Automotive Functional Test

by
Bob Stasonis
Marketing Manager
GenRad, Inc.

Category:
Automotive

Products Used:
MXI-3
LabWindows™/CVI
TestStand™
4060 DMM
PXI™-6030E Multifunction I/O
NI 6602 Counter/Timer
NI 5411 Arbitrary Waveform Generator
NI 5112 Oscilloscope
NI 6040E MIO
NI 6533 32 pin Dynamic Dig I/O

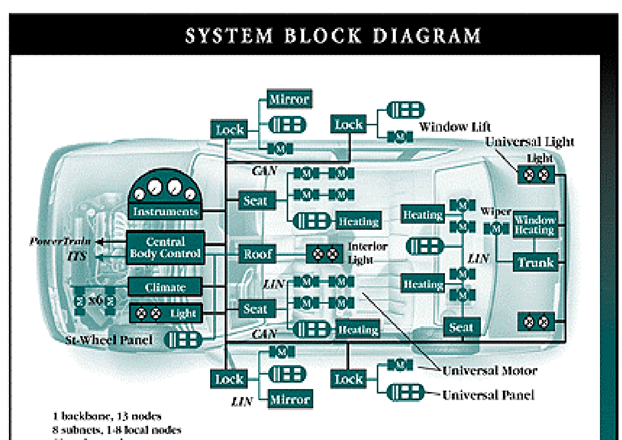
The Challenge:
Understand the global testing problems faced by the Automotive industry. Create a family of low-cost functional test systems that addresses present and future test and technology issues for this industry.

The Solution:
Design a new chassis and switching/scanning subsystem to address the industry testing challenges. Partner with National Instruments and utilize their software and hardware tools to create vertical test solutions.

Abstract
ECU's (Electronic Control Units) in automobiles make the engine burn less fuel, and keep the environment clean. It entertains you, protects you in an accident, and even guides you to your destination.

This paper will give an overview of many of the present and future technology drivers and how they affect test. It will discuss loading requirements, networking, and other important parameters necessary for functional ATE. We will also look at the NI Instruments and software that GenRad selected, as well as the reasons why GenRad designed a 21-slot chassis and 6U form/factor for it's switching and signal conditioning.

Test Issues
When GenRad decided to address the production test requirements of the Automotive industry, we partnered with National Instruments to create our GR Versa family. In order to configure Versa properly, we first needed to fully understand the technology. Here is some of the technology that challenge test.



Courtesy of Motorola

Figure 1

For over 40 years, automobiles have operated on the 12-volt standard. However, there are now more electrical requirements than when this standard was set. The problem is that at 12 volts, currents are quite high. - up to 60 Amps for a single circuit!!!

This is why the automotive industry is migrating to a 42-volt system. Smaller wire sizes, less thermal stress on connectors, etc. are all benefits.

Lighting has its issues. As the voltage increases, you have to make the filament thinner and longer to increase the resistance, which can be damaged by vibration.

That is why the automotive industry is looking to pulse width modulation, or PWM. This technology provides an AC signal that will average out to 12 volts.

The electronics in your car is communicating via one or more serial network standards. The PWM module I mentioned can determine if a light bulb burns out. and notify the dashboard to alert the driver. In addition, the anti-lock brakes are running self test, the engine emission system is monitoring sensors, and your climate control is working to ensure that you are comfortable. Figure 1 gives you an example of the complexity of this architecture.

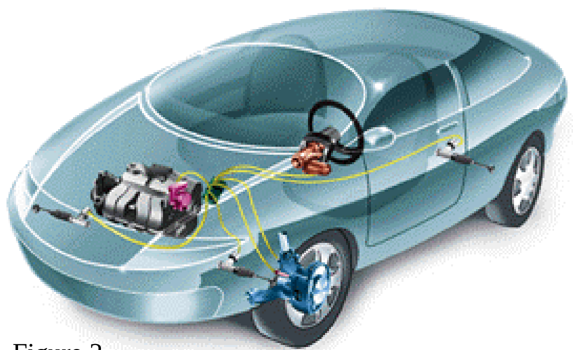


Figure 2

Delphi Automotive X-By-Wire

Automobile manufacturers are developing systems that will steer and stop your vehicle electronically. As seen in Figure 2, "Drive/Steer by Wire" will provide reduced weight, better control in adverse conditions, and lower vehicle costs.

