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New York, USA
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Agenda Item:	AH64: Enhanced Uplink
Source:	Motorola
Title:	E-DCH System performance comparing 2ms vs. 10 ms frame size
Document for:	Information and Discussion for 10.1

Introduction

Single user system performance is compared for 2ms vs. 10ms E-DCH TTI for the specific example were a user is placed at a fixed location close to the cell but experiences Rayleigh fading. It is shown in this case that 2ms TTI results in a progressive improvement in user throughput (up to 25%) compared to 10ms TTI for a Pedestrian A (PA) channel as user speed increases. A similar trend is seen with a Pedestrian B (PB) channel; however, the improvement is less significant (less than 10%) due to smaller Eb/Nt target variation from multi-path diversity.

System Simulation Results comparing 2ms vs. 10 ms TTI

In this contribution, system simulation results are compared for 2ms and 10 ms E-DCH TTI (frame size) without Hybrid ARQ under PA and PB fading channels for various speeds. A single user example is used to simplify the analysis where the user location is chosen to achieve a throughput of close to 1Mbps. The UE traffic is a series of FTP calls where the UE selects the rate on a per TTI basis. UE Rate selection is based on comparing the available normalized power margin ($G_{e\text{-}dch}$) to a set of MCS thresholds where $G_{e\text{-}dch}$ is given by

$$G_{e-dch} = (P_{Maximum} - P_{dpcch} - P_{dpdch}) / P_{dpcch} = P_{Mar.gin} / P_{dpcch} = P_{e-dch} / P_{dpcch} = (b_{e-dch} / b_c)^2 \qquad (1)$$

A mapping from $G_{e\text{-}dch}$ to transmission rate is needed for the UE for enhanced uplink operation. The rate, modulation, and encoding rate or MCS (modulation coding set) is chosen based on Table 1 below. The available normalized power margin ($G_{e\text{-}dch}$) is compared to the MCS threshold value as shown in the last column of Table 1. The MCS chosen is the one with the threshold that $G_{e\text{-}dch}$ exceeded but less than the threshold belonging to the next consecutive MCS in the list. The MCS thresholds are computed based on the equation:

$$MCS_thresh(i) = Rate(i) / (R.eferenceRa\,te * dEcNt(i) * S(i)) \qquad (2)$$

where

- Rate(i) is the rate of MCS i,
- ReferenceRate is the rate of the reference channel (DPDCH) which in this case is 5Kbps,
- dEcNt(i) is a fixed scale factor to account for the delta Ec/Nt between MCS rates,
- S(i) is a scale factor for MCS i used to account for difference in Ec/Nt requirements between reference rate channel (DPDCH) and the E-DCH. There may be different S for 2ms and 10ms and for different channel conditions such as Pedestrian A and Pedestrian B.

Erased frames are counted toward the total delay in computing user throughput based on equation (3) below:

$$T_{user} = \frac{\sum_{i=1}^{N_{mcs}} TTI \cdot \#Tx(i) \cdot Rate(i)}{\sum_{i=1}^{N_{mcs}} TTI \cdot \#Tx(i) / (1 - FER(i))} \qquad (3)$$

Table 1 MCS Mapping for Enhanced Uplink WCDMA (2ms TTI, PA Case)

MCS level	MCS Rate	MCS EncRate	MCS Mod	dEcNt sfactor	S	mcs thresh rate/(RefRate*dEcNtSF*S)
	(bps)				(PA, 2ms)	(RefRate=5000bps)
1	10000	1/3	1	0.85	1.000	**2.4**
2	20000	1/3	1	0.89	0.980	**4.6**
3	24000	2/5	1	0.91	0.960	**5.5**
4	40000	1/3	1	0.95	0.940	**9.0**
5	48000	2/5	1	0.99	0.920	**10.5**
6	80000	1/3	1	1.09	0.900	**16.3**
7	96000	2/5	1	1.12	0.890	**19.3**
8	160000	1/3	1	1.23	0.860	**30.3**
9	192000	2/5	1	1.29	0.880	**33.8**
10	320000	1/3	1	1.44	0.600	**74.1**
11	384000	2/5	1	1.33	0.940	**61.4**
12	640000	1/3	2	1.40	0.720	**127.0**
13	768000	2/5	2	1.33	0.710	**162.7**
14	960000	1/2	2	1.20	0.780	**205.1**
15	1152000	3/5	2	1.06	0.705	**308.3**
16	1280000	2/3	2	0.99	0.690	**374.8**
17	1440000	3/4	2	0.86	0.745	**449.5**
18	1728000	3/5	3	0.71	0.705	**690.4**
19	1920000	2/3	3	0.62	0.640	**967.7**
20	2160000	3/4	3	0.57	0.680	**1114.6**

Table 1 also summarizes the MCS levels simulated while Table 2 shows the simulation parameters. Only the E-DCH, DPDCH (5Kbps) and the associated DPCCH were turned on in the simulation. The HS-DPCCH and E-DPCCH were not enabled. Figure 1 shows the AWGN curves used in the system simulation to account for the different FER vs. Ec/Nt characteristics of the E-DCH for 2 and 10 msec TTI [1]. Table 3 and Table 4 contain the highest user throughput achievable for each TTI-channel case given the constraint of a per MCS FER target of ~10%. The throughput is maximized by optimizing the MCS thresholds via the S vector.

From these Tables it is shown that using 2ms TTI results in a progressive improvement in user throughput (up to 25%) compared to a 10ms TTI for a PA channel as user speed increases (from 3km/h to 15km/h). A similar trend is observed with a PB channel; however, the improvement is less significant (less than 10%) due to smaller Eb/Nt target variation from multi-path diversity.

