UWB antennas:

Directional Vs. Omnidirectional

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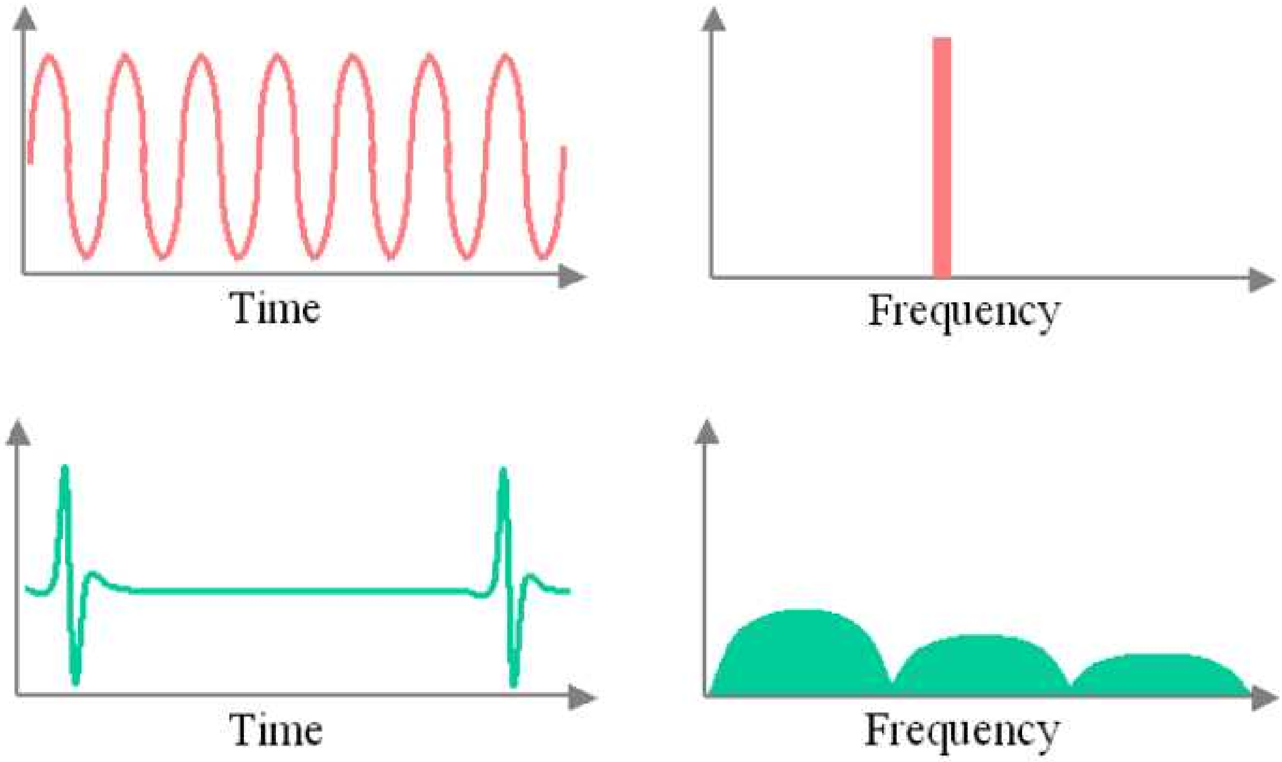
UWB-IR



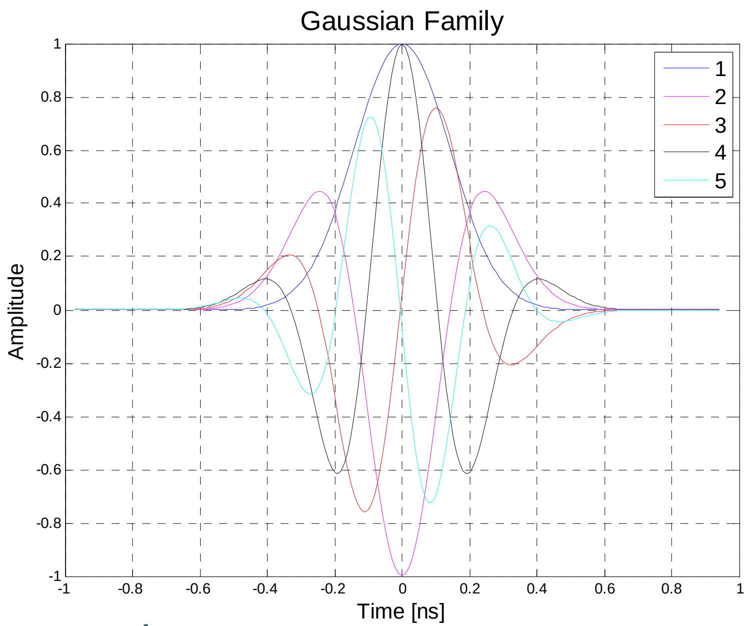
Transmit Signals

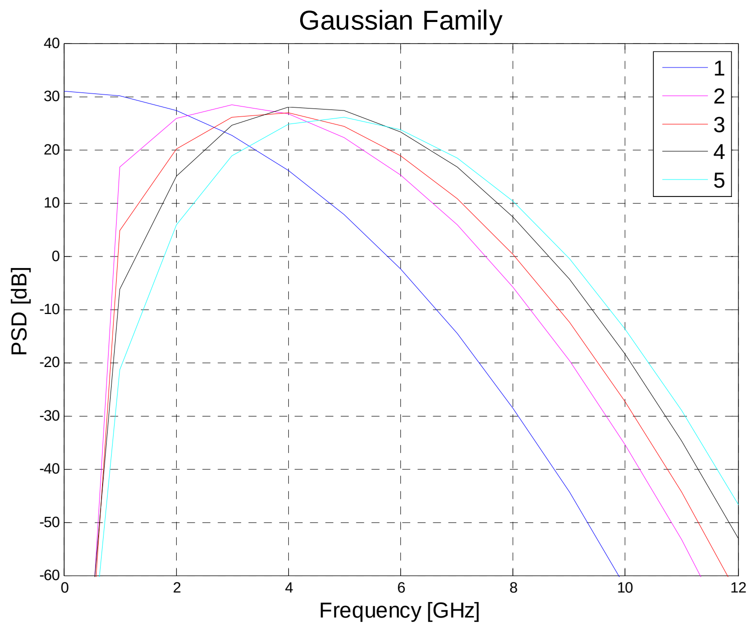
- Pulses with finite-length
- Low transmitting Power
- In the nanoseconds range
- Cover the UWB frequency band
  - Gaussian Pulse
  - Truncated Sine
  - Shifted Sinc

