APPLICATION NOTE

Evaluation and Performance of the SKY72300, SKY72301, SKY72302, and SKY74038 Dual Synthesizers/PLLs

This Application Note briefly describes the benefits of fractional-N synthesis, and presents measured phase noise and channel switching time performance data for Skyworks fractional-N frequency synthesizers.

A simple design method used to calculate loop filter component values is also described. This information helps designers tailor performance to meet specific needs. Refer to the latest Data Sheets for each of these devices for detailed specifications.

Skyworks synthesizers are divided into two product groups:

1. The SKY7230x group:
   - SKY72300 2.1 GHz/500 MHz, 18-bit fractional-N main/10-bit fractional-N auxiliary
   - SKY72301 1.0 GHz/500 MHz, 18-bit fractional-N main/10-bit fractional-N auxiliary
   - SKY72302 6.1 GHz/1.0 GHz, 18-bit fractional-N main/10-bit fractional-N auxiliary
2. The SKY74038 2.6 GHz/800 MHz, 21-bit fractional-N RF main/integer-N IF auxiliary

Each of these devices is a dual synthesizer (RF/IF) that offers low phase noise, superior "no-spur" performance, and fine channel step size (as small as 5 Hz) combined with rapid lock-up time. All of these synthesizers also use $\Delta\Sigma$ technology, the best technological choice for fractional-N synthesis.

The SKY7230x series targets general purpose applications that require high performance, such as base stations and wireless infrastructure equipment, satellite receivers, instrumentation, and tactical radios. Additional features and functionality include Direct Digital Modulation and a built-in oscillator circuit. This series offers software programmable fractional-N or integer-N selection for both the RF (main) and IF (auxiliary) synthesizers.

The SKY74038 synthesizer is optimized for extremely low power consumption and small form factor applications, such as next generation, multi-mode, multi-band handsets. This device also offers fractional-N synthesis on the RF side and integer-N synthesis on the IF side.

Why Use Fractional-N?

Design Flexibility

Skyworks fractional-N technology offers the system designer enormous design flexibility. When a high comparison frequency (up to 25 MHz) is used, channel step size of a few Hz (at GHz VCO frequencies) allows wide loop bandwidth implementations, which facilitate superior channel switching times. The designer does not have to trade-off phase noise or spurious performance to realize these benefits.

Performance behaviors exhibited by classic integer-N synthesizers do not apply to fractional-N synthesizers. Fractional-N technology eliminates the design constraints inherent with integer-N synthesizers. For example, integer-N technology requires the designer to trade-off phase noise to achieve small channel step size. Also, integer-N technology requires the trade-off of reference spur performance to achieve rapid channel switching time.

Designers of next generation wireless network systems face a number of complex design dilemmas that are difficult, if not impossible, to resolve with integer-N synthesizers. One such dilemma is channel switching time requirements, which are reduced to below 200 μs to facilitate ever increasing performance needs.

A major limitation of traditional integer-N synthesizers is the need to maintain the loop bandwidth significantly lower than the channel step size (which is also the comparison frequency for integer-N synthesizers). This implies excessively long switching times as integer-N synthesizers cannot accommodate rapid lock-up times without compromising spectral purity. Once the loop bandwidth is widened to meet the locking time, reference spur feedthrough predominates at the VCO output of an integer-N implementation.

However, fractional-N synthesizers offer a much smaller channel step size (a range of a few Hz) while using a very high comparison frequency (a range of many MHz). The high comparison frequency allows loop bandwidths far in excess of the required system channel step size. Even with a loop bandwidth of 50 kHz, no reference spurs appear at the VCO output because of heavy loop filter attenuation. The result is switching times below 200 μs for large frequency steps of 60 MHz or more.

Channel Spacing Step Size

Today's wireless system designer faces another problem: the need to accommodate different channel spacings for multi-mode operation. For example, a dual mode GSM-TDMA system must offer channel step sizes of 200 kHz and 30 kHz. Because the nearest harmonic shared by these two frequencies is 600 kHz, the chosen system clock or reference source must be evenly divisible by 600 kHz. Further, it would need to be divided by 3, down to 200 kHz, and by 20, down to 30 kHz. With the addition of a third mode, CDMA with 1250 kHz channel spacing, there would not be a common harmonic below 35 MHz.

Fractional-N synthesizers offer a channel step size that is completely "unhinged" from the actual comparison frequency. The system designer can use any clock frequency. Whether 13 MHz, 19.8 MHz, 12.8 MHz, or any other frequency, the channel spacing can be met for virtually any requirement simply by software programming the synthesizer VCO dividers. This saves the expense of re-evaluating existing architectures, internal frequency plans, and system clocking/sampling rate schemes.

To summarize, Skyworks fractional-N synthesizer technology offers the designer low phase noise and spur performance, rapid sub-200 μs switching time, and very small channel spacing using any available reference frequency.

Frequency Accuracy Requirements

Fractional-N synthesizers offer the added benefit of frequency accuracy. Some systems use a Voltage-Controlled Crystal Oscillator (VCXO), Oven-Controlled Crystal Oscillator (OCXO), or Temperature-Compensated Crystal Oscillator (TCXO) device to ensure accuracy, which adds to cost, weight, and power consumption. Fractional-N corrects frequency inaccuracy simply by changing a register value. As long as the frequency error is known, a correction can be performed.

Temperature has the most significant effect on the frequency of uncompensated signal sources. If the system temperature and the temperature versus frequency behavior of the signal source are known, use of a simple firmware lookup table can affect continuous frequency correction for temperature.

