

How to Measure 5 ns Rise/Fall Time on an RF Pulsed Power Amplifier Using the 8990B Peak Power Analyzer

Application Note

Introduction

In a pulsed radar system, one of the key transmitter-side components is the pulse power amplifier (see Figure 1). Power amplifiers, whether solid state or vacuum tube, used in pulse radar systems need to output up to several kilowatts of power. Since WWII, engineers have been trying to

perfect the design of pulsed power amplifiers to support wider bandwidth, thus allowing more data to be transferred, and to increase efficiency to enhance power consumption efficiency.

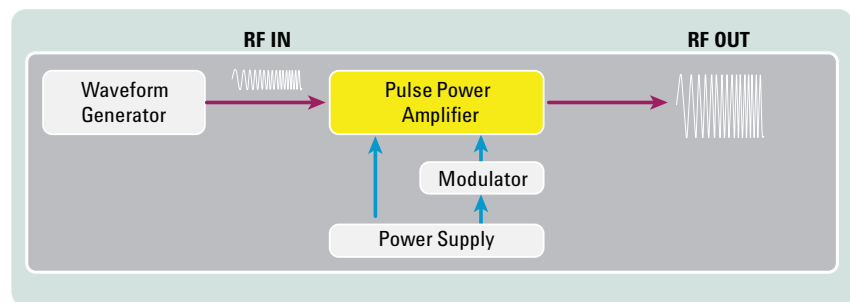


Figure 1. Transmitter block diagram



Agilent Technologies

One of the key measurements required for evaluating a wide bandwidth (greater than 100 MHz) using a pulse power amplifier is pulse rise time. Currently there are several instruments capable of measuring the rise time of the RF pulsed power amplifier, including a high sampling oscilloscope with a diode detector, an RF peak power meter, and an RF spectrum analyzer using zero-span mode. This application note focuses on a new measurement instrument: the Agilent Technologies 8990B peak power analyzer (PPA). It is the highest performance peak power meter in

the power meter test and measurement industry. The 8990B is easy-to-use and provides highly accurate fast rise/fall times measurements.

This application note illustrates how using the 8990B peak power analyzer allows you to confidently measure sub-5 nanosecond rise time on radar pulses (Figure 2). The document also explains how equivalent time sampling (ETS) is used to measure rise time. Some tips are provided to show you how to ensure you obtain the correct rise/fall time measurement results.

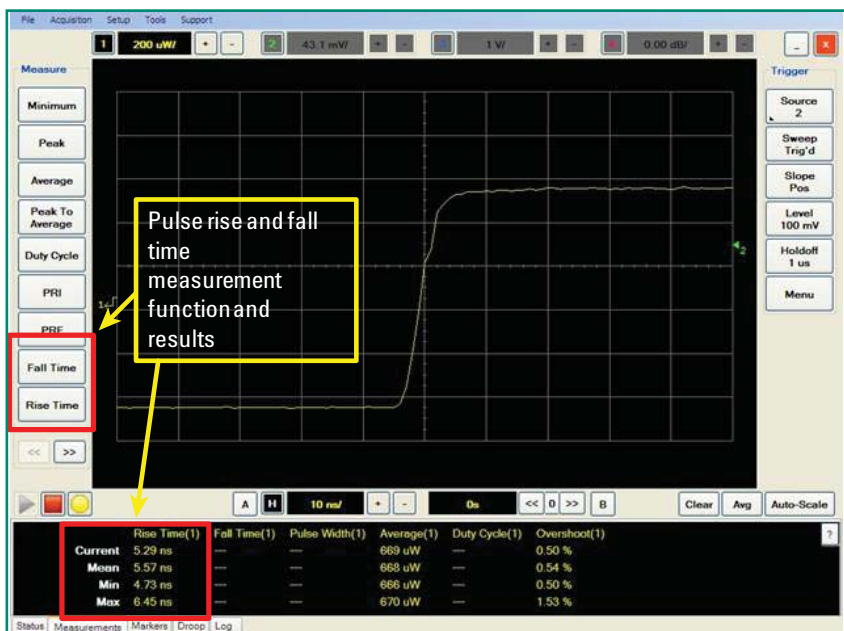


Figure 2. Screen shot of the 8990B PPA measuring a fast RF pulse rise time

Pulse Shaping (Profiling)

When developing a wideband power amplifier or transmitter device, signal processing and modeling techniques such as the pulse profiling or shaping have been used to make sure RF pulses transmitted out meet the bandwidth requirement (see Figure 3). Filtering design also plays an important role in determining the RF pulse profile.

