



## **EDGE Performance Metrics**

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## Enhanced data rates for GSM evolution (EDGE) Performance Metrics

EDGE enhances throughput per timeslot for both HSCSD (ECSD- enhanced circuit switched data) and GPRS (EGPRS enhanced general packet radio service). In EGPRS the data rate per timeslot triples and the peak throughput, with all eight timeslots in use, can reach 473 kbps. This document focuses on EGPRS quality and performance metrics that can be measured and analyzed in the field. Example displays are included for each performance metric.

Enhancements that make EGPRS rates possible include the use of new modulation techniques and error-tolerant transmission methods. A PDTCH/F using GMSK modulation carries information at an instantaneous bit rate up to 22.8 kbps. A PDTCH/F using 8-PSK modulation carries information at an instantaneous bit rate up to 69.6 kbps. The 8-PSK signal is able to carry 3 bits per modulated symbol versus 1 bit per symbol using GMSK. This increased throughput comes at a cost of decreased sensitivity of the 8-PSK signal. Thus, the highest data rates have limited coverage areas since they can only be provided in areas with adequate signal strength.

EGPRS also introduces a new set of coding schemes and quality metrics used with improved link adaptation mechanisms and incremental redundancy. The next section includes a description of the Modulation and Coding Schemes (MCSs) and the quality metrics used to evaluate the radio link. The document concludes with three important performance metrics that can be used to evaluate the health of the data network – reliability, throughput and delay.

### Radio Link Quality Metrics

EGPRS has an impact on the RF and physical layer of the radio interface and on the RLC/MAC protocol. Link Quality Control (LQC) for EGPRS is modified to include incremental redundancy (IR) in addition to link adaptation mode found in GPRS. The LQC includes nine different modulation and coding schemes (MCS 1-9), shown in Table 1, as well as procedures for switching between different MCSs.

**Table 1** Modulation and Coding Scheme (MCS)

MCS	Modulation	Data Rate (kbps)	Family
1	GMSK	8.8	C
2	GMSK	11.2	B
3	GMSK	14.8	A
4	GMSK	17.6	C
5	8PSK	22.4	B
6	8PSK	29.6	A
7	8PSK	44.8	B
8	8PSK	54.4	A
9	8PSK	59.2	A

The GMSK coding schemes (MCS 1-4) are different from GPRS coding schemes (CS 1-4) because the EGPRS packets have different header sizes to support resegmentation – retransmitting with another coding scheme. Resegmentation is not possible with GPRS.

Downlink		Uplink	
RLC Throughput Kb/Sec	-	RLC Throughput Kb/Sec	-
RLC BLER	-	RLC BLER	-
RLC Num of Frames	-	RLC Num of Frames	-
RLC Num of Repeated Frames	-	RLC Num of Repeated Frames	-
LLC Throughput Kb/Sec	-	LLC Throughput Kb/Sec	-
LLC Num of Frames	-	LLC Num of Frames	-
LLC Num of Repeated Frames	-	LLC Num of Repeated Frames	-
Coding Scheme	-	Coding Scheme	-
Timeslot Allocation	-	Timeslot Allocation	-

Attached	IP Address	L1 Mode	Vocoder	Sync Status	C31
No	-	Null	Signaling only	Not Synced	0

C32	Cipher Mode	Attach Status	Ready Timer	ECSC
0	0	No Network	0	-

The **Serving Cell Info** window shown in Figure 1 includes LLC and RLC throughput metrics for both the uplink and downlink paths. The MCS along with the timeslot allocation will define the maximum throughput for both paths.

Shown in tabular form here, this information is also useful in line graphs and maps to show throughput rates across a coverage area.

**Figure 1** Serving Cell Info

The initial MCS for a RLC block is selected based on radio link quality. The network controls the selection of MCSs based on link adaptation algorithms that include radio link quality measurements; Mean Bit Error Probability (BEP) and BEP Coefficient of Variance. The modulation coding scheme can be changed for each radio block (four bursts), but the actual adaptation rate is decided by the measurement interval.

As shown in Table 1, there are three families of coding schemes, A, B and C, that are related by payload sizes and that are used with resegmentation for retransmissions. Unlike GPRS, EGPRS can switch MCSs within a family to retransmit data using more robust coding schemes.

Bit Error Probability (BEP) Measurements

BEP is an enhancement to the channel quality measurements introduced in the Rel'99 specification. It was shown that BEP estimates the channel quality better than RxQual in varying channel conditions such as frequency hopping and varying mobile speed<sup>1</sup>. GPRS performs interference measurements during idle bursts only twice per 240 mS period. BEP is estimated for every burst and is a reflection of the current C/I, the time dispersion of the signal and the velocity of the terminal. A mean BEP is calculated per radio block (four bursts) as well as the variation over the four bursts. This enables quick reaction to changes in the radio link, improving link adaptation.

