Recommendation on LMDS Radio Propagation Channel Models

IEEE 802.16 (BWA Working Group) Presentation Submission Template (Rev. 8)

Document Number: IEEE 802.16.1pp-00/44
Date Submitted: 2000-09-07

Source:

Soma Pitchaiah
Centre for Wireless Communications
The National University of Singapore
#02-34/37 TeleTech Park , 20 Science Park Road
Singapore Science Park-II, Singapore-117674
Voice: +65-8709260
Fax: +65-7795441
E-mail: soma@cwc.nus.edu.sg

Venue:

IEEE 802.16 Session #9 PHY Presentation, 11-15 September 2000, Denver, Colorado, USA.

Base Document:

IEEE 802.16.1pc-00/44 <http://ieee802.org/16/phy/contrib/802161pc-00_44.pdf>

Purpose:

To provide an input to the PHY task group specific criterion called “robustness to channel impairments – multipath fading”

Notice:

This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.

Release:

The contributor grants a free, irrevocable license to the IEEE to incorporate text contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE’s name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE’s sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.

IEEE 802.16 Patent Policy:

The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures (Version 1.0) <http://ieee802.org/16/ipr/patents/policy.html>, including the statement “IEEE standards may include the known use of patent(s), including patent applications, if there is technical justification in the opinion of the standards-developing committee and provided the IEEE receives assurance from the patent holder that it will license applicants under reasonable terms and conditions for the purpose of implementing the standard.”

Welcome…

Recommendation on LMDS Radio Propagation Channel Models

Soma Pitchaiah
Centre for Wireless Communications
#02-34/37 TeleTech Park, 20 Science Park Road
Singapore Science Park-II, Singapore -117674
Email: soma@cwc.nus.edu.sg

Outline

- Introduction
- Measurement Setup
- Path loss and Delay Characteristics
- Static Channel Models
  - Good Channel Model
  - Moderate Channel Model
  - Bad Channel Model
- Time Variant Tapped Delay Line Models
  - Urban Channel Model
  - Suburban Channel Model
  - Rural Channel Model
- Conclusion

Introduction

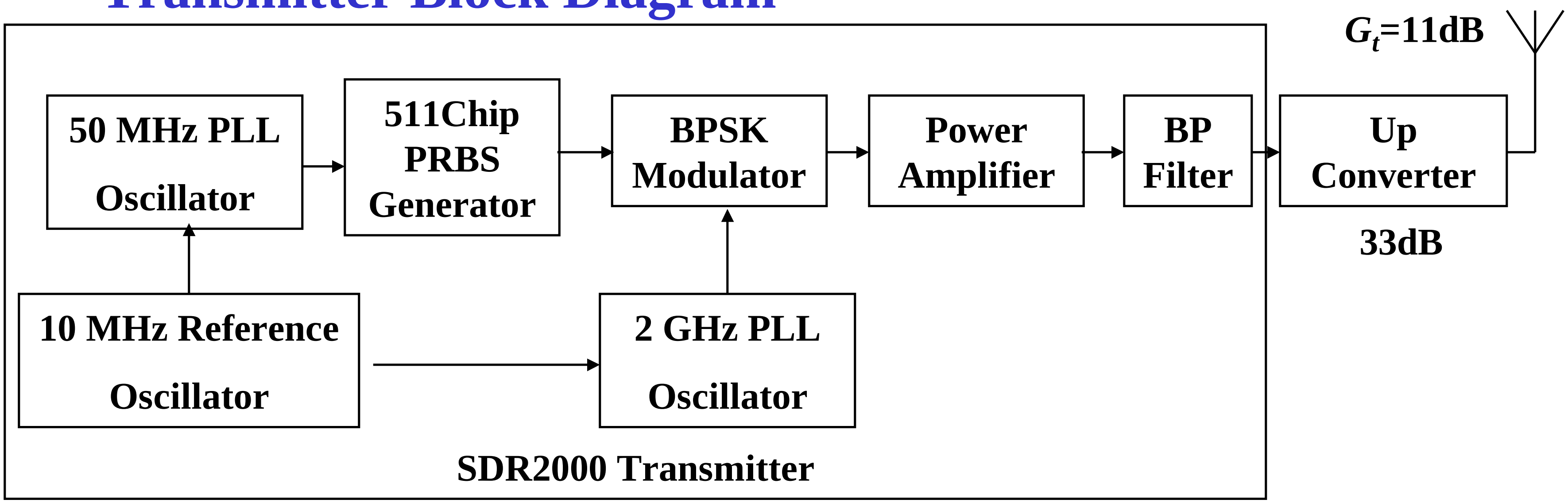
- **Local Multipoint Distribution Service (LMDS)**
  - Last mile solution to provide BWA to fixed networks
  - Operating in the 27.4GHz and higher frequency spectrum
- **Target User Classes**
  - Corporations (large business)
  - Small and Medium-sized Enterprises (SME)
  - Small-Office and Home-Office Users (SOHO)
  - Private Households (HH)
- **Target Services**
  - Voice, one-way video distribution, interactive video, video-on-demand, and real-time video conferencing with high speed internet access.

