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Title	**Per Stream Power Control in CQICH Enhanced Allocation IE**
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Re:	IEEE P802.16-REVe/D7
Abstract	Defines the missing details on per stream power control feedback in CQICH enhanced allocation IE
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

Per Stream Power Control in CQICH Enhanced Allocation IE

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1 Introduction

In section 8.4.5.4.15 of IEEE 80216e/D7, several types of feedback information are specified in the CQICH_Enhanced_Alloc_IE() so that the SS can transmit feedback information of a specified type on the assigned CQICH. However, when per-stream power control feedback is required by the base (feedback type "101"), there is no specification in IEEE 80216e/D7 for how the payload bits are to be interpreted.

This contribution provides the missing specification for how the feedback payload bits for per-stream power weighting feedback are to be interpreted by the BS. More specifically, this contribution provides an efficient method for specifying the range and quantization levels for the power weighting values of the different MIMO streams.

This contribution does **not** specify a method for determining the per-stream power weights for MIMO. A per-stream power control strategy is a vendor-specific implementation and does not need to be specified in the standard. This contribution simply specifies an efficient strategy for encoding the power levels that have been determined by a vendor-specific per-stream power control strategy. The payload bits of the CQICH simply convey the encoded bits that indicate the per-stream power levels.

Power weighting on different streams can be very effective in dealing with the different spatial channel quality in both closed- and open-loop MIMO communications. When the power weighting of streams are ordered and summed up to one, the quantization of the power weightings can be done with very fine granularity and also very efficiently (for example, as proposed in this contribution, three bits of feedback is used for up to two streams, six bits for up to three streams, and nine bits for up to four streams).

2 Feedback Types and Per Stream Power Control Feedback

2.1 Problem Statement

In table 302a of section 8.4.5.4.15 of IEEE 80216e/D7, a three bit feedback type field is defined for each CQICH. For example, "000" indicates that the CQICH should carry the information about Fast DL measurement/Default Feedback with antenna grouping, i.e., both the DL SNR measurement and MIMO mode can be fed back where some codewords for MIMO mode feedback are interpreted differently in case of antenna grouping ("000"), antenna selection ("001"), or reduced precoding matrix code book ("010"), as detailed in section 8.4.5.4.10.7. Feedback type "011" indicates that the MSS shall report the quantized MIMO precoding coefficient according to the mapping defined in section 8.4.5.4.10.6. Feedback type "100" indicates that the MSS shall report the index to the precoding matrix defined in 8.4.5.4.11. However, **bits "101" is defined twice**: once for "channel matrix information" and once for "per stream power control". The "channel matrix information" might mean the same as quantized MIMO coefficients by bits "011". If so, it can be deleted. Otherwise, a new bit word out of the reserved ones must be used for "per stream power control". **The encoding of the payload bits for "per stream power control" is not defined anywhere.** As a result, there is no specification for how to interpret the payload bits for "per-stream power control," which may cause inter-operability problems

2.2 Benefits of Per-Stream Power Control

Although this contribution does not specify a power control strategy that may be dependent on the receiver processing, it is worth pointing out why per-stream power control is beneficial and how the method in this contribution for encoding the per-stream power control levels can be used in the standard. Per stream power weighting can be very effective in dealing with the different qualities of the spatial channels formed in closed-loop MIMO communications. In closed-loop MIMO transmission with horizontal encoding, MAP allocations can assign each beamformed stream a different modulation and coding selection (MCS) level, and the per-stream power control feedback in Section 8.4.5.4.15 can be used to adjust the power levels of the different streams. The ability to adjust the MCS level (through the MAPs) and the power levels (through CQICH_Enhanced_Alloc_IE()) enables the MIMO transmission to better accommodate the different qualities of the spatial streams formed by the transmitter. Furthermore, when the same data rate is used on all the streams and successive cancellation receivers are used, per-stream power control can significantly increase performance, as is shown in the simulation results below. Similarly, per-stream power control in open-loop MIMO transmission with horizontal encoding has been shown [1] to significantly increase the performance of successive cancellation receivers.

2.3 Methodology for encoding per-stream power levels

For the quantization of power weightings for all streams, an efficient quantization method is described here after recognizing the fact that the range of each stream can be refined after the power weightings of previous streams are quantized. The method sequentially quantizes the power weightings of the data streams in a numerical range that depends on the power weighting of the previously quantized stream powers. Also noted here that the streams are indexed in the order of decreasing power weighting and all power weightings sum up to one. So the number of bits assigned to quantize each successive stream can be smaller due to the decreasing range of possible values. Due to the fact that only a minimum dynamic range is quantized, the quantization granularity is very fine. In most of the cases a granularity of less than 0.01 in power difference is achieved with extreme cases being about 0.08. Also, in open-loop transmission, the strongest stream (i.e., the stream that has the largest power weighting) is transmitted from the first antenna; the second stream is transmitted from the second antenna and so on. In the closed-loop case, the strongest stream corresponds to the first beamforming vector (i.e., first column of the beamforming matrix) and so on.

