Agilent

LXI Class-B E5818A Trigger Box
Understanding Its Capability and Use Cases

White Paper

Agilent Technologies

Contents

Introduction 2
Architecture of E5818A trigger box 3
Applications and use cases 5
Summary 9

Introduction

Triggering is a key issue in test systems and consists of both hardware and software signaling. Computer-controlled triggering is asynchronous and subject to operating system jitter and latency. Triggering from device under test (DUT) to instrument or from instrument to instrument sometimes must be buffered, delayed, or converted to multiple trigger signals. Inserting a delay in a hardware trigger path can be especially useful when replacing a slower instrument with a faster instrument just to keep the system running properly. Cable length between instruments introduces trigger propagation delays. Distances between instruments may even prohibit wired connections for trigger signals. Creating delayed, periodic, or N-cycle trigger pulses from a single trigger often requires custom circuitry or expensive pulse generator.

Another challenge facing test system developers is debugging a test system. How can you determine when various operations and events take place over a 20-minute period? Many use a mixed signal oscilloscope (MSO) and place probes on virtually any output signals, including voltmeter complete, channel closed, or output settled, etc. However, it is a challenge to capture information over a period of 20 minutes with an MSO. How can that be made easier?

How can I detect a problem in a test system and respond by shutting down equipment quickly to protect an expensive DUT? Maybe quickly is not good enough, and power supplies must be shut down in a particular order. The computer and associated test software will struggle responding to anything in less than 50 milliseconds, and to provide such capability only complicates your test program. Today's power supplies permit TTL signal inhibits that can be used to shut down power supplies quickly, but how would you create an ordered shutdown?

This paper discusses how the Agilent E5818A trigger box and its LXI Class-B functionality can be used to solve the problems stated earlier. The E5818A can be used to enhance the triggering capabilities of any instrument, and multiple trigger boxes can be used to control, analyze, and enhance your entire system.

Features

- Two channels with time stamp inputs and time trigger outputs
- IEEE time sync (< 50 ns)
- Precision TCXO
- 20 ns time resolution
- Alarm to trigger start time, N-pulses or infinite in a period of 100 µs
- LXI LAN packet to immediate trigger and delayed trigger
- External Trig to immediate trigger and delayed trigger
- Peer-to-peer messaging
- Multicast messaging
- Built-in web server
- Pulse per second BNC

Architecture of the E5818A trigger box

The E5818A trigger box is typically used in a static configuration. You do not need to reconfigure it as often as you would with a DMM, switch, or function generator. It has many configurations, and the configuration you pick will dictate how the unit is connected to the system. The E5818A can be configured from its web pages or SCPI and then inserted into a system. With battery backup of configuration, it is not necessary to reconfigure it when power is removed. Programming the E5818A during a test sequence would mostly involve querying time stamp information or restarting timed events.

The E5818A has two channels, each with an input BNC (EXTn) and an output BNC (TTLn). Each channel has three modes. It includes a fourth mode that involves only the EXTn inputs to generate an LXI LAN packet without generating a trigger output. Figure 1 illustrates one of the two channels of an E5818A trigger box.

Three major modes that cause output triggers

1. You can create an N-pulse or infinite pulse signal with a period as low as 100 µs and a 20 ns resolution start time.
2. An LXI LAN packet message can cause an immediate or delayed trigger.
3. An external trigger can cause an immediate or delayed trigger.

TTLn output can start with a rising or falling edge, and EXTn can look for a rising or falling edge.

