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OFFICE OF THE SECRETARY

John W. Kuzin
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February 16, 2001

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
The Portals, TW-A325
445 12th Street, SW
Washington, DC 20554

Re: ***Ex parte* Notification - ET Docket No. 98-153**
Ultra-Wideband (UWB)

Dear Ms. Salas:

On February 15, 2001, Michal Freedhoff, Keven Trach and Bill Beeler of Time Domain Corporation, Ed Puzeller from Johns Hopkins University Applied Physics Laboratory, Phil Inglis - a consultant, David Hilliard and I from this law firm met with Kenneth Nichols, David Means, Richard Fabina, Steve Dayhoff, Joe Dichoso, Raymond LaForge, and Thomas Phillips of the FCC's Office of Engineering and Technology Laboratory. Mr. Beeler gave a presentation on UWB measurement techniques, and then, along with Mr. Trach, provided a demonstration illustrating these techniques to the Laboratory staff. A copy of the presentation slides used by Mr. Beeler and a copy of a measurement study prepared by technical staff members of Time Domain Corporation, which were distributed at the meeting, are attached.

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Should any question arise concerning this matter, please do not hesitate to contact me.

Sincerely,

John W. Kuzin
Counsel for Time Domain Corporation

Atts.
Ultra-Wideband Measurement Issues Presentation Slides
UWB Radiated Emissions Measurement Study

cc (w/o Atts): Messrs. Nichols, Means, Dayhoff, Dichoso, Fabina, LaForge, and Phillips.

TIME DOMAIN

THE PULSE OF THE FUTURE

Ultra-Wideband Measurement Issues

Rachel.Reinhardt@timedomain.com & Bill.Beeler@timedomain.com

February 15, 2001

Agenda

- Presentation
  - Background
  - Measurement Issues
  - Summary
- UWB Emissions Study
- Demonstration
- Wrap up

Background

- UWB signals present measurement difficulties

$$2\,\frac{f_u - f_l}{f_u + f_l} \geq 0.25$$

Where:
f_u = upper 10 dB down point
f_l = lower 10 dB down point

- Different signal generation techniques
  - Low duty cycle pulse systems (kHz)
  - Moderate duty cycle (Tens of MHz)
  - High duty cycle (Hundreds of MHz)
- UWB signals can also be
  - Periodic
  - Noise coded

Background (cont'd)

- NPRM showed insight into measurement issues
  - Potential inadequacies of existing measurement techniques for characterizing impact on wideband front ends
  - Limits of off-the-shelf instrumentation for making wideband measurements
- NPRM proposed limits and compliance testing derived from Part 15 Class B limits and related measurement techniques
  - Similar levels above 2 GHz with 12 dB step down below 2 GHz
  - A 50 MHz "RBW" mixed time/frequency domain measurement concept
- Did not specify definitive compliance measurement techniques and procedures

Measurement Technique Open Issues

- Measurement Domain?
  1) Frequency and Time Domain?
  2) or Frequency Domain?
  3) or Time Domain?
- 1 m versus 3 m measurement distance.
- Anechoic Chamber or OATS.
- 50 MHz filter topology.

