Texas Instruments

Application Report
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Interfacing the VCA8613 with High-Speed Analog-to-Digital Converters

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ABSTRACT

The VCA8613 is an 8-channel variable gain amplifier ideally suited for portable and mid-range ultrasound applications. Each channel consists of a Low Noise Amplifier (LNA) and a Variable Gain Amplifier (VGA). The VGA contains two parts: a voltage-controlled attenuator (VCA) and a programmable gain amplifier (PGA). The PGA output feeds directly into an integrated 2-pole low-pass Butterworth filter. This integrated filter prevents the need for an external filter between the VCA and the analog-to-digital converter (ADC). This application report reviews different methods of interfacing the VCA8613 with various ADCs, particularly the ADS512x and ADS527x families.

1 Using the VCA8613 with the ADS512x

Texas Instruments' ADS512x family is a series of octal 1.8V converters offering high-performance, 10-bit solutions at various speed nodes.

The VCA8613 output pins sit at a common-mode dc voltage of 1.0V (nominal). The input common-mode voltage of the ADS512x family is also 1.0V dc. This equivalence means that it is possible to dc-couple the VCA8613 with the ADS512x family. DC-coupling would eliminate the space required by 16 capacitors between the VCA8613 and any of the ADS512x devices.

The output impedance of the VCA8613 is very low. As a result, a 20Ω to 50Ω resistor is recommended, placed in series between the VCA8613 and the ADS512x. Optimal results are obtained when a small capacitor (for example, 47pF) is used between the positive and negative inputs of the ADS512x family.

Figure 1 illustrates this approach.

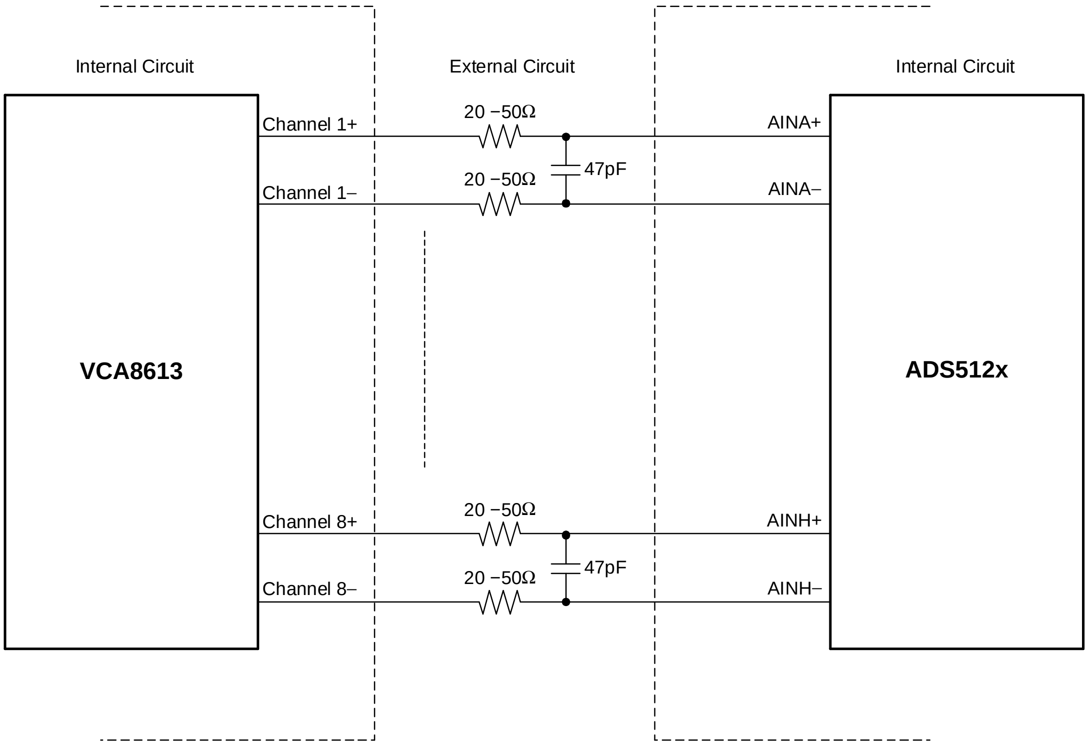

Figure 1. DC-Coupled Interface BetweenVCA8613 and ADS512x

While dc-coupling would appear to be the simplest possible method of linking the VCA8613 with the ADS512x, ac-coupling is a second solution that has several advantages over dc-coupling. There are several reasons why ac-coupling may provide increased functionality for end-user applications.

