An alternative scheme to detect the STTD encoding of PCCPCH

Texas Instruments
March 16th, 1999

1.0 Introduction

In [1] it was proposed that STTD encoding be done on the data symbols of the PCCPCH. The most important issue in doing this is, how would the mobile determine the presence/absence of the diversity antenna during power on and soft handoff. A blind detection scheme based on detecting the diversity antenna pilot symbol pattern was presented in [1]. However it turns out that the time taken to reliably detect the diversity antenna is quite long, it being 30 msec. for a Doppler of 200 Hz. and 250 msec. for 5 Hz Doppler.

In order to reduce the time taken by the mobile to detect the diversity antenna, we propose that an L3 message (1 bit) be transmitted on the broadcast channel (BCH), once every frame of BCH (20 msec.), indicating the presence/absence of the diversity antenna. The PCCPCH is STTD encoded in case the diversity antenna is present at the base station. Even though the mobile does not know whether the diversity antenna is present/absent, it STTD decodes the PCCPCH and receives the L3 message, by *apriori* assuming the presence of the diversity antenna. In the case of the diversity antenna being absent, it is equivalent to assuming extra fingers in the maximal ratio combiner (MRC), and it leads to a very small degradation only for demodulating the L3 message. Once the L3 message is received, the mobile switches over to receiving the BCH with no STTD decoding. *Thus there is no loss in forward link capacity of no diversity systems.* On the other hand, the diversity gain by STTD encoding the PCCPCH is 3 dB. This implies that if the PCCPCH requires a 5%, 10% of the total base station power for no-diversity systems, the STTD encoded PCCPCH power can be reduced to 2.5%, 5% of the total base station power respectively. This leads to a forward link capacity gain of about 2.5%, 5% by STTD encoding the PCCPCH.

Thus, there are significant forward link capacity gains by STTD encoding the PCCPCH (2.5%-5%). Further, the presence/absence of the diversity antenna can be detected by STTD decoding the L3 message on BCH with no loss in capacity for no-diversity systems. Hence, we propose that STTD encoding should be done on the PCCPCH channel. Notice that the above scheme is used both during power-on and soft handoff. No other side information is provided by the network to the mobile about presence/absence of the diversity antenna of neighboring base stations.

2.0 Proposed STTD encoding for 3Gpp

Table 1 gives the proposed STTD encoding for 3Gpp channels

STTD encoding: Primary SCH	No
STTD encoding: Secondary SCH	No
STTD encoding: Data symbols of PCCPCH (N_{data} = 5 symbols)	Yes
STTD encoding: SCCPCH (N_{data} = 36 symbols)	Yes
STTD encoding: DPCH channels	Yes
L3 message (1 bit) on BCH indicating presence/ absence of diversity antenna every frame of BCH (20 msec.)	Yes
Side information by the network indicating presence/ absence of the diversity antenna for neighboring base stations (during soft handoff)	No

Table 1: Proposed STTD encoding for different physical channels

We propose to STTD encode the N_{data} symbols on the PCCPCH as shown in figure 1. The diversity antenna pilot symbol pattern for the Perch channel (PCCPCH) is given in table 2 and the same pattern can be used when using feedback antenna diversity on DPCH.

Figure(1): STTD encoding of the data symbols of the PCCPCH is shown.

	Diversity antenna pilot pattern for Perch channel			
Symbol #	0	1	2	3
Slot # 1	11	11	00	00
2	11	11	00	10
3	11	01	00	10
4	11	10	00	10
5	11	10	00	00
6	11	10	00	00
7	11	01	00	11
8	11	10	00	10
9	11	11	00	11
10	11	01	00	10
11	11	11	00	01
12	11	01	00	10
13	11	00	00	10
14	11	10	00	11
15	11	01	00	11
16	11	00	00	11

Table 2: Pilot symbol pattern for the diversity antenna when STTD encoding is used for the N_{data} symbols of the Perch channel (PCCPCH). Notice that the pilot symbol pattern is the same as the feedback systems.

3.0 Transmit diversity detection

3.1 Diversity antenna detection during power on

As given in table 1, the transmit diversity information is sent as an L3 message (1 bit) on the BCH. The question would be, how should the mobile demodulate the Perch channel (PCCPCH) when it does not know whether transmit antenna diversity is being used on PCCPCH or not? ***Notice that the only impact of wrongly assuming that PCCPCH is STTD encoded, is the increased number of rake fingers in the maximal ratio combiner (MRC).*** Hence the mobile can start demodulating the PCCPCH to receive the L3 message, assuming that it is STTD encoded.