**Table 3** MEAN\_BEP mapping and accuracy

MEAN_BEP	Range of log <sub>10</sub> (actual BEP)	GMSK	8PSK
		Probability that the expected MEAN_BEP is reported shall not be lower than:	Probability that the expected MEAN_BEP is reported shall not be lower than:
MEAN_BEP_0	> -0.60	80 %	80%
MEAN_BEP_1	-0.70 -- -0.60	80 %	80%
MEAN_BEP_2	-0.80 -- -0.70	70 %	80%
MEAN_BEP_3	-0.90 -- -0.80	70 %	80%
MEAN_BEP_4	-1.00 -- -0.90	70 %	80%
MEAN_BEP_5	-1.10 -- -1.00	70 %	80%
MEAN_BEP_6	-1.20 -- -1.10	70 %	80%
MEAN_BEP_7	-1.30 -- -1.20	70 %	80%
MEAN_BEP_8	-1.40 -- -1.30	70 %	70%
MEAN_BEP_9	-1.50 -- -1.40	70 %	70%
MEAN_BEP_10	-1.60 -- -1.50	65 %	70%
MEAN_BEP_11	-1.70 -- -1.60	65 %	70%
MEAN_BEP_12	-1.80 -- -1.70	65 %	70%
MEAN_BEP_13	-1.90 -- -1.80	65 %	70%
MEAN_BEP_14	-2.00 -- -1.90	65 %	80%
MEAN_BEP_15	-2.10 -- -2.00	70 %	80%
MEAN_BEP_16	-2.20 -- -2.10	70 %	80%
MEAN_BEP_17	-2.30 -- -2.20	70 %	90%
MEAN_BEP_18	-2.40 -- -2.30	70 %	90%
MEAN_BEP_19	-2.50 -- -2.40	70 %	90%
MEAN_BEP_20	-2.60 -- -2.50	70 %	90%
MEAN_BEP_21	-2.70 -- -2.60	70 %	80%
MEAN_BEP_22	-2.80 -- -2.70	70 %	80%
MEAN_BEP_23	-2.90 -- -2.80	70 %	80%
MEAN_BEP_24	-3.00 -- -2.90	70 %	80%
MEAN_BEP_25	-3.10 -- -3.00	65 %	80%
MEAN_BEP_26	-3.20 -- -3.10	65 %	80%
MEAN_BEP_27	-3.30 -- -3.20	65 %	70%
MEAN_BEP_28	-3.40 -- -3.30	65 %	70%
MEAN_BEP_29	-3.50 -- -3.40	80 %	70%
MEAN_BEP_30	-3.60 -- -3.50	80 %	80%
MEAN_BEP_31	< -3.60	80 %	80%

The coefficient of variation that measures the relative dispersion of the channel quality is defined for both 8-PSK and GMSK in the table below.

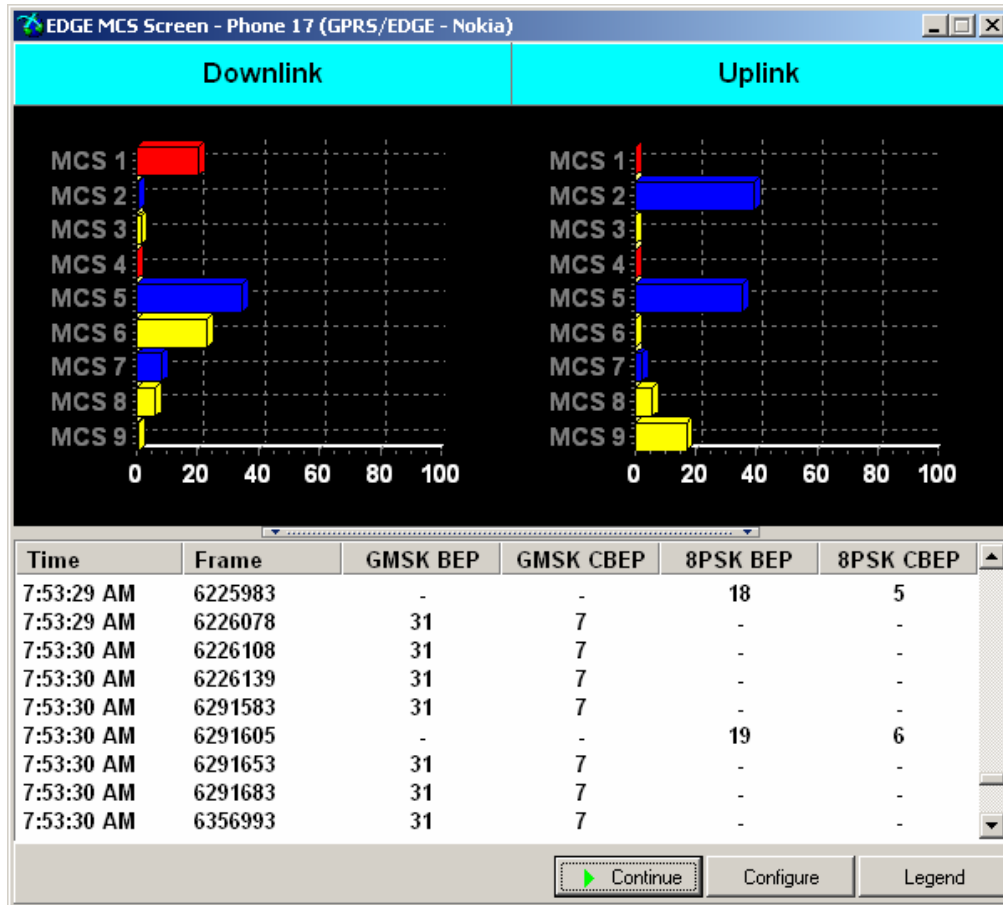
**Table 4** Coefficient of Variation mapping table

