Broadband TEM Horn Antennas for Pulse Radar

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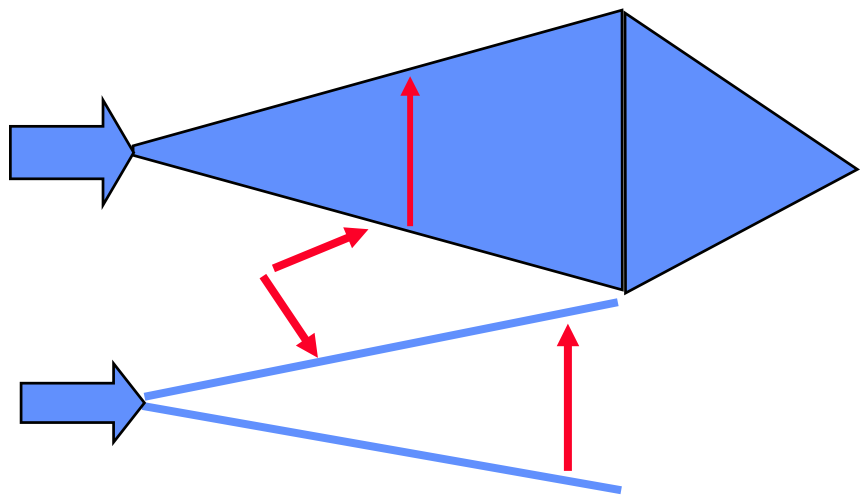
Introduction

- Pulse radar - ground penetrating radar (GPR): receiving reflected pulse signals to detect and locate subsurface objects
  - A trade-off between the resolution and penetrating depth
  - Typical frequency range: 100 MHz to 1000 MHz
  - Typical antenna in use: bow-tie
  - Problem: limited bandwidth resulting in “ringing”
  - Antenna requirement:
    - ultra-wide-band
    - Small and directive

TEM horn antennas

Top view

Side view

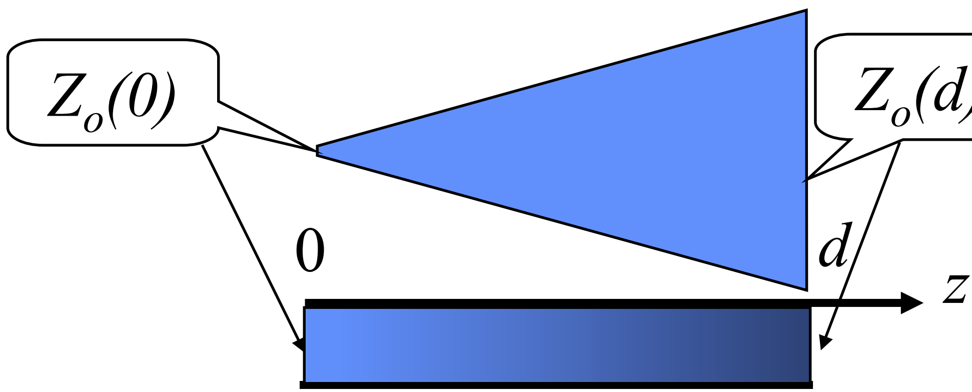


- Advantages: wideband antenna
- Problems:
  - Feed: wideband balun is required
  - limited information on design, but many variables

2. Antenna Design

- Aims:
  - VSWR < 2, between 500 to 3000MHz
  - Small: length < 40 cm
- Theoretical approach
  - Full theoretical analysis not available
  - Models with approximations
    - Transmission line model

Transmission line model



$$\mathrm{Ln}\,\frac{Z_0(z)}{Z_0(0)} = \frac{1}{2}\,\mathrm{Ln}\,\frac{Z_0(d)}{Z_0(0)}\left\{1 + \mathrm{G}\left[B\,,\ 2\left(z/d - 0.5\right)\right]\right\} \quad , \quad 0 \le z \le d$$

$$\left|R(0)\right|_{\max} = \tanh\left[\frac{B}{\sinh B}(0.21723)\,\mathrm{Ln}\left(\sqrt{\frac{Z_0(d)}{Z_0(0)}}\right)\right]$$

$$\beta_{\min}\, d = \sqrt{B^2 + 6.523} \quad , \quad \beta_{\min} = \frac{2\pi f_{\min}}{\nu}$$

