Agilent TS-5400 Series II Remote Keyless Entry

Application Note

Security and Safety: Testing Remote Keyless Entry and Immobilizer Functionality

Security and safety go hand-in-hand in the world of automotive technology. Whether you are testing Remote Keyless Entry (RKE) or Immobilizers that provide protection from vehicle theft, the Agilent Technologies TS-5400 Series II Electronics Functional Test Platform is prepared with test solutions.

As the need continues to increase for luxury technology, automotive RKE systems are equipped with everything from door or trunk release to more sophisticated functions including starting the engine, setting a radio station, positioning seats, and adjusting mirrors. In addition, many RKE systems are equipped with other features that include interior light activation, system disarmament, or automatic panic alert.

Typically, RKE functionality is embedded in the Body Control Module (BCM) that controls electro-mechanical drivers for door locks, windshield wipers, interior lighting, and other such functionality. Developing a dedicated Electronic Control Module (ECM) for RKE functionality is also an option. Figure 1 illustrates the components of a generic BCM with RKE functionality. In addition, the advent of RKE works in conjunction with the need for increased security in cars and the emergence of immobilizers.
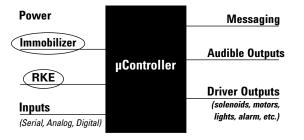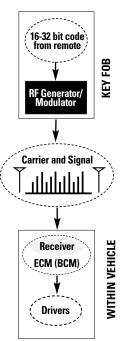
What follows is a sampling of manufacturing functional tests that lead to increased reliability, security, and system integrity using the TS-5400 Series II Electronics Functional Test Platform for RKE and Immobilizers.

The electronics behind RKE functionality lies in translating coded input from a key fob into commands for electromechanical drivers located throughout various parts of the car. In general, activity (as seen in Figure 2) includes code generation by a hand-held key fob, signal detection and processing, followed by authentication code verification. Finally, the Electronic Control Module generates a serial command or direct output to a variety of drivers (door locks, seat positioning motor and more.)

Figure 1: Body Control Module
(With Remote Keyless Entry & Immobilizer)

Figure 2: RKE Functionality Action Flow

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Transmitter

In Figure 2, the key remote (transmitter) includes an identification signal generating integrated circuit and is powered by a small battery. The identification signal is typically a 32-64 bit rolling code, which requires some form of modulation in subsequent signal processing. Issues of security and sensitivity regarding the algorithm for generating this code render it a customer proprietary test section, often requiring treatment as a "black box." In this case, the customer generally supplies the code for the transmitter in the form of a working key fob or modulation device. Since RKE transmitters are inactive virtually 99% of the time, low power modes are important. In its inactive mode an RKE transmitter current of 100nA is generally accepted with a current draw of 10-12mA for active RF transmissions.

Testing

Though not always performed, testing the RF power output of the key fob may be of interest.

Testing may involve checking the signal strength of the key fob output amplitude and center frequency when it enters a particular mode. For example, following a certain keypad command the key fob may enter a continuous wave mode that generates a non-modulated RF output. Other test modes may include generation of an AM or FM output. When testing, a known working key fob maybe used to calibrate the tester, while subsequent testing is completed based on relative signal strength analysis. In conducting these tests, specific spectrum analyzers may be selected from the market.

The Agilent TS-5400 Series II Testing Solution

Any of the Agilent 859#X RF Spectrum Analyzers will meet the specifications needed for key fob power analysis. The test executive (TxSL) has several post-process data extraction, analysis and display capabilities for output amplitude and center frequency determination. The select data may be extracted and presented in a variety of formats including database entries, waveforms, arrays, etc., with associated units for easy-to-read reporting.

Testing

The transmitter is powered by a lithium coin cell battery. Typically, the battery life is expected to be > 5 years at 25˚C. To promote the lifetime of the battery, verification of leakage current during active RF transmission may be required.

The Agilent TS-5400 Series II Testing Solution

The platform may be configured to include a Measurement Control Module (MCM). A built-in feature of the MCM includes the ability to provide a voltage or current source and measure the output current or voltage, respectively. Therefore, using the MCM as a voltage source, the output leakage current from the transmitter may be obtained.

RF Generator

The RF generator modulates the carrier code creating an output for the RKE receiver. RKE RF bands are typically 315MHz in the United States and Japan or 434/868 MHz in Europe. Many current systems employ amplitude shift key modulation (ASK) as ASK-modulated data is easily created with surface acoustic wave (SAW) transmitters. However, frequency shift key (FSK) modulation is developing a wider following as a result of stable and accurate frequency shifting at higher data rates. Specifications for the generator are determined by customer need and may be selected from a variety of products in the market.

