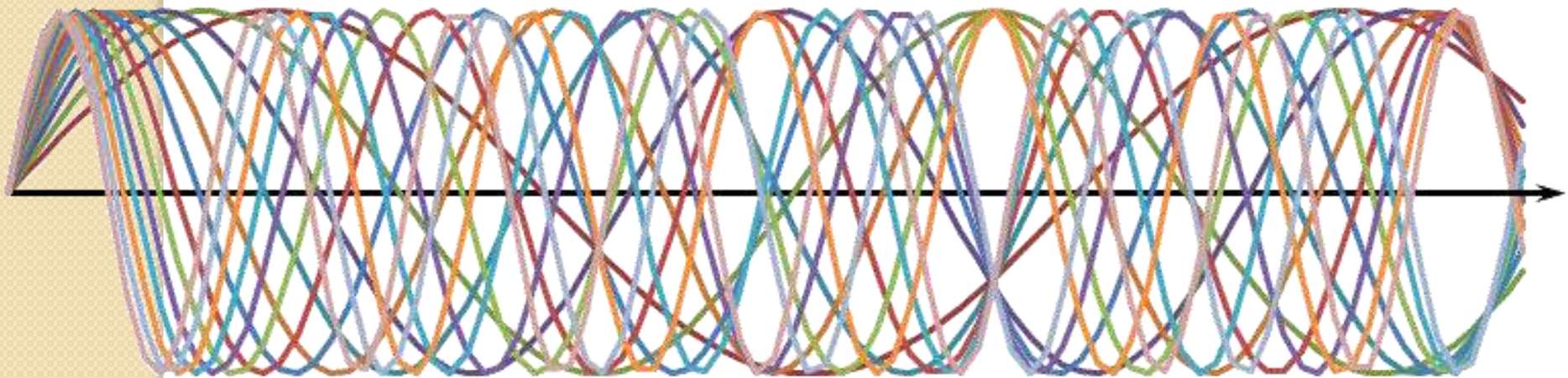


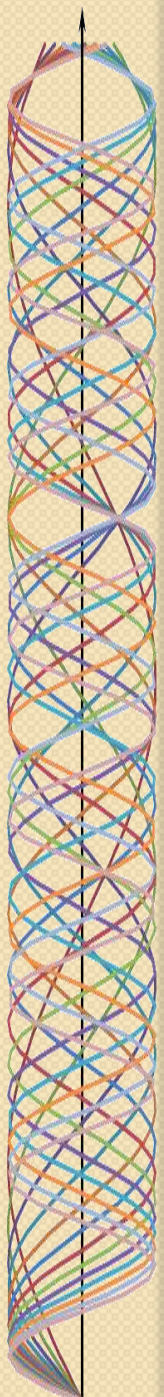
# IEEE p802.3bn EPoC

Channel Model Ad Hoc committee

Informative Channel Models

C h a n n e l   M o d e l   A d   H o c

