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3GPP Enhanced Uplink UMTS Simulation Description and Environment

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ABSTRACT

In this paper, we will evaluate the performance of the SIR-based power controlled enhanced WCDMA uplink system in a selective frequency channel. We propose, also, an improved Signal-to-Interference power Ratio (SIR) estimation scheme. This document describes, also, the way how to set up a link layer simulation for HSUPA. It explains the 3GPP definition of SIR, Ec/No and Eb/No and indicates where these indicators have to be measured. Furthermore, as the simulations are very time expensive, a description of a simplified simulation method is given.

Keywords: *HSUPA, Power Control, simulator, simplified simulator*

1. INTRODUCTION

The target of third-generation (3G) mobile systems is to support high data rate services, to increase system capacity and to ensure a good quality of services. Higher data rates allow the deployment of multi-media applications which involve voice, data, pictures, and video. At this moment, the data rate envisioned for 3G networks is 10Mb/s on downlink with the used of the HSDPA and 5.7Mb/s on uplink with the used if the HSUPA.

Power control is normalised by the 3GPP in the third-generation mobile systems such as UMTS, HSDPA and HSUPA. It is an essential mechanism for Wideband Code Division Multiple Access (WCDMA) systems. It is widely applied to alleviate the effects of the multi-path fading and of the near-far problem. It is required to estimate the SIR of the received signal for the SIR-based power controlled system. As the accuracy of the SIR increases, the transmit power can be reduced without degrading the system performance.

The rest of the paper can be organized as follow: In the second section, we will deal with an overview of characterizations of uplink UMTS transmitter. Then in the third section, we explain the 3GPP definition of SIR, Ec/No and Eb/No. In the forth section, we describe the UPLINK UMTS simulator. In the final sections, we will focus on the power control loops of the HSUPA system.

2. UMTS UPLINK TRANSMISSION

2.1 General Description

An overview (based on [1] TS 25.211 v7.0.0) of the uplink transmission channels is given in the figure 1. The system studied, in this paper, includes the new physical channels introduced for HSUPA (one, t E-DPCCH and a maximum of 4 E-DPDCHs, the number of channels depends on the HSUPA FRC used), the physical uplink channel HS-DPCCH for HSDPA when the HS-DPDCH is used in the downlink and the physical uplink channel DPCCH for the R99 DCH system. This control uplink channel is obligatory for E-DCH to manage the power control.

2.2 The HSUPA Fixed reference channels (FRC)

The FRCs are a set of E-DCH channel configurations defined in 3gpp for performance testing purposes. They are shown in the table below. FRC1 to FRC3 use a 2ms transmission time interval (TTI), whereas the other FRCs are specified for a TTI of 10ms. The maximum bit rate of more than 4Mbps.

Table 1: HSUPA FRCs

Fixed Ref. CH.	TTI [ms]	N_{INF}	SF_1	SF_2	SF_3	SF_4	N_{BIN}	Coding rate
FRC1	2	2706	4	4	0	0	3840	0.705
FRC2	2	5412	2	2	0	0	7680	0.705
FRC3	2	8100	2	2	4	4	11520	0.703
FRC4	10	5076	4	0	0	0	9600	0.529
FRC5	10	9780	4	4	0	0	19200	0.509
FRC6	10	19278	2	2	0	0	38400	0.502
FRC7	10	690	16	0	0	0	2400	0.288

