Slot Antenna Design for Ultra Wide Band Radar Application

EE609 Radiating System Term work Presentation

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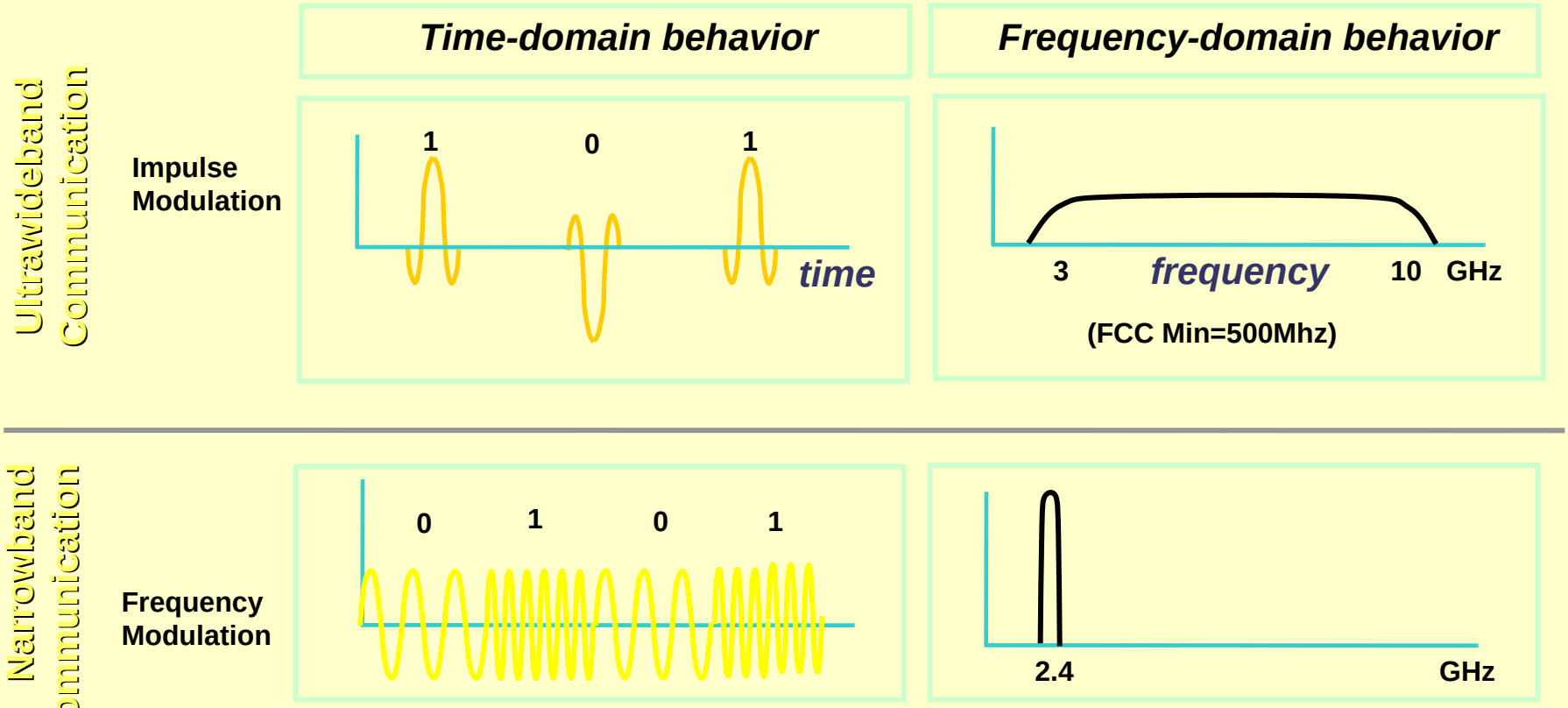
Outline of Presentation

1. Introduction of UWB Radar
2. Special Features of UWB Radar
3. Intricacies Involved in UWB Design
4. Application of UWB Radar
5. Types of Antennas for UWB Radar
6. UWB Antenna Design
7. Conclusion

What is Ultra Wideband?

Radio technology that modulates impulse based waveforms instead of continuous carrier waves



Introduction (Contd..)

- The Frequency Range of Ultra Wide Band
  - $0.25 < \eta < 1$
  - $\eta = (f_{upper} - f_{lower}) / (f_{upper} + f_{lower})$
- Rise in Information Capability
- Reduction in Range Pulse Volume

Special Features of UWB Radar

1. Higher Range Measurement Accuracy and range Resolution
2. Recognition of Target's class, Type & Radar Image
3. Higher Radar Immunity to Interference
4. Increase in Target Detection Probability

Special Features of UWB Radar (Contd..)

5. Reduction in Radar ‘Dead Zone’
6. Increase in Radar operation security
7. Improved Immunity to external Radiation
8. Improved Stability for Target at Low elevation Angle

Intricacies In UWB Radar Design

- Change of Radar Signal Shape during Target Observation
- Dependence of Signal Shape on Antenna Parameter
- Change in Radar Range Equation

$$R(s, t) = \left(\frac{EG(\theta,\phi,S,t)\sigma_{UWB}(t)A(\theta,\phi,S,t)}{(4\pi)^{2}\rho q N_0} \right)^{1/4}$$

- Time Variation of RCS

Application of UWB Radars

- UWB Radar for Study of Air/Sea Interaction
- Through the Wall UWB Radar Life Detection and Monitoring
- Ultra Wideband Radar for Vehicle Detection in Rail Road Crossing
- Detection of Objects in Dense medium i.e.
  - Ground, Ice etc.

Application of UWB Radars (cont.)

- UWB System Frequency Spectrum Sharing and Interference
- Target Imaging and Discrimination
- Target Signal Interaction and Feature Extraction

Types of Antennas for UWB Radar Application

- Wide Slot Antenna for UWB Application
- Circular & Elliptical Microstrip Fed Antenna
- Annual Ring Antenna
- Coupled Planar Dipole UWB Antenna
- Planer Mono pole Antenna on Printed Circuit board

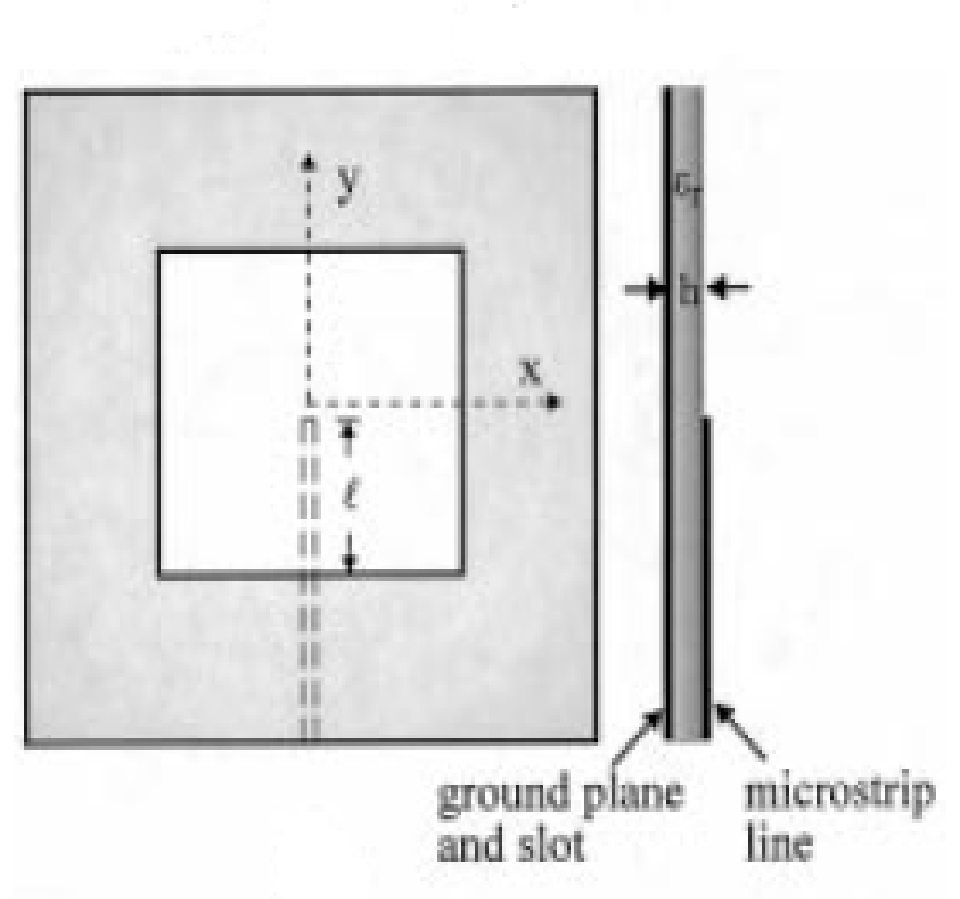
Bandwidth Enhancement in Slot Antenna

- Microstrip – line –fed Printed wide slot antenna with Simple Tuning Stub
- Microstrip – line –fed Printed wide slot antenna with Fork – like tuning stub
- Strip line slot antenna with Fork like Tuning stub

