Tire Pressure Monitoring Systems and Remote/Passive Keyless Entry

Tektronix RF Automotive Test Solution

APPLICATION NOTE

Tektronix®

Introduction

Today, more sophisticated and sensitive RF electronic components and devices are being included in automobiles. These advances have resulted in much safer, efficient, and connected vehicles. They have also created new challenges for RF testing and verification. This application note will discuss the test solution of typical RF automotive applications: tire pressure monitoring system, remote keyless entry, passive keyless entry, and remote start.

Block Diagrams

Remote Keyless Entry (RKE) is an electronic lock that locks and unlocks the car remotely. The RF transmitter on the key fob replaces the traditional mechanical car key.

Remote Start (RS) starts and stops the engine without accessing the car in person. You could stay home and have your car warmed up by the time you get in or turn on the air conditioner to cool down the car on a hot summer day.

The block diagrams of RKE and RS systems are similar. Figure 1 shows a simplified version. Pressing a button on the key fob wakes up the controller or CPU inside the key fob, which sends a signal to the RF transmitter. The receiver in the car will capture and demodulate the signal and send a command to the controller to either open the doors or start the car. The block diagram can be also applied to other similar applications like a garage door opener (GDO).

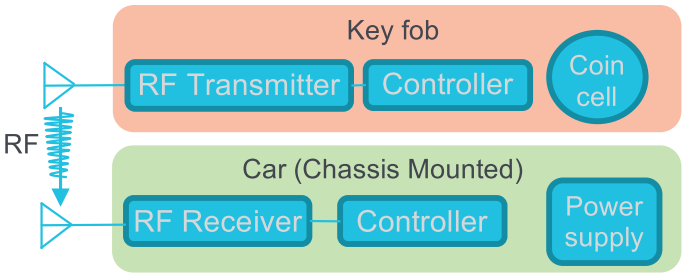

FIGURE 1. Remote keyless entry (RKE)/Remote start.

Passive Keyless Entry (PKE) and **Passive Start (PS)** lock and unlock doors and start and stop the engine without taking out the key or pressing any buttons on the key fob.

Tire Pressure Monitoring System (TPMS) gives a warning that one or more tires are significantly underinflated, which may cause unsafe driving issues. A yellow symbol, or low tire pressure indicator, will appear on the dashboard of your car when this issue is detected.

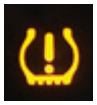

Figure 2 shows the block diagrams of PKE, PS, and TPMS. Compared to Figure 1, these systems add a trigger, IF initiator, and IF receiver into the system.

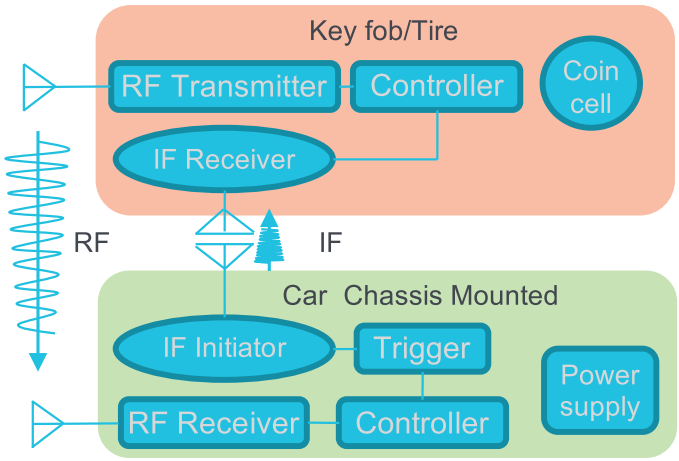

FIGURE 2. Passive keyless entry (PKE/Passive Start (PS)/Tire Pressure Monitoring system (TPMS).

The trigger system for PKE and PS is usually activated when an owner approaches their car or touches a button on the door handle. Then the car transmits a low frequency (LF) signal with an encrypted message to the LF receiver in the key fob, and the key fob sends back an RF signal to the car to request the doors opened or closed or the engine turned on or off.

For TPMS, the controller in the car activates the sensor modules in each tire through the LF initiator to poll the pressure, temperature data, and battery level in sequence. If tire pressure is lower than recommended, that signal is transmitted directly to your dashboard and the indicator light turns on.

RF Physical Layers

The communication systems of RKE, RS, PKE, PS, and TPMS span two frequency domains: LF and RF. Typically, LF uses a 125 kHz ASK modulated signal. The LF link communicates over a short distance (1 meter or less).

For RF, amplitude shift keying (ASK) is a popular modulation scheme used in low-frequency automotive connectivity RF applications. The source transmits a large amplitude carrier when it wants to send a "1" and a small carrier to send a "0" in its simplest form. On-off keying (OOK) modulation is a simplified version of ASK where the source sends no carrier when it wants to send a 0. OOK is popular in battery-operated devices because it saves on transmit power when sending 0s.

