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Agenda Item:

Source: **Nokia**

Title: **MS RECEIVER SENSITIVITY IN UTRA FDD MODE**

Document for:

MS RECEIVER SENSITIVITY IN UTRA FDD MODE

1 INTRODUCTION

This document is Nokia's proposal of how the receiver sensitivity should be defined in a WCDMA system and what physical aspects contributes the requirement. The proposal how the sensitivity can be measured in mobile station is also given.

1.1 Definition

The RX sensitivity of the mobile station is a value calculated from measured minimum Channel Chip Rate power, at which the Bit Error Rate (BER) shall not exceed a specified value. Power measurement is done at the mobile station antenna connector.

1.2 Purpose of the Measurement

Noise Figure (NF) of a receiver is a very key parameter in a WCDMA system. It is essential for mobile phone manufactures to know the maximum allowed value for NF. When they know target NF value, they can design the RF parts of a receiver in a way that a receiver fulfills the NF related requirements even in a mass production line.

It is not so straightforward to measure receiver NF value in a CDMA system. The only reasonable way to measure NF is to define MS receiver sensitivity value, which can easily be measured. If a receiver meets the specified receiver sensitivity value, it also means that receiver's NF is under the maximum allowed value.

1.3 Background Information

Nokia assumes that maximum allowed MS receiver NF is 9 dB. We also think that implementation margin for MS receiver baseband parts should be between 1 – 2 dB. The actual value for BB implementation margin can be set to any value between that range in order to get even numbers for actual receiver sensitivity measurement test. Note that 1 dB BB implementation margin is assumed for following examples.

The receiver sensitivity value can be presented as

$$\text{MS Receiver Sensitivity}\,[\text{dBm}] = \text{Total noise spectrum density}\,[\text{dBm/Hz}] + \text{NF}[\text{dB}] + 10\log\left(\frac{\text{Channel Chip Rate}}{\text{Spreading Factor}} \times 2 \times \frac{\text{User Bit Rate}}{\text{Channel Bit Rate}}\right) + \frac{E_b}{N_0}[\text{dB}] + \text{implementation margin for baseband}\,[\text{dB}].$$

This can be also presented as

$$\text{MS Receiver Sensitivity}\,[\text{dBm}] = \text{-174 dBm/Hz} + 9\text{ dB} + 10\log\left(\text{Channel Symbol Rate} \times 2 \times \frac{\text{User Bit Rate}}{\text{Channel Bit Rate}}\right) + \frac{E_b}{N_0}[\text{dB}] + 1\text{ dB}.$$

The simplest form for receiver sensitivity is given as

$$\text{MS Receiver Sensitivity}\,[\text{dBm}] = \text{-174 dBm/Hz} + 9\text{ dB} + 10\log(\text{User Bit Rate}) + \frac{E_b}{N_0}[\text{dB}] + 1\text{ dB}\ .$$

User Bit Rate means the rate of actual information to be transmitted over the channel e.g., output bit rate of speech codec. **Note also that Eb/No takes into account the entire channel overhead. Following items are calculated as overhead: pilot, TPC, TFI, CRC, tail, repetition, convolution coding or Turbo coding, or other services multiplexed into same DPCH.** Naturally, BER is measured after the turbo/convolutional decoder. This makes it hard to specify needed Eb/No value by using "text book approach".

Example 1:

User Bit Rate of 16 kbps is mapped into a DPCH with rate of 32 ksps . In the mapping process some amount of puncturing is needed. Let us assume that Eb/No (including the entire overhead) equals to 3 dB. **Note that Eb/No value of 3 dB is not based on any simulation, it is just an example of possible value.** Now we get that MS receiver sensitivity value is

$$\text{MS Receiver Sensitivity}\,[\text{dBm}] = \text{-174 dBm/Hz} + 9\text{ dB} + 10\log(16\,000) + 3\text{ dB} + 1\text{ dB} = -119.0\text{ dBm}\ .$$

Example 2:

Output of the EFR codec (12.2 kbps) is mapped into a DPCH with rate of 32 ksps. In that process some amount of repetition bits are needed. The amount of the increased overhead is 1.2 dB (10 x log(16/12.2). Now new simulations are necessary to get the required Eb/No. Note that a new value for Eb/No cannot be calculated based on the Eb/No value in Example 1 (3.0 dB) and the amount of extra overhead (1.2 dB). This is due to the fact that it is not so straightforward to say how puncturing affects to bit error results. Therefore, the correct value for Eb/No is likely to be near 4.2 dB but it needs to be simulated. If we assume that Eb/No value would be 4 dB then MS receiver sensitivity can be presented as

$$\text{MS Receiver Sensitivity}\,[\text{dBm}] = \text{-174 dBm/Hz} + 9\text{ dB} + 10\log(12\,200) + 4\text{ dB} + 1\text{ dB} = -119.1\text{ dBm}\ .$$

Conclusion from Examples:

When we are defining tests for MS receiver sensitivity measurements, we have to specify User Bit Rate and channel symbol rate, which are used in the test. We also have to define how to calculate Eb/No (the entire overhead must be taken into account). Also Eb/No value must be based on simulations having exactly the same User Bit Rate and same channel symbol rate as specified for that test.