Let us now first consider the no-diversity (ND) systems. The STTD decoding of the ND transmitted PCCPCH signal leads to a slight degradation due to the extra interference from the additional fingers. Figure 1 illustrates that this degradation, with WMSA channel estimation, is about 0.2-0.4 dB for a 5 Hz. indoor-to-outdoor pedestrian channel. However, notice that the above degradation only occurs while receiving the L3 message for the presence/absence of the diversity antenna. *Since the L3 message is transmitted once every frame (20 msec.) on the BCH, the mobile can receive more than one frame to improve the detection probability, while not significantly increasing the time required to detect the presence/absence of the diversity antenna. Once the mobile has received the L3 message successfully and it finds out that the diversity antenna is indeed absent, it starts receiving the BCH channel in the normal way with no STTD decoding.* Thus there is no loss in capacity for no-diversity systems, by STTD decoding the PCCPCH to receive the L3 message indicating the presence/absence of the diversity antenna.

Now let us consider the case when the diversity antenna is present. The STTD encoding gives a diversity gain of 3.0 dB for a 5 Hz. indoor-to-outdoor pedestrian channel and 0.6 dB for the 200 Hz (table 4 of [2]) vehicular channel, over a no-diversity (ND)

transmission for DPCH channels. Similar gains are expected for the STTD encoding of the PCCPCH channel. Since the 200 Hz. case requires a significantly less Eb/N0 than the 5 Hz. case, we can assume that the PCCPCH power can be reduced by 3.0 dB upon STTD encoding. For a 5%, 10% PCCPCH power for no-diversity systems, the PCCPCH now requires only 2.5 %, 5% of the total base station power. This leads to a capacity gain of 2.5%-5% for the STTD encoded PCCPCH systems over no-diversity for PCCPCH systems.

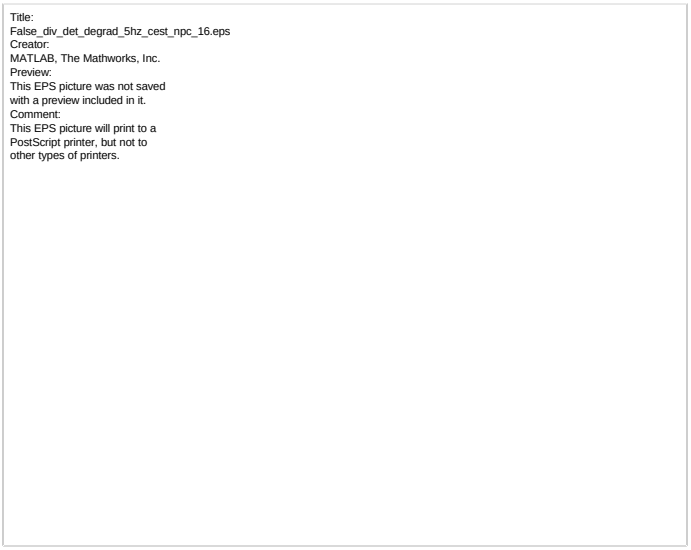

Figure 1: Comparison of normal and STTD decoding of single antenna transmission, for a Doppler of 5 Hz. and indoor-to-outdoor pedestrian channel, including WMSA channel estimation.

3.2 Diversity antenna detection during soft hand off

During soft handoff also, the mobile can use the above scheme of STTD decoding the PCCPCH of the neighboring base station and receive the L3 message to determine whether transmit diversity is being used by the new base station. *Thus, no side information from the current base station about the presence/absence of the diversity antenna for neighboring base stations is required.*

4.0 Conclusions

A summary of the issues involved in STTD encoding the PCCPCH is given.

Diversity antenna detection (during power on)	***Receiving L3 message in BCH by STTD decoding the PCCPCH.***
Diversity antenna detection (during soft handoff)	***Receiving L3 message in BCH by STTD decoding the PCCPCH.***
Impact of STTD decoding the PCCPCH to receive the L3 message indicating diversity antenna presence/absence (on no-diversity systems)	***May have to receive more than 1 frame, hence slightly increased detection time. No impact on forward link capacity of no-diversity system.***
Forward link capacity gains by STTD encoding the PCCPCH	***2.5%-5%***

Thus the mobile can determine the presence/absence of the diversity antenna by directly STTD decoding the BCH to receive the L3 message indicating the presence/absence of the diversity antenna. The only impact on no-diversity systems by doing this, is slightly increased time to receive the L3 message reliably. However, there is no loss in capacity of no-diversity systems. On the other hand, the forward link capacity gain by STTD encoding the PCCPCH is 2.5%-5%, for a nominal PCCPCH power of 5%, 10% of the total base station power for no-diversity systems.
Thus, the improved forward link capacity gains (2.5%-5%), and the fact that the diversity antenna detection can be done with no loss to no-diversity systems, justifies the STTD encoding of the PCCPCH channel.

References:

[1] Texas Instruments, “STTD encoding for PCCPCH”, Tdoc 83/99, 3Gpp RAN WG1#2, February 22nd – 26th 1998, Yokohama, Japan.
[2] Texas Instruments, “Additional results on space time block coded transmit antenna diversity for WCDMA”, Tdoc 25/99, ETSI SMG2 UMTS-L1, 18-20 January 1999, Espoo, Finland.