Keysight Technologies
TS-5020 Automotive Electronics Functional Test System

Technical Overview

KEYSIGHT
TECHNOLOGIES

Introduction

Test Engineering Challenges

On-time test deployment within budget requires a test system that provides adequate test coverage and low test times while ensuring the manufacture of quality products. In developing a test platform, you must balance three competing challenges: time (test development, execution and system deployment); cost (capital and integration); and scope (throughput, accuracy and flexibility) [see figure 1]. In today's automotive electronics manufacturing environment, a reusable, scalable test platform helps meet evolving test requirements and lets you stay competitive.
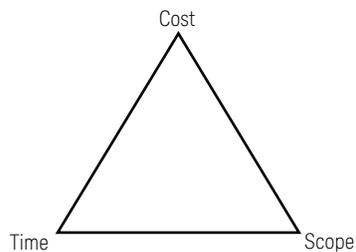

Figure 1. The balancing challenge

There are three approaches for you to choose from when creating a test system: use your in-house test department to develop and build your own, outsource the development of an entire system, or use a commercial off-the-shelf platform as the basis for the test system to be deployed.

The Keysight Technologies, Inc. TS-5020 is a new, off-the-shelf test platform tuned specifically for automotive electronics functional test. With the look and feel of the higher-end Keysight TS-5400 Series II, the TS-5020 addresses the requirement for a lower cost measurement system, catered to a medium pin count range with light duty switching.

Manufacturing Goals

Producing quality electronic control units (ECMs) faster and at a lower cost without compromising test coverage can be a challenge in the fast-paced automotive electronics industry. In exploring the three competing goals of test engineering [see figure 1] it becomes increasingly clear for the need to focus on each challenge individually, while simultaneously studying how they relate to one another. To meet the pressure in getting manufacturing test lines set up on time requires test engineering to perform faster test development, execution and line integration. In turn, increasing throughput to decrease the test cost per ECM requires faster test system to accommodate the rapid introduction of new convenience, security, safety and body electronic modules.

Achieving the proper balance among all the three goals is difficult yet necessary for manufacturers to better meet original equipment manufacturer (OEM) timelines. In an effort to find this balance, where time is the ultimate constraint, manufacturers are forced to make decisions on trading test coverage and for maintaining a lean time to market.

Either this, or manufacturers are forced to make decisions on trading wide ranging, flexible ECM test capability for module-dedicated test systems – a poor use of assets in the long term. Keysight's new TS-5020 ensures that you do not have to trade off quality for test systems capability. The Keysight TS-5020 is a platform that allows for flexibility in scope, and maintains a low cost while simultenously providing you a faster time to market.

The Keysight Solution

The TS-5020 automotive electronics functional test system helps manufacturers get products to market faster by accelerating test system deployment. Engineered with the three critical manufacturing goals in mind, this system caters for flexibility, speed and quality to automotive electronics production.

When it comes to flexibility, a universal test system core of both hardware and software can easily be modified to suit your particular test strategy and range of ECMs. As for speed and quality, the test executive accelerates both the development and execution of tests with over 400 test routines tuned towards automotive applications.

The Keysight TS-5020 is designed to provide performance at a lower cost for applications from simple ECMs such as climate control, immobilizers and remote-keyless entry (RKE), to safety ECMs such as airbag and anti-lock brake system (ABS) or traction control (TC).

The TS-5020 system comes equipped with measurement hardware, switching, a test executive and automotive-tuned library routines. Racking, cabling and optional fixturing are included, as well as standard software development tools that enable test engineers to deploy test systems at a much faster rate than building test systems from individual test systems from individual components.

Keysight TS-5020 Automotive Electronics Functional Test System

At the heart of Keysight TS-5020 [see figure 2] is the award winning Keysight 34980A Switch/ Measurement Unit with a built-in 6.5 digit multimeter. The system interface uses the Express-Connect method. General Purpose Interface Bus (GPIB) instruments can be optionally added to enhance the measurement capabilities of the system together with a range of power supplies.

