Hittite Introduces New 3.3V Wideband PLL with Integrated VCO

by Hittite Microwave

Hittite Microwave Corp. has released the HMC832LP6GE, a 3.3V, wideband, Fractional-N PLL with integrated VCO (PLL+VCO) targeted at high performance applications including cellular base stations and IF stage transceivers in microwave point-to-point radios.

The HMC832LP6GE can generate continuous fractional frequencies from 25 MHz to 3 GHz and features industry leading phase noise and spurious performance. The HMC832LP6GE has low power dissipation and includes an innovative Programmable Performance Technology that allows designers to further reduce current consumption if demands on the noise floor can be relaxed.

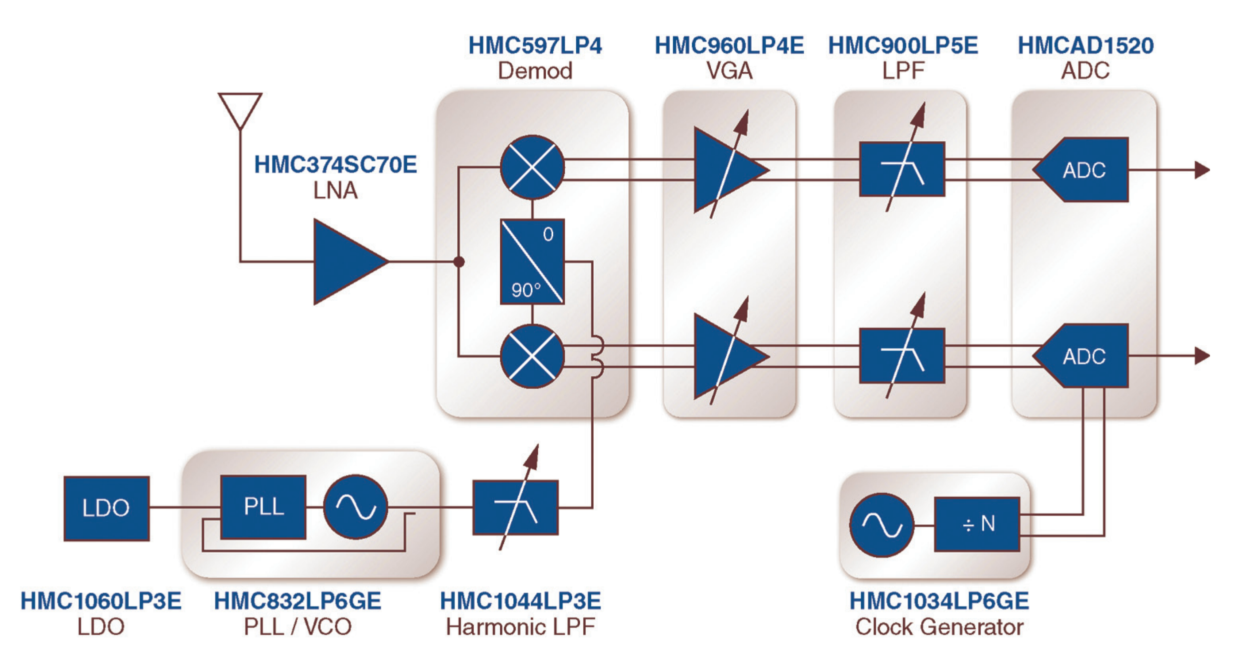

Figure 1: Typical cellular receiver with HMC832LP6GE

Industry leading phase noise and spurious performance of the HCM832LP6GE enable modern communication systems, in cellular infrastructure and backhaul markets, to achieve maximum performance. The HMC832LP6GE ensures that the PLL+VCO is not a limiting factor in system performance, and provides system designers enough margin to optimize performance and cost of their systems.

PLL + VCOs used as Local Oscillators (LOs) have always played a key role in radio designs. Typically in any radio architecture PLL+VCO phase noise forms a critical benchmark that limits maximum theoretical system Signal to Noise Ratio (SNR) and ultimately communication system throughput that the limit is the sum of the transmitter and the receiver PLL+VCO integrated phase noise is equal to maximum achievable system SNR.

In practice, modern communication systems are able to marginally increase this theoretical SNR limit by employing phase error correction algorithms such as carrier tracking loops in single carrier systems and Common Phase Error (CPE) correction algorithms in OFDM systems. In both cases, the correction algorithms are limited by the radio symbol rate. They cannot correct LO phase noise impairments at offsets of the LO that approach the symbol rate of the radio because at the margin where symbol rate of the radio approaches frequency of the phase noise offset, the algorithms cannot differentiate between LO phase noise and actual data transmitted by the system. As a result, radio designers typically require integrated LO phase noise to be better than the maximum system SNR, thereby ensuring that LO phase noise is not a dominant noise contributor, and hence does not limit system SNR performance. Typically, a phase noise margin of 20 dB better then targeted system SNR is required.

