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Agenda item: AH26 (Release 5)
Source: Samsung and Seoul National University
Title: Proposed TR of Tx diversity for multiple antennas
Document for: Discussion and approval

Summary:

Further enhancements of the Tx diversity solutions of Rel.-99 belong to a study item called "Radio link performance enhancements". Before the new solutions can be incorporated to Rel.-00 TSG-R1 should agree on the inclusion of the new solutions and submit a technical report to RAN.

In this contribution a text input to the technical report on the proposed basis selection scheme and new CPICH transmission scheme for multiple Tx antennas are presented[1]-[5].

References

- [1] Samsung and Seoul National University, "Proposal for the use of closed loop Tx diversity with more than 2 Tx antennas," R1-00-0506, TSG-RAN WG1#12, Seoul, Korea, April 2000
- [2] Samsung and Seoul National University, "Further simulation results of Tx diversity for more than 2 antennas," R1-00-0683, TSG-RAN WG1#13, Tokyo, Japan, May 2000
- [3] Samsung and Seoul National University, "Preliminary version of algorithm and Simulation results for Tx Diversity with more than 2 Tx Antennas," R1-00-0882, TSG-RAN WG1#14, Oulu, Finland, July 2000
- [4] Samsung and Seoul National University, "Performance results of basis selection transmit diversity for 4 antennas," R1-00-1073, TSG-RAN WG1#15, Berlin, Germany, August 2000
- [5] Samsung, "New CPICH Transmission scheme for 4-antenna transmit diversity," R1-00-1072, TSG-RAN WG1#15, Berlin, Germany, August 2000

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Technical Report

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; RAN WG1 report on Tx diversity solutions for multiple antennas (Release 5)



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Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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1 Scope

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

?? References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

?? For a specific reference, subsequent revisions do not apply.

?? For a non-specific reference, the latest version applies.

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]}V<a[.b[.c]]>[onwards])]: "<Title>".

- [1] 3G TS 25.211 (v3.3.0): "Physical channels and mapping of transport channels onto physical channels (FDD)".
- [2] 3G TS 25.214 (v3.3.0): "Physical layer procedures (FDD)".
- [3] 3G TS 25.221 (v3.3.0): "Physical channels and mapping of transport channels onto physical channels (TDD)".
- [4] 3G TS 25.224 (v3.3.0): "Physical layer procedures (TDD)".
- [5] Nokia. Recommended simulation parameters for Tx diversity simulations. TSG-R WG1 document, TSGR1#14(00)0867, 4-7th, July, 2000, Oulu, Finland, 5 pp.
- [6] R1-00-0882, "Preliminary version of algorithm and Simulation results for Tx Diversity with more than 2 Tx Antennas," TSG-RAN WG1#14, Oulu, Finland, July 2000

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

<defined term>: <definition>.

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviation format

<ACRONYM> <Explanation>

4 Background and Introduction

5 Descriptions of studied concepts

5.1 Basis selection scheme for > 2 Tx antennas

5.1.1 Tx antenna weights

In closed loop Tx diversity systems, the weights of transmit antennas are determined at a mobile station and fed back to the base station. These weights should result in as high SNR as possible at the mobile. The set of these weights may be viewed as a vector $\underline{w} = [w_1 \ w_2 \ \dots \ w_i \ \dots \ w_M]^T$, where w_i is a complex weight associated with the i th Tx antenna. For the maximum SNR at the mobile, the weights should maximize P below:

$$P \propto \underline{w}^H H^H H \underline{w}, \quad (5.1.1)$$

when $H = [\underline{h}_1 \ \underline{h}_2 \ \dots \ \underline{h}_i \ \dots \ \underline{h}_M]$ and M is the number of Tx antennas. The column vector \underline{h}_i represents an estimated channel impulse response for the i th Tx antenna, and its vector length equals to the number of paths. The weight vector \underline{w} information is periodically fed back to the base station. Note that the amount of feedback information and the implementation complexity increase with the number of Tx antennas. The efficient representation of a weight vector is desired to reduce the amount of feedback data and the implementation complexity. Furthermore, backward compatibility is desirable.

