Application Note

Radar Testing with Simulation Signals

Using Anritsu's

MG3690C Series Microwave Signal Generator
ML2490A Series Peak Power Meter and MA2411B Power Sensor
PowerMax Software Application

/Anritsu

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Chapter 1 — General Information

1-1 Introduction

This application note describes a process for simulating radar signals using an Anritsu MG3690C Series Microwave Signal Generator, an ML2490A Series Power Meter and MA2411B Power Sensor, and Anritsu PowerMax Software.

- Chapter 2 provides a brief review of radar theory, common uses, common configurations, and typical measurements performed on radar sub-systems and components.

- Chapter 3 provides a demonstration on how to use the test equipment to generate and measure radar pulses as well as a way to document the test results.

   The same demonstration in Chapter 3 is also presented in a video that can be viewed by clicking the link http://www.anritsu.tv/en-US/national-instruments-labview-autoradar.

- Appendix A provides a listing of recommended Anritsu equipment for other radar tests that are typically conducted on TX and RX RF chains.

1-2 MG3690C Series Microwave Signal Generator

The MG3690C series of broadband signal generators covers audio, HF, VHF, UHF, RF and microwave frequencies from 0.1 Hz to 70 GHz in single coaxial output and up to 500 GHz or beyond, with external multipliers. In addition, it is easy to operate either through intuitive front panel controls or remotely via GPIB or Ethernet connectivity. Thus, the MG3690C Series is an ideal signal source for both RF and microwave requirements, and is fully configurable for simple to high performance applications.

The MG3690C offers three levels of best-in-class SSB phase noise performance; Standard, Ultra Low Phase Noise (option 3) and Premium Phase Noise (option 3X), along with a full suite of modulation capabilities for signal simulations from simple to the most complex. In particular, the pulse functionality provides a simple yet powerful method to simulate radar related signals.

1-3 ML2490A Series Peak Power Meter

The ML2490A Series Peak Power Meter has been designed for high resolution measurements on radar and the latest 3G and 4G wireless systems, including next-generation systems based on complex new modulation technologies such as OFDM. It has the highest bandwidth and highest resolution in rising edge pulse measurements. A combination of an advanced sampling system and measurement features provides precise and accurate details on the transmitter's power envelope. High quality CW measurement ability compatible with a wide range of sensors adds to its uniqueness by making it universal, with all-purpose flexibility.

The pulse profile mode of the ML2490A Series Power Meter together with wide frequency band and wide video bandwidth MA2411B Power Sensor provides an excellent way for the user to measure radar pulses.

1-4 PowerMax Software Application

The PowerMax application provides a great way of documenting radar pulse test results in either numeric, graphical or pictorial form.

PowerMax is a software package that allows the user to control the ML2480B or ML2490A Series Power Meter (with firmware v2.31 or greater) from a remote PC. Use of the larger PC monitor offers a number of benefits including more immediately comprehensible setting fields, a larger trace display area, and the ability to capture and save trace and image data.

PowerMax is shipped as standard with all ML2480B or ML2490A series power meters purchased, or can be downloaded from the Anritsu web site. An ethernet connection is established between the power meter and the PC and measurement settings and results are then displayed on a Windows based GUI.

The key features of PowerMax are summarized below.

- Full remote control of the power meter allowing continuous real-time monitoring of measurement traces, print outs, and data archiving for later analysis.
- Familiar Windows based GUI maximizes visibility and operability.
- User information and error messages displayed without blocking the view of the trace or readout.
- Simultaneous display of information for all four gates and markers.
- Measurement settings split into a number of easily navigable tabbed pages.
- All changes made within PowerMax relayed automatically to the instrument.
- Save settings to dedicated location on power meter or to a file for transfer to separate PC.

1-5   Applicable Documentation

The following documentation is available in support of using the MG3690C Series Microwave Signal Generators, the ML2480B or ML2490A Series Power Meter and sensors, and the PowerMax Software.

- MG3690C Series Synthesized Signal Generators Operation Manual, part number 10370-10373
- MG3690C Synthesizer Technical Data Sheet (TDS), part number 11410-00515
- ML2480B / ML2490A Wideband Peak Power Meter Operation Manual, part number 13000-00238
- PowerMax Software User Guide, part number 13000-00238
- Power Meters and Power Sensors Technical Data Sheet (TDS), part number 11410-00423

The latest versions of this documentation are available for download from Anritsu at www.anritsu.com.

Chapter 2 — Radar Review

2-1 Introduction

This chapter provides a general review of radar theory.

The MG3690C Series RF/Microwave Signal Generator is ideal for simulating radar signals. It contains an internal pulse modulator and generator, making it easy to simulate these signals.

The pulse profile mode of the ML2490A Series Power Meter together with wide frequency band and wide video bandwidth MA2411B Power Sensor provides an excellent way for the user to measure radar pulses. In addition, the PowerMax Software application provides a great way of documenting results in either numeric, graphical or pictorial form.

2-2 Definition

RADAR is an acronym which stands for Radio Detection And Ranging. The basic concept is that a pulsed electromagnetic wave of known power and frequency is transmitted in a specific direction where it encounters a target that reflects some portion of the signal back, which is measured by a receiving device.

Radars can use CW signals, basic pulses like the example shown in Figure 2-1, or a wide variety of other signal waveforms.
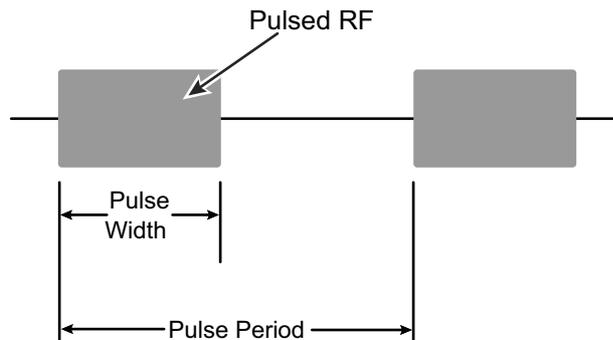

Figure 2-1. Simple Pulsed RF Signal

Figure 2-2 illustrates the concept of a radar system, showing the transmitted and reflected signal and the time duration of signal transit, which may be used to measure an object's range, speed and direction.
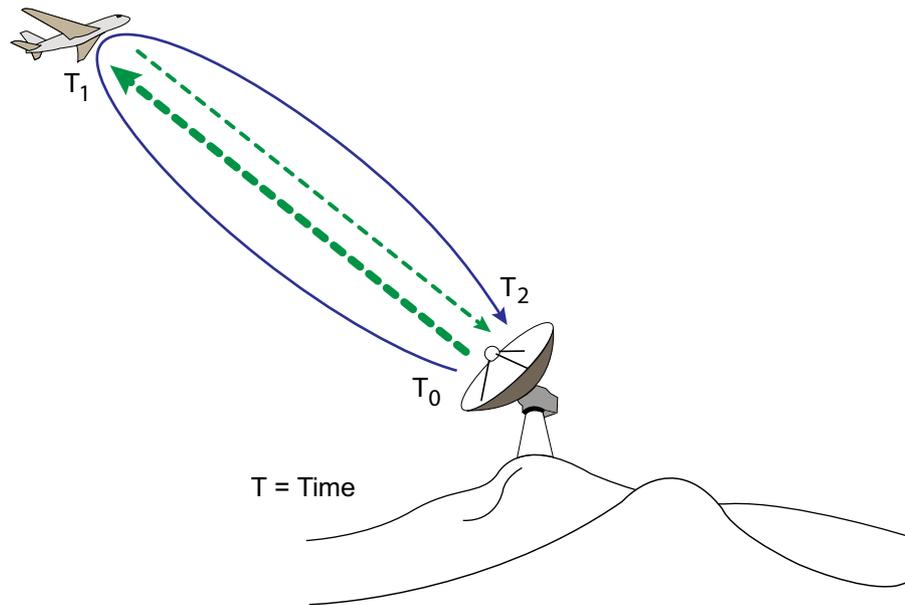

Figure 2-2.   Radar Transmitting / Receiving

2-3   The Radar Equation

The power of the received signal, Pr, or the distance (range, R) between the transmitter and the target can be determined by solving for specific parameters of the radar equation[1].

$$P_r = \frac{P_t \cdot G \cdot \sigma \cdot A_e}{(4\pi)^2 \cdot R^4} \quad \text{or} \quad R = \sqrt[4]{\frac{P_t \cdot G \cdot \sigma \cdot A_e}{(4\pi)^2 \cdot P_r}} \quad \text{or} \quad A_e = \frac{\lambda^2 \cdot G}{4\pi}$$

where

P_r = Received signal power

R = Range between the transmitter and the target

P_t = Transmitted signal power

G = Gain of the radar antenna

σ = Radar cross section of the target

A_e = Effective antenna aperture

λ = Wavelength of the transmitted signal

In addition to range, other information about the target can be detected, such as speed and direction, by varying parameters of the radar system. For example, scanning an area with a highly directive antenna can provide the direction of the target in azimuth and elevation, while measuring the frequency shift of the received signal can provide the target's speed.

