Wireless

Understanding the Limitations of Modern Military Radio Testbeds

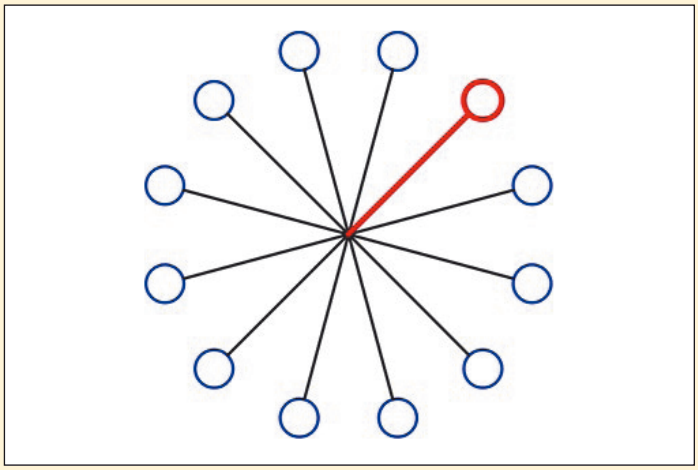

Figure 1: This diagram depicts a 12-port hub fan-out configuration. Here, all ports are connected via a resistive power divider/combiner with a star configuration. There are a total of 12 programmable attenuators

In the past 10 years, the use of military radios has increased dramatically, and, in turn, so has the need to test those radios. In part, this increase stems from the advent of such military-based communication applications as the land mobile radio system and tactical networks, as well as the introduction of both software defined radios and cognitive/multi-user Multiple-Input Multiple-Output (MIMO) wireless radios. Typically, these military radios are tested together in a closed mesh network, with programmable attenuators used to vary the attenuation and simulate different distances between the radios. While this test platform (i.e., military radio testbed) enables test engineers to conduct rigorous, transparent, and replicable testing of military radios, it is not without its limitations: namely the size of the mesh network, or, in simpler terms, the number of radios that can be tested together.

JFW Industries, specialists in attenuation and RF switching, designs and manufactures a wide range of solutions for testing military radios. For those test engineers wanting to build their own testbed by piecing together individual components, JFW provides the necessary programmable attenuators, as well as the power divider/combiners to be cabled together. JFW also provides RF test systems with components already packaged together with a computer interface for test engineers in need of an all-in-one solution. These test systems are available in three different configurations or designs, depending on how many military radios test engineers want to test together. The result is a comprehensive approach to enabling today's test engineers to quickly and successfully test modern military radios.

Military Radio Testbed Options

When testing military radios, a key requirement for the test engineer is to be able to test as many together as possible. Doing so provides the engineer with critical information on how well the military radios will operate and inter-operate in the real world. The problem, however, is that this is not always a straightforward task. The test setup the engineer chooses to use for that testing often has its own set of limitations, and these limitations generally dictate exactly how many radios can be tested together.

JFW offers three different test setups, or designs, for testing military radios: hub fan-out, full fan-out, and limited fan- out. These all-in-one solutions can be used to successfully test up to 64 military radios.

Hub Fan-Out Design

Most test engineers looking to build their own military radio testbeds use a hub-style design to create a mesh network in which each radio is able to communicate with the entire network at one power level. The other ports then have to adjust their own attenuation to the mesh to receive the input radio at the desired power level. The hub fan-out design utilizes a resistive divider/combiner with a star matrix configuration to combine all ports through a central hub. The star configuration limits the number of paths in the matrix to be equal to the number of ports. Each port has a single programmable attenuator (Figure 1). The

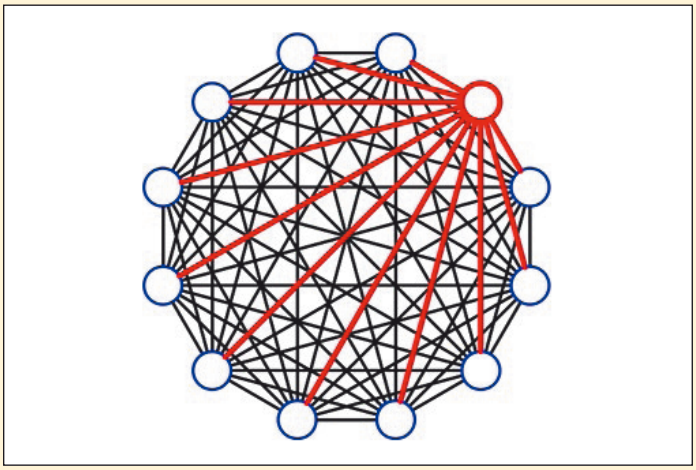

Figure 2: This is a 12-port full fan-out configuration with a total of 66 programmable attenuators