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1.3 System Model

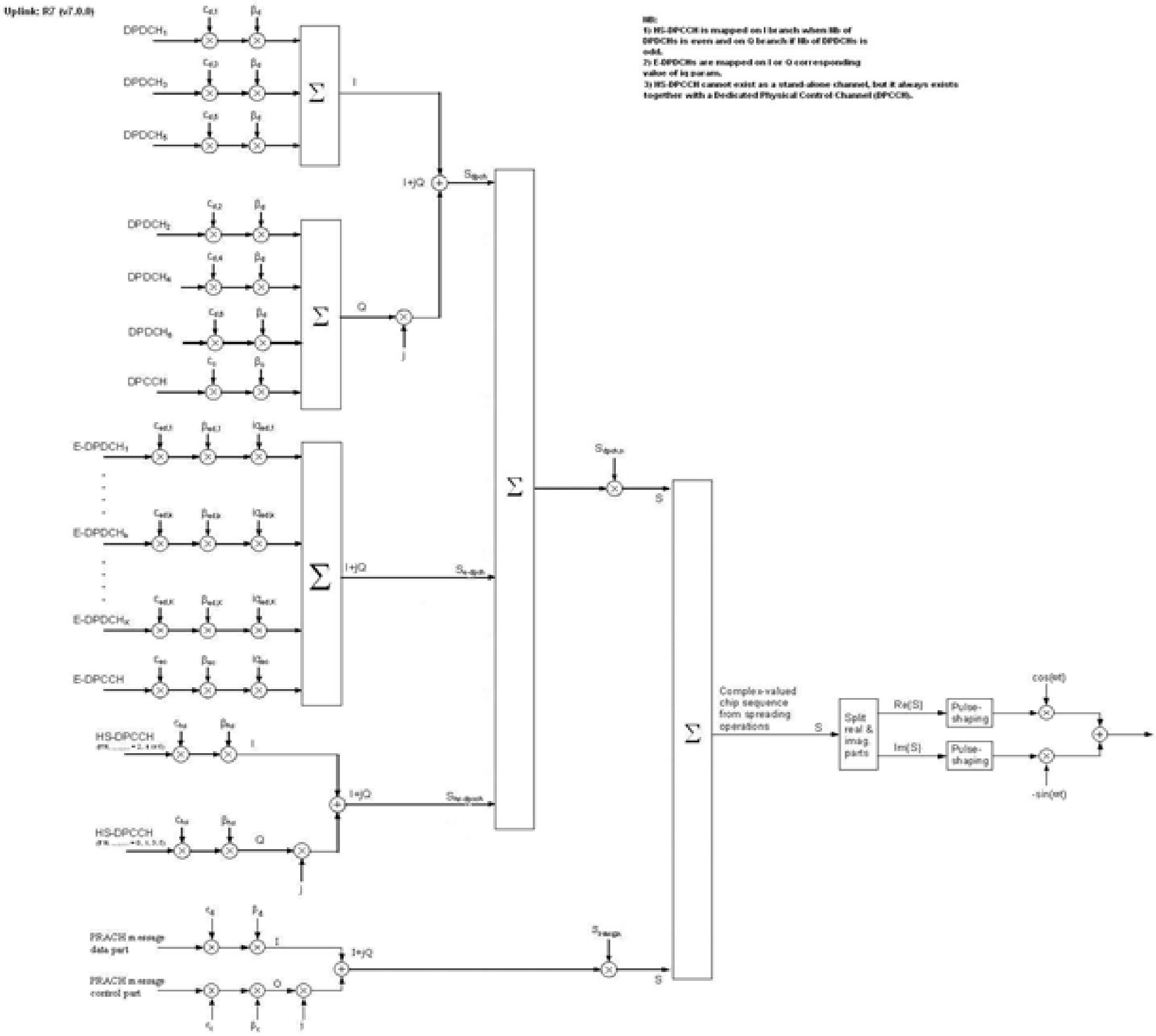

Figure 1: UMTS Uplink Transmission Channels

For the uplink dedicated channels there are the well known R99 DCH (DPCCH + one ore more DPDCHs), the HS-DPCCH, which is the uplink control/feedback channel when HSDPA is used in downlink and the enhanced uplink (HSUPA) channels, namely E-DPCCH and one ore more E-DPDCHs.

Furthermore, we have the PRACH, which is a common channel and used for call set up. The PRACH can theoretically transmit as well user data, but as it is a common channel (shared by al users in the cell). Furthermore, PRACH data transmission is not allowed together with dedicated channel transmission. So PRACH transmission is neglected normally in simulators.

The following table (cf. [4]) indicates the maximum number of simultaneously configurable uplink dedicated channels. It corresponds to the maximum simultaneously allowed combinations of R99 DCH, HSUPA and HSDPA.

Table 2: Maximum Number of Simultaneously Configured Uplink Dedicated Channels

	DPDCH	HS-DPCCH	E-DPDCH	E-DPCCH
Case 1	6	1	-	-
Case 2	1	1	2	1
Case 3	-	1	4	1

So, in practice we could have:

1. E-DCH use only in this case, one or more E-DPDCH, one E-DPCCH and the DPCCH is used. The DPCCH is mandatory for E-DCH use as it manages the power control.
2. E-DCH used together with DCH use in this case a maximum of one DPDCH, the E-DPDCH(s), the E-DPCCH and the DPCCH are to consider.
3. E-DCH used together with HS-DSCH in this case HSDPA is used in the downlink. This means the use of the HS-DPCCH in the uplink. Hence, we have to consider a maximum of two E-DPDCHs, the E-DPCCH, the DPCCH and the HS-DPCCH.
4. E-DCH used together with DCH and HS-DSCH In this case one DPDCH, a maximum of two E-DPDCHs, the E-DPCCH, the HS-DPCCH and the DPCCH are to consider.

This paper is interested in the case 3 scenario, this means, the use of E-DCH (E-DPCCH + up to 4 E-DPDCHs) together with HS-DPCCH. Of course this implies as well the use of the DPCCH which is mandatory due to power control use.

3. 3GPP DEFINITION OF SIR, Eb/No, Ec/No

The definition of the signal to noise ratio can be done differently and on different places. 3GPP has therefore defined some rules in order to be able to compare results.

3.1 SIR

According to [2] the Signal to Interference Ratio *(SIR)* is defined as:

Type 1: Signal to Interference Ratio, is defined as: *(RSCP/ISCP)×SF*. The measurement shall be performed on the DPCCH of a Radio Link Set. In compressed mode the SIR shall not be measured in the transmission gap. The reference point for the SIR measurements shall be the Rx antenna connector. If the radio link set contains more than one radio link, the reported value shall be the linear summation of the SIR from each radio link of the radio link set. If Rx diversity is used in the Node B for a cell, the SIR for a radio link shall be the linear summation of the SIR from each Rx antenna for that radio link. When cell portions are defined in the cell, the SIR measurement shall be possible in each cell portion.

where:

RSCP = Received Signal Code Power, unbiased measurement of the received power on one code.

ISCP = Interference Signal Code Power, the interference on the received signal.

SF=The spreading factor used on the DPCCH.

Type 2: Signal to Interference Ratio, is defined as: (RSCP/ISCP)×SF. The measurement shall be performed on the PRACH control part. The reference point for the SIR measurements shall be the Rx antenna connector. When cell portions are defined in the cell, the SIR measurement shall be possible in each cell portion.

where:

RSCP = Received Signal Code Power, unbiased measurement of the received power on the code.

ISCP = Interference Signal Code Power, the interference on the received signal.

SF=The spreading factor used on the control part of the PRACH.

In our case we consider the data transmission and hence the measurements on DPCCH (i.e. Type1). Note that the exact definition of the SIR has no importance since it does not appear on the quality tables needed. We will assume that the SIR is the signal to noise ratio (Eb/No) (associated to the lowest spreading factor) at the output of the RAKE which a perfect power control aims at maintaining constant. The SIR is an indicator measured by the Node B (for the uplink case). This indicator is subjective and cannot be used (or only roughly) for comparisons. In order to be able to compare QoS tables, an objective measurement is given by the Ec/No values.

