# Optimizing Carrier and Sideband Suppression

Yiannis Papantonopoulos
Wireless Infrastructure - Radio

**ABSTRACT**

This document describes the process for optimizing carrier and sideband suppression.

## 1 Sideband Suppression

There are two ways to change the sideband suppression of the TRF3701. 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 (IVIN, IREF, QVIN, and QREF) have exactly the same amplitude and the phase relationship is: IVIN=0 is IREF=180, QVIN= 90, and QREF=270 degrees respectively. The following graph illustrates these signals. In the real application, the signals are not sinusoidal, but will contain the true WCDMA information.

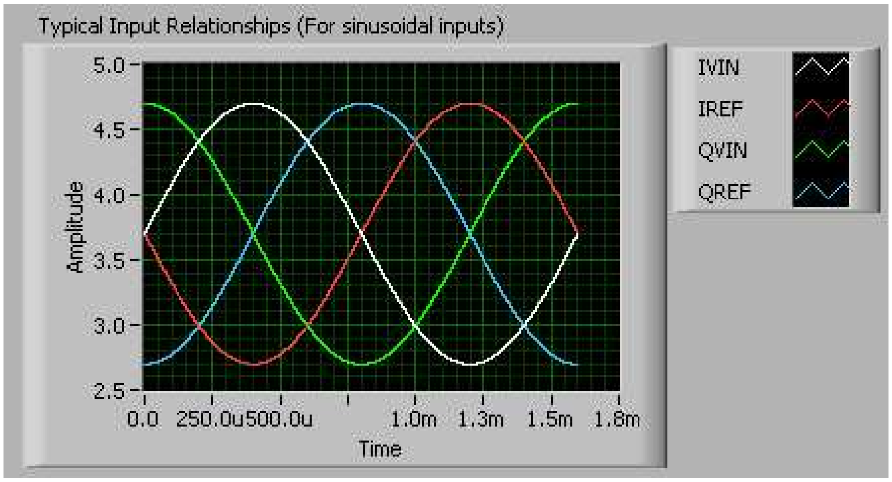


**Figure 1. TRF370x Input Signal Amplitude and Phase**

### 1.1 Amplitude Change

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 desired sideband. This assumes that the baseband inputs delivered to the modulator’s input pins are perfectly matched in amplitude and are exactly 90° out of phase. This is measured in dBc.

An iterative test is required in order to perfectly match 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 TRF3701 datasheet (SLWS145) as the un-optimized sideband suppression.

The sideband suppression can be optimized by adjusting the relative amplitude and phase relationship of the baseband inputs to the modulator. This is an iterative procedure that results in optimized suppression levels that exceed 50dBc and can theoretically be infinite. The level of suppression observed depends on the amount of resolution available from the DAC driving the modulator. By using TI's DAC5686 the user can take advantage of built-in features to optimize the sideband suppression by changing the amplitude relationship of the signals. If another DAC is used, then the user has to provide this level of adjustment through controlling the regular digital inputs to the DAC. The following graph shows a theoretical sideband suppression and phase and amplitude imbalances on an IQ modulator along with equations relating amplitude and phase imbalance to resulting sideband suppression.