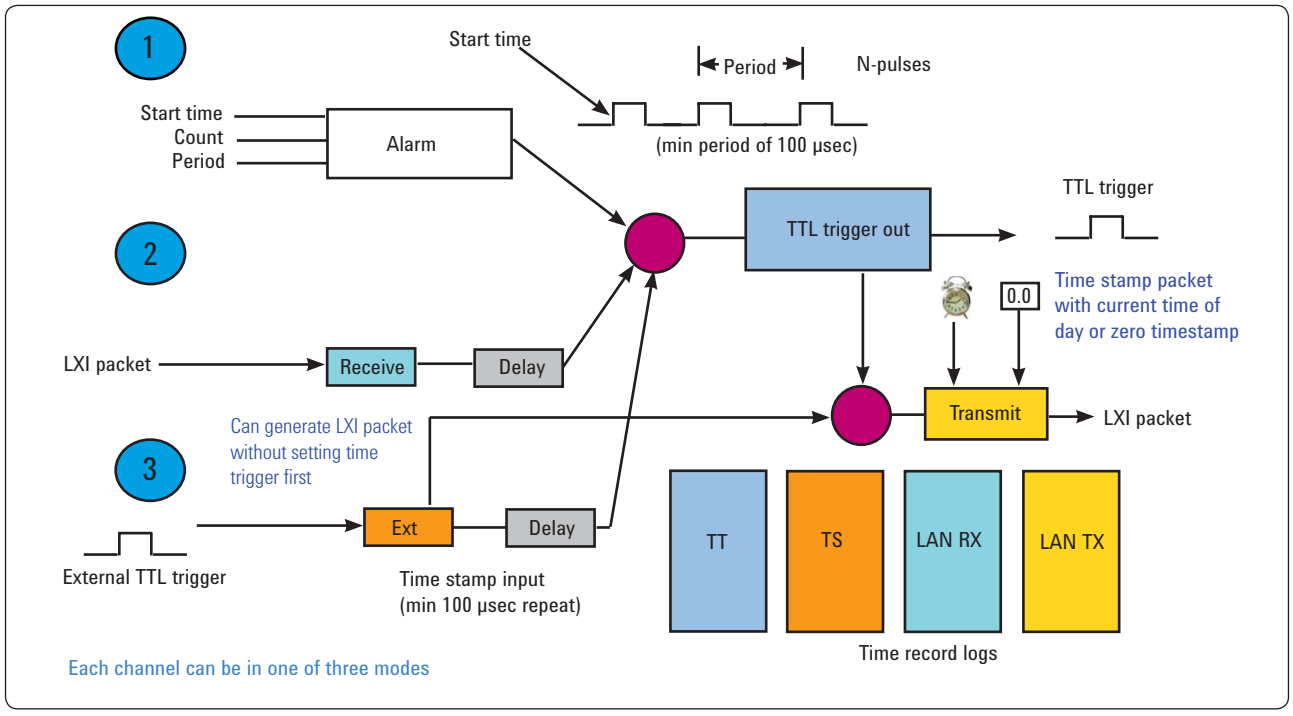

Figure 1. Three major modes that cause output trigger

Each time a TTLn Trig Out occurs from any of the mentioned three modes, an LXI LAN packet can be sent with either a current time of day time stamp or a zero time stamp inside the packet. A zero time stamp received by another device always means "execute whatever you are configured to do immediately". If you are including a current time of day time stamp in the LXI LAN packet, then the receiving instrument uses that time stamp to coordinate the event.

For example, if the delay is set, then the delay starts immediately when receiving a zero time stamp or it is added to the absolute time found inside the LXI LAN packet. The latter case can yield very precise time trigger coordination between instruments in your system.

Note the color of the different boxes. All events are time stamped with the 20 ns resolution of the E5818A's internal clock. The light blue box indicates a time stamp record is entered into the TT event log every time there is a TTLn Trig Out. If a LAN packet is output with a TTLn Trig Out, then the time when the LAN packet is sent is time stamped in the LAN TX box. Likewise, an input edge (rising or falling) to the EXTn input gets time stamped into the TS event log.

