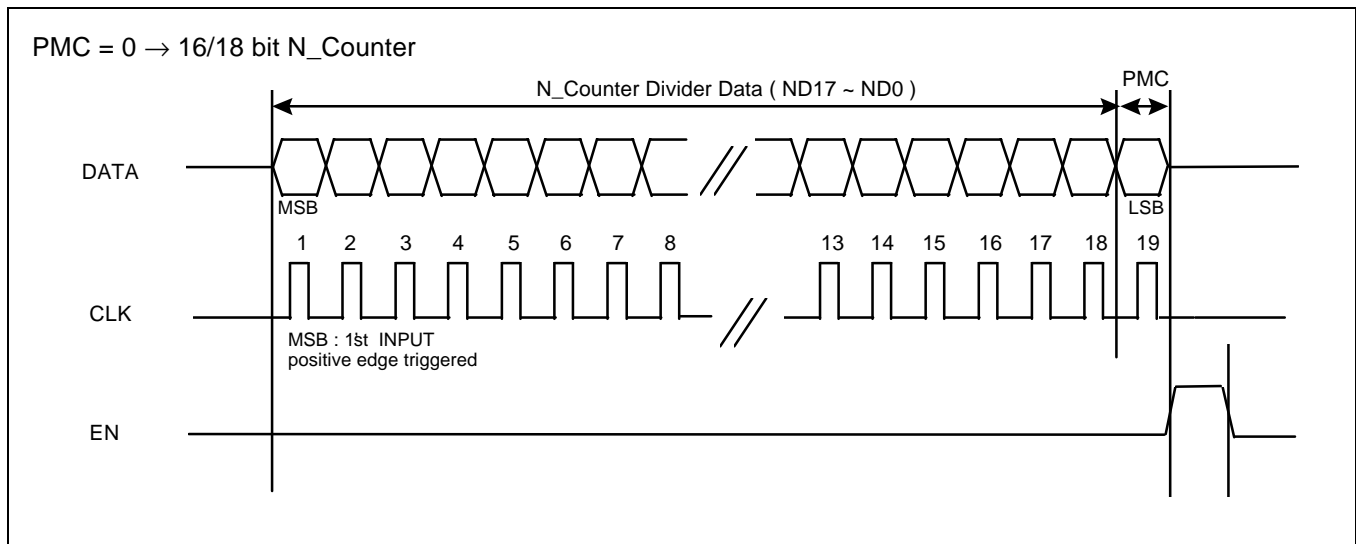


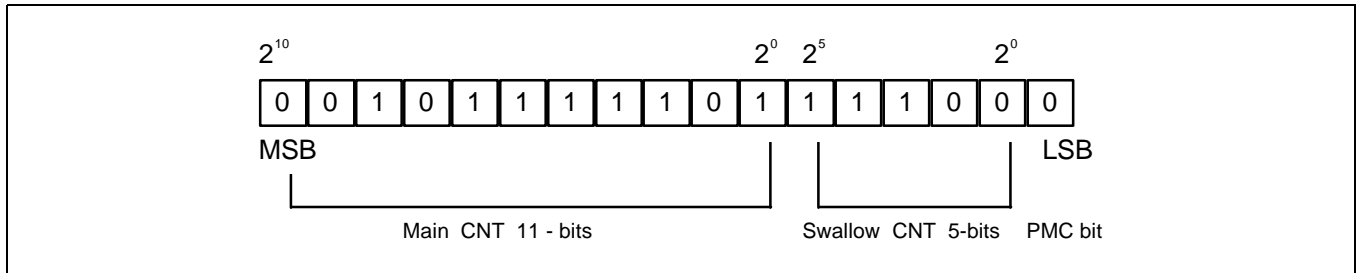
Figure 1. Rx. N - Counter Register Programming Timing