This approach, however, does not correctly approximate the LO contribution to system SNR and throughput for modern OFDM systems such as LTE and WiMAX which typically underestimates the LO contribution

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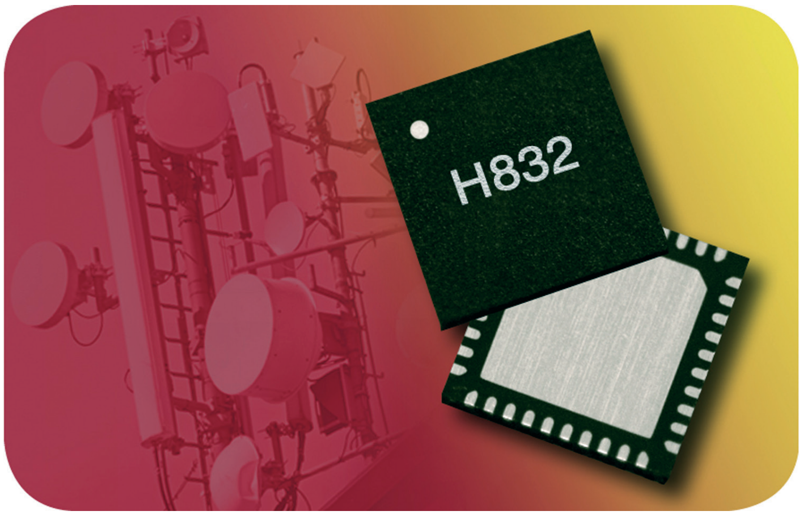
to system SNR by approximately 10 dB. The reason for the discrepancy is that in the OFDM case, LO phase noise does not only FM modulate one carrier, it instead modulates all of the carriers. This can be shown using the distributed property of convolution:

$$f_{LO} * (f_{c1} + f_{c2} + f_{c3} ... + f_{cN}) = f_{LO} * f_{c1} + f_{LO} * f_{c2} + f_{LO} * f_{c3} + \cdots + f_{LO} * f_{cn}$$

Where f_{LO} is the center frequency of the LO frequency and f_{CX} is the center frequency of carrier x.

Therefore LO phase noise convolves with every sub-carrier in the OFDM signal, and because the LO phase noise is significantly wider in frequency than OFDM carrier spacing, LO phase noise convolved with carrier 1 causes interference to all other carriers, and in return, the sum of all other carriers convolved with LO phase noise interferes with sub-carrier 1. This effect is additive to the already well understood LO phase noise impact on system EVM (Error Vector Magnitude) and SNR.

The end effect of this phenomenon is that the OFDM carriers exhibit ICI because they are no longer orthogonal in the presence of LO phase noise. OFDM systems such as WiMAX and LTE do correct for CPE part of ICI, but the amount of correction is limited by the maximum symbol rate of the system. In the LTE example that is ~15 kHz, which is the bandwidth of OFDM sub-carriers.



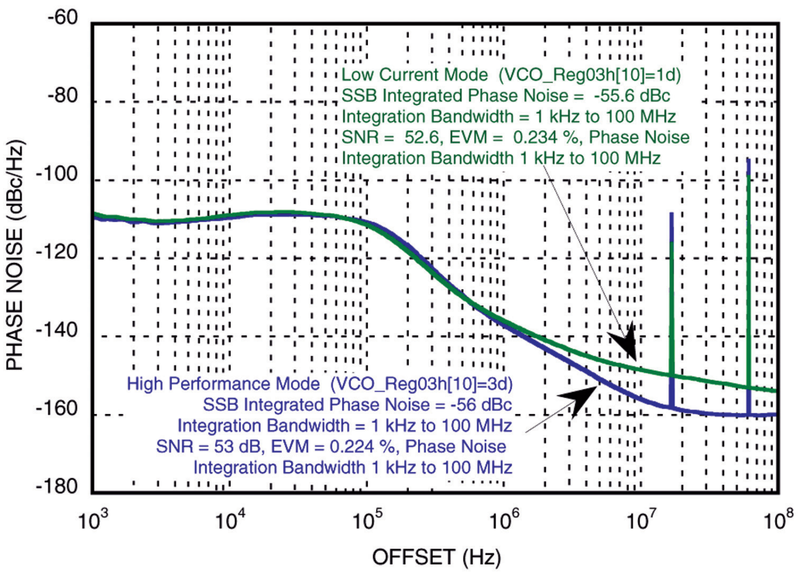


Figure 2: Fractional Spurious Performance at 2646.96 MHz, Exact Frequency Mode ON

Hence vast majority of ICI is not corrected and further degrades system SNR performance.

