Far-Field Antenna Measurements Using LXI Class B

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The antenna is the one key element that affects the performance of a wireless communication link. The antenna is the transducer that picks up the radiated energy from the signal source and transfers it to the receiver.[1] One must control and measure the receiving antenna to characterize impedance, radiation efficiency, polarization, directivity, gain, etc. Whether you are designing or selecting an antenna, system requirements must be satisfied under the expected operating conditions.

The effectiveness of the antenna design can be tested either indoors or outdoors. When testing indoors, the stimulus and response hardware and instruments such as signal generators, spectrum analyzers and power meters are all in relative close proximity. Control lines for moving the receiver antenna, sending commands to instruments and trigger synchronization is very manageable because of the short distances. If you have to separate the signal source and source antenna 100's of feet or farther from the receiving antenna, the control of instruments and triggering becomes a challenging problem. Serial digital links must be created to extend the distance between instruments using wires or electrical to optical converters. This is time consuming, expensive and often causes different programming techniques than if the instruments are in close proximity.

LXI Class B signal generators, network analyzers and spectrum analyzers can simplify the task of separating the source and receiver over long distances. If hardwired LAN is available between the two locations, then direct communication or VPN connection through a metro link is possible. For those applications where you can't run cables between the sites, wireless LAN can be used with directional antennas to achieve even miles of separation. Both the programming and triggering of these instruments can be performed over commonly available LAN equipment.