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1.   Skolnik, Merrill. Radar Handbook. New York: McGraw Hill, 2008.

2-4   Radar Categories

Application

Target range is still a fundamental use for most radar systems. However, radar systems have evolved significantly in how they are constructed, the signals used, the information that can be captured, and how this information can be used in different applications. Radar is used in a wide array of both military and civilian applications, including:

- Surveillance (threat identification, motion detection, or proximity fuses)
- Detection and tracking (target identification and pursuit or maritime rescue)
- Navigation (automotive collision avoidance or air traffic control)
- High resolution imaging (terrain mapping or landing guidance)
- Weather tracking (storm avoidance or wind profiling)

Signal Type
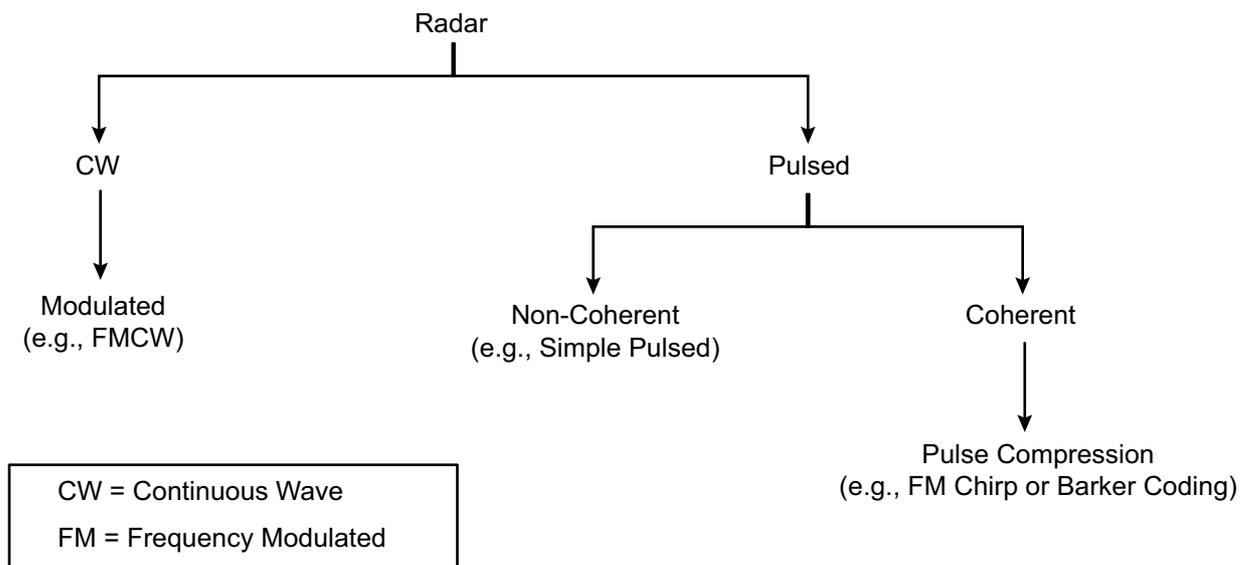
Figure 2-3.   Radar Signal Types

Listed below are some common radar systems with various signal types.

CW (Doppler) Radar: CW radar systems transmit a continuous wave signal at a constant frequency. The received signal includes a Doppler shift, which is used to determine the target's speed. This is a radar system often utilized by police for traffic monitoring.

FMCW Radar: FMCW radar systems apply frequency modulation to a CW signal to generate a timing reference. With that information, the user can determine range in addition to speed. A significant advantage for CW based radars is that they provide continuous results (in contrast to pulsed radar systems). This type of radar system is used in aircraft to measure the exact height during a landing procedure.

Pulsed Radar: A basic (non-coherent) pulsed radar system provides distance and direction of a target by measuring the time between transmitted and received pulses. The system is non-coherent because the phase is random from pulse to pulse. Long-range air surveillance is a common application of these radar systems.

Doppler Pulsed Radar: This is a coherent radar system in which the received pulse-to-pulse phase variations enable the element of speed to be added to the distance and direction of the target. They typically utilize high pulse repetition rates (PRRs), which enables more accurate radial velocity measurements, but have less range accuracy. Doppler pulsed radar systems are used to detect moving targets while rejecting static clutter, which can be very helpful in weather monitoring applications.

Moving Target Indicator (MTI) Radar: MTI radar also uses Doppler frequencies to differentiate echoes of a moving target from stationary objects and clutter. Its waveform is a train of pulses with a low PRR to avoid range ambiguities, at the expense of velocity accuracy. These types of radar systems are often used in ground-based aircraft search and surveillance applications.

Pulse Compression Radar: Short pulse width signals provide better range resolution, but have limited range. Long pulse width signals contain more energy and provide a longer detection range, but sacrifice resolution. Pulse compression combines the power related benefits of long pulse widths with the resolution benefits of short pulse widths. By either modulating the frequency (e.g., linearly for an FM chirp) or the phase (e.g. with a Barker code) of the transmitted signal, the long pulse can be compressed in the receiver by an amount equal to the reciprocal of the modulating signal bandwidth; see Figure 2-4. Many weather monitoring systems have moved to pulse compression radar.
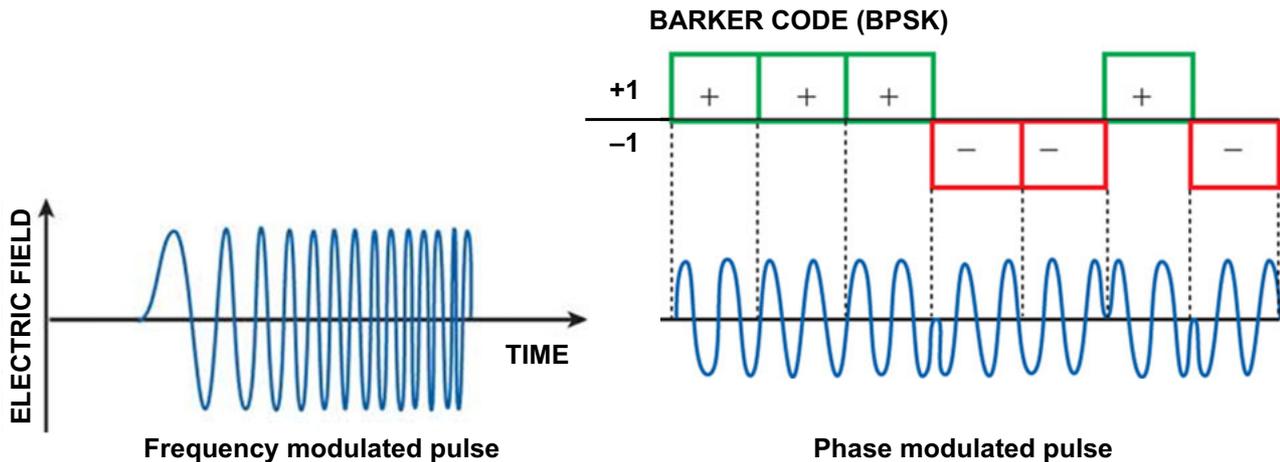

Figure 2-4.

Antenna Configuration

Radar systems can also be categorized by antenna configuration.

Monostatic Radar: In monostatic radar, the transmitter and receiver share the same antenna by way of time-domain multiplexing.

Bistatic Radar: If the transmit and receive antennas are separated (usually by a large distance or offset angle), the radar system is bistatic. Bistatic radar systems are often used for detection of stealth targets, where stealth technology intentionally avoids reflecting radar signals in the direction of the transmitter.

