TSG-RAN Working Group 1 meeting #7bis *TSGR1#7bis(99)E69*
Kyongju, Korea
October 4th-5th, 1999

Agenda Item:
Source: NEC
Title: Adjustment Loop in downlink power control during soft handover
Document for: Discussion

---

1. Introduction

This contribution explains the concept and the performance of adjustment loop in downlink power control during soft handover. Adjustment loop is a solution to eliminate the power drifting problem.

2. Adjustment loop

Adjustment loop is used for balancing downlink power among active set cells during soft handover. For adjustment loop, DL reference power P_{REF} and DL power convergence coefficient r $(0 \quad r \quad 1)$ are set in the active set cells during soft handover so that the two parameters are common to the cells. For simplicity, DL powers of two cells are considered in this explanation. Adjustment loop works in addition to inner loop power control, and DL power at slot i of two cells, $P_1(i)$, and $P_2(i)$, are updated at a certain interval (typically in every slot as in this explanation) as follows:

$$P_1(i+1) = P_1(i)+(1 - r)(P_{REF} - P_1(i))+S_{INNERLOOP1}(i) \qquad (1)$$
$$P_2(i+1) = P_2(i)+(1 - r)(P_{REF} - P_2(i))+S_{INNERLOOP2}(i) \qquad (2)$$

The difference is derived from equations (1) and (2) if TPC error does not occur i.e. $S_{INNERLOOP1}(i)$ and $S_{INNERLOOP2}(i)$ are equal.

$$P1(i+1) - P2(i+1) = r(P1(i) - P2(i)) = r^i(P1(1) - P2(1)) \qquad (3)$$

Equation (3) means that the difference converges at zero when r is smaller than one.

3. Performance

(1) Simulation conditions

The performance of adjustment loop is evaluated by means of computer simulation. The assumptions of the simulation are as follows:

- Active set is determined when a call is originated. During the call, sector average of path loss does not change, and the active set is not updated.
- Maximum active set size is three. Relative threshold for soft handover is 6 dB.
- Initial DL power is set to a value common to all active set cells.
- During a call, DL power is not synchronized by messages from RNC.
- Average holding time is 10 sec.
- Path loss of 3.5th power law, log-normal shadowing, and equal level 4 path Rayleigh fading ($f_D T$=0.1) are considered.
- Both uplink and downlink power is updated by inner loop power control in every slot.
- Delay of inner loop power control is one slot.
- Outer loop power control is employed, in which target FER is 0.01.
- Step size of inner loop power is 1 dB.
- When the SIR of TPC command is smaller than a threshold, the degraded TPC command is not used for inner loop power control.
- Reception error of TPC commands is generated in accordance with received SIR.
- Power control range is 20 dB.
- DL reference power P_{REF} is the center value of power control range.
- DL power convergence coefficient r is 0.96.

(2) Simulation results

Figures 1 shows average of DL power difference among cells during soft handover, Figure 2 shows FER, and Figure 3 shows average DL power of all calls. During soft handover, DL power is the sum of DL powers of the active set cells. In these figures, performance with adjustment loop (ON) is compared with the performance without adjustment loop (OFF). The performance depends on the DL reference power i.e. the center value of the power control range. In this result, ratios of active set size of two and three were both 0.22, and both degraded TPC command rate and TPC error rate were approximately 2 percent.

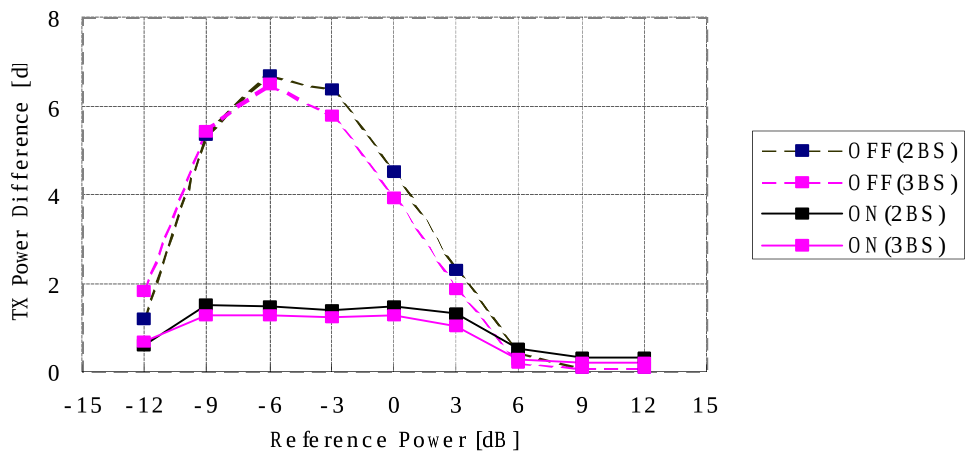


Figure 1 DL power difference.
Figure 2 Frame Error Rate.

