



## HBT DIGITAL PHASE-FREQ. DETECTOR, 10 - 1300, MHz w/ 5-BIT COUNTER, 10 - 2800 MHz

### Typical Applications

This Phase Frequency Detector w/ integrated Counter is a key component in low phase noise frequency synthesis applications such as:

- Satellite Communication Systems
- Point-to-Point Radios
- Military Applications
- Sonet Clock Generation

### Features

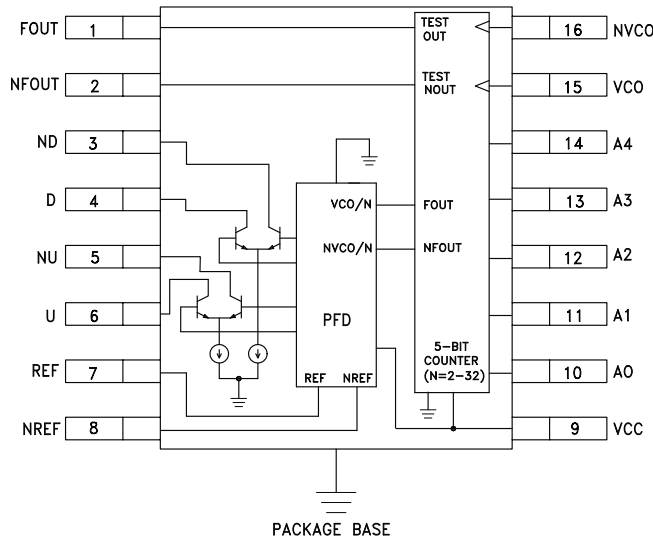
Ultra Low SSB Phase Noise Floor:  
-153 dBc/Hz @ 10 kHz offset @ 100 MHz Reference Frequency.

Programmable Divider (N= 2-32) Operating up to 2.8 GHz

Open Collector Output Buffer Amplifiers for Interfacing w/ Op-Amp Based Loop Filter

QSOP16G SMT Package: 29.4 mm<sup>2</sup>

### Functional Diagram



### General Description

The HMC440QS16G & HMC440QS16GE integrate 10 to 1300 MHz digital Phase-Frequency Detectors with 10 to 2800 MHz 5-Bit Counters (continuous division from 2 to 32) in miniature 16 lead QSOP plastic packages. It is intended for use in low phase noise offset-synthesizer applications. The HMC440QS16G & HMC440QS16GE's combination of high frequency operation along with ultra low phase noise floor make possible synthesizers with wide loop bandwidth and low N resulting in fast settling and very low phase noise. When used in conjunction with a differential loop amplifier, the HMC440QS16G & HMC440QS16GE generate an output voltage that can be used to phase lock a VCO to a reference oscillator.

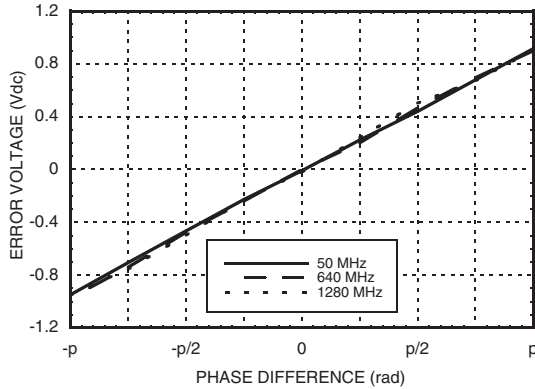
### Electrical Specifications, $T_A = +25^\circ C$ , $V_{CC} = 5V$

| Parameter                    | Conditions                                       | Min. | Typ. | Max. | Units       |
|------------------------------|--------------------------------------------------|------|------|------|-------------|
| Maximum Ref. Input Frequency | Sine or Square Wave Input                        | 1300 |      |      | MHz         |
| Minimum Ref. Input Frequency | Sine Wave Input                                  |      |      | 10   | MHz         |
| Reference Input Power Range  | 100 MHz Frequency                                | -10  |      | +10  | dBm         |
| Maximum VCO Input Frequency  |                                                  | 2800 |      |      | MHz         |
| Minimum VCO Input Frequency  | Sine Wave Input                                  |      |      | 10   | MHz         |
| VCO Input Power Range        | 100 MHz Input Frequency                          | -15  |      | +10  | dBm         |
| Output Voltage               | 200 Ohm Pull Up to Vcc                           |      | 2000 |      | mV, Pk - Pk |
| SSB Phase Noise              | @ 10 kHz Offset @ 100 MHz Ref. Input, Pin= 0 dBm |      | -153 |      | dBc/Hz      |
| Supply Current               |                                                  |      | 250  |      | mA          |

