# Keysight Technologies
# Functional Test Solution for Ultra-wideband Passive Entry Passive Start Automotive Security System

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

Passive entry passive start (PEPS) is a security system that allows a user to unlock his or her car without pressing any button on the key fob, or starting the car without a physical key. The system was first introduced to improve user convenience, where the driver doesn't have to search for the key fob when approaching to enter or start the car. However, issues soon surfaced when it was revealed that the system was vulnerable to relay attacks. Attackers could relay messages between the key and the car, enabling the car to be opened and started even though the car key may be physically as far away as a 100 m from the car. Advanced security technology, such as a built-in immobilizer, is ineffective in this scenario, since communication is been transmit and receive between the car and its genuine key.

Narrowband PEPS exhibit large variations in response deviations – from a few µs to 200-300 µs, making it difficult to detect distant relay attacks with increases of only a few hundreds of ns delay. For this reason, ultra-wideband (UWB) technology is being introduced to PEPS security systems as a long term countermeasure. With its wide bandwidths of greater than 500 MHz, UWB signals are narrow pulses typically less than 2 ns with steep rising and falling edges. This makes them highly immune to interference while being accurate and reliable under distance detection. Manufacturers can define a very accurate zone with the UWB PEPS system – the signal to unlock the door can only be triggered when the driver is truly nearby his vehicle, preventing any unauthorized door release using signal jams.

## UWB PEPS ECU functional testing

Under typical operation, the PEPS electronic control unit (ECU) in the car sends UWB beacon messages periodically to detect the presence of the car key so as to either grant or deny access. When the car key detects this UWB message emitting from the car, it will activate the internal microcontroller and interpret the signals received. After computing the received signals, the smart key will respond to the PEPS, also within the UWB frequency spectrum. Since there is two-way communication between the PEPS and the corresponding key, the functionality of the PEPS lies in its proper detection and translation of codes input from the smart key and also transmission of beacon signals from the PEPS to the smart key.

This paper serves to discuss the key tests for a typical PEPS system, which is the device under test (DUT), using a smart key or signal generator to emulate the UWB communication. Figure 1 provides an overview of the tester setup for functionality checking of the PEPS system. 'Receiver test' and 'sensitivity test' are the tests that receive UWB messages from the smart key for codes detection to validate PEPS receiver detection functionality. Meanwhile 'power transmission test' validates the robustness of the ultra-wide band transmitter by analyzing its transmitted signal. Lastly, there is the option of 'ranging test' – distance detection may or may not be necessary during end-of-line functional test on the manufacturing floor, if the algorithm could be guaranteed during design phase. Concurrently, some common functional tests such as battery voltage input, current drawn during idle or operating mode may be needed, and these can be carried out with a digital multi-meter (DMM).