3.2 Eb/No and Ec/No

According to [3] the energy per bit to noise ratio (*Eb/No*) is defined as:

$$E_b / N_o = \frac{E_c}{N_o} \cdot \frac{L_{chip}}{L_{\inf}}$$

Where:

E_c is the received total energy of DPDCH, DPCCH, HS-DPCCH, E-DPDCH and E-DPCCH per PN chip per antenna from all paths.

N_o is the total one-sided noise power spectral density due to all noise sources

L_{chip} is the number of chips per frame

$L_{\inf}$ is the number of information bits in DTCH excluding CRC bits per frame

First of all this definition establishes the link between the energy per chip and energy per bit.

We notice that the above definition can only provide an Eb/No if the logical channel DTCH is used as $L_{\inf}$ is the number of bits in a DTCH frame. This is of course the case for DCH and E-DCH transmission, but not for the HSDPA feedback bits transmitted on the HS-DPCCH physical channel.

We notice as well, that Ec represents the sum of the energy per chip on the DPDCH(s), DPCCH, HS-DPCCH, E-DPDCH(s) and E-DPCCH and this only per antenna.

In R99, where only one DPDCH and a DPCCH exist, it is straight forward to define Ec as the sum of the energies. With the new UMTS features (HSDPA, HSUPA) people began unfortunately to define their Ec on differently, meaning considering only a part of the possible dedicated channels. For instance, some persons define the enhanced UL Ec as the sum of the E-DPCCH and the E-DPDCH. Some others as the sum of E-DPCCH, E-DPDCH and DPCCH as the enhanced uplink cannot exist without the DPCCH. But only the above definition is correct when dealing with 3GPP. It is important to know the definition of the used energy in order to compare simulation results.

We notice as well that the energy of the PRACH (cf. Figure 1) is not considered. This can be explained by the fact that it is used only for call set up. However, theoretically, it is possible to use it for user data transmission, but this seldom done in practice and cannot take place simultaneously with a transmission on dedicated channels.

The Ec/No is an objective indicator. It allows comparing the performance of simulation results. However, a strict usage of the 3GPP definition is mandatory. Otherwise comparisons cannot be done.

The Ec/No is not a measurement available in the UMTS system itself. It must be done by a external measurements and does only make sense in controlled experimental environments. That's why the UMTS system uses the SIR measurement in what concerns the power control.

4.1 A SIR- Ec/No plot Example

The following plot shows an example of the relation between received SIR and received Ec (Cout) energy. These examples represent an UL transmission. We see clearly that the SIR cannot go lower than a certain value as the receiver's signal estimate is dominated by self-interference at the ouput of the RAKE.

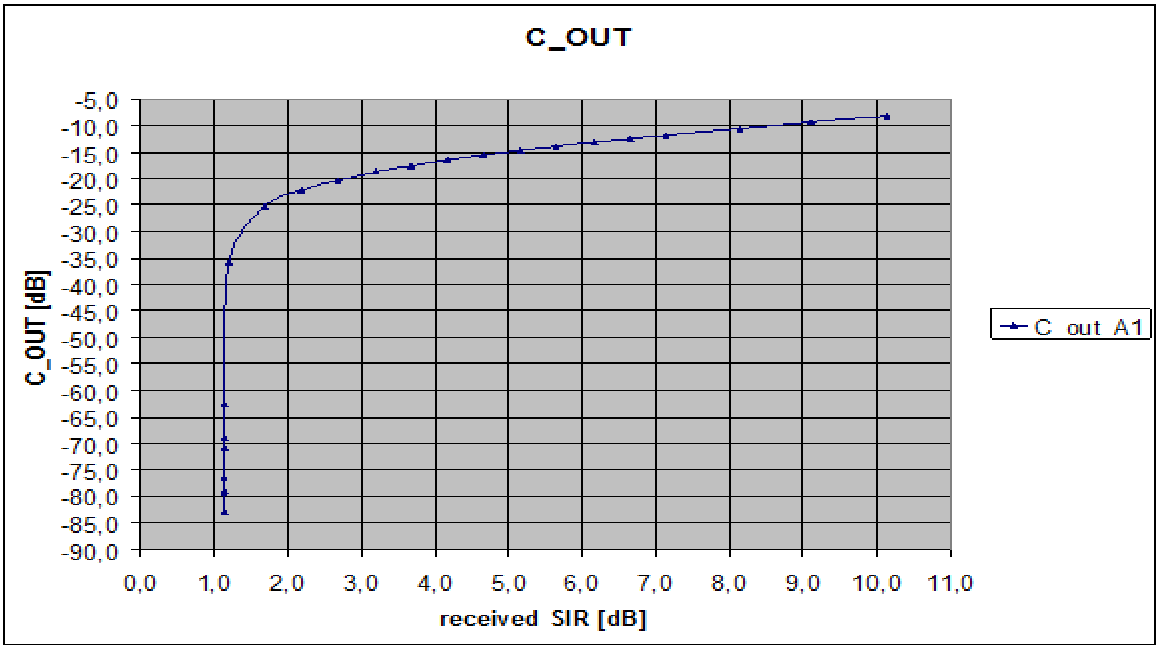

Figure 2: Ec/No per antenna as a function of received SIR Converting 3GPP Eb/No or Ec/No

According to this definition *Ec* can be written as:

$$E_c = \sum_i E_{c,DPDCH,i} + E_{c,DPCCH} + E_{c,HS-DPCCH} + \sum_k E_{c,E-DPDCH,k} + E_{c,E-DPCCH}$$

