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Abstract	This document suggests changes in TGe Draft Document IEEE 802.16e-D6 to define Uplink power control mechanism in order to reduce UL interference in multi-cell deployment.
Purpose	Adopt into the current TGe working draft
Notice	
Release	
Patent Policy and Procedures	

Correction to Power Control for OFDMA PHY

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1 Introduction

A great deal of consideration has gone into designing the power control for the OFDMA PHY in the 802.16e standard. However, there are a number of issues that need clarification or amendment to compliment the work done already.

This contribution is aimed at clarifying the previous PC elements, and organizing those elements and new complementary elements into the complete PC flow.

The contribution is organized as follows: The motivation behind the changes are explained in the next section, followed by an explanation about the changes needed, and finally detailed text changes that need to be implemented.

2 Motivation for the Changes

To simplify the changes needed, this contribution will only address a few issues.

2.1 Open loop power control

Section 8.4.10.3.1 discuses the transmit power of the SS but is missing the value of the transmit power in equation 138a. Moreover, there is no discussion on evaluating the UL path loss and the equation doesn't take into account the possible difference between the Tx and Rx gains of the BS antenna (for example due to beam forming). Another issue that needs clarification is a split into two distinct cases in open loop power control: active mode and passive mode (to restrict unreliable users).

2.2 Initial ranging and periodic ranging

The extensive explanation on initial and periodic ranging is lacking the definition of the transmit power to be used in the ranging process. The 802.16-2004 mechanism doesn't align with the OFDMA zoning limitation. Therefore a common PC process should be implemented in all the different zones of the OFDMA frame.

2.3 Closed loop power control

From the description in section 8.4.10.3, there is no clear definition of closed loop PC. A clear distinction between open loop and closed loop PC needs to be characterized. In addition, the explanation about closed loop power control is incomplete. This contribution will try to clarify these issues.

2.4 Others

To be able to make the above changes, it is necessary to modify the relevant TLV and add missing ones. It is also necessary to have a unified way of looking at power units to prevent confusion.

3 Power control mechanism

3.1 Open Loop Power Control

Each mobile station measures the received signal strength. From this measurement and from information on the link power budget that is transmitted during initial synchronization, the DL path loss is estimated. Assuming a similar path loss for the UL and DL, the mobile uses this information to determine its transmit power. A simplified link budget equation for the downlink can be written:

Equation 1:

$$L_{DL}\ (dB) = BS\_EIRP\ (dBm) - Rx\_RSSI\ (dBm)$$

Where,

L_{DL}	The estimated average current DL propagation loss. It does not include Tx/Rx antenna gains.
BS_EIRP	BS EIRP for the current transmission of the preamble.
Rx_RSSI	Average received DL RSSI (dBm) measured on the active subcarriers of the frame preamble.

Assuming:

Equation 2:

$$L_{DL} = L_{UL} = L$$

The required mobile power per subcarrier to be transmitted is determined by:

Equation 3:

$$P(dBm)= L(dB)+ C/N(dB) +NI(dBm) -10 \log (R)+Offset\_SSperSS+ Offset\_BSperSS$$

Where,

P	SS TX Power level (dBm) per subcarrier for the current transmission
L	The estimated average current UL propagation loss. It does not include Tx/Rx antenna gains. Estimated based on Equation 1
C/N	Normalized C/N of the modulation/FEC rate for the current transmission as specified in the UL map IE. The normalized C/N is defined in Table 334.
R	Number of repetitions for the modulation/FEC rate.
NI	Estimated average power level (dBm) of the noise and interference per SS at the BS, not including Rx antenna gain.
Offset_SSperSS	The correction term for SS-specific power offset, controlled by the SS. Its initial value is zero.
Offset_BSperSS	The correction term for SS-specific power offset, controlled by the BS.

This equation neglects the fact that the mobile's measurement of received base station power is corrupted by DL noise and interference.

To maintain at the BS a power density consistent with the modulation and FEC rate used by each SS, the BS may change the SS TX power as well as the SS assigned modulation and FEC rate. There are, however, situations where the SS should automatically update its TX power without being explicitly instructed by the BS. This happens when the SS transmits in a region marked by UIUC = 0, UIUC = 12, or UIUC = 14. In all these situations, the SS shall use a temporary TX power value set according to Equation 3.

