Antennas Studies for UWB Radio

Program Review May 2002

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UWB Radio Antenna and Electromagnetics Tasks

1. Full-Wave Calculation of Receive Antenna Voltage

(arbitrary input voltage waveform, antenna types, angle of incidence, load impedance, polarization, and T/R matching/shaping networks)

2. Modeling of Antenna Link with Multipath

(model LOS and multipath signals, variable amplitude, possible polarity reversals)

3. Optimization of Transmit/Receive Link

(define “optimum” metric, pulse shaping constraints, power spectral density shaping, antenna efficiency, antenna patterns)

Highlights

1. Time-domain analysis method developed

"Time-Domain Integral-Equation-Based Solver for Transient and Broadband Problems in Electromagnetics," A.O. Boryssenko and D.H. Schaubert, AMEREM 2002, June 2002.

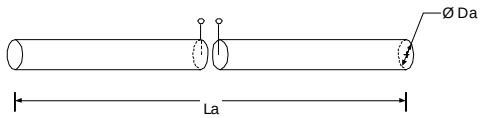
2. Equivalent circuits for typical UWB antennas

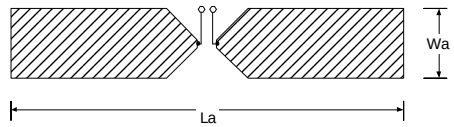
Results of full-wave electromagnetic analysis converted to equivalent circuits compatible with circuit simulation/optimization.

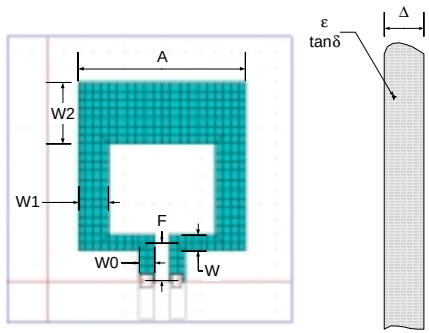
3. Optimization of Pulse Radiation from Simple Antennas

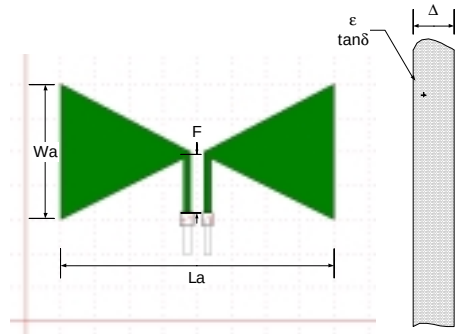
Three methods studied. Some results in "Optimized Ultra-wideband Radiation of Dipole Antennas with Triangular Driving Pulses," A.O. Boryssenko and D.H. Schaubert, AMEREM 2002, June 2002.

