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| Re:            | Working Group Letter Ballot Recirc #28b, Technical Comments and Contributions regarding IEEE Project P802.16j; Draft Amendment P802.16j/D3.  |  |
| Abstract       | This contribution describes the Direct Signaling messages transmitted in the access channel of the AAS Relay Zone to accomplish ranging and bandwidth request and grant.   |  |
| Purpose        | This document provides the necessary access messaging to properly accomplish ranging and bandwidth request/grant within the AAS Relay Zone for Direct Signaling mode of operation.   |  |
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## Access Messages for Direct Signaling in the AAS Relay Zone

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This document describes the access messages required to support bandwidth request/grant, ranging, frequency, and power adjustment in Direct Signaling mode of operation within the AAS Relay Zone.

### Background

Direct Signaling operation within the relay zone provides a bandwidth request mechanism that can scale with an M-fold increase in the number of users afforded by multi-user beamforming.

Section 8.4.4.7.2.3 of Draft P802.16j/D3 describes the AAS Relay Zone access channel but does not detail the access messaging required for managing channel descriptor request, initial bandwidth request/grant, codeword assignment and range/frequency/power adjustment.

### Proposed Solution

The proposed solution is to describe the Uplink bandwidth request/grant mechanism and the required Direct Signaling Access Messages to accomplish it within the AAS Relay Zone.