The BS may control the Offset_BSperSS using PMC_RSP message (6.3.2.3.58), Fast Power Control (FPC) message (6.3.2.3.34) and Power Control IE (8.4.5.4.5). In this mode, the power control values delivered by the power control messages from the PMC_RSP that orders a SS to use the open loop power control shall be accumulated.

<u>Passive Uplink open loop power control</u>

In passive Uplink open loop power control the SS will set Offset_SSperSS to zero and modify the TX power value according to Offset_BSperSS only.

Active Uplink open loop power control

An alternative way is that the SS may adjust Offset_SSperSS value within a range:

Equation 4:

$$\mathit{Offset\_Boundlower} \leq \mathit{Offset\_SSperSS} \leq \mathit{Offset\_Boundupper}$$

Where,

Offset_Boundupper Upper bound of power offset adjustment (dB).

Offset_Boundlower Lower bound of power offset adjustment (dB).

Or the Offset_SSperSS may be updated automatically based on the **Ack/Nack** [if enabled at corresponding UL connections] of an uplink burst within the range specified by Equation 4. The specific algorithm is described as follows (in dB):

if NACK is recieved

$$\mathit{Offset\_SSperSS} = \mathit{Offset\_SSperSS} + \mathit{UP\_STEP}$$

else if ACK is received

$$\mathit{Offset\_SSperSS} = \mathit{Offset\_SSperSS} - \mathit{DOWN\_STEP}$$ [1]

else

$$\mathit{Offset\_SSperSS} = \mathit{Offset\_SSperSS}$$

Where,

UP_STEP The up adjustment step (dB)

DOWN_STEP The down adjustment step (dB)

The operating parameters UP_STEP, DOWN_STEP, Offset_Boundupper, Offset_Boundlower are signaled by a dedicated UCD message TLV.

3.2 Initial ranging and periodic ranging

Uplink ranging consists of two procedures: initial ranging and periodic ranging. Initial ranging (see 6.3.9.5) allows a SS joining the network to acquire correct transmission

[1] *Note that DOWN_STEP here replaces the original value to simplify the equation, maintaining the original methodology. The BS calculates DOWN_STEP based on* FER_{TARGET}.

parameters, such as time offset and Tx power level, so that the SS can communicate with the BS. Following initial ranging, periodic ranging allows the SS to adjust transmission parameters so that the SS can maintain uplink communications with the BS.

In OFDMA the initial ranging and periodic ranging process begins by sending initial-ranging CDMA codes in the UL allocation dedicated for that purpose. The power adjustment shall start from the initial value selected (PTX_IR_MAX) based on open loop power control calculation methodology addressed previously.

4 Detailed Text Changes

1. *[Delete text in section 8.4.10.3, from page 456 lines 5 to page 457 line 24]*

2. *[Insert the following subtitle before the paragraph immediately preceding equation eq. (138)]*

8.4.10.3.1 Closed loop power control

3. *[Modify text in section 8.4.10.3, from page 457 lines 25 to page 458 line 40]*

-------- BEGIN --------

[Insert a new sub-clause 8.4.10.3.~~1~~2:]

8.4.10.3.~~1~~2 Optional open loop power control

When the open loop power control is supported and the uplink power control mode is changed to open loop power control by ~~PCS~~PMC_RSP, the power per a subcarrier shall be maintained for the UL transmission as follows.

This open loop power control shall be applied for the all uplink bursts.

$$P = L + C/N + NI - 10\log 10(R) + Offset\_SS_{perSS} + Offset\_BS_{perSS} \quad (138a)$$

Where,

P	is the TX Power level (dBm) per a subcarrier for the current transmission, including MS Tx antenna gain.
L	is the estimated average current UL propagation loss, not including Tx/Rx antenna gains. ~~It includes Tx/Rx antenna gain, and path loss.~~
C/N	is the normalized C/N of the modulation/FEC rate for the current transmission, as appearing in Table ~~332~~ 334. Table ~~332~~ 334 can be modified by UCD (Normalized C/N override). ~~Additionally, the normalized C/N values for UL ACK region and QPSK 1/3 also can be obtained through UCD~~.
R	is the number of repetitions for the modulation/FEC rate.
NI	is the estimated average power level (dBm) of the noise and interference per a subcarrier at the BS, not including BS Rx antenna gain.
$Offset\_SS_{perSS}$	is the correction term for SS-specific power offset. It is controlled by SS. Its initial value is zero.
$Offset\_BS_{perSS}$	Is the correction term for SS-specific power offset. It is controlled by BS with power control messages.

