User's Guide

SLWU054A – April 2008 – Revised May 2008

TRF3703-17 Quadrature Modulator Evaluation Module

The TRF370317 is a low-noise, direct quadrature modulator, capable of converting complex modulated signals from baseband or IF directly up to RF. The TRF370317 is a high-performance, superior-linearity device that is ideal for RF frequencies of 400 MHz through 4 GHz. For optimum linearity performance, the device is operated at a 1.7-V common-mode voltage. This document outlines the basic procedure for connecting the EVM to test equipment for basic testing. It also illustrates the measurement parameters related to intercept point, sideband suppression, and carrier rejection that are common to modulator devices.

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1 Overview

This document relates to the TRF370317 direct quadrature modulator for applications in the transmit path of base stations and communications equipment. The TRF370317 operates between 400 MHz and 4 GHz. The quadrature modulator is used for upconversion of signals from the transmit chain DAC to the RF power amplifier device. Evaluating modulator complex performance involves careful bias-voltage setup, an LO signal, and two differential (I/Q) signals at the input of the modulator. This document describes the wide range of test options available and the factors that must be considered in using this EVM.

1.1 Purpose

The TRF370317-17 evaluation module (EVM) is intended for the evaluation of the TRF370317 direct-launch quadrature modulators.

1.2 EVM Circuit Overview

The I signals are connected to J4 (I+) and J3 (I–). The Q signals are connected to J5 (Q–) and J6 (Q+). The LO signal is fed to SMA connector J1, whereas J2 must be terminated with 50 Ω to ground. SMA connector J7 is used to monitor the RF output signal from the quadrature modulator (U1).

The quadrature modulator requires a supply voltage of 4.5 V to 5.5 V from a regulated power supply through headers W1 and W2.

The TRF370317 quadrature modulators require a dc common-mode bias voltage of 1.7 V on all four input pins.

1.3 Power Requirements

The TRF3703-17EVM requires two 5-V V_{CC} dc power-supply connectors through headers W1 and W2. Header W1 supplies 5 V to the LO circuitry, and W2 supplies 5 V to the modulator circuitry.

CAUTION

Voltage Limits

Exceeding 5.6 V may damage the TRF3703.

1.4 TRF3703-17EVM Operating Procedure

Set up the EVM as follows:

1. Power-supply connection:
   a. Switch on the V_{CC} (5-V) supply and set the current limit set to 245 mA.
   b. Connect the 5-V supply to headers W1 and W2.
   c. Verify that the current drawn is approximately 210 mA.
2. Use a suitable 50-Ω output signal generator or the TRF370317 to supply the LO signal at the desired frequency to J1, and terminate J2 with 50 Ω to ground.
3. Use a DAC or an arbitrary waveform generator to provide the I/Q input signals. A typical setup is as follows: a 1-Vp-p sine wave, a frequency of 50 KHz, a dc-offset of 0 V, and an output impedance of 50 Ω (typically an ESG vector signal generator or similar).
4. Set the common mode on the ESG to 0.85 V, corresponding to 1.7 V at the device.
5. Connect a spectrum analyzer to the SMA connector marked RFOUT (J7) and monitor the TRF3703-17 output.

1.4.1 Typical Test Results

1.4.1.1 Un-Optimized Sideband Suppression

Un-optimized sideband suppression measures the amount by which the unwanted sideband of the input signal is attenuated in the output of the modulator, relative to the wanted sideband. This assumes that the baseband inputs delivered to the modulator input pins are perfectly matched in amplitude and are exactly 90° out of phase. Un-optimized sideband suppression is measured in dBc. An iterative test is required in order to match perfectly the inputs to the modulator. This ensures that any equipment, board, or signal conditioning component imbalances are corrected before the signals are applied to the device under test. Once the baseband inputs to the modulator are balanced, the amount of suppression attained is a measure of the internal mismatches of the modulator, inherent to any modulator design. This suppression is the one specified in the TRF370317 data sheet. See Figure 1.