- Programmable N-counter consists of 5-bits Swallow Counter, Dual modulars Prescaler and 11-bits Main Counter (if [PBC = 0], than 13-bits Main Counter)
- The Divide Ratio is;  

$$N = (P + 1) \times S + P \quad (M - S) = PM + S;$$

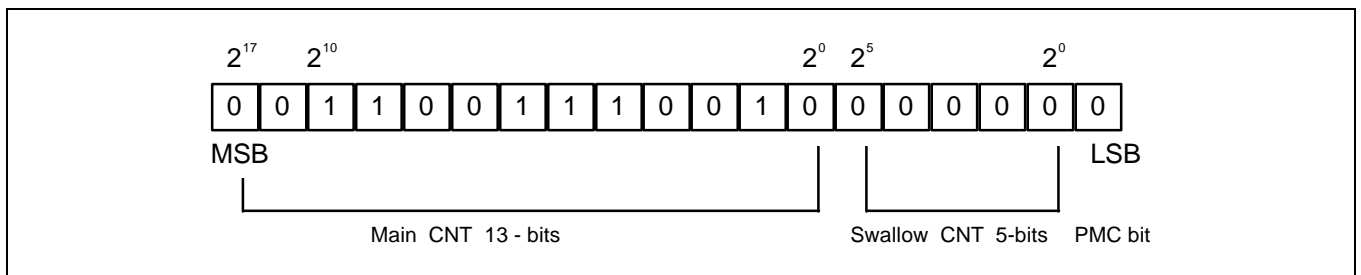
P = Dual Modular Prescaler (32)  
 S = 5-bits Swallow Counter value (0 ~ 31)  
 M = 11-bits (PBC = High, 32 ~ 2047) or 13-bits (PBC = Low, 32 ~ 8291)  
 N = Programmable N-Counter value (N > S)
- The Main Counter can be controlled by PBC pin, when the PBC (pin 9) state set to Low, the Programmable N-counter range will be extend to 262143

- Ex 1) In case of 16-bits program [PBC = High],  $F_c = 325.300\text{MHz}$ , Multiplier = 4,  $F_{in} = 75.975\text{MHz}$   
 $[F_{in} \text{ Freq.} / \text{Ref. Freq.}] = 75.975\text{MHz} / 6.25\text{kHz} = 1256$



**NOTE:** According to the above equation,  $12156 / 32(P) = 379$ , and left = 28 that means, Swallow CNT value is “11100”, Main CNT value is “379”

- Ex 2) In case of 18-bits program [PBC = Low],  $F_{in} = 330\text{MHz}$   
 $[F_{in} \text{ Freq.} / \text{Ref. Freq.}] = [330\text{MHz} / 6.25\text{kHz}] = 52800$



**NOTE:** The PMC bit is program mode control bit, if [0], the N-counter will be enabled

**Table 2. R-Counter Register Program Scheme (19 bits)**

Bit	Bit 18 ~ Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
Name	RD	LDC	FRC	TEST 1	PMC
Description	Ref. R-Counter Data	Lock Detector Control	Frequency of Reference Control	TEST mode control	Program mode control
Function	15 Bit Programmable Ref. R-Counter FRC = 0 : 13 bits (RD12 — RD0) FRC = 1 : 15 bits (RD14 — RD0)	0: Disable LD out 1: Enable LD out	0: R_CNT div. = $8 \times \text{RD}$ 1: R_CNT div. = RD (15bit)	Mainly for the product Test	0: ND Program 1: RD Program

- The Input Reference Frequency (X-tal Oscillator) will be divided by 1/8 Prescaler, and then divided by pre-programmed R-counter value once more.
- Programmable R-Counter consists of Fixed 1/8 Prescaler, 13 / 15-bits Programmable Counter  
 When FRC = 0, Fixed 1/8 Prescaler and 13-bits counter (Min. Divide value: 5) are enabled  
 $\text{RD} = 8, \text{R} = 40 (= 8 \times 5) \sim 65528$  [Multiple 8]

When FRC = 1, Fixed 1/8 Prescaler is disabled, but using 15-bits counter (Min. Divide value: 5)

