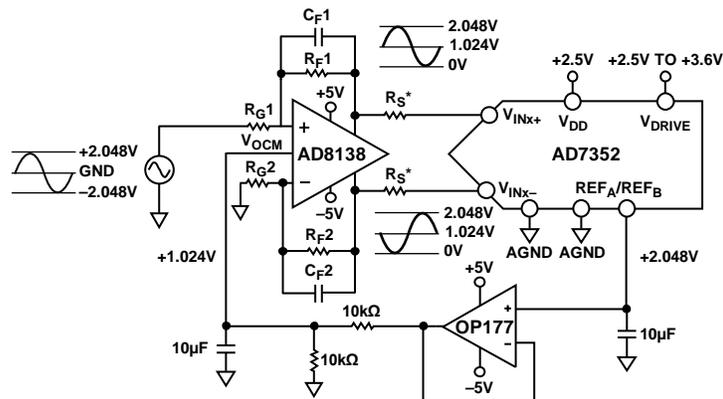


DC-Coupled, Single-Ended to Differential Conversion Using the **AD8138** Low Distortion Differential ADC Driver and the **AD7352** Dual, 3 MSPS, 12-Bit SAR ADC

CIRCUIT FUNCTION AND BENEFITS

The circuit described in this document provides a dc-coupled, single-ended to differential conversion of a bipolar input signal to the **AD7352** dual, 3 MSPS, 12-bit successive approximation register (SAR) analog-to-digital converter (ADC). This circuit is designed to ensure maximum performance of the **AD7352** by providing adequate settling time and low impedance.



*MOUNT AS CLOSE TO THE AD7352 AS POSSIBLE.
 $R_S = 33\Omega$; $R_G1 = R_G2 = R_F1 = R_F2 = 499\Omega$; $C_F1 = C_F2 = 39\text{pF}$.

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Figure 1. **AD8138** as a DC-Coupled, Single-Ended to Differential Converter Driving the **AD7352** Differential Inputs (Simplified Schematic; Decoupling and All Connections Not Shown)

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REVISION HISTORY

11/2017—Rev. A to Rev. B

Document Title Changed from CN0040 to AN-1500	Universal
Changes to Circuit Description Section and References	
Section.....	3

11/2009—Rev. 0 to Rev. A

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

10/2008—Revision 0: Initial Version

CIRCUIT DESCRIPTION

For differential operation, simultaneously drive the V_{INx+} and V_{INx-} pins (x refers to the $V_{INA±}$ and $V_{INB±}$ pins of the [AD7352](#)) of the ADC with two equal signals that are 180° out of phase and are 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 [AD7352](#) is to use a differential amplifier, such as the [AD8138](#). This device can be used as a single-ended to differential amplifier or as a differential to differential amplifier. The [AD8138](#) 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 the source of the analog inputs being used has 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 see the [MT-076 Tutorial](#).

The [AD7352](#) requires a driver that has a fast settling time due to the short acquisition time required to achieve 3 MSPS throughput with a serial interface. The track-and-hold amplifier (THA) on the front end of the [AD7352](#) 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 (68 ns later for 3 MSPS throughput on the [AD7352](#) using a 48 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 [AD7352](#). If the on-chip 2.048 V reference on the [AD7352](#) is to be used elsewhere in a system (as shown in Figure 1), the output from the REF_A or REF_B pin must first be buffered. The [OP177](#) features a high op amp and is an ideal choice for a reference buffer.

The [AD8138](#) operates on dual 5 V supplies, where the [AD7352](#) is specified for power supply voltages of 2.5 V to 3.6 V. Ensure that the input maximum input voltage limits of the [AD7352](#) are not exceeded during transient or power-on conditions (see the [MT-036 Tutorial](#)). The circuit must be constructed 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-AD7352](#) 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 very high precision with very low drift with time and temperature.

REFERENCES

- [MT-031 Tutorial, Grounding Data Converters and Solving the Mystery of "AGND" and "DGND," Analog Devices.](#)
- [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, Analog Devices.](#)