“Ensuring Robustness of Distributed Automotive Systems through Testing”
- Test To Correctness

Testing Exposition
Stuttgart, Germany
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Technical Marketing Manager
Are There Issues with Today’s Vehicles?
10,000’s of Defects are Claimed Annually

The Office of Defects Investigation (ODI) is an office within the National Highway Traffic Safety Administration (NHTSA). ODI conducts defect investigations and administers safety recalls to support the NHTSA’s mission to improve safety on our Nation’s highways. NHTSA is authorized to order manufacturers to recall and repair vehicles.


The Office of Defects Investigation cumulative databases compiled as of March 27th, 2008, list over 70,000 effective recalls and 668,660 complaints linked to road vehicles purchased in North America. The information archived in the ODI database dates back to 1949, but shows an increasing trend for complaints and recalls during that past decade.

28.75% of historical North American recalls occurred for those vehicles produced during the 1990’s, while vehicles produced during the 2000’s have already accounted for 30.50 % of recalls.
What is the Effect of Consumer Realized Problems?

Examples:

- Warranty Costs
- Poor Customer Satisfaction
- Safety Risks

Ultimately a negative impact on the success of a company.
Where Do Errors Come From?

- Design
- Variances in Design Specification Interpretation
- Software Architecture
- Communication Driver Reliability
- Software Implementation
- Hardware Implementation
- Testing
How Big is The Problem?

• According to a McKinsey study from Spring 2006 titled: “Getting Better Software into Manufactured Products”

Network communication was identified as the greatest contributing cost source when repairing defects in manufactured vehicles.
Top 3 Areas Where R&D Should Focus to Improve Automotive System Design (source: Mercer 2006)

1. Functional errors in mechatronic sub-systems
2. Errors in network communication
3. Software errors

These errors typically show up in functional test and integration test.
Why Do These Issues Go Undetected?
- Automotive Complexity

• Number of ECU’s
• Feature Content
• Sharing of Data across Networks
• Inadequate Testing Time
• Weak Tool Performance

Source: DaimlerChrysler
Consideration of the Distributed Functions Where Signals Are Utilized

1000’s of Functions exist in Vehicle Designs

<table>
<thead>
<tr>
<th>Function Type</th>
<th>Example</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Viewable</td>
<td>Lighting</td>
<td>100 ms</td>
</tr>
<tr>
<td>Human Audible</td>
<td>Locking</td>
<td>200 ms</td>
</tr>
<tr>
<td>Powertrain</td>
<td>Shifting</td>
<td>50 ms</td>
</tr>
<tr>
<td>Safety Critical</td>
<td>Airbags</td>
<td>10 ms</td>
</tr>
</tbody>
</table>
Function Interaction - Vehicle Speed Signal

Vehicle Speed
Powertrain Torque Request
Adapative Cruise Control
Infotainment System
Anti-Lock Braking System
Electronic Stability Control
Locking Functionality (Security Locking Feature)
Power Management
Are Your Signals Equipped with Navigation?
How Can We Fix the Problem?

• Through Testing Methods and Equipment
  – Scope of Testing must cover critical paths
  – Selection of Test Tools to meet Testing Needs
  – Standardization of Testing Libraries
  – Minimize Human Steps to reduce errors
  – Minimize Effort for Test Setup (across variants)
  – Automatic Identification of Issues
  – Automatic Isolation of Identified Issues

Improving control of these parameters will greatly enhance productivity and enable a higher degree of problem identification and correction… hence improving quality metrics.
Scope of Testing - Key problem areas:

Signal Integrity?
Noise Immunity?
Error Frame causes?
Are frames transmitted in accordance with specifications?
Are gateway processors maintaining schedule?
Do event sequences happen in correct order and timing?
Do vehicle functions meet timing requirements?
Why Kind of Tools Does Agilent Technologies Provide to Address These Problems?

Combining Robust Physical Layer with protocol measuring technologies delivers to a wide range of test criteria needs.

Scalable from Physical Layer Measurements to Data Link Layer Communication up to Application Layer Testing.
Agilent Automotive Tools

Scalable from Physical Layer Measurements to Data Link Layer Communication up to Application Layer Testing.

Analysis & Simulation

Protocol & Application

Analysis

Noise Injection

Physical
Agilent Offers Flexible Solutions

Web Based Tool Interfaces Enable Access anytime & anywhere

Portability – Battery Operated

Extreme Conditions - Environmental chamber probe testing up to 155 degrees C.
Measuring Robustness in Terms of Risk

The variability can be categorized in degrees of risk.