The estimated average current UL propagation loss, L, shall be calculated based on the total power received on the active subcarriers of the frame preamble, and with reference to the BS_EIRP parameter sent by the BS.

The default normalized C/N values per modulation are given by Table 334. The operating parameters BS_EIRP and NI are signaled by a DCD message [Table 358—DCD channel encoding] .
Additionally, the BS controls the Offset_BSperSS using PMC_RSP message (6.3.2.3.58) to override the Offset_BSperSS value, or using Fast Power Control(FPC) message (6.3.2.3.34) and Power Control IE (8.4.5.4.5) to adjust the Offset_BSperSS value. The accumulated power control value shall be used for Offset_BSperSS.
The Offset_BSperSS can be updated using relative or fixed form (as a function of the relevant adjustment commands used). Fixed form is used when the parameter is obtained from a PMC_RSP message. In this case, the SS should replace the old Offset_BSperSS value by the new Offset_BSperSS sent by the BS. With all other messages mentioned in the previous paragraph, relative form is used. In this case, MS should increase and decrease the Offset_BSperSS according to the offset value sent by BS.

The actual power setting shall be quantized to the nearest implementable value, subject to the specification (8.4.12.1). For each transmission, the SS shall limit the power, as required to satisfy the spectral masks and EVM requirements.

Passive Uplink open loop power control

In passive Uplink open loop power control the SS will set Offset_SSperSS to zero and modify the TX power value only according to Offset_BSperSS

Active Uplink open loop power control

An alternative way is that the ~~A~~ SS may adjust *Offset_SSperSS* value within a range.

$$Offset\_Bound_{lower} \le Offset\_SS_{perSS} \le Offset\_Bound_{upper} \quad (138b)$$

where,

Offset_Boundupper is the upper bound of *Offset_SSperSS*
Offset_Boundlower is the lower bound of *Offset_SSperSS*

Or in case ARQ is enabled at some UL connections the *Offset_SSperSS* may be updated automatically based on the Ack/Nack ~~*of uplink burst*~~ within the range as specified by Equation (138b). The specific algorithm is described as follows (in dB)

if NAK is recieved Offset_SSperSS = Offset_SSperSS + UP_STEP

else if ACK is receivedOffset_SSperSS = Offset_SSperSS – DOWN_STEP ~~(1/ (1/ FER~~~~$_{TARGET}$~~*~~-1)) UP_STEP~~* (138c)

else where Offset_SSperSS = Offset_SSperSS

Where,
UP_STEP is the up adjustment step as specified by" SS-specific up power offset adjustment step" TLV
DOWN _STEP is the down adjustment step as specified by" SS-specific down power offset adjustment step" TLV
~~*FERTARGET is the target frame error rate*~~

The operating parameters *UP_STEP*, *DOWN _STEP* , ~~*FER*~~~~$_{TARGET}$~~~~,~~ *Offset_Boundupper*, *Offset_Boundlower* are signaled by a dedicated UCD message TLV. ~~*The default normalized C/N values per modulation are given by Table 332.*~~
~~*Additionally, BS may control the Offset_BSperSS using PCS_RSP message (6.3.2.3.58), Fast Power Control (FPC) message (6.3.2.3.34) and Power Control IE (8.4.5.4.5). The accumulated power control value shall be used for Offset_BSperSS*~~.

-------- END --------

4. *[Modify section 11.3.1, page 473 lines 34-40 as follows]*

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Name	Type (1 byte)	Length	Value (variable length)
MS-specific up power offset adjustment step	176	1	Unsigned in units of 0.01 dB
~~Target frame error rate of UL burst transmission~~ MS-specific down power offset adjustment step	177	1	~~Unsigned integer of -10*log(FERtarget)~~ Unsigned in units of 0.01 dB