Key Features

Measurement switching

The 34980A provides the switching platform for the TS-5020. To achieve a low cost, low pin count switching, the module supplied with the 34980A is configured up to 32 x 4 x 96 (32 instrument x 4 ABUS x 96 pin) switch matrix. Additional modules can be added and configure every pin matrix card up to 4 x 128 to increase the pin channel support up to 480 pins total.

Measurement

Keeping the TS-5020 a low cost system, the 34980A also offers a built-in digital multimeter (DMM) complete with independently configurable channels for the measurements you choose. This is a 61/2 digits DMM with a .004% of accuracy in DC voltage measurements, complete with channel alarms and math functions.

Load switching

With its eight-slot mainframe, the 34980A can be added with a 20-channel "form A" switch to provide light duty load switching enabling it to support 3 A continuous current with a 5 A peak.

Mass interconnect

The switching interconnects to the unit under test (UUT) via the Express Connect interface. This interconnect consists of an interface connect assembly (ICA) and an interface test adapter (ITA), each having its own connector blocks and matching pins. The ICA is mounted to the system rack and feature a hinged insert that when released, allows the panel to fold down 90° away from the system. This design allows convenient access to the wiring. The ITA inserts into the ICA and locks in place.
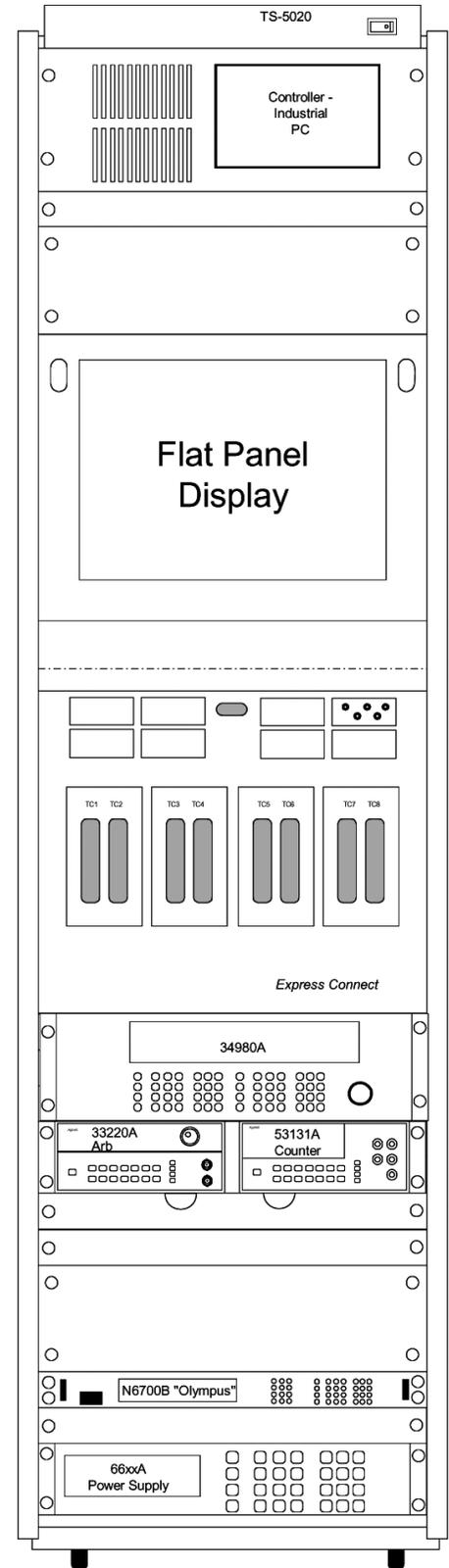

Figure 2. Keysight TS-5020 automotive functional test system

Additional Module Options for 34980

34933/4A Reed matrix module

Increases the pin count when required.

34937A 32-channel form C/ form A switch module

A general purpose switch module. It has 28 1A-relays of Form C switch and 4 5A-relays of Form A switch.

34938A 20-channel 5A form A switch module

A 20-Channel switch that allows for simple light duty load switching, supporting a 3 A continuous current with a 5 A peak.