Microstrip Printed wide slot antenna with simple Tuning Stub

- Wide slot dimensions:
  L X W
- Feed Line 50 ohms
- Centre Frequency:
  1670 MHz
- Bandwidth:

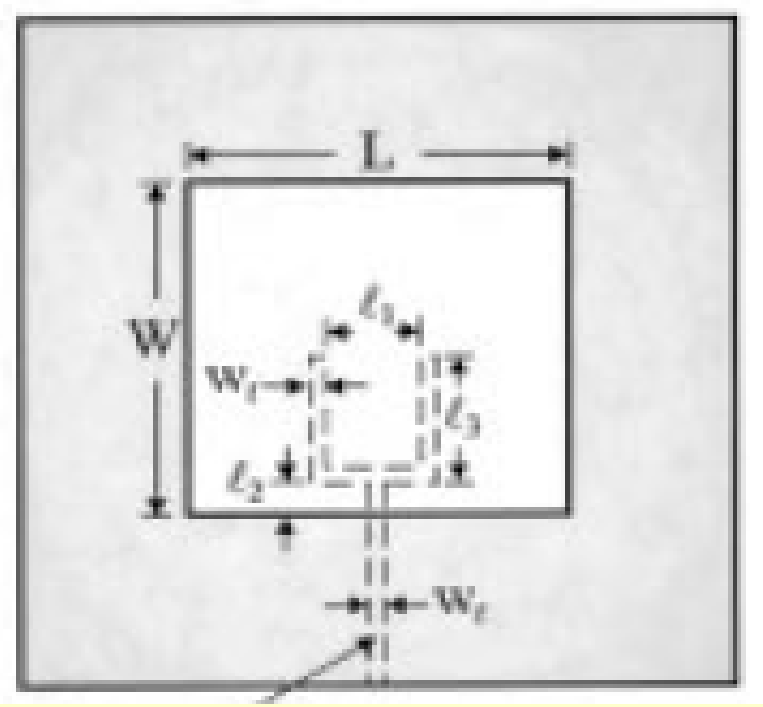
  110 MHz ≤ 6.5 %



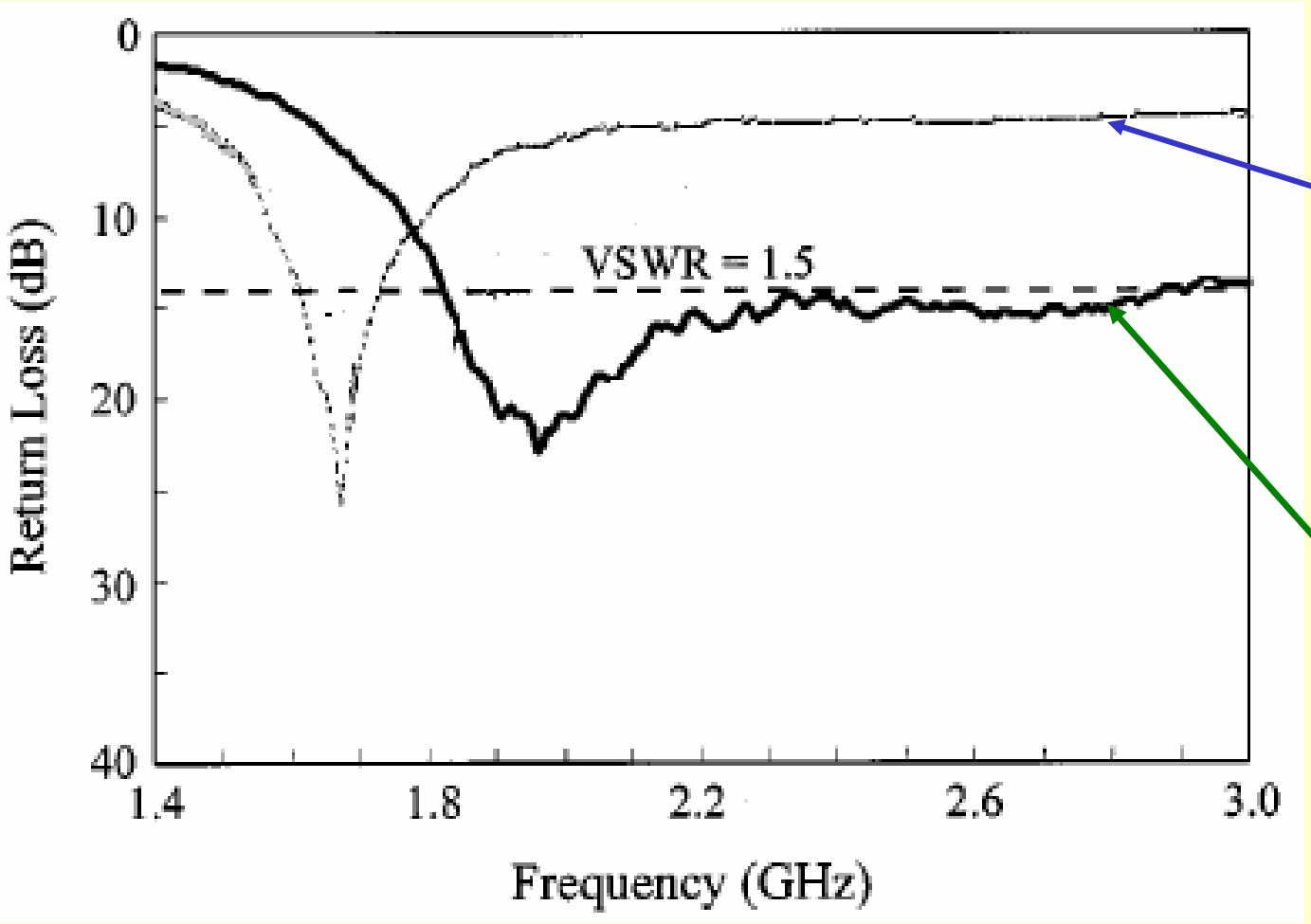
Microstrip Printed wide slot antenna with Fork – like tuning stub

- Wide slot dimensions:

  L X W = 53.7 x 53.7 mm
- Tuning Stub: Fork-like
- Centre Frequency: 2.3 GHz
- Bandwidth: 1.09 GHz ≤ 47 %