The different energies are linked mutually by the beta factors:

$$\frac{E_{c,DPDCH}}{E_{c,DPCCH}} = \frac{\beta_d^2}{\beta_c^2} \qquad \frac{E_{c,DPDCH,k}}{E_{c,DPCCH}} = \frac{\beta_{ed,k}^2}{\beta_c^2} \qquad \frac{E_{c,E-DPCCH}}{E_{c,DPCCH}} = \frac{\beta_{ec}^2}{\beta_c^2} \qquad \frac{E_{c,HS-DPCCH}}{E_{c,DPCCH}} = \frac{\beta_{hs}^2}{\beta_c^2}$$

Using these relations we can rewrite Ec as

$$E_c = \frac{\sum_i \beta_{d,i}^2 + \beta_c^2 + \beta_{hs}^2 + \sum_k \beta_{ed,k}^2 + \beta_{ec}^2}{\beta_c^2} * E_{c,DPCCH}$$

This equation can be used easily for the conversion into any energy. If for instance we are looking for the energy of the E-DPDCHs, we obtain:

$$E_c = \frac{\sum_i \beta_{d,i}^2 + \beta_c^2 + \beta_{hs}^2 + \sum_k \beta_{ed,k}^2 + \beta_{ec}^2}{\sum_k \beta_{ed,k}^2} * \sum_k E_{c,E-DPDCH,k}$$

or if we are looking for the relation to the E-DPCCH energy, we obtain

$$E_c = \frac{\sum_i \beta_{d,i}^2 + \beta_c^2 + \beta_{hs}^2 + \sum_k \beta_{ed,k}^2 + \beta_{ec}^2}{\beta_{ec}^2} * E_{c,E-DPCCH}$$

5. UMTS UL SIMULATIONS

5.1 Transmission characteristics

The uplink transmission modulation uses a BPSK on the I and Q axes. This means, it results in a kind of QPSK. Some transmission channels have a fixed association to one of the modulation axes, others can be mapped either on I or Q (depending on what is defined by 3GPP).

3GPP defines the Eb/No in relation with the total received energy per chip. Therefore, the powers on the different channels are linked by the so called beta factors.

The total transmitted energy $E_{\substack{total,\mathrm{Tx}\\chip}}$ is split on the DPDCH(s), DPCCH, E-DPDCH(s), E-DPCCH and the HS-DPCCH by help of the factors β_d, β_c, $\beta_{ed,k}$, β_{ec} and β_{hs} respectively. When more than one DPDCH is used, all of them have the same β_d in contrary to the use of more than one E-DPDCH, where each E-DPDCH k has its own $\beta_{ed,k}$ .As a consequence we will find the same split on the receiver side.

As the chip sequence is multiplied with the gain factors β their impact on the energy (or power) will be their squared value. As the whole available energy (or transmit power) is split on the UL dedicated transmission channels, it is convenient to define that:

$$\sum_{i=1}^{6} \beta_{d,i}^2 + \beta_c^2 + \sum_{k=1}^{4} \beta_{d,k}^2 + \beta_{ec}^2 + \beta_{hs}^2 \equiv 1$$

The energy amplification on the transmitter side is realized by $E_{\substack{total,\mathrm{Tx}\\chip}}$ managed by the power control loop. This definition respects also the Ec definition of 3GPP. In order to guarantee that the whole energy $E_{\substack{total,\mathrm{Tx}\\chip}}$ is not exceeded, we apply to each β a normalization with the factor:

$$norm = \sum_{i=1}^{6} \beta_{d,i}^2 + \beta_c^2 + \sum_{k=1}^{4} \beta_{d,k}^2 + \beta_{ec}^2 + \beta_{hs}^2$$

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resulting in $\beta_{normalized} \rightarrow \dfrac{\beta}{\sqrt{norm}}$

This can be done without any loss of generality and changes nothing in our simulations. For example, if only a R99 transmission (one DPDCH and one DPCCH) takes place, the other non-concerned beta factors are zero and we have the following modulation scheme:

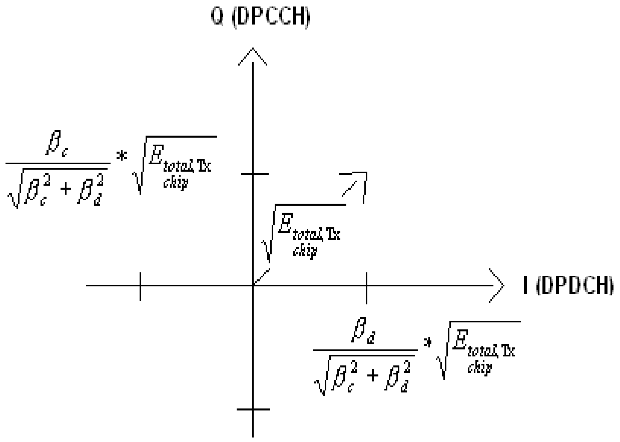

Figure 3: Modulation Scheme of the R99 DPDCH/DPCCH Transmission

The energy split from the transmitter side is found consequently as well on the receiver side. In general this means that we have the following split of energy:

$$E_{\substack{chip\\DPDCH}} = \frac{\beta_d^2}{norm} * E_{\substack{total,\mathrm{Rx}\\chip}}$$

$$E_{\substack{chip\\DPCCH}} = \frac{\beta_c^2}{norm} * E_{\substack{total,\mathrm{Rx}\\chip}}$$

$$E_{\substack{chip\\E-DPCCH}} = \frac{\beta_{ec}^2}{norm} * E_{\substack{total,\mathrm{Rx}\\chip}}$$

$$E_{\substack{chip\\E-DPDCH,k}} = \frac{\beta_{ed,k}^2}{norm} * E_{\substack{total,\mathrm{Rx}\\chip}}$$

$$E_{\substack{chip\\HS-DPCCH}} = \frac{\beta_{hs}^2}{norm} * E_{\substack{total,\mathrm{Rx}\\chip}}$$

