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Devices Connected/Referenced	
AD7626	16-Bit, 10 MSPS, PulSAR, Differential ADC
ADA4932-1	Low Power Differential ADC Driver
AD8031	2.7 V, 800 μA, 80 MHz Rail-to-Rail I/O Amplifier

Single-Ended-to-Differential High Speed Drive Circuit for 16-Bit, 10 MSPS AD7626 ADC

CIRCUIT FUNCTION AND BENEFITS

The circuit shown in Figure 1 provides a method to convert a high frequency single-ended input signal to a balanced differential signal used to drive the AD7626 16-bit, 10 MSPS PulSAR® ADC. The circuit maximizes the AD7626 performance for high frequency input tones using the ADA4932-1 low power differential amplifier to drive the ADC. The true benefit of this combination of devices is high performance at low power.

The AD7626 industry breakthrough dynamic performance of 91.5 dB SNR at 10 MSPS with 16-bit INL performance, no latency, and LVDS interface, all coupled with power dissipation of only 136 mW. A key feature of the SAR architecture used in the AD7626 is the ability to sample at 10 MSPS without the latency, or "pipeline delay," typically incurred with pipeline ADCs coupled with the excellent linearity performance.

The ADA4932-1 has low distortion (100 dB SFDR @ 10 MHz), fast settling time (9 ns to 0.1%), high bandwidth (560 MHz, −3 dB, G = 1), and low current (9.6 mA). These characteristics make it the ideal choice for driving the AD7626. It also features the functionality to easily set the required output common-mode voltage.

The combination offers industry-leading dynamic performance and small board area with the AD7626 in a 5 mm × 5 mm, 32-lead LFCSP, the ADA4932-1 in a 3 mm × 3 mm, 16-lead LFCSP, and the AD8031 in a 5-lead SOT-23 package.

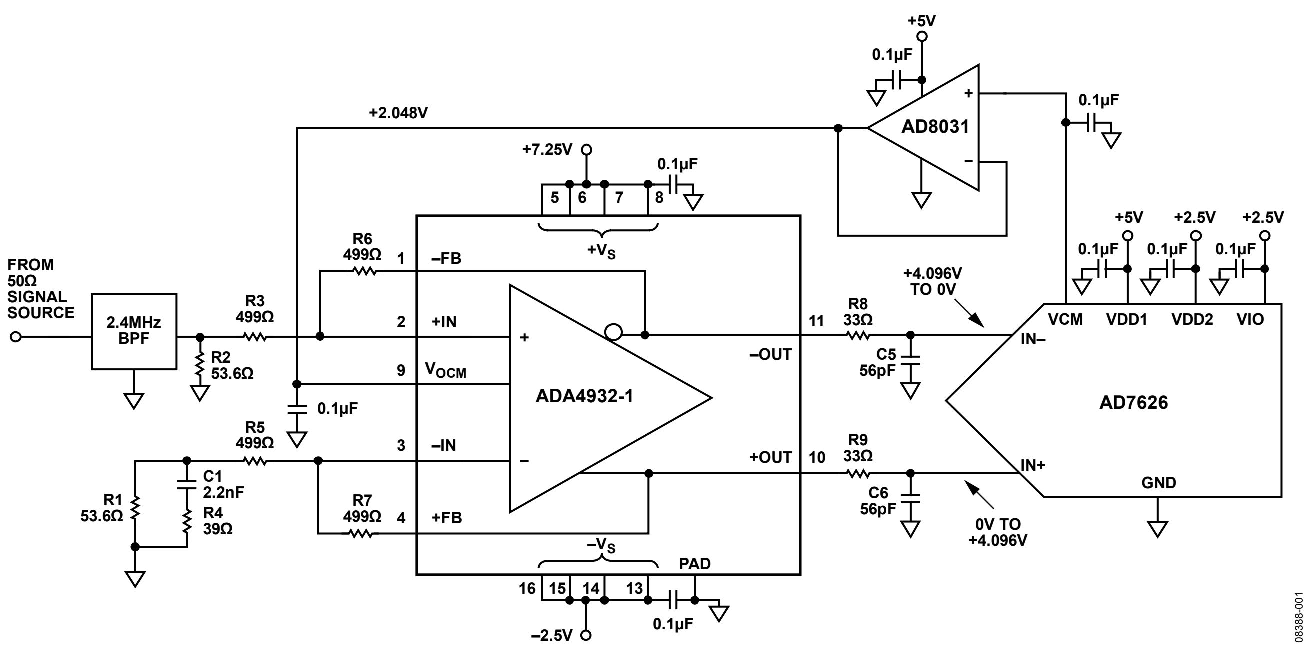

Figure 1 . ADA4932-1 Driving the AD7626 (All Connections and Decoupling Not Shown)

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CIRCUIT DESCRIPTION

Using a differential amplifier to drive an ADC successfully is linked to balancing each side of the differential amplifier correctly.