Electronically Steered Array (ESA): A radar system may employ an array of antennas, sometimes in the 1000s or 10,000s of antennas. By precisely controlling the phase and amplitude of each antenna, the overall beam pattern of the array can be steered or shaped. These phased array antennas are an alternative to mechanically steered antennas, which are often heavier and more failure prone. In addition, mechanical systems can be disabled through a single point failure of the motor, while it is possible that one or more elements of a phase array antenna can fail without completely incapacitating the radar. There are two basic types of these Electronically Steered Array (ESA) radar systems; Passive ESA (PESA) and Active ESA (AESA).

PESA: Passive Electronically Steered Array; Typically, PESA radar systems take a signal from a single source, split it into hundreds of paths and apply selected delay and/or attenuation to some of them with each path terminating in an individual antenna.

AESA: Active Electronically Steered Array; AESA radar systems (Figure 2-5 on page 2-5) contain separate transmit/receive modules (TRMs) for each element of the array. This provides a great deal of flexibility enabling the AESA radar system to operate at multiple frequencies simultaneously, produce multiple beam patterns to accomplish different radar objectives, etc. AESA radars are now the baseline in state-of-the-art combat aircraft.[2]

Figure 2-5.   AESA Radar Systems

2-5   Radar System Elements and Performance Effects

The table below summarizes some of the key elements and their effect on a radar system.[3]

Table 2-1.   Radar System Elements vs Affected Characteristics

Radar System Element	Radar Characteristic Potentially Affected
Transmitter Power	Maximum detection range, physical size of antenna
Receiver Sensitivity	Maximum detection range
Center Frequency	Directivity, target resolution, propagation loss, size of equipment
Pulse Shape	Range accuracy, range resolution, minimum range
Pulse Width	Range resolution, minimum range, minimum detection range
Pulse Repetition Frequency	Max unambiguous range, range rate accuracy, angular resolution, detection probability
Chirp Frequency Bandwidth	Range resolution
Chirp Pulse Ripple/time Side lobes	Target masking, range resolution
Average Gain	Maximum detection range
Scan Rate and Beamwidth	Probability of detection, angular resolution

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2.   Kopp, Carlo, Evolution of AESA Radar Technology, Microwave Journal, August 14, 2012.
3.   Payne, Craig M., Principles of Naval Weapon System. Annapolis, MD: Naval Institute Press, 2006.

2-6   Radar Testing

RF Chain - Transmit/Receive Modules and/or Their Components (PAs and LNAs)

Given the roles of radar systems, they must work as expected or there could be serious consequences. As a result, radar systems are heavily tested. An essential part of the test suite is measuring the performance of the RF chain (shown in Figure 2-6). Testing can be performed on a sub-system level (for example, a transmit/receive module for an AESA radar) or on the specific components in the RF chain (for example, the transmitter's power amplifier or the receiver's low noise amplifier).
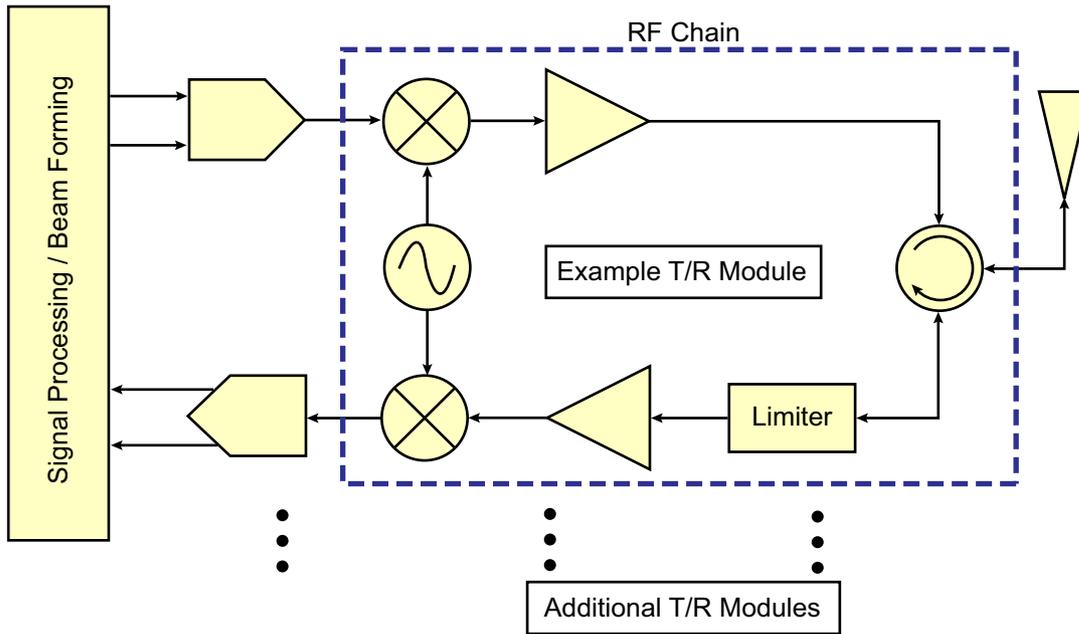
Figure 2-6.   Simplified Block Diagram of a Radar System

Typical Radar Tests

Typical tests performed can include measurements of the following parameters:

Table 2-2.   Typical Radar Sub-system and Component Measurements

TX RF Chain	RX RF Chain
P_{out} versus P_{in}	P_{out} versus P_{in}
Power Added Efficiency (PAE)	Third-Order Intercept (TOI)
Harmonics	Noise Figure
Spurious Emissions	
S-parameters (pulsed)	S-parameters (pulsed)
Pulse Profile	
Phase Setting	Phase Setting
Amplitude Setting	Amplitude Setting

For a listing of recommended Anritsu test equipment that can be used for the tests listed above, refer to Appendix A.

Chapter 3 — Radar Signal Simulation

3-1   Introduction

This chapter provides an example process for simulating radar signals using the MG3690C Series Microwave Signal Generator. The MA2411B Power Sensor and the pulse profile mode of the ML2490A Series Power Meter will enable the measurement of the radar pulse. The PowerMax software application will be used to document the results in either numeric, graphical or pictorial form.

This simulation exercise is also presented in a video that can be viewed by clicking the following link: http://www.anritsu.tv/en-US/national-instruments-labview-autoradar

3-2   Required Equipment

The following equipment is required for this radar signal simulation and associated measurements:

Table 3-1.   Equipment List

Qty	Description
1	Anritsu MG3690C Series Microwave Signal Generator, Option 28 (2 GHz to 10 GHz minimum)
1	ML2496A or ML2495A Power Meter
1	MA2411B sensor and cable for attaching to Power Meter
1	Laptop or desktop PC with PowerMax software pre-installed [a]
1	K(f) to N(m) adapter
1	50 Ω BNC(m) to BNC(m) cable
1	Crossover LAN cable

a. PowerMax Software is available for download from www.anritsu.com.

