How Accurate Sensing Enables Better System Performance and Increased Efficiency

Texas Instruments

Giovanni Campanella
Sector general manager
Industrial Systems

Sensor integrated circuits (ICs) are everywhere and can measure almost any type of physical stimuli. From measuring the ambient temperature and humidity of a room to detecting cars and other obstacles on the road, sensor ICs are the "senses" of a modern system – helping systems more quickly and reliably react to the world around them.

At a glance

1 Sensor ICs for electric vehicles and EV charging stations

Sensor ICs, especially current sensors, are crucial to the shift from combustion engines to electric drivetrains and charging stations.

2 Sensor ICs for modern data centers

Isolated amplifiers and Hall-effect sensors are enabling higher power densities in server power-supply units (PSUs) for data centers - helping maintain energy efficiency as the manage the growing amount of data driving our modern world.

3 Sensor ICs for energy management

Electricity meters are vital to efficient power distribution, helping reliably determine a building's overall energy consumption.

4 Sensor ICs for robotics and ADAS

Learn how collaboration and safety in industrial and automotive applications are made possible through vision, radar and lidar sensing.

Sensor integrated circuits (ICs) are everywhere and can measure almost any type of physical stimuli. From measuring the ambient temperature and humidity of a room to detecting cars and other obstacles on the road, sensor ICs are the "senses" of a modern system – helping systems more quickly and reliably react to the world around them.

Sensor ICs are typically designed for a specific modality or type or sensing; current, voltage, humidity, proximity, radar, etc. Recent sensor IC technology innovations have focused on integrating more capabilities into the IC while also increasing overall accuracy and reliability for its given modality. These innovations have led to better system performance, increased energy efficiency and – in some cases –new applications.

One example is the continuous monitoring of a car's interior and exterior with low-power radar sensing. In the past, radar sensing consumed too much power to be used continuously when the car engine was off. With innovations in millimeter-wave (mmWave) radar sensors, 360° continuous monitoring of a car for unauthorized access or unattended children is now possible.

Sensor ICs for electric vehicles and EV charging stations

Sensing ICs play an important role in the shift from combustion engines to electric drivetrains, particularly in terms of current and voltage sensing for battery management systems, on-board chargers and DC fast charging stations, as shown in **Figure 1**.

DC fast charging stations are an example of how impactful current sensors are in electric vehicles (EVs) - specifically the power-module control loop of the charging station. Current sensors monitor the signal bandwidth, gain and offset errors that can affect the power module's ability to reliably regulate AC-to-DC power conversion, which enables fast charging of the car's battery. In systems where power consumption is a design priority, a shunt-based current design can be implemented with isolated amplifiers or delta-sigma modulators such as the **AMC1306M05** or **AMC3302**.

Figure 1. *An EV at a fast charging station*

Sensor ICs are also involved in automotive systems beyond battery management and charging systems. While not a recent development, the electrification of systems across the entire automobile – from windshield wipers to seat adjustment motors – continues to provide opportunities for more efficient system design through sensing.

Linear, 3D, angle, switch and latch Hall-effect sensors enable precise responses for real-time feedback of the actuator or motors, helping automotive systems contribute to a more responsive and comfortable environment for drivers.

In addition to using sensors to improve driver and passenger comfort in modern vehicles, automotive engineers are seeking to implement systems that can improve the overall safety of the vehicle by detecting failures before they occur. This requires sensor ICs with diagnostic features that support device- and system-level functions to detect, monitor and report failures during operation. Position sensors such as the **TMAG5170-Q1**, **TMAG5170D-Q1** or the **TMAG5173-Q1** are designed to monitor automotive system operation and detect faults quickly – helping engineers meet their regulatory requirements such as those in the ISO 26262 standard up to ASIL D level.

Sensor ICs for modern data centers

As servers in data centers (shown in **Figure 2**) store and analyze an ever-increasing flow of data, server power consumption is growing as well. Achieving higher power densities and thus improved efficiency in server power-supply units (PSUs) is one way to optimize data center operations.

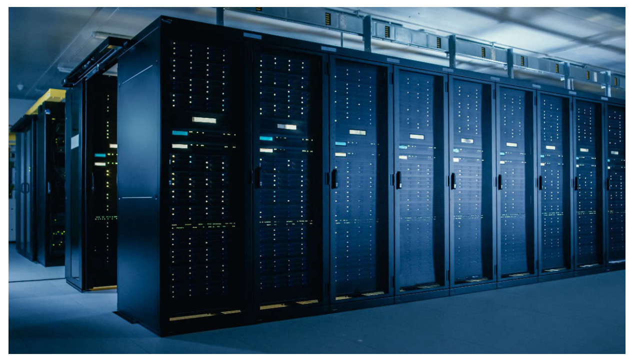

Figure 2. *Server racks in a data center.*

Meeting the strictest efficiency standards for PSUs, 80 Plus Titanium has become a minimum requirement for current and next-generation data centers. Current sensing plays a major role in helping achieve this level of efficiency and can be implemented with isolated amplifiers and Hall-effect current sensors. Sensors like the **AMC3302** and **TMCS1100** precision isolated current sensing ICs can help server PSUs meet the >96% system efficiency threshold required by the 80 Plus Titanium standard.