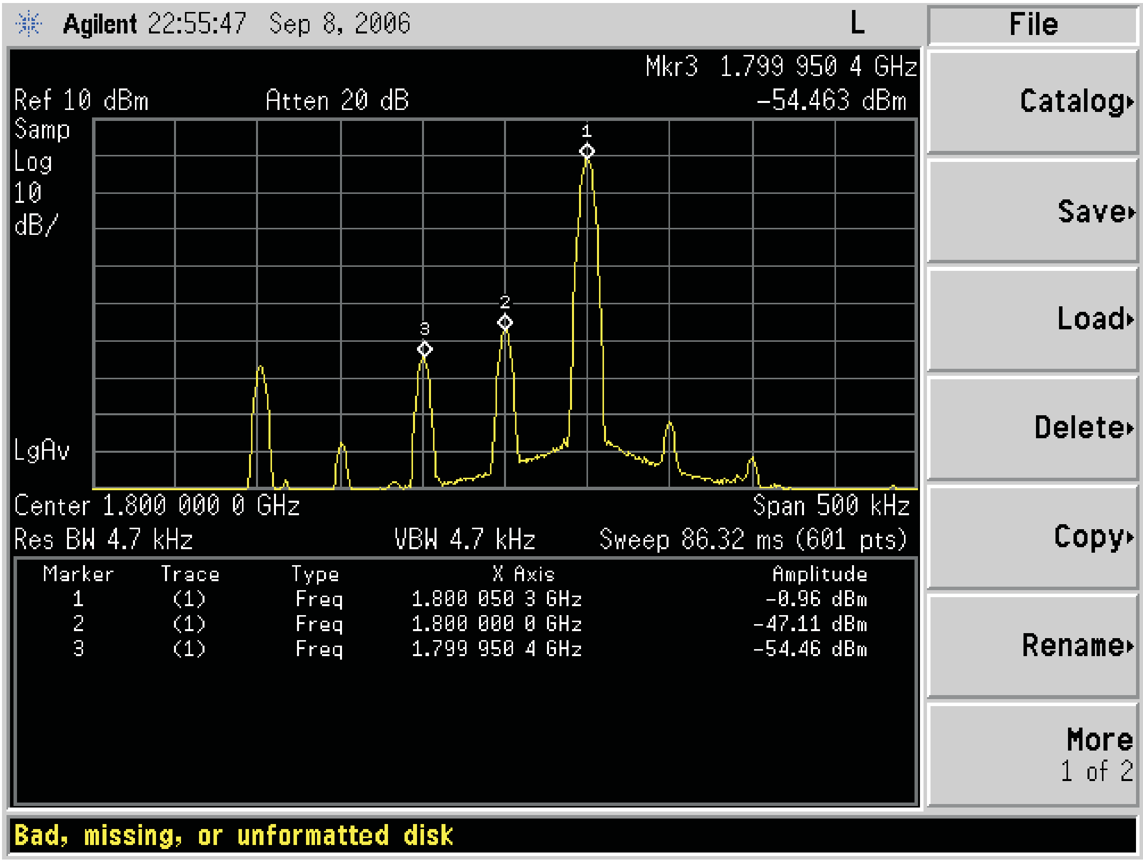

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Figure 1. Un-Optimized Sideband Suppression

1.4.1.2 Optimized Sideband Suppression

There are two ways to change the sideband suppression of the TRF370317. One is the amplitude between the four inputs, and the second is the phase of the four inputs. The ideal condition is when all four inputs (I, $\overline{I}$, Q, and $\overline{Q}$) have exactly the same amplitude and the phase relationship is: I = 0°, $\overline{I}$ = 180°, Q = 90°, and $\overline{Q}$ = 270°. Also, the optimization of the sideband is controlled by the amplitude and phase of the I and Q signals, which are controlled with the gain settings of the DAC. This is an iterative procedure that results in optimized suppression levels that exceeds 60 dBc. The level of suppression observed depends on the amount of resolution available from the DAC driving the modulator. By using TI's DAC568X, the user can take advantage of built-in features (DAC fine gain) to optimize the sideband suppression by changing the amplitude relationship of the signals. If another DAC is used, then the user must provide this level of adjustment by controlling the regular digital inputs to the DAC. See Figure 2.