A weight vector with M elements may be represented as a linear sum of basis vectors, which span an M -dimensional space. Examples of basis vectors for 2-, 3-, 4-dimensional spaces are shown in Appendix A of [6]. Let's assume for explanation that 4 Tx antennas are used for Tx diversity. The optimal weight vector \underline{w}_{opt} for this system has 4 elements and may be represented as a linear sum of four basis vectors, $\underline{B}_1, \underline{B}_2, \underline{B}_3, \underline{B}_4$, as follows:

$$\underline{w}_{opt} \propto c_1 \underline{B}_1 \propto c_2 \underline{B}_2 \propto c_3 \underline{B}_3 \propto c_4 \underline{B}_4 \quad (5.1.2)$$

where c_1, \dots, c_4 are complex coefficients associated with corresponding vectors. Assuming that $|c_1| > |c_2| > |c_3| > |c_4|$, we may approximate \underline{w}_{opt} as

$$\underline{w}_{app_1} \propto c_1 \underline{B}_1, \quad (5.1.3a)$$

$$\underline{w}_{app_2} \propto c_1 \underline{B}_1 \propto c_2 \underline{B}_2, \quad (5.1.3b)$$

$$\underline{w}_{app_3} \propto c_1 \underline{B}_1 \propto c_2 \underline{B}_2 \propto c_3 \underline{B}_3, \quad (5.1.3c)$$

These vectors $\underline{w}_{app_1}, \underline{w}_{app_2}, \underline{w}_{app_3}$, may be viewed as the projections of \underline{w}_{opt} into 1-dim, 2-dim, and 3-dim subspaces. \underline{w}_{app_3} is more accurate representation of \underline{w}_{opt} than \underline{w}_{app_1} and \underline{w}_{app_2} .

5.1.2 Representation of weight vectors

The conventional representation of the vector \underline{w}_{opt} may require $(M-1) \cdot N_c$ bits, where N_c bits are required to represent each element of \underline{w}_{opt} . This representation indicates that the transmission of $(M-1) \cdot N_c$ bits at 1500Hz is required to support Tx diversity with M Tx antennas. The reason for $(M-1) \cdot N_c$ not $M \cdot N_c$ is that one of M Tx antennas may be viewed as reference and the relative weights for other antennas are required. To reduce the required number of bits, we

propose to feedback information on the approximated vector, instead of w_{opt} . The representation of the approximated vector includes the specification of basis vectors and associated coefficients. When there are M Tx antennas and the approximation is made in a S -dimensional subspace, there are ${}^M C_S$ combinations for selecting S basis vectors among M vectors and the required number of bit to specify the basis vector combination is $\lceil \log_2 ({}^M C_S) \rceil$.

5.1.3 Feedback protocol structure

In the simulation, we consider the two cases for antenna selection: **Case 1**) 2 antenna selection ($M=4, S=2$), it noted as 4C2 and **Case 2**) 3 antenna selection ($M=4, S=3$), it noted as 4C3. In both cases, 2bit representation for each element (phase only) is used ($N_c = 2$). The required number of feedback information per signaling word is: **Case 1**) 5 bits, and **Case 2**) 6bits. For detail simulation scheme, we can refer section 6.2.1. The considered frame format of feedback information is:

(Case 1: 2 best selection among 4 basis and combine all 2 with received phase information)

| Slot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Phase | | | | P_1 | P_2 | | | | P_1 | P_2 | | | | P_1 | P_2 |
| Selection | S_1 | S_2 | S_3 | | | S_1 | S_2 | S_3 | | | S_1 | S_2 | S_3 | | |

S_i : Antenna selection bits

P_i : Phase difference with respect to the coefficient associated with the first basis vector

(Case 2: 3 best selection among 4 basis and combine all 3 with received phase information)

| Slot | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|-----------|-------|-------|----------|----------|----------|----------|-------|-------|----------|----------|----------|----------|-------|-------|----------|
| Phase | | | P_{11} | P_{12} | P_{21} | P_{22} | | | P_{11} | P_{12} | P_{21} | P_{22} | | | P_{11} |
| Selection | S_1 | S_2 | | | | | S_1 | S_2 | | | | | S_1 | S_2 | |

S_i : Antenna selection bits

P_{ij} : Phase difference with respect to the coefficient associated with the first basis vector

5.2 New CPICH Transmission scheme for > 2 Tx antennas

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-antenna transmit diversity 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.

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 UEs by their diversity mode as following.