Transmit Signals

- Gaussian Signals

$$T_n(t) = \frac{\tau^n \left(\frac{n}{2}\right)!}{n!} \frac{d^n}{dt^n} e^{-\frac{t^2}{\tau^2}}$$

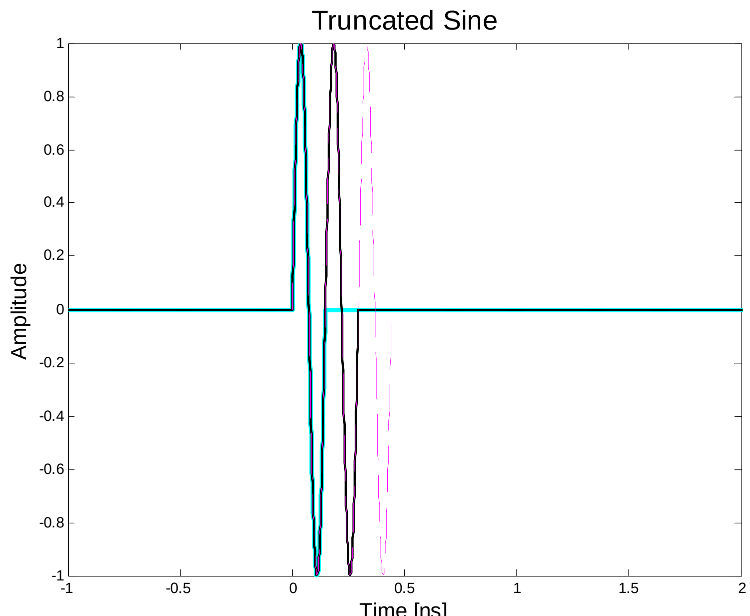


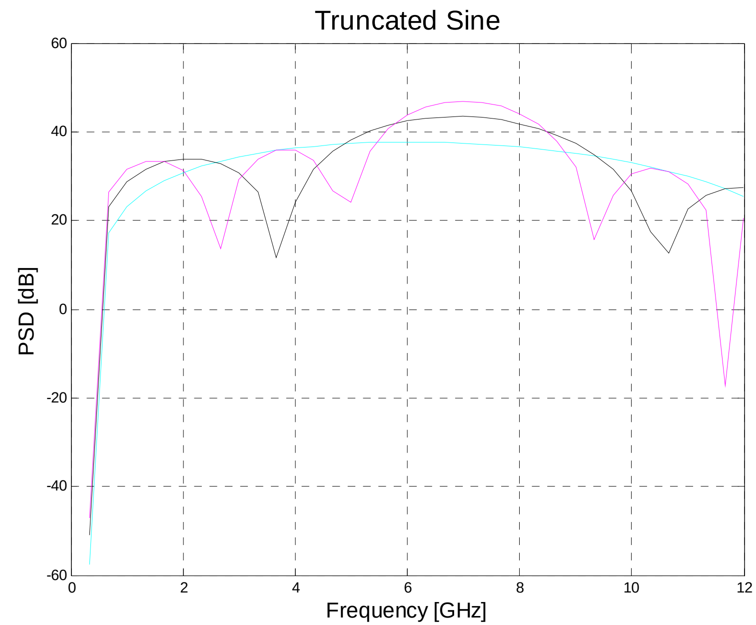


Transmit Signals

- Truncated Sine Signal

$$T(t)=\begin{cases}\sin 2\pi f_C t & 0<t<nT\\ 0 & else\end{cases}$$

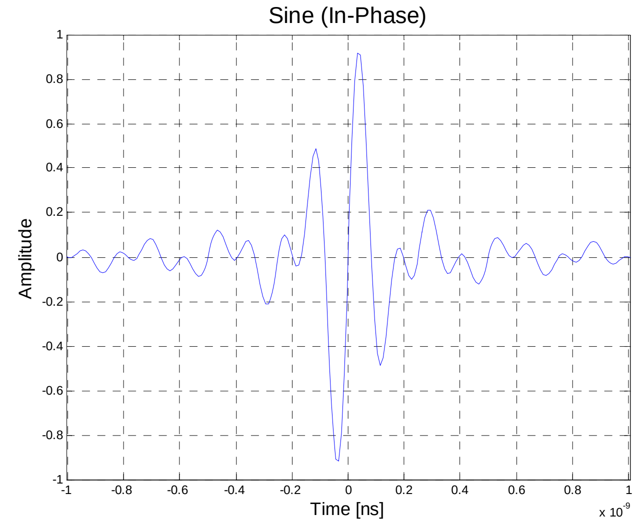


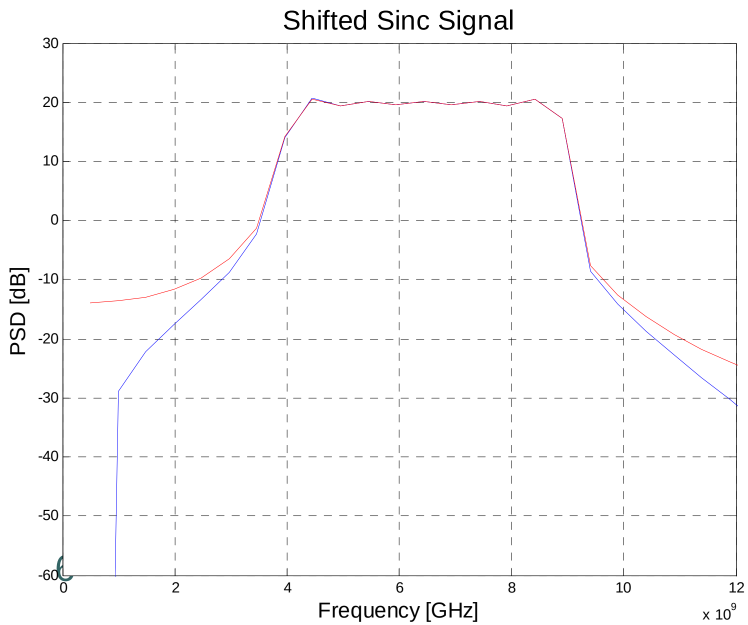


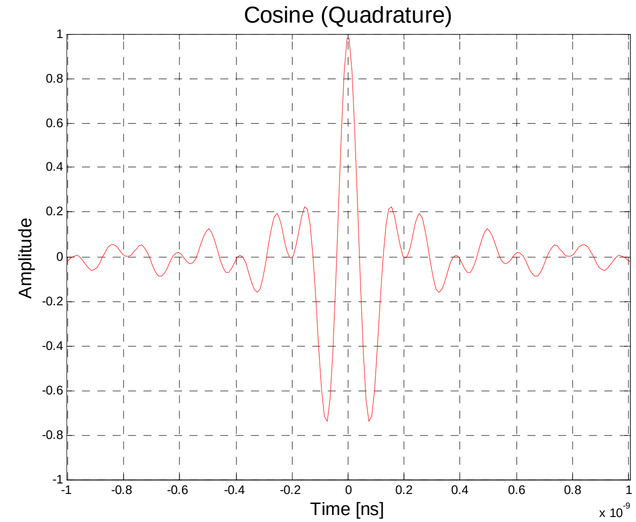
Transmit Signals

- Shifted Sinc Signal

$$T(t) = \frac{\sin(2BWt)}{2BWt}\begin{pmatrix}\sin 2\pi f_C t \\ \cos 2\pi f_C t\end{pmatrix}$$







Frequency Vs. Time domain

Frequency Domain	Time Domain
Assumes steady-state process (cycle followed by an identical and infinite cycle)	Transient process (with a definite beginning and a definite end)
Studies narrow Bandwidth	Preferred for studying wide bandwidth
Obscures time-dependent processes (behind Fourier transforms)	Track fields and energy in time, following their course throughout a physical process

Transfer Function

- Relates the output voltage with the input voltage

$$V_r(\omega) = H(\omega)V_t(\omega)e^{-\frac{j\omega r}{c}}$$

- Can be derived from the Friis' Transmission Equation

$$\frac{P_r}{P_t} = e_{cdt}e_{cdr}\left(1-\left|\Gamma_t\right|^2\right)\left(1-\left|\Gamma_r\right|^2\right)\left(\frac{\lambda}{4\pi R}\right)^2 D_t(\theta_t,\phi_t)D_r(\theta_r,\phi_r)\left|\hat{\rho}_t \cdot \hat{\rho}_r\right|^2$$

Transfer Function

- Considering 2 identical antennas