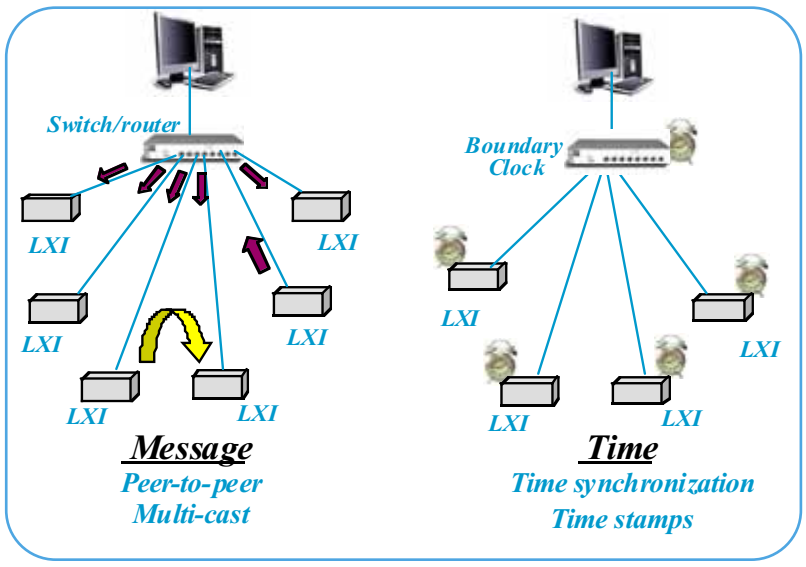

Fig. 1. LXI Class B Instrument Capabilities

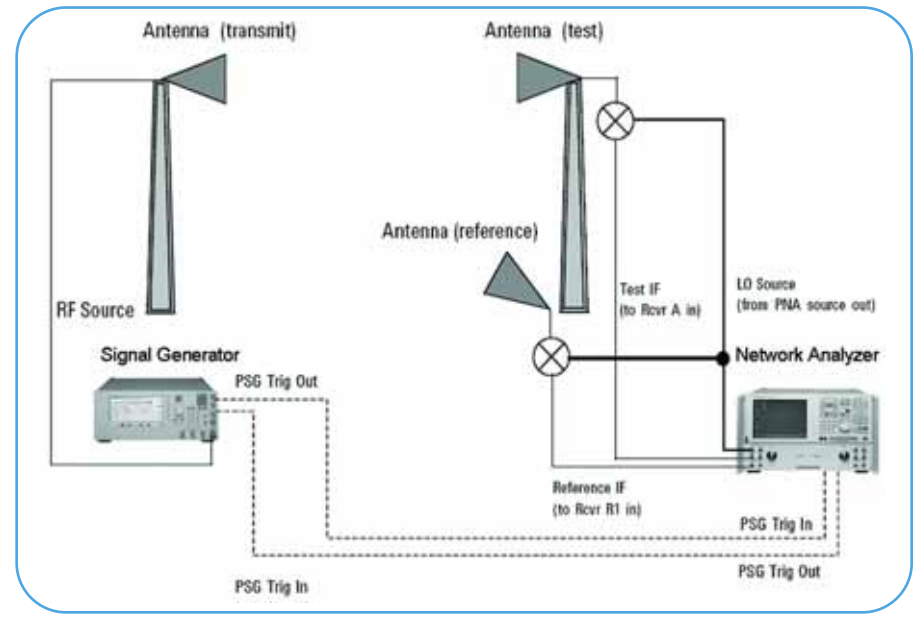

Fig. 2. Instruments in Close Proximity

What is an LXI Class B Instrument?

LXI is LAN extensions for instrumentation. LXI Class C is a typical instrument with a LAN interface that configures and behaves predictably over LAN and has a built-in Web Server. LXI Class B instruments have the added support of peer-to-peer (P2P) and multicast LAN in addition to including time synchronization using the IEEE 1588 protocol.

P2P is a message from one instrument to another, using the TCP protocol. This means instruments can be separated by any distance and using any LAN path, wired or wireless, and the packet is guaranteed to be received. Whereas, Multicast is limited to a subnet of instruments and is equivalent to a GPIB Group Execute Trigger. See Fig. 1.

LXI Class B instruments have real time clocks and can cause events to occur based upon absolute or relative time. The most accurate clock among Class B instruments on a subnet becomes the Master. Its job is to keep all the other clocks synchronized to its clock. LXI Class B instruments are time aware meaning they can tell you the time when virtually anything happened within the instrument.

Typical Antenna Measurement Setup

Figure 2 is a simplified example of a system setup for making far-field antenna measurements. The Signal Generator (SG) drives a stationary source antenna, and a Network Analyzer (NA) is connected to a stationary reference antenna and movable test receiver antenna[2]. The NA performs ratio measurements between its two antennas to compensate for various terrain effects between the transmitter and receiver.

Many Signal Generators, Spectrum Analyzers and Network Analyzers use a programming feature called *List Sweep* where each box has a list of operations it steps through for each antenna position. Rather than sending programming commands for every step and configuration, the *List* is used to select frequency, amplitude and waveform type for the SG, and the NA's list consists of measurement type and/or range. Instruments step through the list by triggering each other. For Fig. 2, the SG selects the first *List* item of frequency, amplitude and waveform type, and it then sends a TTL *Trigger* to the NA to make the measurement. When the NA has completed its measurement, it triggers the SG to go to the next *List* item. The list may have 100's of points. The measurement time in the NA can vary significantly dependent upon frequency range, so this asynchronous handshake is quite efficient and simplifies programming.

Extending the Distance Between Source and Receiver

If you try to separate the SG and NA by long distances, the programming interface and the trigger interfaces must be extended to maintain the current simple and efficient programming approach using *List Sweep* and hardware triggers. If the SG and NA are LAN instruments, optical, wired or

wireless LAN can extend the programming interface. If the instruments are GPIB, LAN to GPIB interfaces can be used, again over optical, wired or wireless connections. However, the trigger interface will require a special solution. Many solutions have been adopted over the years: electrical to optical, specialized serial digital links, and even custom converter boxes that use TCP and UDP trigger packets over LAN. All these trigger extension interfaces take time to implement, are expensive and require engineering support.

As LXI Class B instruments, the SG and NA test program can be modified to use LAN triggering instead of the TTL triggers. Now LXI trigger packets are used to sequence each instrument. In many cases, there is no difference in performance of stepping through the lists using hardwired trigger or LXI packet triggering, even if using wireless LAN. Again, the frequency range of the measurement is often the dominant factor.