3494xA quad 1 x 4 RF multiplexer module

An RF multiplexer that offers bi-directional switching for test signals with high channel isolation. Available in 50 or 75 ohm inputs for 3 GHz and 1.5 GHz respectively.

34945A RF switch/attenuator driver module for 34980A

A switch/attenuator driver that allows control of switches and attenuators external of the system. The module provides power and control signals for many of the popular microwave switches and attenuators.

Additional Instrument Options

33220A / 33522A function / arbitrary waveform generator

A function generator uses direct digital synthesis techniques to create stable, low-distortion output signals that ensure accurate results. It offers standard waveforms plus pulse and arbitrary waveforms. Custom waveforms can be created using the 16-bit, 250 MSa/s, 1M-point arbitrary waveform function. The variable-edge pulse function, along with the PWM, provides excellent flexibility for automotive test applications.

53220A universal frequency counter

A frequency counter that offers up to 12 digits per second of frequency or period resolution and bandwidth of up to 350 MHz. Time interval resolution is as low as 100 ps. An optional third channel provides frequency measurements up to 6 GHz or 15 GHz. With fast signal processing and automated limit tests, the 53220A can make measurements such as frequency, rise/fall time, phase and more quickly and accurately.

L4532/4A 2/4 channel LXI digitizer

A digitizer sample rate up to 20 MSa/s and 16-bit ADC resolution. The input channels have the ability to measure waveforms up to 250 V and are ideal for analyzing transient signals particularly in automotive and aerospace defence applications.

DSO6054L 4-channel LXI digital oscilloscope

An oscilloscope with bandwidth of 1 GHz bandwidth and 12 bit resolution. It takes up only 1U space on the rack.

66xxA DC power supply

This series of 200W linear-regulated DC power supplies is fully programmable via GPIB design to maximize the throughput of UUTs through the manufacturing test process with fast up and down programming time.

N67xxA low-profile modular power supply system

A family of small and flexible modular power supply made of a low-profile, 1U high mainframe that accepts up to 4 modules with each module providing up to 300 W of power. Fast command processing makes it ideal for product test environments.

System Configurations

Key components of the TS-5020

34980A multifunction switch/measure mainframe with built-in DMM

34933/4A dual/quad 4 x 8 Reed matrix module for 34980A

E2235B industrial PC

Optional instruments

34933A/34934A Reed matrix module for 34980A

34937A 32-channel form C/form A switch module for 34980A

34938A 20-channel 5 A form A switch module for 34980A

34941A quad 1 x 4 50 ohm 3 GHz RF multiplexer module for 34980A

34942A quad 1 x 4 75 ohm 1.5 GHz RF multiplexer module for 34980A

34945A RF switch/attenuator driver module for 34980A

66xxA DC system power supply, 200 W

N67xxA low-profile modular power supply system, 50 W-300 W

33220A/ 33522A function/arbitrary waveform generator

53220A universal frequency counter

Block Diagrams and Hardware Overview

The architecture of the TS-5020 utilizes a Windows XP Pro-based controller connected to the Keysight 34980A multifunction switch/measure mainframe with a choice of plug-in modules which include switching, D/A converters and a light load module.