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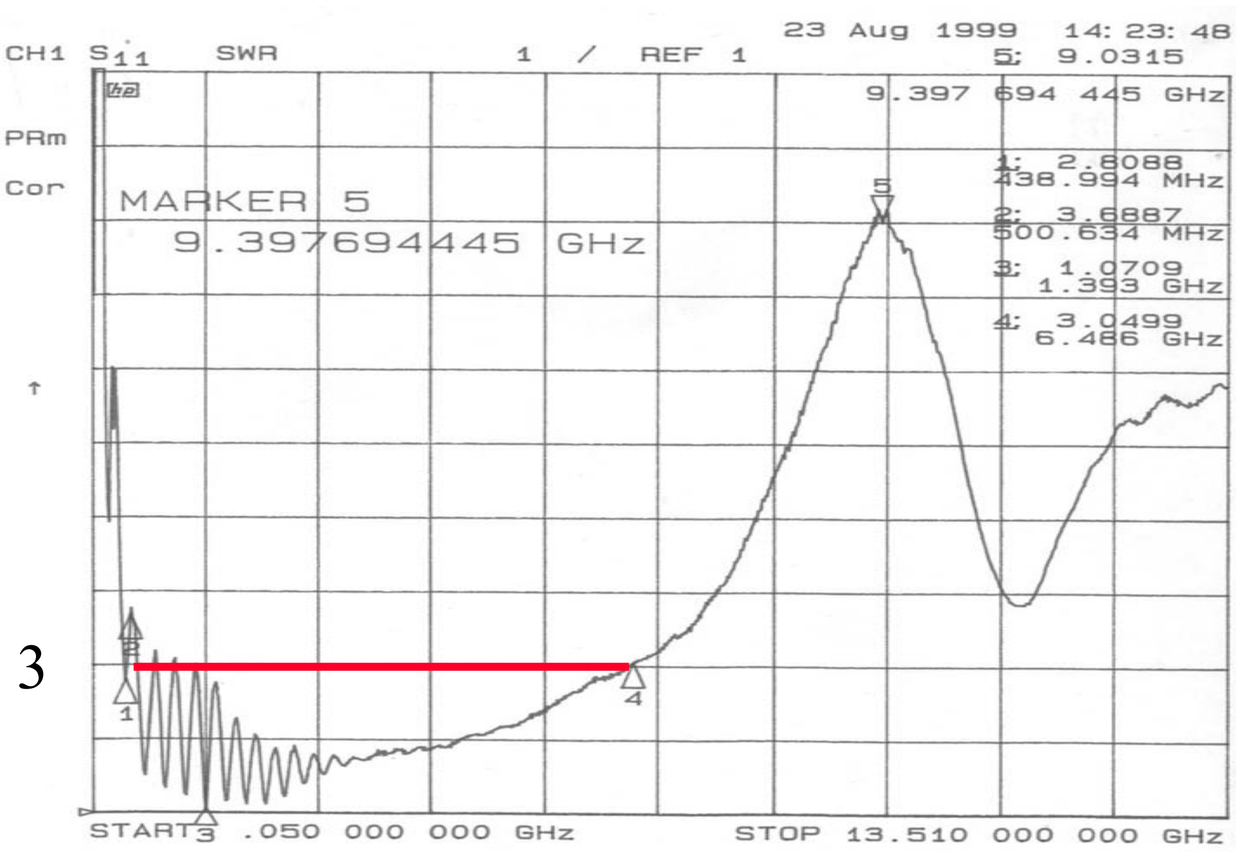
One example with limited success



