# Description

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The 8V97053L is a high performance Wideband RF Synthesizer / PLL optimized for use as the local oscillator (LO) in Multi-Carrier, Multi-mode FDD & TDD Base Station radio card. It is offered in a compact 5 × 5 mm, 32-VFQFN package.

The 8V97053L Wideband RF Synthesizer / PLL offers a default Fractional Mode with the option to use it with an Integer mode. It requires an external loop filter.

The 8V97053L with integrated Voltage Controlled Oscillator (VCO) supports output frequencies from 34.375MHz to 4400MHz and maintains superior phase noise and spurious performance.

 $RF_OUT_{[A:B]}$  output drivers have independently programmable output power ranging from -4dBm to +7dBm. The  $RF_OUT$  outputs can be muted. The mute function is accessible via a SPI command or mute pin.

The operation of the 8V97053L is controlled by writing to registers through a 3-wire SPI interface. The 8V97053L also has an additional option that allows users to read back values from registers by configuring the MUX\_OUT pin as a SDO for the SPI interface. The SPI interface is compatible with 1.8V logic and tolerant to 3.3V.

In multi-service base stations, very low noise oscillators are required to generate a large variety of frequencies to the mixers while maintaining excellent phase noise performance and low power. The 8V97053L offers a large tuning range capable of providing multi-band local oscillator (LO) frequency synthesis in multi-mode base stations, thus limiting the use of multiple narrow band RF Synthesizers and reducing the BOM complexity and cost. The device can operate over -40°C to +85°C industrial temperature range.

# Applications

- Wireless Infrastructure
- Test Equipment
- CATV Equipment
- · Military and Aerospace
- Wireless LAN
- Clock Generation

## Features

- Dual Differential Outputs
- Output frequency range: 34.375MHz to 4400MHz (continuous range)
- RF Output Divide by 1, 2, 4, 8, 16, 32, 64
- Open Drain Outputs (see Output Distribution Section)
- Fractional-N synthesizer (also supports Integer-N mode)
- 16-bit integer and 12-bit fractional (16-bit fractional when using the extended registers)
- 3- or 4-wire SPI interface (compatible with 3.3V and 1.8V)
- Single 3.3V supply
- Logic compatibility: 1.8V
- Integrated high performance low dropout regulators (LDOs) for excellent power supply noise rejection
- Programmable output power level: -4dBm to +5dBm (up to +7 when using the extended registers)
- Mute Function
- Ultra low PN for 1.65GHz LO: -142.21dBc/Hz @ 1MHz Offset, (typical)
- Lock Detect Indicators
- Input Reference frequency: 5MHz to 310MHz
- 32-Lead, 5 × 5 mm VFQFN package
- · Automatic VCO band selection (Autocal feature)
- -40°C to +85°C ambient operating temperature
- · Lead-free (RoHS 6) packaging
- Supports case temperature ≤ 105°C operations

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## 8V97053L Block Diagram





## **Pin Assignment**



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# Pin Description and Characteristic Tables

## Table 1. Pin Description<sup>1</sup>

Pin	Name	Туре		Description	
1	SCLK	LVCMOS Input	Pulldown	Serial Clock Input. High-Impedance CMOS input. 1.8V logic. 3.3V tolerant.	
2	SDI	LVCMOS Input	Pullup	Serial Data Input. High-Impedance CMOS input. 1.8V logic. 3.3V tolerant.	
3	nCS	LVCMOS Input	Pulldown	Load Enable. High-Impedance CMOS input. 1.8V logic. 3.3V tolerant. Active Low.	
4	CE	LVCMOS Input	Pullup	Chip Enable. On logic Low, powers down the device and puts the charge pump into High-Impedance mode. Powers up the device on logic High.	
5	FLSW	Analog		Fast Lock Switch. A connection should be made from the loop filter to this pin when using the fast lock mode.	
6	V_CP	Power		Charge Pump Power Supply. V_CP must have the same value as V <sub>DDA.</sub> Place decoupling capacitors to the ground plane as close to this pin as possible.	
7	CP_OUT	Analog		Charge Pump Output. When enabled, this output provides $\pm$ ICP to the external loop filter. The output of the loop filter is connected to V <sub>TUNE</sub> to drive the internal VCO.	
8	GND_CP	Ground		Charge Pump Power Supply Ground.	
9	GNDA	Ground		Analog Power Supply Ground.	
10	V <sub>DDA</sub>	Power		Analog Supply. This pin ranges from 3.3V $\pm$ 5%. $V_{DDA}$ must have the same value as $V_{DDD.}$	
11	GNDA_VCO	Ground		VCO Analog Power Supply Ground.	
12	RF_OUT <sub>A</sub>	Output		Clock Output pair A. The output level is programmable.	
13	nRF_OUT <sub>A</sub>	Output		Clock Output pair A. The output level is programmable.	
14	RF_OUT <sub>B</sub>	Output		Clock Output pair B. The output level is programmable.	
15	nRF_OUT <sub>B</sub>	Output		Clock Output pair B. The output level is programmable.	
16	V <sub>VCO</sub>	Power		VCO Supply. This pin ranges from 3.3V ± 5%. $V_{VCO}$ must have the same value as $V_{DDA.}$	
17	V <sub>VCO</sub>	Power		VCO Supply. This pin ranges from 3.3V ± 5%. $V_{VCO}$ must have the same value as $V_{DDA.}$	
18	GNDA_VCO	Ground		VCO Analog Power Supply Ground.	
19	V <sub>BIAS</sub>	Analog		Place decoupling capacitors (10 $\mu$ F) to ground, as close to this pin as possible.	
20	V <sub>TUNE</sub>			Control Input to tune the VCO.	
21	GNDA_VCO	Ground		VCO Analog Power Supply Ground.	
22	R <sub>CP</sub>	Analog		Sets the charge pump current. Requires external resistor.	
23	V <sub>COM</sub>	Analog		Place decoupling capacitors (1 $\mu$ F – 10 $\mu$ F) to ground, as close to this pin as possible.	
24	V <sub>REF</sub>	Analog		Place decoupling capacitors (10 $\mu F)$ to ground, as close to this pin as possible.	
25	LD	LVCMOS Output		Lock Detect. Logic High indicates PLL lock. Logic Low indicates loss of PLL lock.	
26	MUTE	LVCMOS Input	Pullup	$RF\_OUT_A$ and $RF\_OUT_B$ Power-Down. A logic low on this pin mutes the $RF\_OUT$ outputs and puts them in High-Impedance.	
27	GNDD	Ground		Digital Power Supply Ground.	

# Table 1. Pin Description<sup>1</sup> (Continued)

28	V <sub>DDD</sub>	Power		Digital Supply. $V_{DDD}$ must have the same value as $V_{DDA}$ .
29	REF_IN	LVCMOS Input	Analog	Reference Input. This CMOS input has a nominal threshold of $V_{DDA}/2$ and a DC equivalent input resistance of $100k\Omega$ . This input can be driven from a TTL or CMOS crystal oscillator, or it can be AC-coupled.
30	MUX_OUT	LVCMOS Output		Multiplexed Output and Serial Data Out. Refer to Table 4C, Page 18.
31	GND_SD	Ground		Digital Sigma Delta Modulator Power Supply Ground.
32	V <sub>DD_SD</sub>	Power		Digital Sigma Delta Modulator Supply. $V_{\text{DD}\_\text{SD}}$ must have the same value as $V_{\text{DDA}}$
EP	Exposed Pad	Ground		Must be connected to GND.

NOTE 1. Pullup and Pulldown refer to internal input resistors. See Table 2, Pin Characteristics, for typical values.

#### Table 2. Pin Characteristics

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C <sub>in</sub>	Input Capacitance			4		pF
R <sub>OUT</sub>	LVCMOS Output Impedance	MUX_OUT & LD		38		Ω
R <sub>PULLUP</sub>	Input Pullup Resistor			51		kΩ
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		kΩ

## Table 3. Supply Pins and Associated Current Return Paths

Power Supply Pin Number	Power Supply Pin Name	Associated Ground Pin Number	Associated Ground Pin Name
10	V <sub>DDA</sub>	9	GNDA
28	V <sub>DDD</sub>	27	GNDD
32	V <sub>DD_SD</sub>	31	GND_SD
16, 17	V <sub>VCO</sub>	11, 18, 21	GNDA_VCO
6	V_CP	8	GND_CP

# **Principles of Operation**

### Synthesizer Programming

The Fractional-N architecture is implemented via a cascaded programmable dual modulus prescaler. The N divider offers a division ratio in the feedback path of the PLL, and is given by programming the value of INT, FRAC and MOD in the following equation:

N = INT + FRAC/MOD (1)

INT is the divide ratio of the binary 16-bits counter (refer to Table 5B, Page 22).

**FRAC** is the numerator value of the fractional divide ratio. It is programmable from 0 to (MOD – 1). Refer to Table 5C when in 12-bit mode, or Table 12K when in 16-bit mode.

**MOD** is the 12-bit or 16-bit modulus. It is programmable from 2 to 4095 in 12-bit mode, and 2 to 65535 in 16-bit mode. Refer to Table 6D when in 12-bit mode, or Table 12J when in 16-bit mode.

The **VCO** frequency ( $f_{VCO}$ ) at RF\_OUT<sub>A</sub> or RF\_OUT<sub>B</sub> is given by the following equation:

 $f_{VCO} = f_{PFD} x (INT + FRAC/MOD)$  (2)

f<sub>PFD</sub> is the frequency at the input of the Phase and Frequency Detector (PFD).

The 8V97053L offers an Integer mode. To enable that mode, the user has to program the FRAC value to 0.

The device's VCO features three VCO band-splits to cover the entire range with sufficient margin for process, voltage, and temperature variations. These are automatically selected by invoking the Autocal feature. The charge pump current is also programmable via the ICP SETTING register for maximum flexibility.

Via Register 4, one can enable RF\_OUT<sub>A</sub> or both outputs. Similarly, one can disable RF\_OUT<sub>B</sub> or both outputs.

### **Reference Input Stage**

The 8V97053L features one single-ended reference clock input (REF\_IN). This single-ended input can be driven by an ac-coupled sine wave or square wave.

In Power Down mode this input is set to High-Impedance to prevent loading of the reference source. The reference input signal path also includes an optional doubler.

## **Reference Doubler**

To improve the phase noise performance of the device, the reference doubler can be used. By using the doubler, the PFD frequency is also doubled and the phase noise performance typically improves by 3dB. When operating the device in Fractional mode, the speed of the Sigma Delta modulator of the N counter is limited to 125MHz, which is also the maximum PFD frequency that can be used in the fractional mode. When the part operates in Integer-N mode, the PFD frequency is limited to 310MHz.

The user has the possibility to select a higher PFD frequency (up to 310MHz in Integer mode) by doing the following steps using the extended registers (Register 6 and 7):

- 1. The user needs to increase the size of the Band Select Clock Divider (normally 8-bits) by setting the bit [D6:D3] in the Register 6 to divide down to a frequency lower than 500kHz and higher than 125kHz.
- 2. Use the Bit[D27:D26] to increase the lock detect precision for the faster PFD frequency.

The Lock Detect window should be set as large as possible but less than a period of the phase detector. The phase detector frequency should be greater than 500kHz.

