UNDERSTANDING THE ADS1251, ADS1253, AND ADS1254 INPUT CIRCUITRY

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SUMMARY

This application report describes the ADS1251, ADS1253, and ADS1254 input circuits to better illustrate the loading seen by the signal source.

INPUT CIRCUIT

The ADS1251, ADS1253, and ADS1254 measure the input signal using internal capacitors that are continuously charged and discharged. Figure 1 shows a simplified schematic of the ADS1251, ADS1253, and ADS1254 input circuitry, with Figure 2 showing the ON/OFF timings of the switches. Switches S1 are closed during the charging phase. With S1 closed, C_{A1} charges to $+V_{IN}$, C_{A2} charges to $-V_{IN}$, and C_B charges to $(+V_{IN}) - (-V_{IN})$. For the discharge phase, S1 first opens and then S2 closes. C_{A1} and C_{A2} discharge to approximately $0.25V_{DD}$ and C_B discharges to 0V. This 2-phase charge/discharge cycle repeats with a frequency of CLK/6. Note that the S2 switches represent the internal discharging process within the ADS1251, ADS1253, and ADS1254. The actual circuitry inside the ADS1251, ADS1253, and ADS1254 is different, but the net effect is the same.

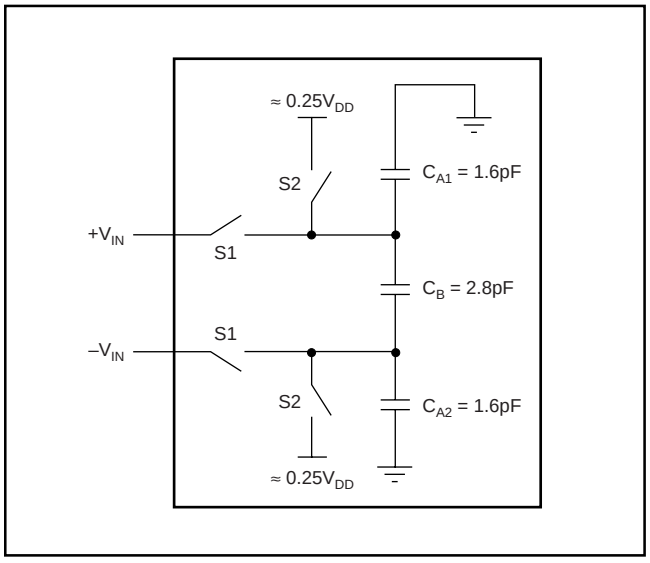

FIGURE 1. ADS1251, ADS1253, and ADS1254 Simplified Input Circuit.

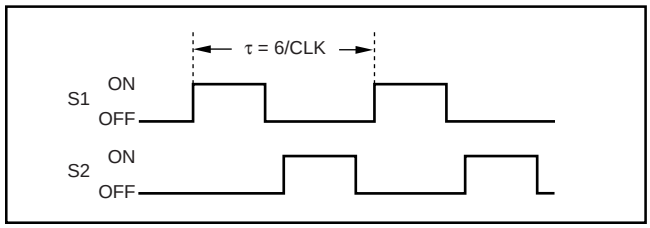

FIGURE 2. Switch Timing for Figure 1.

When driving the inputs of the ADS1251, ADS1253, and ADS1254, it is important to consider the effects of the loading from the input circuitry. The constant charging and discharging of the capacitors present a dynamic load resulting in input current spikes that exponentially decay as the capacitors are charged. The external circuitry driving the ADS1251, ADS1253, and ADS1254 inputs must be able to handle this load. To help understand the requirements on the external circuitry, it is often helpful to consider the effective impedance presented by the switching capacitor load.

EFFECTIVE IMPEDANCE OF A SWITCHED-CAPACITOR

Consider first, a simple capacitor that is charged and discharged, as shown in Figure 3 (with the same switch timings that are shown in Figure 2).

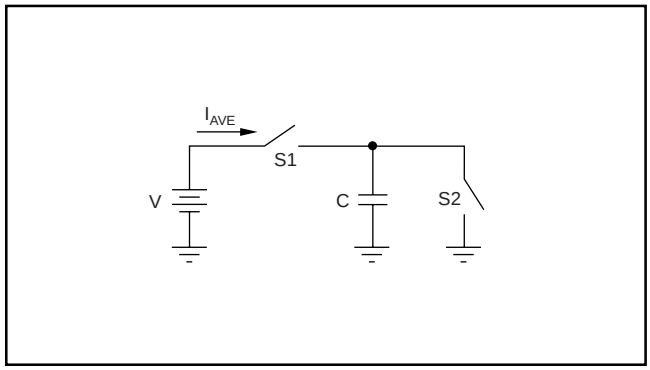

FIGURE 3. Simple Capacitor Example.