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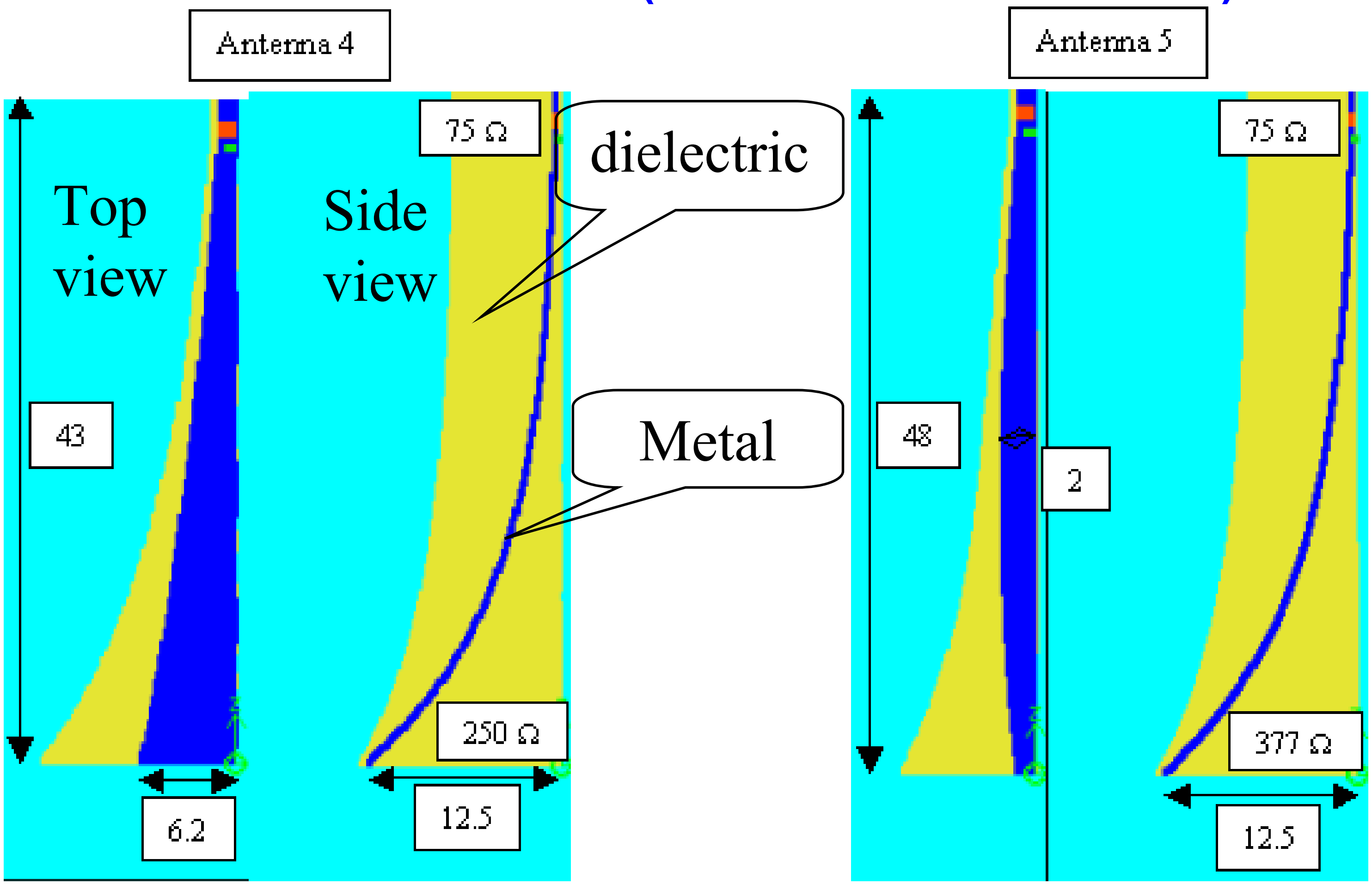
FDTD simulation (1/4 of the antenna)



