Agenda item:	
Source:	Nokia, Motorola, Texas Instruments
Title:	Text proposals for closed loop modes 1 and 2
Document for:	Discussion and approval

Summary:

At TSG RAN WG1 #7, Ad hoc 6 agreed on the selection of 2 FB modes for FDD mode for Release 99. This document contains detailed text proposals for 25.214 in line with this decision.

The following modification is proposed to TS 25.211 v2.2.1:

---Start text proposal---

5.3.2.2 Dedicated channel pilots with feedback mode transmit diversity

~~For certain sub-modes of feedback mode transmit diversity, orthogonal pilot sequences can be applied between the diversity antennas (see Figure 15 a, where the different shading indicates different pilot patterns). This assists in some types of antenna verification. Pilot symbol patterns are defined in Table 10 and Table 12. Otherwise, the pilot symbol patterns from both of the antennas are the same (see Figure 15 b).~~ In feedback mode 1 orthogonal pilot patterns are used between the transmit antennas. Pilot patterns defined in the Table 10 will be used on the non-diversity antenna and pilot patterns defined in the Table 12 on the diversity antenna. This is illustrated in the Figure 1a which indicates the difference in the pilot patterns with different shading.

In feedback mode 2 same pilot pattern is used on both of the antennas (see Figure 1b). The pattern to be used is according to the Table 10.

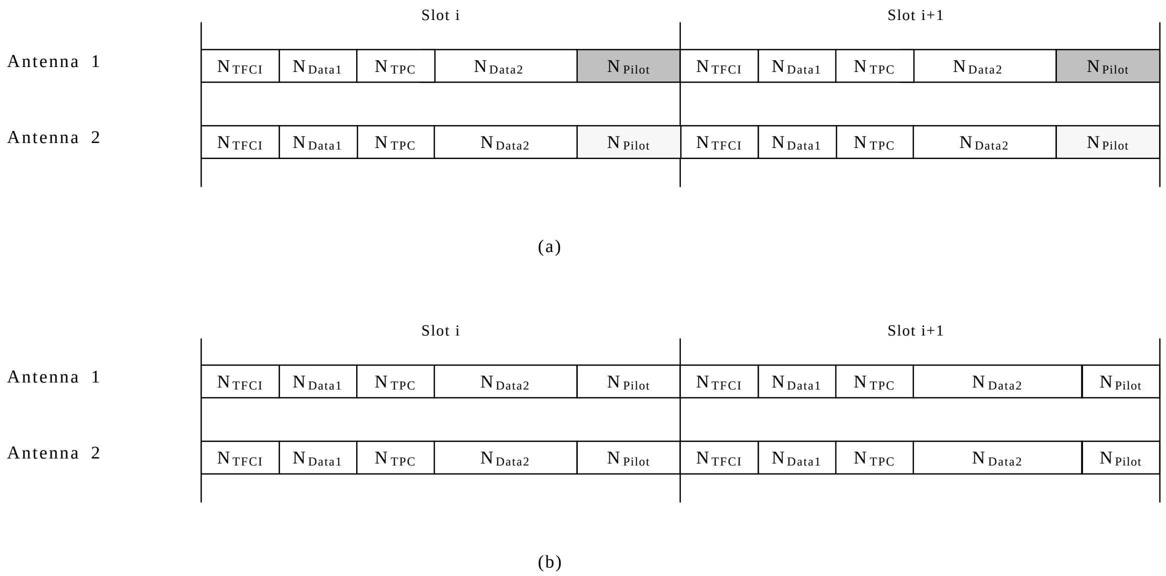

Figure 111~~15~~: Slot structures for downlink dedicated physical channel diversity transmission. Structure (a) ~~may be used in conjunction with antenna verification~~ is used in feedback mode 1. Structure (b) is used ~~otherwise~~ in feedback mode 2. Different shading of the pilots indicate orthogonality of the patterns.

---End text proposal---

The whole chapter 8 of TS 25.214 v1.1.2 is proposed to be replaced with the following:

--Start text proposal--

8 Feedback mode transmit diversity

The general transmitter structure to support Feedback (FB) mode transmit diversity for DPCH transmission is shown in Figure 2. Channel coding, interleaving and spreading are done as in non-diversity mode. The spread complex valued signal is fed to both TX antenna branches, and weighted with antenna specific weight factors w_1 and w_2. The weight factors are complex valued signals (i.e., $w_i = a_i + jb_i$), in general.