2-ant diversity UE: UE in 2-antenna diversity mode (open/closed)

4-ant diversity UE: UE in 4-antenna diversity mode (open/closed)

5.2.1 Proposed CPICH Transmission Scheme

5.2.1.1 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, since each antenna has its own path. 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 2-ant diversity UE and 4-ant diversity UE, respectively. Figure 5.2.1 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

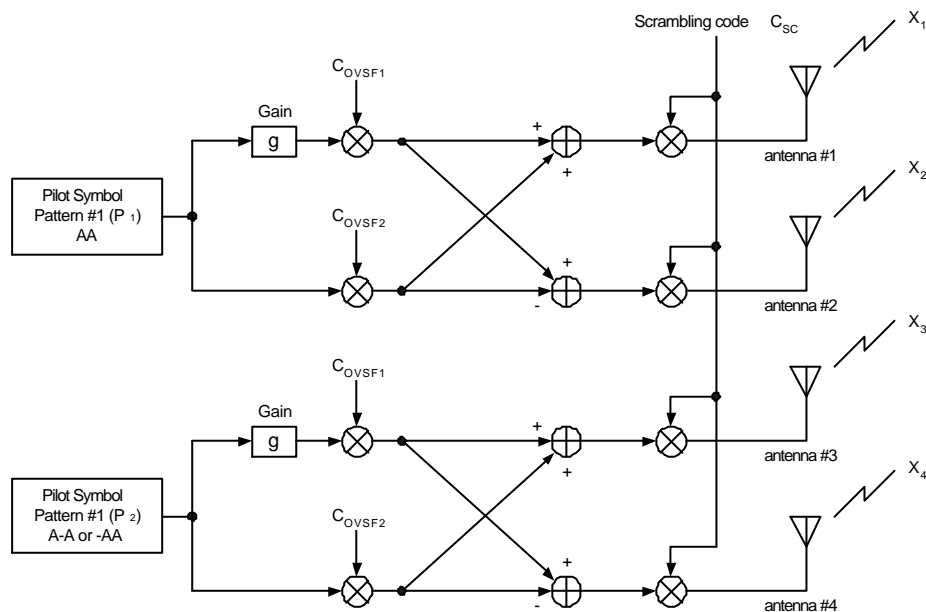


Figure 5.2.1. Proposed CPICH transmission scheme for 4 antenna transmit diversity

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.

$$\begin{aligned}
 X_1 &= P_1 \cdot (g \cdot C_{OVSF1} \cdot C_{OVSF2}) \cdot C_{SC} \cdot h_1 \\
 X_2 &= P_1 \cdot (g \cdot C_{OVSF1} \cdot C_{OVSF2}) \cdot C_{SC} \cdot h_2 \\
 X_3 &= P_2 \cdot (g \cdot C_{OVSF1} \cdot C_{OVSF2}) \cdot C_{SC} \cdot h_3 \\
 X_4 &= P_2 \cdot (g \cdot C_{OVSF1} \cdot C_{OVSF2}) \cdot C_{SC} \cdot h_4
 \end{aligned} \tag{5.2.1}$$

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. ([6]), 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. ([6]) 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 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. ([6]) 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.

5.2.1.2 Receiver Structure of Proposed CPICH

5.2.1.2.1 Receiver structure of 4-ant diversity UE

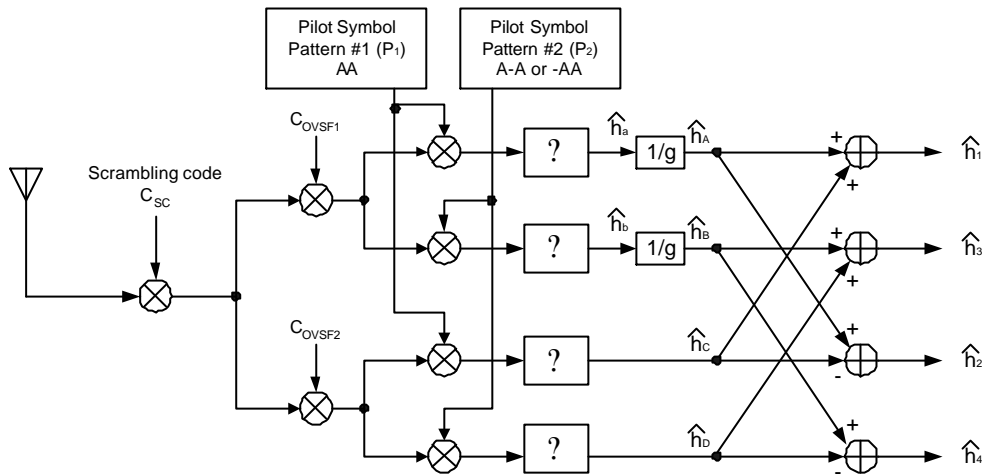


Figure 5.2.2. Receiver structure of 4-ant diversity UE

Figure 5.2.2 shows how the 4-ant diversity UE can receive and estimate the 4 channels. In Figure 5.2.2, \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.

