



Research Consortium in Speckled Computing

Channel Estimation for Short Range Sensor Network

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Introduction

- ❑ To determine the relationship between the Received and the Transmitted signal.
- ❑ Determination of Channel Parameters
 - ❖ Higher Order Channel Statistics
 - ❖ Data Rate and the required Bandwidth
 - ❖ Path Loss and Equalization
- ❑ Noise and Interference in the ISM Band

Sequence of Presentation

- ❑ **Narrow Band Sounding**
 - ❖ Large scale Fading Loss
- ❑ **Wide Band Sounding**
 - ❖ Small scale Fading Loss
- ❑ **Channel Sounding in Frequency Domain**
- ❑ **Noise and Interference**
- ❑ **Conclusion**
- ❑ **Question and Answer Session**

Narrow Band Sounding Technique

Large Scale Fading Effects

❖ Single Tone at 2.45 GHz though Directional and Non Directional Antenna

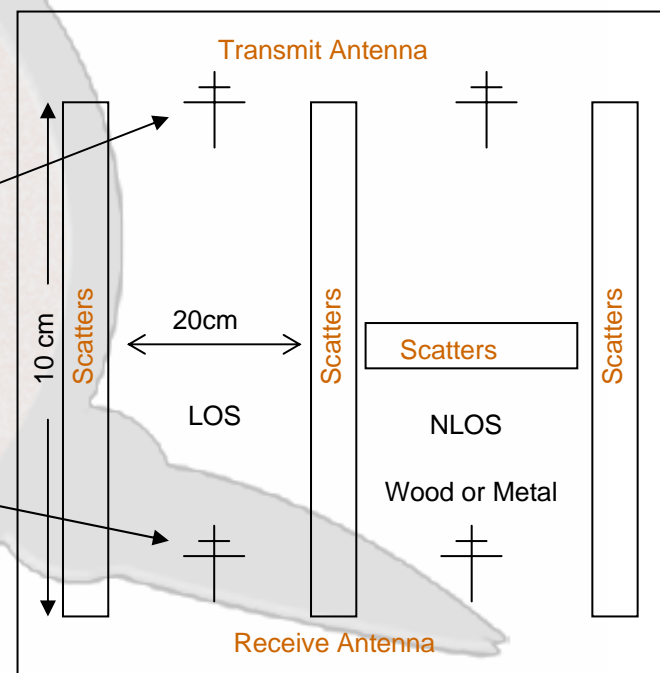
- MMSE Estimates is used based on the Measured and Estimated value.
- The sum of squared errors between the measured and estimated values is given by :

