

ATLANTA, GA OCTOBER 11-14



UNLEASHTHE POWER OF IMITLESS CONNECTIVITY





Wireline Access Network

Preparing for DOCSIS® 4.0 Upstream

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Higher Upstream Splits -> Higher Capacity & Complexity



Baselines:



CM Tx Power /6.4MHz

Required Input Level @ Amplifier/Node Port



Return Path BW	Input Power to Return Path Amp. (dBmV/6.4MHz)
85 MHz	16
204 MHz	12
396 MHz	9
492 MHz	8

Baselines:



FDD Upstream Allocated Spectrum Bandwidths

Constellation vs Power vs CNR @ Node/Amp Port

US Spectrum				Transition Band	1										
199 MHz TCS1 (Legacy HS)	Legacy	US	2 (Single TCS)	204 MHz to 258 MHz				DS SC-QAM or O	FDM (All	CMs)			OFI (A	DM on ly All CMs)	
					UHS Transition B	and									
80 MHz TCS1 192 MHz TCS2	Legacy US		US	US	300 MHz to 372 f	MHz	DS SC-QAM or OFDM (AII CMs)			OFI (A	DM on ly All CMs)				
							UHS Transition Band								
80 MHz TCS1 288 MHz TCS2	Legacy US		US	US	US		550 M 2 10 452 M 2		DS	SSC-QAI	MorOFDM (AIICMs)		OFI (A	DM only All CMs)	
-								UHS Transition Band 492 MHz to 588 MHz							
80 MHz TCS1 384 MHz TCS2	Legacy US		US	US	US		US	DS SC-QAM or OFDM (AII CMs)			OFI (A	DM only All CMs)			
_											UHS Transition Band 684 MHz to 834 MHz				
80 MHz TCS1 576 MHz TCS2	Legacy US		US	US	US		US	US	U	S	•	DS SC-QAM or OFDM (All CMs)	OFI (A	DM only All CMs)	
TCS Lega Bar	icy Transitic nd (85-108)	10 n	08 2/ FDI Alloca	04 3 D Upstream ated Spectrum	00 TCS_FD	39 D	96 49 Freque (not t	92 58 ncy [MHz] to scale)	38	68	4 FDD Tra Ba	ansition 1002 I nds	ИНz		17 M
DOCSIS 3.1 High-Split Mode DOCSIS 4.0 Mode															
	US Spectrum 199 MHz TCS1 (Legacy HS) 80 MHz TCS1 192 MHz TCS2 80 MHz TCS1 288 MHz TCS1 384 MHz TCS1 384 MHz TCS1 576 MHz TCS1 CS Lega Ba	US Spectrum 199 MHz TCS1 Legacy 80 MHz TCS1 Legacy 192 MHz TCS2 US 80 MHz TCS1 Legacy 288 MHz TCS2 US 80 MHz TCS1 Legacy 384 MHz TCS2 US 80 MHz TCS1 Legacy 576 MHz TCS1 Legacy US CCS US Legacy Transitio Band (85-108)	US Spectrum 199 MHz TCS1 (Legacy HS) 80 MHz TCS1 192 MHz TCS2 80 MHz TCS1 80 MHz TCS1 80 MHz TCS1 80 MHz TCS1 105 105 105 105 105 105 105 10	US Spectrum 199 MHz TCS1 (Legacy HS) 80 MHz TCS1 192 MHz TCS2 80 MHz TCS1 288 MHz TCS2 80 MHz TCS1 108 C 108 C	US Spectrum 204 MHz to 281 MHz 199 MHz TCS1 (Legacy HS) Legacy US (Single TCS) US 80 MHz TCS1 192 MHz TCS2 US 80 MHz TCS1 288 MHz TCS2 US 80 MHz TCS1 288 MHz TCS2 US 80 MHz TCS1 288 MHz TCS2 US 80 MHz TCS1 108 204 3 108 FDD Upstream 80 MHz TCS1 108 204 3 FDD Upstream Band (85-108) AD US 108 FDD Upstream Allocated Spectrum	US Spectrum 199 MHz TCS1 Legacy US (Single TCS) 80 MHz TCS1 192 MHz TCS2 80 MHz TCS1 280 MHz TCS1 290 MHZ TCS1	US Spectrum 199 MHz TCS1 (Legacy HS) Legacy US (Single TCS) 80 MHz TCS1 Legacy US	US Spectrum US Spectrum US Spectrum US Spectrum US MHz TCS1 Legacy US (Single TCS) US	US Spectrum NHz TCS1 Legacy US (Single TCS) VIS Transition Bard 20 MHz TCS1 Legacy US (Single TCS) US	Transition Bard 199 MHz TCS1 (Legacy US (Single TCS) Image: Colspan="6" Colspan="6	US Spectrum Transtan Band Image: Spectrum 199 MHz TCS1 (Legacy US (Single TCS) Image: Spectrum Image: Spectrum 199 MHz TCS1 (Legacy US (Single TCS) Image: Spectrum Image: Spectrum 80 MHz TCS1 192 MHz TCS1 192 MHz TCS1 192 MHz TCS1 192 MHz TCS1 193	US Spectrum Mit to SBM/H to SB	US Spectrum Testion Bard MMI: b 28 MM Image: b 28 MM Distribution Bard MMI: b 20 MMI: b 2	US Spectrum Textbolled NH/z TCS1 Legacy US (Single TCS) US DS SC-QAM or OFDM (AII CMS) OF (A 199 MH/z TCS1 (Legacy HS) Legacy US (Single TCS) US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MH/z TCS1 192 MHz TCS1 US Legacy US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MHz TCS1 192 MHz TCS1 US Legacy US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MHz TCS1 288 MHz TCS1 US US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MHz TCS1 288 MHz TCS1 US US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MHz TCS1 US US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 80 MHz TCS1 US US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 100 MHz TCS1 US US US US US US DS SC-QAM or OFDM (AII CMS) OF (A 100 MHz TCS1 US US US US US US </td <td>US Spectrum Image: Spectrum Image: Spectrum Image: Spectrum OPEN (AI CMs) 199 MHz TCS1 (Legacy HS) Legacy US (Single TCS) OPEN (AI CMs) OPEN (AI CMs) 0 MHz TCS1 192 MHz TCS1 193 MHz TCS1 1</td>	US Spectrum Image: Spectrum Image: Spectrum Image: Spectrum OPEN (AI CMs) 199 MHz TCS1 (Legacy HS) Legacy US (Single TCS) OPEN (AI CMs) OPEN (AI CMs) 0 MHz TCS1 192 MHz TCS1 193 MHz TCS1 1

