TSG-RAN Working Group1 meeting #5 **TSGR1#5(99)576**

Source: **InterDigital Communications Corporation**

Title: **Issues Regarding Open Loop Schemes for Uplink Power Control in TDD**

1 Introduction

S1.24 specifies two options for power control of uplink dedicated channels in TDD mode: Closed loop power control, or open loop power control. The performance of closed loop scheme is robust with respect to uncertainties in the transmit/receive gains and uncertainties in the interference level. In contrast with closed loop schemes, the performance of open-loop schemes may be severely degraded due to such uncertainties. Several papers [1,2,3] have shown than when ignoring gain and interference uncertainties, open-loop schemes may outperform closed loop scheme. However, gain and interference uncertainties can not be ignored. This paper discussed the impact of gain and interference uncertainties on the uplink performance.

2 Performance of Open Loop Schemes with no Uncertainties

Figures 1-2 compare the performance of open-loop schemes to the performance of closed loop power control. For reference we have also included the case of "no power control", where the transmit power is set at and remains constant. Figure 1 is for mobile speed of 30 km/h, while Figure 2 is for mobile speed of 60 km/h. The performance is expressed in terms of the required E_s/N_o for raw bit error rate (BER) of 10^{-2} as a function of time delay between the uplink time slot and the most recent down-link slot. The delay is expressed by the number of time slots. E_s is the energy of the complex symbol. The simulation model and assumptions are described in [1]. The weighted open loop power control scheme is presented in [2]. Figures 1-2 demonstrate that, when gain uncertainties are ignored, the weighted open loop power control schemes outperforms all other schemes.

Expressing the results in terms of the required E_s/N_o for a given BER is commonly done in the context of closed loop schemes where the closed loop guarantees that the desired E_s/N_o will be achieved. However, in the presence of gain and interference uncertainties, the transmitted power may be too high or too low. In these cases, the desired value of E_s/N_o cannot be achieved, and the uplink performance is severely degraded. Thus, presenting the performance of open-loop method by the required E_s/N_o for a given BER may be misleading. The results for "no power control" are misleading because of the same reason. The following section discusses the impact of gain uncertainties on the performance of open loop schemes.

3 Impact of Gain Uncertainties on the Performance of Open Loop Power Control Schemes

According to S1.24 the transmitter power of UE shall be calculated by the following equation:

$$P_{UE} = L_{CCPCH} + I_{BTS} + \text{Constant value}$$

where, P_{UE} : transmitter power level in dBm,
L_{CCPCH}: measured path loss in dB (transmit power is broadcasted on BCH),
I_{BTS}: interference signal power level at cell's receiver in dBm, which is broadcasted on BCH
Constant value: This value shall be set via Layer 3 message (operator matter).

The constant value can be evaluated (by the network) as (see [1])

$$\text{Constant value} = SIR_0 + \Delta G$$

SIR_0 is the target SIR and ΔG is a gain adjustment term representing the difference in dB between the down-link and uplink gains.

It follows that there are at least two sources of error that may cause the transmitted power of the UE to deviate from its nominal value.

1. Uncertainty in ΔG. This is probably the most significant source of error.
2. Uncertainty in the Interference level.

These uncertainties may cause the transmitted power to be too high or too low than the nominal value. Figure 3 shows the BER as a function of the deviation of transmit power from the nominal value, for the case where the required raw BER is 10^{-2}. As may be expected, even moderate deviations from the nominal Tx power level may cause significant deviation from the required BER. If the transmitted power is too low, the resulting BER is significantly higher than the required BER (by factor of 6 for 4 dB deviation). If the transmitted power is too high, the resulting BER are lower than the required error. However, in this case, the excessive transmitted power causes excessive interference and reduces battery life.

4 Conclusions

This paper discusses the impact of gain uncertainties and uncertainties in the interference level on the performance of open loop schemes. Such uncertainties may cause a significant degradation is the system performance, because the desired value of E_b/N_0 (or E_s/N_o) cannot be achieved. It follows that a power control scheme with no closed loop component cannot be considered.

5 References

[1] InterDigital, "Performance of Open Loop and Closed Loop Schemes for Uplink Power Control in TDD Mode", Tdoc R1-99359, Yokohama, Japan, April 1999.

[2] InterDigital, "Performance of Weighted Open Loop Schemes for Uplink Power Control in TDD mode", Tdoc R1-99575, Cheju, Korea, June 1999.