Receiver and Drivers

An antenna with low voltage and current ratings receives input from the RF modulator. The receiver should operate on a 9-16V car battery. The receiver detects a valid transmission (message authentication code or MAC) from the key fob transmitter, which includes the transmitter ID, rolling count, command code and status flags. To validate the MAC, the receiver compares its rolling count with the transmitter ID rolling count. The transmitter ID rolling count is stored in the receiver's nonvolatile memory. For validity, the transmitted rolling count should be greater than or equal to the receiver stored count within a given count "window." If the rolling counts do not match within this window, the receiver may initiate a resynchronization. If the rolling counts match, the ECM generates a serial command to the drivers controlling door locks, interior lights, alarms and more.

Testing

As a general practice, there are two ways of verifying RKE functionality. Since RKE ECM test developers are not privy to the details of the rolling code, one way is to verify the serial command generation by the ECM and the second is by observation of the electromechanical driver response to a given input command. Each component of RKE functionality (seat positioning, interior lighting, panic alert, trunk release, etc.) may be tested this way by sending a transmitter command and verifying action via the serial link or through the relevant driver response.

The Agilent TS-5400 Series II Testing Solution

The platform can be configured to include a custom card for mounting the key fob/black box provided by the customer directly on the tester. The RF signal source is typically chosen between the ESG 1000A and the 8647A Economy Signal Generator for their bandwidth and modulation capabilities. Serial communication supported by the platform includes common interfaces such as ISO-9141, J1850 and CAN/J1939. Agilent TestExec SL includes support for easy integration of message-based instrumentation. By following the well documented instrument integration procedure in TestExec SL, a user familiar with the message-based instrument and its desired parameters can establish integration and comprehensive action definitions in under thirty minutes.

A few TestExec SL actions related to serial port communication follow. Aside from the expected Read/Write/Configure software capabilities for serial communication provided, the test executive streamlines common process steps used in ECM functional testing. For example, sending the ECM a periodic "keep alive" message (referred to as a group message below) to maintain TEST mode (rather than RUN mode) is made significantly easier with the following actions:

mComConfigGroup: Configures any of the support serial interfaces for a group message.

mComStartGroup: Specifies the time between groups, between group elements, group repeat count and the group message itself. GroupRepeatCount = 0 represents indefinite repetition of a keep alive message.

Response Time

To gain appeal as a luxury commodity, the consumer-based success of RKE technology lies in the system's ability to respond quickly to the user's press of the keypad.

Testing

Normally, the elapsed time between pressing the RKE keypad and message generation should be < 300ms. Therefore, determining the time to transmit, verify the code and generate a message is of utmost importance, and is measured in addition to the total time (including driver execution) of the system function (<1s).

The Agilent TS-5400 Series II Testing Solution

A counter, such as the Agilent E1333A 3-Channel Universal Counter, may be used to measure the time difference between pressing the key fob and the resulting action (either code verification or total time). Supporting this hardware solution is the test executive software envelope with action routines for the E1333A Counter.

A sampling of the Agilent TestExec SL actions for the E1333A Counter include the following:

ctrConfTrigIn: Sets the input trigger.

trigfirst: Parameter used for trigger usage before reading. 0 for no, 1 for yes.

ctrIsSet: Waits until the Counter is ready for measurement (returns true when ready).

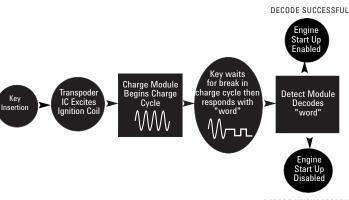**ctrInitiate:** Starts the previously configured Counter measurement.

ctrGetResults: Reads the Counter results.

Immobilizers Protect Against Theft

As mentioned above, the advent of RKE is coupled with the need for increased security in cars and the emergence of immobilizers to protect them from theft. As the cost and complexity of the average car rises, so too does the need for greater security to protect it from theft. Car manufacturers as well as insurance companies are raising the standard features on cars. As a result, the industry is moving towards wider use of immobilizers and basic security systems.

Whereas RKE systems provide remote control convenience and vehicle entry security, immobilizers provide protection against vehicle theft. When an improper key is used in the ignition, immobilizers turn off the starter circuit so the engine will not engage.

Immobilizers are composed of a magnetic coil wound around the ignition, a charge and detect module (transceiver) in the ECM, as well as a remote key fob equipped with a transponder. As the action flow in Figure 3 illustrates, immobilizer functionality lies in the signal communication between the transponder and charge/detect module of the ECM so the system can determine whether or not to start the engine. In most cases, immobilizer functionality is part of the BCM while dedicated immobilizer ECMs are uncommon.

Figure 3: Immobilizer Functionality Action Flow

Radio Frequency Identification (RFID) Transponder

The key fob contains a transponder integrated circuit. When the key is placed in the ignition, the integrated circuit induces a current in the magnetic coil surrounding it, thereby exciting the coil, which feeds into a tuned circuit. Once the charge cycle (burst of RF energy) is initiated by the transceiver, the transponder is prompted to transmit its modulated authentication message. This message prompt comes in response to a 120-250ms break in

the transceiver charge cycle. The transponder response is generally characterized as AM or FM modulated in Non-Return to Zero (NRZ) mode with duration of <20ms.

