AN-1501
APPLICATION NOTE

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DC-Coupled, Single-Ended to Differential Conversion Using the AD8138 Low Distortion Differential ADC Driver and the AD7356 5 MSPS, 12-Bit SAR ADC

CIRCUIT FUNCTION AND BENEFITS

This circuit provides a dc-coupled, single-ended to differential conversion of a bipolar input signal to the AD7356 5 MSPS, 12-bit successive approximation register (SAR) analog-to-digital converter (ADC). The design of this circuit ensures maximum performance of the AD7356 by providing adequate settling time and low impedance.

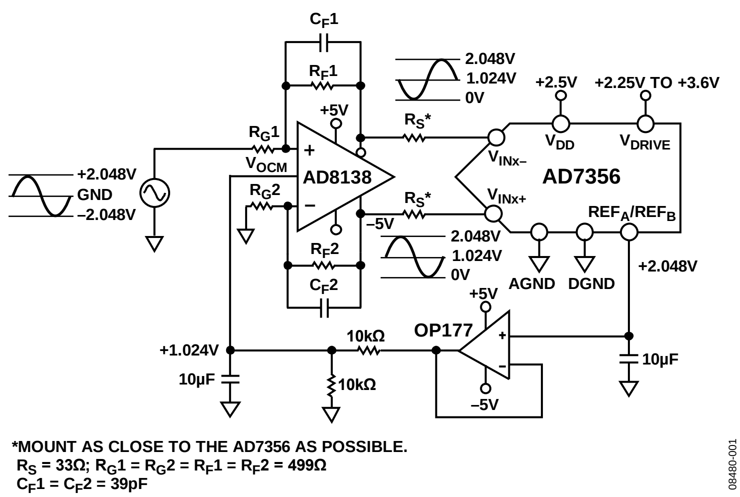

Figure 1. AD8138 as a DC-Coupled, Single-Ended to Differential Converter Driving the AD7356 Differential Inputs (Simplified Schematic: Decoupling and All Connections Not Shown)

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REVISION HISTORY

11/2017—Rev. B to Rev. C

Document Title Changed from CN0041 to AN-1501 ... Universal
Changes to Circuit Description Section, Common Variations Section, and References Section ... 3

1/2013—Rev. A to Rev. B

Changes to Figure 1 ... 1

11/2009—Rev. 0 to Rev. A

Updated Format ... Universal
Changes to Circuit Note Title ... 1

2/2009—Revision 0: Initial Version

CIRCUIT DESCRIPTION

For differential operation, simultaneously drive the AD7356 V_{INx+} and V_{INx-} pins (x refers to the $V_{INA\pm}$ and $V_{INB\pm}$ pins of the AD7356) of the ADC with two equal signals that are 180° out of phase and centered around the proper common-mode voltage. Because not all applications have a signal preconditioned for differential operation, there is often a need to perform a single-ended to differential conversion. An ideal method of applying differential drive to the AD7356 is to use a differential amplifier, such as the AD8138. The AD8138 can be used as a single-ended to differential amplifier or as a differential to differential amplifier. It also provides common-mode level shifting. Figure 1 shows how the AD8138 can be used as a single-ended to differential amplifier in a dc-coupled application. The positive and negative outputs of the AD8138 are connected to the respective inputs on the ADC through a pair of series resistors to minimize the loading effects of the switched capacitor inputs of the ADC. The architecture of the AD8138 results in outputs that are highly balanced over a wide frequency range without requiring tightly matched external components. The single-ended to differential gain of the circuit in Figure 1 is equal to the feedback resistor divided by the gain resistor (R_F/R_G), where $R_F = R_F1 = R_F2$ and $R_G = R_G1 = R_G2$.

If using an analog input source with zero impedance, all four resistors (R_G1, R_G2, R_F1, and R_F2) are the same as shown in Figure 1. If the source has a 50 Ω impedance and a 50 Ω termination, for example, increase the value of R_G2 by 25 Ω to balance this parallel impedance on the input and ensure that the positive and negative analog inputs have the same gain. This impedance match also requires a small increase in R_F1 and R_F2 to compensate for the gain loss caused by increasing R_G1 and R_G2. For analysis of the terminated source condition, use the ADI DiffAmpCalc™ interactive design tool and the MT-076 Tutorial.

The AD7356 requires a driver that has a fast settling time due to the short acquisition time required, achieving 5 MSPS throughput with a serial interface. The track-and-hold amplifier (THA) on the front end of the AD7356 enters track mode on the rising edge of the 13th SCLK period during a conversion. The ADC driver must settle before the THA returns to hold (38 ns later for 5 MSPS throughput on the AD7356 using an 80 MHz SCLK). The AD8138 has a specified 16 ns settling time that satisfies this requirement.

The voltage applied to the V_{OCM} pin of the AD8138 sets up the common-mode voltage. In Figure 1, V_{OCM} is connected to 1.024 V, which is a divided version of the internal 2.048 V reference on the AD7356. If the on-chip 2.048 V reference on the AD7356 is to be used elsewhere in a system (as shown in Figure 1), buffer the output from the REF_A or REF_B pin first. The OP177 features high precision performance and is an ideal choice for a reference buffer.

In Figure 1, the AD8138 operates on dual 5 V supplies, where the AD7356 is specified for power supply voltages of 2.25 V to 3.6 V. Ensure that the maximum input voltage limits of the AD7356 are not exceeded during transient or power-on conditions (see the MT-036 Tutorial). Construct the circuit on a multilayer printed circuit board (PCB) with a large area ground plane. Proper layout, grounding, and decoupling techniques must be used to achieve optimum performance (see the MT-031 Tutorial, MT-101 Tutorial, and the EVAL-AD7356 evaluation board layout).

COMMON VARIATIONS

The OP07D, an ultralow offset voltage op amp, is a lower cost alternative to the OP177. It offers similar performance with the exception of the offset voltage specification. Alternatively, the AD8628 or the AD8638 offers high precision with low drift over time and temperature.

REFERENCES

MT-031 Tutorial, *Grounding Data Converters and Solving the Mystery of "AGND" and "DGND,"* Analog Devices, Inc.

MT-036 Tutorial, *Op Amp Output Phase-Reversal and Input Over-Voltage Protection*, Analog Devices.

MT-074 Tutorial, *Differential Drivers for Precision ADCs*, Analog Devices.

MT-075 Tutorial, *Differential Drivers for High Speed ADCs Overview*, Analog Devices.

MT-076 Tutorial, *Differential Driver Analysis*, Analog Devices.

MT-101 Tutorial, *Decoupling Techniques*, Analog Devices.

John Ardizonni and Jonathan Pearson, *"Rules of the Road" for High-Speed Differential ADC Drivers* (Analog Dialogue, Volume 43, May 2009, Analog Devices).

ADI DiffAmpCalc (Differential Amplifier Tool), Analog Devices.