Meeting Objectives

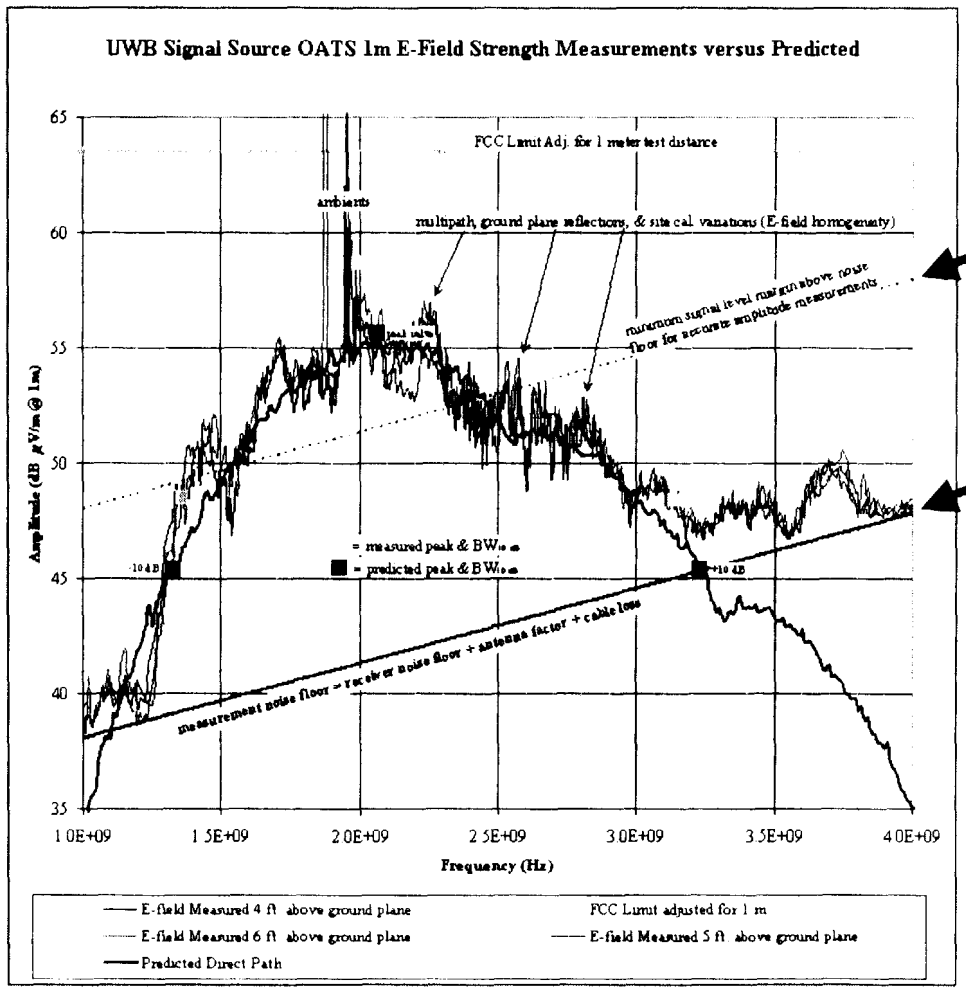
- Propose more definitive UWB compliance measurement technique
- Resolve issues
  - Measurement distance
  - Measurement environment
  - Wideband measurement technique
- Set the stage for defining the “limits”

Frequency Domain Measurement Issues

- Measurement at 1m versus 3m.
  - For accurate measurements S/N should be at least 10 dB. Cannot be obtained at 3 m.
  - 10 dB Bandwidth can only be accurately measured at 1 m.
  - True Peak Identification for time domain measurements can only be obtained at 1 m.
- Measurements should be made in an anechoic chamber to eliminate ambient errors. Masks true peak level and frequency.
- Average detector or display averaging must be used when PRFs are less than the RBW. Narrow VBW yields erroneous results.

Receiving System Noise Floor Limitations

1 Meter Measurement!



Instrument's 10 dB SNR level

Signals below this line are below the instrument noise floor

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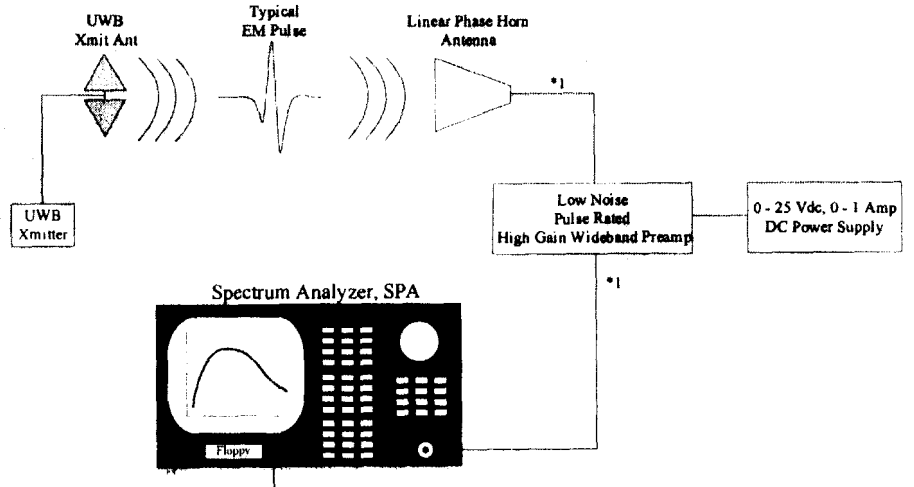
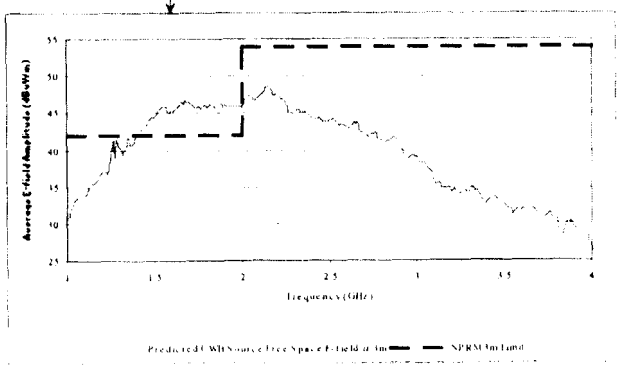
Frequency Domain Test Setup



