

# “Ensuring Robustness of Distributed Automotive Systems through Testing”

- Test To Correctness



Testing Exposition  
Stuttgart, Germany  
May 5, 2007

Cary Brown  
Agilent Technologies  
Technical Marketing Manager



# Are There Issues with Today's Vehicles?

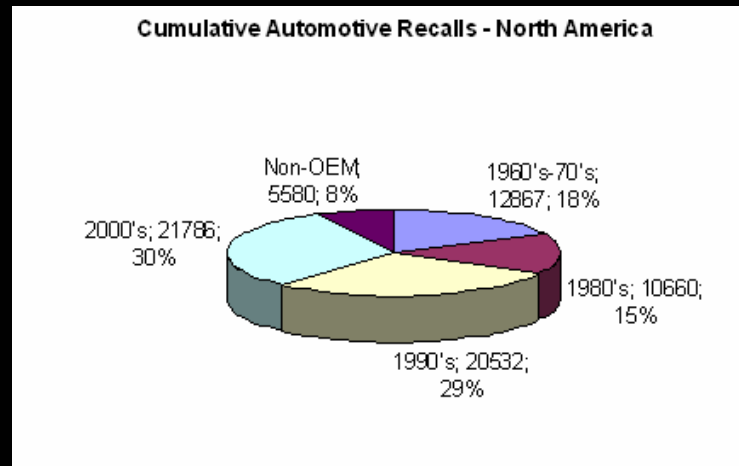


# 10,000's of Defects are Claimed Annually

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.

<http://www-odi.nhtsa.dot.gov>

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?

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

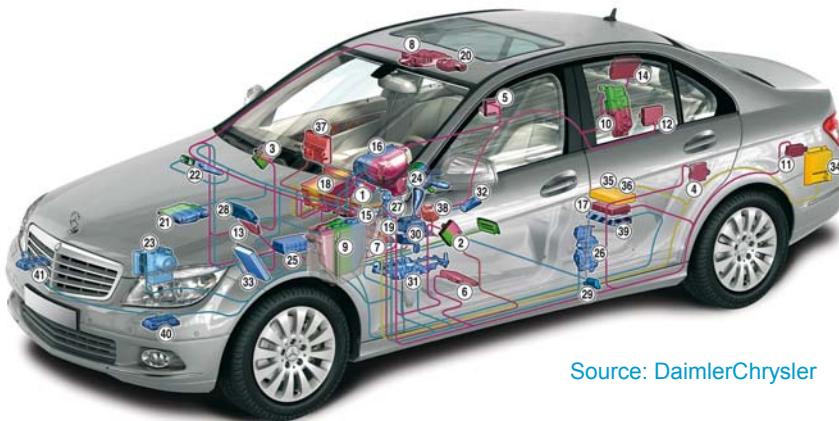
➔ These errors typically show up in functional test and integration test.



# 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

**System Komplexität**  
Beispiel: E / E System VW Tuareg



**DELPHI**

32 Kabelkanäle  
30 Tüllen  
300 CDP Komponenten  
Gehäuse: ca. 600 St  
Wickelband: ca. 320m  
Wellrohr: ca. 30m

**Kabelverlegung**

Leitungen: 1200 - 1500  
Kontakte: 1600 bis 2000  
Leitungslänge max.: 2800 m  
Gewicht: 60 - 70 kg



**DELPHI**





# Consideration of the Distributed Functions Where Signals Are Utilized

1000's of Functions exist in Vehicle Designs



<u>Function Type</u>	<u>Example</u>	<u>Timing</u>
Human Viewable	Lighting	100 ms
Human Audible	Locking	200 ms
Powertrain	Shifting	50 ms
Safety Critical	Airbags	10 ms

# Function Interaction - Vehicle Speed Signal

Powertrain Torque Request

Adaptive Cruise Control

Infotainment System

Anti-Lock Braking System

Electronic Stability Control

Locking Functionality (Security Locking Feature)

Power Management





**In Vehicle Complexities**

**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

The screenshot displays a software interface for data analysis. On the left, a 'Risk of Data' legend indicates three levels: Minimal (green), Low (yellow), and High (red). The main area contains a table titled 'Distribution of Measured Transmit Interval' with columns for time intervals and corresponding data counts. A circular gauge labeled 'VCT' is overlaid on the table. To the right, a physical device with multiple ports is shown.

Interval	Count	Risk
[7.04]	100	Minimal
[5.04]	200	Low
[5.04]	300	Low
[5.04]	400	Low
[5.04]	500	Low
[5.04]	600	Low
[5.04]	700	Low
[5.04]	800	Low
[5.04]	900	Low
[5.04]	1000	Low
[5.04]	1100	Low
[5.04]	1200	Low
[5.04]	1300	Low
[5.04]	1400	Low
[5.04]	1500	Low
[5.04]	1600	Low
[5.04]	1700	Low
[5.04]	1800	Low
[5.04]	1900	Low
[5.04]	2000	Low
[5.04]	2100	Low
[5.04]	2200	Low
[5.04]	2300	Low
[5.04]	2400	Low
[5.04]	2500	Low
[5.04]	2600	Low
[5.04]	2700	Low
[5.04]	2800	Low
[5.04]	2900	Low
[5.04]	3000	Low
[5.04]	3100	Low
[5.04]	3200	Low
[5.04]	3300	Low
[5.04]	3400	Low
[5.04]	3500	Low
[5.04]	3600	Low
[5.04]	3700	Low
[5.04]	3800	Low
[5.04]	3900	Low
[5.04]	4000	Low
[5.04]	4100	Low
[5.04]	4200	Low
[5.04]	4300	Low
[5.04]	4400	Low
[5.04]	4500	Low
[5.04]	4600	Low
[5.04]	4700	Low
[5.04]	4800	Low
[5.04]	4900	Low
[5.04]	5000	Low
[5.04]	5100	Low
[5.04]	5200	Low
[5.04]	5300	Low
[5.04]	5400	Low
[5.04]	5500	Low
[5.04]	5600	Low
[5.04]	5700	Low
[5.04]	5800	Low
[5.04]	5900	Low
[5.04]	6000	Low
[5.04]	6100	Low
[5.04]	6200	Low
[5.04]	6300	Low
[5.04]	6400	Low
[5.04]	6500	Low
[5.04]	6600	Low
[5.04]	6700	Low
[5.04]	6800	Low
[5.04]	6900	Low
[5.04]	7000	Low
[5.04]	7100	Low
[5.04]	7200	Low
[5.04]	7300	Low
[5.04]	7400	Low
[5.04]	7500	Low
[5.04]	7600	Low
[5.04]	7700	Low
[5.04]	7800	Low
[5.04]	7900	Low
[5.04]	8000	Low
[5.04]	8100	Low
[5.04]	8200	Low
[5.04]	8300	Low
[5.04]	8400	Low
[5.04]	8500	Low
[5.04]	8600	Low
[5.04]	8700	Low
[5.04]	8800	Low
[5.04]	8900	Low
[5.04]	9000	Low
[5.04]	9100	Low
[5.04]	9200	Low
[5.04]	9300	Low
[5.04]	9400	Low
[5.04]	9500	Low
[5.04]	9600	Low
[5.04]	9700	Low
[5.04]	9800	Low
[5.04]	9900	Low
[5.04]	10000	Low

