



Agilent TS-5020 Tire Pressure Monitoring Systems (TPMS) Application Note

Tire Pressure Monitoring Systems (TPMS)

Safety electronics in automobiles continue to be designed and enhanced to add for passenger safety. The Tire Pressure Monitoring System (TPMS) is a safety feature that updates the driver on the level of pressure in his tires from within the comfort of the car cabin.

Studies have shown that it is very common to have running tires with low air pressure; hence tire pressure maintenance is an important safety factor throughout the automotive industry. The US government has passed legislations that require all passenger cars and small trucks with gross vehicle weight of less than 10,000 pounds to be equipped with TPM system. The main purpose of TPM system is to warn drivers of the loss of pressure in their tire(s) for greater safety and automobile handling performance.

Agilent Technologies TS-5020 TPMS Solution

The TPMS solution is an enhancement solution using the existing TS-5020 base platform. The 34980A Switch / Measure unit in the TS-5020 has already prepared the TS-5020 to be used for RF measurement. By adding a signal generator and spectrum analyzer connected via a RF switch extends its application as a RF parametric tester. Basic RF measurements; power level, spurious, phase noise, adjacent channel power etc, can be measured using signal generator ESG4432B and spectrum analyzer ESA4402B.

TPMS Operation

A conventional TPMS module consists of pressure and temperature sensors attached to each wheel with a data transmitter, and a central receiver mounted on the central body. The operating frequency uses ISM bands of 315, 434, 868 and 915MHz with typically an ASK/FSK modulation scheme.

Electronically, the TPMS module functionality lies in translating the coded input from each wheel into the receiver module to display the pressure level. **Figure 1** depicts its functionality. Typically the data format is sent at 9600 bps and Manchester encoded using FSK/ASK modulation. Manchester encoding is described as a digital signal in which value transitions between high and low is halfway through each bit period.

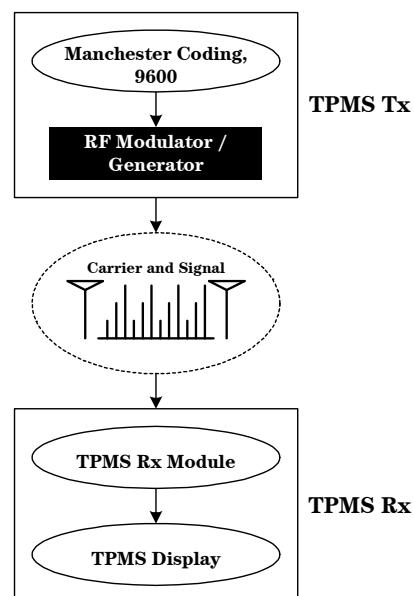


Figure 1: TPMS Functionality Action Flow

TPMS Transmitter

In **Figure 1**, the transmitter includes a tire identification integrated circuit which is powered by a lithium cell battery. The tire ID is typically 32 bits in length. The TPMS transmitter module is based on low battery consumption and thus the components within the TPMS transmitter module must have minimum current requirements and use very little energy. Typical active operating current is approximately 1 to 5mA and during standby mode, typically, 100nA is accepted.

Testing

Testing of the transmitter module involves checking signal power level, frequency deviation (FSK), and burst measurement (ASK), demodulation of ASK/FSK signal. A wakeup signal of 125 KHz is needed by the DUT to “wake-up” the microcontroller, to generate continuous RF transmission. To conduct these tests, an appropriate spectrum analyzer should be selected

The Agilent TS-5020 Testing Solution

Agilent spectrum analyzer ESA4402B is selected as a TS-5020 TPMS standard option to perform power level and demodulation analysis. Other ESA models can also be used, but since the operating frequency is low, this model is sufficient to conduct the tests. **Figure 2 & 3** depict the ESA4402B capability to measure the frequency deviation and demodulation data bits.