Notes.
*1) Low Loss Cable
*2) All components must be accurately characterized with a network analyzer to determine S_{21}, S_{11}, phase delay, antenna factor, and preamp gain all versus frequency.



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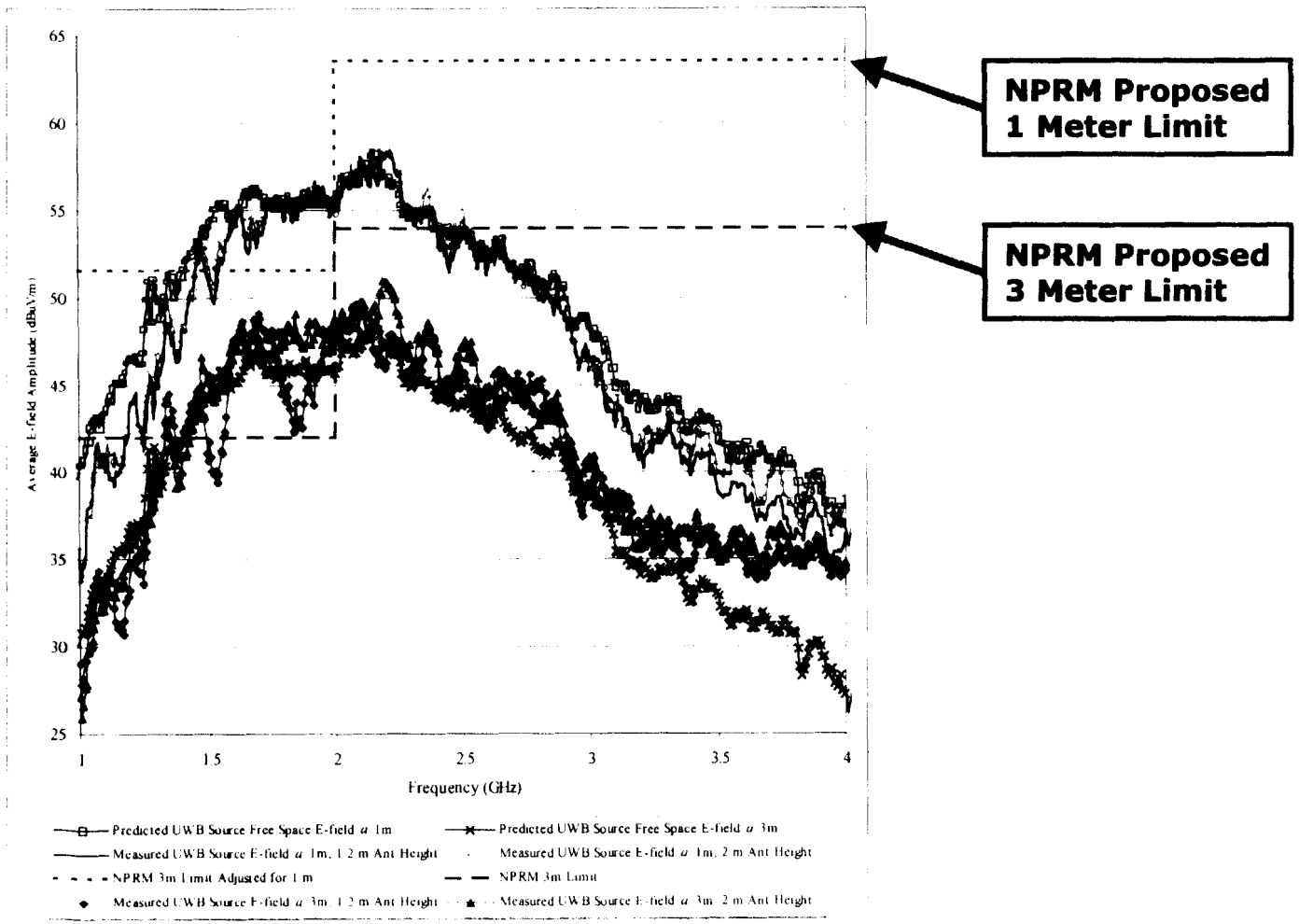
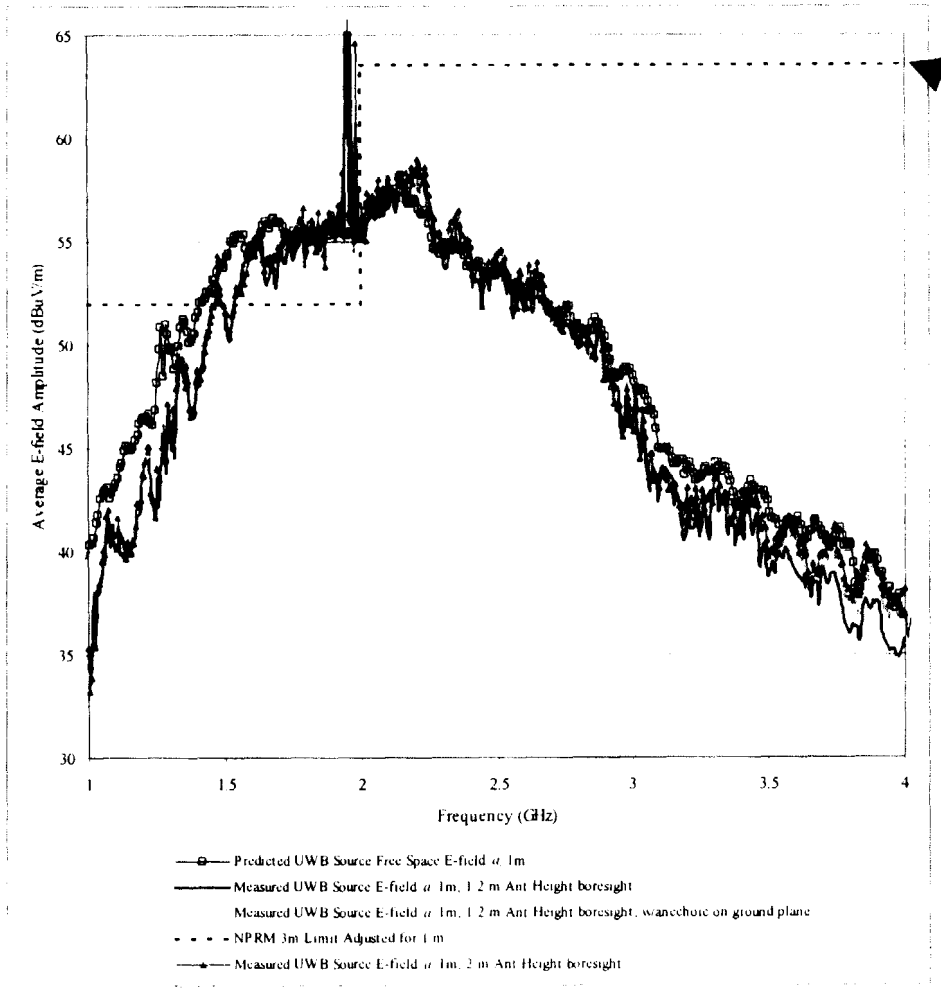
Anechoic Chamber Measurements



