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Source: Siemens AG
To: TSG RAN WG1
Title: Considerations about transmission and coding of uplink synchronization control (ULSC)
Document for: Discussion

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1. Introduction

This paper introduces some simulation results for low chip rate TDD for performance analysis of the uplink synchronization underlining the benefit of both 1/8 chip precision, the do-nothing symbols and the repetition of ULSC commands.

For the benefit of uplink synchronization see [1].

2. Simulation assumptions

The following channels are used for the simulations in this section.

Table : Outdoor to Indoor and Pedestrian Test Environment Tapped-Delay-Line Parameters

Tap	Channel A		Doppler Spectrum
	Rel. Delay (nsec)	Avg. Power (dB)	
1	0	0	CLASSIC
2	110	-9.7	CLASSIC
3	190	-19.2	CLASSIC
4	410	-22.8	CLASSIC
5	-	-	CLASSIC
6	-	-	CLASSIC

Speed: 3 km/h
Smart Antennas: No, (only 1 RX antenna is used)

For the modeling of uplink synchronization control a real ULSC algorithm was assumed including ULSC commands derived from erroneous measurements as well as erroneous reception of the ULSC commands in the UE.
These simulations are carried out under the assumption of full load and without ideal power control. Full load means 8 users each with 2 codes of spreading factor 16. The service in the simulation multiplexes 12.2kbps data and 2.4kbps data.
The simulations are only carried out for the user BER. The ZF-BLE was assumed to be the detector.

3. Simulation results

To access the performance of ULSC, the control precision of 1 chip, ½ chip, 1/8 chip shift was taken into account. The performance with do-nothing and without do-nothing has been evaluated in the simulation. According to the frame structure of TD-SCDMA, each user has two bursts in the same time slot, so one control symbol or two control symbols can be used to transmit the synchronization control symbols.

3.1. SC with different precision of ULSC.

In Figure 1 PC is switched off during the simulation. At the UserBer of 10^{-2} point, ULSC with a precision of 1/8 chip improves the performance by 6.9 dB compared to 1 chip precision. The performance is 3.2 dB better than if ½ precision is applied.

This result demonstrates that a 1/8-chip precision of the ULSC is advantageous and improves the performance significantly.

