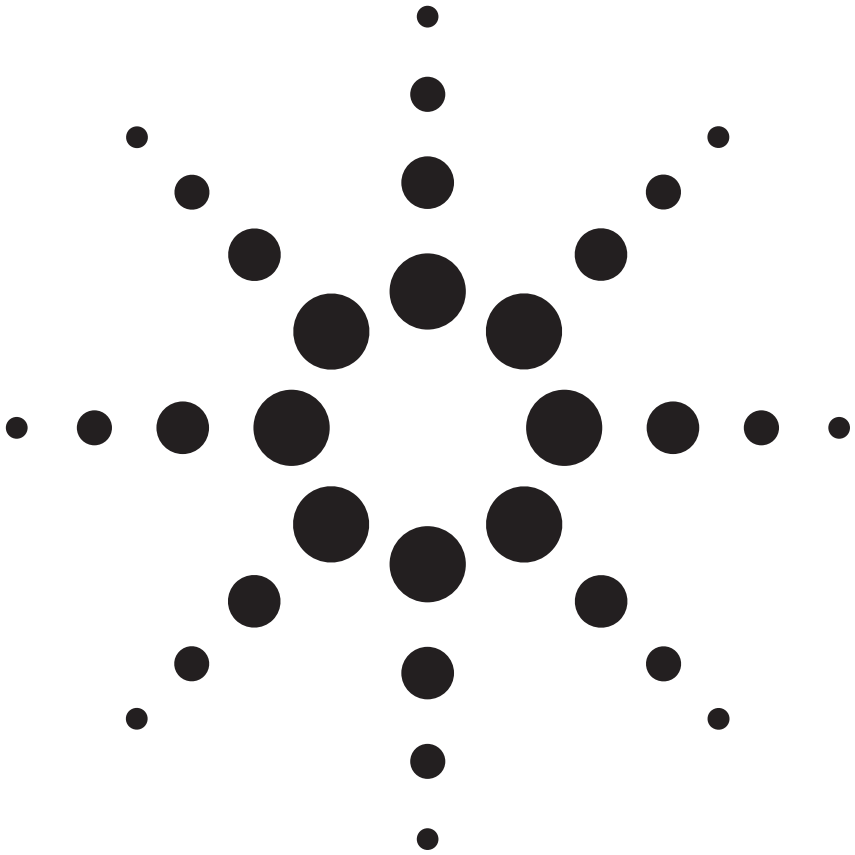
Agilent Triggering PNA Microwave Network Analyzers for Antenna Measurements

White Paper



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Introduction

Triggering is a key part of many test setups such as antenna measurements. The purpose of this paper is to give an overview of recent changes to the PNA Series network analyzer's triggering system, and to explain how they can be applied to an antenna measurement setup.

A thorough explanation of the PNA's triggering capability, and how to remotely program this triggering, is provided in the PNA Help system. This paper provides an overview of the capability, with a focus on the newly added features.

The data below applies to E836xB models with firmware revision 3.5 or higher. Earlier PNA models and firmware revisions will have some, but not all, of the described features.

Trigger Source

The PNA supports three different trigger sources:

1. Internal trigger - PNA supplies continuous trigger signals
2. Manual trigger - User supplies a trigger signal by pushing a front panel button, clicking the mouse, or using a remote GPIB or COM command.
3. External Trigger - Trigger signal is supplied by an external piece of hardware

Antenna Application
Typically in an antenna measurement setup, the PNA is externally triggered. This is required to synchronize the PNA's data collecting with other hardware such as signal sources and antenna positioners.

External Trigger Control Lines

Accessing the PNA trigger line when using External Trigger as the trigger source can be accomplished in one of two ways:

1. Pin 19 of the Aux I/O connector on the back panel
2. ***NEW*** BNC on the back panel labeled “I/O (TRIG IN)”. The impedance of this input is a few kΩ.

Antenna Application
Connecting a trigger signal to a BNC connector is much more convenient than connecting the signal to the correct pin of the Aux I/O connector.

Trigger Mode

NOTE
Edge triggering can currently only be set up via remote SCPI CONTrol:SIGNal commands, and can only be done when the PNA is set to Point Triggering as described on the following page.

1. Level Trigger - When active, the PNA is triggered continuously. When not active, the PNA is waiting for the next trigger. User can specify the “active” level to be high or low.
2. ***NEW*** Edge Trigger - The edge of a pulse supplies a single trigger to the PNA. User can specify the PNA to be triggered on either the rising (ie. positive) or falling (ie. negative) edge.

