Application Report
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Time Division Duplexing (TDD) Adjusted Carrier-Feedthrough Evaluation

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ABSTRACT

Time Division Duplexing (TDD) is a communication technique allowing for two-way communication within the same frequency band by alternating the transmission times of a device. An important parameter for devices in these TDD-transmission systems is the transient response of the adjusted carrier feedthrough when the devices are rapidly turned on and turned off. When a device transitions to the active transmitting state, quickly achieving and maintaining the lowest adjusted carrier-feedthrough levels possible is important. Quickly achieving the lowest adjusted carrier-feedthrough levels keeps the carrier signal from masking the desired information and allows for greater available transmission time. To demonstrate an evaluation of the adjusted carrier feedthrough performance in a TDD application, this application report uses the low-noise quadrature modulator, TRF37T05, which provides a fast power-down pin that reduces power dissipation while maintaining optimized adjusted carrier-feedthrough performance in TDD applications.

Resources:

- TRF37T05, product folder
- High Speed Data Converter Pro, software
- DAC30H84 Graphical User Interface (GUI), software

Figure 1. Photograph of TSW1400 and TSW30H84 Evaluation Modules

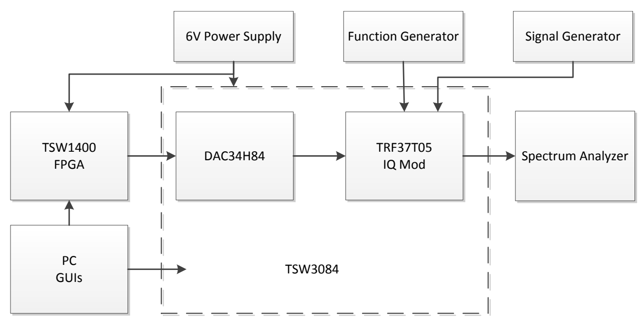

Figure 2. Block Diagram of Evaluation Setup

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1 Introduction

When modulators are used in TDD systems, they can rapidly turnon and turnoff to provide two-way communication in the same frequency band which results in power conservation. In order to meet the closed-loop spectral-mask emissions with digital pre-distortion, users generally require the adjusted carrier-feedthrough level of the transmitter be at least 55 dBc at an output power of 5 dBm. Transmitters typically have a pre amplifier with a gain of approximately 20 dB after the modulator. In order to meet the system requirement, the carrier-feedthrough level at the output of the modulator must reach approximately –70 to –75 dBm within 10 s of µs. This measurement was designed to verify the ability of the TRF37T05 quadrature modular in order to maintain the required carrier-suppression power level while rapidly turning on and turning off in TDD systems.

The adjusted carrier-feedthrough suppression occurring in the TRF37T05 is accomplished by a quadrature modulator inside the device. The carrier feed through occurring on the RF output is a result of a mismatch in the DC offset voltages in the IQ signals. In order to achieve significant carrier suppression at the RF output, the DC mismatch must be finely adjusted achieve the greatest cancellation. Because of the sensitivity of the circuit to the DC offset, a DAC34H84 is used to control the DC offset of the IQ-baseband signals in this evaluation. The DAC34H84 has the ability and resolution to fine tune the DC offset of the baseband signals to achieve the required level of carrier suppression.

The TDD adjusted carrier-feedthrough measurement is a time-domain measurement that reviews the transition from the off-state of the device to the on-state of the device. The measurement evaluates how quickly the device achieves the desired adjusted carrier-feedthough power level. A properly setup spectrum analyzer executes this measurement.

2 Evaluation Set Up and Procedure

There are several pieces of equipment that must be properly setup in order to evaluate the adjusted carrier-feedthrough transient response in a TDD application. Figure 3 is a block diagram of the evaluation set up.