OATS 1 m Measurement



NPRM Proposed 1 Meter Limit

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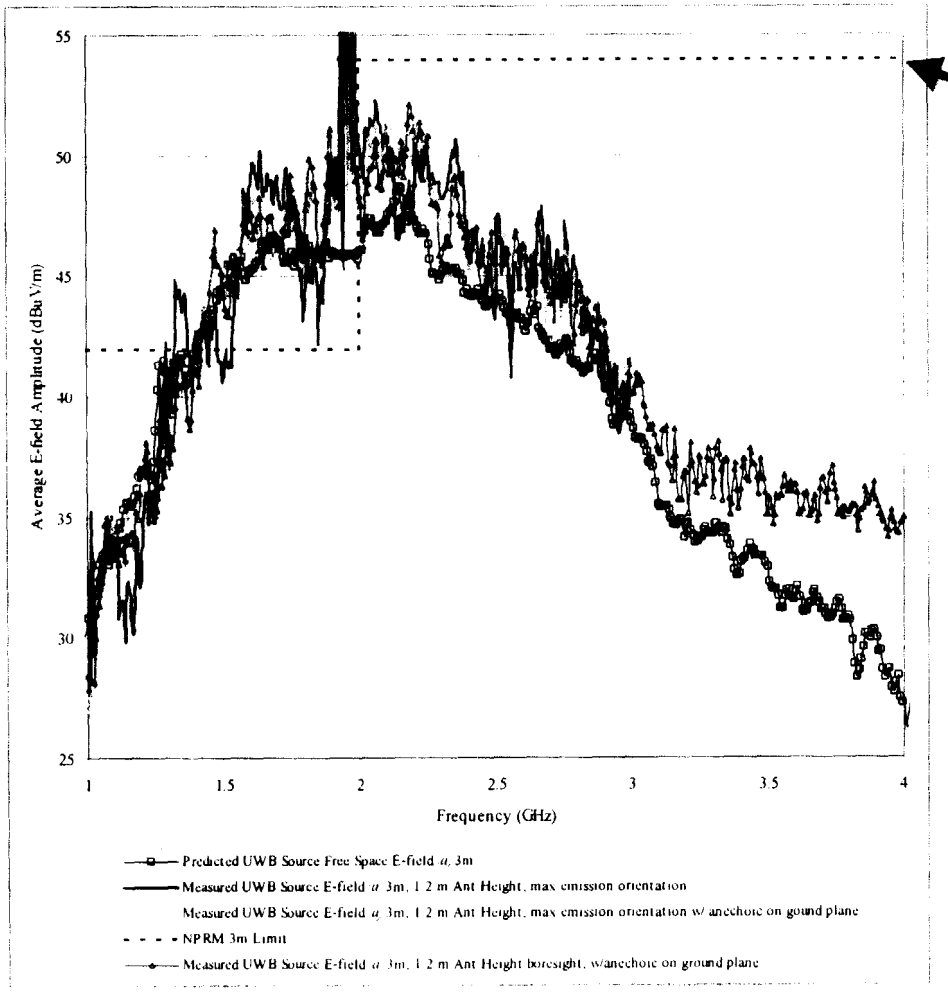
OATS 3 m Measurement