The weight factors (actually the corresponding phase adjustments) are determined by the UE, and signaled to the UTRAN access point (=cell transceiver) using the D-bits of the FBI field of uplink DPCCH.

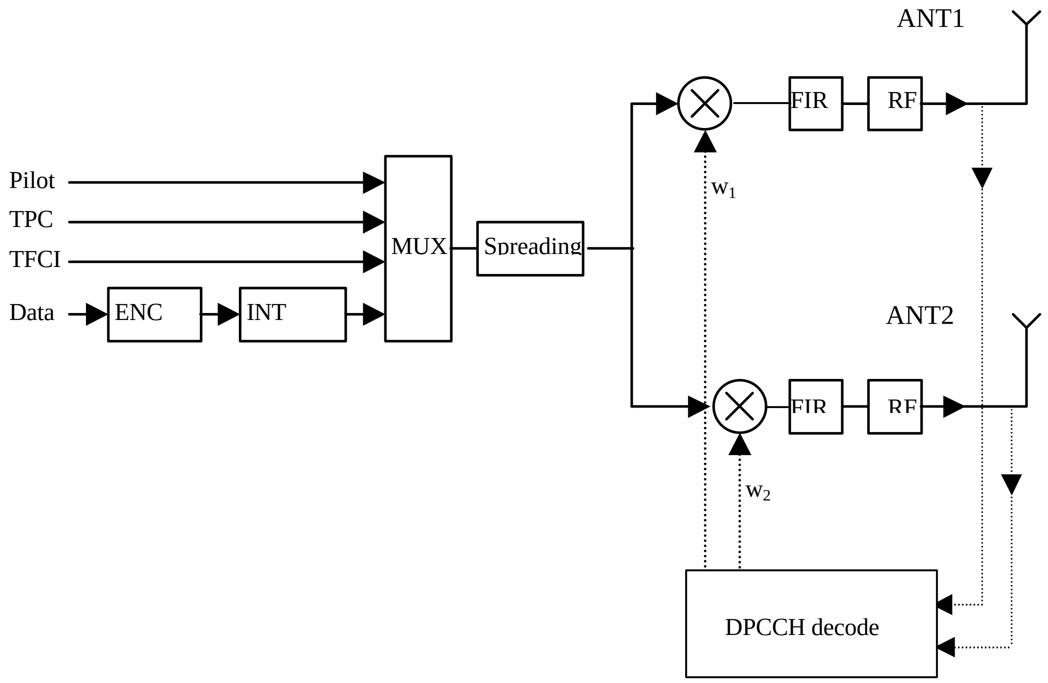

Figure 2. The generic downlink transmitter structure to support FB Mode Transmit Diversity for DPCH transmission (UTRAN Access Point)

There are twofeedback modes whose characteristics are summarized in the Table 1. The use of the modes is controlled by the UTRAN access point.

Table1. Summary of number of feedback information bits per slot, N_{FBD}, feedback command length in slots, N_W, feedback command rate, feedback bit rate, number of phase bits, N_{ph}, per signaling word and amount of constellation rotation at UE for the two feedback modes.

FB mode	N_{FBD}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}	Constellation rotation
1	1	1	1500 Hz	1500 bps	0	1	$\pi/2$
2	1	4	1500 Hz	1500 bps	1	3	N/A

8.1 Determination of feedback information

The UE uses the Common PIlot CHannel (CPICH) to separately estimate the channels seen from each antenna.

Once every slot, the UE computes the phase adjustment, f, and for mode 2 the amplitude adjustment that should be applied at the UTRAN access point to maximize the UE received power. In a generic sense for the non-soft handover case, UE solves for weight vector, $\underline{w}$, that maximizes

$$P=\underline{w}^H H^H H \underline{w} \qquad (1)$$

where

$$H=[\underline{h}_1 \;\; \underline{h}_2 \ldots]$$

and where the column vector $\underline{h}_i$ represents the estimated channel impulse response for the i'th transmission antenna, of length equal to the length of the channel impulse response. The elements of w correspond to the phase and amplitude adjustments computed by the UE.

