Text proposal for the working CR for 25.224 regarding 1.28 Mcps TDD

3GPP TSG RAN WG1#17 **TSGR1#17(00)-1468**

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Agenda item:	AH:1.28 Mcps TDD
Source:	Samsung
Title:	Downlink Tx Diversity Schemes for 1.28Mcps UTRA TDD
Document for:	Discussion and approval

Abstract

Downlink transmit diversity schemes are proposed for the 1.28Mcps UTRA TDD. In the proposed TSTD 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 UTRA TDD, 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 requires little changes to receive the TSTD transmitted signal. Even though the performance of TSTD may not be the best among other transmit diversity schemes mentioned above, at worst the performance of TSTD is on par with the single antenna case. Furthermore, taking advantage of the frame structure of 1.28Mcps UTRA TDD, 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 long as the system cost is concerned.

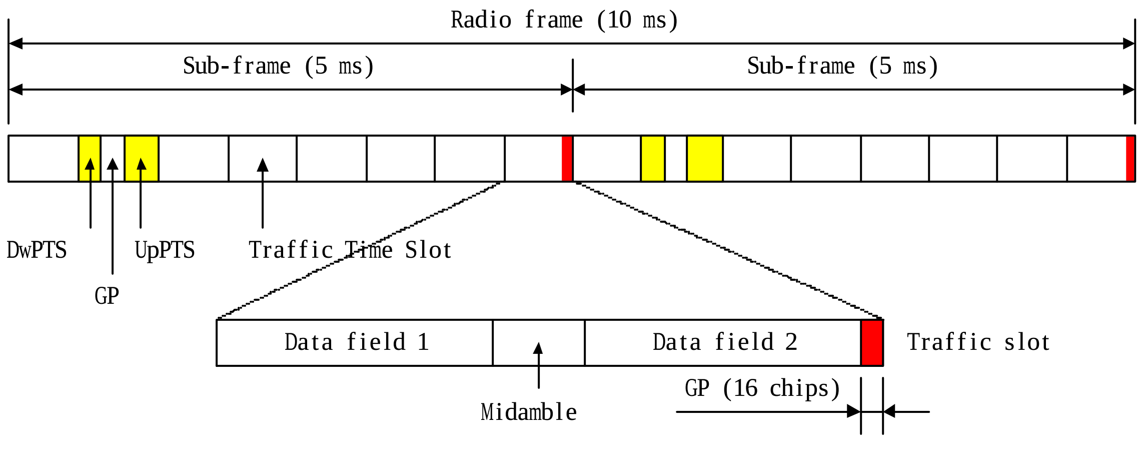

Figure 1. The frame and sub-frame structure of 1.28Mcps TDD mode.

Frame Structure of 1.28Mcps TDD mode

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

TSTD Transmission

In 1.28Mcps UTRA TDD, we can take advantage of the 12.5 ?sec guard period for TSTD transmission. Figure 2 shows an example of the structure of the proposed TSTD transmitter of 1.28Mcps UTRA TDD. 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 antennas 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.
- Negligible additional hardware cost for base station (no additional power amplifier).
- There is little impact on UE receiver structure.
- TSTD requires minimal higher layer signalling. The higher layer only need to inform the UE that TSTD scheme is used so that UE can use appropriate power control algorithm.