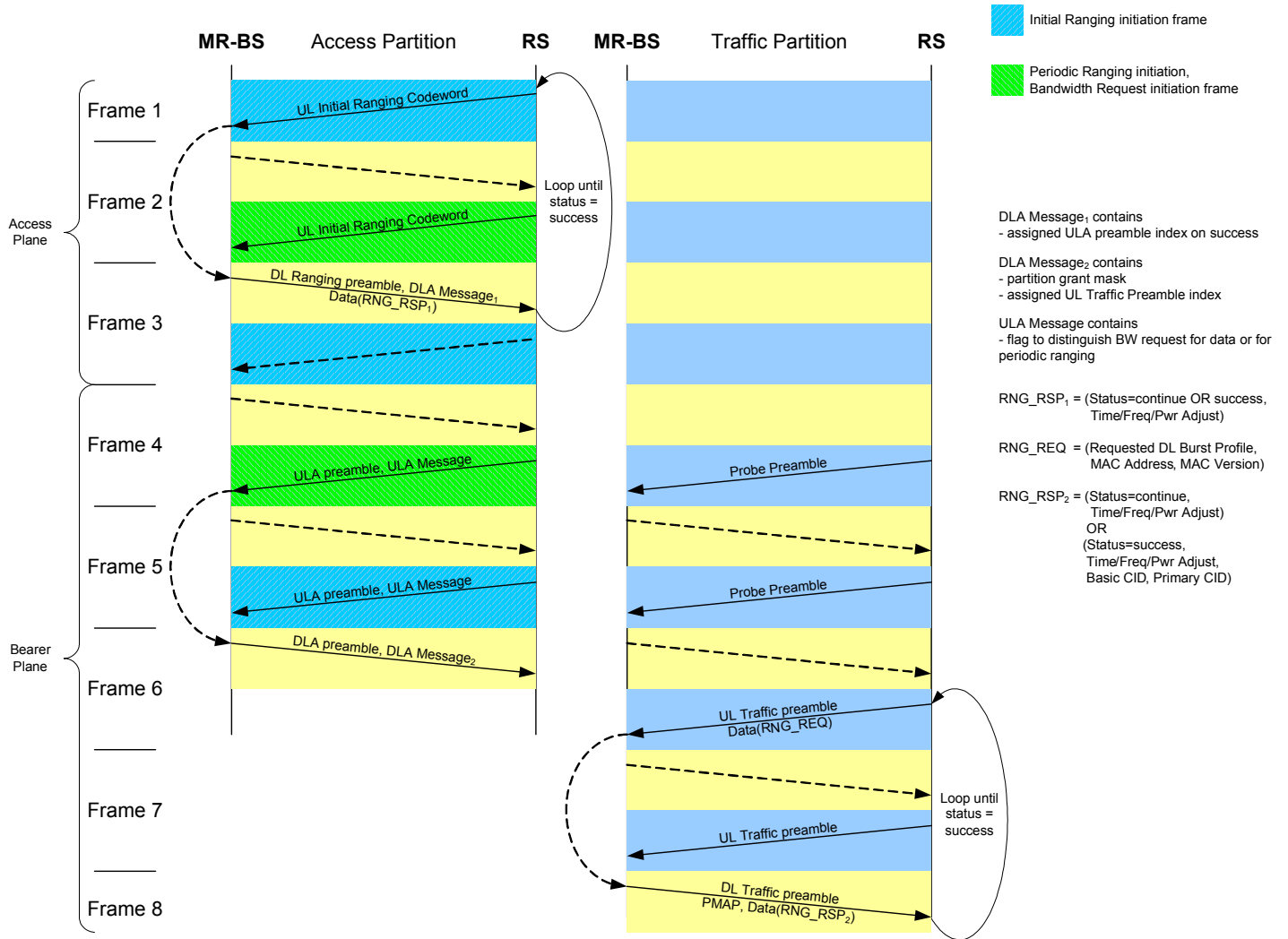
### Detailed Solution

#### Overview

The AAS-DS Private Map structure provides information for supporting bandwidth grant. AAS-DS Resource allocation utilizes the follow definitions:

- 1) Partition – a partition of frequency within the carrier channel. AAS-DS partitions utilize AMC slots and are therefore comprised of 1 or 2 bins as defined by the AMC subchannel permutation (1 bin x 6 symbols or 2 bins x 3 symbols). The partition is the smallest unit of allocation granularity within a burst for the AAS Relay Zone. Partitions are numbered with an index in ascending order based on frequency (starting with an index of 0). A partition allocation is a coupled resource allocation which is granted in both the DL subframe and UL subframe for each frame of allocation.
- 2) Burst – a burst is the unit resource allocation within the AAS zone. A burst is comprised of 1 to 8 partitions. The AAS zone can support 1 to 4 bursts per user. Bursts are defined to be HARQ enabled or disabled within the partition control structure described in the DL Access Message section.
- 3) Partition Control actions
  - a) Probe – a training preamble that allows the BS to unobtrusively determine interference characteristics between the probing users and current active users within a single partition of frequency.
  - b) Open – an allocation grant of the partition resource
  - c) Close – a de-allocation of the partition resource
  - d) Maintain – maintain the allocation of partition resource (used to maintain synchronization of partition resource allocation between the BS and RS since the partition controls are all delta state related.).

The initial ranging message sequence for an entering RS shows the migration from the Access partition utilizing the DLA for bandwidth grant and physical layer control to a traffic partition as part of a burst allocation where the PMAP is then used for bandwidth grant and physical layer control. The initial ranging message sequence for an RS entering the network in the AAS Relay zone is as follows:



### Uplink Access (ULA) Message

The ULA is sent from the RS to MR-BS and is used to:

- request bandwidth for ranging (via the ULA purpose) or for transport (via the ULA purpose, transport CID, and queue depth) as described in the AAS network entry procedure (within 8.4.4.7.2.3) or to
- request the compact or full channel descriptor (as described in 8.4.4.7.2.3.3) via the ULA purpose.

The following table defines the AAS\_ULA Message structure:

Table 1: Structure of AAS\_ULA()

| ULA Component             | Bits | Reps | Slot | Comment                              |
|---------------------------|------|------|------|--------------------------------------|
| AAS_ULA Message {         |      |      |      |                                      |
| CID                       | 16   | 1    |      | Transport CID                        |
| Partition Exploratory Map | 24   | 1    |      | Sized for 24 partitions (i.e 10 MHz) |
| Probe Codeword index      | 2    | 1    |      | Probe Codeword index                 |

|                |    |   |  |
|----------------|----|---|--|
| Queue Depth    | 2  | 1 | Sized for 4 levels   |
| ULA Purpose    | 4  | 1 | value<br>0=Transport BW Request<br>1=Ranging BW Request<br>2=Compact Chan Description Req<br>3=Full Chan Description Req |
| Reserve        | 40 | 1 | Reserved for Future use  |
| CRC            | 8  | 1 | CRC-8  |
| }              |    |   |  |
| Total ULA Bits | 96 | 2 |  |

