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The RFFC5071A in ISM Band Shift Applications

Introduction

The RFFC5071A is a highly integrated RF frequency conversion device containing two mixers, a fractional-N synthesizer, and voltage controlled oscillators (VCOs). The mixers are wideband and can operate to 6GHz for both up and down conversion. The synthesizer can provide a maximum local oscillator (LO) frequency of 4.2GHz. This means that the RFFC5071A is ideal for band shift applications, including up to the 5.8GHz ISM band.

In band shift applications the idea is that a standard 2.4GHz transceiver (for example) can be used to implement a low-cost radio at another frequency band, with minimum risk and development time. The band shift can be to lower frequencies, such as the 433MHz or 915MHz ISM bands, or to higher frequencies. This application note focuses on using the RFFC5071A to translate between the 2.45GHz ISM band and the 5.8GHz ISM band.

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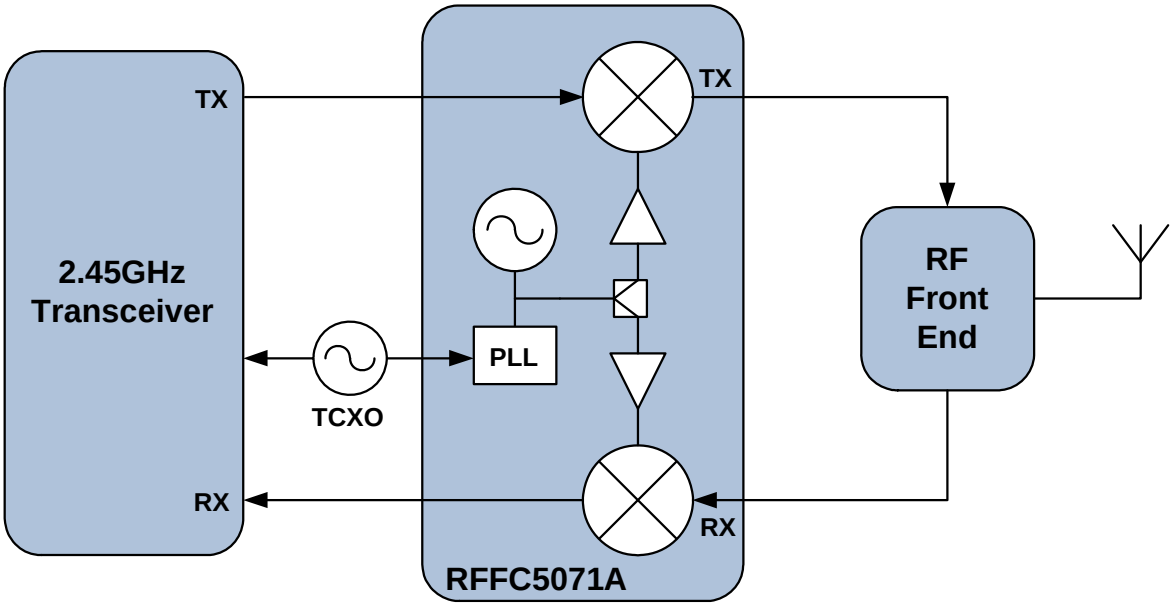

