RF Testing in Automobiles

Introducing a High-Efficiency, and Low-Cost RF Test Solution for TPMS, RKE or PKE

Presented By:
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Market Development Manager

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1. Automotive Electronics Briefing
2. Tire Pressure Monitoring System (TPMS) Overview
3. Introducing a High-Efficiency, Low-Cost RF Test Solution
   - RF Testing Challenges
   - Transmitter Testing
   - Receiver Testing
4. Wrap up: Top 3 take-aways, and references
## Automotive Electronics by Technology

### Power Train
- Engine Management ECU (Fuel injection, timing control, throttle control etc.)
- Automatic Gearbox, Transmission ECU
- Power Steering ECU (Electro-Hydraulic, Electric)
- Steer-by-wire ECU

### Safety Electronics
- ABS ECU (Conventional, Traction Control)
- Brake-by-Wire ECU; Airbag ECU (Conventional, Adaptive)
- Collision Avoidance Electronics (DSRC, Radar)
- Tire Pressure Monitoring Systems
- Security ECU (Remote Keyless Entry, Alarms, Immobilizers)

### Body Electronics
- Driver Assistance ECU (Night Vision, Cruise Control, Line Departure Warning, Park/Reverse Assist,)
- Electronic Suspension ECU (Passive, Active)
- Convenience/Comfort ECU (Lighting, Climate Control, Hands-Free, Door Modules, Memory seats)

### Infotainment and Telematics
- Telematics (e.g. ETC, GPS Navigation, Remote Diagnostics)
- In-Car entertainment, Video and Audio Electronics (e.g. VOD, XM Radio, DAB, DVB, DMB, TV)
- In-Car Networking Electronics: MOST, Wireless technology (e.g. Bluetooth, WLAN)
- Instrumentation ECU (Cluster, dashboard, Trip Computer)
Electronic components make cars clean & economic, safe & secure, comfortable & connected

- Communication Systems (GSM, WCDMA, CDMA2000, LTE)
- Wireless audio reception (Bluetooth)
- Radio (AM, FM, etc.)
- TV (DAB, UHF DVB-T, etc.)
- TPMS
- RKE/PKE
- Collision Avoidance
- Diagnostic system (Zigbee, Bluetooth)

Navigation system
Opportunities and Challenges for Safety Electronics

~8% price decrease per year

Double-digit market growth
Introducing Agilent’s RF Test Solution

TPMS/PKE/RKE Measurement Challenges

Agilent’s High-Efficiency and Low-Cost RF Test Solution
TPMS – For your Safety and Energy saving

**Safety**

TPMS alerts the driver in real time, when the tires have:

- Too high pressure
- Too low pressure
- Too high temperature

**Energy saving**

TPMS optimizes vehicle’s performance:

- The right tire pressure optimizes coefficient of friction
- Less gas needed
TPMS is required for passenger cars and light trucks in the U.S and Europe

EC Regulation No.661.2009, article 9(2):
Vehicles of category M 1 shall be equipped with an accurate tire pressure monitoring system capable of giving, when necessary, an in-car warning to the driver when a loss of pressure occurs in any tire, in the interests of optimum fuel consumption and road safety.

With effect from 1 November 2012, national authorities shall refuse to grant on grounds relating to the areas of vehicle safety and tires covered by Articles 5 to 8, Article 9(2) and Article 11.
Facts about TPMS

Tire Pressure Measurement System (TPMS)
- Includes tire pressure monitoring module in the tires and the MCU in the vehicle control unit
- Measures conditions in each tire and transmit the data to the MCU via radio
- Works at ISM band, e.g. 315MHz, 433.92MHz, 868MHz or 915MHz
- Modulation format: FSK or ASK with Manchester encoding

Transmitter

Pressure & temperature information → FSK modulation → ISM band (315/433/868/915 MHz) → Monitor Center

Receiver
What are the challenges for TPMS testing?

Example block diagram:

**Transmitter Test:**
- Frequency
- Power
- FSK deviation

**Receiver Test:**
- Sensitivity
- Bit error
- Frequency
Similarities in RKE/PKE Testing

RKE/PKE also utilizes the same technologies:
ISM bands and ASK/FSK modulation format.
RF Measurements in Automotive Electronics
- Agilent Low Cost RF solution for TPMS/RKE/PKE application
Transmitter Test Solution for TPMS transmitter

“The ONLY low cost spectrum analyzer that meets both of your RF and FSK demodulation analysis needs.”

