Application Report
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TRF3722 Operation With Local Oscillator (LO) 3rd Harmonic

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ABSTRACT

The TRF3722 is a high performance modulator with integrated PLL/VCO for supplying the local oscillator (LO) source. There is a known coupling mechanism within the device that degrades zero-IF (ZIF) linearity when the LO frequency is in the fundamental range of the VCO. Operating at a low IF input solves the issue, but in cases where a low IF offset is not possible, another option is to use the 3nd order LO harmonic as the mixing component. The third order harmonic is relatively strong and consistent. It can be used with a reduction in signal gain but with better linearity performance.

Contents

1 Introduction 2
2 Problem Statement 2
3 Resolution 4
4 Reliability 5
5 Conclusion 6

List of Figures

1 WCDMA ACPR Performance With 30-MHz IF 2
2 Baseband Distortion 3
3 WCDMA ACPR at Zero-IF 3
4 WCDMA Spectrum at 900-MHz LO at Zero-IF 4
5 WCDMA Spectrum at 3 x LO 5
6 3 x LO Relative Gain Histogram 5
7 3 x LO Relative Gain versus Temperature 6
8 3 x LO Relative Gain versus Voltage 6

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1 Introduction

The TRF3722 is a high performance modulator with integrated PLL/VCO for supplying the local oscillator (LO) source. The LO range is large; it operates from 280 MHz to 4100 MHz. The device employs four independent Voltage Controlled Oscillators (VCOs). The fundamental range of the four VCOs covers 2050 MHz to 4100 MHz. Frequency dividers generate the lower frequencies.

2 Problem Statement

There is a known issue with the TRF3722 device when the LO operates within the VCO fundamental range. Baseband signal coupling into the LO path generates second order distortion centered around the LO. When the baseband signal is centered at 0 Hz (that is, Zero-IF or ZIF), the coupling centered at the LO coincides with the modulated signal. The output spectrum resembles a signal with elevated distortion. If the baseband signal is at a low-IF, then the coupling is not coincident with the output signal. If the LO frequency is lowered below the VCO fundamental range, then the dividers engage and provide isolation to the coupling path. The issue is only present when operating at ZIF between 2050 MHz and 4100 MHz

Figure 1 illustrates the spectrum with a 5-MHz WCDMA signal. The baseband signal is offset by 30 MHz. The LO is programmed to 2.7 GHz. The output signal lands at 2.73 GHz and has excellent Adjacent Channel Power Ratio (ACPR) at over 73 dBc.

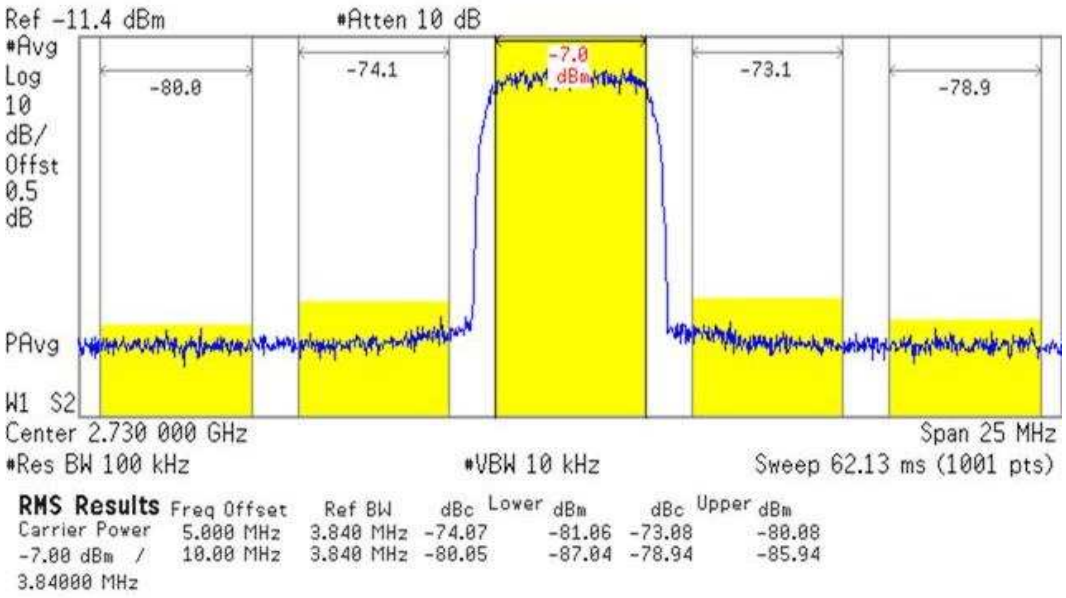

Figure 1. WCDMA ACPR Performance With 30-MHz IF

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Figure 2 illustrates the spectrum at the LO frequency in the same setup. The tone at the center is the expected LO feedthrough. The distortion hump around the LO is the undesired effect.