Figure 1 shows the schematic for the ADA4932-1, AD7626, and associated circuitry. In the test circuit used, the signal source is followed by a 2.4 MHz band-pass filter. The band-pass filter eliminates harmonics of the 2.4 MHz signal and ensures that only the frequency of interest will be passed and processed by the ADA4932-1 and AD7626.

The source in this case has a characteristic impedance of 50 Ω and is ac-coupled to the ADA4932-1 via the band-pass filter. Applying the signal source to the positive input of the ADA4932-1 requires that source is properly terminated in 50 Ω as well (or in general whatever the source impedance is). The termination resistor, R2, is selected such that the parallel combination of R2 and the input impedance of the ADA4932-1 is equal to 50 Ω. The input impedance of the ADA4932-1 (looking into resistor R3) can be calculated using the following equation:

$$R_{IN} = \frac{R_G}{1 - \frac{R_F}{2 \times (R_G + R_F)}}$$

where R_G = R3 = R5 = 499 Ω, and R_F = R6 = R7 = 499 Ω. For these values the input impedance of this circuit is approximately 665 Ω. The ADA4932-1 665 Ω input impedance in parallel with the 53.6 Ω resistor (R2) equals 50 Ω (i.e., the input source impedance).

To maintain proper balance and symmetry between the two inputs of the ADA4932-1, the equivalent Thevenin impedance of the input source impedance and termination must be added to the inverting input. In this case, this involves the ac characteristics of the filter.

The Thevenin equivalent network is shown on the inverting input of the ADA4932-1 in Figure 1. This circuit is optimized for performance at 2.4 MHz. Resistor R1 is paralleled by the series combination of C1 and R4. At 2.4 MHz, the complex series combination of C1 and R4 equals 55.6 Ω. The 55.6 Ω impedance in parallel with R1 is within a few ohms of the Thevenin equivalent circuit input impedance on the noninverting input. Matching of the two inputs ensures that the outputs will be symmetrical , balanced, and optimized for lowest distortion.

For a more detailed explanation of how to terminate a single-ended input please refer to the ADA4932-1 data sheet or Application Note AN-1026 "High Speed Differential ADC Driver Design Considerations". Also the ADI DiffAmpCalcuator™ Design Tool greatly simplifies this exercise and provides keen insight to other differential amplifier design related issues.

The ADA4932-1 differential driver is configured in a gain of approximately 1 (single-ended input to differential output). As a result of the 50 Ω signal source and the termination matching at the ADA4932-1 input, the net overall gain of the channel is approximately 0.5 with respect to the Thevenin equivalent signal source voltage.

The common-mode voltage at the output of the ADA4932-1 is set by buffering the VCM output voltage (nominally +2.048 V) from the AD7626 with a AD8031 configured as a unity gain buffer. The AD8031 provides the ADA4932-1 V_{OCM} pin with a low source impedance and is also capable of driving the large bypass capacitor as shown in Figure 1.

The ADA4932-1 is particularly useful when driving higher frequency inputs to the AD7626, a 10 MSPS ADC with a switched capacitor input. The resistor (R8, R9) and capacitor (C5, C6) circuit between the ADA4932-1 and AD7626 IN+ and IN− pins acts as a low-pass filter to noise. The filter limits the input bandwidth to the AD7626, but its main function is to optimize the interface between the driving amplifier and the AD7626. The series resistor isolates the driver amplifier from high frequency switching spikes from the ADC switched capacitor front end. The AD7626 data sheet shows values of 20 Ω and 56 pF. In the circuit shown in Figure 1 these values were empirically optimized to 33 Ω and 56 pF. The resistor-capacitor combination can be optimized slightly for the circuit and input frequency being converted by simply varying the R-C combination—however, keep in mind that having the incorrect combination will limit the THD and linearity performance of the AD7626. Also, increasing the bandwidth as seen by the ADC introduces more noise.

Another aspect of optimization is the selection of the power supply voltages for the ADA4932-1. In the circuit, the output common-mode voltage (VCM pin) of the AD7626 is 2.048 V for the internal reference voltage of 4.096 V, and each input (IN+, IN−) swings between 0 V and +4.096 V, 180° out of phase. This provides an 8.2 V full-scale differential input to the ADC. The ADA4932-1 output stage requires about 1.4 V headroom with respect to each supply voltage for linear operation. Optimum distortion performance is obtained when the supply voltages are approximately symmetrical about the common-mode voltage. If a negative supply of −2.5 V is chosen, then a positive supply of at least +6.5 V would be needed for symmetry about the common-mode voltage of 2.048 V.

