How To Right-Size Your Wireless Testing

Whether mobile devices, Internet of Things, or industrial RF applications, the world runs on wireless.

As a result, wireless testing is more important than ever before. But how do you balance thoroughness, speed, and budgets? Quipping "pick any two of the three" isn't a good answer. Testing must be thorough, fast enough to keep up with getting to market, and yet within tight budgets.

Test engineers should adopt a right-sizing approach to manage trade-offs and find solutions that are the best fit for a particular situation.

SPEC OUT THE TEST REQUIREMENTS

Right-sized wireless testing starts with comparing and contrasting the two general types of wireless test systems: transceiver and handover. Transceiver testing means testing how radios directly communicate with one another. In handover testing, you test how antennas or access points perform with radios, which generally are called handsets.

Whether looking at transceiver or handover testing, testing gear has the following considerations:

- Ports connect devices to the test system.
- Internal RF components attenuate, divide, or combine signals.
- Attenuators may be remotely programmable or manual.
- Systems work over specific frequency ranges.
- Configurations establish paths of communications among devices.

The ports, attenuators and divider/combiners, frequency ranges, and internal configurations are where tradeoffs will happen that affect overall testing speed, thoroughness, and cost.

MAKING CHOICES

In a perfect world, you would have the most flexible test system available. It would connect any set of radios or collection of handsets and antennas that you wanted to test. Every path between two devices would have a programmable attenuator to separately adjust the signal strength between the devices and include the ability to adjust signal strength over time to simulate signal fading.

However, as the numbers of ports, potential paths, and RF components increase, so does the expense. Additional components expand the amount of rack space necessary for housing. They also put greater demands on power and heat dissipation.

If you reduce the number of components in the test system; size, power, and cooling demands decrease, as does cost. The price you pay is a loss of testing flexibility. Some test configurations may be impossible to model. Other scenarios could take longer as decreased flexibility necessitates more testing iterations to cover individual cases and more time in the schedule to accommodate additional setup and stages of testing.

In handover testing, an additional source that can balance flexibility, time, and savings is the use of manual attenuators. They are less expensive than programmable ones because they lack the circuitry for remote programming. Instead, an engineer sets them through knobs on the front of the attenuators. The manual action increases the time for configuration and cannot accommodate all testing scenarios, like fading the dB setting over time to simulate signal fading.

Even input power specifications can pressure a budget. Test equipment frequently accepts limited antenna or access point power input, like 1 watt, versus a typical commercial 40 watt device, because of the power dissipation characteristics of the equipment components. Adding a dedicated attenuator instead of running tests at full power is far less costly than upgrading the test system's components.

Although not strictly a trade-off, the use of technically neutral language can broaden your options in searching for appropriate test equipment. The frequencies used by LTE wireless differ by country, for example. Specify actual frequency ranges. Companies vary in how they refer to frequency ranges. Some specify everything in megahertz; others quote gigahertz. Look for the appropriate values under each to be sure you don't shortchange your search.

WHAT ARE YOUR NEEDS TOMORROW?

Trade-offs affect the future as well. Test engineers cannot only consider today's needs, because test devices usually aren't reconfigurable. If you buy a unit that works for a current project, next year may bring another design that has more expansive requirements and will need a separate test system. And yet, that second unit likely could have covered the current test cases, so overly narrow economics can also be self-defeating.

In some cases, the additional expense of greater coverage might be negligible. For example, if you want to test transceivers in the frequency range of 900 MHz to 2 GHz, a customized test system might cost virtually the same as one that would cover 698 MHz to 3 GHz because the latter could use more standard parts, gaining off-the-shelf cost efficiencies.

Consider the amount of attenuation you will need on connections. There are typical ranges, such as from 0 dB to 95 dB in 1 dB steps up to 6,000 MHz, or 0 dB to 127 dB in 1 dB steps up to 3,000 MHz. The more you can contain your testing attenuation needs into typical ranges, the more likely the test system will use less expensive standard components.

TRANSCEIVER TESTING

Each port in transceiver test equipment will represent one RF signal for one of the radios being tested. Each antenna, with radios often in a shielded enclosure to control the testing environment, is connected to the port through a cable.