$$J(n) = \sum_{i=1}^k (p_i - \hat{p}_i)^2$$

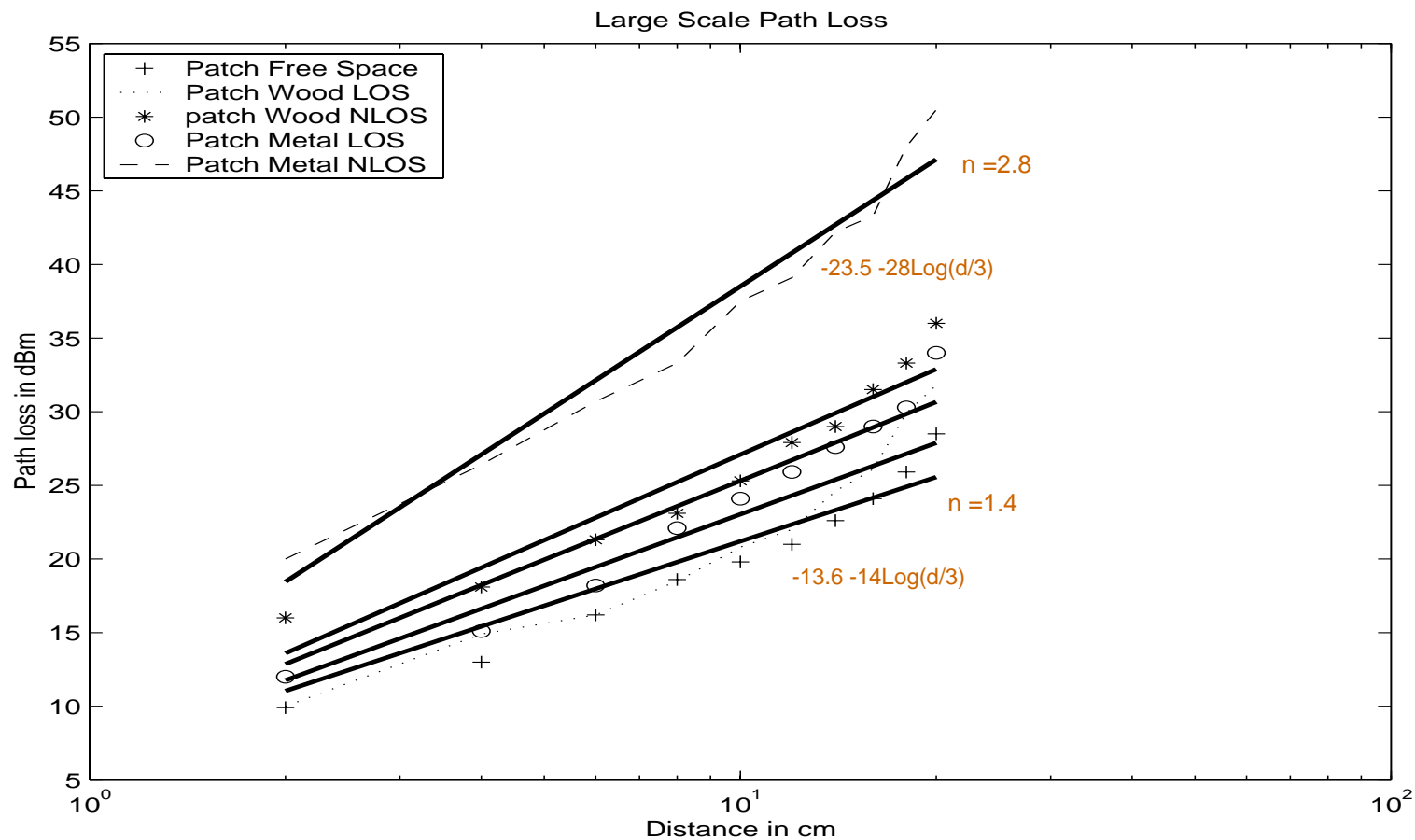
$$p_r(d) = \bar{p}_r(d_o) - 10n \log_{10} \left(\frac{d}{d_o} \right)$$