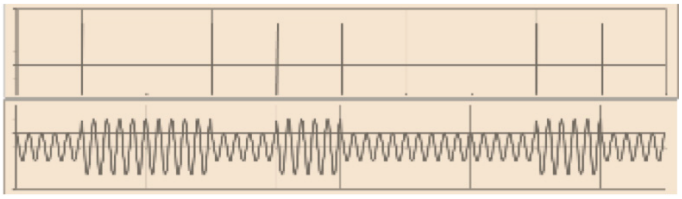

FIGURE 3. Amplitude shift-keying (ASK).

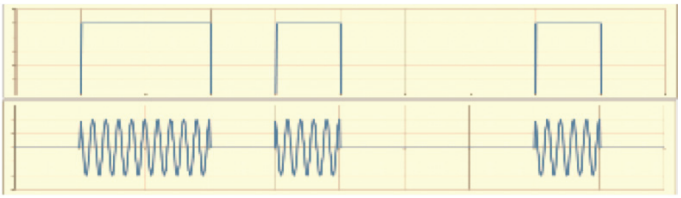

FIGURE 4. On-off keying (OOK).

Another modulation in short-range automotive RF applications is frequency shift keying (FSK), which transmits "1" and "0" by different carrier frequencies. An advantage of FSK systems is the transmitted signal has constant envelope so that more power-efficient class-C nonlinear power amplifiers can be used in the transmitter. Also, it's more bandwidth efficient than ASK and OOK. However, the cost of FSK modulation is usually higher than ASK and OOK.

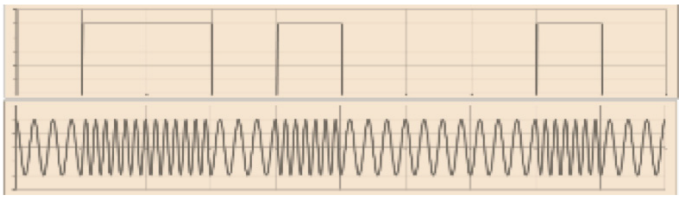

FIGURE 5. Frequency Shift Keying (FSK).

Most TPMS, RKE, PKE, and RS systems use an "unlicensed" ISM (industrial, scientific and medical) band as the carrier frequency, often around 434 MHz in Europe and 315 MHz in the rest of the world. The baud rate is flexible, usually between 2 kHz and 20 kHz, and no pulse shaping filters are normally used. These systems aren't based on specific wireless communication standards.

The Transmitter Tests

Channel power/transmit power give the total average RF power (and other measures) in a given channel. It's an important factor to decide the transmit range of communication systems. However, the maximum transmit power level limits are regulated on a country-by-country basis. Therefore, the actual maximum transmit power levels need to be measured to make sure they're less than the published regulatory limits.

Frequency offset is the difference between receive and transmit frequencies of a radio channel. Mismatch in carrier frequency can result in intercarrier interference (ICI).

Occupied bandwidth is a measurement of the frequency band bandwidth that contains a specified percentage of the total power of the signal. For example, for nonspecific short-range applications in Europe, the occupied bandwidth has to be less than 25 kHz and from 433.05 to 434.79 MHz.

Modulation quality measures the degree of closeness to which the modulation follows the ideal theoretical modulation, determined by the rms difference between the actual deviation and the expected deviation for the transmitted symbols. In FSK, frequency deviation is most commonly used.

Out of band emission is any radio frequency not deliberately created or transmitted, especially in a device which normally does create other frequencies. A harmonic or other signal outside a transmitter's assigned channel would be considered a spurious emission. Local regulatory standards, such as the FCC in the US, provides the limit (permissible value) of spurious emission power of a given unwanted emission domain.

SignalVu-PC is the RF and vector signal analysis software used with **Tektronix Real-Time USB Spectrum Analyzers, RSA300/500/600 series**. The general purpose digital modulation analysis provides analysis of 23 modulation types.

FIGURE 6. Low cost transmitter test solution.