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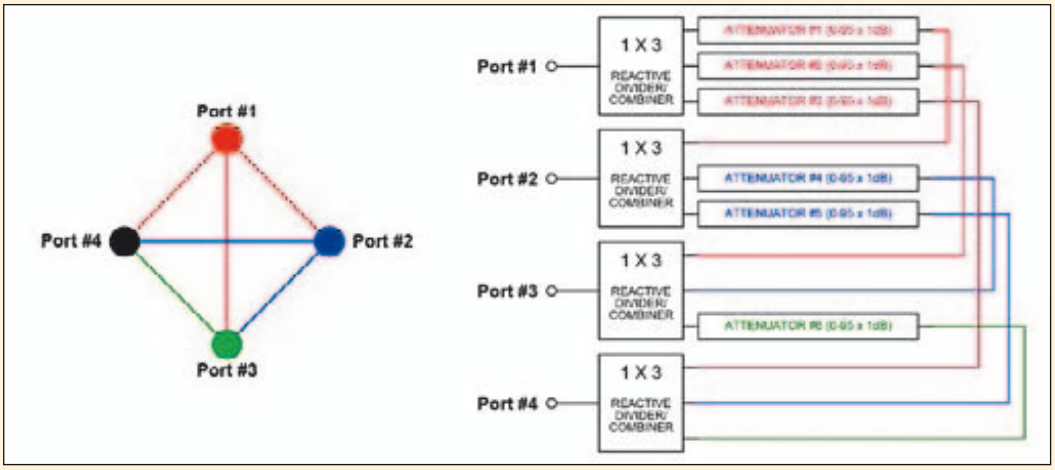

Figure 3: This is a four-port full fan-out transceiver test system example. The left diagram shows how the ports are connected, while the right diagram shows the attenuator addressing for each path. A full fan-out four-port transceiver test system requires six programmable attenuators and allows for each path to be set to its own unique attenuation setting. As a result, a radio connected to port #1 can transmit a signal to radios on ports #2, 3, and 4 at different signal levels simultaneously

attenuators can be remotely controlled to simulate static or dynamic environments.

The hub fan-out design can be used for radio-to-radio communication testing to test up to 18 radios. Because of the lower number of programmable attenuators it uses (no more than 18), it is much lower in cost than the other two design options.

Full Fan-Out Design

For test engineers wanting to test between 19 and 32 radios up to 3 GHz, the simple hub fan-out design does not provide a viable option. Instead, a test system based on a full fan-out design is recommended (Figure 2).

The full fan-out design is constructed as a fully meshed matrix with a path between every pair of ports, with each path having its own individually controlled programmable attenuator. An example of a four-port full fan-out transceiver test system is shown in Figure 3. The attenuators enable the test engineer to set a different dB setting for every path through the matrix. Those values can even be faded over a time interval to simulate signal fading between radios. During testing, each port can be connected to a device (e.g., a radio or handset) that can transmit/receive signals. Most JFW test systems utilizing this design cover either 30...3000 MHz or 500...6000 MHz.

In contrast to the hub fan-out design, the full fan-out design uses a reactive, rather than a resistive, combiner/divider. These differences allow the full fan-out design to test more radios – up to 32 radios (32 ports) simultaneously. The design also offers maximum signal fade testing flexibility. And, because it allows every path to be set to a unique attenuation, the full fan-out is ideal for testing radio-to-radio communication. This is the most expensive of the three configurations presented here, as the number of attenuators scales quadratically with the total number of radios.

Limited Fan-Out Design

For test engineers wanting to test more than 32 radios up to 3 GHz, the limited fan-out design offers the best option. With this design configuration, each individual port connects to only "L" number of its neighboring ports, and the number of those neighboring ports varies depending on the application (Figure 4). The limited fan-out design is particularly useful for reducing the size and cost of designs with a large number of ports. Essentially, by reducing the number of internal paths through the matrix, the size and cost of the test system is reduced. The reduced number of internal paths means a greater number of ports can be offered, and that, in turn, means a greater number of radios can be tested simultaneously.

Whereas a full fan-out 48-port design would require 1,128 programmable attenuators, for example, a limited fan-out 48-port LC16 design would require only 384 programmable attenuators. The difference in cost and size between the full fan-out design and the limited fan-out design is 66 percent in this case, or roughly 1/3 the price. Currently, JFW offers a limited fan-out design with 40 ports, although models with up to 64 ports (i.e., 64 radios) are possible.

Identifying the Limitations

While each of the three military radio testbed designs presented offers a number of benefits, they also come with different limitations. Understanding these limitations is critical to determining which option is best for any given radio testing application.