SKY7230x Performance

A standard SKY72300 Evaluation Board was tested using the following parameters (results are identical for the SKY72301 and SKY72302 Evaluation Boards):

- **Reference source**: on-board crystal oscillator with external 24 MHz quartz crystal
- **Supply voltage**: 3.0 V
- **Charge pump current**: 1 mA/2π radians
- **Comparison frequency**: 24 MHz
- **Mode**: 18-bit fractional-N
- **Channel step size**: 91.55 Hz
- **Carrier frequency**: 1850 MHz (N = 77.0833...)

Figures 1 and 2 illustrate the phase noise and switching time measurements, respectively, using the above testing parameters.

SKY74038 Performance

A standard SKY74038 Evaluation Board was tested using the following parameters:

- **Reference source**: 10 MHz external source
- **Supply voltage**: 3.0 V
- **Charge pump current**: 480 μA/2π radians
- **Comparison frequency**: 10 MHz
- **Mode**: 21-bit fractional-N
- **Channel step size**: 4.77 Hz
- **Carrier frequency**: 2380 MHz

Figures 3 and 4 illustrate the phase noise and switching time measurements, respectively, using the above testing parameters.

Loop Filter Design Procedure

The following documents, available at *www.skyworksinc.com*, provide the calculations needed to determine the specific device loop filter component values for a given filter topology:

- SKY72300 Frequency Synthesizer Evaluation Board User Guide (document #101395)
- SKY72301 Frequency Synthesizer Evaluation Board User Guide (document #101407)
- SKY72302 Frequency Synthesizer Evaluation Board User Guide (document #101408)
- SKY74038 Frequency Synthesizer Evaluation Board User Guide (document #101483)

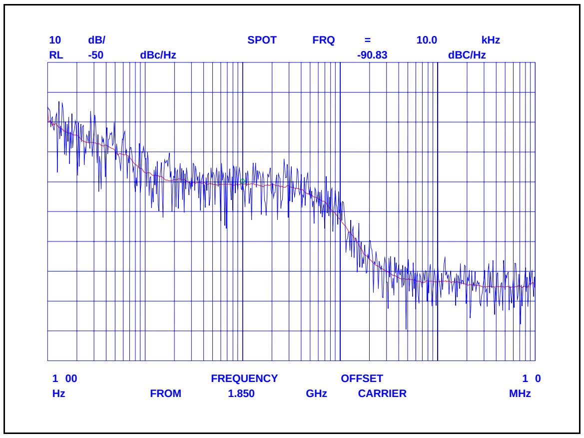

Figure 1. SKY72300 Main Synthesizer Phase Noise at 1850 MHz

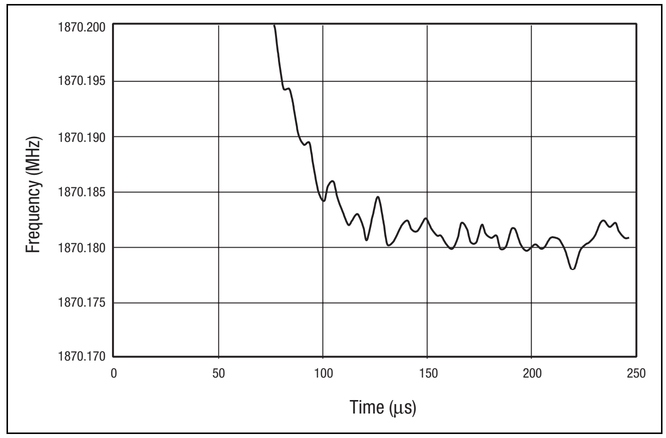

Figure 2. SKY72300 Main Synthesizer Switching Time for 50 MHz Frequency Steps

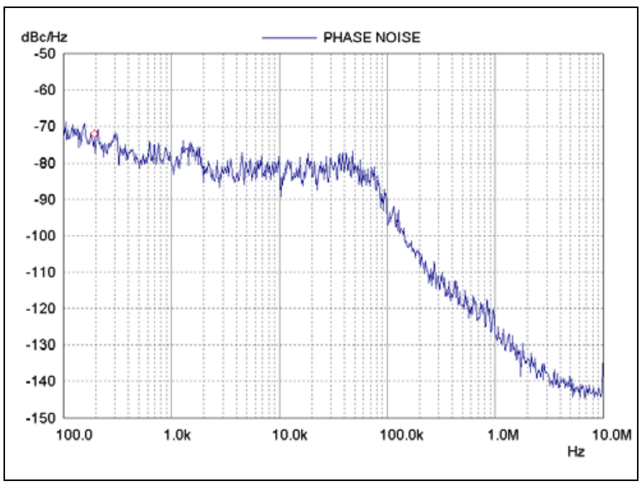

Figure 3. SKY74038 RF Synthesizer Phase Noise at 2380 MHz

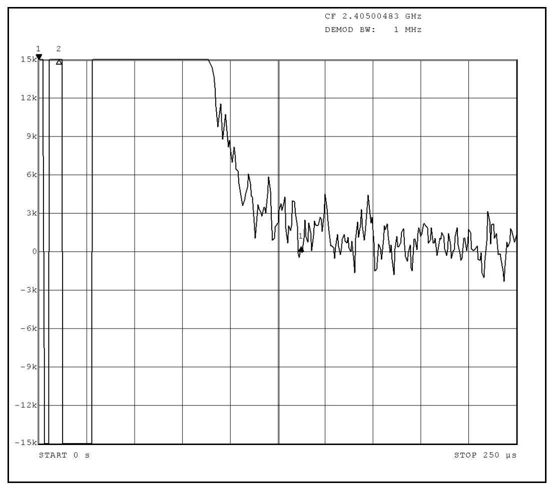

Figure 4. SKY74038 RF Synthesizer Switching Time for 50 MHz Frequency Steps