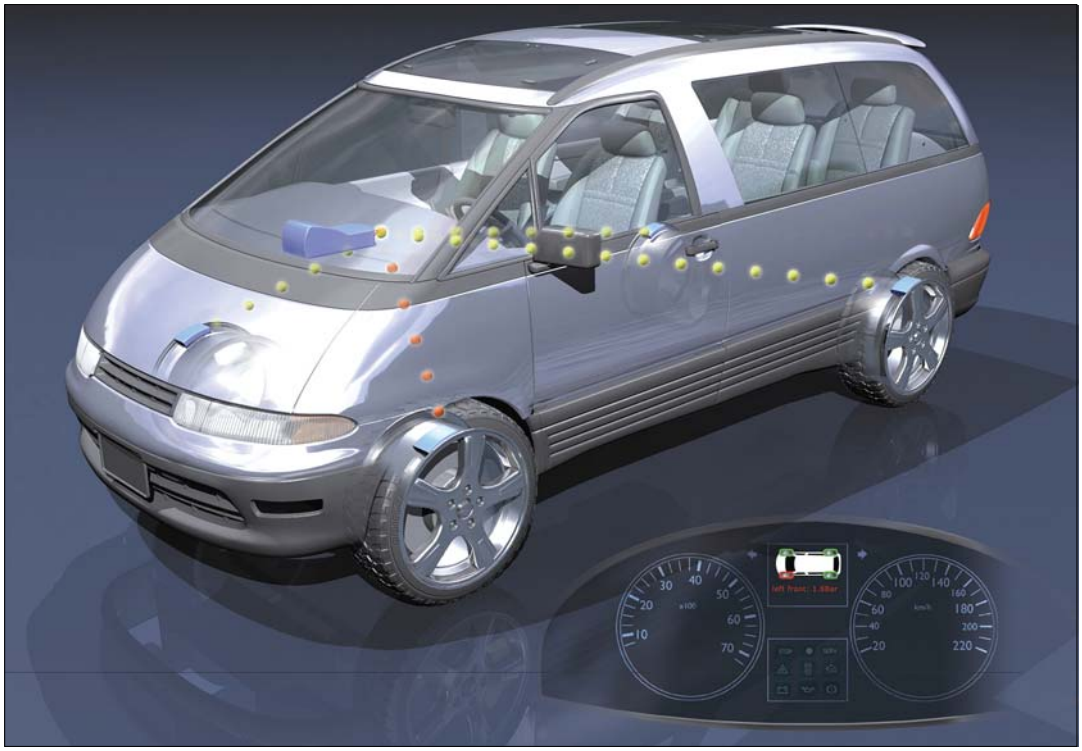
Tire pressure monitoring increases car safety

By Joerg Becker
Marketing Manager
Car Access & Immobilizers
Philips Semiconductors



TPMS is based on a pressure sensor with an ASIC for conditioning the pressure and temperature signal.

Safety is the main driving force behind the requirement for the tire pressure monitoring system (TPMS), following a number of road traffic accidents linked to faulty tires.

Incorrect tire pressure can compromise the stability of a vehicle, its handling and braking and, according to industry statistics, may be responsible for thousands of accidents per year. Tire pressure may have an influence on any crash that involves braking, since low tire pressure can result in increased stopping distances.

Many car drivers ignore their tires, although they are one of the most crucial elements for a vehicle's performance. Properly inflated tires enhance safety, performance, fuel economy and tire life. However, one in five tires is underinflated by up to 40 percent. This leads to a significant decrease in the life of the tire and an increase in fuel consumption by around 1 percent for every 3PSI-underinflation, according to Goodyear.

The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) has mandated that all vehicles sold in the United States must be equipped with TPMS from the year 2007 onward. These systems will warn drivers when a tire is more than 25 percent underinflated, preventing tire damage and subsequent accidents caused when tires do not have enough air to carry a fully loaded vehicle.

In the United States, law has already required that TPMS be installed in new cars beginning in late 2003. This stemmed from a series of accidents that occurred in the summer of 2000 when treads on some tires separated after use while underinflated. The new mandate calls for more advanced direct TPMS, which has pressure monitors in each wheel. Direct TPMS will not only help prevent accidents, but will also save as much as $1.7 billion each year in fuel and vehicle maintenance costs, as underinflated tires shorten tire life and increase fuel consumption, according to NHTSA.