Table 2. Simulation Parameters

Simulation Parameter	*Value*
No. of slots/frame	3 or 15
No. of chips/second	3.84 Mcps
E-DCH TTI	2 msec or 10 msec

Modulation	BPSK/QPSK/8PSK
Hybrid ARQ Max number of Tx	Not supported NA
Channels	Rayleigh Fading, PA, PB 3km/hr, 8km/hr, 15km/hr
Receiver	Rake
Channel Estimation	Ideal
Inner-Loop PC	ON
Outer-Loop PC	ON
PC delay and error	2 slots, 0%
No. of antennas	2
Reference Channel	DPDCH 5Kbps , 10%FER
$(\beta_d/\beta_c)^2$ $\beta_{e\text{-}dch}/\beta_c$ is variable	2 -- depends on rate selected

Table 3 System Simulation Single User Throughput (T_{user}) results with 0.5dB TPC step size

Simulation Cases	Rise (dB)		%Rise Outage (dB)					FER	User T-put
(TTI, Channel, Svector)	Avg	Stdev	4.0	4.5	5.0	5.5	6.0	(%)	(Kbps)
02ms, PB03, 1.1E	1.7	1.4	7.2	4.3	2.5	1.2	0.5	8.5	1072
02ms, PB08, 1.1F	1.8	1.4	7.7	4.5	2.6	1.2	0.5	10.4	1010
02ms, PB15, 1.1G	1.7	1.3	6.8	3.9	2.3	0.9	0.4	11.3	923
10ms, PB03, 1.1J	1.7	1.3	6.8	4.2	2.3	1.1	0.4	10.9	969
10ms, PB08, 0.89J	1.5	1.3	5.6	3.4	2.1	0.9	0.3	9.8	936
10ms, PB15, 0.84L	1.5	1.3	5.6	3.2	1.7	0.8	0.5	8.1	883
02ms, PA03, H	1.8	1.4	7.3	4.2	2.5	1.1	0.5	10.2	1269
02ms, PA08, I	1.8	1.4	7.6	4.5	2.5	1.1	0.5	11.9	1104
02ms, PA15, 0.89I	1.8	1.4	7.4	4.3	2.4	1.1	0.5	12.7	954
10ms, PA03, 0.92K	1.6	1.3	5.4	3.3	1.8	0.8	0.5	7.3	1015
10ms, PA08, 0.92K	1.6	1.3	6.3	3.8	2.3	1.0	0.4	10.1	890
10ms, PA15, 0.89K	1.6	1.3	6.2	3.7	2.1	0.9	0.4	7.3	873

Table 4 System Simulation Single User Throughput (T_{user}) results with 1 dB TPC step size

Simulation Cases	Rise (dB)		%Rise Outage (dB)					FER	User T-put
(TTI, Channel, Svector)	Avg	Stdev	4.0	4.5	5.0	5.5	6.0	(%)	(Kbps)
02ms, PB03, B	1.7	1.3	6.9	4.0	2.4	1.1	0.4	9.2	990
02ms, PB08, B	1.7	1.4	7.3	4.3	2.5	1.1	0.5	7.8	979
02ms, PB15, B	1.7	1.3	6.5	3.8	2.1	0.9	0.4	8.2	943
10ms, PB03, D	1.6	1.3	5.6	3.4	1.8	0.8	0.3	9.0	1005
10ms, PB08, 0.98*D	1.5	1.3	5.3	3.2	1.8	0.7	0.3	8.9	924
10ms, PB15, 0.98*D	1.4	1.3	5.1	3.1	1.6	0.8	0.4	10.6	863
02ms, PA03, A	1.8	1.4	7.1	4.1	2.4	1.1	0.5	8.8	1213
02ms, PA08, A	1.8	1.4	7.6	4.4	2.5	1.1	0.4	7.7	1155
02ms, PA15, 0.95A	1.7	1.4	7.1	4.1	2.3	1.0	0.4	11.2	1062
10ms, PA03, 0.98*C	1.5	1.3	4.9	2.6	1.5	0.7	0.4	6.6	1166
10ms, PA08, 0.85*C	1.5	1.3	5.1	3.0	1.8	0.7	0.3	9.4	957
10ms, PA15, 0.98*B	1.5	1.3	5.0	3.1	1.7	0.7	0.4	8.2	918

Conclusions:

The following conclusions are drawn from the simulation results presented in this contribution:

1. 2ms TTI results show a progressive improvement in user throughput (up to 25%) compared to 10ms TTI for a Pedestrian A channel as user speed increases. A similar trend is seen with a Pedestrian B channel; however, the improvement is much less significant (less than 10%) due to smaller Eb/Nt target variation from multi-path diversity.
2. An effective MCS selection method has been found but MCS threshold optimization is sensitive to channel type and TTI length (see Figure 2 and Figure 3). Much of the variation in thresholds can be eliminated by only considering multi-path channels.
3. 98%-ile Rise was around 5dB in this single user 1Mbps example with the rise mean between 1.5 to 1.8dB.
4. Ideal channel estimation was assumed with these results. With non-ideal channel estimation [3] showed that a $(\beta_d/\beta_c)^2$ ratio (with regard to DPDCH to DPCCH power ratio) of 0.25 is required to come close to ideal channel estimation throughput performance.

References

[1] Motorola, R1-03-0697, "Performance comparison between 2 ms and 10 ms frame size for E-DCH", Aug 25-29, 2003.
[2] Motorola, R1-03-0599, "Link Simulation Results for Enhanced Uplink – 2msec vs.10 msec", May 19-23, 2003.
[3] Motorola, R1-03-0704, "Effect of non-ideal channel estimation on enhanced uplink system capacity", May 19-23, 2003.