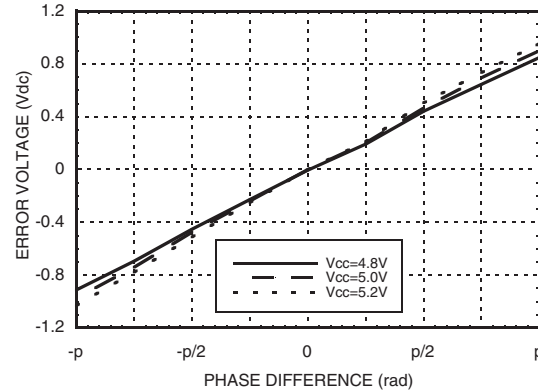


**HBT DIGITAL PHASE-FREQ. DETECTOR,  
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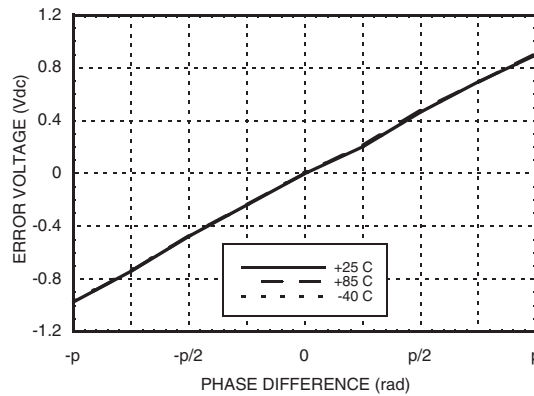
**Error Voltage vs. Frequency,  $P_{in}= 0 \text{ dBm}^*$**



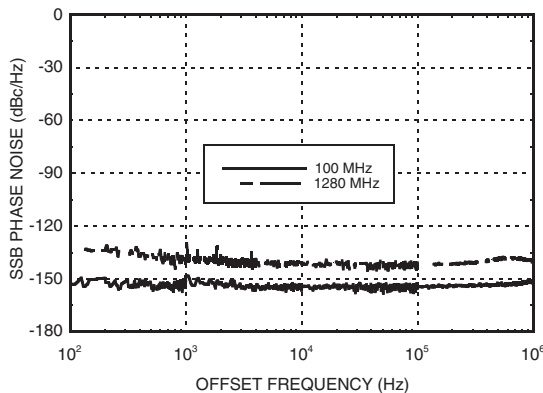
**Error Voltage vs. Supply Voltage,  
 $P_{in}= 0 \text{ dBm}, F_{in}= 640 \text{ MHz}^*$**



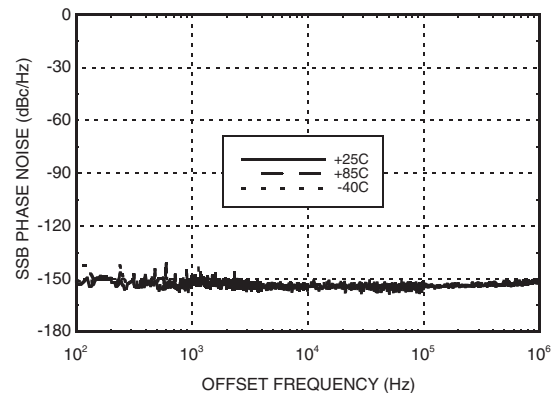
**Error Voltage vs. Temperature,  
 $P_{in}= 0 \text{ dBm}, F_{in}= 640 \text{ MHz}^*$**



**SSB Phase Noise Performance,  
 $P_{in}= 0 \text{ dBm}, T= 25 \text{ }^\circ\text{C}$**



**SSB Phase Noise Performance,  
 $P_{in}= 0 \text{ dBm}, F_{in}= 100 \text{ MHz}$**



\* See Gain & Error Voltage Test Circuit herein.