The future business for TPMS is set to be huge. Consultant firm Strategy Analytics expects tire pressure monitoring to become the fastest-growing automotive electronics system over the next few years–reaching 30 million units by 2010.

Direct measuring systems

A direct TPMS is one that always measures the pressure directly inside the tire. For this, the modules are located inside the tire–usually attached to the inflation valves–and broadcast their data via RF to a central receiver. The link uses the same RF principles and range; and as remote keyless entry (RKE) systems are already installed in modern vehicles, the module can be shared with the RKE system to reduce the overall system cost. Philips' TPMS uses the same RF link as its RKE technology, which is field-proven in automotives and being used by manufacturers such as Siemens VDO Automotive in their passive entry systems.

The tire module consists of the pressure sensor (usually piezoresistive analog), pressure sensor signal-conditioning chip (which can be integrated in the sensor) and RF transmitter unit.

The tire modules have to withstand temperatures from -40°C to over 150°C, combined with acceleration ranges of up to 2kg. In this harsh environment, special components will be used to ensure a lifetime of up to 10 years.

The pressure sensor inside the tire module is a typical microelectromechanical system (MEMS) component.

The package, which is also a key element, may include the pressure sensor signal-conditioning chip (P2SC). The signal from the silicon sensor has to be amplified and digitized and the full device calibrated and initialized. Philips' P2SC picks up the signal from the sensor bridge, changes it to digital, measures the temperature directly on chip and performs all the calibration and initialization needs. The P2SC includes the Starc-based RISC 2G microcontroller core, which is field-proven in RKE applications and dedicated to TPMS.

Currently, external SAW- or PLL-based UHF transmitters are used. But Philips has introduced the 2G P2SC with the UHF PLL integrated on-chip. This will lead to further reduction of cost and space on the PCB of the pressure-sensing module. Future devices will be fully integrated in the "smart sensor" housing–one chip, one package solution–of the tire.

As mentioned, the receiver unit for TPMS is based on similar techniques as the installed receivers for the RKE system. Hence, the existing RF receivers can be shared between TPMS and RKE. This leads to a significant cost reduction–thus, carmakers have already urged their suppliers to integrate RKE and TPMS into one system.

After calibration and initialization, each tire is able to send its pressure information to the dashboard; the body controller knows from which tire the signal is coming. But what happens if the car driver changes or

rotates the tires? There are several ways to overcome this problem:

- Dedicated RF receiver for each wheel;
- Inertial sensing of speed, combined with ABS/ESP information;
- Amplitude analysis of the RF signals (RSSI);
- Bidirectional RF links;
- LF wake-up.

Philips has chosen the low-frequency wake-up solution for tire location. The solution is fairly inexpensive and enables an immediate and reliable identification. Small low-frequency (125kHz) wheelhouse antennae send wake-up patterns to the specific tire module, which responds via the RF link. The low-frequency wake-up has to bridge a distance of about 1m from the wheelhouse antenna to the tire module. This has already been proven feasible using passive keyless entry technology, where a similar distance has to be bridged to open a car remotely. A 3D interface in the tire module guarantees an orientation-independent sensitivity for incoming wake-up patterns.

TPMS was implemented a number of years ago, but only on high-end luxury vehicles. The current generation of TPMS is based on a pressure sensor that includes an ASIC for conditioning the pressure and temperature signal. However, new legislation will see TPMS become a standard feature across all models.

The P2SC is a direct measurement solution offering low-frequency wake-up and high-frequency return, which means that the system can "ask" each tire for current pressure and relay this information to the driver. Each tire is "woken-up" every time the ignition is switched on to give the driver status information on the tires before driving and get regular status updates throughout the journey. In the event of a sudden drop in pressure, the tire will automatically relay this information to the driver without first needing to be woken up. The driver would be made aware of the tire pressure through different systems, such as an icon display or virtual car on the dashboard.

Next-generation products, such as Philips' P2SC, are replacing the ASIC with a microcontroller. Since battery cost and lifetime in tire modules will remain an issue, the automotive electronics industry will continue working on "batteryless" solutions, such as using inductive coupling or passive GHz technologies. □