LMP90100

A Unique Approach to Developing Sensor Signal Path Solutions

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A Unique Approach to Developing Sensor Signal Path Solutions

— Harold Joseph, Senior Marketing Manager

Introduction

One of the challenges in developing sensor systems is the time it takes for system designers to develop, validate, and prototype a solution. Complete solutions need to address sensor drive and output requirements, sample rate, signal path calibration, performance, sensor diagnostics, and power consumption needs. Simplifying the cycle and reducing development time can mean a faster time-to-market and more designs completed per year. Most existing approaches address only a few of these issues and are time consuming and complicated to develop.

Taking a New Approach

National Semiconductor has released a family of configurable Sensor Analog Front End ICs (Sensor AFEs) to help solve these challenges. Along with WEBENCH Sensor Designer software and a bench-top development platform, they comprise an integrated hardware/software solution that allows a system designer to select a sensor, design and configure a solution, then download configuration data to the Sensor AFE for validation.

This article describes how the LMP90100, the industry’s first multi-channel, low-power, 24-bit Sensor AFE with continuous background calibration and sensor diagnostics, is used to easily interface with multiple types of sensors at the same time. The LMP90100 WEBENCH Sensor Designer software is used to select and configure an RTD (temperature sensor) and pressure sensor signal path. A development platform is also available to evaluate and validate the design.

The LMP90100 is the first in a family of pin-compatible Sensor AFEs that provide 16- or 24-bit performance and allow designers to select a Sensor AFE based on the number of required channels and whether or not a current supply is required to drive the sensors.

Voltage Sensor Interface

The LMP90100 is designed to interface with voltage output sensors. Some of the most popular voltage output sensors measure temperature, pressure, load, and force. Common temperature measurement techniques include RTDs (resistive temperature devices), thermocouples, and thermistors. These sensors are used in every major industry and are often used together in the same application. Temperature sensors in particular are often used in applications with pressure sensors and load cells.

Temperature, pressure, load and force can usually be supported with the same type of analog signal path, provided the sensor signal path can accommodate a wide range of sensitivities—typically 20 mV to 5V. Many sensors require voltage supplies and it is often possible to use the system voltage supply as a supply source for the sensor. Some sensors, such as RTD’s, require a current supply which is not commonly available in most systems. Therefore, a solution designed to address a wide range of sensors should provide a constant current source.
Truly configurable products. Faster time-to-market.

**Complete Analog Signal Path Solution Between Sensor and Microcontroller**

Precision sensing systems based on custom analog solutions take weeks—if not months—to design. From IP to prototype and test to writing system algorithms, designers have not been able to simplify the development and production cycle for critical sensor systems. But National Semiconductor’s Sensor AFE system offers an integrated hardware and software development platform that allows customers to quickly create a design online, configure for their requirements, and rapidly prototype. With products optimized for specific types of sensors, the Sensor AFE delivers an alternative to long hardware development cycles.

![Diagram](image)

*Shown: LMP90100 supports multiple sensor types.*

**Design Online or On the Bench**

The easy-to-use WEBENCH® Sensor AFE Designer reduces design time and provides performance and configuration for all signal path solutions. Simply select a sensor and start your design.

**Customize and Calibrate**

Configure range, offset, gain, sample rate, and diagnostics for each signal path right from within the software tool. LMP91000 is designed for toxic gas and LMP90100 for temperature, pressure, load, and force sensing.

**Prototype Immediately**

Save and download configuration data to a Sensor AFE IC for immediate prototyping and delivery within days. Complete evaluation systems are available to further reduce development time.