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3 MS RECEIVER SENSITIVITY

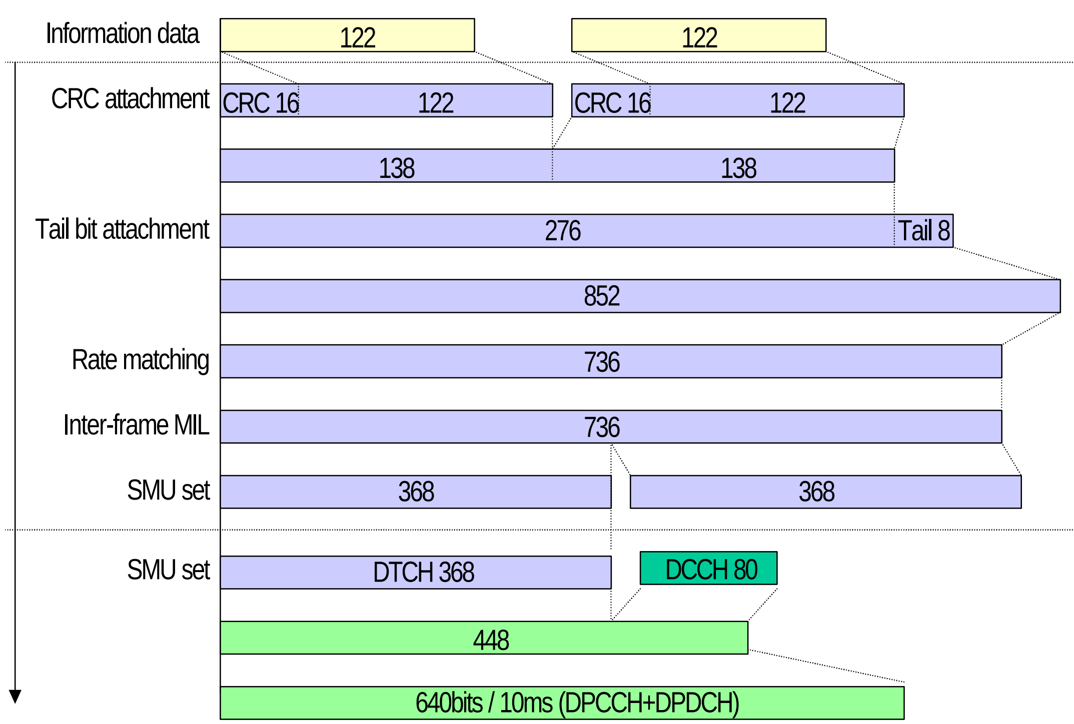
3.1 Proposed User Bit Rate

There will be many kind of terminals in a WCDMA system. Some of them are speech only terminals and others support also higher user bit rates. A user bit rate, which is used in MS receiver sensitivity test should be such that all terminals support it. This is how we can avoid defining sensitivity tests for each possible user bit rate.

It is proposed that a dedicated traffic channel (DTCH) and a dedicated control channel (DCCH) is multiplexed into DPCH. MS transmits DTCH bits back to BS and BS measures bit errors by comparing received bits to transmitted bits. BS can send standard control messages to MS through DCCH. Standard control messages mean messages that can be transmitted by BS also in real networks. For example, call terminating command is such a standard message.

Figure 1 shows how multiplexing of DTCH and DCCH is done. Proposed rate for DTCH is 12.2 kbps. DCCH has 80 coded bits in a 10 ms frame, which corresponds to around 2 kbps depending on the used multiplexing length for DCCH control messages. The control channel definition shall be updated according WG1 proseeding at later phase. Note also that the numbers shown in Figure 1 mean that rate information bits are to be used in a receiver.

Figure 1. DPCH channel contents



3.2 Receiver Sensitivity Value Based on Simulated Eb/N0 Values

Nokia has simulated the needed Eb/No value for DTCH bits presented in Figure 1. Other parameters were like in Table 1 (see the next page). The result was that 5.2 dB (including overhead) is needed in order to achieve BER 10^{-3}. By assuming 1.9 dB BB implementation margin, we get that receiver sensitivity is -117 dBm. Calculations are shown below.

$$\text{MS Receiver Sensitivity}\left[\text{dBm}\right] = \text{-174 dBm/Hz} + 9\text{ dB} + 10\log\left(12\,200\right) + 5.2\text{ dB} + 1.9\text{ dB} = -117\text{ dBm}$$