Constellation	CNR (dB)	Power Level (dBmV/6.4 MHz)
256-QAM	29.0	3
512-QAM	32.5	3
1024-QAM	35.5	3
2048-QAM	39.0	10
4096-QAM	43.0	13



Plant Model Analyzed









Rx Power/6.4MHz @ Amp/Node Port

Plant Model with Two-Way



Rx Power/6.4MHz @ Amp/Node Port







Boosting CM Tx

Plant Model with Two-Way Splitter



Upstream performance will not be power limited for most cases.

Higher CM Tx Powers Must be Balanced

• Higher transmit power from the CMs can increase the risk of neighbour interference.



Reference: Optimizing the 10G Transition to Full-Duplex DOCSIS® 4.0, Richard S Prodan, Comcast – with proposed changes to the methodology

SCTE

CABLE-TEC EXPO

Noise Funneling

All Ports Funneled

Total Number of Amplifiers	CTN	CIN	Source MER (38 dB)	Source MER (40 dB)	Source MER (47 dB)
16	45.36	49.98	37.04	38.56	42.28
22	/2 35	/8 22	36.35	37.61	40.3
	40.97	47.55	25.02	27.04	20.2
56	30.07	47.55	25 52	36.54	38.18
68	39.07	46.00	35.12	36.04	37.73

Single Node Leg

CTN	CIN	Source MER (38 dB)	Source MER (40 dB)	Source MER (47 dB)
51.38	49.98	37.55	39.31	44.29
48.37	48.22	37.26	38.87	43.05
46.99	47.55	37.08	38.61	42.4
45.94	46.97	36.9	38.37	41.84
15 1	46.00	26.68	28.07	/1 10
	CTN 51.38 48.37 46.99 45.94 45.1	CTN CIN 51.38 49.98 48.37 48.22 46.99 47.55 45.94 46.97 45.1 46.00	CTNSource MER (38 dB)51.3849.9837.5548.3748.2237.2646.9947.5537.0845.9446.9736.945.146.0036.68	CTNSource MER (38 dB)Source MER (40 dB)51.3849.9837.5539.3148.3748.2237.2638.8746.9947.5537.0838.6145.9446.9736.938.3745.146.0036.6838.07

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CABLE-TEC EXPO

- Amplifier NF: 6 dB
- Amplifier CIN: 56 dB
- Input level to each amplifier in the return path: 6 dB flat across the spectrum
- Number of ports utilized in the node: 4
- CTN: All the amplifiers on either the entire node or each leg that would contribute to signal degradation
- CIN: Only the amplifiers in series on each leg of the node that would contribute to signal degradation

Noise Funneling

All Ports Funneled



Single Node Leg



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CABLE-TEC E

MER Degradation (All Ports Funneled)

Conclusions

- DOCSIS 4.0 upstream is very likely to work with high performance for a majority of cases
 - The biggest areas of concern are:
 - High flat loss areas that the CM will have to 'overcompensate' for in the upstream
 - Higher transmit powers may increase the likelihood of neighbour interference
 - Starting/Source MER from the modems in the return is the highest indicator of performance (assuming no plant impairments)
 - Thermal noise and distortion funneling from amplifiers can degrade the performance, but not by a large amount
 - Isolating node ports can be very important for limiting noise to a single port
 - High transmit powers should be balanced with neighbour interference

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Thank You!

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