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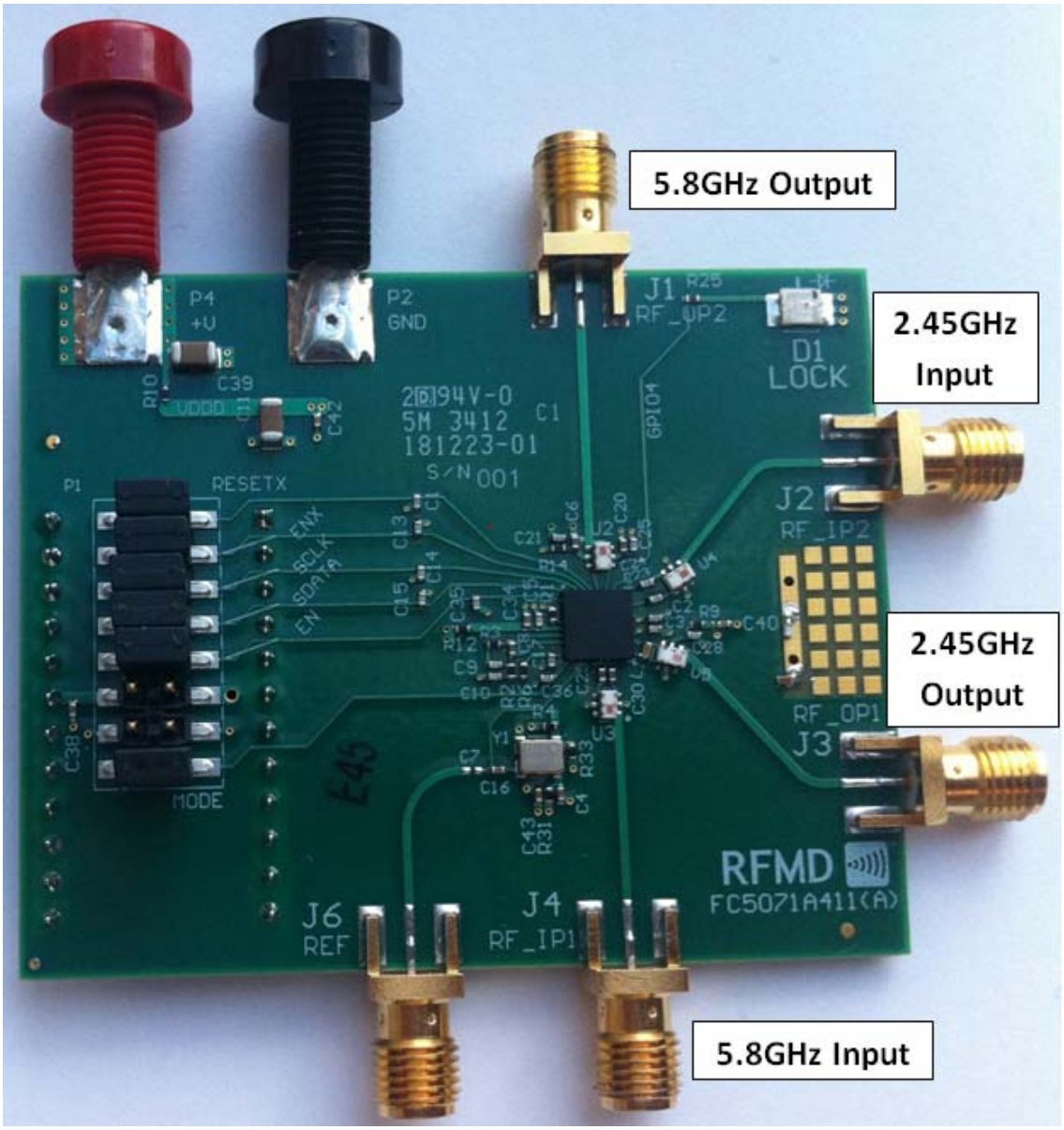
RFFC5071A Band Shift PCB

An evaluation board was produced with hybrid ceramic baluns on the mixer ports at 2.45GHz and 5.8GHz respectively. The baluns used were Johanson Technology parts:

U2 and U3	5400BL15B050, 50Ω to 50Ω, 4900MHz to 5900MHz
U4	2450BL15B050, 50Ω to 50Ω, 2400MHz to 2500MHz
U5	2450BL15B200, 200Ω to 50Ω, 2400MHz to 2500MHz



