Cable Channel and Noise Characteristics- Simulation and Impact on Bit-loading

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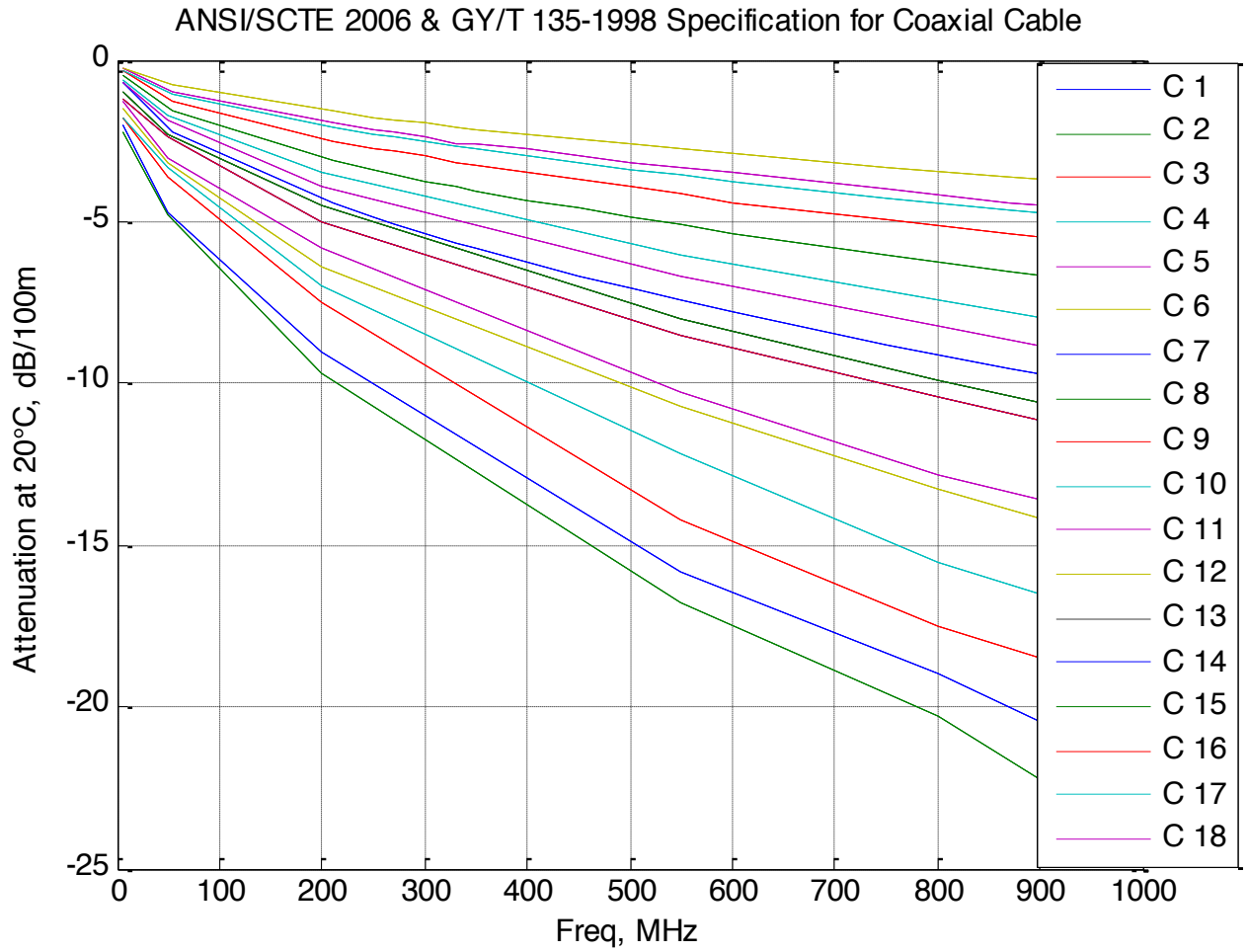
Summary

- Fixed, non-transient channel and noise characteristics
- Downstream
- Bitloading and data rate statistics
- Upstream
- RB capacity statistics