- The value of Path loss (n) which minimize the mean squared error is computed

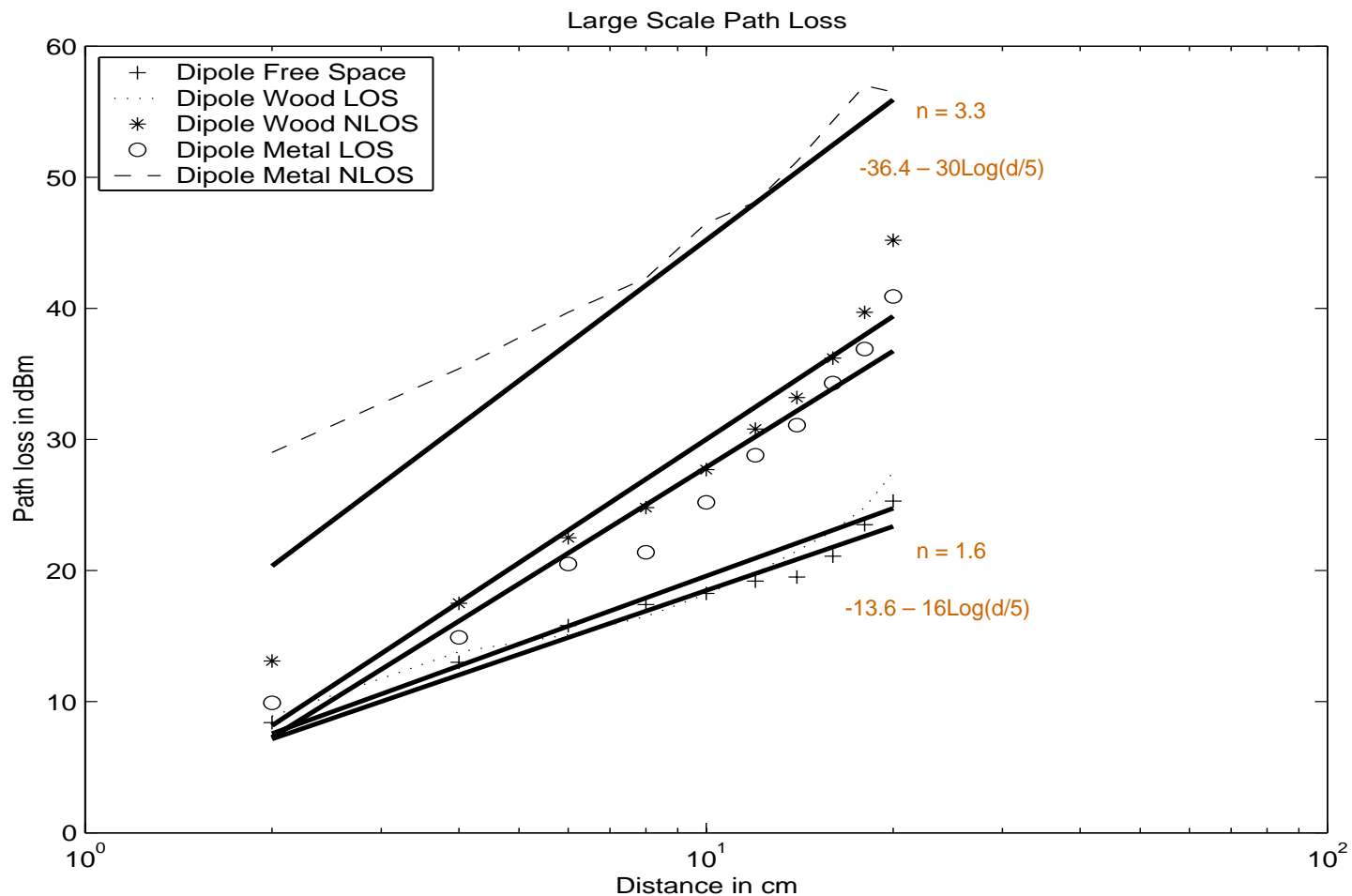
$$p_r(d) \text{ (dBm)} = \bar{p}_r(d_o) - 10n \log_{10} \left(\frac{d}{d_o} \right) + x_\sigma$$



Narrow Band Sounding (Directional Antenna)



Narrow Band Sounding (Non Directional Antenna)



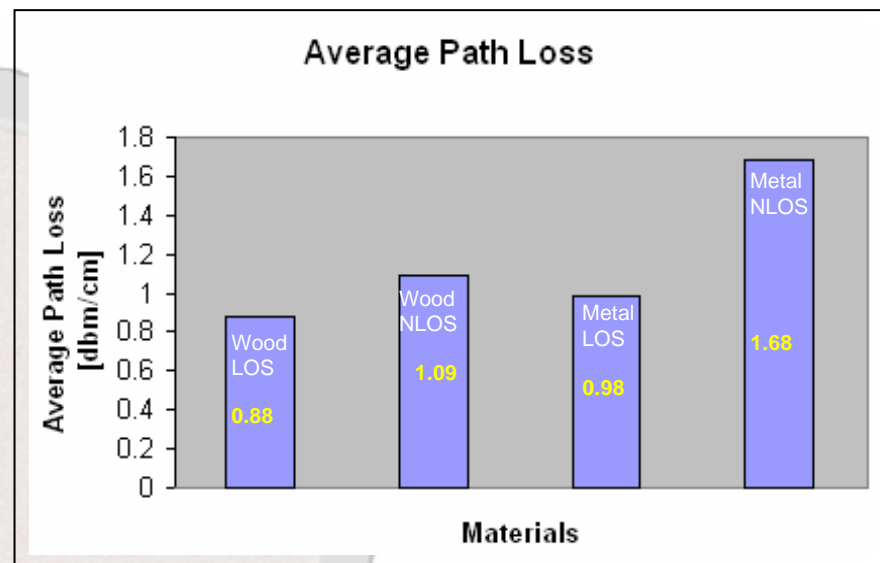
Narrow Band Sounding Technique

S/No	Environment	Path Loss [n]	Standard Deviation [dB]
1	LOS Free Space	1.4	1.2
2	Wood LOS	1.6	1.6
3	Wood NLOS	2.1	2.1
4	Metal LOS	1.8	1.9
5	Metal NLOS	2.8	1.7