Introduction (*con…*)

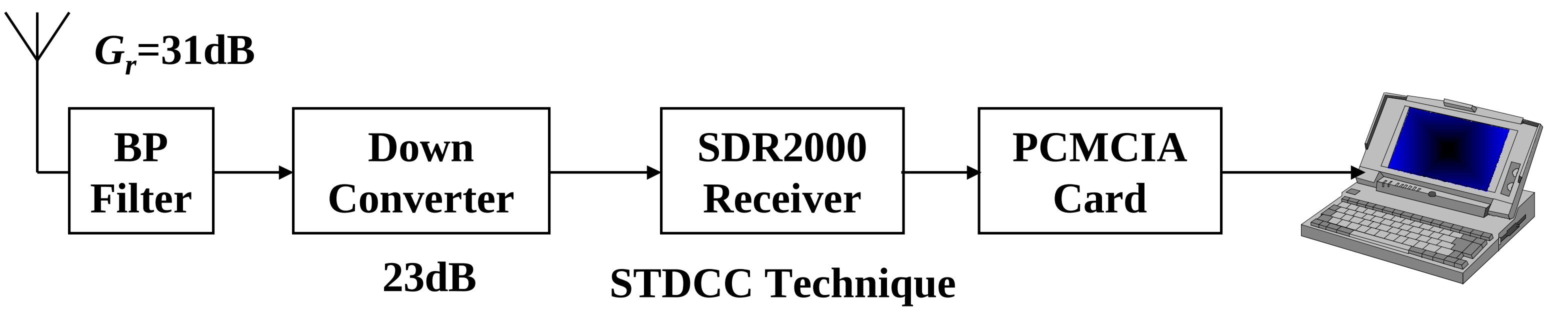
- **Merits Over Wired Solution**
  - Large bandwidth, high data rates, lower installation cost, ease of deployment, cost-effective network maintenance.
- **Propagation Issues**
  - More favourable compared to mobile comm. system
  - Most susceptible to rain effects (depolarisation, excess loss)
  - Building blockage and vegetative losses reduce coverage
  - Frequency selective fading occurs at high data rates
  - Highly directional antennas at receiver side
  - Accurate channel models are required for the system design