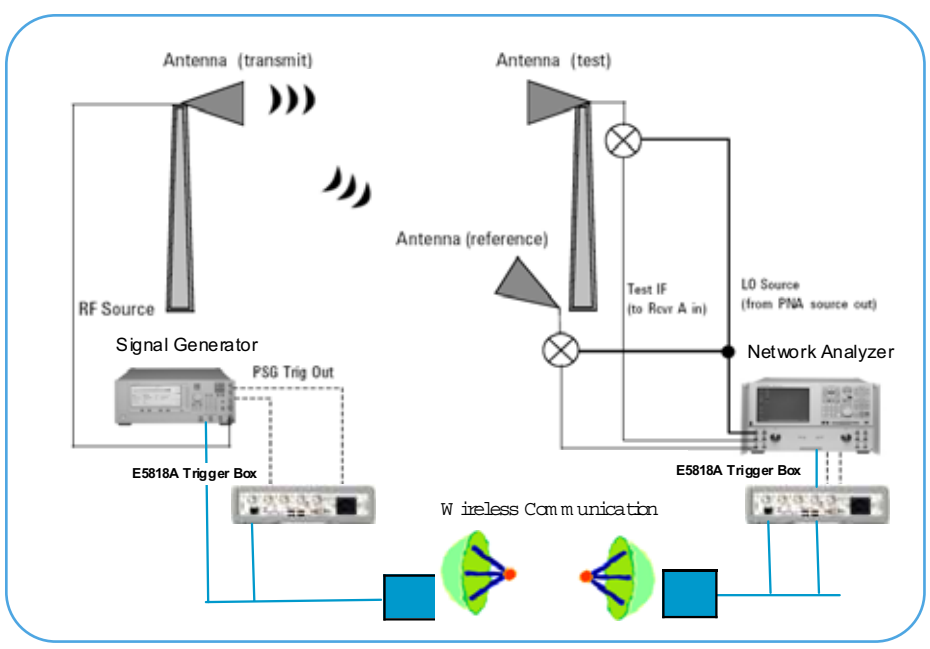

Fig. 3. Instruments separated by long distances

What if My SG and NA Instruments Are Not LXI Class B?

There are bridge products on the market today that permit using GPIB, RS-232, USB, VXI and PXI instruments over LAN. There is also a product by Agilent Technologies that creates a bridge to LXI Class B. The E5818A LXI Class B Trigger Box provides LAN and time-triggering for virtually any instrument. The instrument need only have trigger inputs and trigger outputs to be connected to the trigger box.

In a particular antenna measurement application, it was undesirable to run any long distance cable between the transmitter and receiver, so wireless LAN was selected. Whether the SG and NA are LAN or GPIB, wireless LAN can still be used with a LAN to GPIB converter. Fig. 3 illustrates how the Class B trigger box can intercept the TTL triggers from the SG and NA and convert those into a peer-to-peer LXI packet that is sent to the other trigger box over the wireless LAN.

Other Considerations

Another critical component of this antenna measurement application is the need for a 10 MHz Reference. This can be provided in a couple of different ways. A GPS to 10 MHz reference or an IEEE 1588 to 10 MHz reference can be used remotely. The latter 1588 device can be used when you have a good LAN connection and LXI Class B instruments, which use the 1588 protocol for time synchronization.

Another consideration is the wireless LAN implementation. Great distances can be achieved with standard off-the-shelf equipment from electronic stores. The secret is to purchase the Wireless Router or Wireless Access Point with an SMA or other connector to replace the existing antenna. You can then attach a directional antenna to the wireless device.

Directional antennas are plentiful, and they do not need to be expensive. You can even build your own directional antenna using potato chip cans or aluminum foil shaped like a parabolic reflector. These devices can achieve 10 to 12 dB gain, and some claim good performance with line of sight connections up to 1 mile.

Conclusion

Far-field antenna measurements require that both the programming and triggering interfaces be extended great distances between the transmitting and receiving instruments. LXI is built on the ubiquitous LAN specification, and there are advanced feature instruments built to the LXI Class B specification. The LAN and Time triggering provided by Class B are what makes extending the distance between transmitter and receiver instruments relatively inexpensive and efficient. In addition, there are LXI Class B bridges that permit using legacy instruments at great distances, making them programmatically appear to be in close proximity.

With LXI Class B, it is no longer necessary to expect custom and expensive solutions to separating instruments in far-field antenna measurements. Readily available LAN products from your local electronics store will suffice to provide either wired or wireless LAN solutions.

About the Author:

Conrad Proft is a product planner and applications engineer. He has worked for HP/Agilent for 29 years and spent about half of that time between R&D and marketing, specializing in general-purpose instrumentation for bench and system measurements. Conrad holds both B.S.E.E. and M.S.C.S. degrees.

References:

[1] Jeffrey A. Fordham, Microwave Instrumentation Technologies, LLC. An Introduction to Antenna Test Ranges, Measurements and Instrumentation.
[2] Agilent Technologies Triggering PNA Microwave Network Analyzers for Antenna Measurements.

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