LDP_Ext2 (D27 of Register 6)	LDP_Ext1 (D26 of Register 6)	LDP (D7 of Register 2)	LDP value (ns)
0	0	0	10
0	0	1	6
	Use of Extend	led Register 6	
0	1	0	3
0	1	1	3
1	0	0	4
1	0	1	4.5
1	1	0	1.5
1	1	1	1.5

#### Table 4A. Lock Detect Precision (LDP)

## Feedback Divider

The feedback divider N supports fractional division capability in the PLL feedback path. It consists in an integer N divider of 16-bits, and a Fractional divider of 12-bits (FRAC) over 12-bits (MOD). FRAC and MOD can be extended to 16-bits when using extended registers.

To select an integer mode only, the user sets FRAC to 0.



Figure 1. RF Feedback N Divider

The 16 INT bits (Bit[D30:D15] in Register 0) set the integer part of the feedback division ratio.

The 12 FRAC bits (Bit[D14:D3] in Register 0) set the numerator of the fraction that goes into the Sigma Delta modulator. FRAC can be extended to 16-bits using the EXT\_FRAC bits in Register 7.

The 12 MOD bits (Bit[D14:D3] in Register 1) set the denominator of the fraction that goes into the Sigma Delta modulator. MOD can be extended to 16-bits using the EXT\_MOD bits in Register 7.

From the relation (2), the VCO minimum step frequency is determined by (1/MOD) \* fPFD.

FRAC values from 0 to (MOD - 1) cover channels over a frequency range equal to the PFD reference frequency.

The PFD frequency is calculated as follows:

$$f_{PFD} = REF_{CLK} \frac{1+D}{R}$$
(3)

Use 2R instead of R if the Reference Divide by 2 is used.

- **REF<sub>CLK</sub>** = the input reference frequency (REF\_IN)
- **D** = the input reference doubler (0 if not active or 1 if active)
- **R** = the 10-Bits programmable input reference pre-divider

The programmable modulus (MOD) is determined based on the input reference frequency (REF\_IN) and the desired channelization (or output frequency resolution). The high resolution provided on the R counter and the Modulus allows the user to choose from several configuration (by using the doubler or not) of the PLL to achieve the same channelization. Using the doubler may offer better phase noise performance. The high resolution Modulus also allows to use the same input reference frequency to achieve different channelization requirements. Using a unique PFD frequency for several needed channelization requirements allows the user to design a loop filter for the different needed setups and ensure the stability of the loop.

The channelization is given by 
$$\frac{f_{PFD}}{MOD}$$
 (4)

In low noise mode (dither disabled), the Sigma Delta modulator can generate some fractional spurs that are due to the quantization noise.

The spurs are located at regular intervals equal to  $f_{PFD}/L$  where L is the repeat length of the code sequence in the Sigma Delta modulator. That repeat length depends on the MOD value, as described in Table 4B.

Condition (Dither Disabled)	L	Spur intervals
MOD can be divided by 2, but not by 3	2 x MOD	f <sub>PFD</sub> /(2*MOD)
MOD can be divided by 3, but not by 2	3 x MOD	f <sub>PFD</sub> /(3*MOD)
MOD can be divided by 6	6 x MOD	f <sub>PFD</sub> /(6*MOD)
Other conditions	MOD	f <sub>PFD</sub> /MOD (channel step)

Table 4B. Fractional	Spurs Due to the	e Quantization Noise
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In order to reduce the spurs, the user can enable the dither function to increase the repeat length of the code sequence in the Sigma Delta modulator. The increased repeat length is  $2^{21}$  cycles so that the resulting quantization error is spread to appear like broadband noise. As a result, the in-band phase noise may be degraded when using the dither function.

When the application requires the lowest possible phase noise and when the loop bandwidth is low enough to filter most of the undesirable spurs, or if the spurs won't affect the system performance, it is recommended to use the low noise mode with dither disabled.

## Phase and Frequency Detector (PFD) and Charge Pump

The phase detector compares the outputs from the R counter and from the N counter and generates an output corresponding to the phase and frequency difference between the two inputs the PFD. The charge pump current is programmable through the serial port (SPI) to several different levels.

The PFD offers an anti-backlash function that helps to avoid any dead zone in the PFD transfer function.



Figure 2. Simplified PFD Circuit using D-type Flip-flop

The Band Select logic operates between 125kHz and 500kHz. The Band Select clock divider needs to be set to divide down the PFD frequency to between 125kHz to 500kHz (logic maximum frequency).

## **PFD Frequency**

The VCO Band Selection can be used while operating at PFD frequencies up to 310MHz.

If the application requires the PFD frequency to be higher than 125MHz, the user can use one of the following two techniques (Technique A is the recommended procedure):

A. The user can use the extended register ExtBndSelDiv[4:1] bits (Bits[D6:D3]) in Register 6. These additional band select divider bits extend the band select divider from 8-bits (available in Register 4) to 12-bits. The four additional band select divider bits in Register 4 are the most significant bits of the divide value. For proper VCO band selection, the PFD frequency divided by the band select divide value must be  $\leq$ 500kHz and  $\geq$ 125kHz.

B.If choosing this second technique, the user must follow the three following steps:

- 1. Disable the Phase Adjust function by setting the bit D28 In Register 1 to 0, keep the PFD frequency lower than 125MHz, and program the desired VCO frequency.
- 2. Enable the phase adjust function by setting BAND\_SEL\_DISABLE (Bit D28 in Register 1) to 1.
- **3.** Set the desired PFD frequency and program the relevant R divider and N counter values.

In either technique, the Lock Detect Precision should be programmed to be lower than the PFD period using the bit [D7] in Register 2 and the bits [D27:D26] in Register 6 (Refer to Table 4A, Page 10).

### **External Loop Filter**

The 8V97053L requires an external loop filter. The design of that filter is application specific. For additional information, refer to the Applications Information section.

#### Phase Detector Polarity

The phase detector polarity is set by bit D6 in Register 2. This bit should be set to 1 when using a passive loop filter or a non-inverting active loop filter. If an inverting active filter is used, this bit should be set to 0.

#### **Charge Pump High-Impedance**

In order to put the charge pump into three-state mode, the user must set the bit D4 [CP HIGHZ] in Register 2 to 1. This bit should be set to 0 for normal operation.

### Integrated Low Noise VCO

The VCO function of the 8V97053L consists in three separate VCOs. This allows keeping narrow tuning ranges for the VCOs while offering a large frequency tuning range for VCO core. Keeping narrow VCO tuning ranges allows for lower VCO sensitivity ( $K_{VCO}$ ), which results in the best possible VCO phase noise and spurious performance.

The user does not have to select the different VCO bands. The VCO band select logic of the 8V97053L will automatically select the most suitable band of operation at power up or when Register 0 is written.

For optimal performance, it is recommended to recalibrate the VCO by re-writing Register 0 when the temperature has varied more than 90°C from the temperature at which the previous calibration occurred.

## **Output Distribution Section**

The 8V97053L device provides two outputs. These two outputs can generate the same frequency ( $f_{VCO}$  / M0) or two integer related different frequencies (in this case, RF\_OUT<sub>B</sub> would generate a frequency equal to the VCO frequency and RF\_OUT<sub>A</sub> would generate  $f_{VCO}$  / M0).



Figure 3. Output Clock Distribution

RF\_OUT and nRF\_OUT are derived from the drain of an NMOS differential pair driven by the VCO output (or by the M0 Divider), as shown in Figure 4, *Output Stage*.



Figure 4. Output Stage

Eight programmable output power levels can be programmed from -4dBm to +7dBm (see RF Output Power section).

The 8V97053L offers an auxiliary output (RF\_OUT<sub>B</sub>). If the auxiliary output stage is not used, it can be powered down by using the RF\_OutB\_En bit in Register 4.

The supply current to the output stage can be shut down until the part achieves lock. To enable this mode, the user will set the MTLD bit in Register 4. The MUTE pin can be used to mute all outputs and be used as a similar function.

## **Output Matching**

The outputs of the 8V97053L are Open Drain Output and can be matched in different ways.

A simple broadband matching is to terminate the open drain RF\_OUT output with, for example, a 50 $\Omega$  to V<sub>DDA</sub>, and with an AC coupling capacitor in series. An example of this termination scheme is shown on Figure 5, *Broadband Matching Termination*.



Figure 5. Broadband Matching Termination

This termination scheme allows to provide one of the selected output power on the differential pair when connected to a  $50\Omega$  load. (See the RF Output Power section for more information about the output power selection).

The  $50\Omega$  resistor connected to V<sub>DDA</sub> can also be replaced by a choke, for better performance and optimal power transmission.

The pull up inductor value is frequency dependent. For impedance of 50  $\Omega$  pull-up, the inductance value can be calculated as

 $L = 50/(2^{*}3.14^{*}F)$ , where F is operating frequency. In this example,

L = 3.9nH is for an operating frequency of approximately 2GHz.



Figure 6. Optimal Matching Termination

See Applications Information section for more recommendations on the termination scheme.

### **Band Selection Disable**

For a given frequency, the output phase can be adjusted when using the Band\_Sel\_Disable bit (Bit D28 in Register 1). When this bit is enabled (Bit D28 set to 1), the part does not do a VCO band selection or phase resync after an update to Register 0.

When the Band\_Sel\_Disable bit is set to 0, and when Register 0 is updated, the part proceeds to a VCO band selection, and to a phase resync if phase\_resync is also enabled in Register 3 (Bits[D16:D15] set to D16 = 1 and D15 = 0).

The "Band\_Sel\_Disable" bit is useful when the user wants to make small changes in the output frequency (<1MHz from the nominal frequency) without recalibrating the VCO and minimizing the settling time.

## Phase Adjust

The output phase is controlled by the 12-Bit phase value Bits[D26:D15] in Register 1. The output phase can vary over 360° with a 360°/MOD step. For dynamic adjustments of the phase after an initial phase setting, it is recommended to select the BAND\_SEL\_DISABLE function by setting the Band\_Sel\_Disable bit (D28 in Register 1) to 1.

The PHASE value can be extended to 16-bits when using the extended registers. In this 16 bit mode, both registers 1 and 7 define the PHASE value.

#### Phase Resync

The phase alignment function operates based on adjusting the "fractional" phase, so the phase can settle to any one of the MOD phase offsets, MOD being the modulus of the fractional feedback divider.

The phase adjustment can provide a 0-360° of phase adjust, assuming that the output divider ratio is set to 1.

The phase step is TVCO/MOD for the normal case of fundamental feedback. TVCO is the period of the VCO.

The feedback select bit (FbkSel bit, Bit D23 in Register 4) gives the choices of fundamental feedback or divided feedback. This bit controls the mux that sends the VCO signal or the output divider signal to the feedback loop. The user can get larger phase steps in the divided mode, but the phase noise may be degraded, especially in fractional mode. Should the user select this option, the phase adjustment step would be  $\sim T_{OUT}/MOD$ , where  $T_{OUT}$  is the output signal period.