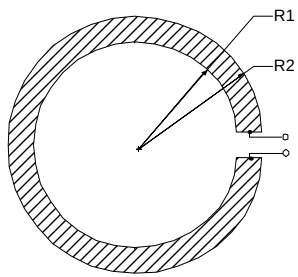
Some Simple Antenna Shapes

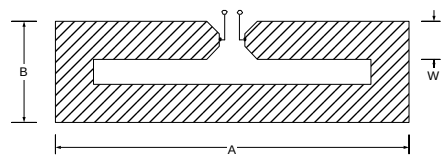






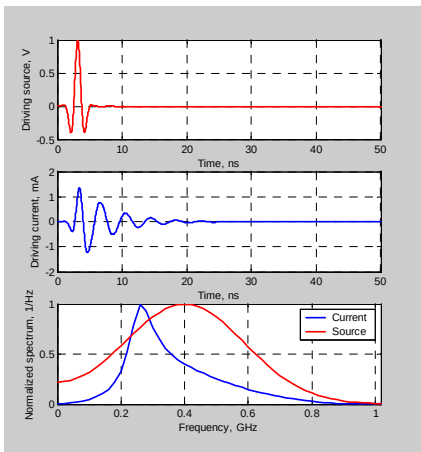






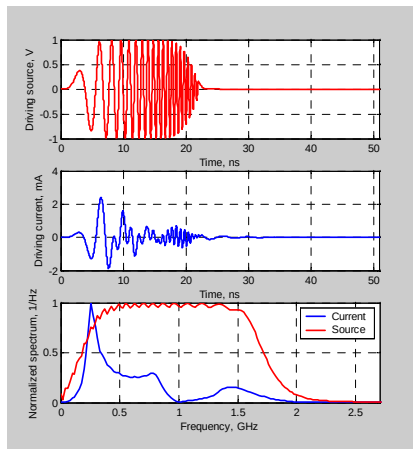
Time-Domain Integral Equation Analysis

0.5-m Thin-Wire Dipole Reception

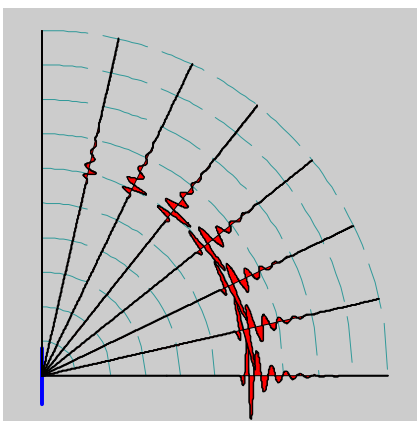


Incident Electric Field

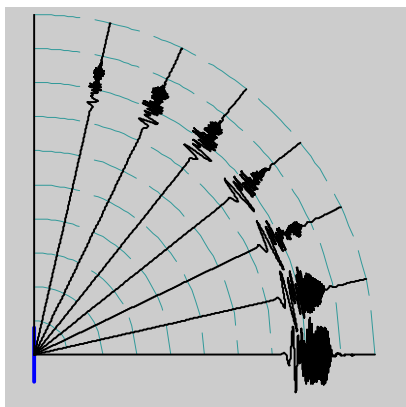
Terminal Current



Power Spectra



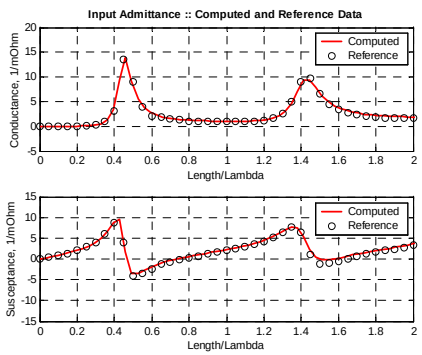
Scattering Patterns



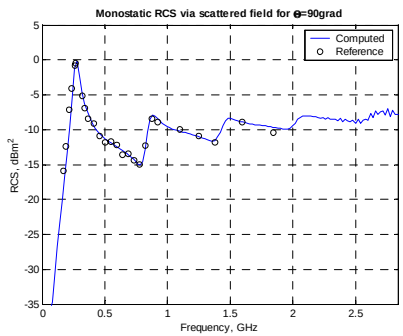
Time-Domain Integral Equation Analysis

0.5-m Thin-Wire Dipole

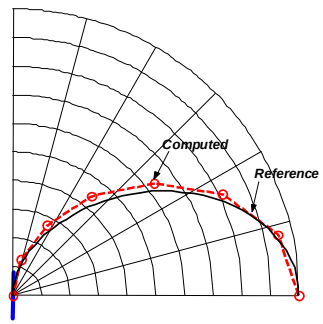
Comparisons of computed results to reference cases