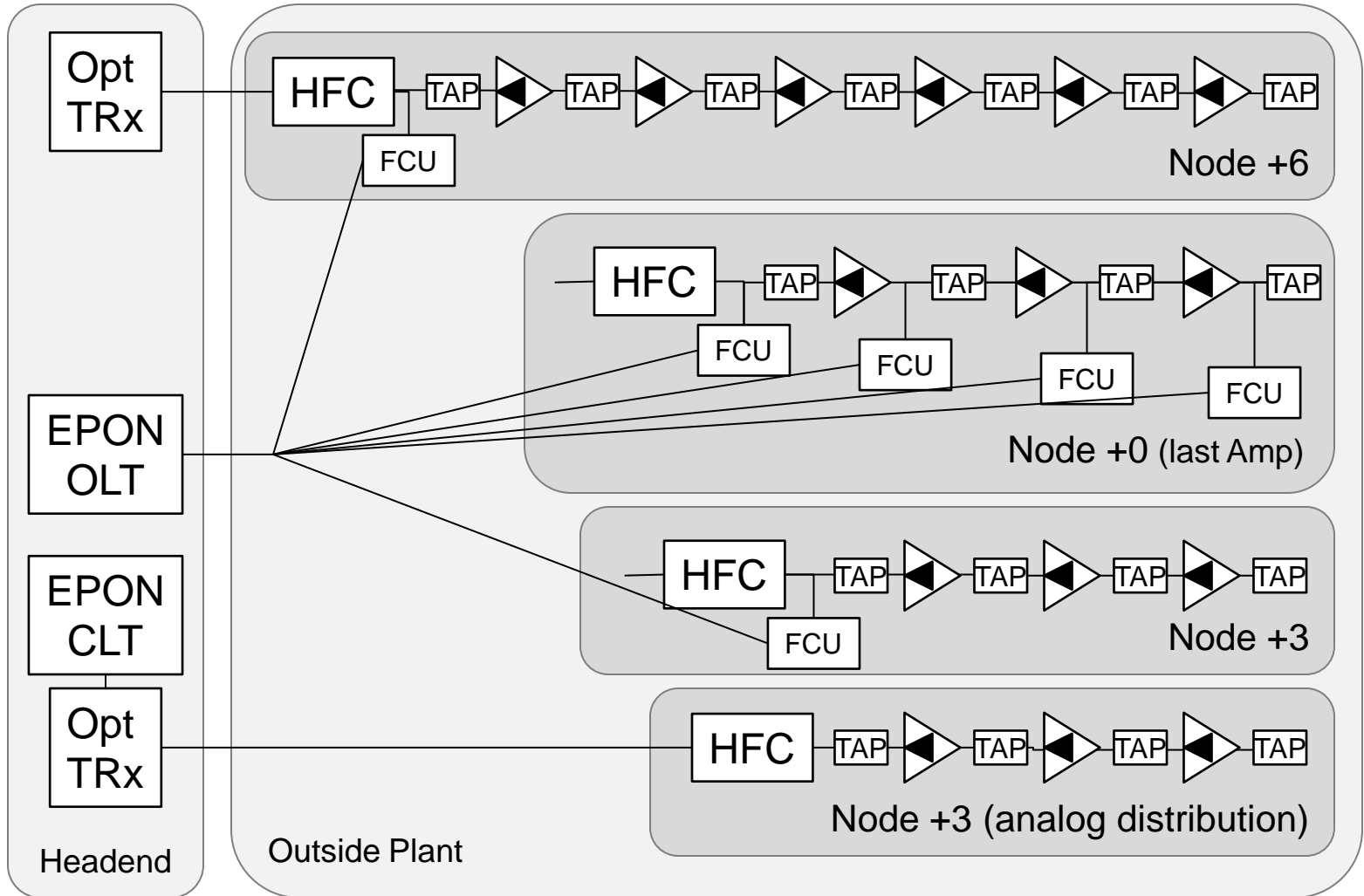




# Agenda

- Topology illustrations
- Parameter Tables

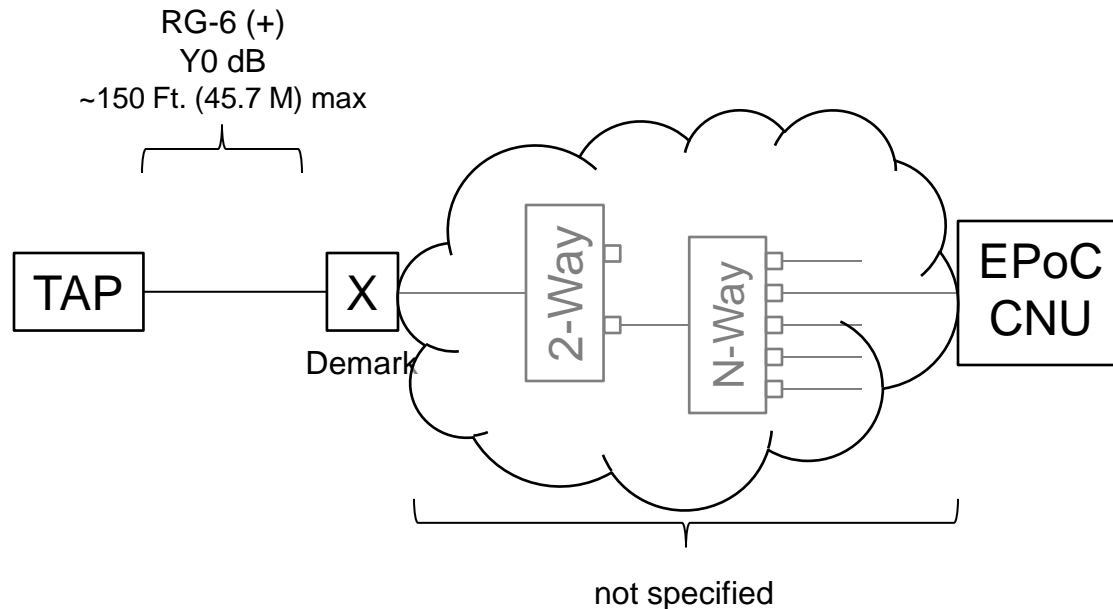
# Informative Topologies



# Drop / Subscriber Premise

## Not Preferred

