Superior ACPR Performance of TI’s TRF3703xx Family

Kal Mustafa/Russell Hoppenstein HPA/HSP

ABSTRACT

This report presents the adjacent-channel power ratio (ACPR) performance of TI’s TRF3703xx quadrature modulator family. ACPR measures the total system interference and distortion performance. ACPR is a system measurement and is generally defined as the ratio of the average power in the adjacent frequency channel to the average power in the transmitted frequency channel (wanted or modulated signal). It is a critical measurement for CDMA and WCDMA transmitters and their components. It describes the amount of distortion generated due to nonlinearities in RF components. In 3GPP-WCDMA, the ACPR is known as adjacent-channel leakage ratio (ACLR), and it is a measure of the intermodulation distortion in the sidebands of the modulated signal. It is analogous to third-order intercept (OIP3) measurements used to characterize the linearity performance of a device. Superior ACPR performance makes the TRF3703xx devices suitable for multicarrier WCDMA, CDMA, TD-SCDMA, WiMAX, and WiBro applications.

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1 Introduction

The TRF3703xx quadrature modulators are high-performance, very low-noise, high-linearity devices that exceed the stringent requirements of WCDMA, CDMA2000, WiMAX, LTE, TD-SCDMA, and multicarrier GSM communication standards. These modulators enable upconversion of baseband or IF signals directly to RF frequencies. The TRF3703xx modulators are easily interfaced with TI’s high-performance digital-to-analog converters, such as the DAC568x and DAC56x2 families. Together, they provide an integrated solution for multicarrier wireless communication standards. The modulators' superior output third intercept point (OIP3) of greater than 26 dBm significantly improves ACPR performance in base-station transmitter applications. The DAC568x and DAC56x2 in conjunction with TRF3703xx allow service providers to support multiple wireless standards on a single, compact transceiver card. This report presents the ACPR performance of three TRF3703xx devices. A combined ACPR performance using the DAC5672 and TRF370317 is also presented. The ACPR of WCDMA carriers shown because WCDMA modulation schemes generate closely-spaced intermodulated components in a modulated carrier. Nonlinearities of those intermodulated spectral components cause spectral regrowth around the carrier (LO) frequency and can seep out into adjacent channels.

1.1 What is ACPR?

ACPR is an overall performance measure (a figure of merit) that describes the level of spectral regrowth. It shows the relationship between the desired in-band (modulated) and out-of-band signals. In other words, it measures the amount of interference or power in adjacent-frequency channels. In general, it is defined as the ratio of the average power in the adjacent frequency channel to the average power in the transmitted-frequency channel; ACPR measures the amount of distortion due to nonlinearities in the transmit chain. It is typically measured in dBc (dB below the main carrier power).

Figure 1 shows the power spectrum of a single-carrier WCDMA signal and the adjacent channel power resulting from a third-order intermodulation product. In this figure, the carrier power is –12.8 dBm, the power of the two adjacent channels (upper and lower) are: f3 = –79.6 and f2 = 80.2 dBc. The alternate channels are f4 = –81.1 dBc and f1 = 81.3 dBc.

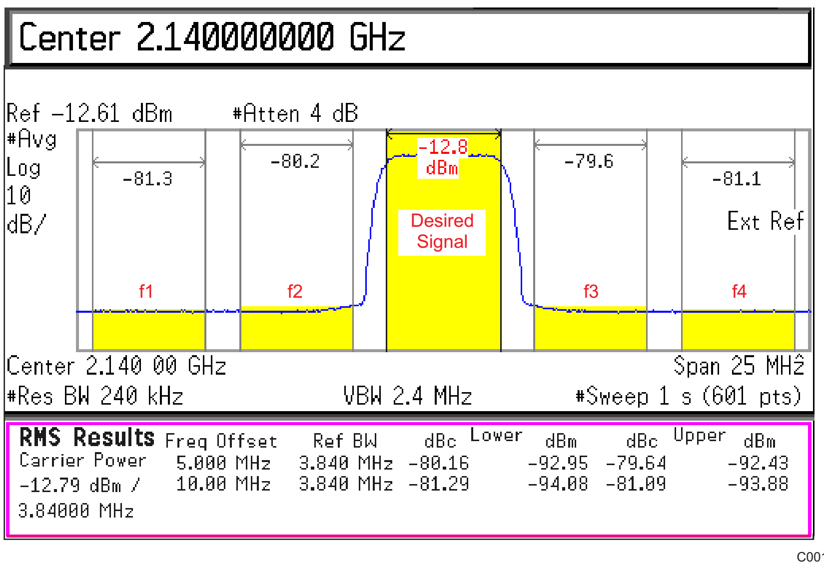

Figure 1. ACPR Spectral Representation of Modulated (Desired) and Adjacent Channels

