Application Note

MEASURING HIGH VOLTAGES (5 TO 1,000 VOLTS) WITH THE CS5521/23, CS5522/24/28, AND CS5525/26 A/D CONVERTERS

By
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The CS5521/23, CS5522/24/28, and CS5525/26[1] A/D converters include a low input current (<300 pA input current over -40 to +85°C), chopper-stabilized programmable gain instrumentation amplifier (PGIA). A charge pump control loop is also included on-chip to provide a negative supply to the amplifier. This pump, which uses external components, enables the amplifier to measure ground-referenced signals even though the A/D is powered from a single +5 V supply (see Figure 1).

This applications note discusses the features of the amplifier and how it can be used to measure large dc voltages.

INPUT CVF (SAMPLING) CURRENT

The programmable gain instrumentation amplifier in the CS552x family is a CMOS, chopper-stabi-

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1. The CS5529 is not included in this Application Note because it does not contain an instrumentation amplifier.
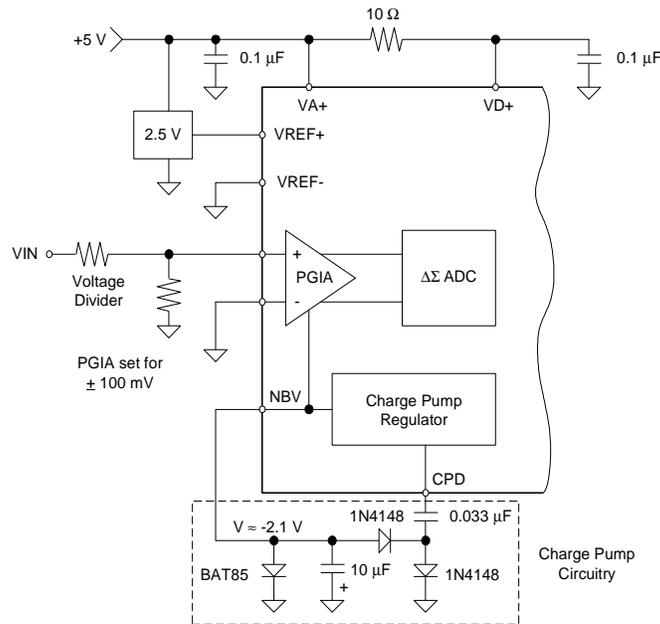
Figure 1. CS552X ADC with Charge Pump

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lized amplifier with has three low level input ranges (±25 mV, ±55 mV, and ±100 mV) and very low input current. The amplifier's input current is dynamic current (CVF current; for explanation of CVF current, see the Summary) which is caused by charge injection. Charge injection occurs due to inherent mismatch of the chopping switches in the chopper circuitry of the amplifier.

The magnitude of the CVF current is a function of the frequency used to operate the chopping switches. The CS552x family has two bits in the configuration register (Chop Frequency Select bits) which allow the user to program the rate of the chopping frequency, (i.e. the user can control the magnitude of the input CVF current). When set for the lowest chopping rate, the chop clock frequency is 256 Hz when XIN = 32.768 kHz. Note that if the XIN clock frequency is changed, the chop frequency scales proportionally. At a chop clock rate of 256 Hz, the CVF current of the PGIA inputs will be below 300 pA over the industrial temperature range. For the 100 mV input range at 25 °C, this equates to an input impedance of approximately 1000 MΩ (100 mV/ 100 pA).

Many competitors ADCs, which are "designed" for low level signal measurement, exhibit CVF input currents of 10-30 nA, or as much as 100 times higher. This current is typically not specified in the datasheet.

MEASURING HIGH VOLTAGES

The very low CVF current on the ±100 mV and lower ranges allows the use of fairly large source impedances in front of the amplifier. This enables this series of ADCs to use high impedance resistive dividers in front of the ADC to divide down high level input voltages.