**HBT DIGITAL PHASE-FREQ. DETECTOR,  
10 - 1300, MHz w/ 5-BIT COUNTER, 10 - 2800 MHz**

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FREQUENCY DIVIDERS & DETECTORS - SMT

**Absolute Maximum Ratings**

|                                                                  |                      |
|------------------------------------------------------------------|----------------------|
| RF Input (Vcc= +5V)                                              | +13 dBm              |
| Supply Voltage (Vcc)                                             | +5.5V                |
| Counter Logic Input (A <sub>0</sub> - A <sub>4</sub> )           | -0.5 to Vcc +0.5 Vdc |
| Channel Temperature (T <sub>c</sub> )                            | 135 °C               |
| Continuous Pdiss (T = 85 °C)<br>(derate 56.8 mW/° C above 85 °C) | 2.84 W               |
| Storage Temperature                                              | -65 to +150 °C       |
| Operating Temperature                                            | -40 to +85 °C        |



**ELECTROSTATIC SENSITIVE DEVICE  
OBSERVE HANDLING PRECAUTIONS**

**Typical Supply Current vs. Vcc**

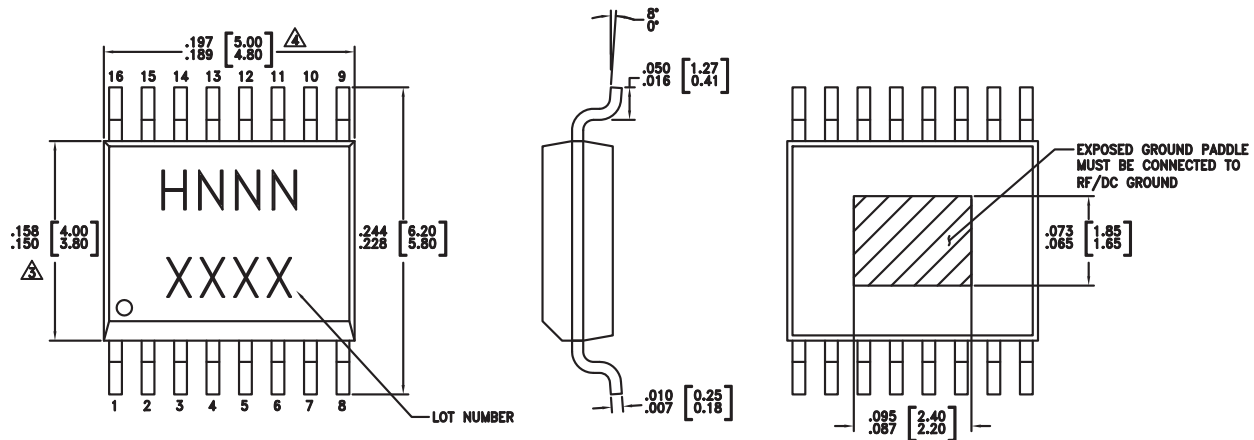
| Vcc (Vdc) | Icc (mA) |
|-----------|----------|
| 4.8       | 229      |
| 5.0       | 250      |
| 5.2       | 266      |

Note: HMC440QS16G will work over full voltage range above.

**Typical DC Characteristics @ Vcc = +5V**

| Symbol | Characteristics      | +25C |      |      | Units |
|--------|----------------------|------|------|------|-------|
|        |                      | Min. | Typ. | Max. |       |
| Icc    | Power Supply Current | 229  | 250  | 266  | mA    |
| Voh    | Output High Voltage  | 5.0  | 5.0  | 5.0  | V     |
| Vol    | Output Low Voltage   | 2.9  | 3    | 3.1  | V     |

**Outline Drawing**



NOTES:

1. LEADFRAME MATERIAL: COPPER ALLOY
2. DIMENSIONS ARE IN INCHES [MILLIMETERS]
- △ DIMENSION DOES NOT INCLUDE MOLDFLASH OF 0.15mm PER SIDE.
- ▲ DIMENSION DOES NOT INCLUDE MOLDFLASH OF 0.25mm PER SIDE.
5. ALL GROUND LEADS AND GROUND PADDLE MUST BE SOLDERED TO PCB RF GROUND.