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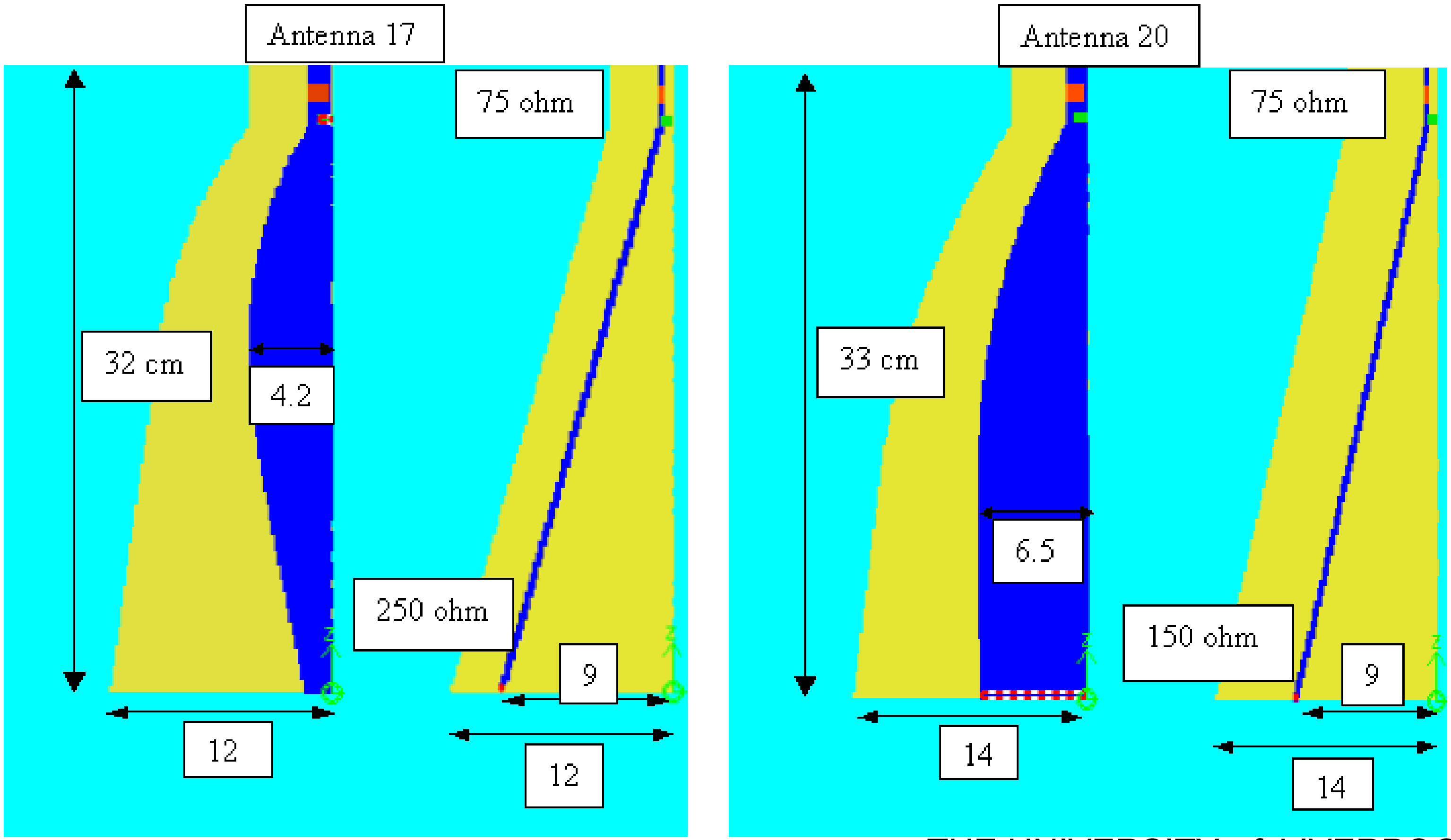
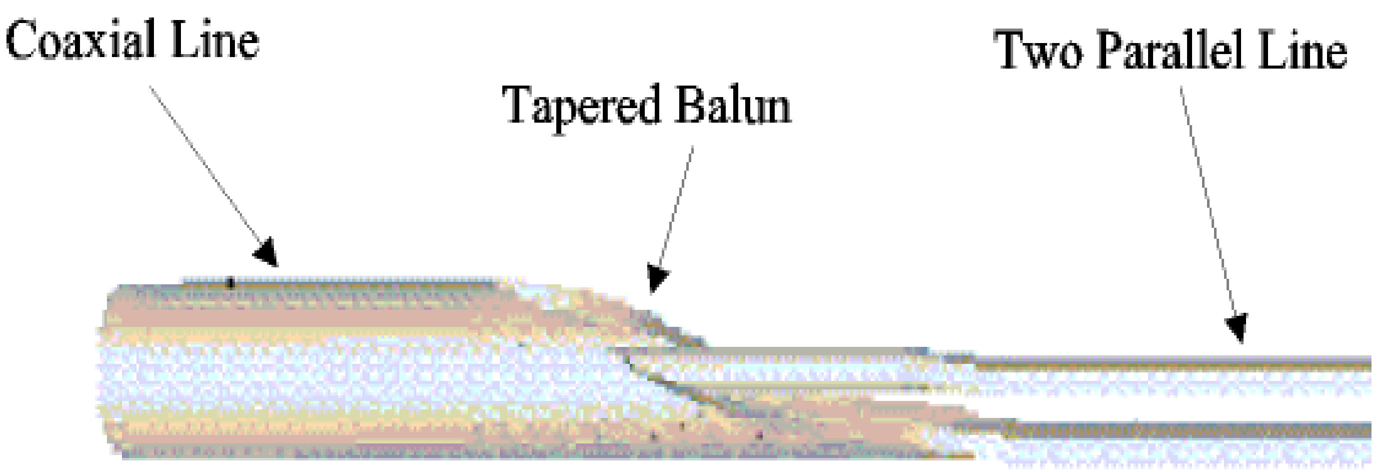
FDTD simulation



