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| **Re:** | IEEE 802.16m-09/0028r1, "Call for Comments and Contributions on Project 802.16m Amendment Content".<br>Target topic: "Call for Comments and Related Contributions on Amendment Working Document" | |
| Abstract | This contribution proposes a MIMO downlink per-stream power control (PSPC) to be included in the 802.16m amendment working document. | |
| Purpose | To be discussed and adopted by TGm for 802.16m amendment working document. | |
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# MIMO Downlink Per-Stream Power Control (PSPC)

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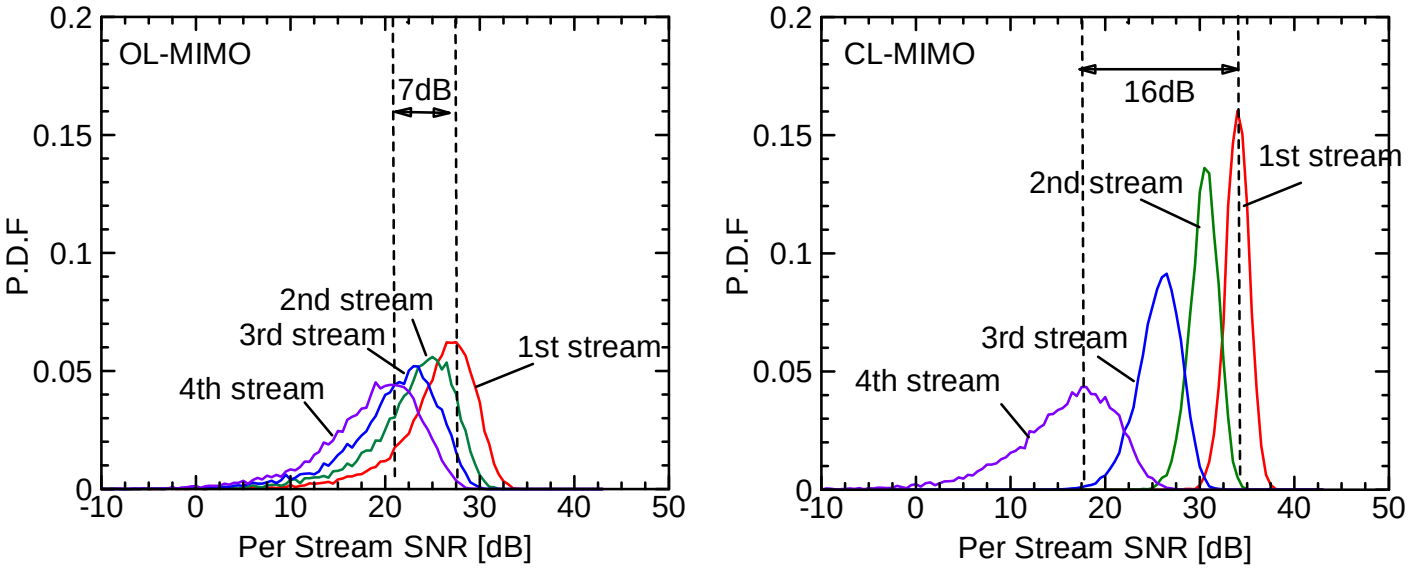
## 1 Introduction

This contribution proposes the text of MIMO downlink Per-Stream Power Control (PSPC) to be included in the IEEE 802.16m amendment [1]. The technical text is inherited from the IEEE 802.16m SRD [2], SDD [3], and IEEE P802.16 Rev2/D9 [4].

## 2 Problem Statement

***Vertical encoding*** may reduce the performance of CL-MIMO due to difference among channel eigen values. More specifically, the difference among channel eigen values for downlink streams would lead to LLR imbalance of FEC decoder at the receiver side of the MS. In addition, these imbalances in CL-MIMO are larger than the LLR imbalances in OL-MIMO. This phenomenon is illustrated in Figure 1. In this situation, rank adaptation, per-stream power control (PSPC), and mixed mode with rank adaptation and PSPC are useful to improve the MIMO performance.




