

Keysight Technologies

TS-5400 High Performance PXI Functional Test System with Mac Panel Interface

Data Sheet



Introduction

Test Engineering Challenges

For automotive electronics manufacturers, industry-wide automotive trends are driving the need to improve test systems to address the growing complexity of automotive electronics and increasing volume demands:

- Environment: Increasingly tighter worldwide government regulations regarding vehicle emissions are driving automotive manufacturers to achieve zero emissions.
- Affordable cars: The introduction of more complex electronics into entry level cars with lower price points is resulting in higher market demand and volume for automotive electronics.
- Quality: To reduce expensive vehicle recalls, automotive manufacturers and their suppliers are pursuing more comprehensive test coverage strategies to achieve zero-defect goals.

With the introduction of more affordable cars into regions with high populations, automotive electronics manufacturing volumes are increasing.

The confluence of these trends presents new challenges to automotive electronics manufacturers. They are faced with limited resources for capital equipment, finite factory floor space, and the push to reduce labor. So how do manufacturers improve test yields, maintain good test coverage for devices under test (DUT) that have increasing complexity and pin counts, and meet management goals for reducing the cost of test? In short, how do automotive electronics manufacturers balance their goals with three conflicting areas of cost, time, and scope of test (see Figure 1)?

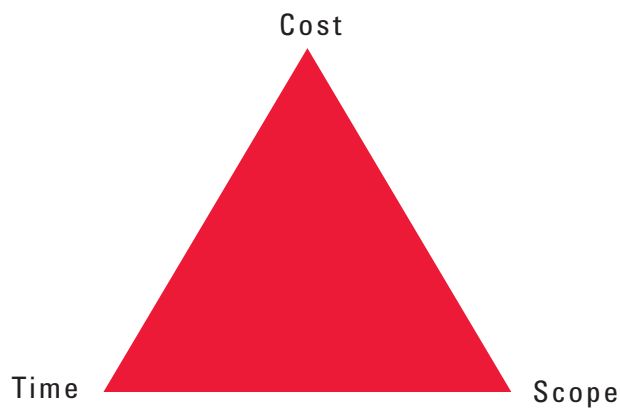


Figure 1. The balancing challenge

The Keysight Solution

The Keysight Technologies, Inc. TS-5400 PXI Series automotive functional test system solves this dilemma by providing manufacturers with a global, PXI-based, standard platform that supports up to 464 test nodes, giving manufacturers the ability to test single or multiple DUTs simultaneously (see Figure 2). With this new configuration, customers are able to achieve a net throughput improvement of 30 percent compared to the earlier TS-5400 VXI-based platform.

With significant throughput increases, manufacturers can also achieve lean manufacturing goals by reducing the number of testers, production operators, and floor space requirements (see Figure 3).

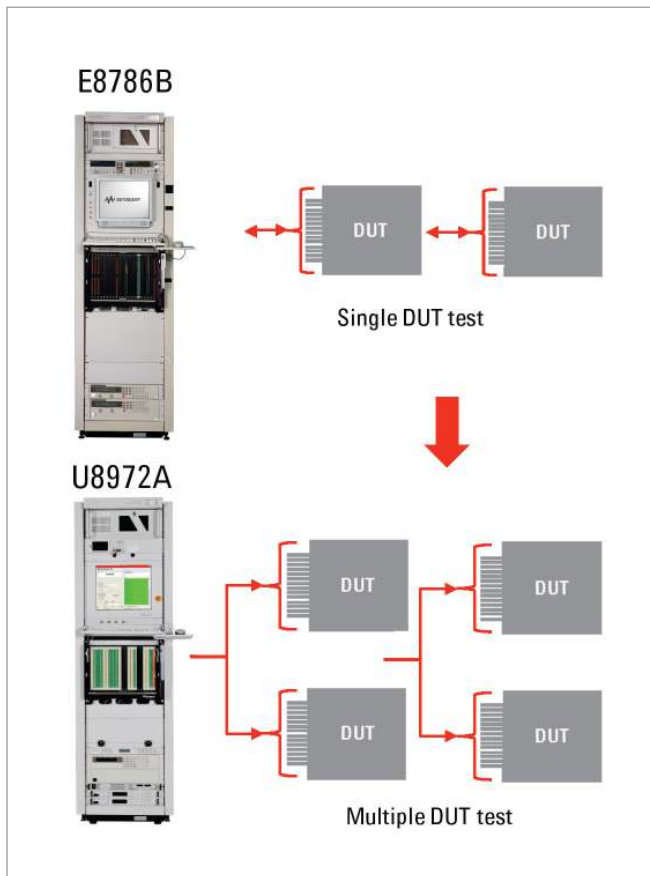


Figure 2. Multiple DUT throughput improvements using TS-5400 Series test system featuring U8972A.

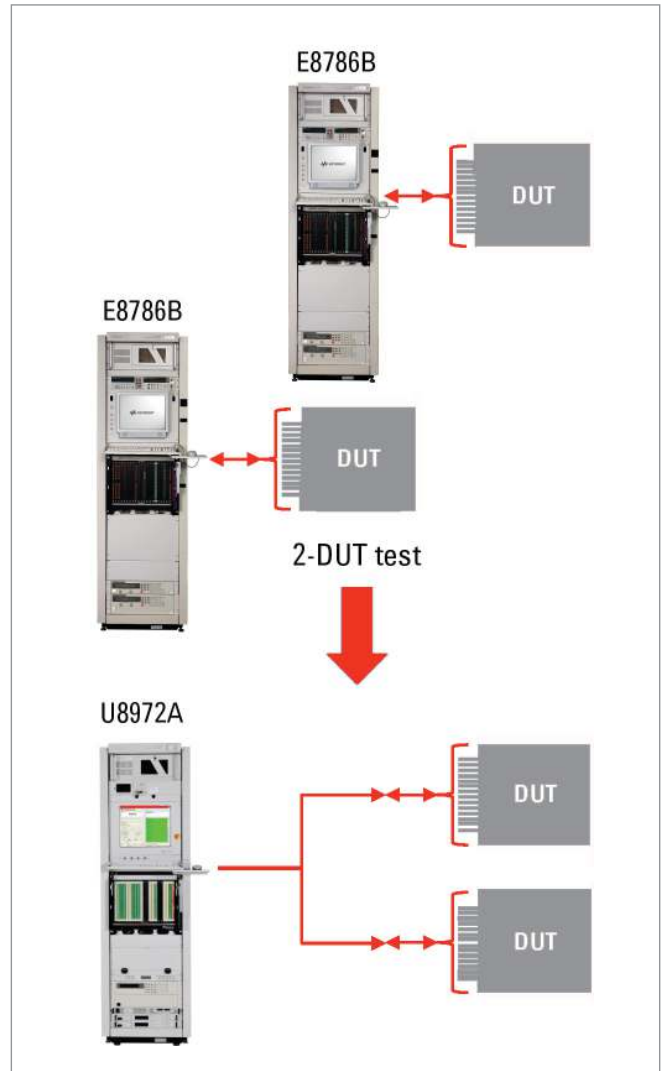


Figure 3. Reduction in floor space and labor via improved throughput per TS-5400 PXI functional test system.

With a built-in thermal and airflow management system, the lifespan of the Keysight TS-5400 PXI Series functional test system is extended, improving the manufacturer's return on invested capital via more efficient testing (see Figures 4 and 5).

The improved user accessibility and ergonomics of the PXI instrument access panel (Figure 4, item 4), PXI mainframe mounting kit (Figure 4, item 5) and power distribution module (Figure 4, item 6) simplifies the test engineers' user experience and shortens the time needed for them to make system configuration changes and provide support .

Four base platforms test the range of automotive ECMs. From simple ECMs like climate control, immobilizers, and remote-keyless entry (RKE), to safety ECMs like airbag and ABS/TC, and complex ECMs like engine management systems, the TS-5400 PXI Series provides the price and performance required.