The quantization scheme is given as (note that the quantization step includes both the lower and upper range values and the remaining B-2 levels are uniformly positioned between the lower and upper limits):

1. Determine the maximum number of data streams that the BS and MSS support based on the number of antennas at MSS and BS (e.g., up to N_s data streams)
2. Determine the power weighting P_1 of the strongest data stream between $1/N_s$ and 1. Quantize the squared root of P_1 (i.e., α_1=sqrt(P_1)) with B_1 bits (B_1=3 if N_s=2, B_1=4 if N_s=3 or 4).
3. For the m-th stream where m=2 to N_s-1, determine the power weighting of the m-th data stream that should be in the range of $\frac{1}{N_s+1-m}(1-\sum_{n=1}^{m-1}\alpha_n^2) \le \alpha_m^2 \le \min(\alpha_{m-1}^2, 1-\sum_{n=1}^{m-1}\alpha_n^2)$. Quantize α_m with B_m bits (B_2=2 if N_s=3, B_2=3 and B_3=2 if N_s=4).

4. The power weighting of the last stream is $1-\sum_{n=1}^{N_s-1}\alpha_n^2$, which does not need to be fed back.

Thus the total amount of feedback (in number of bits) needed for the power weight is $\sum_{m=1}^{N_s-1}B_m$. A three-bit CQICH is allocated if the feedback for up to N_s=2 streams is requested by the BS. A six-bit CQICH is allocated (or two three-bit CQICH) if the feedback for up to N_s=3 streams is requested by the BS. A six-bit and a three-bit CQICH (or 3 three-bit CQICH) are allocated if the feedback for up to N_s=4 streams is requested by the BS. Note that if the MSS preferred a stream number smaller than N_s, the remaining streams will be allocated with zero power.

2.4 Simulation Results

Although this contribution does not specify a per-stream power control strategy, simulation results are now presented to show the benefits of using the per-stream power weighting feedback option that is currently in the standard and also the benefits of successive interference cancellation at the receiver. The channel was simulated using a COST-259 channel model with 2.0 μsec RMS delay spread with a 15 degree angular spread at the BS and a 360 degree angular spread at the MSS. The BS has four transmit antennas and the MSS has four receive antennas. The BS sends four data streams to the MSS and horizontal encoding of the data is used. Each stream is a rate ½ convolutionally encoded QPSK data stream. A matrix codebook of 64 vectors was used and the codebook was designed using the criteria discussed in [2]. The codebook selection criterion at the MSS is to choose the codebook matrix that maximizes the capacity. Equal-stream power using the codebook matrix to transmit the data streams is compared to per-stream power weights which are designed to equalize the MSE on each data stream after successive cancellation reception. Figure 1 shows the FER results comparing the different methods. Note that linear MMSE combining is significantly worse than successive cancellation (SC) reception for equal power weightings. Also note that there is a significant improvement for using per-stream power weightings along with the matrix codebook selection.