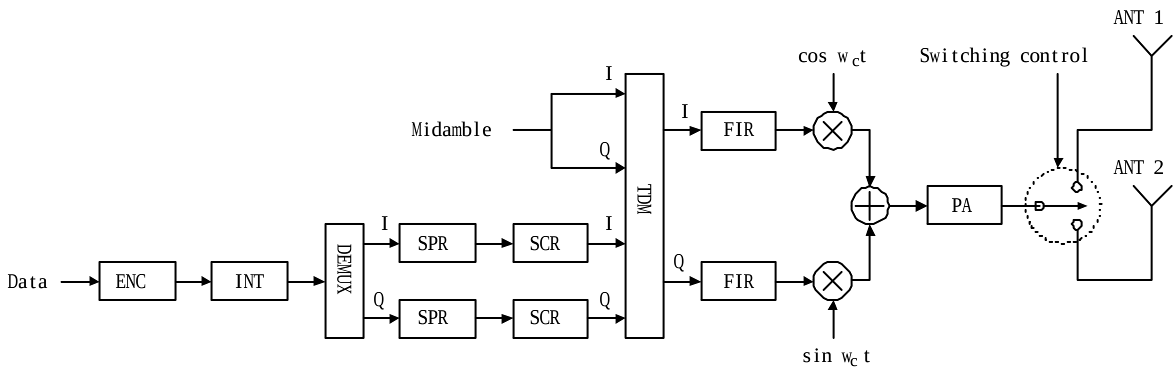

Figure 2. Transmit air-interface protocol of TSTD base-station

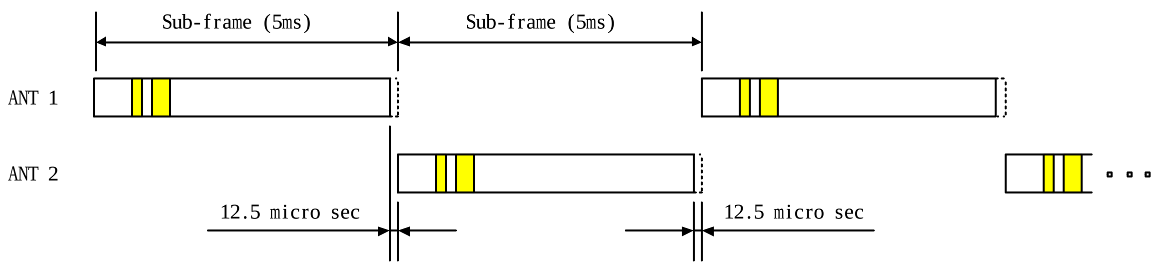

Figure 3. TSTD switching pattern utilizing sub-frame structure

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Tx Diversity and Beamforming

Depending on the capability of the base station and the characteristics of the physical channels, many different combinations of TSTD, STTD, and beamforming are possible. For DwPCH, STTD cannot be used due to its nature. For P-CCPCH, both of the STTD and TSTD can be used but beamforming cannot be used because P-CCPCH carries the broadcast channel BCH. On the other hand, beamforming as well as Tx diversity schemes such as STTD or TSTD can be used for DPCH. Table 1 summaries the possible cases of the combination of these technologies for three physical channels: DwPCH, P-CCPCH, DPCH.

Table 1. Tx Diversity and beamforming

	DwPCH	P-CCPCH	DPCH
Case 1	None	None	None or BF
Case 2	None or TSTD	STTD	BF
Case 3	TSTD	TSTD	TSTD or BF

When the base station is equipped with an array antenna, TSTD can be used with beamforming (case 2 or case 3); 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.

Uplink Synchronization with TSTD

If TSTD is used, the channel between the UE and antenna 1 and 2 are different, which may cause a different propagation delay between the odd numbered sub-frame and even numbered sub-frames. However, as shown in [1], when two separate antennas are used, more than 99% of the difference of the propagation delays between the two antennas is less than 12nsec, where 1 chip corresponds to 781.25 nsec and 1/8 chip corresponds to 97.7 nsec. Thus, even though the channel environment of the two antennas are differenct, the difference does not affect the uplink synchronization procedure of 1.28Mcps UTRA TDD.

Simulation Result

Although the performance of DPCH can be improved by using beamforming, beamforming is an optional feature and not every base station is expected to be equipted with beamforming capability because of its complexity. In that case, DPCH can be transmitted using TSTD.