These platforms are tuned for functional test of automotive electronics and consist of measurement resources, switching, a test executive, and automotive-tuned library routines. Racking, cabling, and optional fixturing are included, as well as standard software development tools, which enable test engineers to deploy test systems up to **three times faster** than building test systems from individual components.

Just Enough Test

With the growth in convenience and safety ECMs, test engineering needs to meet production throughput goals while maintaining a competitive cost of test for today's market and in the future. The unique architecture of the TS-5400 PXI Series lets you purchase "just enough test" resources to meet current ECM test requirements, and allows you to add test capabilities to the system when new ECMs move into production.

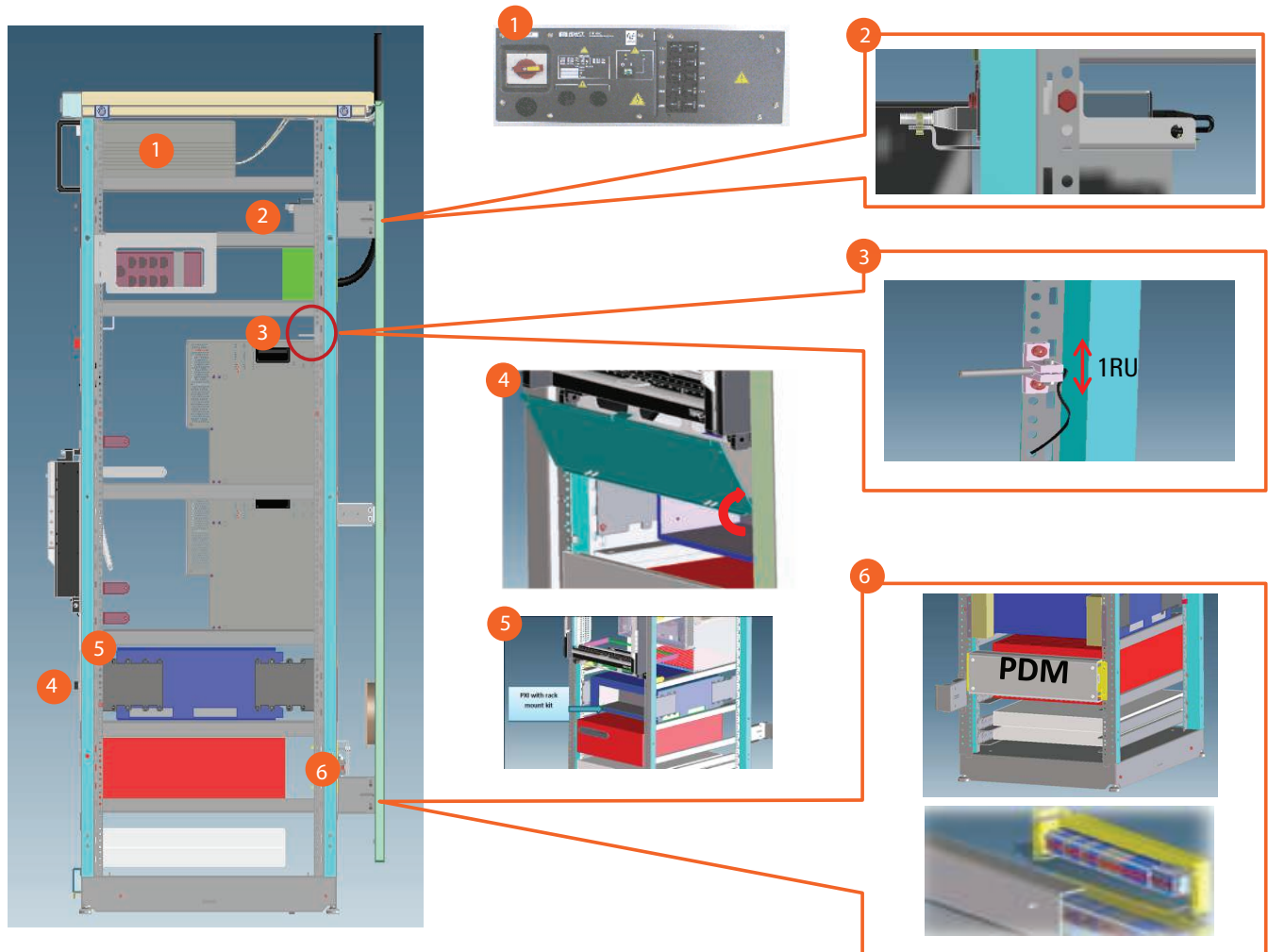


Figure 4. Feature enhancements to the TS-5400, improving system reliability and user ergonomics.

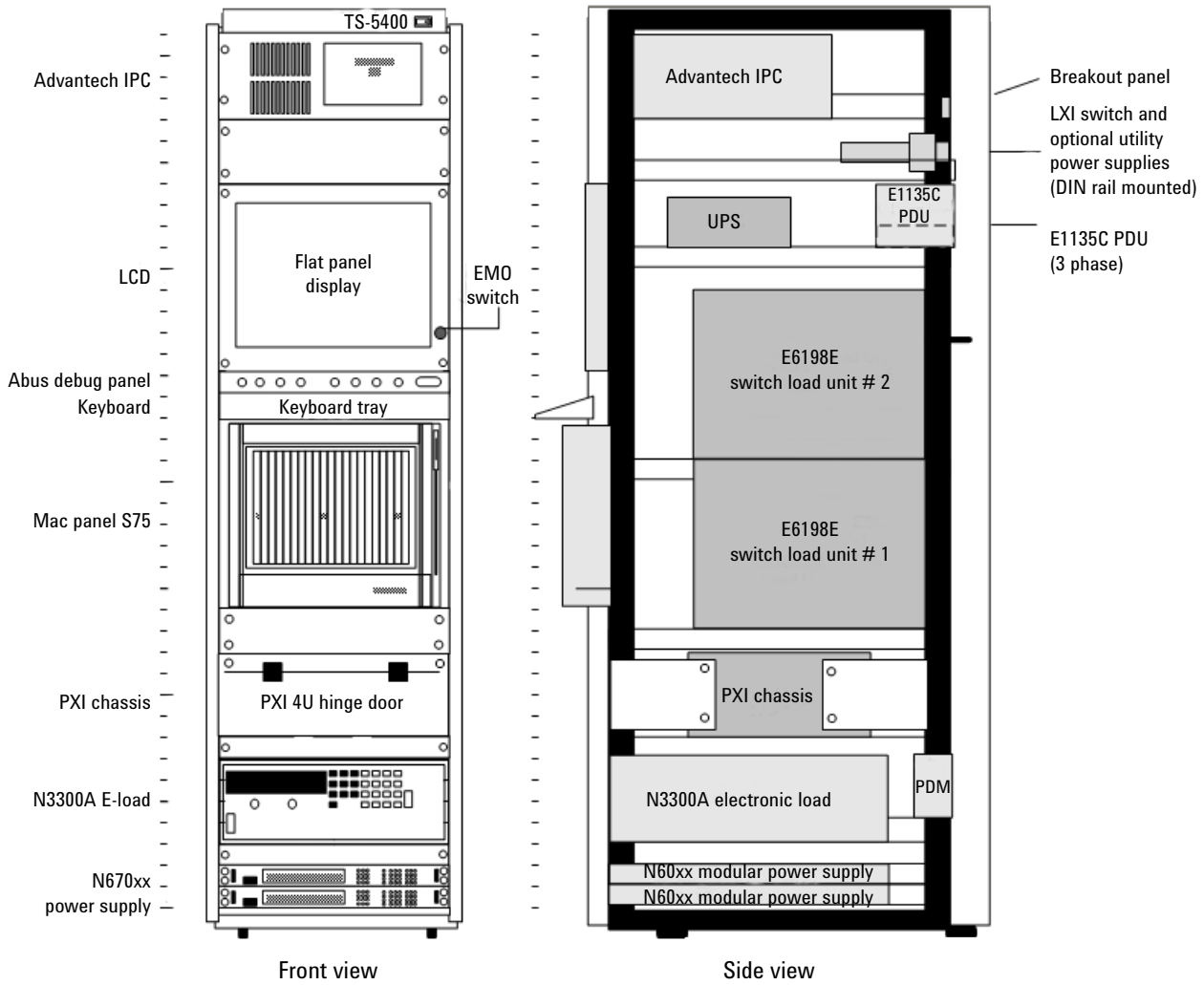
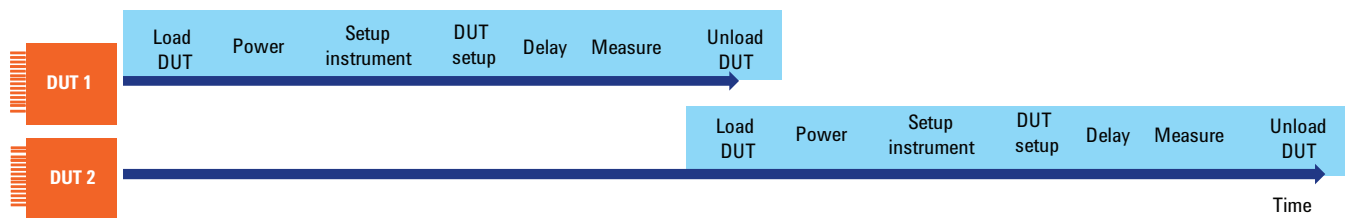