5.2.1.2.2 Receiver structure of 2-ant diversity UE

Figure 5.2.3 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 5.2.2. 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 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.

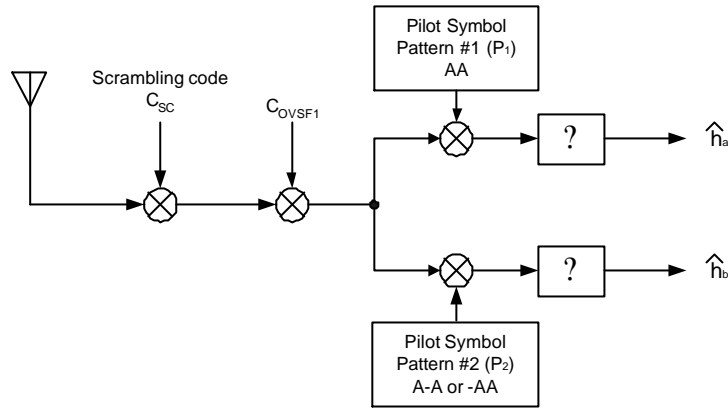


Figure 5.2.3. Receiver structure of 2-ant diversity UE

5.2.1.2.3 Summary of channel estimation outputs

Table 5.2.1 shows the summary of demodulation parameters and the channel estimation output according to the UE diversity mode. In table 5.2.1, the related physical channel implies the physical channel that utilises the corresponding channel estimation output during demodulation. The main idea of the table 5.2.1 is that the transmission structure of the related physical channel should be designed carefully with considering the corresponding channel estimation output.

Table 5.2.1. 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 | |
| 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} | $C_{OVSF1} = C_{ch,256,0}$ $C_{OVSF2} = C_{ch,256,1}$ | 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 |

5.2.2 Proposed Common Physical Channel Tx Scheme

5.2.2.1 Common Physical Channel Tx 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 5.2.4 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.

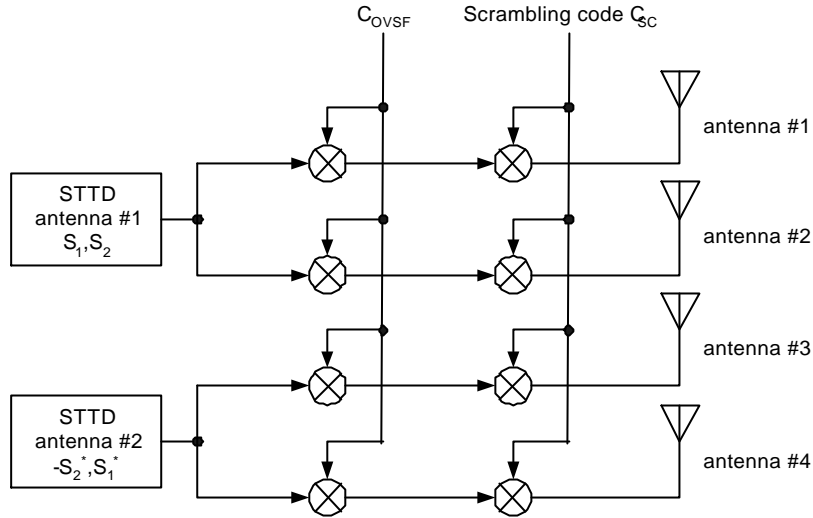


Figure 5.2.4. Common Physical Channel Transmission

5.2.2.2 Receiver Structure of Proposed Common Physical Channel Tx Scheme

If the common physical channel transmission scheme in Figure 5.2.4 is used, 2-ant and 4-ant diversity UE can receive the signals with the conventional STTD decoder as shown in Figure 5.2.5.

