Electro Rent

THE FUTURE OF THE AUTOMOBILE

Managing Test Capabilities in Rapidly Evolving Electronic Environments

Contents

Overview

In this paper, Electro Rent examines current and future changes in the U.S. automotive sector and the impact of the accelerating rate of technological change and innovation on the test function. The document explores the ways in which automotive OEMs and Tier 1 suppliers are partnering with test equipment solution providers to address emerging issues in this sector. It also provides an overview of the consultative approach taken by Electro Rent in advising automakers and auto engineers about the most cost-effective strategies for acquiring and managing modern test technology, while saving time and money and ensuring access to the latest equipment.

How to Manage Test Capabilities in the Rapidly Evolving Automotive Sector

The automotive industry is undergoing major upheaval as we move from driver-controlled vehicles to the adoption of Advanced Driver Assistance Systems (ADAS), and eventually the prospect of fully autonomous vehicles. The underlying technology is becoming ever more complex as additional functionality is integrated into vehicle architectures to support higher degrees of connectivity. As technology evolves, at some point driving may become secondary, transforming driver into passenger in a completely automated vehicle.

Advances in automotive engineering — especially in the areas of sensor fusion, power management, and artificial intelligence — mean that more sophisticated test strategies may be required to address the automotive revolution that is now upon us.

Along the way, advances in automotive engineering must continue to support the development of vehicles to meet the needs of future automotive buyers—especially in

the areas of sensor fusion, power management, and artificial intelligence. While the implementation of emerging technologies presents design engineers with considerable challenges, it can also strain test department resources. Consequently, more sophisticated test strategies may be required to address the automotive revolution that is now upon us.

Automotive Innovation

The journey to autonomous vehicles is a primary, long-term objective of the automobile industry. It began years ago as electronics were increasingly added to vehicles, mostly as separate modules that provided additional features and functionality. In recent times, automakers have been replacing mechanical functionality with new, solid-state electronic systems to reduce weight, increase fuel economy and improve reliability. These advances mean that most models today have computing and processing capabilities far beyond what would have been found in the past in large mainframe computers.

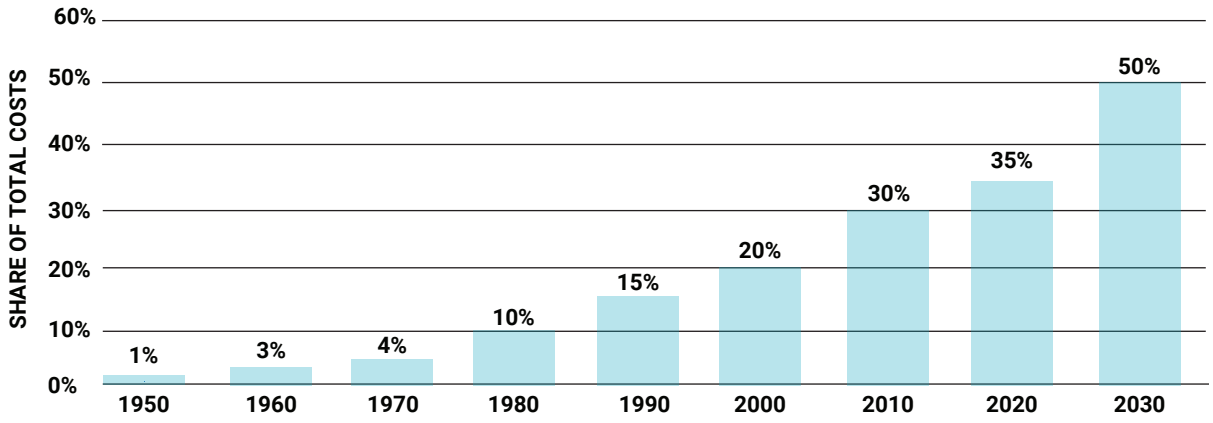


Figure 1: Automotive Electronics Cost as a Percentage of Total Car Cost [Source: Statista]

The migration toward greater electrification and semi-autonomous driving runs the gamut of vehicles. Not only high-specification luxury models, but economy versions too. Even commercial, construction and agricultural vehicles are becoming more automated, efficient, and safer through the introduction of new electronic systems.

