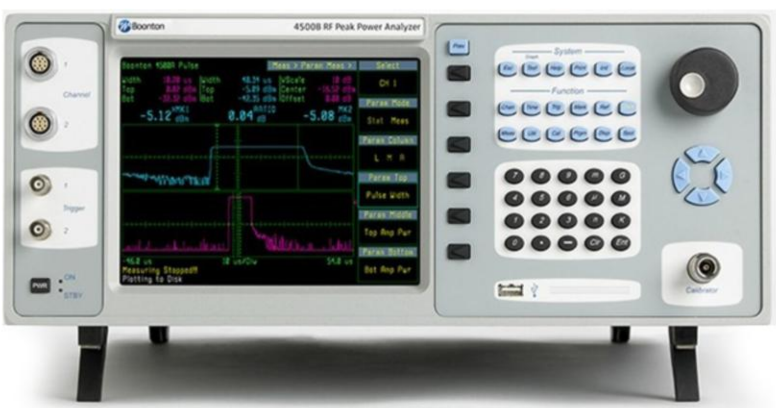
Boonton 4500B: Power Measurement of a Complex Pulse Train

Authors: Mazumder Alam and Stephen Shaw,

Wireless Telecom Group

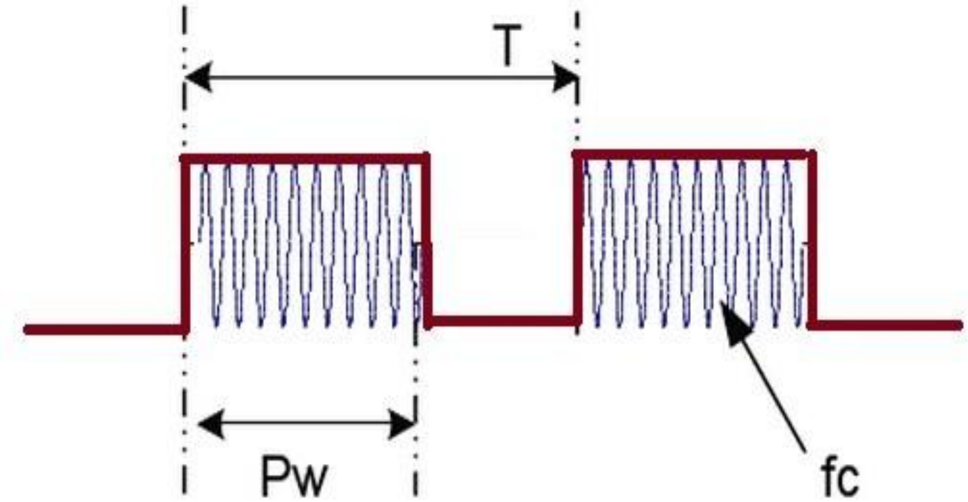


Who Needs to Measure a Pulse Signal?

- Different types of radar systems, including Weather Radar, Target Tracking Radar and Astronomical Doppler Radar
- Pulse power measurement in remote sensing & tracking systems.
- Certain wireless communication applications (eg WiMax and LTE signals)
- Magnetic Resonance Imaging (MRI) systems

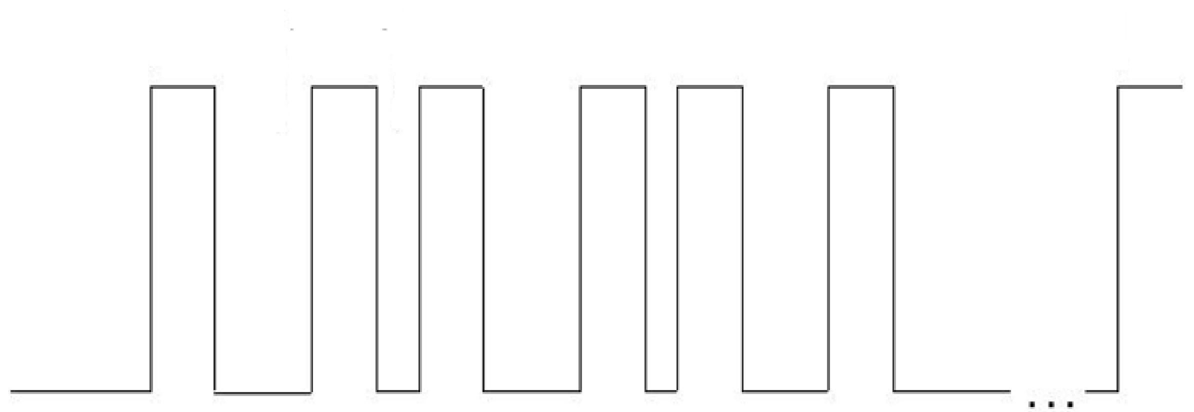
What is a Pulse Signal? (1)

- A rapid, transient change in the amplitude of a signal from a baseline value to a higher/lower value (eg 0’s and 1’s)
- A Pulse wave or pulse train is a kind of non-sinusoidal waveform that is similar to a square wave.
- T=Pulse Period
  Pw= Pulse Width
  fc= Carrier Frequency
- An example of a single pulse

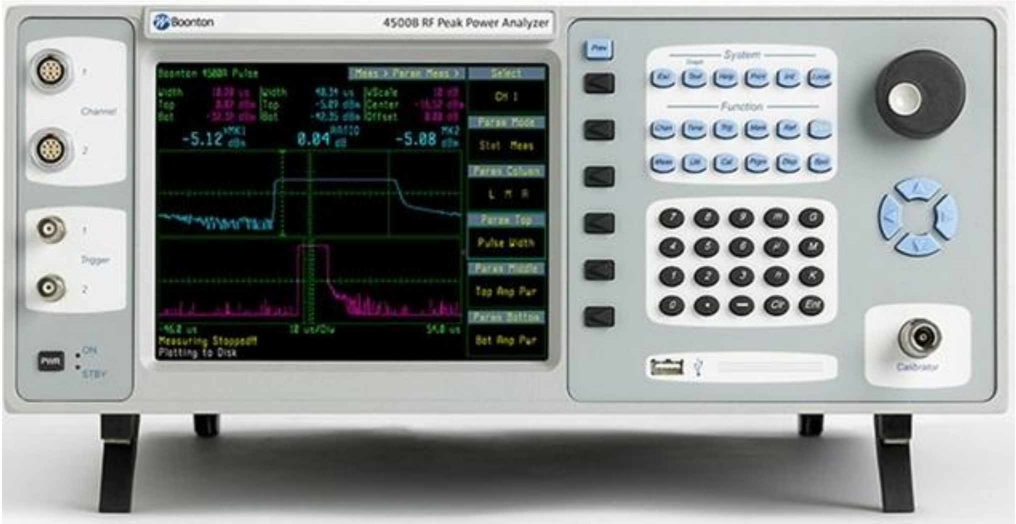


What is a Pulse Signal? (2)

- Data encoding scheme where the position of transmitted pulses can be modified.
- Typically a long stream of pulses that are unevenly spaced in time.
- Example of typical pulse train



4500B Power Meter Test Setup (1)



- A pulse signal generator can be used to simulate a radar signal
- A typical radar signal has a low pulse repetition frequency (PRF) which can be difficult to measure with some peak power sensors.
- The simulated radar signal can be used as an external pulse input to the 4500B power meter

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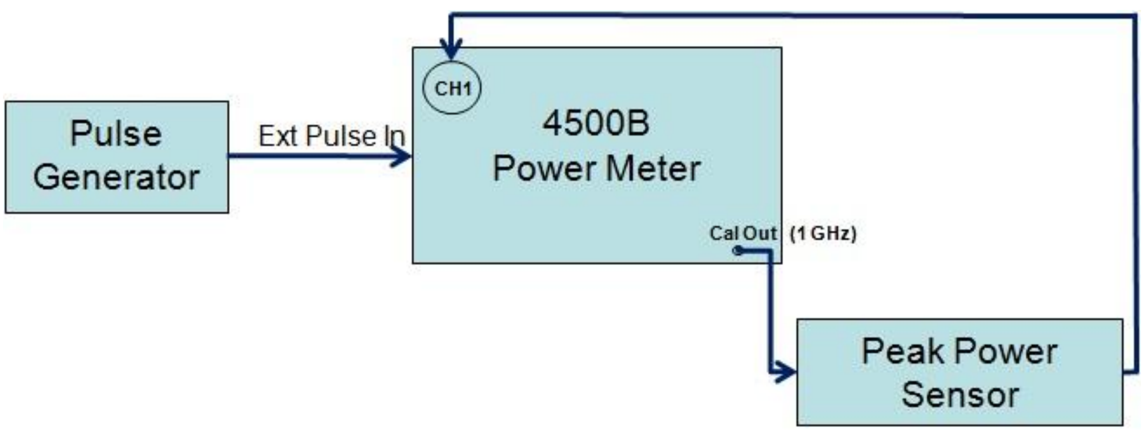
4500B Power Meter Test Setup (2)