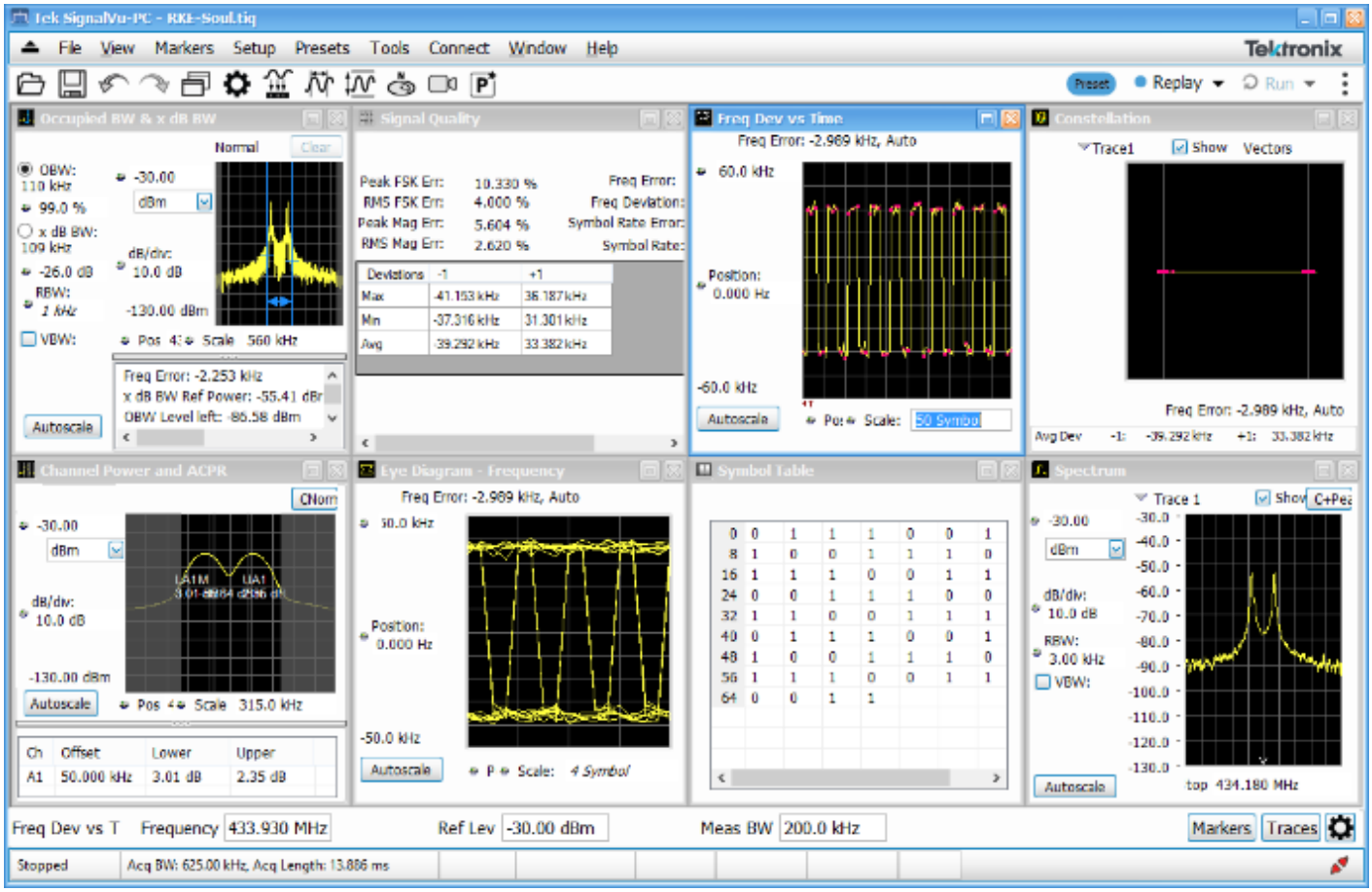

FIGURE 7. FSK analysis in Tektronix SignalVu-PC.

Figure 7 shows the SignalVu-PC software and RSA306B spectrum analyzer making transmitter tests on a wireless key fob. The DUT was sending out an FSK-modulated signal in the 433 MHz band, and SignalVu-PC provided 8 different sets of test results including occupied bandwidth, signal quality summary, frequency deviation, constellation diagram, channel power & ACPR, eye diagram, demodulated symbol table, and spectrum analysis. More tests can be added as needed.

Receiver Tests

Sensitivity is one of the most important measurements of a receiver's capability in wireless communication systems. The ability of a radio receiver to pick up the required level of radio signals will enable it to operate more effectively within its application.

Blocking measures the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer on frequencies other than those of the spurious response or adjacent channels.

The **TSG4100A Series RF Vector Signal Generator** offers mid-range performance at an entry-level RF signal generator price. Soft key upgrade is available for vector/digital modulation at a low cost. The most common modulation used in TPMS and RKE/PKE systems, ASK and FSK, are supported by TSG4100A.

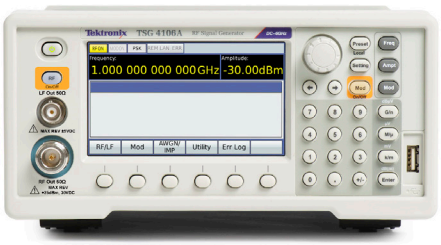

FIGURE 8. TSG4100A RF Signal Generator.

FIGURE 9. TSG4100, RSA600, and SignalVu-PC Software for TPMS transceiver tests.

Figure 9 shows TSG4100A being used with RSA600 as a complete solution for the transceiver tests of TPMS and RKE/PKE systems.

Summary

Tire pressure monitoring system (TPMS), remote keyless entry (RKE), passive keyless entry (PKE), and remote start (RS) are being more commonly used in modern cars. Testing for these automotive applications is essential. This application note features Tektronix models and software for measuring those automotive components. Real-Time USB Spectrum Analyzers RSA300/500/600 with SignalVu-PC software are useful for measuring the transmitters of these automotive applications at a low cost. TSG4100A can be used for receiver tests. DPX is a new low-cost precompliance capability that minimizes time and expenses in getting your products EMI certified.

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