

# Simplifying Environmental Measurements in Power Conscious Factory and Building Automation Systems with Nanopower Op Amps

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As the devices in our homes get smarter and more connected, so are industrial systems in factories and the field. This rapid progression of Industry 4.0 and connected building automation is paving the way for sensors to be wirelessly connected to mesh networks. This technology is used for a range of purposes, from keeping you comfortable using your connected household thermostat to keeping a production line running smoothly and safely. Usually, these wired and wireless sensing nodes operate on a limited power budget and need to provide reliable data over their lifetime. This emergence of IoT allows for immediate and remote responses to unexpected conditions, reducing downtime and lowering maintenance costs.

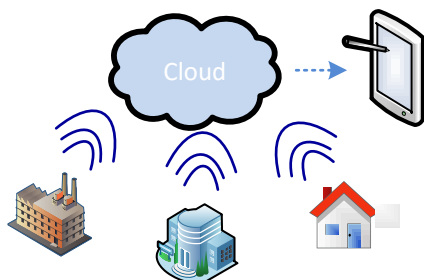


Figure 1. Factory and Building Automation

Whether on the factory floor or in our homes, the sensing of gas, temperature, and pressure, can be part of this connected network. As an example, in gas sensing applications, gases such as oxygen, carbon dioxide, and carbon monoxide need to be detected and accurately monitored. Accurate sensors that fit the specific application need to be carefully chosen (examples of 2-lead and 3-lead gas detection circuits are shown [Figure 2](#) and [Figure 3](#)). Selecting the best operational amplifier to convert and amplify the output of the sensor for the ADC is just as important. Low power and precision in these applications are necessary and become even more critical when applied to industrial applications. To minimize the system power consumption and the error introduced to the measurement by the op amp, the op amp must have low quiescent current and precision performance characteristics like low drift and a small offset voltage.

One suitable op amp for this application is the LPV821. The LPV821 is the industry's first zero-drift nanopower amplifier, with an offset voltage and quiescent current of only  $\pm 10 \mu\text{V}$  and  $650\text{nA}$  respectively. The zero-drift, self-calibrating architecture of the LPV821 also makes it an excellent choice for this application.

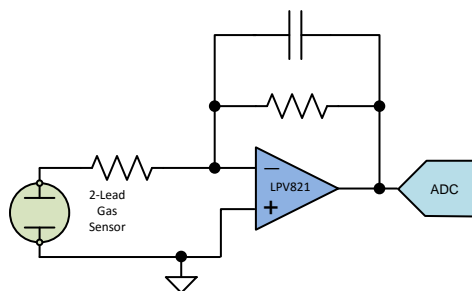


Figure 2. 2-Lead Gas Detector

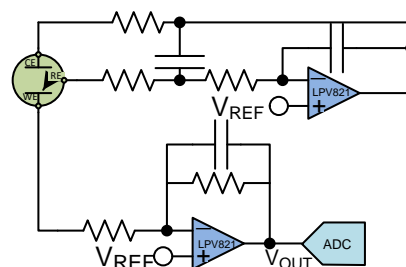


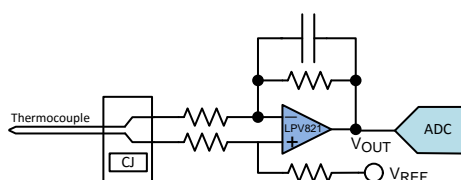
Figure 3. 3-Lead Gas Detector

Measurement errors can be introduced by both gas detection sensors and op amps and can be minimized through careful sensor and op amp selection. Gas detector sensors can be temperature and humidity dependent. As these errors are inherent to the sensor, they introduce error to the overall system. To minimize any additional errors to these sensor outputs, the op amps selected to interface with these sensors need to have low offset and sometimes zero drift capability, such as in the LPV821.

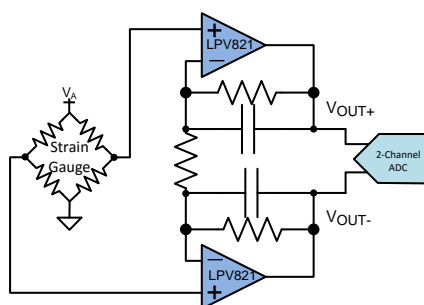
Bias currents inherent to the op amps can also lead to errors in gas sensing. 2-Lead gas detectors output a small current that is proportional to the gas level measured. When high measurement resolution is needed, op amp bias current is even more important as it adds error to this sensor output current. The LPV821 has only picoamps of bias current which can help minimize this error.

