Making sense of the world around us with sensor ICs

How accurate sensing enables better system performance and increased efficiency.

By **Giovanni Campanella, Sector General Manager, Industrial Systems at Texas Instruments**

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Sensing types

Sensor ICs are typically designed for a specific modality or type of sensing; current, voltage, humidity, proximity or radar, for example. 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 unauthorised access or unattended children is now possible.

EVs and charging stations

Sensing ICs play an important role in the shift from internal 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/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 TI's AMC1306M05 precision current sensing reinforced isolated modulator or its AMC3302 precision current sensing reinforced

Figure 1: An EV at a fast-charging station.

Figure 2: Server racks in a data centre.

isolated amplifier with integrated DC/DC converter.

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 TI's TMAG5170-Q1, TMAG5170D-Q1 or the TMAG5173-Q1, are designed to monitor automotive system operation and detect faults quickly in order to help engineers meet regulatory requirements such as those in the ISO 26262 standard up to ASIL D level.

Data centres

Servers in data centres store and analyse an ever-increasing flow of data, which increases server power consumption. Achieving higher power densities and thus improved efficiency in server power-supply units (PSUs) is one way to optimise data centre operations.

Meeting the strictest efficiency standards for PSUs, 80 Plus Titanium has become a minimum requirement for current and next-generation data centres. 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 ±50mV, 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 >1mΩ for high-current sensing.

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 ADC with a wide dynamic range and internal calibrations, e.g., 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.

Robotics and automation

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 co-exist 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 (advanced driver assistance systems), sensors are deployed around the vehicle to provide a

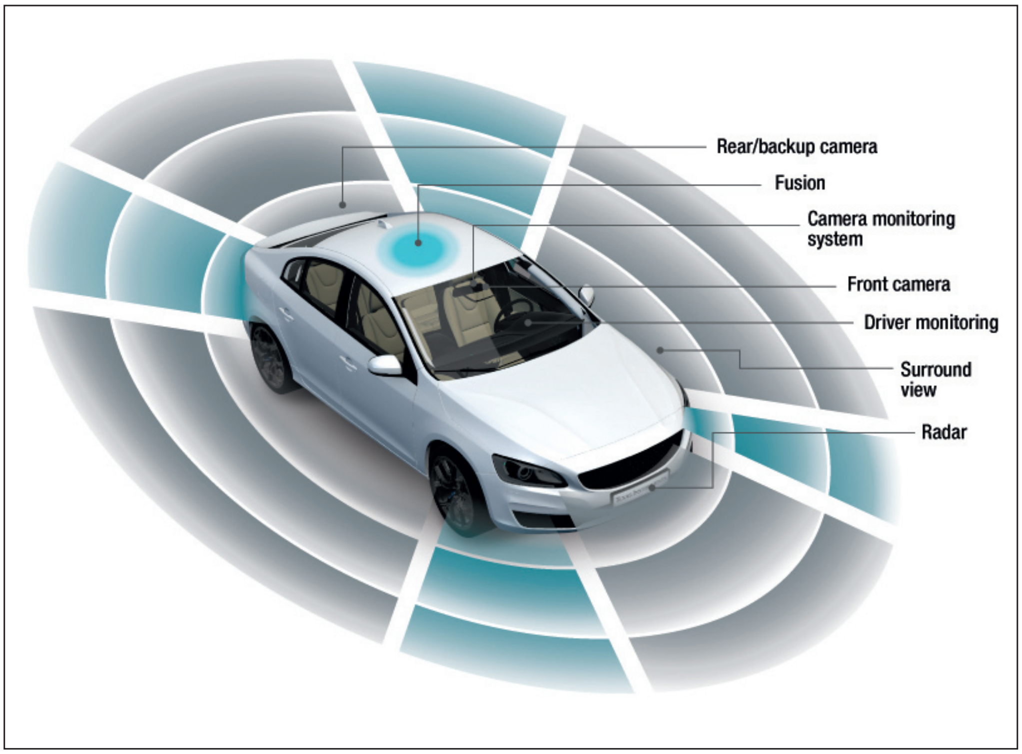

Figure 3: Radar sensing for ADAS showing the range of view for multiple cameras and sensors.

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.

TI mmWave radar sensors, for example, the IWRL6432, can 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. Information is derived from measuring the rotation of wheels on the robot's platform. 3D Hall-effect position sensors, e.g., the TMAG5170, provide high precision at speeds up to 20ks/s while using less power. The TMAG5170 also has an integral angle calculator engine, which frees up the microcontroller for other functions.

Sensing technologies can drive forward the potential of sensing in modern systems to allow electronics to act and react faster and more accurately to the world around us.

Figure 4: An autonomous mobile robot in a warehouse.