Application Brief

Understanding the Difference between Switched Capacitor and Fully Differential Amplifier (FDA) Inputs for Isolated Data Converters

Introduction

Isolated delta-sigma modulators are a common solution for current measurement in high-voltage systems such as motor drives, inverters, and power conversion stages. By digitizing the analog input on the high-voltage side and transmitting a bitstream across a galvanic isolation barrier, these devices protect low-voltage signal circuitry while rejecting large common-mode voltages inherent to switching power stages.

Two input architectures are present in today's isolated modulator solutions: the fully differential amplifier (FDA) front-end, which actively buffers and conditions the analog signal before it reaches the modulator, and the direct switched-capacitor input, which connects the modulator directly to the analog inputs without an intermediate amplifier stage. This document compares the two types of inputs and how to properly design an input filter for each type.

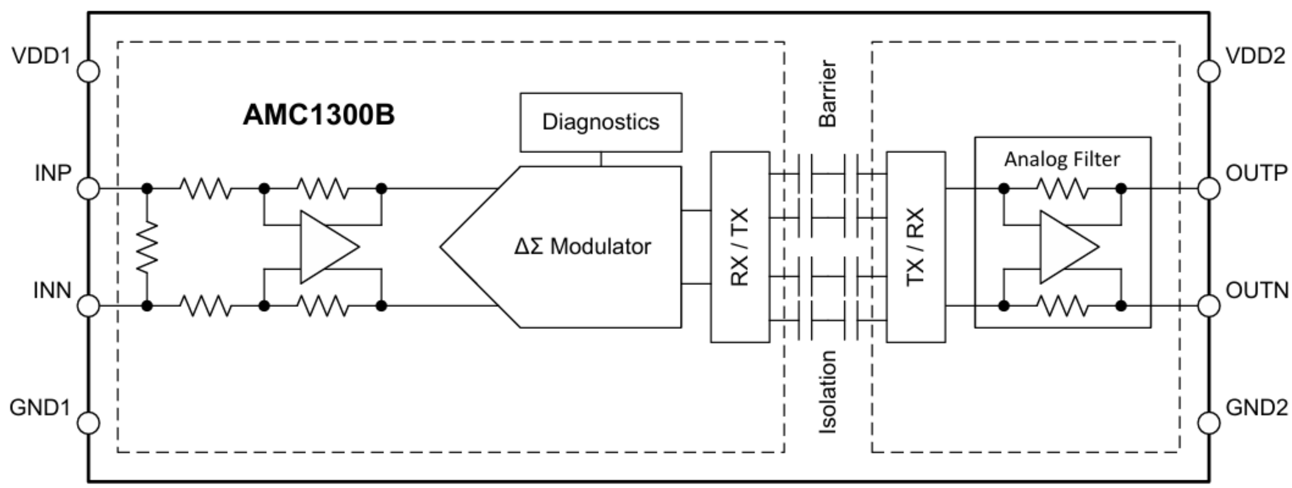

Figure 1. Fully Differential Amplifier Input

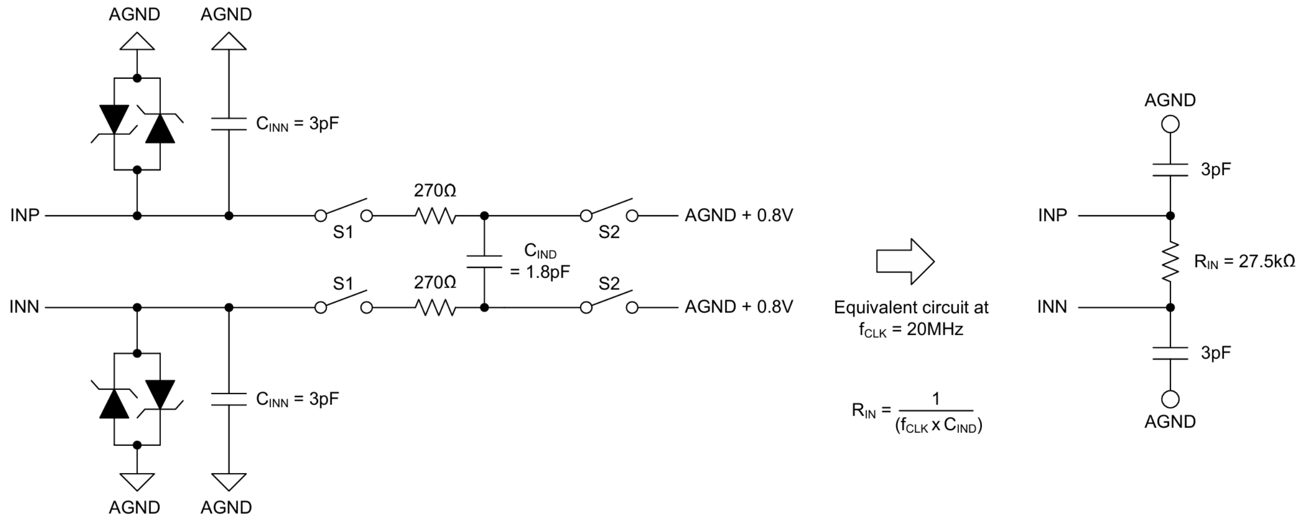

Figure 2. Switched-Capacitor Input

The main difference between the switched-capacitor input and the FDA is the op-amp input stage on the input of the delta-sigma modulator on the FDA architecture. Omitting this amplifier on the input allows for more cost-effective solutions for designers. The layout of the input filtering also looks different between the two inputs.

Both input architectures should have a differential capacitor between the inputs. Due to the switched capacitors' higher peak current draw, common-mode capacitors should also be placed between both inputs to ground. These capacitors should be 10 to 20 times smaller than the differential capacitor between the inputs. The design of the differential input filter does not change between the two input structures; namely, it should follow these guidelines:

- The cutoff frequency of the differential filter is at least one order of magnitude lower than the sampling frequency (20MHz) of the ΔΣ modulator
- The input bias current does not generate significant voltage drop across the DC impedance of the input filter
- The impedances measured from the analog inputs are equal