When the part is in fractional mode, the device is dithering the feedback divider value. As an example, when using a 4GHz VCO frequency, the feedback divider value may dither between Div-by-20 and Div-by-21. Since the period is 250ps, there will be 250ps of jitter added to the phase detector. This jitter is filtered by the loop, but can still show up at the output if the loop bandwidth is high. When using a divider before the feedback divider, the effective VCO period is increased. If a Div-by-64 is used for example, the period becomes 64x250ps = 16ns. This means that there could be an additional 16ns of jitter at the PFD, rather than 250ps. It is more challenging for the loop to filter this larger amount of jitter and this will degrade the overall performance of the part, unless the user chooses to use a very low loop bandwidth. With normal loop bandwidth configurations (for optimal noise), the phase noise would be degraded when using a divided feedback mode.

The Phase Resync is controlled by setting Bits[D16:D15] in Register 3 to D16 = 1 and D15 = 0. When phase resync is used, an internal timer generates sync signals every  $T_{SYNC}$  where:

 $T_{SYNC} = ClkDiv \ x \ MOD \ x \ T_{PFD}$ (5)

- ClkDiv = the value (from 1 and 4095) programmed in the 12-bit clock counter in Bits[D14:D3] in Register 3. The 12-bit counter is used as a timer for Fast Lock and for the Phase Resync function.
- **MOD** = the Modulus value (Bits[D14:D3] of Register 1)
- **T**<sub>PFD</sub> = the PFD period

In *Equation 5*, the minimum of either MOD value or 4095 is used for calculating  $T_{SYNC}$  when in 16-bit mode.



Figure 7. 12-bit Counter for Fast Lock and Phase Resync

After the user program a frequency, the second sync pulse coming from the 12-bit counter, after the nCS is asserted high, is used to resynchronize the output phase to the input phase. To ensure that the PLL is locked before to resynchronize the output phase, TSYNC must be larger than the worst case lock time.

## **Fast Lock Function**

The device uses a fast-lock mode to decrease lock time.

In order to allow the Fast Lock mode, the Fast Lock Switch (FLSW) is shorted to Ground and the charge pump current (ICP) is changed temporarily until the Fast Lock mode is disabled.

The loop bandwidth needs to be increased temporarily in order to allow a faster lock time. By doing this, the loop filter needs to be initially designed so that it addresses the risk of instability of having the zero and the poles too close to the actual bandwidth knee, when the user switches to a fast lock mode.

The loop bandwidth is proportional to:

RS and ICP (BW ~ RS \* ICP)

Where:

**BW** = the loop bandwidth

**RS** = the damping resistor

**ICP** = the programmable charge pump current

In order to enable the fast lock mode, the charge pump current is increased to the maximum value in order to increase the loop bandwidth. In parallel, the FLSW filter is set to ON so that the RS value is ¼ of its initial value in order to maintain the loop stability. By doing so, the zero and the first pole are moved (by a factor of 4x in the example below), so that the zero and the pole are kept at a suitable distance around the loop bandwidth.



Figure 8. Example of Fast Lock Mode Loop Filter Topology

In the example of Figure 8, *Example of Fast Lock Mode Loop Filter Topology*, the damping resistor RS is equal to: RS1 + RS2 in normal mode (FSLW switch OFF), with RS2 = 3 \* RS1

When the FLSW switch is ON, the damping resistor value is reduced by ¼ of its initial value (RS = RS1).

The second pole defined by R3 and C3 need needs to be designed so that there is no risk of instability when widening the loop bandwidth.

## **RF Output Power**

For RF\_OUT<sub>A</sub> and RF\_OUT<sub>B</sub>, the output power can be programmed from -4dBm to +7dBm.

Refer to Table 9I, Table 9J, Table 11E and Table 11F in the Register Map section for more information.

## MUX\_OUT

MUX\_OUT is a multipurpose output that can be programmed to provide the user with some internal status and values for test and debugging purpose. In addition, MUX\_OUT can also be programmed to provide an additional Serial Data Out Pin for a 4-wire SPI interface when needed. The MUX\_OUT function is described in the Table 4C and can be programmed in Bits[D28:D26] in Register 2.

Table 4C. MUX\_OUT Pin Configuration

MUX_OUT Register Value	MUX_OUT Function
000	High-Impedance Output
001	V <sub>DDD</sub>
010	GNDD
011	R Counter Output
100	N counter Output
101	Reserved
110	Lock Detect
111	MUX_OUT configured as SDO

### **Power-Down Mode**

When power-down is activated, the following events occur:

- **1.** Counters are forced to their load state conditions
- 2. VCO is powered down
- 3. Charge pump is forced into three-state mode
- 4. Digital lock detect circuitry is reset
- 5. RF\_OUT buffers are disabled
- 6. The input stage is powered down and set to High-Impedance
- 7. Input registers remain active and capable of loading and latching data

### **Default Power-Up Conditions**

All the RF outputs are muted at power up until the loop is locked. Refer to the Register Map section for default values in registers.

#### **Program Modes**

Table 4D and the Register Map indicate how the program modes are set up in the 8V97053L.

#### Table 4D. Control Bits Configuration

Co	ntrol Bits (C	:В)	
C3	C2	C1	Register
0	0	0	Register 0
0	0	1	Register 1
0	1	0	Register 2
0	1	1	Register 3
1	0	0	Register 4
1	0	1	Register 5
1	1	0	Extended Register 6
1	1	1	Extended Register 7

#### **Double Buffering**

The following bits are Doubled Buffered:

- 1. PHASE (Bits[D26:D15] in Register 1)
- 2. MOD (Bits[D14:D3] in Register 1)
- 3. REF DOUBLER (Bit D25 in Register 2)
- **4. REF DIV2** (Bit D24 in Register 2)
- 5. R COUNTER (Bits[D23:D14] in Register 2)
- 6. ICP SETTING (Bits[D12:D9] in Register 2)

The user must proceed to the following steps before any value written in these bits are used.

- 1. The new values are written in the double buffered bits
- 2. A new Write is performed on Register 0

The RF DIVIDER value in Register 4 (Bits[D22:D20]) is also double buffered, but only if the DOUBLE BUFFER bit (Bit D13 in Register 2) is set to 1.

# **Timing Characteristics**



Figure 9. SPI Write Cycle Timing Diagram



Figure 10. SPI Read Cycle Timing Diagram

Table 4E. SPI Read / Write Cycle Timing Parameters

Symbol	Parameter	Minimum	Maximum	Unit
f <sub>CLK</sub>	SCLK Frequency	-	20	MHz
t <sub>SU</sub>	nCS, SDI Setup Time to SCLK	10	ns	
t <sub>H</sub>	SCLK to nCS, SDI Hold Time	10	-	ns
t <sub>LO</sub>	SCLK Low Pulse Width	25	-	ns
t <sub>HI</sub>	SCLK High Pulse Width	25	-	ns
t <sub>PW</sub>	nCS De-asserted Pulse Width	20	-	ns

# 3- or 4-Wire SPI Interface Description

The 8V97053L has a serial control port capable of responding as a slave in an SPI compatible configuration to allow access to any of the internal registers (see section, "Register Map" on page 22) for device programming or examination of internal status. See the specific sections for each register for details on meanings and default conditions.

SPI mode slave operation requires that a device external to the 8V97053L has performed any necessary serial bus arbitration and/or address decoding at the level of the board or system. The 8V97053L begins a cycle by detecting an asserted (low) state on the nCS input at a rising edge of SCLK. This is also coincident with the first bit of data being shifted into the device. In SPI mode, the first bit is the Most Significant Bit (MSB) of the data word being written. Data must be written in 32-bit words, with nCS remaining asserted and one data bit being shifted in to the 8V97053L on every rising edge of SCLK. If nCS is de-asserted (high) at any time except after the complete 32<sup>nd</sup> SCLK cycle, this is treated as an error and the shift register contents are discarded. No data is written to any internal registers. If nCS is de-asserted (high) as expected at a time at least t<sub>SU</sub> after the 32<sup>nd</sup> falling edge of SCLK, then this will result in the shift register contents being acted on according to the control bit in it.

It is recommended to write the registers in reverse sequential order, starting with the highest register number first and ending with Register 0.

The word format of the 32-bit quantity in the shift register is shown in Table 4F. The register fields in the 8V97053L have been organized so that the three LSBs in each 32-bit register row are not used for data transfer. These bits will represent the base address for the 32-bit register row.

To perform a register Read, the user needs set the MUX\_OUT bits (Bits[28:D26]) in Register 2 to 111 to configure the MUX\_OUT pin as SDO. Register 7 (Instruction register) needs to be set for Read operation. Bit D3 of Register 7 will set the Read or Write command, and Bits[D4:D6] determine the read back address.

If a read operation is requested, 32-bits of read data will be provided in the immediately subsequent access. nCS must be de-asserted (high) for at least t<sub>PW</sub> and then reasserted (low).

If SCLKE = 1 (default condition), one data bit will be transmitted on the SDO output at the falling edge of nCS and each falling edge of SCLK as long as nCS remains asserted (low), and the master device should capture data on the rising edge of SCLK. If SCLKE = 0, one data bit will be transmitted on the SDO output at each rising edge of SCLK as long as nCS remains asserted (low), and the master device should capture data on the falling edge of SCLK. If SCLKE = 0, one data bit will be transmitted on the SDO output at each rising edge of SCLK as long as nCS remains asserted (low), and the master device should capture data on the falling edge of SCLK.

If nCS is de-asserted (high) before 32-bits of read data have been shifted out, the read cycle will be considered to be completed. If nCS remains asserted (low) longer than 32-bit times, then the data during those extra clock periods will be undefined. The MSB of the data will be presented first.

#### Table 4F. SPI Mode Serial Word Structure

	MSB					LSB			
Bit #	31		5	2	2 1 0				
Meaning				Control Bits					
Width				3					

# **Register Map**

# Register 0

## Table 5A. Register 0 Bit Allocation

BITS	D31	D30	D29	D28	D27	D26	D25	D24	D23	D22	D21	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	B
NAME	RESERVED	NDiv16	NDiv15	NDiv14	NDiv13	NDiv12	NDiv11	NDiv10	NDiv9	NDiv8	NDiv7	NDiv6	NDiv5	NDiv4	NDiv3	NDiv2	NDiv1	FDiv12	FDiv11	FDiv10	FDiv9	FDiv8	FDiv7	FDiv6	FDiv5	FDiv4	FDiv3	FDiv2	FDiv1	CB3	CB2	CB1
DESCRIPTION	RESERVED			FE	ED	BAC	K D	IVID	ER	NTE	GEI	R VA	ALUI	E (IN	IT)			F	EEC	)BA(	CK E	DIVIE	DER (FR	FRA AC)	ACTI	ION/	AL V	'ALU	ΙE	СС	NTR BITS	iol i

## Table 5B. Register 0: 16-Bit Feedback Divider Integer Value (INT). Function Description

Name	Description	Factory Default	Function
			0000 0000 0000 0000 = Not allowed
			0000 0000 0000 0001 = Not allowed
			0000 0000 0000 0111 = Not allowed
	Foodback Divider Integer Value (INT)	0000 0000 0110 0100	0000 0000 0000 1000 = 8
		(INT = 100)	
			0000 0000 0001 0111 = 23
			0000 0000 0001 1000 = 24
			1111 1111 1111 1111 = 65,535

## Table 5C. Register 0: 12-Bit Feedback Divider Fractional Value (FRAC). Function Description<sup>1</sup>

Name	Description	Factory Default	Function
			0000 0000 0000 = 0
FDiv[12:1]	Eadback Divider Fractional Value (ERAC)	0000 0000 0000	0000 0000 0001 = 1
		(FRAC = 0)	
			1111 1111 1111 = 4095

NOTE 1. This table is used when bit 16b\_12b\_sel is set to 0 (default). If the 16b\_12b\_sel is set to 1, refer to Table 12K, Page 42.