Regardless of whether the drivetrain is based upon the internal combustion engine, Electric Vehicle (EV), or Hybrid Electric Vehicle (HEV), electronic content is proliferating and will continue to do so. In fact, according to Statista, the electronics content in an

average car is now around one third of its total cost, and this is predicted to grow to nearly half during the next decade.

By increasing electronic content in vehicles, it will be possible to shift more of the responsibility for decision-making from the human driver to the vehicle itself. While some see this as a revolution, it is in fact an evolution. In the United States, the Society of Automotive Engineers (SAE) mapped out the path toward vehicle autonomy by defining the key stages.

Each of the stages outlined in SAE J3016 shows how key functions of driving will be deferred to the vehicle and its systems. We are already moving down this path, with many vehicles being produced today that are already at either SAE Level 1 or Level 2.

SAE LEVEL	NAME	NARRATIVE	STEERING, ACCELERATION / DEDELERATION	MONITORING OF DRIVING ENVIRONMENT	FALLBACK PERFORMANCE OF DYNAMIC DRIVING TASKS	SYSTEM CAPABILITY (DRIVING MODES)
0	NO AUTOMATION	Full-time human driver (even when enhanced by warning or intervention systems)	HUMAN	HUMAN	HUMAN	N/A
1	DRIVER ASSISTANCE	Driver assistance system (either steering —or— acceleration / deceleration); human performs remaining driving tasks	HUMAN AND SYSTEM	HUMAN	HUMAN	SOME DRIVING MODES
2	PARTIAL AUTOMATION	Driver assistance system (both steering —and— acceleration / deceleration); human performs remaining driving tasks	SYSTEM	HUMAN	HUMAN	SOME DRIVING MODES
3	CONDITIONAL AUTOMATION	System performs all driving tasks; expectation that human will respond appropriately to request to intervene	SYSTEM	SYSTEM	HUMAN	SOME DRIVING MODES
4	HIGH AUTOMATION	System performs all driving tasks; even if human does not respond appropriately to request to intervene	SYSTEM	SYSTEM	SYSTEM	SOME DRIVING MODES
5	FULL AUTOMATION	System performs all driving tasks under all road and environmental conditions that can be managed by a human	SYSTEM	SYSTEM	SYSTEM	ALL DRIVING MODES

Figure 2: The Steps Leading to Full Vehicle Automation Defined by the SAE J3016 Standard [Source: SAE International]

Implications for Automotive Test

While the changes the auto industry faces are significant, and the timeframes compressed, the steps involved are clearly defined. Nevertheless, there remains a significant amount of uncertainty. First, there is little definition or understanding of the technical issues that lie ahead. Despite the huge amount of manpower and financial resources dedicated to developing the vehicles of the future, the industry will almost certainly be on the receiving end of some unexpected challenges. If we turn to industry analysts and commentators for certainty, we may be disappointed. Depending on which column you read, you could be convinced that fully autonomous motoring is just around the corner, or conversely that it is many years away.

One of the areas, however, where we can be certain of at least a few things, is automotive test and measurement. As new technologies emerge, test strategies must evolve accordingly. In some cases, this means a reconfiguration of existing facilities or upgrading equipment for faster or more accurate measurement speed. In other cases, it may be a completely new function that requires a new or different type of instrumentation.

As new technologies are introduced, test strategies must evolve accordingly. Sometimes, a reconfiguration or upgrade of existing facilities is required; other times, a completely new function may require a new or different type of instrumentation.

The pace of change in the industry and the lack of certainty regarding which technologies might be adopted are going to drive an unprecedented need for auto test departments and suppliers to react more quickly and become far more flexible. Due to the pace of technological change, test equipment is likely to become obsolete earlier in its lifecycle. Budget-constrained test engineers will need new strategies to address the competing goals of getting the job done while working within increasingly stringent budget constraints.