(a) Eigenvalue PDF for OL-MIMO (b) Eigenvalue PDF for CL-MIMO

**Figure 1: Eigenvalue distribution.**

The performance degradation in LLR imbalance of FEC decoder is further shown in Figure 2. The simulation results indicate that for a power imbalance of 3 dB between two streams, the loss relative to perfectly balanced reception is about 1 dB.

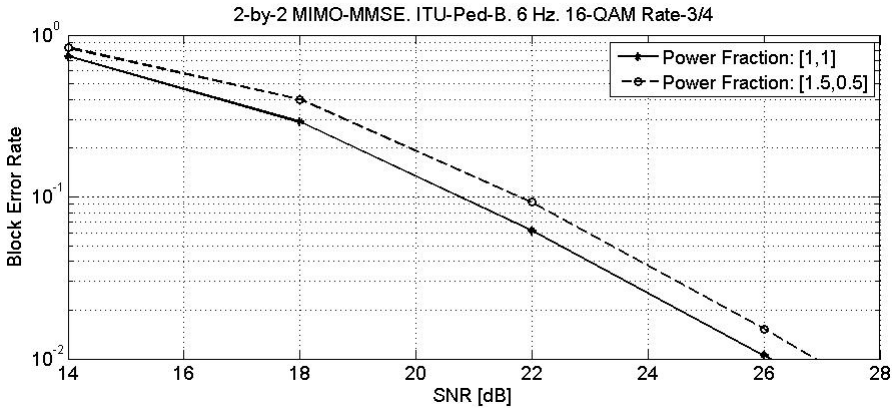
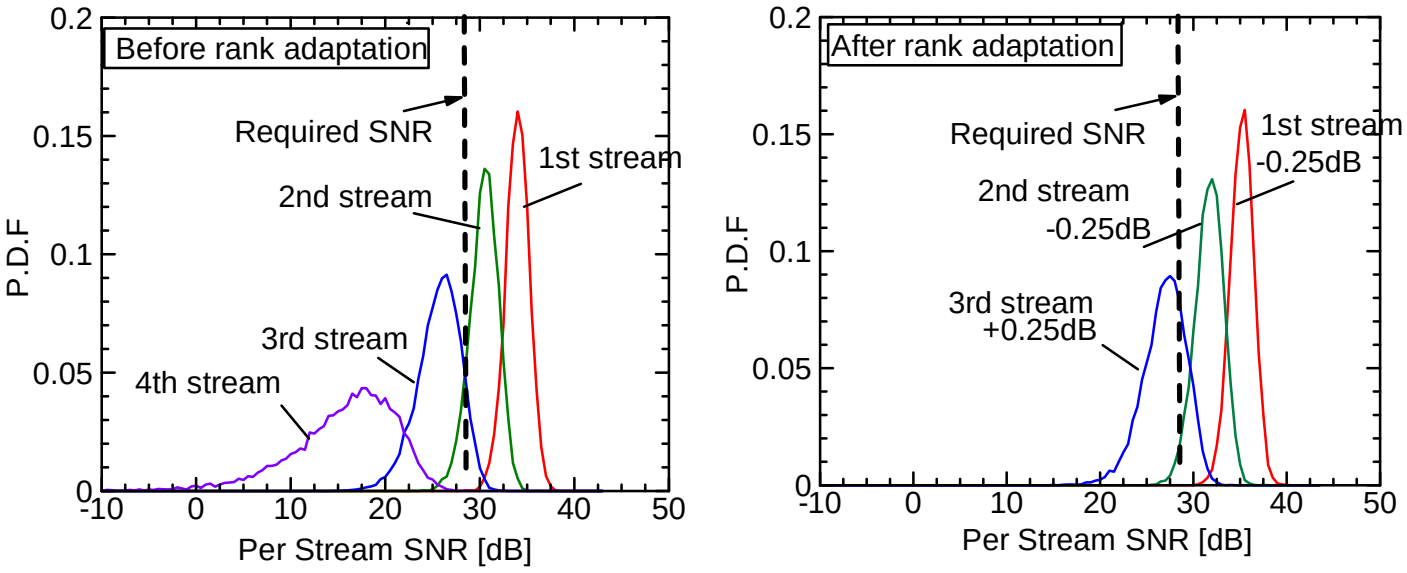



**Figure 2: Example of FEC imbalance**

# 3 Proposed Solution

In order to solve the imbalance problem among channel eigen values in CL-MIMO, rank adaptation, per-stream power control (PSPC), and mixed mode with rank adaptation and PSPC should be used. Especially, PSPC is one solution to achieve the required SNR for all streams over vertical encoding.

