

EMI-Hardened Op Amps Reduce Errors in EKGs

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Precision Amplifiers

Medical devices such as infusion pumps, EKG's and pulse oximeters are designed with great care for electromagnetic compatibility (EMC). In other words, they must be compatible with their environment and not cause any interference.

Before the creation of electromagnetic interference (EMI)-hardened amplifiers, board and system-level engineers struggled to come up with the best possible filtering schemes without compromising signal chain performance, especially that of the analog front end. Operational amplifiers needed special care and attention due to common mishaps, such as placing a capacitor across the inputs of the amplifier.

While the goal was to eliminate undesirable voltage spikes at the output of the amplifier, it usually resulted in unstable circuits.

Similarly, filters on the output, passive, low-pass filters (RC) particularly, can be a headache. Lowering the cutoff frequency often implies using a large capacitor, which not every op amp can drive. Conversely, increasing the resistor value causes gain errors.

Put The Op Amp To Work

The easiest way to deal with rejecting unwanted RF signals and electromagnetic interference is selecting active components with integrated filters. Every TI op amp designed in the last seven years provides such filters.

To determine whether the EMI rejection is sufficient for the application, a plot like the CMRR and PSRR, called the EMIRR (EMI rejection ratio), is provided in the datasheet.

The choice of amplifiers ranges from the [INA828](#) high-voltage instrumentation amplifier to the ubiquitous [OPA192](#), which comes in single, dual, and quad options.

To better appreciate the benefits of EMI filters in the amplifier, consider an example:

A first-order filter at 10 MHz rejects 40 dB at 1 GHz. However, a 10 MHz device with a cut-off at 100 MHz has a rejection of only 20 dB at 1 GHz.

EMI errors can have serious consequences on the system. Suppose 100 mV is injected into an amplifier with gain of 100. This example uses an op amp with no EMI filters, but still provides 30 dB of rejection (1 GHz).

316 mV is present at the output of the op amp [$(100 \text{ mV} / 31.6) \times 100$]. Now assume the output is fed to a 12-bit ADC with a 5-V FSR.

The loss of counts caused the injected signal (EMI) can be computed as follows:

$5 \text{ V} / (2^{12}) = 1.22 \text{ mV}$. Dividing the output of the op amp by 1.22 mV ($316 \text{ mV} / 1.22 \text{ mV}$) to determine a loss of nearly 260 counts.

Using an op amp like the [OPA192](#) reduces the count loss to roughly eight.

When making a design more immune to EMI without compromising the circuit performance, look up TI's precision amplifiers portfolio.

See [this clip](#) for additional information on avoiding electromagnetic interference (EMI).

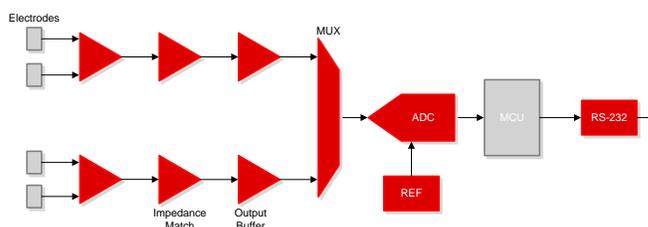


Figure 1. Typical Block Diagram for EKG

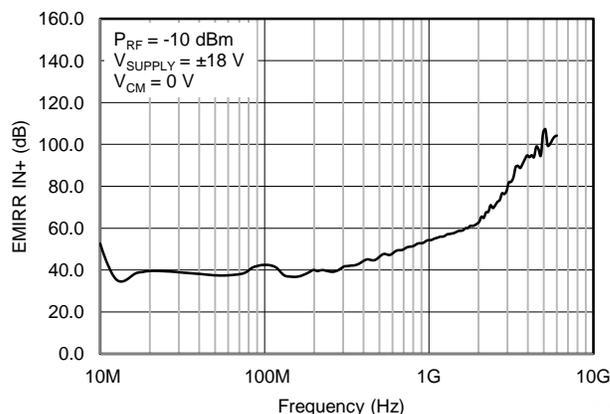


Figure 2. [OPA192](#) EMI Rejection Ratio Plot Versus Frequency

Table 1. Alternative Device Recommendations

Device	Unity Gain Bandwidth	Description
OPA189	14 MHz	14 MHz, MUX-Friendly, Low-noise, Zero-Drift, RRO, CMOS Precision Operational Amplifier
OPA188	2 MHz	Precision, Low-Noise, Rail-to-Rail Output, 36 V Zero-Drift Operational Amplifier
OPA388	10 MHz	10 MHz, CMOS, Zero-Drift, Zero-Crossover, True RRIO Precision Operational Amplifier
OPA333	350 kHz	1.8 V, 17 μ A, microPower, Precision, Zero-Drift CMOS Op Amp
OPA187	550 kHz	Zero Drift, Low-Power, Rail-to-Rail Output Amplifier

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