3-3   Equipment Connections

Set up the equipment as shown in Figure 3-1.
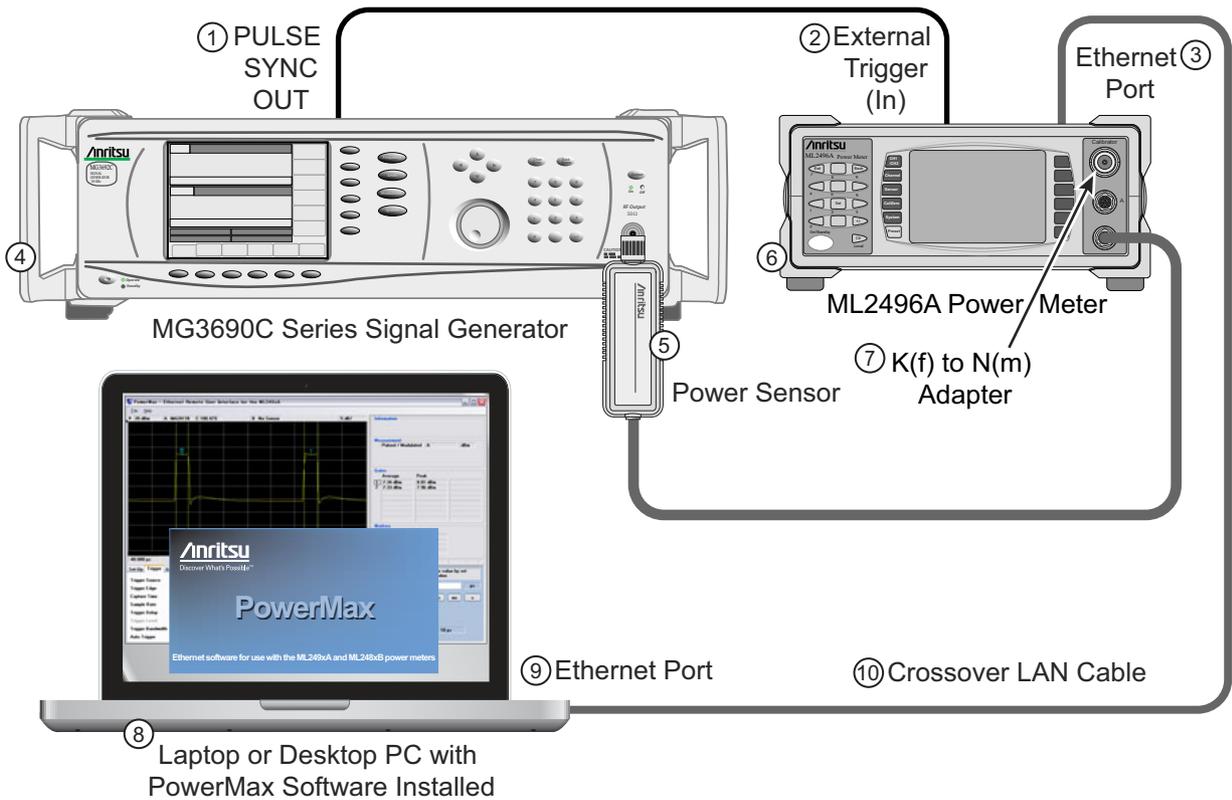
Index	Description
1	Pulse Sync Out
2	External Trigger (In)
3	Ethernet Port (Power Meter)
4	MG3690C Series Microwave Signal Generator
5	MA2411B Sensor and Cable
6	ML2496A or ML2495A Power Meter
7	K(f) to N(m) adapter
8	Laptop with PowerMax Software Installed
9	Ethernet Port (Laptop)
10	Crossover LAN Cable

Figure 3-1.   Radar Simulation Setup

1. Using a BNC cable, connect the signal generator **PULSE SYNC OUT** to **External Trigger** of the power meter.

2. Using a crossover LAN cable, connect the PC and Power Meter Ethernet ports.

MG3690C Pulse Modulation Menu Map

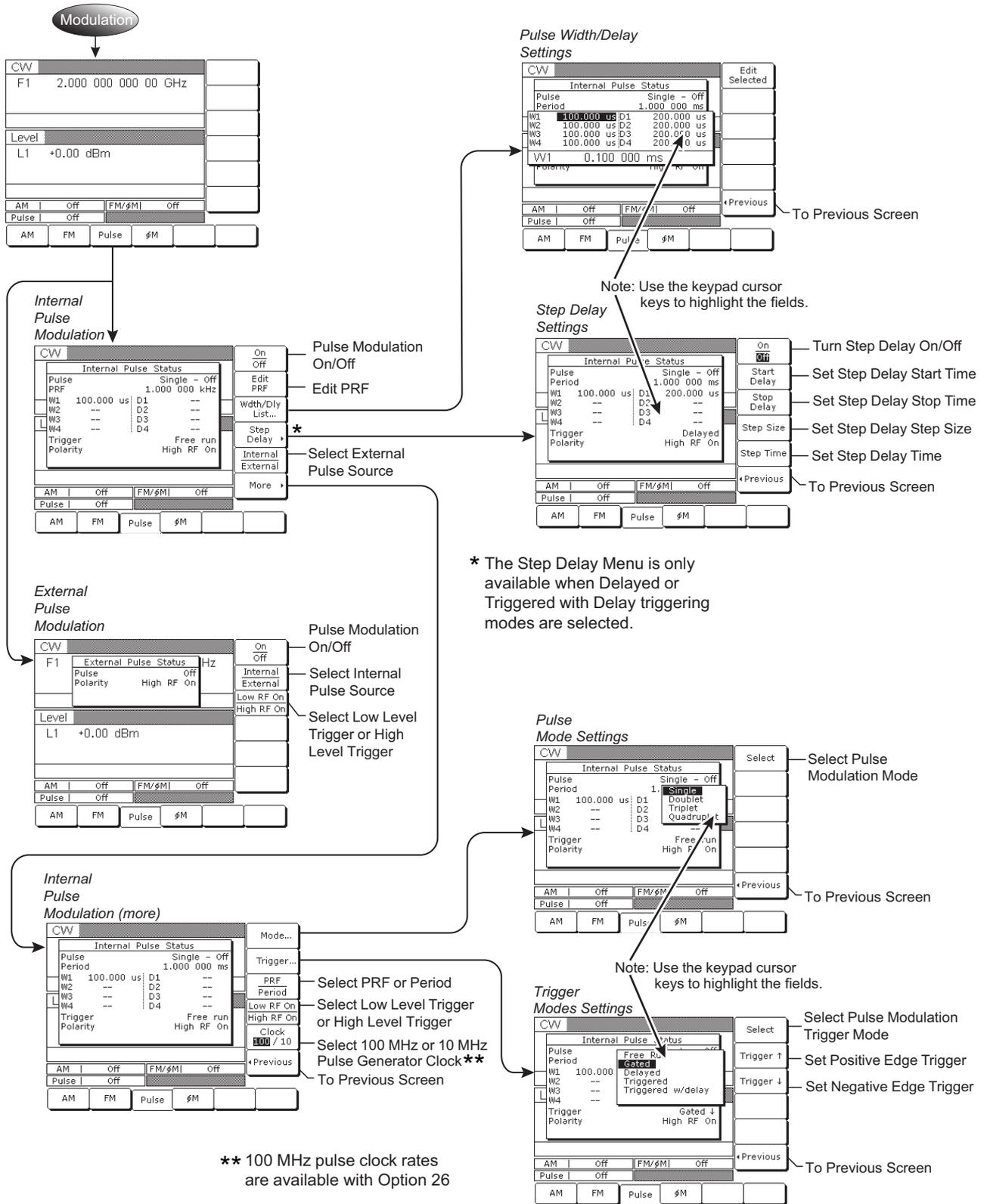Figure 3-2 on page 3-3 shows the menu map for a MG3690C to assist in setting pulse parameters.

Figure 3-2.   MG3690C Pulse Modulation Menu Map

3-4   Procedure

Power Meter Setup

1. Zero and calibrate the Power Meter for a frequency of 9.5 GHz using PowerMax.

2. Set up the Power Meter as follows:

  a. Mode: Pulse Modulated

  b. Measurement: Averaged

  c. Display: Profile

  d. Ref Level: 20 dBm

  e. Scale: 5 dB/div

  f. Trigger: External trigger rising edge

  g. Capture time: 1 ms

Synthesizer Setup

3. Reset the synthesizer.

4. Set up the synthesizer to generate a pulsed RF signal with the following parameters:

  a. RF Frequency: 9.5 GHz

  b. Amplitude: 10 dBm

  c. Pulse Mode: Internal, Single

  d. Pulse Width: 50 μs

  e. Pulse Period: 1 ms

  f. RF Output: ON

  g. Clock: 10 MHz

5. The PowerMax interface should appear as shown in .

6. With the current settings, the minimum leveled pulse width you can set is:

  • 100 ns at frequencies ≥ 1 GHz

  • 1 μs at frequencies < 1 GHz

To generate pulses less than 100 ns, disable the ALC and adjust the fixed gain to the desired level. The internal pulse generator can generate pulses as narrow as 10 ns. This is true even if using an external pulse generator.