For example, to achieve the required SNR, ABS would first determine the rank adaptation (Figure 3(a)). Then, as shown in Figure 3(b), the ABS would boost the 3rd eigen value according to the feedback from AMS by using PSPC feedback information to achieve the required SNR.




(a) Before rank adaptation

(b) After rank adaptation

**Figure 3: Example of rank adaptation and PSPC**

Furthermore, the simulation results of PSPC in localized CL-MIMO are shown in figure 4. The results again confirm that boosting the stream with poor SINR will deliver the best performance.

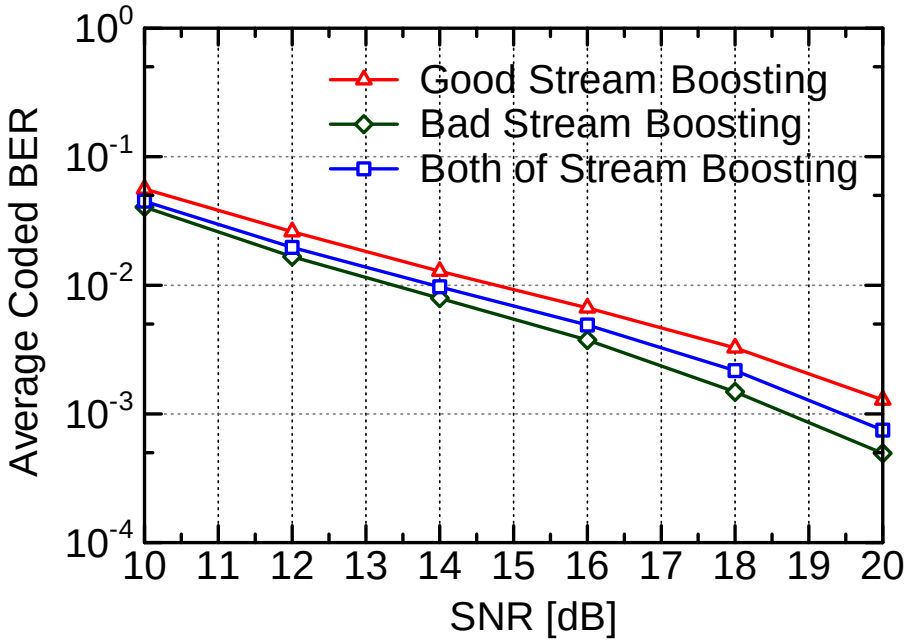



Figure 4: effect of per stream power control
(Vertical encoding, 16QAM 3/4, 2x2MIMO, 2stream, Ped-B 0Hz )

Therefore, we propose that AMS monitors DL SINR for each stream and feeds back PSPC information to ABS along with other MIMO feedback information. Then, the ABS decides per-stream downlink transmit power based on the PSPC feedback from AMS.

# 4 Proposed Text

*[----------Start of Text Proposal----------]*

## 15.3.6 Downlink control structure
## 15.3.6.4 Downlink power control

*[Insert subclause 15.3.6.4.2 as follows]*

### 15.3.6.4.2 Per-Stream Downlink Power Control

Per-stream downlink transmit power that ABS uses for an AMS can be set according to the direct power adjustment signaling from the AMS. In DL MIMO control parameters, ABS can indicate whether or not per-stream power control is applied. ABS can further indicate in DL MIMO control parameters whether long-term or short-term power control is applied, if per-stream power control is used. Per instruction from ABS, AMS reports the desired downlink transmit power adjustment for each stream together with PMI and other MIMO feedback information in uplink secondary fast feedback control channel.