Tapered Wide-band Balun



- a transformer from 50 Ω to 75 Ω
- difficult in simulation

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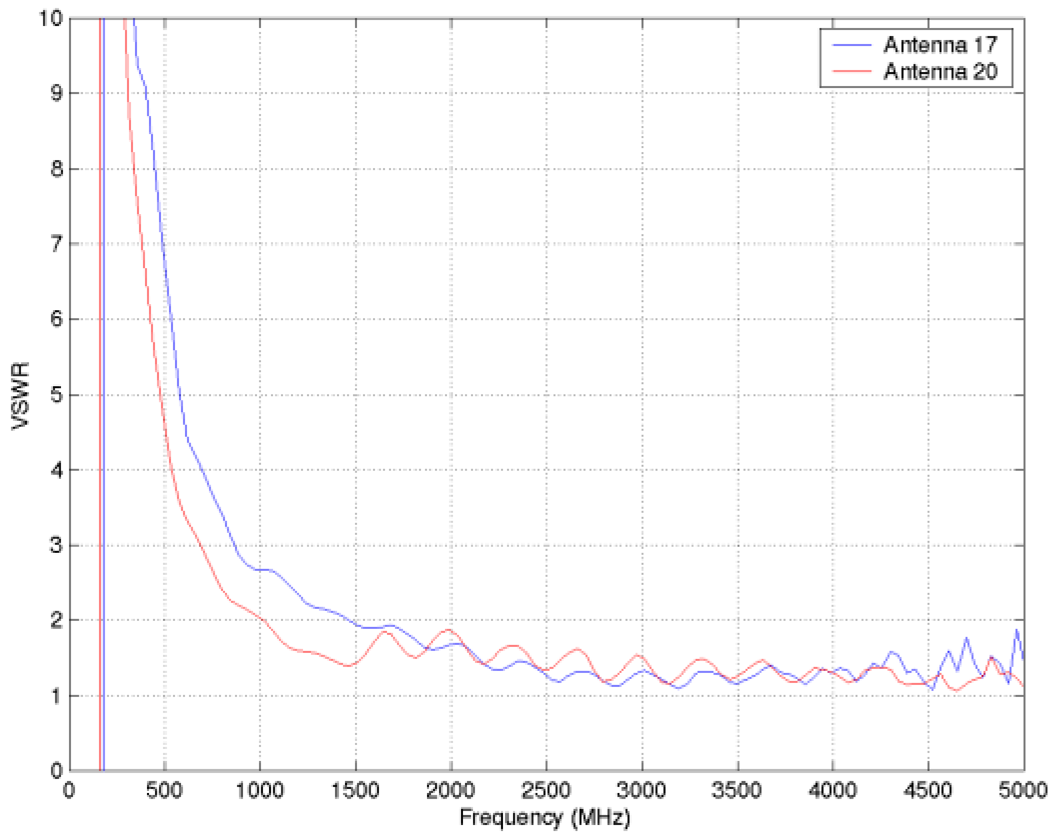
VSWR vs. Freq