$$\frac{V_r}{V_t} = \sqrt{\frac{Z_{cr}}{Z_{ct}}}\sqrt{e_{cdt}e_{cdr}\left(1-\left|S_{11}\right|^2\right)\left(1-\left|S_{22}\right|^2\right)\left(\frac{\lambda}{4\pi R}\right)^2 E_t(\theta_t,\phi_t)E_r(\theta_r,\phi_r)\left|\hat{\rho}_t g \hat{\rho}_r\right|^2}$$

$Z_{cr} = Z_{ct}$, $E_t = E_r$, $\left|\hat{\rho}_t g \hat{\rho}_r\right|^2 = 1$ (polarization loss factor)

$$\frac{V_r(\omega)}{V_t(\omega)} = e_{cdt}\left(1-\left|S_{11}\right|^2\right)\left(\frac{\lambda}{4\pi R}\right)E_t(\theta_t,\phi_t)$$

Transfer Function

- We define the System transfer function

$$H(\omega) = H_t(\omega) H_{ch}(\omega) H_r(\omega) = \frac{V_r}{V_t} e^{\frac{j\omega r}{c}}$$

- Where H_t, H_r and H_{ch} are the transfer functions of the Transmission antenna, Receiver antenna and Channel, respectively.

Transfer Function

- The transmitting and receiving antennas are related by reciprocity:

$$H_t(\omega) = j\omega H_r(\omega)$$

- Channel Transfer Function of Free Space

$$H_{ch} = \frac{\lambda}{4\pi r} \mathrm{e}^{jkr}$$

where

$$k = \frac{2\pi}{\lambda}$$

The Antennas

- Antennas can be classified into two main categories according to their type of radiation
  - Omni-directional: better suited for mobile systems
  - Directional: may be required for systems transmitting in a specific direction

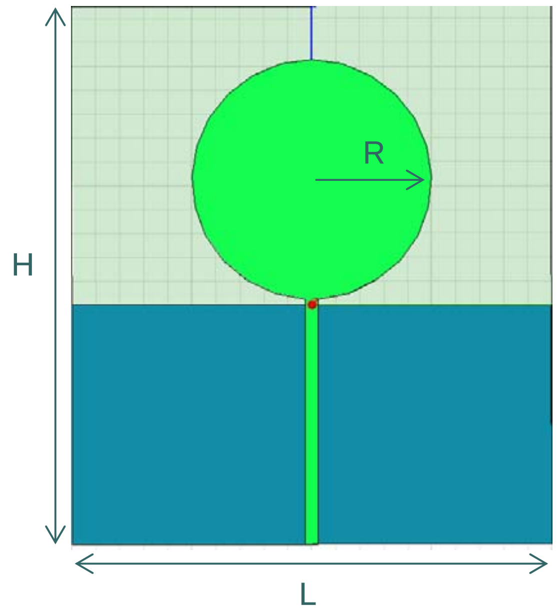
The Antennas

- Two different UWB antennas were simulated in Ansoft HFSS
  - Printed circuit
  - Return loss below than -10dB
- Their impulse responses were obtained
- Antennas:
  - Circular Monopole – Omni-directional
  - Vivaldi Antenna – Directional