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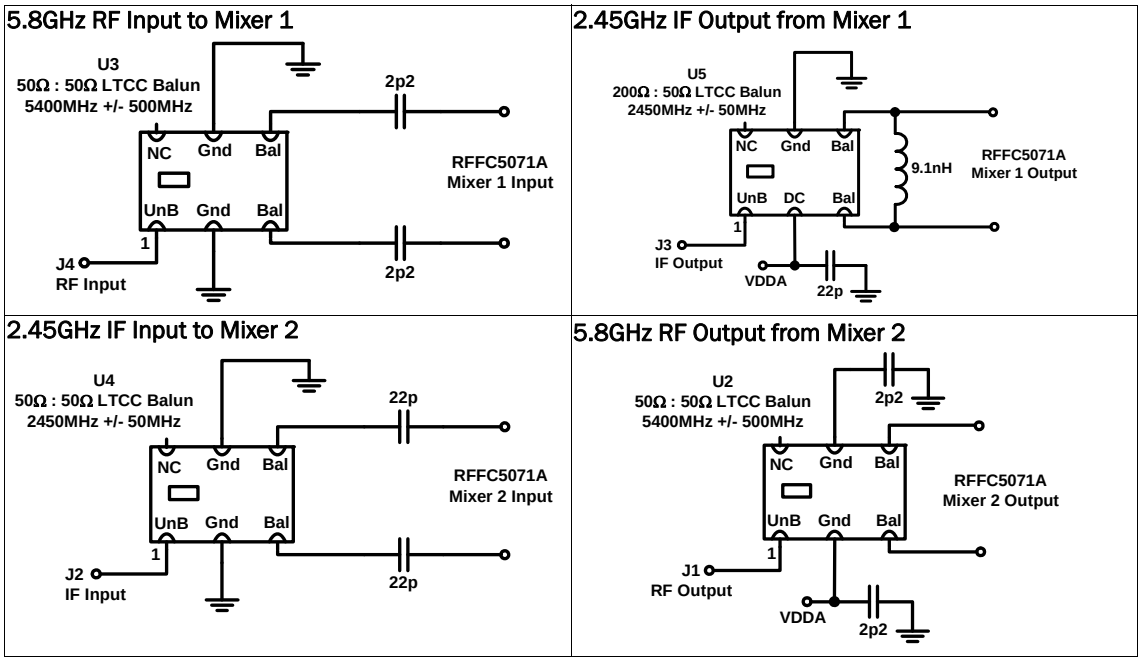
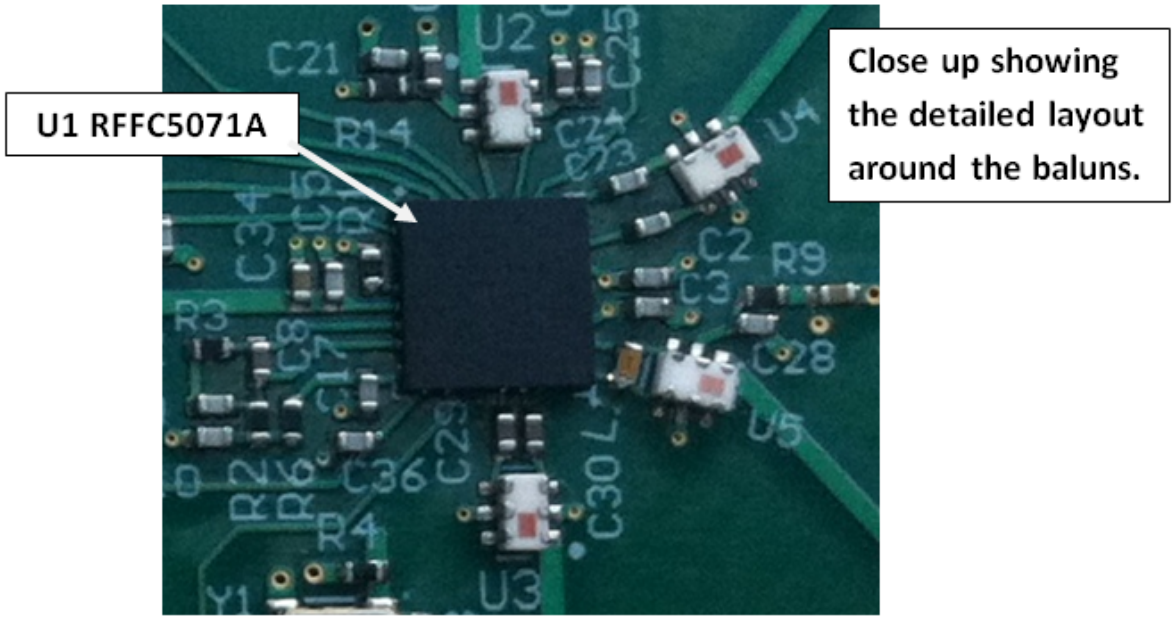
RFFC5071A Baluns and Matching

The balun configurations for the mixer IF and RF ports are shown below. Minimal matching is required, just a 9.1nH shunt inductor, L1, on the output of mixer 1 to peak the gain response at 2.45GHz.