Unlike common physical channels, DPCH is closed loop power controled and the closed loop power control algorithm of UE needs to be changed when TSTD is used. However, the only required change in power control algorithm is how to produce the power control command, and the basic flow of the power control procedure remains the same. Since it is assumed that the distance between antenna 1 and antenna 2 is far enough for non coherent transmission, the channel environment between the UE and antenna 1 is different from that between UE and antenna 2. Thus, because of the TSTD transmission pattern shown in figure 3, the measurement of the received signal by UE in sub-frame n and sub-frame n+1 corresponds to different antennas and channels. This feature is considered in the new power control algorithm for TSTD. The new power control algorithm uses a linear combination of the two measurements of the received signal power in two consecutive sub-frames to update transmit power level. The performance of the new power control algorithm varies depending on the linear combination coefficients. Let w1 and w2 be the linear combination coefficient of the first (older of the two) and second (more recent) measurements, respectively. Two extreme cases of the linear combination coefficients are when w1 = 1, and w2 = 0, and w1 = 0 and w2 = 1. In the first case, the Rx power measurement only in sub-frame n is used to update the DL transmit power in sub-frame n+2. Thus Rx power measurement from antenna 1 is used to update the Tx power of antenna 1, and the Rx power measurement from antenna 2 is used to update the Tx power of antenna 2. In the second case, the Rx power measurement from antenna 1 is used to update the Tx power of antenna 2, and vice versa. In general, w1 > 0 and w2 > 0 can be used as the linear combination coefficients, where w1 + w2 = 1. In the following, simulation results are presented to show the performance of TSTD with closed loop power control in comparison with a single antenna case. The simulation parameters used are as follows.

Target FER	1%
Channel	1-path fading
Service	12.2kbps voice
Channel coding	1/3 convolutional coding
Channel estimation	Ideal channel estimation

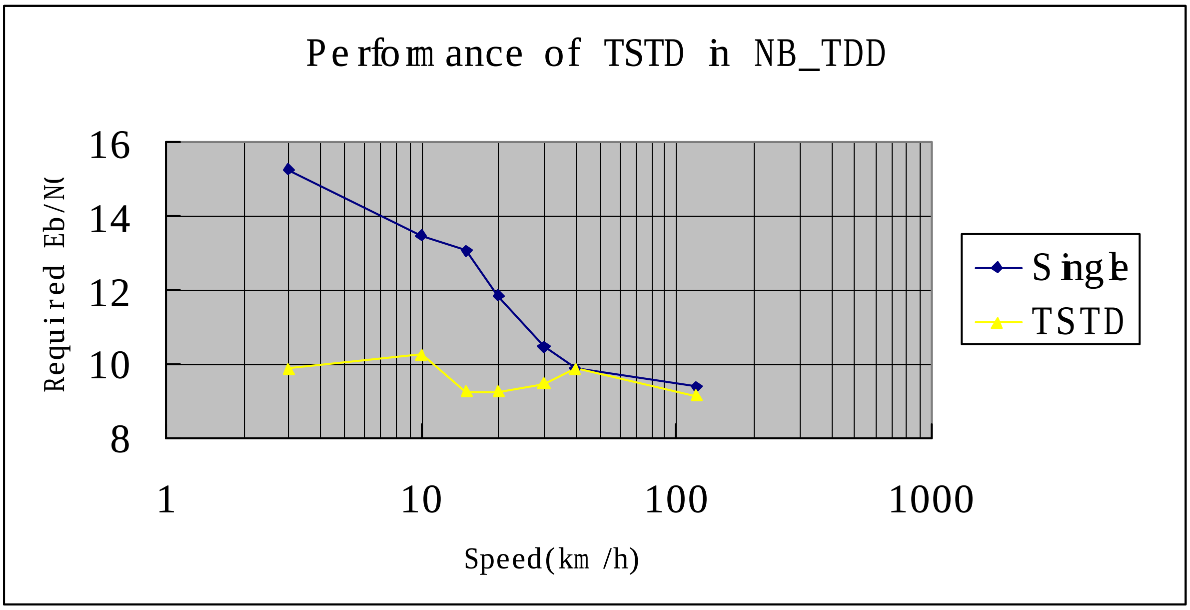

Figure 5. The performance of TSTD with DL closed loop power control: Required Ec/Ior vs. Speed

Figure 5 and 6 show the simulation result.