Experiments performed indicate that a positive supply of +7.25 V gives the best overall distortion for a 2.4 MHz tone.

Using a low jitter clock source and a single tone −1 dBFS amplitude 2.402 MHz input to the AD7626 yielded the FFT results shown in Figure 2 of 88.49 dB SNR and −86.17 dBc THD. As can be seen from the plot, the harmonics of the fundamental alias back into the pass band. For example when sampling at 10 MSPS the 3rd harmonic (7.206 MHz) will alias into the pass band at 10.000 MHz – 7.206 MHz = 2.794 MHz. A second FFT plot shown in Figure 3 for a tone with an amplitude of −6 dBFS.

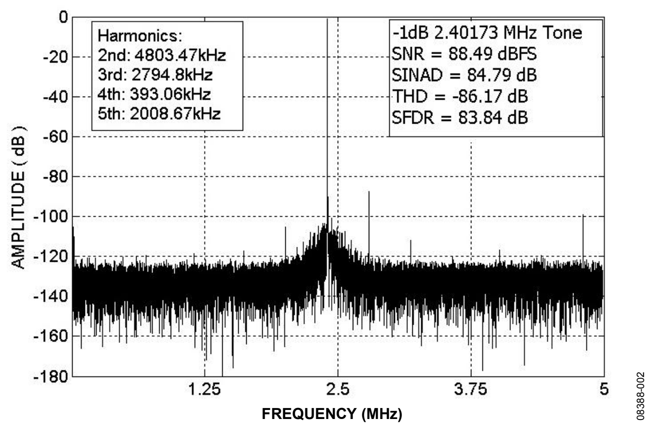

Figure 2. AD7626 Output, 64,000 Point , FFT Plot, −1 dBFS Amplitude, 2.40173 MHz Input Ton ,10.000 MSPS Sampling Rate

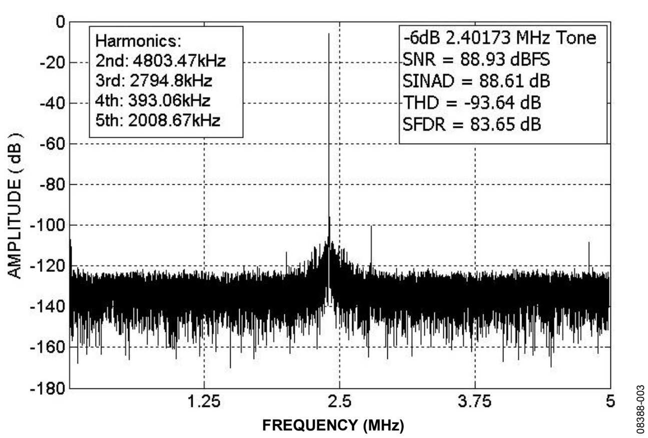

Figure 3. AD7626 Output, 64,000-Point FFT Plot, −6 dBFS Amplitude, 2.40173 MHz Input Tone, 10.000 MSPS Sampling Rate

The non-harmonic noise admitted through the pass band of the band-pass filter used in the circuit is replaced by the average noise across the Nyquist bandwidth when calculating the SNR and THD.

The performance of this or any high speed circuit is highly dependent on proper PCB layout. This includes, but is not limited to, power supply bypassing, controlled impedance lines (where required), component placement, signal routing, and power and ground planes. (See MT-031 Tutorial, MT-101 Tutorial and the article *A Practical Guide to High-Speed Printed-Circuit-Board Layout* for more detailed information regarding PCB layout.)

AD7626—Typical Connections and Reference Configurations

The typical connection diagram for the AD7626 is shown in Figure 4. The AD7626 has an integrated internal reference as well as two provisions for external references if system requirements dictate. The reference voltage can be generated by applying the ADR280 reference (1.2 V) output to the REFIN pin, which is amplified internally by the on-chip reference buffer to the correct ADC reference value of 4.096 V. The ADR280 can be supplied by the same 5 V analog rail used for the AD7626 and also make use of the on-chip reference buffer. Alternatively, a 4.096 V external reference (ADR434 or ADR444) may be applied to the unbuffered REF input of the ADC. This approach is common for multichannel applications where the system reference is typically buffered discretely (using an AD8031) and is shared by all ADC channels. The ADR434 and ADR444 configurations also excel for single channel applications where a low reference temperature coefficient (3 ppm/°C max for ADR434B and ADR444B) is required. The positive rail used to supply the ADA4932-1 amplifier can also supply the VIN supply pin of the ADR434 or ADR444.

COMMON VARIATIONS

This circuit is proven to work with good stability and accuracy with the component values shown. While this circuit is dc coupled, another common application is ac coupling. Common variations to this circuit include single supply voltage, inputs that are driven differentially, and inputs that require attenuation of the signal. Other ADC drivers/differential amplifiers can also be used to tailor the performance to the application (e.g. power, noise, bandwidth, architecture, etc.)