Antenna Application
Typically, most triggering is done via edge triggering, not level triggering. Level triggering makes the PNA very difficult to trigger properly, since multiple triggers could occur while the trigger signal is at the active level, even if the user only wants a single trigger from the pulse edge. With the implementation of edge triggering, this challenge is solved.

Trigger Scope

When a PNA is set up with multiple measurement channels, there are a variety of ways in which the channels can be triggered.

- **Global** - A trigger applies to all channels. The channels make their measurements in order.
- **Channel** - A trigger applies to a single channel. When a trigger is applied, the waiting channel makes its measurement, and then all measurements pause. At the next trigger, the subsequent channel makes a measurement, and then all measurements pause.
- **Point** - "Point Triggering" is actually a subset of Channel Triggering. In this mode, each trigger causes a single measurement point to be taken. Therefore, a 101 point sweep would require 101 triggers to complete. After a given channel is done with its point measurements, the first point on the next channel is triggered.

Antenna Application
For most antenna applications, triggering must take place on a point-by-point basis. Some examples of this:

1. An external signal source is being used to provide the RF frequency. Thus when sweeping frequency, the external source and receiver must both be triggered to step one frequency point at a time. It would be nearly impossible to synchronize their frequency sweeps without this capability.
2. An antenna pattern at a single frequency is being measured by stepping a positioner. The user wants a single data point at each antenna position. The receiver must be triggered on a point-by-point basis.

Trigger Delay

When using the PNA with trigger source set to "External", the user can enter a delay time from 0 to 1 seconds with 6 microsecond resolution. This delay time is in addition to the inherent trigger delay time of the PNA trigger system. When the PNA receives the trigger signal, it will wait the specified delay time before beginning the next measurement.

Antenna Application
It may be useful to enter a delay time here to allow all external equipment (signal sources, positioners, antenna probes, etc.) to completely settle before taking data.

Triggering Other Equipment and Handshaking

PNA receives external trigger

In many setups, the PNA will be responsible for outputting a trigger signal to other pieces of equipment, or the user may simply want to know when the PNA is ready to be triggered again. There are two signals available from the back panel for these operations. One must understand the operations a PNA goes through when it receives a measurement trigger in order to use these signals correctly.

Assume the PNA is set to point triggering in step-sweep mode with an external edge trigger. It will go through the following process upon receiving a trigger signal:

1. External Trigger received
2. ***Ready for trigger*** goes high (inactive). This occurs a couple µS after the trigger signal is received
3. PNA setup time (gain ranging, anti-alias filter settling, etc.). Time is typically 70 µS in step-sweep mode
4. Data acquisition. Time is roughly 1 / (IF Bandwidth)
5. ***Output trigger*** (if enabled)
6. Step to next frequency. Time is widely variable and depends on how large a frequency step, if there is a band crossing or retrace, etc.
7. Synthesizer settling time
8. ***Ready for trigger*** goes low (active)

PNA sends external trigger

The output trigger is available via a BNC connector on the back panel and is controlled via the CONTrol:SIGNal SCPI commands. Output triggering allows the PNA to send a trigger signal to other pieces of equipment, such as a signal source set up in list mode. The output trigger is a pulse about 2 µS wide, and typically occurs 5-10 µS after data acquisition is complete, but before the PNA has stepped to the next measurement frequency. Output triggering is only available in point-sweep mode.

The Ready for Trigger (RFT) signal is available via Pin 18 on the Aux I/O connector on the rear panel. It is an active low signal. Therefore when the PNA is initially triggered via an external signal, the RFT signal will go high a few microseconds after the external trigger is received. The signal will remain high until all operations are complete and the PNA is ready to receive the next trigger input.

Having both input and output triggering enabled on the PNA allows for handshaking to occur between the PNA and an external source to create the fastest possible sweep times, as shown in Figure 1.

Antenna Measurements Example

Below is a simplified example of a system setup for making far-field antenna measurements. In this example, a system controller (not shown) would control the antenna positioner (also not shown) and the PNA. The PNA is in frequency-offset mode, which allows its source to provide a microwave LO frequency and its receivers to measure the IF frequency. In addition to the trigger connections shown, there must be a 10 MHz reference connection between the PNA Series network analyzer and PSG signal source.