Channel and Noise Impairments Affecting Bit-loading

- Coax characteristics
  - Attenuation
  - Tilt
- Network characteristics
  - Echo/ Multipath
  - Taps, splitters, amplifiers
- Interferers and legacy
  - FM
  - Analog video
  - Digital video
- Signal Impairments
  - IM products
  - CSO and CTB
  - CPD

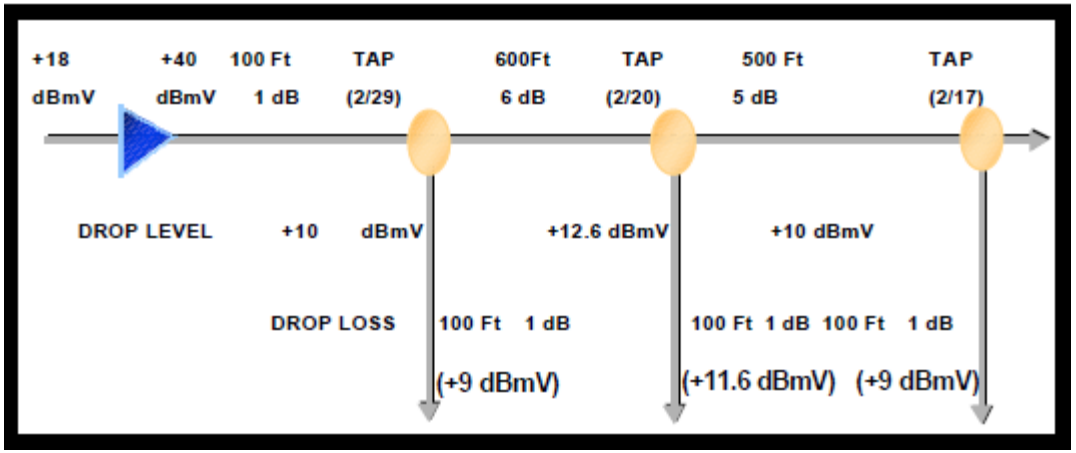
Coaxial Cable Attenuation/Tilt



[1] "Specification for Trunk, Feeder and Distribution Coaxial Cable," ANSI/SCTE 15 2006
[2] "Specifications and methods of measurement on coaxial cable with physically - Foamed polyethylene insulation used in CATV systems," GY/T 135-1998

Assumptions

- Amplifiers in the coax path counter coax loss, tilt
- Taps with decreasing insertion loss along the feeder cable



- Coax from tap to home has tilt, unaccounted loss
- Assume 50m to 200m length from tap to home

Echo/Multipath

- IEEE 802.14 over-estimates echo
- Use Redesign model [5]
- Assume 2 reflections

in 200 ns (within home)

- Assume 4 reflections

in 200 to 800ns (multi-tap)