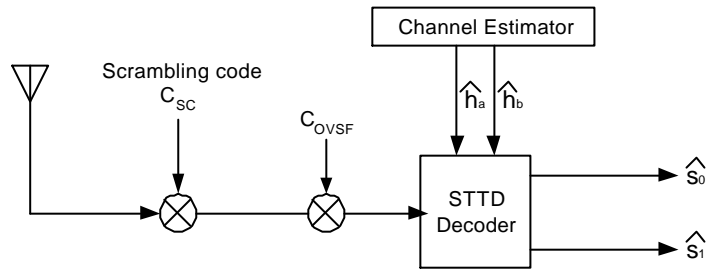


Figure 5.2.5. Receiver Structure for Common Physical Channel Transmission Scheme 1

The received signal after multiplication of OVSF in Figure 5.2.4 is given by

$$\begin{aligned}
 r_{t1} &= S_1(h_1 \otimes h_2) \otimes S_2^*(h_3 \otimes h_4) \otimes S_1 h_a \otimes S_2^* h_b \\
 r_{t2} &= S_2(h_1 \otimes h_2) \otimes S_1^*(h_3 \otimes h_4) \otimes S_2 h_a \otimes S_1^* h_b
 \end{aligned}
 \tag{5.2.2}$$

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.

5.2.3 Proposed Dedicated Physical Channel Tx 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 available channel estimation output as given in Table 5.2.1

5.2.3.1 Dedicated Physical Channel Tx Scheme for 2-ant UE

For 2-ant diversity UE, the available channel estimation is $h_a \otimes g(h_1 \otimes h_2)$, $h_b \otimes g(h_3 \otimes h_4)$ (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 5.2.6 and 5.2.7 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)

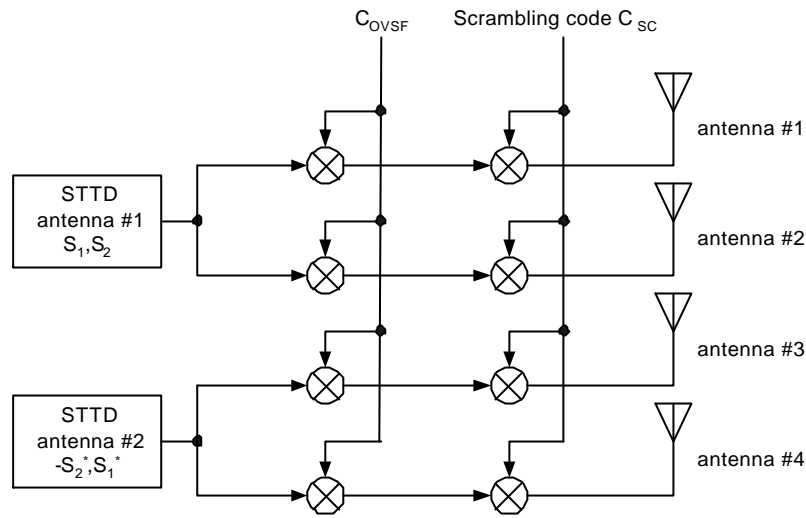


Figure 5.2.6. Dedicated physical channel transmission scheme for 2-ant STTD diversity UE

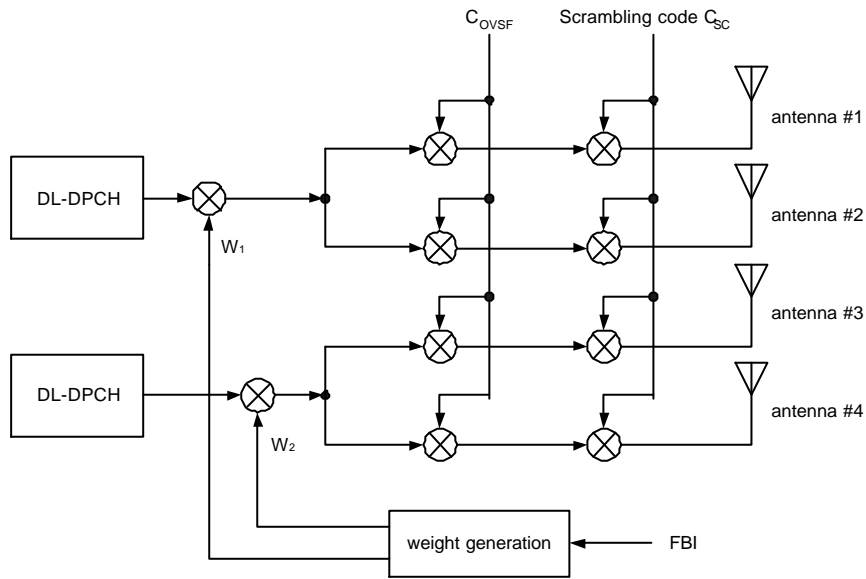


Figure 5.2.7. Dedicated physical channel transmission scheme for 2-ant closed loop transmit diversity UE

5.2.3.2 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 5.2.1). 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.

