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WHITE PAPER

Testing Radar Simulation System Effectiveness

by Marcelo Ramos, Vice President of Engineering for RF Sources/Receivers

Abstract

When designing electronic warfare (EW) equipment—in this case, radar simulation systems—or any other defense-focused project, the aim of preserving lives makes system effectiveness a principal concern. To achieve this end, test equipment must be both accurate and reliable, especially in adverse conditions. This white paper examines the challenges faced by EW system engineers in testing the effectiveness of their designs—in terms of technical demands, in-house capability, and, of course, cost.

Overview of Radar Simulation Challenges

Radar simulation systems, comprising RF sources and/or receivers, depending on the application, must perform to an exacting minimum standard if they are to definitively prove the field-worthiness of EW systems. Transmitter frequency set-on time must be as fast as possible and frequency needs to be as stable as possible over the entire operational and temperature range, as well as across a wide bandwidth. A common demand is a set-on time of 1 microsecond (µs) and the frequency held within 1 millisecond (ms).

Similarly, receivers must measure frequency accurately, as fast as possible, while maintaining a stable frequency over the entire operational and temperature range, as well as across a wide bandwidth. Normally, system designers measure within 100 nanoseconds (ns) with an accuracy of one megahertz (MHz). Of these two test elements, greater challenges are encountered with the transmitter due to testers' desire for an ever-faster signaling time (even faster than 1 µs).

Although test systems can be built in-house by companies in need, but often know-how or resources are lacking. Organizations seeking to achieve these efficiencies in-house often err in budget, timeframe, resources, expertise, or a combination of those factors. Some companies overestimate their in-house

capabilities, while others underestimate the complexity of designing and building the product or miscalculate the cost of doing it in-house.

Background

Often, the extent of these companies' problems only becomes apparent late in the engineering process. Designers discover that creating a solution with the proper capabilities—meeting specific size, weight, and power (SWaP) requirements, within their budget and timeline—is not possible.
For example, SWaP needs generally are rigid in these equipment specifications. Smaller platforms (e.g., a drone) are likely to have tight size specifications. Prime power, though, often represents the most challenging specification to fulfill. Customers always want a more efficient system, drawing less power. Generally, customers have a baseline number in mind.

Several options exist for creating and receiving a signal, and testers must determine the optimal equipment relevant to their systems. Both frequency-locked oscillators (FLOs) and voltage-controlled oscillators (VCOs) can cover a range of frequencies. FLOs can be designed to accommodate various modulations, such as AM, FM, and PM—representing one of their key desirable attributes.

As an alternative, synthesizers can achieve significantly faster signaling times than oscillator-based test systems, but synthesizer technology is limited by several disadvantages. Primarily, synthesizers cannot be easily modulated in FM, and bandwidth suffers. Further, synthesizers commonly suffer spurious signals (spurs) and, most critically, synthesizers cost almost 10 times more than oscillator-based test systems.

Finally, developers must consider system control elements. Antenna control units (ACUs) are able to play prerecorded antenna patterns and can compensate for platform movements. For example, they can compensate for tilt and roll when mounted on an aircraft. Instantaneous frequency measurement (IFM) units measure frequency and power level, as well as detect pulse on pulse signals.

Digital control units (DCUs) are capable of controlling a single FLO and other RF equipment. Integrated DCUs (IDCUs) combine the control and interface power of a DCU with the RF capabilities of a FLO and the capabilities of an ACU for a complete integrated system controller in a single unit. While it absolutely is possible to create a radar simulation system in-house, it's also pragmatic to acknowledge that a superior system can be obtained at a lower cost from a vendor with specific experience building test systems.

Custom Radio Frequency (RF) Receivers and Sources	
FLO	**Frequency Locked Oscillators** cover frequencies ranging from 2 to 36 GHz. They are capable of changing frequencies in the order of hundreds of nanoseconds. FLOs offer various modulations, such as AM, FM and PM.
IFM	**Instantaneous Frequency Measurement** units measure frequency, as well as power level. They also detect pulse on pulse signals. The DIFM (also available from dB Control) is a dual-channel IFM.
DCU	**Digital Control Units**are capable of controlling a single FLO and other RF equipment. The DCU can be controlled and set up with a network port or can be pre-programmed with a removable SCD card.
ACU	**Antenna Control Units** are able to play prerecorded antenna patterns and can compensate for platform movements. For example, they can compensate for tilt and roll when mounted on an aircraft.
IDCU	**Integrated DCUs** combine the control and interface power of a DCU with the RF capabilities of a FLO and the capabilities of an ACU for a complete integrated system controller in a single unit.
Custom	Companies often have a problem of compatibility when they possess RF units of different generations. dB Control analyzes these situations and builds translation units that allow older systems to communicate and interact with newer ones.