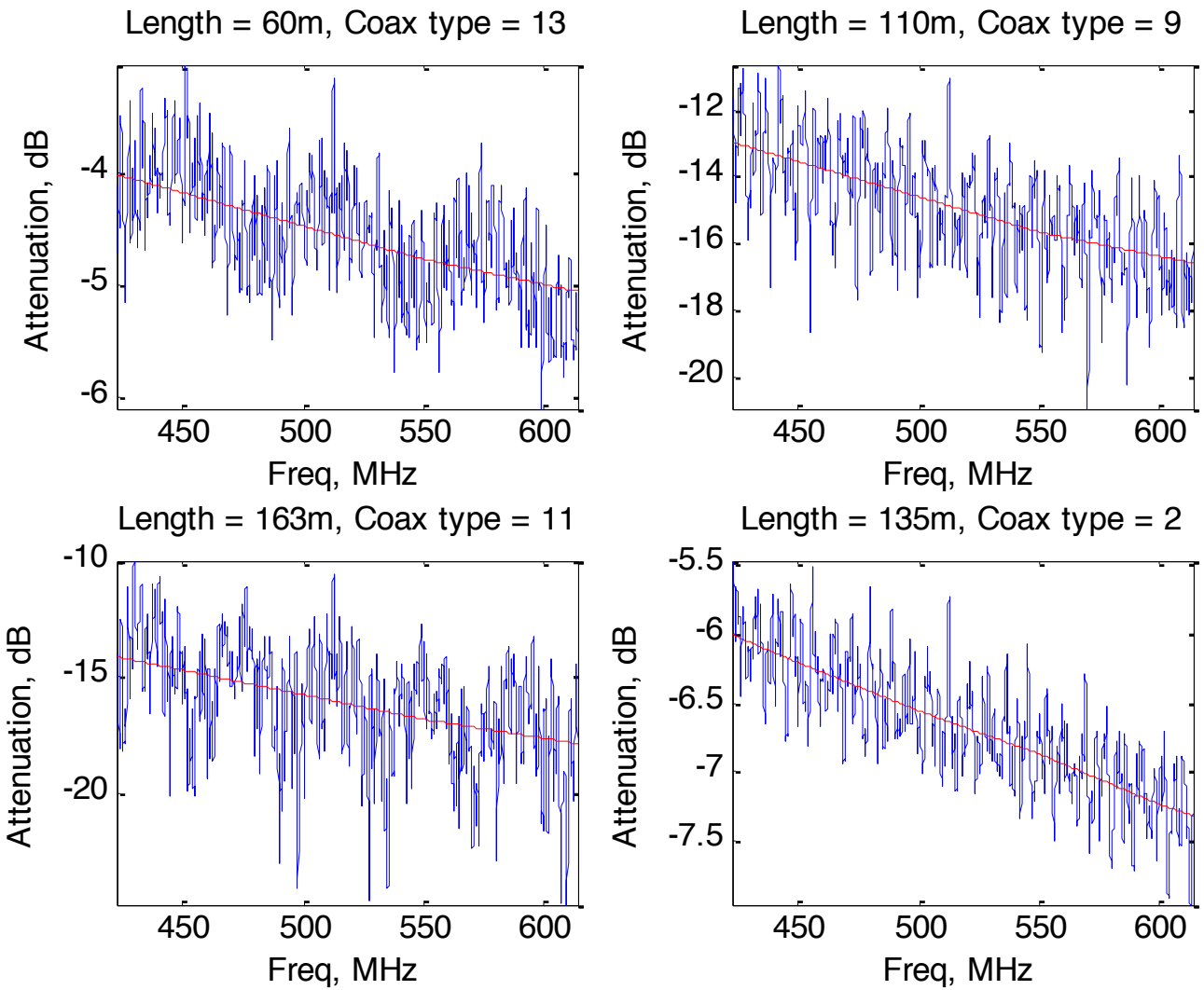
- Allow up to 20dB lower

echo power

Power (dB)	Delay (ns)
-11	0-200
-14	200-400
-17	400-800
-23	800-1200
-32	1200-2500
-40	2500-15000

[5]. ReDeSign "HFC Channel Model," December 2008

Sample Downstream Channels 422 to 614 MHz



Noise floor

- -160 to -140 dBm/Hz

[3] Chen, W.Y.; Kerpez, K., "Coaxial cable distribution plant performance simulation for interactive multimedia TV," *Global Telecommunications Conference, 1995. GLOBECOM '95., IEEE* , vol.1, no., pp.173,177 vol.1, 14-16 Nov 1995

Ave	-140
50%	-150
90%	-140
95%	-136
99%	-128

Table gives average, 50 (median), 90,95, and 99 percentile noise (dBm/Hz)

[4] Prodan et al., "Analysis of Cable System Digital Transmission Characteristics," 1994 NCTA TECHNICAL PAPERS