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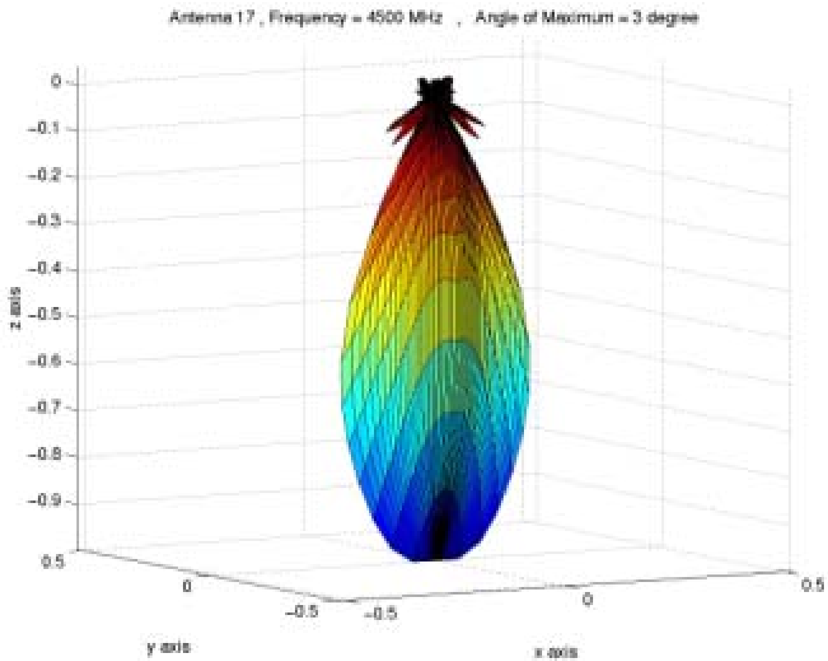
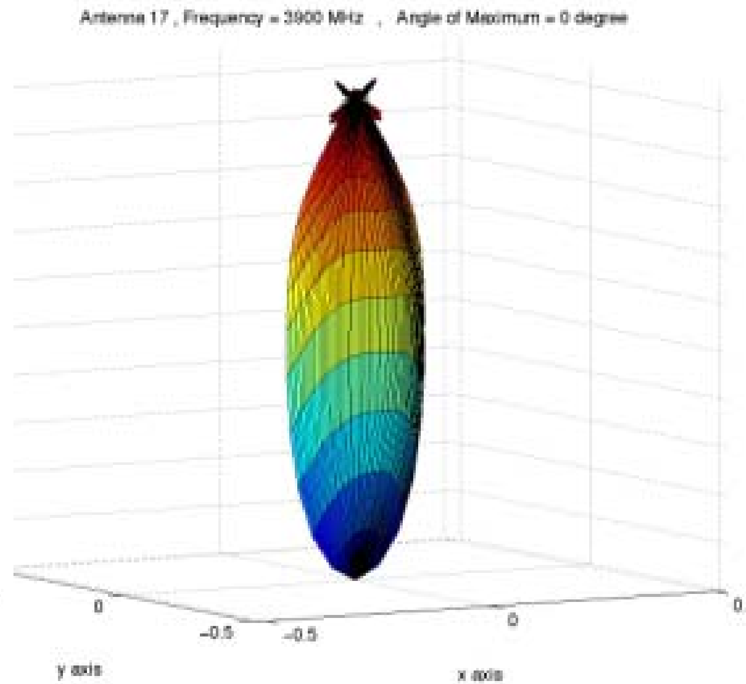
Radiation patterns

Freq. low



Freq. high



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Antenna is made and measured