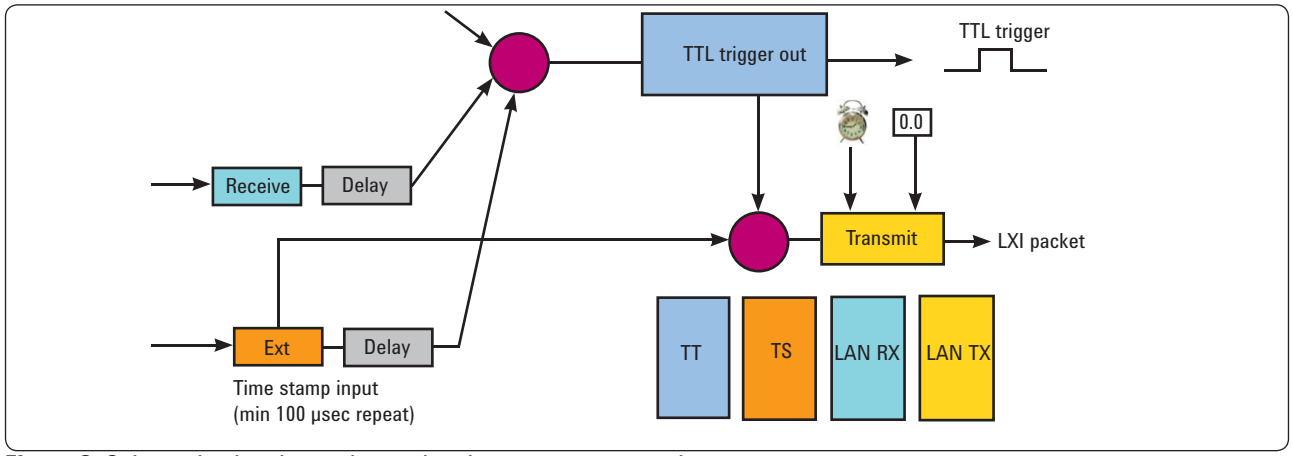

Figure 2. Color code showing major modes that causes output trigger

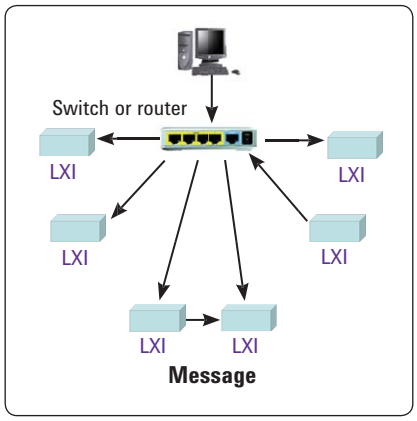

Figure 3. P2P multicast

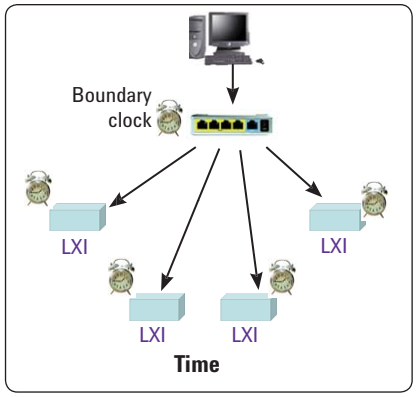

Figure 4. Time synchronization time stamps

LXI Class-B instruments support peer-to-peer (P2P) and multicast LAN packet messaging. Note that the computer does not need to be involved in these messages, although the computer can receive or generate a packet and also can monitor packets. Agilent's I/O Library Suite 15.0 includes an API for LXI LAN packet messaging and also includes a tool called Interactive LXI for monitoring and causing both message and time stamped packets.

P2P is a message from one instrument to another, using the TCP protocol. This means instruments can be separated by any distance and use any LAN path, wired or wireless, and the packet is guaranteed to be received. In contrast, multicast is limited to a subnet of instruments and is equivalent to a GPIB Group Execute Trigger. Note that a VPN connection can be established between equipment in such a way that it appears that the device is part of a local subnet. In such cases, the multicast message would be passed through.