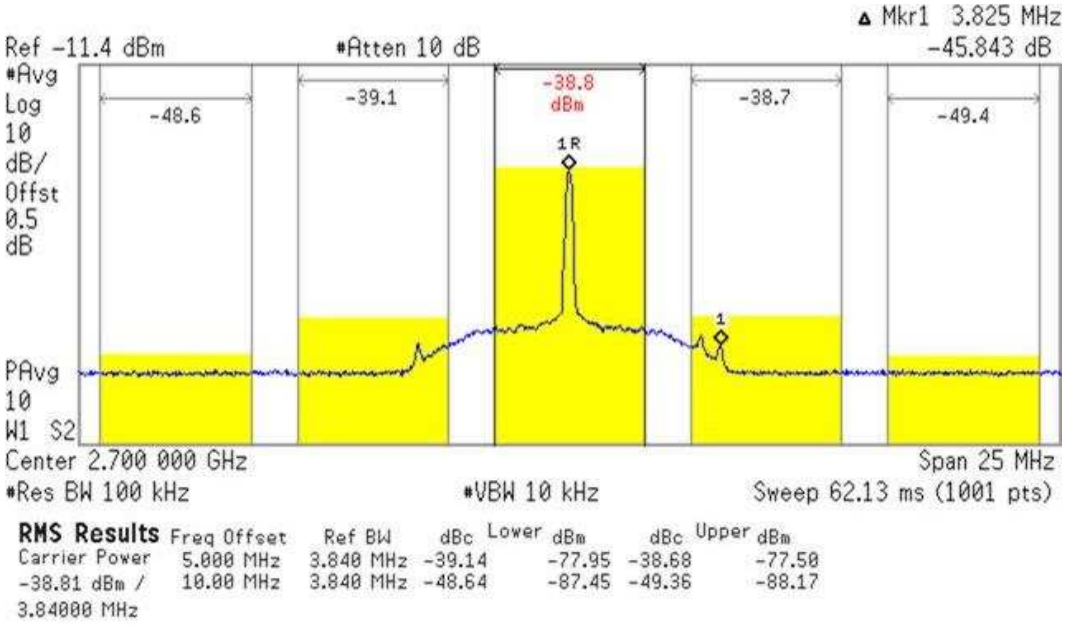

Figure 2. Baseband Distortion

Figure 3 illustrates the problem with ZIF operation. In this test the baseband signal is not offset; it is at 0 Hz. The LO is kept the same. The signal and the distortion now coincide at 2.7 GHz. The resulting spectrum appears distorted with degraded ACPR of around 56 dBc. This issue results in a 17-dB ACPR degradation when operating in ZIF.

