3GPP TSG RAN WG1#16 **TSGR1#16(00)-1265**

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Agenda item:

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Title: Downlink Tx Diversity Schemes for 1.28Mcps TDD

Document for: Discussion and approval

Abstract

Downlink transmit diversity schemes are proposed for the 1.28Mcps TDD mode. In the TSTD of the proposed schemes, two spatially separated antennas are alternately used at the base station to transmit each consecutive sub-frame of the downlink physical channels. The proposed TSTD scheme takes advantage of the frame structure of the 1.28Mcps TDD mode, where the frame structure makes TSTD transmission possible with a single power amplifier.

Introduction

The performance of a mobile communication system depends largely on how well the system is designed to overcome the time varying characteristics of the communication channel. One way of improving the performance in time varying channel environment is to use diversity technology. TSTD (Time Switched Transmit Diversity), TxAA (Transmit Antenna Array), and STTD (Space Time Transmit Diversity) are three of the methods that use (time and) space diversity technology. Each of these three methods has its own advantages and disadvantages. The advantages of TSTD are that it is quite simple to implement and the receiver structure does not need to be changed to receive the TSTD transmitted signal. Even though TSTD's performance may not be the best among the above mentioned methods, at worst the performance of TSTD is on par with the single antenna case. Furthermore, taking advantage of the frame structure of 1.28Mcps TDD mode, the base station can use TSTD with only a single power amplifier, by alternately switching the power amplifier between the two antennas. Since the power amplifier is the most expensive part of the base station system, this feature makes TSTD a quite attractive technique as far as the system cost is concerned.

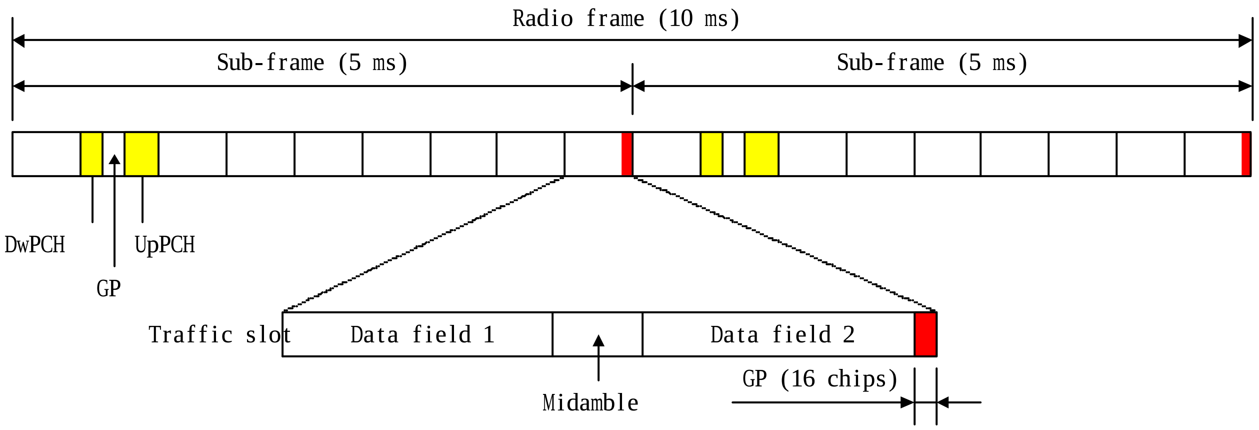

Figure 1 The frame and sub-frame structure of 1.28Mcps TDD mode.

Frame Structure of 1.28Mcps TDD mode

Figure 1 shows the frame structure of 1.28Mcps TDD mode. As shown in the figure, a 10 ms radio frame consists of two 5 ms sub-frames, each of which in turn consists of 7 traffic timeslots, DwPCH (Downlink Pilot CHannel), UpPCH (Uplink Pilot CHannel) and a Guard Period. And the traffic timeslot consists of two data fields and a midamble part and a 16 chip guard period at the end of the timeslot. Thus, in each sub-frame, there is a 16 chip guard period of 12.5 ?sec at the end of the sub-frame.