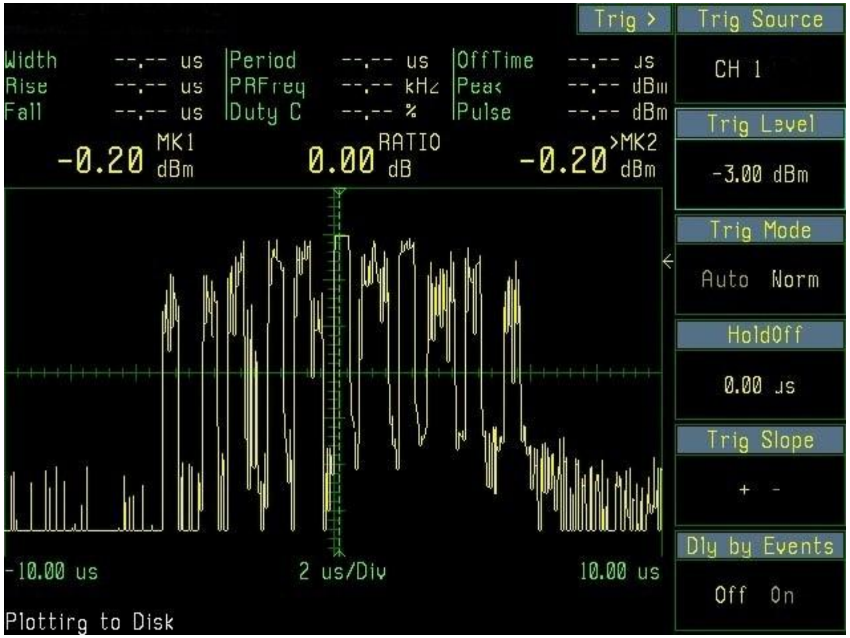
- Boonton peak power sensor with high dynamic range (eg 59318 or 57006) is used to handle the lower pulse radar frequency.
- In this example, pulse generator is connected to the “External Pulse In” of 4500B and the internal 1 GHz RF calibration source is controlled by the pulse stream.
- Peak sensor is connected from Channel 1 or 2 to the “Calibration Out” port to measure the internal calibration signal which is modulated by the source.



Peak Power Sensors

Model	Frequency Range	Dynamic Range
Impedance Connector	(Low Bandwidth)	Peak Pwr Rng CW Pwr Rng Int. Trigger Range
		For us
57006 50 ohm N (M)	0.5 - 6 GHz (0.05 - 6 GHz)	-50 to +20 dBm -60 to +20 dBm -40 to +20 dBm
59318 50 ohm N (M)	0.5 - 18 GHz (0.05 - 18 GHz)	-24 to +20 dBm -34 to +20 dBm -10 to +20 dBm
59340 50 ohm K (M)	0.5 - 40 GHz (0.05 - 40 GHz)	-24 to +20 dBm -34 to +20 dBm -10 to +20 dBm

Pulse Train without Trigger Delay



• 4500B peak power analyzer can trigger on the edge of a pulse but the pulse position is random

• Peak power analyzer can not synchronize (locate traces on the faster time bases) between measurement cycle and the actual event of the burst given this trigger setup.

•The time off period in between pulses are longer which makes it difficult to capture any particular edge.

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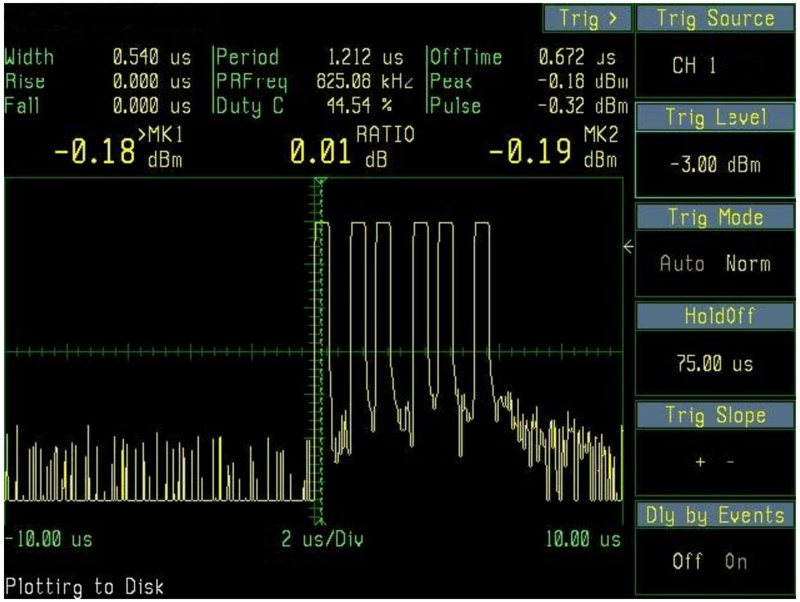
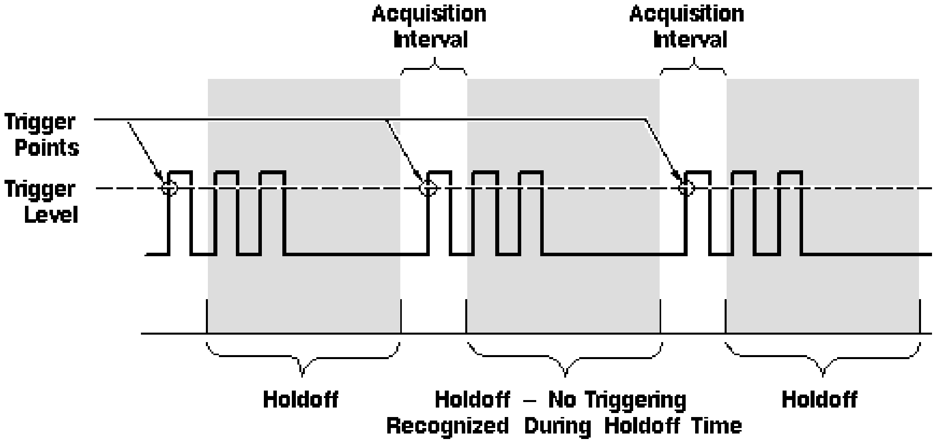
Trigger Holdoff with Delay





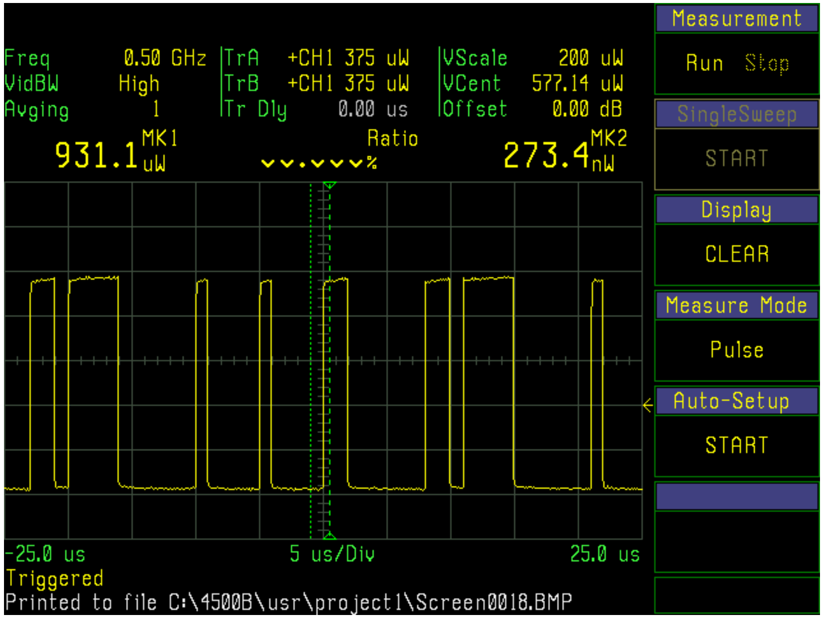
• Trigger holdoff is the effective way to stabilize the display of such complex waveform

• This function allows to specify a period of time when triggering is inhibited which should be less than the burst cycle time (for the above example, duty cycle is 100 uS & holdoff is75 uS).

• 4500B will “Lock on” to the first edge of the pulse train and any specific pulse can be analyzed within a burst of pulses.

