Project	**IEEE 802.16 Broadband Wireless Access Working Group** **<http://ieee802.org/16>**
Title	**Proposed Revision to Section 8.3.4.15 (System Throughput and Modulation Efficiency)**
Date Submitted	**2001-10-19**
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Re:	Proposal to revise Section 8.3.4.15 of document 80216ab-01_01r2 with provided text.
Abstract	A complete revised section 8.3.4.15 of document 80216ab-01_01r2 is provided. This contribution completely simplifies and merges two subsections into one with more accurate results.
Purpose	Incorporate provided text as revision of section 8.3.4.15 of document 80216ab-01_01r2.
Notice	
Release	
Patent Policy and Procedures	

SC-FDE System Capacity and Modulation Efficiency

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8.3.4.15 SC-FDE System Capacity and Modulation Efficiency

The Parameters and values defining the various operating modes of the Single carrier transmission of the PHY are summarized in Table 202.

Table 202. Parameters and Values Defining Operating Modes for SC Systems

Selection Level	Parameter	Symbol	Set of Values
System-Dependent Parameters	Channel BandWidth (MHz)	W	1.75, 3.5, 7, 14, 1.5, 3, 6, 12
	Design Maximum Delay Spread (μsec)	d	4, 10,20
	Spectral Guard Factor	γ	0.18, 0.25
	Symbol Rate (MSymb/sec)	R	$R = (1+\gamma)W$
Link-Dependent Parameters	Number of QAM Constellation States	M	4, 16, 64
	Convolutional (Inner) Code Rate	r_I	1/2, 2/3, 3/4, 7/8
	Reed-Solomon (Outer) Code Rate	r_O	239 / 255 = 0.937
Traffic-Dependent Parameter	Burst Data Payload Size for uplink (in Bytes)	P	239, 717, 1195, 1673
Traffic-Dependent Parameter	Continuous Data Payload Size for downlink (in Bytes)	P	1673, 2151, 2629, 3585

Note to Table 202:
This value should be set to be nominally sufficient to estimate the peaks and notches of a channel exhibiting the Design Maximum Delay Spread, and fading with a coherence time nominally equal to the Block Period.

Note also, the corresponding Unique Word (UW size) design with U = R • d, rounded up to the nearest power of 2. [U is the parameter that we use for UW length in the document]

For Single-carrier systems, system throughput for the **burst transmission modes** (e.g., for the uplink).will vary with the operating modes and with the frame structure that is given in 8.3.5.12. The SC-FDE system throughput then is derived from:

$$T_{burst} = \frac{8PR\log_2(M)}{\left(\frac{8P}{r_I r_O} + (A+U)\log_2(M)\right)}$$

In a burst mode application, a quiet interval (RxDs burst element) of length U symbols is appended to the end of a burst to allow delay spread to clear the receiver. However, this element is not necessary for continuous mode operation. Therefore, the throughput associated with an example **continuous mode** system would be:

$$T_{cont} = \frac{8PR\log_2(M)}{\left(\frac{8P}{r_I r_O} + A\log_2(M)\right)}$$

In these calculations, P is the burst data size and A is used as the average frame preamble size (in symbols), as defined in 8.3.5.12. Other frame preamble sizes, are, of course possible; the choice of A=2U for the uplink and the choice of A=4U for the downlink were taken here as examples. The difference in values of A is because for continuous downlink mode, the preambles are transmitted once per frame with the MAP broadcast time. Therefore, the downlink data payload will be much longer than the payload data of the uplink burst mode. Hence, the payload data and the corresponding Preamble A are being selected to be much longer the uplink payload and the preamble size.

Furthermore, these calculations account for the rate reduction induced in applying an outer Reed-Solomon code (r_O) with correction capability 8 symbols, for all burst data sizes shorter than 255 coded bytes. For burst sizes that are not integrally divisible by 255 coded bytes, the fractional part above 255 bytes is encoded using a shortened Reed Solomon block containing the remainder of the data burst, with 16 overhead bytes to enable 8 byte correction capability on the shortened block.

$$E_{burst} = T_{burst}/W = \frac{T_{burst}}{(1+\gamma)R} = \frac{8P\log_2(M)}{(1+\gamma)\left(\frac{8P}{r_I r_O} + (A+U)\log_2(M)\right)}$$

$$E_{cont} = T_{cont}/W = \frac{T_{cont}}{(1+\gamma)R} = \frac{8P\log_2(M)}{(1+\gamma)\left(\frac{8P}{r_I r_O} + A\log_2(M)\right)}$$

Tables 203a and 203b present typical channel throughput and system efficiency for SC-DFE system with a 1.75 MHz channel Bandwidth for the uplink and 6 MHz for the

downlink. Similar typical results for higher channel bandwidths will be proportionally larger. The following throughput and modulation efficiency results are based on roll factor of $\gamma = 0.18$.