[neat.com/sensorafe](http://national.com/sensorafe)
A Unique Approach to Developing Sensor Signal Path Solutions

Temperature and Pressure Sensor Interface
RTDs and pressure sensors are used in process control applications and a single LMP90100 can accommodate both. The LMP90100 is a multi-channel IC designed to provide a solution for multiple sensors like RTDs, thermocouples, pressure sensors, and load cells, as well as most other voltage output sensors. The LMP90100 includes a flexible input MUX, two matched current sources, sensor diagnostics, an embedded PGA supporting gains from 1x to 128x, and a 24-bit Sigma-Delta analog-to-digital converter with 50 to 60 Hz signal rejection and adjustable sample rates. The flexible input MUX accepts 4 differential or 7 single-ended inputs or a combination of the two.

The LMP90100 also includes functions designed to support the end application. These include true continuous background calibration (to correct for offset and gain over time and temperature without disturbing the signal path), background sensor diagnostics, and the ability to optimize for low-power applications. Similarly, each sensor attached to the LMP90100 will require a different signal path configuration. Since each input channel can be independently configured in the LMP90100, the user can specify an individual gain, sample rate and sensor diagnostics for each sensor connected.

RTD Signal Path Design
The LMP90100 supports all RTDs which are available in two-, three-, and four-wire configurations and two standard performance classes—A and B. Just two wires are needed to make the temperature measurement. RTDs with three or four wires allow for resistance compensation and provide a more accurate signal measurement over long distances. An RTD’s performance changes over temperatures and the best accuracy is with a class A platinum RTD which is accurate to 1.5°C at 0°C. This example uses a three-wire class A RTD.

WEBENCH Sensor Designer software is available both online and for offline use with the development platform. For this example, all figures will be from the downloadable tool. Figure 1 shows the entry page of the LMP90100 software. Each of the colored blocks is configurable by clicking on the block. On the left side is the help bar. The first item Select a Sensor is highlighted and is the first step in the design process. Highlighting Select a Sensor displays the types of sensors available to interface with the LMP90100, as shown in Figure 2. In this example, the RTD tab has been selected to show available RTDs. Selecting a three-wire, class A Omega RTD (model PR-20-2-100-1/4-2-E-T) in Figure 3 drops the RTD to the first open location on the LMP90100 as shown in the diagram in Figure 4. Default conditions of the RTD are a gain of 1X, a sample rate of 26.8 sps, and a voltage span of 2V. Designers can use these settings or modify the parameters to meet their specific application’s requirements.
In Figure 4, the gain block has been highlighted which pulls up a configuration window for that block. The help bar can also be used to highlight a parameter and pull up a configuration window. Designers can reassign the RTD to other input MUX channels if desired and configure parameters such as VREF inputs, current sources, gain, background calibration, sensor diagnostics, clock sources, and sample rate. Sliders are also available at the bottom of the page to adjust the gain and sample rate.

Performance and power consumption specifications are listed for all configurations. In Figure 5, the performance tab shows noise, ENOB, NFR, power consumption, and device error (offset error + gain error) based on the designer’s configuration choices.

In most cases, a designer can select an RTD, specify a current source, set gain and sample rate, and check performance in just a few minutes.

The Omega RTD model PR-20-2-100-1/4-2-E-T selected is a precision PT100 (100Ω) platinum, thin film, class A RTD. It has a maximum temperature range of -50 to 260°C and a temperature coefficient of resistance of 0.00385Ω/Ω/°C.

Let’s assume that the application requires a temperature range of -40°C to 85°C. As mentioned previously, the LMP90100 includes two current sources. Specifying one current source to provide a 1 mA drive for the 100Ω RTD will produce a 100 mV output at 0°C. The output change over the temperature range of the RTD will be 84.27 mV to 132.81 mV.
Selecting an RTD in the design tool automatically takes into account the parameters of that RTD. Designers can specify a reference value and look at performance and power trade-offs as gain and sample rate are changed. The LMP90100 features eight gain settings and a 24-bit Sigma Delta ADC, providing a wide range of configuration choices. Tradeoffs can be reviewed quickly using the sliders to adjust gain and sample rate. For this example, an 8x gain and 26.8 sps provides good performance and low power consumption.

