AN-1321
APPLICATION NOTE

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

Common-Mode Transients in Current Sense Applications

by Kristina Fortunado

INTRODUCTION

Current sense amplifiers are used in a variety of applications, such as motor or solenoid control, load current monitoring, and fault detection. In such applications, it is typical for the input common-mode voltage to swing from ground to a certain high-side supply. However, while a user may work with the assumption that the input common-mode swings are limited to this high-side supply, there are transient voltages that must be considered. The result of these transients is that a supposed low voltage application tends to appear as a high voltage application, and the current sense amplifier must be robust enough to handle these occurrences.

TRANSIENT VOLTAGES IN A MOTOR DRIVE CIRCUIT

One can consider a motor drive circuit to gain insight into these transient voltage events. The circuit shown in Figure 1 uses the ADuM3223 to drive the gates of two MOSFETs in a half-bridge configuration. The inputs of the ADuM3223 are driven with inverted pulse-width modulation (PWM) signals with duty cycles of 50%, enabling switching between the two MOSFETs.

The node between the emitter of the high-side FET and the collector of the low-side FET is the half-bridge point of the motor drive circuit. This node becomes the connection to the shunt resistor, R_{SH}, and the motor load, represented by an inductance, M. In this circuit, the AD8418, a current sense amplifier, is used to monitor the differential voltage across the shunt resistor. Since this differential voltage is typically a small value in the range of millivolts, the common-mode voltage seen by the current sense amplifier is essentially the voltage at the half-bridge point, and is denoted as V_{CM} in Figure 1.

When the low-side FET turns on, the half-bridge point is pulled down to ground. When the low side FET switches off and the high side FET turns on, the half-bridge point switches to the bus voltage, V_{BUS}. It is during this momentary switching that transients become apparent. These transients are caused by the fast switching speed of the load, along with the reactive nature it presents to the driver.

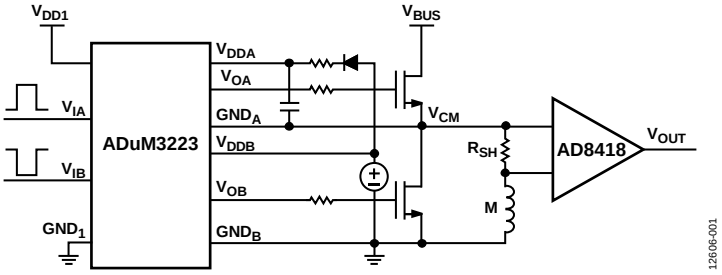

Figure 1. Motor Drive Circuit with the ADuM3223 and the AD8418

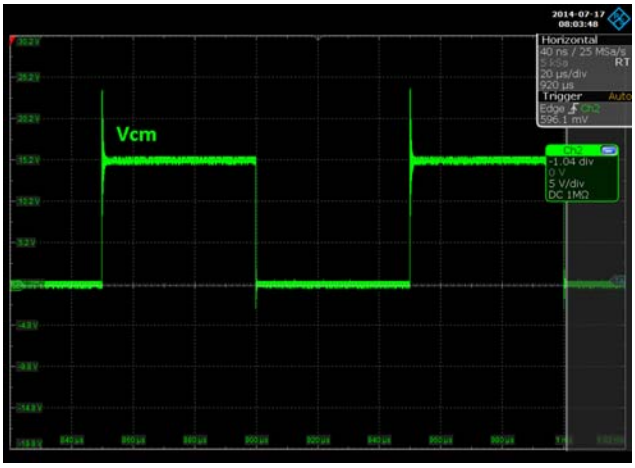

Figure 2. Common-Mode Voltage at the Half-Bridge Point

Figure 2 shows the common-mode voltage taken at the half-bridge point with a switching frequency of 10 kHz and a bus voltage of 15 V. A close look at the plot shows transients at both swings of the common-mode voltage. The transient at the rising edge reaches almost 8 V, which is more than 50% of the bus voltage. At the falling edge, there is a transient of about −2.5 V. For applications where higher bus voltages and faster switching frequencies are used, the transients may effectively become higher.

CHOOSING AN AMPLIFIER

Figure 3 and Figure 4 show the typical response of the AD8418 to the common-mode voltage transients from the ADuM3223 motor drive circuit. The AD8418 output deviates from the expected voltage by about 30 mV to 40 mV as the common-mode voltage switches, then settles back to the expected output in a few microseconds. The capability of the current sense amplifier to handle these high transients is dictated by its input common-mode voltage range specification. Other amplifiers may have an absolute maximum specification, shown either as the common-mode voltage survival range or the continuous input common-mode voltage.

The Analog Devices, Inc. line of current sense amplifiers are designed to operate with a wide range of input common-mode voltages. The AD8418, for example, has a common-mode voltage survival range from −4 V to +85 V. For applications with larger negative transients, current sense amplifiers such as the AD8202 can survive common-mode voltages down to −8 V.

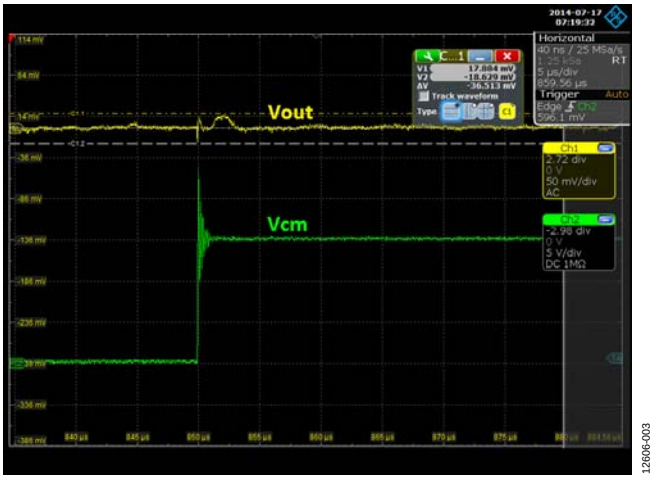

Figure 3. AD8418 Output at Rising Edge

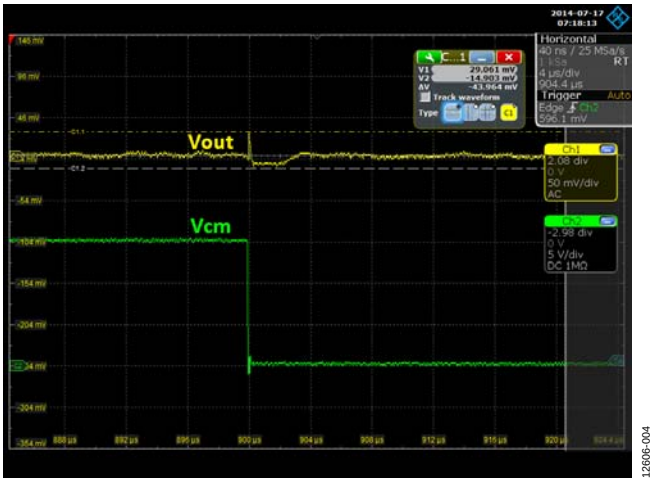

Figure 4. AD8418 Output at Falling Edge

CONCLUSION

Amplifier choice ultimately depends on the requirements of the current sense application. It is important for the user to recognize the occurrence of common-mode transient voltages and to accommodate these when choosing the appropriate amplifier. The varied input common-mode voltage ranges of the line of current sense amplifiers from Analog Devices provide the user with flexibility for these considerations.