During soft handover or SSDT power control, the antenna weight vector, $\underline{w}$ is determined so as to maximize the criteria function,

$$P=\underline{w}^H (H_1^H H_1 + H_2^H H_2 + \cdots)\underline{w} \qquad (2)$$

where H_i is an estimated channel impulse response for BS#i. In regular SHO, the set of BS#i corresponds to the active set. With SSDT, the set of BS#i corresponds to the primary base station(s).

The UE feeds back to the UTRAN access point the information on which phase/power settings to use. Feedback Signaling Message (FSM) bits are transmitted in the portion of FBI field of uplink DPCCH slot(s) assigned to FB Mode Transmit Diversity, the FBI D field (see 25.211). Each message is of length $N_W = N_{po}+N_{ph}$ bits and its format is shown in the Figure 3~~Figure 3Figure 3~~. The transmission order of bits is from MSB to LSB, i.e. MSB is transmitted first. FSM_{po} and FSM_{ph} subfields are used to transmit the power and phase settings, respectively.

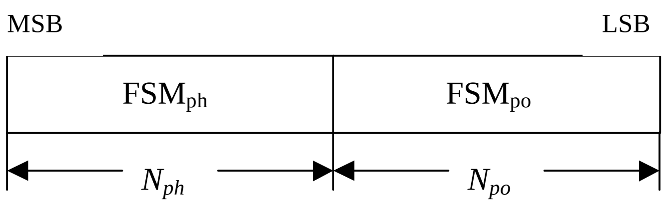

Figure 3. Format of feedback signaling message. FSM_{po} transmits the power setting and FSM_{ph} the phase setting.

The adjustments are made by the UTRAN Access Point at the beginning of the downlink DPCCH pilot field.

8.2 Feedback mode 1

In FB mode 1 UE first rotates the CPICH signal received from non-diversity antenna by $N\frac{p}{2} \bmod p$. Next the UE calculates the phase adjustment as described in 8.1 and quantizes it into two values, 0, and π. If value is 0, a command '0' is send to Node B using the FSM_{ph} field. Correspondingly, if value is π, command '1' is send to Node B using thr FSM_{ph} field.

Due to rotation of the constellation at UE the Node B interprets the received commands according to Table 1 which shows the mapping between phase difference, f_i, and received feedback command for each UL slot. Note that no rotation is used (i.e. N=0) when calculating the value of feedback command for first slot of the UL frame.

Table 1. Feedback commands and corresponding phase differences, f, for the slots of the UL radio frame.

FB command	f														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	0	90	0	90	0	90	0	90	0	90	0	90	0	90	0
1	180	-90	180	-90	180	-90	180	-90	180	-90	180	-90	180	-90	180

The received phases are filtered by averaging over 2 slots. Conceptually, the filter must be implemented as shown in the Figure 444. There are two memory cells, one for each possible FB command. Whenever a new command is received, the value of the corresponding memory cell is updated accordingly. After each update a new average is calculated. Algorithmically, the average is calculated as follows:

$$C = \frac{\sum_{i=0}^{1} \sin(f_i)}{2} + j\frac{\sum_{i=0}^{1} \cos(f_i)}{2} \tag{2}$$

where,

$$\begin{aligned} f_0 &\in \{0,180\} \\ f_1 &\in \{90,-90\} \end{aligned} \tag{3}$$

The filtered phase difference between antennas, f_{Tx} , is then calculated from C. The weight vector, *w*, is:

$$w = \begin{bmatrix} w_1 \\ w_2 \end{bmatrix} = \begin{bmatrix} 1 \\ \cos f_{Tx} + j \sin f_{Tx} \end{bmatrix} \tag{4}$$

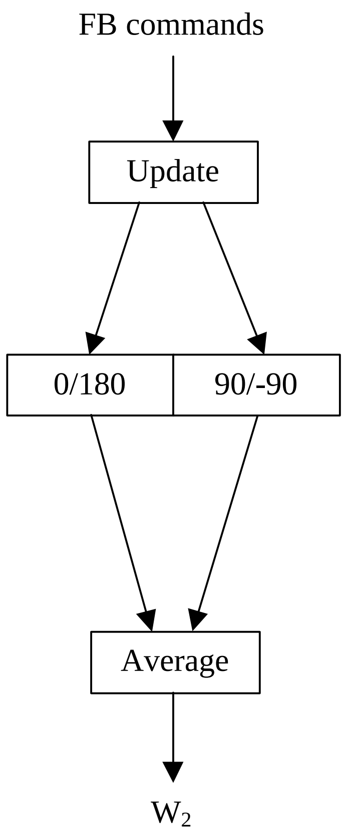

Figure 4~~44~~. Conceptual description of the Node B filter for FB mode 1.