Figure 5 shows required Ec/Ior vs. mobile speed.

- When no transmit diversity scheme is used (marked "Single", meaning single antenna), the required Ec/Ior for the target FER of 1% decreases as the speed increases. This is due to the interleaving and convolutional coding gain.
- When TSTD is used, the new power control algorithm is used. Figure 5 shows the results when two consecutive Rx power measurements are combied to produce the power control command (marked "TSTD"). As shown in the figure, the new power control algorithm has the better performance for all velocity ranges; more than 5dB performance gain at low speed, and about the same performance above 40km/h. Since the channel environments from the two antennas to the UE are different, when TSTD is used, the probability of loosing both of the two consecutive sub-frames is lower than single antenna case, and hence the probability of recovering the data is higher, which leads to smaller required transmit power for the base statation at low speed. On the other hand, at high speed, because of the interleaving and coding gain, the effect of transmit diversity gain is relatively small and thus the overall performance of TSTD scheme is about the same as the single antenna case.

Figure 6 shows the FER vs. Ec/Ior at the mobile speeds of 3Km/h and 10Km/h.

- At the mobile spped of 3Km/h (blue & pink), on the FER = 2E-02, the performance of TSTD (pink) has more than 5dB gain compared to a single antenna case (blue). The figure shows that the gain increases with Ec/Ior, which is an expected result because TSTD has higher order diversity than single antenna case.
- At the mobile spped of 10Km/h (yellow & skyblue), on the FER = 1E-01, the performance of TSTD (skyblue) has about 2dB gain compared to a single antenna case (yellow).

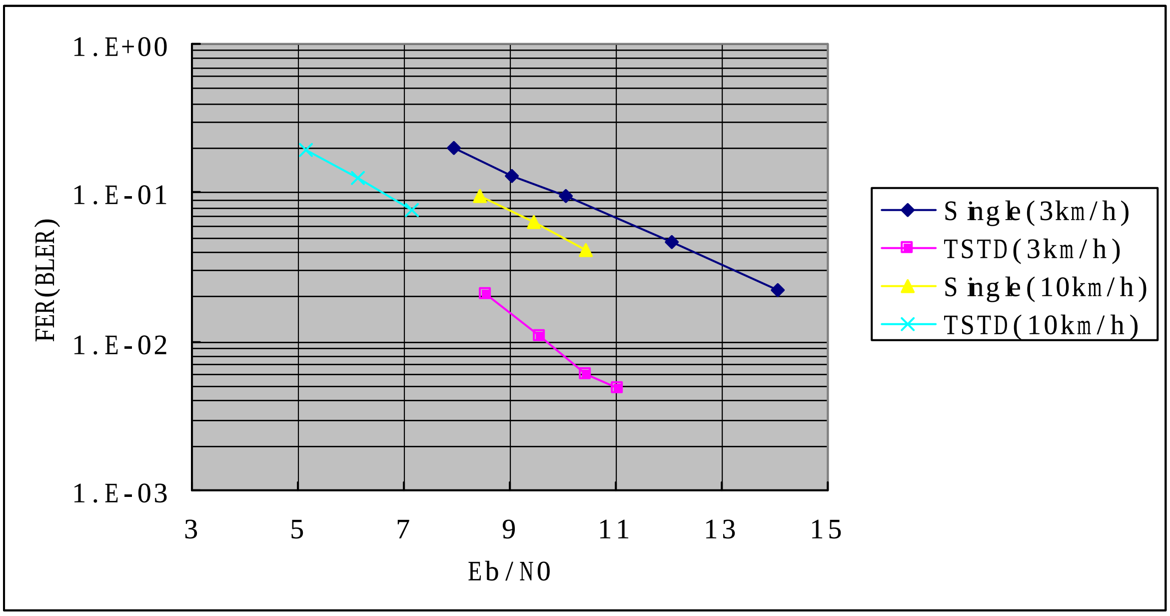

Figure 6. The performance of TSTD with DL closed loop power control: FER (BLER) vs. Ec/Ior

Note: I_{or} is the total transmitted power density by a BTS. Since the base statation has a fixed amount of power determined by the BTS power amplifier size, it is the average transmit (often called allocated) power by the BTS to the MS that determines the user capacity of the forward link. This fraction of the allocated power is called average traffic channel *Ec/Ior* and is inversely propotional to the forward link capacity [2].

Conclusion

We propose a TSTD scheme for downlink physical channels of 1.28Mcps UTRA TDD. The proposed scheme utilizes the sub-frame structure of 1.28Mcps UTRA TDD. The proposed scheme obtains a Tx diversity gain with little extra hardware complexity of RF switch and additional antenna of the base station, and the receiver structure of the UE requires minor change for the generation of DL TPC command.

Some simulation results are included to show the performance gain of the TSTD scheme for Dedicated channel with closed loop power control.

The following is the proposed text for the working CRs for TS 25.221 and TS 25.224.

Reference

[1] SMG2 UMTS-L1 317/98, "Complexity requirements of OTD and TSTD", Motorola.

[2] Physical Layer Aspects of UTRA High Speed Downlink Packet Access, TSGR1#16(00)1306, Pusan, Korea, Oct. 10 – 13, 2000.

---------------------------- Beginning of the proposed changes of the working CR for 25.221 ---------------------------------

6.4 Transmit Diversity for DL Physical Channels

Table X1 summarizes the different transmit diversity schemes for different downlink physical channel types in 1.28Mcps TDD that are described in [9].

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Table X1: Application of Tx diversity schemes on downlink physical channel types in 1.28Mcps UTRA TDD
"X" – can be applied, "–" – must not be applied

Physical channel type	Open loop TxDiversity		Closed loop TxDiversity
	TSTD	Block STTD	
P-CCPCH	–	X	–
DwPCH	X	–	–
FPACH	–	–	X
DPCH	–	–	X

Physical channel type	Open loop TxDiversity		Closed loop TxDiversity
	TSTD	Block STTD	
P-CCPCH	X	X	–
DwPCH	X	–	–
DPCH	X	–	X

~~Note: Closed loop transmit diversity for the FPACH makes use of the UpPCH~~

---------------------------------- End of the proposed changes of the working CR for 25.221 --------------------------------

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5.5 Downlink Transmit Diversity for 1.28 Mcps UTRA TDD

5.5.1 Transmit Diversity for DPCH

Closed loop Transmit Diversity or Time Switched Transmit Diversity (TSTD) may be employed as transmit diversity scheme for downlink DPCH.

5.5.1.1 TSTD for DPCH

TSTD can be employed as transmit diversity scheme for downlink DPCH. An example for the transmitter structure of the TSTD transmitter 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. Then, after pulse shaping, modulation and amplification, DPCH is transmitted from antenna 1 and antenna 2 alternately every sub-frame. Not all DPCH in the sub-frame need to be transmitted on the same antenna and not all DPCH within a sub-frame have to use TSTD. Figure [F2] shows an example for the antenna switching pattern for the transmission of DPCH for the case that all physical channels are transmitted with TSTD and are using the same antenna in the sub-frame.

