Channel Model Downstream Description and Update

802.3bn Face to Face, Jan 2013

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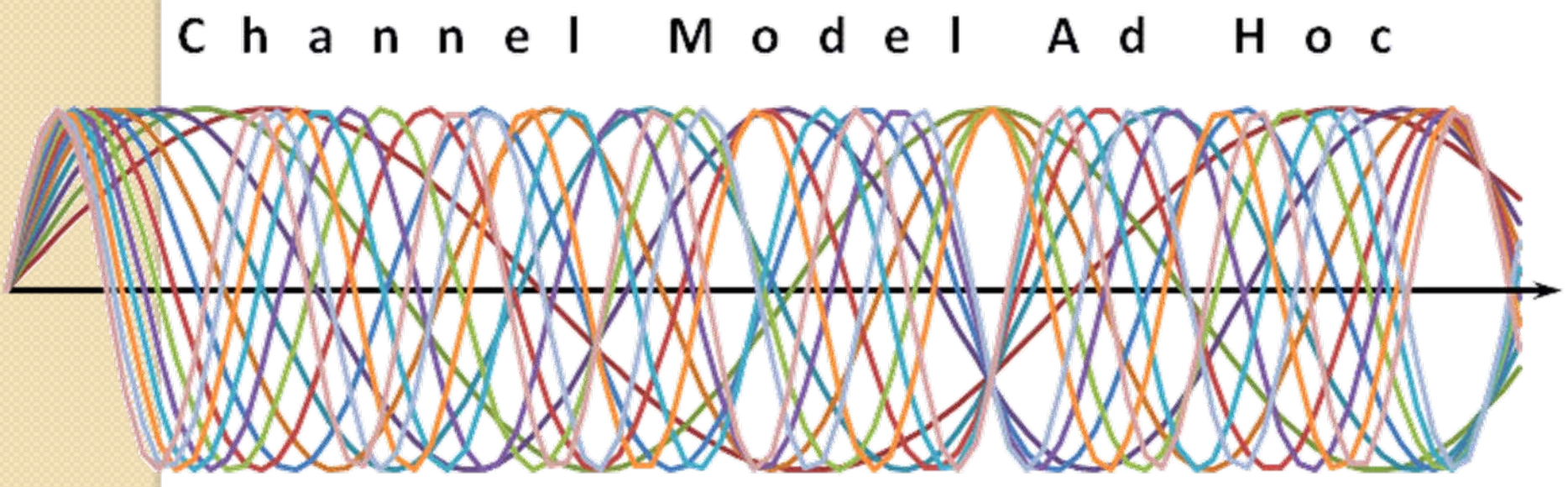
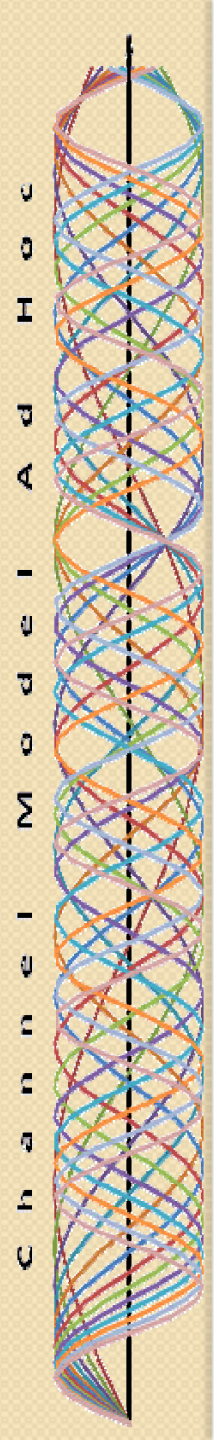