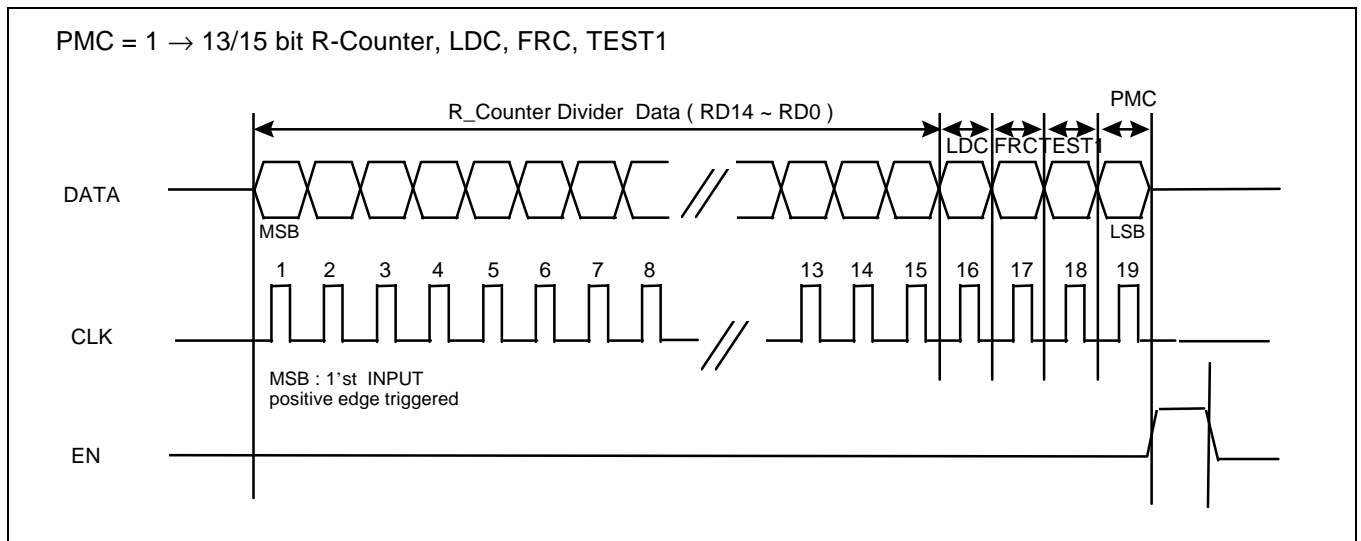
$RD = R = 5 \sim 32767$  [All value]

**CONTROL MODE FOR R-COUNTER REGISTER**

LDC	LDC Pin State	Description
0	Low	LDC function is independent of the other Control Bit
1	Normal Operation	

FRC	R-Counter Value	Description
0	$8 \times R\_cnt$ value ( $OSCI / 8 \times R$ ), Use 13 bits R-Counter	FRC function is independent of the other Control Bit
1	R-cnt value ( $OSC / R$ ), Use 15 bits R-Counter	

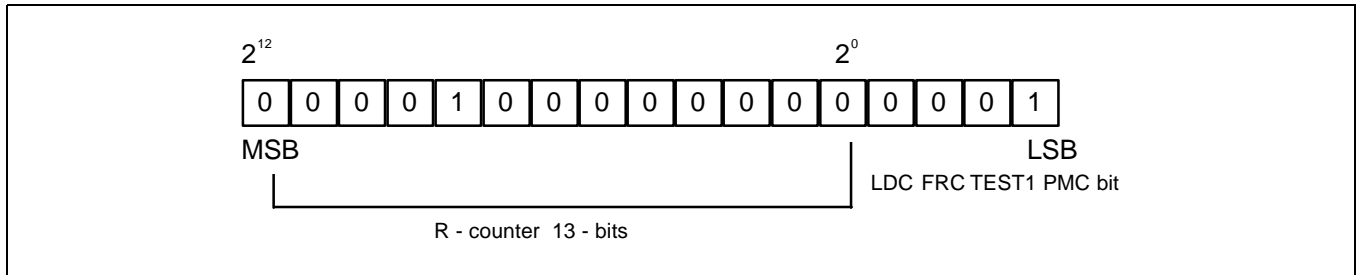
TEST1	TEST	LD state	FL state	Description
0	0	Normal	Normal	• FRC is independent of the other control bit
1	0	Normal	Normal	
0	1	Fn (N-CNT)	High state	• Test is related with Test, when Test = High → Test Mode
1	1	Fr (N-CNT)	Normal	