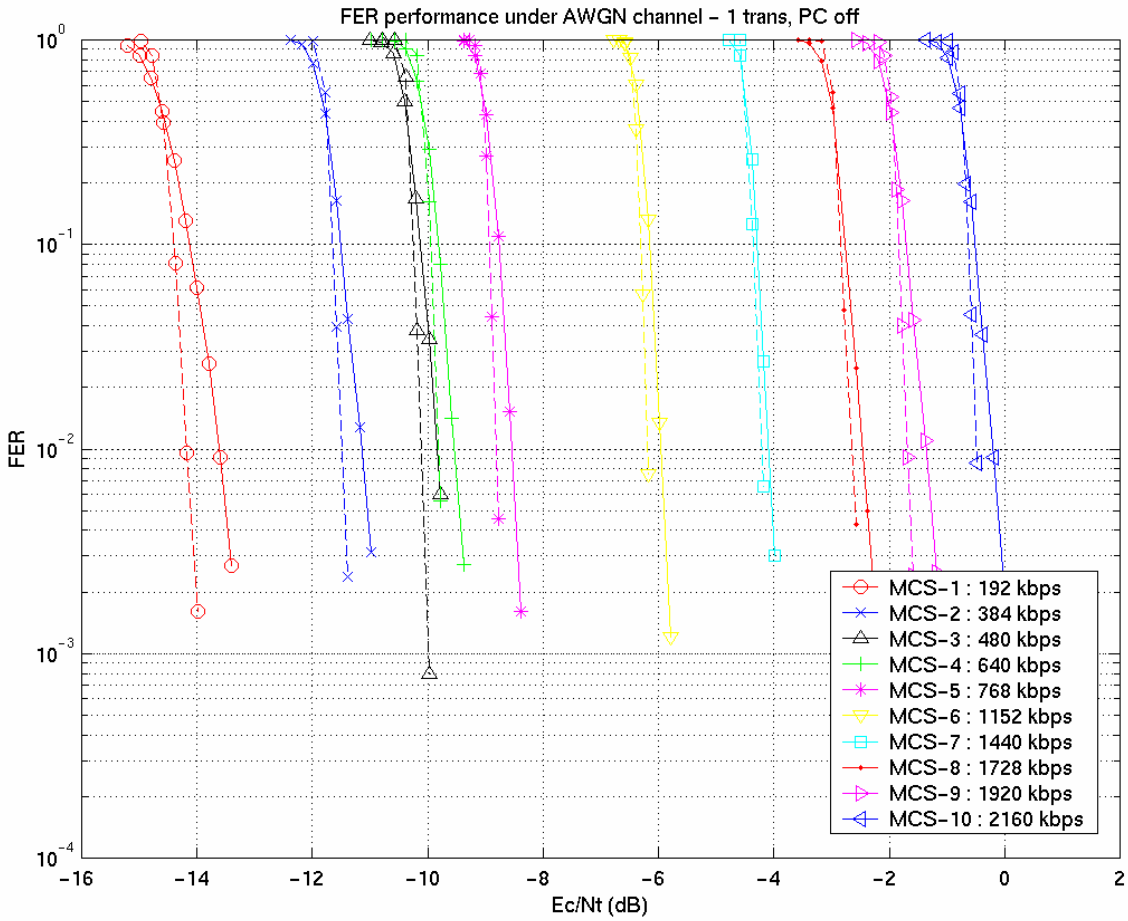


Figure 1. AWGN receiver performance for 2ms and 10ms TTIs. H-ARQ and Power Control were off and non-ideal channel estimation was used.

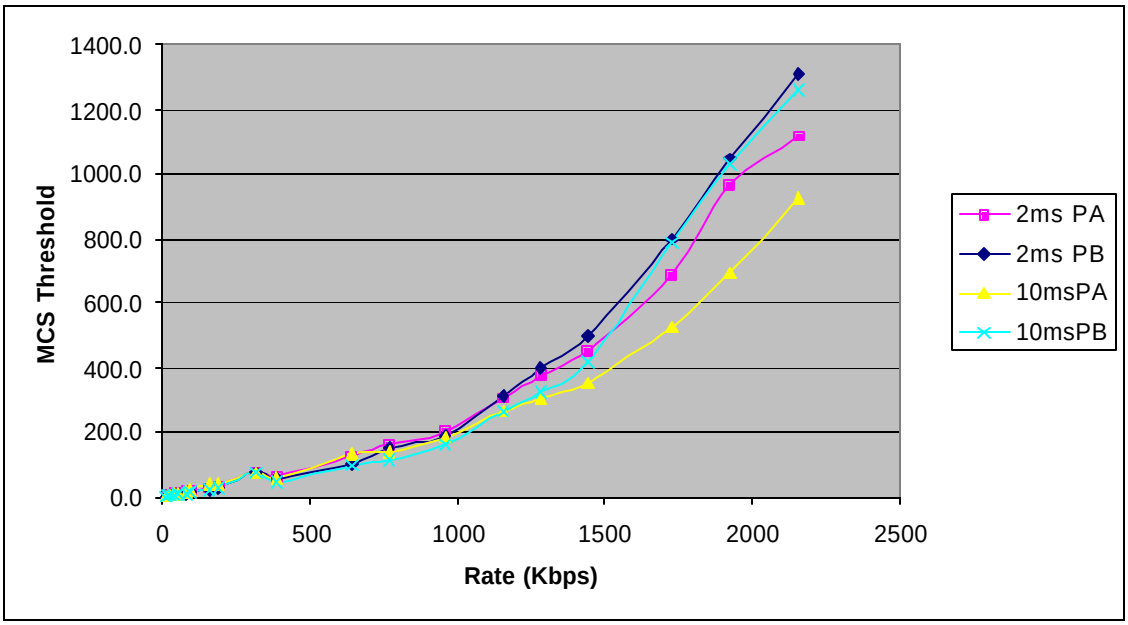


Figure 2. MCS thresholds for 2ms and 10ms TTI, PA and PB channels, with 1dB TPC step. Svectors A, B, C, D.