Figure 5. TS-5400 PXI functional test system's Mac panel interface, front, and side views.

Throughput Multiplier

The throughput multiplier test strategy (multiple-up UUT testing) is one way to increase throughput in a manufacturing environment. Multiple-up UUT testing consolidates tasks common to multiple modules, such as load/unload, instrument signal set up, and load routing. It is also an effective strategy for overlapping inherent latencies in the UUT or test system (see Figure 6).

Single-up DUT test



Multiple-up DUT test

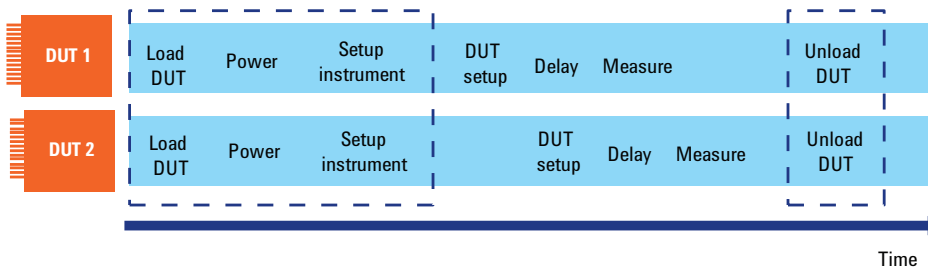


Figure 6. Single-up versus multiple-up DUT testing.

UUT-Assisted Test

As shown in Figure 7, most ECM designs include a serial interface. Communication protocols vary by manufacturer, but most comply with OBD2 standards. Alternative communication protocols supported by manufacturers include ISO-9141, J1939/CAN, and J1850. The serial link is used in the automobile itself and can also assist in the testing of the module.

As a programmable device, the ECM can be loaded with either operational code or test code. Operational code is present in the ROM during testing, or it is downloaded when the unit is shipped. Test code is either included in the ROM or downloaded through the serial link into the module. By using test code as part of the test program, the TS-5400 PXI Series establishes a set of conditions to which the ECM responds. This test approach is called UUT-assisted test.

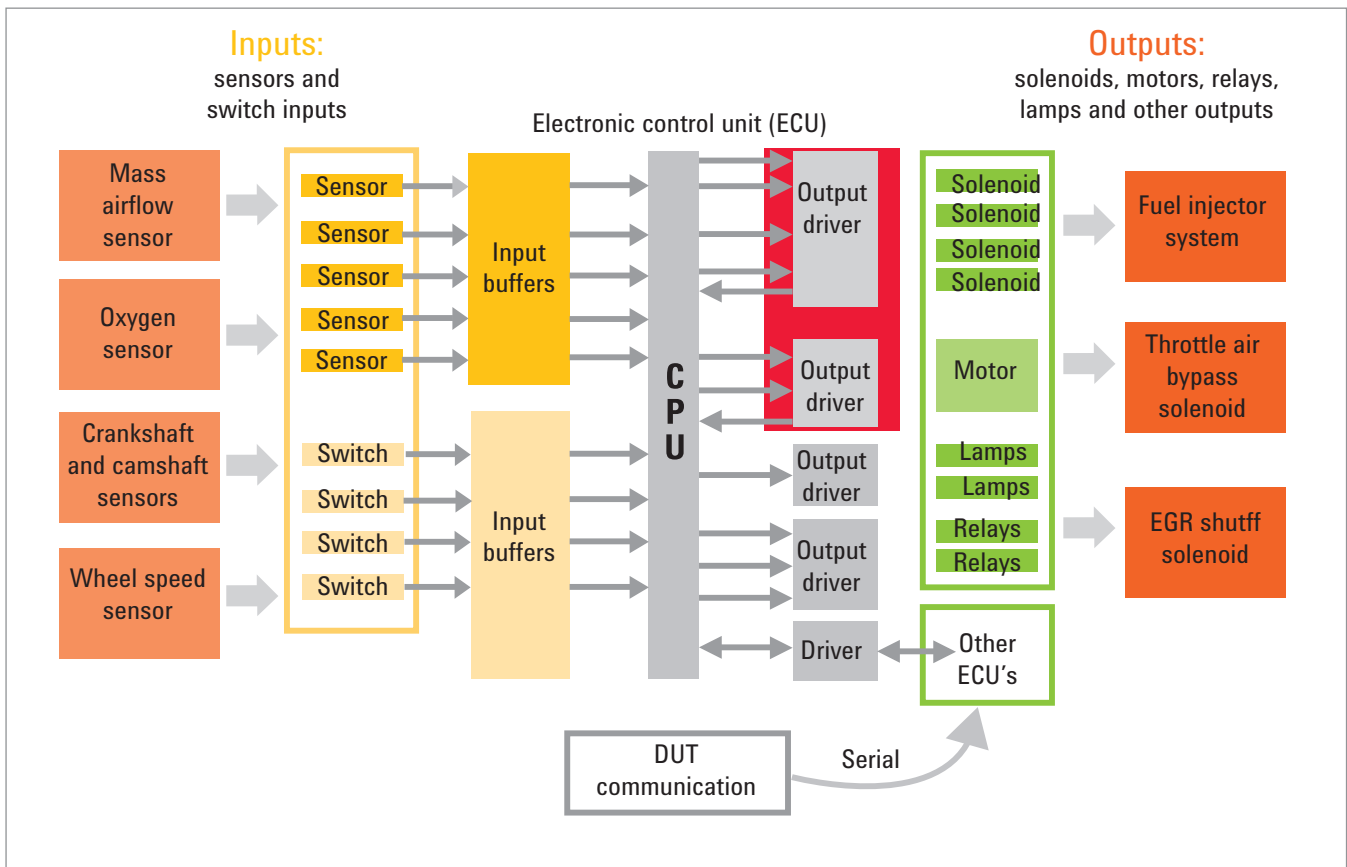


Figure 7. UUT-assisted test for engine control ECM.

Three modes

The TS-5400 PXI Series enables three different modes for performing UUT-assisted test. The best choice of mode depends on the test stimulus source and response destination.

- Serial Link Evaluation:
This mode simply evaluates the serial link and microcontroller. Commands sent to the microcontroller over the serial link prompt a response that is sent back to the test system. The system then verifies the response and may perform a full CRC memory check. Parametric tests may also be run to test serial link characteristics such as delay, rise or fall time, and input impedance.