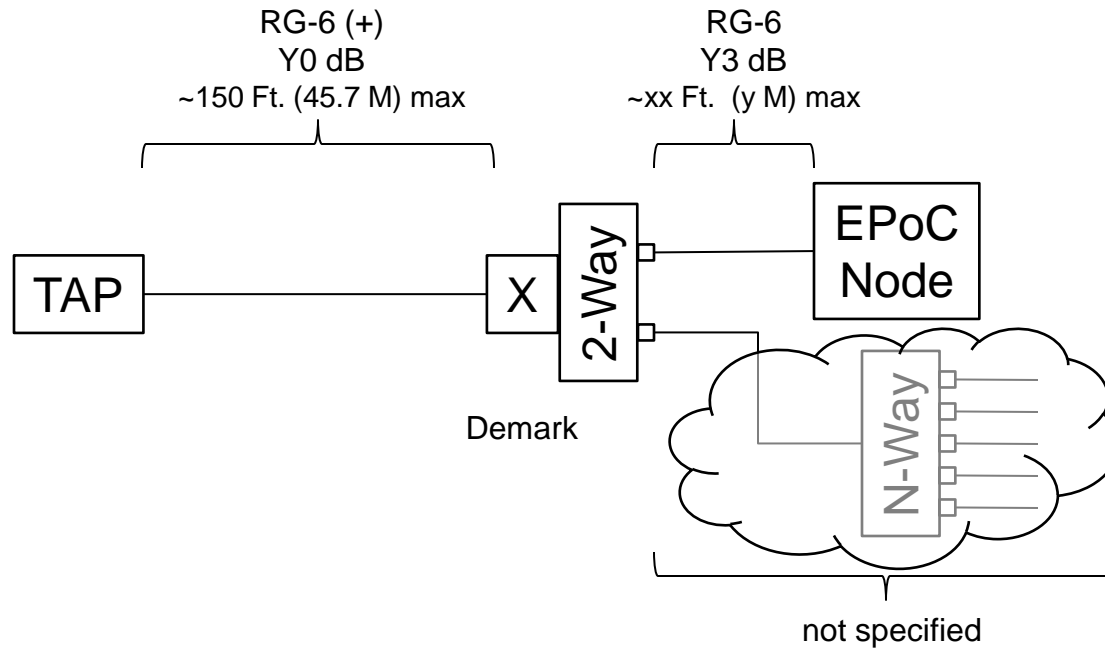
(EPoC Node located in unspecified premise wiring)



# Drop / Subscriber Premise

## Better

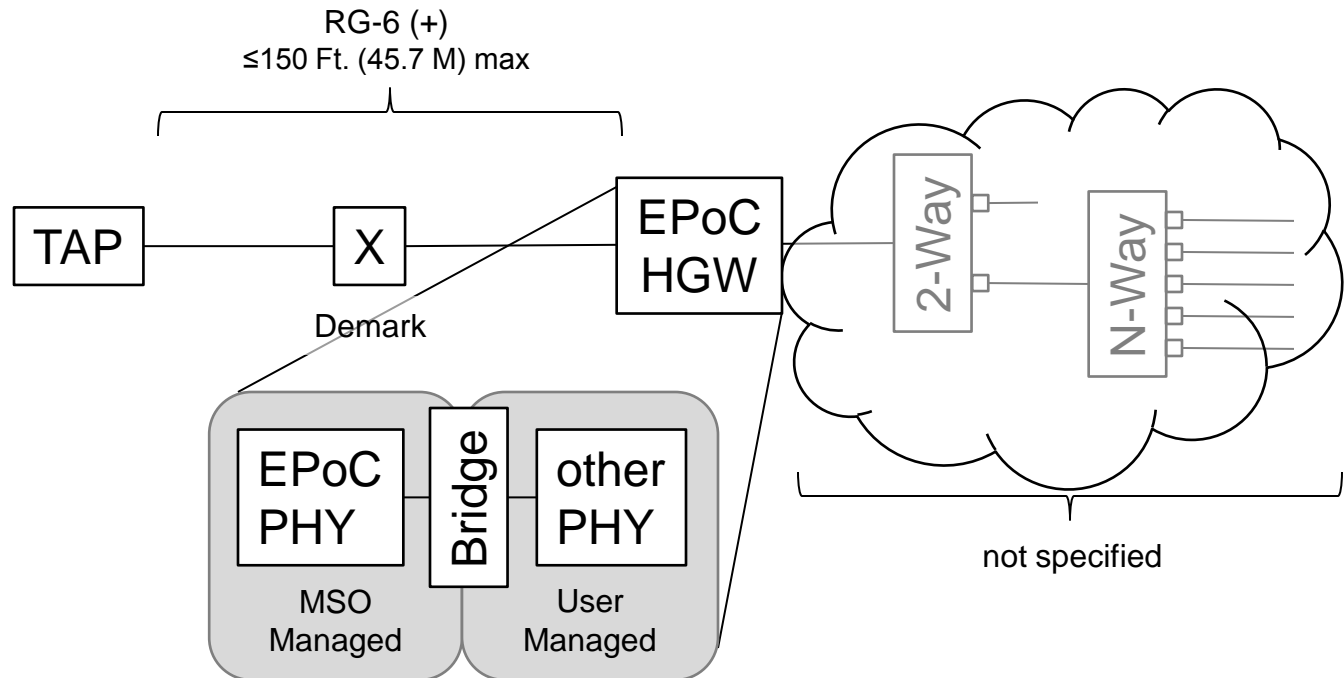
(2-Way splitter integrated with Demark)