8.2.1 Mode 1 End of frame adjustment

In FB mode 1 at frame borders the command for slot 14 from previous frame and the command for slot 0 of the next frame update the same memory cell of the filter. Thus, at the border the average is calculated based on the command for slot 13 of the previous frame and the command for slot 0 of the next frame.

8.2.2 Mode 1 Normal Initialisation

For the first frame of transmission using closed loop mode 1 UE determines the feedback commands in a normal way and sends them to Node B.

At Node B the filter is initialized so that the memory cell for command 90/-90 degrees is always initialized to the value of 90 degrees.

8.2.3 Mode 1 Recovery from slotted mode

When recovering from the slotted mode no special actions are taken. The old values of the memory cells of the filter are used. When the first feedback command is received from UE the corresponding memory cell is updated and new average of w_2 is calculated to be used for the next downlink slot.

8.3 Feedback mode 2

In FB mode 2 there are 16 possible combinations of phase and amplitude adjustment from which the UE selects and transmits the FSM according to tables 3 and 4. No constellation rotation is done at UE. Similarly, no filtering of the received weights is performed at the Node B.

Table 3 FSM_{po} subfield of FB mode 2 signalling message.

FSM_{po}	Power_ant1	Power_ant2
0	0.2	0.8
1	0.8	0.2

Table 4 FSM_{ph} subfield of FB mode 2 signalling message.

FSM_{ph}	Phase difference between antennas (degrees)
000	180
001	-135
011	-90
010	-45
110	0
111	45
101	90
100	135

When N_{po}=0, equal power is applied to each antenna.

To obtain the best performance, progressive updating is performed at both the UE and the UTRAN Access point. Every slot time, the UE refines its choice of FSM, from the set of weights allowed given the previously transmitted bits of the FSM. This is shown in figure 7.

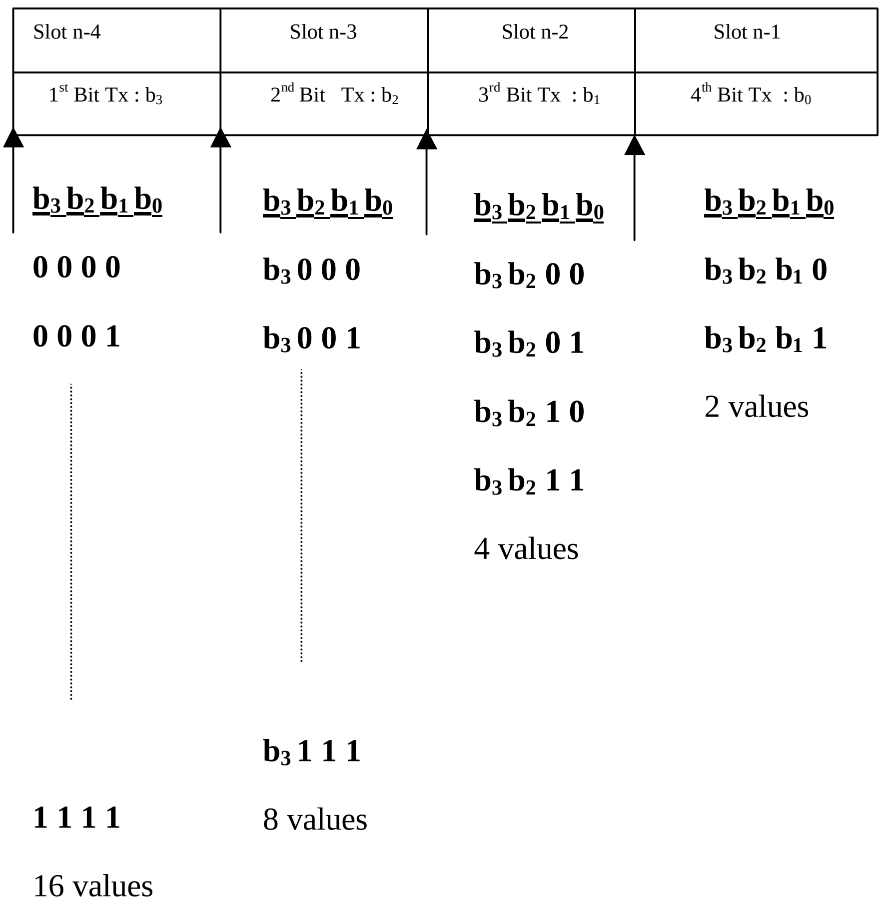

Figure 7. Profressive Refinement at the UE for FB mode 2.