- I/O Status Evaluation:
This mode uses the test system I/O to determine ECM input states. It does this by sending a message over the serial link to the ECM, prompting it to run a test routine. For example, this mode may be used to apply an analog input to the ECM to verify A/D conversion and the module's handling and communication of data over the serial link. (For example, the analog input may be a simulation of a sensor's output for air or water temperature, the throttle position indicator (TPI), manifold air pressure (MAP) and the like.) In this mode, the test system can use UUT-assisted testing to assess proper functioning of several functions at once, including the controller, serial link, A/D and waveform processing circuitry.

- Input Evaluation:
In this mode, the test system supplies an input then reads the value at either the input or output of the module. For example, this would include dynamic tests such as the application of a cam/crank phase synchronous waveform (MAP or TPI input). The evaluation can verify proper receipt of the signal at the module input or if the input caused the appropriate output.

What Makes Automotive Functional Testing Unique

Testing of automotive ECMs requires an understanding of the key characteristics in design and manufacturing. Table 2 provides a description of the general requirements for testing an automotive ECM using an engine control module as the unit under test. The table provides a corresponding overview of the TS-5400 PXI Series' system architecture attributes, illustrating its benefits as a functional test solution for automotive electronics.

Table 2. Engine control ECM testing characteristics and the TS-5400 PXI Series solution

Characteristics of testing engine management ECMs	Keysight TS-5400 PXI Series solution
Fast switching for multiple signal and load routing	<ul style="list-style-type: none"> - Programmable switch/load unit - Multiple load card capabilities with fast relays - 42 V-ready solution - Pull-up and pull-down load capabilities - Bridge load capabilities
"Real world" waveform and signal generation	<ul style="list-style-type: none"> - Variable reluctance and hall-effect sensor simulation - Knock signal simulation
High current/voltage response handling	<ul style="list-style-type: none"> - Flyback voltage/current handling - Voltages up to 500 V, currents up to 30 A - Period, frequency, timing, and duration measurement capabilities
Serial communication	<ul style="list-style-type: none"> - ISO-9141 capability - J1850 capability - J1939/CAN capability
Requires high throughput (< 20 s for a 100 pin-count ECM)	<ul style="list-style-type: none"> - Optimized software (fast sequences, pre-compiled tests, state tracking) - Fast (0.5 ms) measurement matrix relays

What Makes Automotive Functional Testing Unique (*continued*)

Testing engine management ECMs requires a dynamic range of both stimulus and response signals with flexible loading, high-speed, high resolution measurements, and comprehensive serial communication capabilities. Therefore, this type of EMC represents the most difficult challenge for today’s automotive electronics test systems. Some sample tests for engine control ECM are shown in Table 3.

Table 3. Sample test measurements for an engine control ECM.

Sample of tests for an engine control ECM	Sample measurements
Power up	<ul style="list-style-type: none"> – Input current – Input capacitance
Analog sensor input	<ul style="list-style-type: none"> – Response to Analog In
Input pin parameter	<ul style="list-style-type: none"> – Input bias – Clamp voltage – Leakage current – Pull-up loads – Pull-down loads
Output pin parameter	<ul style="list-style-type: none"> – Saturation voltage – Leakage current – Flyback voltage – Smart driver timing – Duration of flyback
Dynamic	<ul style="list-style-type: none"> – Spark advance (MAP, TPI varying) relative to TDC – Timing and width of fuel injection pulses

The TS-5400 PXI Series Architecture

The TS-5400 High Performance PXI functional test system is designed to assist in test system deployment while ensuring quality measurements and industry-leading uptime. (See Figure 8, next page, block diagram of the TS-5400 PXI Series.) Its architecture consists of the following components:

- An industrial PC controller with Windows 7 Professional, i5-2400 processor with 8 GB RAM, and 500 GB hard drive with a 17-inch industrial LCD display
- TestExec 7.1 test sequencer and switch manager
- TS-5000 libraries version 7.0 with 400+ built-in handlers and actions
- 3-Phase power distribution unit
- 21-Slot switch load unit with swappable pin matrix and load cards
- Keysight 18-slot M9018A PXI chassis with PXIe backplane
- Keysight PXI and LXI instruments
- Keysight N6700B/N6702A/N5764A/N5765A power supplies
- Keysight N3300A eLoad mainframe and modules
- MAC Panel Series S75 mass connect interface

The TS-5400 PXI Series Architecture (continued)

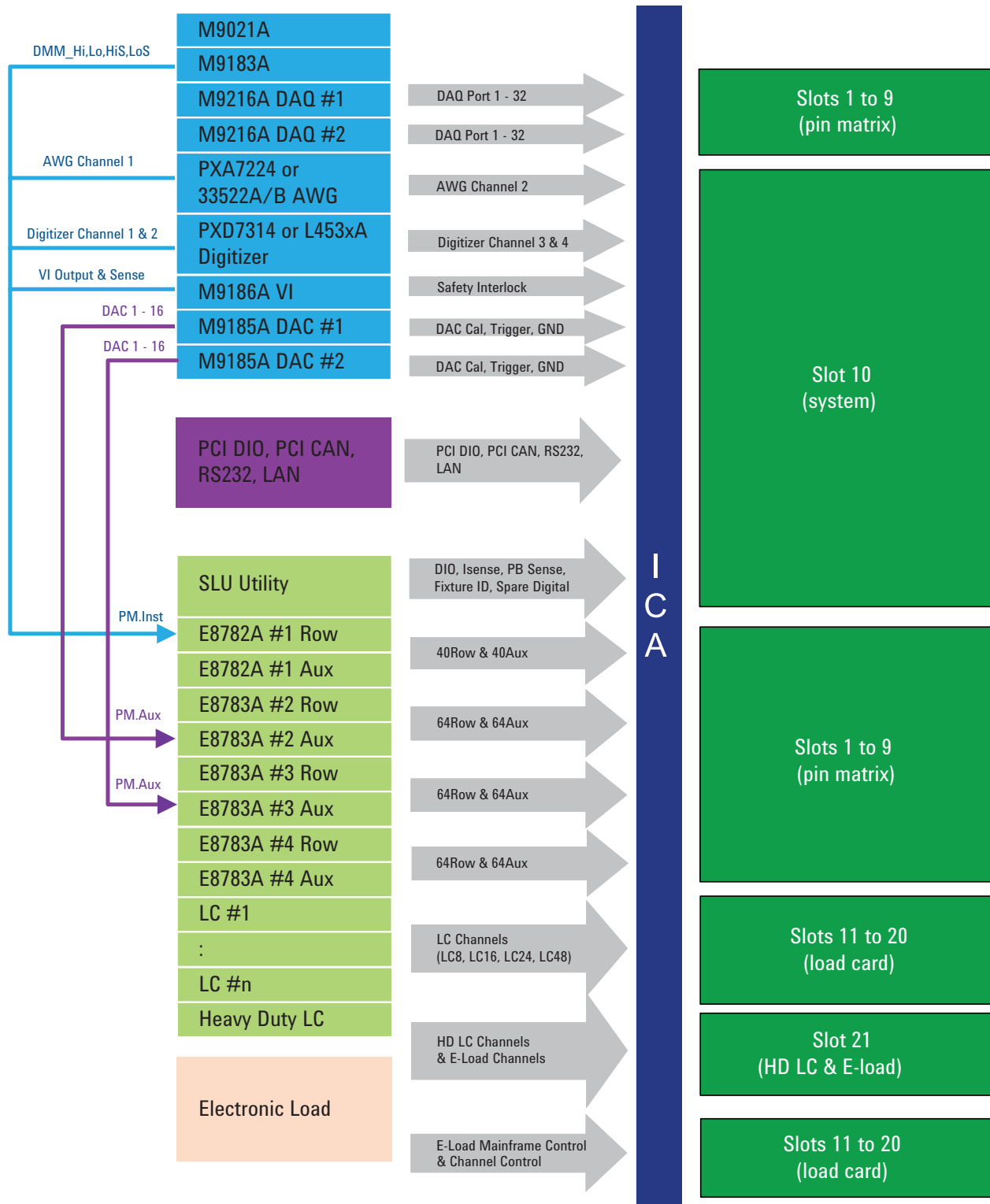


Figure 8. TS-5400 high-performance PXI functional test system block diagram.

