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Title: **Toward a System Impairment Model**

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Toward a System Impairment Model

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Process

- Identify primary performance degradation sources
- Model and parameterize these sources
- Establish performance metrics
- Establish baseline characterization techniques

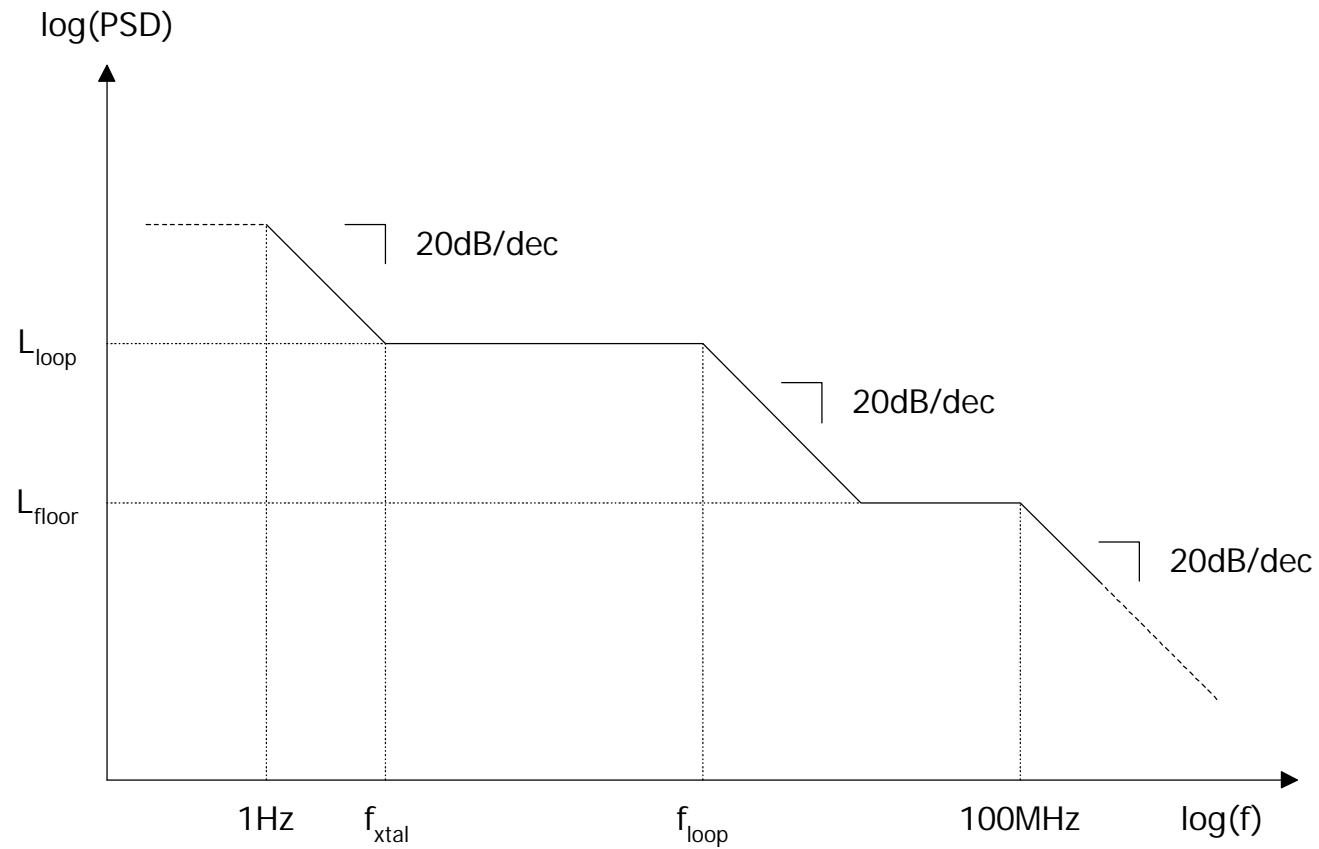
Performance degradation sources

- Phase noise
- Power amplifier
- Multi-path
- Model parameters may be
 - Set by group and simulated by contributors
 - Stated and simulated by contributors