Measurement Setup

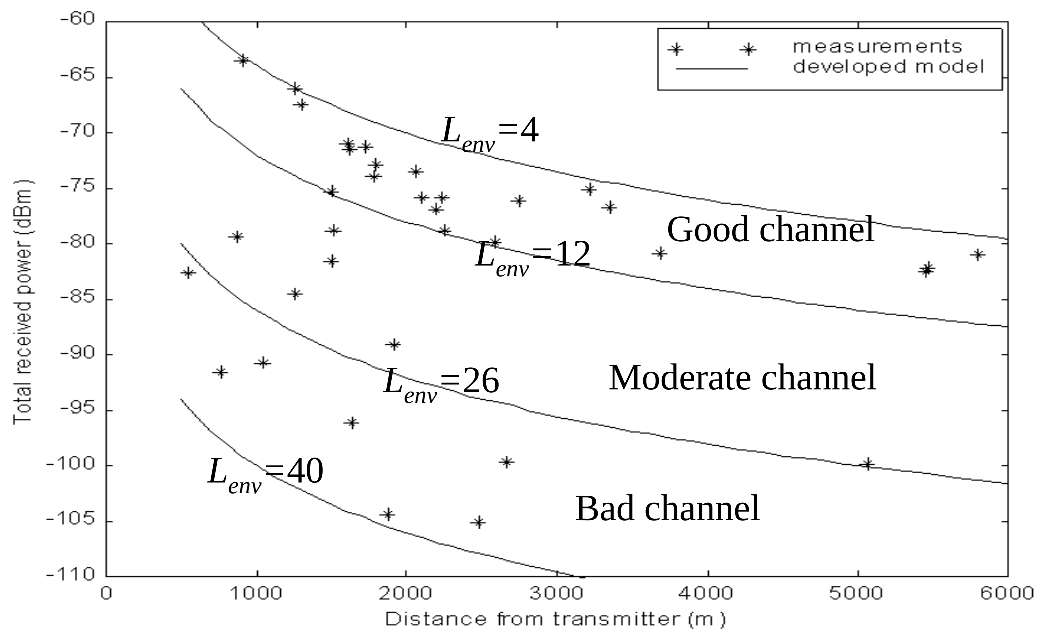
- Transmitter Block Diagram



- Receiver Block Diagram

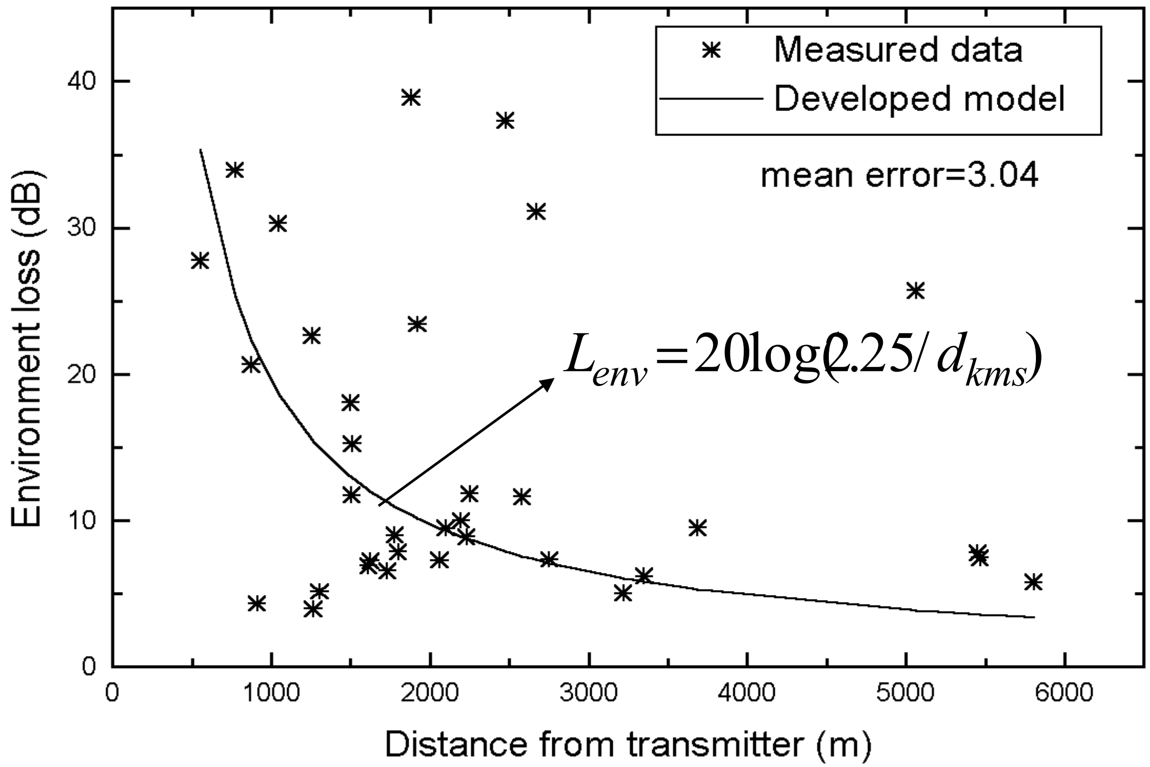


Total Received Power Vs Distance



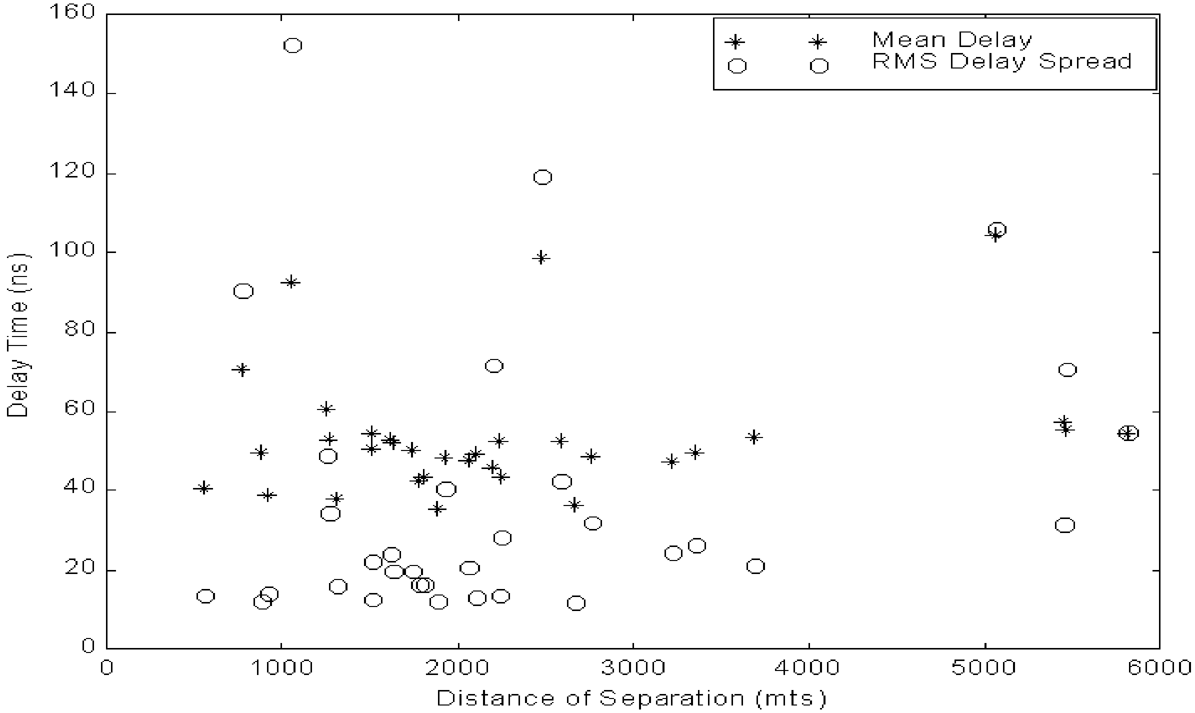
- Total received power(dB), $P_r = P_t + G_t + G_r - 32.44 - 20\log(f_{GHz} d_m) - L_{ex}$
- Excess path loss (dB), $L_{ex} = P_t + G_t + G_r - 32.44 - 20\log(f_{GHz}) + L_{env}$
- Good channel $\Rightarrow 4 \leq L_{env}\,(dB) < 12$
- Moderate channel $\Rightarrow 12 \leq L_{env}\,(dB) < 26$
- Bad channel $\Rightarrow 26 \leq L_{env}\,(dB) < 40$

