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Agenda item:
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1 Introduction

A limited set of amplitude ratios between the DPDCH-channels and the DPCCH-channel in uplink is proposed in order to simplify the coefficients for the terminal. The IQ-modulated uplink format has, typically, different symbol rates in the DPDCH and the DPCCH channels. In order to optimise quality on both the DPDCH and the DPCCH channels at a minimum transmitted power, the power can be set independently of each other. Therefore according S1.13 all the DPDCH channels are multiplied with the parameter G_i, see Figure 1.

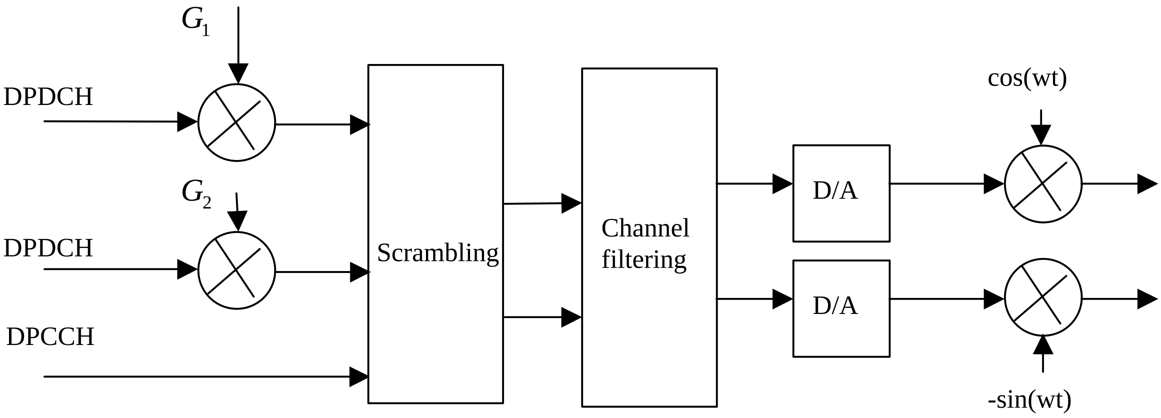

Figure 1: Unbalanced powers when transmitting one control channel and two codes for the dedicated channel.

The power ratio between the DPCCH and the DPDCH channels is given by the network during the dedicated channel negotiations. By limiting the number of bits to represent G_i, the network can signal the power ratio with quite few bits. In this paper the structure and the quantization of the gain parameters are discussed.

2 Discussion

When considering how the gain of the codes shall be quantized there are some items to note:

1. A terminal will not be implemented as in Figure 1. In this figure a change of the parameter G_i affects the transmitted output power immediately. There are two disadvantages with this. First the dynamic range of G_i must be supported by the D/A converter which requires an increased number of bits in the conversion. Secondly, the PA must for a number of reasons, e.g. to optimize the PA efficiency, have full control of the transmitted output power.
2. It is the ratio of the power of the transmitted DPDCH and the DPCCH that must be controlled with a good accuracy. The absolute level is controlled by the closed loop TPC process, but if the ratios are changed without a good accuracy the closed loop power control will control the DPCCH to a constant power but the received DPDCH power may then be too low. This will be changed by the outer loop power control but it takes a quite long time during which the DPDCH is received with a power level lower than required.
3. The ratios specified shall be possible to implement with low complexity. If the ratios do not reflect an implementation a limited word length used in the implementation will increase the modulation inaccuracy. This will use a large part of the specified maximum modulation inaccuracy.

The structure in Figure 1 indicates that the G is larger than 1. One also get the impression that G_i will control the power of the channel. However, this will never be implemented because then the power control is made before the D/A converter and the dynamic range of this power control will lead to many more bits in the D/A converter and thereby much larger power consumption. It can be assumed that all power control should be done in the PA.

One disadvantage with the structure shown in Figure 1 is also that it requires quite many bits to get a good dynamic range of the power ratio. If instead the strongest channel always have G_i=1.0 while the other codes are multiplied with a factor less than 1.0, the requirement of number of bits in the multiplication decreases for a given accuracy.