The average current load of this signal (I_{AVE}) is:

$$I_{AVE} \equiv \frac{Q}{t} = \frac{CV}{\tau} = CV\frac{f_{CLK}}{6} \quad (1)$$

Defining the effective impedance as:

$$Zeff \equiv \frac{V}{I_{AVE}} \quad (2)$$

and combining with Equation 1 results in:

$$Zeff = \frac{1}{C\left(\frac{f_{CLK}}{6}\right)} \quad (3)$$

EFFECTIVE INPUT CIRCUIT

With the help of Equation 3, the circuitry of Figure 1 can be redrawn with effective impedances, as shown in Figure 4. Table I lists the effective impedances versus CLK frequency.

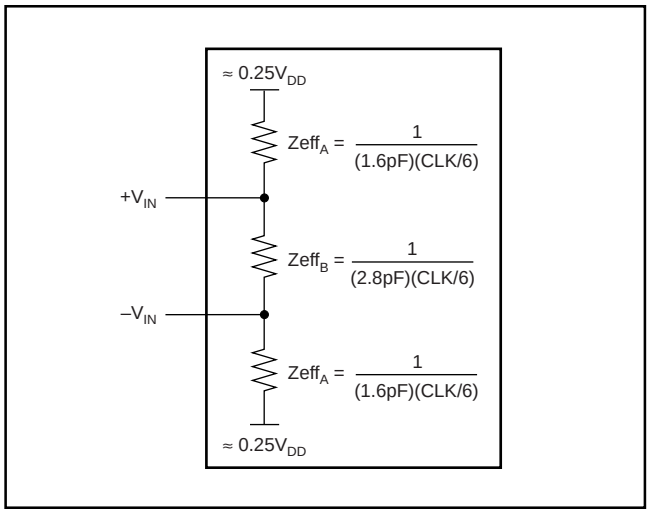

FIGURE 4. Effective Input Impedances of the ADS1251, ADS1253, and ADS1254.

CLK FREQUENCY (MHz)	$Zeff_A$ (MΩ)	$Zeff_B$ (MΩ)
0.0384	96	56
1	3.7	2.2
4	0.92	0.54
8	0.46	0.27

TABLE I. Effective Input Impedances for Different CLK Frequencies.

It is sometimes convenient to consider the input impedance with respect to the differential and common-mode voltages shown in Figure 5. Using Z_{DM} (differential effective input impedance) and Z_{CM} (common-mode effective input impedance), the input currents are:

$$I_+ = Z_{DM}V_{DM} + Z_{CM}(V_{CM} - 0.25V_{DD}) \quad (4)$$

$$I_- = -Z_{DM}V_{DM} + Z_{CM}(V_{CM} - 0.25V_{DD}) \quad (5)$$

Referring to the circuit in Figure 4, it can be shown that:

$$Z_{DM} = Zeff_B \,\|\, 2Zeff_A \quad (6)$$

$$Z_{CM} = Zeff_A \quad (7)$$

Table II lists the differential and common-mode effective impedances versus CLK frequency.

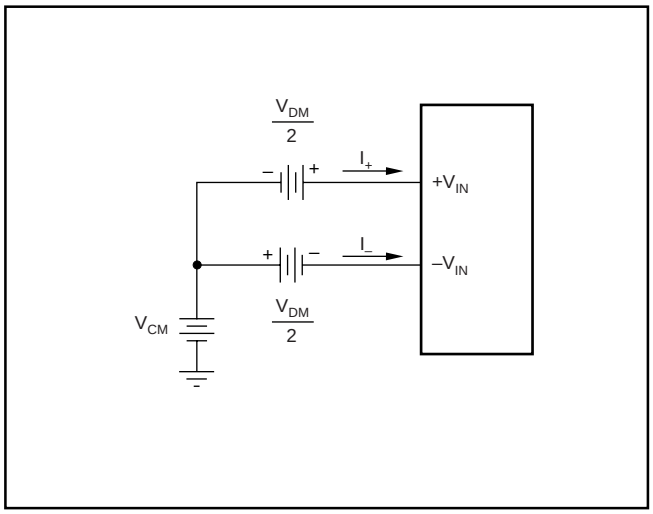

FIGURE 5. Differential and Common-Mode Signal Definitions.

CLK FREQUENCY (MHZ)	Z_{DM} (MΩ)	Z_{CM} (MΩ)
0.0384	43	96
1	1.7	3.7
4	0.42	0.92
8	0.21	0.46

TABLE II. Differential and Common-Mode Effective Input Impedances for Different CLK Frequencies.

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