Input Admittance

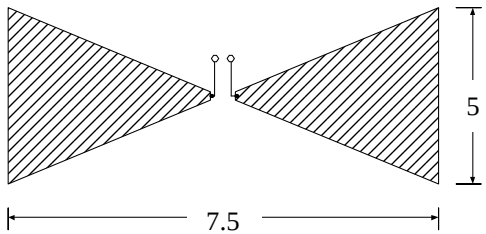


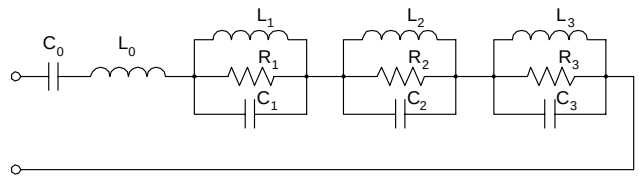
RCS



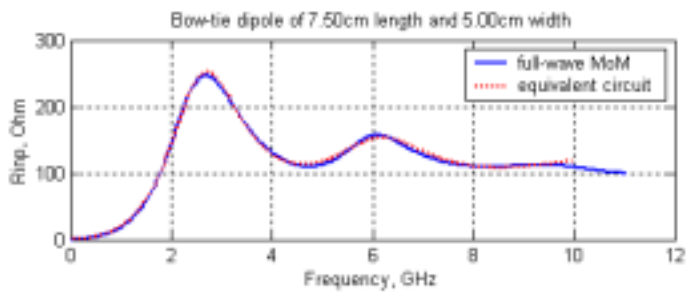
Radiation Pattern

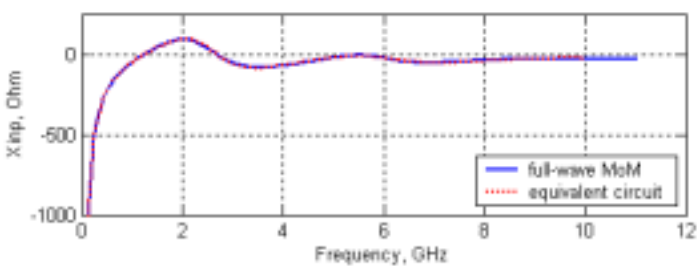
Equivalent Circuits for Simple Antennas





C_0 pF	L_0 nH	C_1 pF	L_1 nH	R_1 Ω	C_2 pF	L_2 nH	R_2 Ω	C_3 pF	L_3 nH	R_3 Ω
1.19	0.6	0.58	1.1	99	0.35	10.0	244	0.18	1.1	105

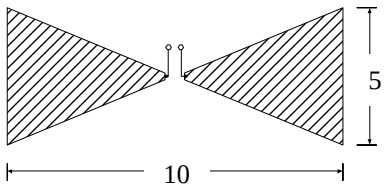


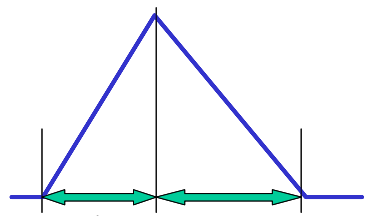


Higher order resonances are primarily for electronic circuit design/analysis

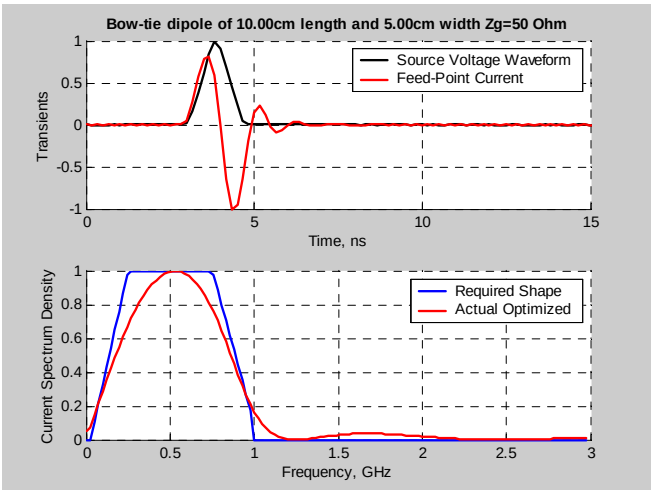
Optimization of Pulse Radiation from Simple Antennas