Results

Circular Monopole

- Characteristics:
  - Omni-directional Radiation Pattern
  - 3 dB Gain



R = 10mm

H = 45mm

L = 40mm

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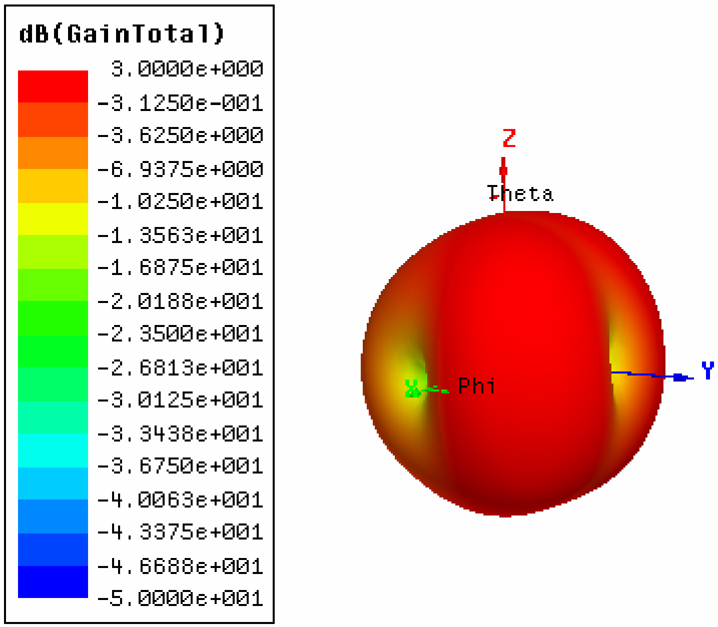
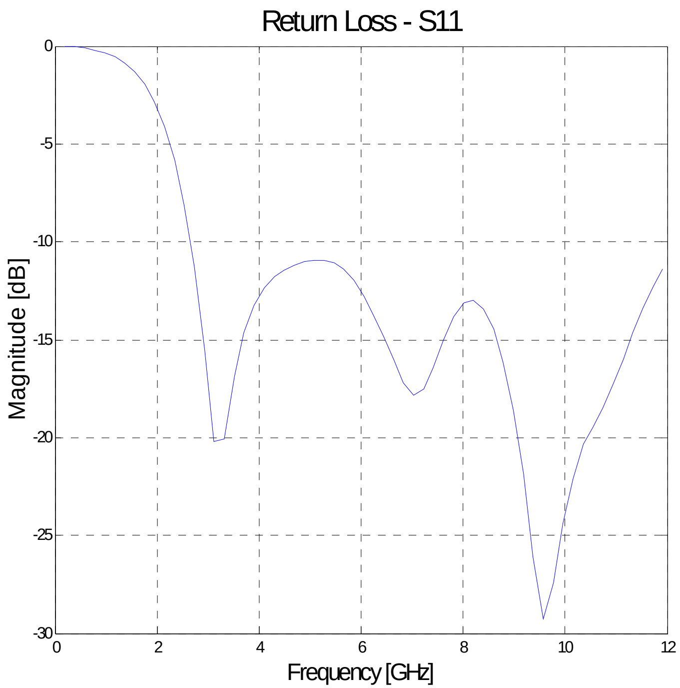
Circular Monopole