Since the MG3690C internal pulse modulator has a rise/fall time of approximately 10 ns, the minimum pulse width that can be generated by the MG3690C with an external narrow pulse generator is 10 ns.
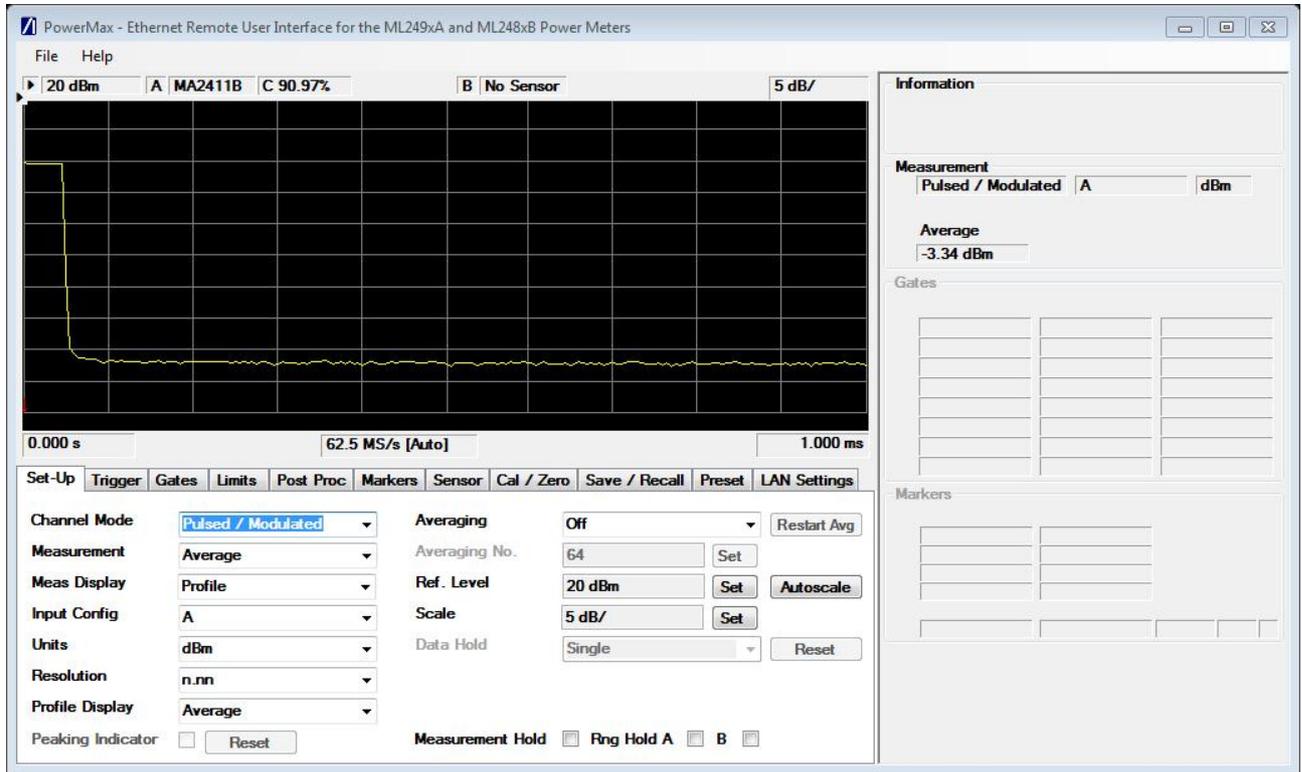
Figure 3-3.   Pulse Shown on PowerMax Interface - Pulse Width = 50 μs

3-5   Target Simulation

When a target is moving, the time between the transmit pulse and the received pulse will be constantly changing. On other signal generators, this requires an arbitrary waveform generator to simulate this. However, the standard Step Delay feature in the MG3690C makes this easy to set up.

To simulate a moving target, the Step Delay feature enables the pulse generator to sweep its delay in a stepped sweep mode (similar to the frequency's step sweep function). Before examining a moving target, it may be useful to simulate a stationary target first.

Distance to Target and Time to Target

Radio waves travel at 186,000 mi/sec or 3 x 108 meters/sec. To determine the distance to the target for a radar, the equations work out to be:

(Delay Time (sec) / 2) * 186,000 = Distance (mi)

or

(Delay Time (sec) / 2) * 3 x105 = Distance (km)

The delay time is divided by 2 because the signal must travel to the target and back. This means the signal must travel twice the distance of the target. Therefore, to get the distance to the target, the signal's round trip distance must be divided by 2.

Stationary Target Simulation (using Pulse Delay)

Since a 50 µs pulse has already been set up, a delay can be set to simulate the return from a target:

1. Press **Modulation**.

2. If the pulse parameters are not already displayed, press **Pulse.**

3. Press Width/Delay List. Move the cursor to Delay 1 field and adjust to 100 µs.

   In this example, a 100 us delay simulates the radar return from a single stationary target that is 9.3 miles or 15 km away.

4. Press Previous | More | Trigger then select Delayed

   The PowerMax display appears as shown in Figure 3-4.

Moving Target Simulation (using Step Delay)

To set up for a moving target using the step delay feature:

1. Press Previous | Previous | Step Delay then set as follows:

   a. Start Delay: 100 µs

   b. Stop Delay: 900 µs

   c. Step Size: 500 ns

   d. Step Time: 10 ms

   e. On/Off: ON to turn on the Step Delay function

   This sets the delay to step sweep from 100 µs to 900 µs in 500 ns steps. It dwells at each step for 10 ms before moving to the next step.

   The pulse slowly moves left to right on the screen. This simulation could represent the radar return from a target (e.g., an aircraft). Because the delay from the radar return is increasing, the measurement would indicate the target is moving away from the radar system.
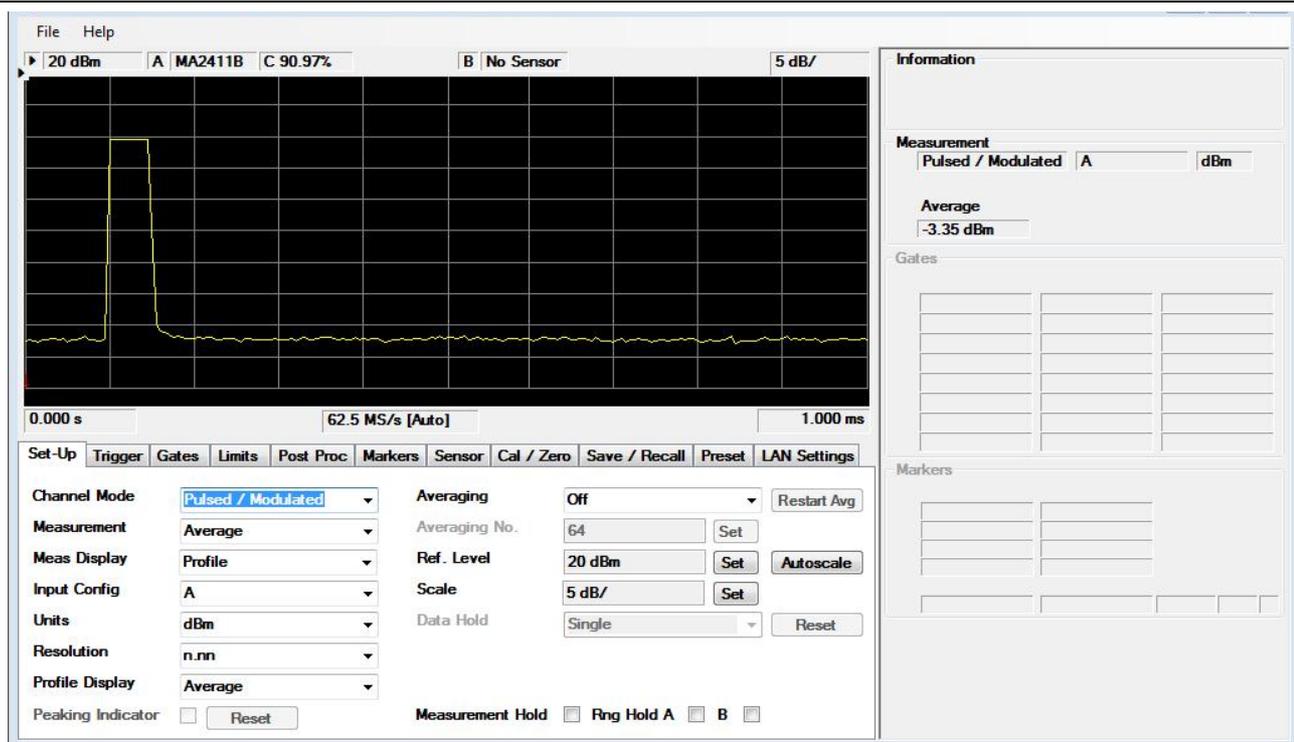

Figure 3-4.   Simulated Return from a Stationary Object

Signal Amplitude and Target Movement

When a target is moving, the amplitude of the pulse signal will also vary with respect to the distance from the receiver. Adding AM to the pulse provides a simple means by which you can vary the amplitude of the pulse over time. The rate is the time in which the variation in amplitude occurs. The depth defines how much the amplitude varies. 1 kHz is selected to line up with the period of the pulse (1/1 ms = 1 kHz). The modulation wave is set to ramp down to simulate the decreasing power of the radar return of a target moving away (which corresponds to the increasing delay we set). Using AM in this way is only a conceptual simulation because the amplitude reduction of an actual radar return would not be linear. Rather, it is proportional to $1/R^4$ as described in the Radar Equation (see Section 2-3).