The controller runs Keysight TestExec SL software, a mature test executive with hundreds of pre-tested automotive-tuned library routines.
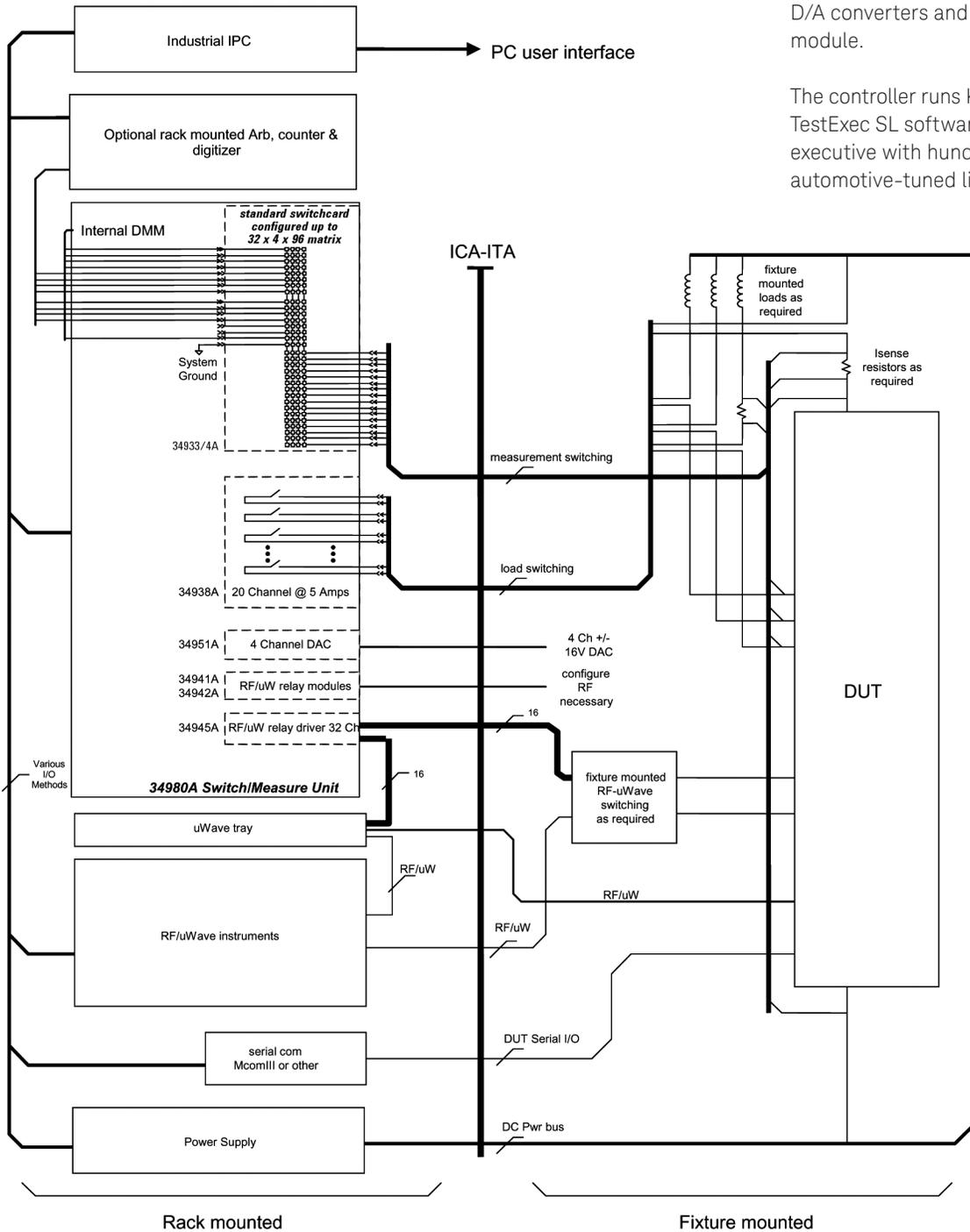
Industrial IPC