This means that the power differences are expressed by:

$$\Delta P_{DPDCH} = \frac{E_{\substack{chip\\DPDCH}}}{E_{\substack{chip\\DPCCH}}} = \frac{\beta_d^2}{\beta_c^2}$$

$$\Delta P_{E-DPDCH,k} = \frac{E_{\substack{chip\\DPDCH,k}}}{E_{\substack{chip\\DPCCH}}} = \frac{\beta_{ed,k}^2}{\beta_c^2}$$

$$\Delta P_{E-DPCCH} = \frac{E_{\substack{chip\\E-DPCCH}}}{E_{\substack{chip\\DPCCH}}} = \frac{\beta_{ec}^2}{\beta_c^2}$$

$$\Delta P_{HS-DPCCH} = \frac{E_{\substack{chip\\HS-DPCCH}}}{E_{\substack{chip\\DPCCH}}} = \frac{\beta_{hs}^2}{\beta_c^2}$$

5.2 Signal-to-Interference Power Ratio

Let $\hat{S}_k$ *is the* k^{th} *symbol estimated after rake:*

$$\hat{S}_k = \sum_{i=1}^{L}\sum_{j=1}^{L} h_i h_j^* S_k + \hat{I}_k$$

Where S_k *is the* k^{th} *transmitted symbol and* $\hat{I}_k$ *is the Interfenece with the noise (AWGN)*

and where h_i *is the path gain*

The SIR_k *definition of the* k^{th} *transmitted symbol is:*

$$SIR_k = \frac{RSP_k}{IP_k}$$

Where RSP_k *is the Received Symbol Power and the* IP_k *is the Interference Power.*

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$$RSP_k = \left| \sum_{i=1}^{L} \sum_{j=1}^{L} h_i h_j^* S_k \right|^2 = E_s \left| \sum_{i=1}^{L} |h_i|^2 \right|^2$$

$$IP_k = \left| \sum_{i=1}^{L} |h_i|^2 S_k - \hat{S}_k \right|^2$$

Where E_k is the Energy of symbol and $\hat{S}_k$ is the estimated symbol associated to the lowest spreading factor used.

$$SIR_{estimated} = \sum_k SIR_k$$

In a diversity receiver $SIR_{estimated}$ must be compute separately to each antenna, and after that there are summed up to get SIR_{tot} :

$$SIR_{tot} = \sum_{n=1}^{N\,ant} SIR_{estimated,n}$$

5.3 Throughput definition

The throughput of an arbitrary transmission (without retransmissions) is given by:

$$\begin{aligned} Throughput &= \frac{block\_size}{block\_duration} * (1 - BLER) \\ &= \frac{block\_size}{block\_duration} * \frac{Nb\ correct\ received\ blocks}{Nb\ transmitted\ blocks} \\ &= \frac{block\_size}{block\_duration} * \frac{Nb\ transmitted\ blocks - Nbfalse\ blocks}{Nb\ transmitted\ blocks} \\ &= \frac{block\_size}{block\_duration} * (1 - BLER) \end{aligned}$$

Note that one very important feature of HSUPA is Hybrid ARQ. The average BLER with respect to the average Ec/No should take into account chase or IR retransmission.

5.4 Functioning of the Power Control Loop

The power control loop defined in UMTS can be divided in two parts:

1. Outer Loop:

It is a slow power control between Node B and RNC. If the BLER at RNC doesn't meet the requirements, the RNC corrects the SIR target value used in the Node B. This will impact by consequence on the mobile transmission power. The outer loop is a higher layer procedure. It is normally not implemented in link layer simulations.

2. Inner loop:

The inner loop power control is used to counteract the fast fading. It can be divided into two steps:

a. open loop: the open loop fixes the initial transmit power via a path-loss estimate.
b. closed loop: at the Node B the received SIR is calculated and compared to the SIR target value. If the SIR is bigger (smaller) than the target value the Node B sends the TPC command "down" ("up") to the mobile in order to decrease (increase) the mobile transmit power.

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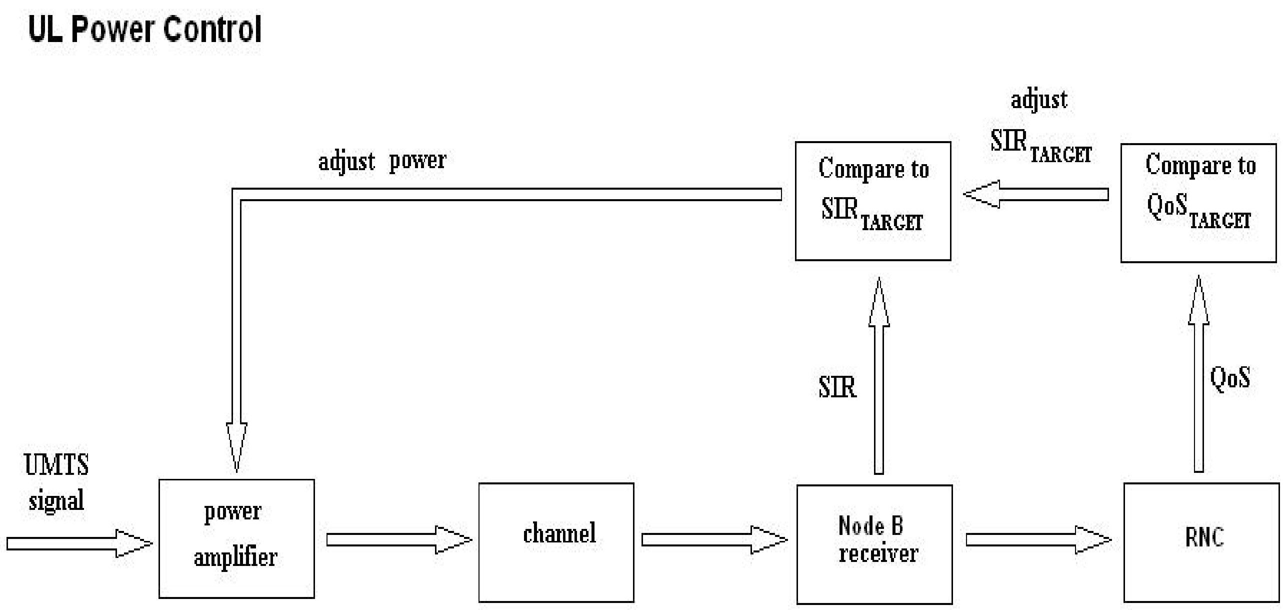