VSWR Bandwidth

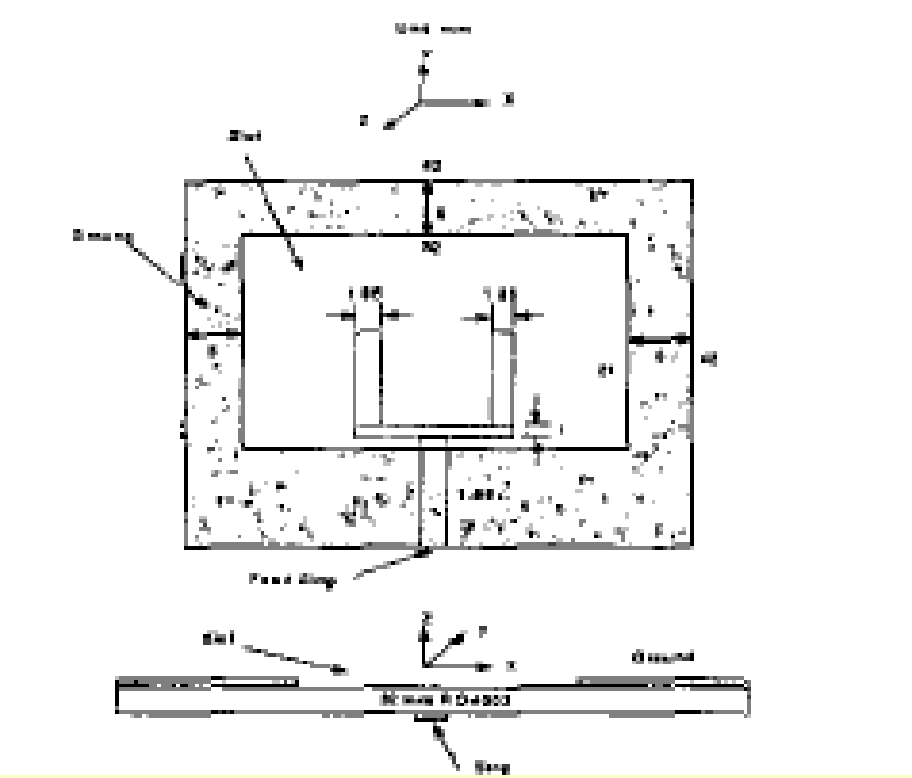


Simple tuning Stub

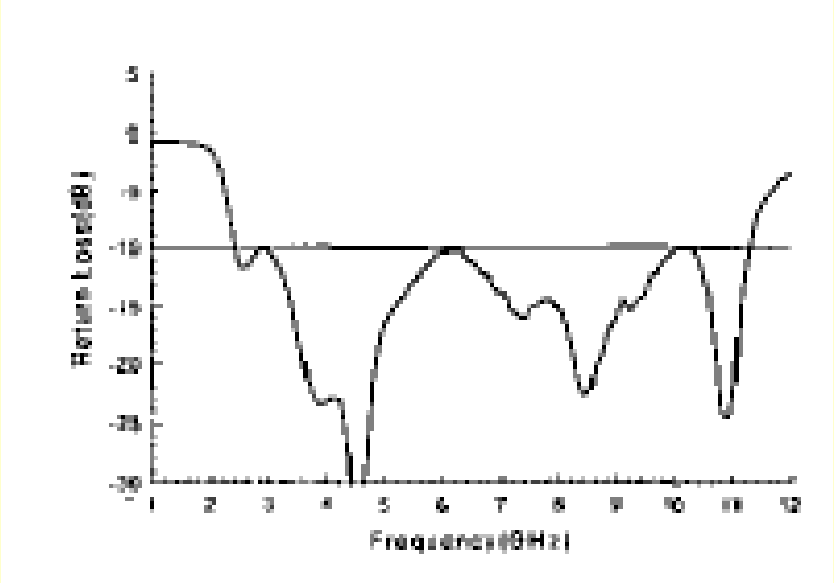
Fork-like tuning Stub

Optimization of slot antenna with Fork-like Tuning Stub

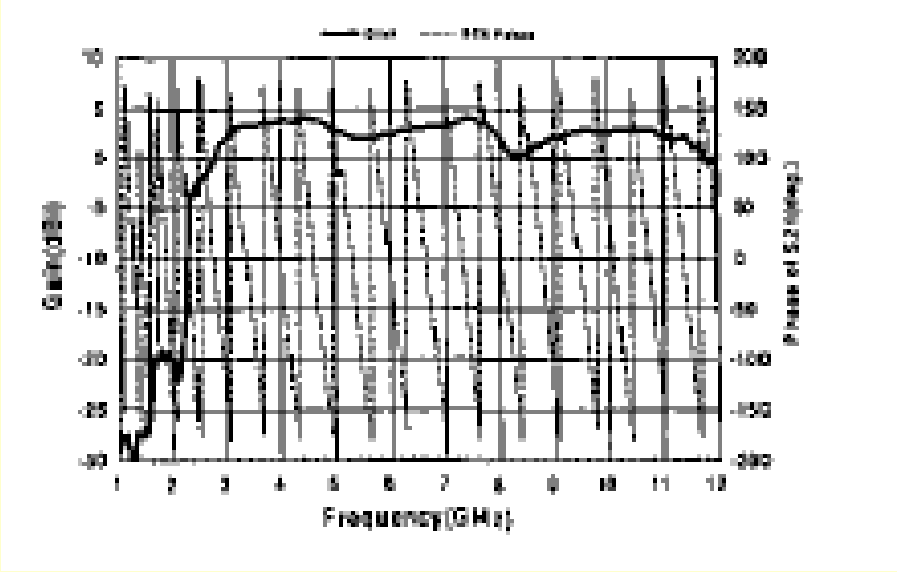
- The Frequency band achieved = 2.5 GHz to 11.3 GHz
- Gain variation < 4 dB