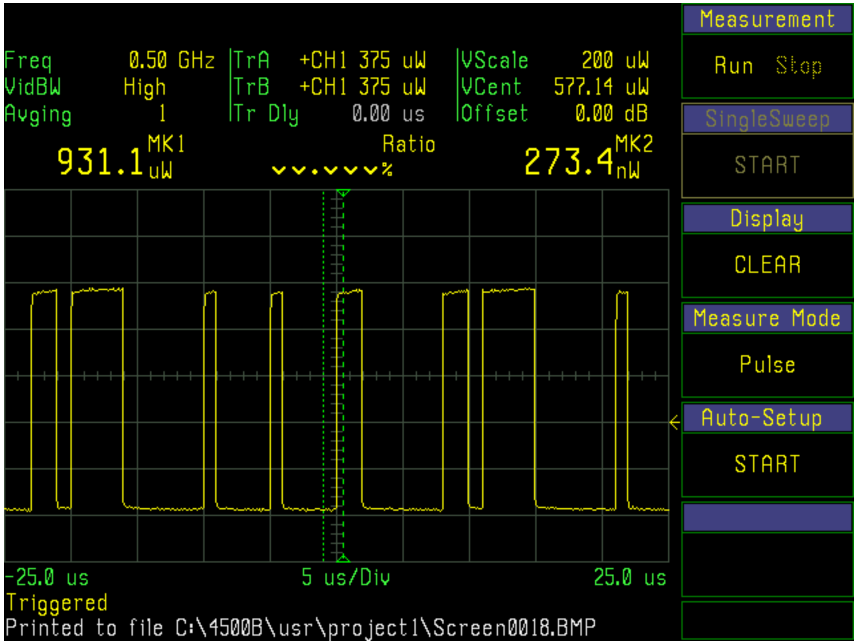
• Easier to verify peak and average power, rise/fall times, pulse width and delays.

Delay by Event Trigger



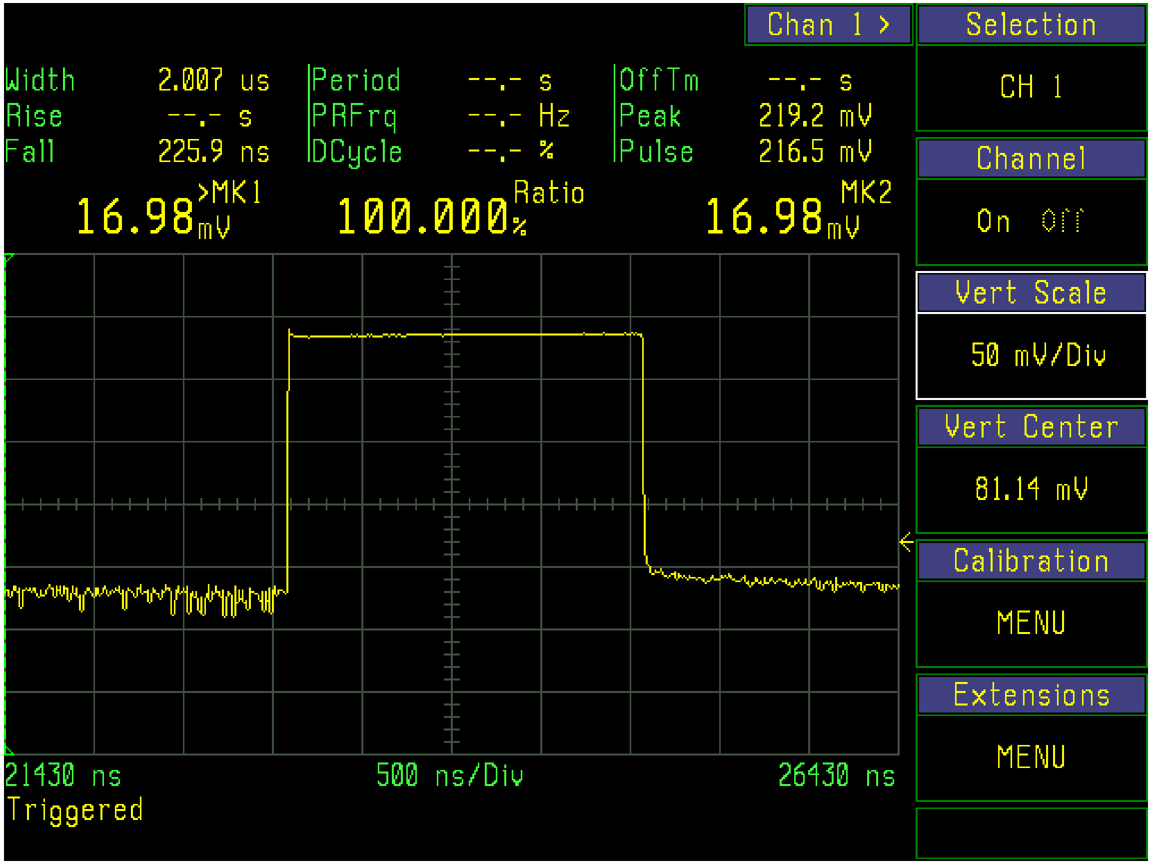
- Standard feature of 4500B Power Meter
- Extends the system functionality to trigger on specific events within a pulse burst
- 4500B will count events and hold the trigger until the event count has been reached (1 to 999,999 events)
- Delay by events trigger allows a user to synchronize and observe the n^{th} pulse of a burst even if its time position is highly variable

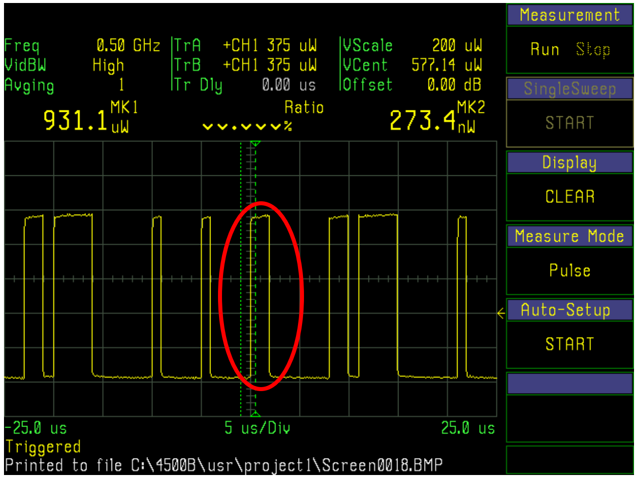
Delay by Time Trigger



- Standard feature of 4500B Power Meter
- Similar to the Delay by Event facility, but in this case the trigger is inhibited until a specified time has elapsed
- Can be set from 0 to 1 sec in 10ns increments

Analyzing a Specific Pulse in 4500B (1)