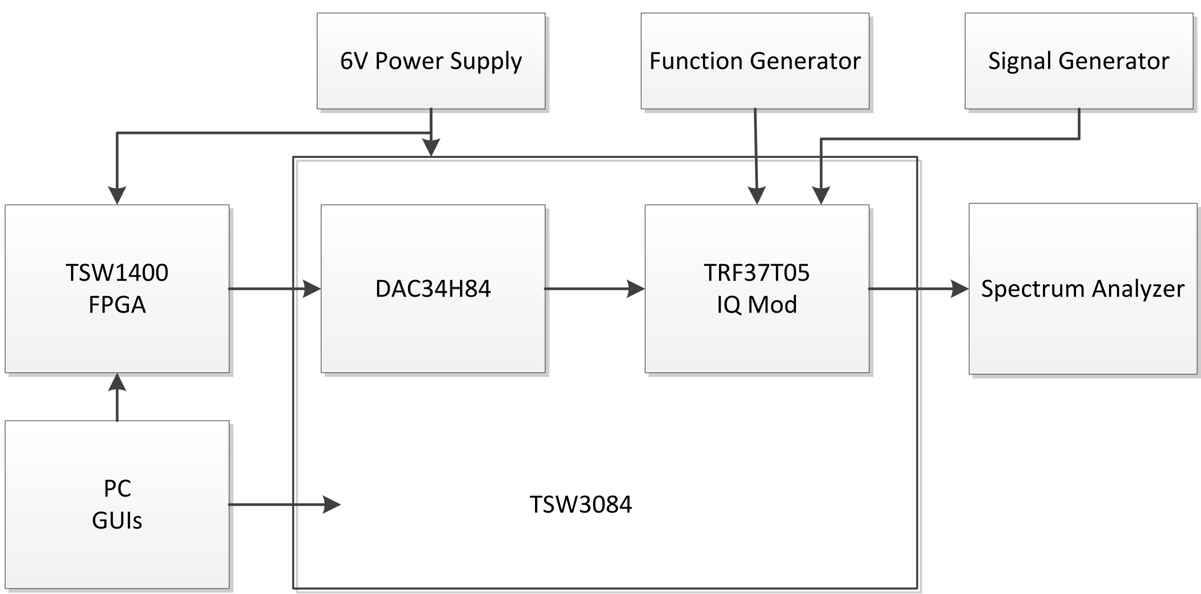

Figure 3. Block Diagram of Evaluation Set Up

The difficulty in the spectrum-analyzer setup is achieving the correct resolution to properly see the transition between the on-state and off-state of the device. The spectrum-analyzer attenuation is set to 0 and the pre-amplifier is turned on in order to lower the noise floor of the spectrum analyzer to detect the low level of the adjusted carrier feed through signal. Sufficient resolution for this evaluation was obtained by setting the resolution bandwidth and video bandwidth to 5 MHz. Setting the resolution bandwidth too low influences the transient response of the carrier power level and results in an inaccurate representation of the true carrier-feedthrough power level during the rapid transitions.

Another accuracy issue that must be addressed when setting up this evaluation is keeping the phase noise of the up-converted baseband signals from interfering with the carrier-feedthrough measurement. When measuring low power levels and opening up the resolution bandwidth, steps must be taken to keep unwanted signals from appearing in the measurements. The purpose of the solution used in this evaluation is not to provide the modulator with any baseband signals. Note that the TSW1400 GUI register setting *Scaling Factor* is set to 0 and does not generate a baseband signal. Unwanted phase noise is also eliminated by placing a bandpass filter before the spectrum analyzer to attenuate the baseband-signal noise from interfering with the carrier-feedthrough measurement.

Adjusting the DC offset of the IQ signals with DAC34H84 is important to achieve the lowest carrier suppression each time a measurement is taken or each time a parameter is changed due to the sensitivity of the device to the DC offset. The DC offset is sensitive enough that just touching a baseband cable or bumping the setup could result in 20 dB of change in the carrier suppression. Using PCB traces from the DAC34H84 to the TRF37T05 instead of two EVMs and cables was observed to reduced the sensitivity of the DC offset adjustments. This evaluation uses a DAC30H84 EVM with the TRF3705 replaced with a TRF37T05.

1. Program the TSW1400 and DAC34H84 with the register settings described below.

TSW 1400 GUI and Register Settings (See Figure 4)

Preamble:	0
Data rate (SPS):	307.2 M
DAC option:	2's compliment
Active channel:	Channel 1
Tone BW:	0
Number of tone:	1
Tone Center:	1 M
3 samples:	65536
Tone selection:	Complex
Tone selection:	0