    1. Turn AM on.

    2. Set the Depth to 6 dB and rate to 1 kHz.

Note	Modulation depth is the ratio of the message amplitude to the carrier amplitude. The depth value 6 dB corresponds to ~75%

    3. Set the Modulation Wave to Ramp Down.

P_r is received signal power. P_t is transmitted signal power. P_r/P_t is proportional to radar Cross Section (RCS), $1/f^2$, and $1/R^4$ where f = frequency and R = range. With a range difference of 9:1, the signal should be 38 dB lower when at the most distant range. The return signal strength also varies dependent on radar cross section. For example a high RCS could be a pick up truck; a low RCS could be an animal, a missile head-on, or a stealth type aircraft.

Although with higher frequencies, received signal power falls off at a rate of $1/f^2$, an advantage of using higher frequencies is that you get more bandwidth. This allows carrying more communication information, which translates to increased resolution in radar applications.

    4. Turn off the AM.

Distance to Target Example

Target is first seen by radar at 93 miles range.

Target speed toward radar is 334.8 miles/hour.

You want to simulate the radar tracking the target from 93 miles away to the time it reaches the radar site.

    1. Calculate the delay time to simulate a target at 93 miles range. This will be the Start Delay.

       Time for radar pulse to reach target 93 miles away is:

          Distance/speed of light = 93 (miles) / 186,000 (miles/second) = 0.5 ms

       However, a radar signal has to travel to target and back again so Start Delay time must be double (1.0 ms).

    2. Calculate Stop Delay:

       You want to track the target to zero miles range so Stop Delay is zero (the minimum setting in a MG3690C with 10 MHz Pulse Clock is 100 ns).

3. Calculate Step Size and Step Time.

These settings depend of the rate of change in delay over time.

The total change in delay is:

(Start Delay – Stop Delay) = (1.0 ms – 100 ns) = 0.9 ms; however, to make the math easy, we could account for the non-zero Stop Delay by adding 100 ns to the Start Delay.

The target is moving at 334.8 miles/hr and so will cover the distance of 93 miles in:

0.28 hours = 16.7 minutes = 1000 seconds

This means we need to change the delay by:

1.0 ms in 1000 seconds = rate of change of delay (Sweep Rate) = (1×10^{-3}) /1000 = 1×10^{-6} sec/sec

Sweep Rate = (Step Size)/(Step Time) = 1×10^{-6} sec/sec

Any combination of Step Size and Step Time can be selected as long as it results in the desired Sweep Rate.

4. Now choose the Step Size to be 100 ns:

Step Time = (Step Size)/(Sweep Rate) = $(100 \times 10^{-9})/(1 \times 10^{-6})$ = 100 ms

So to simulate a target moving towards the radar at 334.8 miles/hr from 93 miles to zero range, the settings need to be:

    a. Start Delay: 1.1 ms

    b. End Delay: 100ns

    c. Step Size: 100 ns

    d. Step Time: 100 ms

In this case, you would get an error indication because the delay time plus pulse width is greater that the Pulse Repetition Interval.

5. Set the Pulse Repetition Rate to 1.2 ms and change the Power Meter Capture Time to 1.2 ms; adjust the AM rate to 1/1.2 ms or 833 Hz to compensate for the change in PRR.

This should cause the error indicator to disappear.

Time to Target Example

Assume you wish to simulate a missile flying toward you at 500 miles/hr. You first see the missile 100 miles away and you track it until it reaches your ship. Use the previous example to calculate the values for Start and Stop Delay as well as the for values for Step Size and Step Time.

1. Calculate Start and Stop Delay.

Start Delay = d_s/2 * 186,000 = 100, d_s = 0.001075 = 1.075 ms

End Delay = d_e/2 * 186,000 = 0, d_e = 100 ns

2. Select Step Size and calculate Step Time.

Step Size = 100 ns, and the Sweep Rate = (0.000975 s /[(100 mi/ 500 mph) * (3600 s/1 hr)]) = $1.35 * 10^{-6}$

Step Time = 100 ns/Sweep Rate = 100 ns/$1.35 * 10^{-6}$ = 74.1 ms

Again, note that step size and step time could be any numbers as long as the rate of change is 1350 ns/sec.

3. After you first pick up the target, how much time do you have to launch your FA18 jets and shoot down the missile to save the ship?

100 mi / 500 miles/hr = 0.2 hr = 12 min.

3-6 Working with Multiple Pulses

If there were a second missile (perhaps 1 mile further away), a doublet pulse could be used to simulate the radar return.

D2 = (8 miles/186,000 miles/sec) = 42.8 µs

In this case you would get an error because D2 is smaller than W1.

To alleviate the above error, you would reduce W1 to 20 µs, then D2 can be set to 42.8 µs.

Note	To change pulse settings see Pulse Mode screen Figure 3-2.

The diagram below shows how the width/delay table works. D1 is the delay of the leading edge of pulse one from the trigger (internal or external). All other delays are the delay of pulse n's leading edge from the leading edge of pulse n-1. So that pulses do not coalesce into one bigger pulse, all delays "n" before the next pulse must be greater than the current pulse width.

Consider another example of using multiple pulses described below.

1. Switch off Step Delay.

2. Set up the width/delay as shown in the table below and then turn on Quadruplet Pulse Mode.

W1	100 µs	D1	100 ns
W2	100 µs	D2	100 µs
W3	200 µs	D3	200 µs
W4	100 µs	D4	300 µs

You will see an error indicator displayed because with W1 = 100 µs and D2 = 100 µs, there is no gap time between pulse 1 and pulse 2 (as shown in Figure 3-5).
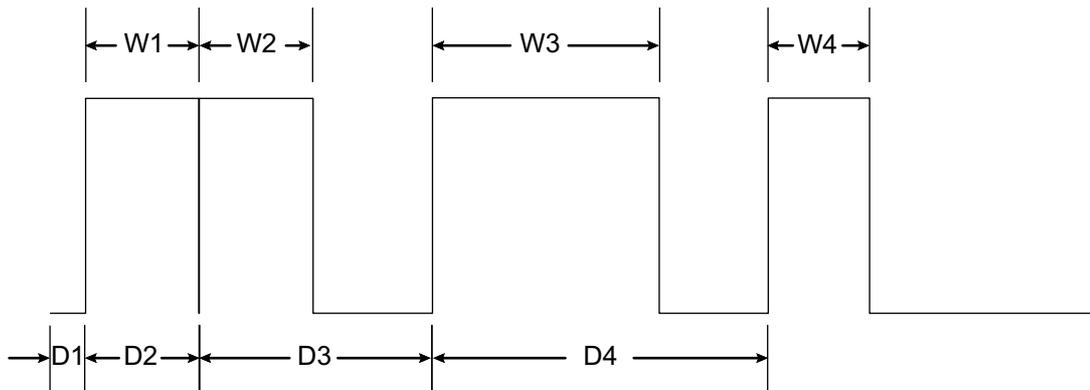

Figure 3-5. Pulse Width and Delay - Error Indication Cause

3. Change W1 to 50 μs. The error indicator should disappear because there is now a gap in time between the trailing edge of the first pulse and the leading edge of the second pulse as illustrated in Figure 3-6.
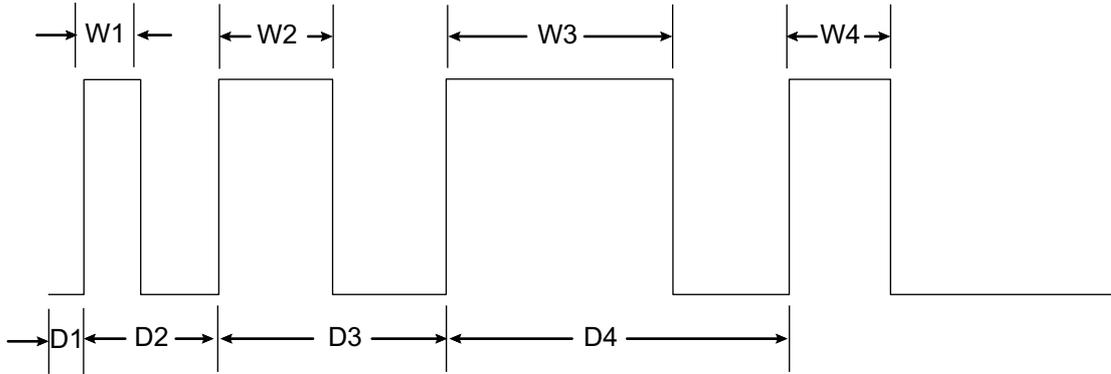

Figure 3-6.   Pulse Delay Error Corrected

Finding Receiver Recovery Time

Another use of multiple pulses is to find a radar receiver's recovery time. The following will set up a simulation of radar return (with the quadruplet pulse function on the signal generator) for a pair of targets that have been illuminated using doublet pulses. Doublets permit velocity to be determined by looking a single doublet return.