The wide range of technologies—including power management and control, high-data-rate communication busses, wireless connectivity, and sensing technologies employed in modern vehicles will add to the pressures involved.

Electrical Powertrain

Especially relevant to HEVs and EVs, managing efficient use of power from the battery string will become a key competitive advantage for vehicle manufacturers. The complex vehicle power system will include DC-DC converters that supply different areas of the vehicle, and energy-recovery braking systems that ensure all available energy is directed toward increasing driving range.

Bus Systems/Sensors

As vehicles move toward full autonomy, no longer can electronic systems be a collection of disparate functional modules. To provide the intelligence, perception, and decision making required to approach human awareness in vehicles, each of these functions must combine into a single, ultra-intelligent system. As many of these functions are safety-critical (such as ADAS obstacle detection), ultra-low latency within the system will be required.

In-vehicle networking is coming to the forefront, and traditional automotive busses such as CAN-FD, LIN, FlexRAY, and MOST are being augmented with other technologies such as Ethernet. High-speed busses need high-speed test capability.

Connectivity

Until recently, vehicle communication was limited to infotainment and satellite navigation systems. However, with the prospect of vehicles being connected to each other and to the infrastructure of smart cities, a communication transformation must occur. Vehicle-to-infrastructure (V2I) connectivity enables vehicles to be notified, in advance, about accidents, closures, obstacles in the road, or the availability and location of parking spaces at their destination. It also allows municipal authorities to monitor traffic flow, minimize traffic congestion at peak times, and reduce emissions.

In addition to V2I communication, future vehicles will also communicate with each other via vehicle-to-vehicle (V2V) communication. This will enable one vehicle to broadcast its intention to leave a road lane or arrive at an intersection, thereby reducing collision risk. Likewise, details of traffic issues, such as an unexpected obstacle ahead, will be sent between vehicles to make them aware of issues in advance. In a V2X scenario, vehicles could share information about road conditions with other devices—including traffic signals, sensors, emergency roadside warnings, and hazard systems—and with pedestrians and sensors embedded in road systems.

Modern vehicles already allow passengers to connect via their smart devices, allowing access to applications that make journeys easier, safer, and more efficient. The ongoing proliferation of in-vehicle communication will lead to multiple protocols such as WLAN, Bluetooth, and NFC within the vehicle itself, and mobile protocols such as LTE and LTE Advanced for external communications with other vehicles and the local environment.

EMC Considerations

The amount of electronics in modern vehicles continues to rise, which brings challenges regarding electro-magnetic compatibility (EMC)—the amount of radiated energy created by the vehicle and the susceptibility of sensitive electronics inside the vehicle to externally-generated radiation.

The ongoing proliferation of in-vehicle communication will lead to multiple protocols for external communications with other vehicles and the local environment.

As vehicles become more aware of their environment, sensors are becoming ever more important, and as with any new technology, they require comprehensive testing and verification. GHz-band radar is a key development for vehicles and is also used in infrastructure applications for position sensing and object detection. Applying radar technologies to advanced automotive solutions such as advanced driver assistance systems and autonomous vehicles helps avoid potential risks from other vehicles, pedestrians and road objects and makes self-driving cars possible. Major applications of automotive radar include advanced emergency braking, blind spot monitoring, lane change assist, adaptive cruise control, parking assist, front and rear cross traffic alert, stop-and-go, and more.

ADAS

A major goal of the move toward automated vehicles is to increase safety on roads through ADAS. Through such systems, it is possible to detect objects such as vehicles or pedestrians, allowing them to be avoided without driver intervention. To ensure operational integrity of ADAS systems as they become increasingly complex, significant testing will be required, often to meet ASIL specification and other safety standards.

Time for a Test Revolution

Accelerating development cycles and continually-advancing technologies are putting a significant burden on test departments and their budgets. The default model of simply buying all necessary equipment up-front could well exacerbate financial strain in these swiftly-changing times.

To ensure operational integrity of ADAS systems as they become increasingly complex, significant testing will be required, often to meet ASIL specification and other safety standards.