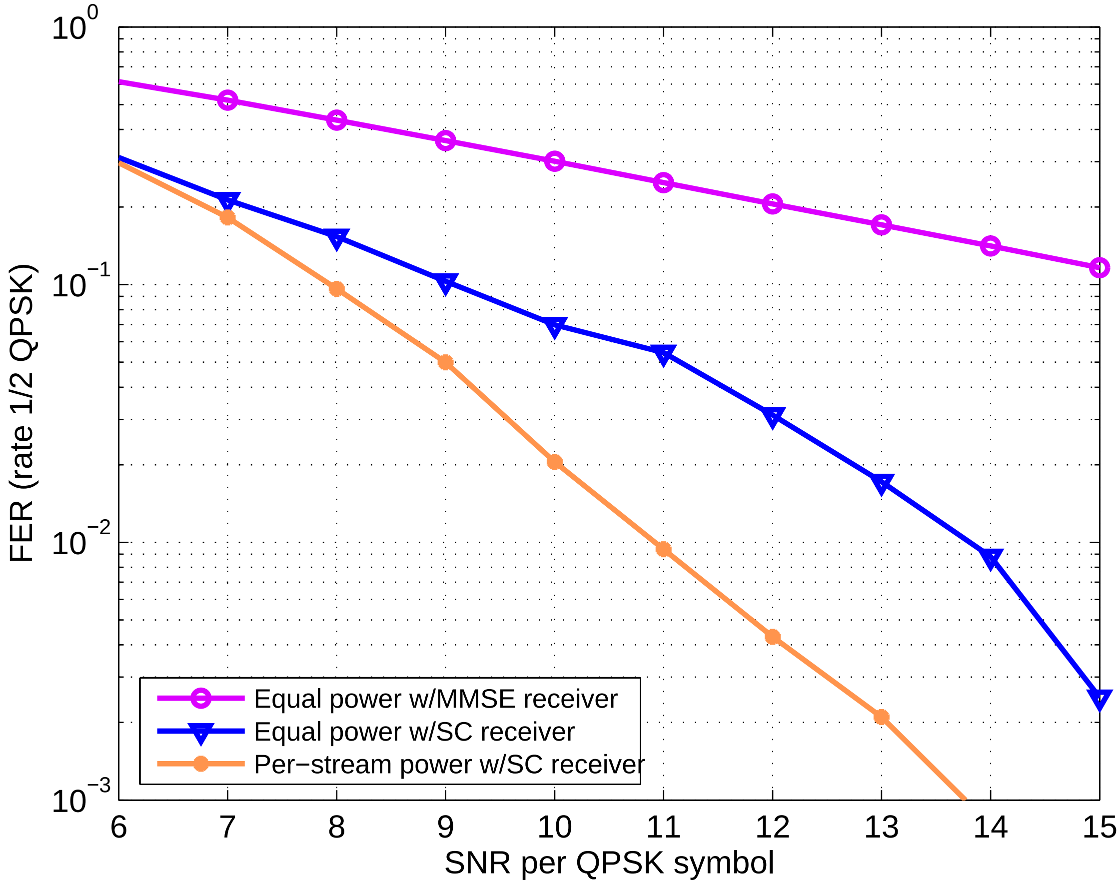

Figure 1. Simulation results showing the benefits of per-stream power weighting for four data stream closed-loop MIMO for four antennas at the BS and four antennas at the MSS.

3 Specific Text Changes

[NOTE: In the following, we propose that the working group adopt one of two functionally equivalent remedies that enable the per-stream power control scheme described above: The first version (Section 3.1) specifies the per-stream power control strategy with both equations and tables to show the specific encoding values. The second version (Section 3.2) omits the tables and contains only the equations.]

3.1 Remedy 1 – Version with Formulas and Tables

[Insert the following after Section 8.4.5.4.10.12:]

8.4.5.4.10.13 Per Stream Power Control

When the feedback type field in CQICH Enhanced Allocation IE is "101" = Per stream power control, the BS require the power weighting of each spatial streams that can be supported by the MSS if the BS considers sending more than one stream to this MSS. If required by the BS, the MSS shall report the square root of the power weighting factors of the spatial streams (i.e., to report α_i with i=1..N_s (number of streams) where $\sum_i \alpha_i^2=1$). The first stream shall correspond to the largest weighting and the second stream to the second largest weighting, and so on. The power weighting of the last stream can be derived as the remaining power and thus needs not to be reported. When no codebook matrix is fed bck, the first stream (i.e., the stream that has the largest power weighting) is transmitted from the first antenna; the second stream is transmitted from the second antenna and so on. When a beamforming codebook matrix is also fed back, the strongest stream corresponds to the first beamforming vector (i.e., first column of the beamforming matrix) and so on.

The feedback allocation and power weighting quantization procedure is as follows:

If the BS wants the MSS to feed back the power weightings for up to Ns=2 streams, one 3-bit CQI channel is allocated. A numerical range of [$\sqrt{1/2}$,1] is first uniformly divided into 2^3=8 levels (i.e., with the interval between levels being (1-$\sqrt{1/2}$)/7) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level according to table XXX. All "1" means the first stream uses all transmit power (i.e., a single stream is preferred by the MSS, rather than two streams).

Table XXX. Encoding of the payload bits for per-stream power control (up to 2 streams case)

α_1 bits	000	001	010	011	100	101	110	111
α_1	0.7071	0.7489	0.7908	0.8326	0.8745	0.9163	0.9582	1.0000

If the BS wants the MSS to feed back power weighting for up to Ns=3 streams, one 6-bit CQI (or two 3-bit CQI channels) is allocated. The first power weighting is quantized using 4 bits and the second using 2 bits. A numerical range of [$\sqrt{1/3}$,1] is first uniformly divided into 2^4=16 levels (i.e., with the interval between levels being (1-$\sqrt{1/3}$)/15) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level (denoted as α_1). Then, 2 bits are used to quantize the range of [$\frac{1}{2}(1-\alpha_1^2)$, min($\alpha_1^2, 1-\alpha_1^2$)]. The exact quantization is given in table YYY-1 and YYY-2.

