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Fast reliable detection of STTD encoding of PCCPCH with no L3 messaging overhead

Texas Instruments, April 13, 1999

Summary:
As has been discussed previously in WG1 #2, 3 one of crucial issues in STTD encoding of PCCPCH is how would the mobile determine the presence/absence of STTD encoding of PCCPCH. In [1] T.I. presented a blind detection scheme which searched for the pilot pattern on the diversity antenna. This scheme does not require any overhead L3 message on the broadcast channel (BCH) but has the drawback of long detection time (upto 250 msec. for 5 Hz. Doppler). Hence T.I. proposed an alternative scheme [2] to send a 1 bit of layer 3 (L3) information on the BCH indicating the presence/absence of the diversity antenna. The mobile apriori assumes the presence of STTD encoding on PCCPCH and decodes the 1 bit information on the BCH (by going through the Viterbi decoder) to determine whether the diversity antenna is present or not. This scheme was accepted by the Adhoc 6 and the plenary of WG 1 # 3 held in Nynashamn, Sweden, March 1999. In the above scheme the mobile can reliably determine the presence/absence of the diversity antenna in a short amount of time (1 to 2 frames duration of BCCH = 20-40 msec.). However the scheme has a drawback of requiring the overhead of L3 messaging and the mobile having to go through the Viterbi decoder to decode the 1 bit information sent on the BCH.
Hence, it will be preferred if it is possible to determine the presence/absence of the diversity antenna without the transmission of the L3 message and without the long detection time of the blind detection. ***In this proposal we propose an alternative technique which will not need any L3 message transmission on BCH and also will not require the long detection time of the blind detection.***
The idea is to transmit a ***+1/–1*** pattern on the primary (PSC) and secondary synchronization code (SSC) of the synchronization channel (SCH) to indicate the ***presence/absence*** of the diversity antenna. This does not impact the stages 1, 2 and 3 of acquisition at all. This scheme alos requires a ***short detection time of less than 40 msec. to reliably detect the presence/absence of the diversity antenna. Further, no L3 messaging on BCH is required and the mobile does not have to go through the Viterbi decoder.***

1.0 The proposed scheme

Figure (1) shows the current transmission of PSC and SSC when there is a single antenna for transmission.

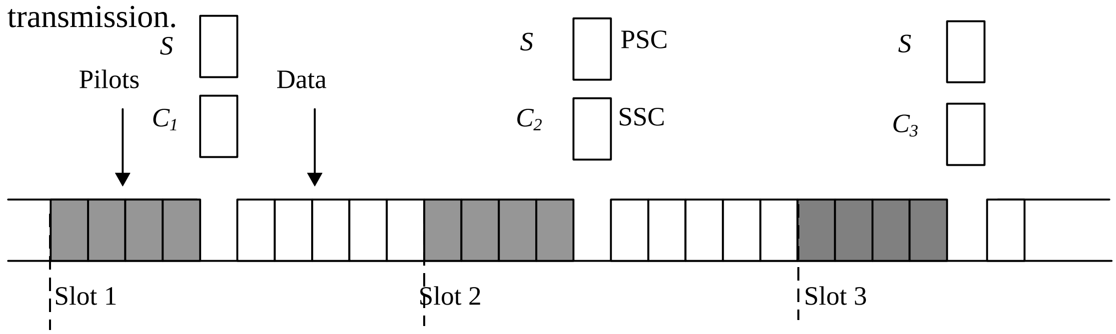

Figure 1: *The current transmission of PSC and SSC is shown for a single antenna system.No modulation is applied on the PSC and the SSC.*

A Hierarchical sequence S is transmitted on the PSC and a set of comma free codes C_i, (denote C_i, $i = 1, \ldots, 16$ to denote the time slots) is transmitted on the SSC. We now propose that the PSC and SSC be transmitted with a 1 bit modulation $a = +/- 1$, as given in the following table to indicate the presence/absence of the diversity antenna:

	Current PSC	***Proposed PSC***	Current SSC	***Proposed SSC***
Diversity antenna absent	*S*	***a S; a = -1***	C_i	***a*** C_i***; a = -1***
Diversity antenna present	*S*	***a S; a = +1***	C_i	***a*** C_i***; a = +1***