Use -150 to -160 dBm/Hz for downstream

Downstream Sharing

- Analog TV
- Digital TV
- FM
- Assume

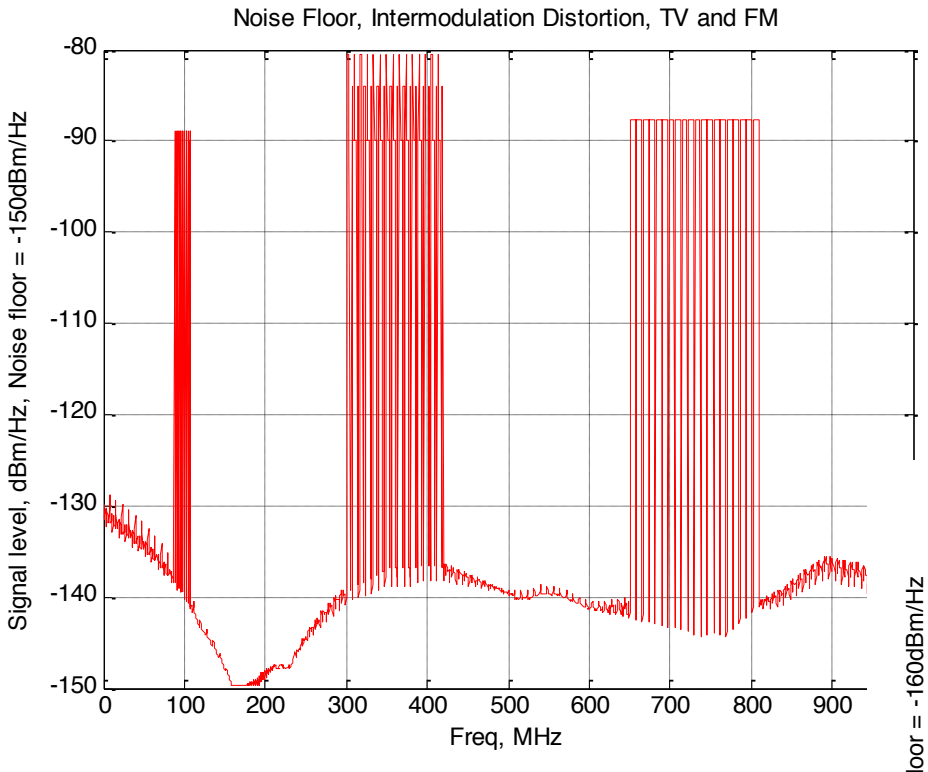
- 15 PAL channels starting at 300MHz
- 20 Digital channels starting at 650MHz
- 20 FM stations in 88 to 108 MHz range

IM Products - Nonlinearities

- IM products with one or more digital parents have “broad” spectrum with a low PSD
- IM products from PAL/SECAM signals only have a “narrow’ spectrum with a high PSD
- Narrowband beats in the frequency domain have [5]: A variable signal level with an average level of 24 dB above the noise level.
- **FCC system specification for CSO and CTB: equal to or greater than 51 dB [6]**