Path Antenna

S/No	Environment	Path Loss [n]	Standard Deviation [dB]
1	LOS Free Space	1.6	1.0
2	Wood LOS	1.7	1.3
3	Wood NLOS	2.4	2.3
4	Metal LOS	2.1	2.2
5	Metal NLOS	3.3	2.8

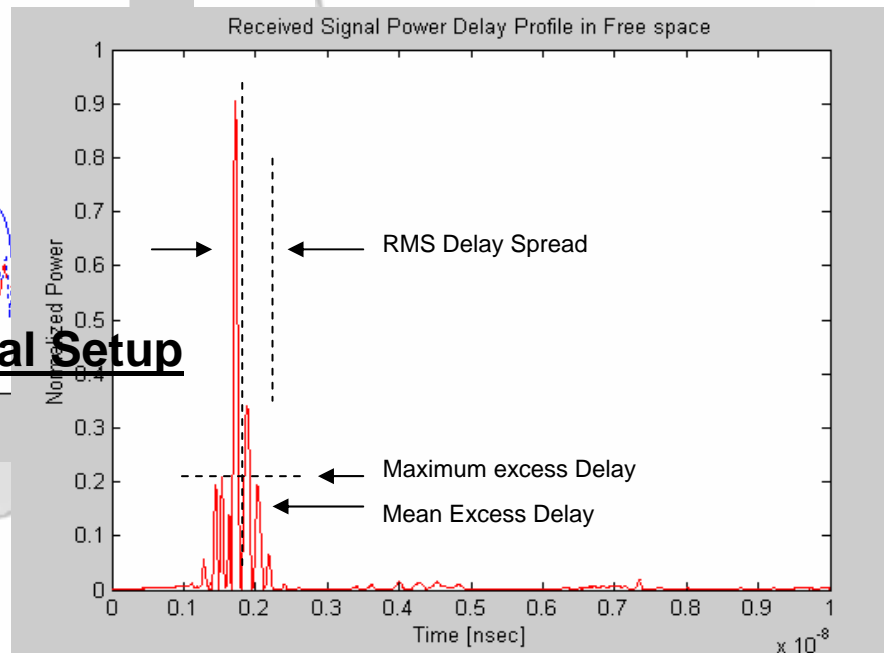
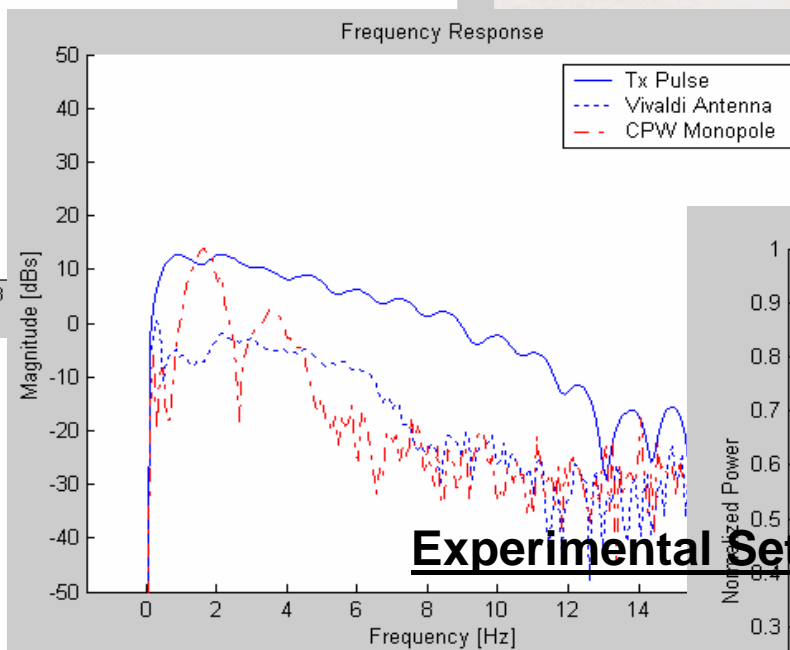
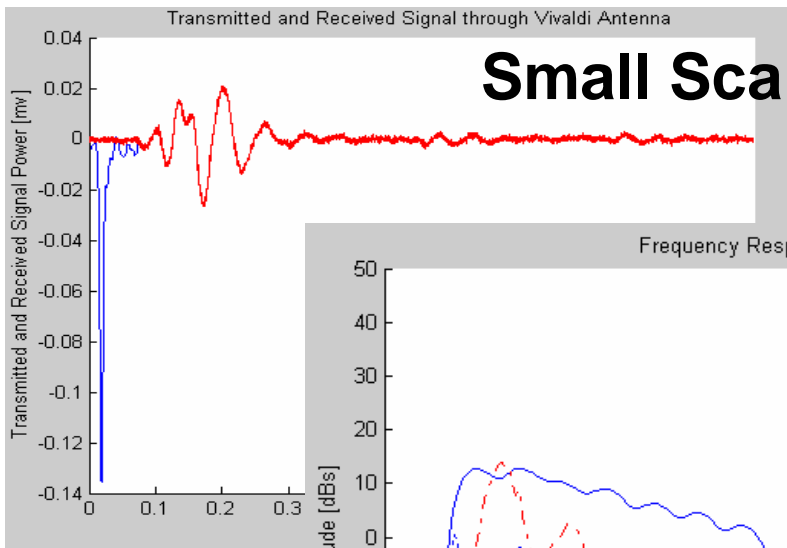
Dipole Antenna



