

## AN-1414 Application Note

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

# Interfacing the ADL5371 I/Q Modulator to the AD9779A Dual-Channel, 1 GSPS, High Speed DAC

#### **CIRCUIT FUNCTION AND BENEFITS**

This circuit provides a simple interface between the ADL5371 I/Q modulator and the AD9779A high speed DAC. The ADL5371 and the AD9779A are well matched devices because they have the same bias levels and similarly high signal-to-noise ratios (SNR). The matched bias levels of 500 mV allow for a glueless interface; there is no requirement to add a level shifting network that adds noise and insertion loss along with the extra components. The addition of the swing limiting resistors (RSLI and RSLQ) allows the DAC swing to scale appropriately without loss of resolution or of the 0.5 V bias level. The high SNR of each device preserves a high SNR through the circuit.

#### **CIRCUIT DESCRIPTION**

The ADL5371 interfaces with minimal components to members of Analog Devices family of TxDAC\* converters. The baseband inputs of the ADL5371 require a dc commonmode bias voltage of 500 mV. With each AD9779A output swinging from 0 mA to 20 mA, a single 50  $\Omega$  resistor to ground from each of the DAC outputs provides the desired 500 mV dc bias. With just the four 50  $\Omega$  resistors in place, the voltage swing on each pin is 1 V p-p, resulting in a differential voltage swing of 2 V p-p on each input pair.

By adding the RSLI and RSLQ resistors to the interface, the output swing of the DAC reduces without any loss of DAC resolution. Place the resistor as a shunt between each side of the differential pair, as shown in Figure 1. It has the effect of reducing the ac swing without changing the dc bias already established by the  $50\ \Omega$  resistors and the DAC output current.

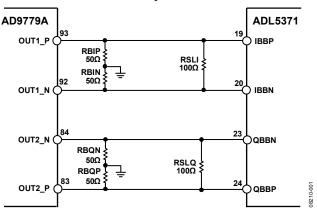


Figure 1. Interface Between the AD9779A and the ADL5371 with  $50\Omega$  Resistors to Ground to Establish the 500 mV DC Bias for the ADL5371 Baseband Inputs (Simplified Schematic)

The value of this ac swing limiting resistor is chosen based on the desired ac voltage swing. Figure 2 shows the relationship between the swing limiting resistor and the peak-to-peak ac swing that it produces when 50  $\Omega$  bias setting resistors are used. Note that all Analog Devices I/Q modulators present a relatively high input impedance on their baseband inputs (typically >1 k $\Omega$ ). As a result, the input impedance of the I/Q modulator has no effect on the scaling of the DAC output signal.

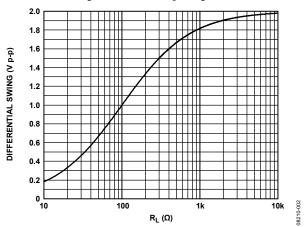


Figure 2. Relationship Between the AC Swing Limiting Resistor and the Peak to Peak Voltage Swing with 50 Ω Bias Setting Resistors

It is generally necessary to low-pass filter the DAC outputs to remove image frequencies when driving a modulator. The interface shown in Figure 1 lends itself well to the introduction of such a filter. Insert the filter between the dc bias setting resistors and the ac swing limiting resistor because doing so establishes the input and output impedances for the filter.

AN-1414 Application Note

### **TABLE OF CONTENTS**

Circuit Function and Benefits	Common Variations
Circuit Description	References
Revision History	
REVISION HISTORY	
8/2016—Rev. A to Rev. B	
Document Title Changed from CN-0017 to AN-1414 Universal	
Changes to Circuit Description, Figure 3 Caption, and	
Common Variations Section	
5/2009—Rev. 0 to Rev. A	
Updated FormatUniversal	

10/2008—Revision 0: Initial Version

Application Note AN-1414

A simulated filter example is shown in Figure 3 with a third-order, elliptical low-pass filter and a 3 dB frequency of 3 MHz. Matching input and output impedances makes the filter design easier; therefore, the shunt resistor chosen is 100  $\Omega$ , producing an ac swing of 1 V p-p differential for a 0 mA to 20 mA DAC full-scale output current. In a practical application, the use of standard value components, along with the input impedance of the I/Q modulator (2900 k $\Omega$  in parallel with a few picofarads of input capacitance), slightly changes the frequency response of this circuit.

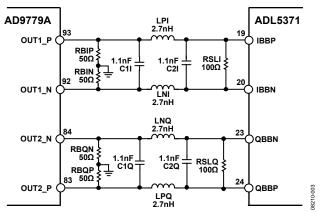


Figure 3. DAC Modulator Interface with 3 MHz Third-Order, Elliptical Low-Pass Filter (Calculated Component Values)

Connect the power supply pins of the ADL5371 to the same 5 V source. Tie adjacent pins of the same name together and decouple them to a large area ground plane with a  $0.1~\mu F$  capacitor. Locate these capacitors as close as possible to the ADL5371. The power supply can range between 4.75~V and 5.25~V.

Tie the COM1, COM2, COM3, and COM4 pins of the ADL5371 to the same ground plane through low impedance paths. Solder the exposed paddle on the underside of the package to a low thermal and electrical impedance ground plane. If the ground plane spans multiple layers on the circuit board, stitch them together with nine vias under the exposed paddle. The AN-772 Application Note discusses the thermal and electrical grounding of the LFCSP in greater detail.

#### **COMMON VARIATIONS**

The interface described can interface any TxDAC converter with ground referenced 0 mA to 20 mA output currents to any I/Q modulator with a 0.5 V input bias level. For zero IF applications, the AD9783 dual DAC provides a low voltage differential signaling (LVDS) interface, whereas the complementary metal-oxide semiconductor (CMOS) driven AD9788 dual DAC generates a fine resolution complex IF input to the I/Q modulator.

The ADL5370/ADL5371/ADL5372/ADL5373 family of I/Q modulators provides narrow-band operation with high output 1 dB compression point and output third-order intercept (OIP3), whereas the ADL5375 provides broadband high performance operation from 400 MHz to 6 GHz. The ADL5385 I/Q modulator uses a 2× local oscillator (LO) and operates from 30 MHz to 2.2 GHz.

#### **REFERENCES**

Griffin, Gary. AN-772 Application Note, A Design and Manufacturing Guide for the Lead Frame Chip Scale Package (LFCSP). Analog Devices.

Kester, Walt. MT-016 Tutorial, *Basic DAC Architectures III:* Segmented DACs. Analog Devices.

Kester, Walt. MT-017 Tutorial, *Oversampling Interpolating DACs*. Analog Devices.

Kester, Walt, Bryant, James, and Byrne, Mike. MT-031 Tutorial, Grounding Data Converters and Solving the Mystery of "AGND" and "DGND". Analog Devices.

MT-080 Tutorial, Mixers and Modulators. Analog Devices.

MT-101 Tutorial, Decoupling Techniques. Analog Devices.

Zumbahlen, Hank. Linear Circuit Design Handbook, Chapters 4 and 11. Analog Devices.