[6] Operation and Design of the HFC Network , PS # 10348 -TG Rev.1.0 053105

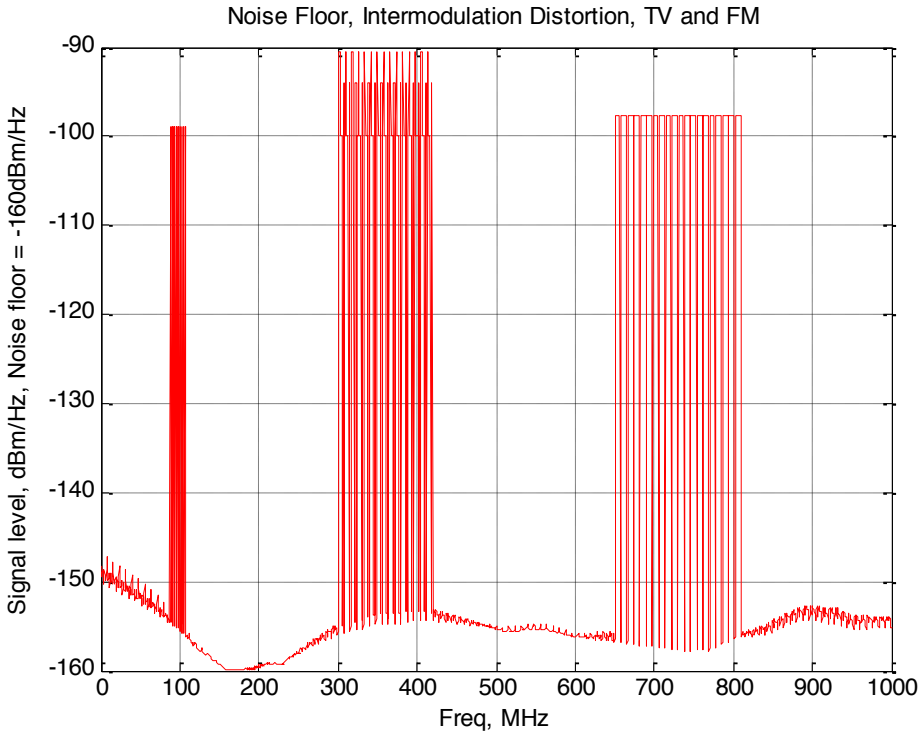
Sample Downstream Noise and Legacy



- 15 PAL channels starting at 300MHz
- 20 Digital channels starting at 650MHz
- 20 FM stations in 88 to 108 MHz range

Figures show intermodulation affects :

- Raised broadband noise floor
- Narrowband peaks



Analyze downstream rates in 422 to 614 MHz

Downstream Simulation

Channel Profile

- Select distance from tap to user (50m to 200m)
- Select cable type (1 to 18)
- Get basic attenuation profile
- Select number of multipath components (Up to 20dB lower than ReDesign)
- Add multipath