Hittite's HMC832LP6GE PLL+VCO provides this performance margin for systems such as 64QAM LTE. As an example, integrated phase noise of HMC832LP6GE at ~2.6 GHz is ~ -53 dB. Typically 64QAM LTE system requires ~25 dB SNR. Assuming ~10 dB ICI contribution to system SNR and EVM on top of integrated phase noise contribution of the LO phase noise, the HMC832LP6GE provides ~18 dB of performance margin (53 dB, - 25 dB, - 10 dB), thereby ensuring that PLL+VCO phase noise does not impact system performance.

A lower margin would affect the system SNR and could cause it to fail the performance requirements. As an example, phase noise margin of only 10 dB would reduce system SNR performance by ~0.5 dB if the system is already at the edge of its performance limit. For example:

$$10log\left(10^{-25}/_{10} + 10^{-35}/_{10}\right) = -24.5\ dB$$

Microwave point-to-point radios typically used in cellular backhaul applications are even more phase noise constrained then the cellular access systems. Such high capacity radios often have constellations in the order of 2048QAM or even 4096QAM. Typically the phase noise bottleneck in these systems are RF stage microwave VCOs, but the total phase noise budget includes both RF and IF

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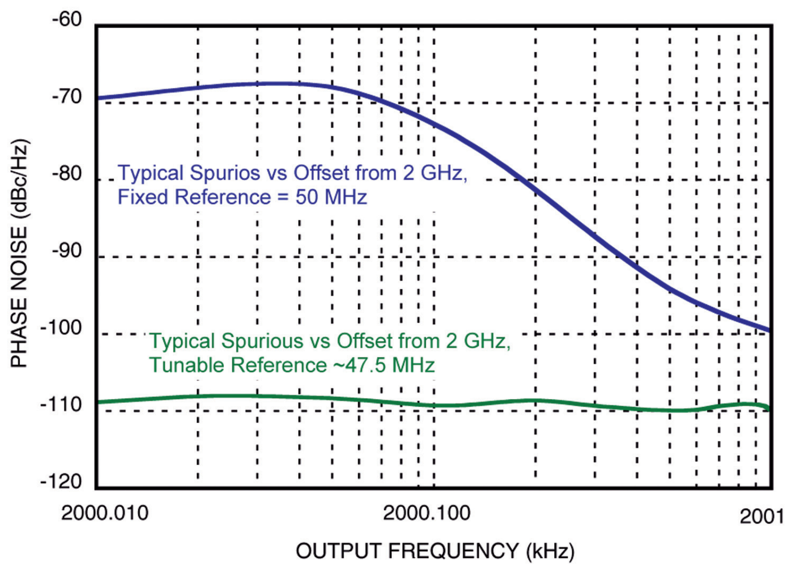

Figure 3: Typical Spurious vs. Offset from 2 GHz, Fixed vs. Tunable Reference

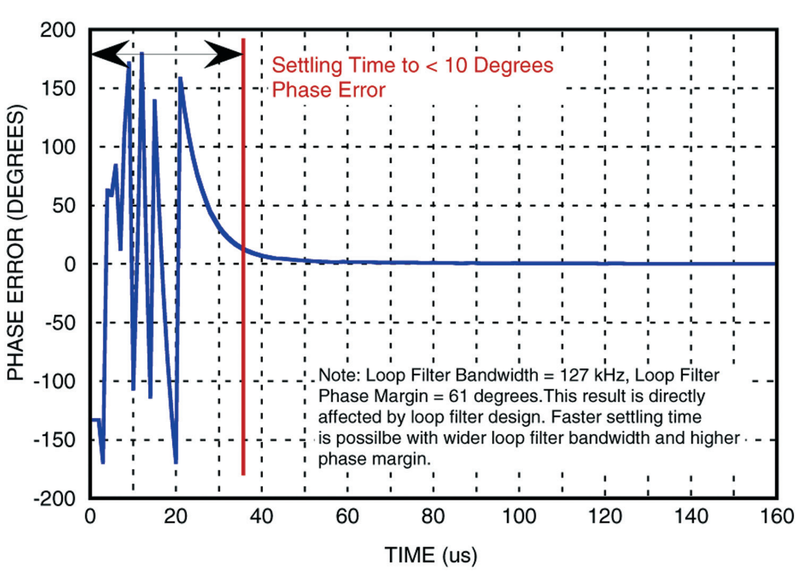

Figure 4: Phase Settling after Frequency Change (Manual Calibration)

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stage LOs. Therefore it is crucial that the IF stage PLL+VCO does not add any noise to the microwave LO phase noise. The industry leading phase noise performance of the HMC832LP6GE provides sufficient phase noise margin and therefore enables high capacity microwave links to realize their maximum performance.