# Table 5D. Register 0: 3-Bit Control Bits. Function Description<sup>1</sup>

CB[3:1]     Control Bits     000 = Register 0 is programmed	Name	Description	Function
	CB[3:1]	Control Bits	000 = Register 0 is programmed

NOTE 1. The user has to set CB[3:1] to 000 in order to write to Register 0.

## **Register 1**

## Table 6A. Register 1 Bit Allocation

DESCRIPTION	NAME	BITS
RE	Reserved	D31
SER	Reserved	D30
/ED	Reserved	D29
BAND_SEL_DISABLE	Band_Sel_Disable	D28
UNUSED	Unused	D27
	Phase12	D26
	Phase11	D25
	Phase10	D24
PHA	Phase9	D23
ASE	Phase8	D22
VAL	Phase7	D21
UE (	Phase6	D20
(PH4	Phase5	D19
ASE)	Phase4	D18
)	Phase3	D17
	Phase2	D16
	Phase1	D15
	Mod12	D14
	Mod11	D13
ſ	Mod10	D12
MOE	Mod9	D11
DULL	Mod8	D10
JS V	Mod7	6 <b>0</b>
/ALU	Mod6	D8
IE (N	Mod5	D7
ЛОD	Mod4	DG
)	Mod3	D5
	Mod2	D4
	Mod1	D3
CO	CB3	D2
NTF BITS	CB2	D1
iol i	CB1	DO

## Table 6B. Register 1: 1-Bit BAND\_SEL\_DISABLE. Function Description

Name	Description	Factory Default	Function
Band_Sel_Disable	BAND_SEL_DISABLE	0	<ul> <li>0 = VCO Band Selection occurs after a Write to Register 0</li> <li>1 = VCO Band selection is not active and hold to previous VCO band selection</li> </ul>

## Table 6C. Register 1: 12-Bit Phase Value (PHASE). Function Description

Name	Description	16b_12b_sel (Bit D20, Register7)	Factory Default	Function
Phase [12:1]				0000 0000 0000 = 0
	PHASE	0		0000 0000 0001 = 1
		Ŭ		
				1111 1111 1111 = 4095
				0000 0000 0000 = 0
		1	0000 0000 0001	0000 0000 0001 = 16
		I		
				1111 1111 1111 = 65520

Name	Description	Factory Default	Function
			0000 0000 0000 = Not Allowed
			0000 0000 0001 = Not Allowed
Mod[12:1]	MOD	0000 0000 0010	0000 0000 0010 = 2
			1111 1111 1111 = 4095

NOTE 1. This table is used when bit D20 in Register 7 (16b\_12B\_sel) is set to 0 (default). If 16b\_12b\_sel is set to 1, refer to Table 12J, Page 42.

## Table 6E. Register 1: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	Control Bits	001 = Register 1 is programmed

NOTE 1. The user has to set CB[3:1] to 001 in order to write to Register 1.

# RENESAS

## **Register 2**

### Table 7A. Register 2 Bit Allocation

DESCRIPTION	NAME	BITS
SERVED	RESERVED	D31
ISF MODE	ModeNoise1	D30
	ModeNoise2	D29
MU	MUX_OUT3	D28
IX_C	MUX_OUT2	D27
DUT	MUX_OUT1	D26
<b>DOUBLER</b>	RefDoub	D25
REF DIV2	RDiv2	D24
	R10	D23
	R9	D22
	R8	D21
R	R7	D20
COL	R6	D19
JNTI	R5	D18
ER	R4	D17
	R3	D16
	R2	D15
	R1	D14
BLE BUFFER	DoubBuff1	D13
IC	ChrgPmp4	D12
P SE	ChrgPmp3	D11
ΞΤΤΙΙ	ChrgPmp2	D10
NG	ChrgPmp1	6 <b>D</b>
LDF	LDF	D8
LDP	LDP	D7
POLARITY	PD_pol	D6
WER DOWN	PwrDwn	D5
SP HIGHZ	CP_HIGHZ	D4
UNUSED	Unused	D3
CO	CB3	D2
NTF	CB2	5
ROL	CB1	D0

## Table 7B. Register 2: 2-Bit NOISE MODE. Function Description

Name	Description	Factory Default	Function
			00 = Low Noise Mode (Dither OFF)
ModeNoise[2:1] NOISE MODE	00 01 = Reserved 10 = Reserved 11 = Low Spur Mode (Dither Enabled)	01 = Reserved	
		10 = Reserved	
		11 = Low Spur Mode (Dither Enabled)	

## Table 7C. Register 2: 3-Bit MUX\_OUT. Function Description

Name	Description	Factory Default	Function
MUX_OUT[3:1]			000 = High-Impedance output
			001 = V <sub>DDD</sub>
		010 = GNDD	010 = GNDD
		000	011 = R counter output
	MOX_001	$000 = High-Impedance output$ $001 = V_{DDD}$ $010 = GNDD$ $011 = R counter output$ $100 = N counter output$ $101 = Reserved$ $110 = Lock Detect$ $111 = MUX OUT configured as S$	100 = N counter output
			101 = Reserved
			110 = Lock Detect
			111 = MUX_OUT configured as SDO

## Table 7D. Register 2: 1-Bit REF DOUBLER. Function Description

Name	Description	Factory Default	Function
RefDoub	REF DOUBLER	0	0 = Disabled 1 = Enabled

#### Table 7E. Register 2: 1-Bit REF DIV2. Function Description

Name	Description	Factory Default	Function
	0	0 = Disabled	
		0	1 = Enabled

#### Table 7F. Register 2: 10-Bit R COUNTER (R). Function Description

Name	Description	Factory Default	Function
			00 0000 0000 = Not Allowed
			00 0000 0001 = 1
R[10:1]	R	00 0000 0001	00 0000 0010 = 2
			11 1111 1111 = 1023

## Table 7G. Register 2: 1-Bit DOUBLE BUFFER. Function Description<sup>1</sup>

Name	Description	Factory Default	Function
DoubBuff1	DOUBLE BUFFER	0	0 = Disabled 1 = Enabled

NOTE 1. Bit D13 enables or disables Double Buffering of Bits[D22:D20] in Register 4. Refer to Program Modes section.

Name	Description	Factory Default	Function
			Icp (mA) assuming RCP = $5.1 k\Omega$
			0000 = 0.31
			0001 = 0.63
			0010 = 0.94
			0011 = 1.25
			0100 = 1.56
			0101 = 1.88
			0110 = 2.19
ChrgPmp[4:1]	ICP SETTING	0000	0111 = 2.50
			1000 = 2.81
			1001 = 3.13
			1010 = 3.44
			1011 = 3.75
			1100 = 4.06
			1101 = 4.38
			1110 = 4.69
			1111 = 5.00

### Table 7H. Register 2: 4-Bit Charge Pump Setting (ICP SETTING). Function Description

# Table 7I. Register 2: 1-Bit Lock Detect Function (LDF). Function Description<sup>1</sup>

Name	Description	Factory Default	Function
	LDF	0	0 = 40 consecutive cycles (recommended for FRAC-N mode)
		0	1 = 5 consecutive cycles (recommended for INT-N mode)

NOTE 1. LDF controls the number of PFD cycles that needs to be considered by the Lock Detect function to decide if the part has achieved lock.

#### Table 7J. Register 2: 1-Bit Lock Detect Precision. Function Description

Name	Description	Factory Default	Function
אס ו	ם ח	0	0 = 10ns
		0	1 = 6ns

#### Table 7K. Register 2: 1-Bit Phase Detector Polarity. Function Description

Name	Description	Factory Default	Function
		1	0 = NEGATIVE
	PD_Pol PD POLARITY		1 = POSITIVE

#### Table 7L. Register 2: 1-Bit Power Down. Function Description

Name	Description	Factory Default	Function				
PwrDwp		0	0 = Disabled				
PwrDwn	POWER DOWN	0	1 = Enabled				

#### Table 7M. Register 2: 1-Bit Charge Pump High-Impedance. Function Description

Name	Description	Factory Default	Function
		0	0 = Disabled
		0	1 = Enabled

## Table 7N. Register 2: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	Control Bits	010 = Register 2 is programmed

NOTE 1. The user has to set CB[3:1] to 010 in order to write to Register 2.

## RENESAS

## **Register 3**

#### Table 8A. Register 3 Bit Allocation

BITS	D31	D30	D29	D28	D27	D26	D25	D24	D23	D22	D21	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11	D10	60	D8	D7	D6	D5	D4	D3	D2	5	
NAME	RESERVED	BandSelCM	Unused	Unused	RESERVED	RESERVED	Unused	RESERVED	ClkDivMode2	ClkDivMode1	CIkDiv12	CIkDiv11	CIkDiv10	CIkDiv9	CIkDiv8	CIkDiv7	CIkDiv6	CIkDiv5	CIkDiv4	CIkDiv3	CIkDiv2	CIkDiv1	CB3	CB2								
DESCRIPTION			R	ESE	RVE	ΞD			BAND SELECT	UNUSED	UNUSED	RESERVED		UNUSED	RESERVED					(	CLO	CKC	COU	NTE	R V/	ALU	E			сс	)NT BIT	F

#### Table 8B. Register 3: 1-Bit Band Select Clock Mode. Function Description<sup>1</sup>

Name	Description	Factory Default	Function
			0 = LOW (125kHz)
BandSelCM	BAND SELECT (CLOCK RATE)	0	1 = HIGH (up to 500kHz logic sequence for
			Faster Lock applications)

NOTE 1. BAND SELECT (CLOCK RATE) selects the speed of the logic sequence for the band selection. BandSelCM = 1 sets the logic sequence rate faster, which is recommended for fast lock operation and when high PFD frequencies are used. BandSelCM = 0 is recommended when low PFD frequencies (125kHz) are used. When using BandSelCM = 1, the value of the BAND SELECT CLOCK COUNTER (BndSelDiv[8:1]) must be less than or equal to 254.

#### Table 8C. Register 3: 2-Bit Clock Divider Mode. Function Description

Name	Description	Factory Default	Function
			00 = Clock Divider OFF
	CLK DIV MODE	00	01 = Fast Lock Enabled
ClkDivMode[2:1]		00	10 = Resync Enabled
			11 = Reserved

#### Table 8D. Register 3: 12-Bit Clock Divider Value (CLKDIV). Function Description

Name	Description	Factory Default	Function
			0000 0000 0000 = Not allowed
			0000 0000 0001 = 1
ClkDiv[12:1]	CLKDIV	0000 0000 0001	0000 0000 0010 = 2
			1111 1111 1111 = 4095

# Table 8E. Register 3: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	CONTROL BITS	011 = Register 3 is programmed

NOTE 1. The user has to set CB[3:1] to 011 in order to write to Register 3.