First, there is an inherent output common-mode variation associated with the output pins of the VCA8613. This variation is independent of the PGA gain setting. Final test measurements show that at the highest post gain (PG) gain setting of 01, this variation can be as high as 50mV to 70mV. (Note that most production units fall within ±30mV of 1.0V; however, there are units which may shift slightly more.) One other point of note here is that the offset between the positive and negative output pins of any one channel on the VCA8613 is almost negligible. It is only the absolute value that appears to vary. The problem that this shift may present is a slight loss in dynamic range. This variation is observed from channel to channel as well as from chip to chip. AC-coupling between the VCA8613 and ADS512x family would solve this problem.

There is also a settling time observed at the output of the VCA8613 when the control voltage is pulsed. The output settles after several time constants; the time constant is set by the internal value of an RC circuit between the VCA and PGA. AC-coupling at the output can override this internal time constant and can enable the VCA8613 to recover quickly. The shorter the acceptable time constant, the more quickly the VCA8613 appears to settle.

TI recommends that each user come to his or her own conclusion by trying various combinations, and choosing that combination which works best to fit the system requirements. Figure 2 shows an alternative solution to the interfacing problem.

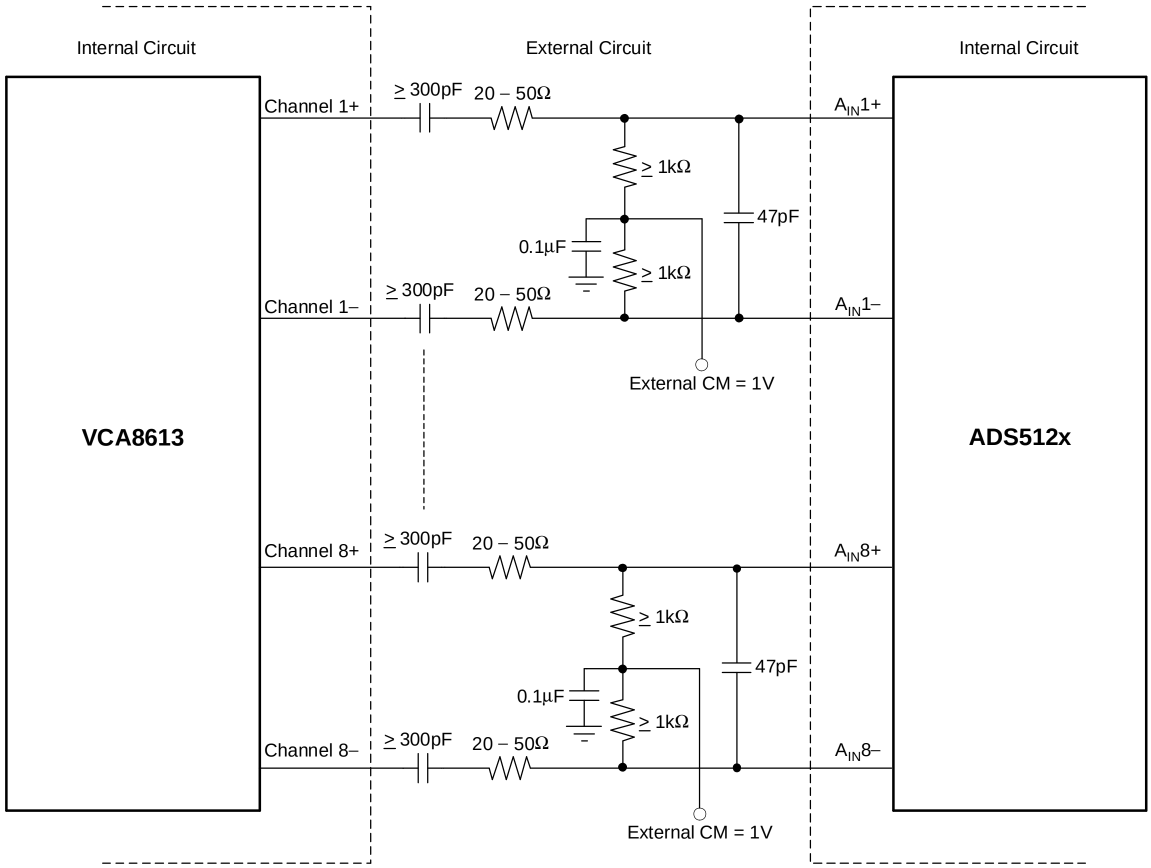

Figure 2. AC-Coupled Interface Between VCA8613 and ADS512x

2 Overload Conditions

The VCA8613 output pins can output more than $1V_{PP}$ in single-ended mode, or greater than $2V_{PP}$ in differential mode. Back-to-back clipping diodes across the input and output of the PGA limit the output signal of the VCA8613 to approximately 0.6V to 0.7V peak on each output. This limited output means that the clipping diodes turn on when the signal reaches roughly $2.4V_{PP}$ to $2.5V_{PP}$ in differential mode. Under heavy overload conditions, even when the signal is clipped, the VCA8613 can output slightly more than $3V_{PP}$. Since the input of the ADS527x can only handle $2V_{PP}$ in the linear region, the ADS527x ADC will overload when the VCA8613 output exceeds $2V_{PP}$. The ADS527x will recover to 1% accuracy within 3 to 4 clock cycles. This rate means that a recovery to 1% accuracy occurs within 80ns at 50MSPS. If this recovery time is sufficient, then the above-described solutions should work well in all systems.