Topics

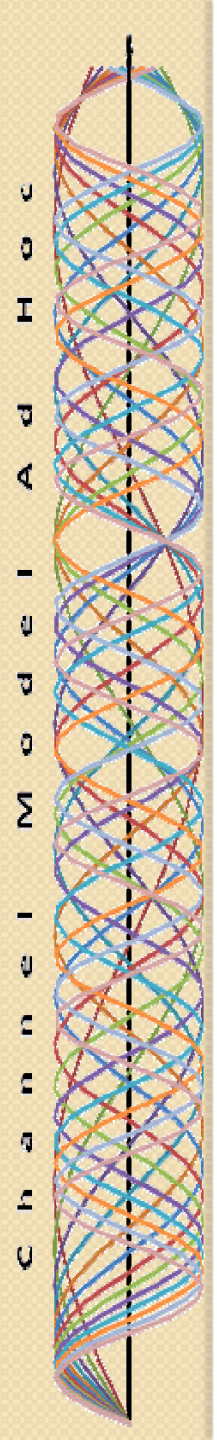
Downstream Table (HFC Architecture Case)

Question and TBD Items

EPoC Architectures to Evaluate

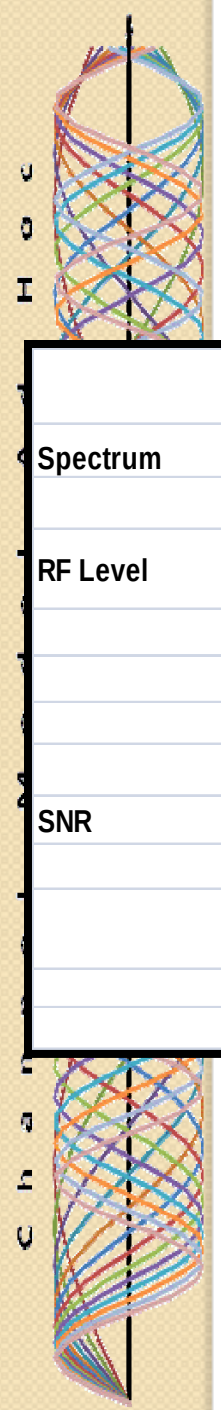
- Downstream
- Upstream

Upstream Table (Parameters only)



Page 1 of 5 of D/S Table

Scenario		A
HFC D/S Spectrum		1.0 GHz
Cascade Depth		N+6 (EOL)
Channel Loading		79 Analog + 53 Digital
Optical Architecture		Linear Optics 1310 nm, nominal link leng
Home Architecture		Up to max drop length & 4-way splitter



Page 2 of 5

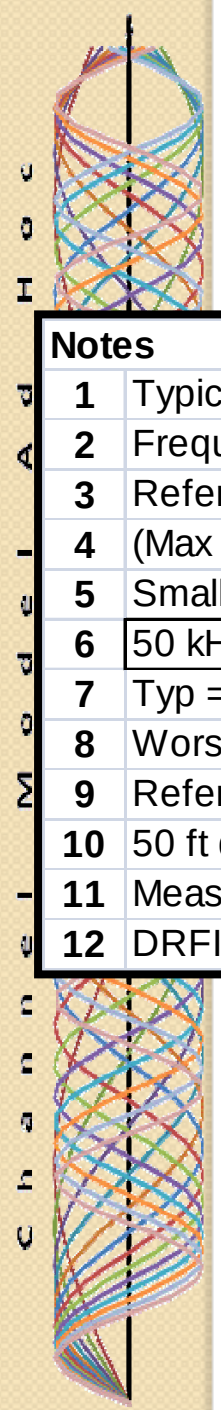
	#	Parameters	Typical[1]	Limit	Good	Notes/Dependency
Spectrum	1	**Frequency range**	54 MHz - 1 GHz			
	2	**OFDM Bandwidth**	192 MHz			
RF Level	3	**OFDM Power at CPE Input (dBmV)**	15 dBmV, 100 ft, 2-way	10 dBmV, 150 ft, 4-way	20 dBmV, 50 ft, direct	Notes 2, 3
		6 MHz BW	-2	-14	10	Note 4
		24 MHz BW	4	-8	16	
		96 MHz BW	10	-2	22	
		192 MHz BW	17	5	28	Note 5
SNR	4	**SCN Ratio (Signal to Composite**	43	40	46	
		Variation over 6 MHz BW (dB)	N/A	N/A	N/A	Reference Basis is 6 MHz
		Variation over 24 MHz BW (dB)	1.5	Ops Field Alignment Criteria	0.5	
		Variation over 96 MHz BW (dB)	2.0	Q1	1.0	
		Variation over 192 MHz BW (dB)	2.0		1.5	(TBD CL Data Anonymization)