- 1) **CID** - Transport CID for which a bandwidth request is being made
- 2) **PEM** - Partition Exploratory Map. Partitions are the unit of resource allocation in AAS Direct Signaling mode. They are logical groupings of one or more subchannels based on the AMC subchannel permutation construction (either 2x3 or 1x6 as described in 8.4.4.7.2.3). The PEM describes the partitions for which the UL Probe training was transmitted. One bit per partition - sized for 24 partitions (i.e 10 MHz)
- 3) **Probe Codeword Index** – Identifies an UL training preamble (as described in 8.4.4.7.2.3) transmitted in a traffic partition in order for the BS to determine link quality and interference characteristics.
- 4) **Qdepth** – Encode for an aggregate Qdepth level of the transport CID that is requesting an initial bandwidth allocation. One of four pre-configured levels can be described.
- 5) **ULA Purpose**
- 6) The purpose for which the asynchronous access is being requested, including:
  - i) 0x0 = Transport Bandwidth Request
  - ii) 0x1 = Ranging Bandwidth Request
  - iii) 0x2 = Compact Channel Description Request as described in section 8.4.4.7.2.3.3
  - iv) 0x3 = Full Channel Description Request as described in section 8.4.4.7.2.3.3
- 7) **CRC** - CRC-8 covers both slots

### Downlink Access (DLA) Message

The DLA is sent from the MR-BS to the RS and provides code word assignments (as defined by section 8.4.4.7.2.3.1), bandwidth grant, supportable MCS for UL/DL, and range time/frequency/power adjustment during the AAS network entry and subsequent allocations procedure defined in section 8.4.4.7.2.3. Link adjustments (time/frequency/power) are provided in the DLA message to support more accurate transmission of subsequent messages in the access channel or beamforming of subsequent messages in the allocated traffic partitions.

The following table defines the AAS\_DLA Message structure:

Table 2: Structure of AAS\_DLA()

| DLA Component     | Bits | Reps | Slot | Comment                                     |
|-------------------|------|------|------|---|
| AAS_DLA Message { |      |      |      |   |
| PB_Ctl_0          | 7    | 1    |      | Partition/Burst control described in Table2 |
| PB_Ctl_1          | 7    | 1    |      | Partition/Burst control described in Table2 |
| PB_Ctl_2          | 7    | 1    |      | Partition/Burst control described in Table2 |
| DIUC              | 3    | 1    |      | DL MCS level                                |
| PB_Ctl_3          | 7    | 1    |      | Partition/Burst control described in Table2 |
| PB_Ctl_4          | 7    | 1    |      | Partition/Burst control described in Table2 |
| PB_Ctl_5          | 7    | 1    |      | Partition/Burst control described in Table2 |

|                         |    |   |                                   |
|-------------------------|----|---|-----------------------------------|
| Codeword Type           | 1  | 1 | 0=access, 1=transport             |
| UIUC Offset             | 2  | 1 | UL MCS offset from the DIUC index |
| Reserved                | 6  | 1 |                                   |
| UL Range Adjust         | 2  | 1 |                                   |
| UL Frequency Adjust     | 2  | 1 |                                   |
| UL Access PwrCtrl       | 2  | 1 | 2 bits/partition                  |
| UL PwrCtl               | 12 | 1 | 2 bits/partition                  |
| Assigned Codeword Index | 16 | 1 |                                   |
| CRC                     | 8  | 1 |                                   |
| }                       |    |   |                                   |
| Total DLA Bits          | 96 | 2 |                                   |

- 1) **PB\_Ctl\_x** (7 bit encode) – This structure describes a control action related to the state of an allocation. Probe, open, maintain mean to initiate or continue the codeword (preamble) training sequence on the allocated partition. Close means the resource is no longer allocated.. The other attributes of the partition/burst are contained in the FLP (DLA) Message or Private Map (PMAP) which contains this control structure. The partition/burst control encode is described in Table 3 below

Table 3: Partition/Burst Control encode

| 5 bit Value | 2 bit encode Value    | Description  |
|-------------|-----------------------|--|
| 0-23        | 0-3 (burst index)     | Probe, Open or Maintain (p,o,m) the partition indexed by the 5 bit value in the burst indexed by the 2 bit encode value. |
| 24          | 0-3 (partition index) | Close Partition in the 4 partition range 0-3 indexed by the 2 bit encode value   |
| 25          | 0-3 (partition index) | Close Partition in the 4 partition range 4-7 indexed by the 2 bit encode value   |
| 26          | 0-3 (partition index) | Close Partition in the 4 partition range 8-11 indexed by the 2 bit encode value  |
| 27          | 0-3 (partition index) | Close Partition in the 4 partition range 12-15 indexed by the 2 bit encode value   |
| 28          | 0-3 (partition index) | Close Partition in the 4 partition range 16-19 indexed by the 2 bit encode value   |
| 29          | 0-3 (partition index) | Close Partition in the 4 partition range 20-23 indexed by the 2 bit encode value   |
| 30          | 0-3 (burst index)     | Close all partitions in burst using 2 bit encode as burst number   |
| 31          | 0-3                   | 0: Fast power control for MCS increase (affects all partitions in current burst)<br>1-3: <i>Reserved</i>                 |