## 15.3.6.5.2.9 Feedback Allocation A-MAP IE

*[Modify Table 682 as follows]*

**Table 682—Feedback Allocation A-MAP IE**

| Syntax | | Size(bit) | Notes |
|---|---|---|---|
| Long period feedback | | STC rate | For MIMO modes 0, 1 and 2 |
| | | Subband selection | For CRU allocations, indicating which subbands are preferred |
| | | Stream index | For MIMO mode 3, indicating which streams are preferred. |
| | | Quantized Correlation matrix | For transformation codebook feedback mode and long term wideband beamforming |
| | | PMI report for serving cell [TBD] | For long-term wideband beamforming |
| | | PMI report for neighboring cell | For PMI coordination among multiple BSs |
| | | CQI | For link adaptation (MCS selection) |
| | | Per stream power control | For per stream power control, indicating how transmit power of each stream should be adjusted |
| Short period feedback | | CQI | For link adaptation (MCS selection) |
| | | PMI report for serving cell | For short-term beamforming with MIMO modes 2 and 4 |
| | | Per stream power control | For per stream power control, indicating how transmit power of each stream should be adjusted |
| Event-driven feedback | | Preferred MIMO feedback mode | For MS reporting of its preferred MIMO mode in unsolicited manner |

## 15.3.7 Downlink MIMO

## 15.3.7.2.5.3 MIMO feedback information

Table 690 specifies the feedback information required for MIMO operation.

*[Modify Table 690 as follows]*

**Table 690—MIMO feedback information**

| Feedback information type | | Description |
|---|---|---|
| Long period feedback | STC rate | For MIMO modes 0, 1 and 2 |
| | Subband selection | For CRU allocations, indicating which subbands are preferred |
| | Stream index | For MIMO mode 3, indicating which streams are preferred. |
| | Quantized Correlation matrix | For transformation codebook feedback mode and long term wideband beamforming |
| | PMI report for serving cell [TBD] | For long-term wideband beamforming |
| | PMI report for neighboring cell | For PMI coordination among multiple BSs |
| | CQI | For link adaptation (MCS selection) |

| | | |
|---|---|---|
| | Per stream power control | For per stream power control, indicating how transmit power of each stream should be adjusted |
| Short period feedback | CQI | For link adaptation (MCS selection) |
| | PMI report for serving cell | For short-term beamforming with MIMO modes 2 and 4 |
| | Per stream power control | For per stream power control, indicating how transmit power of each stream should be adjusted |
| Event-driven feedback | Preferred MIMO feedback mode | For MS reporting of its preferred MIMO mode in unsolicited manner |

*[Insert following tables at the end of section 15.3.7.2.5.3]*

**Table xxx Power Control（2stream）**

| | index | Power Control | Description |
|---|---|---|---|
| Per Stream Power Control bit | 0～3 (2bit) | 00～11 | 1st bit represents the power boost for 1st stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 2nd bit represents the power boost for 2nd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. |

**Table xxx Power Control（3stream）**

| | index | Power Control | Description |
|---|---|---|---|
| Per Stream Power Control bit | 0～7 (3bit) | 000～111 | 1st bit represents the power boost for 1st stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 2nd bit represents the power boost for 2nd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 3rd bit represents the power boost for 3rd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. |

**Table xxx Power Control（4stream）**

| | index | Power Control | Description |
|---|---|---|---|
| Per Stream Power Control bit | 0～15 (4bit) | 0000～1111 | 1st bit represents the power boost for 1st stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 2nd bit represents the power boost for 2nd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 3rd bit represents the power boost for 3rd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 4th bit represents the power boost for 4th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. |

**Table xxx Power Control（8stream）**

| | index | Power Control | Description |
|---|---|---|---|
| Per Stream Power Control bit | 0～255 (8bit) | 00000000～ 11111111 | 1st bit represents the power boost for 1st stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 2nd bit represents the power boost for 2nd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 3rd bit represents the power boost for 3rd stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 4th bit represents the power boost for 4th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 5th bit represents the power boost for 5th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 6th bit represents the power boost for 6th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 7th bit represents the power boost for 7th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. 8th bit represents the power boost for 8th stream, 0 = -0.25dB boost, 1 = 0.25dB boost. |

## 15.3.7.2.5.4 MIMO feedback modes

Table 691 specifies the feedback information required for MIMO operation.

