Amplifier cancels common-mode voltage

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Since the dawn of time—or at least since the dawn of precision electronics—a major headache for analog designers has been CMV (common-mode-voltage)-induced errors, also known as the dreaded ground loop. Although almost mystical is the fear it strikes in the hearts of engineers, there's nothing particularly mysterious about CMV. CMV errors occur for a simple reason: The common voltage references—that is, ground—of circuitry in different places, such as sensors in one chassis and an ADC in another, are apt to differ. Therefore, when you

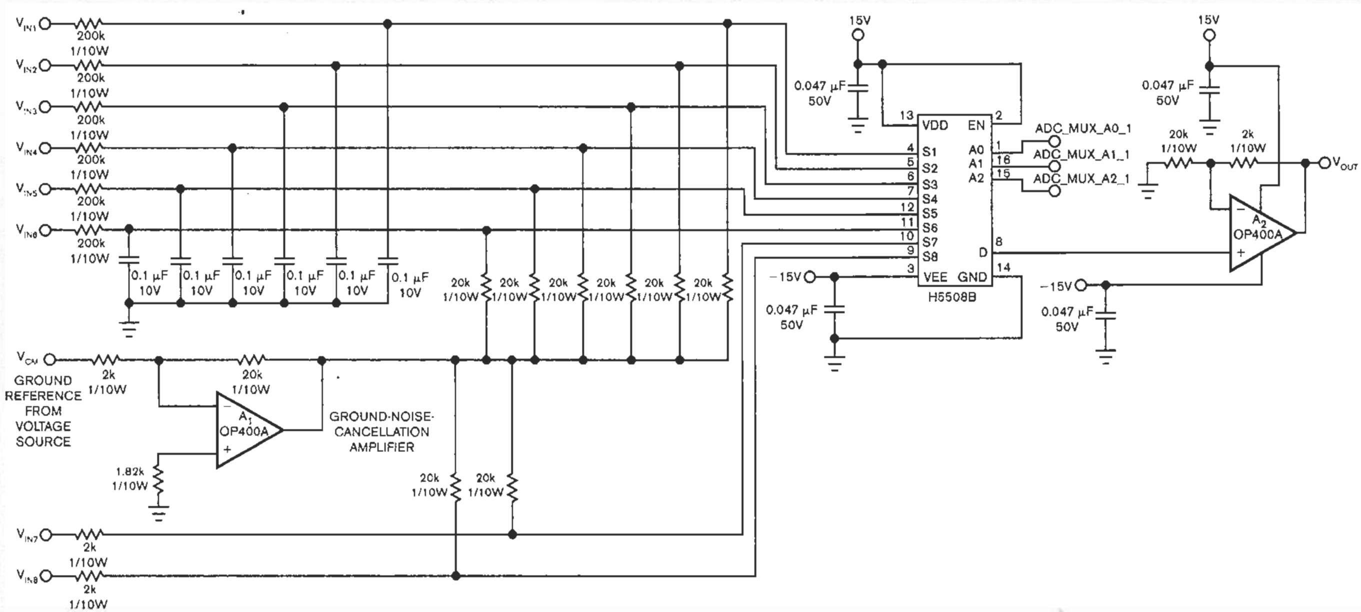

Figure 1 Amplifier A_1 amplifies and inverts the common-mode voltage by a factor of −10. Then, the circuit applies this signal to an array of passive summation networks. An analog multiplexer selects the desired input signal, and op amp A_2 supplies a compensating gain.

route signals between remotely located circuits, the CMV differential appears as additive noise and offset, corrupting the desired signals.

Many approaches exist for eliminating CMV errors. These methods include the brute-force approach of using massive amounts of copper in ground interconnections, fully differential instrumentation-amplifier signal conditioners, and galvanic isolators. Each has its place, depending on such factors as the severity of the CMV problem and the number of signal channels needing CMV remediation. One of the most popular and effective CMV remedies is differential amplification, in which you perform an analog subtraction to remove the CMV component from the signal. The downside of this method is that it requires a dedicated amplifier for every signal channel. The circuit in **Figure 1** is a variation on that same differential-amplifier idea, but it combines two shared CMV amplifiers with simple passive-resistor pairs among eight multiplexed channels to provide CMV cancellation for a large number of analog channels at minimum component count.

ONE OF THE MOST POPULAR AND EFFECTIVE CMV REMEDIES IS DIFFERENTIAL AMPLIFICATION, IN WHICH YOU PERFORM AN ANALOG SUBTRACTION TO REMOVE THE CMV COMPONENT FROM THE SIGNAL.

Here's how it works. Amplifier A_1 amplifies and inverts the CMV by a factor of −10. You then apply this CMV to an array of passive-summation networks—one for each input signal. The 10-to-1 ratio of the two legs of each network combines the incoming input-voltage and CMV signals with the −10V CMV ground-noise reference: $V=10/11\times(V_I+V_{CM})+1/11\times(10\times V_{CM})=10/11\times V_I+10/11\times(V_{CM}-V_{CM})=10/11\times V_I$. V_{CM} is attenuated by a factor depending mainly on the accuracy of 20- versus 2-kΩ resistor-ratio matching. For 1% matching, the CMRR (common-mode-rejection ratio) is approximately 100-to-1, or 40 dB; for 0.1% matching, CMRR is 1000-to-1, or 60 dB.

The analog multiplexer then selects the desired input voltage for input to the 11/10 scale-factor-correction amplifier, A_2. The optional 0.1-μF filter capacitors provide a modicum of low-pass noise filtering, and you should tailor them for the bandpass requirements of your application. The approximately 180 μsec, or approximately 88 Hz, is too slow for many applications and too fast for others. EDN