TSTD Transmission

In 1.28Mcps TDD mode, we can take advantage of the 12.5 ?sec guard period for TSTD transmission. Figure 2 shows the proposed transmitter structure of 1.28Mcps TDD mode. As shown in the figure, channel coded and interleaved data is QPSK modulated, and then spread and scrambled before it is time multiplexed with the midamble sequence. The time multiplexed signal is then transformed into analog signal by pulse shaping filter, where it is then modulated to the carrier frequency. The modulated signal is then amplified to an appropriate power level by using power amplifier. For TSTD transmission, two spatially separated antennas alternate with each other to transmit the signal every sub-frame. During the 12.5 ?sec period at the end of each sub-frame, the power amplifier is switched from one antenna to the other of the two antennas every 5 ms sub-frame. Thus, each of the two antenna transmits the signal 100 times a second, for 5 ms each time, and the power amplifier is switched from antenna 1 to antenna 2 or from antenna 2 to antenna 1 200 times a second. Because of the 12.5 ?sec, TSTD transmission is possible with only one power amplifier as shown in figure 2. The transmission pattern of the two TSTD antennas is shown in figure 3. Note that TSTD transmission is identical to the transmission of the signal by a single antenna without Tx diversity, except for the switching operation between the two antennas.

A summary of the proposed scheme is as follows.

- The proposed scheme takes advantage of the sub-frame structure of 1.28Mcps TDD mode.
- Downlink receiver performance is enhanced, even in low cost base station with/without antenna array.
- Negligible additional hardware cost for base station (no additional power amplifier).
- There isno impact on UE receiver structure.

Tx Diversity and Beamforming

Depending on the capability of the base station, many different combinations of TSTD, STTD, and beamforming are possible. Table 1 summaries the possible cases of the combination of these technologies.

Table 1 Tx Diverstiy and Beamforming

	DwPCH	P-CCPCH	DPCH
Case 1	No	No	No/BF
Case 2	No/TSTD	STTD	STTD/BF
Case 3	TSTD	TSTD	TSTD/BF

The first case is when no Tx Diversity is used for DwPCH and P-CCPCH. In this case, DPCH may or may not use beamforming. The second case is when Node B is capable STTD transmission. In this case, P-CCPCH can be transmitted using STTD, and DPCH can use STTD or beamforming (if Node B is capable of beamforming). However, DwPCH will use either TSTD or no Tx Diversity. The third case is when Node B is capable of beamforming but not STTD. In this case, P-CCPCH and DwPCH can use TSTD, and DPCH can use beamforming or TSTD.

When the base station is equipped with an array antenna, TSTD can be used with beamforming; beamforming can be used for the transmission of dedicated channels, but common channels such as P-CCPCH or S-CCPCH can be transmitted using TSTD. In this case, the TSTD transmission can be achieved by using two antenna elements from the array antenna as shown in figure 4 (a). In the distane of the two antenna elements are not far enough to get enough diversity gain, only one antenna elements from the array antenna can be used with an additional extra antenna as shown in figure 4 (b).

Conclusion

We propose a TSTD scheme for downlink physical channels of 1.28Mcps TDD mode. The proposed scheme utilizes the sub-frame structure of 1.28Mcps TDD mode. The proposed scheme obtains a Tx diversity gain with little extra hardware complexity of the base station, and the receiver structure of the UE requires minor change for the reception of the TSTD transmitted signal.