Risks Needs To Be Eliminated

<table>
<thead>
<tr>
<th>Risk Range</th>
<th>Deviation from Mean</th>
<th>Variability Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal Risk</td>
<td>&lt;5%</td>
<td>&gt;95ms</td>
</tr>
<tr>
<td>Low Risk</td>
<td>&lt;25%</td>
<td>&gt;75ms</td>
</tr>
<tr>
<td>Moderate Risk</td>
<td>&lt;35%</td>
<td>&gt;65ms</td>
</tr>
<tr>
<td>High Risk</td>
<td>&gt;=35%</td>
<td>&lt;135ms</td>
</tr>
</tbody>
</table>

Distribution of Measured Transmit Interval

Risk of Data
- Minimal
- Low
- Moderate
- High

Limits
- Lower: 64.999, 44.999, 24.999, 14.999
- Upper: 134.999, 124.999, 114.999, 104.999

Population = 50 Samples
Eliminate Risks – High Speed Hardware Decoding

1. Fast waveform/decode update rates enhance usability

2. Enhances probability of capturing and decoding infrequent errors
Eliminating errors in safety-critical automotive systems is CRITICAL!
Eliminate Risks – Identify Causes of Error Frames

Header CRC Error
Eliminate Risks – Identify Causes of Error Frames

- 60 kHz Switching Power Supply Noise
- FlexRay Decode Shows HCRC Error
Eliminate Risks - Ensuring Signal Integrity

Real-time Eye Mask Test
Signal Integrity - FlexRay Real-time Eye-Diagram

Based on Recovered Receiver Clock
Eliminate Risks - FlexRay “Stop-on-failure” Mask Test

Based on Recovered Receiver Clock

Infrequent timing violation
Eliminate Risks - FlexRay Mask “Unfolded” to 1st Violation

Based on Recovered Receiver Clock

With FlexRay protocol decoding turned on, it is discovered that random timing violation occurred during static frame ID: 6. Infrequent timing violation.
Eliminate Risks - Scope’s timebase expanded on mask violation - Based on Recovered Receiver Clock

It appeared that the 2nd pulse on-screen occurred 30 ns late and was interpreted as a "1" (LSB). Further analysis revealed that this pulse was the next BSS pulse occurring 85 ns early.
Eliminate Risks - Verification of Boundary Stability

Verify timing of slot and segment boundaries
Eliminate Risks –
Programmable Testing Stimulus

Pulse Generator
1µHz – 120 MHz pulse with variable rise/fall time
Trigger and Clock up to 120 MHz
Coupled / uncoupled channels

Function Arbitrary Generator
1µHz – 240 MHz sine
14 bit, 2 GSa/s arbitrary waveforms
FM, AM, PM, FSK, PWM up to 10 MHz modulation frequency, internally or externally

Noise Generator
Crest factor (Peak/RMS) selectable 3.1, 4.8, 6, 7
Noise type: repeatable, random and triggerable
Signal repetition >> 26 days

Unique

Patents pending
FlexRay Receiver Test

**Customer requirement:** Simulates a participant on the bus to test receivers and stress the bus in regards to timing, noise and glitches.

### FlexRay Parameters
- **Bitrate (Mbps):** 10.000000
- **Cycle Time (us):** 0.000
- **Static SLM (us):** 44

### Pulse Generator Parameters
- **Amplitude:** 54
- **Offset:** 30
- **Freq Deviation (pct):** 0
- **Trigger Source:** External
- **Delay Time:** 0.0

### Connection Details
- **Number of Frames:** 6
- **Frame Len. (Bytes):** 20
- **Initial Frame ID:** 0
- **Number of Frames:** 6
- **Number of Cycles:** 12

### Equipment Used:
- **81150A Pulse F.A.N.**
- **VPT 1000**
- **BNC**
- **MSO**
- **100 Ohm Termination**

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*Agilent Technologies*

DVS Automotive
Agilent Restricted
May, 2007
Agilent Tools Summary

**Agilent 81150A; Programmable Waveform Stimulus**
- CAN/LIN/FlexRay Stimulus; High Timing Accuracy;
- Test Communication Reliability; Inject Noise Conditions

**MSO 6000/7000; Network Decoding Mixed Signal Oscilloscopes**
- CAN/LIN/FlexRay Triggering & Real-time Decode
- Segmented Memory for Automotive Serial Applications

**VPT 1000; Network Protocol Testing/Analysis**
- CAN/FlexRay Frame and Signal Measurements
- Standalone Data Recording

Agilent provides compelling tool sets which deliver unique solutions designed to be efficiently configured and powerful enough to identify **ALL** FlexRay physical layer and protocol related issues.

Agilent provides the tools needed for ensuring networking robustness - quality
Agilent Technologies

Come by the booth and let us show you how Agilent products can help you to address your testing needs.


- **Network Analyzers:** [www.agilent.com/find/vpt1000](http://www.agilent.com/find/vpt1000)


- **Logic Analyzers:** [http://www.home.agilent.com/agilent/product.jspx?nid=-536902500.0.00&cc=US&lc=eng](http://www.home.agilent.com/agilent/product.jspx?nid=-536902500.0.00&cc=US&lc=eng)

- **DVS Automotive Product Support:** dvs-automotive_support@agilent.com

- **AiA (Customer viewable):** [www.agilent.com/find/automotive-test](http://www.agilent.com/find/automotive-test)