- ❖ Variance and Path Loss is more for Non directional antennas
- ❖ Material Dependent Attenuation is included in the path loss model to have more accurate path loss.

Wide Band Sounding Technique

Small Scale Fading Effects



Experimental Setup

Wide Band Sounding Technique

Small Scale Fading Statistics For Directional Antenna

RMS Delay Spread

Free Space: 0.065 ns

Wood : 0.07 ns

Metal : 1.21 ns

Channel Statistic

Mean Excess Delay : 2.1 ns

Coherence Bandwidth : 165.2 MHz

Small Scale Fading Statistics For Non-Directional Antenna

RMS Delay Spread

Free Space: 0.093 ns

Wood : 0.131 ns

Metal : 1.651 ns

Channel Statistic

Mean Excess Delay : 2.94 ns

Coherence Bandwidth : 121.2 MHz

Wide Band Sounding Technique

□ Observations:

- ❖ Angular dependencies of the antenna are added in the channel response.
- ❖ This will offer a general characterization of the channel as would be seen by similar antennas.
- ❖ Because of Multipath, Signal Dispersion and Scattering is more in case of Non Directional Antenna, this also result in higher value of delay spread.
- ❖ Power Delay Profile has a higher value in metals (LOS) as compared to wood.
- ❖ The amplitude of the signal in case of NLOS (metals) decay to 36.8% after travelling one Skin depth.(9.7 μm at 2.45 GHz)

Wide Band Sounding Technique

□ **The bandwidth of the transmitted signal is well within the Coherence bandwidth of the channel.**

❖ No Equalization is needed at the receiver

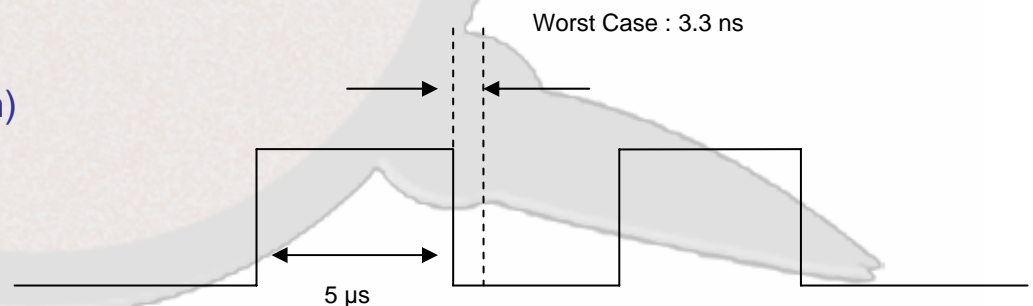
❖ Flat Faded channel

❖ Inter Symbol Interference

➤ Data Rate : 300 Mbps

(Exceeds Coherence Bandwidth)

