



APPLICATION NOTE 282

MAX2721 Direct-Frequency Upconverter Minimizes Chip Count and Is Ideal for Wideband Application

Abstract: This article describes the MAX2721 for use in wideband transmitters. A WCDMA application at 2.3GHz is described. Direct conversion at 2.4GHz is difficult because I/Q amplitude and phase match must be very good. The MAX2721 typically has $\pm 0.2\text{dB}$ and ± 1 degree matching, 31dB carrier suppression, 35dB sideband suppression, and 32dB of gain control range. Driver amplifier offers +12.5dBm with a 1dB compression point. Performance summary shows 6.6% EVM in WCDMA application at 2300MHz.

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Introduction

The wireless industry is experiencing demands for improved data rates and channel capacity to provide high-quality multimedia performance services. These systems often require spread-spectrum techniques, such as the higher rate extension of the direct-sequence spread spectrum (DSSS) system for wireless LAN application in the 2.4GHz band, in accordance with IEEE® 802.11b. Third-generation systems, like the 3GPP and the wireless local loop (WLL), also employ the WCDMA (wideband code division multiple access) modulation scheme, operating with 5MHz and 10MHz channel spacing, respectively.

The MAX2721 direct-upconverter quadrature modulator IC is designed specifically to simplify wideband transmitter design in the 2.4MHz band. It reduces system cost compared to IF-based transmitter architectures, as an IF oscillator and synthesizer are eliminated. In this application note, the system performance of a complete direct-upconverter WCDMA transmitter operating at 2.3GHz for WLL application is characterized to demonstrate a new, simple, and elegant alternative to IF-based transmitters. See **Figure 1** for a block diagram of the transmitter built for characterization.