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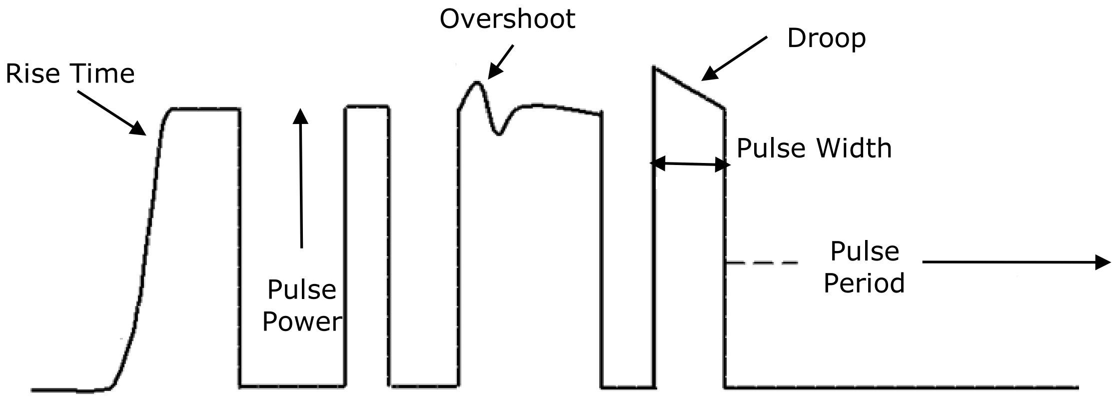
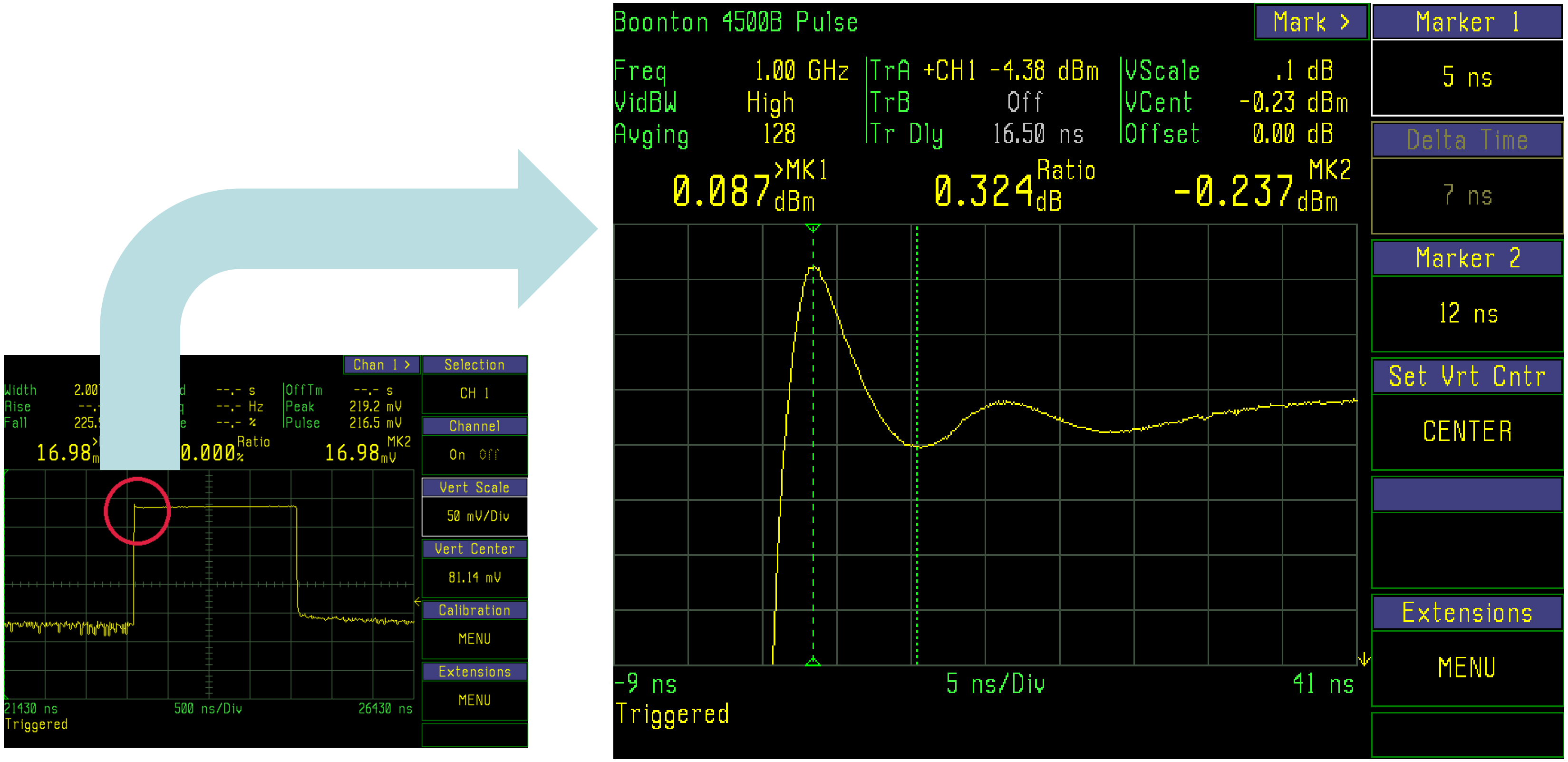
Analyzing a Specific Pulse in 4500B (2)

- The specific position of the pulse in the burst is “locked-on” and the time scale has been changed to make an accurate measurement of the rise/fall time
- Parameters such as pulse width, period, and repetition frequency can only be displayed if there are sufficient number of pulse transitions on the display.
- All of the following key time domain characteristics of a radar pulse can easily be measured using the 4500B



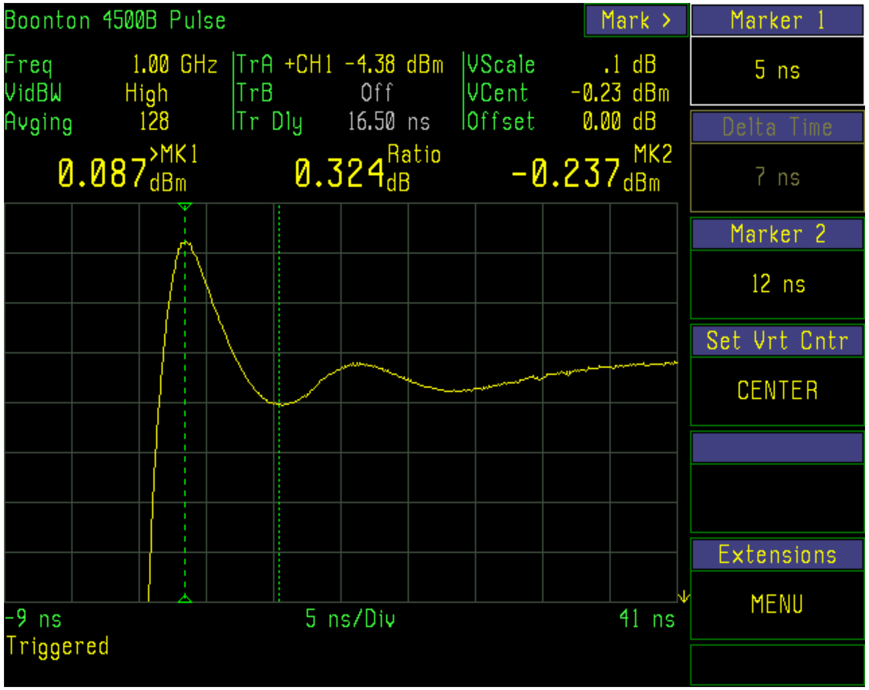
Example of Radar Pulse Characteristics

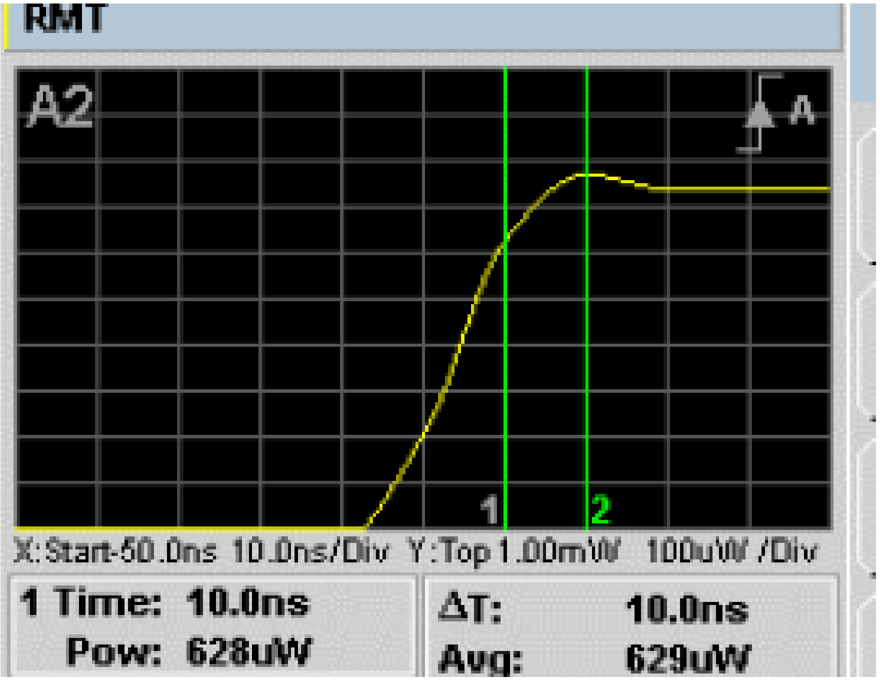


- Pulse characteristics such as overshoot, risetime and droop provide additional information about the radar‘s qualities.

- Pulse top amplitude and pulse width are important for calculating the total energy in a given pulse (Power x Time).

Details of a Pulse Characteristics





Boonton 4500B Power Meter

Conventional RF Power Meter

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4500B Power Meter

Ordering Information:

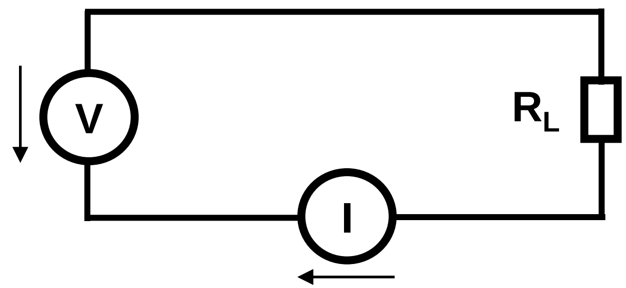
MODEL	OPTIONS	DESCRIPTION
4500B		RF PEAK POWER ANALYZER Single Channel, Front Panel Input
	-01	Dual Channel, Front Panel Input
	-02	Single Channel , Rear Panel Input
	-03	Dual Channel, Rear Panel Inputs
	-06	Trigger Output (Rear Panel Only)
	-07	Calibrator, Rear Panel Output
	-10	Statistical Package (Includes Gated CCDF and PDF)
	-18	High Volt External trigger
	-30	Warranty Extended to 3 Years
	-CARE1	One Calibration and one year of extended warranty

Why Not Measure Voltage?