Figure 3 illustrates an example of the ADC being used with external divider resistors to achieve the measurement of a ±10 V input signal. The input current from the 10 V source will be about 10 μA (10 V/ 10MΩ). The input current to the amplifier

will not exceed 300 pA over the industrial temperature range if XIN = 32.768 kHz and the lowest chop clock frequency (256 Hz) is used. The ratio of these two currents is about 3333 to 1; therefore the possible measurement error, due to the CVF current, is approximately 1/3333 or about 0.03%. Figure 3 illustrates an alternative divider with less initial error due to the CVF current, typically 0.003%. Note that errors caused by initial resistor tolerances and by the initial CVF current can be removed by using system calibration (refer to the CS552x datasheet for more detail on system calibration). Since these initial errors can be removed, the residual error becomes a function of the resistor tempco and the drift of the CVF current. Figure 4 illustrates an example of the measurement of a very high voltage: 1,000 V dc. If very high voltages are measured be certain the resistors have adequate voltage breakdown capability and sufficient power dissipation capability.
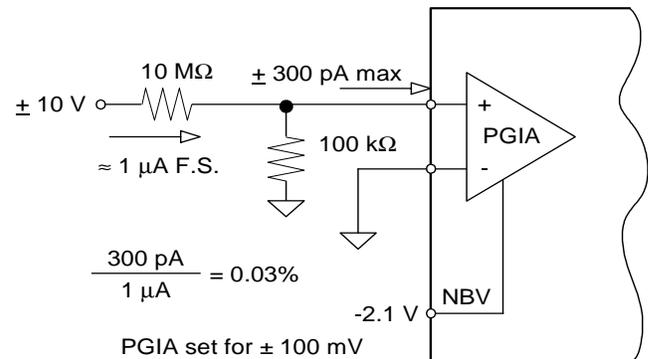
Figure 2. Resistor Divider for ± 10 V Input
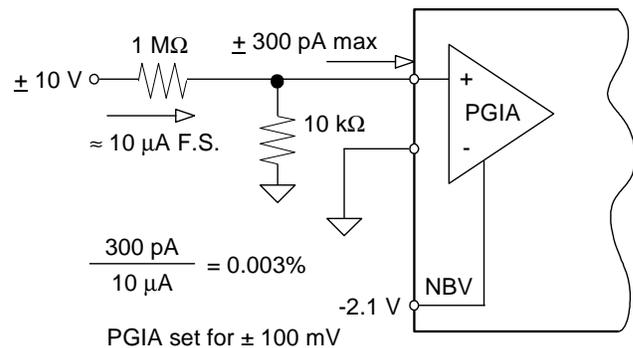
Figure 3. Alternate ± 10 V Divider
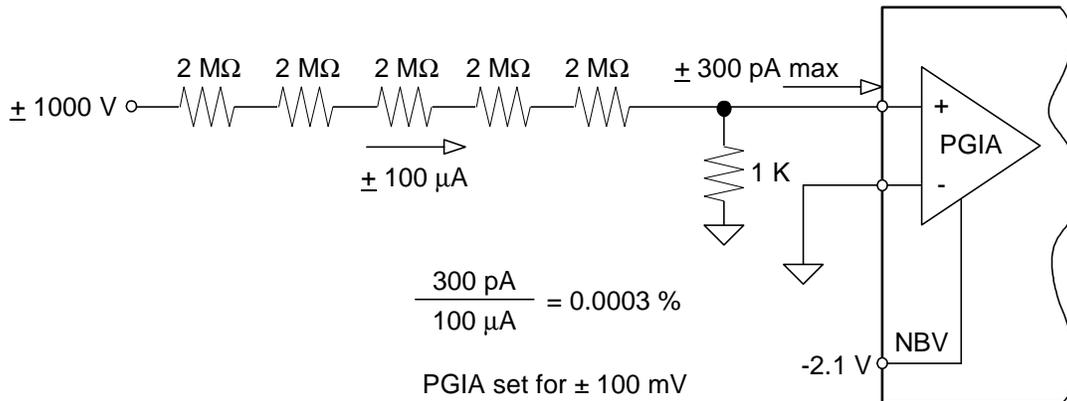
Figure 4. Resistive Divider for Very High Voltage

SUMMARY

CVF current is a sampling current caused by a capacitive-based sampler. A sample capacitor is charged with a voltage when a sample is taken. The CVF current which flows is determined by the equation $I = CVF$, where C is the value of the sampling capacitor, V is the voltage magnitude being sampled with the capacitor, and F is the sampling frequency. An ADC with low input CVF current will exhibit a high input impedance. A high input impedance allows for a high source impedance from the signal to be converted. In this applications note example, high voltages can be measured using a simple high resistance ratio voltage divider.

Refer to Applications Note 30, "Switched-Capacitor A/D Converter Input Structures", as it further discusses the magnitude of CVF currents for different switched-capacitor input structures. Also, refer to Applications Note 152, "Using the CS552x's Charge Pump Drive for External Loads", for more details on using the CS552x's charge pump to drive external loads.

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