**Package Information**

| Part Number  | Package Body Material                              | Lead Finish   | MSL Rating | Package Marking [3] |
|--------------|----------------------------------------------------|---------------|------------|---------------------|
| HMC440QS16G  | Low Stress Injection Molded Plastic                | Sn/Pb Solder  | MSL1 [1]   | H440<br>XXXX        |
| HMC440QS16GE | RoHS-compliant Low Stress Injection Molded Plastic | 100% matte Sn | MSL1 [2]   | H440<br>XXXX        |

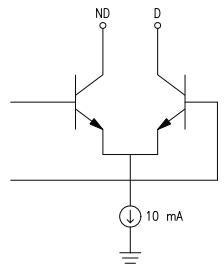
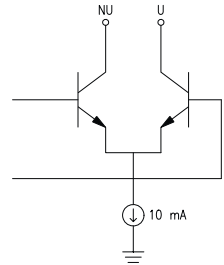
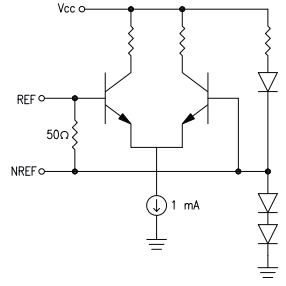
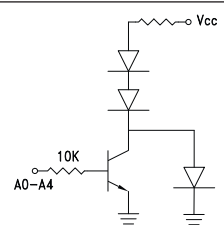
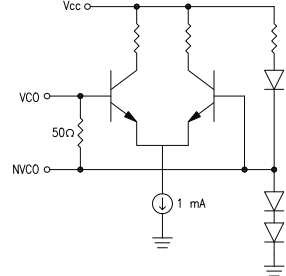
[1] Max peak reflow temperature of 235 °C

[2] Max peak reflow temperature of 260 °C

[3] 4-Digit lot number XXXX

*For price, delivery, and to place orders, please contact Hittite Microwave Corporation:  
20 Alpha Road, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373  
Order On-line at www.hittite.com*

**Pin Description**

| Pin Number | Function      | Description                                                                                                                                                 | Interface Schematic                                                                   |
|------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 1<br>2     | FOUT<br>NFOUT | (These pins are DC coupled and must be DC blocked externally).<br>Both outputs are test ports only and are intended for use with hi-impedance scope probes. |                                                                                       |
| 3<br>4     | ND<br>D       | Down Output Compliment<br><br>Down Output                                                                                                                   |    |
| 5<br>6     | NU<br>U       | Up Output Compliment<br><br>Up Output                                                                                                                       |   |
| 7<br>8     | REF<br>NREF   | (These pins are AC coupled and must be DC blocked externally.)<br><br>Reference Input<br><br>Reference Input Compliment                                     |  |
| 9          | Vcc           | Supply voltage 5V ± 0.2V                                                                                                                                    |                                                                                       |
| 10 - 14    | A0 - A4       | CMOS compatible control input bit 0 (LSB) - 4.                                                                                                              |  |
| 15<br>16   | VCO<br>NVCO   | (These pins are AC coupled and must be DC blocked externally.)<br><br>VCO Input<br><br>VCO Input Compliment                                                 |  |