For example, a sloping leading edge (rise time) affects the minimum range as well as range accuracy or resolution. This means that the range resolution of a pulsed radar system is fundamentally limited by the bandwidth of the transmitted pulse; the wider the bandwidth, the better the range resolution.

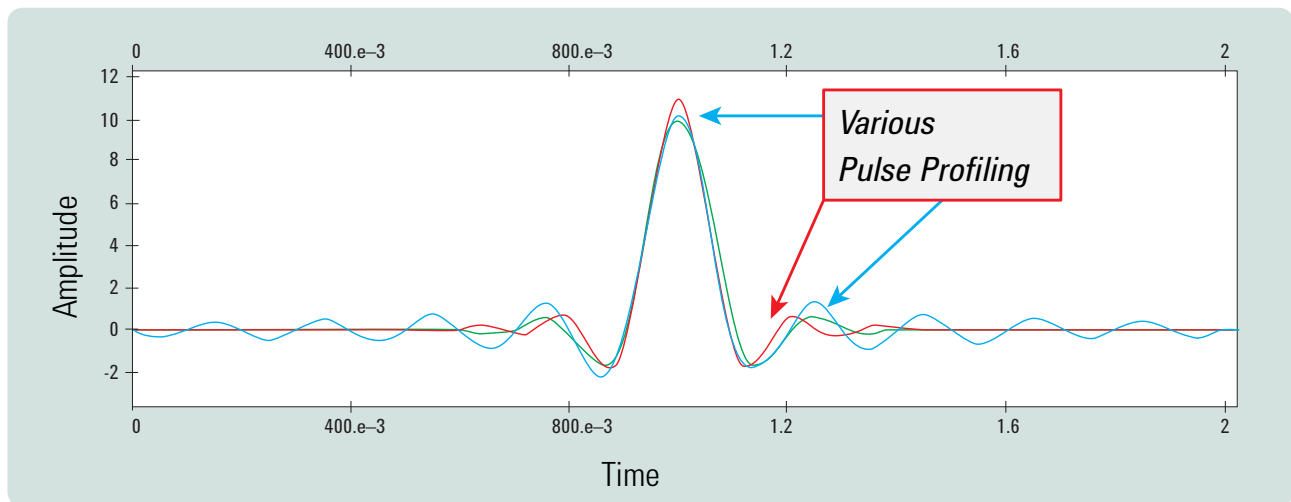


Figure 3. Pulse profiling illustration

The Challenge in Measuring Fast Rise Time

When trying to measure a very fast pulse rise/fall time on an RF pulse, minimizing measurement uncertainty is important. Consequently, obtaining an accurate rise time on the device under test (DUT) requires the use of a measurement device with a rise time that is faster than the expected rise/fall time. To further reduce measurement uncertainty, it is desirable to directly measure the RF pulse from the DUT, eliminating the use of adaptors or convertors.

As mentioned earlier, the 8990B PPA has a sub-5 nanosecond rise time capability using equivalent time

sampling (ETS). (ETS is explained in the next section.) Using the 8990B with two wideband and fast power sensors (the N1923A and N1924A), the DUT's RF pulse signals can be measured directly. This setup is ideal, particularly when measuring a fast rise/fall time, since measurement uncertainty is kept to minimum because the signal correction is done inside the power meter.

Figure 4 shows the rise time measurement error (in percentage) versus the DUT's actual rise time. The graph is constructed based on the following simple error equation:

$$\text{Risetime Error} = \frac{\sqrt{\text{Risetime}_{\text{Instruments}}^2 + \text{Risetime}_{\text{DUT}}^2} - \text{Risetime}_{\text{DUT}}}{\text{Risetime}_{\text{DUT}}} \times 100\%$$

