Development of Tire-Pressure Monitoring System

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1. Introduction

A vehicle's tire performance has a major influence on the performance of the vehicle's three basic functions – running, turning, and stopping – as well as on ride comfort, noise, and fuel efficiency. To enable the tires to perform to their full potential, it is crucial to maintain the correct tire pressures at all times. However, many motorists continue to drive their vehicles without any awareness of decreased and otherwise inadequate tire pressures. Tire-pressure monitoring systems represent a solution that is attracting much interest. In the United States, it will soon be legally compulsory for every vehicle to have a tire-pressure monitoring system.

With regard to tire-pressure monitoring systems, Mitsubishi Motors Corporation (MMC) led the motor industry by providing the 1995 Mitsubishi DIAMANTE with a system that detected tire-pressure abnormalities indirectly by identifying differences between wheel speeds using information from the wheel-speed sensors of the antilock braking system.

MMC recently took a further step forward by equipping the ENDEAVOR, a new model for the North American market, with a tire-pressure monitoring system that measures the tire pressures directly (and with concomitantly superior accuracy) using a pressure sensor located inside each tire. This paper presents an overview of this new tire-pressure monitoring system.

2. System configuration and operation

As shown in **Fig. 1**, the ENDEAVOR's tire-pressure monitoring system consists mainly of sensor/transmitter units, a receiving antenna, a receiver, and a warning lamp.

Tire-pressure values measured directly by the sensor/transmitter units are transmitted as radio signals to the receiver via the receiving antenna. The receiver determines whether the tire-pressure values are acceptable. If it identifies an abnormality, it causes the warning lamp (this is located in the meter cluster) to illuminate to warn the driver of the need for a tire-pressure check.

Since tire-pressure values are transmitted as radio signals, there is a risk that the receiver will receive signals from the sensor/transmitter units of other vehicles equipped with the same type of system. To enable the receiver to identify and use signals from its own sensor/transmitter units and ignore those from other vehicles' sensor/transmitter units, each sensor/transmitter unit has a unique identification code, which it transmits together with tire-pressure data. The receiver is programmed to recognize the identification codes of its own sensor/transmitter units, so it uses only the relevant tire-pressure data to determine the necessity of activating the warning lamp.

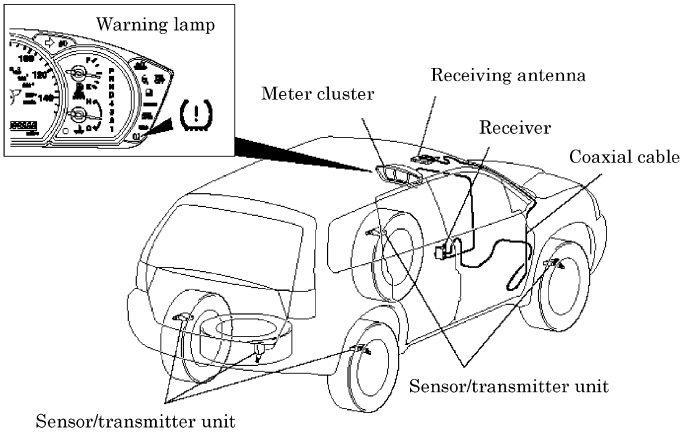

Fig. 1 System configuration

Further, the receiver is programmed to activate the warning lamp not only in the event that it receives abnormal tire-pressure signals but also in the event of an abnormality in the system's operation (for example, failure to receive signals from the sensor/transmitter units). The receiver causes the warning lamp to illuminate continuously for a tire-pressure warning and to flash for a system-malfunction warning, so the user can differentiate between the two types of warning.

With a direct-detection-type tire-pressure monitoring system that uses radio signals, the antenna must be located in such a way that it can constantly receive all signals emitted by each sensor/transmitter unit. The ENDEAVOR's antenna is mounted in the roof (between the roof panel and the trim) in the position that best enables it to receive signals from all four sensor/transmitter units. The coaxial cable that connects the antenna to the receiver is routed in a way that prevents it from being affected by electromagnetic noise generated by other electrical and electronic devices in the vehicle.

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Fig. 2 Sensor/transmitter unit on wheel

Table 1 Specifications

Detection system	Direct detection
Warning method	Continuous illumination of warning lamp (for abnormal tire pressure) Flashing of warning lamp (for system malfunction)
Warning-activation tire pressure	174 kPa or less (recommended pressure: 220 kPa)
Frequency of radio signals	433.92 MHz
Data transmission interval	When vehicle is running: every minute When vehicle is not running: every hour

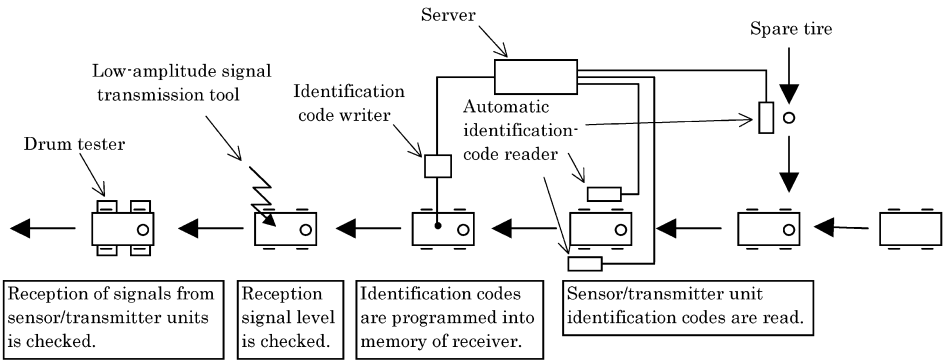

Fig. 3 Production process

Each sensor/transmitter unit forms an integral part of the tire's air valve and is located in the valve hole of the wheel. The wheels on the ENDEAVOR are specially designed to accommodate the sensor/transmitter units (including enough space for their installation and removal). **Fig. 2** shows a sensor/transmitter unit as installed on a wheel.

3. Specifications

The main specifications of the ENDEAVOR's tire-pressure monitoring system are presented in **Table 1**.

The system operates not only while the vehicle is being driven but also while the vehicle is parked (with the ignition switch off). If the receiver detects an excessive decrease in any tire pressure when the engine is not running, it activates the warning lamp immediately after the ignition switch is next turned on.

4. Production-line processes

As mentioned, the receiver must have in its memory the identification codes of the corresponding sensor/transmitter units before it can discriminate between tire-pressure signals from its own sensor/transmitter units and tire-pressure signals from sensor/transmitter units on other vehicles. On the ENDEAVOR assembly line, therefore, the identification codes are efficiently programmed into the receiver as follows: Each sensor/transmitter unit is subjected to a special radio signal that causes it to emit its identification code. A code reader automatically reads the identification code and programs it into the receiver via the vehicle's diagnosis connector (**Figs. 3** and **4**). (When identification-code

Fig. 4 Automatic identification-code reader

programming is necessitated by part replacement or other work performed in a service workshop, a separate method involving a diagnosis tool is used).

In the inspection process performed on the production line, special low-amplitude radio signals are emitted by a transmission tool held near the antenna and the strength of the signals detected by the receiver is monitored to enable confirmation that the antenna and receiver are correctly connected. For verification of the system's communication quality, a check is made for correct reception of radio signals from the sensor/transmitter units while the vehicle is running on a drum tester.

5. Conclusion

MMC plans to equip more vehicle models with the tire-pressure monitoring system that it developed for the ENDEAVOR. We look forward to developing other new products that enable us to meet our customers' needs in a timely manner.


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