**Analysis**

**Noise Injection**

Physical

The image shows two pieces of Agilent automotive testing equipment. On the left is an oscilloscope displaying a waveform on its screen. On the right is a noise injection device, which is a rectangular unit with various ports and a control panel.

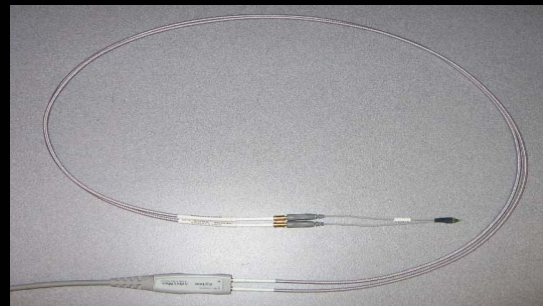
# Agilent Offers Flexible Solutions



Web Based Tool Interfaces Enable  
Access anytime & anywhere

Portability – Battery Operated

Extreme Conditions -  
Environmental  
chamber probe testing  
up to 155 degrees C.

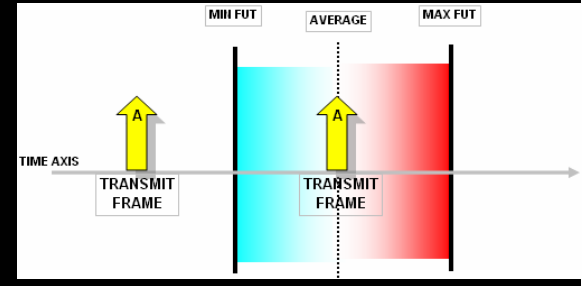




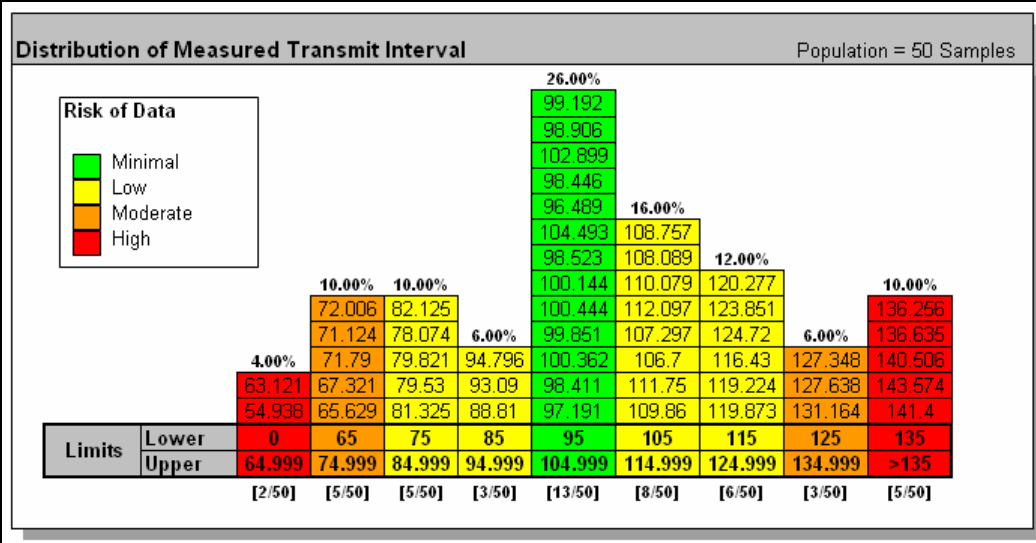
# Measuring Robustness in Terms of Risk

The variability can be categorized in degrees of risk.