NPRM Proposed 3 Meter Limit

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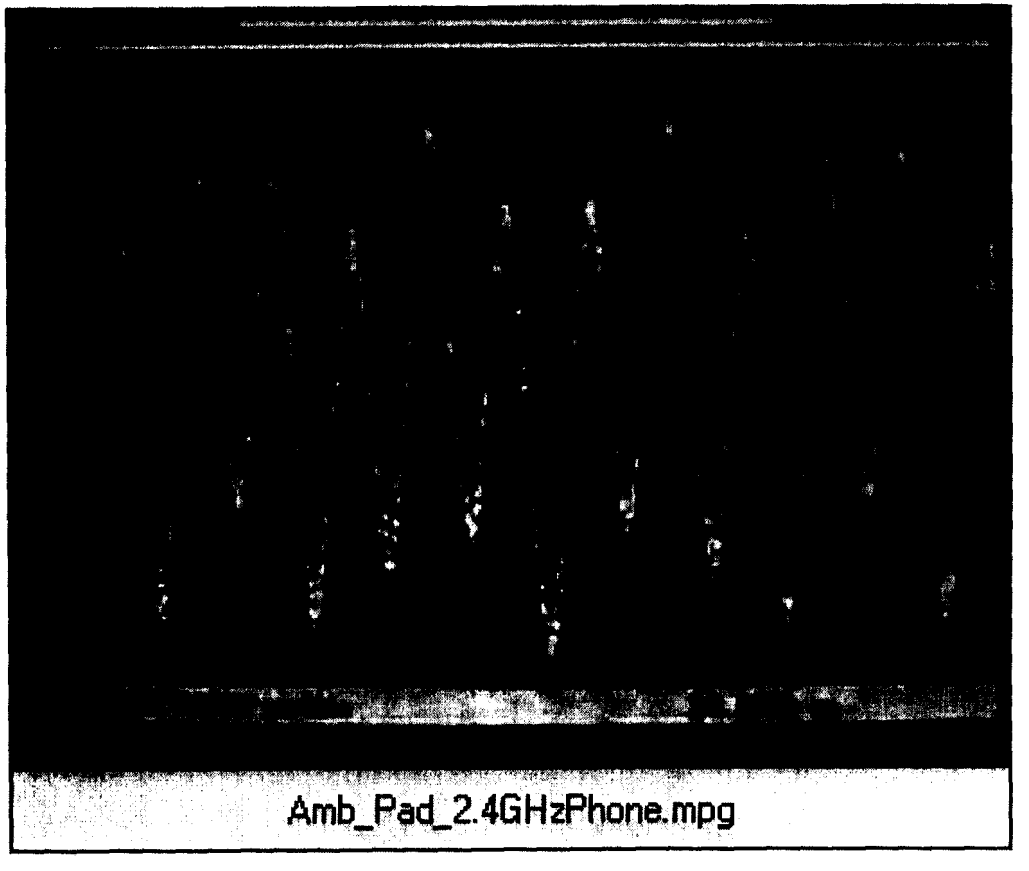
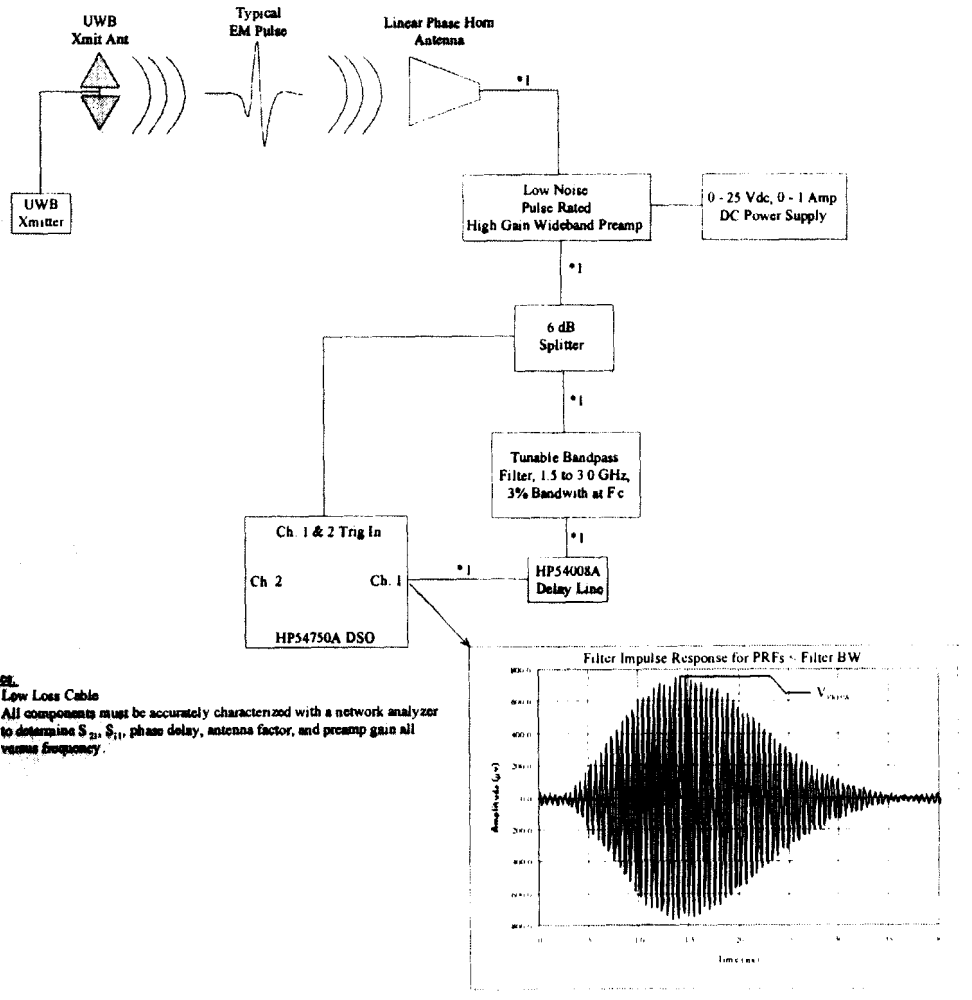
Bandlimited Time Domain Measurement Issues

- Measurement at 1m versus 3m
  - In order to faithfully reproduce the pulse shape measurements should be made such that the signals within the 10 dB bandwidth maintain a 10 dB S/N ratio. In other words minimize pulse distortion.
- Measurements should be made in an anechoic chamber to eliminate ambient errors. Ambient signals can cause filter output voltage error.
- 50 MHz Filter Type must be specified. Filter output voltage varies with filter type.
- All test setup components should be selected to have linear phase characteristics. Simplifies test setup calibration.
- Requires high speed Digital Sampling Scope (DSO) and tunable filter.