LXI Class-B instruments have real time clocks and can cause events to occur based upon absolute 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. In most cases, the SCPI Status Register events would be events that are time stamped. This adds considerable value to the test engineer, who can run a test sequence and then observe how long certain events took to execute inside the instrument. You won't have to run timing loops to find out that information.

The E5818A trigger box is a forerunner to broad availability of LXI Class-B functionality in all LXI instruments. The E5818A is a bridge that gives Class-B functionality to virtually any instrument, LAN-based or using any other interface. As long as the target instrument has trigger inputs and outputs, the E5818A can be used to enhance that device.

Applications and Use Cases

As the introduction indicated, wherever you have instruments that can be triggered or can trigger, you have an opportunity to enhance that application with the E5818A trigger box. The following are some examples.

Precision trigger control

The E5818A trigger box has two channels that can place triggers within 2 ns of each other if firing at the same time of day or from the edge of an external trigger. Each channel can delay the trigger independently with 20 ns resolution. In timer mode, N-pulses can be output on both channels independently. The period of the pulse train is limited to 100 µs, but the absolute start time of each channel can be set in increments of 20 ns.

A LAN message can be sent to the trigger box with either P2P or multicast, either from the computer or from another trigger box or Class-B instrument Trigger output can be delayed, immediate, or precisely coordinated at a particular time between two time-synchronous instruments.

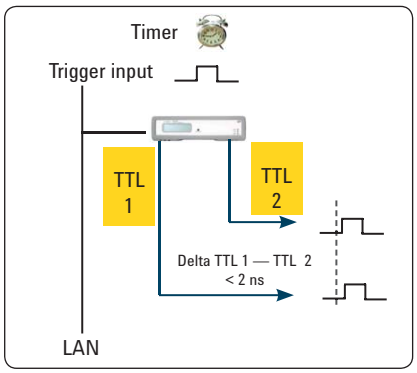

Figure 5. Synchronized triggering events

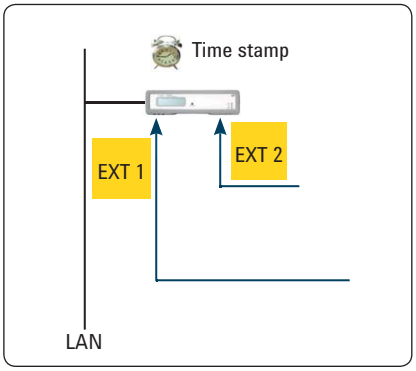

Figure 6. Time stamp inputs

Characterizing system performance

The E5818A trigger box clock is synchronized with the other Class-B instruments in the subnet. That is, all instruments are time aware, so time stamping of events in the system is correlated. All you need is TTL outputs from instruments in your test system and input to one or more trigger boxes. Each event log can store 5,000 entries and can span hours or days.