The dB-9001 is a custom-mounted Instantaneous Frequency Measurement (IFM) *unit operating in the C, X and Ku-band frequency range providing highly accurate measurements at 100 nanoseconds (ns) to CW pulse width measurements. The IFM units measure frequency, as well as power level and pulse duration. The IFM units are packaged in a custom configuration with integral forced-air and conduction cooling.*

The dB-9003 is a custom-mounted Integrated Stabilized RF Source (ISRFS) *operating in the I and Ka-band frequency range providing highly accurate RF Source at high frequency switching speeds. The ISRFS can be controlled and set up with a digital port. The ISRFS units are packaged in a custom configuration with conduction cooling.*

Solution

Defense electronics manufacturer dB Control always bids in compliance to a specification that the customer has provided. The company's custom equipment meets hard-to-fill user expectations. In fact, this equipment is difficult (or impossible) to acquire off the shelf or to design in-house. dB Control's

specialty and expertise lies in meeting stringent requirements at a price point, size, weight, and prime power that meet all stipulated customer requirements.

Additionally, dB Control guarantees accuracy that can be otherwise difficult to obtain, especially over the temperature range many testers demand. For example, one dB Control client requires parts that work from -40°C (-40°F) to +71°C (159.8°F). That temperature operating range is solved through various methods, including design, choice of materials, and heating components inside the unit that maintain a constant internal temperature. dB Control also digitally calibrates every system element to compensate for whatever may not have been addressed (in terms of temperature) via physical means.

Many of dB Control's products have been available for decades, establishing a reputation for system reliability and stability over that span. Since the base designs of such systems have changed little over that time, the company's designers have focused on improvements that allow the systems to perform optimally over a long timeline.

As an example of the customization process, the previously mentioned client that needed equipment which would remain effective across a range of temperature extremes. That client came to dB Control with precise specs; they know exactly what they want. A second client's experience, though, is more typical: dB Control had visited this client, observed their resources, and helped the company to, in effect, generate appropriate specs for the application.

Regardless of the starting point, the test system inevitably is tweaked by dB Control for optimal operation—primarily because the digital interface needs to be personalized for each customer; it's very specific.

While dB Control is not unique among test system vendors, dB Control has the expertise to meet a wide range of customer requirements. For example, competitors generally want precise specs and, once something is agreed upon, everything is set in stone. dB Control can, and does, modify orders even after the design process has begun.

This flexibility is aided by diverse in-house expertise; not only does dB Control have expertise in frequency products, but in amplifiers, as well, making it one of the few companies with expertise and products in both realms.

Timelines are handled on a case-by-case basis with the customer. They can be affected by incomplete or ambiguous specifications from the customer. Obviously, this process can be drawn out by a lot of back-and-forth, or a customer not knowing exactly what they want. Ultimately, any challenge is welcomed.

Conclusion

While any supplier can offer a radar simulation system that they claim will work as promised, customers often face unforeseen issues after a sale is complete. dB Control takes a consultative approach to designing custom test systems. Considering what's at stake, and the budgets surrounding EW equipment, a consultative approach to test system design has advantages over a transactional one. The latter path could be devoid of guiding expertise in its early stages (e.g., providing aid in setting your specs), or lacking in post-sale support (e.g., adjusting the system on the fly, as needed).

Resources

Datasheets for dB Control's Instantaneous Frequency Measurement Units, Integrated Stabilized RF Sources and Integrated Digital Control Units can be downloaded from **https://www.dbcontrol.com/datasheet-library/**

About The Author

Marcelo Ramos is the vice president of engineering for RF Sources/Receivers at dB Control. As co-founder of TTT-Cubed, Inc., a company acquired by dB Control in 2019, he developed most of the company's electrical systems, software, firmware, and FPGA code. Ramos enjoys technical challenges and prides himself on pushing current technologies to develop better and more advanced products. He came to the U.S. during the dot-com era to work for Lucent Technologies. He later worked at REMEC and Teledyne, where he specialized in military products, gaining expertise in those products' hardware and software. Ramos graduated with honors from the Universidad Tecnica, Santa Maria, Chile with BS and MS Degrees in Electronics Engineering. While there, he won multiple electrical and mechanical engineering competitions and earned national coverage for several of his inventions.

About dB Control

Established in 1990, dB Control supplies mission-critical (often sole-source) products worldwide to military organizations, major defense contractors, and commercial manufacturers. The company designs and manufactures reliable high- and low-voltage power supplies, high-power TWT Amplifiers (TWTAs), microwave power modules (MPMs), transmitters, and high-voltage power supplies (HVPS) for radar, electronic countermeasures (ECM) and communication applications on airborne, maritime, and ground-based military platforms. Since acquiring Paciwave in 2021 and TTT-Cubed in 2019, dB Control now offers specialized RF/microwave components, integrated microwave subsystems and custom radio frequency (RF) receivers and sources, including Instantaneous Frequency Measurement Units (IFMs), Frequency Locked Oscillators (FLOs), Digital Control Units (DCUs), Antenna Control Units (ACUs) and

Integrated DCUs. In addition, dB Control provides specialized contract manufacturing and repair depot services from its modern 40,000-square-foot facilities in Fremont, California. The company is AS9100D and ISO 9001:2015 certified. More information is available at www.dBControl.com.

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