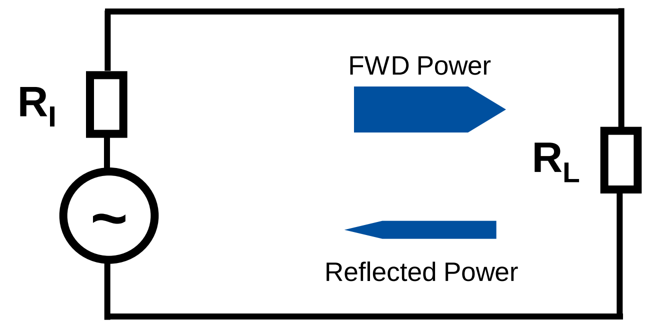
DC and low frequency power measurements are relatively easy and can be calculated by the formula: Power (Watts) = V^2/R.

RF and MW systems can show different behaviour: Voltage and Current can vary depending on the position measured. But Power stays the same at every point.

A waveguide setup makes it very difficult to measure voltage.



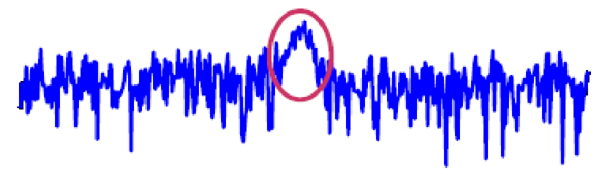
Low frequency allow easy power measurements



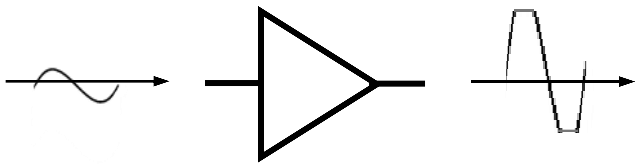
Importance of Power Signal Levels

A component output signal level is often the critical factor in the design of almost all RF and MW equipment.

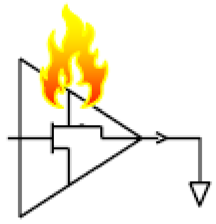
- Signal too low
  - information gets lost in noise
- Signal too high
  - Signal is clipped
  - Component can be destroyed



Signal content gets lost in noise, causing high BER

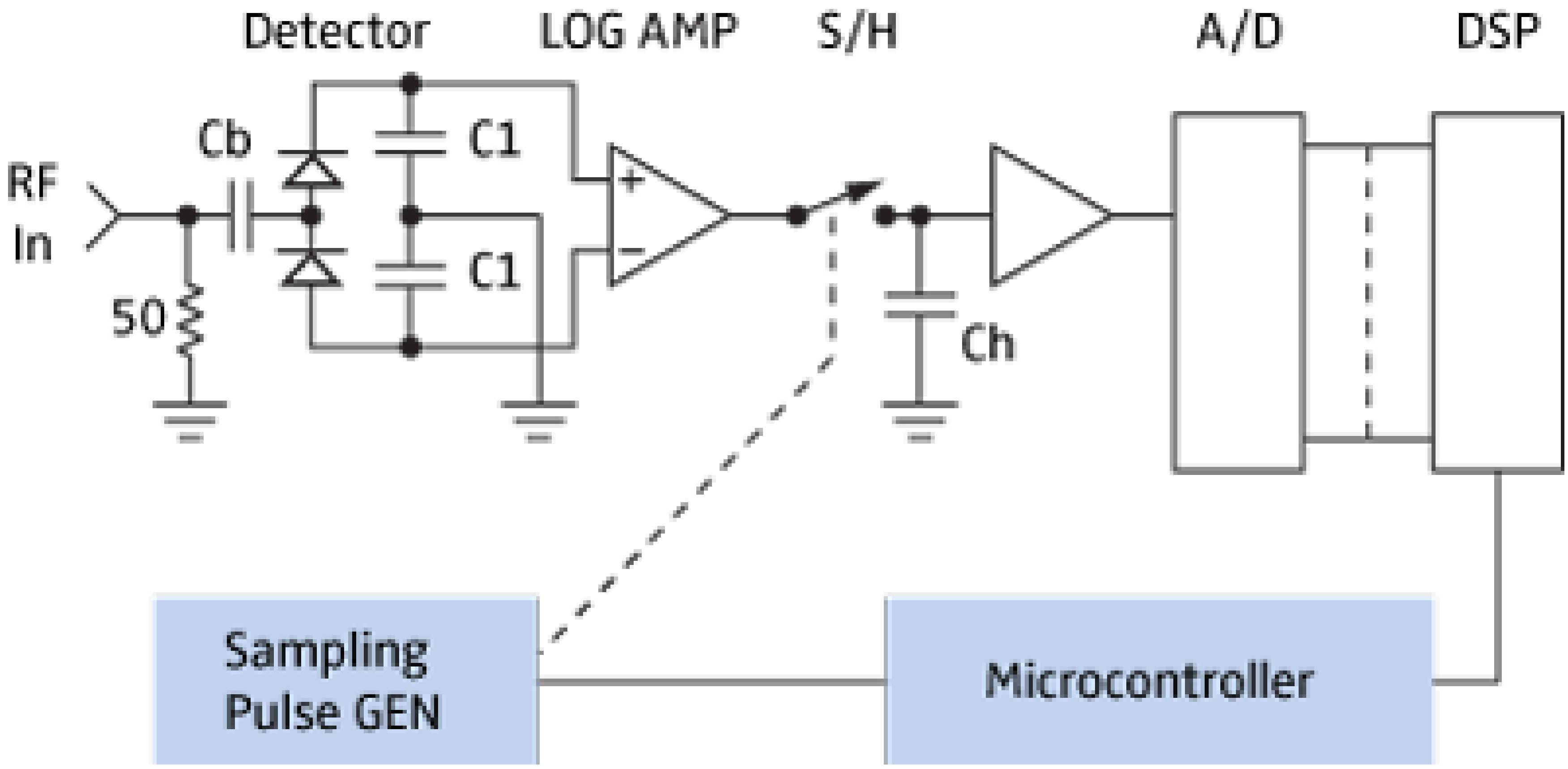


Signal information gets lost, due to clipping



Too much power destroys circuitry

4500B Peak Power Measurement System



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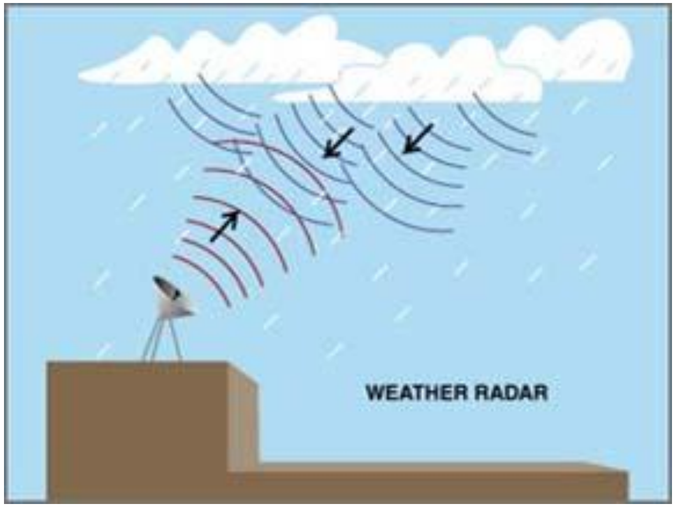
Weather Radar

- Modern weather radars use pulse-Doppler technology.