With the hub fan-out design, that limitation stems from its utilization of a resistive divider/combiner, which effectively limits the number of radios that can be tested together. In JFW's case, for example, two different types of hub fan-out transceiver test systems are offered. The largest resistive divider/combiner with a star configuration that JFW makes to work at DC-3 GHZ is an 18-port model. Consequently, the number of radios that can be tested together up to 3 GHz with the test system is limited to 18. Likewise, the largest resistive divider/combiner with a star configuration that JFW makes to work at DC-6 GHZ is a 12-port model. Here, the number of radios that can be tested together up to 6 GHz is

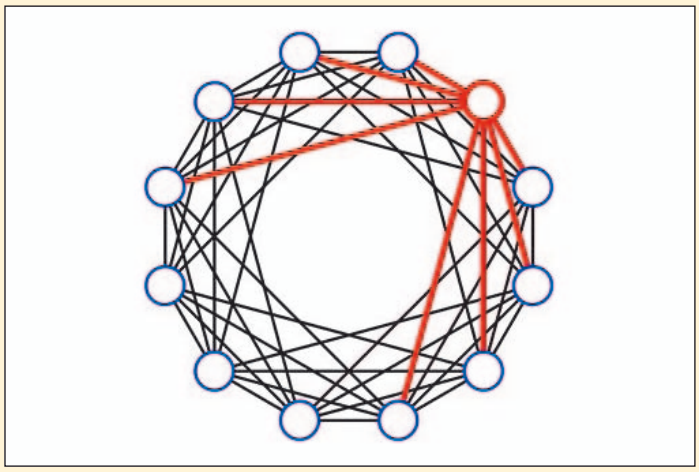

Figure 4: In this 12-port LC8 design, each port is connected to only its eight closest neighboring ports (four upper neighboring ports and four lower neighboring ports). The design requires only 48 programmable attenuators as opposed to 66 attenuators if it were a 12-port full fan-out configuration

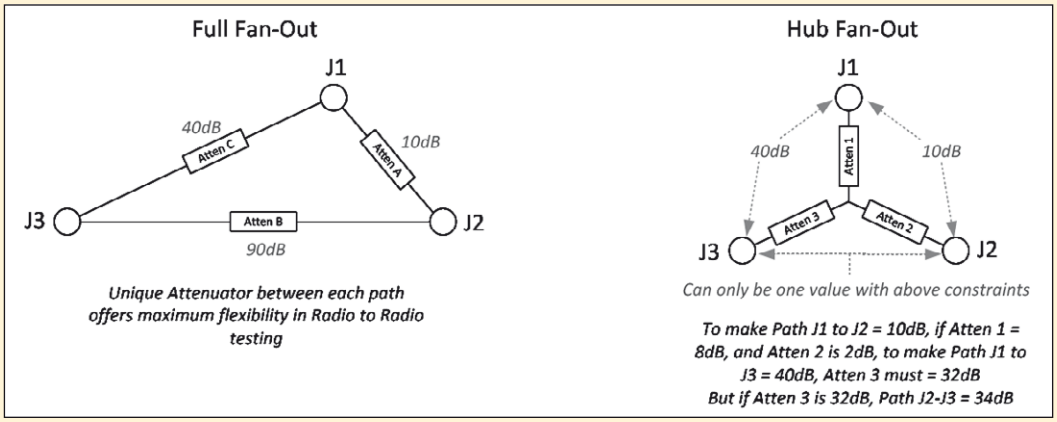

Figure 5: With the hub fan-out configuration, setting paths to a desired attenuation level will dictate what other path's attenuation must be. A full fan-out design is fully flexible by having a unique attenuator for every path combination

JFW Current Capabilities				
	Hub Fan-Out (Figure 2)		Full Fan-Out (Figure 4)	Limited Fan-Out (Figure 5)
Number of Radios/ Ports	3-12 radios	13-18 radios	3-32 radios	4-64 radios
Frequency Range	30-6000 MHz	30-3000 MHz	30-3000 MHz or 50-6000 MHz	30-3000 MHz or 50-6000 MHz
Number of Attenuators	number of ports	number of ports	N x (N-1)/2 N = number of ports	N x L/2 N = number of ports L = number of adjacent ports each port can see

limited to 12. The hub fan-out design is also limited in its flexibility of not being able to set every possible path to a desired attenuation (Figure 5).

In the case of the full fan-out design, the limitation is the size of the test system. It is limited to just 32 radios or 32 ports. With this design, a connection is required from any given port to any other port. So, for example, for 32 ports, a total of 496 internal paths would be required, with each path containing a programmable attenuator. The 32-port full fan-out model offered by JFW takes up one entire 19-inch rack. The table shows the general limitations and abilities of each of the three designs. Relative cost and size can be estimated by the number of attenuators.

Conclusion

Testing as many military radios together as possible is a key goal for test engineers performing radio testing these days. For this task, there are three different types of test setups or designs that can be employed, each with its own set of limitations. Generally speaking, however, for testing up to 18 military radios, the hub fan-out design is the best option. On the other hand, when testing either up to 32 or 64 military radios, a full fan-out or limited fan-out design, respectively, should be used. For maximum flexibility, some applications may also require every unique path to have its own attenuation. In this case the full fan-out configuration must be used.

JFW offers a wide-range of transceiver test systems for each type of design, all of which are built in an ISO 9001:2008 compliant factory. These test systems meet or exceed the requirements of today's most demanding test applications. Moreover, all JFW products are designed to the most exacting standards to provide test engineers with the most innovative, high quality and cost-effective solutions in a wide variety of global applications.

For more information on the different possible test setups for transceiver testing, go to: www.jfwindustries.com/catalog/Transceiver_Testing-148-1.html. ◄