A DIVISION OF CIRRUS LOGIC

CS5525/6/9 FAQ

Technical Brief

FAQ (FREQUENCLY ASKED QUESTIONS)

1) Do you have a four channel part?

   Not at this time, but we have plans to do a multi-channel product Q4 ‘97. We also have 4 digital output lines which can be used to control either switches or a multiplexer through the ADC’s serial port, thus eliminating the use of an extra port on the system µC and additional opto-isolators in isolated applications.

2) How does the 4-bit digital latch on a DS ADC allow me to change channels?

   The CS5525 and CS5526 as well as the CS5504 family of ADC’s are designed to settle in one conversion cycle. This means a mux can be switched from channel-to-channel with every conversion while maintaining resolution and accuracy.

3) What determines the input span of the converter?

   Performing a full scale gain calibration, or modifying the reference voltage. For example, if the reference voltage is reduced by 50% the default input ranges scale by one half. Example:
   Vref = 2.5 V, Vin = 25 mV to 5 V and
   Vref = 1.25 V, Vin = 12.5 mV to 2.5 V.

4) How does the output word rate affect the ADC’s bandwidth?

   The input bandwidth is limited to 1/2 the selected output word rate due to the Nyquist theory of sampling. Example: With the default 15 Hz output word rate the available signal bandwidth of the ADC is 7.5 Hz.

5) What is recommended if I need more or less bandwidth than is provided by the on-chip digital filter?

   Use an external clock between 30 kHz and 100 kHz to scale the digital filters corner frequency accordingly. Example: Using a 3x clock = 3x32.768 kHz = 3 x the word rate = 3 x 3.76 Hz to 3 x 202 Hz = 11.28 Hz to 606 Hz.

6) How fast can the converter shift data from its serial port?

   Up to 2 MHz.

7) How does the instrumentation amplifier’s chopping frequency affect the converter’s input impedance and input current?

   The input impedance of the converter is a dynamic impedance and depends on whether the instrumentation amplifier is engaged or not. For the lower ranges (25 mV, 55 mV, 100 mV), the instrumentation amplifier is engaged setting the input impedance to 1/fC (where C is 2 pF, and f is the chopping frequency, either 256 or 32,768). A typical input impedance for the lower ranges is 1900 MW (with f = 256, and C = 2 pF). For the higher ranges (1 V, 2.5 V, and 5 V), the amplifier is bypassed leaving an equivalent input impedance of 1/fC where C is 32 pF and f is either 256 or 32,768. A typical input impedance for the higher ranges is 120 MW (with f = 256 and C = 2 pF).

   The input current is a dynamic current and also depends on whether the instrumentation amplifier is engaged or not. For the lower ranges

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(25 mV, 55 mV, 100 mV), the input current is fVosC (where Vos is the offset of the instrumentation amplifier, typically less than 40 mV, f is the chopping frequency, either 256 or 32,768, and C is 2 pF). A typical input current for the lower ranges is 100 pA. For the higher ranges (1 V, 2.5 V, and 5 V), the input current is [(VAIN+)-(VAIN-)]fC where (VAIN+)-(VAIN-) is the voltage between AIN+ and AIN-, f is either 256 or 32,768, and C is 32 pF. A typical input current for the higher ranges is 1.2 μA/V.

8) When reading the conversion data I get all zeroes no matter what the analog signal is. Please explain why.

Check the voltage between pins 19 and 20 (VREF+ and VREF-). If it is zero, the converter will compute all zeros because the digital output word represents the ratio of the input signal to the voltage reference.

9) Is calibration required to use the converter?

When the CS5525/26 is reset, the registers are set to known values. If the signal to be measured by the converter is within the nominal range, the converter can perform conversions without the need for calibrations. Errors in the system remain present when calibration is not performed, however, this may be acceptable if the errors are insignificant to the measurement or if the errors are removed by some other means, such as software and registers in the microcontroller.

10) How often do I need to recalibrate?

To answer this question one must ask: 1) What accuracy is required from the A/D converter? 2) What effects will temperature changes have upon the entire circuit, including components outside the A/D? To obtain optimum calibration accuracy, a calibration should be performed approximately one minute after power is applied to allow the chip to reach thermal equilibrium.

A higher accuracy measurement requirement will generally require calibrations more often, because, after the initial calibration has been performed, the converter is subject to some drift if the operating temperature changes. Typical offset drift and gain drift are given in the data sheet tables. The observed drift in the application circuit may be considerably greater due to parasitic thermocouple effects and gain drift caused by the limited tempco tracking of the external resistors. Once an estimate of drift is determined for the entire application circuit (drift will usually be dominated by error sources external to the converter), an assessment of how it affects measurement accuracy as temperature changes can be made. Once the amount of drift is known, you can determine if a new calibration is required. A good rule of thumb is to recalibrate the converter (or system) with every ten degrees of ambient temperature change.

11) What do the numbers in the calibration registers actually mean?

There are two internal read/write calibration registers in the CS5525/26 (offset, and gain). One LSB in the offset register is 2^{-24} proportion of the input span (bipolar span is 2 times the unipolar span). The MSB in the offset register determines if the offset that is to be trimmed is either positive or negative. The converter can typically trim ±50% of the input span. The gain register spans from 0 to $(2 - 2^{-23})$. The decimal equivalent meaning of the gain register is:

$$D = b_0 2^0 + b_1 2^{-1} + b_2 2^{-2} + b_3 2^{-3} + ... + b_N 2^{-N}$$

where the binary numbers have a value of either zero or one. After a gain calibration has been performed, the numeric value in the gain register should not exceed the range of 0.5 to 2.0 (decimal) [400000(Hex) to FFFFFF(Hex)].