1. Set up pulse widths and delays as shown in the table below.

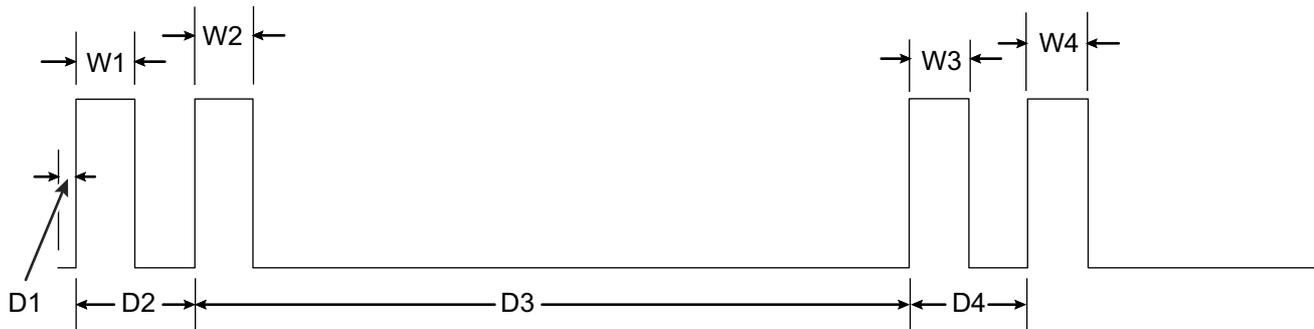| W1	50 μs	D1	100 ns
W2	50 μs	D2	100 μs
W3	50 μs	D3	600 μs
W4	50 μs	D4	100 μs

Figure 3-7.   Doublet Pulses for Finding Receiver Recovery Time

Reduce delay three (D3) with the knob. If this were connected to a radar receiver, it would enable you to determine at what point the radar stopped being able to see the second, more distant, target. This is called the recovery time. In this example, the recovery time would occur when D3 is reduced to W2.

3-7   Triggering on Multiple Pulses Using the ML2495A

This section describes how an ML2495A power meter can trigger on bursts of multiple pulses without the need for an external trigger.

1. Set the Signal Generator Width 2 to 100 μs and Delay 3 to 300 μs.

W1	50 μs	D1	100 ns
W2	100 μs	D2	100 μs
W3	50 μs	D3	300 μs
W4	50 μs	D4	100 μs
PRR	1.0 ms		
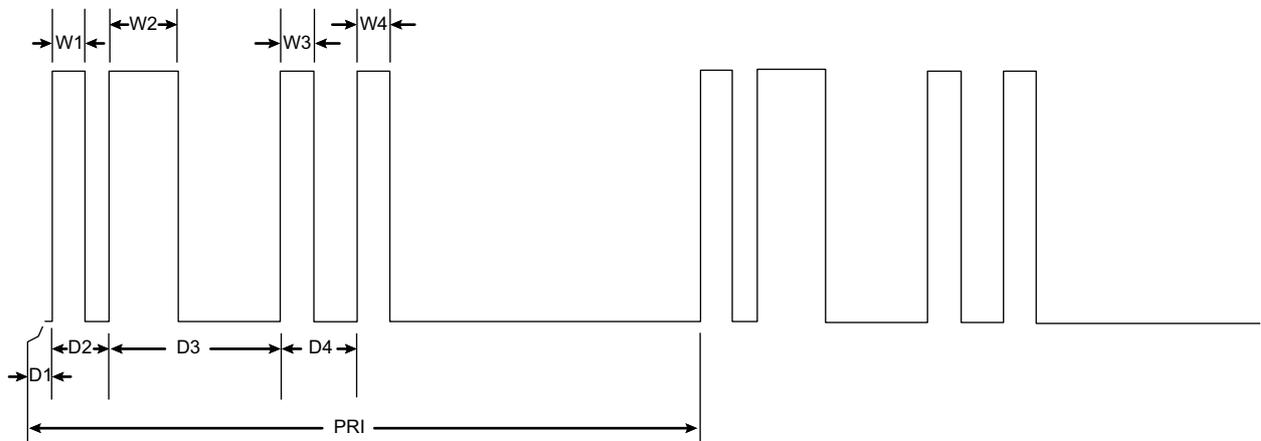
Figure 3-8.   Quadruplet Burst of Pulses for Finding Receiver Recovery Time

2. Switch the power meter trigger to Internal. This will illustrate the effectiveness of frame arming.

The trace appears unstable because the power meter is triggering on any one of the pulses in the quadruplet burst.

3. Now select Frame Arming and enter a value for Frame Duration that is longer than the longest inter-pulse period between adjacent pulses in the quadruplet burst. See .

This causes the trace to become stable because "Frame Arming" disables the trigger for the length set by "Frame Duration". All the gaps between the pulses are less than the set value of "Frame Duration". This means that the trigger will ignore the leading edges of pulses 2 thru 4 and will only trigger on pulse 1.
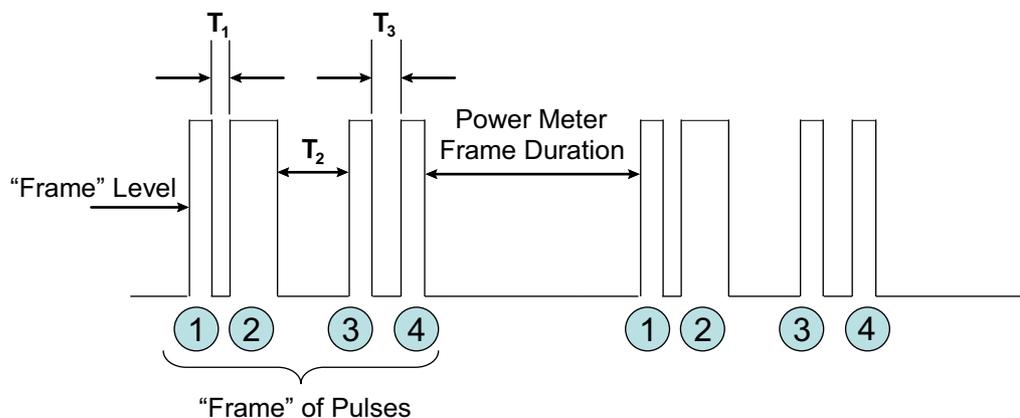
Power Meter "Frame Duration" is greater than times (T_1, T_2 and T_3) between all 4 pulses in one "frame". For this example, the frame duration must be greater than 100 μs.