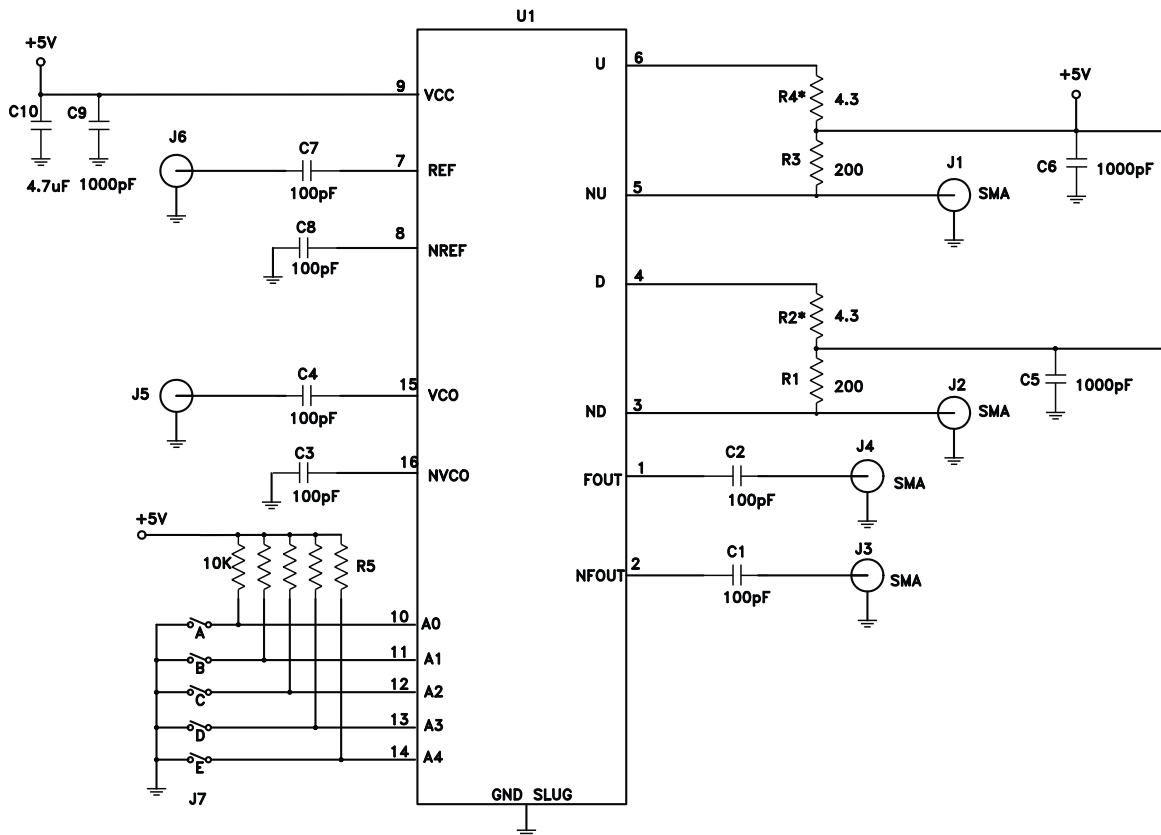
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20 Alpha Road, Chelmsford, MA 01824 Phone: 978-250-3343 Fax: 978-250-3373  
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### HMC440QS16G Programming Truth Table

| Function   | (LSB)<br>A0 | A1 | A2 | A3 | A4 |
|------------|-------------|----|----|----|----|
| Output Low | 0           | 0  | 0  | 0  | 0  |
| / 2        | 1           | 0  | 0  | 0  | 0  |
| / 3        | 0           | 1  | 0  | 0  | 0  |
| / 4        | 1           | 1  | 0  | 0  | 0  |
| -          | -           | -  | -  | -  | -  |
| / 32       | 1           | 1  | 1  | 1  | 1  |