Figure 2 shows ACPR performance vs the carrier power of of the TRF370317 driven by a DAC5687. It is evident from this figure that from –20 dBm to –13 dBm the ACPR is dominated by noise, whereas the performance from –10 dBm to –4 dBm is dominated by the nonlinearity of the modulator. It is noteworthy to see that the intersection of the two lines is the combined performance of noise and nonlinearity, labeled as Total ACPR. The two carrier frequencies that were selected for each test case are 2140 MHz and 1960 MHz.

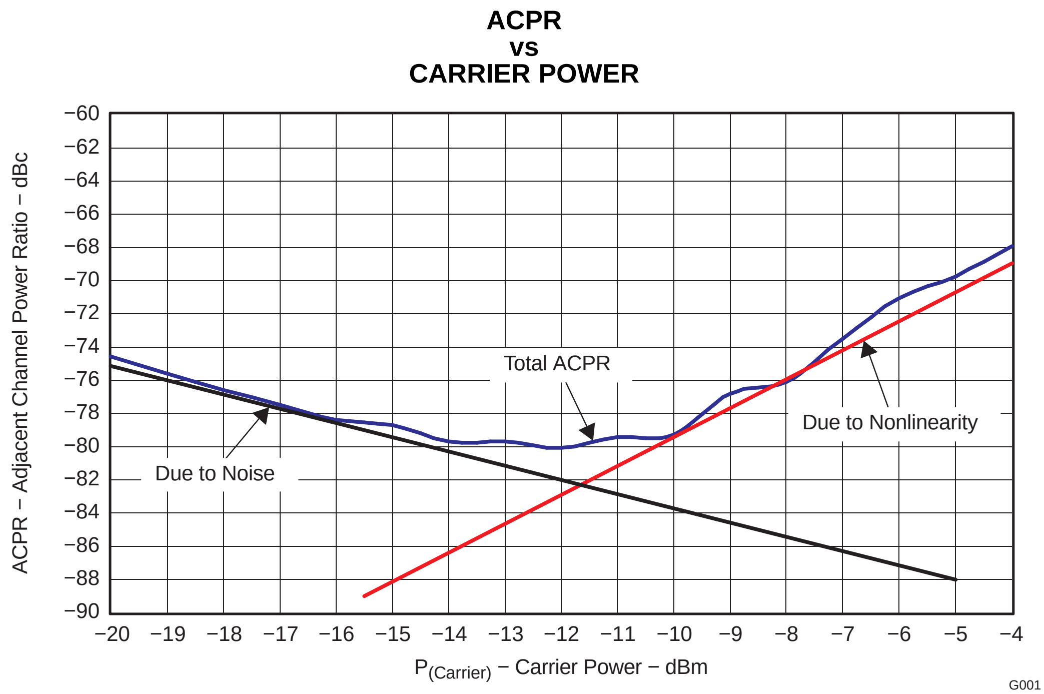

Figure 2. ACPR Performance of Single-Carrier WCDMA Signal Using DAC5687 and TRF370317 vs Carrier Power

1.2 Test Setup With the DAC5687

The following is the test setup used in taking ACPR measurements using the DAC5687 and TRF3703xx. The low-pass filters (LPFs) are used to eliminate any noise from the DAC and only show performance of the TRF3703xx modulators.