Independent, third-party solution providers are well positioned to provide advice and recommendations that help users make more informed decisions regarding product selection, acquisition method, and financing alternatives. This substantially reduces testing costs and provides flexibility to upgrade equipment or technology as needed.

It is now recognized that complex, multi-site projects can rarely be served with a one-size-fits-all approach. Therefore, there are great benefits in working with a partner that offers a wide array of sourcing options to manage test equipment throughout the entire project lifecycle, from concept to prototyping, development, and full-scale production.

Instrumentation can be sourced through various methods, including short-term renting, longer-term leasing, rent-to-buy, new equipment, or certified pre-owned equipment. Rented equipment incurs a charge only for as long as it is kept. If a project ends, or new technology means that different instrumentation is required, the rented items can be sent back or replaced with newer units featuring the latest testing technology.

This means that there is no risk of equipment becoming outdated or investments in new testing product being wasted. Similarly, purchased equipment—whether originally bought new or acquired through the certified pre-owned program—can be sold back, making funds available for sourcing other equipment. Once your solution provider understands your situation, which may include both short and long-term needs and

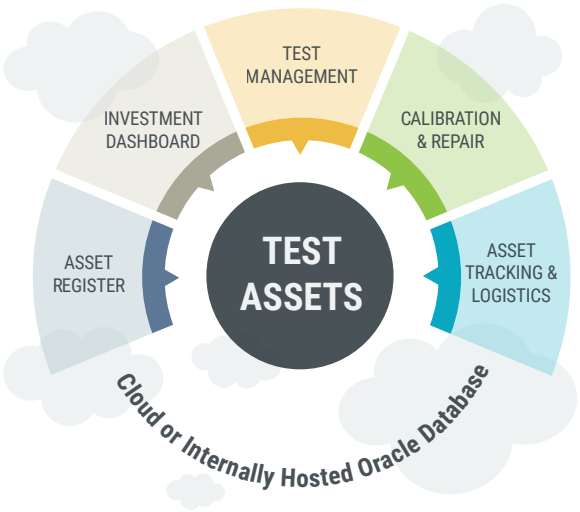
CapEx or OpEx priorities, they can recommend various options, or a mix of solutions, to achieve the greatest savings and efficiencies.

Asset Optimization Solutions

Electro Rent offers a complete asset optimization solution for test departments that includes equipment tracking, auditing, and management. This modular platform provides complete test asset visibility, allowing the location and details of each piece to be identified quickly and easily.

Using the latest evolution of Bluetooth® low energy solutions, real-time asset management of high-value testing equipment is now possible. Bluetooth® beacons with a battery life of four to five years are affixed to each asset to transmit low-energy signals that are recognized by the application on the user's mobile device or by static readers.

Asset Optimization



While modern test and measurement equipment enables projects to be completed in an efficient and timely manner, these Bluetooth®-enabled asset management devices help companies reduce costs, increase visibility and accountability, eliminate redundant assets, and improve equipment utilization.

Accessed via a smartphone, tablet, or PC, engineers, product managers, and finance teams can gain access to a real-time view of all test and measurement equipment.

Users can manage maintenance, repair, and calibration schedules for each item, and monitor equipment utilization and asset performance.

With this information, companies can approve requests, estimate cost and delivery times, allocate costs, and make informed rent vs. buy decisions. The system also helps users eliminate unnecessary purchases, arrange for sale of used instruments, and free up storage space and associated operating costs for lightly-used or no-longer-used equipment.

Conclusion

The automotive world is moving into a new era that will be defined by increasing connectivity, greater levels of electronic content, and work toward autonomous vehicle operation. The pace of change is increasing. New technologies such as 5G, the Internet of Things, and industrial automation are emerging that will significantly broaden the scope of items that require testing and verification. To keep up with this demand and budget constraints, test departments must seek out intelligent and multifaceted solutions that can be tailored to their needs--without compromise.

The pace of change is increasing and new technologies are emerging that will significantly broaden the scope of items that require testing and verification.