Every slot time the UTRAN constructs the FSM from the most recently received bits for each position in the word. This is shown in figure 8.

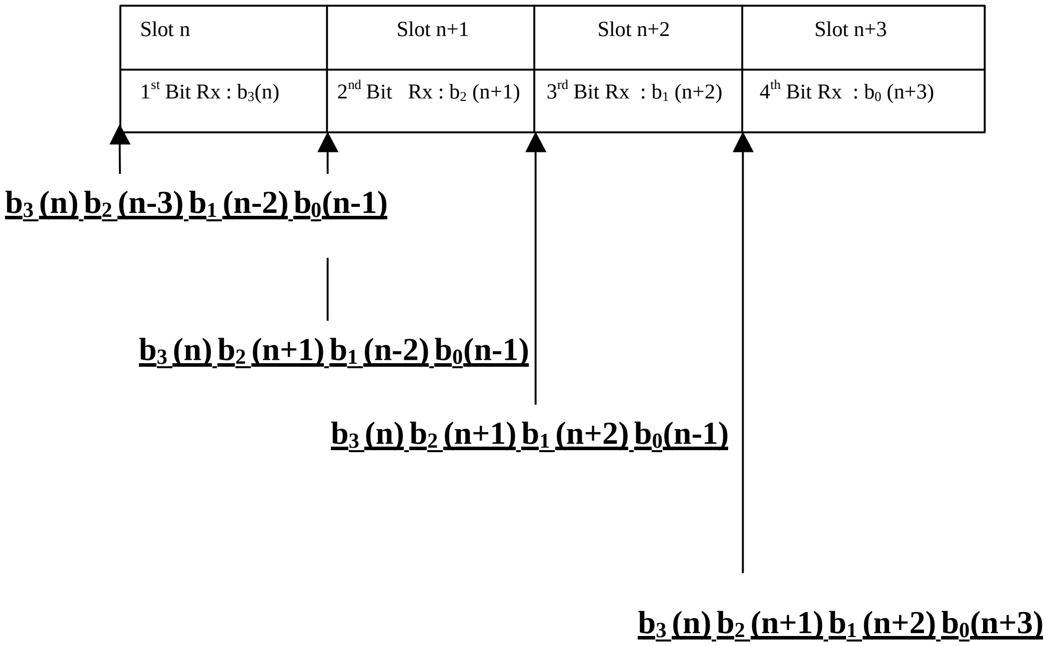

Figure 8. Profressive Refinement at the UTRAN Access Point for FB mode 2.

The weight vector, *w*, is then calculated as:

$$\underline{w} = \begin{bmatrix} \sqrt{power\_ant1} \\ \sqrt{power\_ant2}.\exp(jp.phase\_diff / 180) \end{bmatrix} \qquad (6)$$

8.3.1 Mode 2 End of frame adjustment

The FSM must be wholly contained within a frame. To achieve this an adjustment is made to the last FSM in the frame where the UE only sends the FSM_{ph} subfield, and the Node B takes the amplitude bit FSM_{po} of the previous FSM.

8.3.2 Mode 2 Normal Initialisation

For the first frame of transmission using closed loop mode 2, the operation is as follows.

The UE starts sending the FSM message in slot 0 in the normal way, refining its choice of FSM in slots 1 to 3 from the set of weights allowed given the previously transmitted bits of the FSM.

During the reception of the first three FSM bits (that is before the full four bits are received), the UTRAN Access Point initialises its transmissions as follows. The power in both antennas is set to 0.5. The phase offset applied between the antennas is updated according to the number and value of FSM_{ph} bits received as given in table 5.

Table 5 FSM_{ph} normal initialisation for FB mode 2.