Wide Slot Antenna - Results

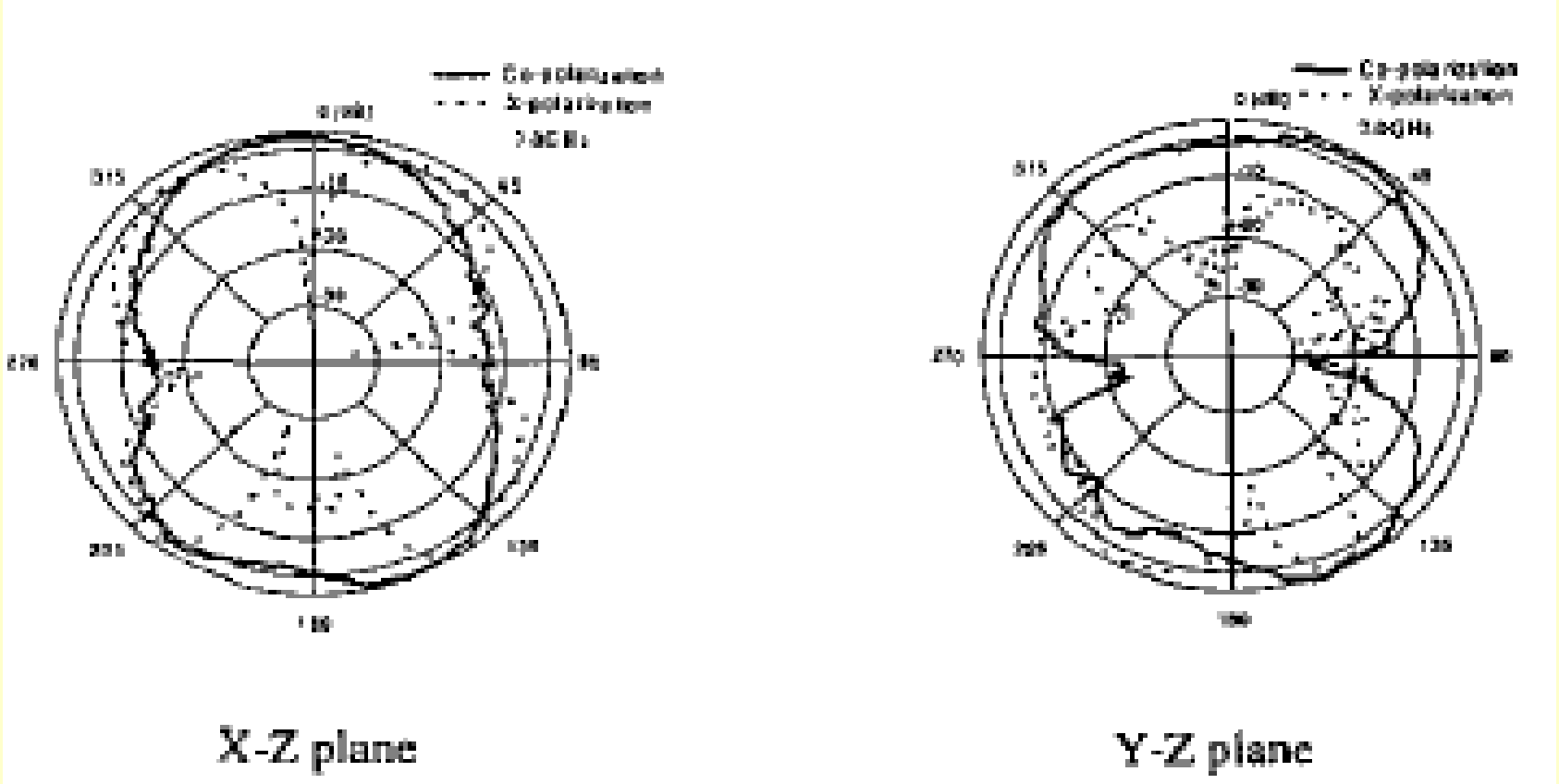


Measured Return Loss



Measured Gain & Phase response

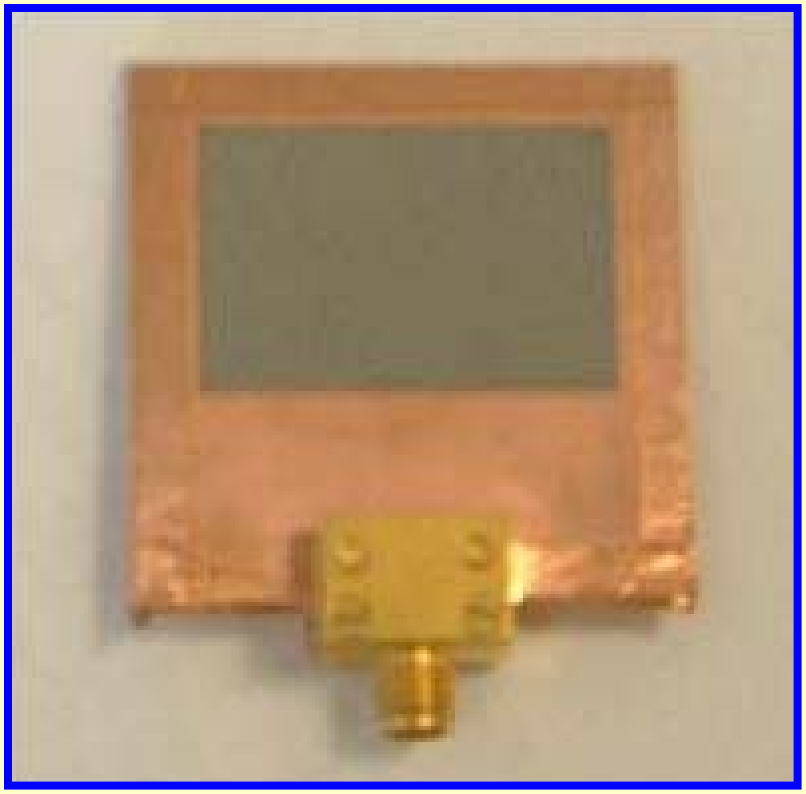
Wide slot Antenna – Radiation Pattern



X-Z plane

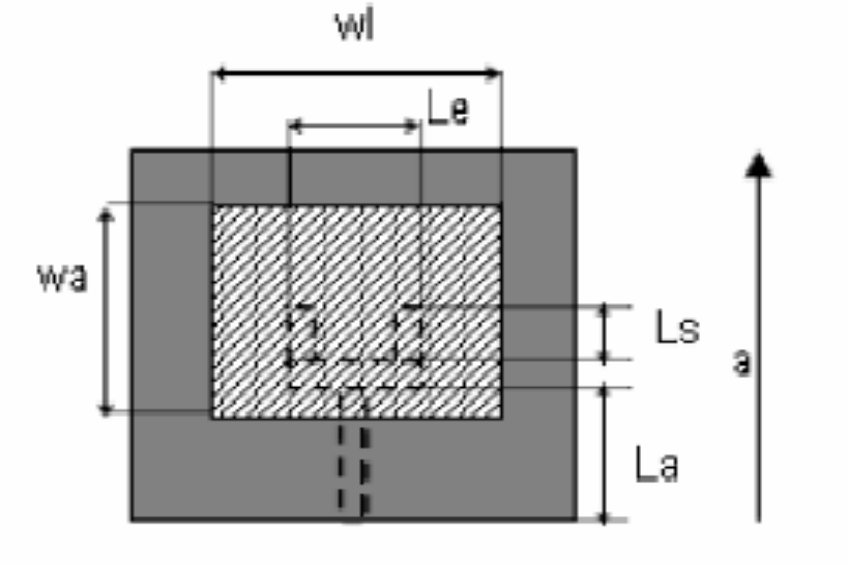
Y-Z plane

Stripline Slot Antenna for UWB Application



Stripline Slot Antenna with Stripline launcher

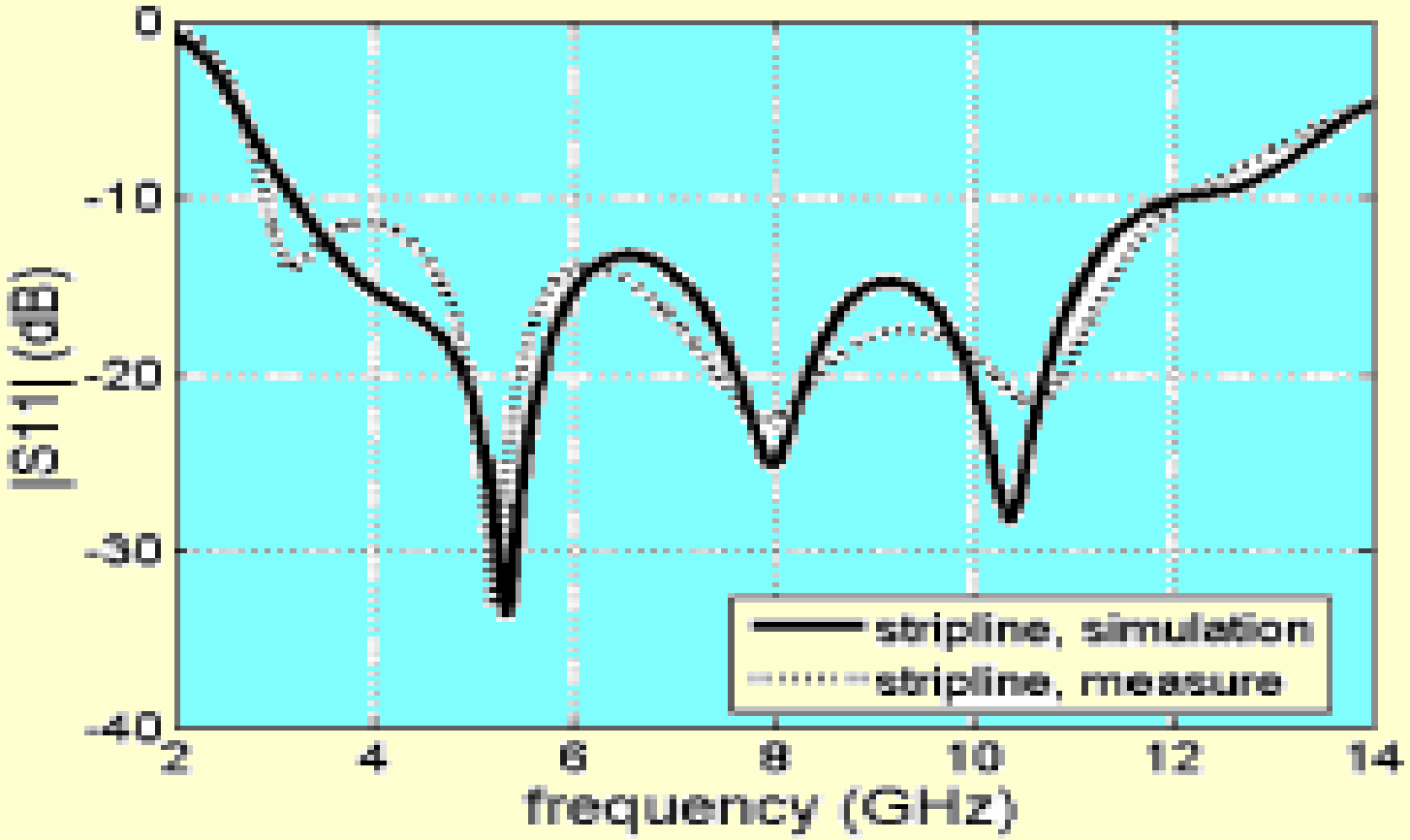
Stripline Wide Slot Antenna



Antenna Geometry

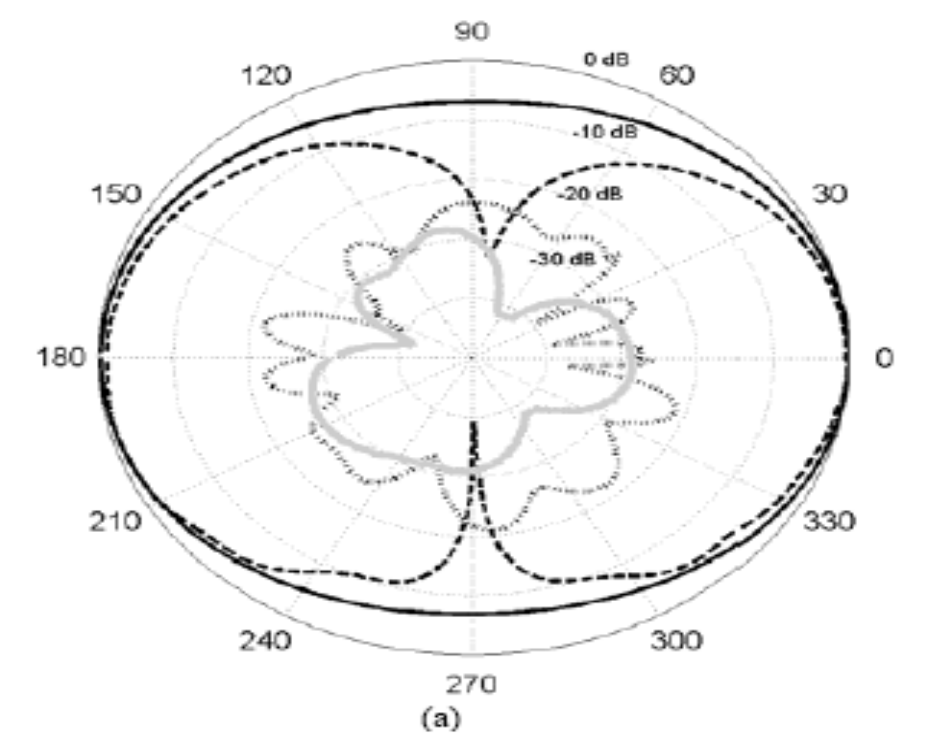
a = 42 mm
Wl= 32 mm
Wa = 21 mm
La = 16.57 mm
Le = 8.26 mm
Ls = 8.8 mm