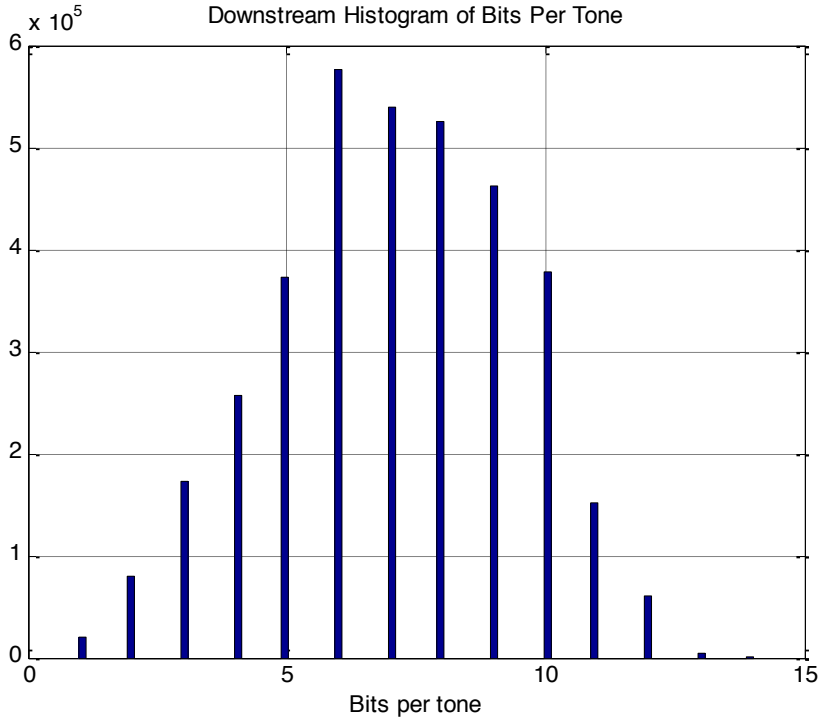
Noise Profile

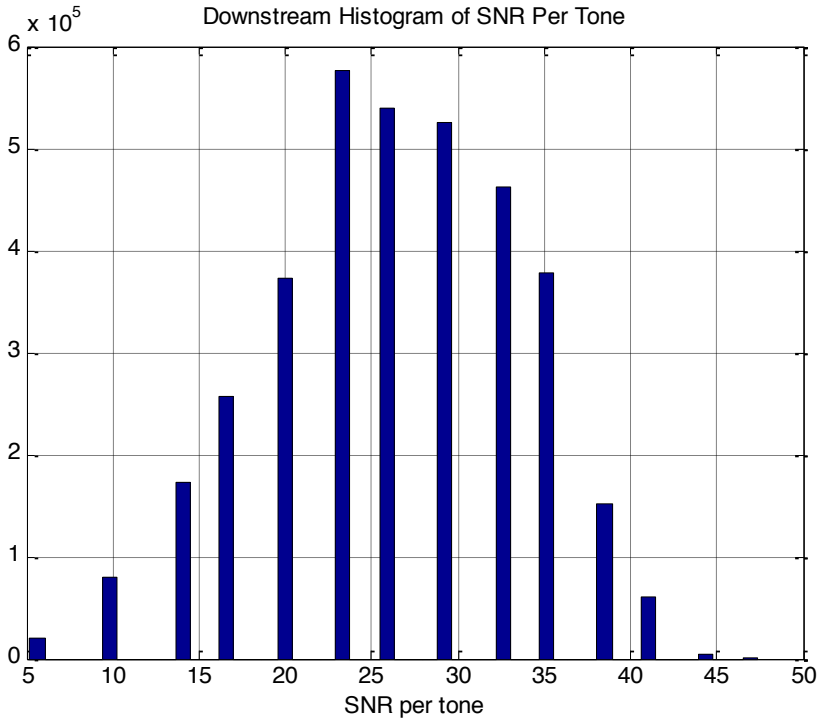
- Select basic noise level (-150 to -160 dBm/Hz)
- Add intermodulation products