3 Proposal

The dynamic range of G is rather large, say between 0 and 15 dB. To have a good accuracy in this multiplication requires many bits. In order to compress this range we suppose the parameter $b = 1/G$ is used in the multiplication. That changes the scheme into what is shown in Figure 2.

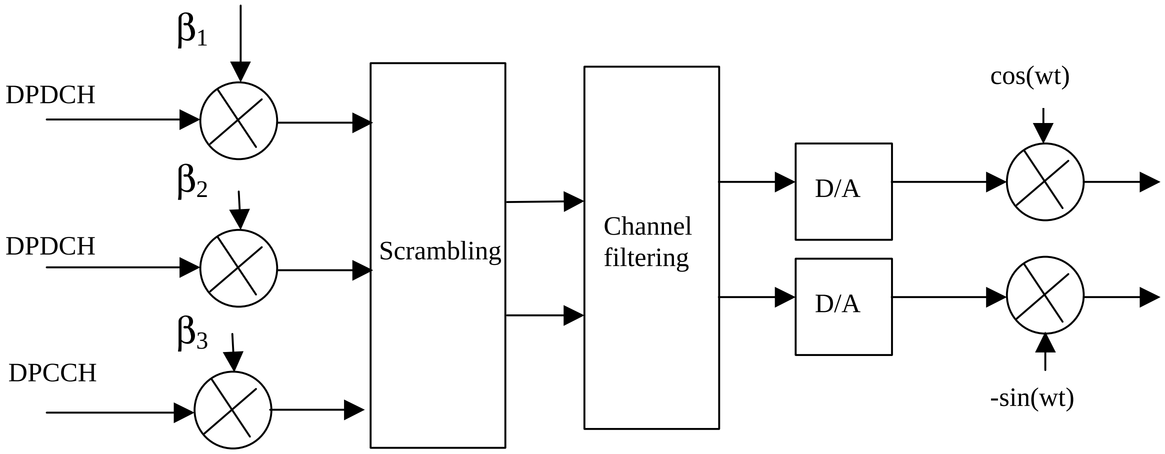

Figure 2: The same scheme as in Figure 1 but with b-parameters instead.

All codes are then multiplied with this parameter β_i instead. The largest β value is always 1.0. The other β values are quantized with 4 bits (16 levels). With this algorithm the quantization error is kept small while the complexity of the terminal will not be larger than multiplying with G>1. The total signal will anyway be normalized before the D/A conversion and the power setting is then set in the PA.
The proposal is that instead of a requirement of multiplying with the optimum coefficients, simplified multiplication coefficients are specified with 16 levels, which can be implemented with a 4 bit multiplication. The proposed quantization of b, b_{quant}, is given in Table 1. It is important to note that since the multiplication is done on chip rate, the number of bits used in the multiplication should be minimized.
In the table the range of the coefficient β before quantization is given. This means that the "optimum" β is always increased to the next higher power level. By always increasing the weakest signal the total transmitted extra power is kept low while the implementation is kept simple. If the β-value instead should be decreased, to guarantee a good performance on both codes, the total output power also on the stronger code must be increased. The maximum power increase due to the quantisation of β with 4 bits is negligible, see Section 4 Performance. In the table there is also a column giving the maximum extra power transmitted compared to an optimal value. This example is for two codes only when one has β=1 and the other one has β according to the table.
During DTX, when only the DPCCH is transmitted, β for the DPCCH will always be equal to 1.0 because then it is the maximum power since the power of the DPCCH can be fully controlled in the PA. Hence the proposed scheme does not lead to any error in transmitted power during DTX, when the DPDCH is switched off.

Table 1: Proposed quantization of b and an example of the transmitted extra power given one DPDCH and one DPCCH.