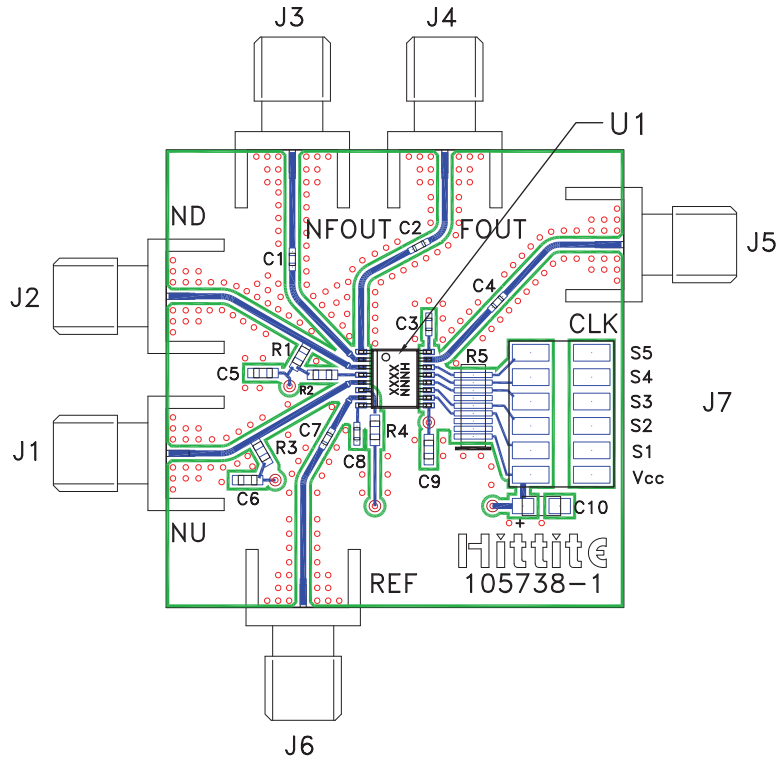
Note: A0 through A4 are CMOS compatible logic control inputs.

### Evaluation PCB Circuit



\* Choose values of R2 & R4 between 4.3 and 20 Ohms for best noise performance.

### Evaluation PCB



The circuit board used in the final application should use RF circuit design techniques. Signal lines should have 50 ohm impedance while the package ground leads and backside ground slug should be connected directly to the ground plane similar to that shown. A sufficient number of via holes should be used to connect the top and bottom ground planes. The evaluation circuit board shown is available from Hittite upon request.

### List of Materials for

#### Evaluation PCB 105811 [1]

| Item          | Description                  |
|---------------|------------------------------|
| J1 - J6       | PC Mount SMA RF Connector    |
| J7            | 2 mm DC Header               |
| C1-C4, C7, C8 | 100 pF Capacitor, 0402 Pkg.  |
| C5, C6, C9    | 1000 pF Capacitor, 0603 Pkg. |
| C10           | 4.7 $\mu$ F Capacitor        |
| R1, R3        | 200 Ohm Resistor, 0603 Pkg.  |
| R2[3], R4 [3] | 4.3 Ohm Resistor, 0603 Pkg.  |
| R5            | Resistor Network, 10k Ohm    |
| U1            | HMC440QS16G / HMC440QS16GE   |
| PCB [2]       | 105738 Eval Board            |

[1] Reference this number when ordering complete evaluation PCB

[2] Circuit Board Material: Rogers 4350

[3] Choose values of R2 & R4 between 4.3 and 20 Ohms for best noise performance

#### Evaluation PCB Truth Table

| Function   | S1 | S2 | S3 | S4 | S5 |
|------------|----|----|----|----|----|
| Output Low | 0  | 0  | 0  | 0  | 0  |
| / 2        | 1  | 0  | 0  | 0  | 0  |
| / 3        | 0  | 1  | 0  | 0  | 0  |
| / 4        | 1  | 1  | 0  | 0  | 0  |
| -          | -  | -  | -  | -  | -  |
| / 32       | 1  | 1  | 1  | 1  | 1  |

Note: 0 = Jumper Installed.  
1 = Jumper Not Installed.

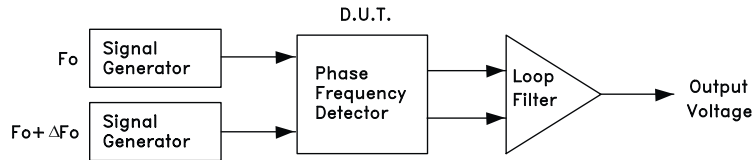
Note: The evaluation PCB for the HMC440QS16G contains 10K Ohm pull up resistors for each of the five control inputs A0 through A4. Programming the 31 distinct division ratios consists of installing or removing jumpers S1 through S5, as shown below.