Do bit-loading

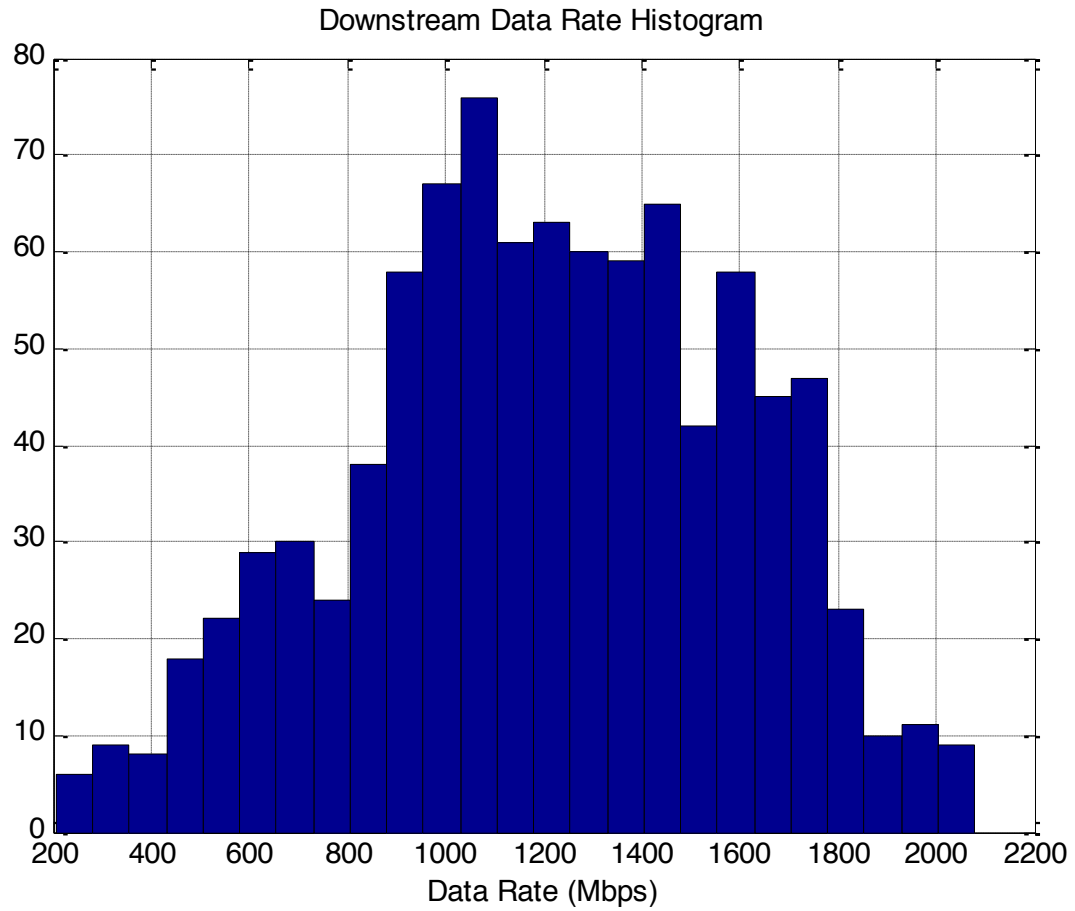
Measure data rate

Downstream Results





Downstream Data Rates

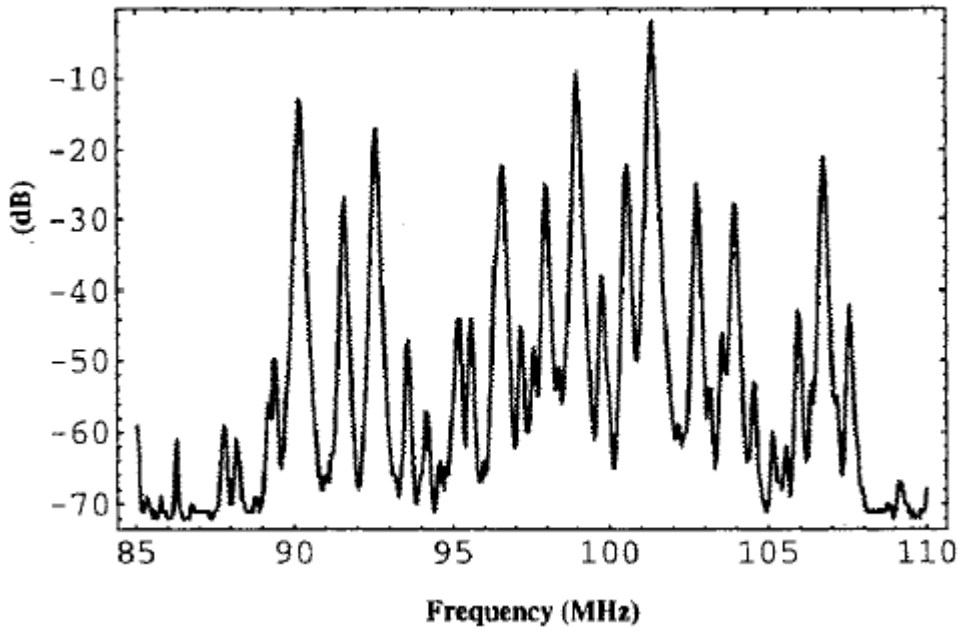


Upstream

- Up to 300MHz
- Higher noise than downstream
- FM interference
- Common path distortion (CPD), intermodulation products

FM shielding

- FM Radio band - 88 to 108 MHz



Measured FM spectrum (assumed baseline)

Ave	67
50%	58
90%	42
95%	36
99%	27

Table gives average, 50 (median), 90,95, and 99 percentile home wiring shielding (dB)

[4] Prodan et al., "Analysis of Cable System Digital Transmission Characteristics," 1994 NCTA TECHNICAL PAPERS

Common Path Distortion

- Occurs on the part of the network common to the forward and return Path
- Composed of distortion products of the downstream signals
- 2nd or 3rd order or both
- Amplitudes vary with conditions

[7] NCTA Recommended Practices for Measurements on Cable Television Systems' 2nd edition (revised 1993), SUPPLEMENT on UPSTREAM TRANSPORT, October 1997
[8] Barry Pater, "CHARACTERISATION OF COMMON PATH DISTORTIONS," http://cable.doit.wisc.edu/cpd/cpd2.v2.html#origins

Upstream Simulation

Channel Profile

- Select distance from tap to user (50m to 200m)
- Select cable type (1 to 18)
- Get basic attenuation profile
- Select number of multipath components (Up to 20dB lower than ReDesign)
- Add multipath