CV_BEP_0	2.00	> CV_BEP >	1.75
CV_BEP_1	1.75	> CV_BEP >	1.50
CV_BEP_2	1.50	> CV_BEP >	1.25
CV_BEP_3	1.25	> CV_BEP >	1.00
CV_BEP_4	1.00	> CV_BEP >	0.75
CV_BEP_5	0.75	> CV_BEP >	0.50
CV_BEP_6	0.50	> CV_BEP >	0.25
CV_BEP_7	0.25	> CV_BEP >	0.00

BEP has a higher accuracy than RxQual. The measurements reported by the mobile station (MS) for the network are MEAN\_BEP and CV\_BEP where the MEAN\_BEP (ranges from 1 to 32) is the average of the block mean BEP during the reporting period and the CV\_BEP (ranges from 1

to 8) is the average of the block Coefficient of Variation ( $CV = \text{Std}(\text{BEP})/\text{Mean}(\text{BEP})$ ) during the reporting period. Higher relative MEAN\_BEP values (1-32) correspond to lower actual BEPs. Higher CV\_BEPs (1-8) indicate lower actual CV and greater data consistency. Lower CV-BEPs indicate a higher actual CV and greater dispersion around the mean. Look up tables of MEAN\_BEP versus CV\_BEP can be used in the link adaptation process to select the appropriate MCS for the radio link environment. MCSs and hence throughput increase as the MEAN\_BEP and CV\_BEP values increase.

The MCS information can change rapidly and it is useful to view the dynamic metrics in a rolling histogram of MCS assignments for the uplink and downlink paths.



**Figure 2** MCS Histogram Display

Figure 2 above shows the histogram of MCS assignments. Note that the MCS values are color coded to match their family resegmentation relationship. All raw measurements are recorded and displayed per the configuration settings. Users select the number of measurements to be displayed in the histogram and thus the time window of the measurements. This display shows the engineer the dominant MCS and link adaptation in work as MCS assignments change based on BEP mean and CV measurements.

This information can also be displayed in the EDGE SAM display, shown below in Figure 3, which includes RSSI, throughput and MCS percentage of use for the data session.

EDGE SAM Display - Phone 17 (GPRS/EDGE - Nokia)									
Cell	Layer		RSSI	IP Address			MCS DL		
1003			-98	10.208.168.114			6		
DL Timeslots	UL Timeslots		Est. DL Thrput	Est. UL Thrput		MCS UL			
2	1		6.95 Kbps	6.98 Kbps		2			
	MCS-1	MCS-2	MCS-3	MCS-4	MCS-5	MCS-6	MCS-7	MCS-8	MCS-9
DL	21.0%	6.4%	2.4%	0.3%	25.7%	30.2%	5.8%	3.2%	1.3%
UL	1.7%	35.3%	2.2%	0.0%	33.6%	5.6%	3.0%	3.0%	15.5%

**Figure 3: EDGE Table Display**

### Data Performance Metrics

Three important EGPRS radio link performance metrics in the radio access network (RAN) are reliability, throughput and delay.