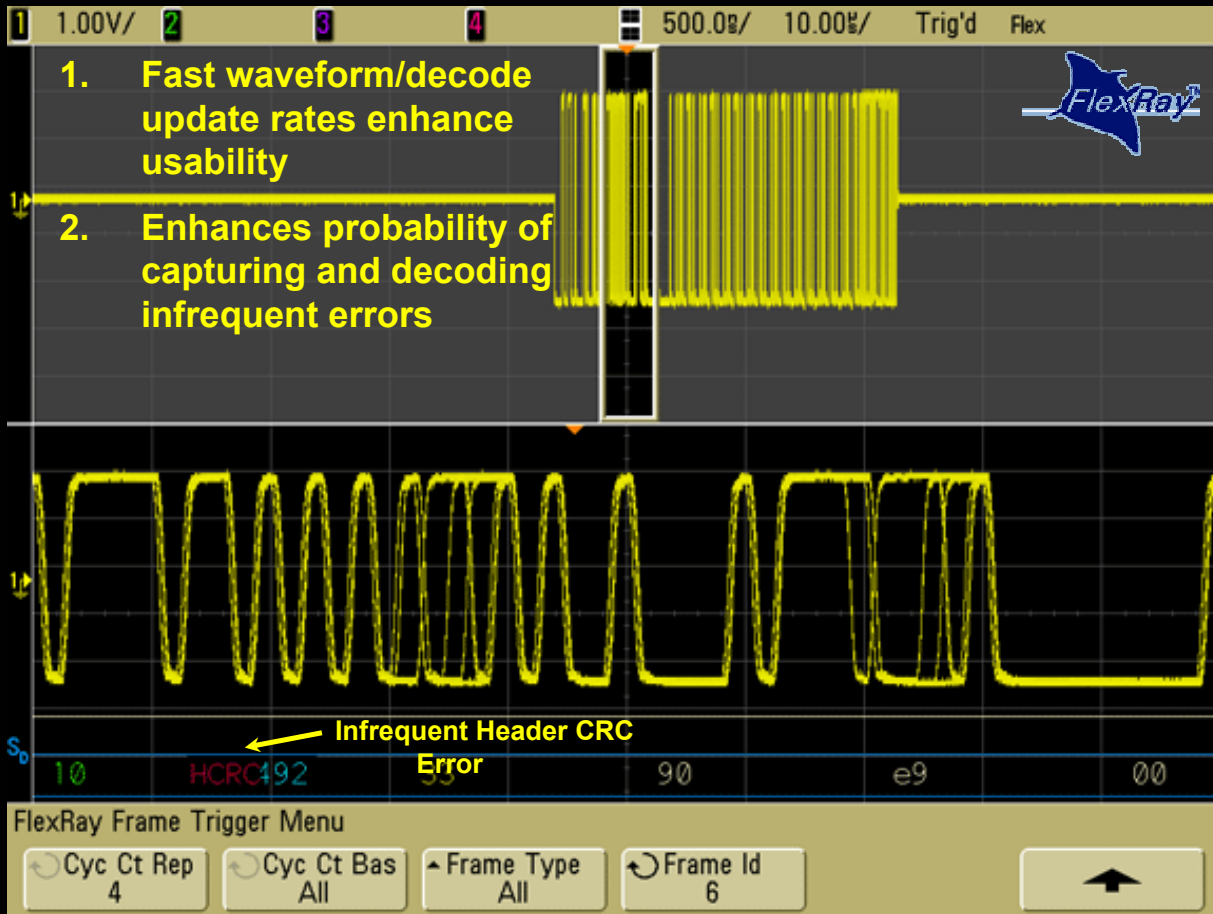
## Risks Needs To Be Eliminated



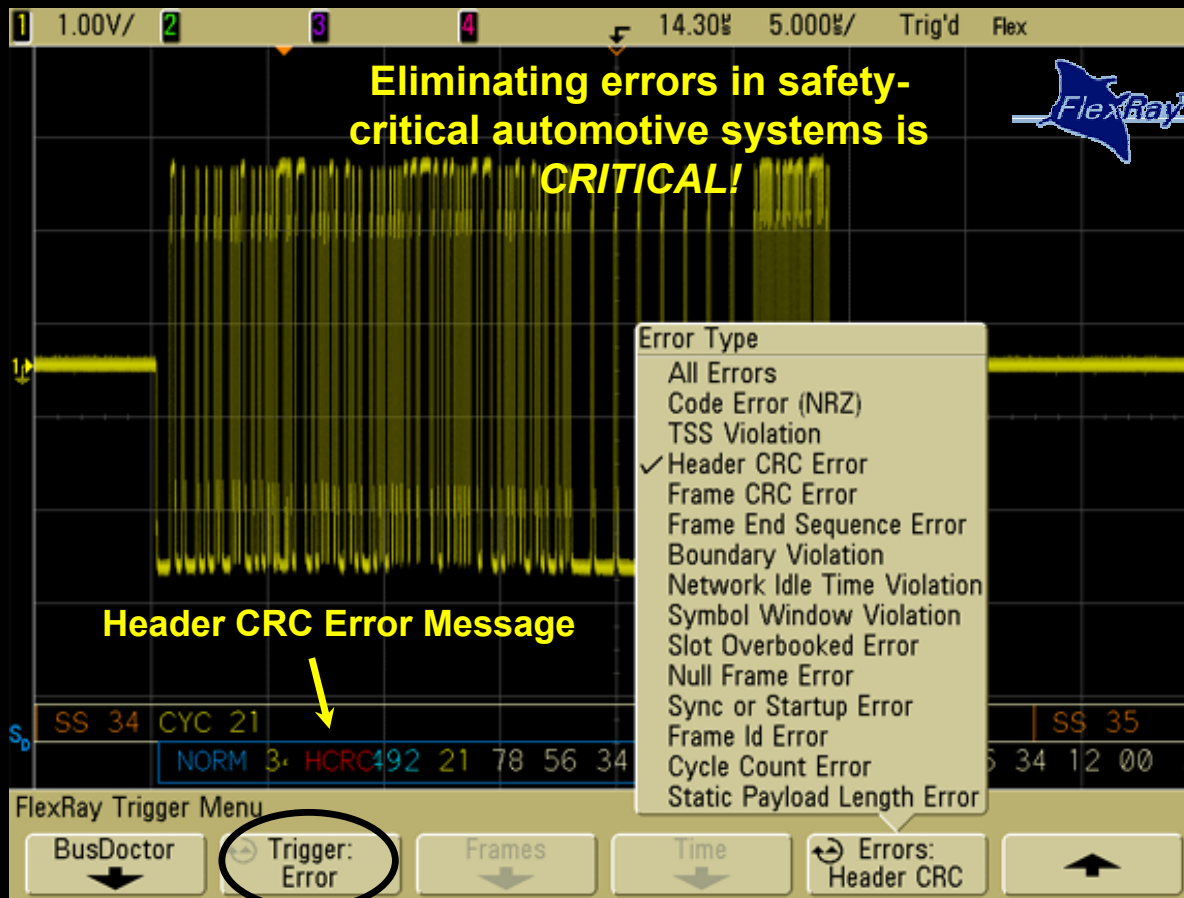
Risk Range	Deviation from Mean	Variability Limits	
		Min	Max
Minimal Risk	<5%	>95ms	<105ms
Low Risk	<25%	>75ms	<125ms
Moderate Risk	< 35%	>65ms	<135ms
High Risk	>=35%		