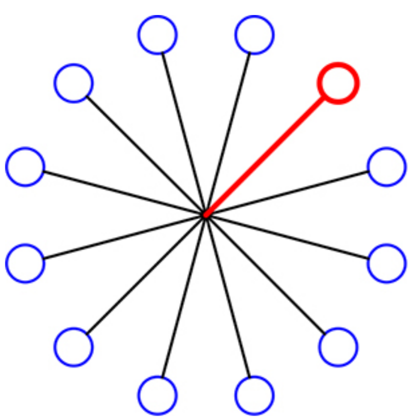
There are three types of configurations you may find in transceiver test equipment:

- Full fan-out
- Limited fan-out
- Hub fan-out

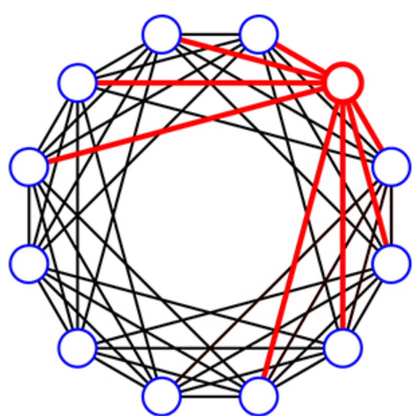
Full fan-out is the most flexible because it offers a fully meshed matrix. It is also the most expensive because it requires the most RF components. In a full fan-out configuration, there is an attenuator for each possible path between radio pairs. If you have 12 ports, there are (12 x 11)/2, or 66, possible two-way paths, each requiring a programmable attenuator. With 6 ports, there are (6 x 5)/2, or 15, possible paths, and, so, 15 programmable attenuators.

In a limited fan-out, each port connects to a specific subset of other ports to either side. If you take a 12 port box and have an 8 limited fan-out design, each of the 12 ports will connect to the four immediately above it and the four immediately below. That would reduce the number of paths needing attenuators to 48. The more ports, the more economically attractive a limited fan-out design can be. A 36-port full fan-out box would need 630 programmable attenuators. Switch to a 36-port 12 limited fan design and the number of programmable attenuators you need is now only 216, a savings of about two-thirds. A limited fan-out can work, if in real-world use, the radios would be spread out geographically far enough so that not all would directly communicate.

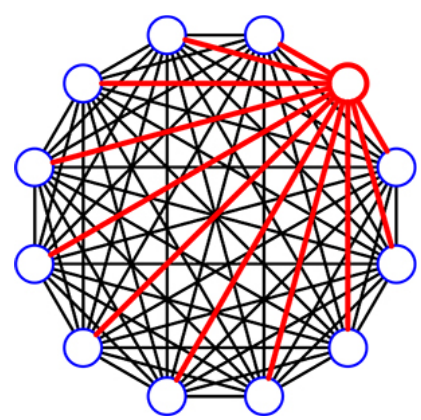
The hub fan-out is the simplest design, using a hub and spoke topology. There is only one programmable attenuator per port. But you sacrifice flexibility. Each radio communicates to every other radio through the test system at the same time.



The example diagram shown is a 12 port hub fan-out configuration. All ports are connected via a resistive power divider/combiner with a star configuration. There are a total of 12 programmable attenuators.



The example diagram shows a 12 port LC8 design. Each port is connected to only its 8 closest neighboring ports (4 upper neighboring ports & 4 lower neighboring ports). This design requires only 48 programmable attenuators.



The example diagram above is a 12 port full fan-out configuration. This 12 port design will have a total of 66 programmable attenuators.

When you set the attenuator on one port, you've now limited its transmission to every other port, rather than independently setting the attenuation for each possible pair of communicating devices. You can still program a specific amount of attenuation between any one pair of radios, but you lose flexible control over the attenuation on all other possible paths.

HANDOVER TESTING

In handover testing, there are two types of ports: input and output. Input ports represent antennas: base stations, access points, cell towers, or some other type of connection to the communications network. Output ports represent handsets or mobile devices. The terms "input" and "output" in this case are naming conventions, as all paths for a handover test system operate bi-directionally. There are three types of handover configurations:

- Full fan-out
- Limited fan-out
- Manual handover

As with a transceiver test system, a full fan-out handover system means all inputs can talk to all outputs. Each input port is connected to an RF divider/combiner to split the signal into multiple paths corresponding to the number of output ports. Each path has an attenuator. Then each path enters a divider/combiner for the associated output port. To find the number of paths in a full fan-out handover system, multiply the number of input ports by the number of output ports. An 8x4 system would have a 1x4 divider/combiner and 4 attenuators for each input port and a 1x8 divider/combiner for each output. That makes 32 attenuators and 12 total divider/combiners.

In a limited fan-out, each input has an attenuator, so the same signal strength reaches all the antennas. All the inputs lead into a single divider/combiner, which in turn leads to another divider/combiner connected to the outputs. For the 8x4 configuration, there are only 8 attenuators and 2 divider/combiners. The number of components is far smaller, but you can't independently adjust attenuation for each path from a handset to an antenna.

Manual handover systems also use a limited fan-out configuration. The difference between manual and programmable limited fan-out is that, in a manual system, manual rotary attenuators replace programmable ones. Manual handover systems are the simplest and least expensive type and are usually employed in early R&D.

FIND THE RIGHT SIZE

Options are great to have. They also complicate the process of making decisions. No one can tell you what is best for your specific needs because no one else has to balance your schedule, complexity, and budget. However, chances are you can find the right type of testing equipment to meet your specific needs.

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