#### Reliability

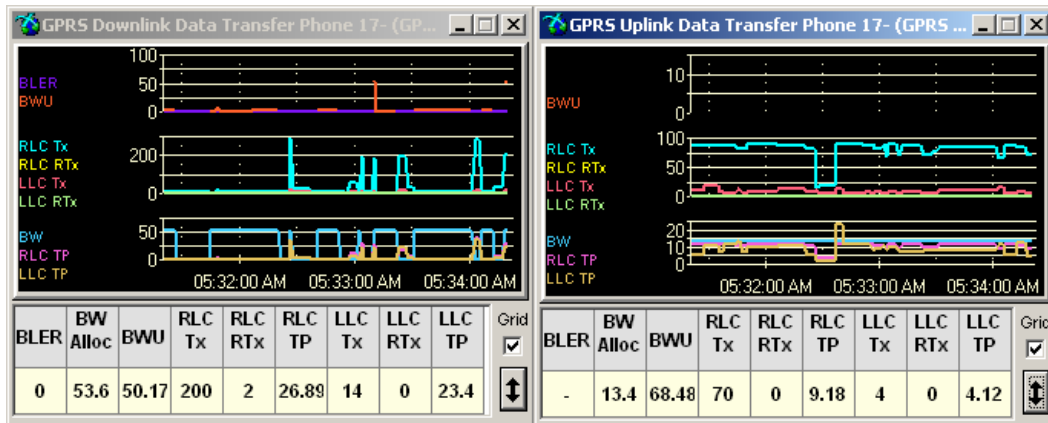
Reliability can be defined as the probability of erroneous radio link control (RLC) blocks delivered to the logical link control (LLC) layer. Reliability depends on the operation mode of the RLC layer across coding schemes. In most cases, retransmissions are required if block errors are detected. Reliability can be measured and presented as a ratio of the number of RLC data blocks correctly received for the first time across each coding scheme versus the number or retransmitted RLC data blocks across each coding scheme. Reliability measurements can be made on both uplink (UL) and downlink (DL) data transfers.

#### Throughput

Throughput is the amount of data delivered per unit of time. It is useful to view the instantaneous throughput, calculated average and percentile throughput values across the network:

- A. LLC Throughput: number of bytes in the Information Field of each LLC frame, excluding header and Frame Check Sequence (FCS) received or transmitted during the observation period.
- B. RLC/MAC Throughput: number of first transmissions of RLC Data Blocks of each coding scheme
- C. RLC/MAC Overhead Throughput: number of RLC Data Blocks retransmitted and the RLC/MAC Control Blocks (CS-1 coded) received for that same Temporary Block Flow (TBF).

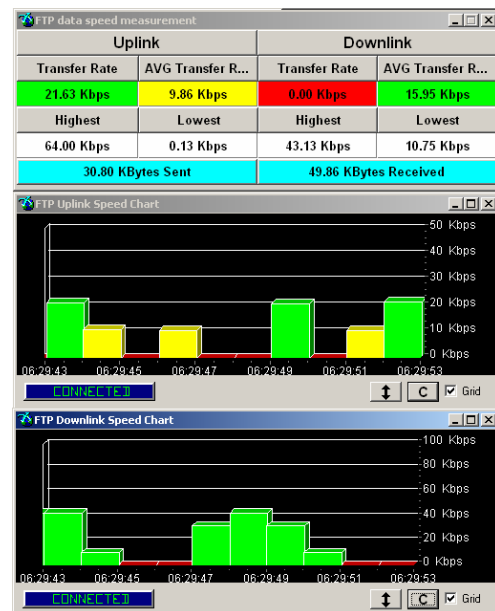
Xi's downlink and uplink EGPRS data transfer screens display GPRS specific parameters in graphical format. The graphs depict the uplink and downlink RLC/LLC throughputs, RLC/LLC retransmissions, block error rate, allocated bandwidth and actual bandwidth used.



**Figure 4: LLC/LLC Throughput Graphs**

- D. Application Throughput: number of bytes in the data field of each IP packet excluding the IP header received or transmitted during the observation period.
- For downlink – time duration shall be from the time of reception of the Packet Paging to the time of the last RLC Data Block acknowledgement by the network
  - For uplink – time duration shall be from the time of the transmission of the first Packet Channel Request to the time of reception of the last IP Ack at the application layer.

Xi's automated FTP session generator displays application uplink and downlink actual and average throughput charts and tables.



Delay

Delay is defined as the time it takes for a LLC Protocol Data Unit (PDU) to be transferred from the Serving GPRS Support Node (SGSN) to the MS or from the MS to the SGSN. PING commands can be used to measure the response time at the application layer. A heavily loaded network may have excessively long response times that may disrupt application and transport layer protocols.

<sup>1</sup> Tdoc SMG2, 464/99, Link Quality Control Measurements for EGPRS, April 12-16, 1999, Dublin, Ireland.