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Agenda Item:	**AH26 (Release 2000)**
Source:	**Samsung Electronics Co., Ltd.**
Title:	**New CPICH Transmission scheme for 4-antenna transmit diversity**
Document for:	**Discussion & Approval**

In Release 99 specification, transmit diversity using 2 antennas is included. Currently, various transmit diversity schemes using 4 transmit antenna are considered for possible extension to Release 2000.
However, the most important thing that should be solved first is the pilot reference channel for 4-antenna.

In this document, we propose a new CPICH transmission scheme for 4-antenna transmit diversity. The most important thing that should be kept in mind when proposing new CPICH transmission scheme for 4 transmit antenna is the backward compatibility. Here, the backward compatibility means that the Release 99 UE should be able to demodulate the whole physical channels (dedicated or common physical channel) without any change in receiver structure. That is, Release 99 UE receiver should use the same channelisation code and estimate the channel within the same accumulation duration. In addition, downlink transmit power should be distributed evenly to all transmit antennas to reduce the PAPR (Peak to Average Power Ratio).

In section 1, the transmission scheme of CPICH for 4-antenna transmit diversity is described and the backward compatibility is proved. In section 2, corresponding common physical channel transmission scheme with 4 transmit antenna to satisfy the backward compatibility is proposed. And the corresponding transmission schemes of dedicated physical channel with 2-antenna and 4-antenna transmit diversity UE are described in section 3.

Let's distinguish UE by the diversity mode it uses as following.

non-diversity UE:	UE in 1-antenna mode
2-ant diversity UE:	UE in 2-antenna diversity mode
4-ant diversity UE:	UE in 4-antenna diversity mode

1. Proposed CPICH Transmission Scheme

1.1 CPICH Transmission Scheme

If UTRAN supports 4 transmit diversity (open or closed loop) for dedicated channel to UE in the cell, then it should provide 3 additional diversity pilot channels as well as primary CPICH. However, since the CPICH is a common physical channel it also should be received by all UEs with different diversity mode, and thus one and only one CPICH transmission scheme should be used. Each UE should estimate the channel(s) as many as the number of transmit antenna if single path per antenna is assumed. That is, common CPICH transmission scheme for 4 transmit antenna shall have the property that it must be recognised as one, two, or 4 pilot channels to non-diversity UE, 2-ant diversity UE, and 4-ant diversity UE, respectively. Figure 1 shows the proposed CPICH transmission scheme for 4 transmit antenna which satisfies the property. The main characteristics of the proposed CPICH transmission scheme are:

- using two OVSF codes (C_{OVSF1} and C_{OVSF2})
- same pilot pattern as Release 99' 2-ant CPICH (AA and A-A/ –AA)
- different control of pilot channel gain for 2-ant or 4-ant diversity reception
- backward compatible with Release 99
- reduce PAPR by distributing physical channels to 4 antenna

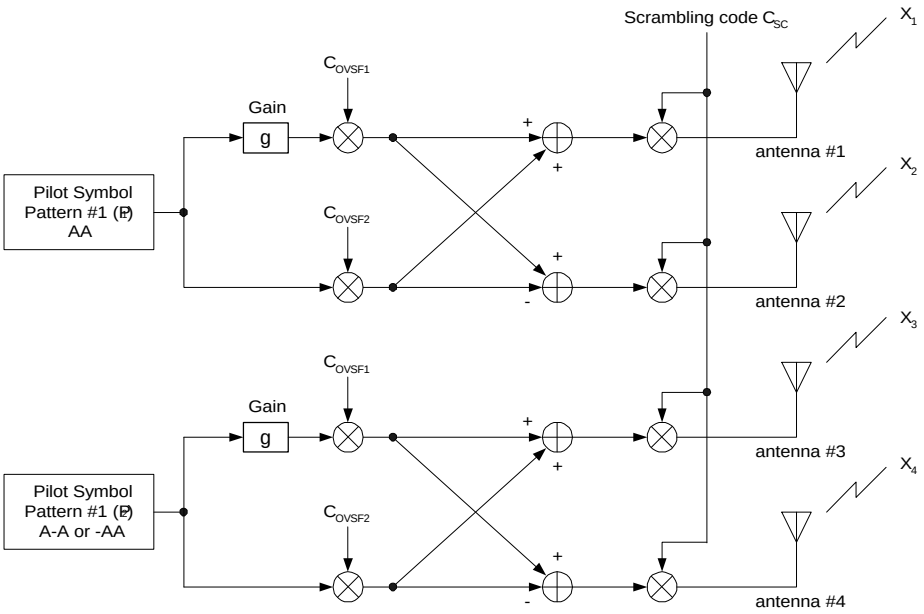

Figure 1. Proposed CPICH transmission scheme for 4 antenna transmit diversity

The CPICH signal from each antenna at the receiver side is given by the following equations. We ignore the timing index and background noise for simplicity.

$$\begin{aligned} X_1 &= \mathrm{P}_1 \times (g \cdot C_{OVSF1} + C_{OVSF2}) \times C_{SC} \times h_1 \\ X_2 &= \mathrm{P}_1 \times (g \cdot C_{OVSF1} - C_{OVSF2}) \times C_{SC} \times h_2 \\ X_3 &= \mathrm{P}_2 \times (g \cdot C_{OVSF1} + C_{OVSF2}) \times C_{SC} \times h_3 \\ X_4 &= \mathrm{P}_2 \times (g \cdot C_{OVSF1} - C_{OVSF2}) \times C_{SC} \times h_4 \end{aligned} \qquad (1)$$

where P_1 (=AA) and P_2 (=A-A or –AA) are the two pilot patterns defined for 2-ant CPICH in Release 99, and C_{SC} is the primary scrambling code. In Eq. (1), C_{OVSF1} and C_{OVSF2} are two OVSF codes where C_{OVSF1} is $C_{ch,256,0}$ and C_{OVSF2} is one additional OVSF code. h_1, h_2, h_3, h_4 are the channel coefficients for each antenna path. It is worth noting that the parameter *g* in Eq. (1) is the gain factor to discriminate the received pilot power for 2-ant and 4-ant diversity UE. By varying the gain *g*, we can control the effective received pilot strength to 2-ant diversity UE and 4-ant diversity UE. For 2-ant diversity UE only C_{OVSF1} is used and thus the second term in Eq. (1) is removed. On the other hand, for 4-ant diversity UE, both C_{OVSF1} and C_{OVSF2} will be used and it can discriminate 4 different antenna paths. Detail receiver structure of different diversity UE are described in next section. For non-diversity UE, there's no impact to the transmitter and receiver at all.

1.2 Receiver Structure of Proposed CPICH

1.2.1 Receiver structure of 4-ant diversity UE

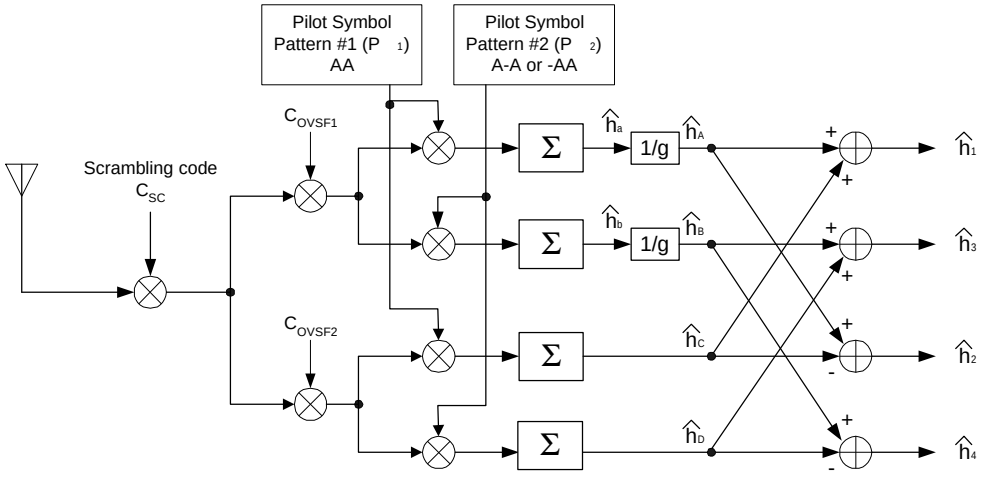

Figure 2. Receiver structure of 4-ant diversity UE

Figure 2 shows how the 4-ant diversity UE can receive and estimate the 4 channels. In Figure 2, $\hat{h}_a, \hat{h}_b$ denote the channel estimation of $h_a = g(h_1 + h_2)$, $h_b = g(h_3 + h_4)$, respectively. Similarly, $\hat{h}_A, \hat{h}_B, \hat{h}_C, \hat{h}_D$ denote the estimation of $h_A = h_1 + h_2$, $h_B = h_3 + h_4$, $h_C = h_1 - h_2$, $h_D = h_3 - h_4$, respectively. Note that these channel estimation pairs $\{\hat{h}_a, \hat{h}_b\}$, $\{\hat{h}_A, \hat{h}_B, \hat{h}_C, \hat{h}_D\}$, or $\{\hat{h}_1, \hat{h}_2, \hat{h}_3, \hat{h}_4\}$ can be used to compensate the common or dedicated physical channels.

1.2.2 Receiver structure of 2-ant diversity UE

Figure 3 is the CPICH receiver structure of 2-ant diversity UE and it can also be used with the proposed CPICH transmission scheme without any change. Note that the channel estimation value with the receiver is exactly same as the output of the first branch output in Figure 2. That is, $h_a = g(h_1 + h_2)$ and $h_b = g(h_3 + h_4)$. Consequently, there's no change required to Release 99 UE in terms of pilot channel estimation. The only difference is the effective channel through which the pilot signal is transmitted. In order for the proposed CPICH transmission scheme to become fully backward compatible , UTRAN also should modify the transmission structure of common/dedicated physical channels with considering the channel estimation outputs of non-diversity UE, 2-ant diversity UE, and 4-ant diversity UE. The detail of the common/dedicated physical channel transmission structure is given in section 2 and 3.

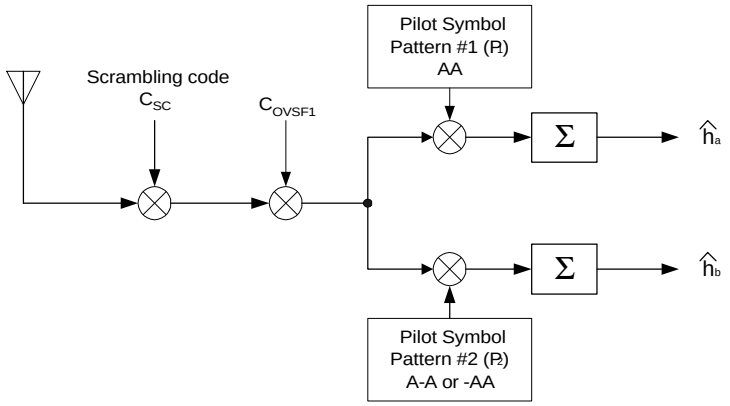

Figure 3. Receiver structure of 2-ant diversity UE

1.2.3 Summary of channel estimation outputs

Table 1 shows the summary of demodulation parameters and the channel estimation output according to the UE diversity mode. In table 1, the related physical channel implies the physical channel that utilises the corresponding channel estimation output during demodulation. The main idea of the table 1 is that the transmission structure of the related physical channel should be designed carefully with considering the corresponding channel estimation output.

Table 1. Summary of demodulation parameters and channel estimation output

Rx parameters / UE mode	Pilot Channel				Related physical channel
	scrambling code	channelisation code	pilot pattern	channel estimation output	
non-diversity	C_{SC}	C_{OVSF1} = $C_{ch,256,0}$	AA	gh_1	Common CH Dedicated CH
2-ant diversity	C_{SC}	C_{OVSF1} = $C_{ch,256,0}$	AA A-A/-AA	$h_a = g(h_1 + h_2)$ $h_b = g(h_3 + h_4)$	Common CH Dedicated CH
4-ant diversity	C_{SC}	C_{OVSF1} = $C_{ch,256,0}$ C_{OVSF2} = $C_{ch,256,i}$	AA A-A/-AA	$h_a = g(h_1 + h_2)$ $h_b = g(h_3 + h_4)$	Common CH
				h_1, h_2, h_3, h_4	Dedicated CH

2. Proposed Common Physical Channel Transmission Scheme

2.1 Common Physical Channel Transmission Scheme

Common physical channel should be transmitted with one and only one transmission scheme. However, each UE should receive the common physical channel as their transmit diversity mode. Figure 4 is the proposed common physical channel transmission scheme where the original symbols (S_1, S_2) are transmitted to antenna 1 and 2, while the STTD encoded symbols ($-S_2^*$, S_1^*) are transmitted to antenna 3 and 4. Backward compatibility of this scheme can be easily proved and shown in section 2.2.