Ambient Impact in the Time Domain



Bandlimited Test Setup



Notes:
*1) Low Loss Cable
*2) All components must be accurately characterized with a network analyzer to determine S_{21}, S_{11}, phase delay, antenna factor, and preamp gain all versus frequency.

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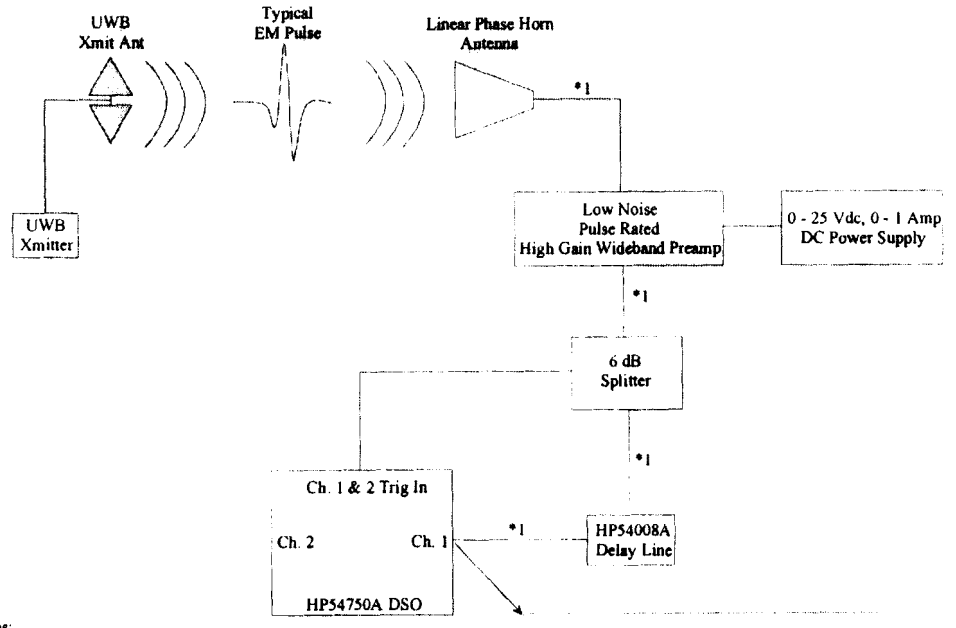
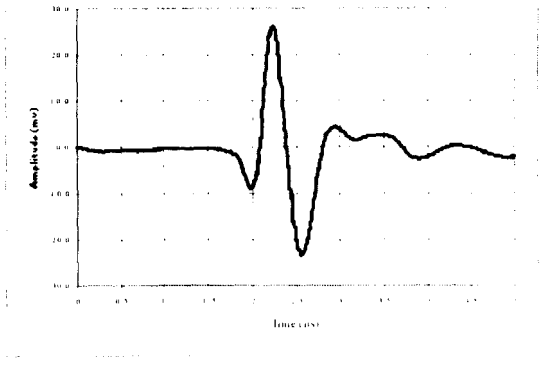
Absolute Peak Time Domain Measurement Issues

- Measurement at 1m versus 3m
  - In order to faithfully reproduce the pulse shape measurements should be made such that the 10 dB bandwidth frequencies maintain a 10 dB S/N ratio. In other words minimize pulse distortion.
- All test setup components should be selected to have linear phase characteristics. Minimizes post processing calculations.
- Requires high speed Digital Sampling Scope (DSO) that can save ASCII data on magnetic media and math program.
- Measurements should be made in an anechoic chamber to eliminate ambient errors. Ambient signals can distort time domain pulse and in some instances can completely mask the pulse.

Absolute Peak Test Setup



Notes:
*1) Low Loss Cable
*2) All components must be accurately characterized with a network analyzer to determine S_{21}, S_{11}, phase delay, antenna factor, and preamp gain all versus frequency.