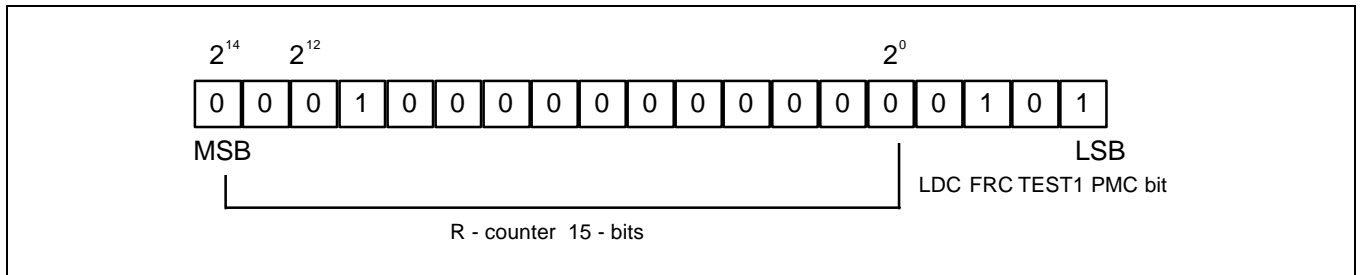
**Figure 2. Ref. R-Counter Register Programming Timing**



- Ex 1) FRC = 0, In case of 13bits Program, Fosc = 12.8MHz and 1/8 prescaler is used  
 $[(\text{Osc. Freq.} / \text{Prescaler}) / \text{Ref. Freq.}] = [(12.8\text{MHz} / 8) / 6.25\text{kHz}] = 256$



- Ex 2) FRC = 1, In case of 15bits Program, Fosc = 12.8MHz and 1/8 prescaler is used  
 $[\text{Osc. Freq.} / \text{Ref. Freq.}] = [12.8\text{MHz} / 6.25\text{kHz}] = 2048$