Table 2: *The new PSC and SSC to be transmitted to indicate presence/absence of the diversity antenna are given. A 1 bit modulation a = +/- 1 is transmitted on the PSC and SSC to indicate the presence/absence of the diversity antenna.*

The transmission of the PSC and SSC for a single antenna is shown in figure (2):

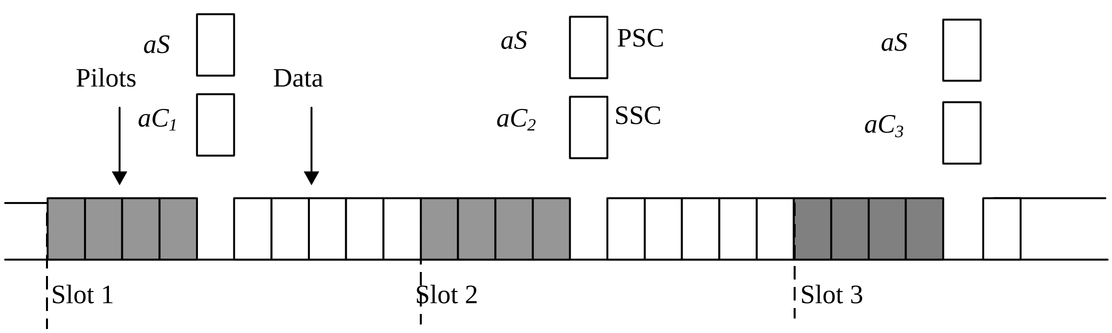

Figure 2: *The proposed transmission of PSC and SSC is shown for a single antenna system*

The exact transmission of PSC and SSC with two transmit antennas is still being discussed by RAN WG1. There is a proposal by Panasonic [3] to use time switched time diversity (TSTD) on PSC and SSC. *In case TSTD is not applied for PSC and SSC*, we propose the modulated PSC and SSC transmission as shown in figure (3). The proposed PSC and SSC as given in table (1) are transmitted from both the antennas with a 3 dB lower power. There is no diversity gain by doing this, however the advantage of this scheme over the TSTD scheme proposed by Panasonic [3] is the reduced peak to average ratio of the power amplifiers for the two antennas at the base station. In case TSTD is applied for the SCH, then the modulated PSC and SSC transmission is given in figure (4). For the purposes of analysis, when the diversity antenna is present, we assume that TSTD is actually not applied to the SCH and hence assume the modulated PSC and SSC as given in figure (3). We show that the mobile can reliably detect the presence/absence of antenna diversity by demodulating the symbol *a* modulated on the PSC and SSC. Applying TSTD to SCH further improves the probability of demodulating the symbol *a* correctly because of the increased diversity for SCH. Thus the case that we have considered, the one in figure (3), is actually the worst case as far demodulating the symbol *a* is concerned.

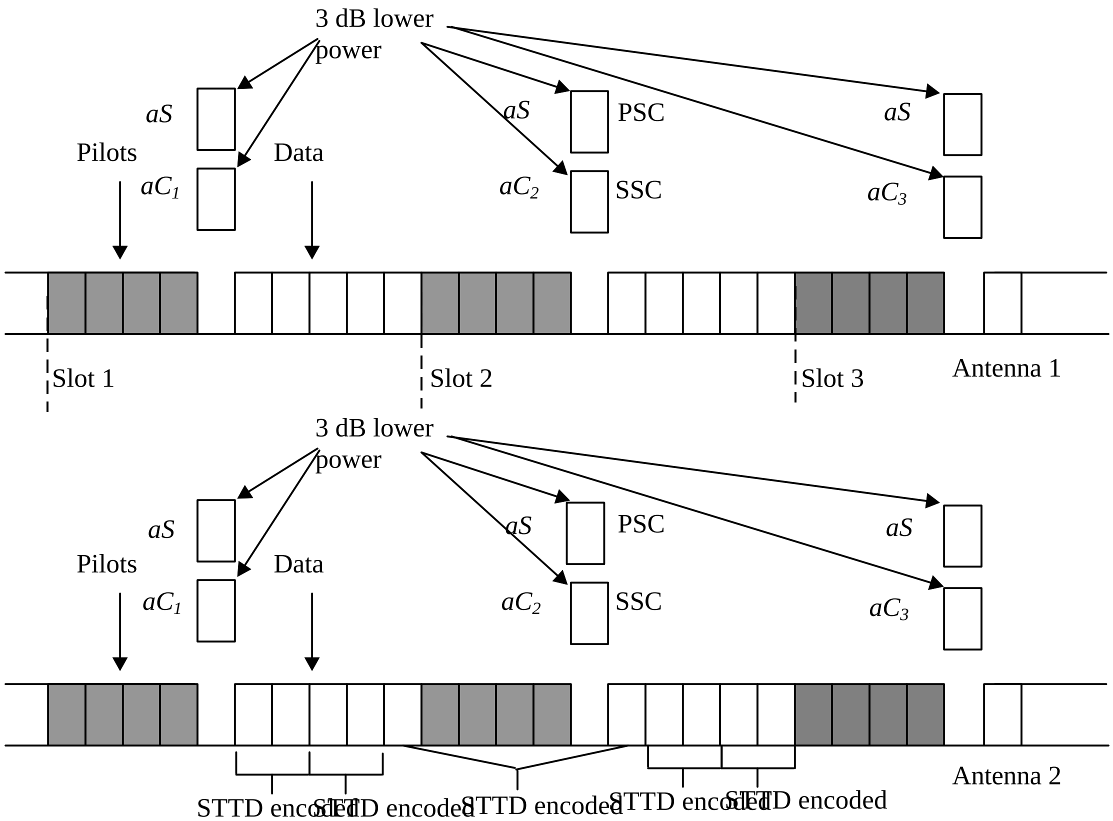

Figure (3): *The proposed modulated PSC and SSC transmission when TSTD is not used for SCH.*

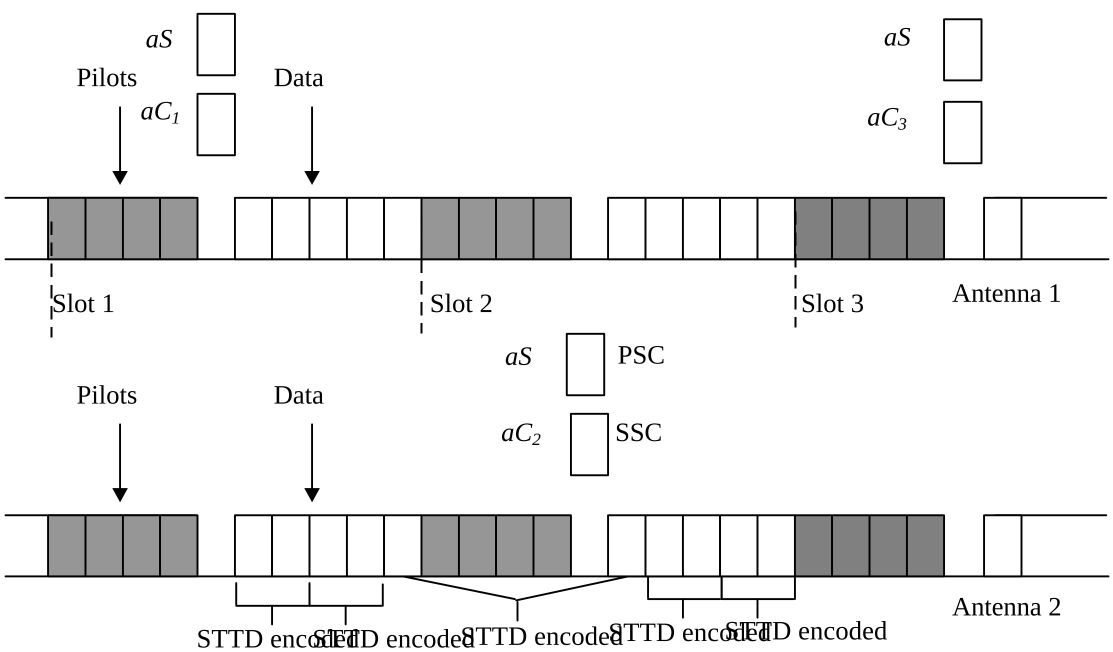

Figure 4: *The proposed modulated PSC and SSC transmission when TSTD is used for SCH.*