If it is necessary to protect the ADS527x ADC further, TI then recommends that the user increase the value of the series resistor from between 25Ω to 50Ω to approximately 300Ω. This increase ensures that the ADS527x ADC will never overload, even when the VCA8613 is severely overloaded. The downside to this solution, however, is that the 300Ω series resistor in conjunction with the 600Ω shunt resistor will cause a 33% attenuation factor, even at low signal levels when no attenuation is required.

3 Interfacing the VCA8613 with the ADS527x Family

The ADS527x devices are an octal, 3.3V ADC family that provides 12-bit solutions. The input common-mode of the ADS527x family is 1.5V. Consequently, ac-coupling is the recommended option available to customers who wish to link the two devices.

Once again, a small series resistor of approximately 25Ω to 50Ω is recommended between the VCA8613 and the ADS527x inputs. A 5pf to 10pF capacitor is also recommended between the positive and negative inputs of the ADS527x. Figure 3 shows this recommended approach.

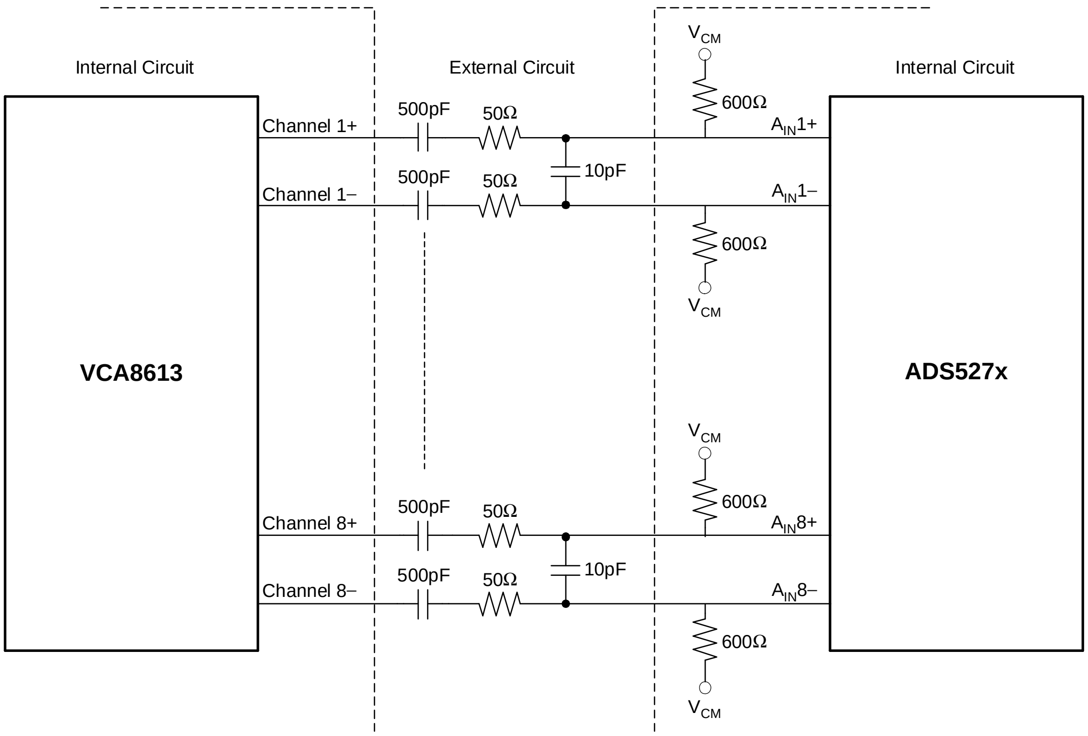

Figure 3. AC-Coupled Interface Between VCA8613 and ADS527x

The ADS527x family has an internal 600Ω resistor from each input pin to common-mode. The small 25Ω to 50Ω series resistor, in conjunction with the 600Ω shunt resistor, provides a small attenuation factor. Users should take this attenuation factor into consideration when interfacing the VCA8613 with an ADS527x device. Note also that this 600Ω resistor is fixed.

Again, TI recommends that each user come to his or her own conclusion by trying various combinations, and choosing that combination which works best to fit the system requirements.

It is possible to dc-couple the VCA8613 with the ADS527, because the VCA8613 allows for an external voltage to be applied to pin 29 (V_{FIL}) that will override the output common-mode voltage of the VCA8613. By externally applying +1.5V dc to pin 29, the common-mode dc voltage level of the VCA8613 output pins changes from 1V to 1.5V. Using this configuration enables the customer to dc-couple the VCA8613 with the ADS527x.