# Drop / Subscriber Premise

## What we dream of ... All IP (Demark Gateway with isolated home network)



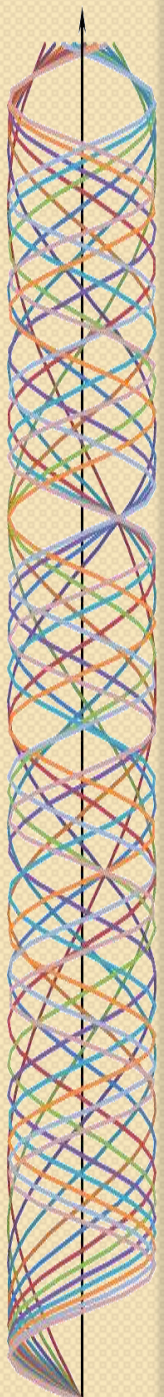
# Exemplary Parameter Table A (1 of 5)

## Node+6 Downstream

### System Description

HFC D/S Spectrum	1.0 GHz
Cascade Depth	N+6
Channel Loading	48 Analog + 75 Digital
Optical Architecture	Linear Optics 1310 nm, nominal link length EPoC Transport
Home Architecture	Up to max drop length & 4-way splitter

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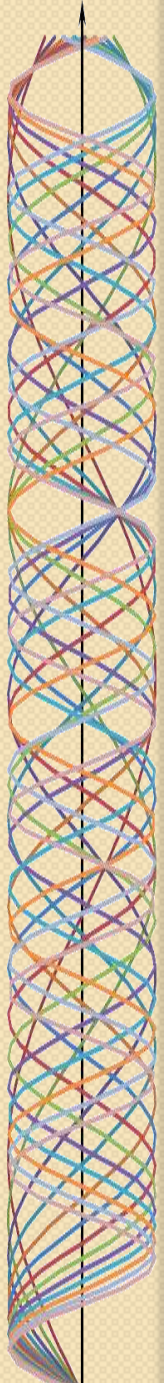


# Exemplary Parameter Table A (2 of 5)

## Node+6 Downstream

	#	Parameters	Typical <sup>1</sup>	Limit	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	Notes 2-4
		6 MHz BW	-2	-14	
		24 MHz BW	4	-8	
		96 MHz BW	10	-2	
		192 MHz BW	14	2	Note 5
SNR	4	SCN Ratio (Signal to Composite Noise Ratio)	43	40	Note 6
		Variation over 6 MHz BW (dB)	N/A	N/A	Reference Basis 6 MHz
		Variation over 24 MHz BW (dB)	1.5	3.5	
		Variation over 96 MHz BW (dB)	2.5	4.5	
		Variation over 192 MHz BW (dB)	3.0	5.0	





# Exemplary Parameter Table A (3 of 5)

## Node+6 Downstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependency
<b>Interference</b> <i>Narrowband</i>	5	<b>CTB Interference (20 kHz BW)</b>			Note 7-8
		# of interfered subcarriers @ 30-35 dBc	0%	1%	
		35-40	1%	0%	
		40-45	0%	0%	
		>45	0%	0%	
	6	<b>CSO Interference (20 kHz BW)</b>			Note 9
		# of interfered subcarriers @ 30-35 dBc	0%	2%	
		35-40	0%	0%	
		40-45	2%	0%	
		45-50	0%	0%	
	>50	0%	0%		
	7	<b>LTE Interference</b>			
	<b>D/S</b>	Bandwidth (MHz)	10	40	
		Level, dBc (PSD)	-30	-30	
	<b>U/S</b>	Bandwidth (MHz)	10	10	
	Level, dBc (PSD)	-40	-5		
	8	<b>Additive Interference (other)</b>			Additional bands TBD
		Range of dBc	-41	-29	CL 1997 Report
		Percentage of effected subcarriers	1	1	
<i>Wideband</i>	9	<b>Burst Interference</b>			Note 10
		Bandwidth (MHz)	30	TBD	
		Level, dBc (PSD)	-20	-5	
		Duration (usec)	16	25	
		Period (Hz)	Infrequent	10	
	10	<b>Impulse (white) Noise</b>			Laser Clipping
		Level, dBc (PSD)	-25	-25	Note 11
		Duration (nsec)	0.5	0.5	
		Period (kHz)	10	10	