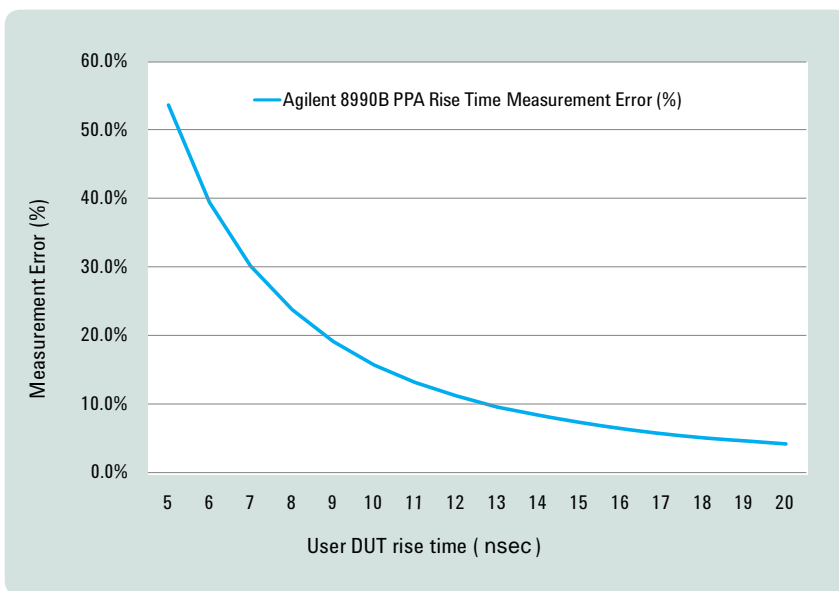


Figure 4. 8990B rise time measurement error vs. DUT rise time

Equivalent Time Sampling

Equivalent time sampling (ETS) works by constructing a picture or waveform of the input signal by accumulating samples over many waves of triggering cycles. As illustrated in Figure 5, when the ETS feature of the 8990B PPA is turned on, an accurate time-to-digital converter (DTC) subdivides 10 more bins (points) over multiple triggers samples, meaning the DTC can accurately locate 10 more smaller time samples in each trigger. The

sampling rate of the power meter channels (channels 1 and 4) are effectively boosted up from the 100 MSa/s real-time sampling to 1 GSa/s sampling when ETS is used. This is a common sampling technique and is used in some of the conventional digital oscilloscopes to effectively increase the sampling rate to capture fast and repetitive signals.