Table YYY-1. Encoding of the payload bits for per-stream power control (up to 3 streams case)

α_1 bits	0000	0001	0010	0011	0100	0101	0110	0111
α_1	0.5774	0.6055	0.6337	0.6619	0.6901	0.7182	0.7464	0.7746
α_1 bits	1000	1001	1010	1011	1100	1101	1110	1111
α_1	0.8028	0.8309	0.8591	0.8873	0.9155	0.9436	0.9718	1.0000

Table YYY-2. Encoding of the payload bits for per-stream power control (up to 3 stream case)

α_1 bits	0000	0001	0010	0011	0100	0101	0110	0111
α_2: "00"	0.5774	0.5627	0.5470	0.5301	0.5118	0.4920	0.4706	0.4472
"01"	0.5774	0.5770	0.5759	0.5740	0.5712	0.5599	0.5355	0.5090
"10"	0.5774	0.5913	0.6048	0.6179	0.6306	0.6279	0.6005	0.5707
"11"	0.5774	0.6055	0.6337	0.6619	0.6901	0.6958	0.6655	0.6325
α_1 bits	1000	1001	1010	1011	1100	1101	1110	1111
α_2: "00"	0.4216	0.3934	0.3619	0.3261	0.2845	0.2340	0.1667	0
"01"	0.4799	0.4477	0.4118	0.3711	0.3238	0.2663	0.1897	0
"10"	0.5381	0.5020	0.4618	0.4162	0.3631	0.2986	0.2127	0
"11"	0.5963	0.5564	0.5118	0.4612	0.4024	0.3310	0.2357	0

If the BS wants the MSS to feed back power weighting for up to Ns=4 streams, one 6-bit CQI and one 3-bit CQI (or three 3-bit CQI channels) are allocated. The first power weighting is quantized using 4 bits, the second using 3 bits, and the third using 2 bits. A numerical range of [$\sqrt{1/4}$,1] is first uniformly divided into 2^4=16 levels (i.e., with the interval between levels being (1-$\sqrt{1/4}$)/15) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level (denoted as α_1). Then, 3 bits are used to quantize the range of [$\frac{1}{3}(1-\alpha_1^2)$, $\min(\alpha_1^2, 1-\alpha_1^2)$] for the second stream squared-root power weighting (denotes as α_2). Finally, 2 bits are used to quantize the range of [$\frac{1}{2}(1-\alpha_1^2-\alpha_2^2)$, $\min(\alpha_2^2, 1-\alpha_1^2-\alpha_2^2)$] for the third stream squared-root power weighting. The exact quantization is given in table ZZZ-1, ZZZ-2, and ZZZ-3.

Table ZZZ-1. Encoding of the payload bits for per-stream power control (up to 4 streams case)

α_1 bits	0000	0001	0010	0011	0100	0101	0110	0111
α_1	0.5000	0.5333	0.5667	0.6000	0.6333	0.6667	0.7000	0.7333
α_1 bits	1000	1001	1010	1011	1100	1101	1110	1111
α_1	0.7667	0.8000	0.8333	0.8667	0.9000	0.9333	0.9667	1.0000

Table ZZZ-2. Encoding of the payload bits for per-stream power control (up to 4 streams case)

α_1 bits	0000	0001	0010	0011	0100	0101	0110	0111
α_2: "000"	0.5000	0.4884	0.4757	0.4619	0.4468	0.4303	0.4123	0.3925
"001"	0.5000	0.4948	0.4887	0.4816	0.4734	0.4641	0.4534	0.4336
"010"	0.5000	0.5012	0.5017	0.5013	0.5001	0.4979	0.4945	0.4746
"011"	0.5000	0.5076	0.5147	0.5211	0.5267	0.5316	0.5356	0.5157
"100"	0.5000	0.5141	0.5277	0.5408	0.5534	0.5654	0.5767	0.5567
"101"	0.5000	0.5205	0.5407	0.5605	0.5800	0.5991	0.6178	0.5978
"110"	0.5000	0.5269	0.5537	0.5803	0.6067	0.6329	0.6589	0.6388
"111"	0.5000	0.5333	0.5667	0.6000	0.6333	0.6667	0.7000	0.6799
α_1 bits	1000	1001	1010	1011	1100	1101	1110	1111
α_2: "000"	0.3707	0.3464	0.3191	0.2880	0.2517	0.2073	0.1478	0
"001"	0.4095	0.3826	0.3525	0.3182	0.2780	0.2290	0.1633	0
"010"	0.4482	0.4189	0.3859	0.3483	0.3043	0.2506	0.1787	0
"011"	0.4870	0.4551	0.4193	0.3784	0.3306	0.2723	0.1942	0
"100"	0.5257	0.4913	0.4526	0.4085	0.3569	0.2940	0.2097	0
"101"	0.5645	0.5275	0.4860	0.4386	0.3833	0.3157	0.2251	0
"110"	0.6033	0.5638	0.5194	0.4688	0.4096	0.3373	0.2406	0
"111"	0.6420	0.6000	0.5528	0.4989	0.4359	0.3590	0.2560	0