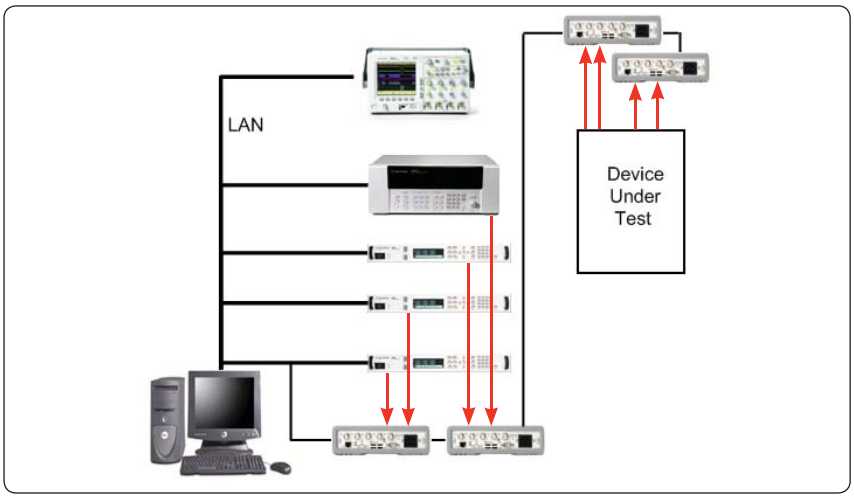

Figure 7. Test system performance

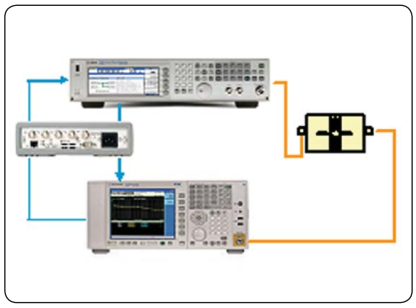

Figure 8. Delayed trigger control

Delayed trigger control

Some instruments may be difficult to interface with respect to external triggering. Polarity, delay, output drives are all considerations that make this difficult. In addition, if you have ever replaced an existing product with the "new improved" version, you may find the new box's speed causes your legacy system to stop functioning properly. You want to slow the new instrument down first, before you figure out how to speed things up.

Consider a spectrum analyzer and signal generator running in a mode called List Sweep. Each product has a table of output frequencies, measurement types, amplitudes, etc. that may consist of hundreds of points. The whole purpose of the list sweep mode is to avoid sending all those SCPI commands from the computer. Instead, the signal analyzer (SA) and signal generator (SG) hardware trigger each other to the next point in the sequence. What if you had a situation where the SA triggered the SG, and the SG responded with a trigger before the SA was ready? The simple solution is to delay the trigger either to the SG or from the SG. This can be done easily with the E5818A trigger box.

Emergency shutdown

An expensive DUT must be protected from over-current or test failure. Modern power supplies offer over-current shutdown and also have inhibit inputs that can be driven from other devices. However, sometimes you need to create a shutdown sequence of power supplies to make sure circuits are not back-biased. Using the E5818A allows you to receive the fault conditions for many devices and coordinate a shutdown.

Multiple E5818A trigger boxes can solve this problem. Any fault signal from any of the instruments or DUT can cause an LXI LAN message to be multicast over the LAN to the other E5818A trigger boxes. Each E5818A can typically react to the LAN message in 1 msec and cause its outputs to execute in sequence. The sequence is created by assigning delays to each output relative to the time stamp in the LAN packet. The LAN packet would have the time stamp of the event, so the delay actually starts at the event rather than from the receipt of the LAN packet.