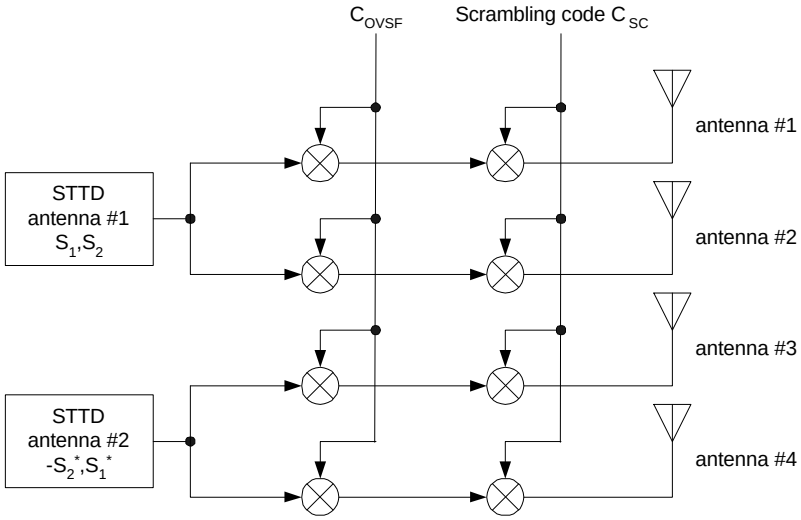

Figure 4. Common Physical Channel Transmission

2.2 Receiver Structure of Proposed Common Physical Channel Transmission Scheme

If the common physical channel transmission scheme in Figure 4 is used, 2-ant and 4-ant diversity UE can receive the signals with the conventional STTD decoder as shown in Figure 5.

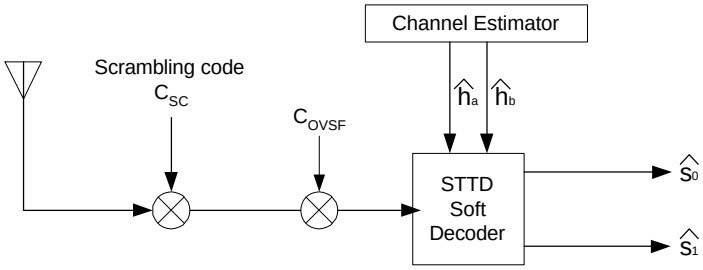

Figure 5. Receiver Structure for Common Physical Channel Transmission Scheme 1

The received signal after multiplication of OVSF in Figure 5 is given by

$$r_{t1} = S_1(h_1 + h_2) - S_2^*(h_3 + h_4)$$
$$r_{t2} = S_2(h_1 + h_2) + S_1^*(h_3 + h_4)$$

where $t1, t2$ denote the time unit. Since the channel estimation provided by 2-antenna CPICH receiver are $\hat{h}_a$ and $\hat{h}_b$ (See Table 1), conventional STTD receiver can be used without any change.

3. Proposed Dedicated Physical Channel Transmission Scheme

In case of a dedicated physical channel, transmission scheme should be different for each UE according to the diversity mode. However, the transmission scheme should be carefully designed with considering the avilable channel estimation output as given in Table 1.

3.1 Dedicated Physical Channel Transmission Scheme for 2-ant UE

For 2-ant diversity UE, the available channel estimation are $h_a = g(h_1 + h_2)$, $h_b = g(h_3 + h_4)$ (See Table 1). It means that the antenna 1 and antenna 2 should transmit one signal, and antenna 3 and antenna 4 should

transmit the other signal. Based on the above constraint, Figure 6 and 7 show the proposed transmission scheme for dedicated physical channel to 2-ant STTD and closed loop transmit diversity UE, respectively. By distributing 2-antenna signals to 4-antenna, such situation that the power of 2-ant diversity UE's concentrate on two antenna can be avoided. Definitely, it reduces the PAPR (Peak to Average Power Ratio)

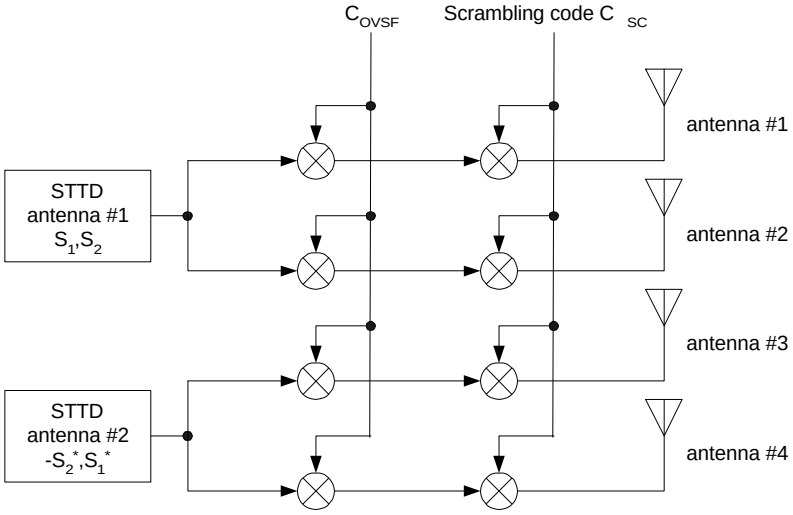

Figure 6. Dedicated physical channel transmission scheme for 2-ant STTD diversity UE

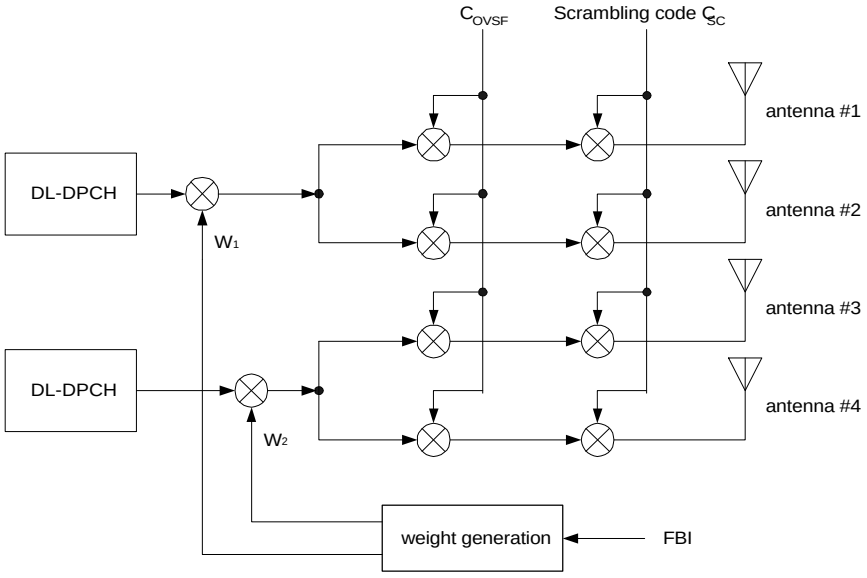

Figure 7. Dedicated physical channel transmission scheme for 2-ant closed loop transmit diversity UE

3.2 Dedicated Physical Channel Transmission Scheme for 4-ant UE

If a dedicated physical channel is transmitted to a 4-ant diversity UE, the transmission scheme should be designed with considering the available channel estimations output to the UE. With the proposed CPICH transmission scheme, the available channel estimation output of the 4-ant diversity UE are $\hat{h}_1, \hat{h}_2, \hat{h}_3, \hat{h}_4$ (See Table 1). Currently, there is no accepted 4-antenna open/closed loop transmit diversity scheme but the proposed CPICH transmission scheme can be used with any kind of open/closed loop diversity proposal.

Conclusion

In this contribution, a new CPICH transmission scheme was proposed for 4 transmit antenna. The proposed scheme satisfies the backward compatibility with Release 99 non-diversity, 2-ant diversity UE. We also considered the proper common/dedicated physical channel transmission scheme to be used with the proposed CPICH transmission scheme. With only one additional channelisation code, the proposed CPICH transmission scheme can be used as diversity pilot for 4 transmit antenna.

References

[1] 3G TS 25.214: "Physical layer procedures (FDD)"

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