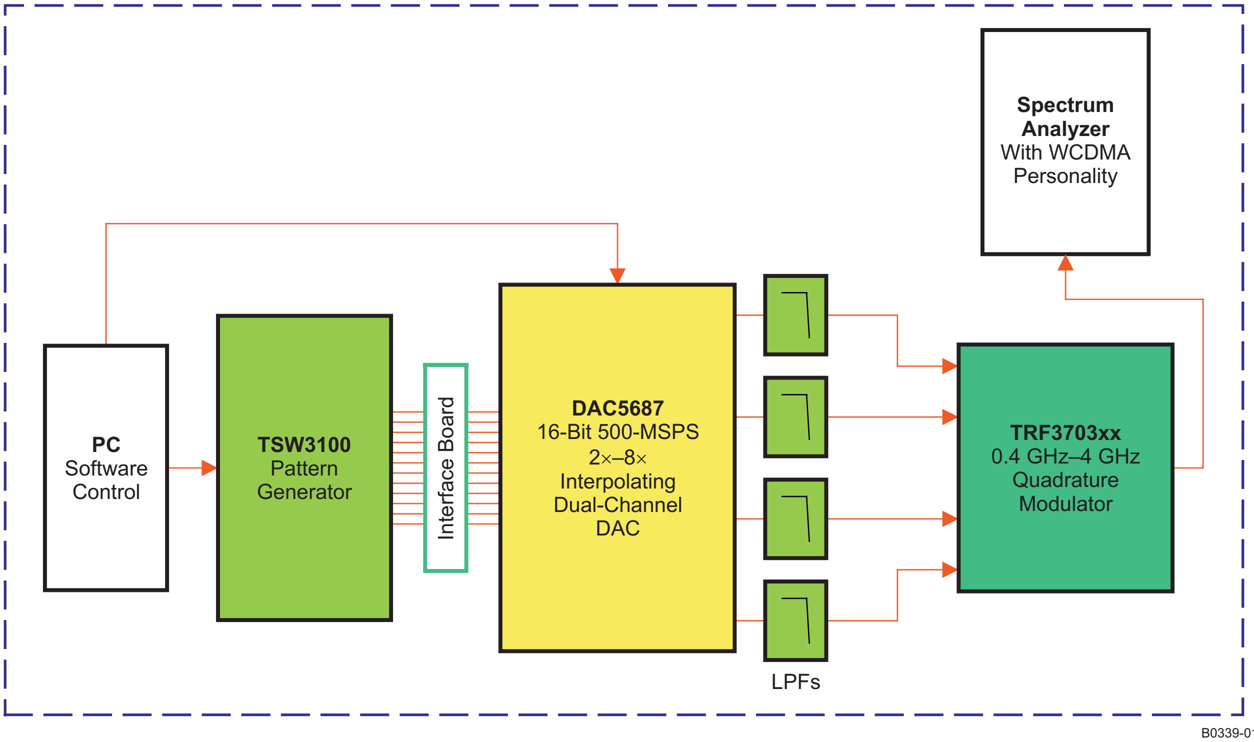

Figure 3. ACPR Test Setup for DAC5687 and TRF3703xx

2 ACPR Results

This section shows ACPR results from all the DAC and modulator combinations used in this test. The first set of data shows ACPR performance using the DAC5687 and all devices in the TRF3703xx family. The TRF3703xx family consists of the TRF370315, TRF370317, and TRF370333. The last two digits in the name indicate the operating common-mode voltage for which each modulator is designed. The DAC568x family has a 3.3-V common-mode voltage, whereas the DAC56x2 family has a common-mode voltage close to 0.5 V. Figure 4 through Figure 9 show the ACPR performance of TRF3703xx devices using the DAC5687 with TTE LPFs . The TTE filters (part number LE760T) are ninth-order LPFs designed with a 1-dB corner frequency at 1.92 MHz, suitable to pass a single received baseband WCDMA signal. Using these filters eliminates any ACPR contribution from the source and only measures the modulator performance.