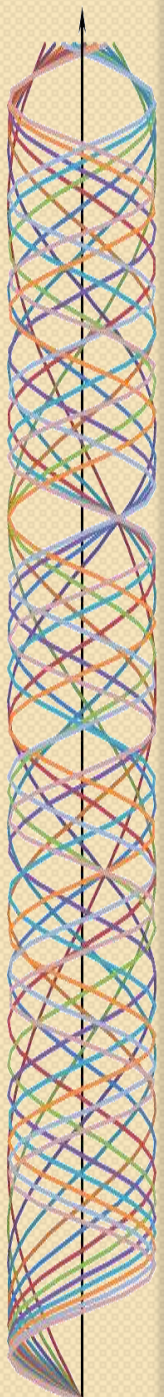
# Exemplary Parameter Table A

(4 of 5)

## Node+6 Downstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependency
<b>Freq Response</b>					
<i>Amplitude</i>	11	<b>Amplitude Slope</b>			Note 12
			0.01	0.02	
	12	<b>Amplitude Variation</b>			
		(dB pk-pk/6 MHz)	1.5	6	
		(dB pk-pk/24 MHz)	3.5	8	
		(dB pk-pk/192 MHz)	6	11	
		(dB pk-pk/Total DS BW)	10	15	
<i>Phase</i>	13	<b>Group Delay Variation, nsec</b>			
		Over 24 MHz			
		Mid Band	50	100	
		Band Edge (24 MHz)	290	340	
		Over 192 MHz			
		Mid Band	400	800	
		Band Edge (24 MHz)	640	1040	
<i>Echo</i>	14	<b>Echo Profile, dBc</b>	99%	SCTE-40	Note 13-14
		.5 usec	-20	-10	
		1 usec	-25	-15	
		1.5 usec	-30	-20	
		2 usec	-35		
		3 usec	-40		
		4.5 usec	-45	-30	
		5 usec	-50		
<b>Spurious Modulation</b>	15	<b>AM/Carrier hum modulation</b>	3%	5%	

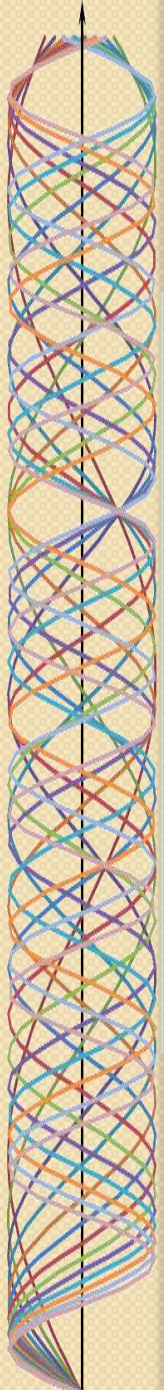
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# Exemplary Parameter Table A (5 of 5)

## Node+6 Downstream

Channel Model Add Hoc



Notes	
1	If not defined otherwise, assume typically behaving link but where the 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; 15 dBmV Tap port level, 100 ft drop, 2-way splitter
4	(Max Freq - OFDM BW) spectrum range used for drop loss
5	Small drop slope effect on calculation
6	SCN includes HFC geography impact (location in cascade depth)
7	50 kHz Subchannel Reference, Live Video, fully contained within subchannel Subcarriers with Interference (50 kHz subcarriers): Every 70 subcarriers, a cluster of three interferers: $I_0$ , $I_0 + 25$ kHz, $I_0 - 25$ kHz
8	Typ = CTB/CSO Worst Case Freq; Good CTB/CSO in low-distortion band, Analog contiguous at low end of band NCTA measurement method (avg); Error rate simulation should account for PAR and peak durations
9	Worst spectrum regions for CTB and CSO are not the same
10	D/S Burst Characterization in process; BW based on percentage of errored carriers in 8-Channel wide DOCSIS CM Duration based on large scale CM sweep of UCER with known interleaver settings; Levels per ReDesign channel model
11	Laser Clipping PSD captured in SCN for out-of-band EPoC Signals
12	Typical tilt, first tap, not equalized, 50 ft drop assumed (Minimum drop impact)
13	Echo mask range for a Single Dominant echo - Does not imply an assumptions about multiple echoes.
14	Meas@700-800 MHz, representative of 99% of modems

# Exemplary Parameter Table B (1 of 4)

## Node+3 digital distribution Downstream (Notes not repeated)

### System Description

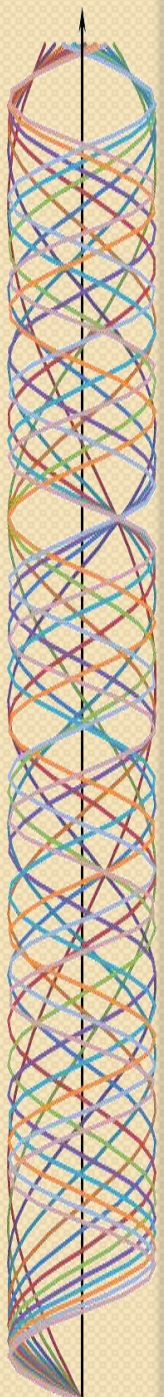
HFC D/S Spectrum	1.0 GHz
Cascade Depth	N+3
Channel Loading	All Digital
Optical Architecture	Linear Optics 1310 nm, EPoC RF Coupled after Node
Home Architecture	Up to max drop length & 4-way splitter