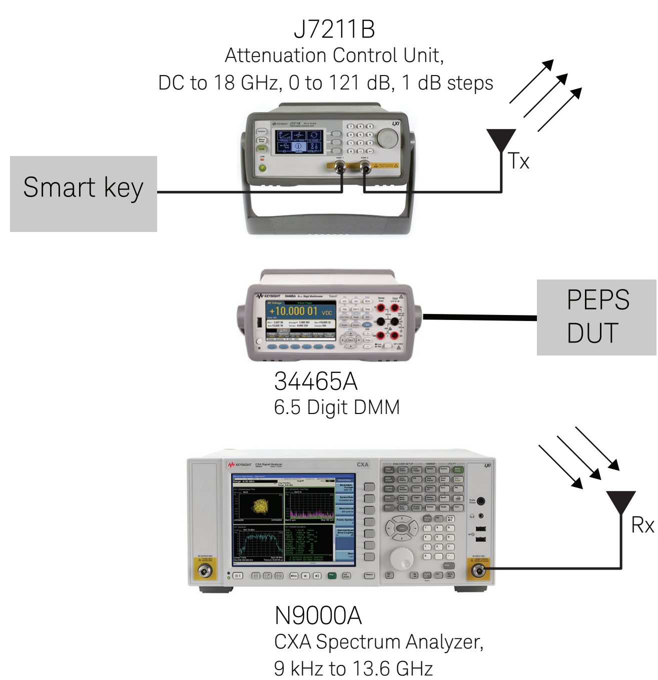



Figure 1. Block diagram of PEPS functionality test setup

## Receiver Test

Receiver test requires an emulator that can generate the smart key signal, with the purpose of verifying the on-board UWB reception circuitry of the PEPS DUT. A pulse-based UWB of over 500 MHz bandwidth using combined burst position modulation (BPM) and binary phase-shift keying (BPSK) modulation to gain the benefit of immunity to multipath interference. You can consider vector radio frequency (RF) signal generators, or high-speed wideband arbitrary waveform generators in the market that can be used to produce the multiband UWB signals. However, high precision may not be an absolute requirement for production line testing, since for the purpose of functionality checking, you will only need a smart key that can communicate with the PEPS. Hence, manufacturers usually develop a special module at lower cost that can emulate the smart key UWB functionality. The special module is designed to work at DUT operating frequency, and is programmable to imitate the smart key that is paired to the DUT. When the command is triggered, the special module transmits the UWB key signal, through the transmission antenna that is placed at a fair distance from the DUT. The signal transmitted is a specific UWB message defined by the user. The DUT then receives and compares the contents of the message, cross-checking to ensure no error code found for receiver's functionality validation.

## Sensitivity Test

The purpose of this test is to verify the sensitivity level of the DUT's receiving circuitry. Sensitivity can be translated as performance in relation to working distance between smart key and the PEPS, which eventually helps to estimate the operating zone of the PEPS. In this test, a programmable attenuator is placed in series between the smart key module and transmission antenna to adjust the power level from the smart key transmission. By setting maximum attenuation level at the beginning of the test, the receiving test is performed to validate whether the message sent from the smart key is successfully retrieved at the weakest signal strength. The sequence will be repeated with decreasing attenuation levels until the message sent is retrieved. The attenuator dB level will then be indicative of the DUT sensitivity level. Figure 2 illustrates the sequence for this sensitivity measurement. In order to achieve more accurate results, RF cable loss, attenuator insertion loss, as well as distance between the transmission antennae to the DUT have to be factored into the sensitivity test.

Keysight offers a wide range of programmable attenuators, PXI card types (M9168C) and LXI-compliant (J7211B) attenuator control units at frequencies ranging from DC to 18 GHz, suitable for PEPS UWB applications. The solutions also offer excellent flatness across frequencies, with attenuations of as low as 1 dB steps to enhance measurement sensitivity.

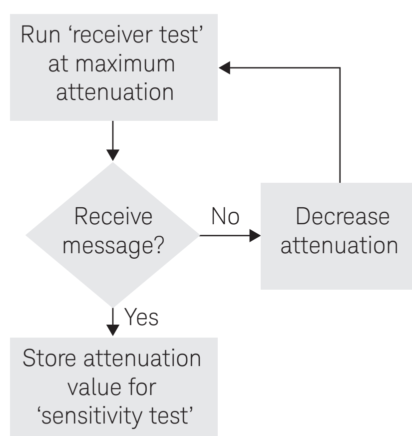



Figure 2. Sensitivity test flow

## Power Transmission Test

Transmitted power, its center frequency and the occupied bandwidth are transmission tests that validate the DUT's UWB transmitter functionality. The tests measure transmitter RF signal quality, ensuring the transmitter meets specifications that are vital for the PEPS operation. You will need a signal analyzer that is capable of measuring individual spectral components across frequencies in order to acquire these test parameters. In this test, the DUT is configured in continuous transmitting mode with no drop-off of UWB signals, ensuring the signal analyzer accurately measures the signal. Figure 3 shows the screenshot of a transmitted UWB signal from a signal analyzer, displaying the composite power in band – total power across UWB from start frequency to stop frequency, the occupied bandwidth and its center frequency designed at 3993.6MHz.

Unlike narrowband PEPS that operate with RF signals on low frequency (LF) and ultra-high frequency (UHF) spectrums, the UWB PEPS ECU communicates with its smart key via RF signals on higher frequency UWB spectrums that beyond 3 GHz. Keysight offers an affordable N9000A CXA X-Series signal analyzer that adequately provides effective functional validation in manufacturing lines. CXA frequency ranges from 9 kHz to 7.5 GHz or 9 kHz to 13.6 GHz are an excellent fit to measure the UWB PEPS transmitter's spectrum.