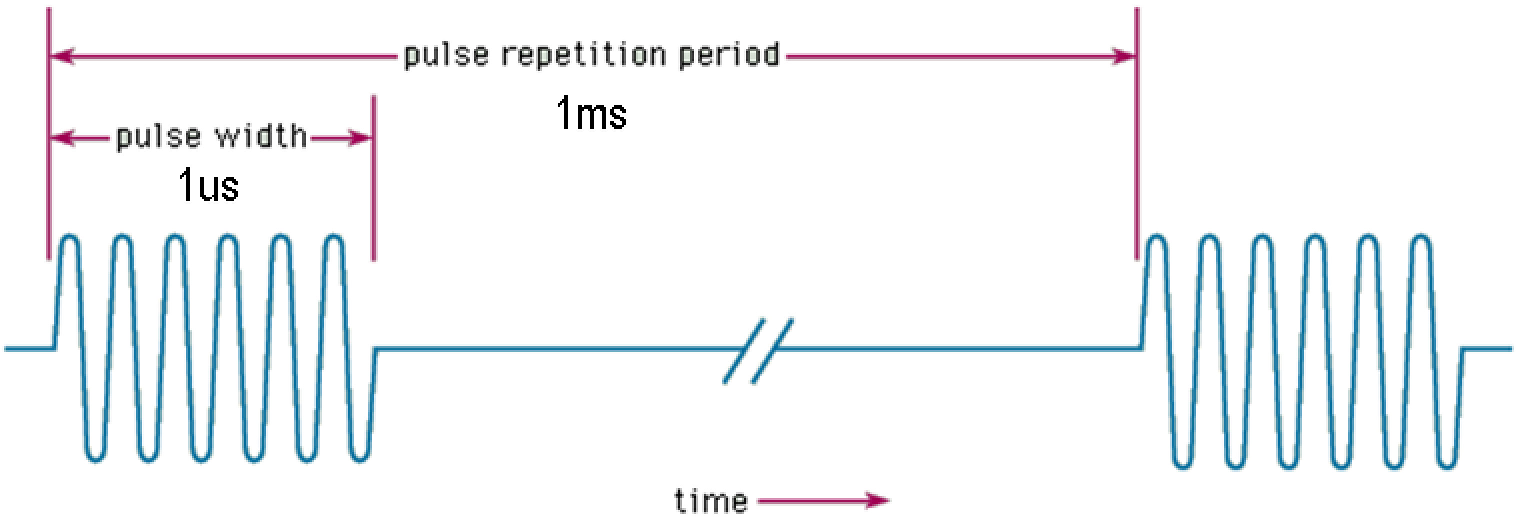
- They are able to measure:
  Position of the precipitation
  Calculate its motion
  Estimate its type (snow, hail, rain etc)
  Predict its future position and intensity



- They employ microwave pulses from 3GHz to 30GHz. These are the frequencies at which Rayleigh Scattering occurs.

Weather Radar

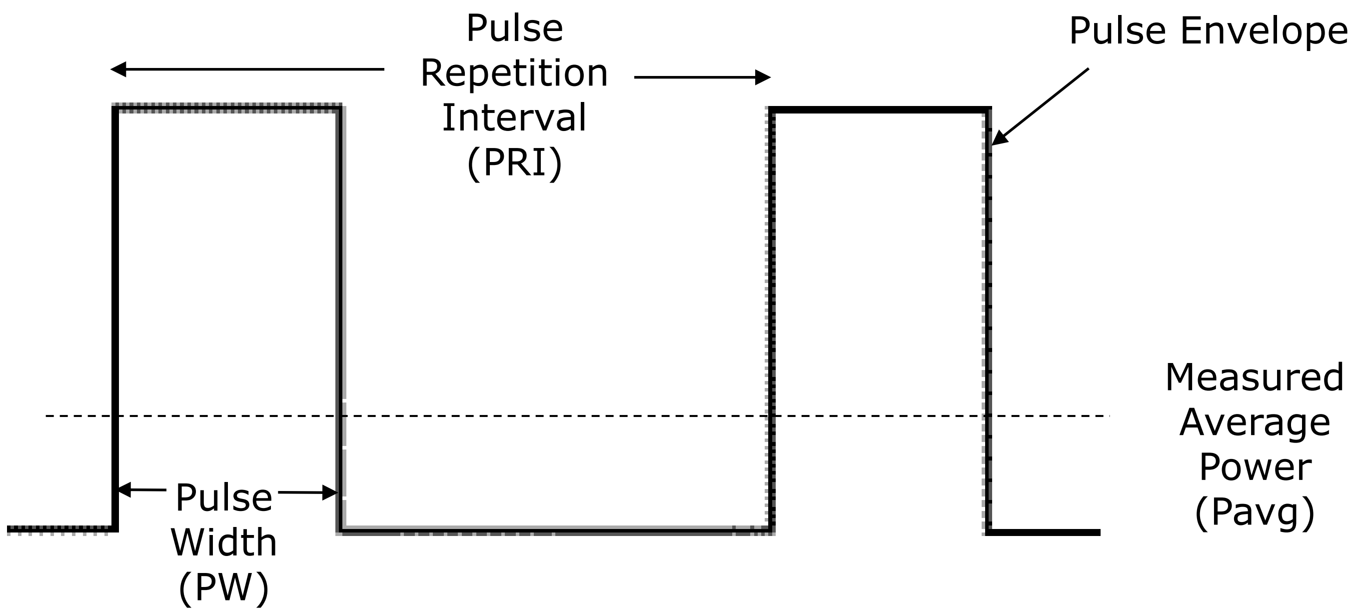
A typical pulse waveform transmitted by a Weather Radar.



This pulse has a duty cycle of 0.1%. Low duty cycles are necessary in order that the reflected pulse returns to the antenna before the next pulse is transmitted.

Pulse Power

Transmitted power determines maximum range



Duty Cycle = PW / PRI

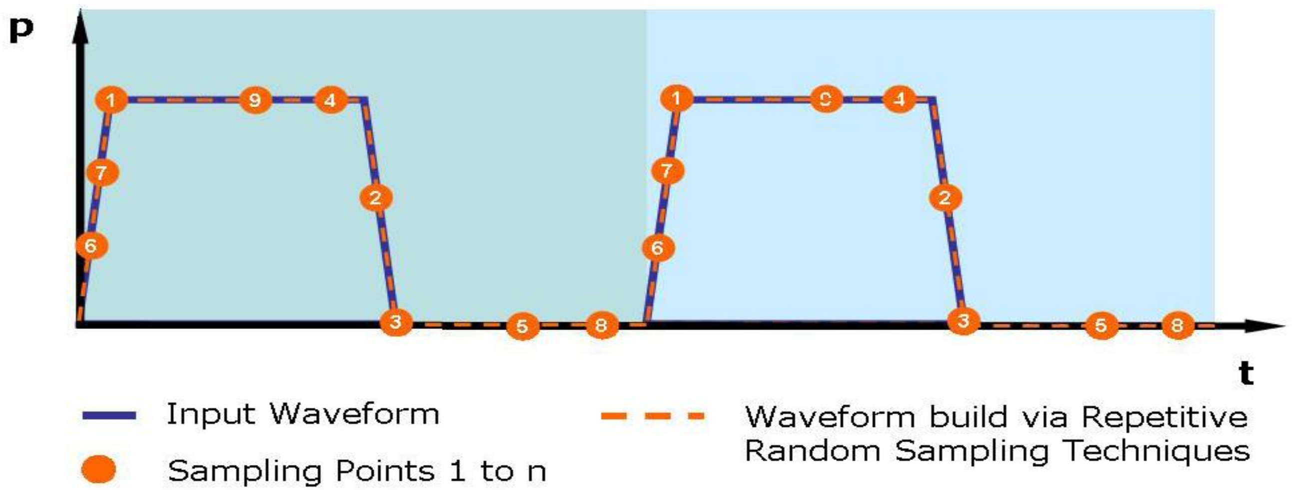
Pulse Power = Pavg / Duty Cycle

Pulse Mode Automatic Measurements

Pulse width
Pulse rise-time
Pulse fall-time
Pulse period
Pulse repetition frequency
Pulse duty cycle
Pulse off-time
Peak power

Pulse power
Overshoot
Average power
IEEE Top level power
IEEE Bottom level power
Skew
Edge delay

Repetitive Random Sampling



The 4500B takes continuous samples independent of the trigger event. Although the samples are taken sequentially in time, they are always completely random with respect to the trigger. Additional data points are added with every sweep.

As a result, the waveform is <u>completely reconstructed</u>.

This gives an effective sample rate of 10Gsamples/second.