Page 3 of 5

Interference	5	**CTB Interference (20 kHz BW)**				Note 6
Narrowband		# of interfered subcarriers @ 30-35 dBc	0%	1%	0%	Note 7
		35-40	1%	0%	0%	
		40-45	0%	0%	0.5%	
		>45	0%	0%	0.5%	(TBD CL Data Anonymization)
	6	**CSO Interference (20 kHz BW)**				Note 8
		# of interfered subcarriers @ 30-35 dBc	0%	2%	0%	
		35-40	0%	0%	0%	
		40-45	2%	0%	0%	
		45-50	0%	0%	1%	
		>50	0%	0%	1%	(TBD CL Data Anonymization)
	7	**LTE Interference**				
		Bandwidth (MHz)	10	40	None	
		Level, dBc (PSD)	-3	-20	N/A	
	8	**Additive Interference (other)**				Additional bands & levels
		Range of dBc		Q2		(e.g. Land Mobile 808-901 MHz)
		Percentage of effected subcarriers				
Wideband	10	**Burst noise (spectrum, duration, duty, dBc)**	Q3	25 usec, 10 Hz, 0 dBc	None	
	11	**Impulse (white) noise (duration, duty, dBc)**	<.5 nsec, avg 12 usec, 10x AWGN pk	Same	Same	Laser Clipping only type Poisson Impulse train w duration & amplitude PDFs (Note 9)

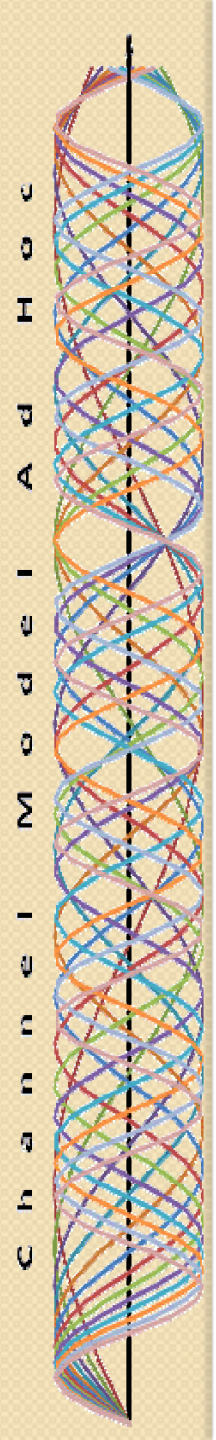
Page 4 of 5

Freq Response						
Amplitude	12	**Amplitude Slope**	Typ Tilt, 1st Tap, not Eq	Max Uptilt or 10 dB Rule	Only (Eq)	
		dB/MHz	0.01	0.02	0.004	Note 10
	13	**Amplitude Variation**	Ops Field Alignment Criteria	Q4	Typ Cascade Rules	SCTE Definition, Echo not included
		(dB pk-pk/6 MHz)		6	1.0	
		(dB pk-pk/24 MHz)			1.5	
		(dB pk-pk/192 MHz)			2.0	
		(dB pk-pk/Total DS BW)			4.0	
Phase	14	**Group Delay Variation, nsec**	Spec Cascade			
		Over 24 MHz				
		Mid Band	40	80		
		Band Edge (24 MHz)	240	300		
		Over 192 MHz				
		Mid Band	320	640		
		Band Edge (24 MHz)	1920	2400		(TBD Model BRCM)
Echo	15	**Delay Spread Profile, dBc**	99%	SCTE-40	Majority	Echo Mask - Does not imply a particular number of echoes
		.5 usec	-20	-10	-30	Note 11
		1 usec	-25	-15	-35	
		1.5 usec	-30	-20	-35	Q5
		2 usec	-35		-40	
		3 usec	-40		-45	
		4.5 usec	-45	-30	-50	
		5 usec	-50		-55	
Spurious Modulation	16	**AM/Carrier hum modulation (dBc)**	-30	-26	-40	