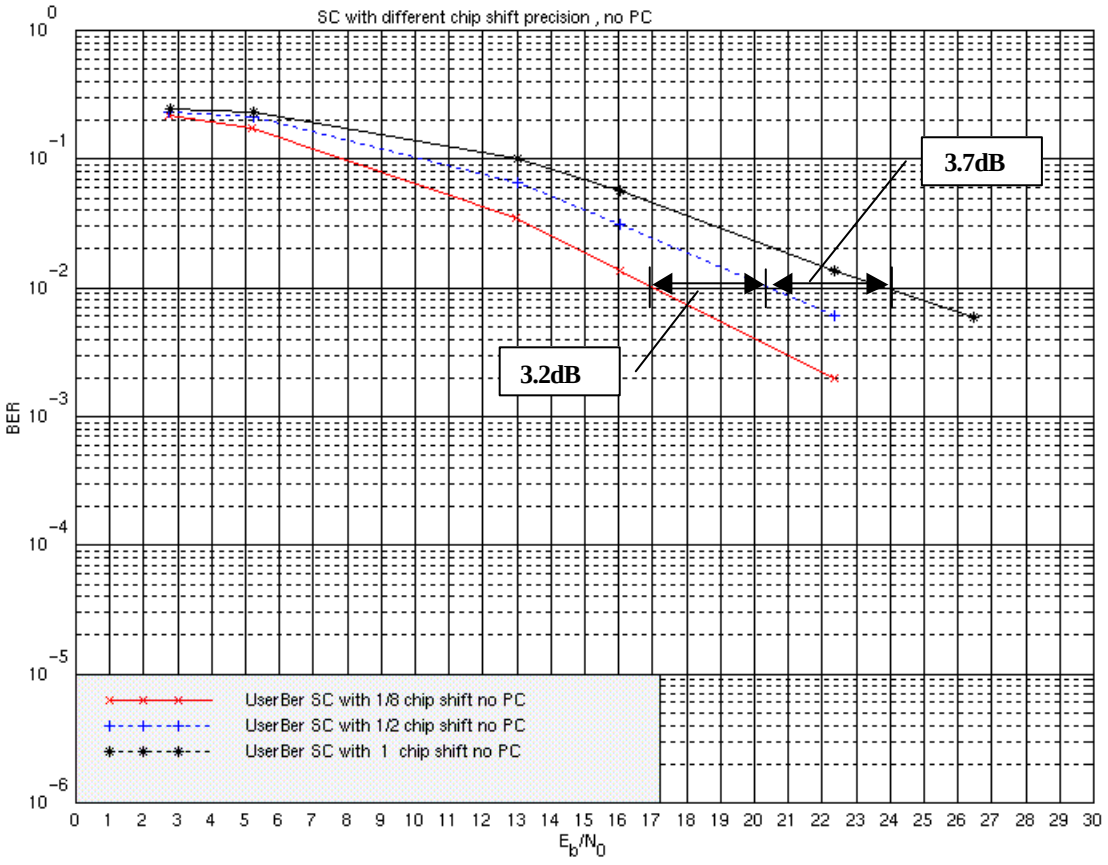


Figure 1 ULSC with different control shift precision without PC (with do-nothing symbol and a repeated ULSC command)

The raw BER and BLER results corresponding to Figure 1 are provided in the Annex.

3.2. ULSC with and without do-nothing symbols, one control symbol and two control symbol

The control algorithm decides by using two (one) threshold(s) for the generation of synchronization shift up, down (and do-nothing). There are two methods to generate the control command. One is with do-nothing symbol, the other is without do-nothing symbol. As mentioned above, the control symbols will be distorted by the mobile radio channel. Consequently the performance of the ULSC will suffer from detection errors of the ULSC commands in the UE. To figure out what is the best method to counteract these errors, two cases are simulated (with do-nothing symbol): for each user, one control symbol or two control symbols (the second is a repetition of the first) can be used to implement ULSC (since each user can has two codes). If only one control symbol is used, the reception of the control symbols is not as reliable, so the performance should be worse than that with two control symbols.
The UserBERs of the simulations with and without do-nothing symbol, and of the simulations with one control symbol and two control symbols are combined in Figure 2