In addition to the superior phase noise, the HMC832LP6GE also leads the market in spurious performance. Spurious emissions are another key performance metric in radio design. In cellular and microwave single carrier systems spurious emissions of the LO can adversely impact radio performance in a number of ways. Spurious emissions are effectively concentrated phase noise at a particular offset. Therefore they add to the integrated phase noise and adversely affect system SNR. For example, if the integrated phase noise of the PLL+VCO is -50 dBc with no spurious, then an added -50 dBc/Hz spur would double (adds 3 dB) the integrated phase noise to -47 dBc. In addition, spurious emissions can mix with other signals outside the band of interest (blocker) and either deteriorate the SNR performance of the radio or, in the worst case, cause signal outage. Transmitted LO spurious emissions can in effect be blockers for other radios and cause a radio design to not adhere to the transmitted spectral mask of the radio standard. LO spurs can mix with other spurious, non-linearities, and harmonics within the radio and deteriorate the performance of the radio, which can be difficult to debug and compensate for.

In OFDM systems spurious emissions can cause a greater effect when the offset of the spurious emission is within the bandwidth of the OFDM signal which can be up to 100 MHz for LTE Advanced. In that case, the spurious emissions, which are typically much greater in power than the phase noise at the particular offset, cause extreme ICI that can completely block an OFDM sub-carrier, wasting an expensive segment of radio spectrum.

Industry leading spurious performance of the HMC832LP6GE simplifies radio designs and enables radio designers to achieve maximum performance. Unparalleled in the industry, the HMC832LP6GE features <~-55 dBc/Hz inside the loop bandwidth spurious performance, and significantly better performance outside the loop bandwidth (<-90 dBc/Hz). More importantly, the HMC832LP6GE does not emit any channel spurs in Exact Frequency Mode, this is critical especially since Exact Frequency Mode is the preferred mode of operation of the PLL+VCO in cellular and microwave radio markets. In these markets, users often program channel step size according to the channel spacing of the particular standard of the radio. Any channel spurs then become interference and/or blockers to adjacent radio channels.

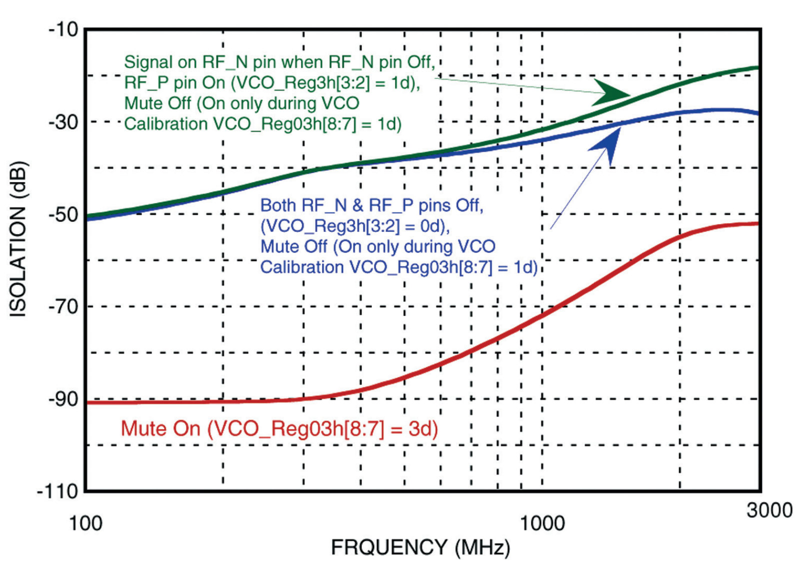

Figure 5: Mute Mode Isolation

For applications that are even more sensitive to spurious, the HMC832LPGE can be placed in a cascaded configuration to operate virtually spurious free (typically <-90 dBc/Hz spurious) at any frequency and any offset.

The HMC832LP6GE integrated phase detector and delta-sigma modulator can operate at up to 100 MHz frequency and allow wider loop bandwidths for optimized performance and lock time. Exact Frequency Mode enables users to generate fractional output frequencies with 0 Hz frequency error. The device includes fast frequency hopping that can execute any size frequency change in ~30 µs and output mute function, with 50 dB or better isolation over the whole frequency range, to automatically mute the output during frequency changes when the device is not locked.

The outputs can be configured as a differential pair or two single-ended outputs if more devices need to be driven with a single LO. The 12 dB of total RF output power can be programmed in fine 1 dB steps. The HMC832LP6GE is footprint compatible to the industry leading HMC830LP6GE PLL+VCO.

For more information, please visit www.hittite.com.

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