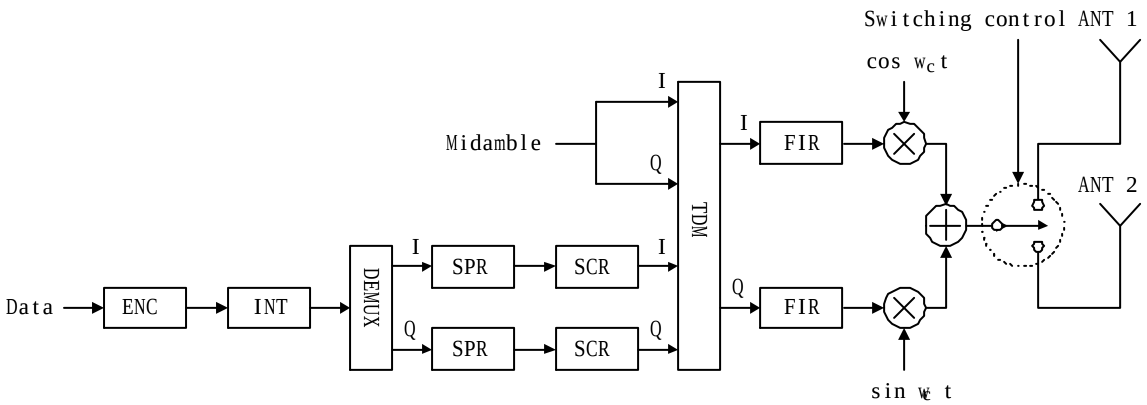

Figure [F1]: Example for TSTD Transmitter structure for DPCH and P-CCPCH.

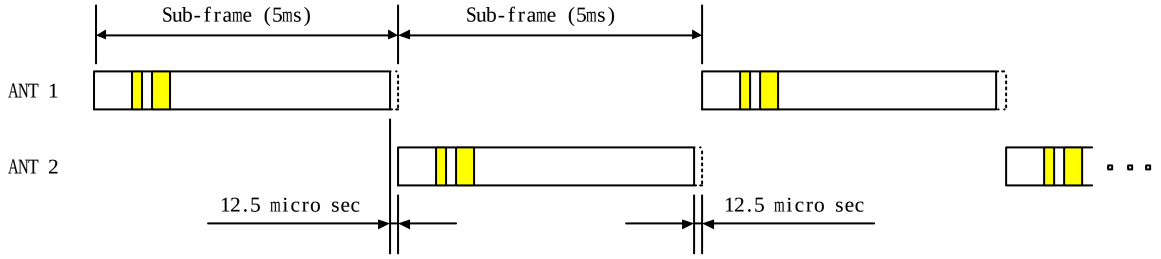

Figure [F2]: Example for the antenna swithing pattern for TSTD transmission of DPCH and P-CCPCH: all physical channels are transmitted with TSTD and are using the same antenna in the sub-frame.

5.5.1.2 Closed Loop Tx Diversity for DPCH

The transmitter structure to support transmit diversity for DPCH transmission is shown in figure [F3]. 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 w1 and w2. The weight factors are complex valued signals (i.e., wi = ai + jbi), in general. These weight factors are calculated on a per slot and per user basis.

The weight factors are determined by the UTRAN.

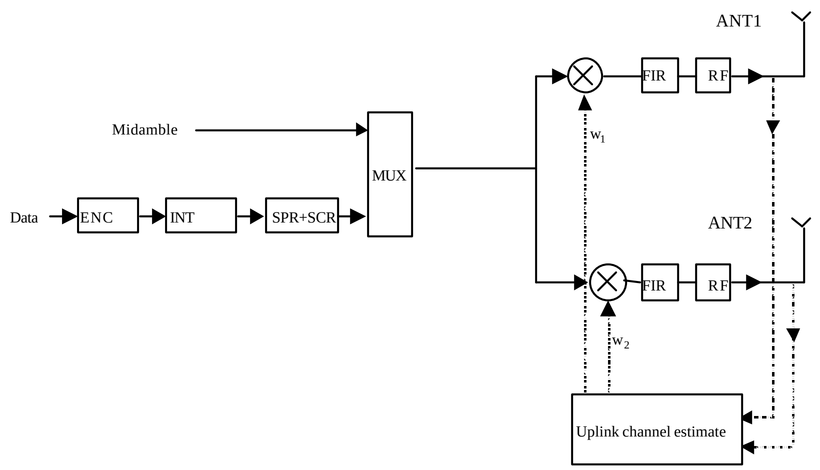

Figure [F3]: Downlink transmitter structure to support Transmit Diversity for DPCH transmission (UTRAN Access Point) in 1.28Mcps TDD

5.5.2 Transmit Diversity for DwPCH

The transmitter structure to support transmit diversity for DwPCH transmission is shown in figure [F4]. DwPCH is transmitted from antenna 1 and antenna 2 alternatively.