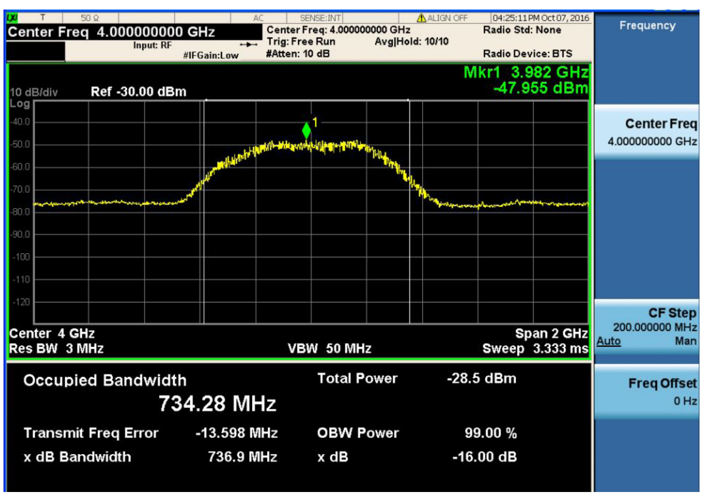



Figure 3. Transmitted UWB signal

## Ranging Test

Ranging test is a test that validates the accuracy of distance detection of the UWB protocol. Typically, the PEPS designer embeds time of flight (TOF) measurement technique to calculate the distance of UWB pulses transmitted from the smart key. The acquired distance is stored in DUT memory, therefore verification of the ranging functionality relies on the ability of a test system to communicate with the DUT. The most common serial interface used in automotive ECUs is the ISO-11898 controller area network (CAN) bus protocol, or local Interconnect Network (LIN). All tests discussed above that require communication are also established with the dedicated DUT communication links.

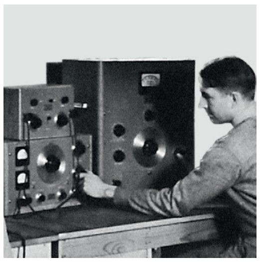
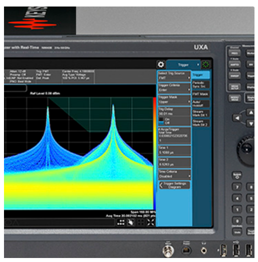
As a solution provider, Keysight works with system integrators to offer automotive communication devices using Keysight software platform, with pre-integrated hardware library without compromising quality and performance.

## Summary

Cyber-attacks pose a severe threat to the automotive wireless eco-system. Keysight is dedicated to working with automakers to continue developing test solutions for new technology that enhance the security systems of automobiles.

## Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.

myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

http://www.keysight.com/find/emt_product_registration
Register your products to get up-to-date product information and find warranty information.

KEYSIGHT SERVICES
*Accelerate Technology Adoption. Lower costs.*

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

CALIBRATION UP TO 10 YEARS WARRANTY ASSURANCE PLANS

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/automotive
www.keysight.com/find/fieldfox

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

**Americas**

| | |
|---|---|
| Canada | (877) 894 4414 |
| Brazil | 55 11 3351 7010 |
| Mexico | 001 800 254 2440 |
| United States | (800) 829 4444 |

**Asia Pacific**

| | |
|---|---|
| Australia | 1 800 629 485 |
| China | 800 810 0189 |
| Hong Kong | 800 938 693 |
| India | 1 800 11 2626 |
| Japan | 0120 (421) 345 |
| Korea | 080 769 0800 |
| Malaysia | 1 800 888 848 |
| Singapore | 1 800 375 8100 |
| Taiwan | 0800 047 866 |
| Other AP Countries | (65) 6375 8100 |

**Europe & Middle East**

| | |
|---|---|
| Austria | 0800 001122 |
| Belgium | 0800 58580 |
| Finland | 0800 523252 |
| France | 0805 980333 |
| Germany | 0800 6270999 |
| Ireland | 1800 832700 |
| Israel | 1 809 343051 |
| Italy | 800 599100 |
| Luxembourg | +32 800 58580 |
| Netherlands | 0800 0233200 |
| Russia | 8800 5009286 |
| Spain | 800 000154 |
| Sweden | 0200 882255 |
| Switzerland | 0800 805353 |
| | Opt. 1 (DE) |
| | Opt. 2 (FR) |
| | Opt. 3 (IT) |
| United Kingdom | 0800 0260637 |

For other unlisted countries:
www.keysight.com/find/contactus
(BP-9-7-17)

DEKRA Certified
ISO9001 Quality Management System

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System


Published in USA, December 1, 2017
5992-1964EN
www.keysight.com