6 Performance

6.1 Link level simulation assumptions

6.1.1 Basis selection for > 2 Tx antennas

Basic link level simulation assumptions described in [5] and additional assumptions described Table 6.1.1.1 were used.

Table 6.1.1.1. Additional simulation parameters.

| | |
|-----------------------|--|
| Comparing output | <i>Ec/Ior</i> |
| Modulation | <i>QPSK</i> |
| Physical channel rate | <i>30ksps</i> |
| Number of antennas | <i>Release 99: 2, Release 2000: 4 (New)</i> |
| Total FSM bits | <i>Release 99 Mode2: 4bits Release 2000 Case I (4C2): 5bits Case II (4C3): 6bits</i> |
| Slot format | <i>#10 (6,2,0,24,8)</i> |
| Channel estimation | <i>WMSA – 4slots (1,4,4,1)</i> |
| MPI modeling | <i>All noncoherent except self (Fig1 and 2) Coherent and noncoherent (Fig 3 and 4)</i> |

6.2 Link level simulation results

6.2.1 Basis selection for > 2 Tx antennas

Release 99 scheme and two other schemes are simulated as in Table 6.2.1.1.

Table 6.2.1.1. Scheme description

| Scheme | Description |
|----------|---|
| 2-mode-2 | <ul style="list-style-type: none"> /// Closed loop mode 2 according to Rel.99 /// Number of Tx antennas = 2 /// Feedback bit rate = 1500 bps /// Total bits of FSM = 4bits: 1bit for gain, 3bits for phase |
| 4C2 | <ul style="list-style-type: none"> /// Number of Tx antennas = 4 /// Feedback bit rate = 1500 bps /// 2 best antenna selection among 4 transmit antenna /// Total bits of FSM = 5bits: 3bits for selection, 2bits for phase |
| 4C3 | <ul style="list-style-type: none"> /// Number of Tx antennas = 4 /// Feedback bit rate = 1500 bps /// 3 best antenna selection among 4 transmit antenna /// Total bits of FSM = 6bits: 2bits for selection, 4bits for phase |

Single path, 0dB Geom.

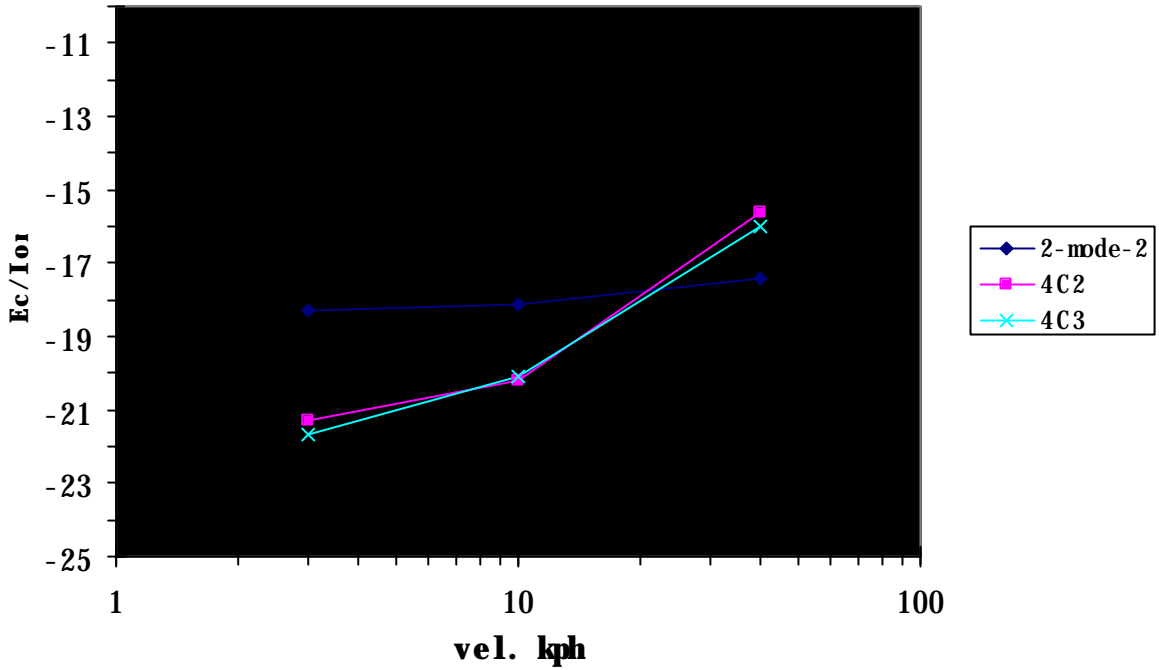


Figure 6.2.1.1. Single path simulation results for 0 dB geometry and 1 % FER.

