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Title: A Proposal of SIR Estimation for Closed Loop Power Control

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Abstract

An SIR estimation method for closed loop power control is proposed in this document. Simulation results show that the performance of the algorithm is satisfying in higher SIR condition.

A Proposal of SIR Estimation for Closed Loop Power Control

Introduction

In uplink and downlink closed loop power control of WCDMA, SIRs of the received uplink DPCCH signal and downlink DPCH signal after RAKE combining should be estimated by base station and mobile station, which indicates TPC commands according to the following rules:

$SIR_{est} > SIR_{target} \rightarrow$ TPC command = "down"
$SIR_{est} < SIR_{target} \rightarrow$ TPC command = "up".

Upon the reception of a TPC command, the mobile station or base station should adjust its transmit power in the given direction with a step of Δ_{TPC} dB. The step size Δ_{TPC} is a parameter that may differ in the region 0.25 – 1.5 dB.

How to estimate the SIR accurately and assert the variable step of Δ_{TPC} is a key technique.

Algorithm

After RAKE combining, the received signal could be described as

$$y_i = c * d_i + e_i \quad (i = 1,2,...,N)$$

where

y_i the *i*-th received complex signal;
c gain of channel, which is considered as a static channel parameter during a slot gap;
d_i the *i*-th transmitted symbol (hard decision) , $d_i = \pm 1 \pm j$;
e_i N~(0, s^2) zero mean non-coherent white noise.

The probability density function of e_i is

$$f(e_i) = \frac{1}{\sqrt{2p}\,s} \exp[-\frac{1}{2s^2} | y_i - cd_i |^2] .$$

Thus the Likelihood Function of c and s^2 can be represented as

$$L(y_1,..., y_i ,.., y_N \mid c, s^2) = \prod_{i=1}^{N} f(e_i)$$

$$= \prod_{i=1}^{N} \frac{1}{\sqrt{2p}\,s} \exp[-\frac{1}{2s^2} | y_i - cd_i |^2]$$

$$= (2ps^2)^{-N/2} \exp\left[-\frac{1}{2s^2} \sum_{i=1}^{N} | y_i - cd_i |^2 \right] .$$

$$\ln(L(y_1,..., y_i ,..., y_N \mid c, s^2) = -\frac{N}{2} \ln(2p) - \frac{N}{2} \ln s^2 - \frac{1}{2s^2} \sum_{i=1}^{N} | y_i - cd_i |^2 .$$

Assumed $c = c_{est}$ and $s^2 = s_{est}^2$ ("est"denotes estimation), the Likelihood Function get maximum

$$L(y_1,..., y_i ,..., y_N \mid c_{est}, s_{est}^2) = Max\{L(y_1,..., y_i ,..., y_N \mid c, s^2)\} .$$

c_{est} and s_{est}^2 are the solutions of

$$\begin{cases} \frac{\partial}{\partial c} L(y_1,..., y_i ,..., y_N \mid c, s^2) = 0 \\ \frac{\partial}{\partial s^2} L(y_1,...,..., y_i ,..., y_N \mid c, s^2) = 0 \end{cases} .$$

i.e

$$\begin{cases} \dfrac{\partial}{\partial c} \ln L(y_1,..., y_i,..., y_N \mid c, s^2) = 0 \\ \dfrac{\partial}{\partial s^2} \ln L(y_1,..., y_i,..., y_N \mid c, s^2) = 0 \end{cases}.$$

c_{est} and s_{est}^2 are obtained as follow:

$$c_{est} = \frac{\sum_{i=1}^{N} y_i d_i^*}{\sum_{i=1}^{N} |d_i|^2}$$ ("*"denotes conjugation)

$$s_{est}^2 = \frac{1}{N}\sum_{i=1}^{N} |y_i - \hat{c}d_i|^2 .$$

In conclusion, SIR is written as

$$SIR = |c_{est}|^2 / s_{est}^2 .$$

Simulation results

Practical communication system require that SIR should be during 5~7dB. Comparing the computed SIR of the aforementioned algorithm with the given SIR, we find that they match very well in higher SIR condition. The bias between them is also depicted by an error curve in the following figure. In lower SIR condition, because d_i potentially be misjudged (noise is processed as signal) the error curve takes on a certain deviation. To improve accuracy of the algorithm, we give out a local error fit curve (thick line in figure) with the polynomial form:

$$SIR_c - SIR_g = 0.04SIR_g^2 - 0.72SIR_g + 3.27 \quad (\ SIR_g \text{ during } 0\sim10 \text{ dB})$$

$$SIR_g = \sqrt{24.783 \times SIR_c - 69.39} - 3.423 \quad (\ SIR_c \text{ during } 3.27\sim10 \text{ dB})$$

where SIR_g and SIR_c respectively denotes the given SIR and the computed SIR. So that we can obtain the more accuracy SIR_g by the above-mentioned formula when SIR_c vary between 3.27~10dB.

If SIR is lower than 0dB, it is unreliable to estimate SIR because BER is very high (hard decision of d_i is not correct). In this situation, the TPC must be "*up*" and the step size Δ_{TPC} must be set as maximum. Additionally, Δ_{TPC} may refer to the simulation curve.