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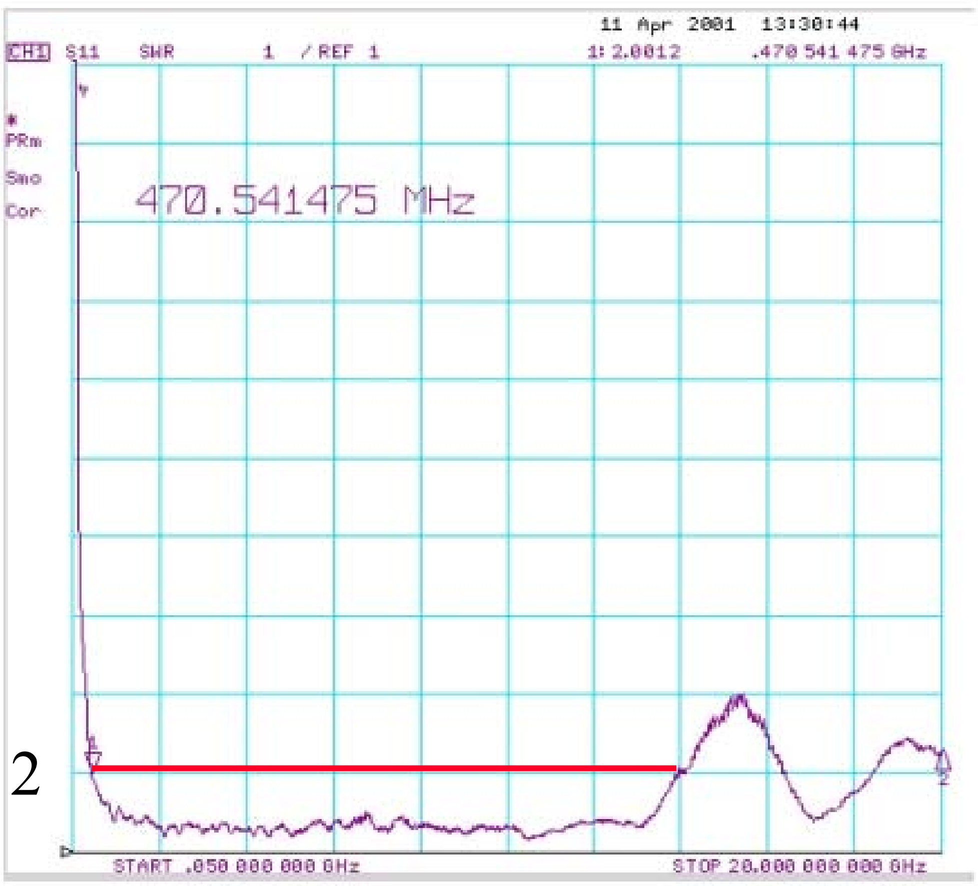
VSWR vs Frequency



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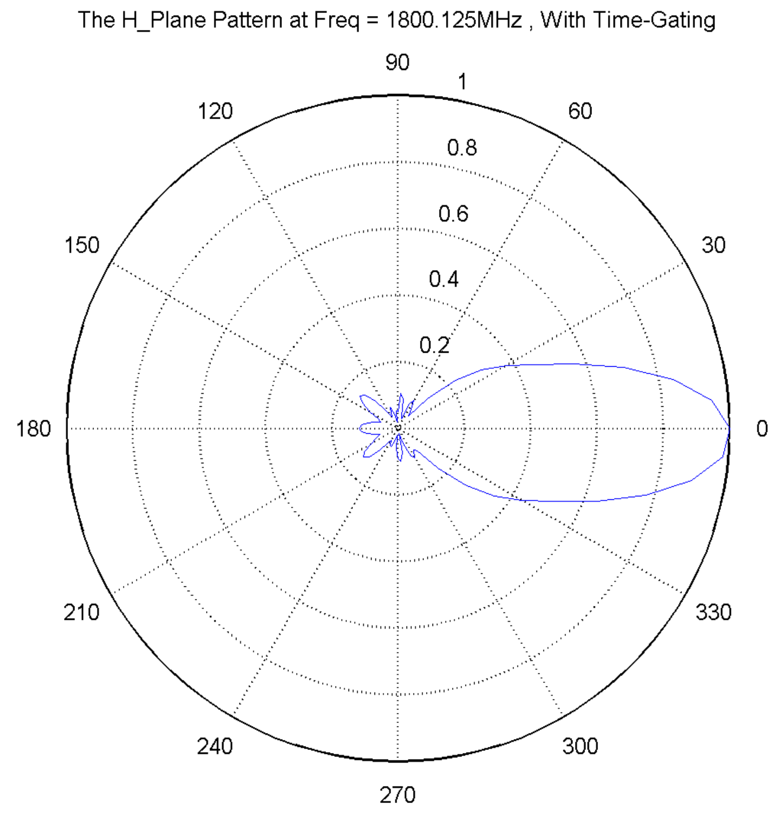
A typical measured radiation pattern



Discussion and Conclusions

- The design process
  - What is the optimal design?
- The dielectric
  - trade-off: size, bandwidth, and weight
- Radiation pattern
  - Low directivity at low frequency
  - How to improve this?
- VSWR
  - High at low frequencies
- An ultra wideband TEM antenna is developed

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