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### Gain & Error Voltage Test Circuit:

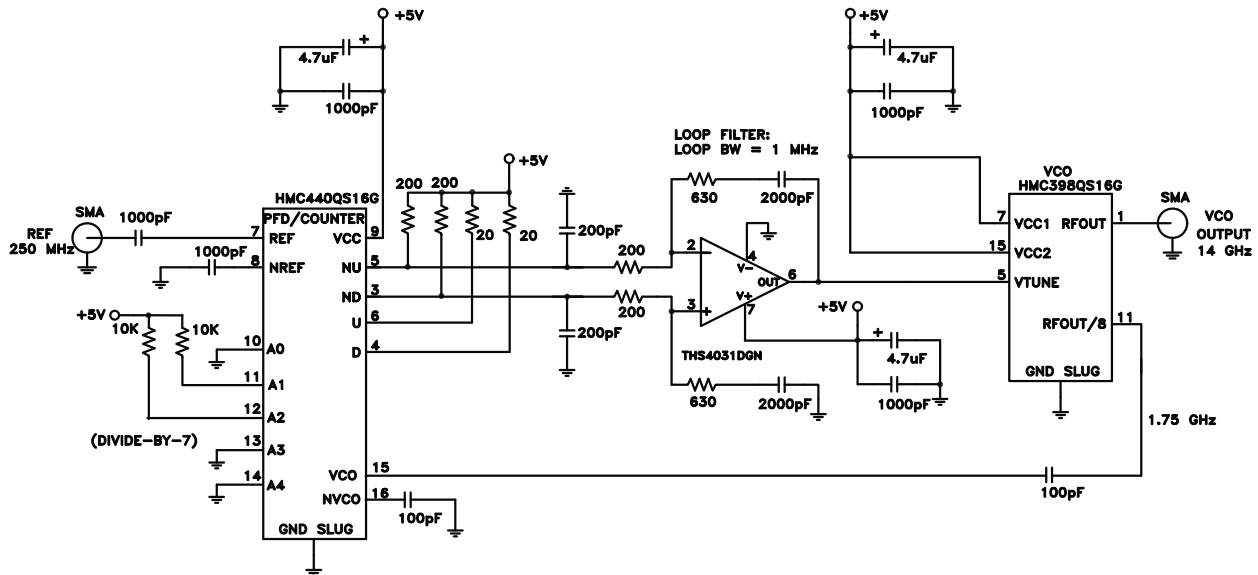
Gain & Error Voltage data taken using test circuit below. Loop filter gain has been subtracted from the result.



$\Delta F_o =$  The beat frequency of the sawtooth waveform.

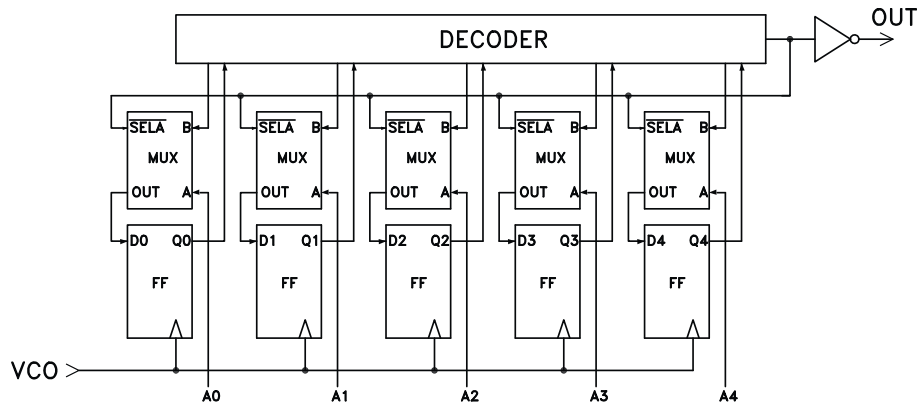
### Typical PLL Application Circuit using HMC440QS16G

PLL application shown for a 14.0 GHz Fout. Contact HMC to discuss your specific application.