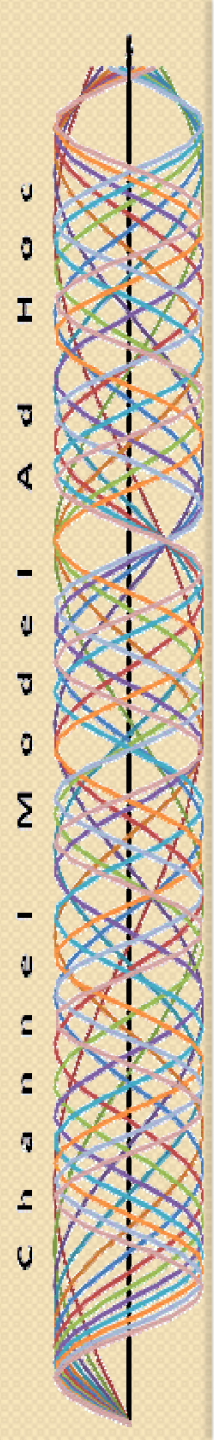
Page 5 of 5

Notes	
1	Typically behaving link but where the normal behavior is the worst (freq, location)
2	Frequency dependence of coax for broadband calculations: Loss B (dB) = Loss A (dB) x SQRT(B/A)
3	Reference virtual port level for 6 MHz signal at 1 GHz
4	(Max Freq - OFDM BW) spectrum range used for drop loss
5	Small drop slope effect on calculation
6	50 kHz Subchannel Reference, Live Video, Fully contained within subchannel
7	Typ = CTB/CSO Worst Case Freq; Good CTB/CSO where distortion is low
8	Worst spectrum regions for CTB and CSO are not the same
9	Reference Technical Papers: Mazo, Shi, Pan & Green
10	50 ft drop assumed (Minimum drop impact)
11	Meas@700-800 MHz. Freq Dep (one-way loss) increase, fmin: 7 dB for .5-1.0 usec, 9 dB for > 1 usec
12	DRFI D/S Mask + J.83B Compliant RF Tuner



