



The Complete **Test and Measurement Guide** for Better Functional Tests





Your equipment has to work. This is especially true for high-stakes industries such as automotive, military, aviation and medical. Whether you are designing a new car or airplane or working on a revolutionary medical device, making sure that your designs do their job is key to keeping your business running, and possibly saving lives.

That is why design engineers rely on high-quality functional testing equipment. Through accurate, reliable and redundant test systems, you can ensure that your devices:

- **Meet performance requirements**
- **Maintain cost-efficient power usage**
- **Hold up to their operational environment**
- **Meet regulatory standards**

Your equipment has to work, and functional tests make sure that they do. This guide will cover why functional tests are so important, how accuracy and reliability are key, and what kinds of testing equipment you can use to ensure that your designs meet expectations.

The Importance of Functional Tests: Switching and Black Box Testing

Functional tests are what help you to validate your designs. They allow you to monitor and record data on the physical integrity and performance of your machines and equipment, as well as streamline the testing of complex electronic systems.

A lot of functional testing revolves around black box testing. Black box testing is where you test out software by examining its functionality without knowing or considering the internal structure of the software. The main goal is to verify that all operational requirements are met, looking at everything from the view of the end user.



Black box testing is the gold standard for qualifying equipment in many high-level industries and ensuring your black box testing is up to code should be a top priority. Testing is not just something that you have to do to get it over with. It is an absolutely critical step to ensuring that whatever design capabilities you had in your mind have transferred to the actual product.

Automated test equipment (ATE) can help to ensure that your black box testing is efficient as possible. The more automated you can make your functional tests—without compromising their ability to output reliable data—the better. ATE engineers rely on automatic switching systems to ensure high-speed testing where strict sequences and combinations of switching must be observed. Switching systems play a vital role in automated test systems by allowing ATE engineers the ability to distribute Input/Output (I/O) instrumentation to multiple test points.

Specifically, relays, which are electronically operated switches, are what help enable automated tests with strict sequences and combinations of switching. The most common types of relays used in automated test system switching are:

- **Electromechanical relays**

- **Reed relays**

- **Solid-state relays**

By using automated switching systems, you can mitigate the chance of testing errors and inaccuracies, especially regarding human error. This leads to more standardized and repeatable test sequences. The configuration of your switching system is determined by your test specification, which comes from the functional test that you are performing.

Why Tests and Measurements Need to be Accurate

When performing a functional test, accuracy and reliability are of the utmost importance. You must be able to count on the results of your tests in order to properly qualify any equipment.

The truth is that high dollar items require a lot of testing. If you are going to charge the government a million dollars for a missile or putting a pretty price tag on a new sports car, you better make sure that your products work. That is why testing accuracy is so critical.

Since your switching system can affect the accuracy of your functional tests, you will want to prioritize better switches and relays. The ideal switch or relay will have the ability to:

- **Meet the current, resistance and voltage needs of your application's testing parameters**

- **Minimize voltage drop across the switch during tests**

- **Reduce rise time and fall time during state changes**

However, since no system is ever perfect in real life, you must factor in the effects of the switch itself and your switching hardware when calculating overall system accuracy. As signals encounter various forms of interference and sources of error when traveling to a destination, signals are often degraded when passing through a connecting cable or switch point. This is especially true with unshielded cables, which often cause current leakage that impacts measurement accuracy.

While no switch is perfect, designing better switching systems will help to minimize any impact on test results, and thus improve the accuracy of your functional tests. The importance of high-quality switching systems is made even more apparent when talking about one-shot destructive tests.



A Note on One-shot Destructive Tests

If you only have one chance at something, you need the best testing systems possible to make sure that you do not waste your opportunity. In the military and aerospace industry, you are often testing very expensive equipment and doing one-shot tests that can cost millions of dollars. This is because many of the tests are destructive and ruin the equipment you are assessing, like when testing an aircraft's fuselage. Get the test wrong, and you are not just throwing out millions of dollars, but also countless hours of work and designing.

That is why redundancy is so critical. If you are going to destroy millions of dollars' worth of equipment for a test, you will want to measure different points with multiple testing systems to ensure the test is not a complete failure if one of the systems goes down.



The Importance of Modular Switching Software

When designing switching software, it is best to take a modular systematic approach. Rather than treating your switching system as an afterthought and trying to piece together a collection of individual switch modules, a proactive modular approach allows you to consolidate everything down into a single mainframe. This results in an optimized switching system with a high-channel count capacity, all with a reduced footprint.

Modular switching systems also give ATE engineers the design flexibility to use domain-specific modules (i.e., power, RF, and low-frequency) that can be combined to cover whatever range of the signal spectrum you need. Switching systems depend on individual switch modules to operate as though they were a single subsystem, interfacing through external cabling, mass interconnect panels and test adapters in order to construct higher channel count multiplexers or matrices. Ignoring how everything comes together as a unified system can lead to:



**Delayed
Development
Timelines**



**Increased
Switching System
Complexity**



**Integration
Difficulties**



**Reduced Signal
Integrity**

That is why a well-integrated modular system is much better than trying to Frankenstein a solution together by connecting disparate switches with external cabling or wiring. A little planning can go a long way.