A parameter called Device is also listed. Its error combines offset, gain, and INL (integral non-linearity) errors. As seen in Table 1, turning on background calibration removes residual offset and gain error with very little increase in power consumption. Device error is determined at a specific temperature and temperature is specified directly below Device Error in WEBENCH Sensor Designer.

### Pressure Sensor Signal Path Design

Next, we will add a pressure sensor channel to the LMP90100. Pressure sensors are used to measure pressure, flow, and level. Outputs can vary from 50 mV to 5V and the sensor drive can be current or voltage.

In Figure 6, a Honeywell model 19U30PGIK is selected. It has a nominal output of 40 mV, requires a voltage drive, and has a typical pressure non-linearity of ±0.1% at 25°C. The 19U30PGIK is a 30 PSIG (pounds per square inch gauge) pressure sensor with a stainless steel media diaphragm protecting a silicon sensing element which allows it to be used for a wide range of process control applications.

As with the RTD, there are a wide range of gain and sample rate choices. Configuring the LMP90100 signal path for a gain of 32X, a sample rate of 107 sps, and enabling calibration and diagnostics yields an LMP90100 performance and power consumption of 9.165 mW at 30 PSI:

- Noise: 0.48 μVrms, ENOB: 19.0 bits, NFR: 17.0 bits, Power: 9.165 mW

If lower power consumption or noise is desired, adjusting the sample rate to 6.71 sps yields:

- Noise: 0.34 μVrms, ENOB: 19.5 bits, NFR: 17.0 bits, Power: 3.7 mW

With a maximum gain of 128, the yield is:

- Noise: 0.44 μVrms, ENOB: 17 bits, NFR: 14.5 bits, Power: 9.165 mW

The adjustable sliders in the WEBENCH Sensor Designer tool make it easy to adjust gain and sample rate and view the resulting performance which makes it very easy to look at design trade-offs.

<table>
<thead>
<tr>
<th>RTD Signal Path Configuration</th>
<th>Performance (Calibration Off)</th>
<th>Performance (Calibration On)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current drive: 1 mA</td>
<td>Noise: 1.08 μV</td>
<td>Noise: 1.08 μV</td>
</tr>
<tr>
<td>Signal gain: 8X</td>
<td>ENOB: 20.0 bits</td>
<td>ENOB: 20.0 bits</td>
</tr>
<tr>
<td>Sample rate: 26.8 sps</td>
<td>Device Error: .018%</td>
<td>Device Error: .0006%</td>
</tr>
<tr>
<td>Ref voltage: 2V</td>
<td>Power Consumption: 4.84 mW</td>
<td>Power Consumption: 4.86 mW</td>
</tr>
</tbody>
</table>

Table 1. RTD Performance Comparison with Background Calibration Off and On
Another consideration when pressure and temperature are measured in the same system is that the RTD and pressure sensor may each require a precision reference. The LMP90100 supports these applications by providing the capability to connect two different references to the IC.

**Robust Development Platform**
The Sensor AFE development platform allows designers to validate their design solutions on the bench. The platform consists of a Sensor AFE IC, an interface to the designer’s sensors, and connects through a PC to WEBENCH Sensor Designer software. A designer can attach sensors, take data over time, and display the result as a histogram, as shown in Figure 7, or monitor a channel continuously in the oscilloscope mode, as shown in Figure 8. Data can also be saved to a file and download for performance evaluation utilizing their own software.

**Conclusion**
With products optimized for specific types of sensors, the Sensor AFE platform delivers an alternative to long hardware development cycles. Specifically, solutions for an RTD and pressure sensor systems can be designed utilizing National Semiconductor’s flagship 24-bit Sensor AFE product, the LMP90100. Unique gain and sample rate can be specified for each sensor signal path and considered configuration trade-offs based on performance, power, and background calibration.

The combination of LMP90100 Sensor AFE IC, WEBENCH Sensor Designer software, and development platform creates a unique design environment that enables fast, easy sensor signal path design. Overall design time is dramatically reduced which allows customers to get to market faster with a reliable, proven solution.
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