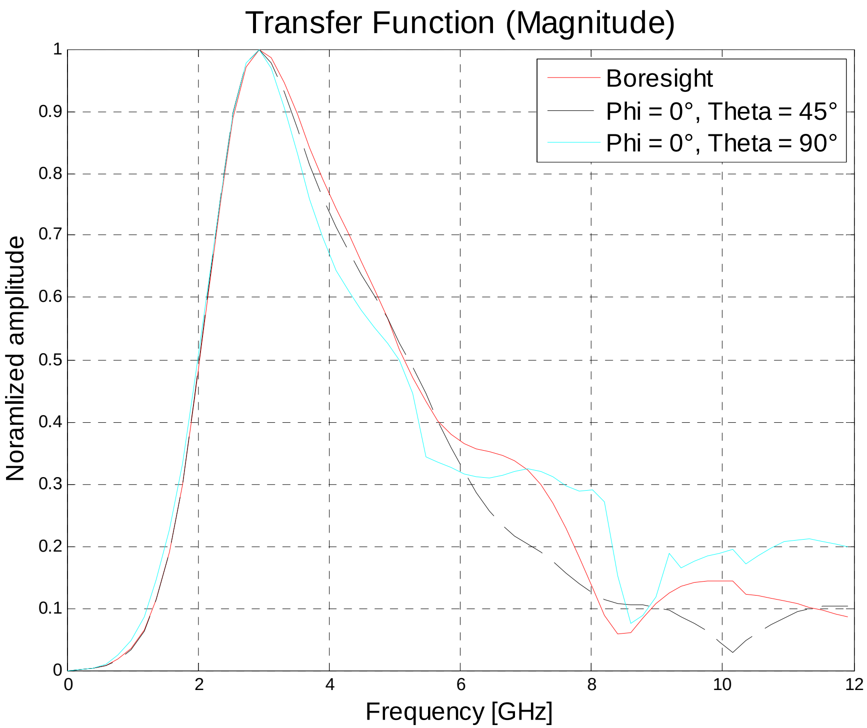


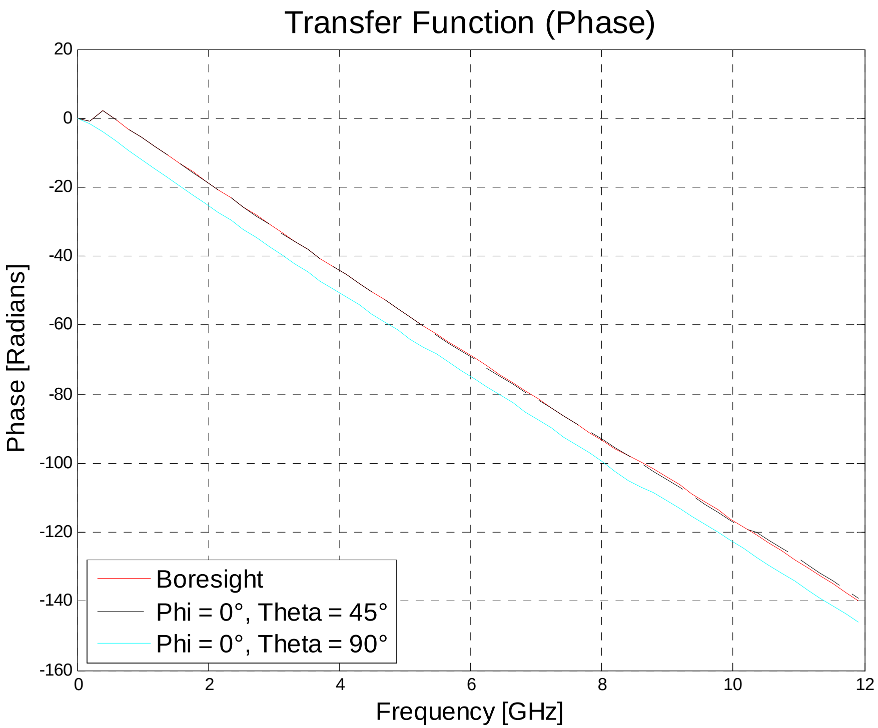


Results

Circular Monopole

$$H(\omega)=\left(1-|S_{11}|^2\right)\left(\frac{\lambda}{4\pi R}\right)E_t(\theta_t,\phi_t)e^{jkR}$$





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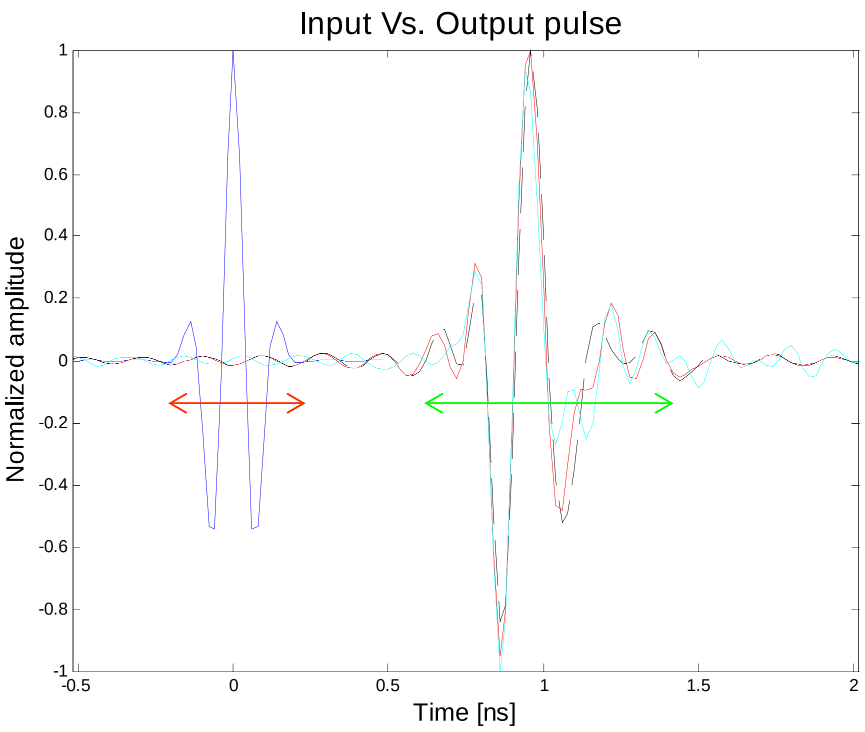
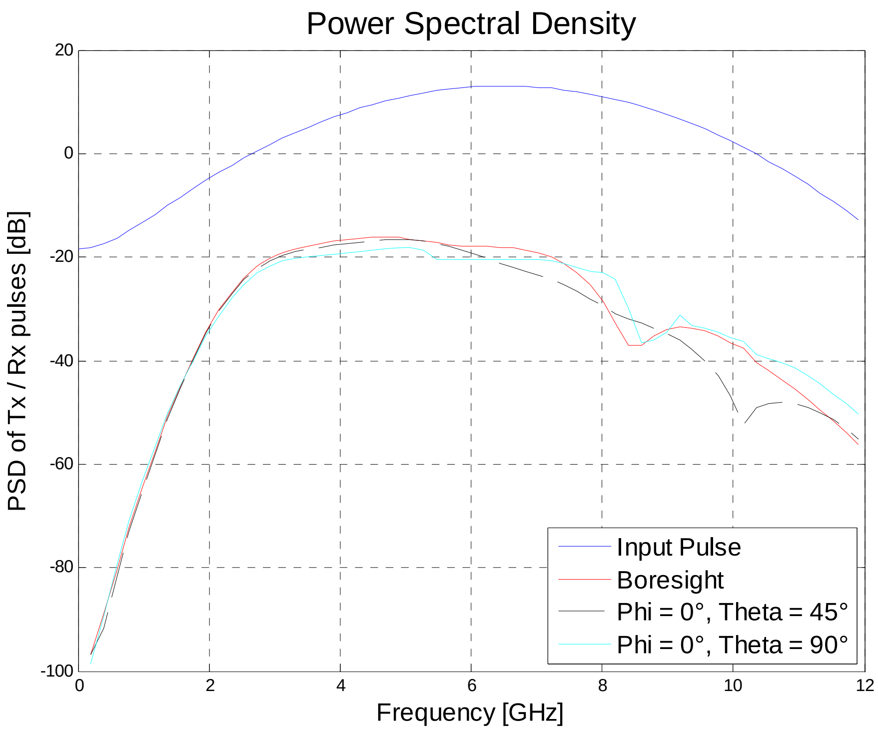
Circular Monopole

$$V_r(\omega) = H(\omega) V_t(\omega)$$

$$V_r(t) = ifft\left(V_r(\omega)\right)$$





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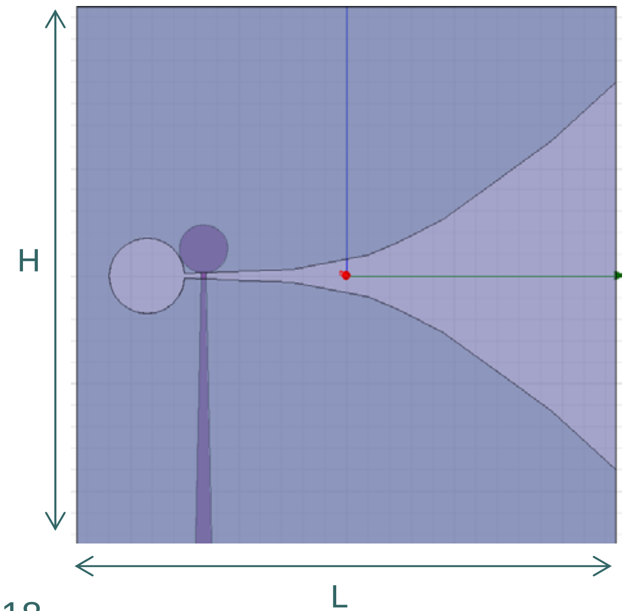
Vivaldi Antenna