Triangular Voltage Pulse

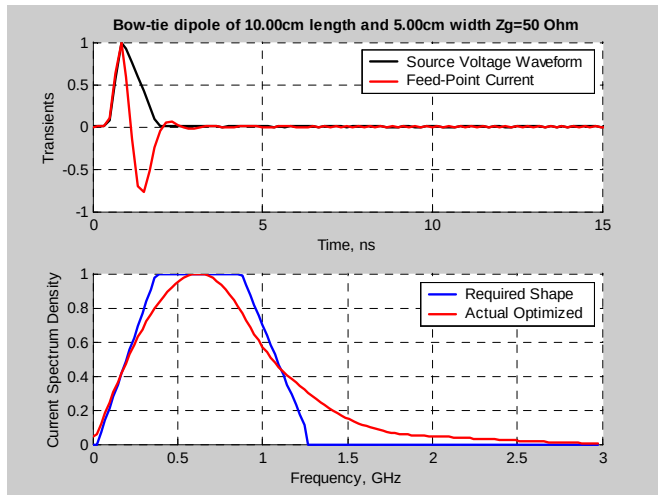




$\tau 1/\tau 2 \sim \tau 2/(\tau 1+\tau 2) \sim 0.61803$



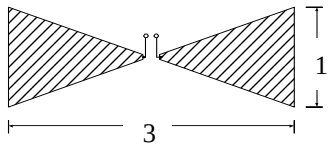
Triangular pulse with some ringing.

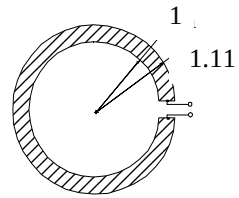


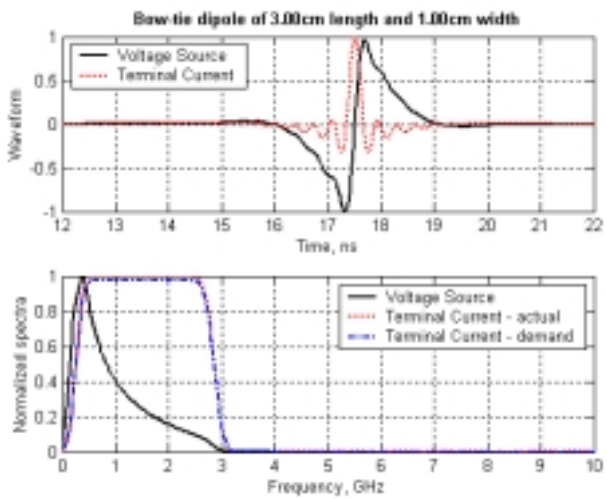
Nearly optimum triangular pulse.

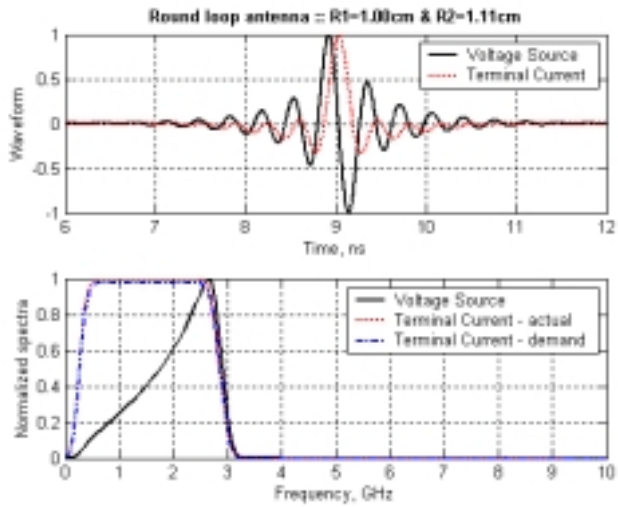
Transfer Function Synthesis

$$V(\omega) = Z(\omega)\, I(\omega) \quad \Longrightarrow \quad i(t) = F^{-1}\{\, V(\omega) / Z(\omega) \,\}$$