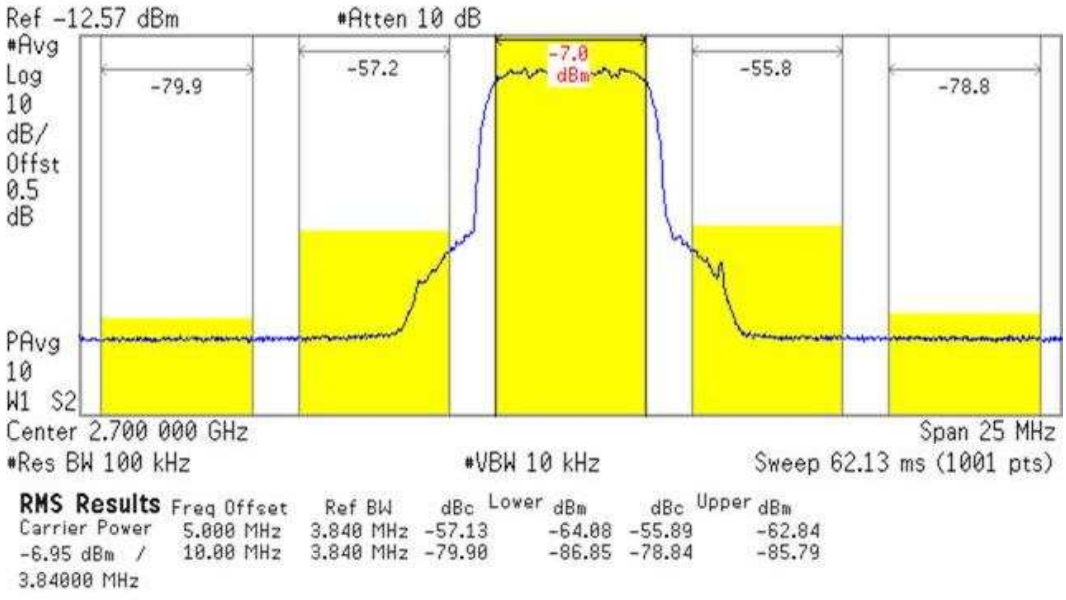

Figure 3. WCDMA ACPR at Zero-IF

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3 Resolution

The obvious resolution is to operate at a Low-IF to decouple the distortion from the signal. If this is not feasible, an alternative method is to use the 3rd harmonic of the LO. Due to the non-linear nature of the divider circuits, the TRF3722 device has a fairly high 3rd order LO component. The programmed LO signal is reduced threefold and the resulting 3rd order LO harmonic resides at the desired set-point. The 3rd order LO harmonic yields an output spectrum that is approximately 10 dB below the fundamental output signal but is decoupled from the previous linearity degradation. Since this set-up places the LO in a divided down location from the VCO fundamental range, there is additional isolation to eliminate the issue. As long as the reduction in amplitude is acceptable, this technique is viable to provide improved spectrum performance.

Figure 4 shows the spectrum at 900-MHz. The ACPR is excellent at better than 75 dBc. The signal power hovers around -7 dBm. The third harmonic is at 2.7 GHz. Figure 5 shows the spectrum performance. The power drops about 10 dB (to -17 dBm), but the ACPR is better than 64 dBc. In this configuration, the ACPR performance is limited by the device noise floor and not its linearity. Despite the lower output power, the ACPR performance yields significantly better than the ZIF case operating in the fundamental range.