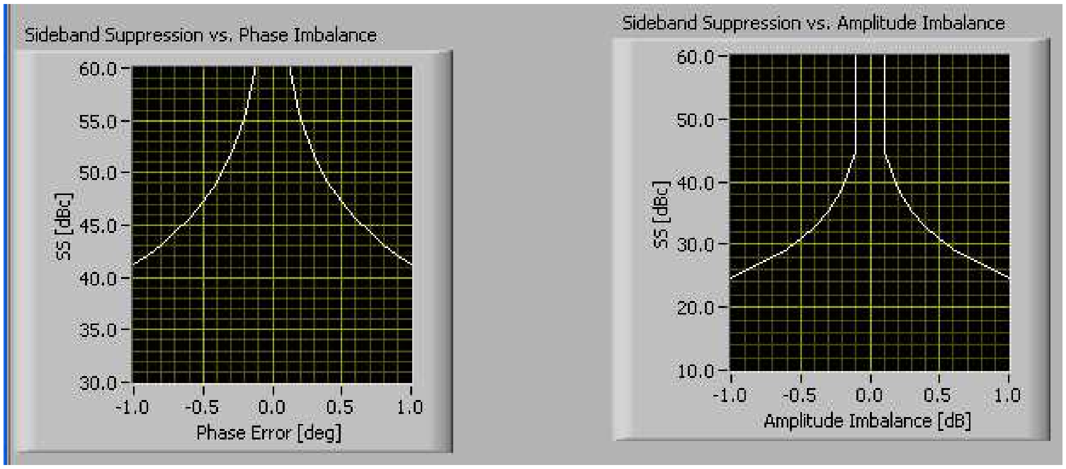


**Figure 2. Theoretical Sideband Suppression and Phase and Amplitude Imbalances**

When amplitude imbalance is zero, sideband suppression caused by phase imbalance can be calculated using the formula:

Sideband Suppression (dB) = -20×log10{ tan (delta/2) } -- (1)

where delta is the phase imbalance in degrees.

Similarly when phase imbalance is zero, sideband suppression caused by amplitude imbalance can be calculated using the formula:

Sideband Suppression (dB) = -20×log10{ (1-A)/(1+A) } --(2)

where A is $10^{(0.05\times \text{amplitude imbalance in negative dB})}$.

## 2 Carrier Suppression

DC-offset is away to control carrier suppression, or the amount of the LO that leaks onto the output spectrum of the modulator. This done in the same as the sideband suppressions described previously. The following graph shows the theoretical carrier suppression versus offset imbalance.

Carrier suppression in the presence of DC-offset can be calculated using the formula:

Carrier suppression (dB) = 20×log10[ (Vbb) / ] --- (3)

Where is the baseband DC-offset and Vbb is the peak baseband voltage

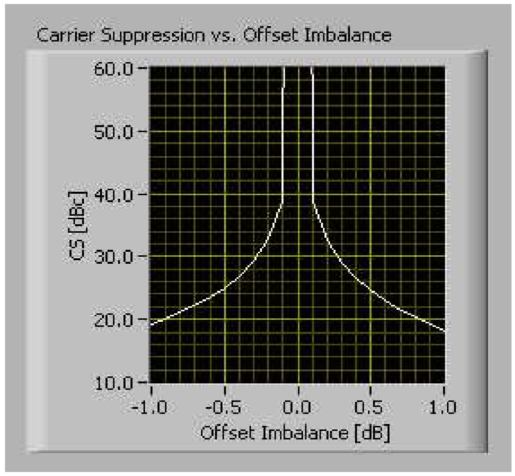


**Figure 3. Theoretical Carrier Suppression vs Offset Imbalance**

Ideally for the TRF3701 inputs (IVIN, IREF, QVIN, and QREF) have to be at around 3.7V. The DC level can be changed through several ways, depending on the architecture. If using the DAC5686, then the internal controls for the IQ offsets provide excellent carrier suppression (very low LO leakage). Alternatively, the DC offset could be changed through a passive resistive level shifting and adjusting network as shown in the following figure. The TRF3701 EVM has two potentiometers that can be used to minimize the leakage. The following schematic shows this implementation on our board. Either supply one external voltage and use the potentiometers to adjust the DC-offset, or provide two different external supplies.