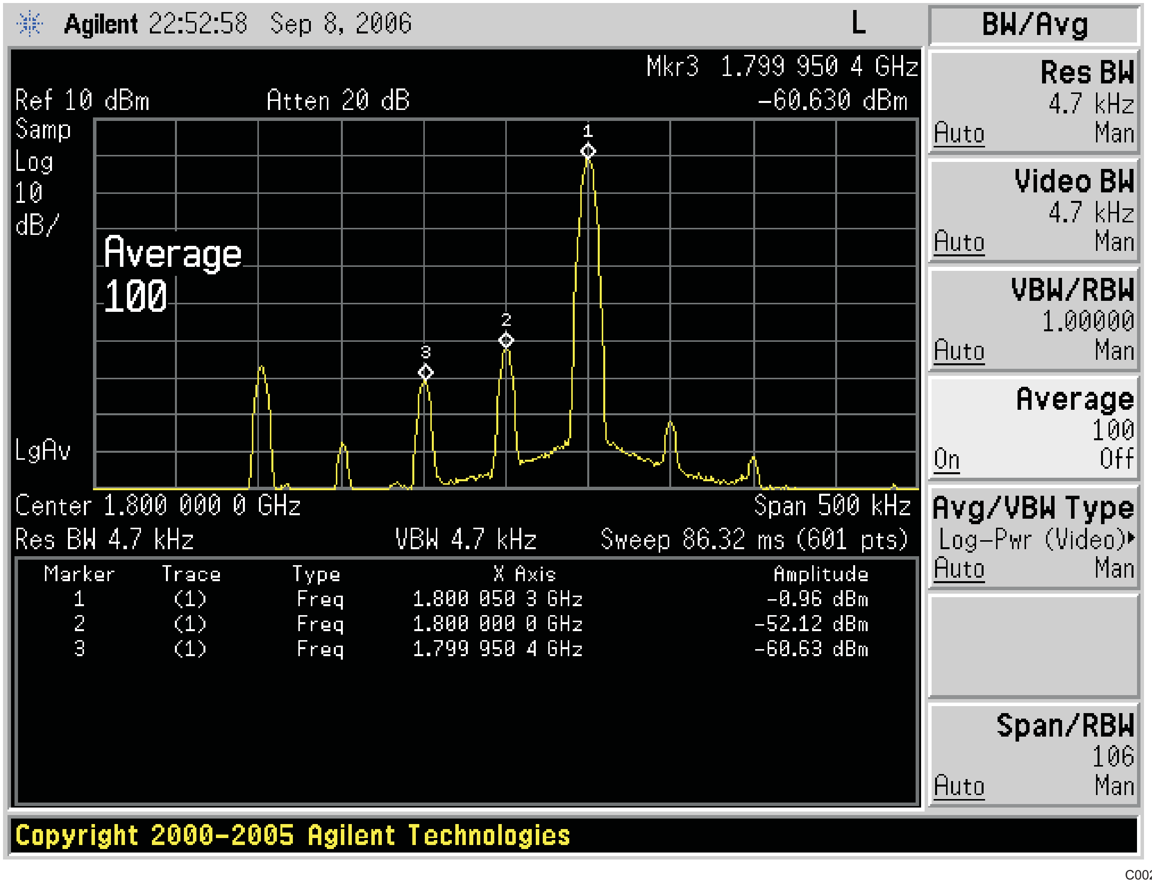

Figure 2. Optimized Sideband Suppression

1.4.1.3 Carrier Feedthrough

Carrier feedthrough is the amount of the LO that leaks onto the output spectrum of the modulator. Ideally for the TRF370317, inputs (I, $\overline{I}$, Q, and $\overline{Q}$) must be at approximately 1.7 V for TRF370317. The DAC dc settings are also useful to correct the dc mismatch between I and $\overline{I}$ and between Q and $\overline{Q}$ to correct for the LO feedthrough. If using TI's DAC568X, then the internal controls for the IQ offsets provide excellent carrier suppression (very low LO leakage). Alternatively, if an ESG is being used, adjust the I and Q voltage offsets in mV steps until you obtain the minimum carrier feedthrough. A typical carrier feedthrough value is below -50 dBm. See Figure 2.