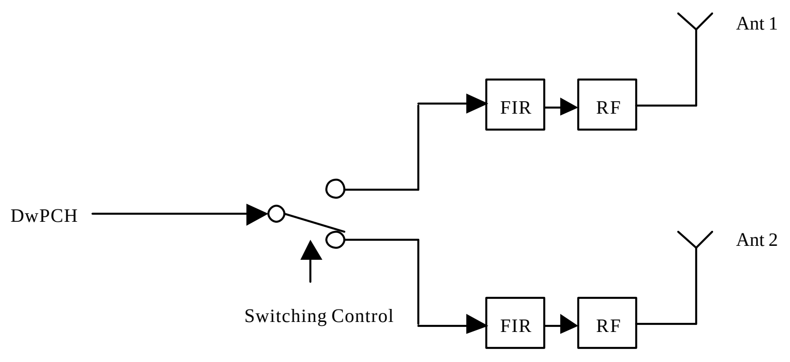

Figure [F4]: Downlink transmitter structure to support Transmit Diversity for DwPCH transmission (UTRAN Access Point) in 1.28Mcps TDd

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

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

5.5.3.1 TSTD Transmission Scheme for P-CCPCH

A block diagram of an example of a 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 [F2].

5.5.3.2 Block STTD Transmission Scheme for P-CCPCH

The open loop downlink transmit diversity employs a Block Space Time Transmit Diversity scheme (Block STTD).

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A block diagram of the Block STTD transmitter is shown in figure [F5]. 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 [F6], 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.

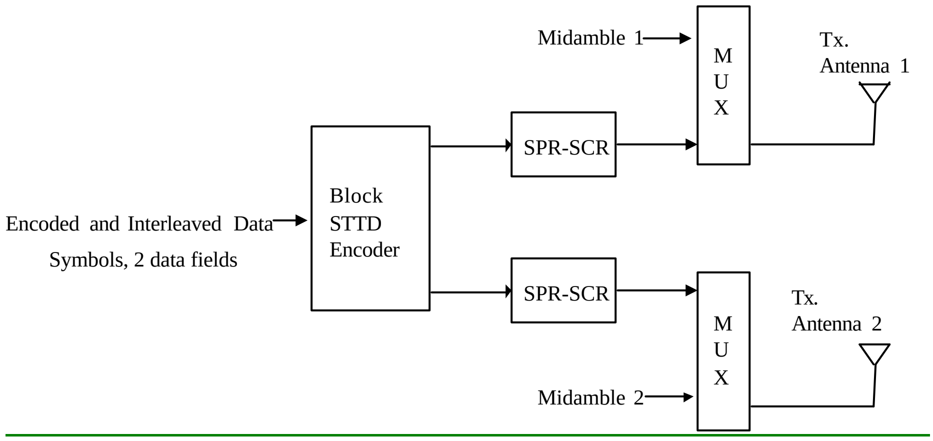

Figure [F5]: Block Diagram of the transmitter (STTD) in 1.28Mcps TDD

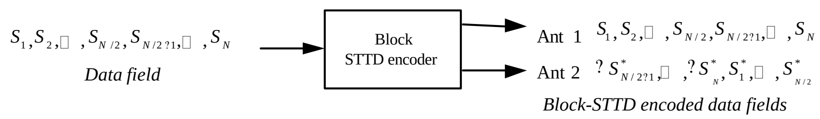

Figure [F6]: Block Diagram of Block STTD encoder in 1.28Mcps TDD. The symbols S_i are QPSK. N is the length of the block to be encoded

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