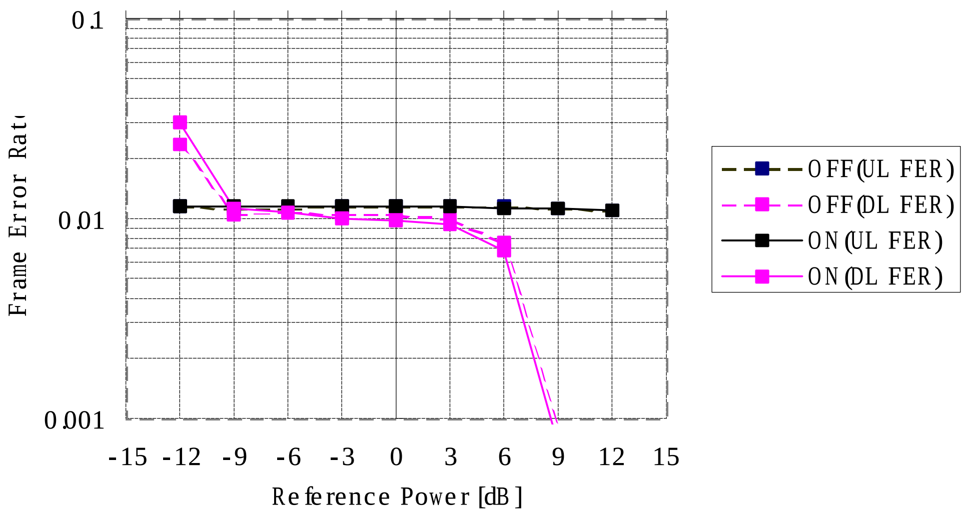
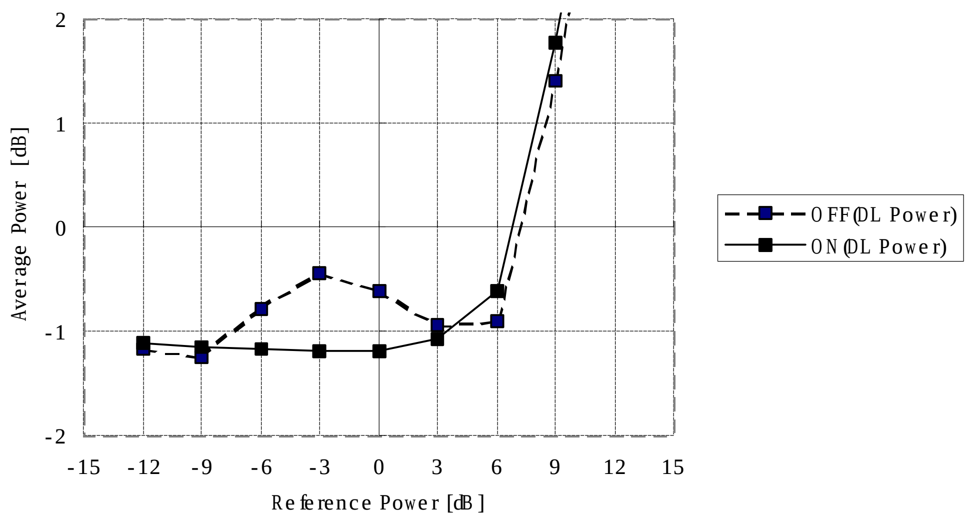


Figure 3 Average DL power.



(3) Discussions

When the reference power is between –9 dB and 6dB, FER is maintained at a target value and average DL power stays relatively low. However, when the reference power is less than –9dB, FER becomes large due to small maximum DL power. On the other hand, when the reference power is more than 6 dB, average DL power is increased due to large minimum DL power.

When adjustment loop is not employed, average DL power depends on the center value of power control range. With adjustment loop, average DL power is not sensitive to the center value of power control range. This means that it is possible to keep DL power low quite easily.

With adjustment loop, it is possible to eliminate power drifting problem without the need of frequent signaling of DL Reference Power, and without negative impact on DL inner loop power control.

During soft handover, DL Reference Power can be reported from RNC to Node-Bs in NBAP messages. If synchronized Radio Link Reconfiguration is not used, power drifting cannot be eliminated since it is not possible to set the DL Reference Power at all Node-Bs at the same time. If synchronized Radio Link Reconfiguration is used, there is a high probability that the difference of the DL Reference Power and the current DL power is large due to large delays. In such cases, if DL power is set equal to DL Reference Power in a slot in each Node-B, the DL power may become too low or too high. Therefore this may have significant negative impact on DL inner loop power control. It should be also noted that frequent signaling of DL Reference Power will have significant increase of control traffic from RNC to Node-B.

With adjustment loop, DL power adjustment is much smaller than a step size of inner loop power control even when the difference of the DL Reference Power and the current DL power is large. This means that it is possible to achieve the high performance of DL inner loop power control.