## RENESAS

## **Register 4**

## Table 9A. Register 4 Bit Allocation

DESCRIPTION	NAME	BITS
	RESERVED	D31
	RESERVED	D30
R	RESERVED	D29
ESE	RESERVED	D28
RVE	RESERVED	D27
ΞD	RESERVED	D26
	RESERVED	D25
	RESERVED	D24
EDBACK SELECT	FbkSel	D23
	RFDiv3	D22
RF DIVIDER	RFDiv2	D21
	RFDiv1	D20
	BndSelDiv8	D19
BAI	BndSelDiv7	D18
ND S C	BndSelDiv6	D17
Sele Oui	BndSelDiv5	D16
ECT	BndSelDiv4	D15
CLC R	BndSelDiv3	D14
)CK	BndSelDiv2	D13
	BndSelDiv1	D12
O POWER DOWN	VCOPwrDwn	D11
MTLD	MTLD	D10
OUTB SELECT	RF_OUTB_Sel	60
OUTB ENABLE	RF_OUTB_En	D8
	RF_OUTB_Pwr	D7
	RF_OUTB_Pwr	D6
OUTA ENABLE	RF_OutA_En	D5
	RF_OUTA_Pwr	D4
	RF_OUTA_Pwr	D3
CO	CB3	D2
NTF BITS	CB2	2
ROL	CB1	8

## Table 9B. Register 4: 1-Bit Feedback Select. Function Description

Name	Description	Factory Default	Function
FbkSel	FEEDBACK SELECT	1	0 = Divided 1 = Fundamental

## Table 9C. Register 4: 3-Bit RF Output Divider (÷ MO) Select. Function Description

Name	Description	Factory Default	Function
			000 = Div by 1
	001 =		001 = Div by 2
			010 = Div by 4
		000	011 = Div by 8
	RF OUTPUT DIVIDER	000	100 = Div by 16
			101 = Div by 32
			110 = Div by 64
			111 = Reserved

#### Table 9D. Register 4: 8-Bit Band Select Clock Counter. Function Description<sup>1</sup>

Name	Description	Factory Default	Function
			0000 0000 = Not Allowed
			0000 0001 = 1
BndSelDiv[8:1]	BAND SELECT CLOCK COUNTER	0000 0001	0000 0010 = 2
			1111 1111 = 255

NOTE 1. BAND SELECT CLOCK COUNTER sets the value of the divider for the band select logic clock input. By default, the output frequency of the R counter is used to clock the band select logic. If this frequency is larger than 125kHz, the Band Select Clock counter can be used to divide the R counter output to a smaller frequency suitable for the band selection logic.

#### Table 9E. Register 4: 1-Bit VCO Power Down. Function Description

Name	Description	Factory Default	Function
		0	0 = VCO Powered Up
		0	1 = VCO Powered Down

#### Table 9F. Register 4: 1-Bit Mute Till Lock Detect. Function Description

Name	Description	Factory Default	Function
МТІП	MTLD	0	0 = Mute Disabled
WITED		0	1 = Mute Enabled

#### Table 9G. Register 4: 1-Bit RF\_OUTB Select. Function Description

Name	Description	Factory Default	Function
RE OUTB Sel		0	0 = Divided Output
			1 = Fundamental

#### Table 9H. Register 4: 1-Bit RF\_OUTB Enable. Function Description

Name	Description	Factory Default	Function
RF_OUTB_En	RF_OUTB ENABLE	0	0 = Disabled (High-Impedance) 1 = Enabled <sup>1</sup>

NOTE 1. RF\_OUT<sub>A</sub> must also be enabled.

## Table 9I. Register 4: 1-Bit RF\_OUTA Enable. Function Description

Name	Description	Factory Default	Function
RF_OUTA_En	RF_OUTA ENABLE	0	0 = Disabled <sup>1</sup> (High-Impedance) 1 = Enabled

NOTE 1. RF\_OUT<sub>B</sub> will also disable.

## Table 9J. Register 4: 2-Bit RF\_OUTA Output Power. Function Description<sup>1</sup>

Name	Description	Factory Default	Function
			00 = -4dBm
RF_OUTA_Pwr[2:1]	F_OUTA_Pwr[2:1] RF_OUTA OUTPUT POWER	10	01 = -1dBm
			10 = +2dBm
			11 = +5dBm

NOTE 1.  $f_{RF_{OUT}} = 34.375 MHz$ .

## Table 9K. Register 4: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	CONTROL BITS	100 = Register 4 is programmed

NOTE 1. The user has to set CB[3:1] to 100 in order to write to Register 4.

## **Register 5**

## Table 10A. Register 5 Bit Allocation<sup>1</sup>

SCRIPTION	NAME RESERVED	BITS D31
	RESERVED	D30
R	RESERVED	D29
ESE	RESERVED	D28
RVF	RESERVED	D27
Ð	RESERVED	D26
	RESERVED	D25
	RESERVED	D24
ACOM	LDPInMode2	D23
	LDPInMode1	D22
	RESERVED	D21
	RESERVED	D20
	RESERVED	D19
	RESERVED	D18
	RESERVED	D17
	RESERVED	D16
	RESERVED	D15
	RESERVED	D14
RES	RESERVED	D13
SER	RESERVED	D12
√ED	RESERVED	D11
	RESERVED	D10
	RESERVED	6 <b>D</b>
	RESERVED	D8
	RESERVED	D7
	RESERVED	D6
	RESERVED	D5
	RESERVED	D4
	RESERVED	D3
со	CB3	D2
NTR	CB2	D1
ROL	CB1	D0

NOTE 1. D19 and D20 must be set to 1.

#### Table 10B. Register 5: 2-Bit LD (Lock Detect) Pin Mode. Function Description

Name	Description	Factory Default	Function
			00 = Low
LDPInMode[2:1]	LD PIN MODE	01	01 = Digital Lock Detect
			10 = Low
			11 = High

## Table 10C. Register 5: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	CONTROL BITS	101 = Register 5 is programmed

NOTE 1. The user has to set CB[3:1] to 101 in order to write to Register 5.

## Extended Registers, (Registers 6 and 7)

### **Register 6**

# Table 11A. Register 6 Bit Allocation<sup>1 2 3</sup>

DESCRIPTION	NAME	BITS
DIGITAL LOCK (RO)	DigLock	D31
BAND_SELECT_DONE (RO)	Band_select_done	D30
RESERVED (RO)	Reserved	D29
RESERVED (RO)	Reserved	D28
TY BUT	LDP_Ext2	D27
	LDP_Ext1	D26
RF_OUTB_HI_PWR	rfoutb_hi_pwr	D25
RF_OUTA_HI_PWR	rfouta_hi_pwr	D24
SDM OPDEP	SDMOrder2	D23
	SDMOrder1	D22
DITHER GAIN	DitherG	D21
SHAPE_DITHER_EN	ShapeDitherEn	D20
ADVE MOS	SDMType1	D19
	SDMType0	D18
	band_select_acc2	D17
	band_select_acc1	D16
	Reserved	D15
	Reserved	D14
RES	Reserved	D13
ER\	Reserved	D12
/ED	Reserved	D11
(RO	Reserved	D10
)	Reserved	6 <b>0</b>
	Reserved	D8
RESERVED	Reserved	D7
EX	ExtBndSelDiv4	D6
(T_B L_I	ExtBndSelDiv3	D5
ND_ DIV	ExtBndSelDiv2	D4
SE	ExtBndSelDiv1	D3
со	CB3	D2
NTF	CB2	5
₹OL Ş	CB1	DO

NOTE 1. It is recommended that the user writes to Register 0 after writing to Register 6.

NOTE 2. Bit D7 must be set to 0 for correct operation.

NOTE 3. RO Bits are Read Only Bits.

#### Table 11B. Register 6: 1-Bit Digital Lock Detect. Function Description

Name	Description	Function
Dial ook		0 = PLL Not Locked
DIGEOCK	DIGITAL LOCK	1 = PLL Locked (according LDF and LDP in Register 2)

#### Table 11C. Register 6: 1-Bit Band Select Status (Read Only). Function Description

Name	Description	Function
Band select done	BAND SELECT DONE	0 = Band Selection Not Complete
Band_select_done	DAND_SELECT_DONE	1 = Band Selection Complete

			Function		
Name	Description	Factory Default	Extra Bit	LDP Bits in Register 2	Value
			00	0	10ns
			00	1	6ns
			01	0	3ns
	LDP_EXT	00	01	1	3ns
שר_בגונצ. ו <u>ן</u>	Extra Lock Detect Precision	00	10	0	4ns
			10	1	4.5ns
			11	0	1.5ns
				1	1.5ns

#### Table 11D. Register 6: 2-Bit Extra Lock Detect Precision. Function Description<sup>1</sup>

NOTE 1. LDP\_Ext[2:1] are Extra Lock Detect Precision bits. When these bits are set to 00, then the precision of the Lock Detect precision only relies on the LDP bit in Register 2, so that the lock detect window is 10ns or 6ns, depending on the LDP bit in Register 2. For high PFD frequencies, the 6ns window may be larger than the entire ref/FB period. The LDP\_ext bits reduce the size of the lock detect window to the value described in Table 11B, Page 36, allowing an accurate lock detection with higher PFD frequencies.

## Table 11E. Register 6: 1-Bit Extra Bit of RF\_OUTB Power. Function Description<sup>1 2</sup>

			Function		
Name	Description	Factory Default	Extra Bit	RF_OUTB OUTPUT POWER Bits in Register 4	Value (dBm)
				00	-4
			0	01	-1
			0	10	+2
rf outh hi pwr		0		11	+5
II_OUID_III_PWI		0		00	+2
			1	01	+5
			•	10	+6
				11	+7

NOTE 1. RF\_OUTB\_HI\_PWR is an Extra Bit of RF\_OUTB Power that increases the output power to the RF\_OUT<sub>B</sub> output. NOTE 2.  $f_{RF_OUT} = 34.375$ MHz.

## Table 11F. Register 6: 1-Bit Extra Bit of RF\_OUTA Power. Function Description<sup>1 2</sup>

			Function		
Name	Description	Factory Default	Extra Bit	RF_OUTA OUTPUT POWER Bits in Register 4	Value (dBm)
				00	-4
			0	01	-1
			0	10	+2
rfouta bi pwr	RE OUTA HI PWR	0		11	+5
n_outa_n_pwi		0		00	+2
			1	01	+5
				10	+6
				11	+7

NOTE 1. RF\_OUTA\_HI\_PWR is an Extra Bit of RF\_OUTA Power that increases the output power to the RF\_OUT<sub>A</sub> output. NOTE 2.  $f_{RF OUT} = 34.375$ MHz.

