

SIGNAL ANALYSIS OF SMART CABLES on the test bench



In safety-critical fields such as law enforcement, emergency services, aviation, construction, or defense, reliable communication is essential for **safe** and **coordinated operations**. Whether securing a mission site, enabling communication on the airfield, or ensuring the safe operation of heavy machinery – functioning, interference-free audio signals are indispensable. Any disruption can have severe consequences, including personal injury, making flawless functionality crucial. In these application areas, intelligent cables are increasingly being used.

In addition to simple **signal transmission**, there are also control functions, embedded components, or programmable electronics integrated. These cables are more complex in design and often feature specially assembled connectors with enhanced sealing or shielding. As a result, conventional connection or functional testing is insufficient.

INITIAL SITUATION

The customer manufactures a wide range of communication devices – from simple point-to-point connections to complex “USB-C to Audio Adapters” with integrated electronics and special connectors. There had been **repeated complaints**, where detailed root cause analysis revealed that not the electronics but the cable itself was defective.

Non-destructive diagnostics had previously not been possible, especially for lines carrying high frequencies and integrated components. Furthermore, there were no test tools on the market that could combine audio analysis, connection testing, and bus communication in a single test system.

OBJECTIVES AND CHALLENGES

Many existing test systems are designed for simple continuity checks or signal quality measurements. However, with the advent of active electronics in cables, the requirements have risen significantly: in addition to conventional tests, **logic-based components**, digital interfaces, and high-frequency (HF) sensitive connections must also be verified.

Particularly in communication cables with USB or Ethernet interfaces, clock frequencies, encoding, and timing introduce new challenges.

An additional difficulty is that high-density connector layouts with minimal pin spacing increase susceptibility to crosstalk and reflections, while potting and sealing systems for high protection classes (e.g., IP66/67) encapsulate the contacts and restrict probing access. This combination makes non-destructive diagnostics and **precise fault localization** highly challenging.

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REQUIREMENTS

To systematically address the mentioned challenges in cable testing, clear requirements for a suitable test system were defined. A central prerequisite was the capability to verify complex communication cables integrating multiple interfaces such as USB, LAN, and audio. The system needed not only to perform simple continuity checks but also to support **functional testing** of active components, ensuring a realistic evaluation of operational readiness.



Another key requirement was the ability to reliably test **digital signals** and bus communication. This called for a standardized yet modular and expandable test architecture, adaptable to a wide variety of connector types. Additionally, a counting function was required to track mechanical wear at the contact points and to document connector usage cycles.

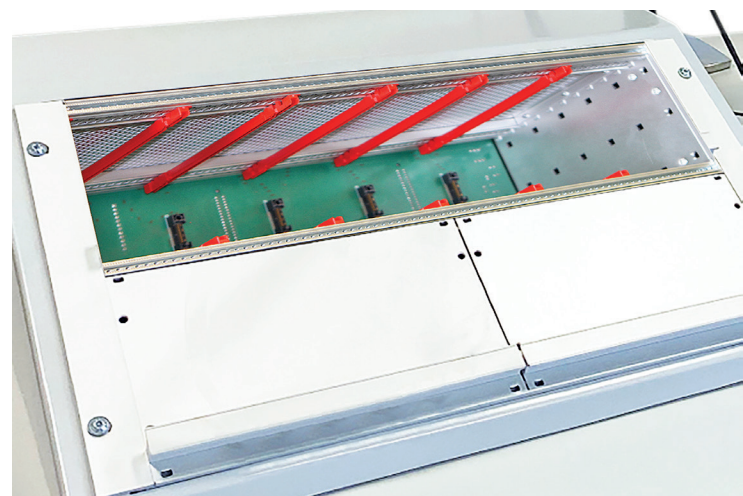
In order to ensure a future-proof solution, the test system had to be deployable both at the customer's site as well as at their suppliers. To ensure long-term and **cost-efficient operation**, it was essential that the customer could independently expand the system in hardware and software, tailoring it to specific test requirements.

SOLUTION CONCEPT

MCD developed a modular test system based on its proprietary universal **VTS 2030** rack platform, into which the relevant 19" measurement components are integrated. The central feature is a cassette concept, with each cassette covering different connector types – e.g., USB-C, LAN, audio, or digital I/Os. Each cassette is equipped with its own electronics for signal generation, measurement, and communication with the DUT, as well as dedicated logic and internal cycle counters for connector wear monitoring.

The central measurement devices in the system – including multimeters, AudioAnalyzers, oscilloscopes, and communication units – are connected to the cassettes via a universal high-frequency-capable backplane. This design combines mechanical robustness with modular expandability while ensuring low-loss transmission of high-frequency signals. Thus, a single infrastructure can reliably support multiple interface standards as well as **future high-speed applications**.

The functional scope also includes expandable EEPROM programming, audio analysis, and oscilloscope-based signal quality testing, as well as live diagnostics of active components using integrated embedded systems.



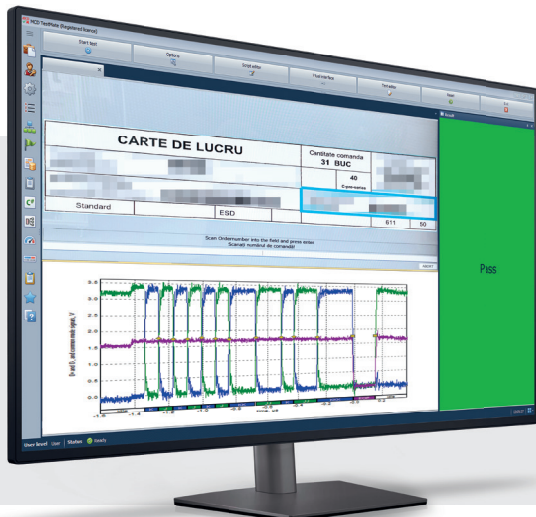
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MEETING THE REQUIREMENTS

All customer requirements were fully met with the **modular system** concept. The combination of universal infrastructure (power supplies, bus system, backplane), application-specific cassette interfaces, and intelligent software provides both standardization and adaptability.



By monitoring the connector cycles of each cassette with the integrated counting system, maintenance intervals become predictable, and production as well as testing processes can be optimized. Customers can independently add new cassettes and configure their functions via the software platform **MCD TestMATE**.



CUSTOMER BENEFITS

With the modular communication cable tester, MCD offers a **highly customizable** and precise solution for multi-level quality assurance of intelligent cables. For maximum modularity, a VTS 2030 rack was used. This flexible system can accommodate 19" assemblies on both sides. With its easy adaptability of common test adapters, the sustainability of the systems is also guaranteed. Reliable and future-proof measurement tools such as AudioAnalyzers, multimeters, and oscilloscopes are integrated and interconnected via a proprietary central backplane.

Thanks to the **cassette technology**, new connector types can be easily integrated, enabling efficient handling of even complex interface standards and accommodating future customer requirements without requiring complete system redesigns. Particular emphasis was placed on HF-capable connections, high bandwidth and signal integrity, as well as the ability for synchronous data acquisition.

The entire test sequence control is managed via **MCD TestMATE**, which interfaces with the connected measurement instruments through hardware-specific control software, the so-called MCD Toolmonitors. Functions such as FFT, frequency and level measurements, I²C communication, or USB/LAN analysis can be flexibly combined in the test sequences. The customer thus benefits from a modern and universal test solution that can be used across multiple production sites or even at qualified suppliers.