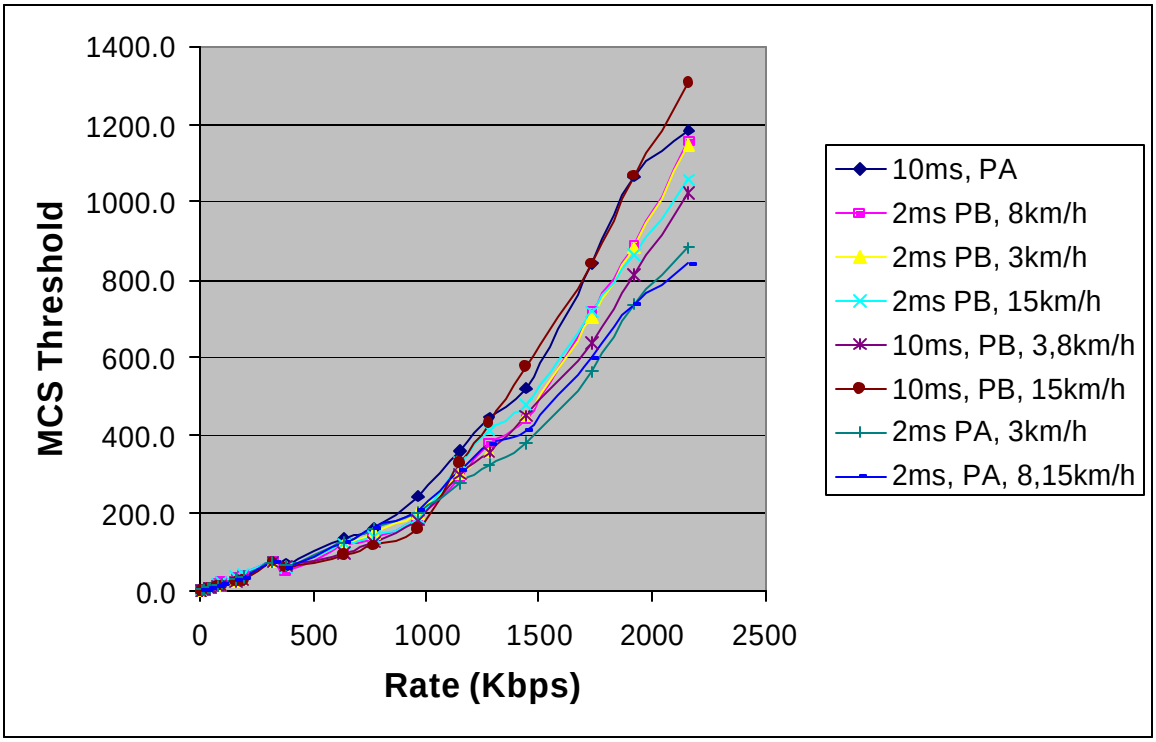
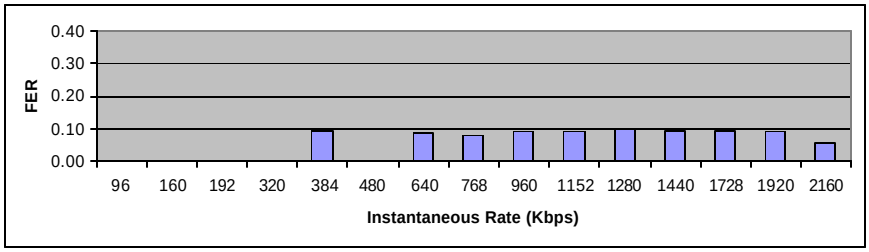
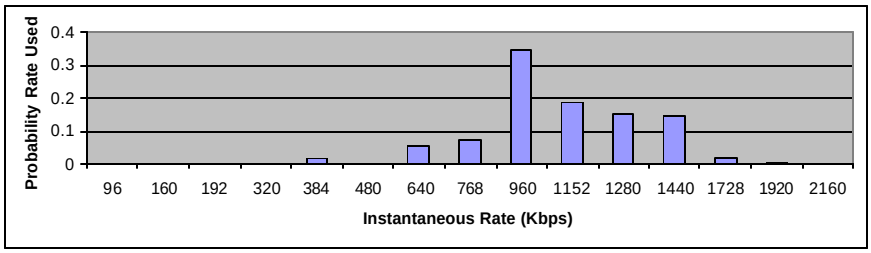


Figure 3. MCS thresholds for 2ms and 10ms TTI, PA and PB channels, with 0.5dB TPC step. Svectors E, F, G, H, I, J, K, L.

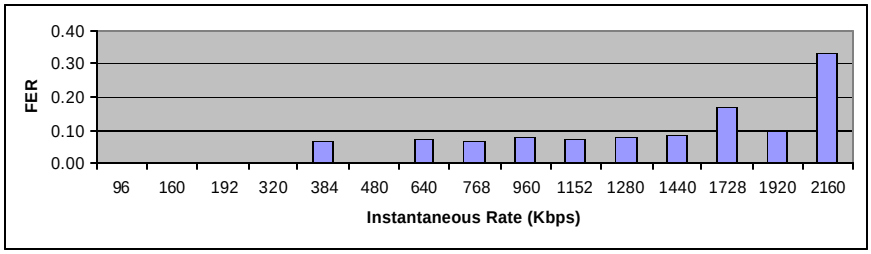
ANNEX A – Single User FER and Rate PDFs for 1dB TPC step size