Figure 4: UL Power Control Mechanism

The mobile transmit power is increased or decreased with the step (normally 1 dB) defined in 3GPP specifications. This impacts on all uplink dedicated channels in the same way. The total transmit power is distributed onto each dedicated channel by the help of beta factors, or more exactly by the squared beta factor of each dedicated channel.

We notice that the absolute value of the SIR is not really important. It is the BLER quality at RNC that corrects via the outer loop the SIR target value of the Node B, if necessary.
The closed loop power control is based on the pilot bits of the DPCCH channel. Please pay attention to the fact that this is not the received energy of the physical channel to decode. Moreover, the SIR value is not objective. Depending on the algorithm to estimate the SIR in the receiver, the value can change. In order to compare simulation results, 3GPP has defined an objective Ec/No, to which the QoS is linked to.

5.5 Saturation Margin

5.5.1 Saturation Phenomenon

The fast power control loop in WCDMA systems aims at countacting the effect of fast fading. Hence, the transmit power is adapted to the transmit channel, i.e. the transmit power raises when the attenuation (fadings) becomes more important. The aim is to hold the received power constant. Theoretically, the transmit power follows the inverse of the channel power distribution function. However, in reality the dynamic range of the transmit power is limited and hence we will have a degradation of the QoS due to the saturation phenomenon.

When a mobile approaches cell edge, the transmit power starts to reach the maximum. If the given target SIR of the power control loop cannot guarantee the wanted quality, the outer loop raises the target SIR and thus increases more and more the transmit power and makes worse the saturation phenomenon.

5.5.2 Definition of the Saturation Margin

The saturation margin is defined as the difference between the target EcOut/No without power control (at P=Pmax) and the target EcOut/No for a transmit power with infinite dynamic range.

$$\text{Saturation Margin} = \left(\frac{Ec_{received}}{No}\right)_{\text{target without PC}} - \left(\frac{Ec_{received}}{No}\right)_{\text{target for } \infty \text{ dynamic range}}$$

The cell range is obtained when the mobile terminal transmits with maximum power. In that case the power amplifier is completely saturated. In order to get the right cell range there are two possibilities:

- We can calculate the link budget with the target EcOut/No value without power control at P=Pmax.
- As so far we dispose of the target EcOut/No values for an *infinite dynamic range* we can also add a margin to the link budget when working with these values. This margin is called the saturation margin.

5.5.3 Average Extra Power (Power rise)

The power rise is defined:

$$AEP = \frac{Ec_{in,avg}}{Ec_{out,avg}}$$

where $Ec_{in,avg}$ is the average of the energy chip at the channel input, and $Ec_{out,avg}$ is the average of the energy chip at the channel output:

$$Ec_{in,avg} = \sum_{r}^{R} \frac{Ec_{in,r}}{R}$$

$$Ec_{out,avg} = \sum_{r}^{R} \frac{Ec_{out,r}}{R}$$

where R is the realisation number and Ec_{in} is calculated by an iterative loop (increase or decrease by a 1dB step).
Ec_{out} is calculated with respect to Ec_{in} at the channel output:

$$Ec_{out} = Ec_{in} \sum_{i=1}^{L} |h_i|^2$$

6. WHERE TO MEASURE Ec/No AND SIR

The Ec is measured at the entrance of the multipath channel and at the exit of the multipath channel. The respective names are Ec_in and Ec_out (or C_in, C_out). The calculation is done over one timeslot. The measurement is averaged over the whole transmission length. After the multipath channel, the AWGN with DSP No is added. These measurements provide hence the Ec/No as defined by 3GPP.

The Ec/No is measured per antenna. In the case of Rx diversity there are hence two Ec_out.
The SIR is measured by the Rake receiver. The measurement is done on the pilot bits in the DPCCH. Moreover, the one total measurement in case of Rx diversity is done by taking into account the diversity.

Hence, depending on the implement algorithms to estimate the RSCP and the ISCP (as defined by 3GPP) the SIR value changes. The estimated SIR value is compared to a SIR target value in order to send a TPC command "up" (SIR < SIR target) or "down" (SIR >= SIR target) to the the transmit amplifier.

The Rake receiver decodes as well the data channel we are interested in. The energy on this data channel is not the same as on the DPCCH. The distribution of the energy depends on the beta factors used for the transmission. The decoded data is compared to the sent data in order to obtain the BER and BLER (averaged over the whole transmission duration).

Now, in order to be compliant with 3GPP, the (average) BLER is associated with the corresponding (average) Ec/No. Please pay attention, that his is not the energy received by the Rake for the corresponding data channel.