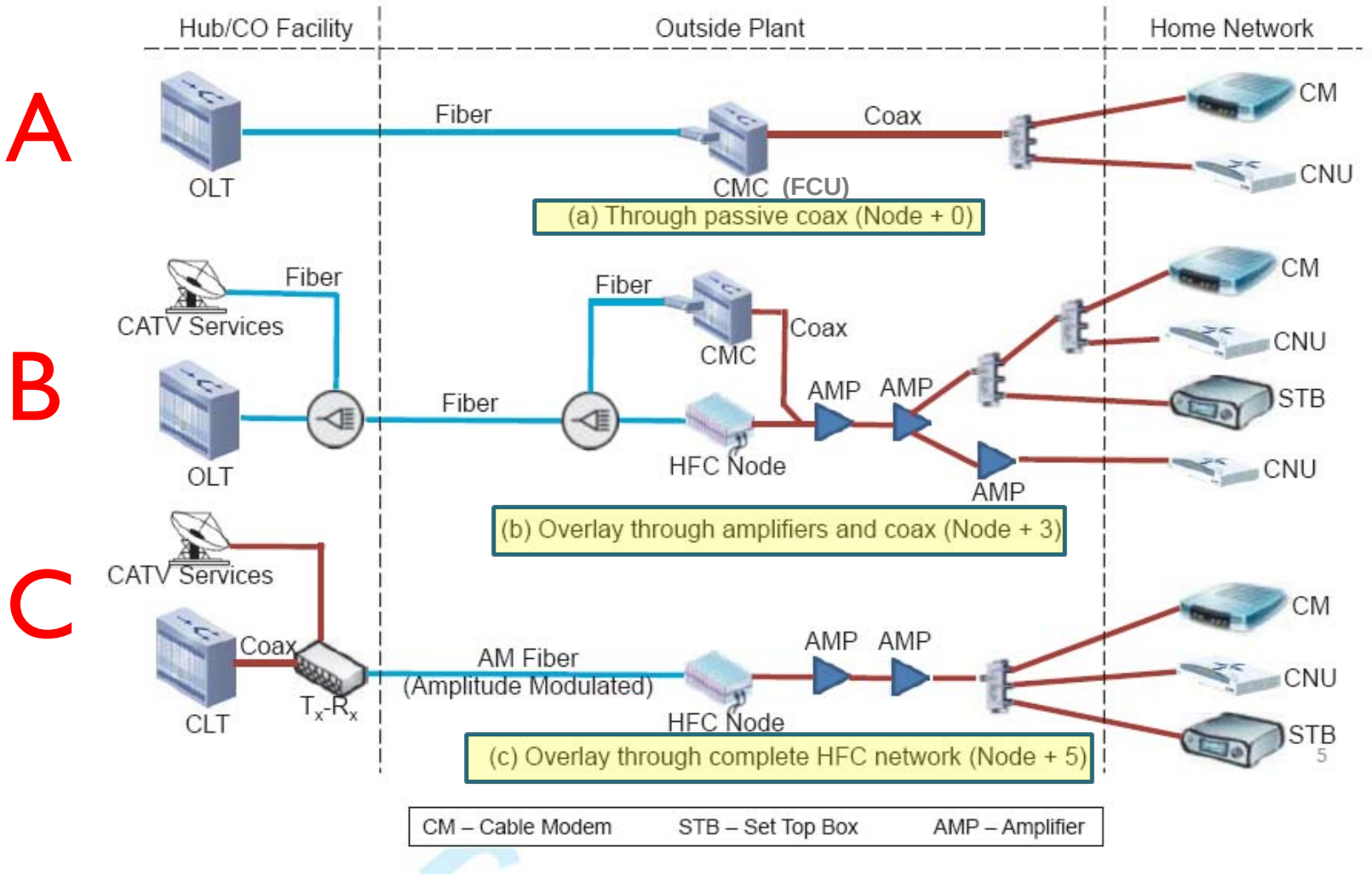
Q1 through Q5 on D/S Table

1) Are there MSO Field Operation guidelines that can be share for setup and alignment of plant levels and CNR variation across a coaxial segment?
2) What other additive narrowband interference sources and relative levels have been noted and recorded (e.g. land mobile)
3) What to assume for "Typical" Burst noise characteristics - WIP
4) Recent plant wideband frequency responses on the reflector indicate some pretty extreme scenarios. How should these be captured? What should be considered as representing a "typical" or "limit" case, and what should be discounted as "in need of repair?"
5) Are there any other freq bands where delay spread has been captured? What cable type typically is run around headend between optical receivers and CMTS?

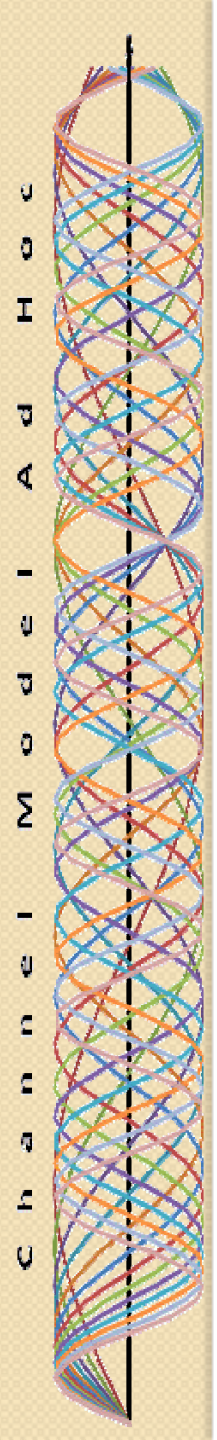


EPoC Architectures to Evaluate

EPoC Architecture Options



Reference: *Bhaumik, Partha et al, "EPON Protocol over Coax (EPoC): System Overview and Design Issues," (TBD), (currently under editorial review IEEE Communications Magazine)*