Switch Load Unit

The switching and load management core of the system is the Keysight E6198B switch load unit (SLU) (see Figure 9 for a block diagram of unit). The programmable SLU is used for instrumentation switching (GPIB, Serial, LXI, or PXI bus-based), plus switching power supply and loads to the ECM. Test system resources (instrumentation, loads, and power

supplies) are routed to the UUT through the pin matrix cards and load cards that plug into the SLU. There are four types of load cards and two types of pin matrix cards. With three dedicated power supplies for each voltage line, maximum power is available to allow full actuation of every relay without the risk of unstable switching states.

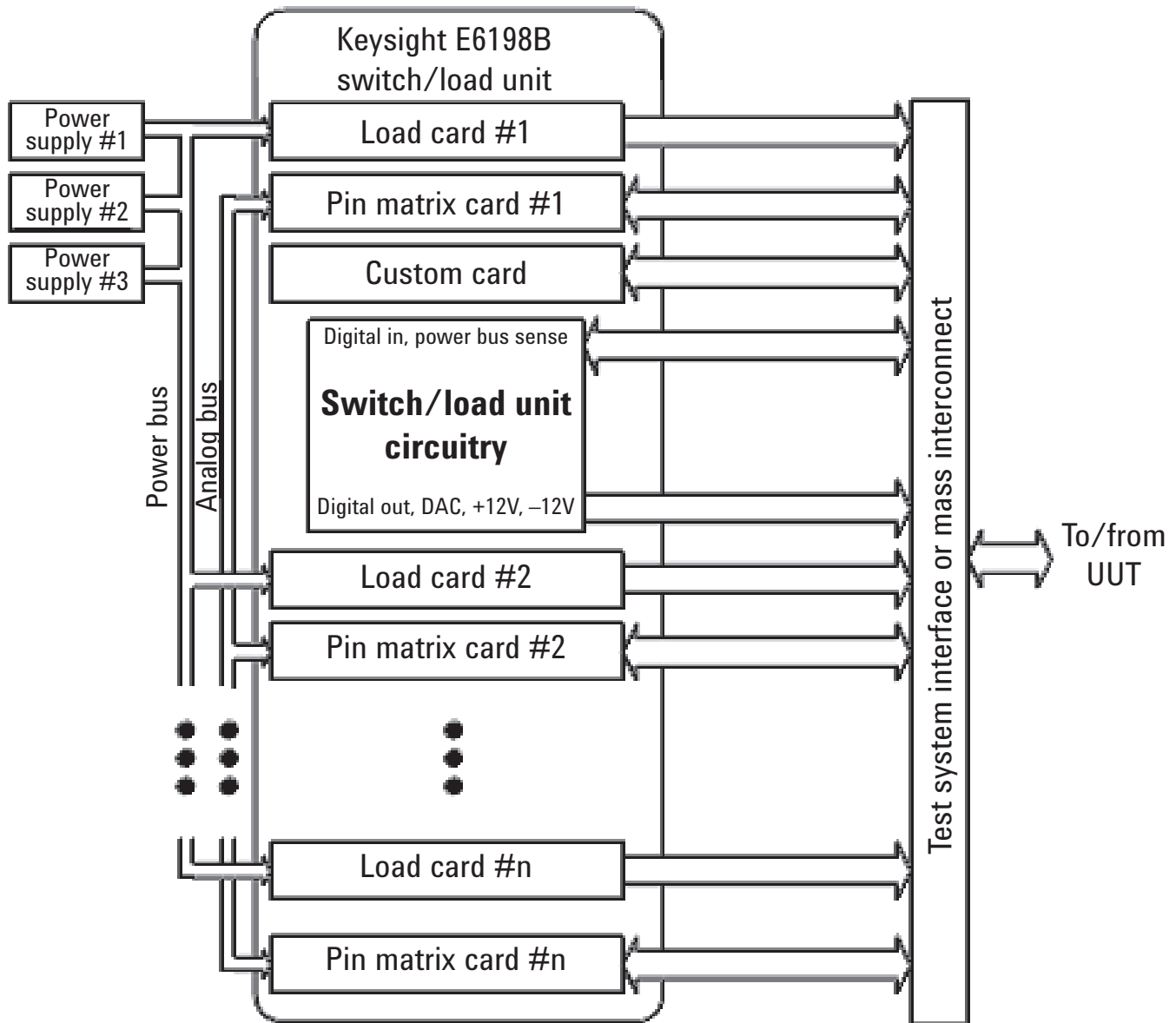


Figure 9. SLU block diagram.

Pin Matrix Cards

The TS-5400 PXI Series supports new Keysight E8782A and E8783A pin matrix cards that provide up to twice the measurement and instrument channels per card as their predecessors, the E8792A and E8793A pin matrix cards. Table 4 highlights the percentage increase in instrument and measurement channels.

With up to double the increase in density, the TS-5400 PXI Series supports up to 464 measurement channels, up from 320 measurement channels provided by the TS-5400 PXI Series platform. Figure 10 shows the block diagram of an E8782A and E8783A pin matrix card combination.

Table 4. Comparison of the E8792A and E8793A pin matrix cards versus the E8782A and E8783A combination.

	1x E8792A + 1x E8793A pin matrix cards combination	1x E8782A + 1x E8783A pin matrix cards combination	Density improvement
Instrument channels	16	24	50%
Measurement channels	64	104	62%

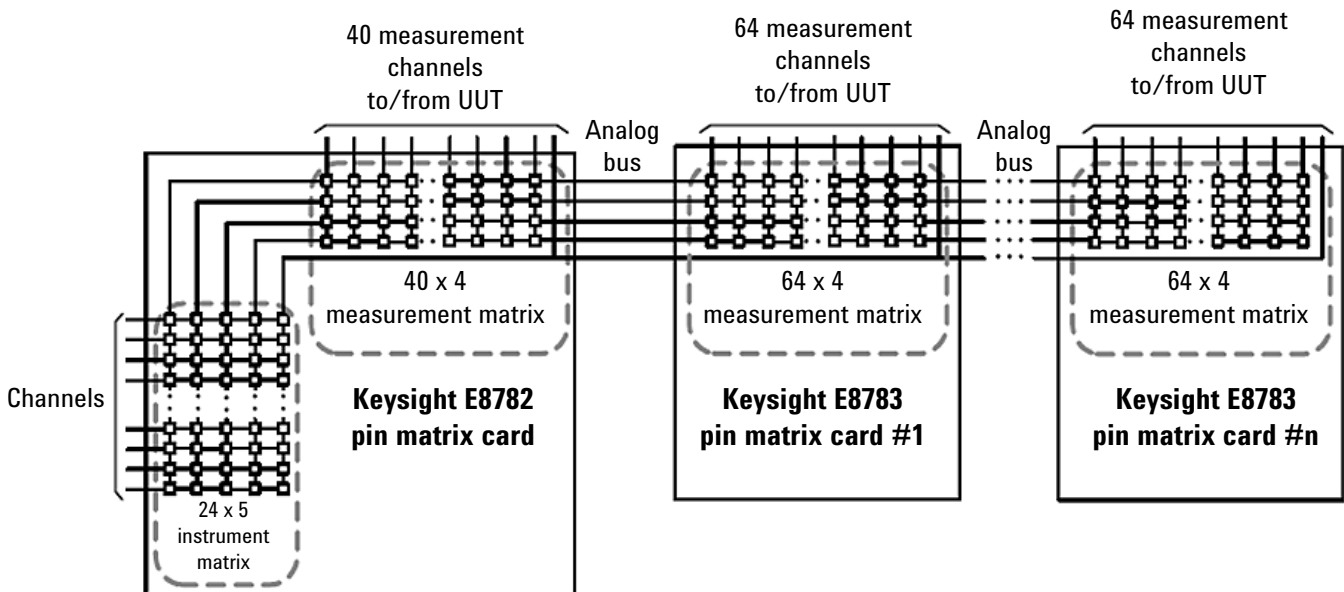


Figure 10. The E8782A and E8783A pin matrix cards combination.