- 2) **DIUC** (3 bit encode) – DL MCS, one of eight defined MCS levels
- 3) **Codeword Type** - Describes the codeword type that is being assigned (0 = Access codeword 1=Transport codeword). (as defined in section 8.4.4.7.2.3.1).
- 4) **UIUC Offset** (2 bit encode) – UL Differential MCS equals the number of MCS levels below the DL MCS
- 5) **UL Time (Range) Adjust** (2 bit encode) - A step size of  $d_t = 0.714$  us is proposed. 0.714 us corresponds to 4 samples at a 5.6 MHz sample rate. Four samples corresponds to a “PS”. The range adjustment encode is described in Table 4 below:

Table 4: UL Range (Time) Adjustment Encoding

| Encoded bits | Time Delay @ BS          | RS UL Adjustment |
|--------------|--------------------------|------------------|
| 00           | $t_e < -\delta_t$        | Delay            |
| 01           | $-\delta_t \leq t_e < 0$ | Delay            |
| 10           | $0 \leq t_e < \delta_t$  | Advance          |

|    |                     |         |
|----|---------------------|---------|
| 11 | $\delta_i \leq t_e$ | Advance |
|----|---------------------|---------|

6) **UL Frequency Adjust** (2 bit encode) – The frequency adjustment encode is described in Table 5 below:

Table 5: UL Frequency Adjustment Encoding

| Encoded bits | Frequency Error @ BS | RS UL Adjustment   |
|--------------|----------------------|--------------------|
| 00           | $f_e < -d_f$         | Increase frequency |
| 01           | $-d_f \leq f_e < 0$  | Increase frequency |
| 10           | $0 \leq f_e < d_f$   | Decrease frequency |
| 11           | $d_f \leq f_e$       | decrease frequency |

7) **UL Power Adjust (Traffic Ps)** (2 bit encode/partition) – 4 levels of adjustment per partition

8) **UL Power Adjust (Access P)** (2 bit encode) – 4 levels of adjustment

9) **Assigned Codeword Index** - Assigned codeword (may be ULA or ULT) as defined by codeword construction in section 8.4.4.7.2.3.1.

## Downlink Initiation (DLI) Signaling

### BS Initiated Traffic and Paging

The base station can initiate traffic or page the RS using the DLI mechanism. The DLI is a unique code provided to the RS registered with the base station. RS continuously search for the DLI using a correlation process using the assigned code as the paradigm. One DLI allocation is included in the MAP in the last slot of symbols 2 and 3. The DLI(i) is the paging mechanism informing the  $i^{\text{th}}$  user to respond on both the access partition and available traffic partitions. DLIs start BS initiated traffic. 200 DLIs per second are available. RS(i) responds to the DLI on the access and traffic partitions with an ULA training sequence and an ULA.

### DLI Codeword Transmission

The Map is constructed to fit into 15 PUSC slots available in symbols 2 and 3. 4 slots are dedicated to the FCH, either 8 or 10 slots are reserved for the Map, and 0 or 2 slots are allocated for broadcast messages such as the DCD/UCD message or the Neighbor Advertisement message. The remaining slot is allocated to the Downlink Initiation (DLI) paging signal.

There are 48 sub-carriers allocated to the DLI. The 48 sub-carriers are split into two groups of 24. If the 48 were numbered sequentially, the first group would be the even sub-carriers and the second group would be the odd subcarriers.. Each group contains a column of a  $24 \times 24$  Hadamard matrix and is BPSK modulated. BPSK has two values. Two values times 24 different columns is 48 total combinations per group. 48 combinations in the first group times 48 combinations in the second group is 2304 total. The BS can ring up 2304 RS per 5 MHz channel.