-------- END --------

5. *[Modify section 8.4.5.3.19, page 255 lines 6-65 as follows]*

-------- BEGIN --------

Syntax	Size	Notes
UL interference and noise level_IE{		
Extended DIUC	4 bits	UL_NI = 0x0F
Length	4 bits	Length = 0x02~5
Bitmap	8 bits	LSB indicates the there exists "CQI/ACK~~/Ranging~~ region NI" field (1). Otherwise, it is '0' The 2nd LSB indicates the there exists "PUSC region NI" field (1). Otherwise, it is '0' The 3rd LSB indicates the there exists "Optional PUSC region NI" field (1). Otherwise, it is '0' The 4th LSB indicates the there exists "AMC region NI" field (1). Otherwise, it is '0' The 5th LSB indicates the there exists "AAS region NI" field (1). Otherwise, it is '0' The 6th LSB indicates the there exists "Periodic ranging region NI" field (1). Otherwise, it is '0'
if (LSB of Bitmap = 1) {		
CQI/ACK~~/Ranging~~ region NI	8 bits	Estimated average power level (dBm) per a subcarrier in CQI/ACK region.
}		
if (The 2nd LSB of ~~Bitmpa~~ Bitmap = 1) {		
PUSC region NI	8 bits	Estimated average power level (dBm) per a subcarrier in PUSC region.
}		
if (The 3rd LSB of Bitmap = 1) {		
Optional PUSC region NI	8 bits	Estimated average power level (dBm) per a subcarrier in optional PUSC region.
}		
if (The 4th LSB of Bitmap = 1) {		
AMC region NI	8 bits	Estimated average power level (dBm) per a subcarrier in AMC region.
}		
if (The 5th LSB of Bitmap = 1) {		
AAS region NI	8 bits	Estimated average power level (dBm) per a subcarrier in AAS region. The interference and noise level shall be estimated before the beam forming.
}		
if (The 6th LSB of Bitmap = 1) {		
Periodic ranging region NI	8 bits	Estimated average power level (dBm) per a subcarrier in Periodic ranging region. The interference and noise level shall be estimated before the beam forming.
}		
}		

-------- END --------

6. *[Modify section 11.3.1.1, page 474 lines 57-65 as follows]*

-------- BEGIN --------

Name	Type	Length	Value
~~Normalized C/N for UL ACK region and QPSK 1/3~~	~~153~~	~~1~~	~~This is a list of numbers, where each number is encoded by one nibble, and interpreted as a signed integer. The first LS nibble corresponds to the C/N difference of the UL ACK region comparing to the CDMA code in Table 332. The last nibble corresponds to the C/N difference of the QPSK 1/3 comparing to the CDMA code in table 332.~~

-------- END --------

7. *[Modify section 6.3.2.3.58, page 119 lines 5-61 as follows]*

-------- BEGIN --------

Syntax	Size	Notes
PMC_REQ message format{		
Management Message Type = 65	8 bits	Type = 65
Power control mode change	~~1~~ 2 bits	~~0~~0b00: Closed loop power control mode 0b01: Reserved 0b10: Open loop power control passive mode 0b11: Open loop power control active mode ~~1: Open loop power control mode~~
Start frame	~~7~~ 6 bits	~~7~~ 6 LSBs of frame number when the indicated power control mode is activated. When it is same with the current frame number, the mode change shall be applied from the current frame.
If (Power control mode change==0) {		
Power adjust	8 bits	Signed integer, which expresses the change in power level (in multiples of 0.25 dB) that the SS shall apply to its current transmission power. When subchannelization is employed, the subscriber shall interpret the power offset adjustment as a required change to the transmitted power density.
} else {		
Offset_BSperSS	8 bits	Signed integer, which expresses the change in power level (in multiples of 0.2 dB) that the SS shall apply to the power control formula in 8.4.10.3.~~1~~ 2.
}		
}		

CID shall be the basic CID of SS. SS shall generate the PMC_REQ message including the following parameters.

Power control mode change

~~0~~0b00: Closed loop power control mode
0b01: Reserved
0b10: Open loop power control passive mode
0b11: Open loop power control active mode
~~1: Open loop power control mode~~

Start frame

~~3~~6 LSBs of frame number when the indicated power control mode is activated. When it is same with the current frame number, the mode change shall be applied from the current frame.

Power adjust

Signed integer, which expresses the change in power level (in multiples of 0.25 dB) that the SS shall apply to its current transmission power. When subchannelization is employed, the subscriber shall interpret the power offset adjustment as a required change to the transmitted power density.

Offset_BSperSS

Signed integer, which expresses the change in power level (in multiples of 0.2 dB) that the SS shall apply to the open loop power control formula in 8.4.10.3.~~1~~ 2.

-------- END --------

8. ***[Modify field 'BS EIRP' in table 358, as follows]***

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Name	Type	Length	Value (variable length)	PHY scope
BS EIRP	2	2	BS equivalent isotropic radiated power. Signed units of 1dbm. For OFDMA PHY, this is measured on the active subcarriers of the frame preamble.	All

5 References

[1] IEEE P802.16-2004.

[2] IEEE P802.16e-D6.

[3] IEEE P802.16e-D5.