Load Cards

In an automotive electronic system there are many special load requirements, from simple resistive loads to highly inductive loads (such as the ignition coil). In many cases it is crucial to simulate the load, while in others cases an actual load is needed to gain accurate visibility into the performance of the UUT. The SLU has a flexible load topology capable of meeting either load strategy. Provisions to measure the current through any load channel have been designed with sense resistors available on the 8- and 16-channel load cards. Table 5 illustrates the different types of load cards available and their applications.

Table 5. TS-5400 PXI Series load card types and features.

Function	Slot size	Number of channels (max)	Number of channels – unshared relays	Maximum current per channel	Current measuring with sense resistor	Current measuring with current transducer	Flyback protection available (user-installed)
E6175A	2	8	4	7.5 A (15 A peak)	Yes	Yes	Yes
E6176A	1	16	16	7.5 A (15 A peak)	Yes	No	Yes
E6177A	1	24	24	2 A	No	No	No
E6178B	2	8	8	30 A	No	Yes	Yes
N9377A	1	16 dual load	16	7.5 A (15 A peak)	Yes	No	Yes
N9378A	1	24 dual load	24	2 A	No	No	No
N9379A	1	48 dual load	48	2 A	No	No	No
U7177A	1	24	24	2 A	Yes	No	No
U7178A	2	8	8	40 A	No	Yes	Yes
U7179A	2	16	16	15 A	Yes	No	Yes

Instrumentations

The TS-5400 PXI Series employs the latest Keysight PXI and LXI solutions that are suitable for various automotive applications. Table 5 highlights these instruments, their features, and applications.

Table 6. Instruments, features, and applications of Keysight PXI and LXI solutions.

Instrument	Key features	Application benefits	Automotive applications
M9183A PXI DMM	<ul style="list-style-type: none"> Provides the lowest latency DMM available on the market for automotive applications (66 μs) Supports > 10 DMM measurement types like DC and AC voltage, DC and AC current, 2- and 4-wire resistance, temperature (RTD, thermistor, and, thermocouple), capacitance, frequency, and period Supports more ranges and higher resistance test current at the range limits (8 DC current ranges; 10 mA test current at the lowest resistance range) 	<ul style="list-style-type: none"> Enables high throughput yields and more measurements to be made (15,000 readings/s DCV) Lowers cost of hardware by supporting more measurement types Enables more accurate measurements 	<ul style="list-style-type: none"> Engine management ECU Body control ECU Safety ECU
M9018A PXI mainframe	<ul style="list-style-type: none"> Provides industry-leading PXIe[®] technologies for future support of more bandwidth intensive applications (8 GB/s to the system slot, 4 GB/s to the user slot) Provides 16 hybrid slots 	<ul style="list-style-type: none"> Provides future proofing and better technology investment Provides backward compatibility for existing PXI-H and CPCI cards 	<ul style="list-style-type: none"> RF measurements in automotive applications
M9186A PXI V/I source	<ul style="list-style-type: none"> Provides a 4-quadrant voltage/current source with 16-bit resolution 	<ul style="list-style-type: none"> Provides very accurate voltage/current source for characterization 	<ul style="list-style-type: none"> HV clamp test using FIMV
M9216A PXI DAQ	<ul style="list-style-type: none"> Provide up to 32 channels (8 channels simultaneously) Provides simultaneous dual range measurements (5 V and 100 V) 	<ul style="list-style-type: none"> Enables faster data acquisition for voltage measurements Enables faster test plan development and throughput 	<ul style="list-style-type: none"> Body control module ECU
M9185A PXI DAC	<ul style="list-style-type: none"> Provides up to ± 16 V voltage output/channel Remote sense feature 8/16 isolated channels 	<ul style="list-style-type: none"> Supports ± 12 V to ± 14 V automotive applications directly without attenuation circuits, reducing hardware costs Provides accurate stimulus output per channel enabling support for higher voltages via “daisy-chaining” the output channels 	<ul style="list-style-type: none"> Body control module ECU (light vehicles) Engine control module (light vehicles)
L4532A LXI digitizer	<ul style="list-style-type: none"> ± 256 V input range allows direct measurement of the high-voltage pulses 16 bit dynamic range combined with low channel input offsets Segmented memory and fast rearm times enable recording of multiple pulses while ignoring inactive periods in between the pulse events 	<ul style="list-style-type: none"> Eliminates attenuation circuits are required for voltage input ranges < 256 V Enable engineers to measure both V_{dson} and $V_{flybackpulse}$ with a single capture Provides ability to record many pulses while ignoring inactive periods in between the pulse events 	<ul style="list-style-type: none"> Solenoid driver output test in engine control modules
N6702A Series power supply mainframe and N6756A power supply modules	<ul style="list-style-type: none"> 1 U height < 1 ms transient response time 	<ul style="list-style-type: none"> Requires less system rack space allowing more instruments or power supplies to be added to Venturi S3 Improves test throughput in functional test 	<ul style="list-style-type: none"> Automotive electronic control modules (ECMs) Automotive body electronics Automotive telematics

More Than Just a Product— It's a Complete Solution

When you choose the TS-5400 PXI Series, you choose to maximize value. The complete TS-5400 PXI Series solution is much more than hardware and software tools. It is a complete system solution—product to services—that includes the following:

- System documentation
- Application consulting
- Customer training
- Software updates
- Cooperative maintenance
- Extended warranties
- Repair, calibration, and self-diagnostics
- Remote support

This wide range of services lets you take advantage of the full value of the TS-5400 PXI Series. Documenting a system can be difficult when test engineering's primary focus is to keep production up and running. The TS-5400 PXI Series provides complete documentation of its unique capabilities including cabling, mass interconnect, power distribution, and software. You only need to document and support the platform's customization.

Keysight also offers system platform training to augment its extensive curriculum of educational products. When it comes to hardware components and unique platform features, the Keysight team provides worldwide support. For optimal uptime of test systems, cooperative support arrangements are available (Figure 11 illustrates this benefit).