2.1 DAC5687 and TRF370315 ACPR Results

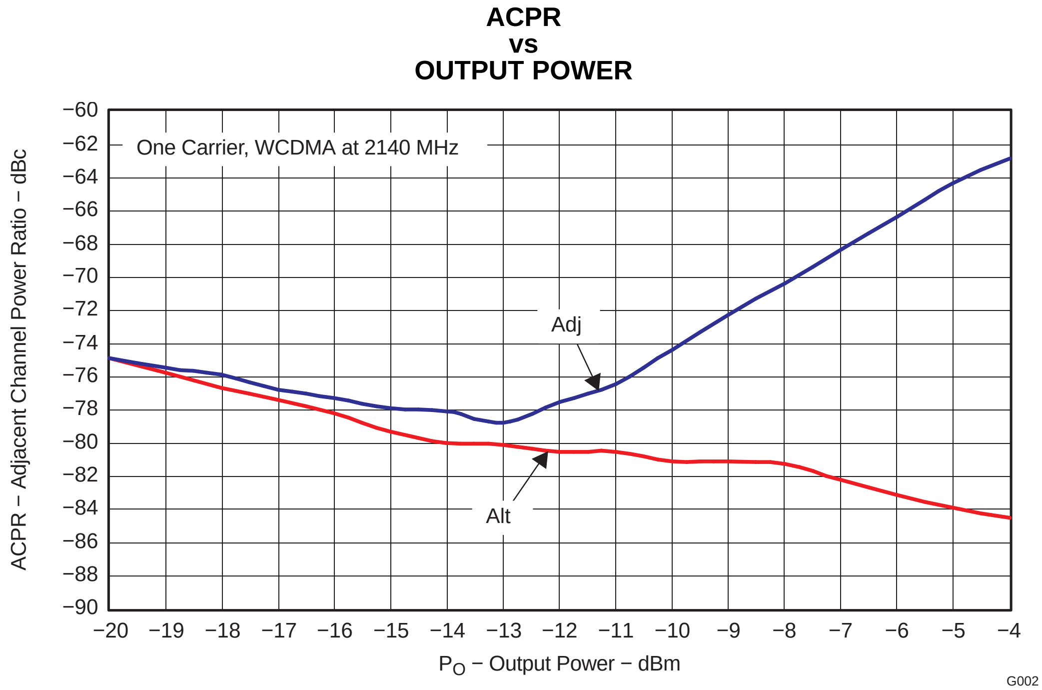

Figure 4. TRF370315 at 2140 MHz

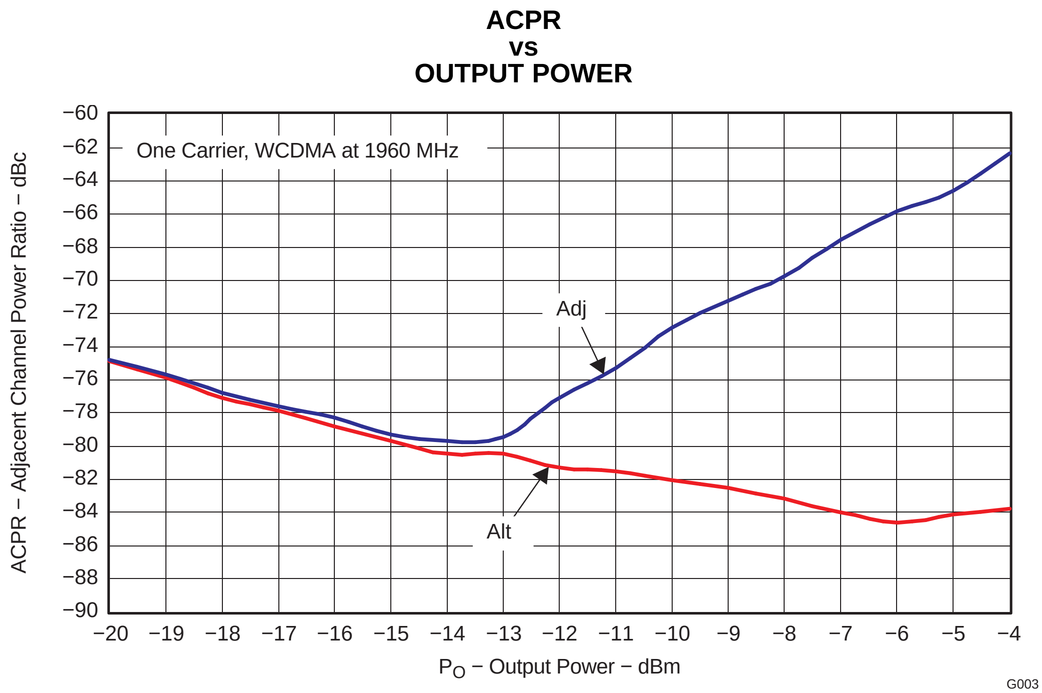

Figure 5. TRF370315 at 1960 MHz

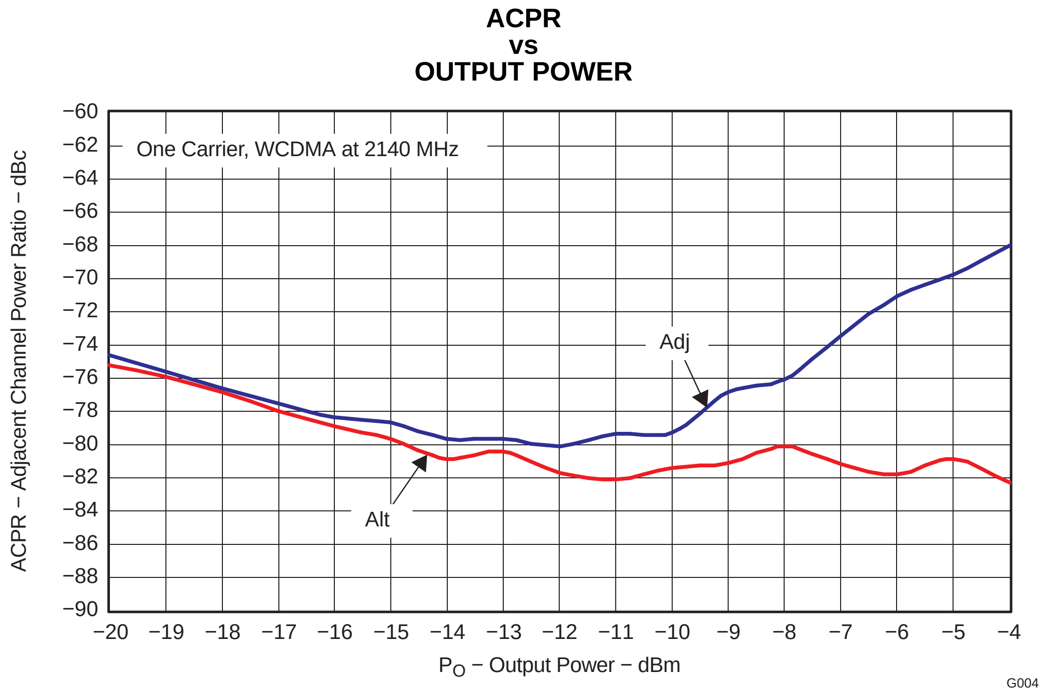

Figure 6. TRF370317 at 2140 MHz