FSM_{ph}	Phase difference between antennas (degrees)
- - -	180 (normal initialisation) or held from previous setting (slotted mode recovery)
0 - -	180
1 - -	0
0 0 -	180
0 1 -	-90
1 1 -	0
1 0 -	90
0 0 0	180
0 0 1	-135
0 1 1	-90
0 1 0	-45
1 1 0	0
1 1 1	45
1 0 1	90
1 0 0	135

This operation applies in both the soft handover and non soft handover cases.

8.3.3 Mode 2 Recovery from slotted mode

For recovery after slotted mode, UTRAN Access Point sets the power in both antennas to 0.5 until a FSM_{po} bit is received. Until the first FSM_{ph} bit is received and acted upon, UTRAN uses the phase offset which was applied before the transmission interruption (table 5). Normal initialisation of FSM_{ph} (table 5) occurs if the uplink signalling information resumes at the beginning of a FSM period (that is if signalling resumes in slots 0,4,8,12). If the uplink signalling does not resume at the beginning of a FSM period, the following operation is performed. In each of the remaining slots of the partial FSM period, and for the first slot of the next full FSM period, the UE sends the first (i.e. MSB) bit of the FSM_{ph} message, and at the UTRAN access point the phase offset applied between the antennas is updated according to the number and value of FSM_{ph} bits received as given in table 6. Initialisation then continues with the transmission by the UE of the remaining FSM_{ph} bits and the UTRAN operation according to table 5. .

Table 6 FSM_{ph} subfield of FB mode 2 slotted mode recovery period

FSM_{ph}	Phase difference between antennas (degrees)
-	held from previous setting
0	180
1	0

---End text proposal--

The whole Annex of TS 25.214 v1.1.2 is proposed to be replaced with the following:

---Start of text proposal---

A.3 Antenna verification

In FB mode 1, if channel estimates are taken from the Primary CCPCH, the performance will also suffer if the UE can not detect errors since the channel estimates will be taken for the incorrect phase settings. To mitigate this problem, antenna verification can be done, which can make use of antenna specific pilot patterns of the dedicated physical channel. The antenna verification can be implemented with several different algorithms. A straightforward algorithm can use a 4-hypothesis test per slot. Alternatively, a simplified beam former verification (SBV) requiring only a 2 hypothesis test per slot can be used. If we have orthogonal pilot patterns on the downlink DPCCH we can apply the SBV as follows:

Consider

$$2\sum_{i=1}^{Npath}\frac{1}{s_i^2}\left\{2\,\mathrm{Re}(gh_{2,i}^{(d)}h_{2,i}^{(p)^*})\right\}>\frac{\ln(\bar{p}(f_{Rx}=p))}{\ln(\bar{p}(f_{Rx}=0))}$$

then define the variable x_0 as, $x_0 = 0$ if the above inequality holds good and $x_0 = \pi$ otherwise. Similarly consider

$$-2\sum_{i=1}^{Npath}\frac{1}{s_i^2}\left\{2\,\mathrm{Im}(gh_{2,i}^{(d)}h_{2,i}^{(p)^*})\right\}>\frac{\ln(\bar{p}(f_{Rx}=-\frac{p}{2}))}{\ln(\bar{p}(f_{Rx}=\frac{p}{2}))}$$

then define the variable x_1 as, $x_1 = -\pi/2$ if the above inequality holds good and $x_1 = \pi/2$ oherwise.
Whether x_0 or x_1 is to be calculated for each slot is given by the following table:

Slot	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0	x_1	x_0

The estimate for the transmitted phase is now obtained as:

$$\sin(f_{Tx})+j\cos(f_{Tx})=\frac{\sum_{i=0}^{1}\sin(x_i)}{2}+j\frac{\sum_{i=0}^{1}\cos(x_i)}{2}$$

where

the x_i values are used corresponding to the current slot and the next slot, except in the case of slot 14 wherein the slot 14 and slot 1 of the next frame values are used.

$h_{2,i}^{(p)}$ is the *i*'th estimated channel tap of antenna 2 using the PCCPCH,

$h_{2,i}^{(d)}$ is the *i*'th estimated channel tap of antenna 2 using the DPCCH,

γ^2 is the DPCH Pilot SNIR/ PCCPCH Pilot SNIR,

a_{i} are the elements of $\underline{w}$,

s_i^2 is the noise plus interference on the *i*'th path.

In normal operation the *a priori* probability for selected pilot pattern is assumed to be 96% (assuming there are 4% of errors in the feedback channel for power control and antenna selection).

--End text proposal---