Agilent N9320B/N9322C spectrum analyzer covers the following general testing items of a TPMS transmitter:

- Center frequency tuning and test
- Power calibration and test
- FSK Deviation
N9320B in ASK/FSK demodulation mode (with option DMA)

- Freq range: 10 MHz to 3 GHz
- Power accuracy: ± 1 dB typ.
- Input power: -30 to +20 dBm
- Synchronized by RF trigger
- ASK depth: 10 to 90%
- FSK deviation: 1 to 400 kHz
- Max measurement length: 1100 symbol
### Why should I use the ASK/FSK demodulation analysis mode in Agilent N9320B/N9322C?

<table>
<thead>
<tr>
<th>Traditional spectrum analyzers</th>
<th>Agilent N9320B/N9322C BSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer needs use “Max hold” to get the spectrum of the FSK modulation signal, then use marker and marker delta to read out the power and FSK deviation</td>
<td>Customer can rely on the ASK/FSK demodulation analysis (option DMA) to easily get all the RF and demodulation metrics in one screen.</td>
</tr>
</tbody>
</table>

**Disadvantages:**
- Time consuming
- Consumes the DUT’s battery power

**Advantages:**
- Fast
- Accurate
- Multiple metrics in one test

**Max-hold takes about 10 seconds to fully capture a FSK signal**

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One-stop demodulation metrics!

<table>
<thead>
<tr>
<th>Metric</th>
<th>Current</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier Power</td>
<td>-20.05dBm</td>
<td>-20.05dBm</td>
<td>-20.05dBm</td>
</tr>
<tr>
<td>ASK Error</td>
<td>0.23%</td>
<td>0.23%</td>
<td>0.23%</td>
</tr>
<tr>
<td>ASK Depth</td>
<td>97.62%</td>
<td>97.62%</td>
<td>97.62%</td>
</tr>
<tr>
<td>ASK Index</td>
<td>95.35%</td>
<td>95.35%</td>
<td>95.35%</td>
</tr>
<tr>
<td>Carr. Freq Offset</td>
<td>-473.402Hz</td>
<td>-473.402Hz</td>
<td>-473.402Hz</td>
</tr>
</tbody>
</table>

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Agilent Technologies
Typical Test Results

Measuring a FSK signal in the normal spectrum analyzer mode, using trace max hold

Tx Measurement example: 2FSK signal (CF = 433.92 MHz, Power = -20 dBm, symbol rate = 4 ksps, Peak-Peak FSK deviation = 50 kHz, Baseband pattern = 1110000110)

Measuring a FSK signal in the ASK/FSK demodulation mode (Opt. DMA)
Typical Test Results

Add Pass/Fail Testing on the FSK deviation (Purple color = Fail, out of tolerance)

Add Pass/Fail Testing on the FSK deviation (White color = Pass)
Receiver Test Solution for TPMS receiver

The economy

Product configuration
N9310A RF Signal Generator, 9 kHz - 3 GHz
33500 Function/Arbitrary Waveform Generator
33503A BenchLink Waveform Builder Pro

The performance

Product configuration
N5172B EXG Signal Generator, 9 kHz - 3 GHz
Custom digital modulation

DUT
## The Economy Receiver Test Solution

“A signal generator and an arbitrary waveform generator combine to measure the RSSI of the DUT.”

<table>
<thead>
<tr>
<th>Receiver test solution</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agilent N9310A RF signal generator</td>
<td>Rx characterization</td>
</tr>
<tr>
<td>Agilent 33500 Series with:</td>
<td>Flexible waveform generation</td>
</tr>
<tr>
<td>- Option 001: 10 MHz external time base</td>
<td></td>
</tr>
<tr>
<td>Intuilight waveform editor or</td>
<td>For PC development of waveform</td>
</tr>
<tr>
<td>33503A BenchLink Waveform Builder Pro software</td>
<td></td>
</tr>
<tr>
<td>Agilent U2531A USB data acquisition module</td>
<td>Simultaneous data acquisition</td>
</tr>
</tbody>
</table>
Higher Performance Receiver Test Solutions
X-Series Signal Generators

- Highest performance RF specifications – phase noise, output power, and more

- Flexible and customizable waveform creation through Signal Studio software
- Basic signal creation through the instrument front panel softkeys
- Low cost of ownership
Additional testing needed: EMC

Precompliance Measurements

X-Series w/ N6141A

Precompliance gives you a close idea of whether or not your device will pass.