#### Table 11G. Register 6: 2-Bit Sigma Delta Modulator Order Configuration. Function Description

Name	Description	Factory Default	Function
			00 = OFF. The device operates in integer mode and the fractional part is ignored.
SDMOrder[2:1]	SDM_ORDER	11	$01 = 1^{st}$ order
			$10 = 2^{nd}$ order
			11 = 3 <sup>rd</sup> order

#### Table 11H. Register 6: 2-Bit Dither Gain Configuration. Function Description

Name	Description	Factory Default	Function
DitherG	DITHER GAIN	0	0 = LSB Dither (Recommended) 1 = LSB x4 Dither

#### Table 11I. Register 6: 1-Bit Dither Noise Shaping Configuration. Function Description

Name	Description	Factory Default	Function
ShapeDitheren	SHAPE_DITHER_EN	1	0 = Dither Noise Shaping Disabled 1 = Dither Noise Shaping Enabled

#### Table 11J. Register 6: 1-Bit Sigma Delta Modulator Type Configuration. Function Description

Name	Description	Factory Default	Function
			00 = Reserved
SDMTure[2:4]		01	01 = SSMF-II
SDMType[2.1]	SDM_TTPE	01	10 = SSMF-I
			11 = SSMF-B

#### Table 11K. Register 6: 2-Bit VCO Band Selection Accuracy Configuration. Function Description

Name	Description	Factory Default	Function
			00 = 1 cycle of the band select clock (output of the Band Select Divider)
hand calent app[2:1]		00	01 = 2 cycles
Dand_Select_acc[2.1]	DAND_SELECT_ACC	00	10 = 4 cycles
			11 = Reserved

## Table 11N. Register 6: 4-Bit Extra Most Significant Bits of Band Select Divider. Function Description<sup>1 2</sup>

Name	Description	Factory Default	Value	Function
				0000 = [BSCC_R4]
				0001 =[BSCC_R4]+256
ExtBndSelDiv[4:1]	EXT_BND_SEL_DIV	0000	IESCC_R4 + [EXT_BND_SEL_DIV]x256	0010 = [BSCC_R4] + 512
				1111 = [BSCC_R4]+3840

NOTE 1. EXT\_BND\_SEL\_DIV are Extra 4 MSBs that extend the Band Select Clock Counter in Register 4. These additional bits are necessary for band selection to divide down to <500kHz when high PFD frequencies are used.

NOTE 2. BSCC\_R4 is the BAND SELECT CLOCK COUNTER value in Register 4.

#### Table 11O. Register 6: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	CONTROL BITS	110 = Register 6 is programmed

NOTE 1. The user has to set CB[3:1] to 110 in order to write to Register 6.

## **Register 7**

#### Table 12A. Register 7 Bit Allocation<sup>1 2</sup>

DESCRIPTION	NAME	BITS
LOSS_DIG_LOCK (SB)	Loss_Dig_Lock	D31
LOSS_ANLG_LOCK (SB)	Loss_Anlg_Lock	D30
SPI_ERROR (SB)	Spi_error	D29
RESERVED	Reserved	D28
R	Rev_ID3	D27
EV_ (RO)	Rev_ID2	D26
ID )	Rev_ID1	D25
DE	Dev_ID4	D24
EV_I	Dev_ID3	D23
D (R	Dev_ID2	D22
(O)	Dev_ID1	D21
16b_12b_SEL	16b_12bsel	D20
RESERVED	RESERVED	D19
RESERVED	RESERVED	D18
RESERVED	RESERVED	D17
RESERVED	RESERVED	D16
E	ext_mod4	D15
XT_	ext_mod3	D14
MO	ext_mod2	D13
D	ext_mod1	D12
E	ext_fdiv4	D11
XT_	ext_fdiv3	D10
FRA	ext_fdiv2	6 <b>0</b>
C	ext_fdiv1	D8
SCLKE	sclke	D7
	Rd_Addr3	D6
READBACK_ADDR	Rd_Addr2	D5
	Rd_Addr1	D4
SPI_R_WN	SPI_R_WN	D3
CO	CB3	D2
NTR	CB2	5
ROL	CB1	DO

NOTE 1. SB Bits are Sticky Bits and need to be cleared.

NOTE 2. RO Bits are Read Only Bits.

#### Table 12B. Register 7: 1-Bit Loss of Digital Lock. Function Description<sup>1</sup>

Name	Description	Function	
Loop Dig Look		0 = Locked since last time register was cleared	
LOSS_DIG_LOCK	2000_DIG_200K	1 = Loss of Digital Lock since last time register was cleared	

NOTE 1. This bit is a sticky bit and needs to be cleared with a SPI write of 1 to detect further Loss of Digital Lock occurrences.

#### Table 12C. Register 7: 1-Bit Loss of Analog Lock. Function Description<sup>1</sup>

Name	Description	Function	
Loop Anla Look	LOSS ANLE LOCK	) = Band Selection remained the same since last time register was cleared	
LOSS_ANIG_LOCK LOSS_ANLG_LOCK		1 = Band selection occurred since last time register was cleared	

NOTE 1. This bit is a sticky bit and needs to be cleared with a SPI write of 1 to detect further Band Selection occurrences.

#### Table 12D. Register 7: 1-Bit SPI Error. Function Description<sup>1</sup>

Name	Description	Function
Spi error	SPL ERROR	0 = No SPI write error detection
opi_onoi		1 = SPI Write error

NOTE 1. Spi\_error Bit goes high if the SPI interface detects a cycle with the incorrect number of SCLK cycles between nCS asserted Low and nCS asserted High. The SPI interface expects 32 clock cycles between nCS asserted Low and nCS asserted High. Any Read/Write via the SPI interface with more or less than 32 clock cycles will result in the Spi\_error Bit switched to 1. This bit is a sticky bit and needs to be cleared with a SPI write of 1 in order to detect further possible SPI Write/Read errors.

#### Table 12E. Register 7: 3-Bit Revision ID. Function Description

Name	Description	Factory Default
Rev_ID[3:1]	REV_ID	001

### Table 12F. Register 7: 4-Bit Device ID. Function Description

Name	Description	Factory Default
Dev_ID[4:1]	DEV_ID	0110

## Table 12G. Register 7: 1-Bit Resolution Select. Function Description

Name	Description	Factory Default	Function
			0 = FRAC, PHASE and MOD set to 12-Bit resolution,
16b_12b_sel	12b_sel 16b_12b_SEL	0	Bit[D19:D8] set to 0 and unused
			1 = FRAC, PHASE and MOD set to 16-Bit resolution

				Function	
Name	Description	Factory Default	MOD	EXT_MOD	Value
	EXT MOD			0000	Not Allowed
				0001	Not Allowed
			0000 0000 0000	0010	2
ext_mod[4:1] EXT_MOD				1111	15
		0000		0000	16
		0000	0000 0000 0001 11		
				1111	31
				0000	65520
		1111 1111 1	1111 1111 1111		
				1111	65535

#### Table 12J. Register 7: 4-Bit Extra Bits of MOD Value. Function Description<sup>1</sup>

NOTE 1. Bit D20 in Register 7 (16b\_12b\_SEL) is required to be set to 1 when using this table. If Bit D20 in Register 7 (16b\_12b\_SEL) is set to 0, refer to Table 6D, Page 25.

## Table 12K. Register 7: 4-Bit Extra Bits of FRAC Value. Function Description<sup>1</sup>

				Function	
Name	Description	Factory Default	FRAC	EXT_FRAC	Value
				0000	0
			0000 0000 0000 0000 0000 0000 0000 0000 0000	0001	1
ext_fdiv[4:1] E				1111	15
				0000	16
	EXT_FRAC	0000			
				1111	31
				0000	65520
		1111			
				1111	65535

NOTE 1. Bit D20 in Register 7 (16b\_12b\_SEL) is required to be set to 1 when using this table. If Bit D20 in Register 7 (16b\_12b\_SEL) is set to 0, refer to Table 5C, Page 22.

#### Table 12L. Register 7: 1-Bit SCLKE. Function Description

Name	Description	Factory Default	Function
0			0 = Output Data in a Read Cycle on a Rising Edge of SCLK
Scike	SCLKE	1	1 = Output Data in a Read Cycle on a Falling Edge of SCLK

## Table 12M. Register 7: 1-Bit READBACK\_ADDR. Function Description<sup>1</sup>

Name	Description	Function
	000 = Re	000 = Register 0
		001 = Register 1
		010 = Register 2
Pd Addr[2:1]		011 = Register 3
Ra_Add[[3:1]	READDACK_ADDR	100 = Register 4
		101 = Register 5
		110 = Register 6
		111 = Register 7

NOTE 1. In order to Read a register, the user must write to Register 7 first and set the SPI\_R\_WN Bit to 1 (READ) and indicate the address of the register to read in the READBACK\_ADDR Bit (Bits[D6:D4]).

#### Table 12N. Register 7: 1-Bit SPI\_R\_WN. Function Description<sup>1</sup>

Name	Description	Factory Default	Function
		0	0 = WRITE
SFI_K_WN		0	1 = READ

NOTE 1. Writing this bit to a '1' will allow the user to read back the register selected in READBACK\_ADDR on the next 32 SCLK cycle. This bit will revert back to '0' once it is written with '1' and will not retain the '1' value.

#### Table 12O. Register 7: 3-Bit Control Bits. Function Description<sup>1</sup>

Name	Description	Function
CB[3:1]	CONTROL BITS	111 = Register 7 is programmed

NOTE 1. The user has to set CB[3:1] to 111 in order to write to Register 7.

# **Absolute Maximum Ratings**

NOTE: Stresses beyond those listed under **Absolute Maximum Ratings** may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond

#### Table 13. Absolute Maximum Ratings

Item Rating Supply Voltage, VDDX 3.63V Analog Supply Voltage, VDDA 3.63V Input, V<sub>I</sub> REF\_IN -0.5 to V<sub>DDA</sub> + 0.5V Other Inputs (MUTE, SDI, FLSW, V<sub>TUNE</sub>) Outputs, V<sub>O</sub> -0.5 to V<sub>DDA</sub> + 0.5V RF\_OUT<sub>A-B</sub>, nRF\_OUT<sub>A-B</sub> Outputs, V<sub>O</sub> (SCLK, LD, nCS, MUX\_OUT) -0.5 to V<sub>DDA</sub> + 0.5V Outputs, IO Continuous Current 40mA Surge Current 65mA Outputs, I<sub>O</sub> (SCLK, LD, nCS, MUX\_OUT) 8mA Continuous Current 13mA Surge Current Junction Temperature, T<sub>.I</sub> 125°C -65°C to 150°C Storage Temperature, T<sub>STG</sub>

NOTE: V<sub>DDX</sub> denotes V<sub>DDD</sub>, V<sub>CP</sub>, V<sub>DD\_SD</sub>, V<sub>VCO</sub>.

those listed in the *DC Characteristics or AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

# **DC Electrical Characteristics**

Table 14A. Power Supply DC Characteristics,  $V_{DDX} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to +85°C<sup>1 2 3</sup>

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Unit
V <sub>DDX</sub>	Core Supply Voltage		3.135	3.3	3.465	V
V <sub>DDA</sub>	Analog Supply Voltage		3.135	3.3	3.465	V
I <sub>DDX</sub> <sup>4</sup>	Power Supply Current			95	105	mA
I <sub>DDA</sub> 5 Analog Supt		RF_OUT <sub>A</sub> / nRF_OUT <sub>A</sub> - Active RF_OUT <sub>B</sub> / nRF_OUT <sub>B</sub> - Muted		60	75	mA
	Analog Supply Current	RF_OUT <sub>A</sub> / nRF_OUT <sub>A</sub> - Active RF_OUT <sub>B</sub> / nRF_OUT <sub>B</sub> - Active		80	100	mA
		RF_OUT <sub>A</sub> / nRF_OUT <sub>A</sub> - Muted RF_OUT <sub>B</sub> / nRF_OUT <sub>B</sub> - Muted		37	45	mA
I <sub>VCO</sub>	VCO Supply Current			60		mA
	Power Down Mode			15	20	mA

NOTE 1.  $V_{DDX}$  denotes  $V_{DDD}$ ,  $V_{CP}$ ,  $V_{DD}$ ,  $V_{VCO}$ .