DS Priority Architectures – A & B

Optics

EPoN Link – 20 km (no RF performance contribution)

Cascade Depths

N+0 (A)

N+3 (B)

Drop Architecture

150 ft RG6

2-Way Splitter

15 dBmV Tap Port Level (Ref 6 MHz carrier)

Coaxial Spectrum

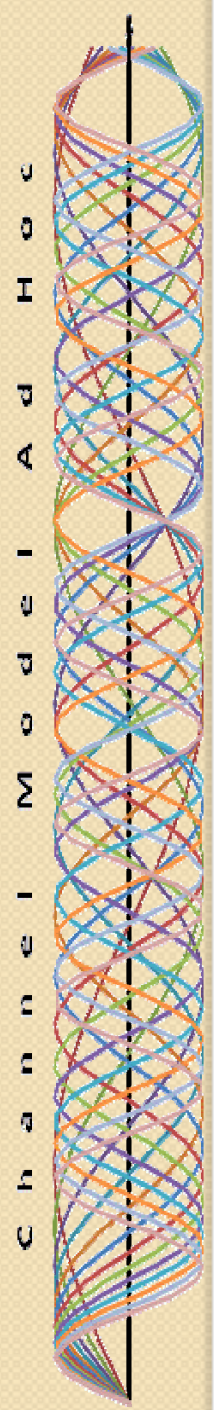
54 MHz – 1 GHz, 14 dB Uptilt (B)

1.2 GHz – 1.7 GHz, same dB/MHz Uptilt (A)

RF Loading

0 Analog, OFDM @ Current Digital Levels (PSD) (B)

Consider some Tx Level & Path Loss assumptions



US Priority Architectures – A & B

Optics

EPON optical link (No RF contribution)

RF Cascades

N+3, Node with 4x RF Combining, # Amps = 12 (B)

N+0, Node with no RF Combining (A)

Spectrum Allocations

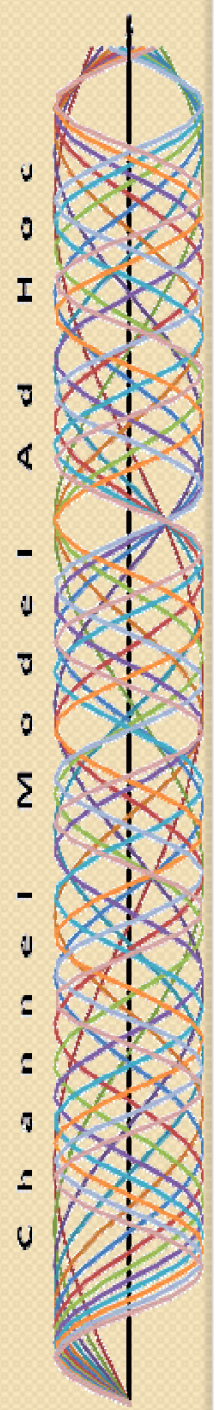
5 MHz – 85 MHz

5 MHz – 200 MHz

1.2 GHz – 1.7 GHz (*N+0 Only*), upgraded Taps (A)

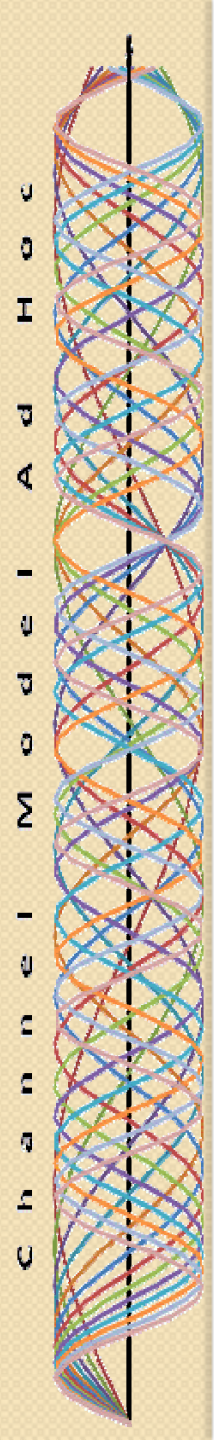
900 MHz – 1.1 GHz, excess Tap BW only (A maybe B)