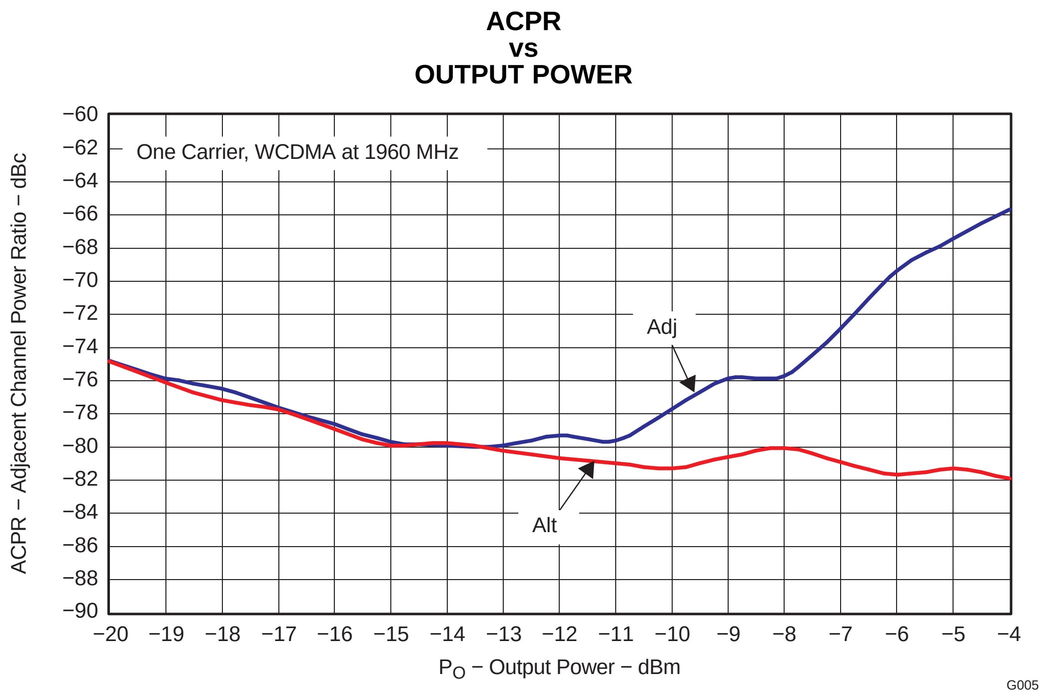

Figure 7. TRF370317 at 1960 MHz

ACPR
vs
OUTPUT POWER

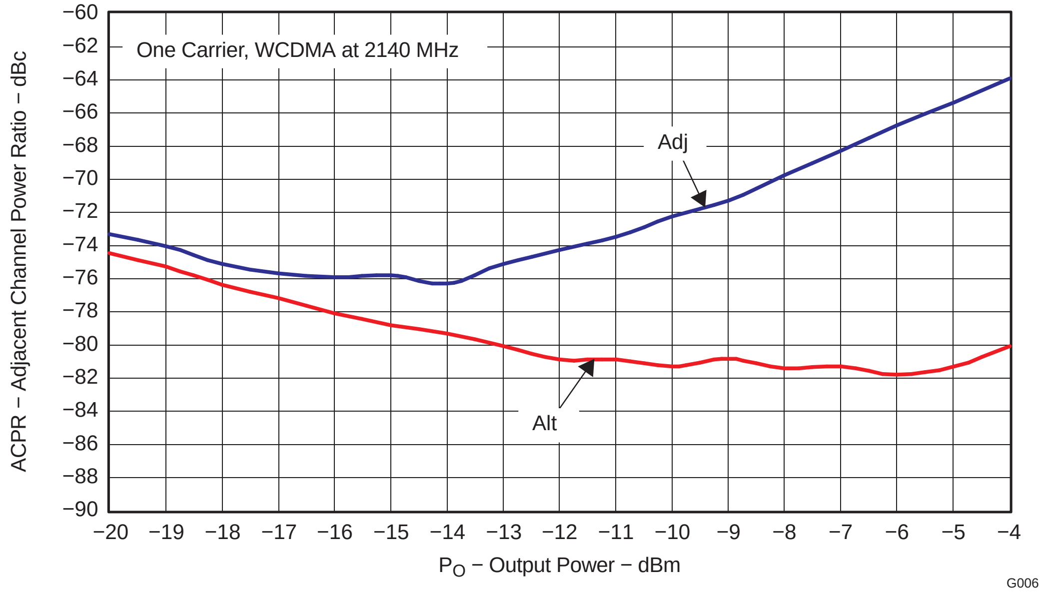

Figure 8. TRF370333 at 2140 MHz

ACPR
vs
OUTPUT POWER

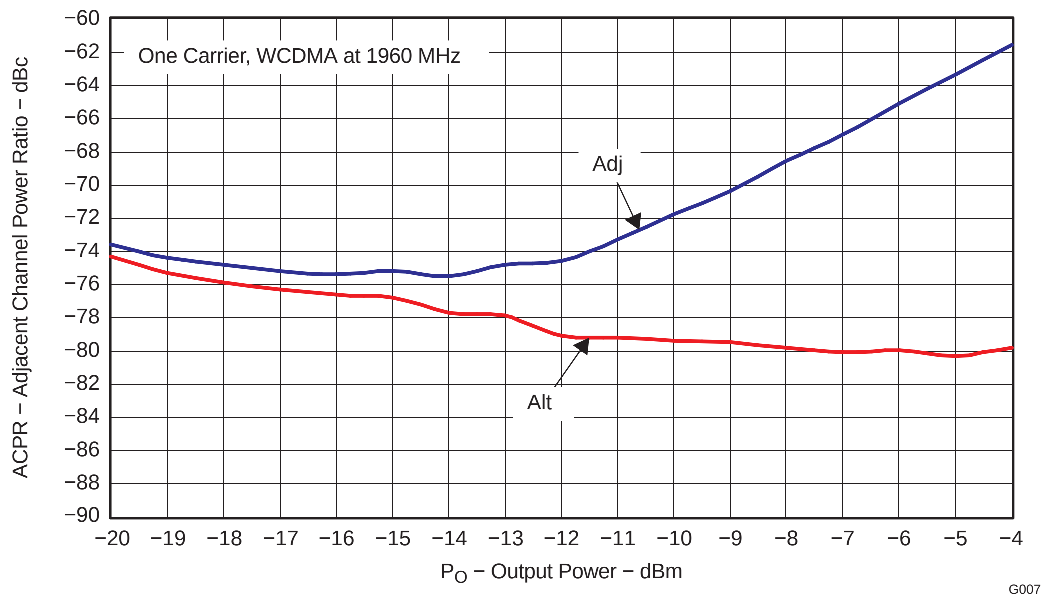

Figure 9. TRF370333 at 1960 MHz

2.2 Test Setup With DAC5672

Figure 10 shows the test setup used for taking ACPR measurements using the DAC5672 and TRF3703xx. There were no LPFs used to eliminate DAC noise. Figure 11 shows the ACPR performance of both the DAC5672 and TRF370317 quadrature modulator.