# Exemplary Parameter Table B (2 of 4)

## Node+3 digital distribution Downstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependency
<b>Spectrum</b>	1	<b>Frequency range</b>	54 MHz - 1 GHz		
	2	<b>OFDM Bandwidth</b>	192 MHz		
<b>RF Level</b>	3	<b>OFDM Power at CPE Input (dBmV)</b>	15 dBmV, 100 ft, 2-way	10 dBmV, 150 ft, 4-	Notes 2-4
		6 MHz BW	-2	-14	
		24 MHz BW	4	-8	
		96 MHz BW	10	-2	
		192 MHz BW	14	2	Note 5
<b>SNR</b>	4	<b>SCN Ratio (Signal to Composite Noise Ratio)</b>	45	41	Note 6
		Variation over 6 MHz BW (dB)	N/A	N/A	Reference Basis 6 MHz
		Variation over 24 MHz BW (dB)	1.5	3.5	
		Variation over 96 MHz BW (dB)	2.5	4.5	
		Variation over 192 MHz BW (dB)	3.0	5.0	

Channel Model And Hoc





# Exemplary Parameter Table B (3 of 4)

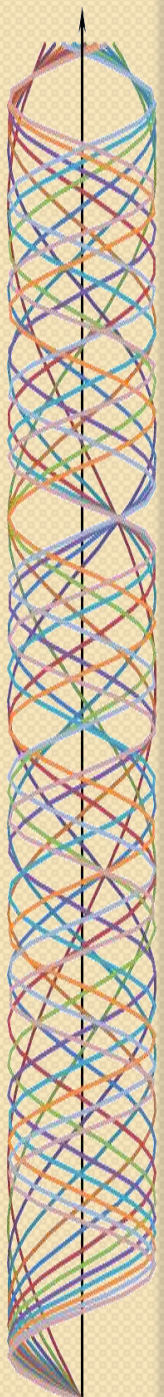
## Node+3 digital distribution Downstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependency
<b>Interference</b> <i>Narrowband</i>	5	<b>CTB Interference (20 kHz BW)</b>	N/A	N/A	Note 7-8
		# of interfered subcarriers @ 30-35 dBc			
	6	<b>CSO Interference (20 kHz BW)</b>	N/A	N/A	Note 9
		# of interfered subcarriers @ 30-35 dBc			
	7	<b>LTE Interference</b>			
	<b>D/S</b>	Bandwidth (MHz)	10	40	
		Level, dBc (PSD)	-30	-30	
	<b>U/S</b>	Bandwidth (MHz)	10	10	
		Level, dBc (PSD)	-40	-5	
	8	<b>Additive Interference (other)</b>			Additional bands TBD
		Range of dBc	-41	-29	CL 1997 Report
		Percentage of effected subcarriers	1	1	
<b>Wideband</b>	9	<b>Burst Interference</b>			Note 10
		Bandwidth (MHz)	30	TBD	
		Level, dBc (PSD)	-20	-5	
		Duration (usec)	16	25	
		Period (Hz)	Infrequent	10	
	10	<b>Impulse (white) Noise</b>			
		Level, dBc (PSD)	N/A	N/A	Note 11
		Duration (nsec)	N/A	N/A	
		Period (kHz)	N/A	N/A	

# Exemplary Parameter Table B (4 of 4)

## Node+3 digital distribution Downstream

Channel Model Add Hoc



	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependency
<b>Freq Response</b>					
<b>Amplitude</b>	11	<b>Amplitude Slope</b>			Note 12
			dB/MHz	0.01	0.02
	12	<b>Amplitude Variation</b>			
			(dB pk-pk/6 MHz)	1.5	6
			(dB pk-pk/24 MHz)	3.5	8
			(dB pk-pk/192 MHz)	6	11
<b>Phase</b>			(dB pk-pk/Total DS BW)	10	15
	13	<b>Group Delay Variation, nsec</b>			
			Over 24 MHz		
			Mid Band	50	100
			Band Edge (24 MHz)	290	340
			Over 192 MHz		
<b>Echo</b>			Mid Band	400	800
			Band Edge (24 MHz)	640	1040
	14	<b>Echo Profile, dBc</b>	99%	SCTE-40	Note 13-14
			.5 usec	-20	-10
			1 usec	-25	-15
			1.5 usec	-30	-20
			2 usec	-35	
			3 usec	-40	
		4.5 usec	-45	-30	
		5 usec	-50		
<b>Spurious Modulation</b>	15	<b>AM/Carrier hum modulation</b>	3%	5%	