Other technology issues include:

- A PC providing Internet surfing, voice recognition for the cellular phone, and control of multimedia and GPS.
- Passive Remote keyless entry systems that sense the transponder in your pocket and sets up the car the way you like it - mirrors, seat, climate control, CD/radio.
- A fiber-optic network for routing video and games to seat backs and music to the appropriate headsets.
- Cruise Control that works with radar to maintain vehicle speed and the appropriate distance from adjacent cars for safety.
- Enhanced infrared night vision projecting the findings on a heads up display.

Technologies	Engine Management Unit	Electric Power Steering	ABS Module	Body Controller	Transmission Controller	Air Bag Control	Keyless Entry	Interactive Cruise Control
Parameters								
I/O Count	60 - 130	25	10	80	25	25	10	NA
Analog % of I/O	80%	90%	100%	50%	10%	90%	90%	80%
Voltage Range	400 VAC	15VDC	200 VAC	15 VDC	15 VDC	200 VAC	15 VDC	15 VDC
Frequency Range	50 KHz	NA	20 KHz	DC	10 KHZ	DC	350 - 450 MHz	8 GHz
Current Range (Type of Load)	50 AMP (Fuel Injectors) 10 AMP (Ignition Coil)	60 AMP (Power Steering Pump)	30 AMP (Brake Pump)	20 AMP (Window Motor)	20 AMP (Transmission Solenoid)	20 AMP (Squib Firing - Maximum Force)	10 AMP (Lock Solenoid)	10 AMP (Throttle Control Motor)
Max Peak Current (Time)	100 Micro S	5 S	1 S	10 S	1 S	100 Ms	500 Ms	3 S
Number of High Current Nodes	12	1	2	10	8	2	3	1
Average Current	10 AMP	20 AMP	2 AMP	2 AMP	2 AMP	500 Ma	5 AMP	5 AMP
Networked	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 1

How Do We Test This Technology?
Let's look at how Automotive test has to evolve to address these challenges.

Concurrency has to do with the ability to make multiple measurements in parallel. This is important for several reasons:

- ECUs takes longer to test when you can only make one measurement at a time.
- Asynchronous functions
- Palletized ECUs in manufacturing.
- The increased popularity of in-line testing

For concurrency in testing, ATE needs a software environment that supports multiple threads, each controlling one particular stimulus or measurement of one or more ECUs. Also, local instrument intelligence, which can be defined as having the capability to work independently of other instruments with minimal CPU bandwidth, can play a role in concurrent testing. When a test is captured or signals generated, the instrument would send the test status and relevant data to the CPU.

As with any new technology, the test requirements for ECUs are expanding. Looking at Table 1, you can see average test requirements for the major ECUs. A functional test platform has to test these ECUs and be expandable to support future technology.

For network test, the issues are the number of channels and their respective protocols. Complex ECUs have multiple network channels. A central ECU might communicate with the engine control, ABS brakes, and transmission. And if you are testing ECUs in a panelized format, you have to either switch your tester's network channels between UUTs or have instrumentation that supports all of the channels required.

As an automobile is very electro-mechanical, there will always be motor or solenoid simulation. Window motors, power locks, fuel injectors, etc. – these loads need to be incorporated or emulated in the test system.

System load problems depend upon the ECU being tested. For example, Engine Management Units have to fire fuel injectors and spark coils. Most injectors have a high inrush current – in some cases, up to 50 AMPS. Spark coils are lower in current, but tend to exhibit very high back EMF signals during the firing cycle. Design of load circuits must take into account these parameters, reliability of the tester, and operator safety. It may be required to characterize the waveform across these loads during test.

What is Missing?
After looking at all of these requirements, we then started to define the technology required. Below are the decisions we made to address this market.

In order to handle the large number of measurements for panelized, high volume ECUs, we needed more than the seven instrument slots available in the standard National Instruments PXI chassis. So we designed a 21-slot chassis, which appears to address many of the worst-case scenarios we could come up with.

While the 3U size is ideal for instrumentation, we found that we needed to move to the 6U size devices for switching and signal conditioning. GenRad designed their switching modules, which are called PXIscan, in what we call a "6U Plus" dimension. As seen in Figure 3, we designed our switching and signal conditioning to be approximately 3 times the size of 3U PXI cards – almost 80 square inches. This allows for maximum use of system slots for a compact test system. It should be noted that SCXI was considered. However, our design allowed for a smaller system footprint, which was necessary for an automated environment. Cabling was also reduced in terms of lengths and complexity.