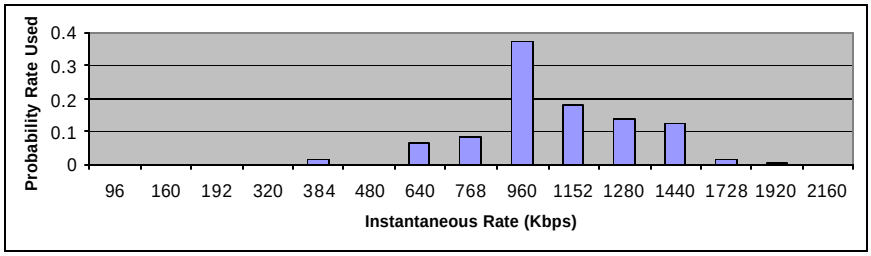
2ms TTI, PB 3km/h, Ideal Channel Estimation, User T-put = 990Kbps



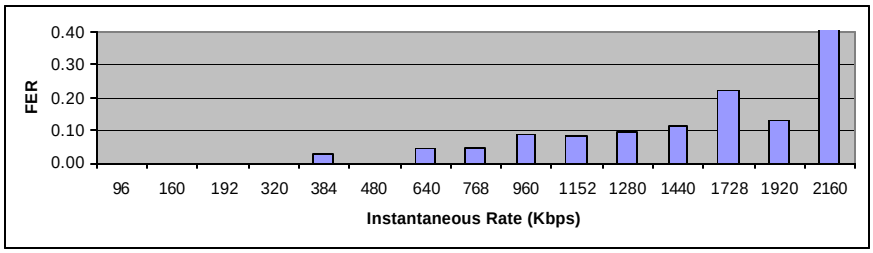


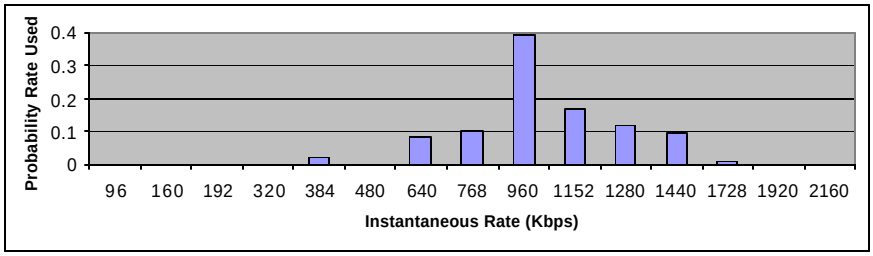
2ms TTI, PB 8km/h, Ideal Channel Estimation, User T-put = 979Kbps



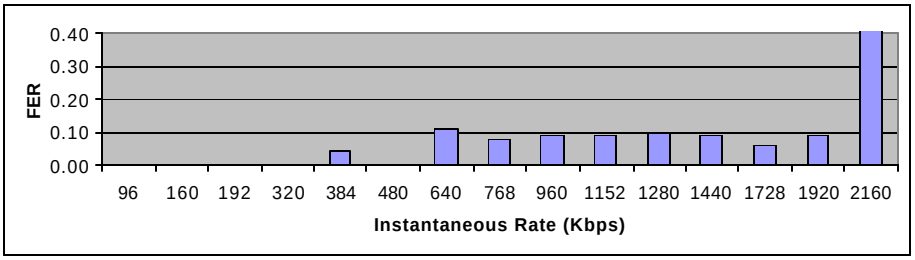


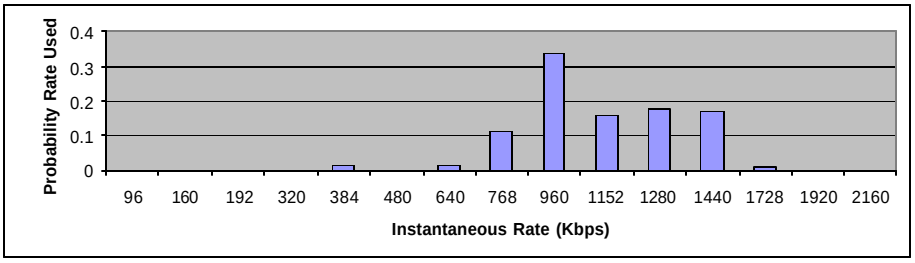
2ms TTI, PB 15km/h, Ideal Channel Estimation, User T-put = 943Kbps



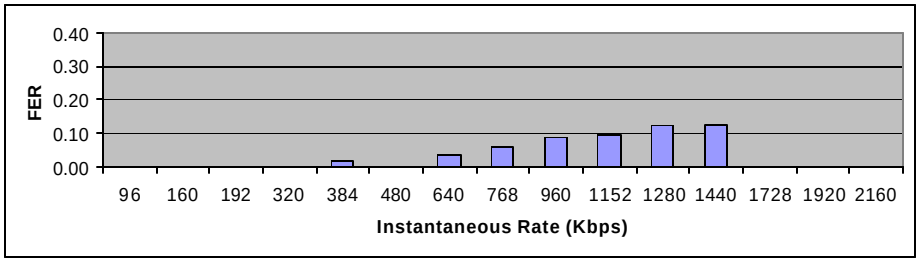


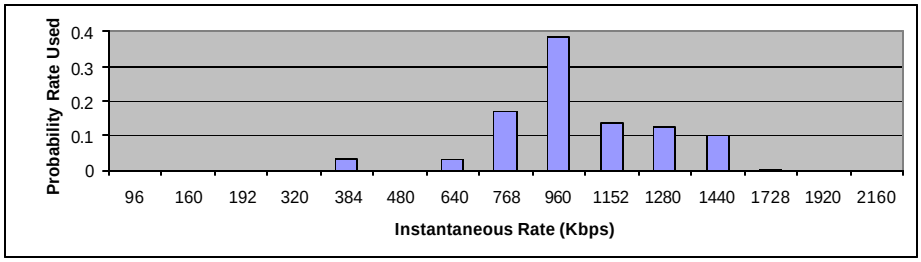
10ms TTI, PB 3km/h, Ideal Channel Estimation, User T-put = 1005Kbps