# Exemplary Parameter Table C (1 of 5)

## Node+0 Upstream

<b>System Description</b>		
HFC U/S Spectrum	85 MHz	
Node Architecture	N+0	
Channel Loading	Remote Tx/Rx	
HE Architecture	N/A	
Premise Architecture	Two Way Combining	

# Exemplary Parameter Table C (2 of 5)

## Node+0 Upstream

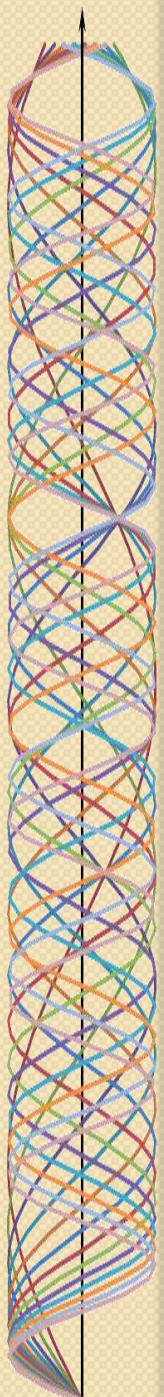
	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependencies
<b>Spectrum</b>	<b>1</b>	<b>OFDM Bandwidth</b>	48		
	<b>2</b>	<b>Frequency range</b>	37-85 MHz		
<b>Path Loss</b>	<b>3</b>	<b>Path Loss</b>	44	50	Max loss to first active
		Variation Freq, 6.4 MHz BW	1	1	Note 1
		Variation Freq, 24 MHz BW	2.5	2	
		Variation Freq, 80 MHz BW	5	5	
<b>Added Noise</b>	<b>4</b>	<b>Input Noise PSD</b>	N/A	N/A	

# Exemplary Parameter Table C (3 of 5)

## Node+0 Upstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependencies
<b>Interference</b>	<b>5</b>	<b>FM Band Interference</b>	N/A	N/A	Overload concern only
		<i>Narrowband</i>	Bandwidth	Out of Band	Out of Band
		Level, dBc (PSD)	-40	TBD	Note 2
	<b>6</b>	<b>Common Path Distortion</b>			
		dBc	N/A	-32	50 kHz subcarriers
		% effected subcarriers	N/A	3%	
	<b>7</b>	<b>Other Known Bands</b>	TBD		New Upstream
		dBc	-50	-10	Note 3
<i>Wideband</i>		% effected subcarriers	1%	0.5%	50 kHz subcarriers
	<b>8</b>	<b>Burst Interference</b>			Note 4
		Bandwidth (MHz)	TBD	TBD	Non-white characteristics (Note 5)
		Level, dBc (PSD)	0	-10	
		Duration (usec)	1	10	
		Period (Hz)	1000	1000	
	<b>9</b>	<b>Impulse (white) Noise</b>	N/A	N/A	
		Level, dBc (PSD)			
		Duration (nsec)			
		Period (kHz)			





# Exemplary Parameter Table C (4 of 5)

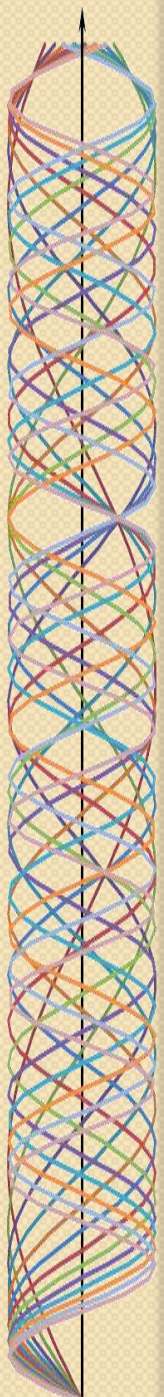
## Node+0 Upstream

	#	Parameters	Typical <sup>1</sup>	Limit	Notes/Dependencies
<b>Freq Response</b>					
<b>Amplitude</b>	<b>10</b>	<b>Amplitude Slope</b>	N/A	N/A	Captured in Path Loss Range
	<b>11</b>	<b>Amplitude Variation</b>			SCTE Definition, Echo not included
		(dB pk-pk/24 MHz)	1	2.5	
		(dB pk-pk/48 MHz)	1.5	4.0	
<b>Phase</b>	<b>12</b>	<b>(ns/MHz)</b>			
		Over 24 MHz	12	85	
		Over 48 MHz	82	100	
<b>Echo</b>	<b>13</b>	<b>Delay Spread Profile, dBc</b>			Note 6-7
		.5 usec	-15	-10	
		1 usec	-20	-20	
		1.5 usec	-25	-30	
		2 usec	-30	-30	
		2.5 usec	-35	-30	
		3 usec	-40	-30	
		4 usec			
<b>Spurious Modulation</b>	<b>14</b>	<b>AM/Carrier hum modulation</b>	5%	7%	