7. DESCRIPTION OF SIMULATED SCENARIO

IN this work, we are especially interested in the following uplink transmission scenario: the HSUPA transmission (E-DPCCH and E-DPDCHs) takes place together with an HSDPA transmission. This means that the uplink feedback channel of the HSDPA (i.e. HS-DPCCH) has to be taken into account. Furthermore, we consider the case where no DCH transmission is done together with HSUPA. Hence, the transmission of the DPDCHs can be neglected. Summarizing the simulator has to implement the following uplink transmission channels define in case 3 (table2).
The Node B receiver has two antennas. The transmitting mobile has one antenna. The simulation has therefore to take into account receive diversity.

Furthermore, we are interested in the average Throughput of the transmission (obtainable via BLER). The fact that retransmissions can occur has to be taken into account. Concerning the radio propagation channel, the two scenarios we are interested in are the ITU Vehicular A channel at 3km/h and the ITU Pedestrian A channel at 3km/h. Furthermore, we are interested in the simulations results with and without power control. For simulations with power control, the mobile transmitter amplifier has an unlimited dynamic range (-100 dB, 100 dB).

7.1 Simulation Results

The Figure 5 shows the BLER performance of the FRC4, FRC5 and the FRC6 of the HSUPA system with and without power control. We see that considerable performance gain is obtained only by the use of a fast power control with an accurate instantaneous SIR estimation. This gain achieves almost 4dB for the FRC5 and FRC6 at a BLER=10^{-3}.

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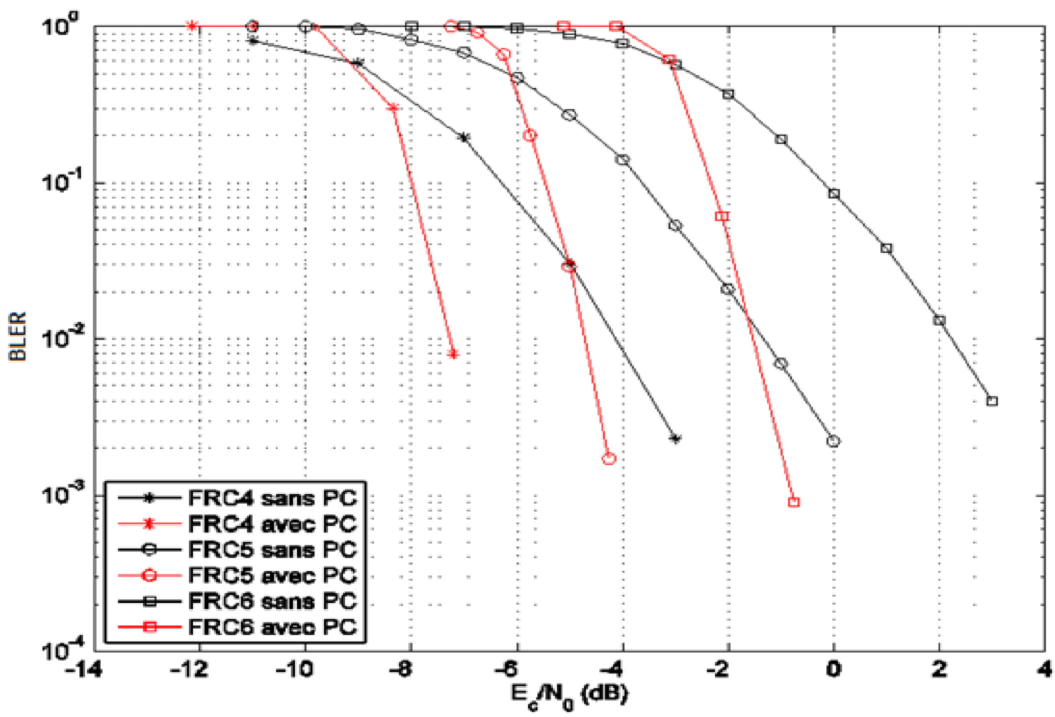

Figure 5: Simulation Results for HSUPA System with and without Power Control

8. SIMPLIFIED LINK LEVEL SIMULATION METHOD

8.1 Introduction

Since HSUPA users are seen as low mobility user (3km/h), the quasi –static channel assumption, i.e., each coded block sees a single channel outcome, is relevant. For a fixed quality of service SIRtarget corresponding to the signal to noise ratio of the data channel with lowest spreading factor, this methodology should be able to provide:

1. The average Ec at the input of the channel (Ecin) assuming perfect power control
2. The associated average Ec at the output of the channel (Ecout) assuming perfect power control
3. The average BLER corresponding to a given SIRtarget. It can be deduced from the AWGN quality table of the considered Fixed Reference Channel Scheme (FRC) thanks to the quasi-static channel assumption and the Gaussian Approximation on the interference. Indeed, given these assumptions, the SIRtarget is equivalent to a constant Eb/No. In the case of IR, this is not so simple: a "compression" method should be applied to get an equivalent single SIR. we will begin with chase combining.

For the sake of headroom computation, the average BLER with respect to average Ecin without power control (average Ecin= average Ecout) should be simulated also. In this case, the same kind of fast methodology as the one developed for HSDPA can be applied. Unfortunately, perfect channel estimation is to be assumed for this fast methodology.

8.2 Description of the Fast Methodology with Perfect Power Control

Since the fast methodology in the case of no power control is the same as the one developed for HSDPA, only the HSUPA simplified simulator with fast power control is described below. We assumed that the factors betas are given and that the AWGN noise variance is fixed to 1.