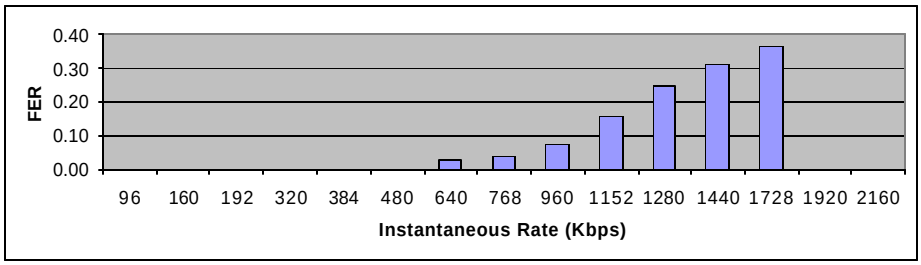


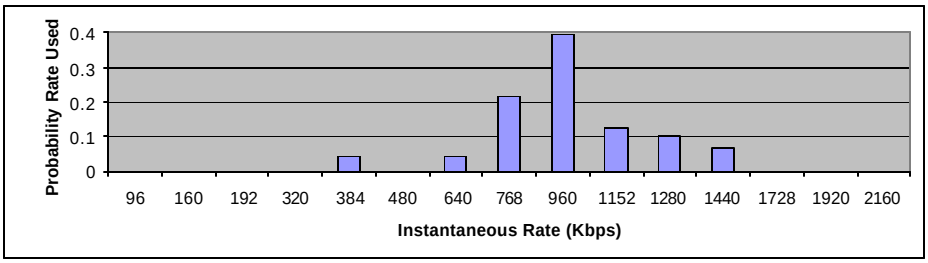
10ms PB 8km/h, Ideal Channel Estimation, User T-put = 924Kbps



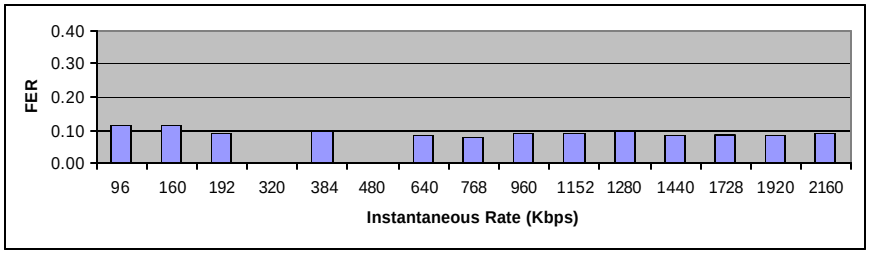


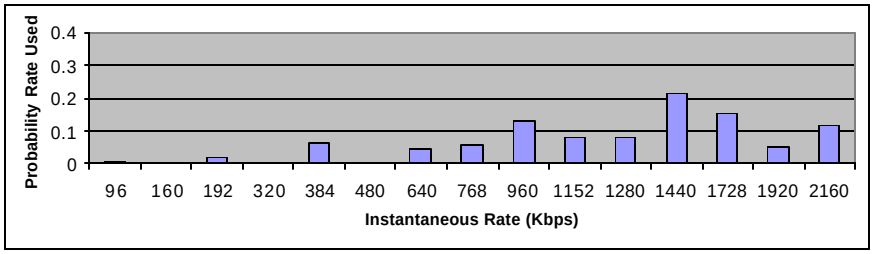
10ms PB 15km/h, Ideal Channel Estimation, User T-put = 863Kbps



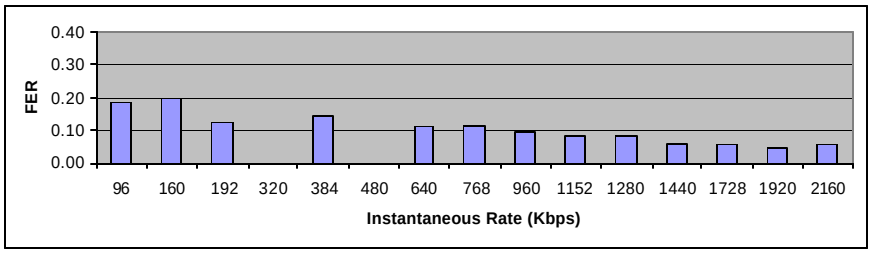


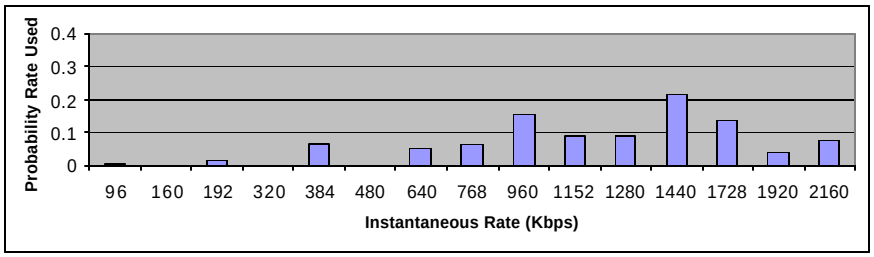
2ms TTI, PA 3km/h, Ideal Channel Estimation, 1213Kbps