By leveraging the right information from those with expertise and knowledge in test management, and by understanding the variety of sourcing options available, test engineers and managers can choose the best combination for their projects on a case-by-case basis. At the same time, new sourcing methods generate significant savings for reinvestment. If new technologies arise, they allow the flexibility to upgrade as required without the need for additional investments. Similarly, if a project moves from prototyping to large-scale production, the number of test units can be increased quickly to meet the new projected demand.

Keysight
M8195A Arbitrary Waveform Generator (AWG)

The Keysight M8195A arbitrary waveform generator (AWG) provides up to 65 GSa/s, 25 GHz bandwidth, 8 bits vertical resolution, and up to 4 channels in a 1-slot AXIe module - simultaneously. As devices and interfaces become faster and more complex, the M8195A AWG gives you the versatility to create the signals you need for digital applications, advanced research, wideband radar, satcom, and optical communications.

Key Facts

As devices and interfaces become faster and more complex, the M8195A AWG gives you the versatility to create the signals you need for digital applications, optical and electrical communication, advanced research, wideband radar and satcom.

- Multi-level / Multi-channel digital signals - generate NRZ, PAM4, PAM8, DMT, etc. signals at up to 32 GBaud
- In addition, protocols such as HDMITM, C-PHYTM and D-PHYTM are supported
- Embed/De-embed channels, add Jitter, ISI, noise and other distortions
- Electronics research – generate any mathematically defined arbitrary waveforms, ultra-short yet precise pulses and extremely wideband chirps
- Wideband RF/µW - generate extremely wideband RF signals with an instantaneous bandwidth of DC to 25 GHz

Driver Assistance

Rohde & Schwarz
FSW85 Signal and Spectrum Analyzer

The R&S®FSW85 signal and spectrum analyzer is ideal for measuring radar sensor RF parameters such as frequency, effective isotropically-radiated power (EIRP), and occupied bandwidth and spurious emissions during development, production and verification.

The analyzer scans the range from 2 Hz to 85 GHz (up to 90 GHz with the R&S®FSW-B90G option) and analyzes RF signals produced by radar sensors in the E band. No external harmonic mixers are required.

Infotainment

Rohde & Schwarz
SMW200A Vector Signal Generator

The R&S®SMW200A is the vector signal generator for demanding applications. With its flexibility, performance and intuitive operation, it is especially suited for generating complex, digitally-modulated signals of high quality.

The SMW200A is the ideal generator for digitally-modulated signals required for the development of new wideband communications systems.

The I/Q modulation bandwidth of up to 2 GHz with internal baseband satisfies fourth- and fifth-generation standards (e.g. 5G, LTE-Advanced and IEEE802.11ac/ad), and is designed to meet future requirements.

Key Facts

- Frequency range from 100 kHz to 3 GHz, 6 GHz or 20 GHz
- Optional second RF path with 100 kHz up to 3 GHz, 6 GHz or 20 GHz
- Versatile configuration: from single-path vector signal generator to multichannel MIMO receiver tester
- Ideal for MIMO, MSR or LTE-Advanced applications thanks to up to eight signal sources and up to 16 fading channels
- Modular architecture for optimal adaptation to the application at hand

Power Management

Tektronix
MDO4000 Series Mixed Domain Oscilloscope w/ Power Analysis Application

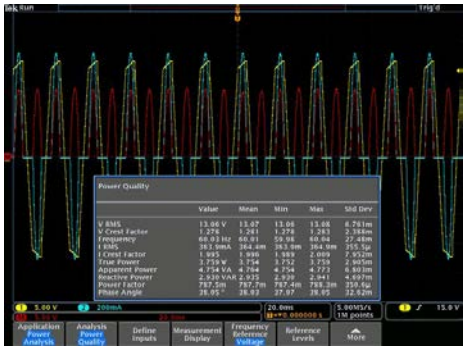
The Tektronix MDO4000 Series oscilloscopes with power analysis application module dramatically simplifies the analysis of power supplies. Automated power measurements such as harmonics, power quality, switching loss, safe operating area, slew rate, modulation and ripple ensure fast analysis. Simplified setup and deskview of probes provides maximum accuracy.