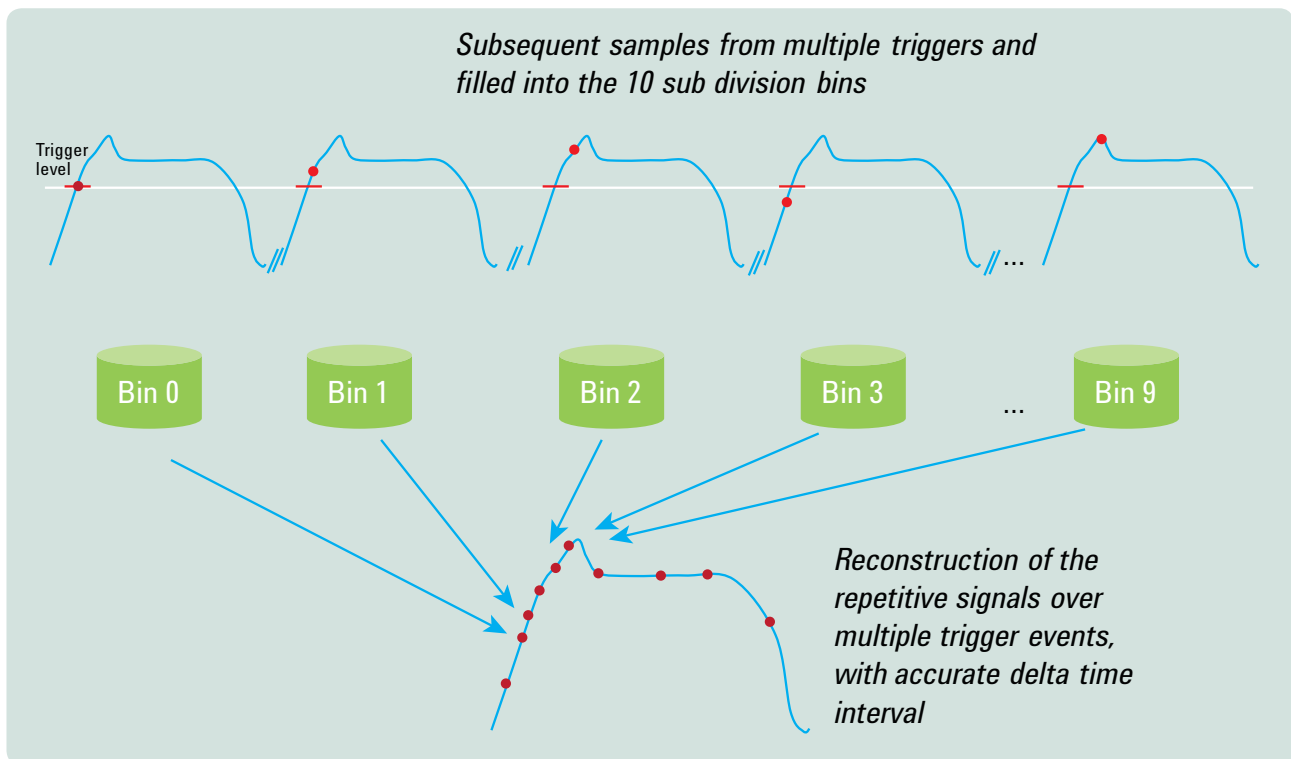


Figure 5. 8990B equivalent time sampling illustration

In the 8990B PPA, ETS is turned on automatically only when the time base setting is set below 500 ns/div. At 500 ns/div and above, ETS is turned off; in other words it is in real time sampling of 100 MSa/s. To check whether ETS is turned on

or off, simply click on the Status tab at the bottom of the 8990B measurement panel (shown in Figure 6 below). The panel also shows if the ETS acquisition status is acquiring or completed.

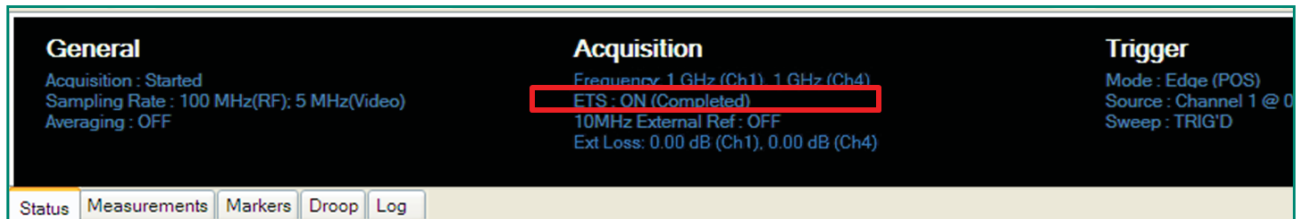


Figure 6. 8990B ETS status bar

The limitation of this measurement method is that ETS works best on repetitive signals. ETS cannot be used for single-shot or non-repetitive signals because there are not enough data samples to reconstruct the signal waveform. For these instances, there is an option to manually turn off the ETS even if the time base is set to below 500 ns/div. This allows you to analyze non-repetitive RF pulses, provided the rise/fall time is greater than 50 ns.

The other limitation of ETS is the triggering time. The longer the waiting time for one trigger to be armed and completed, the longer it takes for ETS to fill the 10 acquisition bins and subsequently build back the RF pulse waveform.

Tips For Obtaining Correct Rise/Fall Time Measurement

The flowchart shown in Figure 7 is a guideline to optimize the rise/fall time measurement result in the 8990B PPA. As it shows, there are two pre-determined factors that you need to know in order to obtain the best rise/fall time measurement accuracy. The first is for you to know the expected rise time. This data can be

found in the DUT's data specification documents. The second is for you to know whether the signal is repetitive. In most testing conditions, DUT pulses are repetitive since they can be generated from external RF signal sources or when the DUT is operating in service or self test mode.

