Keysight Technologies

FieldFox Microwave Analyzers

4/6/6.5/9/14/18/26.5 GHz

Introduction

Today, accurate RF and microwave measurements are becoming increasingly necessary in harsh and hard-to-reach environments. These scenarios span a wide range of conditions: day or night, rain or shine, hot or cold; aboard a ship, in an aircraft, or in a vehicle.

In these situations, a handheld instrument must be capable of making the required measurements with sufficient levels of performance and accuracy. Those attributes are important; however, given the expected operating conditions, physical and environmental specifications are equally important to the instrument and the user (Figure 1). This white paper presents general suggestions and specific examples regarding the essential attributes of handheld analyzers that will be used in harsh conditions.

Figure 1. The ideal RF or microwave handheld analyzer must be capable of making accurate measurements in tough working conditions.

Establishing a reference for "ruggedness"

United States military specification US MIL-PRF-28800F provides a set of benchmarks for test equipment that will be used in the testing and calibrating of electrical and electronic equipment. The spec includes four classes that range from the "extremes of world climatic variation" (Class 1) to controlled, protected operational environments (Class 4).

The 88-page specification is quite detailed, and section 3.8 uses 13 major categories to define the environmental requirements. Six of these are especially important in handheld analyzers:

– Environmental conditions (3.8.1)
– Temperature and humidity (3.8.2)
– Altitude (3.8.3)
– Vibration (3.8.4)
– Mechanical shock (3.8.5)
– Water resistance (3.8.6)

Within the bounds of these specifications, an instrument that satisfies Class 2 requirements will be capable of operating in rugged operational environments that include unprotected, uncontrolled climatic conditions. These are high hurdles for handheld RF and microwave instruments.

Another important consideration for handheld analyzers is operation in potentially explosive conditions. One of the key benchmarks is MIL-STD-810G, which covers the environmental considerations a device may experience in its service life and provides relevant laboratory tests. Within the standard, Test Method 511.5 deals with operation in an explosive atmosphere. Testing typically includes operation of the unit-under-test (UUT) in a chamber filled with explosive gases that may ignite if the UUT produces a spark. Passing this test is especially important for handheld instruments that may be used near the flammable fuels or gases present around aircraft, vehicles, mining operations, and so on.

Drawing a line in the sand

As demonstrated by currently available RF and microwave instruments, there are two ways to create a handheld unit: one is to repackage a conventional benchtop analyzer, and the other is to create an all-new instrument designed with field use firmly in mind.

Using MIL-PRF-28800F as a yardstick, many of today's "repackaged" instruments fall short in several key areas: temperature and humidity, vibration, mechanical shock, water resistance and dust exposure. Most stumble due to poor choices in areas such as component selection and package design. For example, components designed to work in an AC-powered device tend to be power-hungry, which has two undesirable consequences. One is shorter battery life, which is a significant shortcoming in the absence of AC outlets or spare batteries. The other is heat: these components often need fan-based cooling, and this requires vents to provide airflow through the instrument enclosure.

With these attributes, a typical repackaged design will have a hard time operating in tough—but typical—conditions: rain, dust, humidity, fluctuating temperatures, and so on. As a worst-case example, imagine a day in the desert, working on satellite ground stations with a fan-cooled handheld. Sandstorms are common and the instrument is likely to ingest significant amounts of foreign matter, which can lead to overheating more quickly than when operating in ideal conditions.

Designing from the ground up

The alternative to a repurposed instrument is a purpose-built device. In the ideal case, industrial and electronic designers would have the freedom to start with a clean slate. Design choices would be shaped by the need to provide high quality RF and microwave measurements in difficult conditions. To reduce the amount of equipment to be carried into the field, the overall design would be flexible enough to provide a wealth of capabilities in a compact package: cable and antenna analysis, vector network analysis, spectrum analysis, power measurement, interference analysis, and vector voltage measurement (Figure 2).