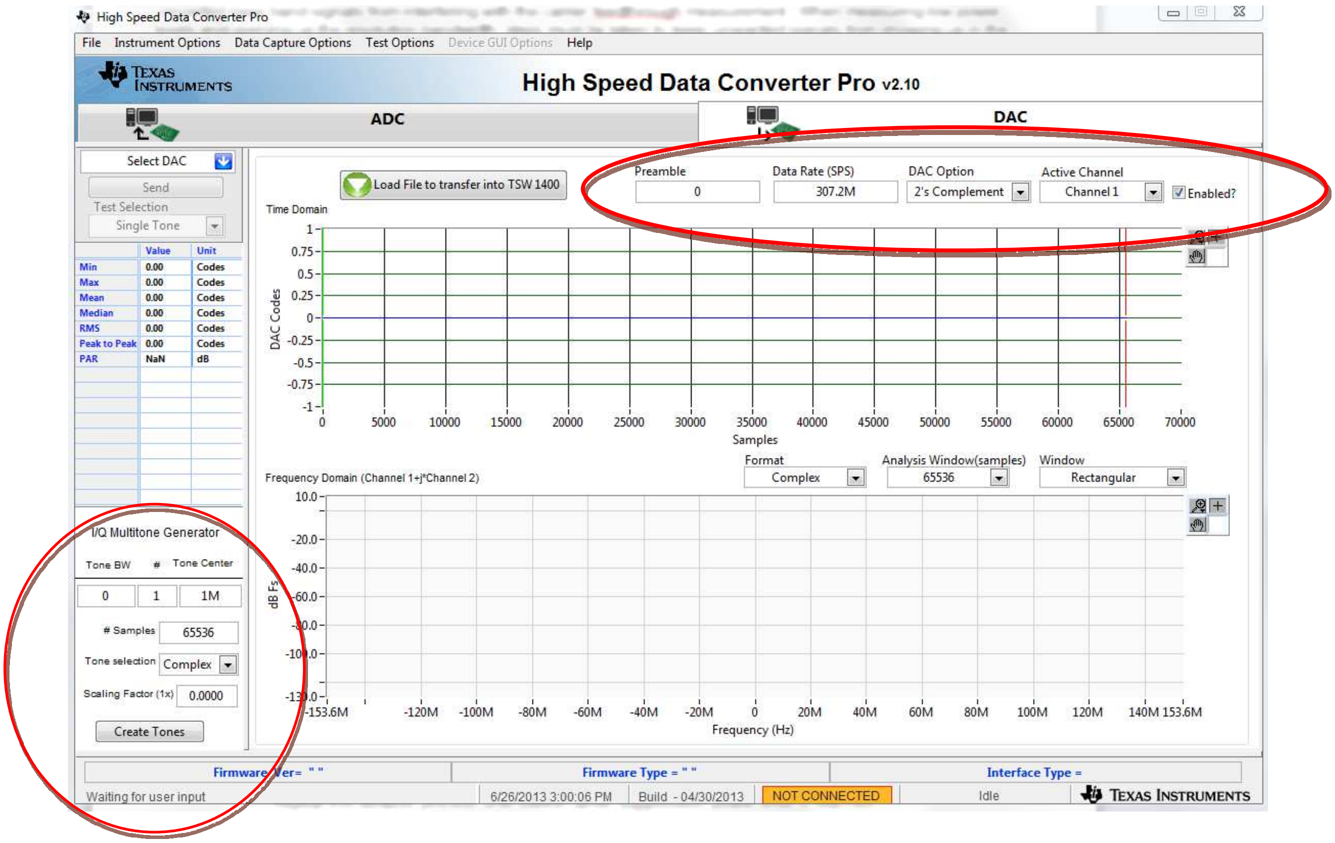

Figure 4. TSW1400 GUI Screen Shot

DAC38H84 GUI and Register Settings (See Figure 5)

Load configuration file :	DAC34H84_FDAC_1228p8MHz_NCO_30MHz_QMCon.txt
Offset adjustment:	Enabled
F sample:	1228.8 MHz