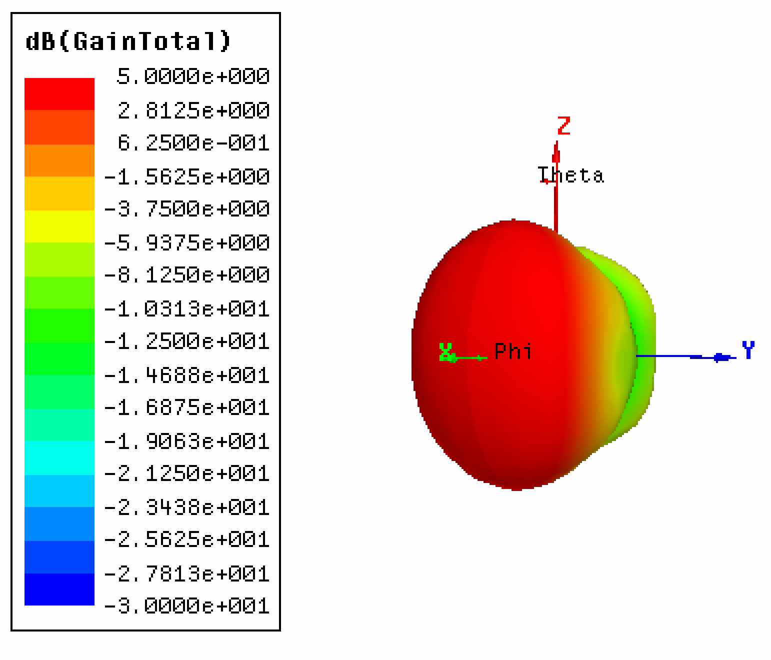
- Characteristics
  - Directive antenna
  - ~5dB gain



L = 50mm

H = 50mm

Vivaldi Antenna



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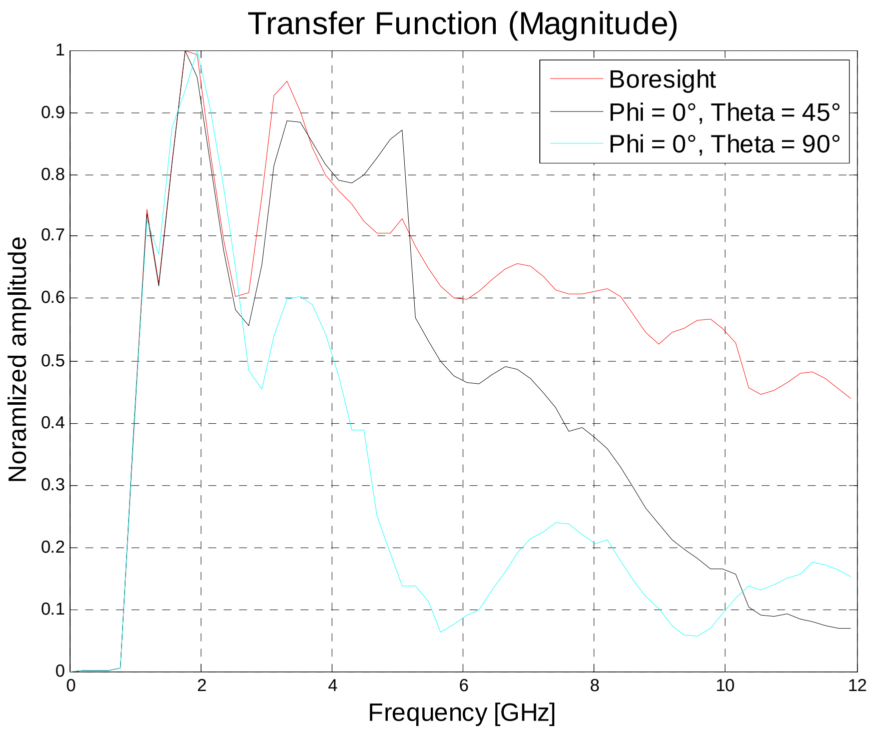
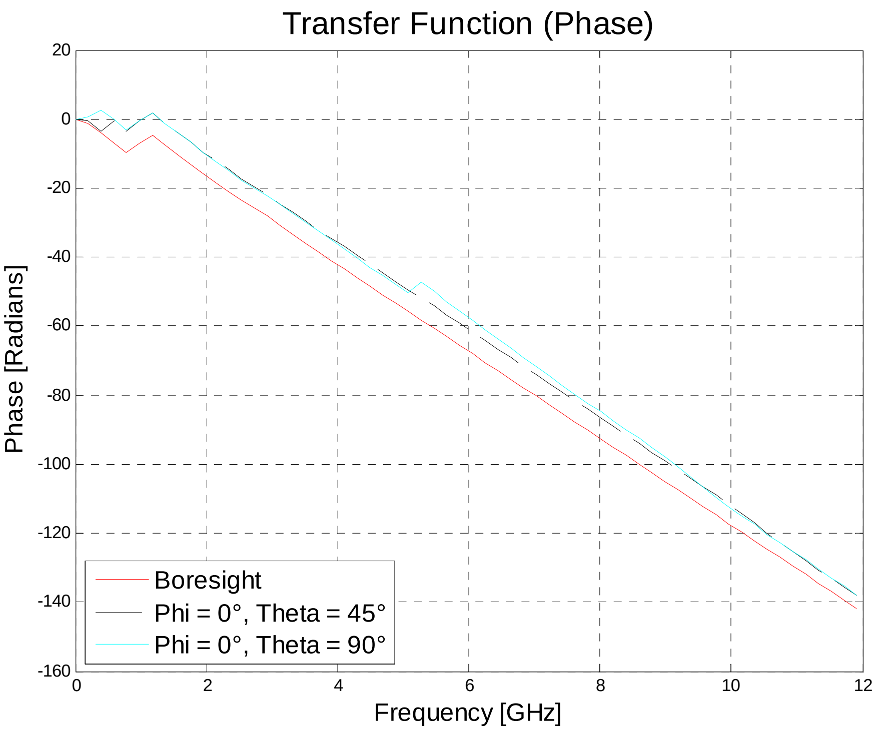
Vivaldi Antenna