As in the case of the remote keyless entry key fob, this section of test is customer proprietary and is supplied as either a working fob or black box. Unlike RKE, however, the code is not rolling code. Rather, it is fixed since this communication is not susceptible to code grabbing techniques of thieves.

Testing
Improper orientation of the transponder IC in the key fob, 180˚ rotation for example, will result in a lower level amplitude output from the transmitter. In this case, orientation should be verified by generating the charge cycle and monitoring the transponder IC "word" response amplitude.

The Agilent TS-5400 Series II Testing Solution

Simulation of the charge cycle may be achieved in two ways: Using the black box or key fob given by the customer as a stimulus; or by emulating the cycle with the automotive-tuned Agilent E6173A Arbitrary Function Generator (a component that can be configured into the test platform).

The test executive software envelope with action routines and test plan examples for the E6173A Arbitrary Function Generator (VXI) or the 33120 (GPIB) supports this hardware solution.

A sampling of the TestExec SL actions for the E6173A ARB include the following:

arbConfOut: Configures the ARB's output circuitry.

arbSet: Programs the arb by transferring all arb settings specified in the configuration.

Arb_Dl_Std_Waveform: Downloads a sine, square/pulse or tri- angle waveform of a specified frequency, amplitude and offset.

Arb_Dl_Custom_Waveform: Downloads a custom, user-defined waveform consisting of up to 10 sequences with 50 segments per sequence to the Arb.

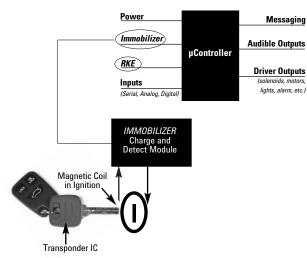**arbConfTrigIn:** Sets input triggering parameters.

arbConfTrigOut: Sets output triggering parameters.

arbInitiate: Starts the arb sequencer to output the waveform.

arbStop: Stops waveform output at end of current sequence on a given channel.

Ignition

A magnetic coil wrapped around the ignition is excited by the transponder IC (see Figure 4). The charge module emits a charge cycle $\leq$ 12Vpp. At the end of the cycle, the module waits until the authentication code from the transponder is detected. Once detected, it is decoded and a serial command is passed to the engine ECM to either grant or deny start-up.

Figure 4: Immobilizer

Testing

Several stages of this process should be tested for system integrity. First, a simple stimulus-response test will determine if the immobilizer decoder is functioning properly. The correct code input is the stimulus, which is either supplied (generally a customer proprietary part of the test) or emulated by use of an arbitrary function generator. Next, the amplitude of the charge module should be checked against design specifications. Finally, verification through serial interrogation will prove that the ECM generated the appropriate serial command to the engine ECM to grant or deny start-up.

The Agilent TS-5400 Series II Testing Solution

The test platform is easily configured to include a custom card for mounting the key fob/black box provided by the customer into the test set-up. The E6173A Arbitrary Function Generator or the 33120 (GPIB ARB) can create a RF charge cycle signal to which the key fob will respond. Verification of serial communication may be accomplished through platform support of the following common interfaces: ISO-9141, J1850, or CAN/J1939.

An RKE/Immobilizer Test Solution

Optional Throughput Multiplier

A dedicated ECM for either RKE or Immobilizer functionality would be characterized as a low pin count/complexity module. Therefore, it is considered a prime candidate for the TS-5400 Series II Optional Throughput Multiplier. The Throughput Multiplier Facilities multiple up UUT (unit under test) testing. Multiple up UUT testing results in decreased set up time of the instrumentation per UUT, consolidating delays in relay closures and overlapping time delays due to inherent UUT latencies. The TestExec SL software tool provides comprehensive support for this test strategy.

Automotive Electronics Manufacturing Environment

The TS-5400 Series II platform offers support for factory automation. From a more basic automation scheme to the use of PLC (Programmable Logic Controllers), the TS-5400 Series II comprehensive serial communication support and digital I/O capabilities allow the platform to be integrated as part of an existing manufacturing environment.

Overall Solution

The test needs for RKE/Immobilizer ECMs as generally outlined in this application note, maybe satisfied by the following instrumentation. *

• RF Generator/Modulator
• RF Spectrum Analyzer
• Counter
• Arbitrary Waveform Generator
• Serial Port Adapter (for support of ISO9141, J1850 and J1939 serial protocol)
• Power Supply
• Measurement Control Module

* Note: This instrumentation list is presented as a general test solution profile, and is not for use as a direct ordering guide. For information on the detailed platform profile, please refer to the Product Note.

References

Jurgen, Ronald. *Automotive Electronics Handbook*. McGraw Hill Inc, 1999.
Mizutani, Shuji. *Car Electronics*. Sankaido Co, Ltd., 1992.

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