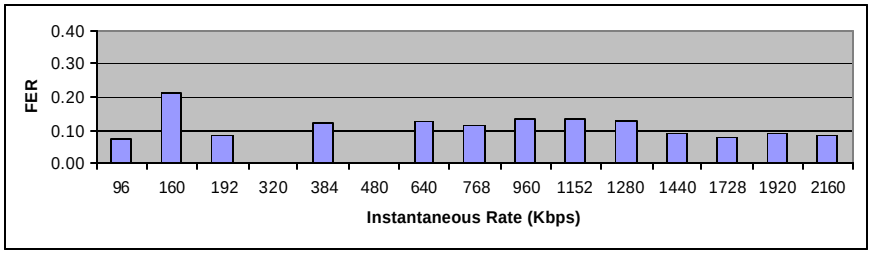


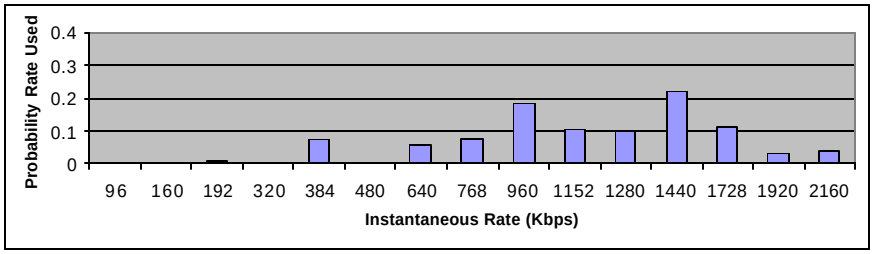
2ms TTI, PA 8km/h, Ideal Channel Estimation, 1155Kbps



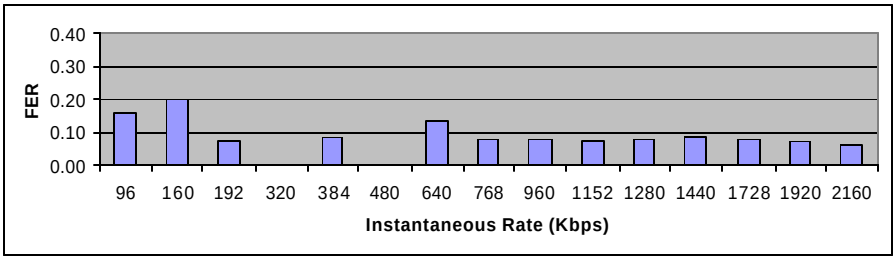


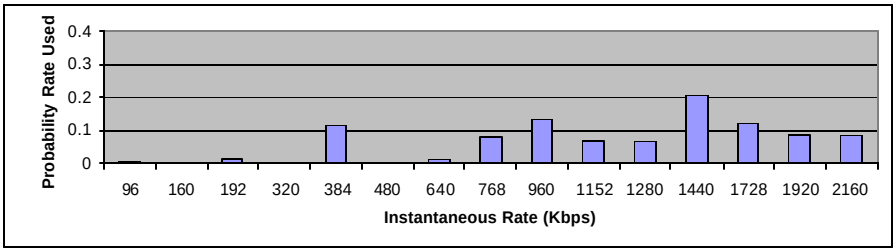
2ms TTI, PA 15km/h, Ideal Channel Estimation, 1062Kbps



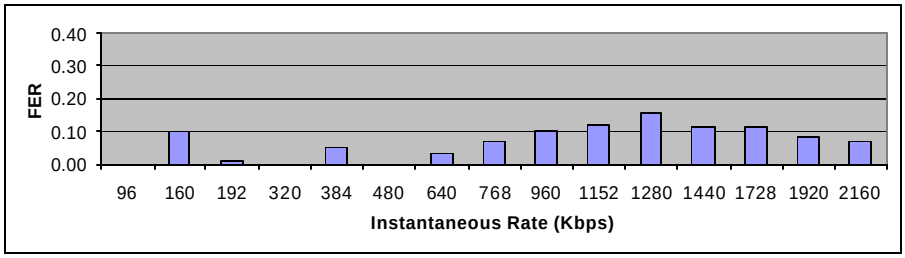


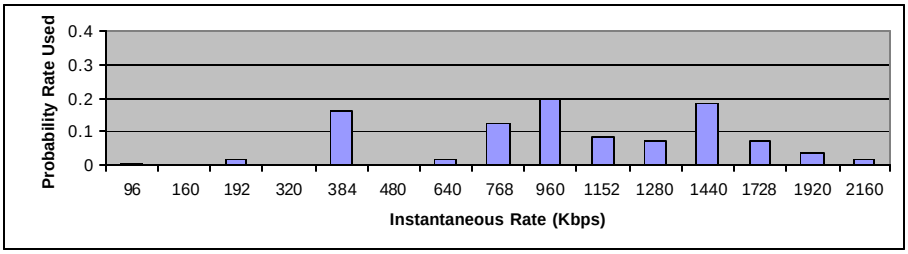
10ms TTI, PA 3km/h, Ideal Channel Estimation, 1165Kbps



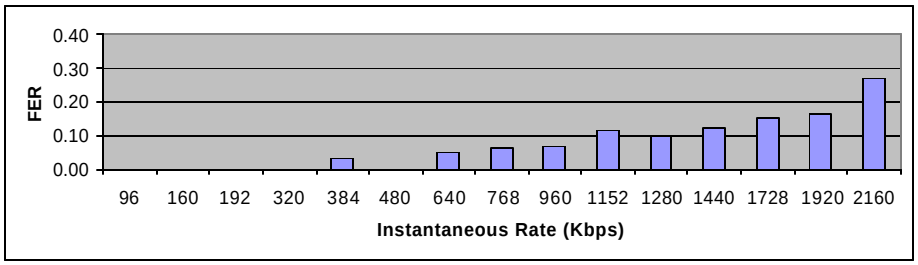


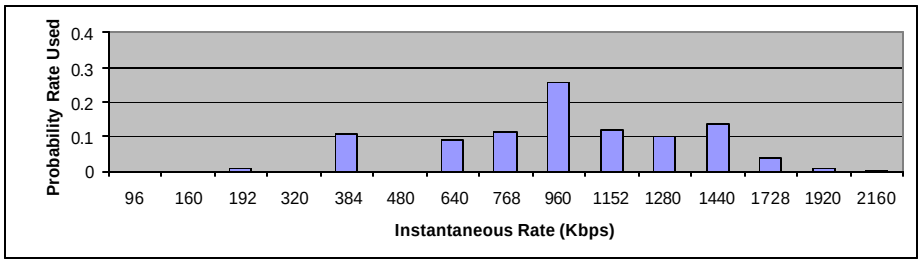
10ms TTI, PA 8km/h, Ideal Channel Estimation, 957Kbps