$$H(\omega) = \left(1 - |S_{11}|^2\right) E_t(\theta_t, \phi_t) \left(\frac{\lambda}{4\pi R}\right) e^{jkR}$$

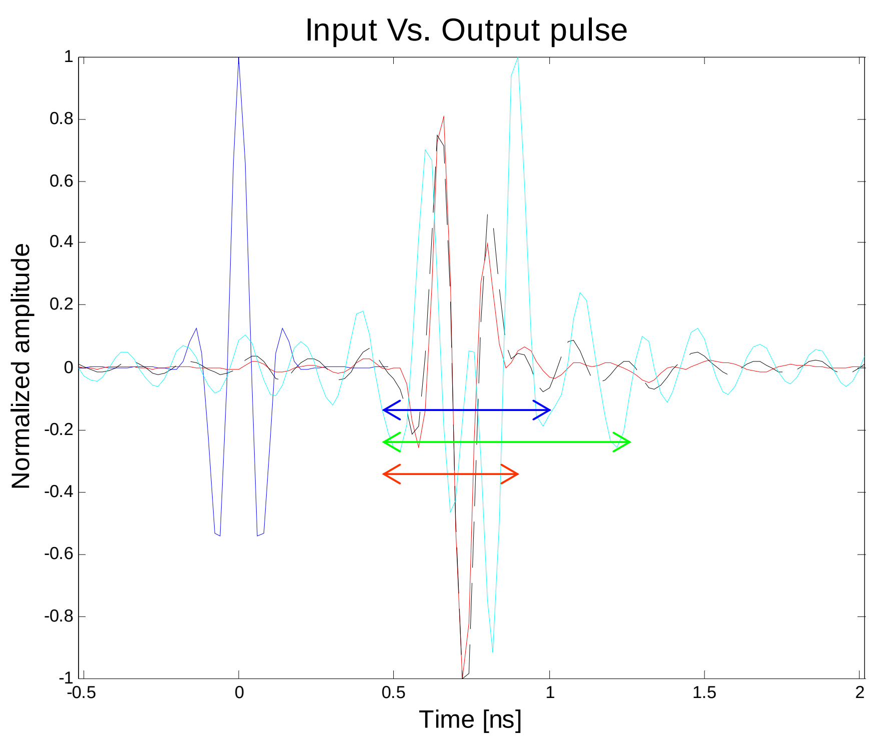


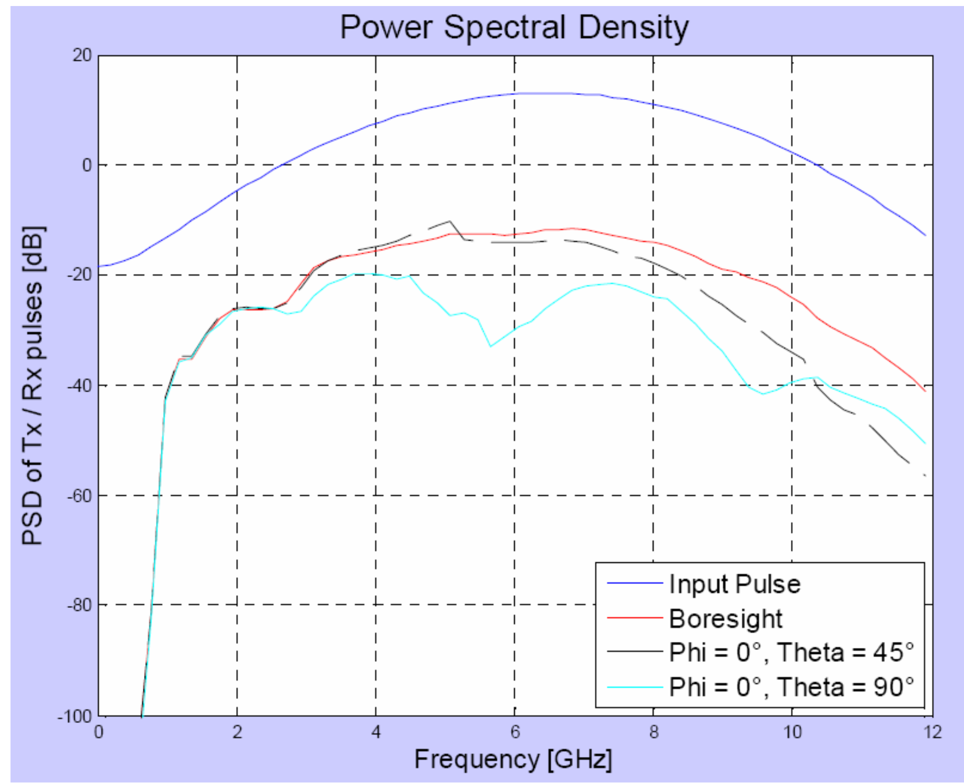


Vivaldi Antenna

$$V_r(\omega) = H(\omega)V_t(\omega)$$

$$V_r(t) = ifft\left(V_r(\omega)\right)$$





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Conclusions

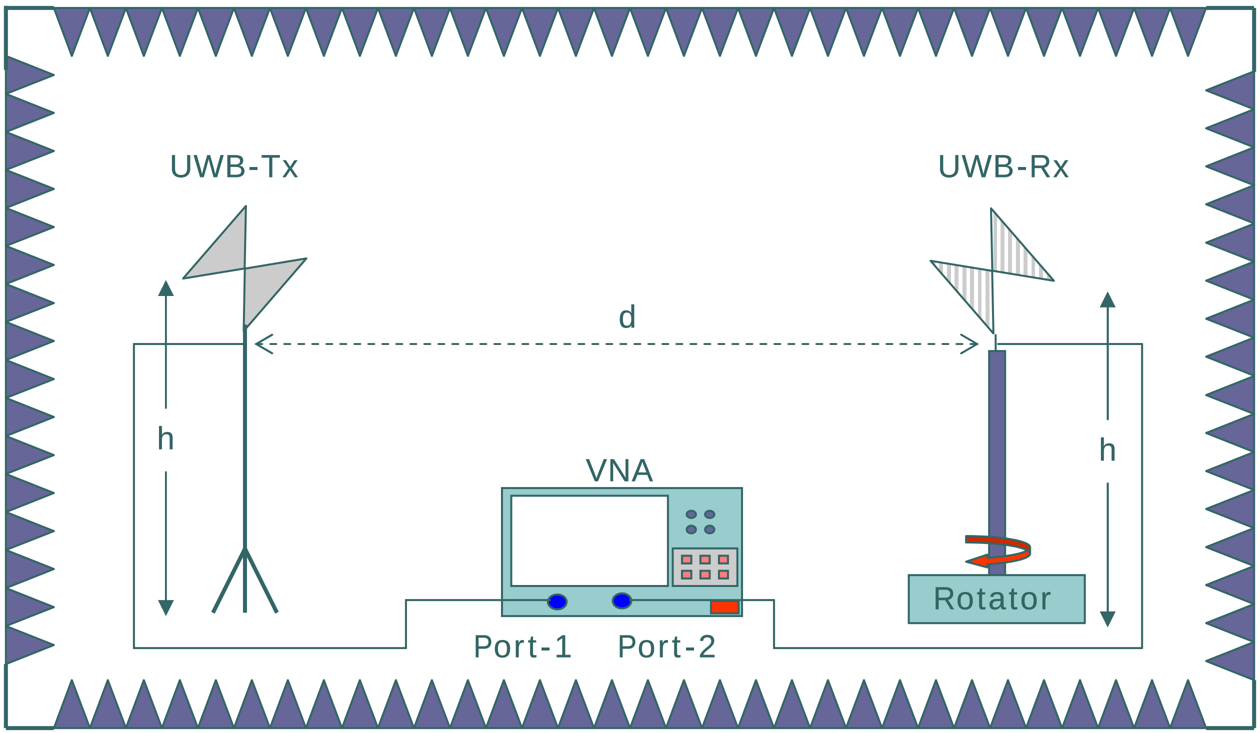
Vivaldi	Monopole
○ Linear phase in all the UWB band at the main beam $\rightarrow$ low pulse distortion ○ Pulse dispersion is less than the monopole at the main beam. ○ The PSD of the Rx pulse is not changed at the main beam.	○ Linear phase in all the UWB band within the azimuth plane $\rightarrow$ low pulse distortion ○ Pulse dispersion is the same at all angles within the azimuth plane (Phi = 0°). ○ The PSD of the Rx pulse is shifted to lower frequencies.

Future Work

- Measurements of the antennas with the correct equipment.