## Applications Information

### Simplified Block Diagram of 5-Bit Counter



### Asynchronous Programming

The 5-Bit programmable counter counts-down from the programmed value of the data bits to zero and issues an output pulse at the end of each cycle. Settling time of the programmable 5-Bit counter is defined as the maximum time required for the counter to change the division ratio N to a new value after the data bits have settled. The worst case settling time occurs if the data bits A0 thru A4 are changing during the load cycle. Under this condition, the data bits may potentially be erroneous when they are clocked in and in the worst case could be all 1's, requiring 32 clock cycles until the correct data is re-loaded into the flip flops. The worst case asynchronous settling time can be calculated as follows:

$$T_{\text{SETTLING MAX}} = 32/f_{\text{IN}} \text{ (For Asynchronous Programming)}$$

As an example, if the input frequency is 1 GHz, the maximum settling time is 32 nS



### Synchronous Programming

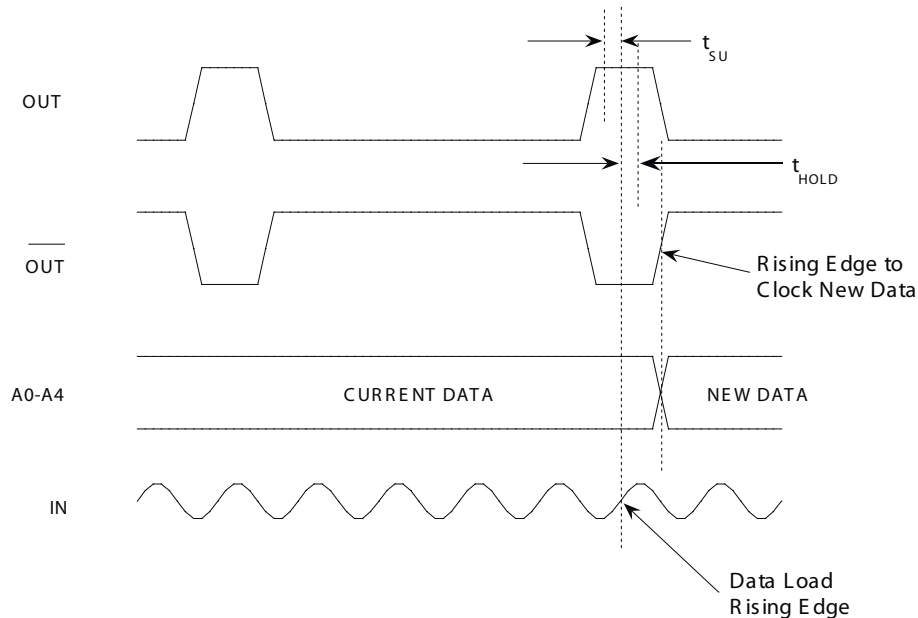
For applications which can not tolerate a momentary undefined division ratio, which normally occurs while changing the data bits (A0-A4) at random, synchronous programming can be used. Data is loaded into the counter on every rising edge of the clock which occurs while the output (OUT) is "HIGH". The typical minimum setup and hold times are shown in the table below as a function of frequency. For precision applications, the rising edge of the complementary output may be used to latch the new data bits (A0-A4), so that all bits are settled before the next load cycle.

$$T_{\text{SETTLING MAX}} = N/f_{\text{IN}} \text{ (For Synchronous Programming)}$$

Where N is the desired division ratio, and  $f_{\text{IN}}$  = Input Frequency (Hz)

| Parameter          | 0.5 GHz | 1 GHz  | 2 GHz  |
|--------------------|---------|--------|--------|
| $t_{\text{SETUP}}$ | 200 ps  | 200 ps | 200 ps |
| $t_{\text{HOLD}}$  | 700 ps  | 300 ps | 120 ps |

### Programmable Divider Timing Requirements for Synchronous Programming





### CMOS/TTL Input Characteristics

Maximum Input Logic "0" Voltage ( $V_{IL\ MAXIMUM}$ ) = 1.1V @ 10 uA.

Minimum Input Logic "1" Voltage ( $V_{IH\ MINIMUM}$ ) = 1.8V @ 500 uA.

Input IV characteristics for the logic inputs (A0-A4) are shown below:

