Agenda item:

Source: **MOTOROLA**

Title: Proposal for improvement of Tx diversity closed loop modes

Document for: Discussion and approval

Summary:

In order to improve the performance of closed loop transmit diversity a slight modification to the existing concept is proposed. By accepting the basic proposal we get the following benefits:

- Constant Update rate of 1500 Hz gives improved performance
- UE knows what coefficients the UTRAN applies on each slot => allows Verification
- Minimal Changes in the Specifications

Note that all the claimed benefits of the refined modes proposed by Nokia are also acheived without any averaging at the UTRAN and with relatively much less changes to the current defined modes.

Moreover, there is no phase ambiguity and difficulty in SHO situation.

The text proposal to TS 25.214 v1.1.1 is included. It adresses the frame termination procedure as well as initialisation of Tx AA in normal and recovery after slotted mode (note that this is a necessary consideration for any feedback signalling scheme, not just for the proposed refinement). New text is given in revision marks. The editor should note however that some sections have also been re-ordered and some text moved between sections.

--**Start text proposal**--

8 Feedback mode transmit diversity

8.1 DPCH transmission scheme

The transmitter structure to support Feedback (FB) mode transmit diversity for DPCH transmission is shown in Figure 1. 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 are determined by the UE, and signaled to the UTRAN access point (=cell transceiver) through the uplink DPCCH.

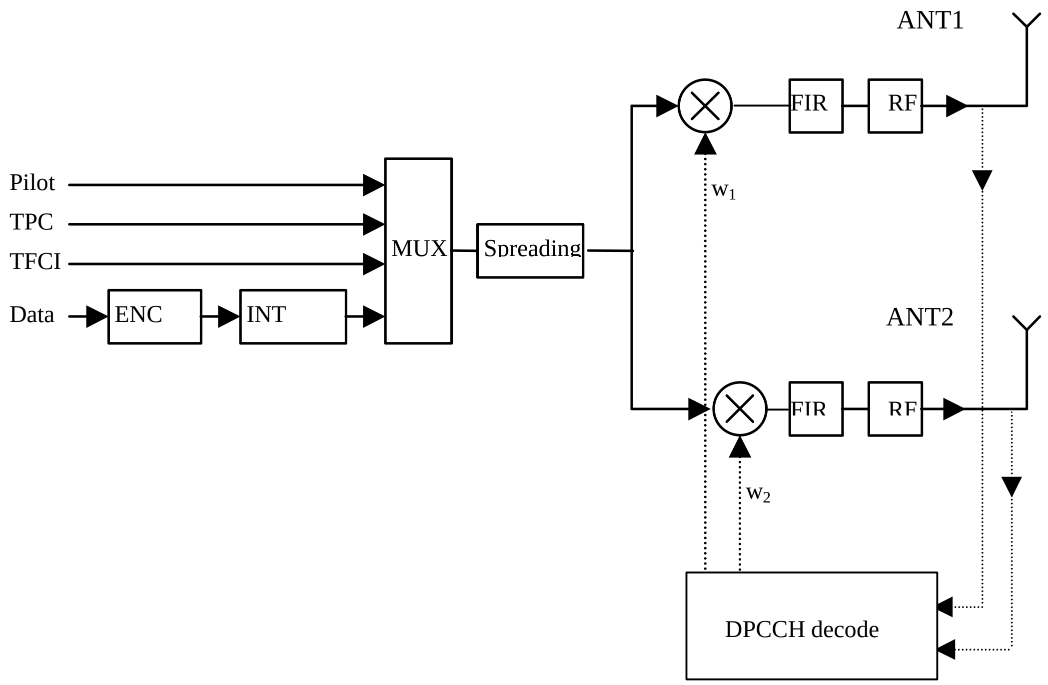


Figure 1. Downlink transmitter structure to support FB Mode Transmit Diversity for DPCH transmission (UTRAN Access Point)

8.1 Determination of feedback information

~~The UE uses the pilots transmitted on the Primary CCPCH to separately estimate the channels seen from each antenna.~~

~~Once every $N_{Slot}=N_W/N_{FBI}$ slot times, the UE computes the phase and power adjustments that should be applied at the UTRAN access point to maximize the UE received power, from within the set of adjustments allowed by the chosen feedback mode defined with Tables 1 to 5.~~

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

Antennas 1 and 2 are uniquely defined by their respective Common Pilot CHannel (CPiCH) codes.

The amplitude and phase applied per antenna is called a "weight", and the set of weights is grouped into a "weight vector". Specifically, the weight vector in the case of 2 antennas is given by

$$\underline{w} = \begin{bmatrix} \sqrt{power\_ant1} \\ -\sqrt{power\_ant2}.\exp(jp.phase\_diff\ /180) \end{bmatrix} \quad (1)$$

Every slot time, the UE determines the optimum weight, from the set of weights allowed given the previously transmitted bits of the feedback message, that should be applied at the UTRAN access point to maximize the UE received power. The phase and power adjustments are defined by Tables 1 to 5 depending on the chosen feedback mode.

Every slot time the UTRAN constructs the Tx AA message (word) from the most recently received bits for each position in the word. The adjustments are make at the beginning of the downlink DPCCH pilot field.

In a generic sense for the non-soft handover case, this is the weight vector $\underline{w}$ that maximizes

$$P=\underline{w}^H H^H H \underline{w} \quad (2)$$

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.

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

$$P=w^H(H_1^H H_1 + H_2^H H_2 + \text{xxxx})w$$

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).

8.2 Uplink signaling channel

The UE feeds back to the UTRAN access point the information on which phase/power settings to use (the "weights"). 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 25.21). Each message is of length $N_W = N_{po}+N_{ph}$ bits and its format is shown in the Figure 2Figure 2Figure 2. 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.

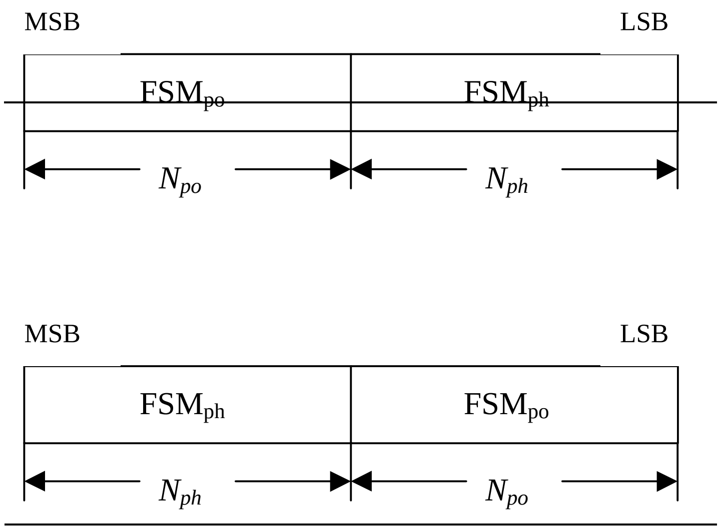


Figure 2. Format of feedback signaling message. FSM_{po} transmits the power setting and FSM_{ph} the phase setting.

Table 1Table 1Table 1 lists the N_{FBD}(number of bits in the FBI D- field of a slot), N_W, update rate, feedback bit rate and number of power and phase bits per signaling word for different feedback modes.

Table 1 N_{FBD}, N_W, update rate, feedback bit rate and number of power and phase bits per signalling word for different feedback modes

FB mode	N_{FBD}	N_W	Update rate	Feedback bit rate	N_{po}	N_{ph}
1	1	1	1500 Hz	1500 bps	0	1
2	1	2	1500 Hz	**1500 bps**	0	2
	2		1500 Hz	**3000 bps**		
3	1	4	1500 Hz	1500 bps	1	3
	2		1500 Hz	3000 bps		

Table 2Table 2Table 2 to Table 5Table 5Table 5 below give the binary signaling words, together with their interpretation at the transmit array (in terms of relative powers and phases to be applied between the antennas).

Table 222 Feedback mode 1 signalling message. No FSM_{po} is transmitted.

FSM_{ph}	Phase_difference between antennas (degrees)
0	180
1	0

Table 3 Feedback mode 2 signalling message. No FSM_{po} is transmitted.

FSM_{ph}	Phase_difference between antennas (degrees)
00	180
01	-90
11	0
10	90

Table 4 FSM_{po} subfield of feedback mode 3 signalling message.

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

Table 555 FSM_{ph} subfield of feedback mode 3 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.