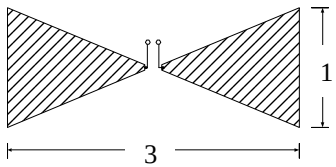




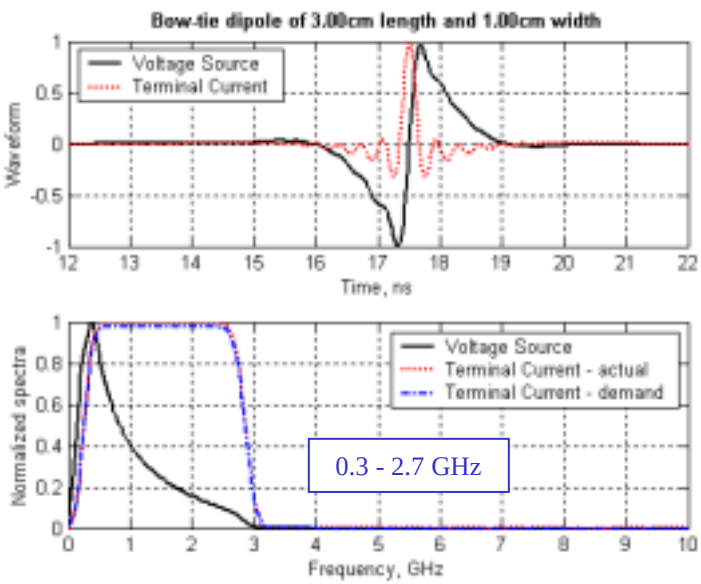


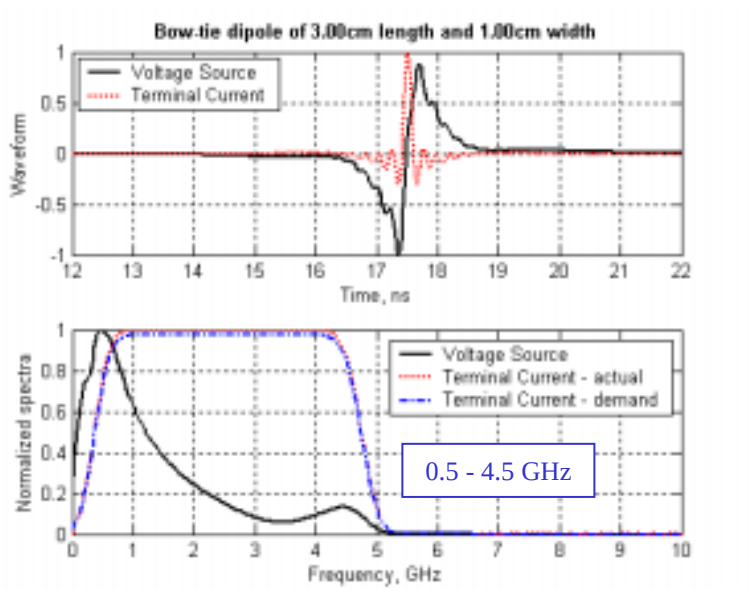
- **Relatively simple voltage waveforms yield moderately well localized current.**
- **Loop antenna requires more complicated voltage source to achieve comparable bandwidth and time localization. (Linear phase assumed.)**

"Matching" Antenna to Bandwidth and Frequency Requirements



- 9:1 bandwidth at 80% level
- Time localization α 1/BW
- Size scaling would maintain simplicity of voltage waveform while increasing operating frequency





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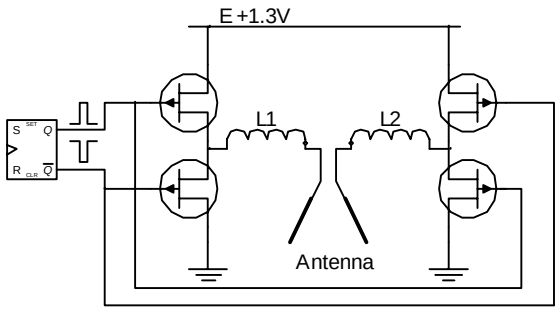
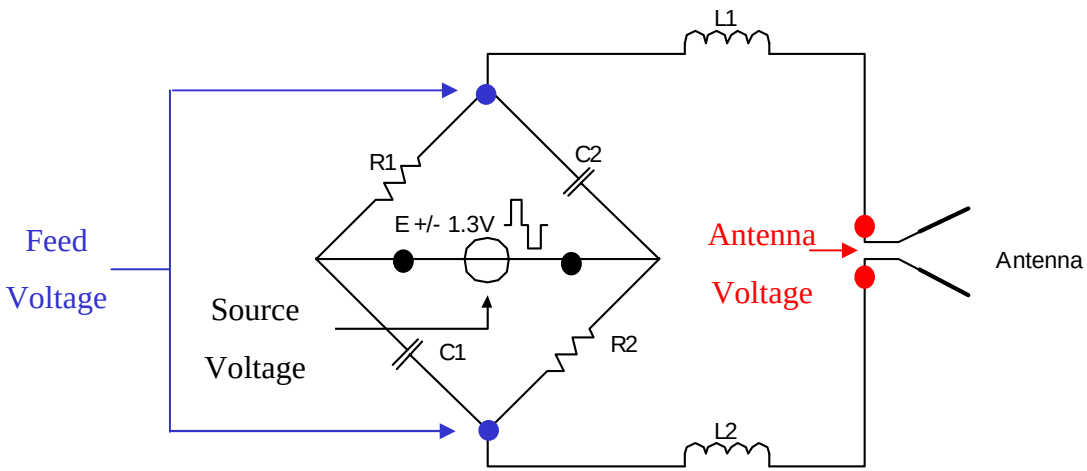
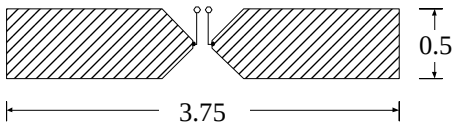
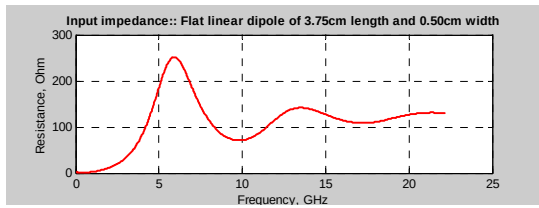
H-Bridge Voltage Driver