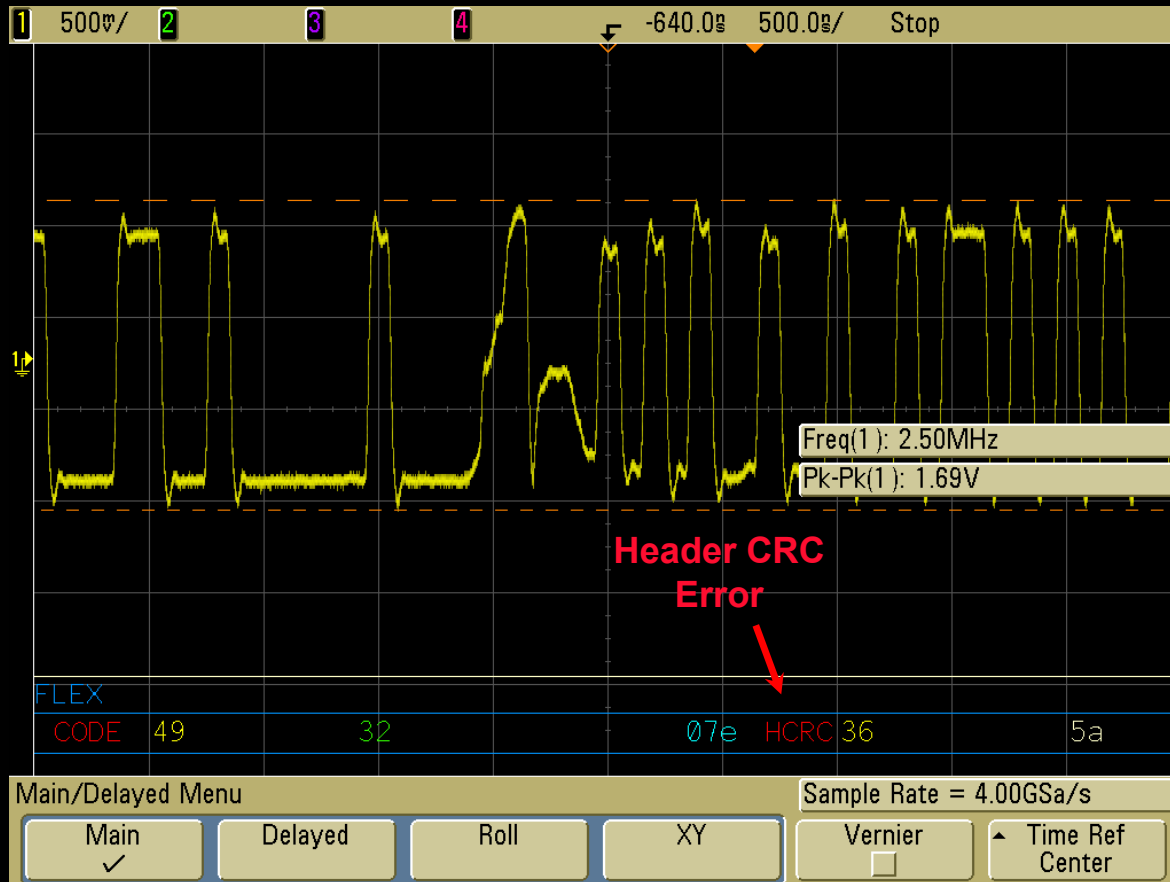
# Eliminate Risks – High Speed Hardware Decoding



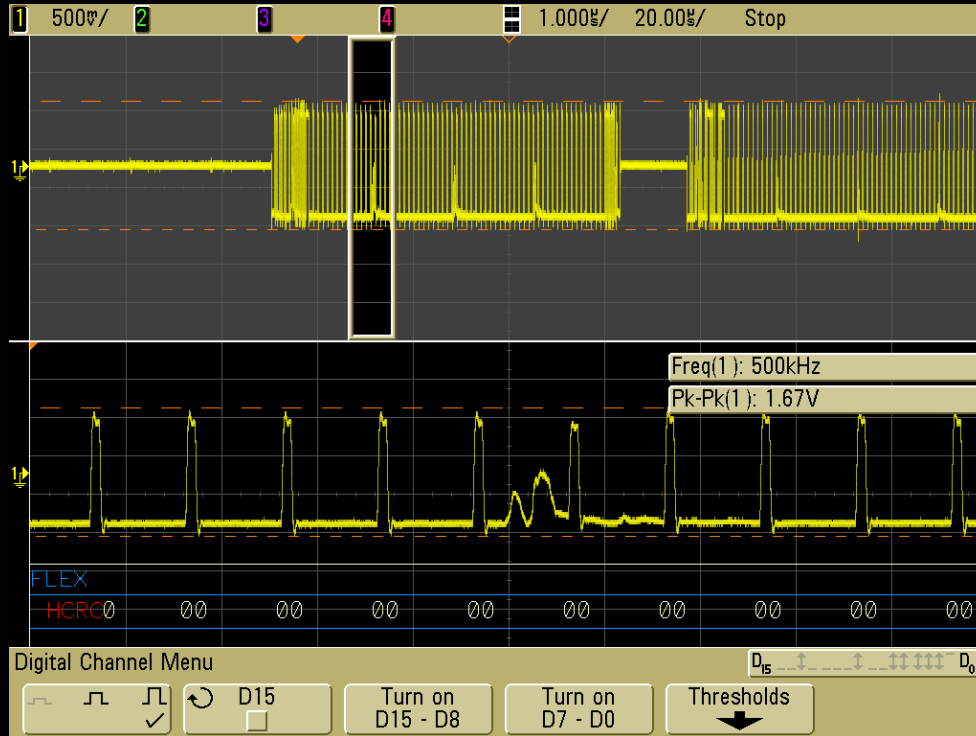
# Eliminate Risks – Robust Error Analysis