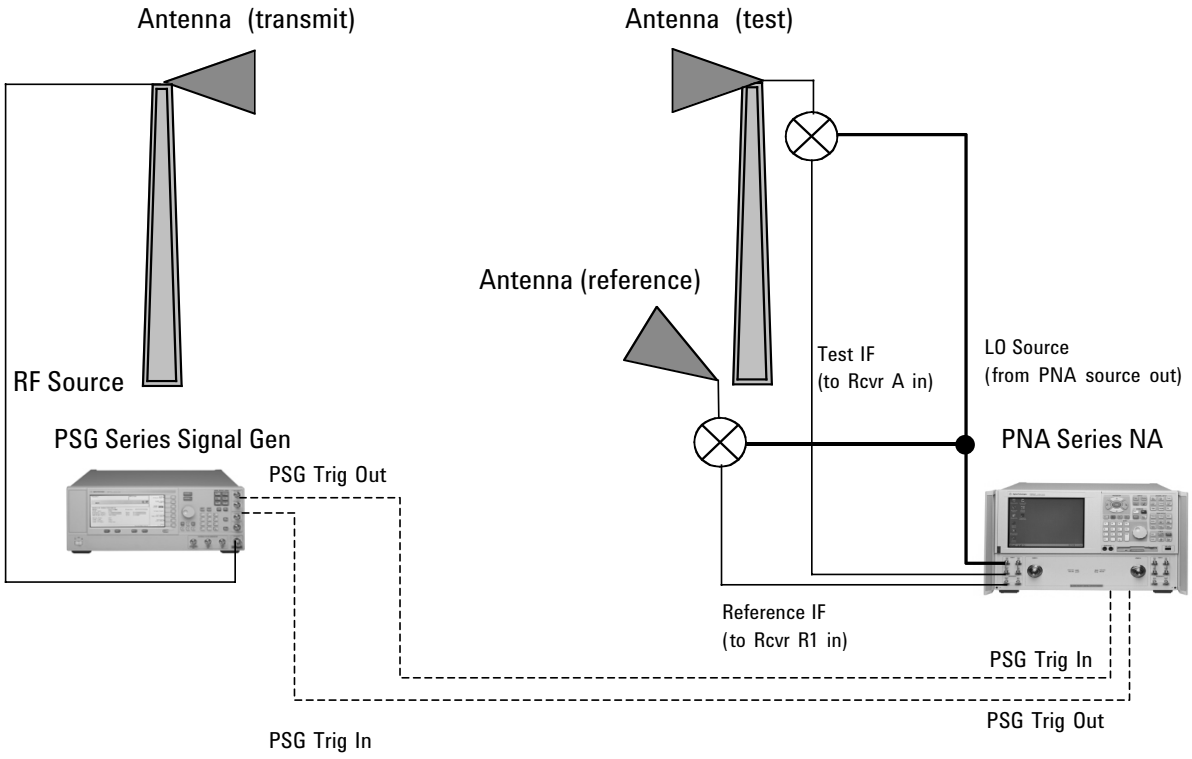

Figure 1. System setup example for making far-field antenna measurements.

1. PSG steps to new frequency
2. PSG sends trigger to PNA
3. PNA makes measurement
4. PNA sends trigger to PSG

   Repeat for every frequency

Example SCPI commands to set up the above triggering are given below.

CONFIGURE PSG

":LIST:TRIG:SOUR EXT"	Set trigger source to external
"TRIG:SLOPE Negative"	Set to trigger on negative edge
"TRIG:OUTP:POL Negative"	Set output trigger polarity to be negative

CONFIGURE PNA

"TRIG:SOUR External"	Set trigger source to external
"TRIG:SCOP Current"	Set trigger scope to "Channel"
"SENS:SWE:TRIG:POIN ON"	Set PNA to trigger on a point-by-point basis
"CONT:SIGN BNC1, TIENEGATIVE"	Set PNA trigger input to respond to a negative trigger
"CONT:SIGN BNC2, TOPNAFTER"	Set PNA output trigger to be a negative polarity

START TRIGGERING

PSG: ":SOURCE:LIST:MODE MANUAL"	Put PSG in a temporary hold state
PNA: ":SENS:SWE:MODE Cont"	Next 3 commands reset sweeping on the PNA
PNA: ":SENS:SWE:MODE Hold"	
PNA: ":SENS:SWE:MODE Cont"	
PSG: ":SOURCE:LIST:MODE AUTO"	Put PSG back into auto trigger mode

This example assumes that the delay in triggering the PSG is long enough for the PNA to proceed to the next frequency point. If this was not the case, one could use the ***Ready for Trigger*** signal instead of the ***Output Trigger*** signal to trigger the PSG.

Conclusion

The triggering capabilities of the PNA make it a powerful tool in a variety of measurement applications. The edge and point triggering features allow for precision synchronization with the other components of an antenna measurement system; and are easily applied to other measurement applications as well.

Web Resources

For additional information about the Agilent PNA Series visit:
www.agilent.com/find/pna

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