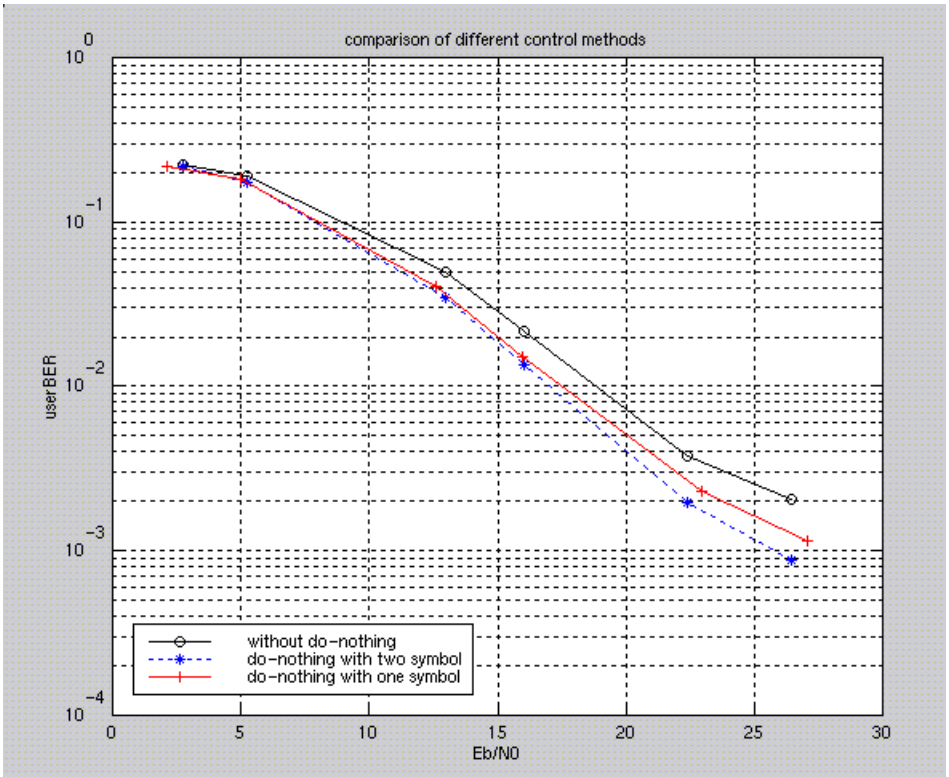


Figure 2 SC with and without do-nothing, one control symbol and two control symbols per user (1/8 chip ULSC precision and erroneous detection of ULSC commands at the UE)

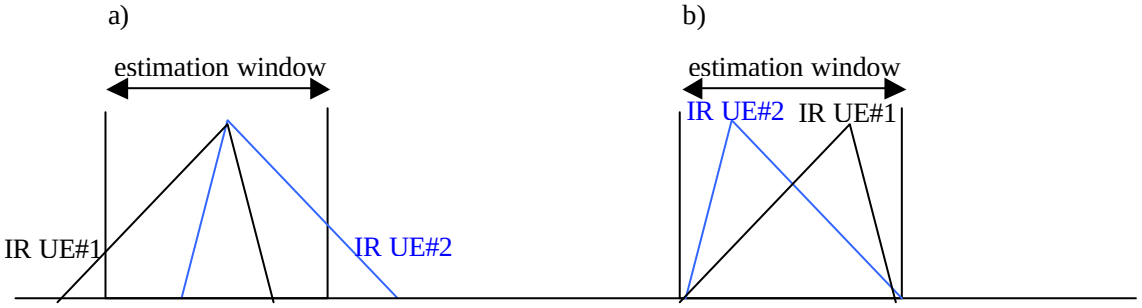
The raw BER and BLER results corresponding to Figure 2 are provided in the Annex.

From Figure 2, it becomes obvious that do-nothing symbols can improve the performance significantly. At a BER of 10^{-2}, with do-nothing (2 symbols), a gain of 1.7 dBis achieved when compared with that without do-nothing symbol. Without do-nothing, the receiver will act each burst, even though the synchronisation is already ensured. Errors will be introduced.
Two control symbols can reduce the BER. At a BER of 10^{-2}, a gain of 0.5 can be achieved when two control symbols is compared with one control symbol.

4. ULSC for UE using multiple UL time slots

It is suggested that the UEs, which have allocated multiple UL time slots, have at least a single ULSC command per time slot they use because of the following reasons:

1. The first objective of thew ULSC is to keep the channel impulse response of every user occupying that time slot with in the channel estimation window. Otherwise the channel impulse responses spill over in the adjacent channel estimation windows and a lot of interference is introduced in the detection process. In order to avoid the along going performance degradation the ULSC target (position of the strongest channel impulse response tap) of the user has sometimes to be changed such that the targets of different users are different. Figure 3 illustrates this. Here the synchronization of the users is sacrificed for the sake of interference minimization. This situation can be different in each time slot. Consequently it is necessary to have different ULSC commands for the codes in different time slots belonging to a single UE.



a) Unwanted: UE#1 and UE#2 have portions of the channel impulse response (IR) outside the channel estimation window but are synchronized
b) Wanted: IR of UE#1 and UE#2 are inside the channel estimations window, synchronization is sacrificed

Figure 3 ULSC guaranteeing that the channel impulse responses are staying within the channel estimation window

2. In case the UE has only one ULSC command for all the time slots per sub-frame and in case it has e.g. has codes in two time slots the network has to co-ordinate the ULSC in two time slots for this users. In this case it can happen, that the UE is neither synchronous in one nor in the other time slot. In order to avoid this coupling, leading to a sub-optimum performance, it is necessary to have separated ULSC commands for the individual time slots.

