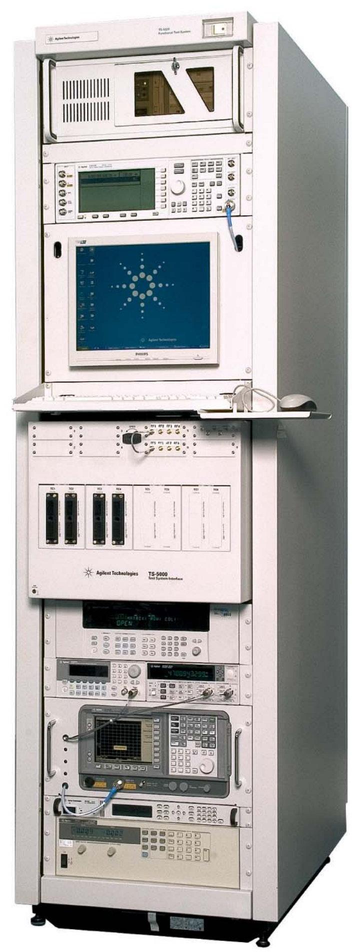

Agilent TS-5020 Tire Pressure Monitoring System (TPMS)

Application Note

Agilent Technologies

Tire Pressure Monitoring System (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 drivers on their tire pressure level 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 monitoring is an important safety factor throughout the automotive industry. The US government has passed a legislation that requires all passenger cars and small trucks with gross vehicle weight of less than 10,000 pounds to be equipped with TPMS. The main purpose of the TPMS is to warn drivers of the loss of pressure in their tires for greater safety and automobile handling performance.

Agilent TS-5020 TPMS Solution

The TS-5020 TPMS is an enhanced solution using Agilent's existing TS-5020 as its base platform. With the built-in Agilent 34980A Switch/Measurement Unit, the TS-5020 base platform comes equipped for RF measurement use. Adding a signal generator and spectrum analyzer connected via RF extends its application as a RF parametric tester. Basic RF measurements, such as 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 band of 315, 434, 868 and 915MHz with typically an ASK/FSK modulation scheme.

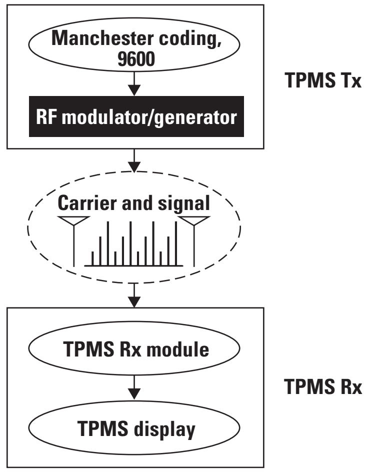

Figure 1: TPMS Functionality Action Flow

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 values transition between high and low halfway through each bit period.

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 must have minimum current requirements and use very little energy. Typical active operating current is approximately 1 to 5 mA and 100 nA during stand-by mode.

Testing

The 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 TPMS 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 due to the low operating frequency, this model will suffice for the test. Figures 2 & 3 depict the ESA4402B capability to measure the frequency deviation and demodulation data bits respectively.

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 it TestExec SL. Following is an example of some of the actions written for ESA:

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

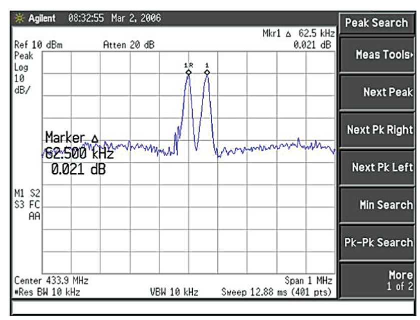

Figure 2: Frequency Deviation on ESA4402B

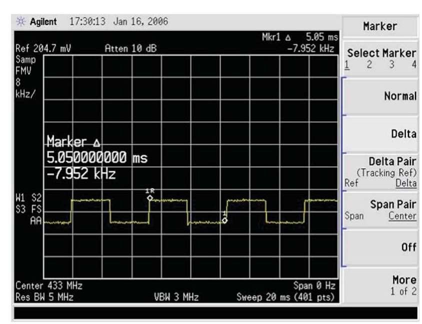

Figure 3: Data bit on ESA4402B

In Test Exec SL, each ESA action will have its own function description. Parameters can be keyed in by user to perform measurement or setup.

RF Generator

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 and 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 various Agilent signal generators. This is not a standard option for Agilent TS-5020 TPMS solution as some users do not require a signal generator to conduct receiver tests. The Agilent model ESG4432B is selected here as an example to generate ASK/FSK signals.

A few Test Exec 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 four tire IDs stored in the memory. If an ID match is found, the pressure data will be processed and the particular tire indicator 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
With the ability of the TS-5020 base platform to be extended as a RF Parametric tester, a calibration path loss solution has been included into Test Exec SL. However, the solution is based on ESA4402B spectrum analyzer, ESG4432B signal generator and E4416 power meter. The example program and calibration file is saved in the following directory:

- 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 above model. Users who are familiar with message based instruments can use TestExec SL to communicate with the respective equipments.

- A power sensor is used to measure the power level at Point A for a set value (for example: 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

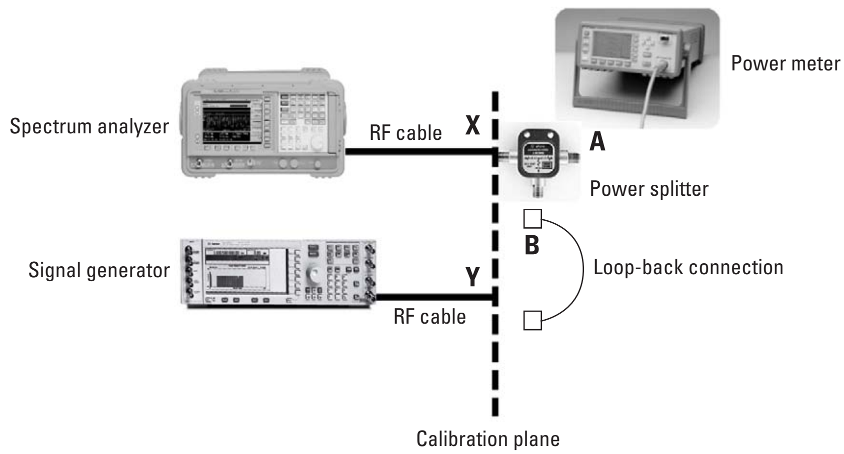

Figure 4: Typical Calibration Setup

Figure 4 depicts the concept of measuring path loss on a TS-5020 base platform:
The above diagram illustrates 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 are examples on how to measure path losses.

Path Loss Measurement @ Calibration Plane X

- Signal generator to source the CW signal at frequency of calibra tion (for example: 315 MHz). ALC is set to internal level

Path Loss Measurement @ Calibration Plane Y

- Signal generator to source the CW signal at frequency of calibration (for example: 315 MHz) and a specified power level (for example: 0 dBm). ALC is set to internal level. NOTE: Power splitter and loop-back connectors are 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 setting 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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Revised: 09/14/06

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, December 11, 2006
5989-5736EN

Agilent Technologies