**NOTE:** The PMC bit is Program Mode Control Bit, if [1], the R-Counter will be Enabled

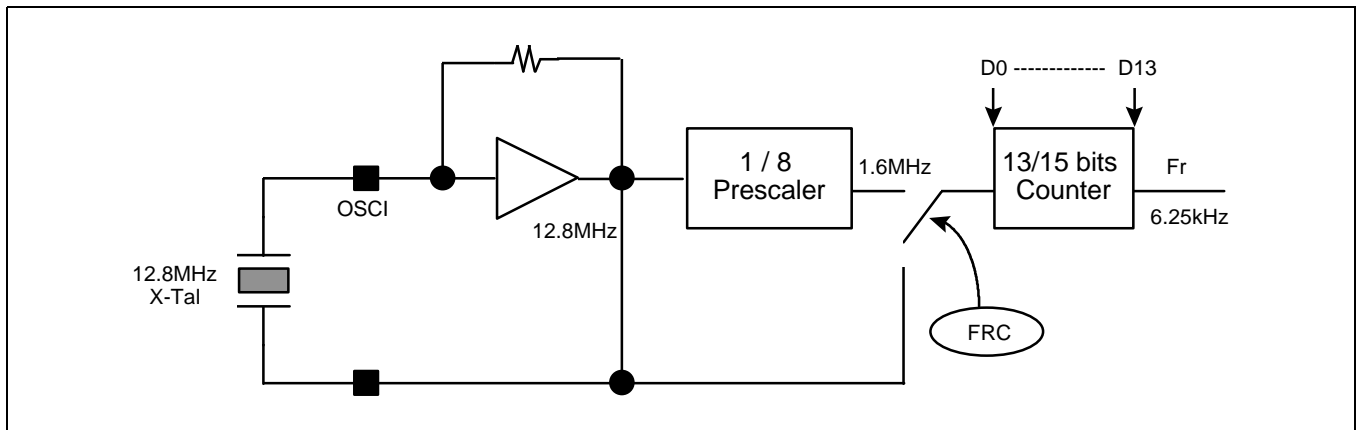


Figure 3. The architecture of R-Count Divider

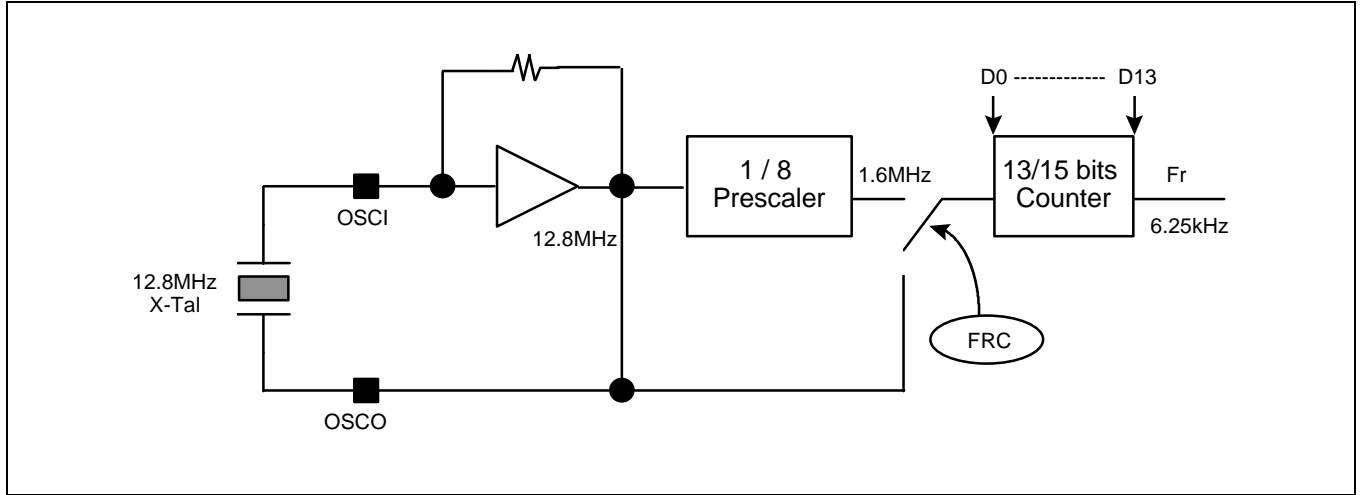


Figure 4. Serial DATA Input Timing

PHASE DETECTOR / LOCK DETECTOR