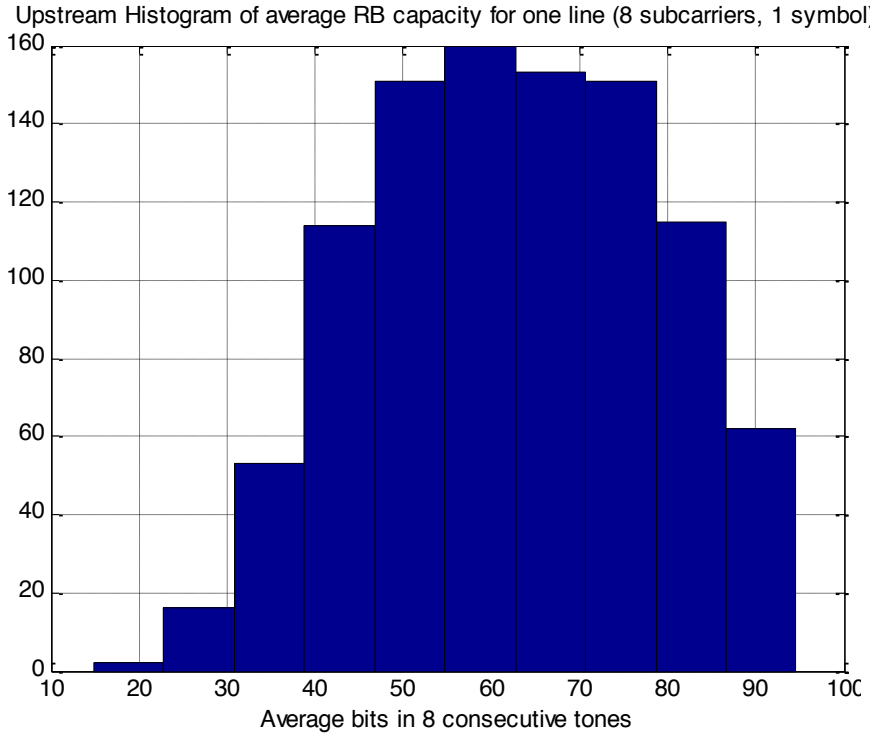
Noise Profile

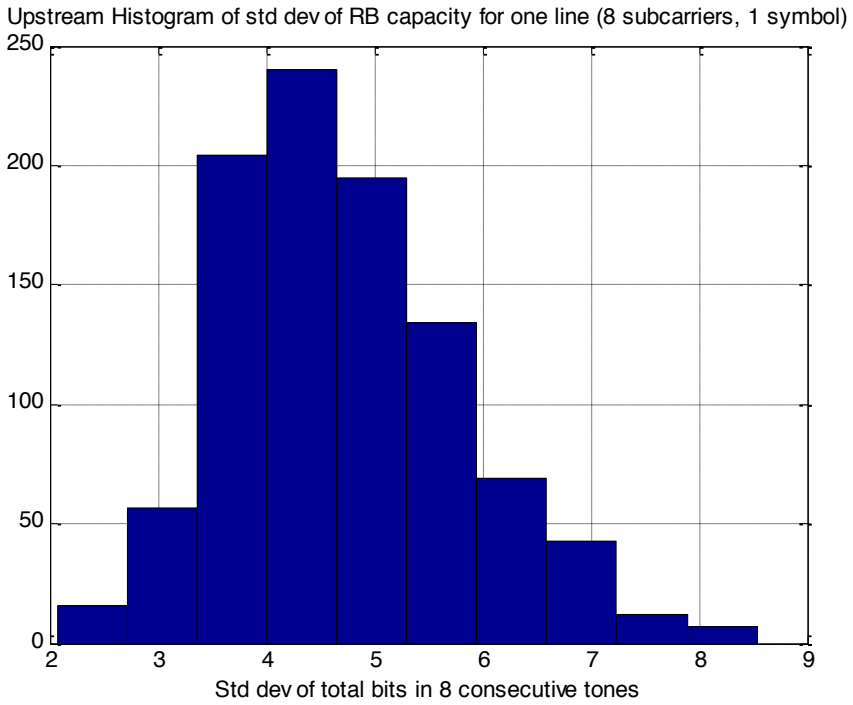
- Select basic noise level
- Add intermodulation products
- Add FM interference

Do bit-loading

Measure RB capacity

Upstream Results





Questions?