*[Modify Table 691 as follows]*

**Table 691—MIMO feedback modes**

| Feedback Mode | Description | Feedback content | Type of RU | Supported MIMO transmission mode |
|---|---|---|---|---|
| Mode 0 | OL SU MIMO SFBC/SM (Diversity) | 1. STC Rate<br>2. Wideband CQI | Diversity (DRU, Mini-band based CRU) | MIMO mode 0 and MIMO mode 1.<br>Flexible adaptation between the two modes<br>STC Rate = 1: SFBC CQI<br>STC Rate 2: SM CQI<br>In DRU: $M_t$=2 for SM.<br>In Miniband based CRU: $M_t$ >=2 for SM |
| Mode 1 | OL SU MIMO SM (Diversity) | 1. STC Rate<br>2. Wideband CQI | Diversity (Mini-band based CRU) | MIMO mode 1 |
| Mode 2 | OL SU MIMO SM (localized) | 1. STC Rate<br>2. Subband CQI<br>3. Subband Selection | Localized (Subband based CRU, Mini-band based CRU) | MIMO mode 1 |
| Mode 3 | CL SU MIMO (localized) | 1. STC Rate<br>2. Subband CQI<br>3. Subband PMI<br>4.Subband selection<br>[5. Wideband PMI]<br>6. Wideband cor-relation matrix<br>7. Subband Per stream power control | Localized (Subband based CRU, Mini-band based CRU) | MIMO mode 2 |
| Mode 4 | CL SU MIMO (Diversity) | 1. Wideband CQI<br>[2. Wideband PMI]<br>3. Wideband cor-relation matrix | Diversity (Mini-band based CRU) | MIMO mode 2 (Mt=1) |
| Mode 5 | OL MU MIMO (localized) | 1. Subband CQI<br>2. Subband Selection<br>3. Stream indicator | Localized (Subband based CRU, Mini-band based CRU) | MIMO mode 3 |
| Mode 6 | CL MU MIMO (localized) | 1. Subband CQI<br>2. Subband PMI<br>3. Subband Selection<br>[4. Wideband PMI]<br>5. Wideband cor-relation matrix | Localized (Subband based CRU, Mini-band based CRU) | MIMO mode 4 |
| Mode 7 | CL MU MIMO (Diversity) | 1. Wideband CQI<br>[2. Wideband PMI]<br>3. Wideband cor-relation matrix | Diversity (Mini-band based CRU) | MIMO mode 4 |