Table ZZZ-3. Encoding of the payload bits for per-stream power control (up to 4 streams case)

$\alpha_1\alpha_2$bits	0000000	0000001	0000010	0000011	0000100	0000101	0000110	0000111
α_3:"00"	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
"01"	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
"10"	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
"11"	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
$\alpha_1\alpha_2$bits	0001000	0001001	0001010	0001011	0001100	0001101	0001110	0001111

α_3:“00”	0.4884	0.4851	0.4818	0.4785	0.4750	0.4715	0.4679	0.4643
“01”	0.4884	0.4884	0.4883	0.4882	0.4880	0.4878	0.4876	0.4873
“10”	0.4884	0.4916	0.4948	0.4979	0.5011	0.5042	0.5073	0.5103
“11”	0.4884	0.4948	0.5012	0.5076	0.5141	0.5205	0.5269	0.5333
$\alpha_1\alpha_2$bits	0010000	0010001	0010010	0010011	0010100	0010101	0010110	0010111
α_3:“00”	0.4757	0.4691	0.4622	0.4550	0.4475	0.4396	0.4315	0.4230
“01”	0.4757	0.4756	0.4753	0.4749	0.4742	0.4733	0.4722	0.4709
“10”	0.4757	0.4822	0.4885	0.4948	0.5009	0.5070	0.5129	0.5188
“11”	0.4757	0.4887	0.5017	0.5147	0.5277	0.5407	0.5537	0.5667
$\alpha_1\alpha_2$bits	0011000	0011001	0011010	0011011	0011100	0011101	0011110	0011111
α_3:“00”	0.4619	0.4517	0.4408	0.4292	0.4169	0.4036	0.3894	0.3742
“01”	0.4619	0.4617	0.4610	0.4598	0.4582	0.4559	0.4432	0.4258
“10”	0.4619	0.4716	0.4812	0.4905	0.4995	0.5082	0.4969	0.4775
“11”	0.4619	0.4816	0.5013	0.5211	0.5408	0.5605	0.5507	0.5292
$\alpha_1\alpha_2$bits	0100000	0100001	0100010	0100011	0100100	0100101	0100110	0100111
α_3:“00”	0.4468	0.4329	0.4176	0.4009	0.3825	0.3622	0.3397	0.3145
“01”	0.4468	0.4464	0.4451	0.4428	0.4353	0.4123	0.3866	0.3579
“10”	0.4468	0.4599	0.4726	0.4848	0.4882	0.4623	0.4335	0.4013
“11”	0.4468	0.4734	0.5001	0.5267	0.5410	0.5123	0.4804	0.4447
$\alpha_1\alpha_2$bits	0101000	0101001	0101010	0101011	0101100	0101101	0101110	0101111
α_3:“00”	0.4303	0.4124	0.3922	0.3694	0.3434	0.3135	0.2784	0.2357
“01”	0.4303	0.4296	0.4274	0.4204	0.3909	0.3568	0.3168	0.2682
“10”	0.4303	0.4469	0.4626	0.4714	0.4383	0.4001	0.3552	0.3008
“11”	0.4303	0.4641	0.4979	0.5224	0.4857	0.4434	0.3937	0.3333
$\alpha_1\alpha_2$bits	0110000	0110001	0110010	0110011	0110100	0110101	0110110	0110111
α_3:“00”	0.4123	0.3901	0.3643	0.3340	0.2978	0.2533	0.1947	0.1000