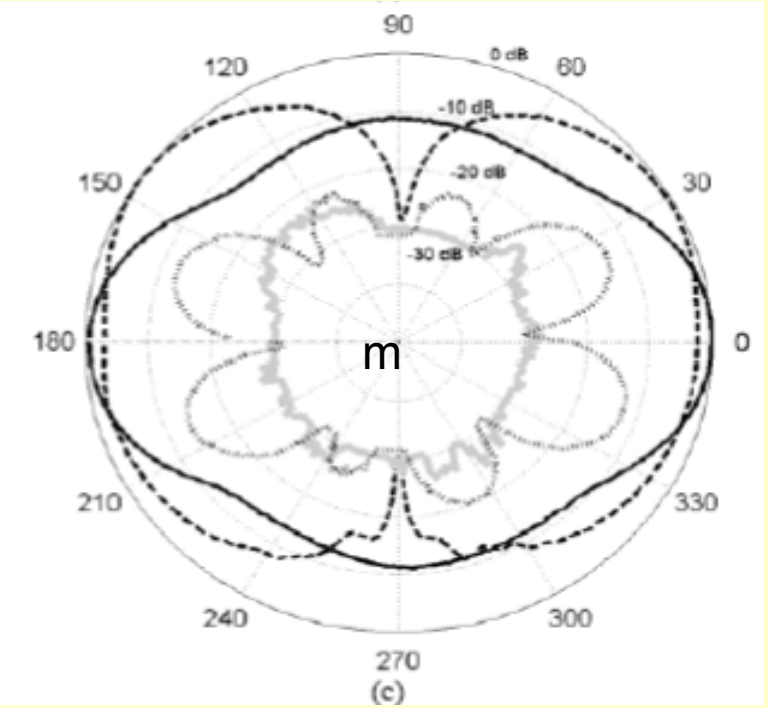
VSWR Bandwidth



Simulated & measured return loss versus frequency

Measured Radiation Patterns for Stripline Slot antenna





F = 3 GHz

F = 11 GHz

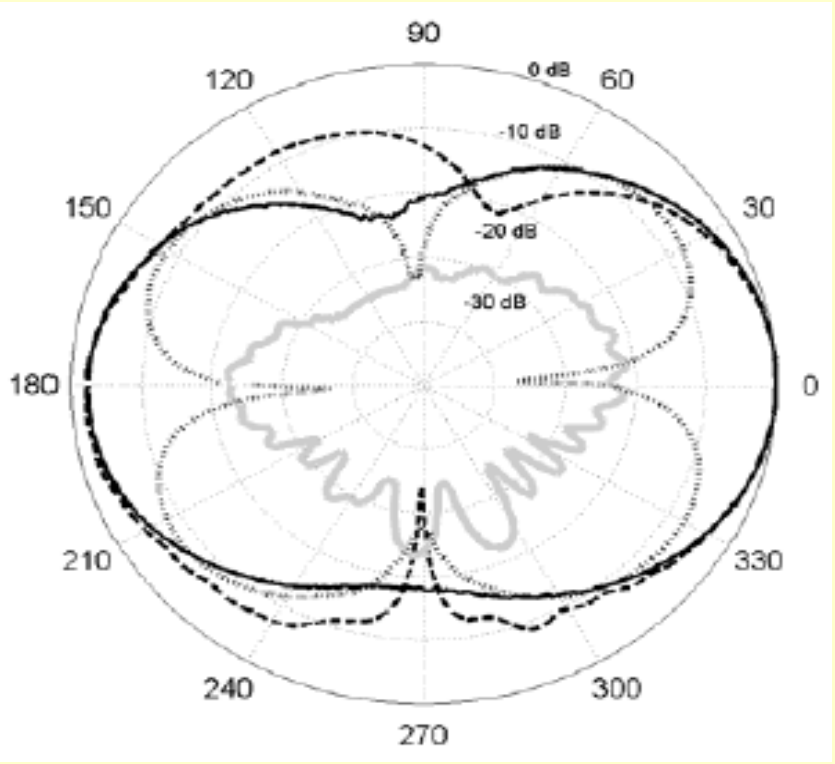
E plane co

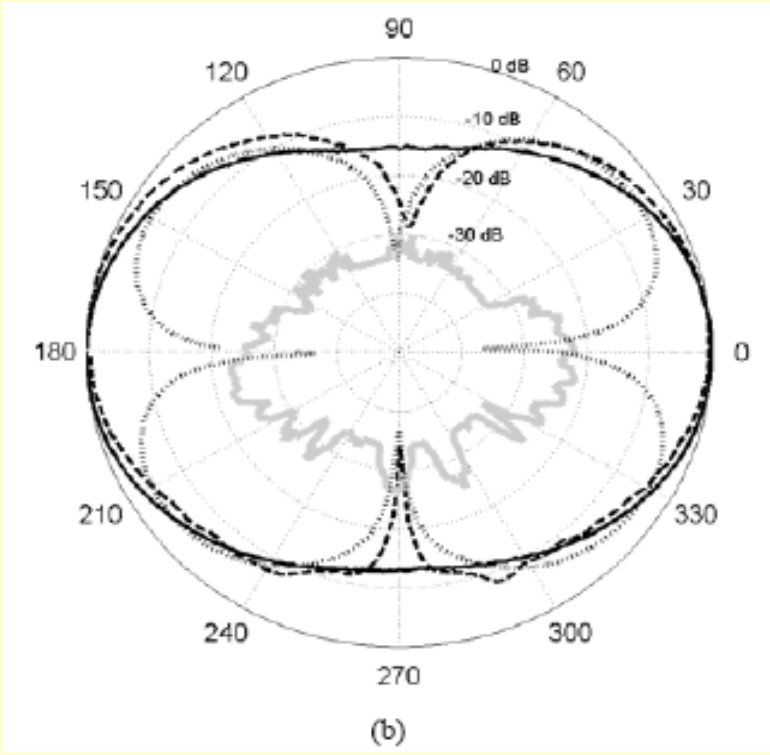
Eplane cc

Hplane co

Hplane cc

Comparison of Wide slot antenna with Stripline Slot antenna





F = 7 GHz with Wide slot antenna

E plane co

Eplane cc

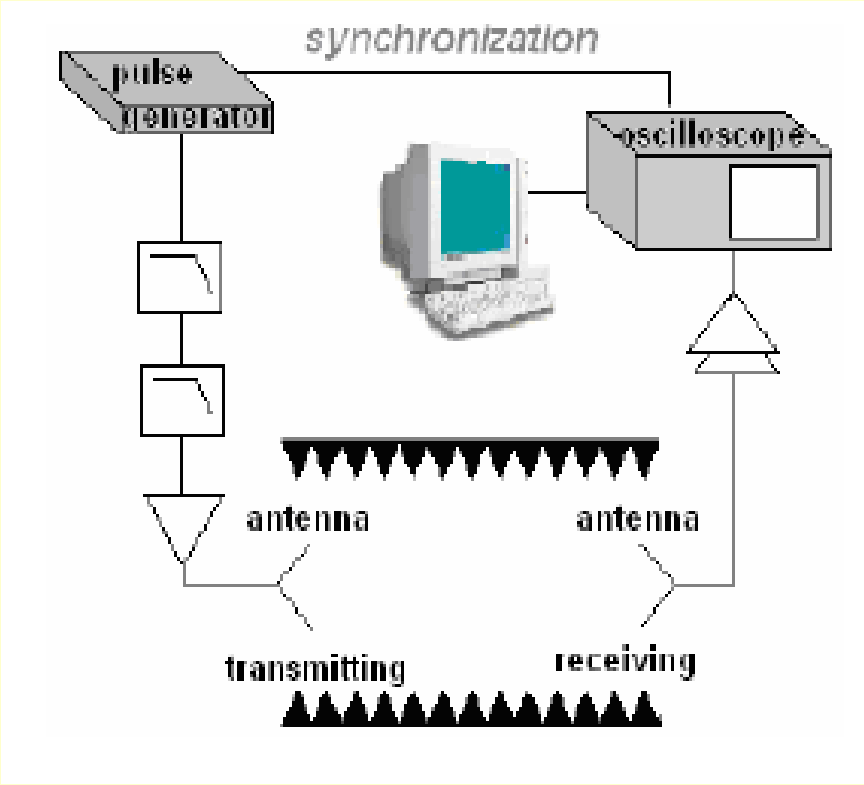
Hplane co

Hplane cc

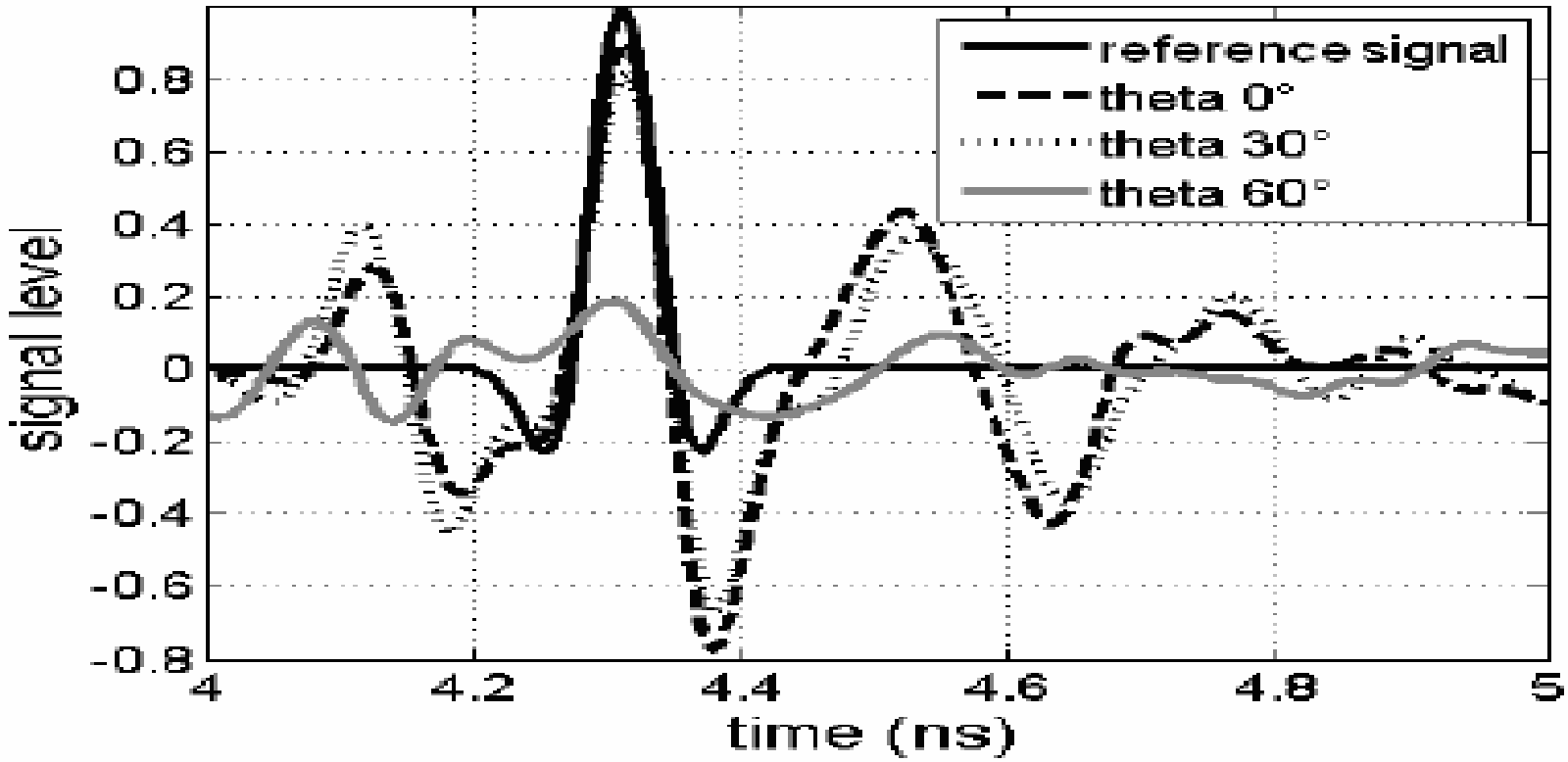
F = 7 GHz with Stripline antenna

Measurement setup

- Time domain measurement done in anechoic chamber
- Distance between the transmit and receive antenna : 1.09 m
- Digital storage Oscilloscope : 5 psec Sampling rate with 20 GHz Bandwidth
- Reference pulse: 0.4 nsec



Time Domain Response



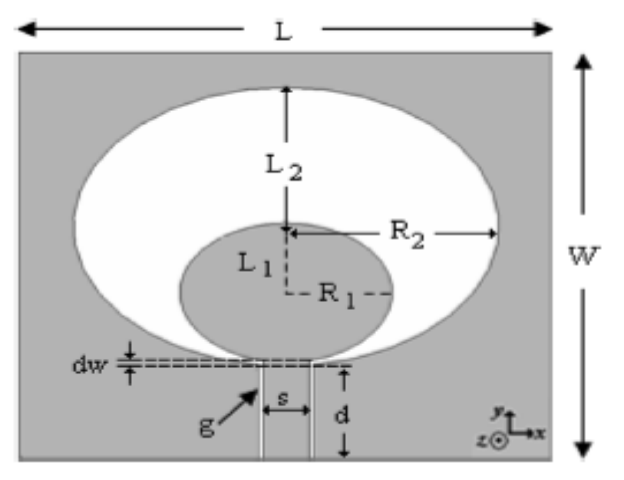
Reference & measured received pulse after a UWB link made with two Stripline slot antennas