Phase noise assumptions

- Purpose: weighing sensitivity of different proposals to phase noise – **not an interface specification**
- Transmitter mmW up-converter and receiver mmW down-converter are expected to dominate phase noise
- Based on PLL-oscillator model

SSB phase noise PSD, $L(f)$



Phase noise model

- The model has four parameters
 - Corner frequency for crystal phase noise
 - Corner frequency for PLL loop
 - LO noise floor level
 - PLL phase noise level
- Two parameters for ease of simulation are a zero at 1Hz, and a pole at 100MHz
- To ease simulation, $1/f$ noise is not accounted for

Phase noise notes

- Thermal noise, discrete spurs and demodulator induced phase noise are **NOT** included in this model.
- Model is to be used for comparison purposes, **NOT** for precise performance evaluation

Power amplifier model

- Two model are proposed
 - Saleh model
 - Rapp model

Saleh model

- Characterize non-linearity in terms of AM/AM and AM/PM conversion functions
- Complex PA envelope is given by
$$Z = A(r) \cdot \exp\{j \cdot (\mathbf{y} + \mathbf{f}(r))\}$$
- AM/AM conversion $A(r) = 2r / (1 + r^2)$
- AM/PM conversion $\mathbf{f}(r) = 2\mathbf{f}_0 \cdot r^2 / (1 + r^2)$
- A.A.M.Saleh “frequency-independent and frequency-dependant non-linear models of TWT amplifiers” IEEE trans. Commun. Vol COM-29, pp. 1715-1720, Nov 1981

Rapp model

- A family of saturation curves

$$v_{OUT} = v_{IN} / \left(1 + (|v_{IN}| / v_{SAT})^{2P} \right)^{1/(2P)}$$

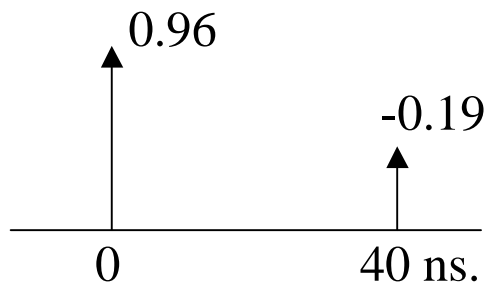
- Where $P_{SAT} = |v_{SAT}|^2$ is the saturated power of the amplifier (P=2)
- The performance metric is lowest backoff, where $Backoff = -10 \log \left(Avg(|v_{OUT}|^2) / P_{SAT} \right)$

Review of Channel Models and/or Measurements for mm-Wave Fixed Wireless Channels with Highly Directional Antennas

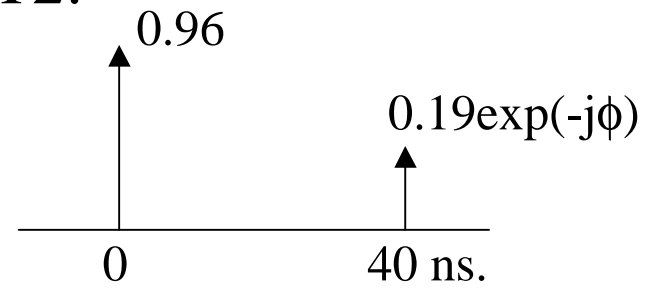
- Papazian et al. measurements in Northglen:
 - P.B. Papazian et al., “Study of the Local Multipoint Distribution Channel”, IEEE Trans. Broadcasting, June 1997.
- ETSI/BRAN models:
 - ETSI/BRAN document HAPHY151TL03, “Channel model suitable for bands over 20 GHz”, 21 Sept. 1999.
- 802.11 model adapted to BBW (N. Chayat):
 - “Some Models for Comparing PHY Proposals”, N. Chayat, IEEE80216pc-YY/nn, Jan. 12, 2000
- CITR measurements in Ottawa:
 - “Multipath Measurements and Modelling for Fixed Broadband Wireless Systems in a Residential Environment”, D. Falconer, IEEE80216pc-00/01, Dec. 20, 1999.