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Typical Results

The following is a summary of the typical results measured for both up and down conversion. These are for the mixer current setting that gives best linearity, MIX_IDD = 5, and for a 3V supply voltage. The mixer current consumption can be reduced in 5mA steps; the mixer will operate with reduced linearity and improved noise figure. Please refer to the RFFC5071A datasheet.

The local oscillator frequency is 3350MHz, with the reference derived from a 26MHz TCXO.

Parameter	Mixer 1 Downconversion 5.8GHz to 2.45GHz	Mixer 2 Upconversion 2.45GHz to 5.8GHz
Conversion Gain (dB)	-5.5	-7.0
Input IP3 (dBm)	+22.5	+24.5
Pin 1dB (dBm)	+12.0	+11.5
Noise Figure (dB)	17.5	20.0
RMS Int PN (°)1K to 40M	0.71	0.71
Total Current (mA)*	135	135
Power (Watts)	0.405	0.405

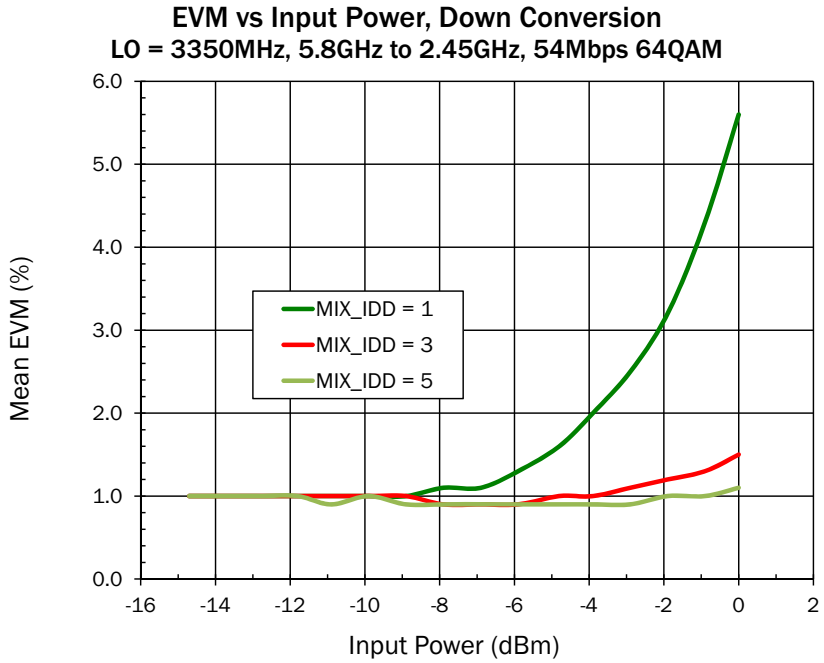
* The total current of 135mA is with one mixer enabled. If two mixers are enabled at once (Full Duplex mode), the typical total current = 200mA

EVM Measurements

To quantify the performance of the RFFC5071A the mean EVM (%) was measured for an 802.11a/g signal at 54Mbps, an OFDM signal with 64QAM modulation, converted through the mixers with an LO frequency of 3350MHz.

Note that the residual EVM of the test equipment was measured as between 0.4% and 0.5% at both 2.45GHz and 5.8GHz. A Rohde & Schwarz AMIQ and SMJ100A vector signal generator were used to produce the modulated signal, and an FSQ8 vector signal analyzer used to measure the EVM.

The EVM was measured with three mixer current settings to show the effect of mixer distortion on the EVM versus input power level.