5. Conclusion

For mobile radio channels with severe multiple paths with full load, the slow uplink synchronization control has a big performance difference with respect to the controller precision. So 1/8 chip precision should be selected in the ULSC.
The benefit of uplink synchronization control with do-nothing shown in this paper. Even though the introduction of the do nothing symbols introduces more errors in the detection of the ULSC commands, the overall performance of the whole control loop is still improved considerably. This is why do-nothing symbols should be used for the ULSC.
It has been shown that the repetition of ULSC commands leads to an improvement of the ULSC performance. Therefore, two control symbols for each user and do-nothing should be introduced to the TD-SCDMA system whenever the allocation of the RU is allowing it..
Finally it has been discussed why it is beneficial to have separate ULSC commands for codes in separate time slots if they belong to the same user.

References

[1] R1-00-0933, “The benefit of uplink synchronization”, TSG RAN, WG1.
[2] TR 25.928, “Radio Access Network (RAN); 1.28Mcps functionality for UTRA TDD Physical Layer”, TSG RAN, WG1.

Annex

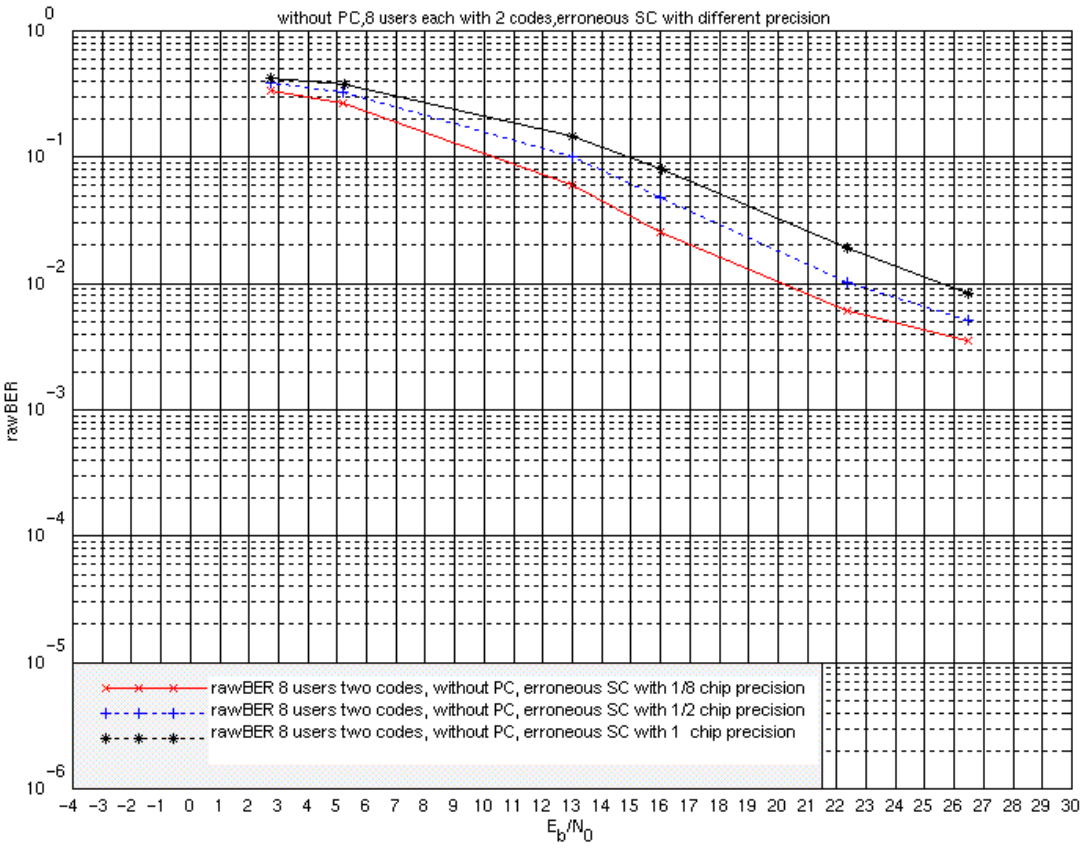


Figure 1-a ULSC with different control shift precision without PC (with do-nothing symbol and a repeated ULSC command) - raw BER