Environment Loss Vs Distance



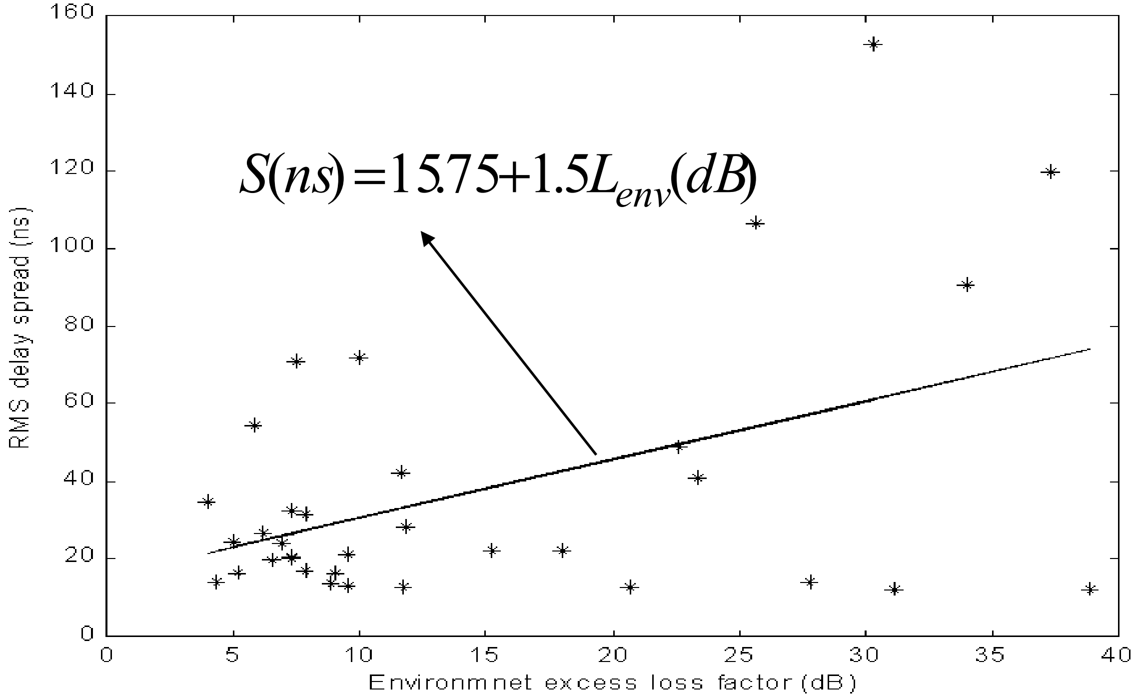
- Additional loss caused by climatic conditions, multipath and shadowing effects from surrounding buildings, foliage etc.,
- Dominant effect at lower distance of separation.
- Link margin has to be provided to compensate this excess loss.

Delay Characteristics



- High delay values are due to the presence of significant multipath components
- Also depends on the received signal to noise ratio.
- Useful in the design of equaliser and selection of suitable data rate.
- For normalised delay spreads (bit rate* *S*) of 0.6 or higher irreducible errors tend to occur.

Delay Spread Vs Excess Loss



• Low excess loss and low delay spread corresponds to a less dispersive and less attenuated good channel.

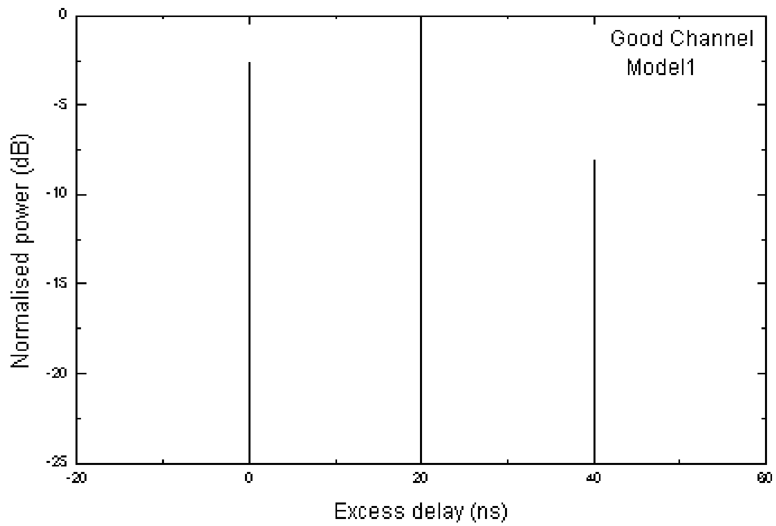
• High delay spread but less excess path loss corresponds clear LOS receiver locations at larger distance.

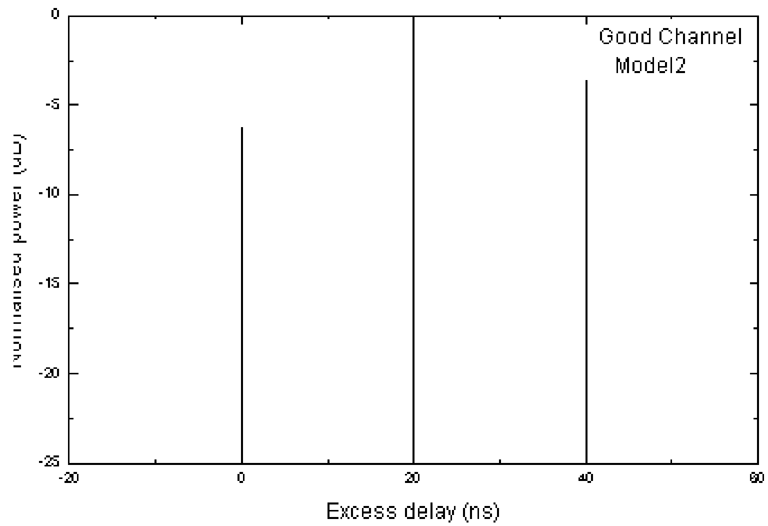
• High delay spread and high excess loss corresponds to the partially blocked nearby receiver locations surrounded by high rise buildings.