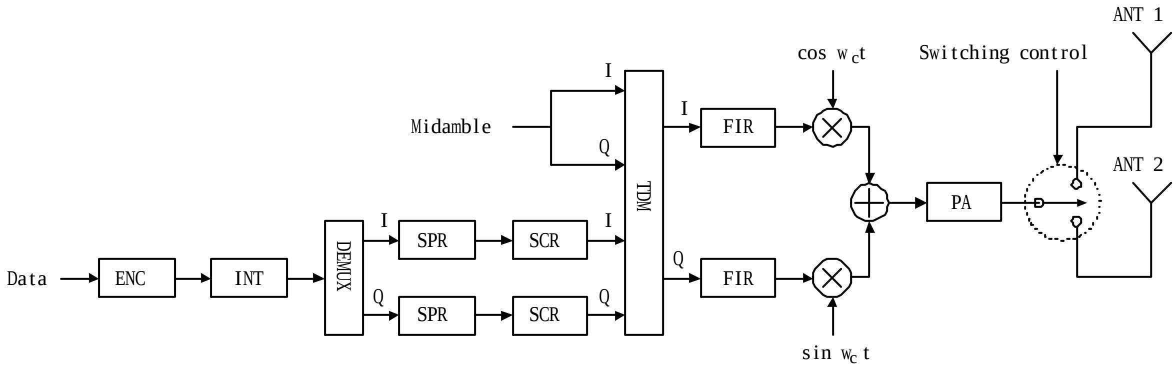

Figure 2. Transmit air-interface protocol of TSTD base-station

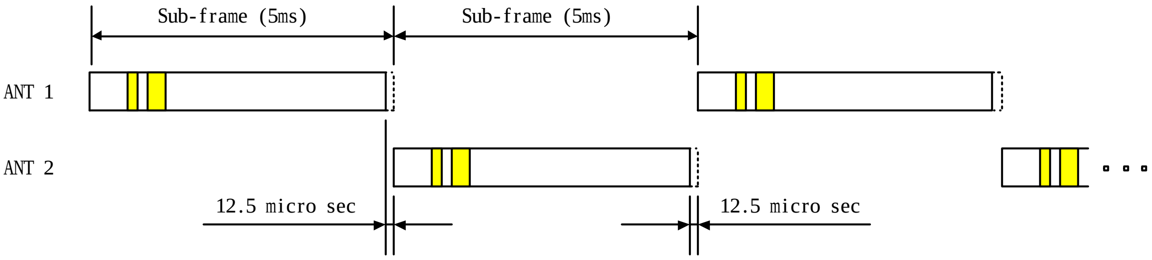

Figure 3. TSTD switching pattern utilizing sub-frame structure

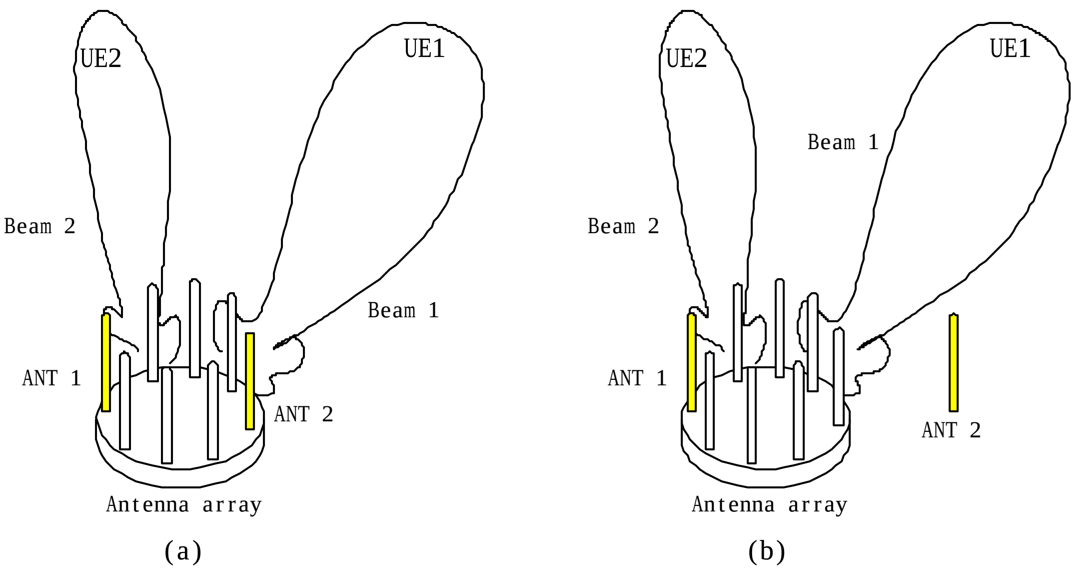

Figure 4. Beamforming and TSTD transmission

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5.5 Downlink Transmit Diversity for 1.28Mcps TDD

5.5.1 Transmit Diversity for DPCH

Closed loop Tx Diversity or TSTD may be employed as transmit diversity scheme for downlink DPCH

5.5.1.1 Closed Loop Tx Diversity for DPCH

The transmitter structure of the closed loop Tx Diversity for DPCH transmission is shown in figure [F1]. Channel coding, rate matching, interleaving, bit-to-symbol mapping, spreading, and scrambling are performed as in the non-diversity mode. Then the data is time multiplexed with the midamble sequence. The complex valued signal from the multiplexor are then fed to both transmit antenna branches. The complex signals on each antenna branch is multiplied by complex valued weight factors W1 and W2, respectively, where the antenna specific weight factors W1 and W2 are determined by UTRAN. The weighted signals are then transformed into analog signal by pulse shaping filters, and then modulated to be transmitted from each antenna after amplification.