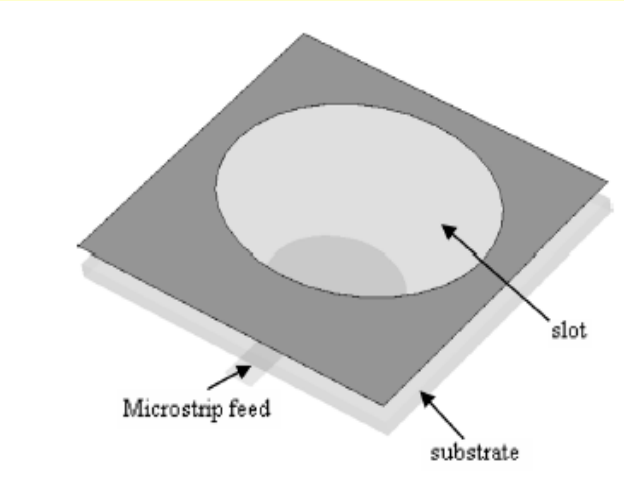
Advantages of Stripline Slot Antenna

- Wider Bandwidth
- Better Radiation pattern
- Bidirectionality
- More stable time domain characteristics

Circular & Elliptical slot Antenna

- Tuning element is circular
- Bandwidth upto 142 % can be achieved
- VSWR bandwidth upto 20 GHz
- Shape of the feed is similar to the slot





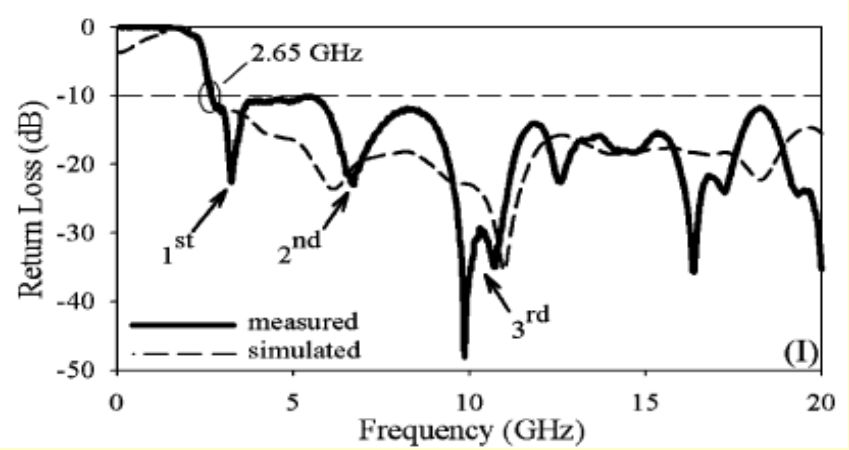
Circular & Elliptical Slot antenna (contd..)

in (mm)	L	W	L_1	R_1	L_2	R_2	d	dw	Type
Prototype I	*40*	*35*	*6*	*8*	*12*	*16*	*8*	*0.3*	**CPW Elliptical**
Prototype II	*40*	*40*	*7.5*	*7.5*	*15*	*15*	*8*	*0.3*	**CPW Circular**
Prototype III	*90*	*90*	*20*	*20*	*35*	*35*	*12*	*0.3*	**CPW Circular**
Prototype IV	*40*	*35*	*6*	*8*	*12*	*16*	*8*	*0.3*	**Microstrip Elliptical**

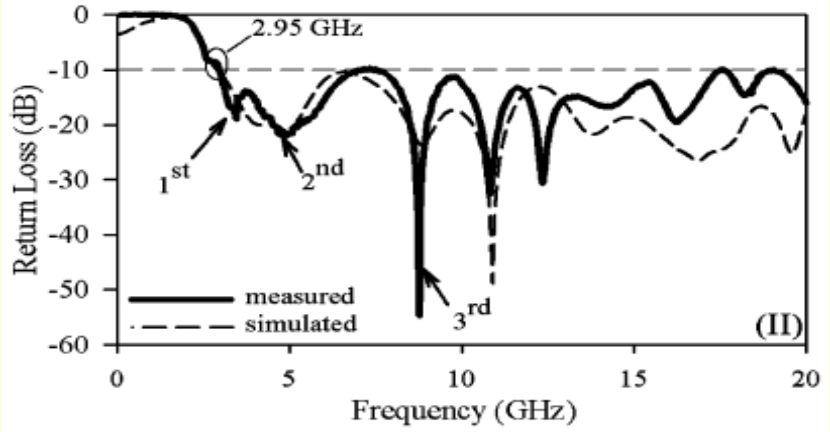
Dimensions of the four antenna prototypes $\varepsilon_r = 3$, h= 1.575 mm

Substrate : TLC-30

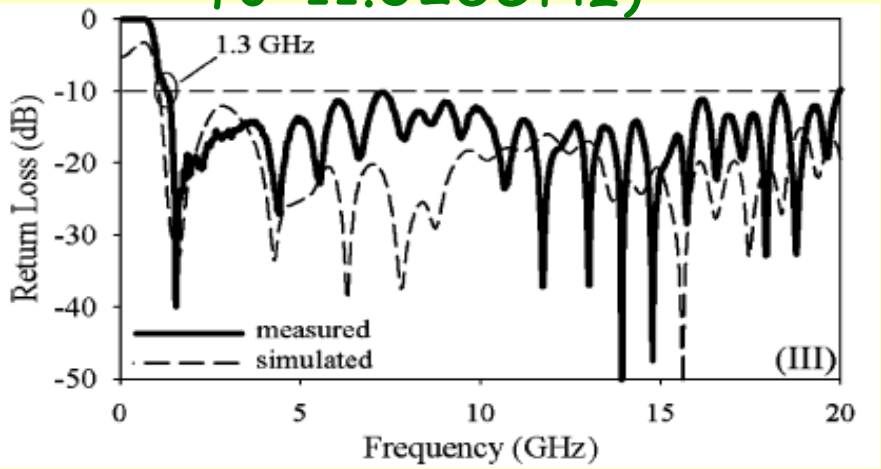
Circular & Elliptical Slot antenna : Results



