EMI-Hardened Operational Amplifiers Reduce Inaccuracies

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Operational amplifiers (op amps) with electromagnetic interference (EMI) filters can reduce significant errors. These types of errors are not always obvious to the system designers. They often impact the signal chain, in particular the analog-to-digital converter in the form of a loss of digital counts.

Discrete Implementation and Integrated Filters

Although filtering of electromagnetic or RF injected signals can be effective at the board level by means of simple first-order filters (typically), it can be rather challenging. The challenge is especially true when each input is filtered with a RC, or if a capacitor is placed across the input terminals. The op amp frequency response is altered, and one must very likely compensate to get the appropriate phase margin, hence making sure the amplifier is unconditionally stable.

The advantage of "on chip" filters is that the IC designer compensates the op amp at the time of design and provides an adequate phase margin for stability. In addition, thermal noise is also accounted for and provided as a total spectral density in the data sheet.

Estimating Errors Induced by EMI or RF

Electromagnetic interference can be a serious problem in several applications from medical instrumentation to automotive and the effects can cause serious headaches.

Let's use an example of an op amp in a gain of 100 being injected with a 100-mV RF signal on its input and let's say the same op amp has an inherent 30 dB of EMI rejection ratio (EMIRR). On the output we would expect to see: (100 mV / 31.6) × 100.

Now let's assume we are using a 12-bit ADC with a full-scale range of 5 V. The output of the op amp feeding into the ADC is now 316 mV /(5 / 2^{12}) which yields a loss of roughly 260 digital counts out of 4096.

Although some op amps are built on processes that are inherently robust, those with filters tend to provide a much better rejection over a wider spectrum. Over the past 7 years, Texas Instruments has taken the initiative to include EMI/RF filters in all the op amps making them less prone to errors often emanating beyond the signal chain.

These op amps range from super high precision like the OPA192 to instrumentation amplifiers like the INA188.

Figure 1 shows different comparison between different process technologies.

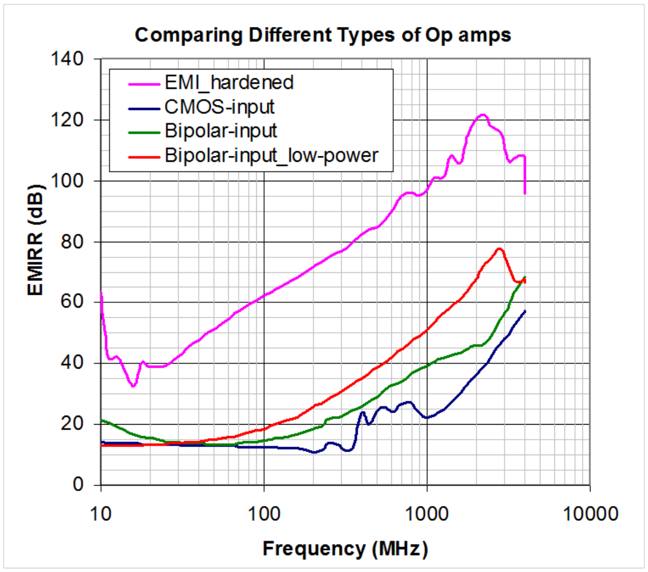

Figure 1.

Figure 2 shows V_{OUT} peaking up to more than 1.5 V as a DC error.

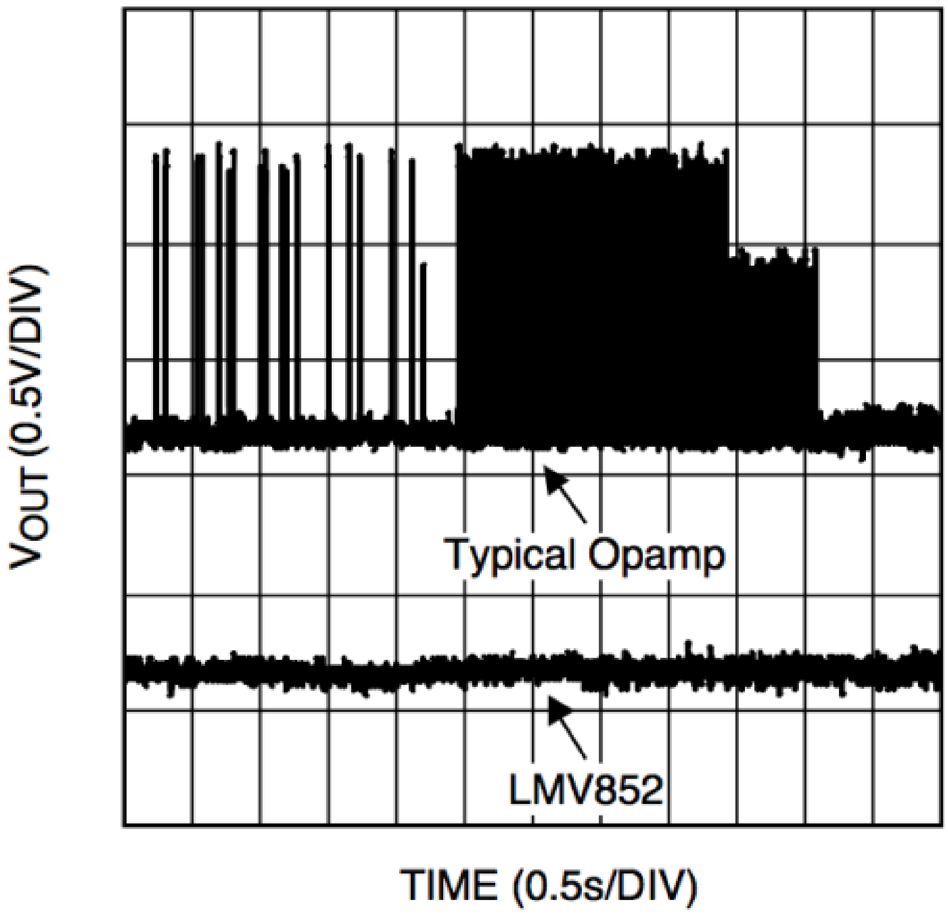

Figure 2.

Table 1. Alternative Device Recommendations

Device	Unity Gain Bandwidth	Description
INA1650	2.7 MHz	High Common-Mode Rejection, Low Distortion Differential Line Receiver
OPA376-Q1	5.5 MHz	Automotive Precision, Low Noise, Low I_Q Operational Amplifier
OPA191	2.5 MHz	High-Voltage RRIO Super Precision
OPA320	20 MHz	Zero Crossover 20MHz RRIO Operational Amplifier

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