Static Channel Models

- **Good Multipath Models for Good Reception**
  - **Environment loss is less than 12dB**
  - **Delay spread range from 10 to 20ns**

Excess Delay (ns)	Tap gain (Model 1) Numeric	dB	Tap gain (Model 2) Numeric	dB
0	0.74	-2.65	0.48	-6.31
20	1	0	1	0
40	0.40	-8.05	0.66	-3.67

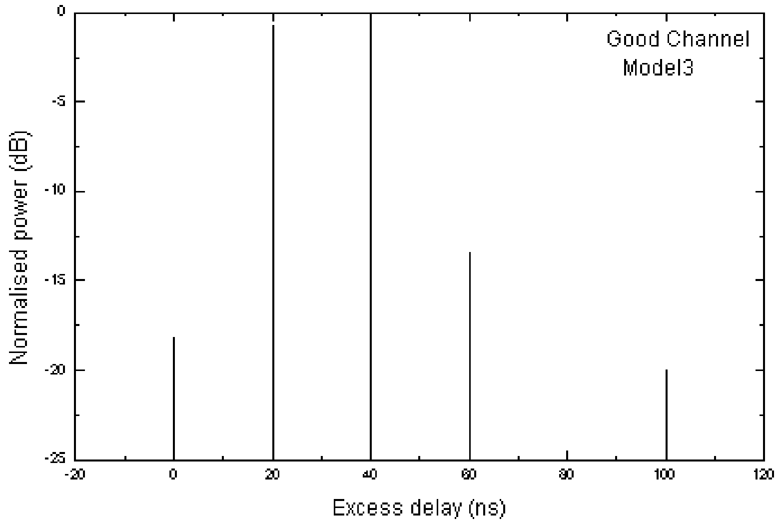


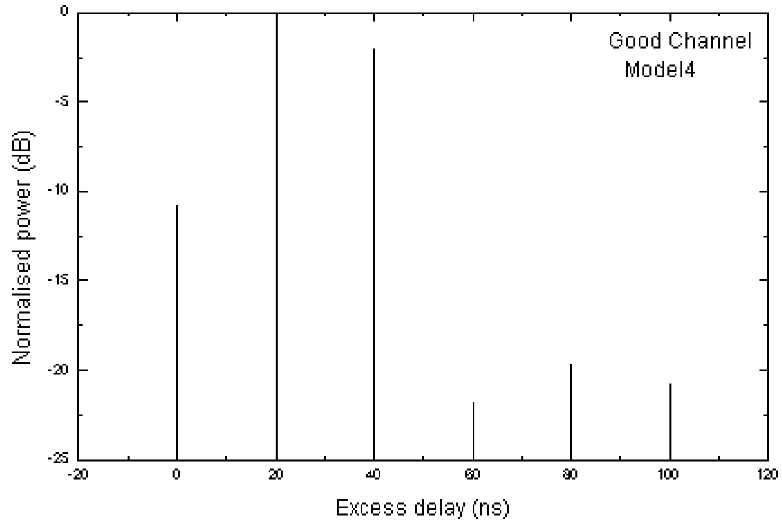


Static Channel Models (*Con…*)

- **Moderate Multipath Models for Good Reception**
  - **Environment loss is less than 12dB**
  - **Delay spread range from 20 to 70ns**

Excess Delay (ns)	Tap gain (Model 3) Numeric	dB	Tap gain (Model 4) Numeric	dB
0	0.12	-18.18	0.29	-10.86
20	0.92	-0.69	1	0
40	1	0	0.79	-2.00
60	0.21	-13.45	0.08	-21.86
80	0.06	-24.54	0.10	-19.68
100	0.10	-20.00	0.09	-20.79