2.0 Impact on stages 1, 2 and 3 acquisition performance by the proposed modulation on the PSC and the SSC

The stage 1 of acquisition runs in a non-coherent fashion, and further since the same symbol value *a* is used for all the time slots (that is either +1 or –1), we can easily see that the PSC modulation given in table 1 will not affect stage 1 acquisition performance. The stage 2 of acquisition is also usually run in a non-coherent fashion. However, there is a possibility of using coherent stage 2 by using PSC to get the channel estimate for SSC. However, notice that in table 1, the same modulation symbol *a* is used for the PSC and the SSC. Hence, we can see that performance of stage 2 of acquisition is also not impacted at all, irrespective of whether it is performed coherently or non-coherently. Finally, the PSC and SSC modulation does not affect the stage 3 of acquisition, which is performed using the PCCPCH pilot and data symbols.

Thus we can see that the proposed PSC and SSC modulation does not have any impact on the stages 1, 2, and 3 of acquisition performance.

3.0 Detection of transmit diversity antenna by demodulating the modulation on the SSC

We propose that the mobile can use the following algorithm to receive the symbol *a* modulating the PSC and the SSC:

(1) The mobile does stages 1, 2 and 3 acquisition in the usual fashion without any concern of the modulating symbol *a* on the PSC and the SSC.

(2) After the long code acquisition of stage 3, the mobile does channel estimation using the pilots of the PCCPCH by *apriori assuming that the PCCPCH is STTD encoded*. If the PCCPCH is not STTD encoded, then similar to the analysis in [2], the channel estimate for the diversity antenna is only noise. In our simulations we have used a two-slot WMSA scheme for channel estimation.

(3) The mobile removes the comma free code on the SSC and derotates it using the channel estimate in step (2).

(4) The mobile now coherently sums the above derotated SSC symbols for the different paths and over several time slots *N*.

(5) The mobile now makes a decision whether the symbol *a* is +1 or –1. If the *a* is +1, it implies that STTD encoding is used on the PCCPCH and if it –1, it implies that STTD encoding is not used on the PCCPCH.

We now do the following simulation:

	Single path model	Indoor-to-outdoor pedestrian model	Vehicular model
Doppler	5 Hz. (figure 5)	5 Hz. (figure 6)	200 Hz. (figure 7)
N, number of slots for averaging	32, 64	32, 48	8, 16
Channel estimation (step 2)	2 slot WMSA from PCCPCH	2 slot WMSA from PCCPCH	2 slot WMSA from PCCPCH
PCCPCH power	Assumed 3 dB higher than SSC	Assumed 3 dB higher than SSC	Assumed 3 dB higher than SSC

Table 2: *Simulation parameters for demodulating the PSC and SSC modulation to detect STTD encoding of PCCPCH.*

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Figure 5: *The probability of error in detecting the presence/absence of the diversity antenna using the SSC modulation is shown for a single path channel and a Doppler of 5 Hz. The x-axis is the channel Eb/N0 for the SSC. Even for a SSC Eb/N0 of 0 dB we can see that with a 4 frame averaging (N = 64), the probability of error less than 2* 10^(-3).*

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Figure 6: *The probability of error in detecting the presence/absence of the diversity antenna using the SSC modulation is shown for indoor-to-outdoor pedestrian channel model and a*

Doppler of 5 Hz. The x-axis is the channel Eb/N0 for the SSC. Even for a SSC Eb/N0 of 0 dB we can see that with a 3 frame averaging (N = 48), the probability of error is less than 10^(-3).