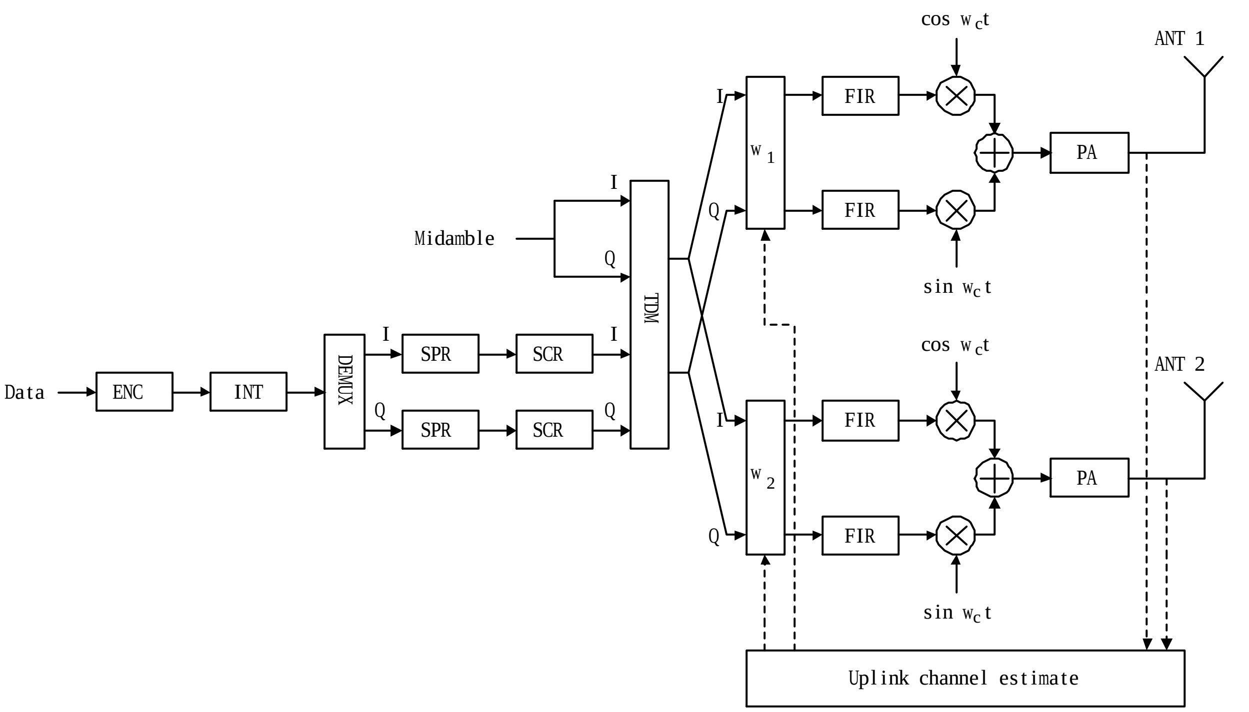

Figure [F1]. Downlink transmitter structure to support Transmit Diversity for DPCH transmission (UTRAN Access Point) in 1.28Mcps TDD

5.5.1.2 TSTD for DPCH

Time Switched Transmit Diversity (TSTD) can be employed as transmit diversity scheme for downlink DPCH. The transmitter structure of the TSTD transmitter is shown in figure [F2]. Channel coding, rate matching, interleaving, bit-to-symbol mapping, spreading, and scrambling are performed as in the non-diversity mode. Then the data is time multiplexed with the midamble sequence. Then, after pulse shaping, modulation and amplification, DPCH is transmitted from antenna 1 and antenna 2 alternately every sub-frame. Figure [F3] shows the antenna switching pattern for the transmission of DPCH.

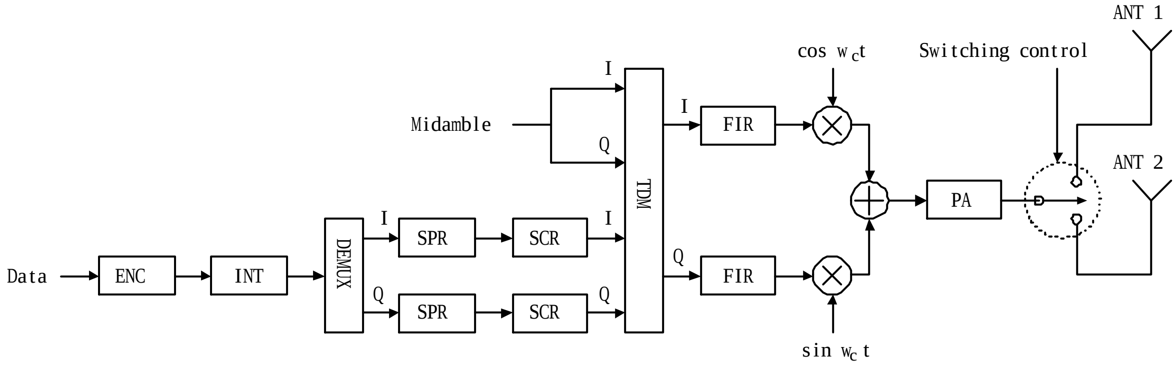

Figure [F2]: TSTD Transmitter structure for DPCH and P-CCPCH.

