Applying precision

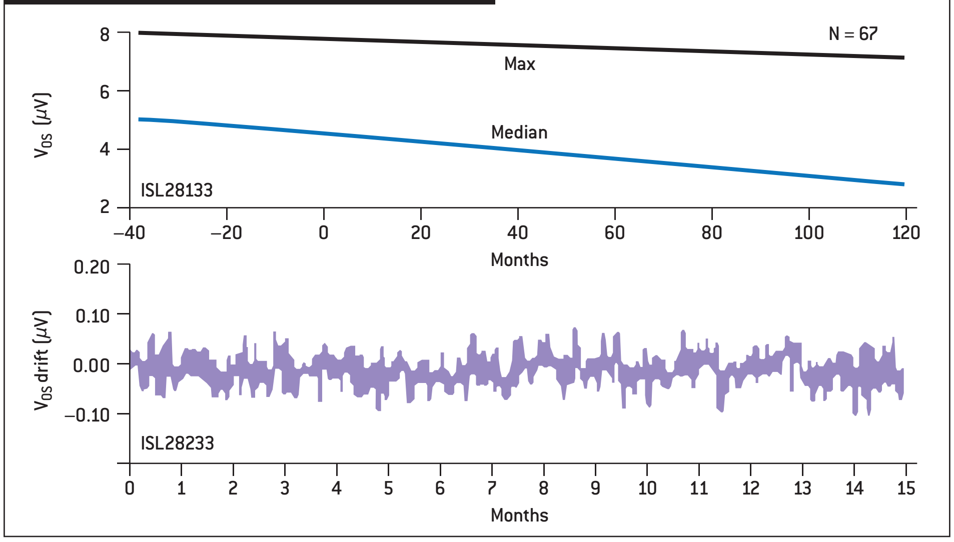
Selecting precision op amps for sensor input processing designs. By **Tamara Schmitz**.

As one of the basic building blocks used in an array of consumer, industrial, scientific and other applications, the operation amplifier (op amp) is amongst the most widely used electronic devices. For most low end applications, the requirements are straightforward and choosing the appropriate device is relatively easy. However, selecting the optimal precision op amp for higher end sensor input processing designs can provide system designers with a challenge.

In particular, op amp selection can be challenging when the types of sensors and/or the deployment environments create special demands, such as ultra low power, low noise, zero drift, rail to rail input and output, solid thermal stability. Repeatability, allowing the device to deliver consistent performance across thousands of readings and/or in harsh operating conditions, is also an important consideration.

When selecting op amps for complex sensor based applications, designers need to look at a number of aspects in order to get the best combination of specs and performance, while balancing cost considerations. In particular, chopper stabilised op amps (zero drift amplifiers) offer excellent solutions for applications which require ultra low offset voltage and zero drift over time and temperature. Chopper op amps achieve high dc precision through an on chip calibration mechanism which runs continuously.

Fig 2: Minimising V_{OS} drift over temperature and time



Although there is no 'one size fits all' formula, the following examples show how the op amp selection can help achieve application objectives.

Weigh scales and pressure sensors

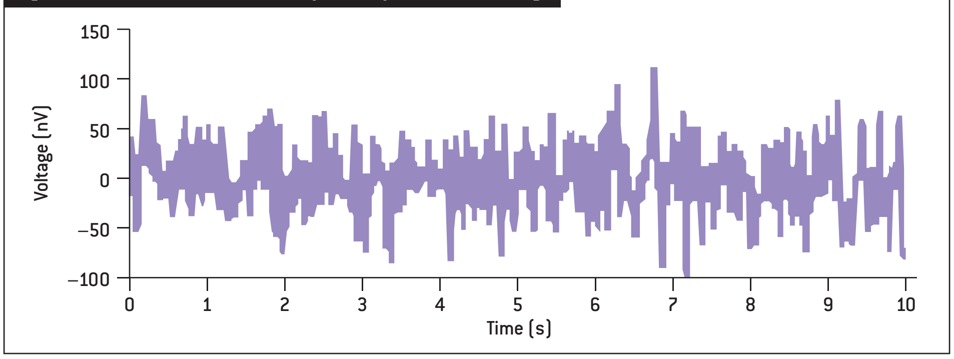
Applications such as these typically use a highly sensitive analogue front end sensor, such as a strain gauge, which provides very accurate measurements, but which also outputs very small signals. For high precision weigh scale applications, designers may use a bridge sensor network, in which individual op amps are paired with gain resistors chosen to provide common mode extraction and to deliver accuracies of up to 20ppm. Such designs require stringent performance from the op amps so very small signals riding on relatively large inputs can be extracted.

In order to amplify these small signals successfully, the op amp must have an ultra low input offset voltage and minimal offset temperature drift, with wide gain bandwidth and rail to rail input/output swing. The op amp should also offer stable frequency noise characteristics close to dc, such as between 0.1Hz and 10Hz.

For high precision weigh scale bridge network sensor applications, designers should consider a zero drift op amp that features very low input offset voltage and low noise, with no 1/f to 1mHz.