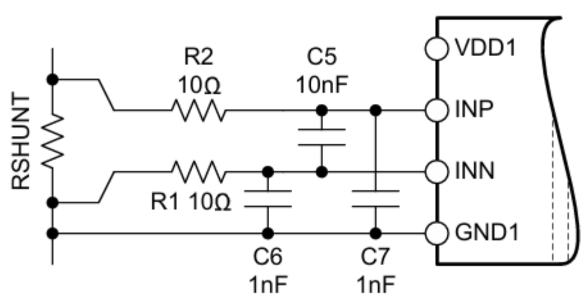

Figure 3. Input Filter for a Switched-Cap Input

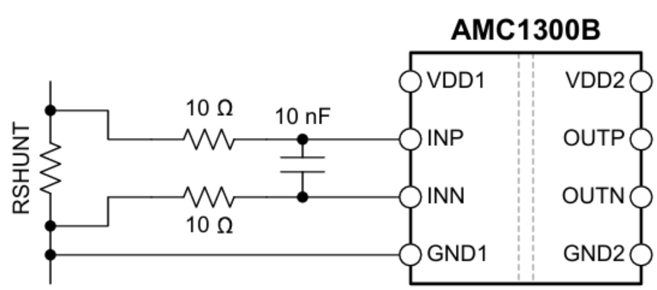

Figure 4. Input Filter for an FDA Input

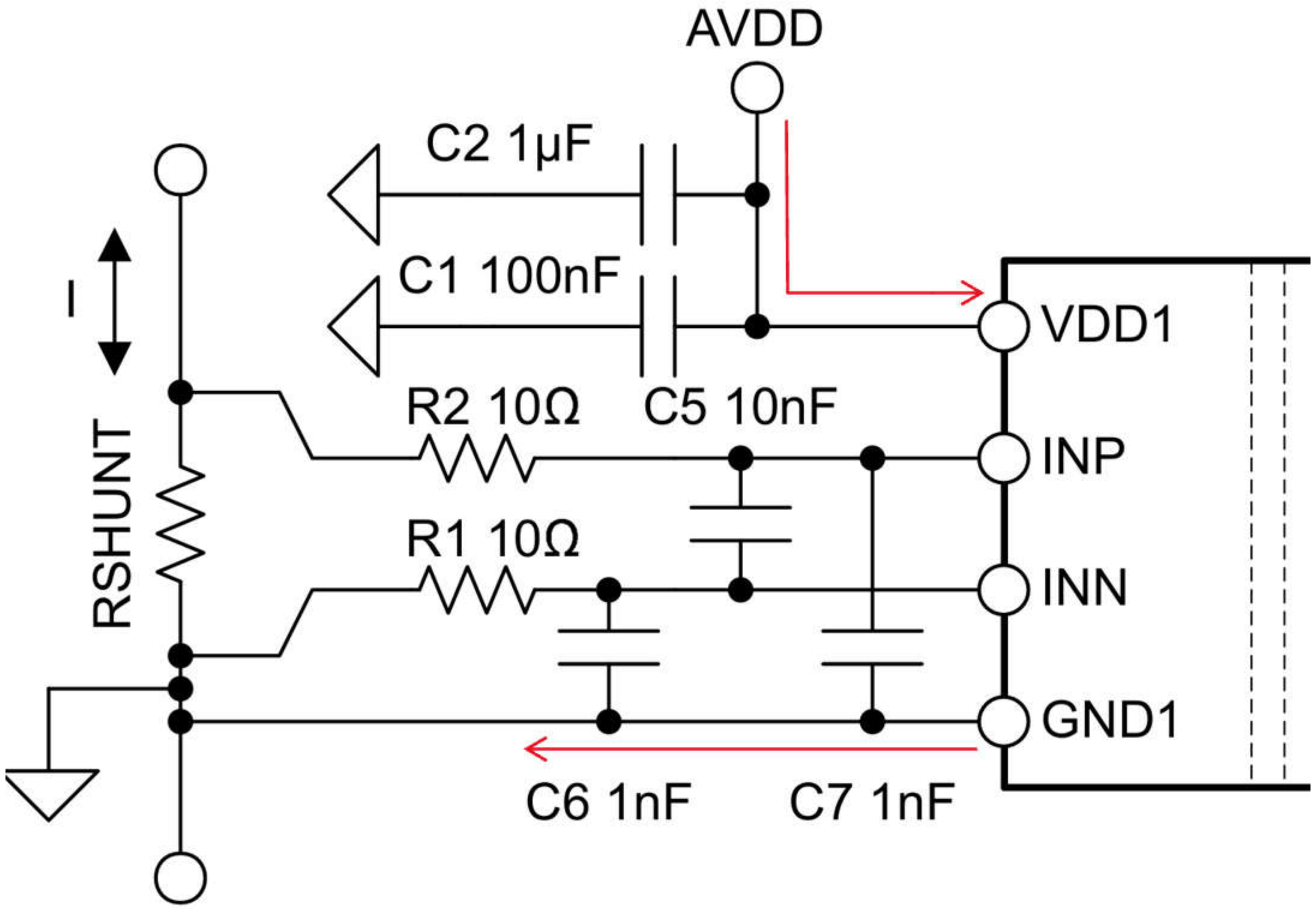

Figure 5. Example High-Side Current Path

It must be noted that a separate trace path should run from the shunt resistor to INN and to GND1. Do not short INN and GND1 together. GND1 is the return path for current flowing into the device, primarily from VDD1. This return current will cause a small but measurable voltage drop on the return path trace. If this voltage drop is coupled onto the INN pin, it will cause errors in the current sense measurements.

This diagram shows an example of the current path on the high side of the circuit. A large current runs into the device at VDD1 and out of the device at GND1. This induces a small voltage across the GND1 trace. If GND1 were shorted to INN, this voltage would be measured and lead to inaccuracies in measurements.

References

- AMC1306 to AMC0306 Migration Guide

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