# Eliminate Risks – Identify Causes of Error Frames



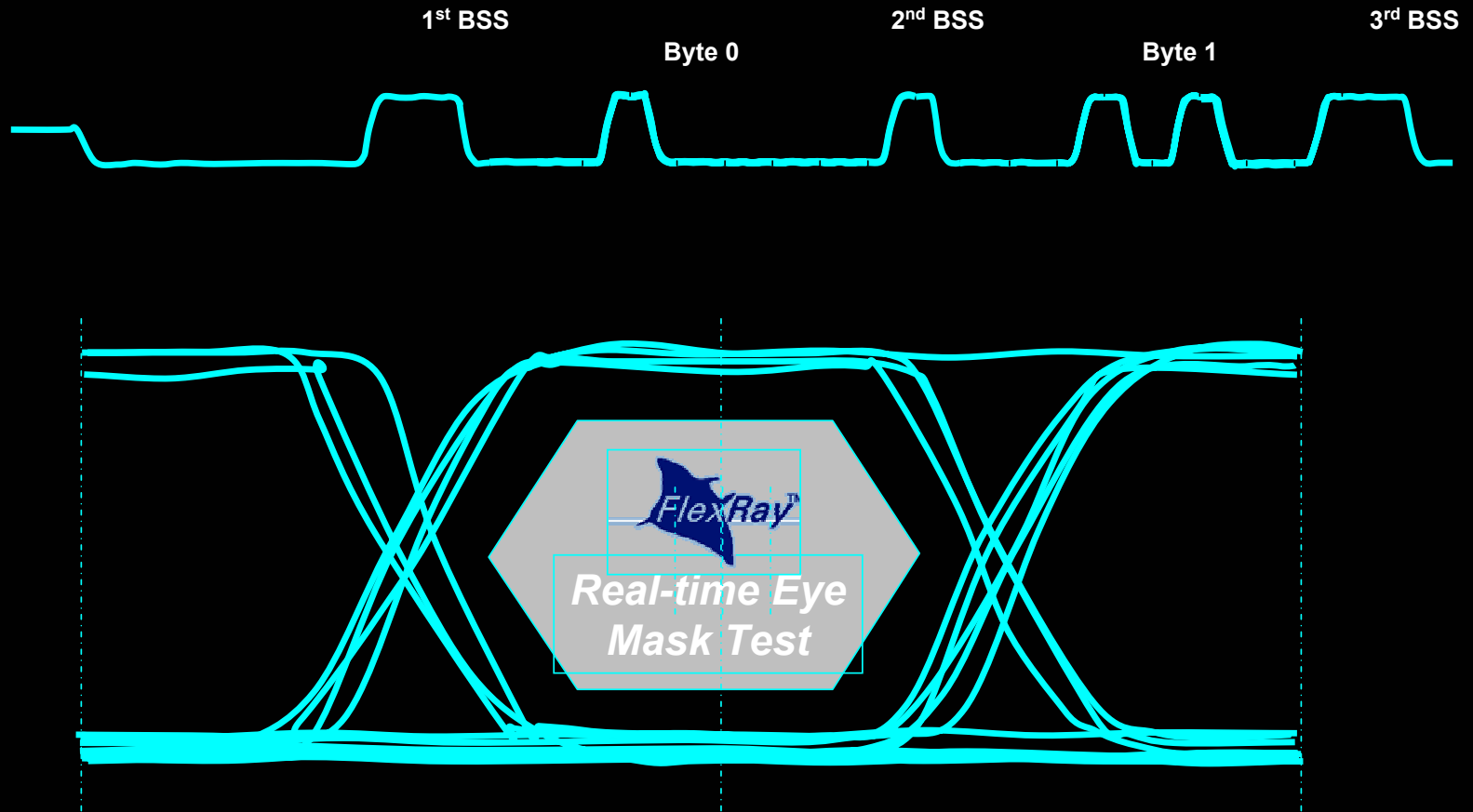
# Eliminate Risks – Identify Causes of Error Frames