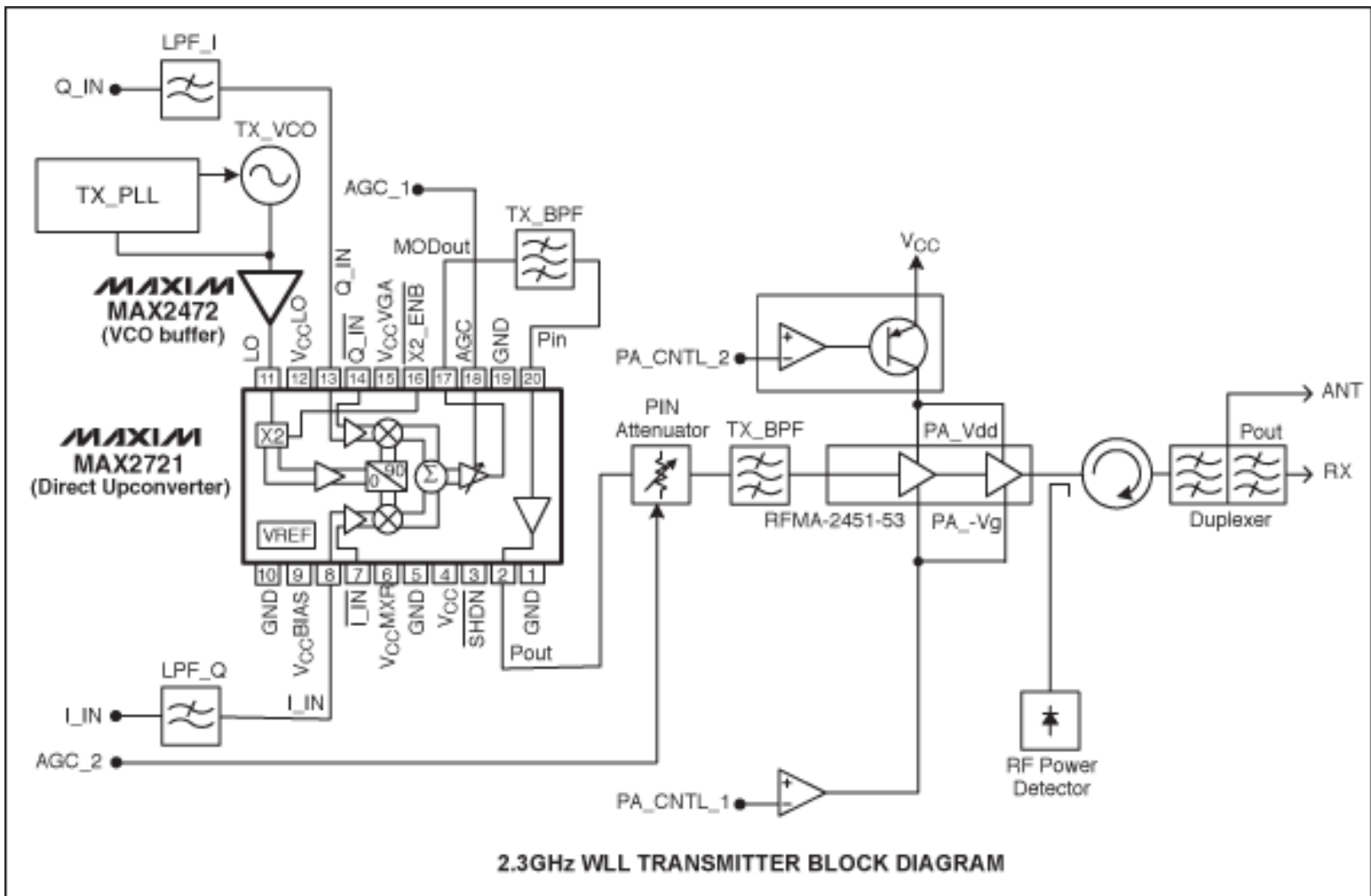


Figure 1. Block diagram of the MAX2721 direct-conversion transmitter.

Requirements and Issues of the Wideband Transmitter

MAX2721 I/Q input ports are specified with a -1dB bandwidth of 20MHz with a 1k Ω impedance. The -1dB input bandwidth has been determined experimentally to be 44MHz at 300 Ω and 250MHz at 50 Ω . Thus, the MAX2721 is more than adequate to accommodate any new wireless standard that requires such wide baseband bandwidth.

Direct-conversion modulation at a 2.4GHz band poses several design challenges to RF IC designers, in particular the I/Q amplitude and phase balance and quadrature accuracy required at the LO signal. Traditionally, quadrature modulators operate at IF frequencies of less than 300MHz. Amplitude and phase matching becomes more difficult to implement at a higher operating frequency. Insufficient sideband and carrier suppression can arise as a result of inadequate quadrature LO generation and/or amplitude imbalance and DC offset at 2.4GHz. Vector amplitude and phase accuracy is best characterized from the error vector magnitude (EVM) measurement. Assuming that the modulating I/Q signal derived from the DSP has minimal amplitude/phase error and DC offset, the MAX2721 typically has ± 0.2 dB and ± 1.0 degree in gain and phase imbalance, respectively, and it is able to achieve 31dB of carrier suppression and 35dB of sideband suppression.

Another issue of primary concern is the VCO injection pulling on the transmit synthesizer by the power amplifier's (PA's) strong signal level. A high-power modulated waveform out of the PA centered at the VCO-tuned frequency leaks back to the VCO either by conduction or radiation. Designers must pay extreme attention to PCB layout and shielding techniques to provide adequate isolation between the PA and the VCO. The MAX2721 has an on-chip LO doubler to reduce this injection-pulling phenomenon. To further enhance the isolation through conduction, a MAX2472 VCO buffer is employed. Typical reverse isolation of the MAX2472 at 2.4GHz is 26dB.

The MAX2721 typically has 32dB of variable-power-control range. This is sufficient for IEEE 802.11b application and eliminates any need for an additional variable-gain amplifier in the transmitter lineup. Additional power-control range for WLL application can be implemented with a PIN diode attenuator and a variable-gain PA to enhance power amplifier efficiency. In the PA circuit shown in Figure 1, both gate and drain voltages are varied on a PHEMT device

to provide variable gain and simultaneously reduce drain current at lower-power operation. The MAX2721 also includes a driver amplifier that has a 1dB compression point of +12.5dBm. Depending on the peak-to-average ratio of the modulated waveform, this driver amplifier delivers a sufficient amount of linear power to interface with a broad selection of power amplifiers from the wireless industry. The performance summary of the transmitter is shown in **Table 1**.

Table 1. Performance Summary

Output Frequency	2300MHz
Modulation	WCDMA
I/Q Chip Rate	4.096Mcps, $\alpha = 0.22$ (HP-E4433B)
Input I/Q Level	200mV _{p-p}
Maximum Power Output	+21dBm
ACPR	-38dBc (integrated over 4.9MHz BW, P _{OUT} = +21.8dBm)
EVM	6.6% (typ)
Carrier Suppression	30dBc
Power-Control Range	25dB (65dB with PIN attenuator and variable-gain PA)
LO Input Frequency	1150MHz ($f_0/2$)
LO Input Level	-13dBm
PLL Synthesizer Step Size	125kHz
PLL Tuning Speed	2ms to ± 1 kHz of final frequency
DC-Supply Voltage	+3.6V and +5.0V for PA

See **Figures 2** and **3** for the ACPR measurement and the EVM measurement, respectively. The LO PLL is synthesized at 1150MHz. The LO doubler is enabled, and the VGA tuning voltage is set at +2.5V. Measured ACPR integrated over 4.9MHz bandwidth is less than -38dBc. Channel power is recorded as +21.8dBm at the antenna port of the duplexer. EVM is recorded at 5.9% (min), 6.6% RMS (typ), and 7.9% RMS (max).