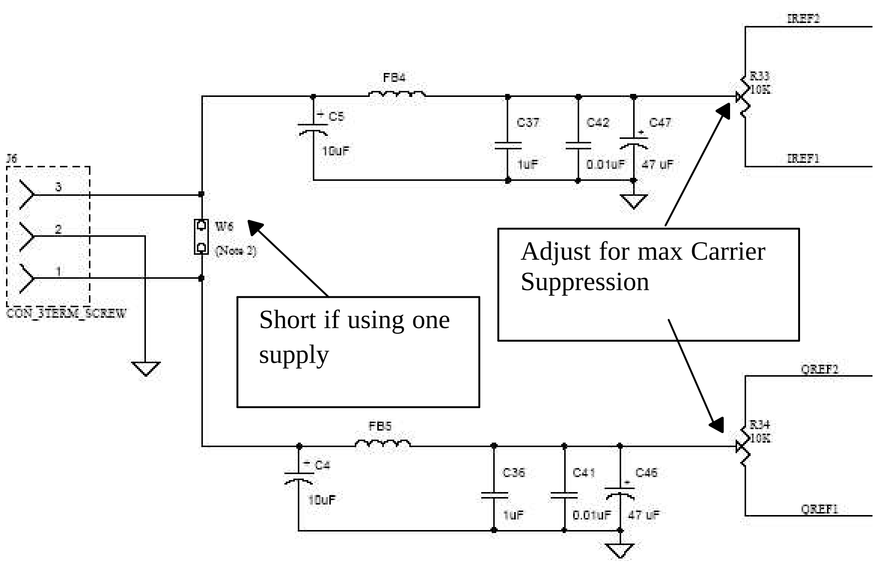


**Figure 4. TRF3701 EVM Implementation**

If one supply is used, then the DAC5686 digital features can be used to optimize the carrier suppression. The following illustration is a schematic of the circuit that interfaces the two components. A passive, 3-resistor network provides the level shifting from the output of the DAC to the input of the modulator (about 3.7VDC).

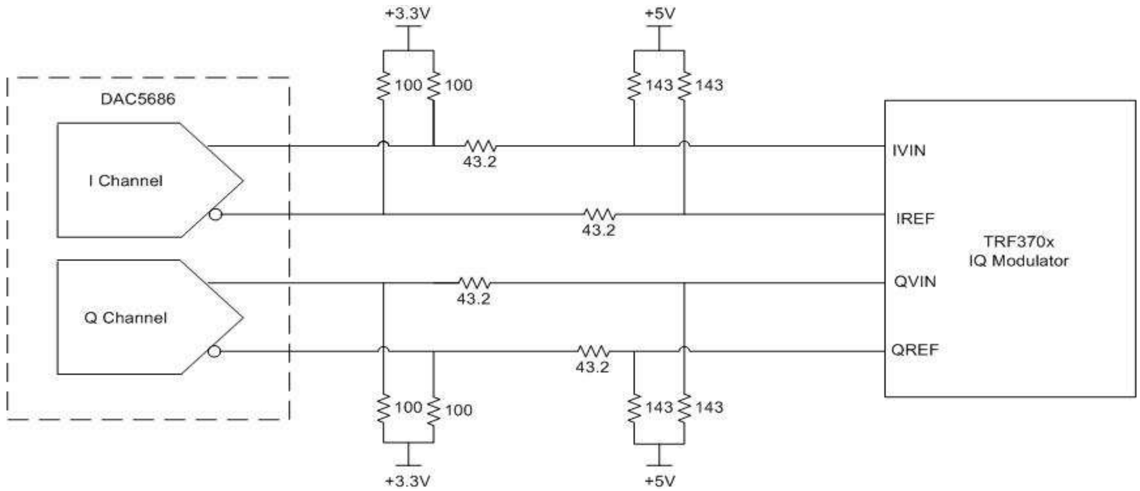


**Figure 5. TRF370x Interface to a DAC5686**

When using this configuration, the internal adjustments of the DAC5686 can be used (iteratively) to provide the desired level of carrier suppression. A 50dBc can be easily achieved through this configuration.

## IMPORTANT NOTICE



Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

| **Products** | | **Applications** | |
|---|---|---|---|
| Amplifiers | amplifier.ti.com | Audio | www.ti.com/audio |
| Data Converters | dataconverter.ti.com | Automotive | www.ti.com/automotive |
| DSP | dsp.ti.com | Broadband | www.ti.com/broadband |
| Interface | interface.ti.com | Digital Control | www.ti.com/digitalcontrol |
| Logic | logic.ti.com | Military | www.ti.com/military |
| Power Mgmt | power.ti.com | Optical Networking | www.ti.com/opticalnetwork |
| Microcontrollers | microcontroller.ti.com | Security | www.ti.com/security |
| | | Telephony | www.ti.com/telephony |
| | | Video & Imaging | www.ti.com/video |
| | | Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265