Figure 4 is an example of this method.

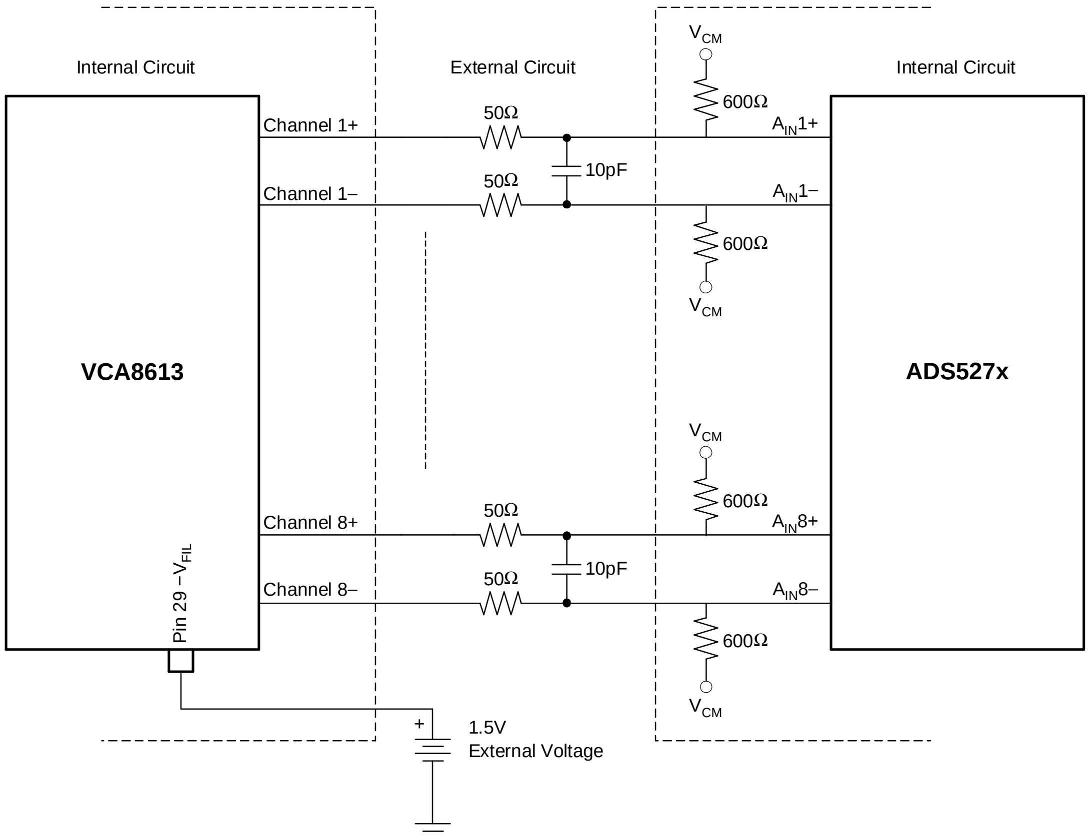

Figure 4. DC-Coupled Interface Between VCA8613 and ADS527x

Note that forcing pin 29 to a different voltage other than what is internally set has several side effects; the user performs this operation at his or her own risk. Changing the common-mode voltage to something other than 1V could possibly affect the output amplifier gain slightly as well as the VCA attenuation levels. This shift occurs because changing this voltage also changes the internal biasing in the amplifier minimally. The shift will also affect the variation in the output common-mode voltage that was alluded to in Section 1.

4 Overload Conditions

The ADS527x devices can handle a maximum signal amplitude of $2V_{PP}$ differential. This limit means that any signal amplitude in excess of $2V_{PP}$ at the output of the VCA8613 will overload the ADS527x. The ADS527x will recover fully within 3 to 4 clock cycles and within 1% accuracy within 1 to 2 clock cycles. This rate means that a full recovery occurs within 80ns at 50MSPS.

If it is necessary to protect the ADS527x ADC further, TI then recommends that the user increase the value of the series resistor from between 25Ω to 50Ω to approximately 300Ω. This increase ensures that the ADS527x ADC will never overload, even when the VCA8613 is severely overloaded. The downside to this solution, however, is that the 300Ω series resistor in conjunction with the 600W shunt resistor will cause a 50% attenuation factor, even at low signal levels when no attenuation is required.

5 Conclusion

The VCA8613 can easily be interfaced with TI's ADS527x family as well as the ADS512x series of high-speed data converters. The VCA8613 can be dc-coupled to the ADS512x. TI recommends, however, that users ac-couple the VCA8613 with the ADS527x, though it is possible to dc-couple the two devices by forcing an external voltage of 1.5V on pin 29 of the VCA8613.