NOTE 2. RF Outputs Terminated 50  $\Omega\pm1\%$  to  $V_{DDA.}$ 

NOTE 3. Output Power set to +2dBm.

- NOTE 4.  $I_{DDX}$  denotes  $I_{DDD} + I_{CP} + I_{DD_SD} + I_{VCO.}$
- NOTE 5. I<sub>DDA</sub> is dependent on the value of the M0 output divider. The numbers indicated for I<sub>DDA</sub> show the current consumption when using the output divider M0 = 64, for which I<sub>DDA</sub> is higher than when using any other M0 divider value.

#### Table 14B. Output Divider Incremental Current<sup>1</sup>

Parameter	Test Conditions	Minimum	Typical	Maximum	Unit
	Divide by 2		8.0		mA
	Divide by 4		7.0		mA
Output Dividor Supply Current	Divide by 8		1.5		mA
Output Divider Supply Current	Divide by 16		1.5		mA
	Divide by 32		1.5		mA
	Divide by 64		1.5		mA

NOTE 1. RF Output divider (+MO) has an incremental increase in current as the divider value increases. This specification is the incremental current change per output divider step. For example, current of divide-by-2 is 8mA more than divide-by-1, current of divide-by-4 is 7mA more than divide-by-2, and so on. The total increase from +1 to +64 is 8mA + 7mA + 1.5mA + 1.5mA + 1.5mA + 1.5mA = 21mA.

### Table 14C. Typical Current by Power Domain<sup>1</sup>

Pin Name	Pin Number	Typical Current	Unit
V_ <sub>CP</sub>	6	24	mA
V <sub>VCO</sub>	16, 17	15	mA
V <sub>DDD</sub>	28	0.5	mA
V <sub>DD_SD</sub>	32	6	mA
V <sub>DDA</sub>	10	52	mA

NOTE 1. Operating conditions are: REF\_IN = 25MHz INT = 100 (integer mode) RF Divider =  $\div$ 1 RF\_OUT<sub>A</sub> = RF\_OUT<sub>B</sub> = 2.5GHz RF<sub>POWER</sub> = -1dBm Charge Pump = 0.31mA

## Table 14D. LVCMOS DC Characteristics, $V_{DDX} = V_{DDA} = 3.3V \pm 5\%$ , $T_A = -40^{\circ}$ C to $85^{\circ}$ C<sup>1</sup>

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Unit
V	Input High Voltago	MUTE, CE		1.8		V <sub>DDx</sub>	V
ЧН	input night voltage	SDI, SCLK, nCS		1.5		V <sub>DDx</sub>	V
V <sub>IL</sub>	Input Low Voltage			-0.3		0.6	V
I	Input High Current	SDI, MUTE, CE	V <sub>DDx</sub> = 3.465V, V <sub>IN</sub> = 1.8V			5	μA
	SCLK, nCS	V <sub>DDx</sub> = 3.465V, V <sub>IN</sub> = 1.8V			150	μA	
1	Input Low Current	SDI, MUTE, CE	V <sub>DDx</sub> = 3.465V, V <sub>IN</sub> = 0V	-150			μA
١L		SCLK, nCS	V <sub>DDx</sub> = 3.465V, V <sub>IN</sub> = 0V	-5			μA
V <sub>OH</sub>	Output High Voltage	MUX_OUT, LD	V <sub>DDx</sub> = 3.465V; I <sub>OH</sub> = -500µA	V <sub>DDX</sub> - 0.4			V
V <sub>OL</sub>	Output Low Voltage	MUX_OUT, LD	V <sub>DDx</sub> = 3.465V; I <sub>OL</sub> = 500µA			0.4	V

NOTE 1. V<sub>DDX</sub> denotes V<sub>DDD</sub>, V<sub>\_CP</sub>, V<sub>DD\_SD</sub>, V<sub>VCO</sub>.

# **AC Electrical Characteristics**

## Table 15A. AC Characteristics, $V_{DDX} = V_{DDA} = 3.3V \pm 5\%$ , $T_A = -40^{\circ}C$ to $85^{\circ}C^{1}$

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Unit
			Ref Doubler Disabled	5		310	MHz
		equency	Ref Doubler Enabled	5		100	MHz
V <sub>PP</sub>	Input Sensitivity	REF_IN	Biased at V <sub>DDA</sub> /2 <sup>3</sup>	0.7		V <sub>DDA</sub>	V
f <sub>VCO</sub>	VCO Frequency		Fundamental VCO Mode	2200		4400	MHz
f <sub>RF_OUT</sub>	Output Frequency		Divider Values: 1, 2, 4, 8, 16, 32, 64	34.375		4400	MHz
f	PFD Frequency		Fractional Mode			125	MHz
PFD			Integer Mode			310	MHz
K <sub>VCO</sub>	VCO Sensitivity				40		MHz/V
t <sub>LOCK</sub>	PLL Lock Time		Time from Low to High nCS until at Normal Mode, Low to High LD		200		μs
-	Output Power Variation				±1		dB
-	RF Output Power		Muted, (M0 ≠ 1)		<-80		dBm
-	Min/Max VCO Tuning Voltage				0.5 / 2.5		V

NOTE 1. V<sub>DDX</sub> denotes V<sub>DDD</sub>, V<sub>CP</sub>, V<sub>DD\_SD</sub>, V<sub>VCO</sub>.

NOTE 2. For REF\_IN <10MHz, the slew rate must be >21V/ $\mu$ s.

NOTE 3. AC-coupling the reference signal ensures  $V_{\mbox{\scriptsize DDA}}/2$  biasing.

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Unit
		f = 156.25MHz Integration Range: 12kHz - 20MHz		220		fs
tjit(Ø)	RMS Phase Jitter (Random)	f = 2.05GHz Integration Range: 12kHz - 20MHz		218		fs
		f = 1.76GHz Integration Range: 12kHz - 20MHz		166		fs
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-122.76		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-146.18		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-147.80		dBc/Hz
φ <sub>N</sub> (5M)	@ 745MHz (Open Loop)	5MHz Offset from Carrier		-155.36		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-156.50		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-157.31		dBc/Hz
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-114.07		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-136.57		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-138.67		dBc/Hz
φ <sub>N</sub> (5M)	@ 1.1GHz (Open Loop)	5MHz Offset from Carrier		-151.50		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-154.42		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-155.93		dBc/Hz
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-114.30		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-139.19		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-141.38		dBc/Hz
φ <sub>N</sub> (5M)	@ 1.65GHz (Open Loop)	5MHz Offset from Carrier		-152.70		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-154.39		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-155.79		dBc/Hz
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-108.48		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-131.19		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-133.38		dBc/Hz
φ <sub>N</sub> (5M)	@ 2.3GHz (Open Loop)	5MHz Offset from Carrier		-147.77		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-152.47		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-155.77		dBc/Hz
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-103.22		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-127.59		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-129.92		dBc/Hz
φ <sub>N</sub> (5M)	@ 3.8GHz (Open Loop)	5MHz Offset from Carrier		-145.39		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-150.27		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-153.72		dBc/Hz

# Table 15B. RF\_OUT<sub>[A:B]</sub> Phase Noise and Jitter Characteristics, $V_{DDX} = V_{DDA} = 3.3V \pm 5\%$ , T<sub>A</sub> = -40°C to 85°C<sup>1 2</sup>

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Unit
φ <sub>N</sub> (100k)		100kHz Offset from Carrier		-100.26		dBc/Hz
φ <sub>N</sub> (800k)		800kHz Offset from Carrier		-125.80		dBc/Hz
φ <sub>N</sub> (1M)	RF Output	1MHz Offset from Carrier		-128.17		dBc/Hz
φ <sub>N</sub> (5M)	<ul> <li>A Phase Noise Performance</li> <li>(a) 4.4GHz (Open Loop)</li> </ul>	5MHz Offset from Carrier		-143.81		dBc/Hz
φ <sub>N</sub> (10M)		10MHz Offset from Carrier		-148.47		dBc/Hz
φ <sub>N</sub> (∞)		Noise Floor (≥30MHz from Carrier)		-153.01		dBc/Hz
-	Spurious Signals Due to PFD Frequency	f <sub>PFD</sub> = 50MHz; RF_OUT <sub>A</sub> = 2.2GHz		-74		dBc
φ <sub>N</sub> (100k)	RF Output Phase Noise Performance @ 745MHz (Open Loop)	100kHz Offset from Carrier		-106.75		dBc/Hz

# Table 15B. RF\_OUT<sub>[A:B]</sub> Phase Noise and Jitter Characteristics, $V_{DDX} = V_{DDA} = 3.3V \pm 5\%$ , T<sub>A</sub> = -40°C to 85°C<sup>1 2</sup>

NOTE 1.  $V_{DDX}$  denotes  $V_{DDD}$ ,  $V_{CP}$ ,  $V_{DD}$ ,  $V_{VCO}$ .

NOTE 2.  $RF_OUT_{[A:B]}$  output power setting = +2dBm.



# Phase Noise (Closed-Loop) at 156.25MHz (3.3V)

Phase Noise (Closed-Loop) at 1.76GHz (3.3V)



Offset Frequency (Hz)



# Phase Noise (Closed-Loop) at 2.05GHz (3.3V)

Offset Frequency (Hz)





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# Phase Noise Performance (Open-Loop) at 1.1GHz (3.3V)

Phase Noise Performance (Open-Loop) at 1.65GHz (3.3V)





# Phase Noise Performance (Open-Loop) at 2.3GHz (3.3V)

# Phase Noise Performance (Open-Loop) at 3.8GHz (3.3V)





# Phase Noise Performance (Open-Loop) at 4.4GHz (3.3V)

Offset Frequency (Hz)

# **Applications Information**

## **Loop Filter Calculations**

## 2<sup>nd</sup> Order Loop Filter

This section helps design a 2<sup>nd</sup> order loop filter for the 8V97053L. A general 2<sup>nd</sup> order loop filter is shown in Figure 11, *Typical 2<sup>nd</sup> Order Loop Filter*. Step-by-step calculations to determine Rz, Cz and Cp values for a desired loop bandwidth are described below. Required parameters are provided. A spreadsheet for calculating the loop filter values is also available.



Figure 11. Typical 2<sup>nd</sup> Order Loop Filter

- 1. Determine desired loop bandwidth fc.
- 2. Calculate Rz:

$$Rz = \frac{2 * \pi * fc * N}{Icp * Kvco}$$

Where,

Icp is charge pump current. Icp is programmable from  $310\mu A$  to 5mA.

N is effective feedback divider. N must be programmed into the following value.

$$N = \frac{Fvco}{Fpd}$$

F<sub>VCO</sub> is VCO frequency. VCO frequency range: 2200MHz to 4400MHz

**Fpd** is phase detector input frequency.

$$Fpd = \frac{F\_ref}{Pv}$$

F\_ref is reference clock (REF\_IN) input frequency.

**Pv** is overall pre-divider setting.

Kvco is VCO gain. Kvco = 40MHz/V

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3. Calculate Cz:

$$Cz = \frac{\alpha}{2*\pi * fc * Rz}$$

Where,

 $\alpha$  = fc/ fz, user can determine an  $\alpha$  number.  $\alpha$  > 6 is recommended.

fz is frequency at zero.