ETSI/BRAN

T1:



T2:

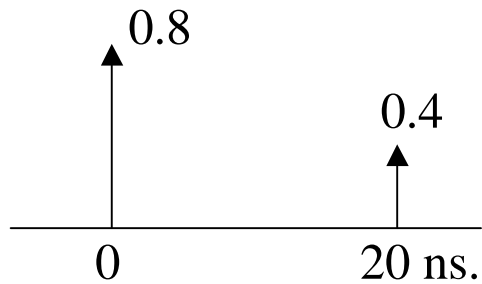


$$\phi = \pi(1 - 0.8(40 \text{ ns.})/T_{\text{symbol}})$$

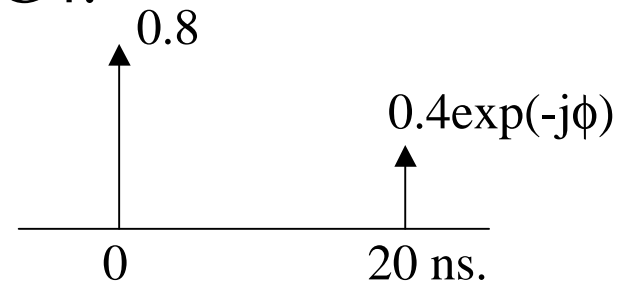
Based on measurements in Europe by Telia

ETSI/BRAN (cont.) and Papazian

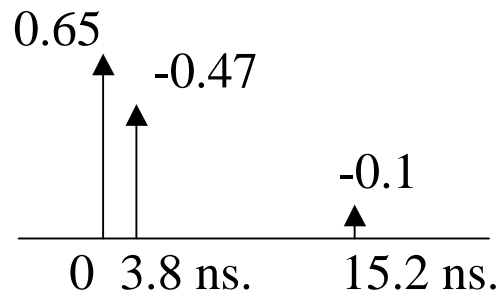
G3:



G4:

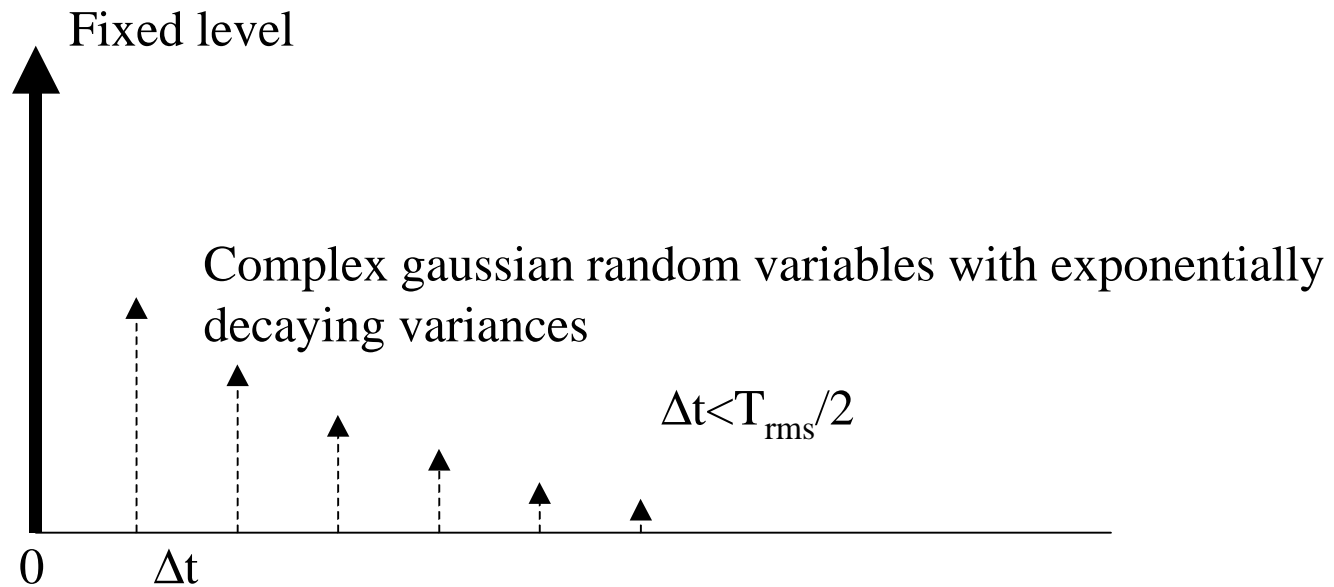


L7/Papazian:



$$\phi = \pi(1 - 0.8(20 \text{ ns.})/T_{\text{symbol}})$$

Adapted 802.11 Model

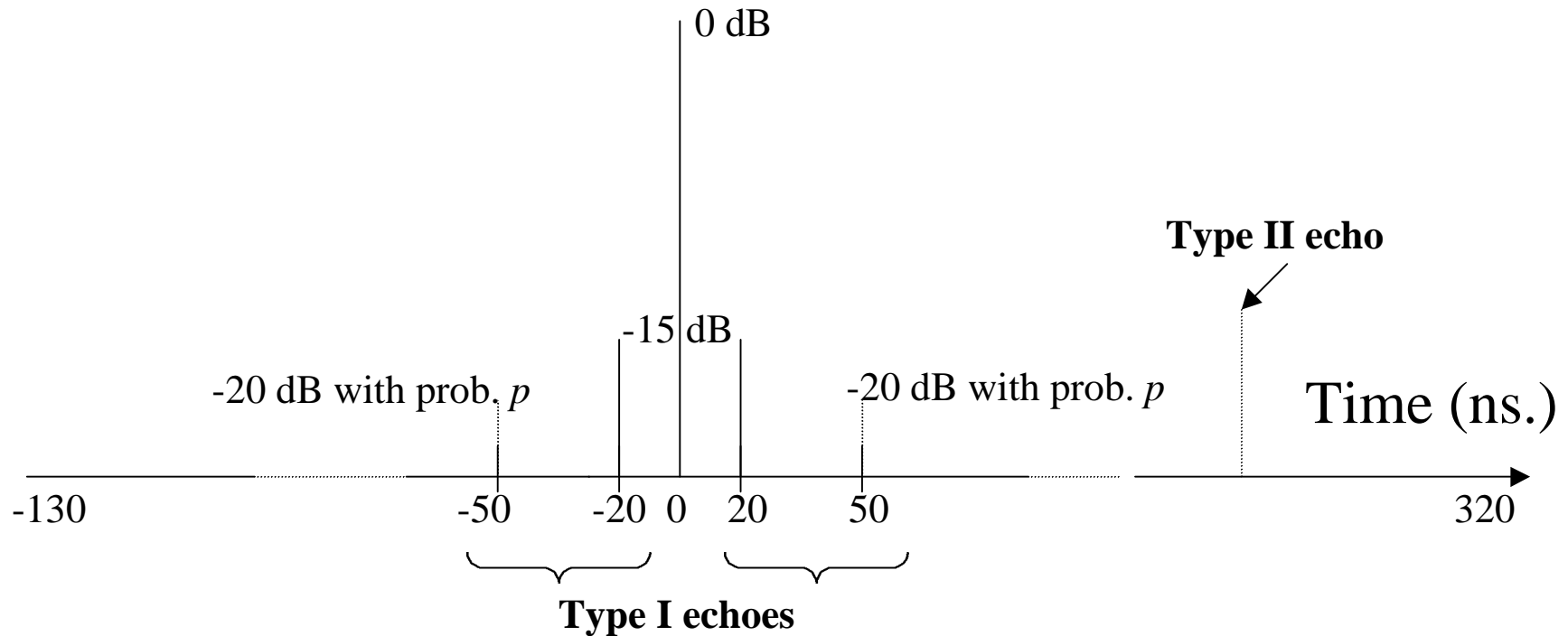


Suitable for:

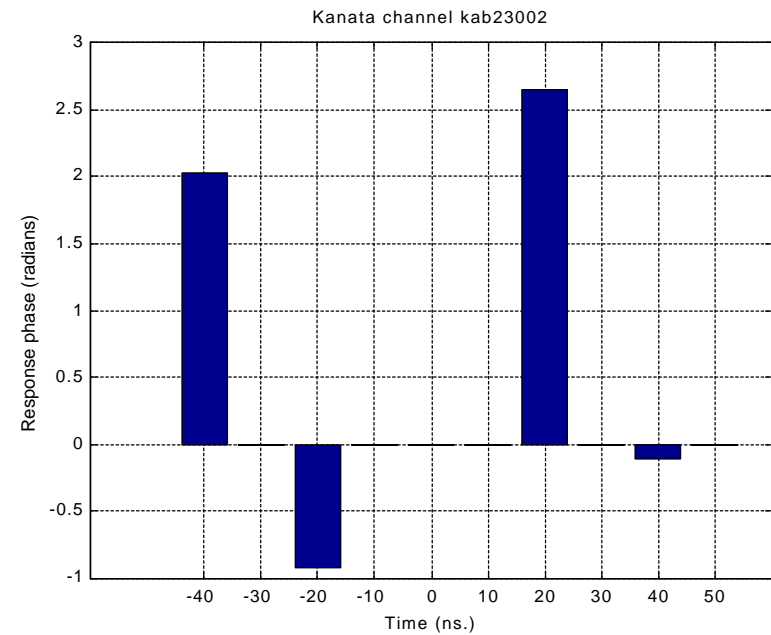
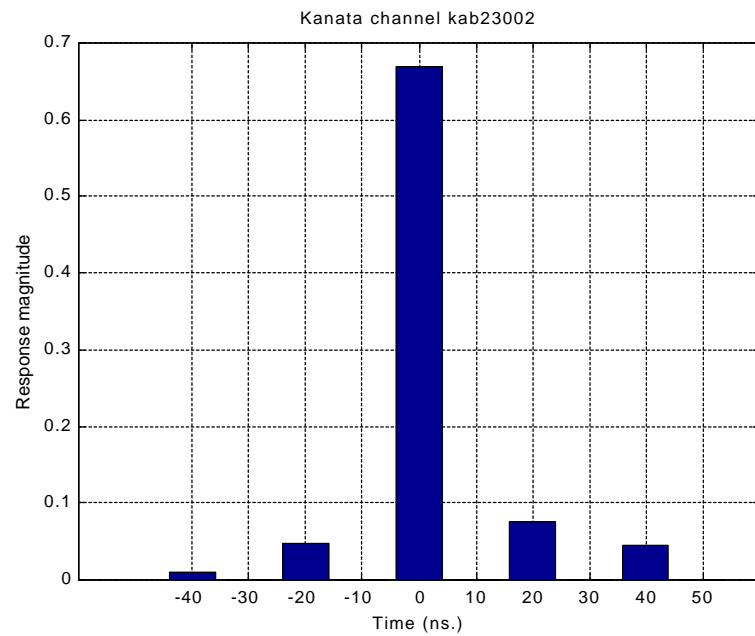
- Low antennas/ non LOS with many incoming echoes
- Or wide antenna beams