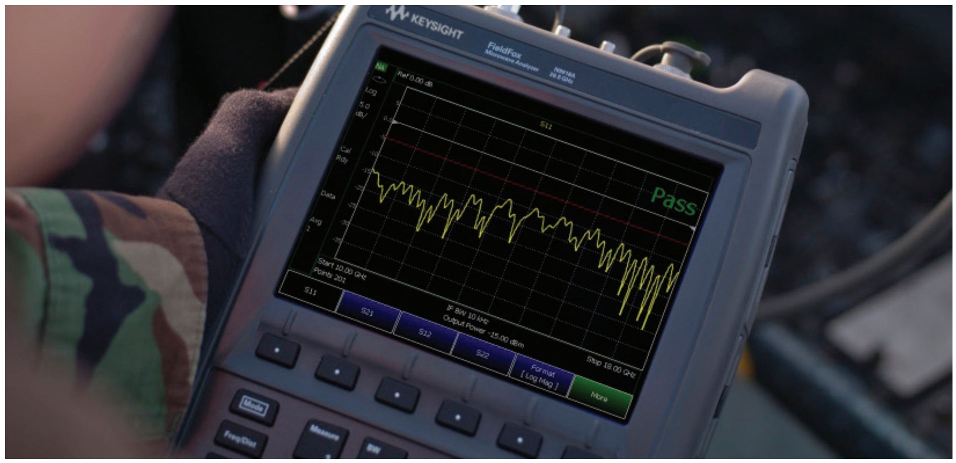

Figure 2. This handheld analyzer was purpose-built to meet the needs of personnel who need to make a variety of precise, on-the-go measurements.

Creating a field-worthy industrial design

To get a firsthand perspective, a Keysight Technologies, Inc. design team left the office behind and tagged along with technicians and engineers in the field. As the field personnel performed routine maintenance, in-depth troubleshooting, and everything in between, members of the Keysight design team were there—observing, asking questions and listening.

The team traveled to a variety of worksites in vans, pickups and trucks. The "good" instruments usually rode up front with the crew; the other gear was often tossed—sometimes literally—into the cargo area of a van or the bed of a pickup. In all cases, the people, vehicles and instruments had to be equipped for a wide range of conditions, day or night, rain or shine.

Those experiences translated into attributes that make a handheld analyzer ready for the toughest conditions. For example, a completely sealed enclosure that is compliant with US MIL-PRF-28800F Class 2 requirements will ensure durability in harsh environments. Consistent with the spec, a water-resistant chassis, keypad and case let the instrument withstand salty, humid environments. Gasket-sealed doors will protect instrument interfaces from moisture, and a dust-free design—with no vents or fans in the case—will help extend instrument availability and reliability.

The package should also withstand shock and vibration, and the connector bay should be designed to protect the RF connectors from damage due to drops or other external impacts. Two additional attributes will help a unit survive drops onto all six faces. One is a case with a curved bottom and rounded corners: These disperse impact and increase structural resistance to shock and impact from all angles. Another useful attribute is the polymer blend used in the case: In addition to its innate durability, the polymer can be formulated to resist shattering at the lowest temperature of the desired operating range.

Defining field-ready ergonomics

Time spent in the field made indelible impressions that led to practical, meaningful decisions about ergonomics. For example, a nonslip rubber grip—built into the case—that fits securely into the user's hands can also be designed to prevent the analyzer from sliding off the hood of a vehicle.

A vertical or "portrait" orientation would make an instrument easy to hold. Coupling that with a carefully designed keypad layout will make it easy for a user to operate the instrument with their thumbs (Figure 3). Also, a weight of about 3.0 kg (about 6.6 lbs) is relatively easy to carry for extended periods in the field.

Because the instrument may be used day or night, inside or outside, the user will benefit from a bright, low-reflective display and multiple display modes that optimize viewing under a wide range of lighting conditions. In addition, backlit keys will enable operation in darkness.

Figure 3. A portrait orientation coupled with sufficiently large front-panel buttons enables easy operation, even when wearing gloves.

Reducing power consumption

The electronic design of a handheld analyzer requires a delicate—and complex—balance between performance, power consumption, heat, and battery life. For FieldFox, in-house scientists modified existing high-performance chips and technologies to retain performance while reducing power consumption. The result: an analyzer that draws about 14 W and lasts 3.5 hours on a single charge. Because the electronics consume just 14 W of power, the enclosure can be completely sealed. The power-efficient design has another benefit: the instrument provides fully specified performance over an operating temperature range of 14 to 131 °F (-10 to +55 °C).