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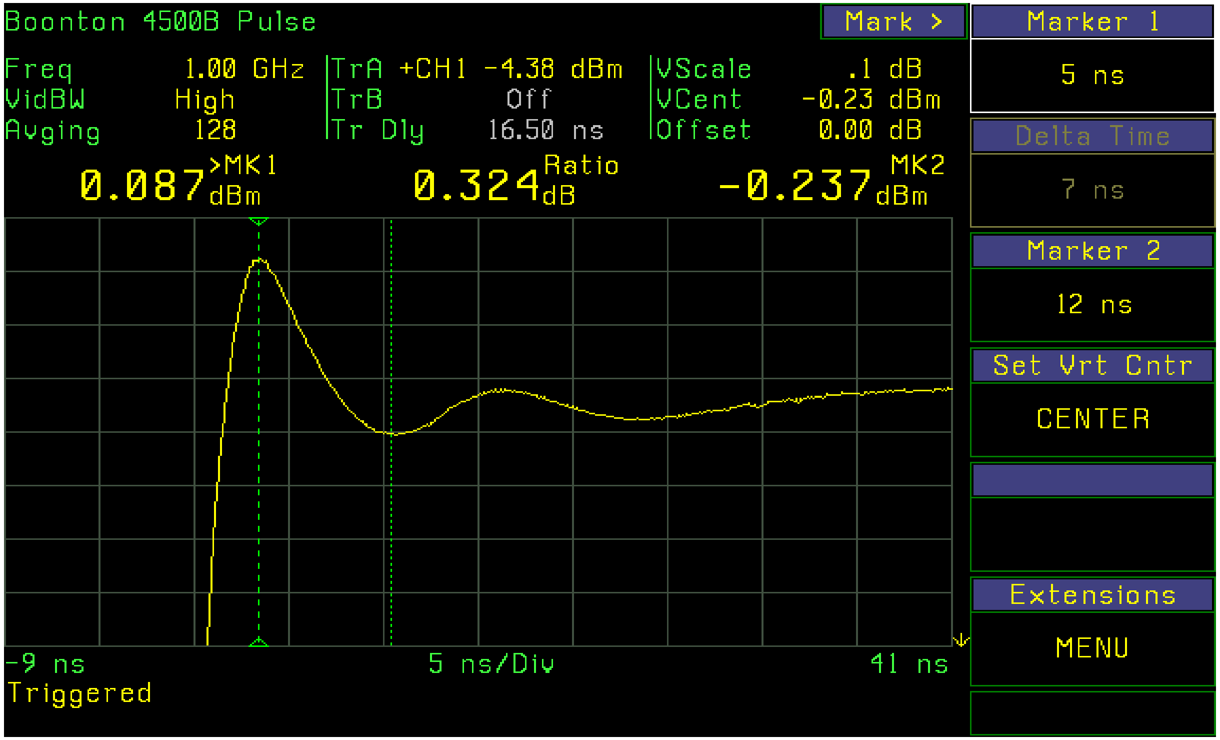
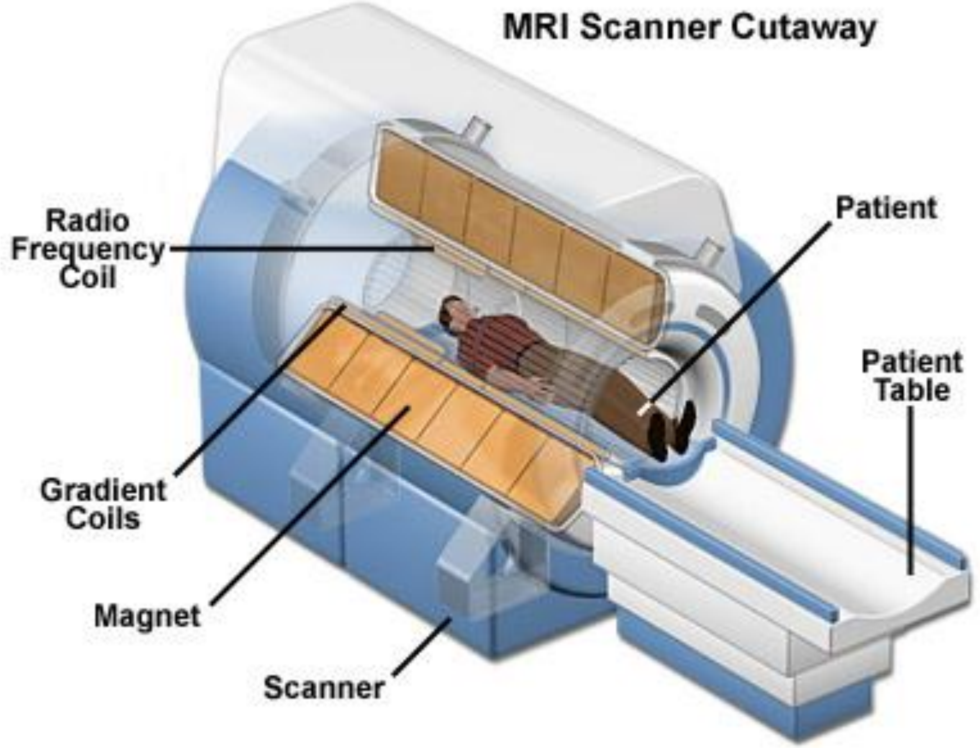
Repetitive Random Sampling



Fastest time base setting – 5ns/division
Number of pixels/division – 50
This equates to a time base resolution of 100ps, and therefore to an effective sample rate of 10Gsamples/second

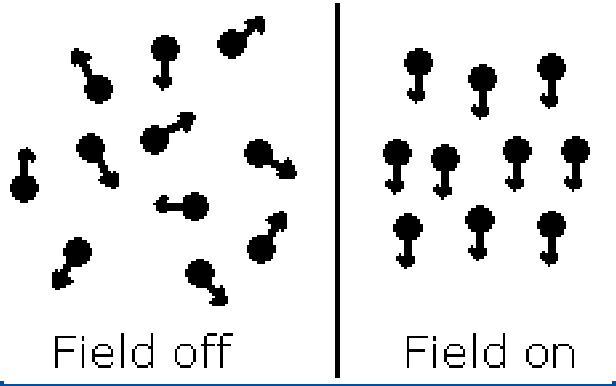
Magnetic Resonance Imaging

- An MRI Scanner is used in medicine to carry out a non-invasive scan of the human body with the use of very powerful magnets and RF pulses.



Magnetic Resonance Imaging

- The main magnet aligns the body's hydrogen atoms so that their magnetic moment is in the direction of the magnetic field.
- Other magnets, called gradient magnets , are switched on and off in such a way that they alter the main magnetic field at a specified location.
- RF pulses, the frequency of which is specific to hydrogen, are used to alter the magnetic moment, and therefore the alignment, of the atoms.



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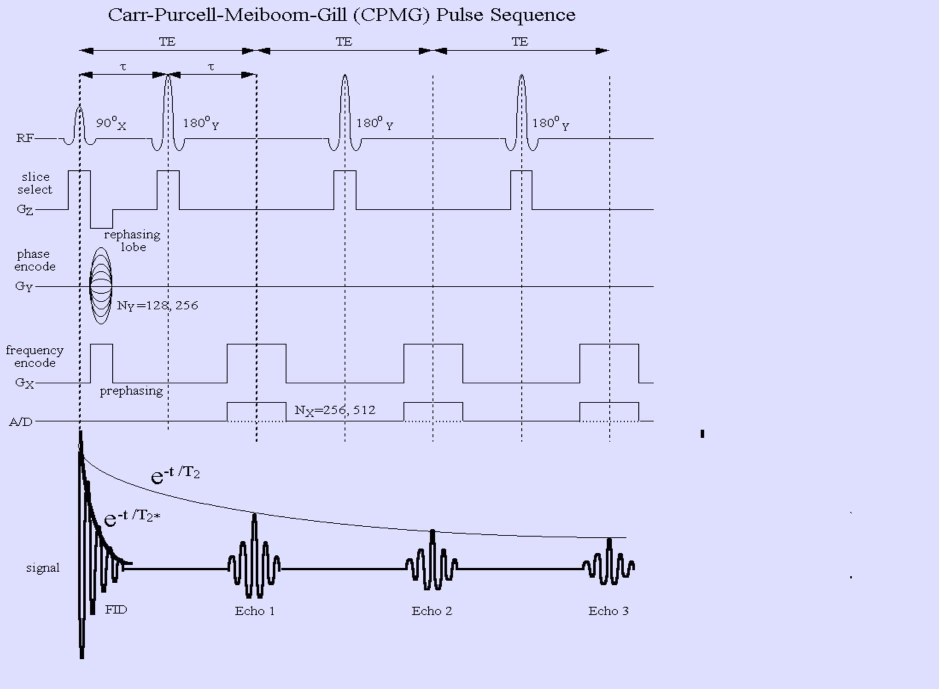
Magnetic Resonance Imaging

- A typical pulse sequence is shown below.
- Key measurements include pulse sequence duration (TR), Echo Time (TE) and echo train length.
- The 4500B can instantly measure all of these parameters.