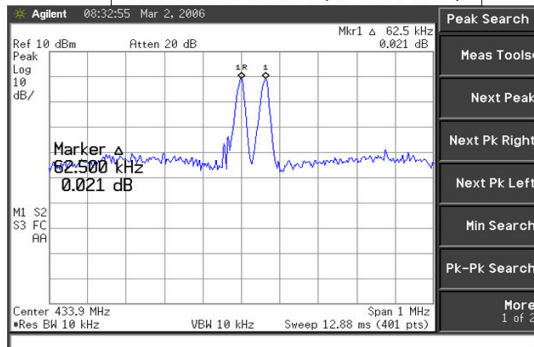


Figure 2: Frequency Deviation on ESA4402B

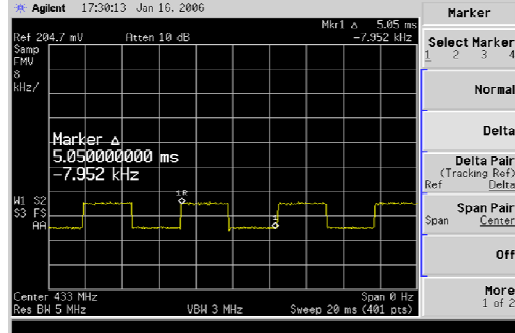


Figure 3: Data Bit on ESA4402B

The test executive, TestExec SL has several capabilities to conduct power level measurement, center frequency determination, bandwidth, etc. The action tests can be retrieved by inserting the action from TestExec SL. Below is an example of some of the actions written for ESA:

- esaSetFreqSpan
- esaSetFreqCenter
- esaSetBandwidth
- esaMarkerPeakSearch
- esaSweepSetTime
- esaMeasFreqDev

Each action will be described in TestExec SL giving its function and available user defined parameters to perform setup and measurements.

TPMS Receiver

The RF generator modulates the carrier signal creating an output for the TPMS receiver. TPMS RF bands are typically 315MHz in the United States & Japan, 433/868 MHz in Europe. To test the receiver module, a signal generator is required to simulate the signal. The specifications of the signal generator may be determined by customer needs and selected from the various Agilent signal generators. This is not a standard option for the TS-5020 TPMS solution since some customer may not need a signal generator to conduct receiver tests. Agilent signal generator ESG4432B is selected here to generate ASK/FSK signals. A few TestExec SL actions related to the signal generator is as follows:

- esgSetPowerStatus
- esgSetPower
- esgSetFrequency
- esgFSKConfig
- esgCustommode

During Receiver Test

After a data frame is received, the tire ID will be compared to the other 4 tire IDs stored in the memory. If an ID match is found, the pressure data will be processed and the proper tire LED will be lit if low tire pressure is detected. Finally, the data frame is sent through the serial interface for external data acquisition and storage.

Calibration Path Loss

Since the Lincoln platform can be leveraged as a RF Parametric tester, calibration path loss solution will be included into TestExec SL. The example below is based on the ESA4402B spectrum analyzer, ESG4432B signal generator and E4416 power meter. An example program and calibration file is available in the directory below:

- C:\Program Files\Agilent\TS-5400 System Software\Testplan\Dgn\TPMS_Dgn.tpa
- C:\Program Files\Agilent\TS-5400 System Software\Bin\TPMS_Pathloss.csv

The setup of calibration path loss procedure can be achieved if users choose not to use the model above. **Users familiar with the message based instrument using TestExec SL is required to communicate with respective equipments.*

Figure 4 depicts the concept of measuring path loss on a Lincoln platform:

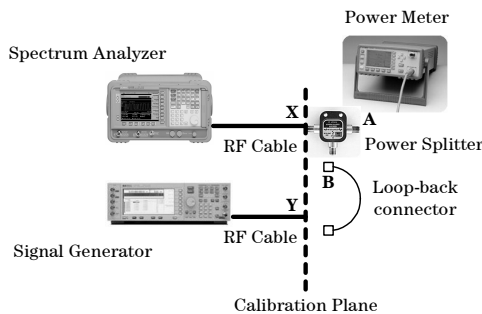


Figure 4: Typical Calibration Setup

Figure 4 depicts path loss measurement by using a signal generator to source the signal via a loop back connector to a spectrum analyzer to measure its signal loss. A power splitter and power meter is used to measure the power level at the

specified calibration plane. Following procedures is an example of how measure the path losses:

Path loss measurement @ calibration plane X

- Signal generator to source the CW signal at frequency of calibration (for eg. 315 MHz). ALC is set to internal leveled.
- A power sensor is used to measure the power level at point A for a set value (for eg. 0 dBm). NOTE: Power level at point X and A should be equal.
- The signal generator is adjusted until the required set power level is obtained.
- Path loss (dB) between point X and input to the spectrum analyzer would be the difference of power measured by the spectrum analyzer and the set power level.

Path loss measurement @ calibration plane Y

- Signal generator to source the CW signal at frequency of calibration (for eg. 315 MHz) and a specified power level (for eg. 0 dBm). ALC is set to internal leveled. NOTE: Power splitter and loop-back connector is not required in this case.
- Use a power sensor to measure the power level directly at point Y. *WARNING: Make sure the source power level set does not exceed the absolute maximum rating of the power sensor.*
- Path loss (dB) would be the difference in power level measured at point Y by the power sensor and power set for the signal generator.

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