PC user interface

Optional rack mounted Arb, counter & digitizer

Internal DMM

standard switchcard configured up to 32 x 4 x 96 matrix

ICA-ITA

fixture mounted loads as required

Isense resistors as required

System Ground

34933/4A

measurement switching

34938A | 20 Channel @ 5 Amps

load switching

34951A | 4 Channel DAC

4 Ch +/- 16V DAC

34941A 34942A | RF/uW relay modules

configure RF necessary

34945A | RF/uW relay driver 32 Ch

16

16

Various I/O Methods

34980A Switch/Measure Unit

DUT

uWave tray

fixture mounted RF-uWave switching as required

RF/uW

RF/uW

RF/uWave instruments

RF/uW

RF/uW

serial com McomIII or other

DUT Serial I/O

Power Supply

DC Pwr bus

Rack mounted

Fixture mounted

Figure 3. System block diagram

Unique Attributes of Automotive Functional Testing

Functional testing of automotive ECMs can strain the capabilities of a typical test system. The TS-5020 can address a wide range of ECMs, from climate control to ABS to air bag control. Table 1 takes a closer look at the test requirements for some of these ECMs and the solution Keysight TS-5020 can provide.
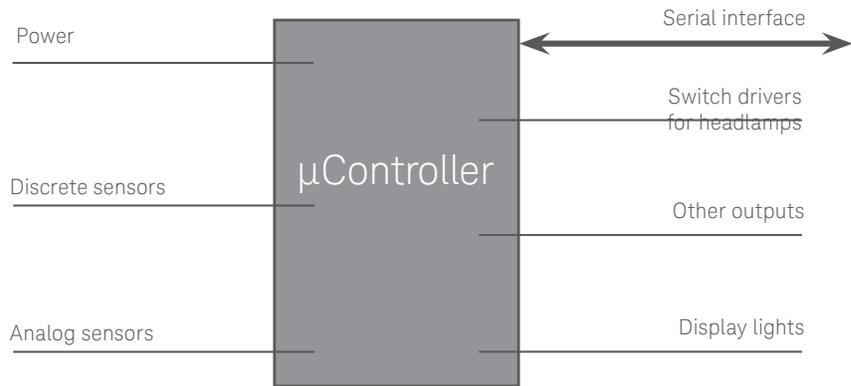

Figure 4. Example of serial interface for an electronic control module (ECM).

Test Requirements

The advancement of electronically controlled functions in today's automobiles require a wide range of capabilities: fast switching, versatile signal generation and serial communications; to name a few. The TS-5020 is designed to meet these challenges by increasing production volume with higher throughput while reducing the cost of test. As summarized in the table below, the TS-5020 offers a variety of solutions for each of the critical test requirements.

Test Methodologies

The ability to test many types of modules with one system improves development leverage. Adding test methodologies that accelerate the measurement of each module, regardless of type, is the next step towards lower-cost test.

The Keysight TS-5020 offers two approaches that improve the flexibility and speed of the testing process. One is UUT-assisted testing in which the ECM becomes an active participant in the testing process. The other is the throughput-multiplier strategy which enables batch testing of multiple identical ECMs.

UUT-Assisted Test

As shown in figure 4 above right, most ECM designs include a serial interface. Communication protocols vary by manufacturer, but most comply with OBD2 standards. Variations 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 either present in ROM during test or is downloaded when the unit is shipped. Test code is either included in ROM or downloaded through the serial link into the module. By using test code as part of the test program, the TS-5020 establishes a set of conditions to which the ECM responds. This test approach is known as UUT-assisted test.

Table 1. TS-5020 solutions for automotive electronic control module testing

Test Requirements for ECM	The Keysight TS-5020 Solution
Fast switching for routing of multiple signals and loads	– Programmable, easy to use switch path editor – Scalable switching solution to cater up to 112 pins – Load switching support up to 5 A – Maximum of 80 load channels – 42 V-ready solution
Real-world waveform and signal generation	– Variable reluctance and Hall-effect sensor simulation
High-current and high-voltage response handling	– Flyback voltage and current handling – Voltages up to 150 V, currents up to 5 A – Period, frequency, timing and duration measurement capabilities
Serial communication	– ISO-9141 capability – J1850 capability – J1939 / CAN capability / fault-tolerant CAN / single- wire CAN

Three modes

The TS-5020 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 delayrise 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
– temperature.) 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 the reads the value at either the input or output of the module. The evaluationcan verify proper receipt of the signal at the module input or if the input cause the appropriate output.

Throughput multiplier

The throughput multiplier test strategy (multiple-up UUT testing) is one way to increase throughput for a manufacturing environment. Multiple UUT testing not only consolidates tasks common to multiple modules, such as load/unload, instrument setup of signal and load routing, it's also an effective strategy for overlapping inherent latencies in the UUT or test system [shown in figures 5 and 6].

Reduce total test cost

Test cost is only one factor in reducing the total cost of manufacturing an ECM. However, it is the tangible cost that can be reduced by test engineering to reduce cost times, equipment costs and floor space. The TS-5020 answers the call by delivering reduced integration costs, floor space and test times.