65 dBmV Available CPE Linear Tx Power

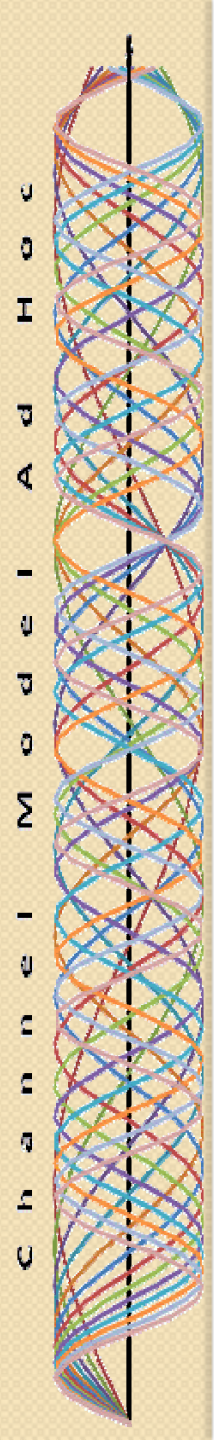


Upstream Scenario Description

Scenario	1	
HFC D/S Spectrum	85 MHz	
Node Architecture	30 Amplifiers	
Channel Loading	Linear DFB Optics 1310 nm, 20 km	
HE Architecture	No HE Combining	
Premise Architecture	Two Way Combining	

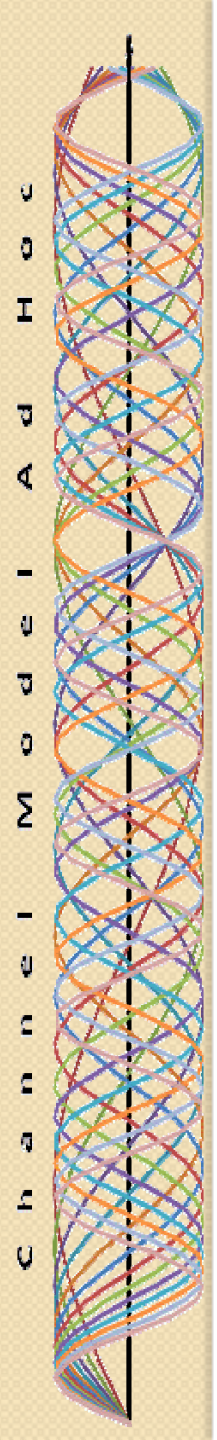


Upstream Table (Parameters Only)



Upstream Parameters

11	Amplitude Slope
12	Amplitude Variation
	(dB pk-pk/6.4 MHz)
	(dB pk-pk/24 MHz)
	(dB pk-pk/192 MHz)
	(dB pk-pk/Total US BW)
13	Group Delay Variation
	(ns/MHz over 24 MHz)
	Mid Band
	Upper Band Edge
	(ns/MHz over 192 MHz)
	Mid Band
	Upper Band Edge
14	Delay Spread Profile, dBc
	.5 usec
	1 usec
	1.5 usec
	2 usec
	3 usec
	4.5 usec
	5 usec
15	AM/Carrier hum modulation



Upstream Parameters

1	OFDM Bandwidth
2	Frequency range
3	OFDM Power at CMTS Input
	6.4 MHz BW
	24 MHz BW
	80 MHz BW
	192 MHz BW
4	SCN Ratio (Signal to Composite Noise Ratio)
	Variation Freq, 6.4 MHz BW
	Variation Freq, 24 MHz BW
	Variation Freq, 80 MHz BW
	Variation Freq, 192 MHz BW

5	FM Band Interference
	Bandwidth
	Level, dBc (PSD)
6	Other Known Bands
7	Common Path Distortion
8	Additive Spurious interference (other)
	dBc Range
	Percentage of effected subcarriers
9	Burst noise (spectrum, duration, duty, dBc)
10	Impulse noise (white, duration, duty, dBc)

THANK YOU