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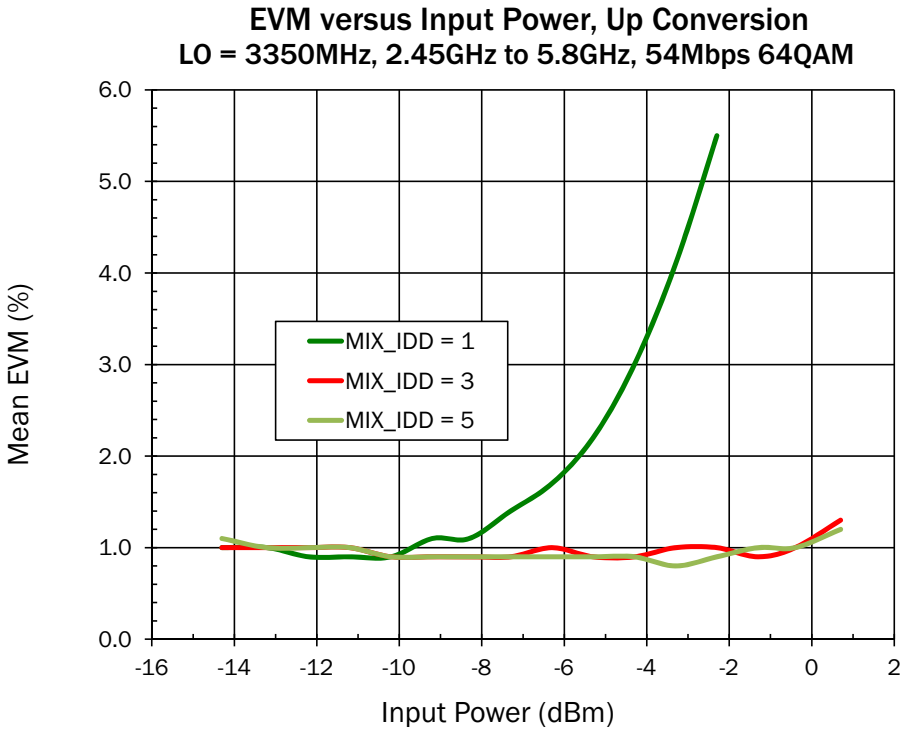
The EVM for the down conversion case shown above is typically 0.9 to 1.0%. It shows that for the lowest mixer current setting the input power is limited to about -9dBm, and for the setting for best linearity this increases to about -1dBm. This follows since the peak to average power ratio for the modulated signal is of the order of 8dB, so the signal level needs to be backed off about 10dB below the 1dB compression point to stay in the linear region of operation.



The EVM for the up conversion case shown above is again typically 0.9 to 1.0%. It shows that for the lowest mixer current setting the input power is limited to about -10dBm, and for the setting for best linearity this increases to about 0dBm. The input power level is slightly lower here than for the down conversion case, seen especially for the curve for MIX_IDD = 1. This is because there is less loss in the input balun and PCB trace at 2.45GHz compared to the loss at 5.8GHz. Less loss on the input results in a slightly lower input compression point.

Conclusions

The RFFC5071A can be utilized as a frequency translation device to band shift a standard transceiver solution to different frequencies, up to a maximum of 6GHz.

A 2.45GHz to 5.8GHz band shifter was implemented with the RFFC5071A using low cost ceramic hybrid baluns on all of the mixer ports. The frequency reference was a low cost commercial TCXO, with frequency of 26MHz. The RFFC5071A has a fractional-N synthesizer that will operate with any reference frequency between 10MHz and 104MHz.

The performance of the RFFC5071A was demonstrated using 802.11a/g signals at 54Mbps, with OFDM 64QAM modulation. The low phase noise and low spur LO signal generated by the RFFC5071A means that the EVM in the conversion is kept below 1%. The mixers have input 1dB compression point above +10dBm, meaning that input powers of about 0dBm can be driven into the mixers without significant degradation of EVM.

The RFFC5071A runs off a single 3V supply, and has low power consumption of about 0.4Watts with one mixer enabled, or 0.6Watts when operating both mixers. The current consumption of the mixers can be reduced further, to operate with reduced linearity and improved noise figure. This may be useful in implementing the receive path of the radio.

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