Industries, Applications and Future Trends

While reliable and accurate tests are great for any operation, certain industries and applications are more heavily dependent on functional tests. These include:



Military, Defense and Aerospace

Whether you are designing a missile for military operations or creating a new fighter jet engine, functional tests help to ensure that your machines and equipment do not fail out in the field. With lives literally on the line in many of these operations, there is little room for mistakes. A single failure could cause you to lose your government contract and force you to look for an entirely new business strategy. It does not even take a flat-out failure – if the speed of your jet is compromised or your missile does not travel as far as it was meant to, your contacts will be looking for another solution fast.



Commercial Aviation

The functional test requirements for a commercial aircraft are very similar to a military aircraft except for two key differences: the regulations that you must uphold and the needs of your customer. Commercial markets are less inclined to shut down your business if performance is slightly affected, but your planes still cannot fall out of the sky. Ever. Using the right functional test equipment can make sure that they don't.



Medical

Meeting all of the different regulatory and performance requirements of the medical device industry requires extensive validation from functional testing. Your testing must show that both the clinical needs and safety requirements of the device are accounted for.



Automotive

In the automotive industry, functional tests are used to validate many different parts of a vehicle, including the engine, airbags and braking system. Functional tests not only determine the performance specs that you can put on a vehicle when trying to sell it, but also things like safety ratings and fuel efficiencies.

While high-quality functional testing is an absolute necessity for the above industries, there are many other opportunities for better testing to improve product quality. When designing commercial appliances like a refrigerator or a dryer, the more you can guarantee reliable performance, the fewer units will fail and the happier your customers will be.

As industry evolves, the future of functional testing will include microwave switching, which will help major companies like Google and Verizon test 5G functionality and IoT devices. Since information is going to be moving at faster and faster speeds, frequencies are going up. Custom switch boxes will help to fully capitalize on high-speed telecommunication technology.

VTI Instruments: Equipment for Better Functional Tests

As part of the AMETEK Programmable Power team, VTI Instruments specializes in precision modular instrumentation and systems for electronic signal distribution, acquisition, and monitoring. Known for innovative testing and signal integrity, VTI Instruments creates functional test equipment and switching systems that produce reliable data the first time, every time.

For better testing in the world's most demanding application, AMETEK Programmable Power and VTI Instruments offer a number of functional test devices. Products span different modular instruments and modular switching devices, including:

SMX Family (PXI Express)



As an extension of VTI's EX1200 series switch family, the SMX series offers the largest collection of PXIe (not PXI) switches on the market. All SMX products offer space-saving, high-density designs without compromising on performance. By using the same switch driver that's used by EX1200, the SMX series allows for seamless integration between product families. With VTI's SMX products, you can easily transition from a low to medium size switch system in PXI Express to a large-scale EX1200 switch system. SMX series products include:

- General Purpose Switch products (SMX-2000/5000 series)
- Multiplexers (SMX-3000 series)
- Matrix Switching (SMX-4000 series)
- RF Switching (SMX-6000 series)
- Microwave switch products (SMX-7000 series)

SMIP (VXI)



VTI's SMIP™ signal switching series have helped revolutionize the automated signal switching market by providing an unprecedented level of modularity, density, and performance for the VXIbus platform. Used with everything from the Boeing 777 to Lockheed LMSTAR Avionics, the SMIP™ family includes power and general-purpose switching systems, multiplexers/scanners, and relay drivers, loads and digital I/O.

As a key part of the SMIP™ signal switching series, the VXI Modular Instrumentation Platform (VMIP™) provides an unmatched level of modularity. Designed for high performance instrumentation, the VMIP™ can make a single VXIbus card slot three times more powerful than typical single device solutions. Choose from over 20 unique instrument modules available on the platform, bringing a robust level of performance and design flexibility to advanced ATE systems.

EX7000 Family (LXI)



VTI's EX7000 product family offers modular microwave switch assemblies with an LXI-complaint LAN interface, enabling superior U wave and RF testing. All products are rack mountable and range in size from 1U to 4U.

EX1200 Instrument Family (LXI)



The award-winning EX1200 product family delivers a modular and scalable series of multifunction, configurable switching units. As the highest density switch and measure/control subsystem available today, the EX1200 series offers uncompromised performance and signal transparency.

In addition to measurably better functional test equipment, AMETEK Programmable Power and VTI Instruments have the testing expertise to make certain that you get the right testing solution. With years of functional testing experience across a variety of demanding applications, we can help you navigate the difficult process of product qualification for a better solution, faster. When a custom solution is what you need, VTI's experts can easily and affordably create a custom signal routing solution tailored to your unique application.

If you want to validate your designs and get your products to market faster without compromising on integrity, then you need functional test equipment from VTI Instruments, the standard in quality and reliability.



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