The signal processing for the transmitter is shown in Figure 1.  $b$  represents the DLI codeword and ranges from 0 to 2303. It is then broken down into two groups of 24.  $i_0$  selects one of 24 Hadamard columns for the first group and ranges from 0 to 23.  $k_0$  selects the BPSK modulation for the first group.  $i_1$  selects one of 24 Hadamard columns for the second group.  $k_1$  selects the BPSK modulation for the second group. The Hadamard matrix is based on the Matlab function:  $\mathbf{H} = \text{hadamard}(24)$ . The first group of 24 sub-carriers is multiplexed with the second group of 24 sub-carriers. If the indices to the sub-carriers of a slot were numbered from 0 to 47,

the even numbered sub-carriers come from the first group of 24 and the odd number sub-carriers come from the second group of 24. The first sub-carrier of the slot is  $H(0, i_0) k_0$ , the second, is  $H(0, i_1) k_1$ , the third is  $H(1, i_0) k_0$ , the fourth is  $H(1, i_1) k_1$ , etc., where zero-based indexing is assumed when accessing the Hadamard matrix,  $H(n, i)$ .

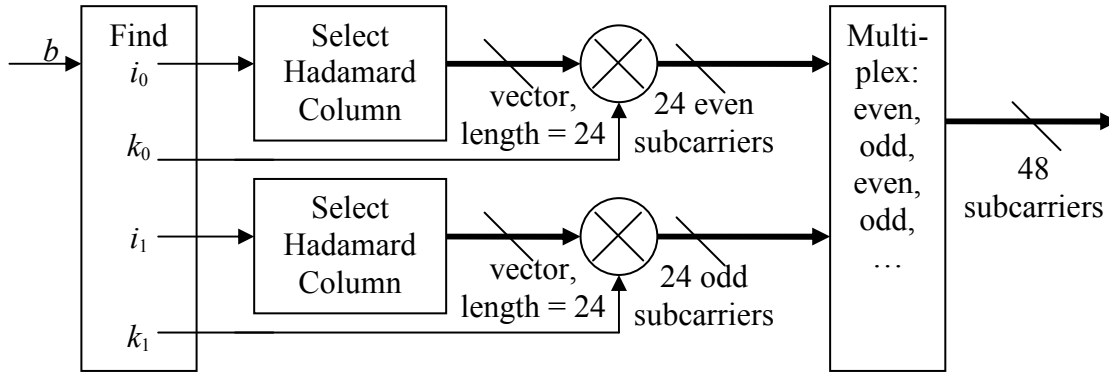


Figure 1. Transmitter Signal Processing

$$g_0 = \lfloor b \div 48 \rfloor \tag{1}$$

$$g_1 = b - 48g_0 \tag{2}$$

$$k_0 = \begin{cases} -1 & \text{if } g_0 < 24 \\ +1 & \text{otherwise} \end{cases} \tag{3}$$

$$k_1 = \begin{cases} -1 & \text{if } g_1 < 24 \\ +1 & \text{otherwise} \end{cases} \tag{4}$$

$$i_0 = g_0 - 12(1 + k_0) \tag{5}$$

$$i_1 = g_1 - 12(1 + k_1) \tag{6}$$

## Proposed Text Changes

*Insert new subclause 8.4.4.7.2.3.4:*

### 8.4.4.7.2.3.4 AAS Relay Zone Access Channel Messaging

*Insert new subclause 8.4.4.7.2.3.4.1:*

#### 8.4.4.7.2.3.4.1 Uplink Access (ULA) Message

The ULA is sent from the RS to MR-BS and is used to

- request bandwidth for ranging (via the ULA purpose) or for transport (via the ULA purpose, transport CID, and queue depth) as described in the AAS network entry procedure (within 8.4.4.7.2.3) or to
- request the compact or full channel descriptor (as described in 8.4.4.7.2.3.3) via the ULA purpose.