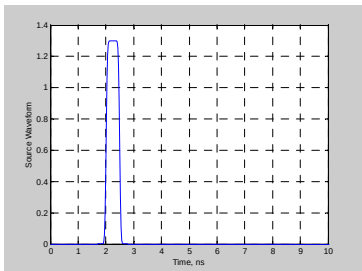


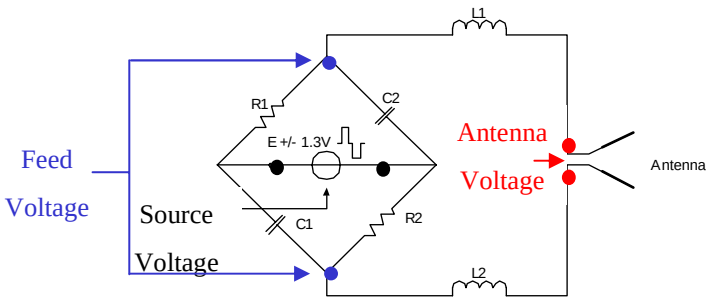


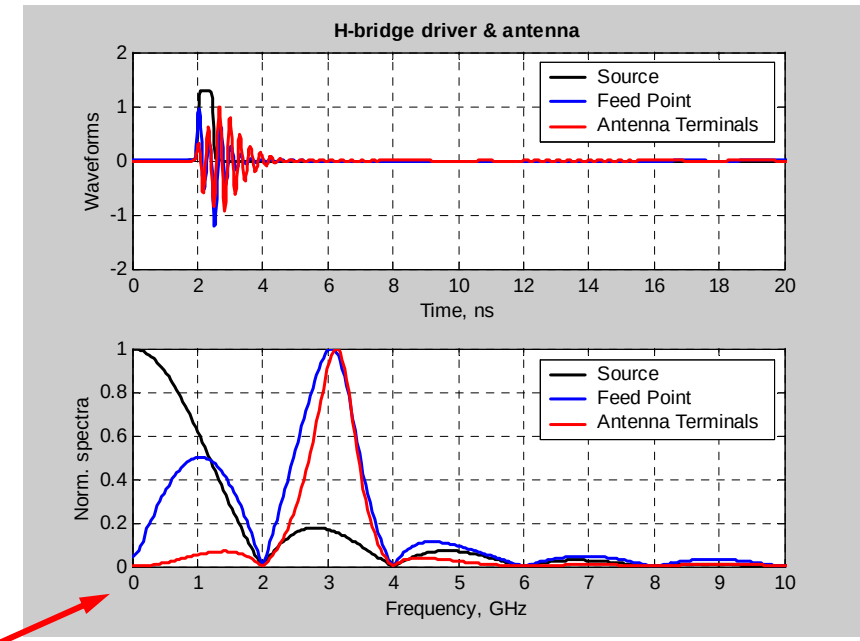
Single Pulse Excitation of Flat Dipole











Spectrum modified by circuit & antenna

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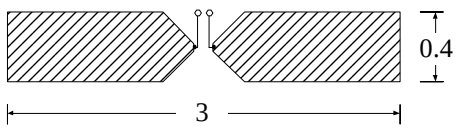
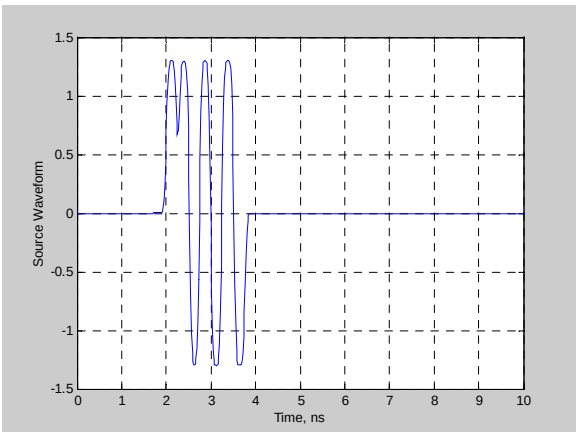
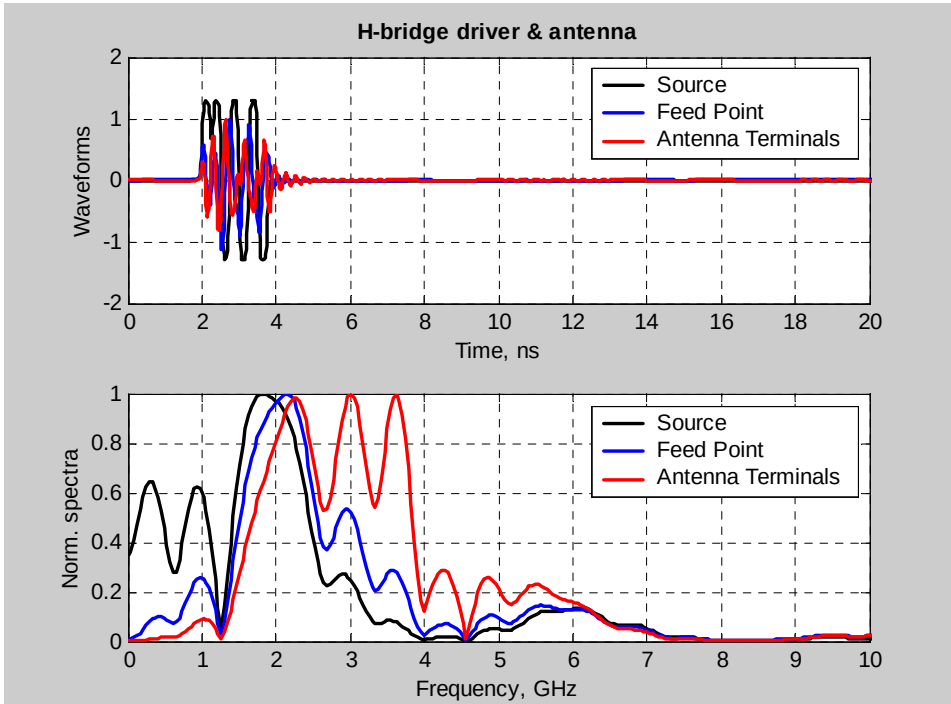
Flat Dipole Driven by H-Bridge Waveform







- **Waveforms and system efficiency highly dependent on parasitic elements and antenna impedance.**

Summary of Accomplishments

1. Time-domain analysis method developed

- Several improvements made during the year.
- Ready to use for UWB antenna analysis and design.

2. Equivalent circuits for typical UWB antennas

- Used to better understand interaction of antenna terminal characteristics and driver circuit.
- Future use for circuit optimization.

3. Optimization of Pulse Radiation from Simple Antennas

- Simple antennas and simple pulses (triangular) yield surprisingly good results, but limited degrees of freedom for further improvement.
- Good wideband antennas and low-parasitic circuits needed.
- Ready to incorporate full-wave radiation, propagation and reception into analysis/design studies.