Key Facts

TEK-MDO4104C/SA0

- 4 analog channels
- Bandwidth 1GHz
- Up to 5 GS/s sample rate waveform capture rate
- 20 M record length on all channels
- 340,000 wfm/s maximum waveform capture rate
- Standard passive voltage probes with 3.9 pF capacitive loading and 1 GHz analog bandwidth
- TPP1000:1GHZ for MDO4104C

Tektronix
DPO4PWR Power Analysis Application Module



With the DPO4PWR Power Analysis Application Module installed on an MDO4000 Series oscilloscope, an embedded designer who rarely deals with power measurements can quickly get the same accurate, repeatable results as a power supply expert. A Power Analysis Application Module with an oscilloscope and differential voltage and current probes form a complete measurement system for power supply design and test.

Key Facts

- Power loss measurement at switching device
- Characterization of power semiconductor devices
- Optimal drive characterization of synchronous rectifiers
- Measurement and analysis of ripple and noise
- Pre-compliance testing to IEC standard EN61000 3-2 Class A, MIL Standard 1399 Section 300A, and up to 400 harmonics
- Debugging active power factor correction circuits
- 340,000 wfm/s maximum waveform capture rate
- Standard passive voltage probes with 3.9 pF capacitive loading and 1 GHz analog bandwidth
- TPP1000:1GHZ for MDO4104C

Power Management

Keysight
N6705C Modular DC Power Analyzer

The N6705C DC Power Analyzer provides productivity gains for sourcing and measuring DC voltage and current into the DUT by integrating up to 4 advanced power supplies with DMM, Scope, Arb, and Data Logger features. Eliminates the need to gather multiple pieces of equipment and create complex test setups including transducers (such as current probes and shunts) to measure current into your DUT. The DC Power Analyzer also eliminates the need to develop and debug programs to control a collection of instruments and take useful measurements because all functions and measurements are available at the front panel.

The N6705C DC Power Analyzer can be used with the 14585A Control and Analysis Software. When automated bench setups are required, the N6705C is fully programmable over GPIB, USB, LAN and is LXI Compliant. The N6705C offers flexible configuration to meet your power sourcing and analysis requirements.

Key Facts

- 4-slot mainframe holds up to 600 W of total power and up to 4 modules.
- More than 30 DC power modules to choose from (modules ordered separately)
- Voltmeter accuracy: Up to 0.025% + 50 µV, up to 18 bits
- Ammeter accuracy: Up to 0.025% + 8 nA, up to 18 bits
- Arbitrary waveform generator function: Bandwidth up to 100 kHz, output power up to 500 W
- Scope function: Digitizes voltage and current at up to 200 kHz, 512 kpts, up to 18 bits
- Data logger function: Measurement interval from 20 µs to 60 s, max of 500 M readings per datalog
- 4 GB of non-volatile data storage for data log, scope traces, instrument settings

Connectivity

Keysight
N5182B MXG X-Series RF Vector Signal Generator

Keysight
N9020B MXA Signal Analyzer, Multi-Touch

Keysight offers accurate and flexible signal generation and signal analysis solutions for the 802.11p design and test lifecycle. The signal generation solution comprises the N7617B Signal Studio for WLAN 802.11a/b/g/j/p/n/ac/ah software, which enables creation of standard-compliant 802.11p waveforms that can be used for accurate receiver testing and evaluation of receiver performance using the N5182B MXG vector signal generator.

The signal analysis solution is made up of the 89601B vector signal analysis (VSA) software with WLAN Modulation Analysis for 802.11a/b/g/p/j (89601B VSA Option B7R) and the N9020B MXG signal analyzers with N9077 WLAN 802.11a/b/g/j/p/n/ac/ah Measurement Application. Together, these signal generation and analysis solutions address and exceed the stringent requirements of 802.11p physical layer tests—from research, development, verification to manufacturing.