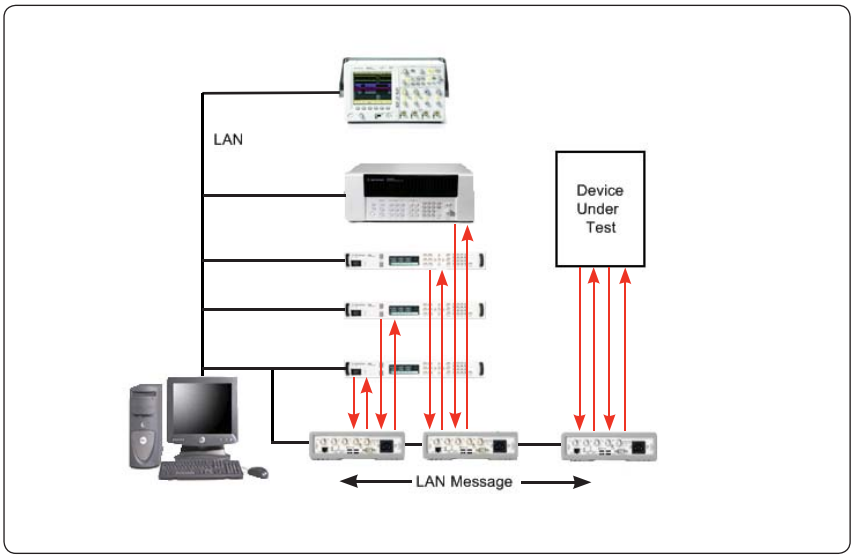

Figure 9. Test system failure protection

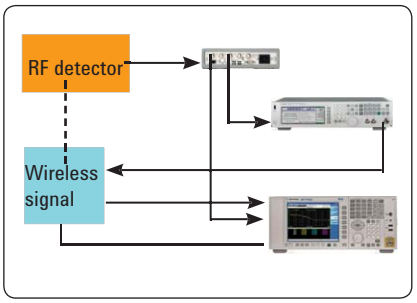

Figure 10. RF detector to E5818A

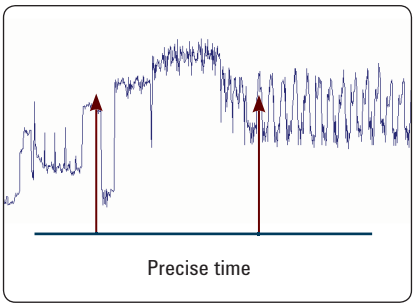

Figure 11. Sychronized time sampling reduces digitization and post processing time

RF detection to trigger

Sometimes you need to operate from the presence of a wireless signal, but you need to control multiple instruments based upon the arrival of that signal. An RF detector, generating a TTL signal, could trigger an E5818A, which can then trigger other instruments in some particular sequence of delayed triggers.

Synchronize measurements near or far

It is desirable to trigger a receiver just before a signal arrives at its input. That signal may be surrounded by noise, so it is advantageous to sample only what you need in order to reduce post processing.

When the instruments are close to each other, a single E5818A trigger box can be used with its two channels. When the instruments are separated by a long distance, you can use two E5818A trigger boxes that are time synchronized.

LAN instruments can be separated by as much as 100 meters, point to point, and still use IEEE 1588 to keep their clocks synchronized automatically. If you need to separate instruments by as much as 100 miles, you could use a VPN connection or a GPS device to synchronize clocks. The transmitter can send a TCP LAN packet over any distance to another instrument and cause it to trigger in the future. If the number of hops between the instruments results in a longer delay than necessary, then both instruments can use a future time to trigger with the necessary delay between triggers.