# Exemplary Parameter Table C (5 of 5)

## Node+0 Upstream

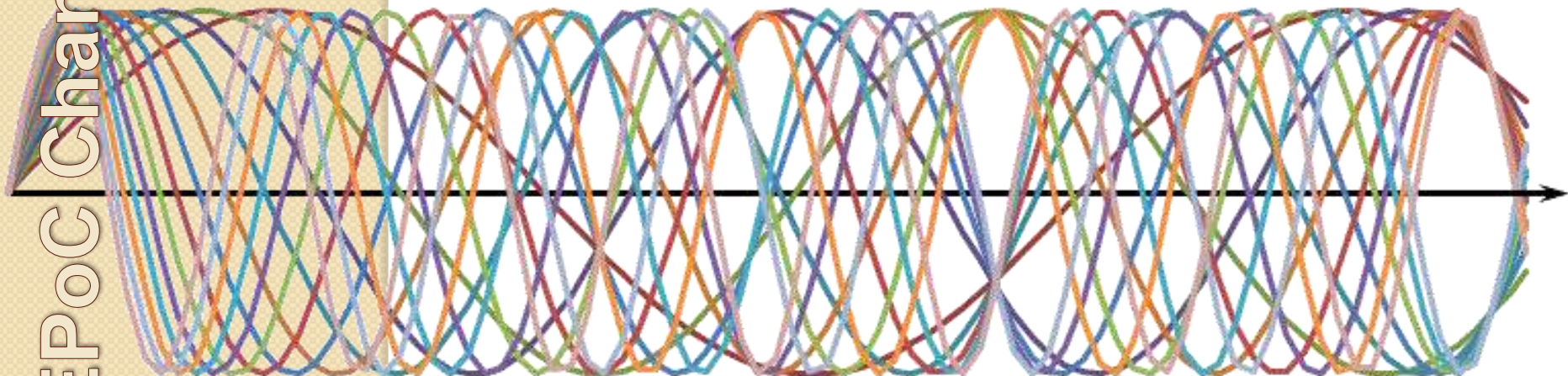
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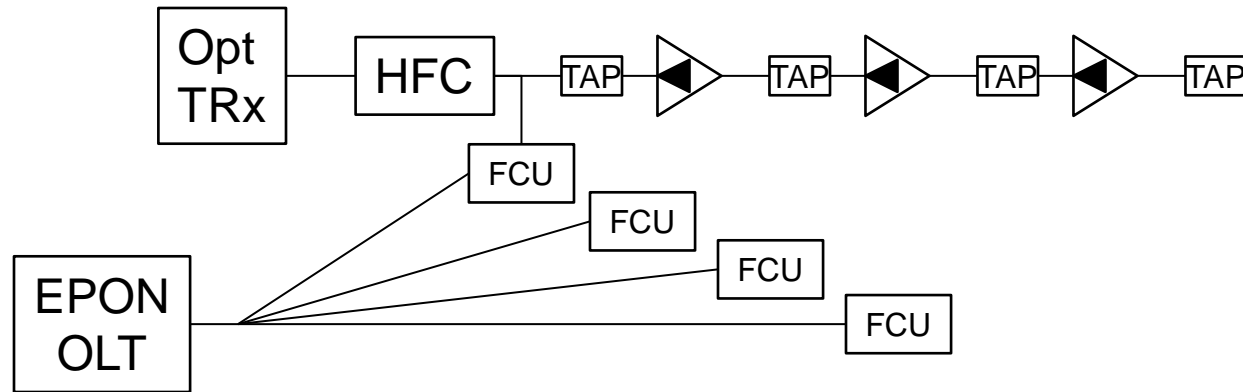
Notes	
1	Path Loss adopted for consistency although return path
2	Measured samples in MSO location of high field strength environment
3	Projected (for 50 kHz) from acceptable D/S interference level for analog video band (now upstream band); single dominant interferer and ingress
4	U/S burst characterization in process; Ref CableLabs 1997 Report "Characterization of Upstream Transient Impairments on Cable
5	No linear optical return - no U/S Laser Clipping (white) impairment
6	Measured Upstream CM (97% criteria) extrapolated to band (30 MHz measured to 100 MHz)
7	Echo mask range for a Single Dominant echo - does not imply an assumptions about multiple echoes

# THANK YOU

C h a n n e l   M o d e l   A d   H o c



# Baseline Channel Topology



- Node +3 (digital EPON distribution)

- Topology parameters needed:
  1. Optical reach of HFC networks
  2. Optical reach of EPON networks per 802.3
  3. All digital channel loading assumed
  4. Amplifier spacing; typical and max.  
ex: typical  $\leq 800$  ft. maximum  $\leq 1500$  ft.
  5. Feeder cable types; ??
  6. Drop Cable types & reach
    - RG 6,  $\leq 150$  ft. (45.7 M)

# Drop / Subscriber Premise

## Baseline