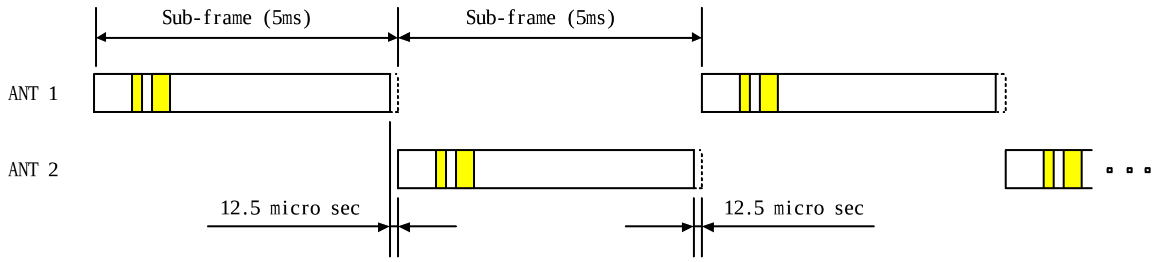

Figure [F3]: Antenna swithing pattern for TSTD transmission of DPCH and P-CCPCH

5.5.2 Transmit Diversity for DwPCH

Time Switched Transmit Diversity (TSTD) can be employed as transmit diversity scheme for the downlink pilot channel DwPCH. If TSTD is employed, DwPCH is transmitted from antenna 1 and antenna 2 alternately. If P-CCPCH and DPCH employ TSTD, and DwPCH also employs TSTD, then DwPCH, P-CCPCH, and DPCH are transmitted from the same antenna within the same sub-frame as shown in figure [F3].

~~5.5.2~~5.5.3 Transmit Diversity for P-CCPCH

Time Switched Transmit Diversity (TSTD) or Block Space Time Transmit Diversity (Block STTD) may be employed as transmit diversity scheme for the Primary Common Control Physical Channels (P-CCPCH).

5.5.3.1 TSTD Transmission Scheme for P-CCPCH

A block diagram of the TSTD transmitter is shown in figure [F2]. Channel coding, rate matching, interleaving, bit-to-symbol mapping, spreading, and scrambling are performed as in the non-diversity mode. Then the data is time multiplexed with the midamble sequence. Then, after pulse shaping and modulation and amplification, P-CCPCH is transmitted from antenna 1 and antenna 2 alternately every sub-frame. An example of the antenna switching pattern is shown in figure [F3]. If P-CCPCH, DPCH, and DwPCH employs TSTD, then DwPCH, P-CCPCH ,and DPCH are transmitted from the same antenna within the same sub-frame as shown in figure [F3].

5.5.3.2 Block STTD transmission Scheme for P-CCPCH

A block diagram of the Block STTD transmitter is shown in figure [F4]. Before Block STTD encoding, channel coding, rate matching, interleaving, and bit-to-symbol mapping are performed as in the non-diversity mode.

Block STTD encoding is separately performed for each of the two data fields present in a burst (each data field contains N data symbols). For each data field at the encoder input, 2 data fields are generated at its output, corresponding to each of the diversity antennas. The Block STTD encoding operation is illustrated in figure [F5], where the superscript * stands for complex conjugate. If N is an odd number, the first symbol of the block shall not be STTD encoded and the same symbol will be transmitted with equal power from both antennas.

After Block STTD encoding both branches are separately spread and scrambled as in the non-diversity mode.

The use of Block STTD encoding will be indicated by higher layers.