"01"	0.4123	0.4112	0.4077	0.3801	0.3390	0.2883	0.2216	0.1138
"10"	0.4123	0.4323	0.4511	0.4262	0.3801	0.3232	0.2485	0.1276
"11"	0.4123	0.4534	0.4945	0.4724	0.4212	0.3582	0.2754	0.1414
$\alpha_1\alpha_2$bits	0111000	0111001	0111010	0111011	0111100	0111101	0111110	0111111
α_3: "00"	0.3925	0.3703	0.3442	0.3133	0.2759	0.2290	0.1645	0
"01"	0.3925	0.3914	0.3877	0.3566	0.3140	0.2606	0.1872	0
"10"	0.3925	0.4125	0.4312	0.3998	0.3521	0.2923	0.2099	0
"11"	0.3925	0.4336	0.4746	0.4431	0.3902	0.3239	0.2327	0
$\alpha_1\alpha_2$bits	1000000	1000001	1000010	1000011	1000100	1000101	1000110	1000111
α_3: "00"	0.3707	0.3497	0.3251	0.2959	0.2606	0.2163	0.1554	0
"01"	0.3707	0.3696	0.3661	0.3367	0.2966	0.2461	0.1768	0
"10"	0.3707	0.3895	0.4072	0.3776	0.3325	0.2760	0.1983	0
"11"	0.3707	0.4095	0.4482	0.4184	0.3685	0.3059	0.2197	0
$\alpha_1\alpha_2$bits	1001000	1001001	1001010	1001011	1001100	1001101	1001110	1001111
α_3: "00"	0.3464	0.3268	0.3038	0.2765	0.2435	0.2021	0.1452	0
"01"	0.3464	0.3454	0.3421	0.3147	0.2771	0.2300	0.1652	0
"10"	0.3464	0.3640	0.3805	0.3528	0.3108	0.2579	0.1853	0
"11"	0.3464	0.3826	0.4189	0.3910	0.3444	0.2858	0.2053	0
$\alpha_1\alpha_2$bits	1010000	1010001	1010010	1010011	1010100	1010101	1010110	1010111
α_3: "00"	0.3191	0.3011	0.2799	0.2547	0.2244	0.1862	0.1338	0
"01"	0.3191	0.3182	0.3152	0.2899	0.2553	0.2119	0.1522	0
"10"	0.3191	0.3354	0.3505	0.3251	0.2863	0.2376	0.1707	0
"11"	0.3191	0.3525	0.3859	0.3602	0.3173	0.2633	0.1892	0
$\alpha_1\alpha_2$bits	1011000	1011001	1011010	1011011	1011100	1011101	1011110	1011111

α_3: "00"	0.2880	0.2717	0.2526	0.2299	0.2025	0.1680	0.1207	0
"01"	0.2880	0.2872	0.2845	0.2616	0.2304	0.1913	0.1374	0
"10"	0.2880	0.3027	0.3164	0.2934	0.2584	0.2145	0.1541	0
"11"	0.2880	0.3182	0.3483	0.3251	0.2864	0.2377	0.1707	0
$\alpha_1\alpha_2$bits	1100000	1100001	1100010	1100011	1100100	1100101	1100110	1100111
α_3: "00"	0.2517	0.2374	0.2207	0.2009	0.1769	0.1468	0.1055	0
"01"	0.2517	0.2509	0.2486	0.2286	0.2013	0.1671	0.1200	0
"10"	0.2517	0.2645	0.2764	0.2563	0.2258	0.1874	0.1346	0
"11"	0.2517	0.2780	0.3043	0.2841	0.2502	0.2076	0.1492	0
$\alpha_1\alpha_2$bits	1101000	1101001	1101010	1101011	1101100	1101101	1101110	1101111
α_3: "00"	0.2073	0.1955	0.1818	0.1654	0.1457	0.1209	0.0869	0
"01"	0.2073	0.2067	0.2047	0.1883	0.1658	0.1376	0.0989	0
"10"	0.2073	0.2178	0.2277	0.2111	0.1859	0.1543	0.1109	0
"11"	0.2073	0.2290	0.2506	0.2340	0.2061	0.1710	0.1229	0
$\alpha_1\alpha_2$bits	1110000	1110001	1110010	1110011	1110100	1110101	1110110	1110111
α_3: "00"	0.1478	0.1395	0.1296	0.1180	0.1039	0.0862	0.0620	0
"01"	0.1478	0.1474	0.1460	0.1343	0.1183	0.0982	0.0705	0
"10"	0.1478	0.1553	0.1624	0.1506	0.1326	0.1101	0.0791	0
"11"	0.1478	0.1633	0.1787	0.1669	0.1470	0.1220	0.0876	0
$\alpha_1\alpha_2$bits	1111000	1111001	1111010	1111011	1111100	1111101	1111110	1111111
α_3: "00"	0	0	0	0	0	0	0	0
"01"	0	0	0	0	0	0	0	0
"10"	0	0	0	0	0	0	0	0
"11"	0	0	0	0	0	0	0	0

Instead of using the CQICH assigned by the BS, the MSS can also use the Feedback header defined in 6.3.2.1.6.1 to provide the per-stream power weighting to the BS. The feedback can be initiated by the MSS for recommending power weightings that do not change rapidly. The feedback type is "1101" and the content of the feedback consists of 3, 6, or 9 bits, corresponding to a maximum of two, three, or four streams sent to the MSS. Other bits in the feedback content field are unused since the allowed number of feedback content bits is 16 in the Feedback header when the CID field is present. The quantization of the per-stream power weighting in Feedback header is the same as in CQI fast feedback.