Model Suggested in IEEE802.16tc-00-01

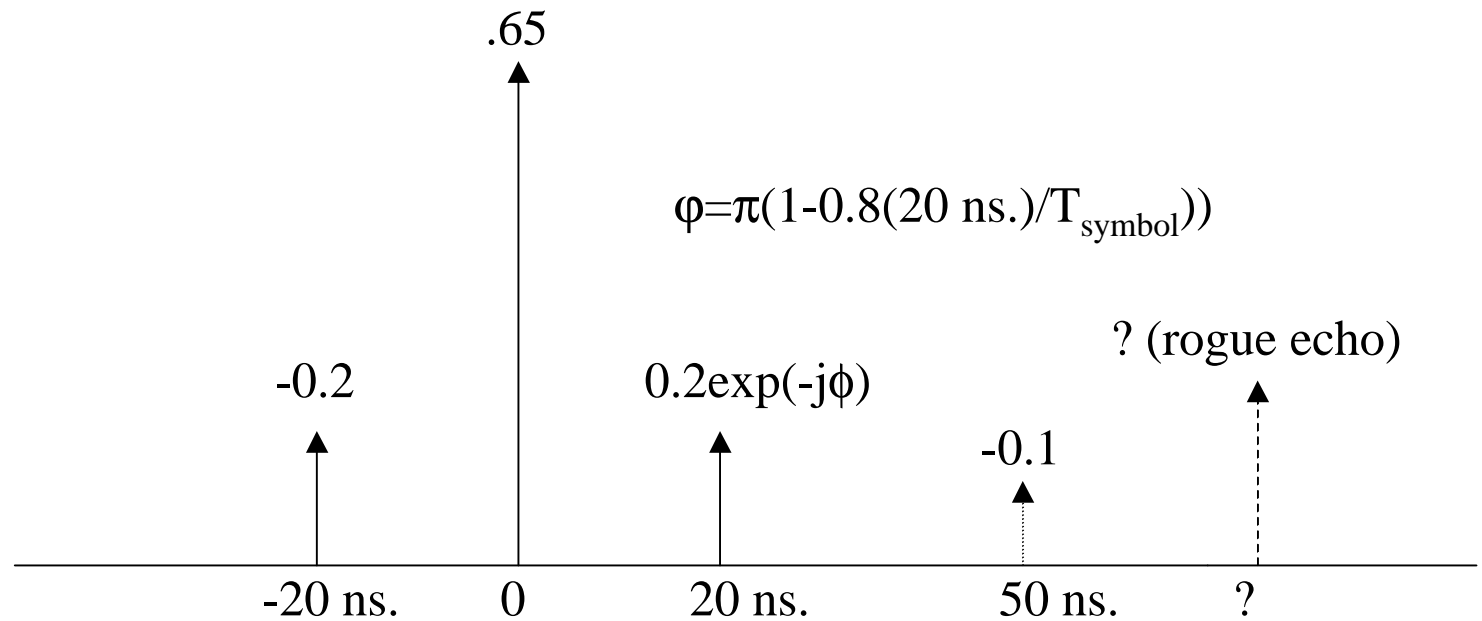
- Based on deviations of measured responses from their means.
- Echoes are zero-mean complex gaussian.



A Measured Kanata Response

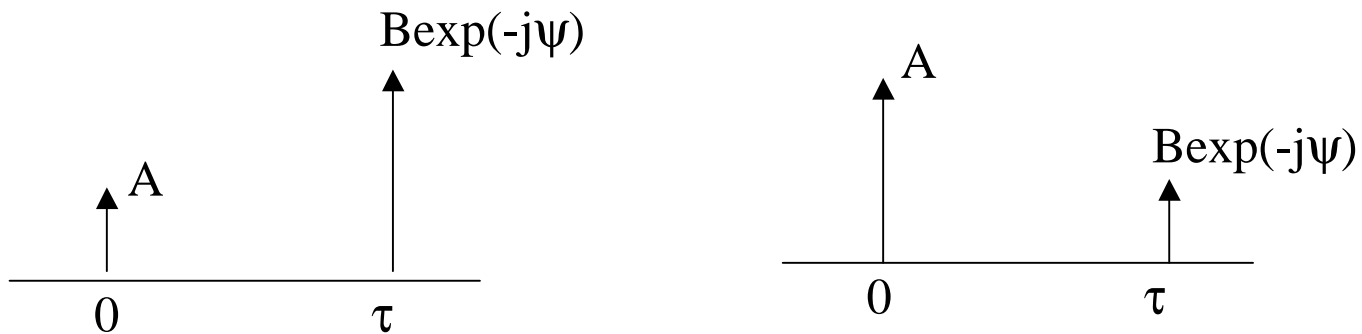


A “Straw Man” Model



Time variation? -- slow compared to symbol rate

A “Straw Man” Model (cont.)



$$A=0.4, B=0.8$$

$$-\pi < \psi < \pi$$

$$0 < \tau < 100 \text{ ns.}$$