➤ Pulse Shaping



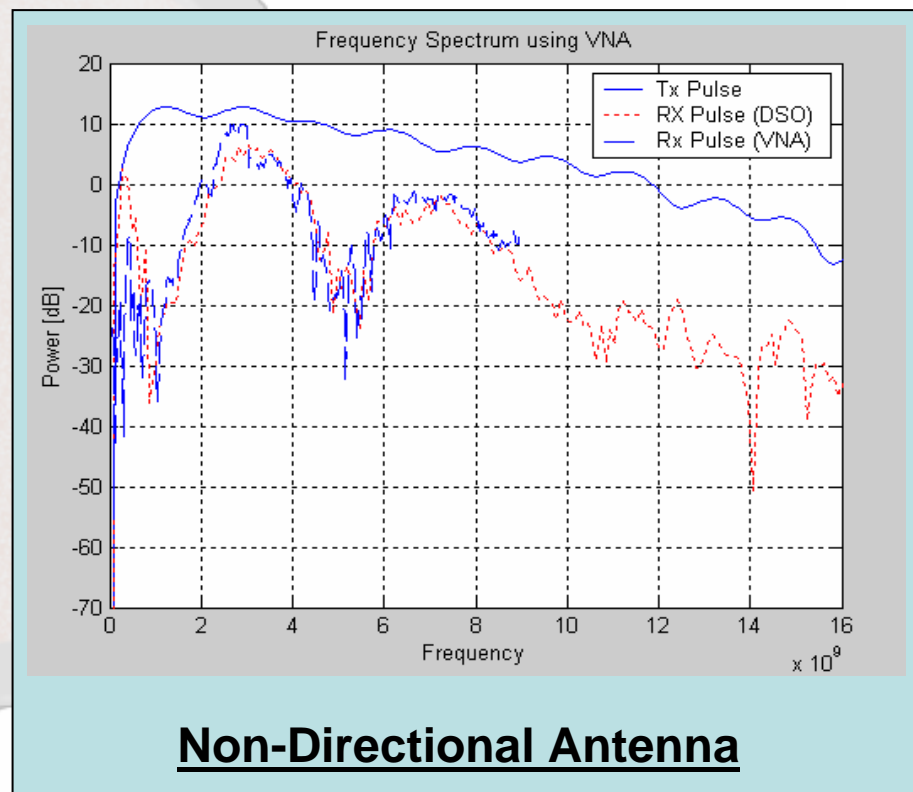
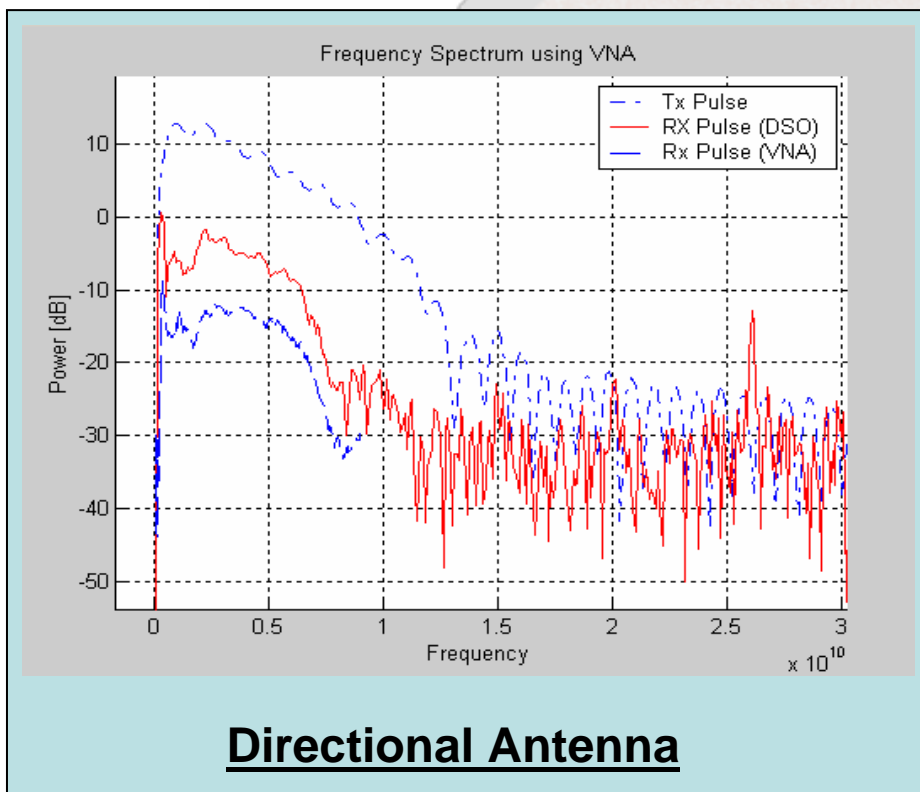
Wide Band Sounding Technique