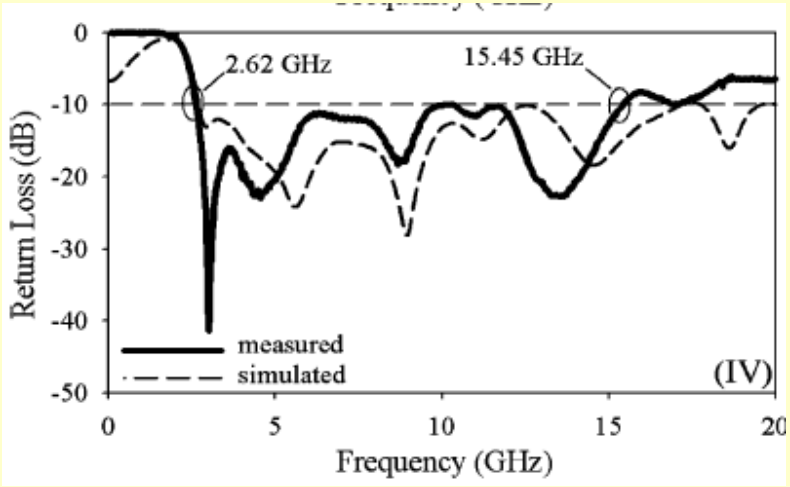
Prototype I (153 % , fo=11.325GHz)



Prototype II, 148 %

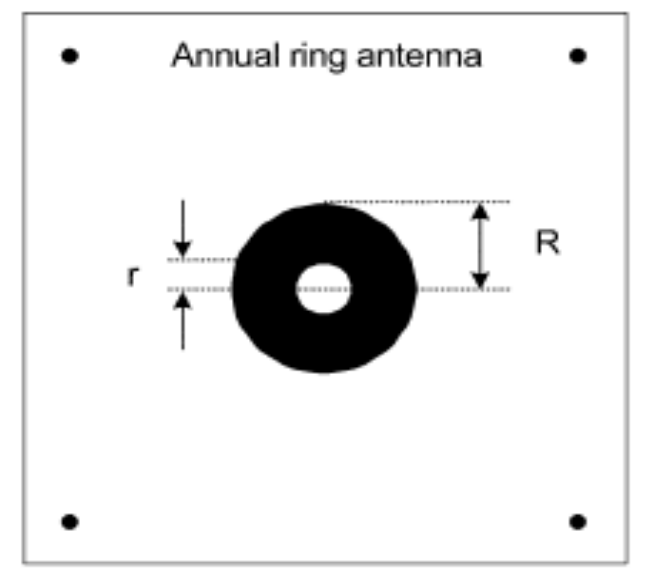


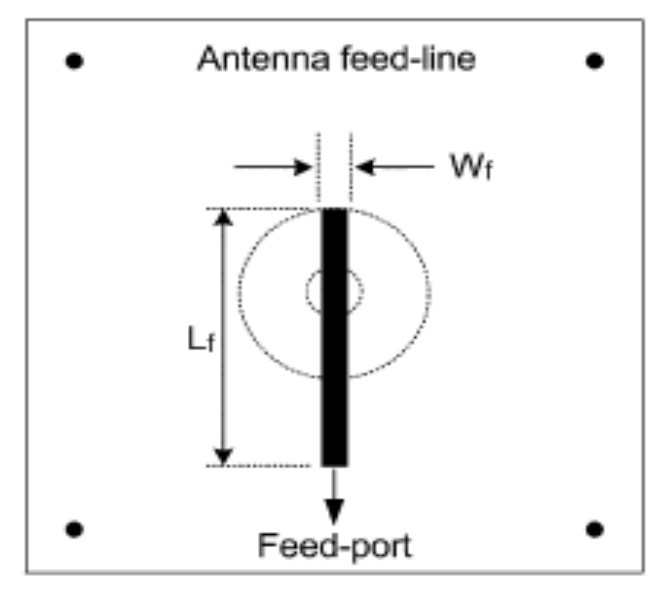
Prototype III, 175 %,



Prototype IV, 142 %,fo= 9.035 GHz

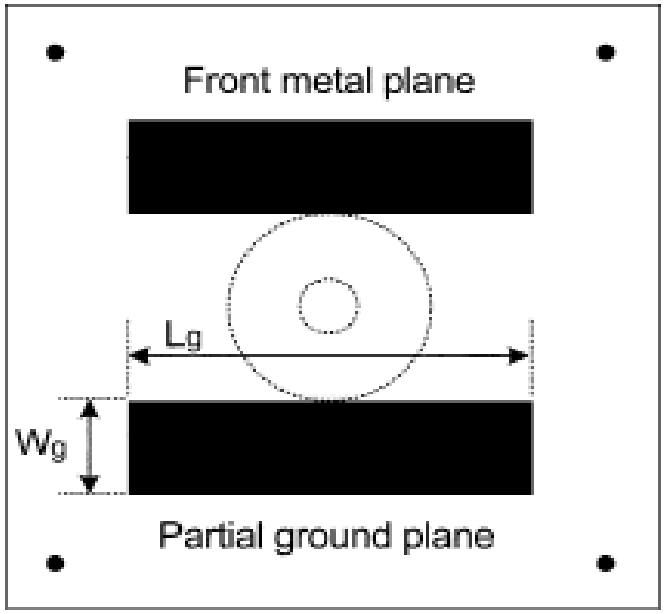
Annual Ring Antenna

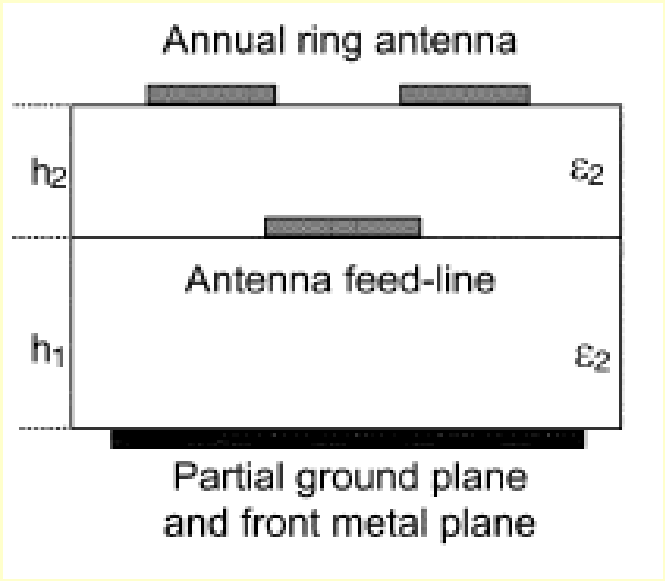




- Return Loss better than 10 dB from 2.8 to 12.3 GHz
- Average gain of 2.93 dBi
- Maximum gain of 5dBi at 7 GHz

Annular Ring antenna (Contd..)





- **Metal Plate behaves as a parasitic resonator to increase the bandwidth.**
- **Inner diameter should be reduced to increase the bandwidth**

Dimensions : 44 X44 mm^2

Inner diameter : 3.5 mm

Outer diameter : 11 mm

Feed line length : 33 mm

Substrate: RT/Duroid 5880

$$\varepsilon_1 = \varepsilon_2 = 2.2$$

Conclusion

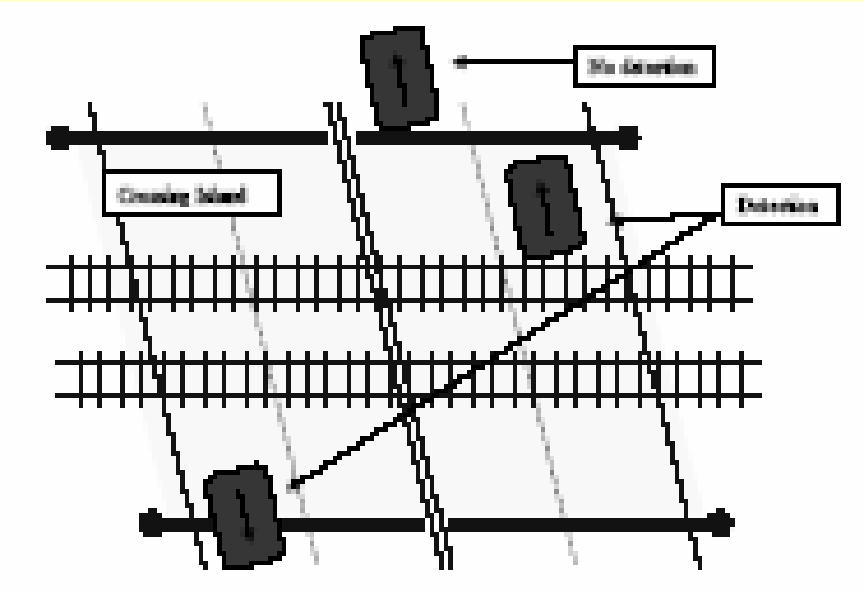
- Difference between Narrowband and Ultra Wideband Radar has been brought out.
  - Design
  - Application
- Technology advancement to enhance the bandwidth of slot antenna for UWB application has been presented.
- Stripline slot gives the better performance