- Analysis and design of other types of antennas.
- Implementation together with the MICS IR-UWB platform.

Questions???

Measurements



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References

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[2] **" Antenna Theory. Analysis and Design "**. Balanis, Constantine A. John Wiley & Sons, Inc.

[3] http://bwrc.eecs.berkeley.edu/Research/UWB/index.htm

[4] **" Free Space Link Budget Evaluation of UWB-IR Systems "**. Promwong, S.; Hachitani, W.; Takada, J.-I. 2004 International Workshop on Ultra Wideband Systems. 18-21 May 2004 Page(s):312 - 316

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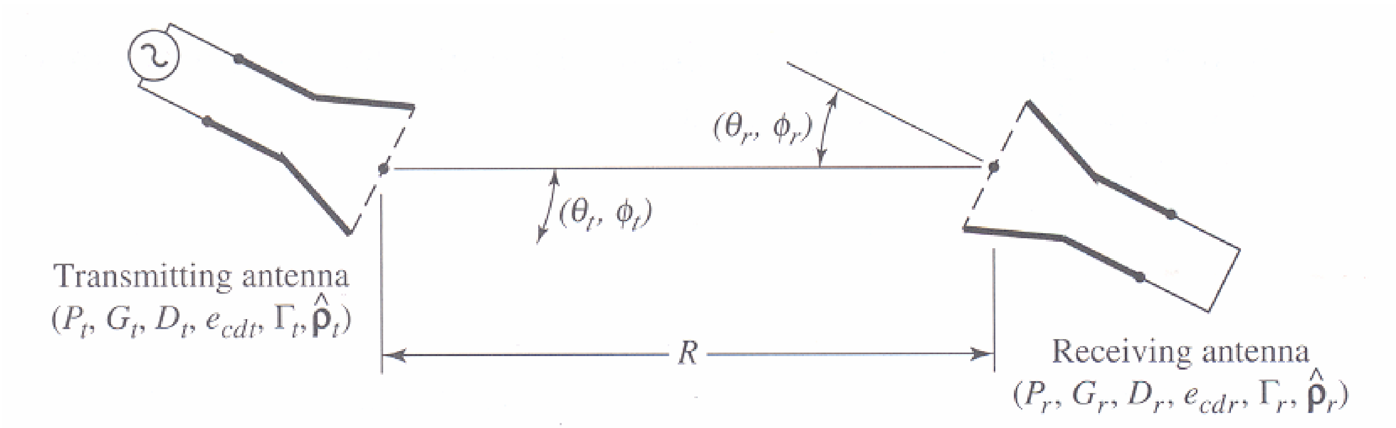
The Antennas



$$\frac{P_r}{P_t} = e_{cdt} e_{cdr} \left(1 - |\Gamma_t|^2\right)\left(1 - |\Gamma_r|^2\right)\left(\frac{\lambda}{4\pi R}\right)^2 D_t(\theta_t, \phi_t) D_r(\theta_r, \phi_r) \left|\hat{\rho}_t \cdot \hat{\rho}_r\right|^2$$