1.4.1.4 GSM (EDGE EVM Measurements)

1. Provide a GSM edge signal of the desired frequency into the differential baseband inputs (example sample rate = 4.33 MHz).
2. Use a spectrum analyzer with edge personality to measure the transmit power to either 0 or –5 dBm.
3. PSA: Mode → GSM(w/ EDGE) → measure → Transmit Pwr(usually 0 or –5 dBm) → more → EDGE EVM.
4. ESG: Mode setup → select waveform → highlight EDGE → select waveform → ARB setup → type 4.33333 MHz → I/Q → I/Q output control → Common mode I/Q offset → (set to either 1.65 V for TRF3703-33 or to 0.75 V for TRF3703-15) → I/Q → I/Q output control → I/Q output atten (adjust to get desired transmit power to either 0 or –5 dBm).

See Figure 3.

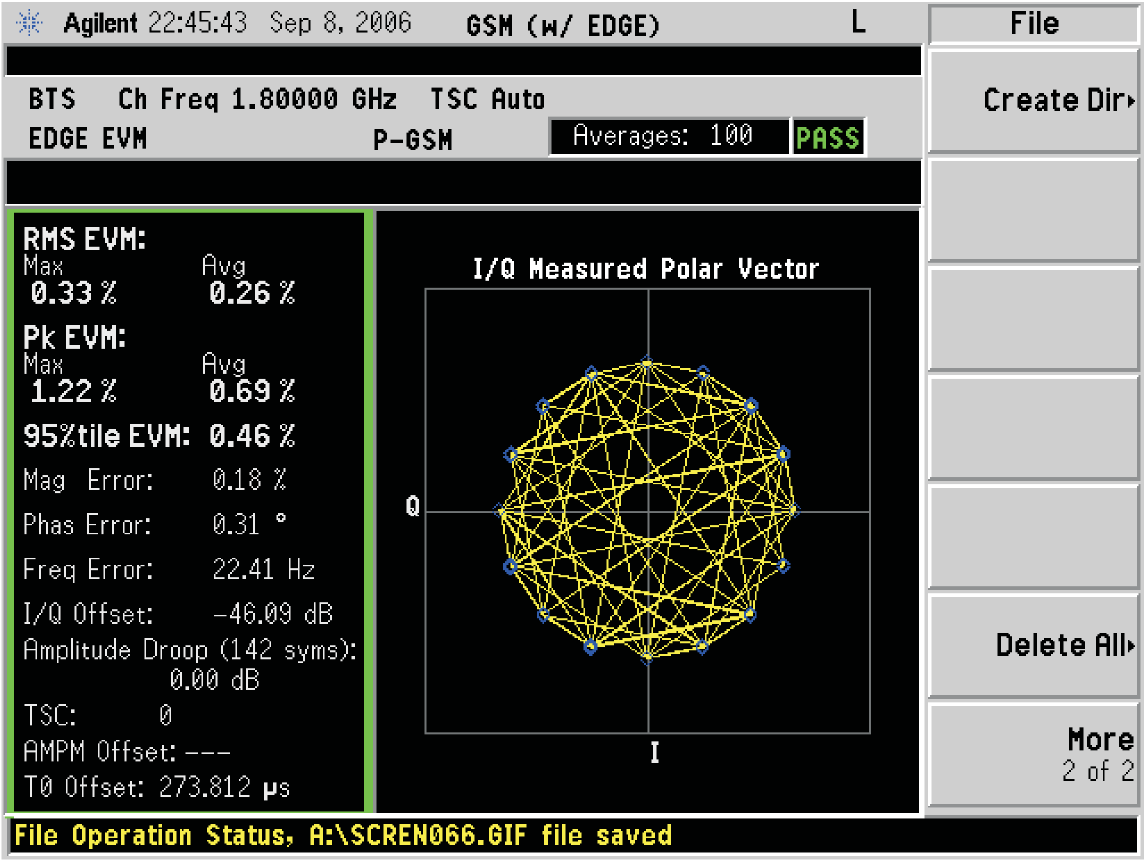

Figure 3. GSM EDGE EVM at 1800 MHz

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 4.5 V to 5.5 V and the output voltage range of 4.5 V to 5.5 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 85°C. The EVM is designed to operate properly with certain components above 85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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