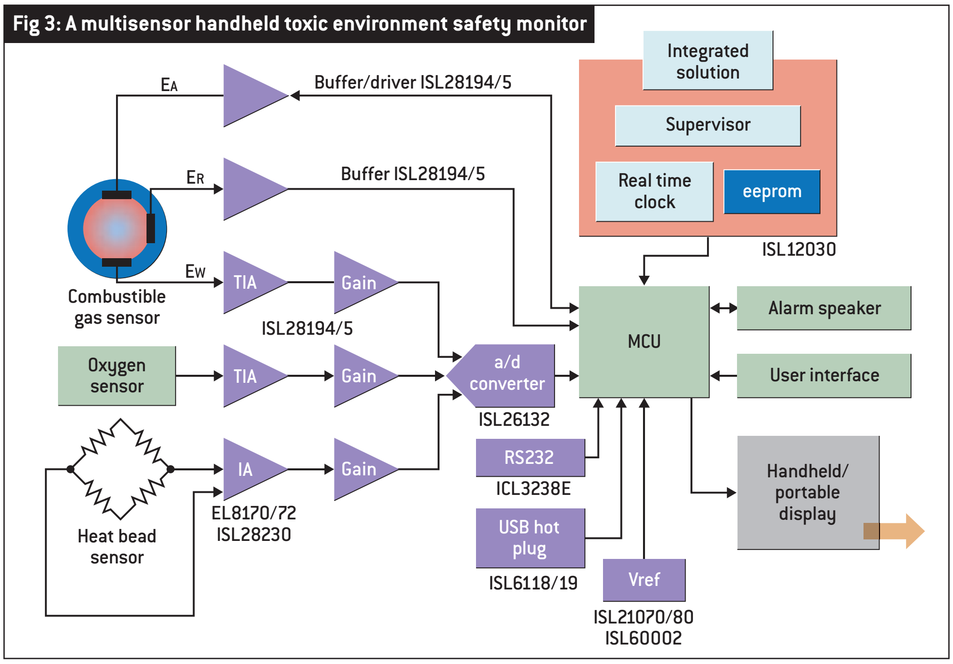
A good example of such a device is the chopper stabilized zero drift ISL28134 op amp, which delivers a virtually flat noise band to dc

Fig 1: The ISL28134's 0.1 to 10Hz peak to peak noise voltage



level (see fig 1). Building on the inherently stable chopper based design, the ISL28134 has a maximum noise gain of 10ppm (seven Sigma), bringing optimal performance to high gain applications while minimising noise gain error.

For portable applications, where low power is an important consideration, designers may want to consider the ISL28133, which combines micropower (25μA max) and low voltage offset (6μV max) characteristics with a chopper stabilised design that delivers flat noise band to dc and near zero drift. For strain gauge applications that need to use higher reference voltages, such as 10V instead of 5V, designers may consider the ISL28217 or ISL28227.



Current sensing and control

There are a number of ways to sense current level, depending on the application. These include shunt sensors using resistors, Hall Effect sensors and current transformers.

Shunt sensor techniques have evolved to provide a high level of accuracy, while offering lower cost and applicability across a range of requirements. In the shunt sense approach, a resistor is placed in the path of the power source being measured. Because the resistor drop impacts power efficiency, it is generally desirable to use the smallest possible resistor value. This means the current sensing application must amplify a relatively small differential power drop in resistance into a large gain. The op amp must also offer high common mode range and high accuracy.

Low power is also important, especially for current sensing in battery powered applications. Embedded current sensing circuits also need to be relatively inexpensive. In addition, many industrial, utility and communications current sensing applications require drift over time and temperature to be minimised. For example, current sensors deployed on utility poles are exposed to relatively harsh environmental swings, but need to provide consistent performance over long periods.

Many shunt based current sensing applications are built using chopper based zero drift op amps such as the ISL28133 or ISL28233. In addition, these cmos devices exhibit low drift over temperature and time.

Current sensing, one of the most pervasive applications across a range of industry segments, is becoming more important with the proliferation of new electronic devices and the increasing emphasis on 'green' power management techniques. Chopper stabilised precision op amp devices offer very low offset voltage and offset drift, rail to rail input and output and low power consumption, supporting growing demand for embedded current sensing applications.

Handheld toxic environment safety monitor

The final application example brings together a number of sensor inputs within one device and illustrates how well designed op amp circuitry can help to manage a multiple sensor signal chain efficiently within a compact portable device.

Handheld devices used to monitor hazardous environments increasingly feature multiple sensors. Such a device might combine a combustible gas sensor, oxygen sensor and catalytic heat band sensor. However, designers are also looking to minimise size while maximising capabilities.

As shown in fig 3, multiple instances of an op amp, such as the ISL28194, provide benefits for multi sensor signal chains within a small handheld device. These devices typically need to operate in an 'always on' mode and the ISL28194 supports extended battery life. Designed to run from a supply in the range from 1.8V to 5.5V, the ISL28194 can be powered by two 1.5V alkaline batteries. In addition, because multiple signal chains can feed into one a/d converter, system complexity and parts count can be minimised.

Because combustible gas sensors, oxygen sensors and heat sensors can typically take up to 10s to settle, op amp bandwidth is less critical but the sensors do need to a constant bias. Outputs from the sensors tend to be very small signals, so the op amp must provide excellent rail to rail noise flatness and drift characteristics over a large gain step.

Meeting demand

Already among the most widely used electronic components, op amp deployment is increasing exponentially as more devices incorporate analogue sensor functionality.

As with any good design practices, the first criteria must be to achieve the system's operational objectives for accuracy and performance, so low noise, low drift and precision in high gain applications will always be critical factors for success. System designers can now choose from a growing range of precision op amps that allow them to meet the most stringent performance and accuracy requirements, while balancing power consumption, design size, parts count and overall cost.

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