-------------------------- End of Text Changes for Remedy 1 --

3.2 Remedy 2 – Version with formulas only (no tables)

[Insert the following after Section 8.4.5.4.10.12:]

8.4.5.4.10.13 Per Stream Power Control

When the feedback type field in CQICH Enhanced Allocation IE is "101" = Per stream power control, the BS require the power weighting of each spatial streams that can be supported by the MSS if the BS considers sending more than one stream to this MSS. If required by the BS, the MSS shall report the square root of the power weighting factors of the spatial streams (i.e., to report α_i with i=1..N_s (number of streams) where $\sum_i \alpha_i^2=1$). The first stream shall correspond to the largest weighting and the second stream to the second largest weighting, and so on. The power weighting of the last stream can be derived as the remaining power and thus needs not to be reported. When no codebook matrix is fed bck, the first stream (i.e., the stream that has the largest power weighting) is transmitted from the first antenna; the second stream is transmitted from the second antenna and so on. When a beamforming codebook matrix is also fed back, the strongest stream corresponds to the first beamforming vector (i.e., first column of the beamforming matrix) and so on.

The feedback allocation and power weighting quantization procedure is as follows:

If the BS wants the MSS to feed back the power weightings for up to Ns=2 streams, one 3-bit CQI channel is allocated. A numerical range of [$\sqrt{1/2}$,1] is first uniformly divided into 2^3=8 levels (i.e., with the interval between levels being (1-$\sqrt{1/2}$)/7) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level. The value of "1" means the first stream uses all transmit power (i.e., a single stream is preferred by the MSS, rather than two streams).

If the BS wants the MSS to feed back power weighting for up to Ns=3 streams, one 6-bit CQI (or two 3-bit CQI channels) is allocated. The first power weighting is quantized using 4 bits and the second using 2 bits. A numerical range of [$\sqrt{1/3}$,1] is first uniformly divided into 2^4=16 levels (i.e., with the interval between levels being (1-$\sqrt{1/3}$)/15) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level (denoted as α_1). Then, 2 bits are used to quantize the range of [$\frac{1}{2}(1-\alpha_1^2)$, $\min(\alpha_1^2, 1-\alpha_1^2)$].

If the BS wants the MSS to feed back power weighting for up to Ns=4 streams, one 6-bit CQI and one 3-bit CQI (or three 3-bit CQI channels) are allocated. The first power weighting is quantized using 4 bits, the second using 3 bits, and the third using 2 bits. A numerical range of [$\sqrt{1/4}$,1] is first uniformly divided into 2^4=16 levels (i.e., with the interval between levels being (1-$\sqrt{1/4}$)/15) and the MSS quantizes the squared root of the power weighting of the first stream to the nearest level (denoted as α_1). Then, 3 bits are used to quantize the range of [$\frac{1}{3}(1-\alpha_1^2)$, $\min(\alpha_1^2, 1-\alpha_1^2)$] for the second stream squared-root power weighting (denotes as α_2). Finally, 2 bits are used to quantize the range of [$\frac{1}{2}(1-\alpha_1^2-\alpha_2^2)$, $\min(\alpha_2^2, 1-\alpha_1^2-\alpha_2^2)$] for the third stream squared-root power weighting.

Instead of using the CQICH assigned by the BS, the MSS can also use the Feedback header defined in 6.3.2.1.6.1 to provide the per-stream power weighting to the BS. The feedback can be initiated by the MSS for recommending power weightings that do not change rapidly. The feedback type is "1101" and the content of the feedback consists of 3, 6, or 9 bits, corresponding to a maximum of two, three, or four streams sent to the MSS. Other bits in the feedback content field are unused since the allowed number of feedback content bits is 16 in the Feedback header when the CID field is present. The quantization of the per-stream power weighting in Feedback header is the same as in CQI fast feedback.

-------------------------- End of Text Changes for Remedy 2 --

3.3 Other Specific Text Changes

3.3.1 Feedback Header Modification for per-stream power weightings

The following addition to the feedback type and content specification defined in Table 7i of 6.3.2.1.6.1 is also proposed to allow the MSS to initiate the per-stream power weighting feedback through the Feedback header. Instead of using the CQICH assigned by the BS, the Feedback header is used when the power weightings do not change rapidly. The feedback type is "1101" and the content of the feedback consists of 3, 6, or 9 bits, corresponding to a maximum of two, three, or four streams sent to the MSS. Since the allowed number of feedback content bits is 16 with the presence of the CID field, the rest of the bits are not used. The quantization of the per-stream power weighting in Feedback header is the same as in CQI fast feedback.

[Add the following field to table 7i at the end of section 6.3.2.1.6.1]

Table 7i. Feedback Type and feedback content.

Feedback Type	Feedback contents	Description
0b1101	Per-stream power weighting in multi-stream transmission (3, 6, or 9 bits for a maximum of two, three, or four streams transmitted to the MSS	The recommended per-stream power weighting when multiple streams are transmitted to a multi-antenna MSS (quantization defined in 8.4.5.4.10.11)
0b1101-0b1111	Reserved for future use	

[End of "Add the following fields to Table 7i at the end of section 6.3.2.1.6.1"]

3.3.2 Modification to MIMO Compact DL MAP IE

The following addition to the MIMO Compact DL-MAP IE is, if necessary, to feed forward the actually applied per-stream power weightings that either confirm or override the MSS recommendation.