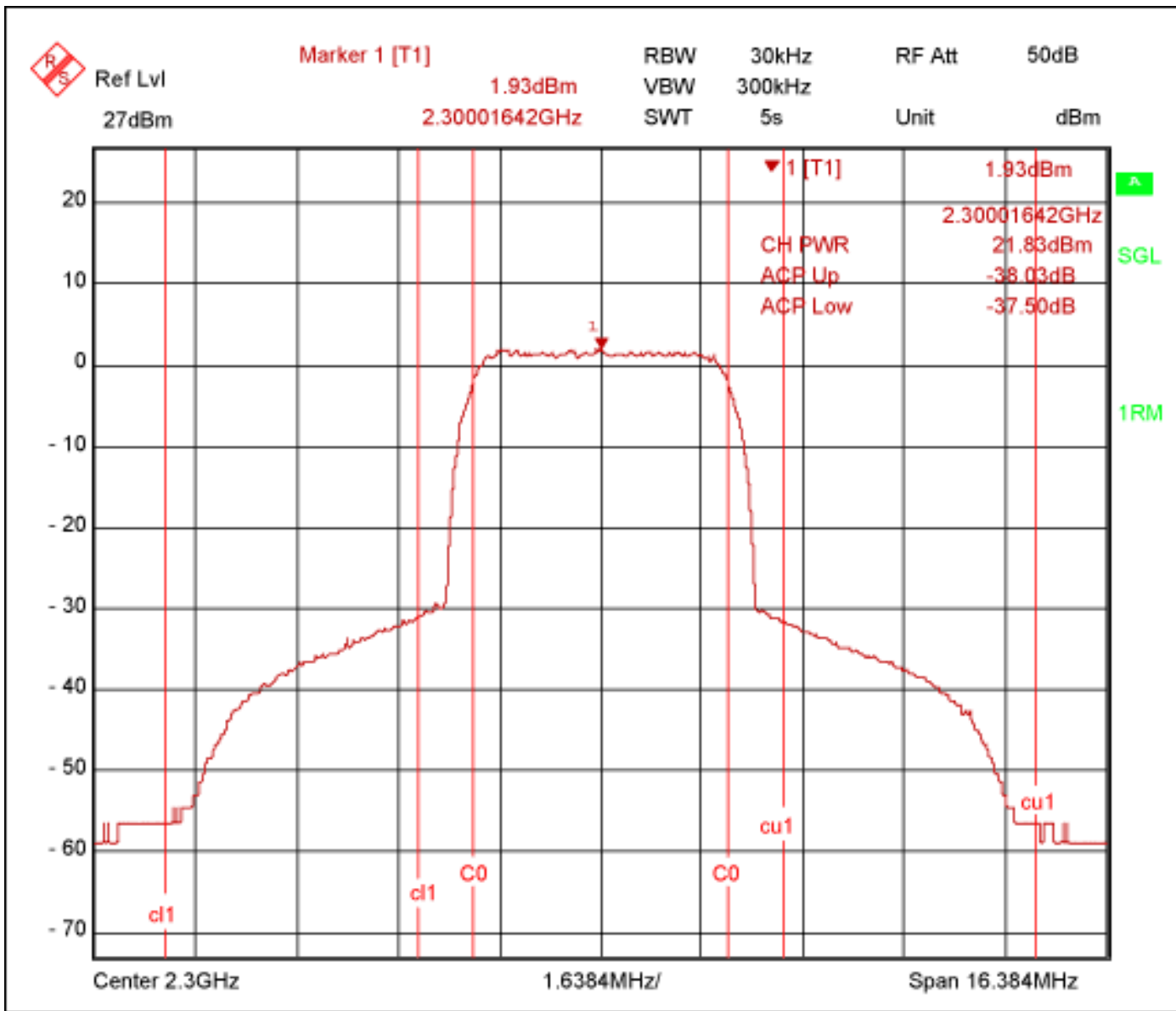


Figure 2. Transmitter spectral display at the antenna port.