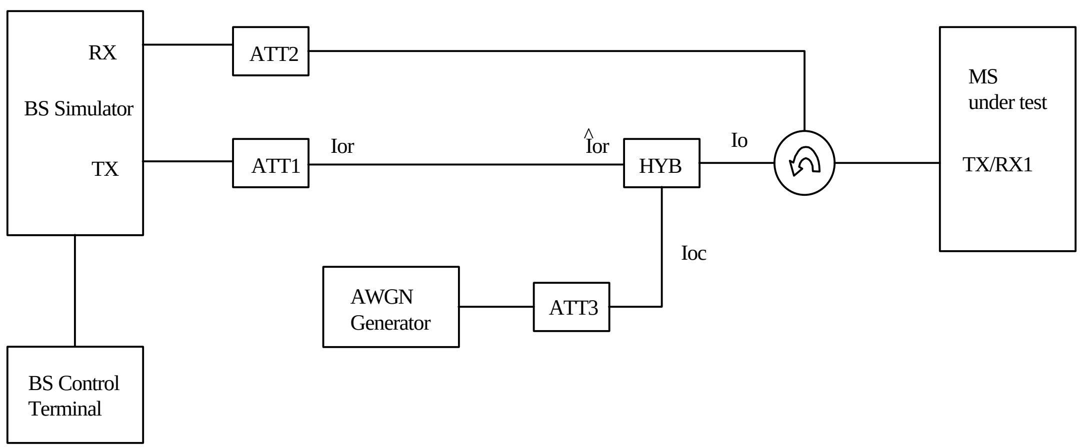
3.3 Proposed Test Conditions and Measurement Method

1) Connect the base station to the mobile station antenna connector as shown in Figure 2. Base Station sends two signals: one DPCH signal and Perch Signal.

2) Set the test parameters as specified in Table 1. Map the DTCH (12.2 kbps) and DCCH into 32 ksps channel as it is presented in Figure 1. Note that power control shall not be used during the measurement.

3) Measure the BER of received information signal.

Figure 2. Measurement Configuration for Receiver Sensitivity Measurement.



Note 1: AWGN generator is not needed in real measurements but only when simulations are made.

Table 1. Test Parameters for MS Receiver Sensitivity Measurement.

Parameter	Unit	Test 1
$\frac{Perch\_E_c}{I_{or}}$	dB	-1
$\frac{DPCH\_E_c}{I_{or}}$	dB	-7
$\hat{I}_{or}$	dBm/4.096 MHz	-110
User Bit Rate	kbps	12.2
Channel Symbol Rate	ksps	32
Rate Information	-	on

Note 1: Perch channel is orthogonal with DPCH channel and therefore it has no effect on required Eb/No value in an AWGN channel. Perch channel is needed for MS initial synchronization. It is natural that Perch channel is transmitted during the measurement since that happens also in a real network. Value –1 dB for Perch channel corresponds to a system with one user. Value –7 dB for DPCH corresponds to a user located approximately at near the cell edge.

Note 2: BER 10^{-3} needs to be complied. This value suits well for many low data rate applications.

Note 3: Eb/No can be calculated from parameters presented in Table 1. The result is shown below

$$\frac{E_b}{N_o} = \frac{\frac{DPCH\_E_c}{I_{or}} \times \frac{\text{Chip Rate}}{\text{User Bit Rate}}}{\frac{I_{oc}}{\hat{I}_{or}}} [dB] - NF[dB] - \text{BB Implementation Margin}[dB]$$

$$= \quad 10 \times \log\left(\frac{10^{-7/10} \times 4096000/12200}{\frac{10^{-107.88/10}}{10^{-110/10}}} \right) - 9 - 1.9 = 5.2 \text{ dB}$$

3.4 Minimum Requirements

The BER of information signal shall not exceed 10^{-3} with certain confidence level. Level should be agreed together with other performance tests.

4 SUMMARY

- In this contribution NOKIA proposes that MS noise figure is 9 dB and BB implementation margain is between 1…2 dB.

- Minimum test case is proposed and it consists of low bit rate speech (eg. 12,2 kbps) channel and control channel multiplexed into DPCH with rate of 32 ksps.

- An equation(s) are presented to define minimum sensitivity requirement with suggested data and control rate.

- During conformance testing no power control scheme should be used.

- Test case should be performing in static channel.

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6 TERMS

DCCH	Dedicated Control Channel
DPCH	Dedicated Physical Channel
DTCH	Dedicated Traffic Channel
$\frac{DPCH\_E_c}{I_{or}}$	The ratio of the average transmit energy per PN chip for the Dedicated physical channel to the total transmit power spectral density.
I_o	The total received power spectral density, including signal and interference, as measured at the mobile station antenna connector.
I_{oc}	The power spectral density of a band limited white noise source as measured at the mobile station antenna connector.
I_{or}	The total transmit power spectral density of the Forward link at the base station antenna connector.
$\hat{I}_{or}$	The received power spectral density of the Forward link as measured at the mobile station antenna connector.
$\frac{Perch\_E_c}{I_{or}}$	The ratio of the average transmit energy per PN chip for the Perch Channel to the total transmit power spectral density.
SF	Spreading factor. The ratio of chip rate to symbol rate.