The **AMC3302** isolated amplifier provides input voltages of ±50 mV, enabling the use of a shunt resistor with smaller resistance to help reduce the amplifier's power dissipation and improve system efficiency. While the **TMCS1100** Hall-effect sensor converts signals through the magnetic field inside the IC itself, eliminating the need for an isolated power rail. These sensors also reduce power losses through their input conductor resistance, which can be >1 mΩ for high-current sensing.

Sensor ICs for energy management

The transition from fossil fuels to renewable energy sources requires more than changes in energy generation; it also depends on the efficient distribution and management of power from electric grids to buildings and homes. A simultaneously sampling analog-to-digital converter (ADC) with a wide dynamic range and internal calibrations like the **ADS131M04** can be used to achieve reliably accurate energy consumption data in an electricity meter, an integral application for efficient energy management.

The **ADS131M04** can connect directly to a resistor divider, current transformer or shunt for designs that require a multiphase meter with shunt measurements. These sensors can reach high measurement accuracies (0.1 accuracy class), while a high sample rate can provide a basis for harmonics measurement to provide load management and other advanced features.

Sensor ICs for robotics and ADAS

Increased demand for automation across all industries is boosting the use of robots in both factories and our daily lives. For autonomous robotic systems to be successful, they must be able to interact in their contextual environments as they collaborate, co-work and coexist with humans and other robots. Collaboration and safety are made possible through vision, radar and lidar sensing in robots since these modalities allow the robot to perceive the proximity and nature of objects around it.

Similar to humans, robots rely on their sense of sight, hearing and touch in order to react to the world around them. These senses allow them to stop or reduce their speed when humans or another robot are approaching, or when there is an obstacle in their path. Similarly, in ADAS, sensors are deployed around the vehicle to provide a comprehensive, real-time 360° view of the surrounding environments, as shown in **Figure 3**. These "senses" provide actionable information for the driver, helping them assess the hazards around them and react accordingly.

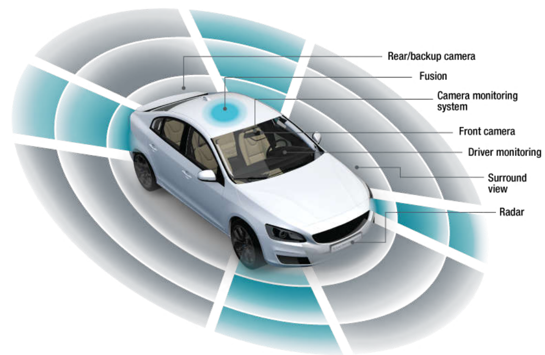

Figure 3. *Radar sensing for ADAS showing the range of view for multiple cameras and sensors.*

TI mmWave radar sensors like the **IWRL6432** provide highly accurate measurements for both robotics and automotive applications. These sensors measure not only the distance of objects in their field of view, but also the relative velocities of any obstacles in challenging environmental conditions like darkness.

These sensors use radio waves and their echoes to determine the direction and distance of a moving object by measuring velocity, angle and range, helping robots and vehicles take more predictive actions based on how quickly objects are approaching the sensor. TI mmWave sensors are also Safety Integrity Level 2-certified and include built-in security to support evolving safety standards at a system level.

Accurate odometry information is essential for navigation in autonomous mobile robots (shown in **Figure 3**); this information is derived from measuring the rotation of wheels on the robot's platform. 3D Hall-effect position sensors like the **TMAG5170** provide ultra-high precision at speeds up to 20 kSPS while using less power. Another benefit of the **TMAG5170** is its built-in angle calculator engine, which frees up the microcontroller for other functions.

Figure 4. *Autonomous mobile robot in a warehouse.*

Conclusion

TI is developing and investing in sensing technologies that drive the potential of sensing in modern systems forward, allowing the electronics we interact with daily to act and react faster and more accurately to the world around us.

To learn how to implement accurate and reliable system monitoring, protection and control with TI's extensive sensing portfolio, see **https://www.ti.com/technologies/sensing.html**.

- **Current sensing solutions**
- **Humidity sensors**
- **Magnetic sensors**
- **mmWave radar sensors**
- **Temperature sensors**

Additional Resources

Read our sensing e-books for technical insights and design tips from our sensing experts:

- ***An Engineer's Guide to Temperature Sensing***
- ***An Engineer's Guide to Current Sensing***

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265