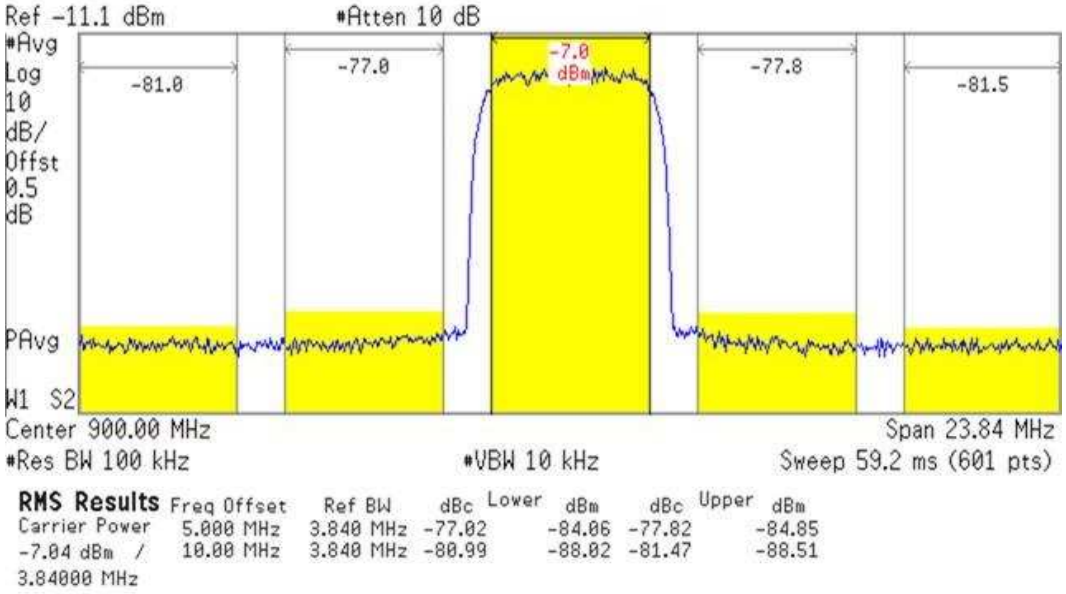

Figure 4. WCDMA Spectrum at 900-MHz LO at Zero-IF

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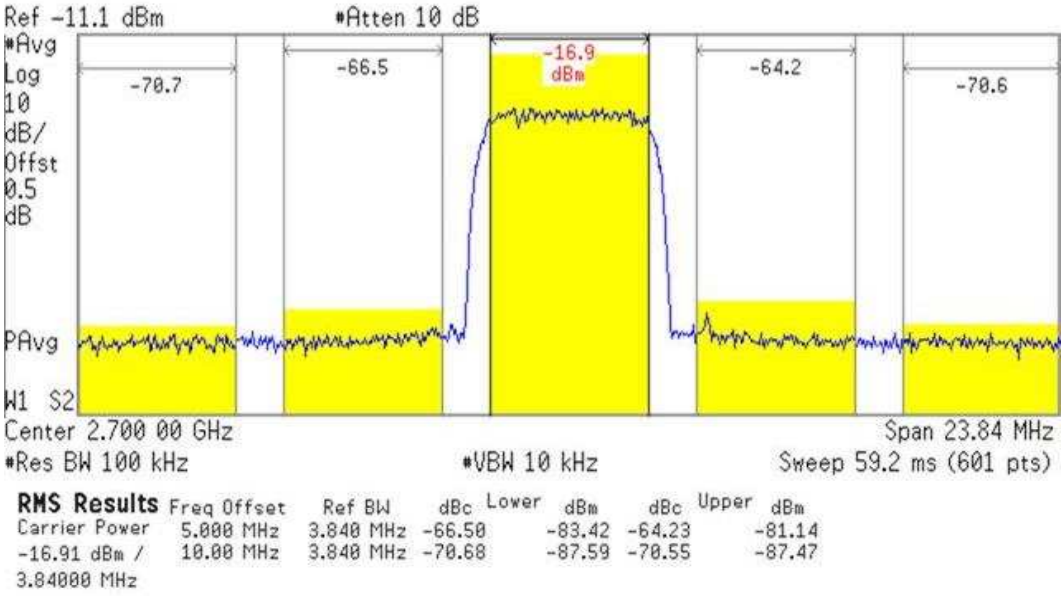

Figure 5. WCDMA Spectrum at 3 x LO

4 Reliability

Operating with the third order harmonic of the LO for the primary output signal is non-conventional; however, empirical testing verifies that this technique is viable. Additional characterization data for this parameter shows that the power of the signal at the third LO harmonic is very stable and repeatable over different devices and different lots. Of course, the desired signal output at the lower frequency must be filtered off so that it doesn't impact system performance. Figure 6 shows the histogram of the output signal from the 3rd order LO mixing over thousands of devices. The output yields an average gain hit of about -9.8 dB with a standard deviation of 0.15 dB. Figure 7 and Figure 8 illustrate the typical gain delta performance across fundamental LO frequency over temperature and voltage variation.

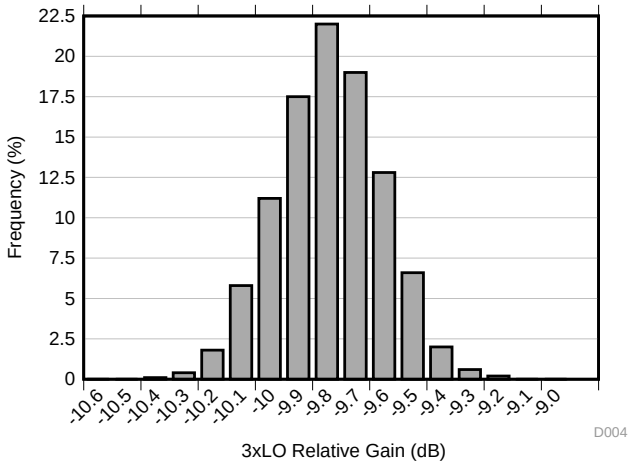

Figure 6. 3 x LO Relative Gain Histogram

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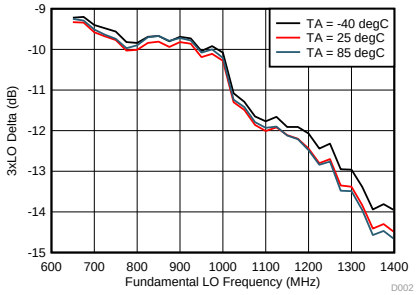

Figure 7. 3 x LO Relative Gain versus Temperature

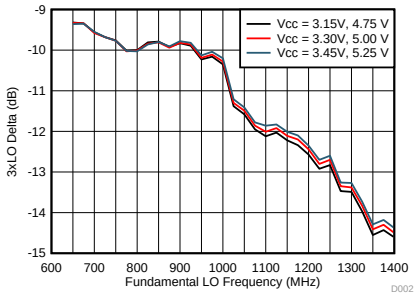

Figure 8. 3 x LO Relative Gain versus Voltage

5 Conclusion

Operating with the 3rd harmonic of the LO is a viable alternative with reasonable performance when the system requires ZIF architecture, and the output frequency is above 2 GHz. The performance of the device is stable and consistent, so the reduced gain can be compensated elsewhere in the line-up with confidence.

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