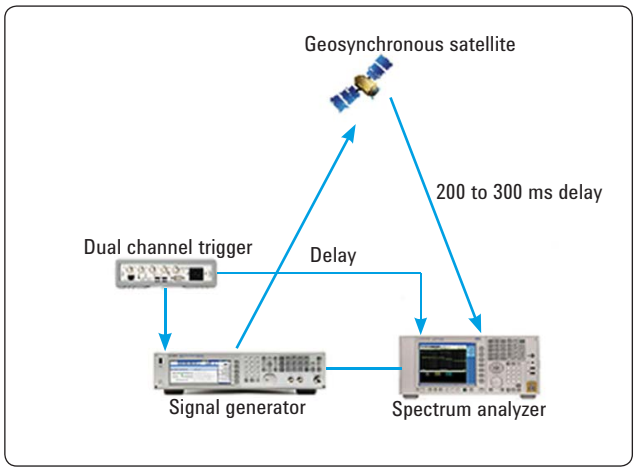

Figure 12. Near field measurement synchronization

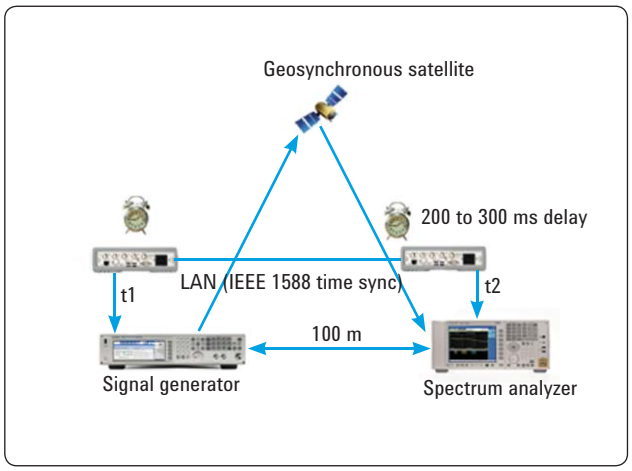

Figure 13. Far field measurement synchronization

Antenna Measurements

An earlier application showed the List Sweep mode between a spectrum analyzer and a signal generator. The same can be done with a network analyzer and signal generator for antenna measurements. If the two instruments are in close proximity, the hardware handshake is simply two BNC cables connected between the instruments, as seen in Figure 14. However, when the instruments are separated by 1,000 feet, it is impractical to run trigger wires between them. If there is no LAN connection between the two sites, the application can still be supported by wireless access points, using directional antennas and two E5818A trigger boxes. The LAN-based instruments can also be programmed over the wireless connection. The hardware handshake is converted to an LXI LAN packet handshake between the two E5818A trigger boxes, with BNC cables then wired to each respective instrument. Performance is slower due to the wireless connection, but everything operates as if the two instruments were hardwired together. No change is required in the front panel or in the programming. Once the two E5818As are configured, they appear transparent to the application. TCP LAN packets can be used between the two E5818As to guarantee that no packet is lost.