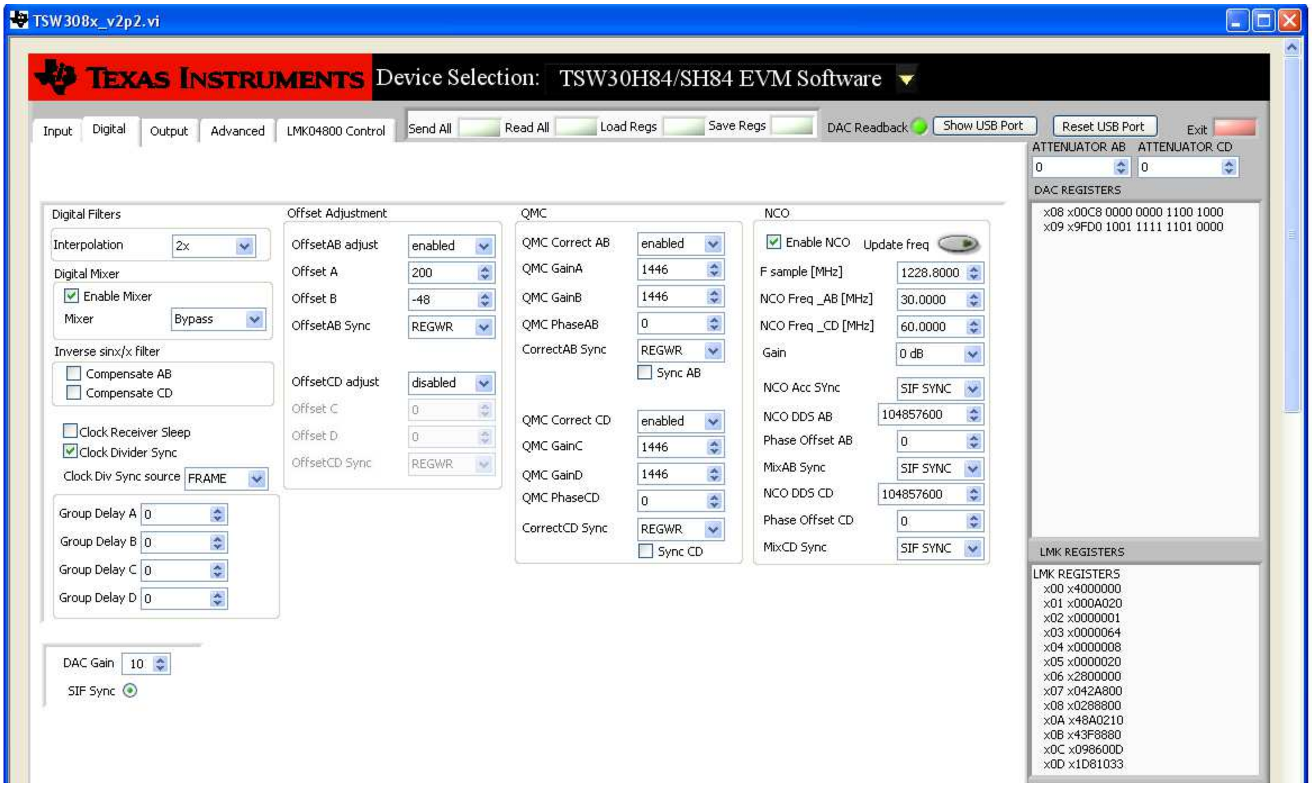

Figure 5. TSW30H84 GUI Screen Shot

2. Set the spectrum analyzer.
   - Sync the trigger of the Spectrum Analyzer and the Function Generator driving the 3.3-V Power Down signal to TRF37T05.

Agilent MXAN9020A Spectrum-Analyzer Settings for TDD-Suppressed Carrier Response

Center Frequency:	900 MHz
Span:	0 MHz
RBW:	5 MHz
VBW:	5 MHz
Sweep:	100 µs [Zoomed image], 6 ms [1 frame image]
Number of sweep points:	1000 points [the more points, the better]
Attenuation:	0 dB
Reference level:	approximately –60 dBm
Trigger level:	1.5 V
Trigger delay:	Negative-edge triggering [adjust as per center image capture]
Detector:	Average [Log / RMS / V]
Scale/div:	3 dB [adjust as per proper image capture]
Reference-level offset:	0.7 dB [adjust as per cables loss]
Internal Preamplifier:	ON

3. Set the signal generator.

Rohde and Schwartz Signal Generator Used as DAC Clock

Frequency:	1228.8 MHz
Power Level:	10 dBm

4. Set the function generators.

HP 33120A 15-MHz Function Generator Driving TRF3705 PD pin

Waveform:	Square
Amplifier:	1.65 V
Offset:	850 mV

Agilent E4438C ESG Vector Signal Generator Used as TRF37T05 Local Oscillator

Frequency:	900 MHz
Power level:	10 dBm

5. Use the offset adjustment of the DAC34H84 GUI to tune the IQ DC offset to achieve the lowest carrier-feedthough level possible.
   (a) Increase or decrease the value in adjustment A until adjustment of the number does not further suppress the carrier.
   (b) Increase or decrease the value in adjustment B until adjustment of the number does not further suppress the carrier.
   (c) Repeat this iterative process until the lowest carrier-suppression power level is reached.
6. 6. Apply a 3.3-V 100-Hz signal to the power-down pin of the TRF37T05.