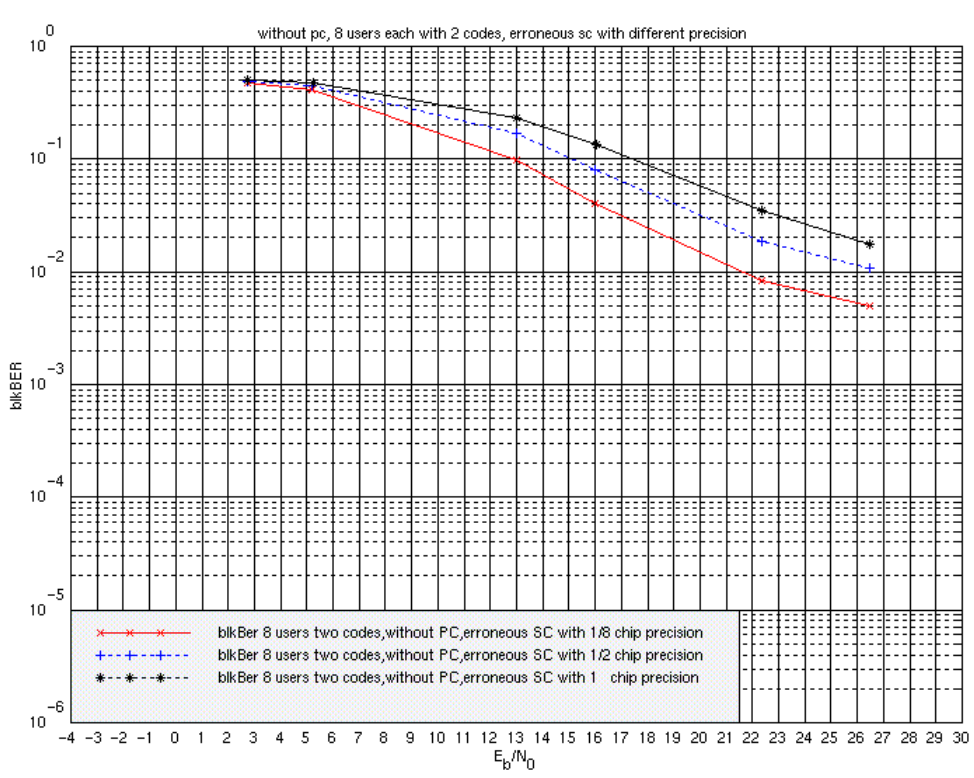


Figure 1-b ULSC with different control shift precision without PC (with do-nothing symbol and a repeated ULSC command) - BLER

