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

This article describes the MAX2721 for use in wideband transmitters. An W-CDMA 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 ±0.2dB 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 summery shows 6.6% EVM in W-CDMA 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 Standard 802.11b. Third-generation systems, like the 3GPP and the wireless local loop (WLL), also employ the W-CDMA (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 W-CDMA 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.

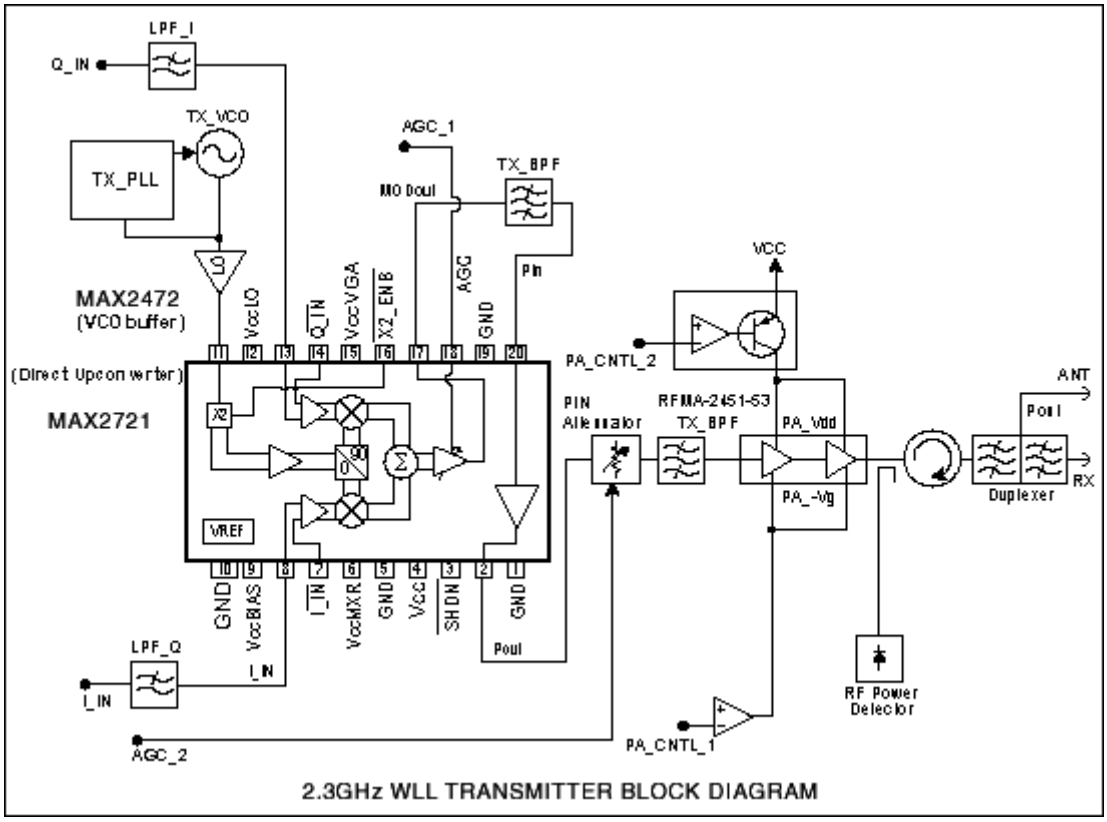


Figure 1. Block diagram of the MAX2721 direct-conversion transmitter

Requirements and Issues of the Wideband Transmitter

MAX2721 I/Q input ports are specified with a -1dB bandwidth of 20MHz with a 1kΩ impedance. The -1dB input bandwidth has been determined experimentally to be 44MHz at 300Ω and 250MHz at 50Ω. 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 ±0.2dB 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 line-up. 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	W-CDMA
I/Q Chip Rate	4.096Mcps, α= 0.22 (HP-E4433B)
Input I/Q level	200mVpk-pk
Maximum Power Output	+21dBm
ACPR	-38dBc (integrated over 4.9MHz BW, Pout = +21.8dBm)
EVM	6.6% typical
Carrier Suppression	30dBc
Power-Control Range	25dB (65dB w/ PIN attenuator and variable-gain PA)
LO Input Frequency	1150MHz (fo/2)
LO Input Level	-13dBm
PLL Synthesizer Step Size	125kHz
PLL Tuning Speed	2ms to +/-1kHz 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 typical, and 7.9% RMS max.