Ped A Channel, 0dB Geom.

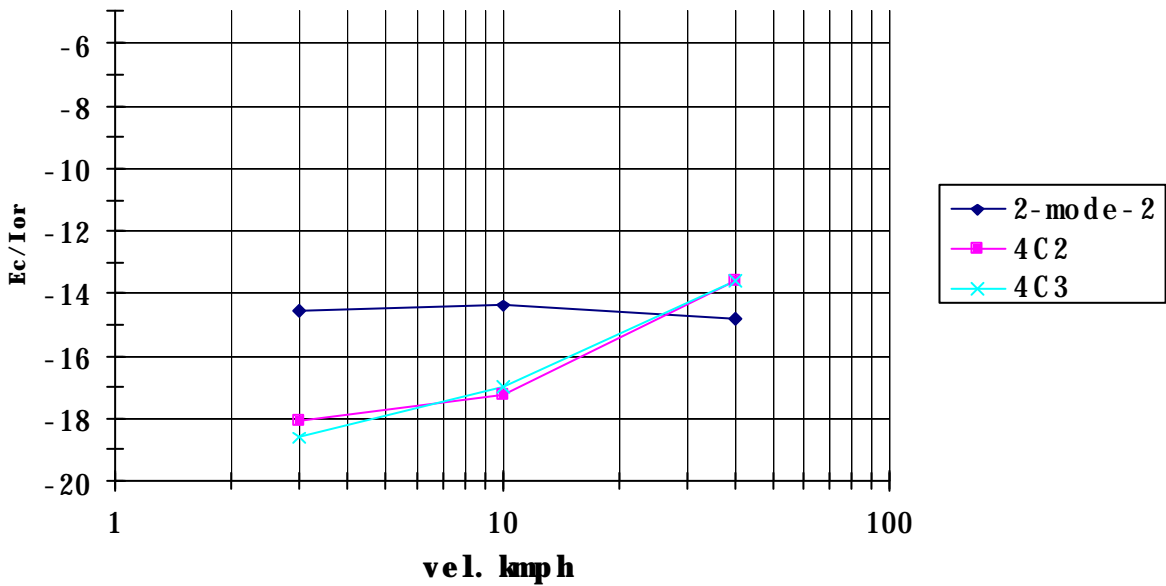


Figure 6.1.2.2. Simulation results for modified ITU Ped. A channel at 0 dB geometry.