Leveraging benchtop capabilities

For the Keysight team, the next step was to pack the required levels of performance and capability into a rugged, ergonomic design that met the criteria described above. As a starting point, they borrowed capabilities from Keysight's benchtop analyzers, many of which are today's best microwave instruments.

For network analysis, the designers leveraged built-in calibration hardware and highly accurate calibration algorithms from high-end vector network analyzers (VNAs) to enable precise, repeatable measurements. With an emphasis on portability, the designers simplified calibration by adding built-in standards, a choice that enables measurements in the field without additional accessories. With most other instruments, the addition of devices such as jumper cables to the test port requires recalibration using an external calibration kit that must be carried into the field.

To enhance spectrum analysis, the design team leveraged the power measurements used in Keysight benchtop signal analyzers. This enables fast, accurate one-button power measurements of channelized communication systems. For improved accuracy, the designers created an internal amplitude alignment function that operates automatically as environmental conditions change. This provides amplitude accuracy of ±0.5 dB with no warm up required across an operating temperature range of 14 to 131 °F.

Covering more ground

Figure 4. The versatile FieldFox handheld analyzers help reduce equipment costs while enhancing convenience and efficiency.

The results of the design process are embodied in the Keysight FieldFox handheld analyzers. Inside and out, the FieldFox family was designed with on-the-go applications—and end users—firmly in mind (Figure 4). Within its compact package, a FieldFox analyzer can be configured as a cable and antenna tester (CAT), spectrum analyzer or vector network analyzer. Additional capabilities include a power meter, a vector voltmeter, an independent signal source, a variable DC supply, a frequency counter, an interference analyzer, and built-in GPS. The FieldFox family consists of 16 models, with top-end frequencies of 4, 6 and 6.5 GHz in the RF models and 9, 14, 18 and 26.5 GHz in the microwave models.

This level of flexibility can replace a variety of instruments. It also enables a user to define a "just right" initial configuration and, later on, easily amend it with additional capabilities as needs change and budgets allow. Because those capabilities are inclusive, a CAT version can be enhanced with any of the other capabilities—spectrum analysis, network analysis, etc.—by simply acquiring and applying a license key. No additional hardware is required, nor is a return to the factory.

As a final point, the product warranty is an important consideration for any instrument that will be used in the field. While most instruments have a one-year warranty, FieldFox handheld analyzers carry the added confidence of a three-year warranty.

Measuring up in the field

It’s one thing to provide handheld microwave measurements that agree with those made using a benchtop analyzer. It’s quite another to put those capabilities into an analyzer that measures up against US MIL-PRF-28800F Class 2 requirements and has been type-tested to meet the MIL-STD-810G test for operation in explosive environments. With a unique combination of advanced measurement capabilities and a durable package, the FieldFox handheld analyzers are equipped to handle routine maintenance, in-depth troubleshooting, and more—virtually anywhere technicians and engineers need to go.

Related literature	**Number**
FieldFox Handheld Analyzers, Brochure	5990-9779EN
FieldFox Combination Analyzers, Technical Overview	5990-9780EN
FieldFox Microwave Spectrum Analyzers, Technical Overview	5990-9782EN
FieldFox Microwave Vector Network Analyzers, Technical Overview	5990-9781EN
FieldFox Handheld Analyzers, Data Sheet	5990-9783EN
FieldFox Handheld Analyzer, Configuration Guide	5990-9836EN
FieldFox N9912A RF Analyzer, Technical Overview	5989-8618EN
FieldFox N9912A RF Analyzer, Data Sheet	N9912-90006
FieldFox N9923A RF Vector Network Analyzer, Technical Overview	5990-5087EN
FieldFox N9923A RF Vector Network Analyzer, Data Sheet	5990-5363EN

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KEYSIGHT TECHNOLOGIES

Published in USA, August 2, 2014
5991-1300EN
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