The following table defines the AAS\_ULA Message structure:

*Insert Table 270a (.16e)/Table 386a (Rev2) as indicated:*

Table xxx—Structure of AAS\_ULA()

| Syntax | Size | Notes |
|--------|------|-------|
|--------|------|-------|

|                             |         |  |
|-----------------------------|---------|--|
| AAS_UL(A) {                 |         |  |
| <b>CID</b>                  | 16 bits | Transport CID  |
| <b>PEM</b>                  | 24 bits | Partition Exploratory Map  |
| <b>Probe Codeword Index</b> | 2 bits  | Partition Probe codeword   |
| <b>Qdepth</b>               | 2 bits  | Qdepth level<br>0b00 = level1<br>0b01 = level2<br>0b10 = level3<br>0b11 = level4   |
| <b>ULA Purpose</b>          | 4 bits  | 0x0 = Transport Bandwidth Request<br>0x1 = Ranging Bandwidth Request<br>0x2 = Compact Channel Description Request<br>0x3 = Full Channel Description Request<br>0x4-0xF = <i>Reserved</i> |
| <i>Reserved</i>             | 40 bits | Shall be set to zero   |
| <b>CRC</b>                  | 8 bits  | CRC-8  |
| }                           |         |  |

*Insert the following parameter descriptions following Table 270a (.16e)/Table 386a (Rev2) as indicated:*

#### **CID**

Transport CID for which a bandwidth request is being made

#### **PEM**

Partition Exploratory Map. Partitions are the unit of resource allocation in AAS Direct Signaling mode. They are logical groupings of one or more subchannels based on the AMC subchannel permutation construction (either 2x3 or 1x6 as described in 8.4.4.7.2.3).

The PEM describes the partitions for which the UL Probe training was transmitted. One bit per partition - sized for 24 partitions (i.e. 10 MHz)

#### **Partition Probe Codeword Index**

Identifies an UL training preamble (as described in 8.4.4.7.2.3) transmitted in a traffic partition in order for the BS to determine link quality and interference characteristics.

#### **Qdepth**

Encode for an aggregate Qdepth level of the transport CID that is requesting an initial bandwidth allocation. One of four pre-configured levels can be described.

#### **ULA Purpose**

The purpose for which the asynchronous access is being requested, including:

0x0 = Transport Bandwidth Request

0x1 = Ranging Bandwidth Request

0x2 = Compact Channel Description Request as described in section 8.4.4.7.2.3.3

0x3 = Full Channel Description Request as described in section 8.4.4.7.2.3.3

#### **CRC**

CRC-8 covers both slots

*Insert new subclause 8.4.4.7.2.3.4.2:*

#### **8.4.4.7.2.3.4.2 Downlink Access (DLA) Message**

The DLA is sent from the MR-BS to the RS and provides code word assignments (as defined by section 8.4.4.7.2.3.1), bandwidth grant, supportable MCS for UL/DL, and range time/frequency/power adjustment during the AAS network entry and subsequent allocations procedure defined in section 8.4.4.7.2.3. Link adjustments (time/frequency/power) are provided in the DLA message to support more accurate transmission of subsequent messages in the access channel or beamforming of subsequent messages in the allocated traffic partitions.

The following table defines the AAS\_DLA Message structure:

*Insert Table 270b (.16e)/Table 386b (Rev2) as indicated:*



**Table xxx—Structure of AAS\_DLA()**

| Syntax                           | Size    | Notes  |
|----------------------------------|---------|--|
| AAS_DLA() {                      |         |  |
| <b>PB_Ctl_0</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>PB_Ctl_1</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>PB_Ctl_2</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>DIUC</b>                      | 3 bits  | DL MCS   |
| <b>PB_Ctl_3</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>PB_Ctl_4</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>PB_Ctl_5</b>                  | 7 bits  | partition control structures as described in Table xxx |
| <b>Codeword Type</b>             | 1 bit   | 0 = Access codeword 1=Transport codeword               |
| <b>UIUC offset</b>               | 2 bits  | UL MCS differential offset from the DIUC index         |
| <i>Reserved</i>                  | 6 bits  | Shall be set to zero                                   |
| <b>UL Range Adjust</b>           | 2 bits  | Encoded step adjustments                               |
| <b>UL Frequency Adjust</b>       | 2 bits  | Encoded step adjustments                               |
| <b>UL Access Power Adjust</b>    | 2 bits  | Encoded step adjustments                               |
| <b>UL Partition Power Adjust</b> | 12 bits | 2 bits encoded adjustment per described partition      |
| <b>Assigned Codeword Index</b>   | 16 bits |  |
| <b>CRC</b>                       | 8 bits  | CRC-8  |
| }                                |         |  |

Insert the following parameter descriptions following Table 270b (.16e)/Table 386b (Rev2) as indicated:

**PB\_Ctl\_x**

This structure describes a control action related to the state of an allocation. Probe, open, maintain mean to initiate or continue the codeword (preamble) training sequence on the allocated partition. Close means the resource is no longer allocated.. The other attributes of the partition/burst are contained in the Downlink Access (DLA) Message or Private Map (PMAP) which contains this control structure. The partition/burst control encode is described in the Table 3below:

**Table xxx - Partition/Burst Control encode**

| 5 bit Value | 2 bit encode Value    | Description  |
|-------------|-----------------------|--|
| 0-23        | 0-3 (burst index)     | Probe, Open or Maintain (p,o,m) the partition indexed by the 5 bit value in the burst indexed by the 2 bit encode value. |
| 24          | 0-3 (partition index) | Close Partition in the 4 partition range 0-3 indexed by the 2 bit encode value   |
| 25          | 0-3 (partition index) | Close Partition in the 4 partition range 4-7 indexed by the 2 bit encode value   |
| 26          | 0-3 (partition index) | Close Partition in the 4 partition range 8-11 indexed by the 2 bit encode value  |
| 27          | 0-3 (partition index) | Close Partition in the 4 partition range 12-15 indexed by the 2 bit encode value   |
| 28          | 0-3 (partition index) | Close Partition in the 4 partition range 16-19 indexed by the 2 bit encode value   |
| 29          | 0-3 (partition index) | Close Partition in the 4 partition range 20-23 indexed by the 2 bit encode value   |
| 30          | 0-3 (burst index)     | Close all partitions in burst using 2 bit encode as burst number   |
| 31          | 0-3                   | 0: Fast power control for MCS increase (affects all partitions in current burst)<br>1-3: <i>Reserved</i>                 |

**DIUC**

DIUC

**Codeword Type**

Describes the codeword type that is being assigned(0 = Access codeword 1=Transport codeword). (as defined in section 8.4.4.7.2.3.1).

**UIUC Offset**

Offset from the DIUC

**UL Range Adjust**

Range Adjustment encode. A step size of  $d_t = 0.714$  us is proposed. 0.714 us corresponds to 4 samples at a 5.6 MHz sample rate. Four samples corresponds to a "PS". The range adjustment encode is described in the table below:

**Table xxx - UL Range (Time) Adjustment Encoding**

| Encoded bits | Time Delay @ BS          | RS UL Adjustment |
|--------------|--------------------------|------------------|
| 00           | $t_e < -\delta_t$        | Delay            |
| 01           | $-\delta_t \leq t_e < 0$ | Delay            |
| 10           | $0 \leq t_e < \delta_t$  | Advance          |
| 11           | $\delta_t \leq t_e$      | Advance          |

**UL Frequency Adjust**

Frequency Adjustment encode described via the following table:

**Table xxx - UL Frequency Adjustment Encoding**

| Encoded bits | Frequency Error @ BS | RS UL Adjustment   |
|--------------|----------------------|--------------------|
| 00           | $f_e < -d_f$         | Increase frequency |
| 01           | $-d_f \leq f_e < 0$  | Increase frequency |
| 10           | $0 \leq f_e < d_f$   | Decrease frequency |
| 11           | $d_f \leq f_e$       | decrease frequency |

**UL Access Power Adjust**

Power adjustment for the access channel

**UL Partition Power Adjust**

Power adjustment for bearer partitions (2 bit encode per partition described in partition control structures)

**Assigned Codeword Index**

Assigned codeword (may be ULA or ULT) as defined by codeword construction in section 8.4.4.7.2.3.1.

**CRC**

CRC-8 covers both slots

***Insert new subclause 8.4.4.7.2.3.5:*****8.4.4.7.2.3.5 AAS Relay Zone Downlink Initiation (DLI) Signaling*****Insert new subclause 8.4.4.7.2.3.5.1:*****8.4.4.7.2.3.5.1 BS Initiated Traffic and Paging**

The base station can initiate traffic or page the RS using the DLI mechanism. The DLI is a unique code provided to the RS registered with the base station. RS continuously search for the DLI using a correlation process using the assigned code as the paradigm. One DLI allocation is included in the MAP in the last slot of symbols 2 and 3. The DLI(i) is the paging mechanism informing the  $i^{\text{th}}$  user to respond on both the access partition and available traffic partitions. DLIs start BS initiated traffic. 200 DLIs per second are available. RS(i) responds to the DLI on the access and traffic partitions with an ULA training sequence and an ULA.