We also designed a module for testing automotive networks in a 6U format. This size gave us the real estate to put enough channels on a single module to address most test requirements.

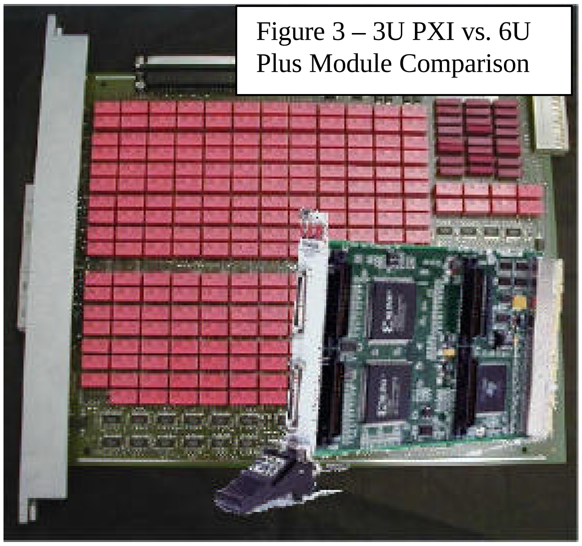


Figure 3 – 3U PXI vs. 6U Plus Module Comparison

Tester Configuration
Below is a sample configuration that addressed a broad set of requirements for Automotive testing. Figure 4 shows a sample system.

<u>GenRad Content</u>
Chassis
PXIscan Controller Module & Software
64 x 4 Differential Scanner
Signal Conditioning Card
Quad Amplifier Card
Hi-Current Scanner
Automotive Network Module
Breadboard Module

<u>National Instruments Content</u>
MXI-3 Controller
NI LabWindows CVI
NI TestStand
NI 4060 DMM
PXI-6030E Multifunction I/O
NI 6602 Counter/Timer
NI 5411 Arbitrary Waveform Generator
NI 5112 Oscilloscope
NI 6040E MIO
NI 6533 32 pin Dynamic Dig I/O

This configuration supports a broad range of requirements from Anti-lock brakes to Engine Management Units. Additional hardware and an application is necessary to complete the system. System integrators are finding that this allows them to concentrate more on their areas of expertise – application development and total integration into their customer's facility.

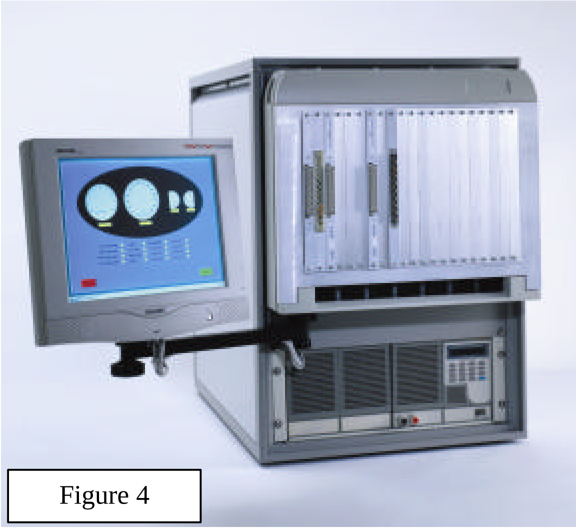


Figure 4

Conclusion
GenRad's assessment of the Automotive industry, their 85-year history in test, and National Instruments' extensive software and hardware tools, have made GR Versa a very successful product. GenRad will continue to evolve this product family, with National Instruments help, to address other industries as well.

References

1. LIN Technology for Automotive – Copyright 2000 by Motorola Inc.
2. Electronics Growth will Drive New Auto Industry – Michael Heidingsfelder, RolandBerger NA – 4/14/2000
3. A Vision of the Future of Automotive Electronics – Daniel K. Ward & Harold L. Fields – Delphi Delco Electronics – Intelligent Vehicle Systems (SAE SP-1538)
4. Automotive testing Requirements – Harry Watt – GenRad, Inc. – 1998
5. Automakers Press for Low-Speed LIN Network – Test & Measurement Online – 3/23/2000