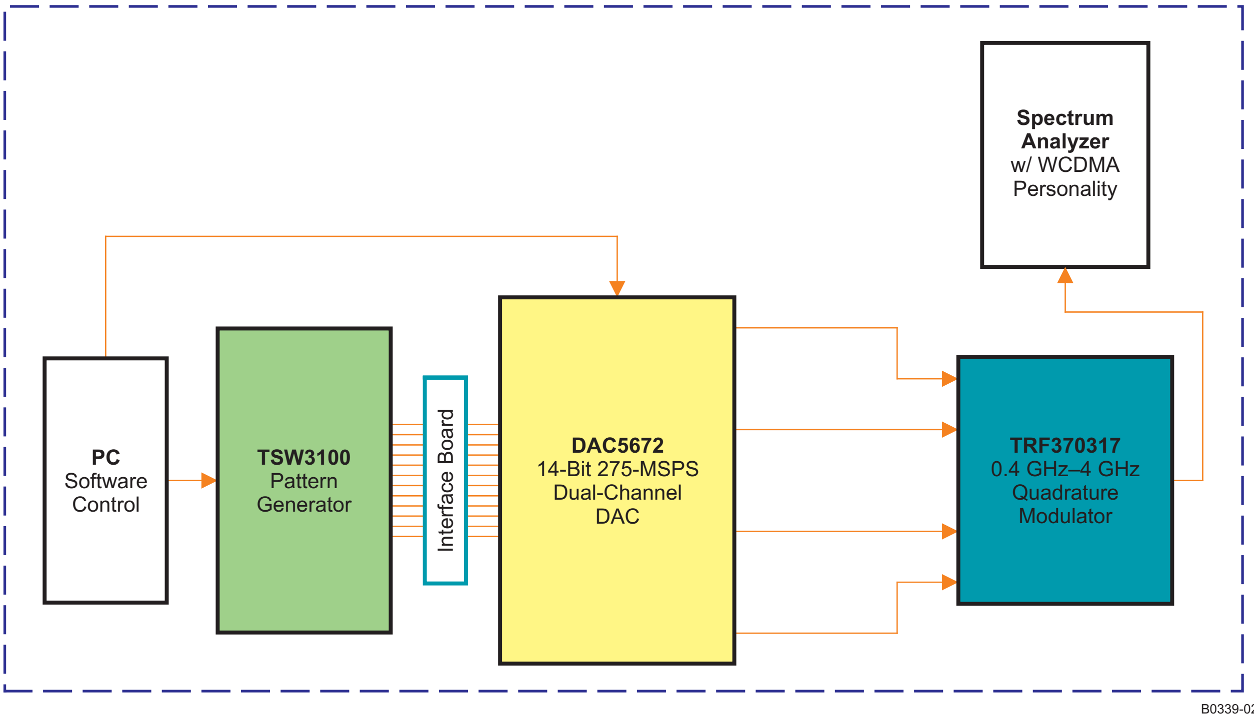

Figure 10. ACPR Test Setup for DAC56x2 and TRF3703xx

3 DAC5672 and TRF370317 ACPR Results

The following set of data is for DAC5672 and TRF3703xx using single-carrier WCDMA signals. The carrier frequencies are 2140 MHz and 1960 MHz. Figure 11 and Figure 12 show show the combined performance of the DAC5672 and the TRF3703xx.