[3] Panasonic, "Usage of CCPCH and Performance Evaluation of Open-Loop Power Control Scheme (TDD)", Tdoc R1-99364, Yokohama, Japan, April 1999.

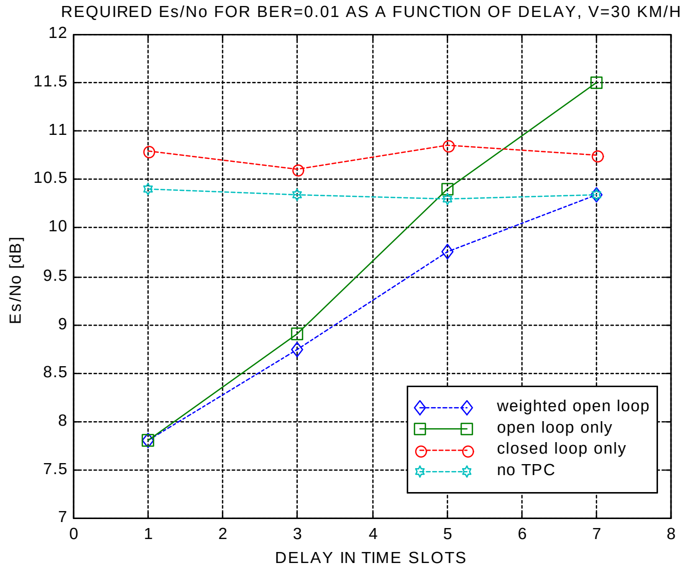

Figure1: Required Es/N0 for BER=0.01 as a Function of Uplink/Downlink Delay. V=30 km/h.

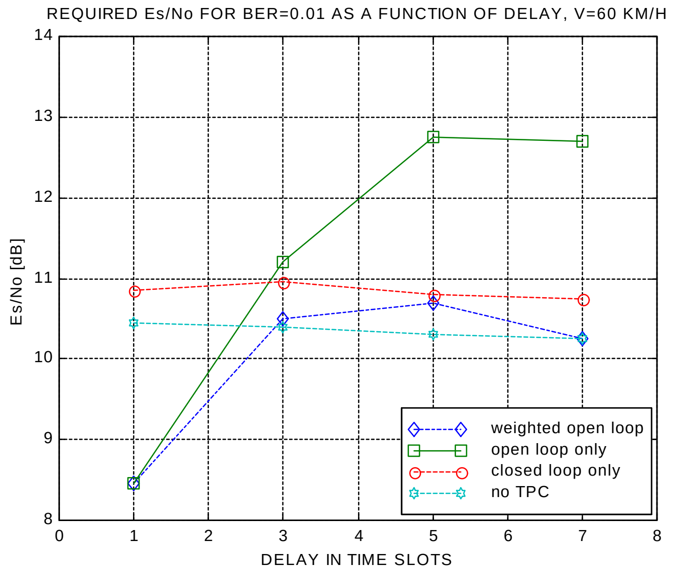

Figure 2: Required Es/N0 for BER=0.01 as a Function of Uplink/Downlink Delay. V=60 km/h.

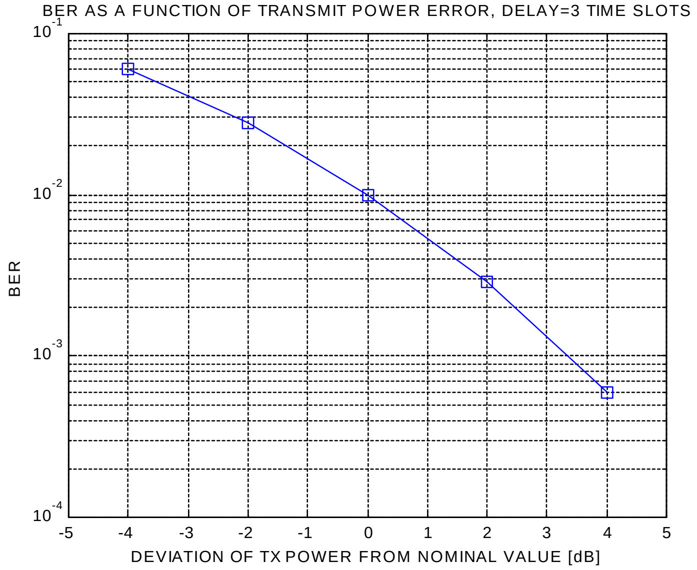

Figure 3: BER as a function of Transmit Power Deviation from Nominal Value. Delay=3 Time-Slots.