Ideal amplitude ratios	Ideal β-ratios	Quantized amplitude ratio (β_{quant})	Maximum extra power [dB]
0	Infinity	Switch off channel	0
1 < G ≤ 1.067	0.9375 < β ≤ 1.0	1.0	0.27
1.067 < G ≤ 1.1429	0.875 < β ≤ 0.9375	0.9375	0.27
1.1429 < G ≤ 1.2308	0.8125 < β ≤ 0.875	0.875	0.26
1.2308 < G ≤ 1.3333	0.75 < β ≤ 0.8125	0.8125	0.26
1.3333 < G ≤ 1.4545	0.6875 < β ≤ 0.75	0.75	0.25
1.4545 < G ≤ 1.60	0.625 < β ≤ 0.6875	0.6875	0.25
1.60 < G ≤ 1.7778	0.5625 < β ≤ 0.625	0.625	0.23
1.7778 < G ≤ 2.0	0.5 < β ≤ 0.5625	0.5625	0.22
2.0 < G ≤ 2.2857	0.4375 < β ≤ 0.5	0.5	0.21
2.2857 < G ≤ 2.6667	0.375 < β ≤ 0.4375	0.4375	0.19
2.6667 < G ≤ 3.2000	0.3125 < β ≤ 0.375	0.375	0.16
3.2000 < G ≤ 4.0	0.25 < β ≤ 0.3125	0.3125	0.14
4.0 < G ≤ 5.3333	0.1875 < β ≤ 0.25	0.25	0.11
5.3333 < G ≤ 8.0	0.125 < β ≤ 0.1875	0.1875	0.08
8.0 < G	0.0 < β ≤ 0.125	0.125	0.07

4 Performance

This proposed scheme has a negligible impact on the system performance. By always increasing the β-parameter to the next quantization level, assuming it is smaller than 1, increases the transmitted output power. This extra power given in the table above was calculated as

$$P_{extra} = 10 \cdot \log\left(\frac{1+\beta_{quant}^2}{1+\beta^2}\right)[dB],$$

taking both DPDCH and DPCCH powers into account. The extra transmitted power due to the quantization is plotted as a function of β in Figure 3.

The effect of using G_i instead in the multiplication is shown in Figure 4.

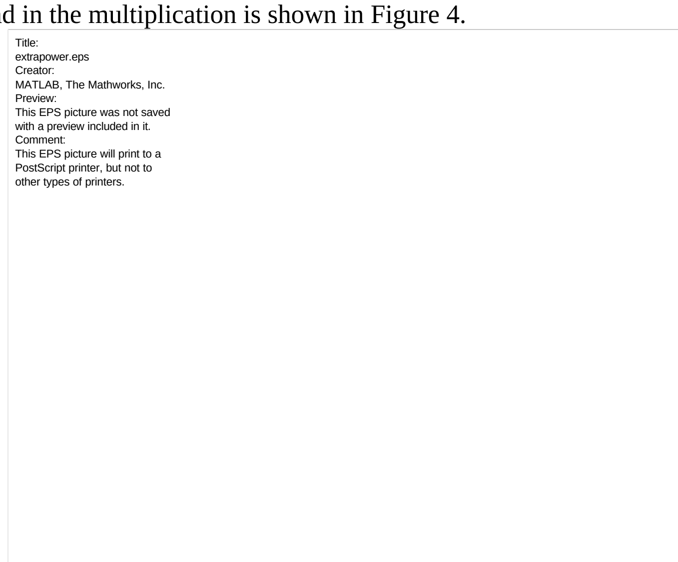

Figure 3: Extra transmitted power in dB due to quantization of $\beta = 1/G$.

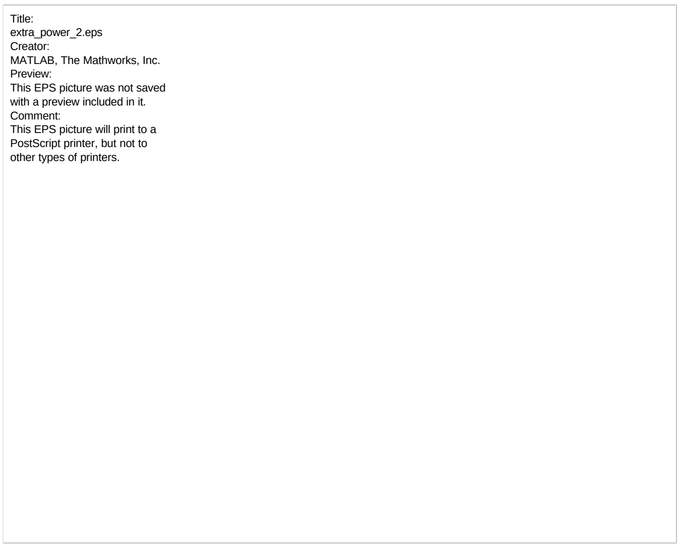

Figure 4: Extra power in dB transmitted when quantizing G.