For each FRC:
Loop SIR target (in order to scan all throughputs)

Initialization:
delta_db =1 or 2 dB (power control step size)
Ecin_average=0
Ecout_average=0
delta = $e^{-delta\_db/10}$
i=0;

Loop on channel outcome
Draw a channel realization h
Ecin_inst= delta
Calculate (simulate) the associated SIR(Ecin_inst, h, betas) at the RAKE output for Chase

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while ((SIR(Ecin_inst, h, betas) –SIRtarget) > delta)

Compare SIR(Ecin_inst, h, betas) with SIRtarget **if** below Ecin_inst=Ecin_inst*delta **else** Ecin_inst (dB) = Ecin_inst/delta
Calculate (simulate) the associated SIR(Ecin_inst, h, betas) at the RAKE output for Chase

end while

Calculate Ecout_inst with respect to Ecin_inst at the channel output

Calculate Ecout_average= (i*Ecout_average + Ecout_inst)/(i+1)

Calculate Ecin_average= (i*Ecin_average + Ecin_inst)/(i+1)

i=i+1

End loop channel outcome

Output:

Calculate the Average Extra Power or power rise: power_rise = Ecin_average/ Ecout_average

Thanks to the AWGN quality table of the fixed reference channel scheme draw the average BLER corresponding to the given SIRtarget

Store (Ecout_average, throughput) for the given FRC

End loop over SIR target

The goal is to have the quality tables for each FRC (Ecout_average, throughput) together with the power rise and the headroom H= Ecin_average (with perfect fast power control)-Ecin_average(without fast power control) for the same quality of service. The saturation margin can be deduced easily from the headroom.

8.3 Simulation Results

Figure 6 and Table 4 show the simulation results of the link simulator and the simplified simulation methodology. We observe that the simplified simulator provides the same performance as that offered by the link simulator. Moreover, during the simulation process, we analyzed the CPU time required by the two simulators. It is seen that with the simplified one, this time is significantly reduced. This gain is due to the prediction of turbo decoding performance using look-up tables.

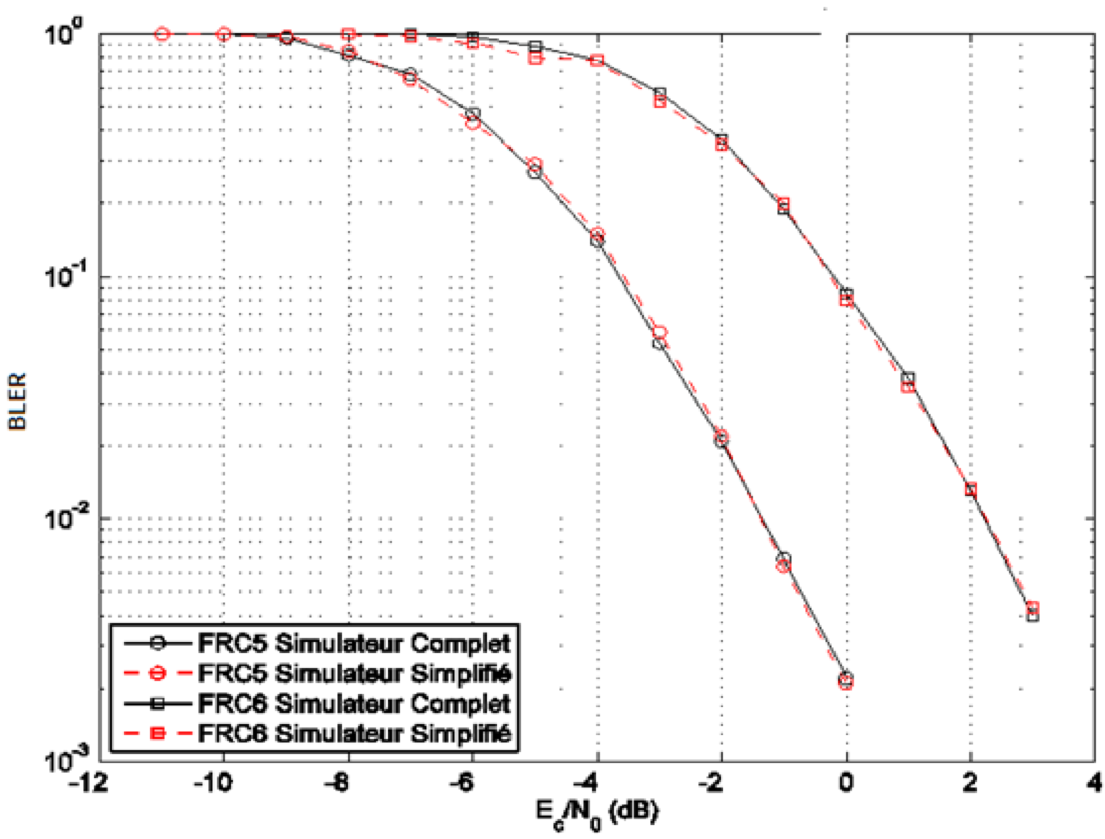

Figure 6: Simplified Simulator for HSUPA System

Table 4: CPU Time required for Simplified Simulator for HSUPA System

	FRC5		FRC6	
	Time (s)	BLER	Time (s)	BLER
HSUPA simulatror	112572	0.0023	306 283	0.0041
Ssimplified simulator	727	0.0023	1001	0.0041

9. CONCLUSION

In this paper, we evaluated the performance of the power control in a Uplink UMTS system in a multipath environment. This loop was enabling wireless systems to increase throughput and spectral efficiency. In this paper, we have proposed, also, a simplified simulation methodology for HSUPA. This technique used the performance on the AWGN channel as reference for giving an abstraction of the HSUPA performance over a multipath channel. It is seen that the same performance as that provided by the link simulator, are determined by a simplified simulator. The CPU time required by this simplified simulator is significantly reduced when comparing with the link simulator.

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