For input frequencies of 1 MHz and less, the ADA4899-1 is the recommended driving amplifier as shown in the AD7626 data sheet. Using the ADA4938-1 is an effective way to drive the AD7626 with higher speed signals up to 10 MHZ, as shown by the high frequency plots in the AD7626 Typical Performance Characteristics section of the data sheet.

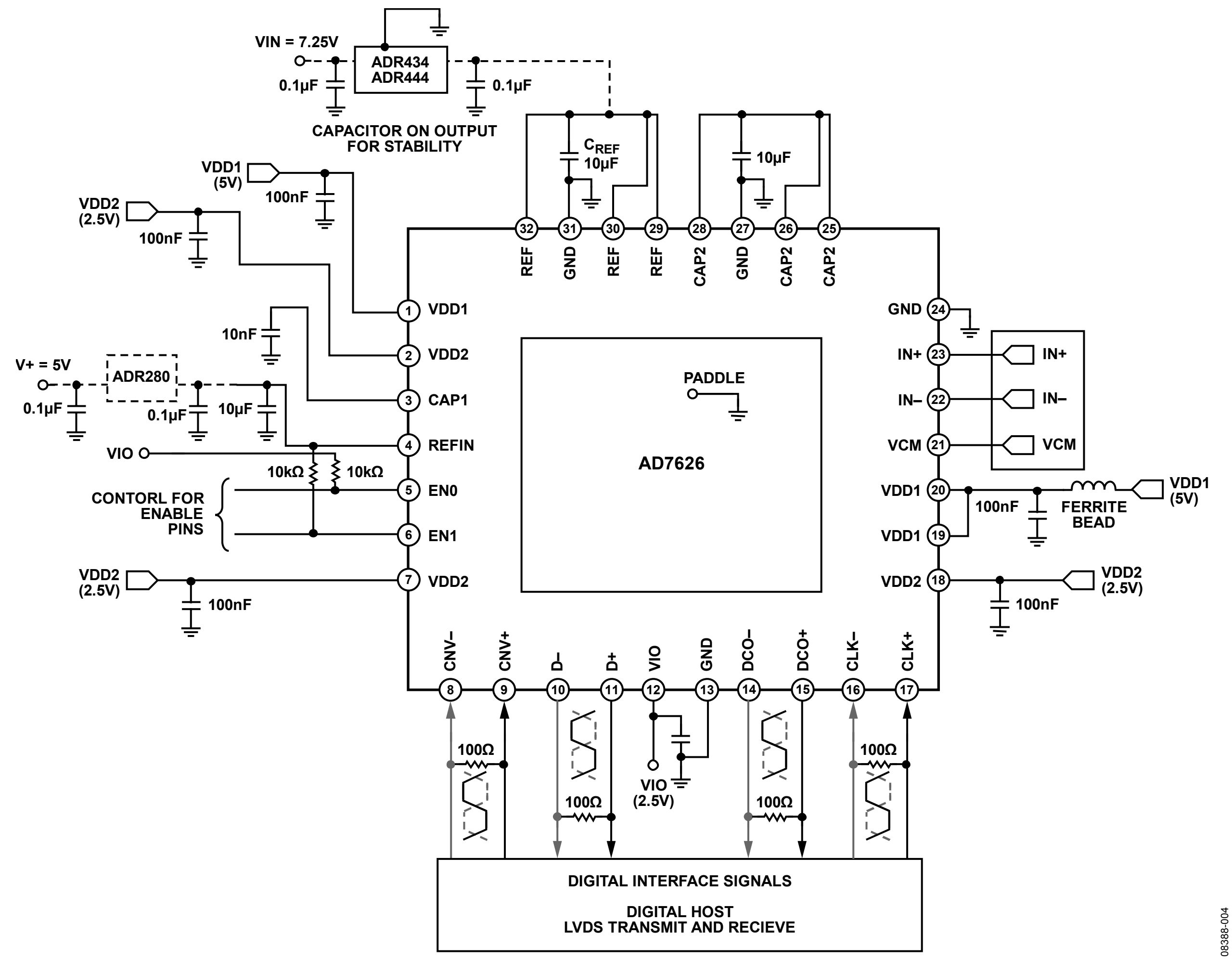

Figure 4. Typical Connection Diagram for AD7626 Showing Decoupling and LVDS Interface Connections.

LEARN MORE

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ADI DiffAmpCalculator™ Design Tool

Data Sheets and Evaluation Boards

AD7626 Data Sheet

AD7626 Evaluation Board

ADA4932-1 Data Sheet

AD8031 Data Sheet

REVISION HISTORY

7/10—Revision 0: Initial Version

CN08388-0-7/10(0)