The same gas sensing circuits described above can also be used in industrial applications such as handheld gas detectors. These detectors are used for the purpose of safety in workspaces to monitor and alert workers of dangerous gas levels. The need for accuracy in gas sensing, as described above, is still relevant in handheld gas detectors and can be critical to the safety of the user. Along with accuracy, handheld detectors also need to be designed to consume minimal power to maximize the life of their batteries. The LPV821 fits these requirements with its high precision and nanopower consumption.

Field transmitters are one of the many industrial applications in the field that are getting smarter. Field transmitters are used in factory automation to pass the output of an environmental sensor down the 4-20mA loop line to the process controller so any necessary actions can be taken. This allows for important monitoring of parameters such as gases, pressure, and temperature. The gas detection circuits described above can be used as part of the analog front-end of field (AFE) transmitters along with the pressure and temperature detection circuits shown in Figure 4 and Figure 5. As with gas detection, pressure and temperature measurements need to be accurate. The LPV821's low offset and extremely low 1/f noise makes it a suitable fit for such DC based applications.



**Figure 4. Temperature Sense Circuit**

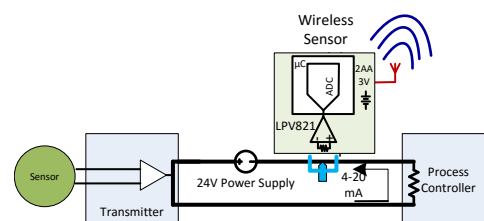


**Figure 5. Pressure Sense Circuit**

While monitoring these parameters, the process controller can initiate any necessary actions and maintain proper performance of the overall system. These wired systems are typically limited by a single power supply on the 4-20mA loop which powers all the devices in this system such as the process controller and field transmitters. The devices on this loop, such as the field transmitters, must perform their tasks with the limited power budget available to them from the power supply. The field transmitter typically has less than 3.6mA of power budget available with the AFE further limited to tens to hundreds of microamps. With its nanopower consumption, the LPV821 is ideal as part of a field transmitter AFE.

As the trend moves towards connected factories and IoT, these power limitations are becoming more critical. Where it is not practical to use wired field transmitters, wireless ones can be used instead. As wireless field transmitters are usually battery powered, they have an even more stringent power budget than their wired counterparts. They are usually expected to operate on a single battery for up to ten years, while still delivering precise measurements. The ultra-high precision, nanopower LPV821 allows wireless field transmitter batteries to last longer due to its nanoamps of quiescent current.

One of the benefits of bringing IoT to the field and factory automation space is the ability to take immediate and remote actions to unexpected conditions. A battery-powered wireless sensor module can be used in existing wired 4-20mA loop based systems to wirelessly transmit the outputs of a field transmitter, to be monitored remotely. An example of this is shown in Figure 6. The wireless sensor module is battery-powered and must be low in power consumption to maximize battery life. As part of the wireless sensor module, the LPV821 can be used to sense the 4-20mA loop current. Its ultra-low offset voltage allows for accurate current sensing while its nanopower current consumption minimizes power budget impact.



**Figure 6. Wireless Sensor Module**

As home and factory automation moves towards IoT, supporting hardware needs to be low in power consumption while also providing precision. The nanopower, zero-drift LPV821 can be used to perform the tasks of these applications and does so in a precise and power efficient manner.

**Table 1. Alternative Device Recommendations**

Device	Quiescent Current (Typ.)	GBW	Offset Voltage (Max)
<a href="#">LPV521</a>	350nA	6.2 kHz	1mV
<a href="#">LPV812</a>	425nA	8 kHz	300uV
<a href="#">OPA369</a>	700nA	12 kHz	750uV
<a href="#">OPA333</a>	17uA	350 kHz	10uV

### Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

**Changes from Original (November 2017) to A Revision**
**Page**

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- Changed title ..... **1**
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