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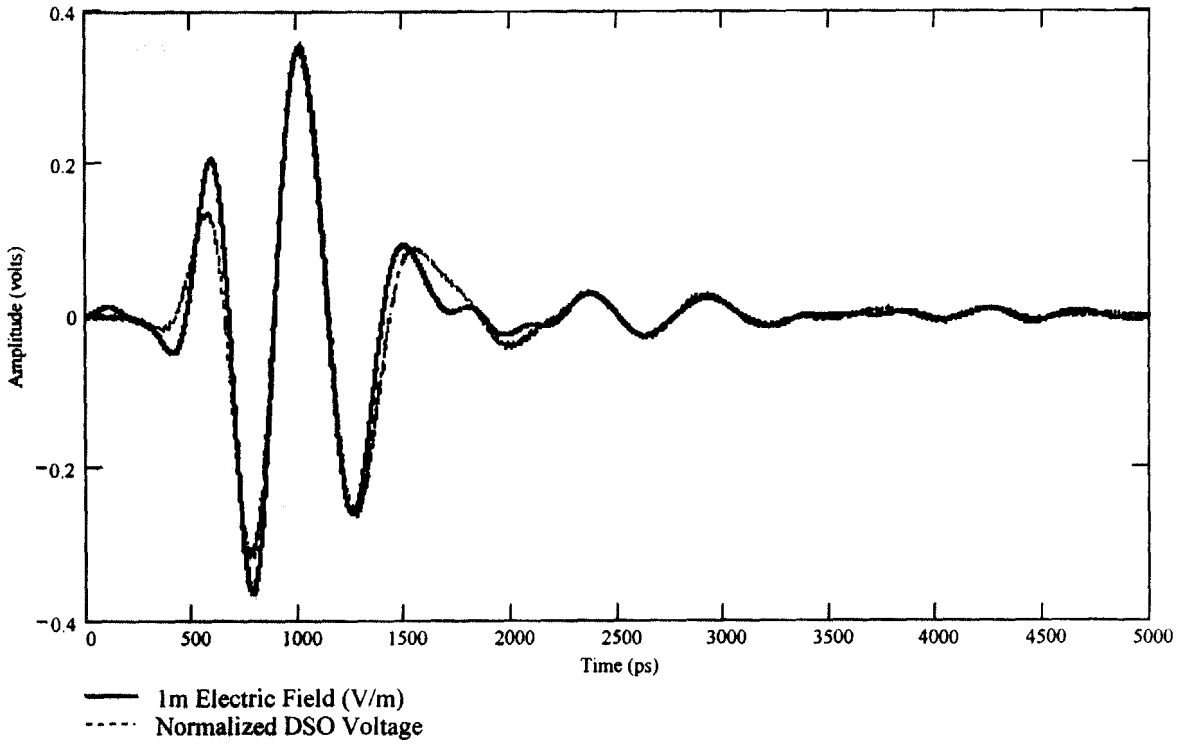
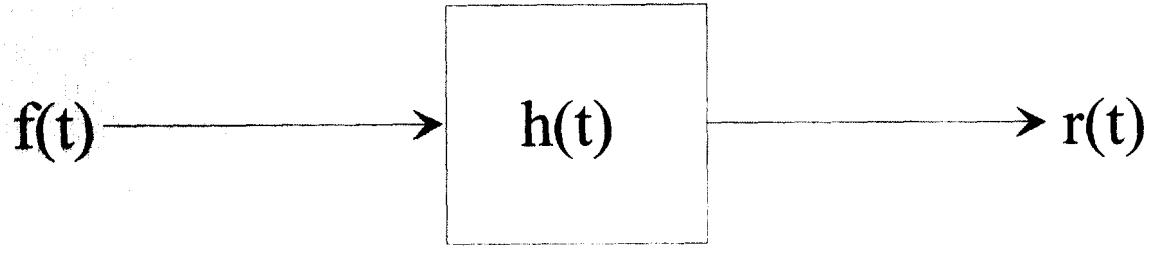
DSO Voltage vs Electric Field Waveform



Absolute Peak Calculations

$$f(t) * h(t) = r(t)$$



$$\mathfrak{F}\{r(t)\} = \mathfrak{F}\{f(t) * h(t)\} = R(j\omega) = F(j\omega)H(j\omega)$$

$$F(j\omega) = R(j\omega)/H(j\omega)$$

$$f(t) = \mathfrak{F}^{-1}\{F(j\omega)\} = \mathfrak{F}^{-1}\{R(j\omega)/H(j\omega)\}$$

$\mathfrak{F}$ and $\mathfrak{F}^{-1}$ are the Fourier transform pair

$*$ is the convolution operator

Summary

- Measurements should be performed at 1 meter.
- Measurements should be made in an anechoic chamber.
- All test setup components should have a linear phase characteristic.
- Results of testing and analysis included in TDC Radiated Emission Measurement Study.