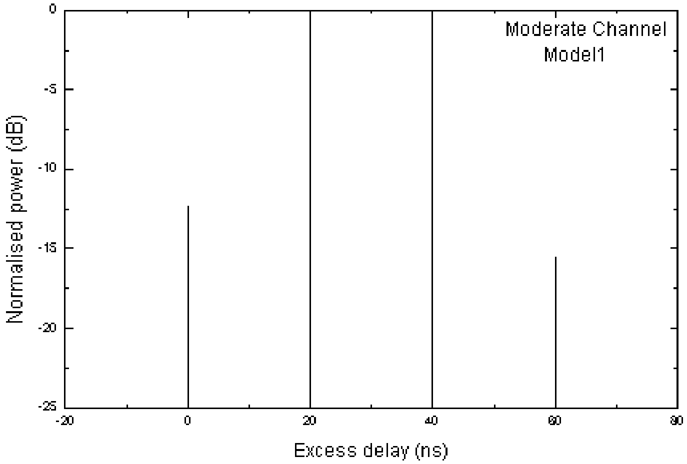


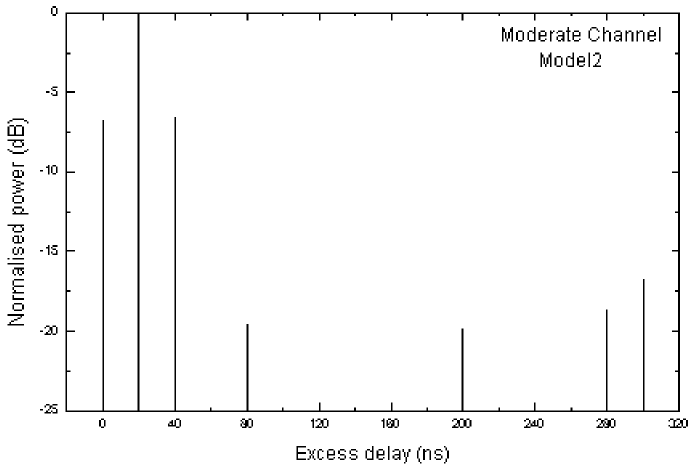


Static Channel Models (*Con…*)

- **Channel Models for Moderate Reception**
  - **Environment loss is in the rage of 12 - 26dB**
  - **Delay spread range from 10 to 100ns**

Excess Delay (ns)	Tap gain (Model 1)		Tap gain (Model 2)	
	Numeric	dB	Numeric	dB
0	0.24	-12.36	0.48	-6.37
20	1	0	1	0
40	0.94	-0.50	0.58	-4.70
60	0.17	-15.56	0.12	-18.16
80			0.10	-20.00
200			0.10	-19.91
280			0.12	-18.71
300			0.15	-16.74
340			0.12	-18.68
360			0.13	-17.65