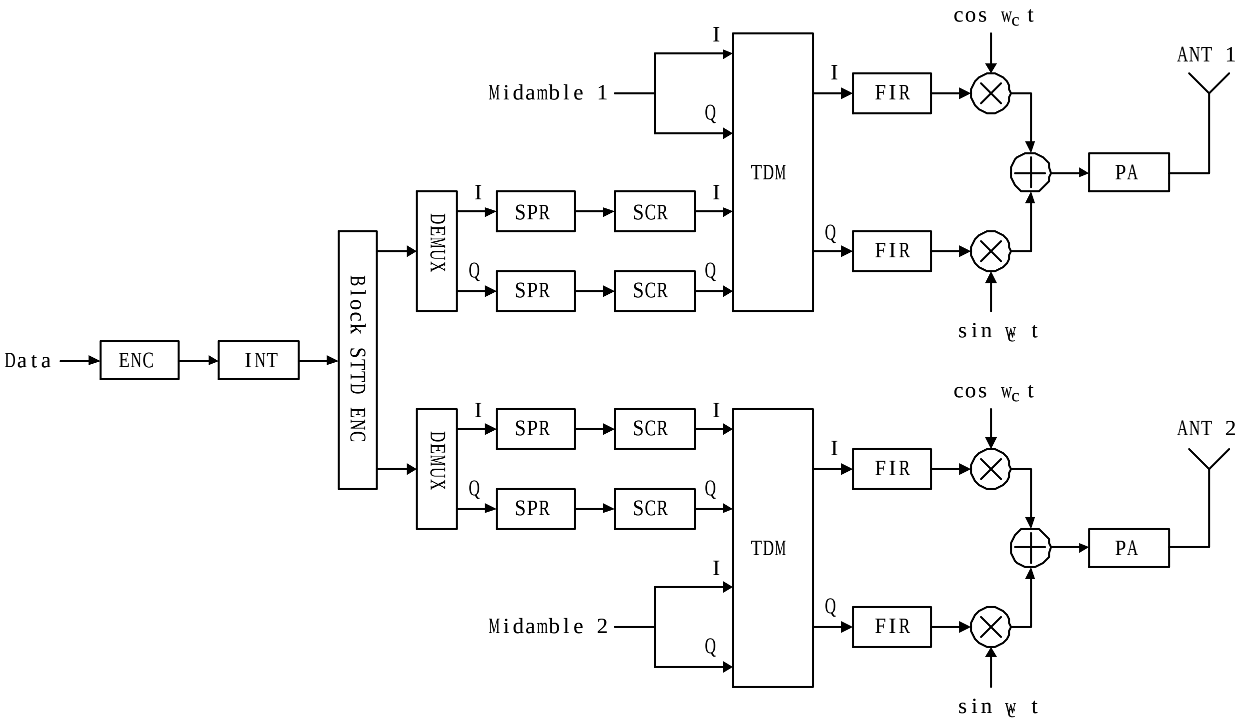

Figure [F4]: Block Diagram of the Block STTD transmitter in 1.28Mcps TDD

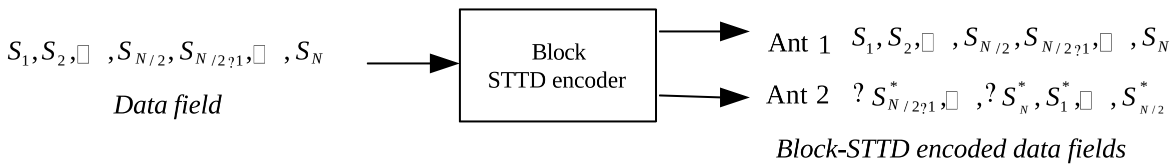

Figure [F5]: Block STTD encoder in 1.28Mcps TDD, the S_i are QPSK symbols and N is the length of the block to be encoded

5.5.4 Transmit Diversity for S-CCPCH

Time Switched Transmit Diversity (TSTD) or Block Space Time Transmit Diversity (Block STTD) may be employed as transmit diversity scheme for the Secondary Common Control Physical Channels (S-CCPCH). If transmit diversity is employed for P-CCPCH, the same transmit diversity scheme shall also be employed for S-CCPCH.

5.5.4.1 TSTD Transmission Scheme for S-CCPCH

TSTD transmission scheme for S-CCPCH is the same as the TSTD transmission scheme for P-CCPCH described in sub-clause 5.5.3.1.

If P-CCPCH, S-CCPCH, DPCH, and DwPCH employs TSTD, then P-CCPCH, S-CCPCH, DwPCH, and DPCH are transmitted from the same antenna within the same sub-frame as shown in figure [F3].

5.5.4.2 Block STTD transmission Scheme for S-CCPCH

Block STTD transmission scheme for S-CCPCH is the same as the transmission scheme for P-CCPCH described in sub-clause 5.5.3.2.

The use of Block STTD encoding will be indicated by higher layers.

~~5.5.3Transmit Diversity for FPACH~~