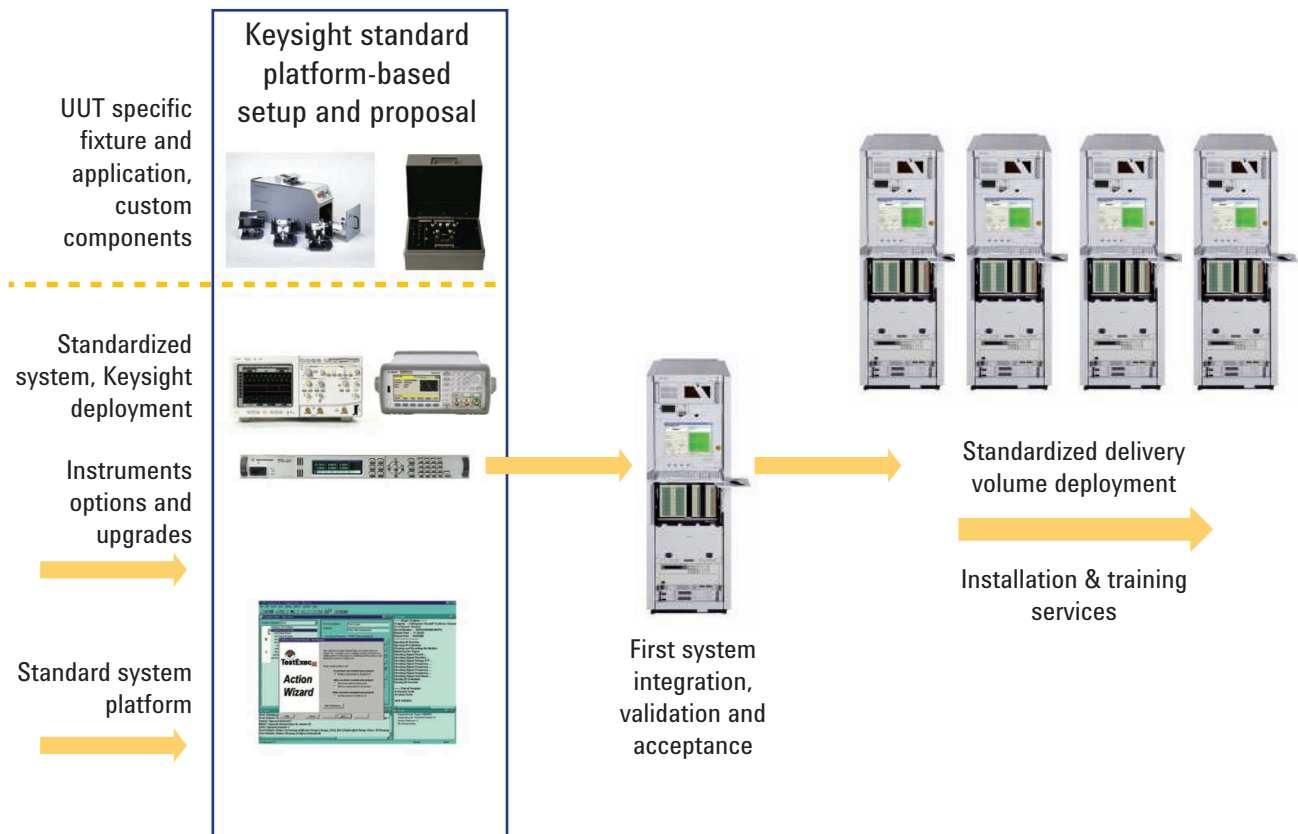


Figure 11. Keysight standard platform based setup and proposal.

Why Buy the TS-5400 PXI Series?

Depending on a manufacturer's production situation, there are numerous benefits to choosing the TS-5400 PXI Series platform to help you with your upcoming projects.

- Reduces test development time

The TS-5400 PXI Series is a pre-built system that provides the majority of a test system solution, so it has never been easier to keep pace with demand. The software development productivity of the TS-5400 PXI Series results from a hierarchical approach to test development designed to maximize the reusable code in a structured process. The high quality software environment, tests, measurements, and utilities are a direct result of intensive design, while the unique platform approach saves steps in developing the complete system.

System design and planning steps are reduced as a result of the solution's pre-defined architecture. The system's interconnections, cabling, and racking are specific activities performed by Keysight, while test engineering focuses on the unique aspects of testing a given ECM. In addition, Keysight provides software documentation, training, and support.

- Saves capital costs

Running tests faster translates to less equipment and lower costs. The TS-5400 PXI Series test platform features an instrumentation set that optimizes throughput by tuning the hardware and software for fast execution. With no special effort or time expended, you can use the Keysight software routines to achieve the fastest test times. The unique combination of multiple-up support for testing more than one UUT at a time and faster test times reduces your capital costs.

- Provides flexibility

Many manufacturing facilities require flexibility to keep pace with the dynamic changes in the automotive electronics manufacturing industry. New production lines are being deployed worldwide. Technologies are constantly changing along with demands for new ECMs and features. As manufacturing requirements continue to evolve, a flexible testing platform approach is better suited to meet your needs. The TS-5400 PXI Series is one solution in the TS-5000 functional test platform which is built with common architectures and cores. Software and hardware for testing ECMs are available, providing a common look and feel across production lines testing different ECMs. The modularity of the system platform lets you add the functionality you need to test different versions and types of ECMs, while simultaneously controlling automation and line integration.

- Simplifies worldwide deployment

Many companies operate in a global business environment. For test departments, this sets the stage for complications, including setting up new production lines in other countries. Typically production lines are duplicated and local people are trained to run the manufacturing process. However, there is often a heavy burden imposed on the central test engineering department to support the test stands. Any software changes or questions concerning operation eventually make their way back to these already overburdened engineers.

Software and test systems may be difficult to troubleshoot and maintain, especially when test engineers have time and resource pressures. With the Keysight test platform approach, stable test results are readily achieved worldwide with extensive diagnostics tests that verify system functionality. Standardized software, hardware, and integration allow Keysight to support the platform worldwide, while support for the integrated solution can be provided locally. Cooperative support between Keysight and the manufacturing site provides maximum up-time.

- Reduces total test cost

Test cost is only one factor in reducing the total cost of manufacturing an ECM; however, it is a tangible cost that can be reduced by test engineering. To reduce test costs, test engineers focus on reducing test times, equipment costs, and floor space. Using the TS-5400 PXI Series achieves all of these objectives.

With the volume increase in safety, security, and convenience modules, manufacturers are looking for ways to meet line-production rates without building up inventory on the production line. Using the throughput multiplier for parallel multiple-up testing of ECMs reduces floor space and increases asset utilization, while decreasing test time per ECM. When the hidden costs of software engineering time, operating costs, and maintenance expenses are factored into the cost equation, they are likely to outweigh the costs tied directly to the instrument hardware. Operation costs include management, facilities, and the skilled personnel needed to run the test systems. With a standard platform of hardware and software, support and training costs are lower than that of a one-of-a-kind system.

Ordering Information

Table 7. The TS-5400 PXI Series comes with a basic system configuration.

Option number	Description
U8972A	TS-5400 High Performance PXI functional test system with MAC Panel interface
U8972A-CORE	CORE material
	1135C power distribution unit
	MAC Panel S75 ICA mass interconnect panel
	Integration kit for 1135C PDU
	Crating for 2.0 m rack
	Rackmount kit for M9018A PXI chassis
	PXI module easy access frame
	2.0 m standard rack with side panel and solid rear door, without PDU and front, enhanced cooling
	TS-5400 switch/load unit with Options E6198B-CORE, E6198B-002, and E6198B-USB
	TS-5400 ABUS debug panel
	Systems thermal monitoring kit
	Kitting, integration, and logistics services
	TS-5400 system warranty (8x5 cooperative support)
	TS-5400 SLU pin card with instrumentation matrix: (24 instrument, 40 measurement
	E8782A, E8783A cable: MAC Panel with ICA connector block
U8972A-OC-BASE	Base option class
U8972A-PC1	TS-5000 family controller: Core i5-2400 1155 3.1 GHz processor, 8 GB RAM, 500 GB HDD, No DVD-RW and FDD
U8972A-001	Microsoft Windows 7 Pro with Keysight I/O libraries
U8972A-013	Test Exec SL Rev 7.0 software license installed on TS-5000 controller
E6249A-014	17-inch industrial grade LCD: With rackmount kit, without BNCs
E2235D-710	Interface card: PCIe Gen 2, x8, 4 Gbps, clock isolation
U8972A-OC-APPSW	TS-5400 applications software options class
E8780B-003	TS-5000 family application software: 7.0V
U8972A-OC-PDUWRG	PDU wiring option class
E8780B-3PN	Wye 3-phase with Neu 5-wire for 220/380-240/415 VAC
E8780B-3PY	Wye 3-phase with Neu 5-wire for 120/208-127/220 VAC
U8972A-OC-LDCBLS	SLU card cables option class
U8972A-843	E6198B SLU cable: Utility and DIO to ICA
U8972A-OC-UTLPS	Utilities power supply options
E2230A-130	Fixed power supply: 12 V
U8972A-OC-PXIMOD	PXI instruments option class
U8972A-300	PXIE chassis M9018A: 18-slot, 3 U, 8 GB ps
U8970A-306	PCIE cable interface M9021A: PCIE, X8 male, 28 AWG, 2 M-LG cable
U8970A-311	PXI DMM M9183A: 6.5 digit enhanced performance
U8972A-OC-ACCY	Accessories
U8972A-HB1	LXI hub E2240A-718: 8-port
E6249A-009	Fixed keyboard and mouse pad tray