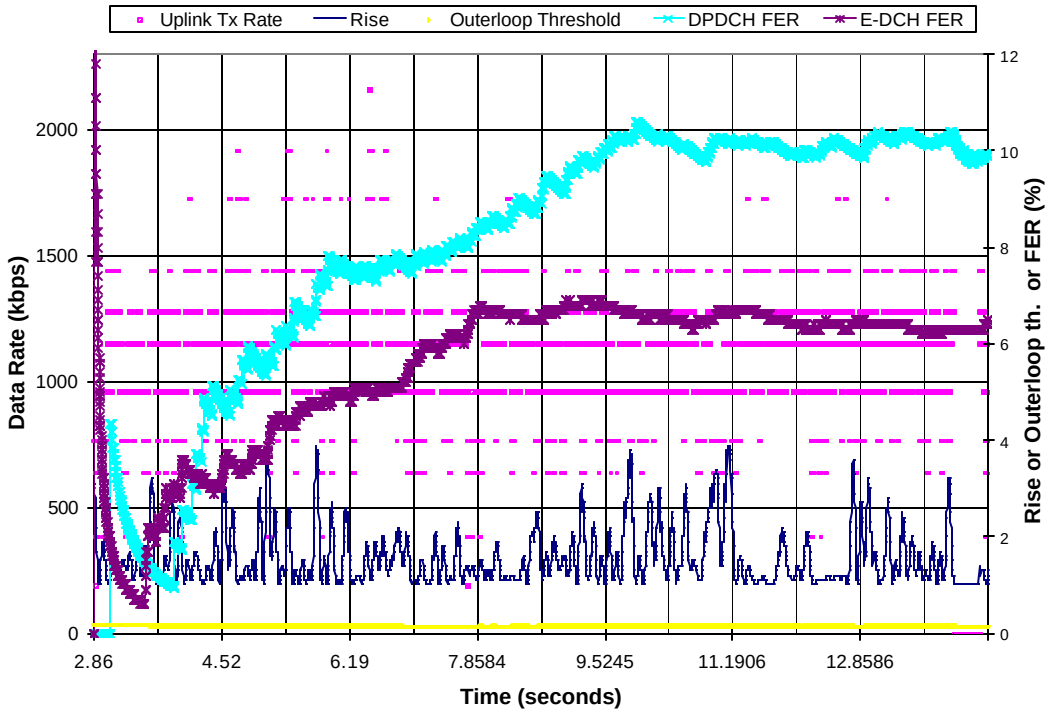
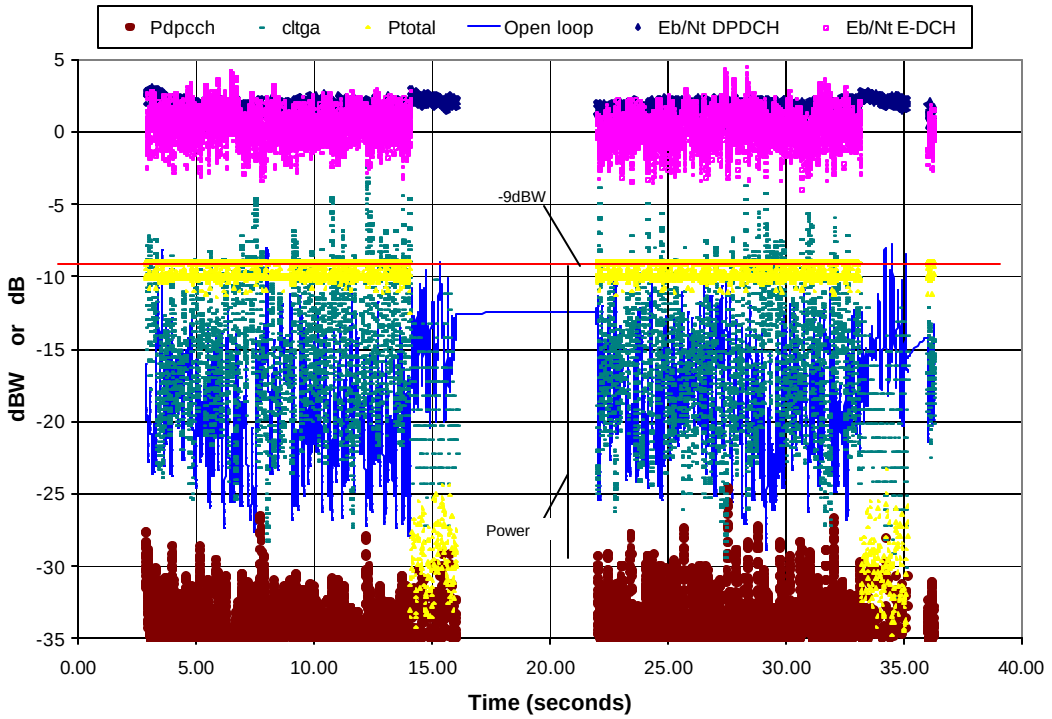




10ms TTI, PA 15km/h, Ideal Channel Estimation, 918Kbps





ANNEX B Time Series for Single User System Results

2ms TTI, 3km/h PB, Ideal Channel Estimation