Evaluate the conducted and radiated emissions of a device using correct detectors and bandwidths before going to a test house for compliance testing.
The CXA Signal Analyzer N9000A

Frequency range  | 9 kHz to 3/7.5/13.6/26.5 GHz
---|---
Analysis bandwidth | 10 MHz standard
| 25 MHz optional
DANL | -163 dBm at 1 GHz preamplifier ON
TOI | +17 dBm at 1 GHz
Phase noise | -110 dBc/Hz at 10 kHz offset (1 GHz carrier)
Amplitude accuracy | ±0.50 dB

* Option T03/T06/CR3/C75/ESC are not compatible with 13.6 GHz and 26.5 GHz models at present

Four frequency models
- N9000A-503, 9 kHz to 3 GHz
- N9000A-507, 9 kHz to 7.5 GHz
- N9000A-513, 9 kHz to 13.6 GHz
- N9000A-526, 9 kHz to 26.5 GHz

Optional full band preamplifier
- N9000A-P03/P07/P13/P26
  - World’s most comprehensive applications set – X-series apps
  - Supports PowerSuite, IQ analyzer and 89600 VSA
  - Support PN, NF, VXA X-Series measurement applications**
  - Remote language and manual user interface compatible with X-Series

*   Option T03/T06/CR3/C75/ESC are not compatible with 13.6 GHz and 26.5 GHz models at present
Pre-compliance test with X-app: W6141A

- Measure designs to the latest CISPR 16-1-1 or MIL-STD requirements
- Perform pre-compliance conducted and radiated emissions tests
- Multiple detectors - peak, quasi-peak, EMI average and RMS average
- Easily identify out-of-limit device emissions and maximize signals to compare against regulatory requirements
  - Signal list, frequency scan and active detector meters are displayed on a single screen
- View signals over time using the strip chart
- Global center frequency support in SA, EMC and analog demodulation modes
- Tune and listen to signals in the frequency scan list
Perform EMI Design Troubleshooting with a Probe

EMI design troubleshooting with the N9311X-100 magnetic field probes:
• Pinpoint the emission source
• Design verification

<table>
<thead>
<tr>
<th>N9311X-100</th>
<th>30 MHz to 3 GHz</th>
<th>30 MHz to 3 GHz</th>
<th>30 MHz to 2 GHz</th>
<th>30 MHz to 3 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="cxasignalanalyzer.png" alt="Image" /></td>
<td><img src="n9311x100_30mhzto3ghz.png" alt="Image" /></td>
<td><img src="n9311x100_30mhzto3ghz.png" alt="Image" /></td>
<td><img src="n9311x100_30mhzto2ghz.png" alt="Image" /></td>
<td><img src="n9311x100_30mhzto3ghz.png" alt="Image" /></td>
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Also addressing the same testing needs from other industrial communications
Wrap up: Agilent solution for TPMS/RKE/PKE

The Transmitter Test Solution

- Agilent N9320B/N9322C BSA Spectrum Analyzer
  - With option DMA: ASK/FSK demodulation metrics
  - With option PA3: 3 GHz preamp or option P07: 7 GHz preamp

The Receiver Test Solution

- Agilent 33500 Series Function/Arbitrary Waveform Generator
- Agilent 33503A BenchLink Waveform Builder Pro software
- Agilent N9310A RF Signal Generator, 9 kHz – 3 GHz
Take-away – The High Efficiency TPMS/RKE/PKE solution

A turn-key solution for you
• Transmitter Test – Use N9320B/N9322C Spectrum Analyzer
• Receiver Test – Use the MXG signal generator or the combination of 33500 series AWG and N9310A RF Signal Generator

ASK/FSK demodulation metrics in a low cost platform
• Demodulation metrics include: transmitter power, FSK deviation, ASK depth, magnitude error, and carrier frequency offset
• View in waveform, symbol, FSK error, or eye diagram

Cost-effective vector signal generation
• Easy to address the ASK/FSK signal needs for receiver test
• Easier on your budget
Low cost ASK/FSK measurement solution demo video can be viewed at on our AgilentSpecAnalyzer YouTube channel.
Any Questions?

Thank you for attending today’s webcast!

For any follow up questions, please contact Allison at allison_douglas@agilent.com