Bus Systems / Sensors

Keysight
Infinivision 6000 X-Series Mixed Signal Oscilloscope

The InfiniiVision 6000 X-Series oscilloscopes are designed for engineers who want bandwidth, visualization power and the flexibility that comes with integrated capabilities but with portability, a familiar embedded OS user interface. Many of today's designs include multiple serial buses. Sometimes it may be necessary to correlate data from one serial bus to another.

InfiniiVision 6000 X-Series oscilloscopes can decode two serial buses simultaneously using hardware-based decoding. They can also display the captured data in a time interleaved "Lister" display. Using a DSOX6AUTO Automotive Serial Trigger/Analysis package, the scope can simultaneously decode and interleave a CAN and LIN bus in an automotive system.

Key Facts

Keysight MSOX6004A

- Bandwidth: 1 GHz
- Channels: 4 analog channels +16 digital channels
- Max sample rate: 20 GSa/s
- Max memory: 4 Mpts
- Display: 12.1-inch capacitive multi-touch display
- Waveform update rate: > 450,000 waveforms per second
- Trigger: InfiniiScan Zone touch trigger + standard advanced triggers
- Advanced math: Standard, display four funtions simultaneously
- Connectivity: Standard USB 2.0, LAN, video (GPIB option), USB mouse, keyboard, and microphone support
- Analysis: Histogram, color grade, jitter/real-time eye diagram (option), enhanced FFT, segmented memory, search/navigate, advanced math functions, limit/mask test (option)

Bus Systems / Sensors

Rohde & Schwarz
ZNB Vector Network Analyzer

The R&S®ZNB family of vector network analyzers feature high measurement speed, outstanding precision and exceptional ease of operation.

Key Facts

- Wide dynamic range from 9 kHz for fast measurements on high-blocking DUTs
- Excellent raw data for high basic accuracy
- High temperature stability for long calibration intervals
- Fast synthesizers for high measurement speed
- Fast embedding/de-embedding for impedance matching using virtual networks
- Mixed-mode S-parameters for balanced DUT characterization
- Redefined S-parameters for flexible test setup configuration
- Extensive analysis functions for efficient trace analysis
- Amplifier measurements with wide power sweep range and receiver step attenuators
- Time domain analysis for distance-to-fault (DTF) measurements and filter adjustment
- Frequency conversion measurements on mixers and amplifiers – fast and simple with two independent internal generators
- The right calibration method for every test application TSM (Through, Short, Match) – full calibration in only five steps
- Automatic calibration units with up to 24 ports
- Flat and clear menu structures for efficient operation
- Optimal display configuration for each task

EMC

Haefely
ONYX30 30kV Electrostatic Discharge Test System

The ONYX30 is a state-of-the-art electrostatic discharge simulator. It is an ergonomic 30 kV ESD gun without an additional base control unit that can be battery or mains operated. The easy to use touch screen, ergonomic design, modular RC units, multilingual interface, remote control software, built-in LED light, and temperature and humidity display allow for trouble-free use of the ONYX in all test sites. Also available in a 16kV version.

Key Facts

- User defined 'smart key' function
- Touch screen interface
- All-in-one design (no base unit)
- Predefined tests according to standards
- Define, store and load tests
- User changeable RC networks
- Automatic polarity switching
- Remote control
- Battery or mains operation, long battery life

Full-compliance and pre-compliance testing to a wide variety of standards: IEC/EN 61000-4-2 Edition 2 (2009), IEC/EN 61326, IEC/EN 61000-6-1 & -6-2, IEC 61340-3-1, ISO 10605, GMW 3097, Ford AB/AC, ANSI C63.16, PSA B21 7110, ISO 14304, ITU-T K.20, RTCA/DO-160, JEDEC 22-A114, MIL-STD-331 / -464 / -883 / -1512 /-1514 / -1541 / -1542, GR-78-CORE, GR-1089-CORE.

Contact Us Today

Contact us today to learn more about our complete portfolio of automotive 5G testing products.

You can reach us by phone at **1.800.553.2255** or email **automotive@electrorent.com**.
Our experts are available to assist with your product testing and financing needs.

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