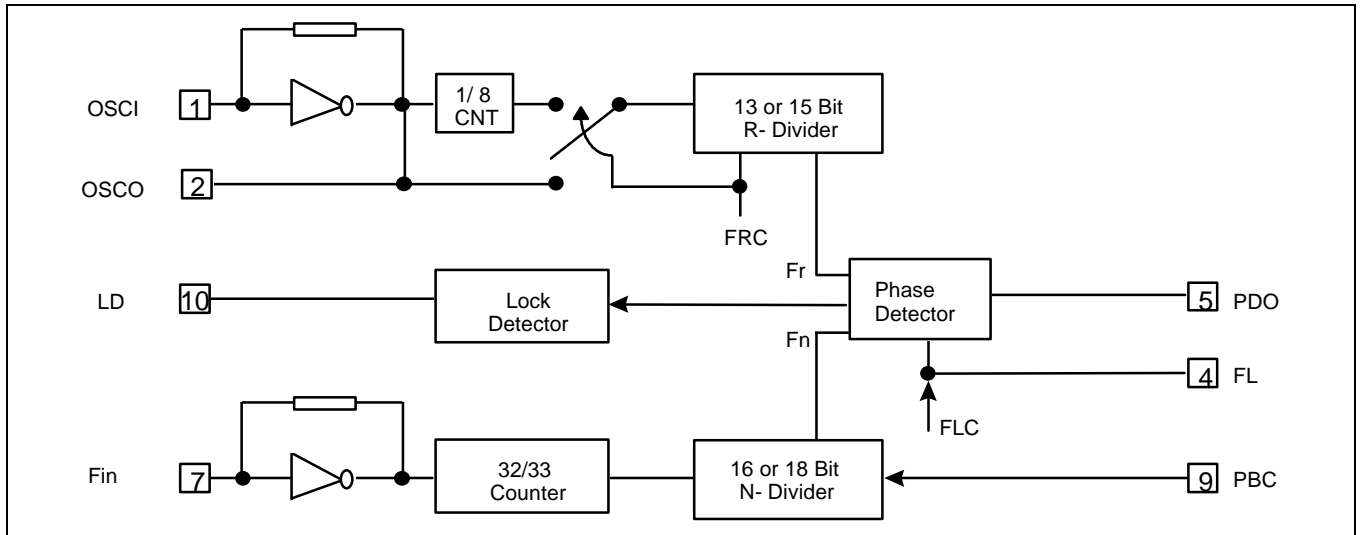


Figure 5. Phase Detector / Lock Detector

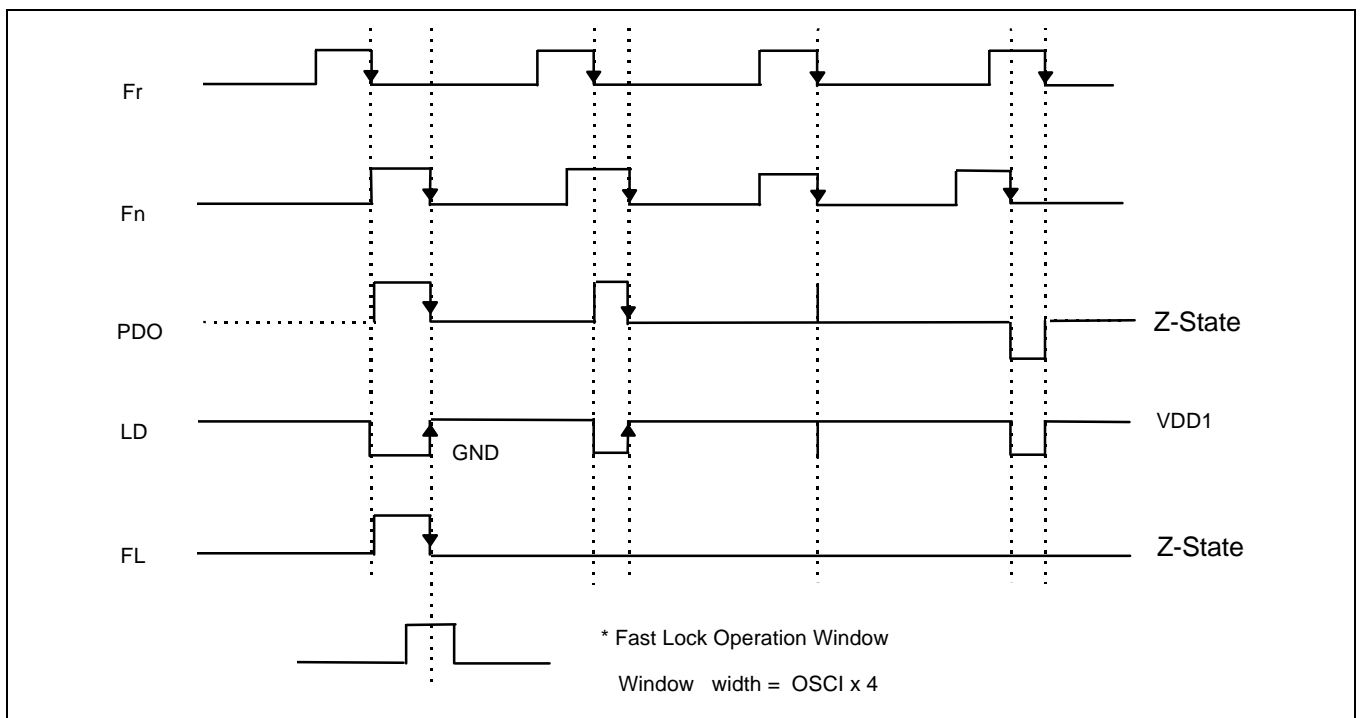


Figure 6. Figure 5-2. Phase Detector / Lock Detector / Fast Lock Output Waveforms

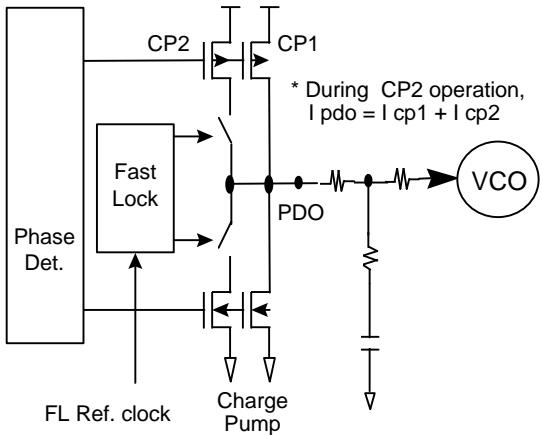
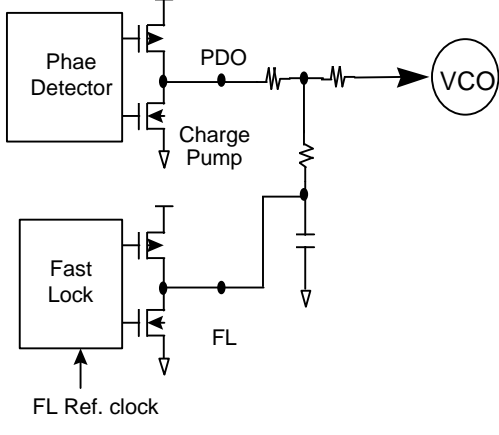
NOTES:

1. Phase detector always compares the Phase difference of N-counter with R-counter, and generates High or Low State as much as the phase difference
2. The LD output is set to Low level same as Phase detector error width

## FAST LOCK

The Fast lock can give faster Acquisition time when the S5T8809 starts up. If Fast Lock signal was generated one time, this circuitry do not operate again even though PLL goes into unlock state.

S5T8809 has two kind of Fast lock; one is to control the Loop band width of Loop filter, the other is to control the charge pump current.

Mode 1	Mode 2
	
<ul style="list-style-type: none"> <li>• CP1: Default charge pump output TR</li> <li>• CP2: When FLC = High, CP2 goes [On] state, the Timing &amp; Phase is just same as FL signal</li> <li>• Mode 1 does not used FL pin, only increase PDO output current same as the width of 1st phase error</li> </ul>	<ul style="list-style-type: none"> <li>• Exceeding a Loop Band width during Fast Lock operation</li> <li>• When the FLC pin set to High level, this function will be available</li> </ul>

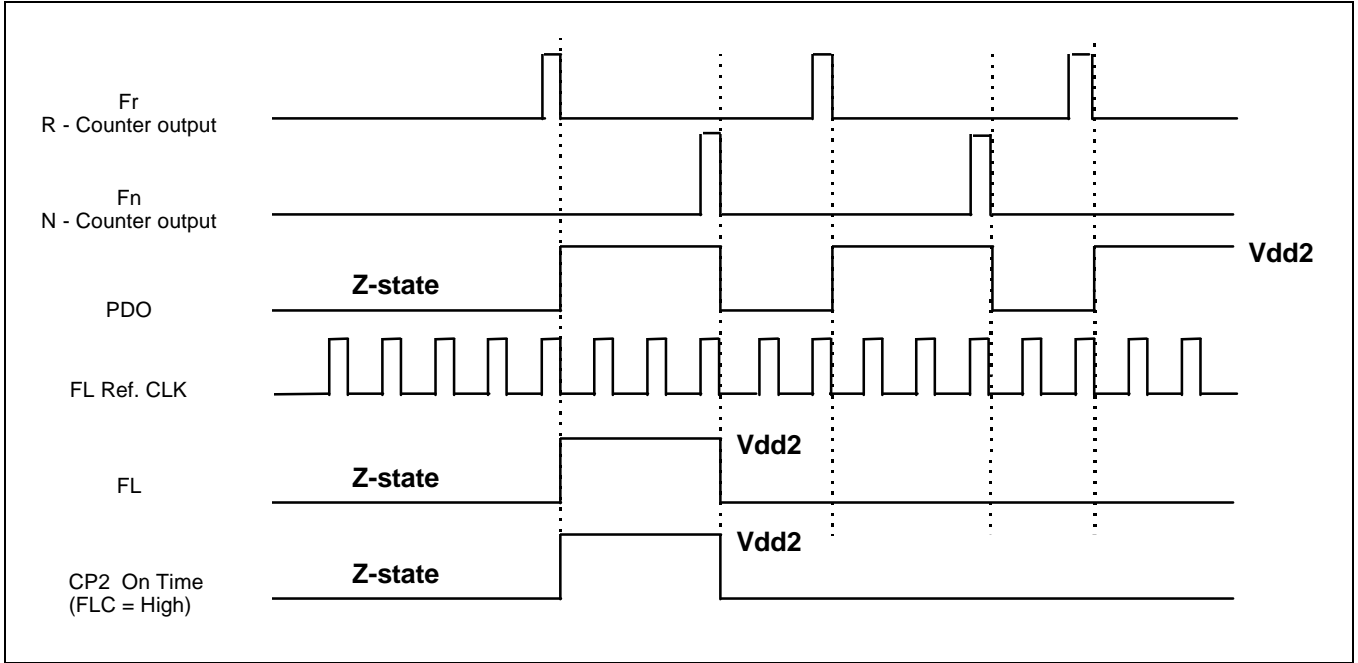


Figure 7.

NOTES