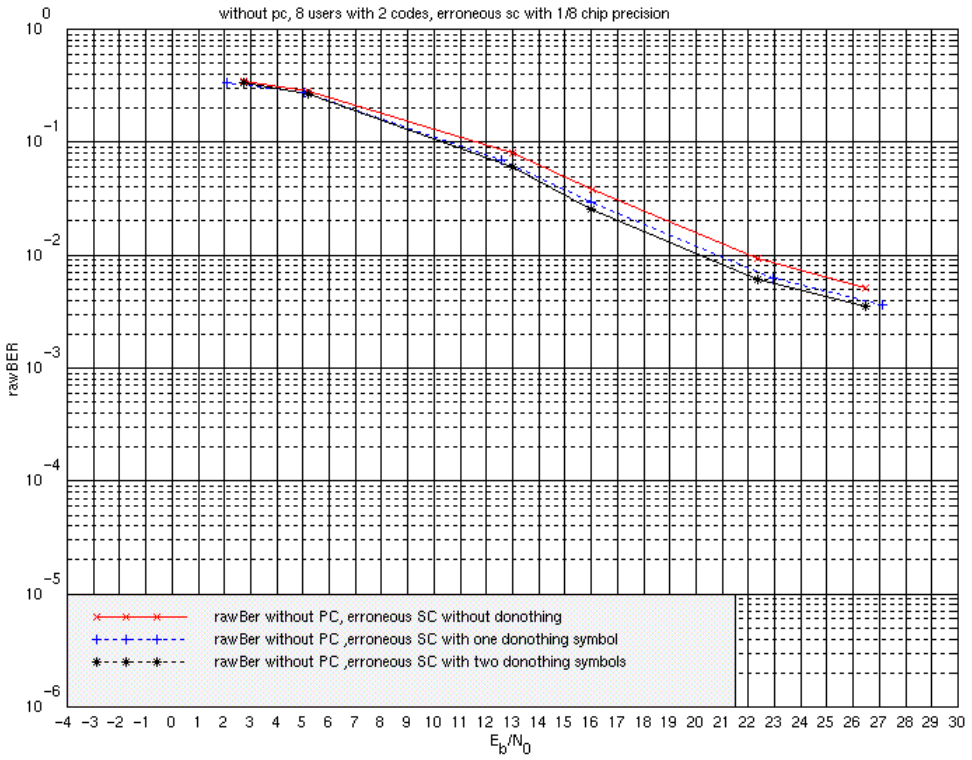


Figure 2-a SC with and without do-nothing, one control symbol and two control symbols per user (1/8 chip ULSC precision and erroneous detection of ULSC commands at the UE) – raw BER

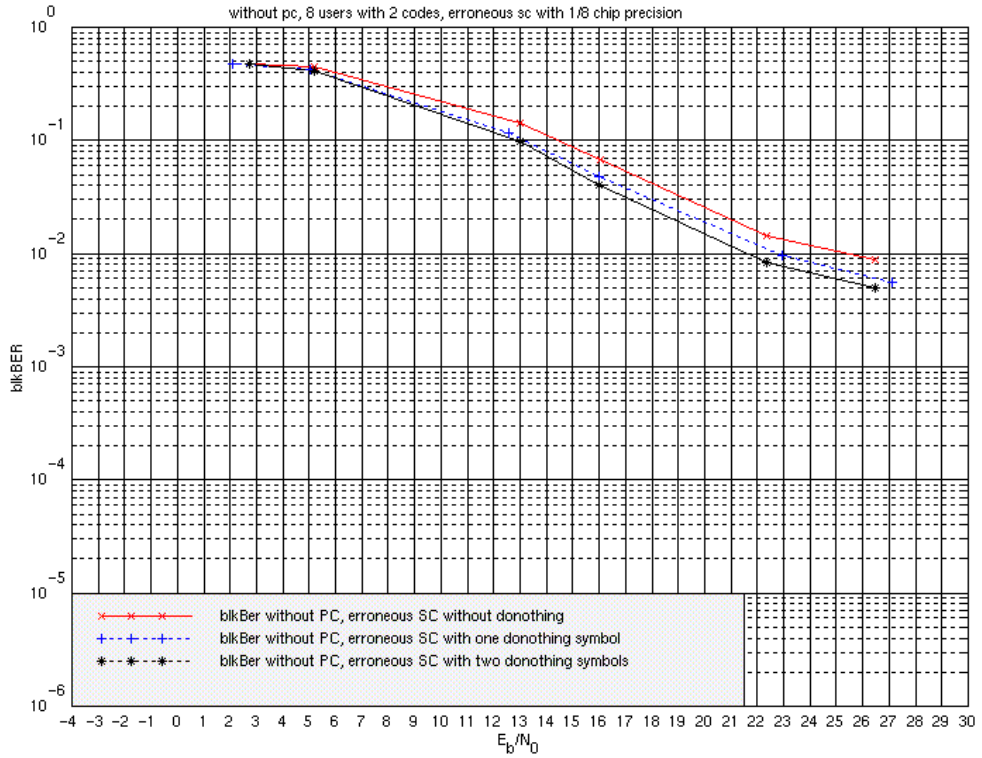


Figure 2-b SC with and without do-nothing, one control symbol and two control symbols per user (1/8 chip ULSC precision and erroneous detection of ULSC commands at the UE) – BLER