Thank You

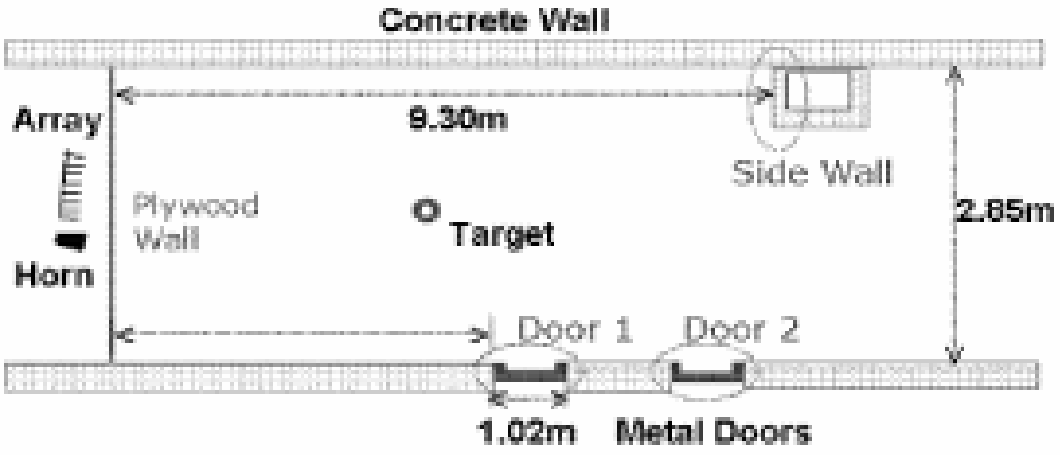
Any Questions ???

Ultra Wideband Radar for Vehicle Detection in Rail Road Crossing

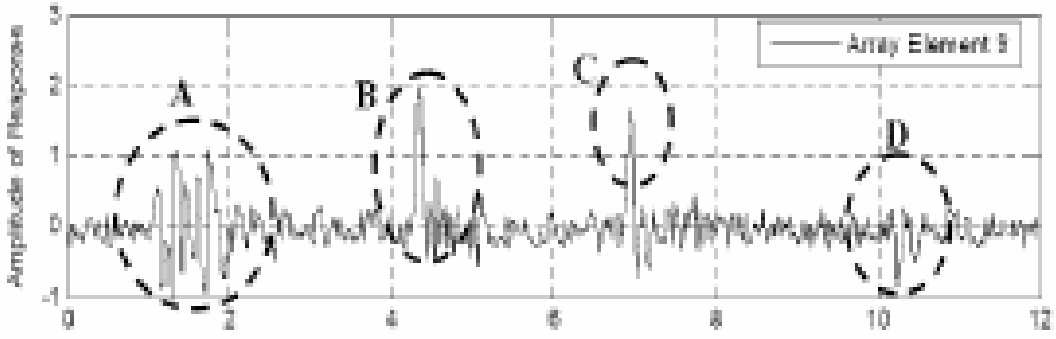
Rail Crossing in Maywood, Illilinois



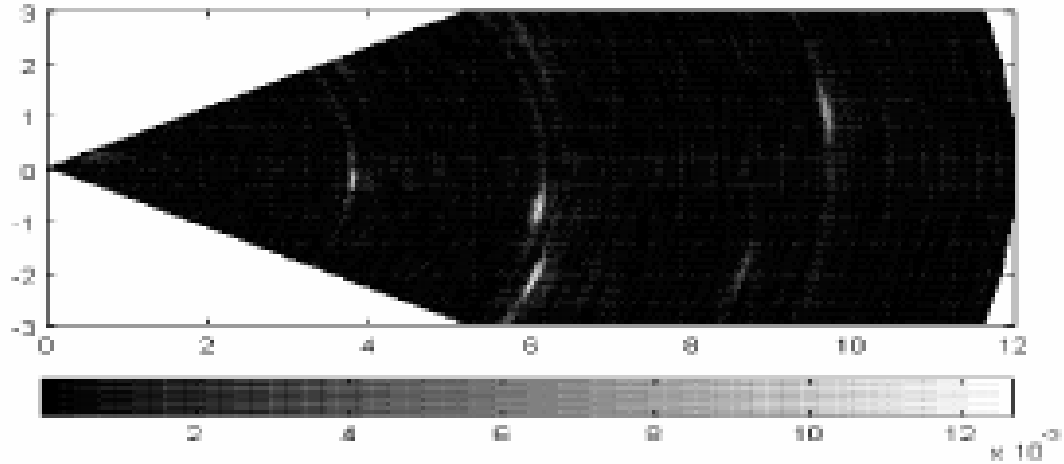
Detection of vehicles in the crossing island



(a)



(b)



(c)

Experimental Scenario

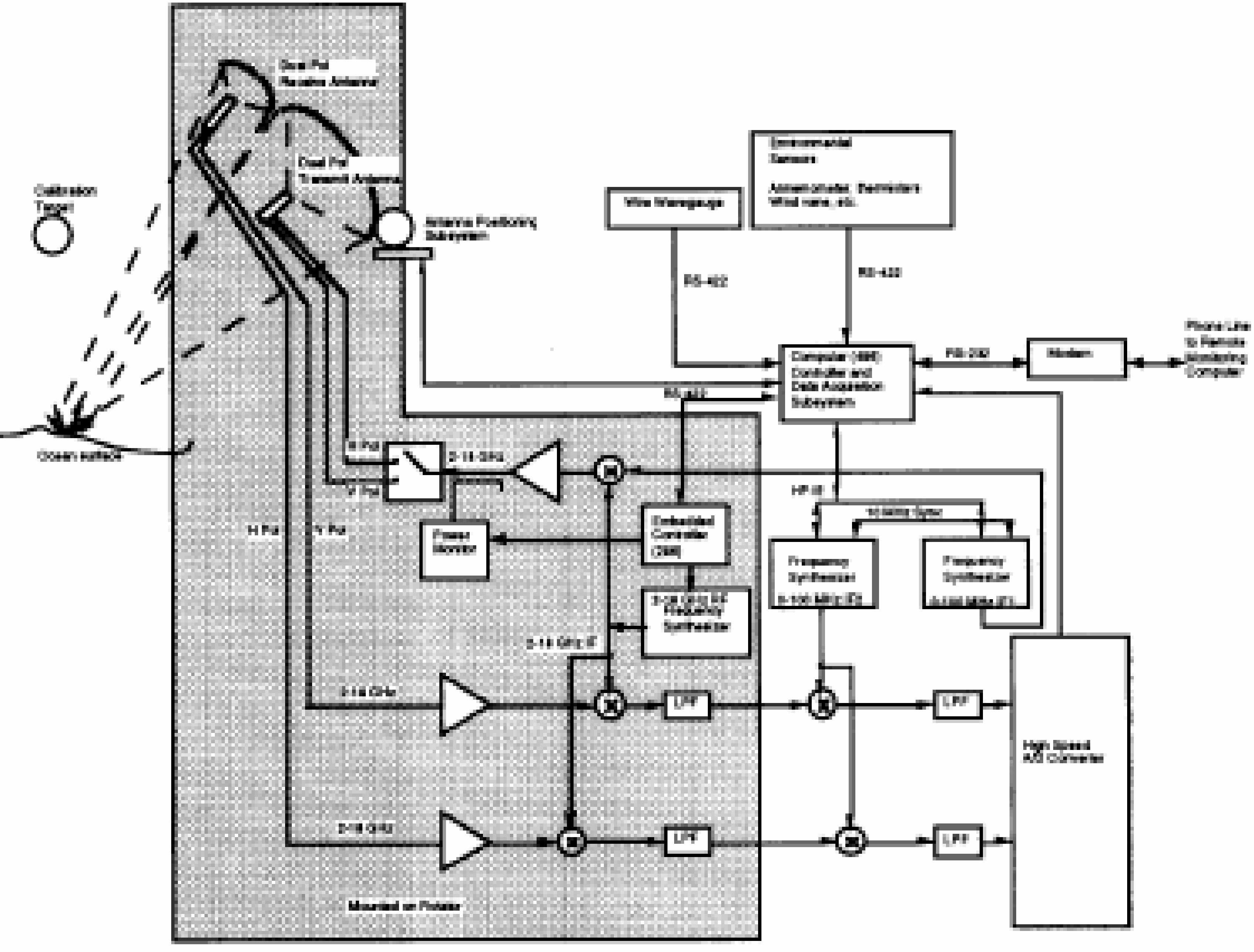
Time response & imaging of UWB radar

A- Coupling of the antenna

B-target

C- Door

D- Sidewall



RF Calibration Loop not shown

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