4. Calculate Cp:

$$Cp = \frac{Cz}{\alpha * \beta}$$

Where,

 $\beta$  = fp/fc, user can determine  $\beta$  number.  $\beta$  > 4 is recommended.

fp is frequency at pole.

5. Verify Phase Margin (PM)

$$PM = \arctan\left(\frac{b-1}{2*\sqrt{b}}\right)$$

Where,

$$b = 1 + \frac{Cz}{Cp}$$

The phase margin (PM) should be greater than 50°.

A spreadsheet for calculating the loop filter component values is available at www.IDT.com. To use the spreadsheet, the user simply enters the following parameters:

fc, F\_ref,  $P_V$ , lcp,  $F_{VCO}$ ,  $\alpha$  and  $\beta$ .

The spreadsheet will provide the component values, Rz, Cz and Cp as the result. The spreadsheet also calculates the maximum phase margin for verification.

## 3<sup>rd</sup> Order Loop Filter

This section helps design a 3<sup>rd</sup> order loop filter for the 8V97053L. A general 3<sup>rd</sup> order loop filter is shown in Figure 12, *Typical 3rd Order Loop Filter*.



Figure 12. Typical 3<sup>rd</sup> Order Loop Filter

The Rz, Cz and Cp can be calculated as 2<sup>nd</sup> order loop filter. The following equation help determine the 3<sup>rd</sup> order loop filter Rp2 and Cp2.

Pick an Rp2 value. Rp2 ~ 1.5xRz is suggested.

$$C_{P2} = \frac{R_Z * C_P}{R_{P2} * \gamma}$$

#### Where,

 $\gamma$  is ratio between the 1<sup>st</sup> pole frequency and the 2<sup>nd</sup> pole frequency.  $\gamma > 4$  is recommended.

## **Recommendations for Unused Input and Output Pins**

### Inputs:

### **LVCMOS Control Pins**

All control pins have internal pullup and pulldown resistors; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

### **Outputs:**

### **Output Pins**

For any unused output, it can be left floating and disabled.

## Schematic Example

Figure 13A and Figure 13B show general application schematic examples for the 8V97053L.

For power rails, bypass capacitors must be provided to all power supply pins. Suggest at least one bypass capacitor per power pin. Value can be ranged from 0.01uF or 0.1uF. Mix values of bypass capacitor can help filtering wider range of power supply noise.

The 8V97053L input is high impedance. The input termination depends on the driver type termination requirements. In these examples, the 8V97053L REF\_IN input is terminated with a matched load termination. For transmission line with characteristic impedance Zo =  $50\Omega$ , the termination resistor R8 is  $50\Omega$ . The input is self biased to proper DC offset after the AC coupling.

The loop filter values can be calculated to meet the loop bandwidth requirement. Please refer to the section, "Loop Filter Calculations" for detailed calculations. For fast lock mode, the loop filter can be configured as Fast Lock Loop Filter Option 1 or Fast Lock Loop Filter Option 2 shown in Figure 13A.

Fast Lock Loop Filter Option 1 is Parallel Resistor Configuration. For normal operating mode, only R5 is active and R5 = Rs, where Rs is the resistor value for normal operating mode loop bandwidth. In fast lock mode, the combination of R4 in parallel with R5 is active. For example, in normal operation mode, if the charge pump current is set at 0000 (ICP = 310uA), then, in fast lock mode, the loop bandwidth is set larger by increasing the charge pump current to ICP~5mA (ICP setting = 1111 or 16 times the normal charge pump current). The combination of the R4 and R5 in parallel is 1/4 \* Rs.

Fast Lock Loop Filter Option 2 is Series Resistor Configuration.

For normal operating mode, both R6 and R7 are active and

R6 + R7 = Rs. For fast lock mode, only R6 is active. For example, in normal operation mode, if the charge pump current is set at 0000 (ICP = 310uA), then, in fast lock mode, the loop bandwidth is set larger by increasing the charge pump current to ICP~5mA (ICP setting = 1111 or 16 times the normal charge pump current).

The sum of R6 and R7 equals to Rs, i.e. R6 + R7 = Rs. R6 = 1/4 \* Rs and R7 = 3/4 \* Rs.

The 8V97053L output pull-up loading can be resistors or inductors. The pull up resistor value is typically  $50\Omega$ . Resistor pull up loading covers wide range of output frequencies. For inductor pull up loading, the inductor value is frequency dependent. One inductor value cannot cover all the output frequency range. This example shows the L = 3.9nH that is suitable for approximately 2GHz operating frequency. The output can also drive single ended LO input. Figure 13B shows an example of the 8V97053L output driving single ended LO input of the mixer through an LC balun. The LC balun component values are frequency dependent. These values can be adjusted to optimize the performance. Single ended LO receiver input also can tap to one side of the differential driver using resistor loading or inductor loading. For single ended LO input, both sides of the differential driver still need to be loaded with pull up. The output power level can also be adjusted further through programming.



Figure 13A. An 8V97053L General Application Schematic Example



Figure 13B. Schematic Example for Driving Single Ended Mixer

## **Power Considerations**

The 8V97053L device was designed and characterized to operate within the ambient industrial temperature range of -40°C to +85°C. The ambient temperature represents the temperature around the device, not the junction temperature. When using the device in extreme cases, such as maximum operating frequency and high ambient temperature, external air flow may be required in order to ensure a safe and reliable junction temperature. Extreme care must be taken to avoid exceeding 125°C junction temperature. The power calculation example below was generated using a typical configuration. For many applications, the power consumption can vary depending on configuration. Please contact IDT technical support for any concerns on calculating the power dissipation for your own specific configuration.

Example 1: VCO Frequency Range = 1991MHz to 2846MHz

#### 1. Power Dissipation.

The total power dissipation for the 8V97053L is the sum of the core power plus the power dissipation in the output driver. The following is the power dissipation for  $V_{DD}$  = 3.465V, which gives worse case results.

Power (core)<sub>MAX</sub> = V<sub>DD\_MAX</sub> \* (I<sub>DDA</sub> + I<sub>VCO</sub> + I<sub>CP</sub> + I<sub>DD\_SD</sub> + I<sub>DDD</sub>)<sub>MAX</sub> = V<sub>DD\_MAX</sub> \* (I<sub>DDA</sub> + I<sub>DDX</sub>)<sub>MAX</sub> = 3.465V \* (100mA + 105) = **710.33mW**

Total Power (with two outputs active at 2dBm output power level) = 710.33mW

#### 2. Junction Temperature.

Junction temperature, Tj, is the temperature at the junction of the bond wire and bond pad, and directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for Tj is as follows: Tj =  $\theta_{JA}$  \* Pd\_total + T<sub>A</sub>

Tj = Junction Temperature

 $\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

Pd\_total = Total Device Power Dissipation (example calculation is in section 1 above)

T<sub>A</sub> = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 34.34°C/W per Table 16 below.

Therefore, Tj for an ambient temperature of 85°C with all outputs active is:

85°C + 0.710W \* 34.34°C/W = 109.39°C. This is well below the limit of 125°C.

This calculation is only an example. Tj will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

#### Table 16. Thermal Resistance $\theta_{\text{JA}}$ for 32 Lead VFQFN, Forced Convection

	$\theta_{\text{JA}}$ by Velocity		
Meters per Second	0	1	2
Multi-Layer PCB, JEDEC Standard Test Boards	34.34°C/W	30.7°C/W	29.12°C/W

**Example 2:** VCO Frequency Range = 2590MHz to 3624MHz

#### 1. Power Dissipation.

The total power dissipation for the 8V97053L is the sum of the core power plus the power dissipation in the output driver. The following is the power dissipation for  $V_{DD}$  = 3.465V, which gives worse case results.

Power (core)<sub>MAX</sub> =  $V_{DD_MAX} * (I_{DDA} + I_{VCO} + I_{CP} + I_{DD_SD} + I_{DDD})_{MAX} = V_{DD_MAX} * (I_{DDA} + I_{DDX})_{MAX} = 3.465V * (90mA + 95mA) = 640mW$ 

Total Power (with two outputs active at 2dBm output power level) = 640mW

#### 2. Junction Temperature.

Junction temperature, Tj, is the temperature at the junction of the bond wire and bond pad, and directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for Tj is as follows: Tj =  $\theta_{JA}$  \* Pd\_total + T<sub>A</sub>

Tj = Junction Temperature

 $\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

Pd\_total = Total Device Power Dissipation (example calculation is in section 1 above)

T<sub>A</sub> = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 34.34°C/W per Table 16.

Therefore, Tj for an ambient temperature of 85°C with all outputs active is:

 $85^{\circ}$ C + 0.640W \* 34.34°C/W = 107°C. This is below the limit of 125°C.

This calculation is only an example. Tj will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

## **Reliability Information**

### Table 17A. $\theta_{JA}$ vs. Air Flow Table for a 32 lead VFQFN

$\theta_{JA}$ vs. Air Flow				
Meters per Second	0	1	2	
Multi-Layer PCB, JEDEC Standard Test Boards	34.34°C/W	30.7°C/W	29.12°C/W	

#### Table 17B. $\theta_{\text{JB}}$ vs. Air Flow Table for a 32 lead VFQFN

$\theta_{JB}$ vs. Air Flow	
Meters per Second	0
Multi-Layer PCB, JEDEC Standard Test Boards	0.472°C/W

NOTE:  $\theta_{JB}$  is independent of airflow.

# **Transistor Count**

The 8V97053L transistor count is: 404,777

# Package Outline Drawings

The package outline drawings are appended at the end of this document and are accessible from the link below. The package information is the most current data available.

www.renesas.com/us/en/document/psc/package-outline-drawing-package-code-nlg32p1-32-vfqfpn-50-x-50-x-09-mm-body-05-mm-pitch

## **Ordering Information**

#### Table 18. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
8V97053LNLGI	IDT8V97053LNLGI	32-lead VFQFN, Lead Free	Tray	-40°C to +85°C
8V97053LNLGI8	IDT8V97053LNLGI	32-lead VFQFN, Lead Free	Tape & Reel	-40°C to +85°C
8V97053LNLGI/W	IDT8V97053LNLGI	32-lead VFQFN, Lead Free	Tape & Reel	-40°C to +85°C

## Table 19. Pin 1 Orientation in Tape and Reel Packaging

Part Number Suffix	Pin 1 Orientation	Illustration
NLG18	Quadrant 1 (EIA-481-C)	Correct Pin 1 ORIENTATION (Round Sprocket Holes) COOOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCOCO
NLGI/W	Quadrant 2 (EIA-481-D)	Correct Pin 1 ORIENTATION CARRIER TAPE TOPSIDE (Round Sprocket Holes)

# **Revision History**

Revision Date	Description of Change
February 2, 2023	Updated POD link in Package Outline Drawings.
August 9, 2018	* Changed incorrect measurement unit nF to nH in Output Matching and Schematic Example
	* Updated Integrated Low Noise VCO
	* Updated the Package Outline Drawings; however, no mechanical changes
August 18, 2016	Initial release.

## Package Outline Drawing



PSC-4171-01 NLG32P1 32-VFQFPN 5.0 x 5.0 x 0.9 mm Body, 0.5mm Pitch Rev.05, Apr 30, 2025



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