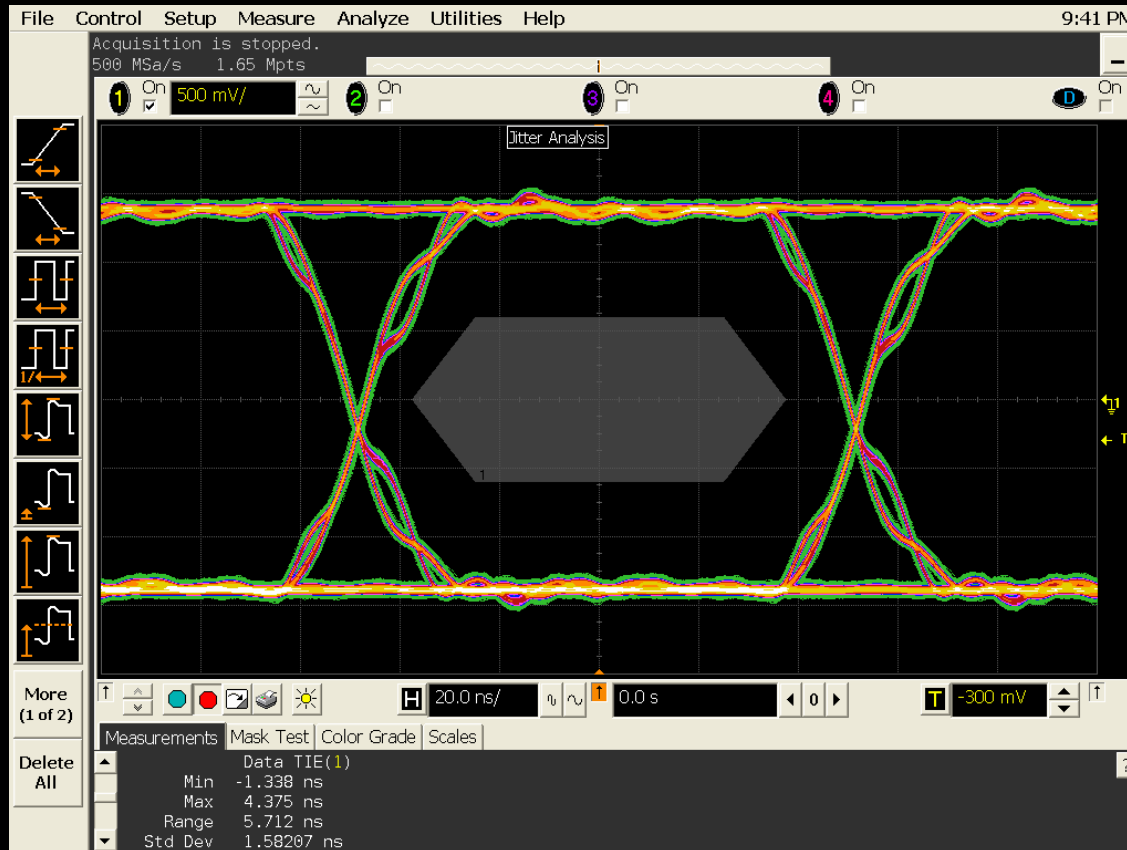
60 kHz Switching  
Power Supply  
Noise

FlexRay Decode  
Shows HCRC  
Error

# Eliminate Risks - Ensuring Signal Integrity

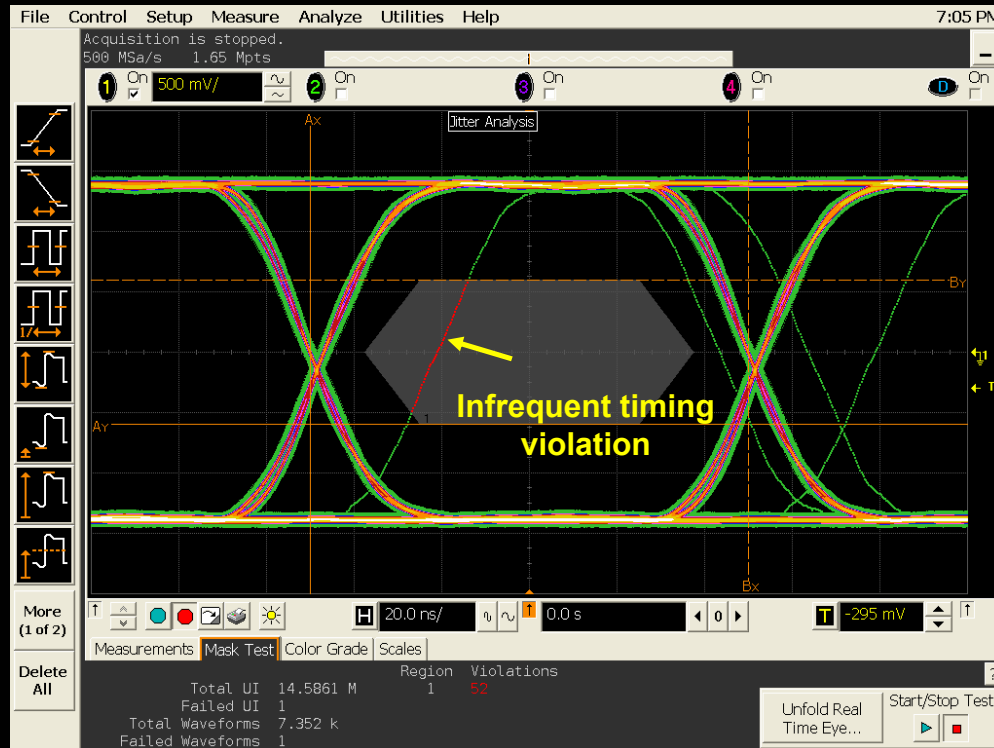


# Signal Integrity - FlexRay Real-time Eye-Diagram Based on Recovered Receiver Clock



# Eliminate Risks - FlexRay "Stop-on-failure" Mask Test

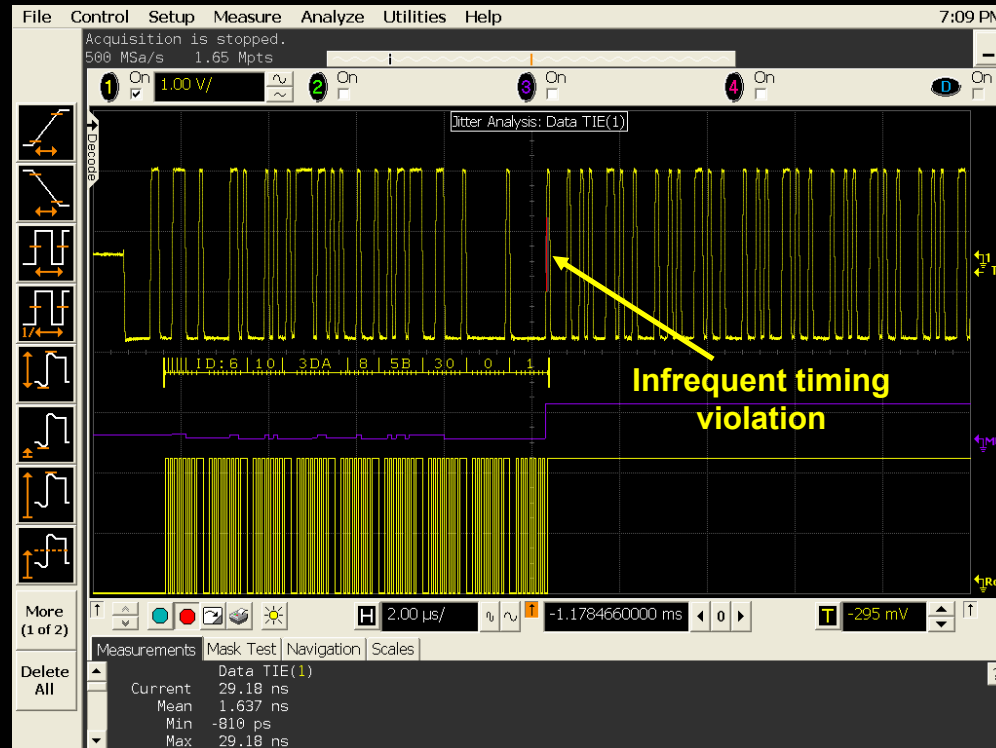
## Based on Recovered Receiver Clock



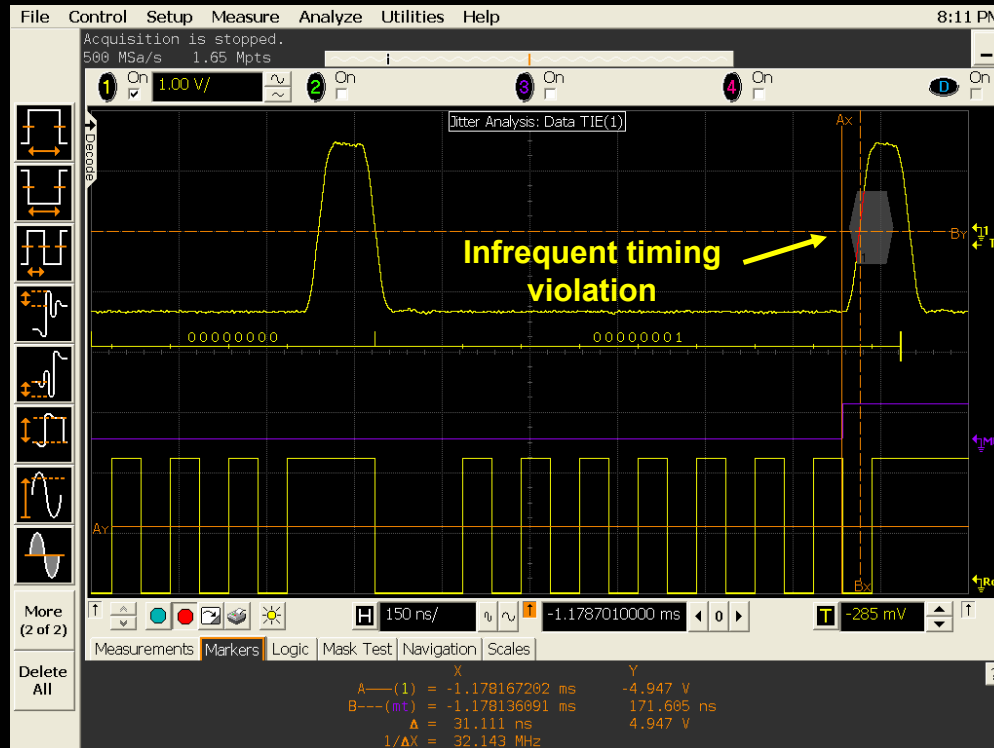


# Eliminate Risks - FlexRay Mask "Unfolded" to 1st Violation

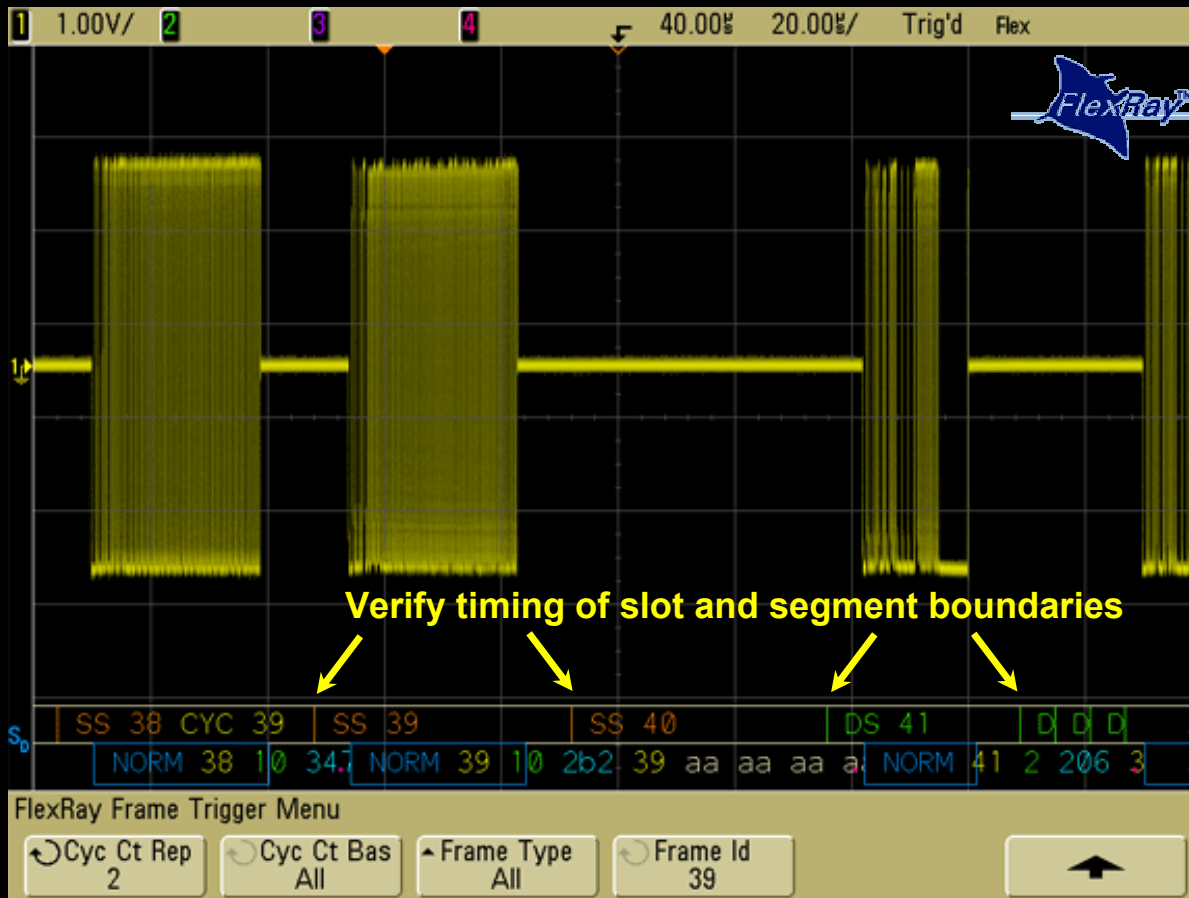
## Based on Recovered Receiver Clock



# Eliminate Risks - Scope's timebase expanded on mask violation *Based on Recovered