LMV831,LMV832,LMV834,LMV851,LMV852,
LMV854,LMV861,LMV862

EMI-Hardened Operational Amplifiers for Robust Circuit Design

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EMI-Hardened Operational Amplifiers for Robust Circuit Design

Application Note AN-1874

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As the number of electronic devices in the world continues to increase, the issue of Electronic Interference (EMI) between these devices becomes a greater challenge.

In response to the growing need for ICs that are resistant to electromagnetic waves, National has developed several op amp families that are hardened to EMI. The LMV851/52/54 low-power CMOS op amps have 8 MHz gain bandwidth, while the LMV861/62 and LMV831/32/34 series have a gain bandwidth of 30 MHz and 3 MHz, respectively.

The effect of EMI can be demonstrated in a setup where a cell phone introduces interference in a pressure sensor application as seen in ***Figure 1***. When the cell phone is called, the application will detect the RF signal transmitted by the cell phone. As a result, the output of Op Amp 2 will show a voltage shift. The magnitude of this unwanted voltage shift depends, among other factors, on the EMI robustness of the op amps.

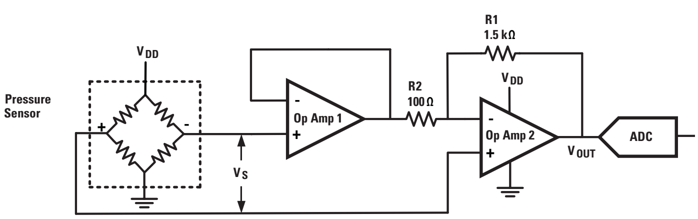

Figure 1. Pressure Sensor Application

The experiment is performed with a typical standard dual op amp and with the LMV852 dual EMI-hardened op amp. The resulting voltage shift on the output of Op Amp 2 is depicted in ***Figure 2***, where the cell phone is placed a couple of centimeters above the application.

The difference between the two types of op amps is clearly visible. The typical standard dual op amp has an output voltage shift (disturbing signal) larger than 1V as a result of the RF signal transmitted by the cell phone. The LMV852 EMI-hardened op amp does not show any significant disturbances.

The op amp can play an important role in making designs significantly more EMI hardened. This is because the EMI robustness between op amps differs and the op amp is often the component where a disturbing RF signal

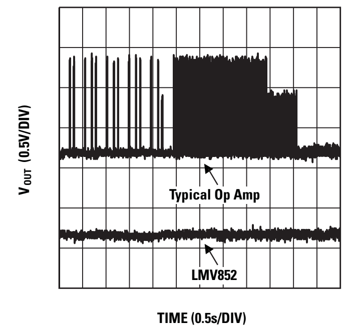

Figure 2. Comparing EMI Robustness

arrives on a PCB. Relatively long connections, to sensors for instance, can easily pick up disturbances and carry them to the op amp. An EMI-robust part will hardly detect the signal and will prevent the detected signal from propagating to the connected circuitry on the PCB. This ensures a proper functioning device.

EMI and Op Amps

To understand the sensitivity of an op amp to EMI, it is important to known how interference arrives at an op amp. Disturbing RF signals can potentially arrive either conductively via the op amp pins or through the air coupling into the IC directly. Since the dimensions of an op-amp IC are relatively small compared to the wavelength of the disturbing RF signals, interference will dominantly arrive through conduction (refer to application note AN-1698). The op amp will receive hardly any disturbances itself. The RF signals interfering with the op amp are thus dominantly received by the PCB and wiring connected to the op amp pins. As a result, RF voltages on the pins of the op amp can be used to represent interference.

RF signals interfere with op amps via the non-linearity of the op amp circuitry. This non-linearity results in the detection of out-of-band signals. The resulting effect is that the amplitude modulation of the out-of-band signal is down converted into the base band.

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This base band can easily overlap with the band of the op-amp circuit. As an example, ***Figure 3*** depicts a typical output signal of a unity-gain-connected op amp in the presence of an interfering RF signal. Clearly, the output voltage varies in the rhythm of the on-off keying of the RF carrier.

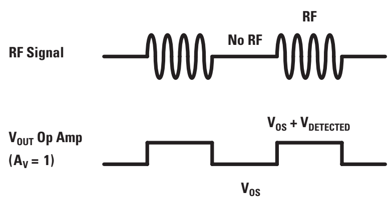

Figure 3. Offset Voltage Variation due to an Interfering RF Signal

The resulting voltage shift for the EMI-hardened op amp series is considerably smaller than for typical op amps which demonstrates the robustness to EMI.

EMI Rejection Ratio (EMIRR) Parameter

To identify EMI-hardened op amps, a parameter is needed that quantitatively describes the EMI performance of op amps. Therefore, the EMI Rejection Ratio (EMIRR) is introduced. This parameter describes the resulting input-referred offset voltage shift of an op amp as a result of an applied RF carrier (interference) with a certain frequency and level. The definition of EMIRR is given by:

$$\mathrm{EMIRR}_{V_{RF\_PEAK}} = 20 \log \left(\frac{V_{RF\_PEAK}}{\Delta V_{OS}} \right)$$

in which V_{RF_PEAK} is the amplitude of the applied unmodulated RF signal (V) and ΔV_{OS} is the resulting input-referred offset voltage shift (V). The offset voltage shift generally depends quadratically on the applied RF level, and therefore, the RF level at which the EMIRR is determined should be specified. The chosen standard level for the RF signal is 100 mV_P. Application note AN-1698 addresses the conversion of EMIRR values measured at signal levels other than 100 mV_P. The interpretation of the EMIRR parameter is straightforward. When two op amps have an EMIRR which differs by 20 dB, the resulting error signals when used in identical configurations differs by 20 dB as well. Thus, a higher EMIRR number means a more robust op amp.

Measuring EMIRR

Each of the op amp pins can be tested separately for EMIRR. The measurement on the IN+ pin is discussed here since it is generally the most sensitive pin together with the IN- pin. For testing the IN+ pin, the op amp is connected in a unity-gain configuration. Applying the RF signal is straightforward as it can be connected directly to the IN+ pin. The circuit diagram is shown in ***Figure 4***.

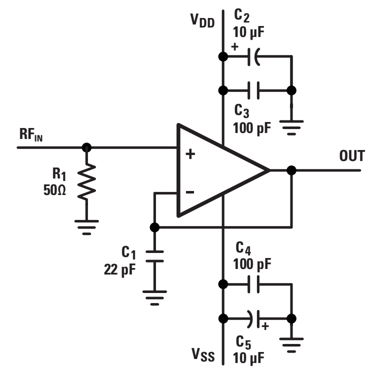

Figure 4. Circuit for Coupling the RF Signal to IN+

For determining the EMIRR, two measurements are needed: one is measuring the DC output level when the RF signal is off; and the other is measuring the DC output level when the RF signal is switched on. The difference of the two DC levels is the output voltage shift as a result of the RF signal. As the op amp is in the unity-gain configuration, the input-referred offset voltage shift corresponds one-to-one to the measured output voltage shift. By knowing the applied RF signal and the input-referred offset shift, the EMIRR can be calculated.

Conclusion

Designing EMI-robust circuits requires careful selection of the op amp used in the circuit, since its EMI robustness can vary substantially. The selection can be made based on the op amp's EMIRR, which quantitatively describes the EMI performance of op amps. ■

To learn more about EMI-hardened amplifiers, visit: national.com/amplifiers

References:

AN-1698 A Specification for EMI-Hardened Operational Amplifiers

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