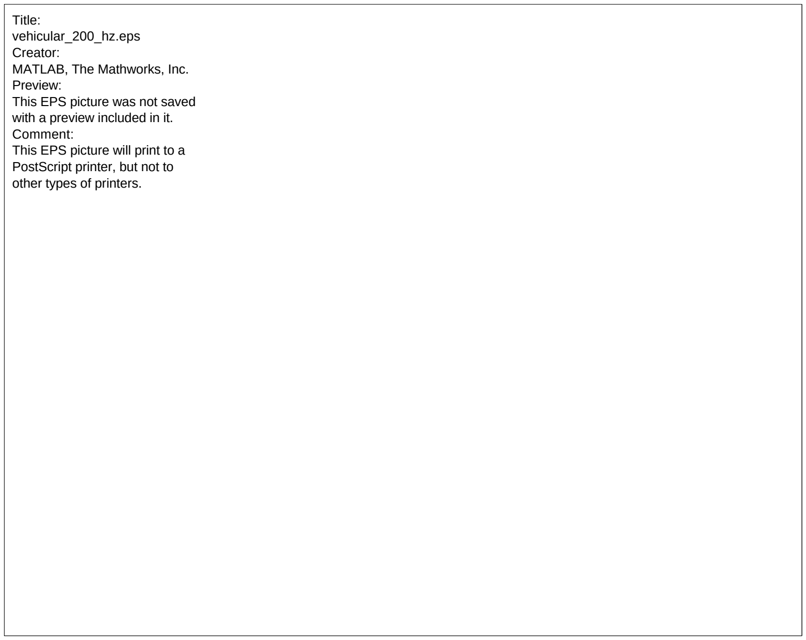

Figure 7:*The probability of error in detecting the presence/absence of the diversity antenna using the SSC modulation is shown for vehicular channel model and a Doppler of 200 Hz. The x-axis is the channel Eb/N0 for the SSC. Even for an SSC Eb/N0 of 0 dB we can see that with a simple 16 frame averaging (N = 16), the probability of error is less than 10^(-5).*

As can be seen from the simulations in figures 5,6, 7 even for a relatively low SSC Eb/N0 of 0 dB, a 40 msec. averaging gives a probability of error of less than $2*10^{-3}$ for the 5 Hz. single path channel, less than 10^{-3} for 5 Hz. indoor-to-outdoor channel and less than 10^{-5} for vehicular 200 Hz. channel.

One of the important issues in modulating the SSC, is the possible impact of two base stations colliding, by getting their SCH aligned in time. Firstly, the probability of this happening is not significant. Secondly, even if this event occurs the comma free codes on the SSC guarantee a distance of atleast 14 between the base stations over the 16 times slots. Hence the maximum degradation in the symbol *a* demodulation is expected to be 20*log10(16/14) = 1.2 dB. However, as can be seen from figures 5, 6, 7 the performance of proposed scheme is quite good. Hence a 1.2 dB loss will not have much effect in terms of increasing the probability of error in detecting the presence/absence of the diversity antenna. On the other hand, the PSC is not immune to base station collision like the SSC. Hence, we do not use the PSC modulation in detecting the symbol *a*. The only reason the PSC is modulated the same way as SSC, is to not impact any coherent stage 2 acquisition.

4.0 Conclusions

We have proposed to modulate PSC and SSC with a +1/-1 symbol to allow the mobile to detect the presence/absence of the STTD encoding of PCCPCH. Doing this does not impact the stages 1,2 and 3 of acquisition. After stage 3 of acquisition, the mobile does the channel estimation using the pilot symbols from the PCCPCH to demodulate the SSC and averages over several time slots to improve detection performance. A simple 64 slot (40 msec.) averaging simulation shows that the mobile can reliably detect the presence/absence of the diversity antenna, in a variety of different channel environments. This time is expected to further reduce, in case TSTD is used for SCH, by the added path diversity.

Thus the mobile can reliably detect the presence/absence of STTD encoding of PCCPCH in a very short time (less than 40 msec.) without any layer 3 signaling overhead on the broadcast channel (BCH).

We propose that PSC and SSC be modulated as given in table 1. We further propose that the 1 bit L3 information in BCH, as proposed in [2] to indicate the presence/absence of the diversity antenna, be not transmitted.

[1] Texas Instruments, "STTD encoding for PCCPCH", Tdoc 83/99, 3Gpp RAN WG1#2, February 22nd – 26th 1998, Yokohama, Japan.
[2] Texas Instruments, "An alternative scheme to detect the STTD encoding of PCCPCH", Tdoc 150/99, 3Gpp RAN WG1#3, 22-26th March 1999, Nyanashamn, Sweden.
[3] Panasonic, "TSTD(Time Switched Transmit Diversity) scheme for SCH", Tdoc 152/99 3GPP RAN WG1, 22-26th, March 1999, Nyanashamn, Sweden