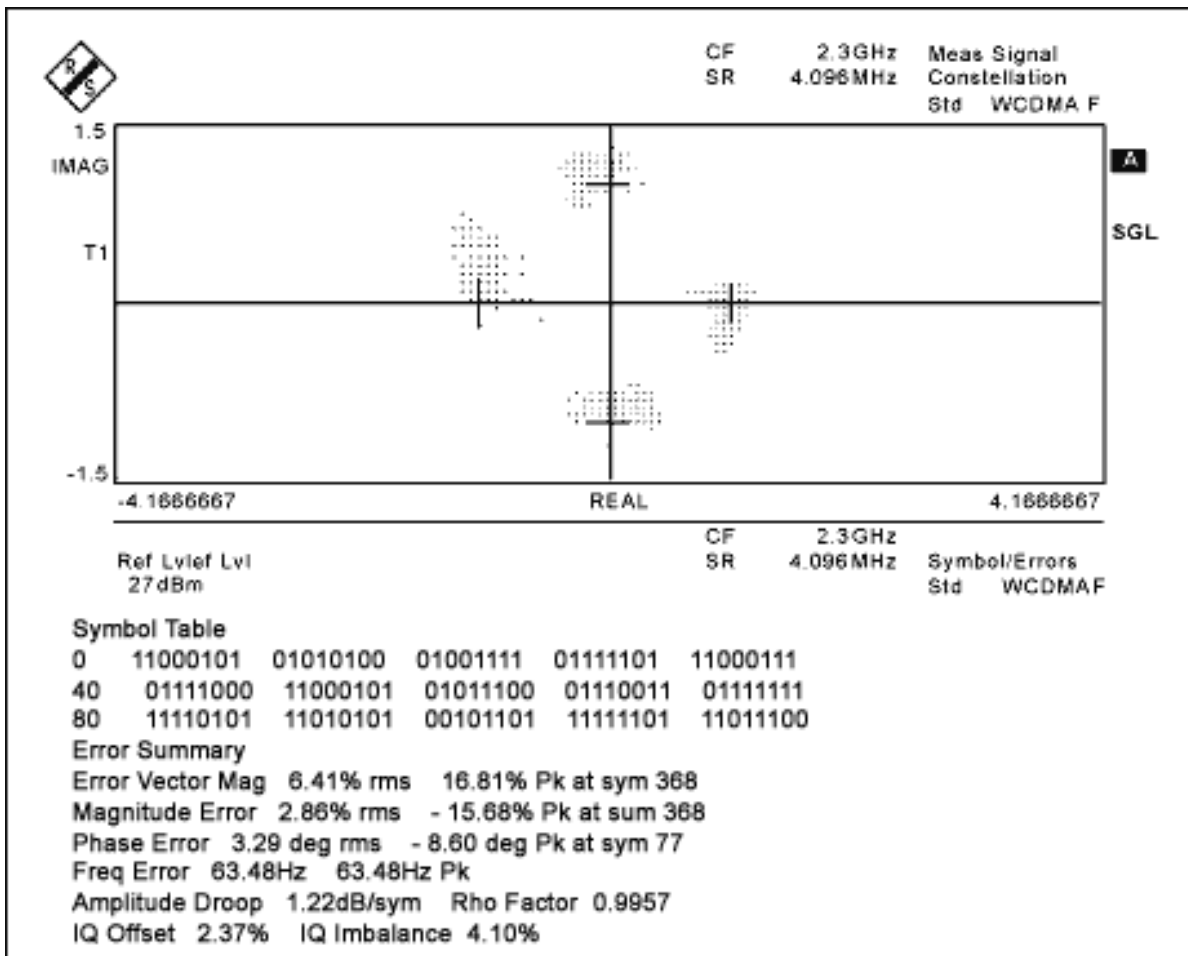


Figure 3. Transmitter constellation and EVM display at the antenna port.

Conclusion

The MAX2721 is ideal for wideband transmitter applications in the 2.4GHz band. This device, with wide baseband bandwidth, an integrated LO doubler, a variable-gain amplifier, and a highly linear driver amplifier, has unlimited potential, serving as a fundamental building block and lending itself to low-cost transmitter applications nicely. Test data at 2.3GHz demonstrates its superb EVM and ACPR performance in a WCDMA scenario.

References

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2. Razavi, Behzad, RF Microelectronics, Prentice Hall, Inc. 1998.
3. [MAX2720/MAX2721](#), 1.7GHz to 2.5GHz, Direct I/Q Modulator with VGA and PA Driver data sheet, Rev 0, January, 2000.
4. [MAX2472/MAX2473](#), 500MHz to 2500MHz VCO Buffer Amplifiers data sheet, Rev 0, June, 1999.

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