## 15.3.7.2.5.6 Quantized MIMO feedback for closed-loop transmit precoding

*[Modify Table 692 as follows]*

**Table 692—DL MIMO control parameters**

| Parameters | Description | Value | Control Channel (IE) | Notes |
|---|---|---|---|---|
| Broadcast Information | | | | |
| $N_t$ | Number of transmit antennas at the BS | 0b00: 2<br>0b01: 4<br>0b10: 8 | SFH (system information) | $N_t$ must be known before decoding the DL A-MAP IE |
| OL_Region[TBD] | OL MIMO region, which signaling is used to indicate MS where is the predefined OL MIMO region and number of streams (1 or 2) | TBD | | Broadcast information |
| SU_CT | SU base codebook type | | Broadcast information | SU base codebook subset indication |
| MU_CT (TBD) | MU base codebook type | | Broadcast information | MU base codebook subset indication |
| BC_SI | Rank-1 base codebook subset indication | BitMAP<br>(Same size as rate-1 codebook for each number of transmit antenna) | Broadcast information | Rate-1 codebook element restriction/recommendation information<br>It shall be ignored if CCE = 0b0 |
| MaxMt (TBD | Maximum number of streams | 0b00: 2<br>0b01: 3<br>0b10: 4<br>0b11: reserved | Broadcast information | If MFM indicates a MU feedback mode: the maximum number of users scheduled on each RU |
| Unicast | | | | |
| MEF | MIMO encoder format | 0b00: SFBC<br>0b01: Vertical encoding<br>0b10: Horizontal encoding<br>0b11: n/a | A-MAP IE (unicast) | MIMO encoder format<br>[MEF bitfield may not be explicitly indicated in DL A-MAP IE]. |
| $M_t$ | Number of streams in transmission | 0b000: 1<br>0b001: 2<br>0b010: 3<br>0b011: 4<br>0b100: 5<br>0b101: 6<br>0b110: 7<br>0b111: 8<br>($M_t <= N_t$) | A-MAP IE (unicast) | Number of streams in the transmission.<br>When MEF=0b00: Mt =2<br>MEF=0b10, $M_t <= 4$.<br>[Bit-field length is variable, depending on the number of Tx at BS] |
| RU allocation (TBD | RU [and stream] indocator for the burst of data | TBD | A-MAP IE (unicast) | Refer to DL control group. |

| | | | | |
|---|---|---|---|---|
| SI(TBD) | Index of pilot stream allocation | 0b00: 1<br>0b01: 2<br>0b10: 3<br>0b11: 4 | A-MAP IE (unicast) | SI shall be indicated if MEF = 0b010 [Bit-field length is variable, depending on the number of Tx at BS<br>RU allocation and SI can be merged together depending on other DG's decision |
| Feedback Allocation IE | | | | |
| MFM | MIMO feedback mode | Refer to Table 691 | Feedback allocation IE (unicast) | To decide the feedback content and related MS processing |
| DLRU (TBD) | Downlink RU, indicating which RUs or which type of RU (DRU or miniband-based CRU) to work on for feedback | TBD (Tree structure, bit map etc) | Feedback allocation IE (unicast) | To process CQI (PMI) estimation for the indicated RUs.<br>Refer to other DG |
| FT | MIMO feedback type | 0b00:codebook<br>0b01:sounding | Feedback allocation IE (unicast) | |
| CM | Codebook feed-back mode | 0b00:standard<br>0b01:transformation<br>0b10:differential | Feedback allocation IE (unicast) | Enabled when FT = 0b00 |
| CCE | Codebook Coordination Enable | 0b0:disable 0b1:enable | | CCE = 0b1: When MS finds rate-1 PMI, it finds within broadcasted codebook entries indicated by BC_ST, [SU_CT and MU_CT] |
| PSPCI | Per Stream Power Control Indicator | 0b00: do not apply per stream power control<br><br>0b01: apply per stream power control using feedback channel (short term)<br><br>0b10: apply per stream power control using feedback channel (Long term) | Feedback allocation IE (unicast) | An indication of whether or not per-stream power control is applied, and how to perform the per stream power control if it is applied. |

## 15.3.9 Uplink control channel

## 15.3.9.3.1.2 Secondary fast feedback control channel

*[Add following row into Table 726]*

**Table 726—SFBCH Feedback Content**

| SFBCH Feedback Content | Related MIMO feedback mode | Description / Notes |
|---|---|---|
| PSPC | | Per Stream Power Control |

*[----------End of Text Proposal----------]*

# 5 Reference

[1] IEEE P802.16 Rev2/D9, “Draft IEEE Standard for Local and Metropolitan Area Networks: Air Interface for Broadband Wireless Access,” Jan. 2009.

[2] IEEE 802.16m-07/002r8, “802.16m System Requirements”

[3] IEEE 802.16m-08/003r8, “The Draft IEEE 802.16m System Description Document”

[4] IEEE 802.16m-08/043, “Style guide for writing the IEEE 802.16m amendment”

[5] IEEE 802.16m-09/0010r1a, “Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Advanced Air Interface (working document)”

[6] IEEE C802.16e-04/529r3, “Per-Stream Bit Loading for MIMO Precoding”