8.3 FSM within a frame

The FSM must be wholly contained within a frame. To achieve this, in certain cases adjustments are required as follows:

- For Mode 2 with N_{FBD}=1, only the MSB of the last FSM per frame is transmitted by the UE. The Node B applies the average phase difference between the 2 possible phase differences allowed given this first bit (i.e. 45 or –135 degrees).

- For Mode 3 with N_{FBD}=1, for the last FSM in the frame the UE sends only the FSM_{ph} portion. The Node B applies the same power ratio as for the previous FSM.

- For Mode 3 with N_{FBD}=2, for the last FSM in the frame the UE sends only the 2 MSBs of the FSM_{ph} portion. The Node B applies the same power ratio as for the previous FSM and maps the 2 first bits to a phase difference according to table 3.

The FSM must be wholly contained within a frame. Since the UTRAN constructs the Tx AA message (word) from the most recently received bits, the following adjustments are made to the last FSM in the frame to achieve the correct frame termination using the modes define in table 1 to 5.

- For Mode 2 with N_{FBD}=1, the UE only sends the FSM_{ph} MSB and the Node B takes the LSB from the previous FSM to construct the word.
- For Mode 3 with N_{FBD}=1, the UE only sends the FSM_{ph} subfield and the Node B takes the amplitude bit FSM_{po} of the previous FSM to construct the word.
- For Mode 3 with N_{FBD}=2, the UE only sends the 2 MSBs of FSM_{ph}. The Node B takes the LSB of FSM_{ph} and amplitude bits of FSM_{po} from the previous FSM to construct the word.

8.4 Initialisation of closed loop Tx AA modes for normal and slotted mode

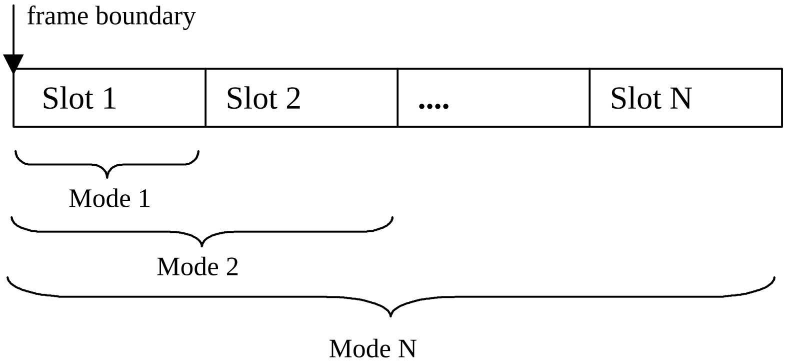
At the starting point, either

- in normal operation at the beginning of the first frame of transmission, or
- upon resumption after slotted mode operation at any slot time in a frame,

the following approaches are used.

8.4.1 Normal initialisation, N_{FBD}=1

For normal operation initialisation with N_{FBD}=1, the feedback commands sent by the UE are progressively updated with increasing resolution as defined by increasing mode number from mode 1. The UE selects from the set of Weights allowed given the previously transmitted bits of the feedback message.



N=1, 2 or 3 depending on chosen mode.

8.4.2 Normal initialisation, N_{FBD}=2

With N_{FBD}=2, the normal operation initialisation the feedback commands sent by the UE are progressively updated with increasing resolution as defined by increasing mode number starting from mode 2. The UE selects from the set of Weights allowed given the previously transmitted bits of the feedback message.

8.4.3 Slotted Mode Recovery, $N_{FBD}=1$

For recovery after slotted mode with $N_{FBD}=1$, if transmission of uplink signalling information resumes part way through a FSM period, signalling for mode 1 is used on the remaining slots of the partial FSM. Normal initialisation then occurs if the N slot initialisation period does not contain the last FSM of the frame.

Mode 1	…	Mode 1	Normal Operation Initialisation

← N times to end a FSM →

If the N slot initialisation period does contain the last FSM of the frame, Mode 1 signalling is used during this FSM period and normal initialisation occurs from the beginning of the next frame.

8.4.3 Slotted Mode Recovery, $N_{FBD}=2$

For recovery after slotted mode with $N_{FBD}=2$, if transmission of uplink signalling information resumes part way through a FSM period, signalling for mode 2 is used on the remaining slots of the partial FSM. Normal initialisation then occurs if the N slot initialisation period does not contain the last FSM of the frame. If the N slot initialisation period does contain the last FSM of the frame, Mode 2 signalling is used during this FSM period and normal initialisation occurs from the beginning of the next frame.

--End text proposal---