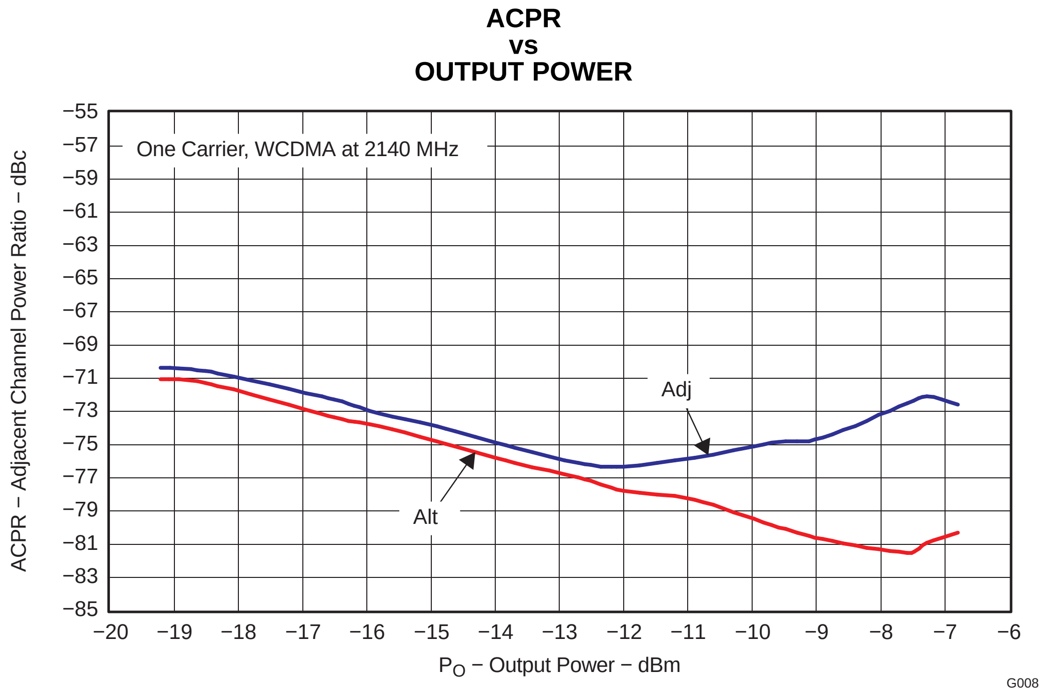

Figure 11. DAC5672 and TRF370317 at 2140 MHz

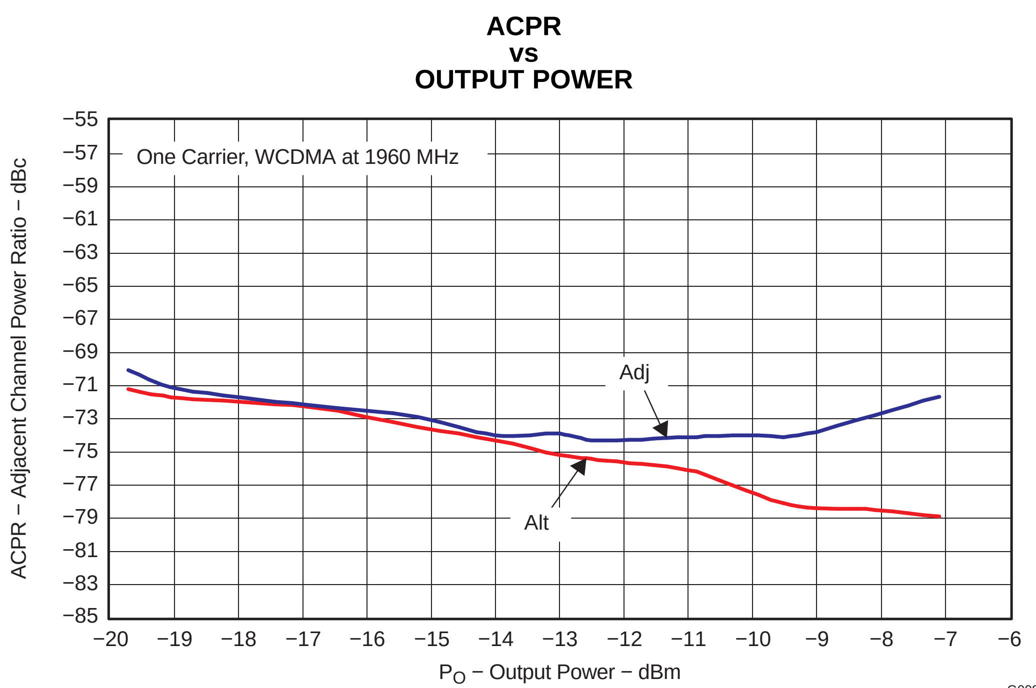

Figure 12. DAC5672 and TRF370317 at 1960 MHz

4 Conclusion

From the previous plots, it is evident that the TRF3703xx quadrature modulator family provides excellent ACPR performance. The exceptional ACPR performance is due to the better linearity performance as indicated in the respective datasheets of the individual devices. The OIP3 performance is better than 26 dBm, OIP2 is better than 60 dBm, and the P1dB compression point is 12 dBm. With such performance, these devices are suitable solution for multicarrier wireless communication standards. The modulators' superior output third-order intercept point (OIP3) allows designs to increase the RF output power while maintaining the stringent ACPR performance required for base-station transmitter applications.

5 References

1. *TRF3703 0.4-GHz to 4-GHz Quadrature Modulator* data sheet, (SLWS184) (for TRF370333 and TRF370315)
2. *TRF370317 0.4-GHz to 4-GHz Quadrature Modulator* data sheet (SLWS209)
3. *TRF3703 Quadrature Modulator Evaluation Module* user's guide, (SLWU042) (for TRF370333 and TRF370315)
4. *TRF3703-17 Quadrature Modulator Evaluation Module* user’s guide (SLWU054)
5. *DAC5687 16-Bit, 500 MSPS 2×–8× Interpolating Dual-Channel Digital-to-Analog Converter (DAC)* data sheet (SLWS164)
6. *DAC5687 EVM* user’s guide (SLWU017)
7. *DAC5672 Dual, 14-Bit 275 MSPS Digital-to-Analog Converter* data sheet (SLAS440)
8. *DAC5672/62/52 14-Bit, 12-Bit, and 10-Bit Dual Channel DAC EVM* user’s guide (SLAU139)
9. *TSW3100 TSW3100 High Speed Digital Pattern Generator* user’s guide (SLLU101)

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