From the curves in Figure 3 and Figure 4 it is seen that the maximum extra power when b is quantized is much smaller than when G is quantized. The maximum extra power when quantizing b is given in Table 1. From the table it is seen that at maximum 0.27 dB extra power is transmitted. The average value depends on what power levels that are optimum. For a typical speech channel, the DPCCH will have a power of roughly ½ of the DPDCH power. The extra power transmitted for this service due to the quantization of b becomes only

$$P_{extra} = 10 \cdot \log\left(\frac{1+0.75^2}{1+0.707^2}\right) = 0.18\ [dB]$$

This value should be compared with the accuracy of the SIR measurements and also on the stepsize.

5 Conclusion

We propose that the amplitude difference between the codes in the uplink is quantized to and represented by a 4 bit number. By using 4 bits, the impact on system performance is negligible while the complexity of the terminal and the number of bits used in the signalling are kept low.

When the multiplication factor is smaller than or equal to 1.0 the quantization error is kept smaller than if the multiplication factor is larger than 1.0. Therefore it is proposed that the structure is as given in Figure 2 and the largest multiplication factor is always equal to 1.0.

By using numbers in the signalling that are possible to implement with high accuracy and a low complexity it is possible to build a terminal where the contribution to the modulation inaccuracy from the power setting in the IQ modulation is very small.

6 Text proposal for S1.13, clause 6

Text proposal follows:

6.2.1 Uplink Dedicated Physical Channels (uplink DPDCH/DPCCH)

Figure 5 illustrates the spreading and modulation for the case of multiple uplink DPDCHs when total data rate is less than or equal to 1024kbps in the 5MHz band. Note that this figure only shows the principle, and does not necessarily describe an actual implementation. Figure 6 illustrates the case for data rate at 2048kbps in the 5 MHz band. Modulation is dual-channel QPSK (i.e.; separate BPSK on I- and Q-channel), where the uplink DPDCH and DPCCH are mapped to the I and Q branch respectively. The I and Q branches are then spread to the chip rate with two different channelization codes and subsequently complex scrambled by a UEspecific complex scrambling code C_{scramb}.

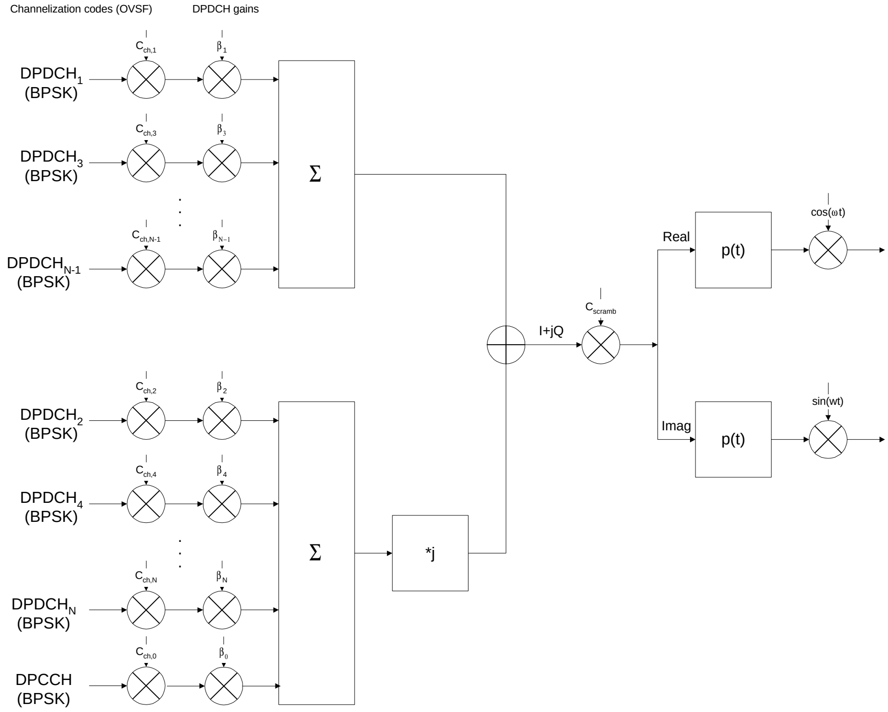

Figure 5 Spreading/modulation for uplink DPDCH/DPCCH for user services less than or equal to 1024kbps in the 5MHz band