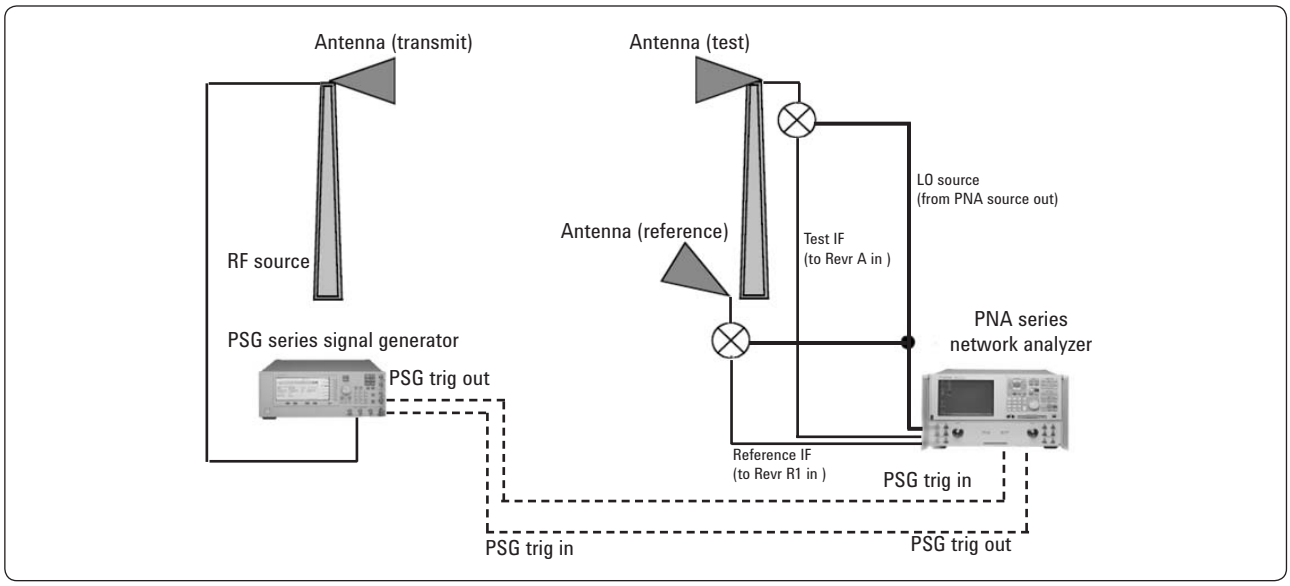

Figure 14. BNC cable connection

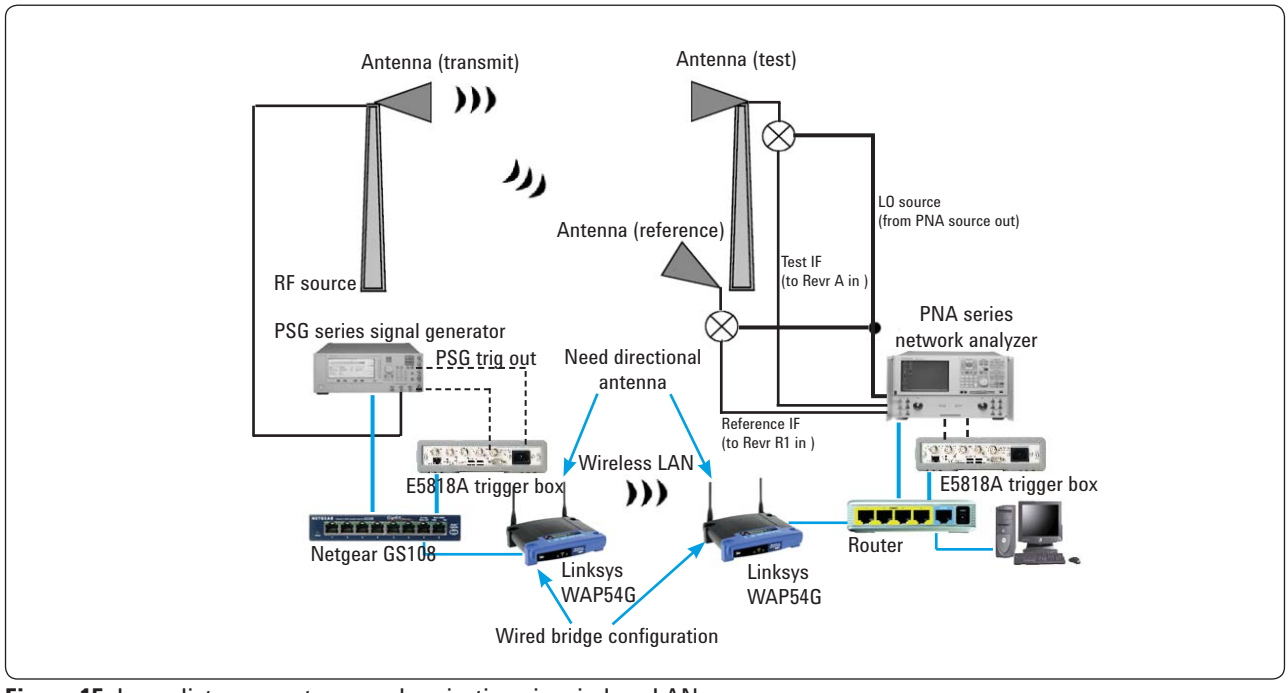

Figure 15. Long distance system synchronization via wireless LAN

Summary

The E5818A trigger box has many applications for coordinating instrumentation, both near and far, with its varied trigger inputs, outputs, use of LXI LAN messaging and time synchronization. It is compact and retains its configuration and clock when power is removed. It creates an interface between instruments, and it allows systems to be characterized and controlled.

The E5818A trigger box is an LXI Class-B instrument, so it has all the benefits that LXI Class-C instruments provide — built-in Web Servers, LAN connectivity, and the widespread availability of LAN and its low cost components. In addition, LXI Class-B instruments provide precision time clocks, time clock synchronization, time stamping of events, peer-to-peer and multicast messaging.

The E5818A trigger box is a bridge into a future where more instruments will be LXI Class-B compliant and will have these capabilities built in. Until that day arrives, the E5818A trigger box can be used to enhance existing instruments in test systems. This provides the benefits of Class-B instruments and the many varied degrees of freedom that come with trigger flexibility, time awareness, time synchronization, messaging, and long distance operation.

Use the following link to learn more about the Agilent E5818A trigger box:
www.agilent.com/find/E5818A

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