With the volume increase in safety, security and convenience modules, manufacturers are looking for ways to meet their line-production rate without building up inventory on the production line. Using the throughput multiplier for parallel multiple-up testing of ECMs not only reduces floor space and increases asset utilization, it decreases test times per ECM.

Instrumentation hardware is often believed to be the most significant contributor to test cost, but that may not always be the case. Hidden costs of software engineering time, operating costs and maintenance expenses must also be considered in the cost equation. 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 with a unique, custom-built system.
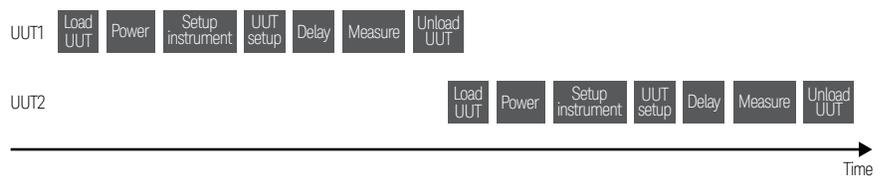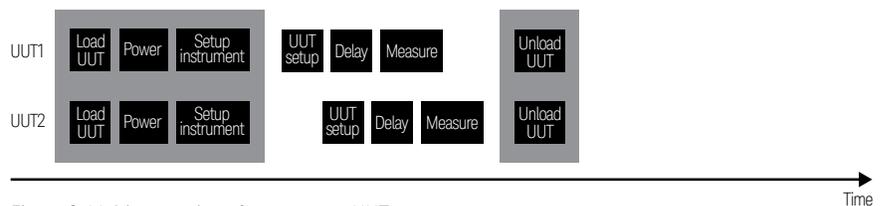

Figure 5. Single-uptesting of two or more UUTs.

Figure 6. Multi-up testing of two or more UUTs.

System Software Reduces Development time

The TestExec SL software which comes with the TS-5020 provides a complete test development and test execution environment for the entire software development job. The test executive environment is tuned for functional testing of electronic devices in manufacturing. The software runs on a PC with Windows XP Pro for optimum performance, and comes pre-installed and ready to use. The TestExec SL development environment is ideal for creating ECM functional test plans. It consists of re-usable tests, measurements and utilities for performing specific functions related to automotive electronics functional test. Templates and examples are provided to serve as a starting point for creating tests. The Keysight test executive allows you to organize and order tests, reconfigure the test stand, profile the execution speed and debug tests. What's more, the software test execution environment allows an operator to test up to N modules simultaneously (where N>1) and report test information back to the operator. Using the software utilities, the test executive can be easily linked with factory automation, bar code readers and printers.

The Keysight TestExec SL Software Development Environment

The hierarchical test development architecture encourages reuse to decrease development time on upcoming projects. The software provides an efficient and effective structure for developing the test plans and sequencing for functional test of automotive ECMs. Many measurements, tests and utilities are already provided as building blocks. Over 400 routines tuned towards automotive test provide maximum quality. A test engineering software team needs only create the test plan and sequencing from the integral building blocks of software, add customization for the manufacturer's specific ECM serial commands and create any customer test and/or measurements.
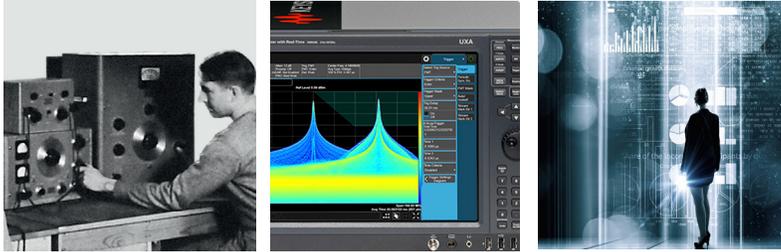
Find the right solution for your needs

To discuss your requirement in detail, please call your local Keysight office to arrange a consultation. To learn more about the TS-5000 family, visit us on the web at www.Keysight.com/find/ts5020. The website also contains information about the full range of Keysight products and services that can help your engineering teams simulate and diagnose system performance in the design stage.

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