Receiver Clock*



# Eliminate Risks - Verification of Boundary Stability



# Eliminate Risks – Programmable Testing Stimulus



## Pulse Generator

1 $\mu$ Hz – 120 MHz pulse with variable rise/fall time  
Trigger and Clock up to 120 MHz  
Coupled / *uncoupled* channels

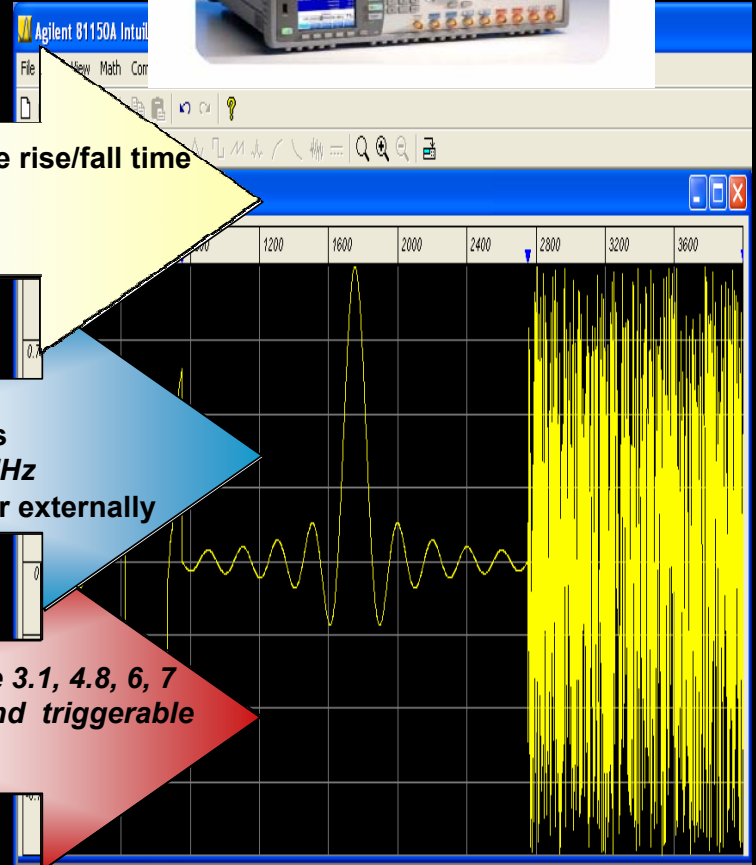
## Function Arbitrary Generator

1 $\mu$ Hz – 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

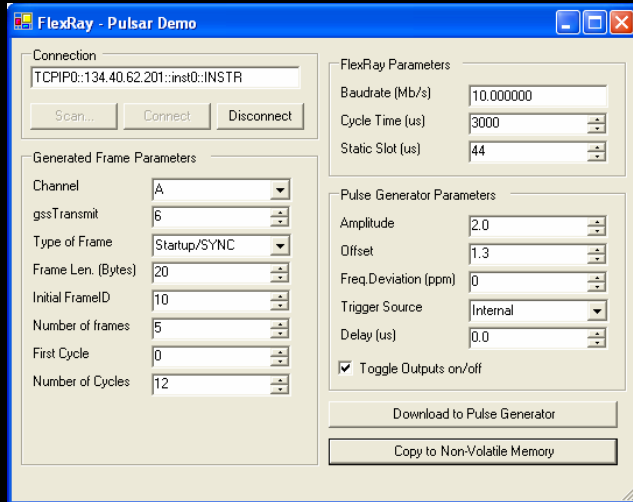
Unique

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



# 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.



MSO



81150A Pulse F.A.N.



BNC

DB9 Connector

100 Ohm Termination



# 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.

- **Oscilloscopes:** <http://www.home.agilent.com/agilent/product.jsp?nid=-34750.0.00&cc=US&lc=eng>
- **Network Analyzers:** [www.agilent.com/find/vpt1000](http://www.agilent.com/find/vpt1000)
- **Pulse Generators:**  
<http://www.home.agilent.com/agilent/product.jsp?cc=US&lc=eng&pageMode=OV&pid=1287544&ct=PRODUCT&id=1287544>
- **Logic Analyzers:** <http://www.home.agilent.com/agilent/product.jsp?nid=-536902500.0.00&cc=US&lc=eng>
- **DVS Automotive Product Support:**  
[dvs-automotive\\_support@agilent.com](mailto:dvs-automotive_support@agilent.com)
- **AiA (Customer viewable):**  
[www.agilent.com/find/automotive-test](http://www.agilent.com/find/automotive-test)



# Q & A