□ Measurement are made in Frequency Domain

- ❖ Vector Network Analyzer
- ❖ Complex Channel Impulse Response (S21 Parameters)
- ❖ $H_n = H(f_{\text{start}} + nf_{\text{inc}})$
 - Increment Frequency = 25 MHz (Sweep BW/N)
- ❖ Received Signals Complex Response is compared in Frequency Domain to confirm the results.

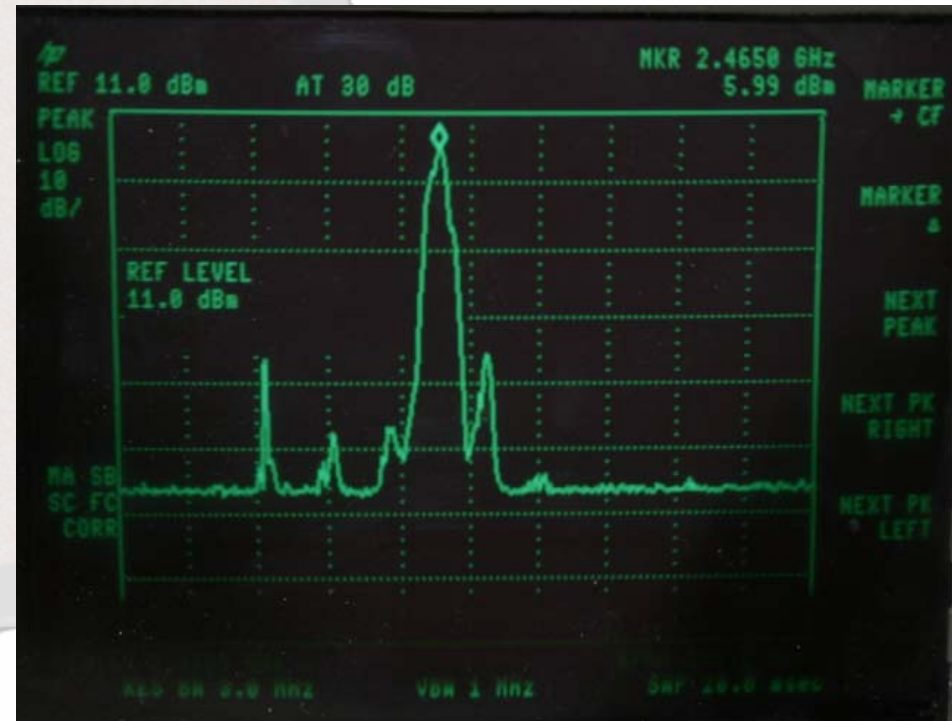
Wide Band Sounding Technique

Comparison of Frequency Spectrum



Noise and Interference

- ❑ Noise and Interference measurements are carried in ISM Band
- ❑ The measurement are carried out through Directional and Non Directional Antennas.
- ❑ Main Sources
 - Reasonable Noise Power at 2.45 GHz has been picked up by both antennas.
 - Random non Repetitive pulse indicated the presence of wide band.
 - Narrow Band noise this band is mostly because of the Microwave oven.



Conclusion

- ❑ The study presents the Channel statistics of tiny transceivers called 'Specks'
- ❑ The research serves as a guide line for DSP Engineers relating to:
 - Coherence Bandwidth
 - Equalization and Pulse Shapers
 - Estimated Received Power
 - Noise and Interference
 - Effect of Antennas and Materials on Channel Parameters

Future Work

- Development of a statistical Model
- BER and Area Coverage Curves
- Link Budget Analysis
- Refinement of results through the actual antenna



Question and Answer Session