Veh A Channel, 0dB Geom

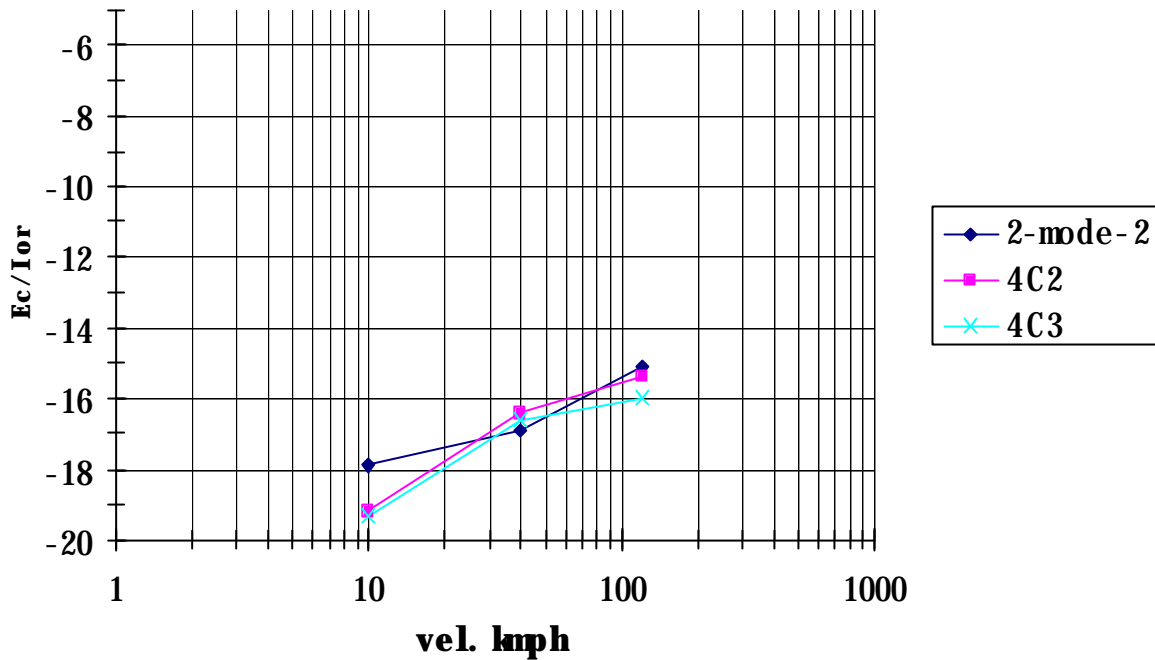


Figure 6.2.1.3. Simulation results for modified ITU Veh. A channel at 0 dB geometry.

In these simulation results, we compared “2-mode-2” scheme, “4C2” scheme, and “4C3” scheme. The “2-mode-2” scheme is closed loop Tx diversity mode 2 of two antennas in Rel 99. In addition, the “4C2” and “4C3” schemes are the basis selection methods of closed loop Tx diversity for more than two antennas. In the “4C2” scheme, the UE selects two antennas among four antennas. Consequently, the UE selects three antennas in “4C3” scheme.

The results of Fig.6.2.1.1., single path case, show that the new scheme has 2.7dB@ FER=1% gain for 4C2 and 3.0dB@ FER=1% for 4C3 over the Release 99 Tx diversity Mode 2 when the UE speed is 3km/h.

As shown in Fig.6.2.1.2, the “modified ITU pedestrian A” channel model is used. The multipath model is “noncoherent”. When compared to “2-mode-2” scheme, performance gains of “4C2” scheme and “4C3” scheme are 3.5dB and 4dB, respectively. The crossover point between “2-mode-2” scheme and other schemes is about 25km/h.

In Fig.6.2.1.3, these schemes are compared in the “modified ITU vehicular A channel”. As the same as in Fig.6.2.1.2, the “noncoherent” multipath model is used. The suggested “4C2” and “4C3” scheme have better performance (approximately 1.3dB) in low speed than that of the “2-mode-2” scheme. If, however, the velocity is higher than 30km/h, performance is similar for three schemes.

6.3 System level performance

7 Impacts to UE and UTRAN implementation

7.1 Impacts to UE implementation

7.1.1 Basis selection scheme for > 2 Tx antennas

In order to obtain feedback weight in UE, it is necessary to perform the matrix operation in Eq. (5.1.1). In general, it is known that the searching is one of the efficient methods to calculate the weight for antennas. If the number of antenna is limited by selection, then the complexity of calculation could be reduced.

In detail, the number of multiplication of Eq. (5.1.1) is proportional to M^2+M if the weight for each antenna is transmitted, where M denotes the number of antenna. It is worth noting that the (M^2+M) is for only one weight vector. Thus the resultant number of multiplication is proportional to (size of weight vector set)* (M^2+M) . Note that the size of weight vector set is L^M , where $L=2^{N_c}$ is the possible number of weight vector per antenna.

If the weight for the reference antenna is set to one, then the number of multiplication is proportional to (size of weight vector set)* $(M(M-1)+M-1)$, where the size of weight vector is L^{M-1} .

If the number of transmit antenna is reduced to S , then the number of multiplication reduces to (size of weight vector set)* $(S(S-1)+S-1)$. In this case, the size of weight vector set reduces to $M C_S * L^{S-1}$ due to the reduced number of antenna.

For example, in case of $M=4$, $S=2$, $N_c=2$, the number of multiplication of the proposed scheme is proportional to $6*4*3=72$ while that of the full representation with reference antenna is $4^3*(12+3)=64*15=960$. Note that in case of $M=2$, $N_c=4$ (3GPP Mode 2), the number of multiplication is $16*3=48$.

7.2 Impacts to UTRAN implementation

8 Impacts to physical layer operation

9 Backwards compatibility to Release-99

9.1 Basis selection scheme for > 2 Tx antennas

9.2 New CPICH Transmission scheme for > 2 Tx antennas

This proposed scheme satisfies the backward compatibility with Release 99 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.

10 Conclusions

History

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