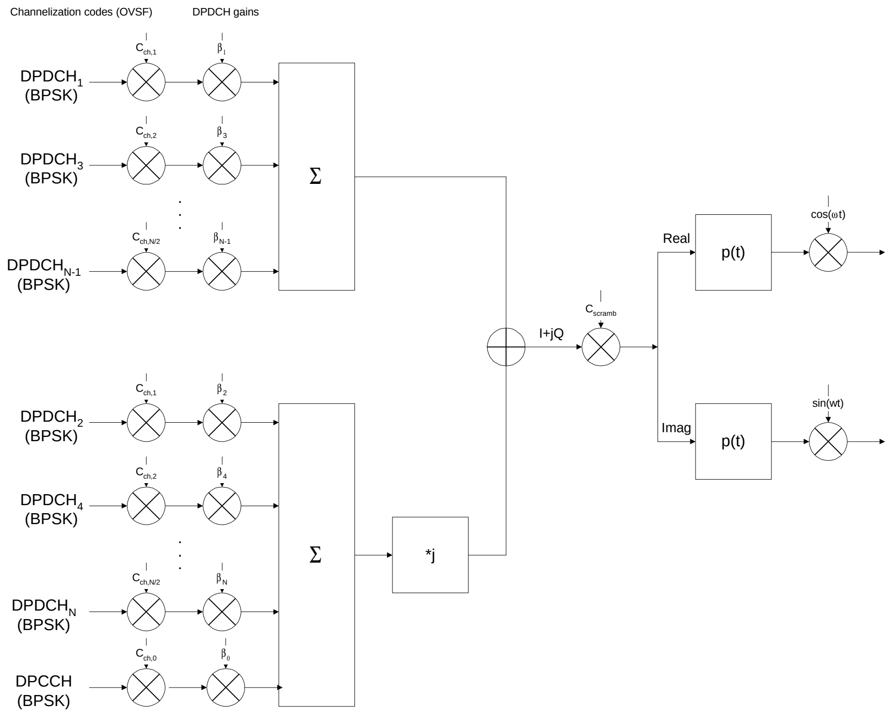

Figure 6. Spreading/modulation for uplink DPDCH/DPCCH for user services at 2048kbps in the 5MHz band

For a single uplink DPDCH transmission, only DPDCH$_1$ and DPCCH are transmitted.]
For services less than or equal to 1024kbps in the 5MHz band, the DPCCH is spread by the channelization code $C_{ch,0}$ and each DPDCH$_i$ is spread by a predefined individual channelization codes, $C_{ch,i}$ (i=1,2,…). For 2048kbps rate in the 5MHz band, the DPCCH is spread by the channelization code $C_{ch,0}$ and each pair of DPDCH$_{2i-1}$ and DPDCH$_{2i}$ is spread by a predefined individual channelization codes, $C_{ch,i}$. The data symbols of both the DPDCHs and the DPCCH are BPSK-modulated and the channelization codes are real-valued. The real-valued signals of the I- and Q-branches are then summed and treated as a complex signal. This complex signal is then scrambled by the complex-valued scrambling code, C_{scramb}. The powers of the transmitted channels may be adjusted by gain factors, β_i ~~G_i~~.

The channel with maximum power has always $b_i \equiv 1.0$ and the others has $b_i \leq 1.0$. The β-values are quantized into 4 bits, and the quantization steps are given in Table 2

Table 2: The quantization of the gain parameters.

	Quantized amplitude ratio (b_{quant})
15	1.0
14	0.9375
13	0.875
12	0.8125
11	0.75
10	0.6875
9	0.625
8	0.5625
7	0.5
6	0.4375
5	0.375
4	0.3125
3	0.25
2	0.1875
1	0.125
0	Switch off