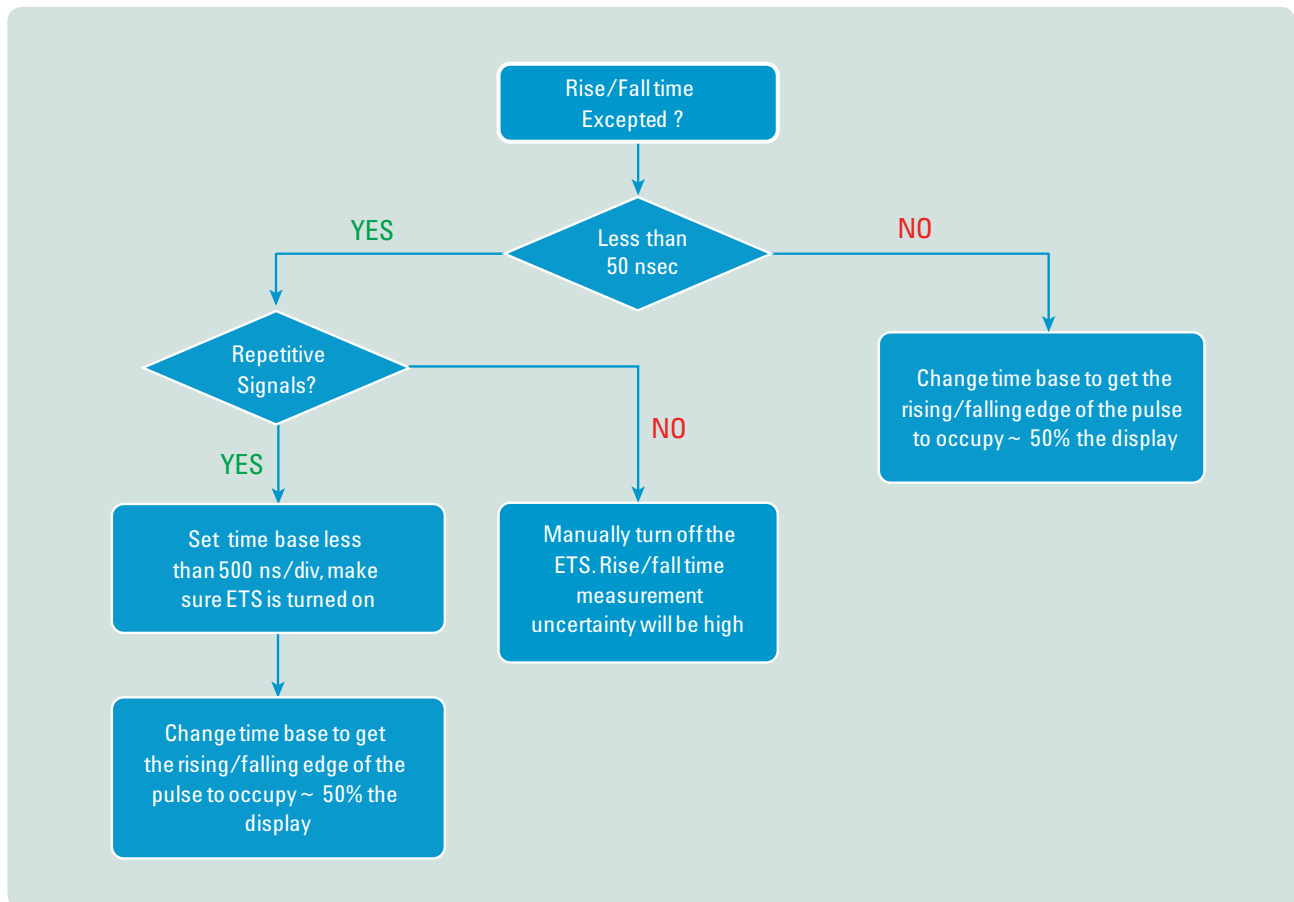


Figure 7. Flow Chart to Get Optimized Rise/Fall Time Measurement

Conclusion

Accurately measuring RF pulse nano-second range rise/fall time requires the use of a suitable measurement instrument that is properly set up. In a wide band pulse power amplifier, accuracy is especially important since the rise/fall time measurement becomes a critical performance measurement parameter.

The new Agilent 8990B peak power analyzer is an ideal test solution, ensuring measurement accuracy with its 5 nano-seconds rise time performance and easy-to-use graphic interface.

Reference

- 1) Principles Of Modern Radar: Basic Principles, Mark A. Richards, James A. Scheer, William A. Holm, Scitech Publishing, ISBN: 978-1-891121-52-4, 2010
- 2) Agilent 8990B Peak Power Analyzer, User's Guide, part number 08990-90005
- 3) Baseband Pulse Shaping for Improved Spectral Efficiency Technical Note, part number 5989-9492EN

 **Agilent Email Updates**

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent Channel Partners

www.agilent.com/find/channelpartners
Get the best of both worlds: Agilent's measurement expertise and product breadth, combined with channel partner convenience.



www.axistandard.org

AdvancedTCA® Extensions for Instrumentation and Test (AXIe) is an open standard that extends the AdvancedTCA for general purpose and semiconductor test. Agilent is a founding member of the AXIe consortium.



www.lxistandard.org

LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Agilent is a founding member of the LXI consortium.



www.pxisa.org

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.



Agilent Advantage Services is committed to your success throughout your equipment's lifetime. To keep you competitive, we continually invest in tools and processes that speed up calibration and repair and reduce your cost of ownership. You can also use Infoline Web Services to manage equipment and services more effectively. By sharing our measurement and service expertise, we help you create the products that change our world.

www.agilent.com/find/advantageservices



For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	(11) 4197 3500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 375 8100

Europe & Middle East

Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700* *0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
United Kingdom	44 (0) 131 452 0200

For other unlisted countries:

www.agilent.com/find/contactus

Revised: June 8, 2011

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2011
Published in USA, December 23, 2011
5990-9661EN