[Add the highlighted rows (blue text) to Table 101b in Section 6.3.2.3.43.6.7 as follows]

6.3.2.3.43.6.7 MIMO Compact DL MAP IE format

Table 101b—MIMO Compact DL-MAP IE format

Syntax	Size (bits)	Notes
MIMO_Compact_DL-MAP_IE() {		
Compact DL-MAP Type	3	Type = 7
DL-MAP Sub-type	5	MIMO = 0x01
Length	4	Length of the IE in Bytes
Mode Change	1 bit	Indicates change of MIMO mode 0 = No change from previous allocation 1 = Change of MIMO mode
Antenna Grouping/Selection	1 bit	Application of antenna grouping/selection to the burst 0 = Not applied 1 = AG/AS applied
Codebook based Precoding	1 bit	Application of codebook based precoding to the burst 0 = Not applied 1 = Codebook based precoding applied
Per-stream power weighting	1 bit	Indicates whether the actual power weighting is included in this IE 0 = Not included 1 = Included
N_layer	2	Number of multiple coding/modulation layers 00 – 1 layer 01 – 2 layers 10 – 3 layers 11 – 4 layers
if(Mode Change == 1){		
Matrix	2 bits	Indicates transmission matrix (See 8.4.8) 00 = Matrix A (Transmit Diversity) 01 = Matrix B (Hybrid Scheme) 10 = Matrix C (Spatial Multiplexing) 11 = Reserved
Mt	2 bits	Indicates number of STC output streams 00 = 1 stream 01 = 2 streams 10 = 3 streams

		11 = 4 streams
if (Antenna Grouping/Selection == 1) {		
Antenna Grouping/Selection Index }	4 bits	Indicates the index of antenna grouping/selection See 8.4.8.3.4 and 8.4.8.3.5
if (Codebook based precoding == 1) {		
Codebook based precoding Index }	6 bits	Indicates the index of precoding matrix W in the codebook See 8.4.8.3.6
if (Per-stream power weighting == 1) {		
Per-stream power weighting}	9 bits	Indicates the actual per-stream power weighting defined in 8.4.5.4.10.11 (uses 3, 6, or 9 bits for a maximum of 2, 3, or 4 transmitted streams. The MSS knows the maximum stream number as the smaller value between the number of its receive antennas and BS antennas)
}		
for (j=1;j<N_layer+1; j++) {		This loop specifies the Nep/DIUC for layers 2 and above when required for STC. The same Nsch and RCID applied for each layer

if (H-ARQ Mode =CTC Incremental Redundancy) {
Nep }
elseif (H-ARQ Mode = Generic Chase) {
DIUC
}
	4 bits	H-ARQ Mode is specified in the H-ARQ Compact_DL-MAP IE format for Switch H-ARQ Mode.

if (CQICH indicator == 1) {		CQICH indicator comes from the preceding Compact DL-MAP IE
Allocation Index[1]}	6	Index to CQICH assigned to this layer.
}		
if (CQICH indicator == 1) {	2	The number of additional CQICHs allocated to this SS. (0 – 3)
CQICH_Num	2	The number of additional CQICHs allocated to this SS. (0 – 3)
for (i=0; i<CQICH_Num; i++) {		
Feedback_type	3	Type of contents on the additional CQICH
Allocation index	6	
CQICH Usage	2	Indicates the usage of this CQICH 00 = 6 bit CQI (default) 01 = DIUC-CQI 10 = 3 bit CQI (even) 11 = 3 bit CQI(odd)

}		
}		
Padding	variabl e	Padding to byte; shall be set to 0
}		

[End of “Add the highlighted rows to Table 101b in Section 6.3.2.3.43.6.7”]

3.3.3 Adding receiver capability to do successive cancellation

[Add a new section 11.7.8.11]

11.7.8.11 Advanced Receiver Capability

This field indicates whether the MSS is advanced receiver capable

Type	Length	Value	Scope
21	1	Bit 0: Successive Interference Receiver Capability Bit 1-7: Reserved	REG-REQ REG-RSP

[End of “Adding receiver capability to do successive cancellation”]

References

[1] T. A. Thomas and F. W. Vook, “A Method for Improving the Performance of Successive Cancellation in Mobile Spread MIMO OFDM,” *Proc. IEEE VTC-2002/Fall*, Vancouver, Canada, September 2002.

[2] D. J. Love, and R. W. Heath Jr., “Limited Feedback Unitary Precoding for Spatial Multiplexing Systems,” *to appear in IEEE Transactions on Information Theory*.