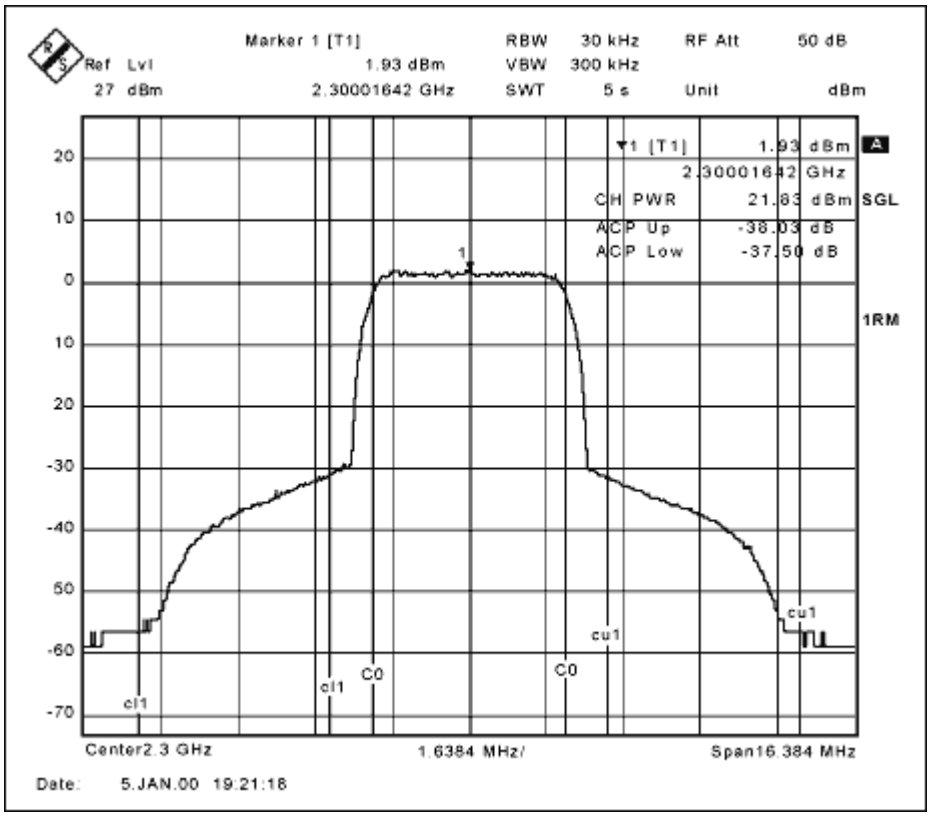
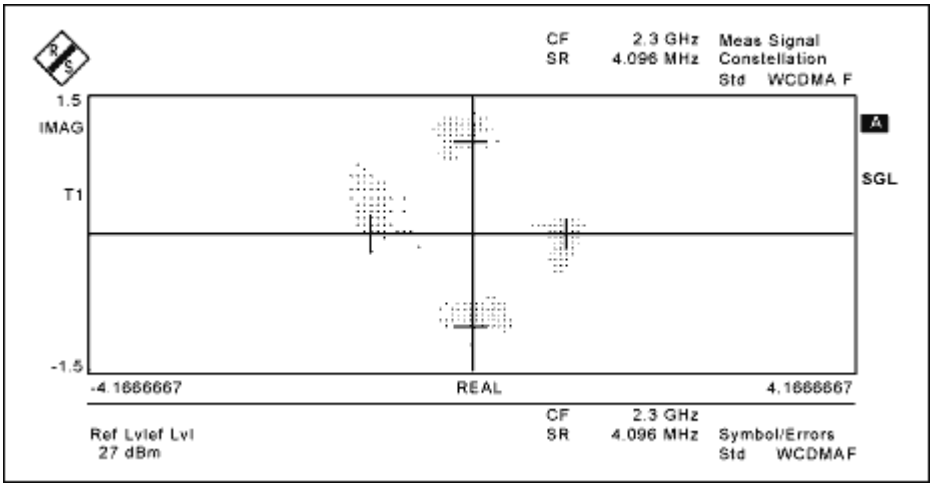


Figure 2. Transmitter spectral display at the antenna port



Symbol Table

0	11000101	01010100	01001111	01111101	11000111
40	01111000	11000101	01011100	01110011	01111111
80	11110101	11010101	00101101	11111101	11011100

Error Summary

Error Vector Mag	6.41% rms	16.81% Pk at sym 368	
Magnitude Error	2.86% rms	- 15.68% Pk at sum 368	
Phase Error	3.29 deg rms	- 8.60 deg Pk at sym 77	
Freq Error	63.48 Hz	63.48 Hz Pk	
Amplitude Droop	1.22 dB/sym	Rho Factor	0.9957
IQ Offset	2.37%	IQ Imbalance	4.10%

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 W-CDMA scenario.

References

1. Draft Supplement to Standard [for] Information Technology. Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer Specifications: Higher Speed Physical Layer Extension in the 2.4GHz Band. IEEE Standard 802.11b/D7.0, July 1999.
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. MAX2742, 500MHz to 2500MHz VCO Buffer Amplifiers data sheet, Rev 0, June, 1999.

MORE INFORMATION

MAX2472: QuickView -- Full (PDF) Data Sheet (256k) -- Free Samples

MAX2721: QuickView -- Full (PDF) Data Sheet (328k) -- Free Samples