***Insert new subclause 8.4.4.7.2.3.5.2:*****8.4.4.7.2.3.5.2 DLI Codeword Transmission**

The Map is constructed to fit into 15 PUSC slots available in symbols 2 and 3. 4 slots are dedicated to the FCH, either 8 or 10 slots are reserved for the Map, and 0 or 2 slots are allocated for broadcast messages such as the DCD/UCD message or the Neighbor Advertisement message. The remaining slot is allocated to the Downlink Initiation (DLI) paging signal.

There are 48 sub-carriers allocated to the DLI. The 48 sub-carriers are split into two groups of 24. If the 48 were numbered sequentially, the first group would be the even sub-carriers and the second group would be the odd subcarriers.. Each group contains a column of a  $24 \times 24$  Hadamard matrix and is BPSK modulated. BPSK has two values. Two values times 24 different columns is 48 total combinations per group. 48 combinations in the first group times 48 combinations in the second group is 2304 total. The BS can ring up 2304 RS per 5 MHz channel.

The signal processing for the transmitter is shown in Figure 1.  $b$  represents the DLI codeword and ranges from 0 to 2303. It is then broken down into two groups of 24.  $i_0$  selects one of 24 Hadamard columns for the first group and ranges from 0 to 23.  $k_0$  selects the BPSK modulation for the first group.  $i_1$  selects one of 24 Hadamard columns for the second group.  $k_1$  selects the BPSK modulation for the second group. The Hadamard matrix is based on the Matlab function:  $\mathbf{H} = \text{hadamard}(24)$ . The first group of 24 sub-carriers is multiplexed with the second group of 24 sub-carriers. If the indices to the sub-carriers of a slot were numbered from 0 to 47, the even numbered sub-carriers come from the first group of 24 and the odd number sub-carriers come from the second group of 24. The first sub-carrier of the slot is  $H(0, i_0) k_0$ , the second, is  $H(0, i_1) k_1$ , the third is  $H(1, i_0) k_0$ , the fourth is  $H(1, i_1) k_1$ , etc., where zero-based indexing is assumed when accessing the Hadamard matrix,  $H(n, i)$ .

Insert Figure xxxa (.16e)/Figure xxxa (Rev2) as indicated:

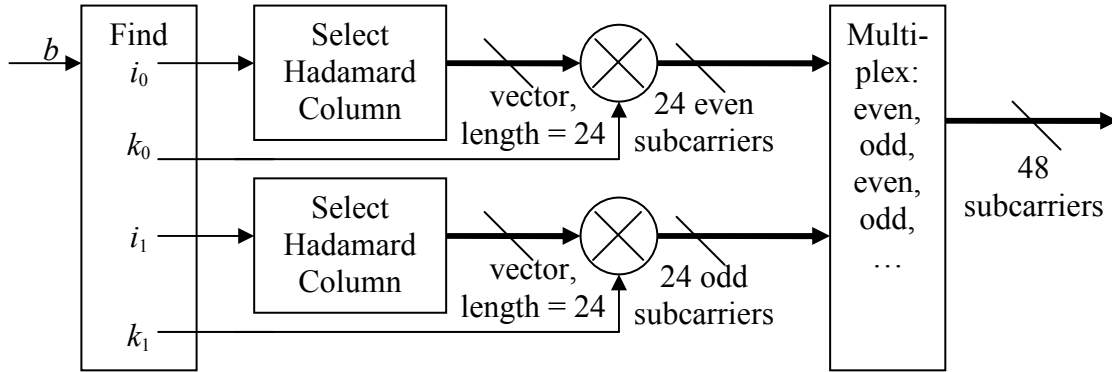


Figure 2. Transmitter Signal Processing

$$g_0 = \lfloor b \div 48 \rfloor \quad (1)$$

$$g_1 = b - 48g_0 \quad (2)$$

$$k_0 = \begin{cases} -1 & \text{if } g_0 < 24 \\ +1 & \text{otherwise} \end{cases} \quad (3)$$

$$k_1 = \begin{cases} -1 & \text{if } g_1 < 24 \\ +1 & \text{otherwise} \end{cases} \quad (4)$$

$$i_0 = g_0 - 12(1 + k_0) \quad (5)$$

$$i_1 = g_1 - 12(1 + k_1) \quad (6)$$