12) How can the gain be calibrated if a full-scale signal is not available?

The CS5525/26 can be gain calibrated with some input signal other than full scale. For example, when the converter is reset, the gain register's calibration word is 1.0 (decimal). If a signal representing ten percent of full scale reads three percent less than it should, the value in the gain register can be scaled up by three percent. Gain accuracy can be improved if output words are averaged while using this technique. Use caution when a calibration signal less than full scale is being used. If the transfer function of the transducer being used to generate the ten percent signal happens to have a major nonlinearity at the point at which calibration is being performed, it will cause the rest of the transfer function to be incorrect.

13) Why does the offset move when the CS5525/26 with a 2.5 V reference, is calibrated several times? What can be done to prevent this?

The CS5526 is a 20-bit ADC with inherent Gaussian thermal and quantization noise associated with each conversion. Therefore, every time the converter is calibrated, a different offset calibration output has a chance of occurring. By averaging conversions, the peak-to-peak noise can be reduced by a factor of 1/sqrt(n) (where n is the number of samples taken). The offset register can be accessed after calibration, and the offset uncertainty of a converter can almost be eliminated (to 1 code) by averaging. The CS5525 (16-bits) always has 1 count of variability, even if averaged, because the noise and calibration can occur at a boundary between two codes. If the calibration code is on the boundary the random noise could toggle the offset between the two codes.

14) Is a different calibration required for each gain getting?

For maximum accuracy, calibrations should be performed for offset and gain for each gain setting. If a factory calibration is performed using a system calibration, the offset and gain register contents can be read by the system microcontroller and stored in EEPROM. These same calibration words can then be uploaded into the offset and gain registers of the converter when power is re-applied to the system, or when the gain range is changed.

15) What is the advantage of performing calibrations at lower output word rates?

Calibrations are performed at the output word rate selected by the WR2-WR0 bits of the configuration register. Since higher word rates result in conversion words with more peak-to-peak noise, it is better to calibrate at lower output word rates. To minimize the digital noise near the device, the user should wait for each calibration step to be completed before reading or writing to the serial port.

16) How can I get the best noise performance from the CS5525/26?

Use the bipolar mode or increase the reference voltage, since each of these increase the size of the LSB.

17) If the charge pump is engaged, how do I ensure that the converter and its external components are intrinsically safe?

Intrinsic safety prohibits the use of electrolytic (or bipolar) capacitors thus limiting the use of certain size capacitors. Although a 10 μF cap. is recommended for the charge pump, two 0.47 μF ceramic caps in parallel can be used.

18) What benefit does an evaluation board offer?

The CDB5525/26 evaluation board saves time and money over prototyping. The preassembled board comes equipped with an 80C51 microcontroller and a 9-pin cable to link the evaluation board to a PC-compatible computer. The evaluation system also includes software which provides easy access to the internal registers of the converter and displays the converter's time domain, frequency domain and noise histogram performance.

19) How do the analog power supply configurations differ between the CS5525/26 and the CS5529?

The CS5525/26 converters can be powered from a single +5 V analog supply and either a +5 V or +3.3 V digital supply. They have a charge pump which uses two external diodes and two external capacitors to generate a negative supply (a negative bias voltage) allowing digitization of ground-referenced signals. The negative bias voltage can be supplied from a separate negative supply, if desired. The CS5529 A/D converter is designed to operate from a single +5 V or a dual ±2.5 V analog supply and either a +5 V or +3.3 V digital supply. Since the CS5529 can be powered from a negative analog supply, level shifting circuitry can be eliminated when measuring ground-referenced signals.

20) How do the voltage references differ between the CS5525/26 and the CS5529?

The CS5529 supports differential reference voltages up to the analog supply allowing the analog supply to serve as the reference voltage. The reference's inputs are buffered through a coarse/fine charge buffer. Since the inputs are buffered, the dynamic current is typically 8 nA and is independent of the reference voltage. The CS5525/26 do not have buffers yet support a differential reference voltage up to 3.0 V. Since their reference inputs aren't buffered the dynamic input current is typically 1.2 µA/V.

21) How do the CS5525/26 and the CS5529 analog input ranges differ?

The CS5529 has a nominal input range of ±2.5 V (with VREF=2.5 V). The analog inputs for this range have a coarse/fine charge buffer which reduces the dynamic current to typically 16 nA. The CS5525/26 have an instrumentation amplifier and a programmable gain amplifier which provides nominal input ranges of 25 mV, 55 mV, and 100 mV. The instrumentation amplifier is a chopper stabilized amplifier and serves as a buffer reducing the dynamic input current to typically 100 pA. In the 1 V, 2.5 V, and 5 V ranges of the CS5525/26, the instrumentation amplifier is bypassed and no buffer exists to reduce the input current. In these ranges the input current is typically 1.2 µA/V.

22) How do the output word rates differ between the CS5525/26 and the CS5529?

All three converters have eight output word rates. The CS5529 samples at ½ the rate of the CS5525/26. Therefore, the CS5529's output word rate are ½ the CS5525/26.

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