Ordering Information *(continued)*

Option number	Description
U8972A-OC-RKFAN	Rack fan option class
E8780B-022	Rack fan assembly for 220 V system
U8972A-OC-GPIB	GPIB card option class
E2235A-020	Keysight 82350B GPIB PCI card
E2235A-021	NI GP-IB PCI card
U8972A-OC-ADDPCI	PCI cards option class
E6249A-015	Serial port Titan cable kit: 8-channel
E2235A-055	DIO card: 32-channels, 2500 VDC isolation
E2235A-052	PCI softing can card and Titan cabling
E2235D-040	Serial PCI card:8 channel
U8972A-OC-UPS	Uninterruptible power supply option class
U8972A-UR1	Rackmount kit for uninterruptible power supply
U8972A-UR2	Casing kit for uninterruptible power supply
U8972A-OC-ADDSLUI	Additional switch load unit option class
U8972A-SL1	Second SLU in system
U8972A-PD1	TS-5400 PXI (MAC Panel) power distribution module
U8972A-OC-PINCRD	Pin card option class
E8782A-FG	TS-5400 SLU ping card with instrumentation matrix: 24 instrument, 40 measurement
E8783A-FG	TS-5400 SLU pin card: 64x4 measurement matrix
U8972A-OC-PINCBL	Pin card cables option class
U8972A-810	E8782A, E8783A cable: MAC Panel with ICA connector block
U8972A-OC-SLUCRD	SLU cards option class
E6177A-FG	Load card: 24-channel
N9378A-FG	Low resistance loadcard for 24 channels
U7177A-FG	Load card with current sense U7177A: 24-channel
N9379A-FG	High density Lladcard for 48 channels
E6178B-FG	ILoad Ccard: 8-channel, 30 A
U7178A-FG	Heavy duty load card: Up to 40 A, 8-channel
U7179A-FG	High current load card: Up to 15 A, 16-channel
E6176A-FG	Load card: 16-channel
N9377A-FG	Dual-load load card: 16-channel
E6175A-FG	Load card: 8-channel
U8972A-OC-LDCBLS	SLU card cables option class
U8972A-839	U7178A/E6178B cable: MAC Panel, 8-channel, 40 A
U8972A-840	U7179A cable: MAC Panel, 16-channel, 15 A
U8972A-841	E6175A/E6176A/N9377A (3x16-ch to 1) and E6177A/U7177A/N9378A (1x24-ch to 1) cable: MAC Panel
U8972A-842	E6175A/E6176A/N9377A (3x16-ch to 1) and N9379A (1x48-ch to 1) cable: MAC Panel
U8972A-845	E6198B SLU cable: SLU to PDM
U8972A-OC-ICA	ICA frame and receiver blocks
U8972A-164	High-power 64-pin receiver block with strain relief kit

Ordering Information *(continued)*

Option number	Description
U8972A-OC-COMBO	Combo material option class
U8972A-CH0	No half rack instruments
U8972A-CH1	One half rack instrument
U8972A-CH2	Two half rack instruments
U8972A-CL1	SLU slot filler
U8972A-CX1	MAC Panel ICA slot filler
U8972A-CP1	Filler 1 U panel
U8972A-CP2	Filler 2 U panel
U8972A-CP3	Filler 3 U panel
U8972A-CP4	Filler 4 U panel
U8972A-CB1	Ballast combo material for power supplies
U8972A-CL2	Material for second SLU in TS series system
U8972A-OC-ACCY	Accessories
U8972A-OB2	Add manual set
U8972A-OC-PWRSUPPLY	Power supply options
U8972A-503	DC power supply N5764A: 20 V, 76 A, 1520 W, including cable
U8972A-504	DC power supply N5765A: 30 V, 50 A, 1500 W including cable
U8972A-OC-MODPS	Modular power supply options
U8972A-LMF	Modular power supply mainframe N6700B: Low power modules (400 W maximum)
U8972A-HMF	Modular power supply mainframe N6702A: High power modules (1200 W maximum)
U8972A-OC-PSMOD	Modular power supply module options
U8972A-L01	DC power module N6752A: High performance, 50 V, 10 A, 100 W
U8972A-L02	DC power module N6762A: Precision, 50 V, 3 A, 100 W
U8972A-H01	DC power module N6756A:— 60 V, 17 A, 500 W
U8972A-OC-PSCABLE	Modular power supply cable options
U8972A-C06	MPS cable: N6752A/N6762A/N6751A/N6761A/N6734A/N6774A/N6775A/N6776A PS module to PDM
U8972A-C07	MPS cable: N6752A/N6762A/N6751A/N6761A/N6734A/N6774A/N6775A/N6776A PS module to PDM
U8972A-C08	MPS cable: Connector cable for N6756A (1 KW configuration)
U8972A-C09	MPS cable: Direct connect N6700B to E6198B SLU
U8972A-OC-PSCOMBO	Modular power supply combination materials
U8972A-P01	MPS brick filler
U8972A-OC-UTLPS	Utilities power supply options
E2230A-131	Fixed power supply: 24 V

Ordering Information *(continued)*

Option number	Description
U8972A-OC-PXIMOD	PXI instruments option class
U8970A-340	PXI isolated V/I source M9186A: 3 W, 100 V, single channel
U8970A-335	PXI isolated DAC M9185A: 8-channel
U8970A-336	PXI isolated DAC M9185A: 16-channel
U8970A-330	PXI high voltage DAQ M9216A: 32-channel, 250 Ksps , 16-bit, 100 V input
U8970A-310	PXI DMM M9182A: 6.5-digit
U8970A-311	PXI DMM M9183A: 6.5-digit, enhanced performance
U8972A-321	PXI digitizer PXD7214 (VX instrument)
U8972A-322	PXI arb PXA7224 (VX instrument)
U8972A-821	PXI V/I source M9186A cable: MAC Panel, to inst matrix and ICA
U8972A-830	PXI HV-DAQ M9216A cable: MAC Panel, HV-DAQ to ICA
U8972A-820	PXI isolated DAC M9185A cable: MAC Panel, to pin matrix AUX
U8972A-823	PXI cable: BNC isolated: PXA7224/PXD7214 to instrument matrix
U8972A-824	PXI cable: BNC isolated: PXA7224 to 210-pin ICA receiver block
U8972A-OC-LXI	LXI Instruments Option Class
U8972A-116	LXI arb 33522B: 30 MHz, 2-channel
U8972A-125	LXI Digitizer L4532A: 20 Msps , 16-bit, 2-channel
U8972A-130	LXI Digitizer L4534A, 20 Msps, 16-bit, 4-channel
U8972A-OC-ELOAD	Electronic load option class
U8972A-100	Electronic load main frame N3300A: 1.8 KW max with options standard
U8972A-101	Electronic load module N3302A: 150 W, 0 to 60 V, 30,A
U8972A-102	Electronic load module N3304A: 300 W, 0 to 60 V, 60 A
U8972A-803	N3300A electronic load cable: MAC Panel, to 64-POS heavy duty ICA
U8972A-804	N3300A electronic load control cable, to ICA
U8972A-805	N3300A electronic load mainframe control cable, to ICA
U8972A-OC-ICAOPT	TS-5400 PXI functional test system interface connector options
U8972A-D01	TS-5400 PXI functional test system (MAC Panel) diagnostic kit

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