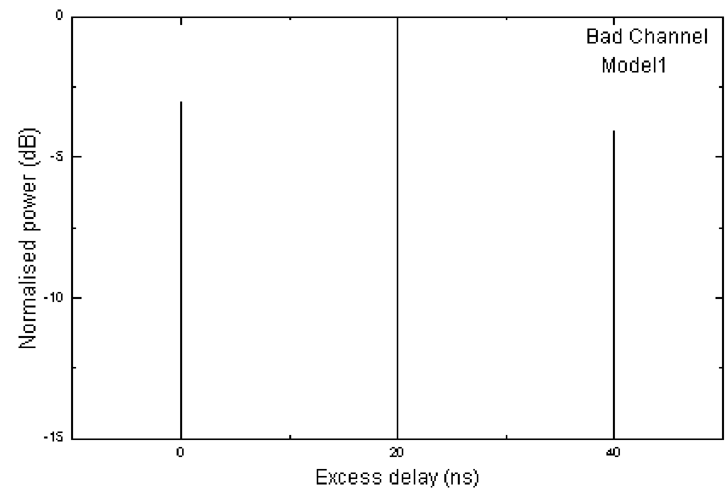


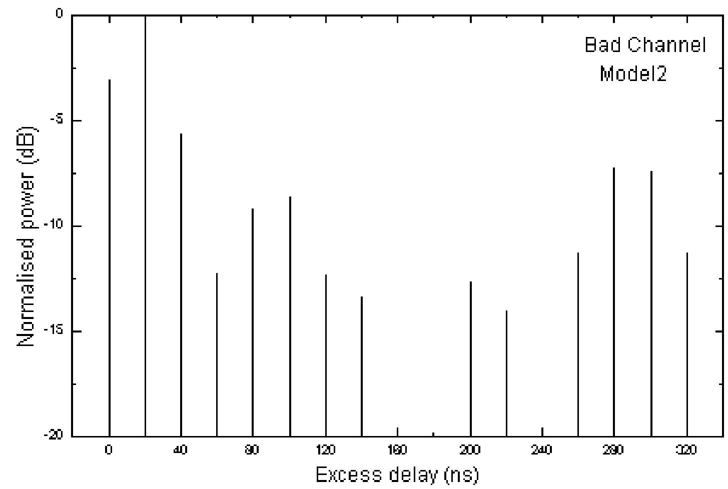


Static Channel Models (*Con…*)

- **Channel Models for Poor Reception**
  - **Environment loss is in the rage of 26 - 40dB**
  - **Delay spread range from 10 to 150ns**
  - **Block holes**

Excess Delay (ns)	**Tap gain (Model 1)**		**Tap gain (Model 2)**	
	Numeric	**dB**	**Numeric**	**dB**
0	0.70	-3.05	0.70	-3.12
20	1.0	0.0	1.00	0
40	0.62	-4.10	0.52	-5.68
60			0.24	-12.31
80			0.35	-9.24
100			0.37	-8.64
120			0.24	-12.34
140			0.21	-13.43
200			0.23	-12.7
220			0.20	-14.1
260			0.27	-11.32
280			0.43	-7.27
300			0.42	-7.44
320			0.27	-11.3





Summary of Static Channel Models

- Static models are simple and easy to understand
- Channel is classified according to the signal reception
  - sub classification based on the multipath contribution
    - → Further classification according to impulse response shape
- Predicts lower delay values than those observed from measurements

Channel Type		Mean Delay (ns)	Delay Spread (ns)	Excess Loss (dB)
Good	Model1	15.46	11.96	0 – 12
	Model2	22.46	14.61	
	Model3	31.72	18.16	
	Model4	27.10	16.65	
Moderate	Model1	28.97	16.67	12 – 26
	Model2	35.27	50.89	
Bad	Model1	18.87	13.69	26 – 40
	Model2	85.35	75.84	

Time Variant Channel Models

- **Impulse response completely describes the radio channel:**
  - **represented by a tapped delay line model at any time, t_k**

$$h(t_k,\tau) = c_k \sum_{n=0}^{N-1} m(\tau_n)\delta(t_k - \tau_n)e^{-j(\omega_c\tau_n+\phi)}$$

  - ***τ is the* excess delay, *n* is tap index and *N* is the total number of taps.**
  - ***$m(\tau)$* gives the tap gains of various multipath delayed components**
  - ***c_k* models the time varying nature of IR (based on measurements)**
  - **ϕ is the uniform random phase in the range of $[0,2\pi)$**

- **Tap gain distribution is given by,**

$$m(\tau_n) = \alpha \exp\left\{ -\beta\left(\frac{\tau_n - \tau_p}{100}\right)^2 \right\}$$

Time Variant Channel Models (*Cont..*)

Table 6. Summary of channel model parameters

Case (i)	Peak time, τ_p (ns)	Attenuation factor, α_i	Decay factor, β_i	Excess delay τ (ns)
1	40 40	1.0 1.0	β_1 β_2	0 – 40 40 – 100
2	100	0.1	β_3	100 – 250
3	320	0.1	β_4	250 – 400

Table 7. Classification of propagation channel

Parameter	Urban	Suburban	Rural
c_k (dB)	-10 – 6	-5 – 3	-5 – 3
β_1	20 – 100	50 – 120	50 – 120
β_2	6 – 20	10 – 25	10 – 25
β_3	0.5 – 10	1 – 10	0
β_4	5 – 50	0	0
τ_{max} (ns)	400	250	100

Conclusion

- Introduction
- Measurement Setup
- Path loss and Delay Characteristics
- Static Channel Models
  - Good Channel
  - Moderate Channel
  - Bad Channel
- Time Variant Channel Model
  - Urban Channel
  - Suburban Channel
  - Rural Channel

Any Questions Please!

Thank You!