The trigger is only re-armed after the signal level stays below the "Frame Level" for the period of time specified by "Frame Duration".
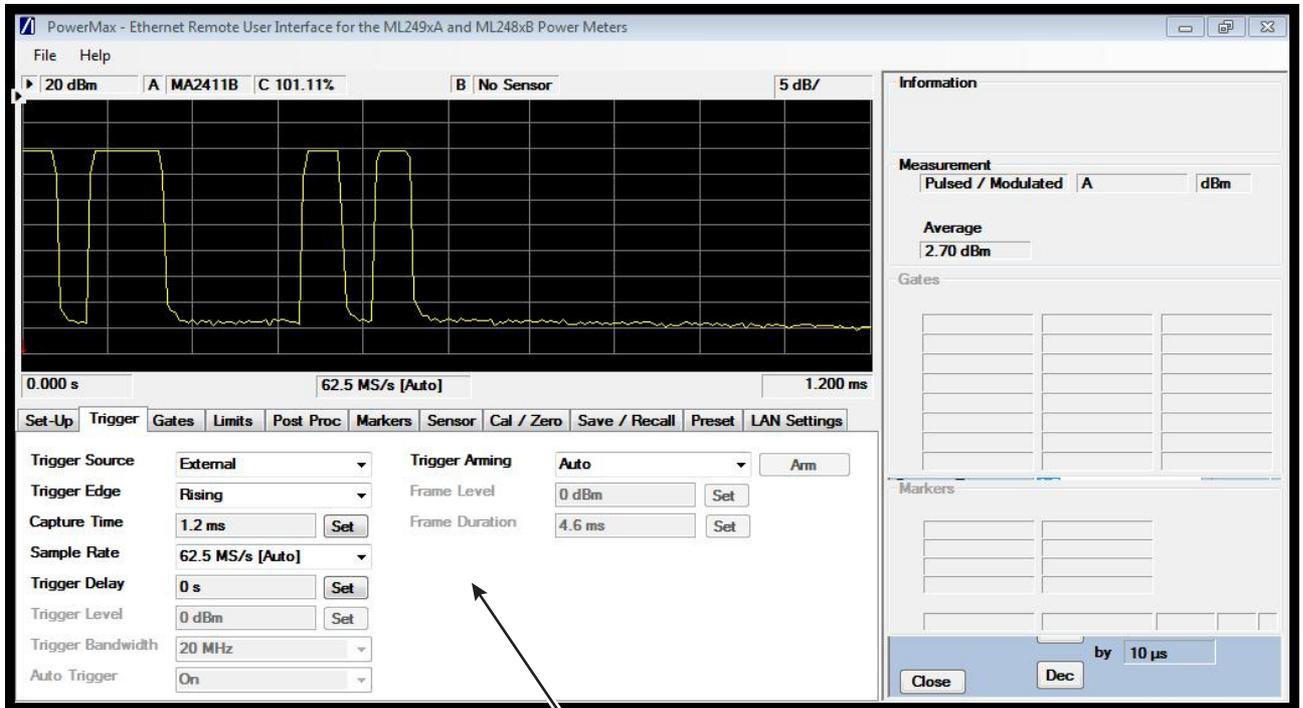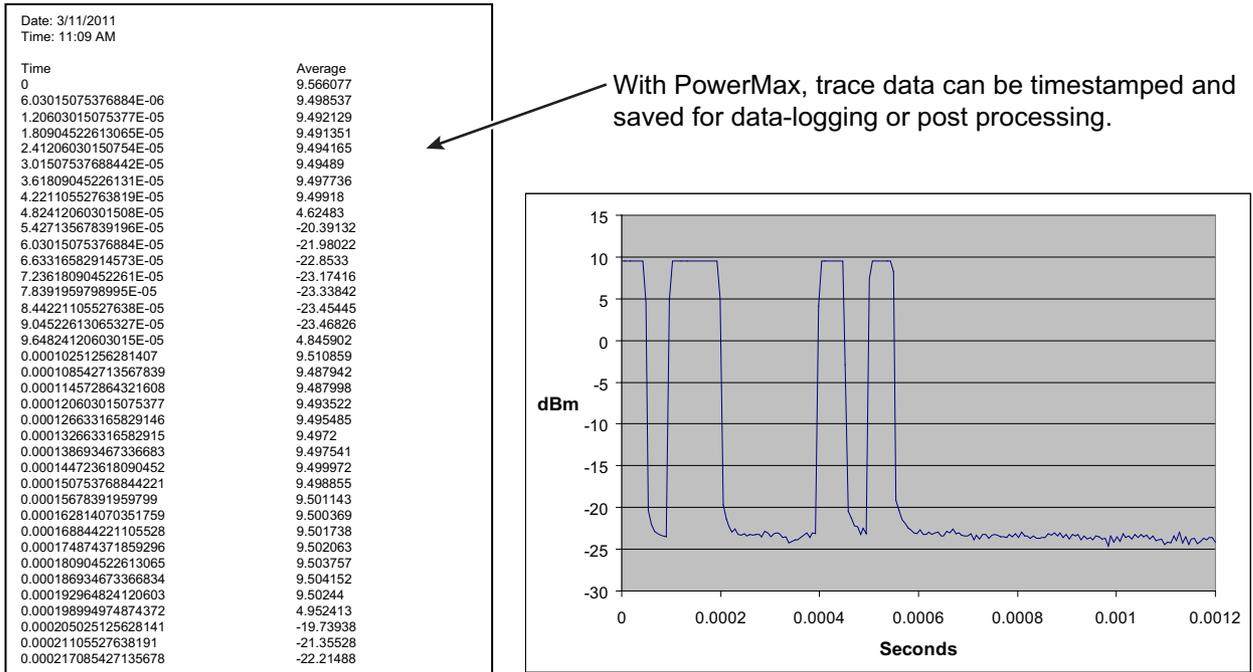
This means the Power Meter will only trigger on Pulse 1 rather than any of the four pulses

Figure 3-9.   Frame Trigger Operation

3-8   Capturing Results with PowerMax Software

Figure 3-10 illustrates the various ways that PowerMax can extract and display information. For additional information about using PowerMax, refer to the PowerMax Software User Guide, part number 13000-00238, available for download from www.anritsu.com.

Date: 3/11/2011
Time: 11:09 AM

Time	Average
0	9.566077
6.03015075376884E-06	9.498537
1.20603015075377E-05	9.492129
1.80904522613065E-05	9.491351
2.41206030150754E-05	9.494165
3.01507537688442E-05	9.49489
3.61809045226131E-05	9.497736
4.22110552763819E-05	9.49918
4.82412060301508E-05	4.62483
5.42713567839196E-05	-20.39132
6.03015075376884E-05	-21.98022
6.63316582914573E-05	-22.8533
7.23618090452261E-05	-23.17416
7.8391959798995E-05	-23.33842
8.44221105527638E-05	-23.45445
9.04522613065327E-05	-23.46826
9.64824120603015E-05	4.845902
0.00010251256281407	9.510859
0.000108542713567839	9.487942
0.000114572864321608	9.487998
0.000120603015075377	9.493522
0.000126633165829146	9.495485
0.000132663316582915	9.4972
0.000138693467336683	9.497541
0.000144723618090452	9.499972
0.000150753768844221	9.498855
0.000156783919597999	9.501143
0.000162814070351759	9.500369
0.000168844221105528	9.501738
0.000174874371859296	9.502063
0.000180904522613065	9.503757
0.000186934673366834	9.504152
0.000192964824120603	9.50244
0.000198994974874372	4.952413
0.000205025125628141	-19.73938
0.00021105527638191	-21.35528
0.000217085427135678	-22.21488

With PowerMax, trace data can be timestamped and saved for data-logging or post processing.

Screen shots can also be saved.

Figure 3-10. PowerMax Outputs

Appendix A — Recommended Equipment for Radar Tests

A-1 Introduction

This appendix provides a list of instruments available from Anritsu that can be used to accomplish the typical radar tests that were noted in Chapter 2. Repeated here for convenience, the tests are:

Table A-1. Typical Radar Sub-system and Component Measurements

TX RF Chain	RX RF Chain
P_{out} versus P_{in}	P_{out} versus P_{in}
Power Added Efficiency (PAE)	Third-Order Intercept (TOI)
Harmonics	Noise Figure
Spurious Emissions	
S-parameters (pulsed)	S-parameters (pulsed)
Pulse Profile	
Phase Setting	Phase Setting
Amplitude Setting	Amplitude Setting

A-2 Recommended Equipment

The following list provides general suggestions for selection of Anritsu test equipment for radar testing. For assistance in selecting the right equipment for your specific radar test requirements, please contact your local Anritsu Sales or Applications Engineer.

To find local support contact information for your region, visit
http://www.anritsu.com/en-US/Contact-Us/Sales-Office.aspx.

For detailed technical specifications on the recommended Anritsu equipment, please visit
http://www.anritsu.com

- ML2490A, ML2480B, and ML2430A Series Power Meters and associated sensors (including the MA2411B Pulse Sensor)
- VectorStar™ Series Vector Network Analyzers
- MG3690C Series RF/Microwave Signal Generators
- MG37020A Series Fast Switching Microwave Signal Generators
- MS2830A Microwave Spectrum/Signal Analyzer

Notes

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