Table 203a- Throughput for various Models in 1.75 MHz Channels (Uplink Burst Mode)

System Throughput for Overlap Save Technique (for Single Carrier Burst Mode U/L with W = 1.75 MHz bandwidth)								
System-Dependent Parameters		**Link-Dependent Parameters**		**System Throughput (in Mbits/sec)**				**System Efficiency**
Symbol [Sample] Rate (MS/sec)	Design Max Delay Spread (U in Symbols)	Number of QAM States	Convolu-tional Code Rate	**Packet Size (P in Bytes)**				**(in MBits/sec/Hz)**
				239	**717**	**1195**	**1673**	**(P= 1673)**
1.5	8	4	1/2	1.37	1.38	1.39	1.39	0.79
			2/3	1.82	1.84	1.85	1.85	1.06
			3/4	2.05	2.07	2.08	2.08	1.19
			7/8	2.38	2.42	2.42	2.43	1.39
		16	1/2	2.72	2.76	2.77	2.77	1.58
			3/4	4.03	4.12	4.14	4.15	2.37
		64	2/3	5.31	5.47	5.51	5.52	3.16
			5/6	6.56	6.82	6.87	6.89	3.94
	16	4	1/2	1.36	1.38	1.38	1.39	0.79
			2/3	1.80	1.83	1.84	1.85	1.05
			3/4	2.01	2.06	2.07	2.07	1.19
			7/8	2.34	2.40	2.41	2.42	1.38
		16	1/2	2.66	2.74	2.75	2.76	1.58
			3/4	3.90	4.07	4.11	4.13	2.36
		64	2/3	5.08	5.39	5.46	5.49	3.13
			5/6	6.22	6.69	6.79	6.84	3.91
	32	4	1/2	1.33	1.37	1.38	1.38	0.79
			2/3	1.74	1.82	1.83	1.84	1.05
			3/4	1.95	2.04	2.06	2.06	1.18
			7/8	2.25	2.37	2.39	2.40	1.37
		16	1/2	2.54	2.70	2.73	2.74	1.57
			3/4	3.65	3.98	4.06	4.09	2.34
		64	2/3	4.68	5.23	5.36	5.41	3.09
			5/6	5.63	6.44	6.64	6.72	3.84

Table 203b- Throughput for various Models in 6 MHz Channels (Downlink Continuous Mode)

System Throughput for Overlap Save Technique (Single Carrier Continuous Mode D/L with W = 6 MHz bandwidth)								
System-Dependent Parameters		**Link-Dependent Parameters**		**System Throughput (in Mbits/sec)**				**System Efficiency**
Symbol [Sample] Rate (MS/sec)	Design Max Delay Spread (U in Symbols)	Number of QAM States	Convolu-tional Code Rate	**Packet Size (P in Bytes)**				**(in MBits/sec/Hz)**
				1673	**2151**	**2629**	**3585**	**(P= 3585)**
5.1	8	4	1/2	4.69	4.95	5.00	5.02	0.84
			2/3	6.22	6.58	6.66	6.69	1.12
			3/4	6.98	7.40	7.49	7.53	1.25
			7/8	8.12	8.62	8.73	8.78	1.46
		16	1/2	9.24	9.84	9.97	10.03	1.67
			3/4	13.65	14.68	14.90	15.00	2.50
		64	2/3	17.94	19.47	19.81	19.96	3.33
			5/6	22.10	24.21	24.68	24.89	4.15
	16	4	1/2	4.62	4.92	4.98	5.01	0.84
			2/3	6.10	6.54	6.63	6.67	1.11
			3/4	6.83	7.34	7.45	7.50	1.25
			7/8	7.91	8.54	8.68	8.74	1.46
		16	1/2	8.97	9.74	9.90	9.98	1.66
			3/4	13.07	14.45	14.76	14.90	2.48
		64	2/3	16.94	19.06	19.55	19.77	3.30
			5/6	20.60	23.58	24.29	24.60	4.10
	32	4	1/2	4.48	4.87	4.95	4.99	0.83
			2/3	5.86	6.44	6.57	6.63	1.11
			3/4	6.53	7.22	7.38	7.45	1.24
			7/8	7.51	8.38	8.58	8.67	1.45
		16	1/2	8.47	9.53	9.78	9.89	1.65
			3/4	12.03	14.00	14.48	14.69	2.45
		64	2/3	15.24	18.30	19.06	19.41	3.24
			5/6	18.14	22.42	23.53	24.04	4.01