3 Evaluation Results

The TRF37T05 demonstrates that it quickly achieves the desired adjusted carrier-feedthrough level in a TDD application. Figure 6 and Figure 7 show that when in the off-state, the TRF37T05 has a carrier power level of –62 dBm and transitions to a carrier power level of –80 dBm in 2 µs while in the on-state .

	Desired Goal	Measured
Adjusted Carrier feed through power level	< –75 dBm	–80 dBm
Time to reach adjusted carrier suppression	< 10 µs	2 µs

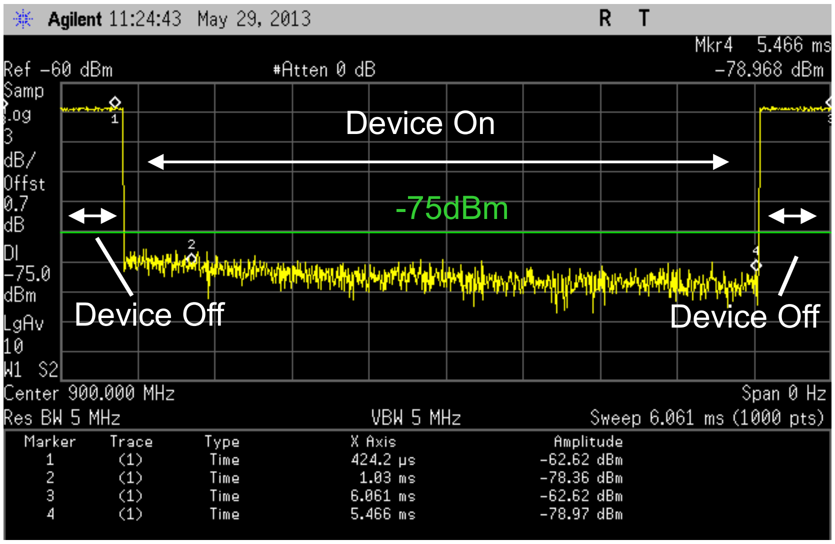

Figure 6. TRF37T05 TDD Adjusted Carrier-Transient Response

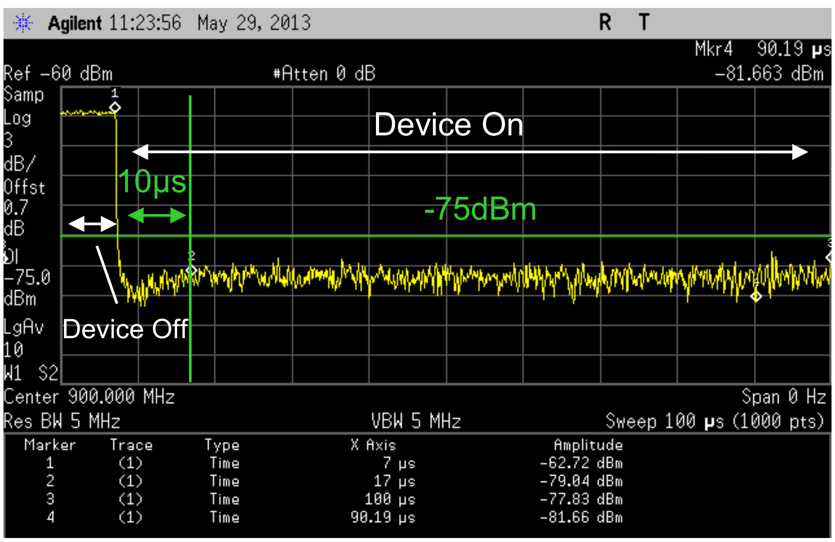

Figure 7. Zoomed in TRF37T05 TDD Adjusted Carrier-Transient Response

4 Conclusion

This evaluation demonstrates the setup required for proper measurement of adjusted carrier feedthough in a Time Division Duplexing (TDD) application. Some difficulty is involved with isolating the carrier-feedthough power level from the modulated baseband signals and ensuring that the spectrum analyzer has enough resolution bandwidth for a proper transient-response measurement. When the measurement equipment is properly set, the TRF37T05 quadrature modulator is clearly able to meet the desired requirements for a TDD operation. The device achieved an adjusted carrier-feedthough level below –70 to –75 dBm within 10 s of µs while rapidly turning on and turning off. The ability of the TRF37T05 to turn on and turn off without losing carrier-feedthrough performance allows the user to save power in TDD applications.

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