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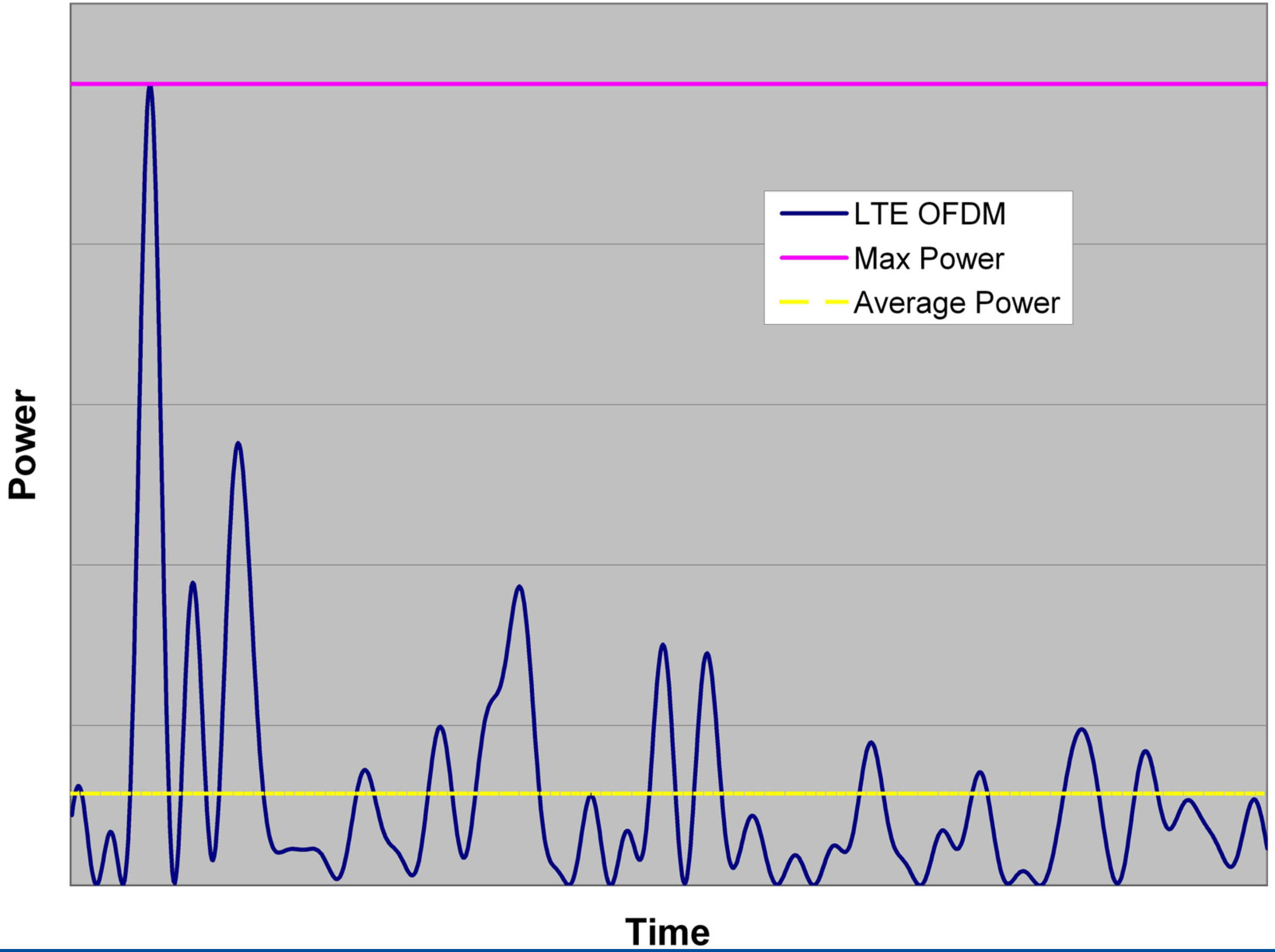
Modern Communication Signals

- Mobile broadband is becoming a reality. It is estimated that 3.4 billion people will have it by 2014.
- LTE uses OFDM as its modulation scheme.
- High Crest Factor. Peaks can be as high as 20dB above the average power level. 100 times greater!
- An LTE signal in the time domain can be equated to a complex pulse train.

Modern Communication Signals



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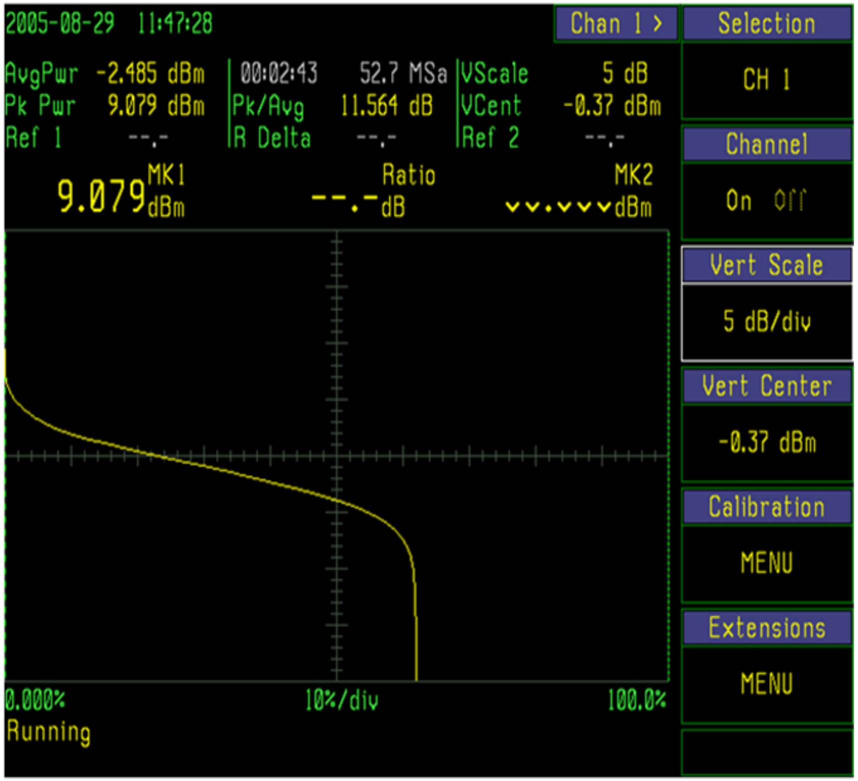
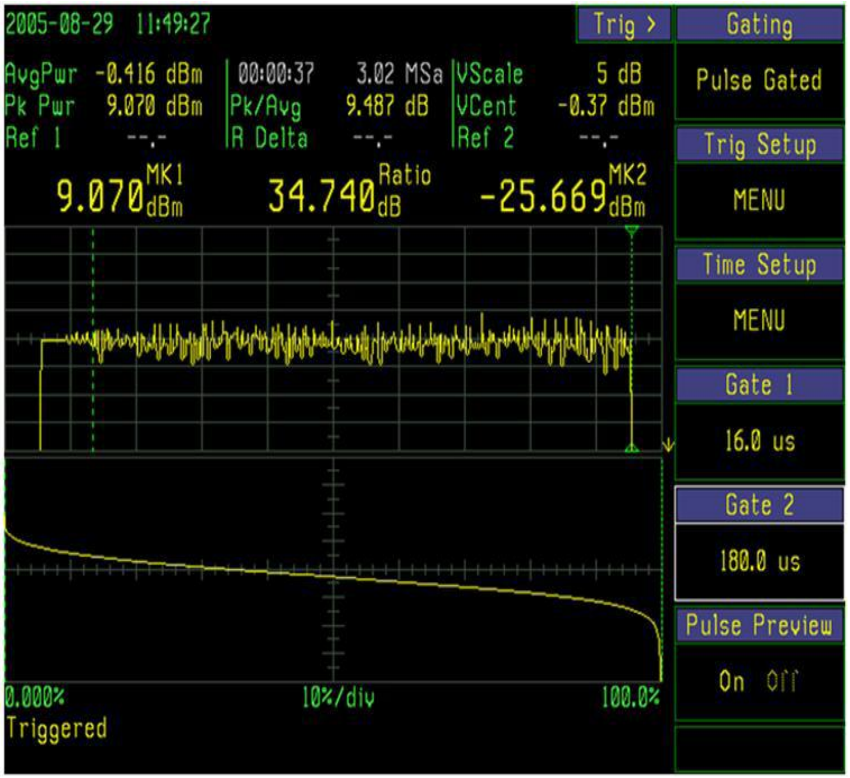
Modern Communication Signals





These 4500B CCDFs of a WLAN signal show the benefits of gating (right) versus free-running (left) acquisitions. The gated CCDF excludes the low-power “off” and low-crest-factor preamble section.

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Summary

- The increasing demands put upon today's data transmission signals has gone hand in hand with increasing complexity.

- This complexity has in turn resulted in the need for tighter specifications and therefore instruments capable of measuring to a high degree of accuracy.

- The Boonton 4500B is equipped to meet the needs of modern engineers.

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Thank You for Participating in Today's Webinar

Any Questions?

WTG Regional Technical Contacts for Additional Questions

- Mr. James Lim - JLim@wtcom.com
- Mr. Tony Lin - Shanghai, China - TLin@wtcom.com
- Mr. Stephen Shaw - Manchester, UK - SShaw@wtcom.com
- Mr. Bob Muro - Parsippany, NJ - RMuro@wtcom.com

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