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Background Noise Measurements of Code Division Multiple Access (CDMA) Mobile Communication System

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Abstract: This study deals with methodology proposes to measure the background noise at each cell site, how background noise impacts Code Division Multiple Access (CDMA) system performance. CDMA is a multiple access technology that utilizes direct-sequence spreadspectrum techniques. With this technology comes a paradigm shift. Contrary to the conventional FDMA and TDMA systems where noise rejection deals primarily with out-of-band noise, a CDMA system concerns mostly with in-band noise. This noise may come from self-jamming (or self-noise), background noise, man-made noise, intermodulation, or noise generated in the receiver. If one can reduce the unwanted in-band noise, such reduction translates directly into improved performance. Thus, the goal of an RF system engineer is to design a network that minimizes the amount of unwanted noise introduced into the receiver on both forward and reverse links.

Key words: Background noise, spectrum analyzer, noise floor, noise figure, interference

INTRODUCTION

Capacity and coverage in CDMA systems are, in part, a function of the background thermal and man-made interference noise levels[1,2]. For the 1.23 MHz CDMA channel, the background thermal noise is approximately -113 dBm[3]. Man-made interference includes automobile ignition noise and spurious emissions from radio and other electronic equipment[4,5]. The background man-made noise will vary from site to site depending on the number and proximity to the cell of interference sources. In order to insure the optimal operation of each of the CDMA cell sites, we recommends that noise floor measurements are considered as a part of the site selection process for CDMA systems.

SUGGESTED MEASUREMENT METHOD

Interference is random in nature, with amplitude and frequency varying over time[6]. Due to the random nature of the background noise, we suggest that a data logging system be employed to measure the noise floor over some period of time. Statistical analysis of the collected data can then be performed to determine an average and cumulative distribution function of the noise floor rise. The cumulative distribution function indicates the amount of time the background noise rise exceeds some specified limit[7].

Test system functional description: A possible configuration of a noise floor test system is shown in Fig. 1 The band-pass filter is used to attenuate out-of-band signals, which otherwise could create in-band inter modulation products. The low noise amplifiers are used to improve the system noise figure and provide enough gain to allow for the measurement of very low-level signals. The step attenuator between the amplifiers is used to limit the system gain, again, to reduce the level of possible inter modulation products[8].

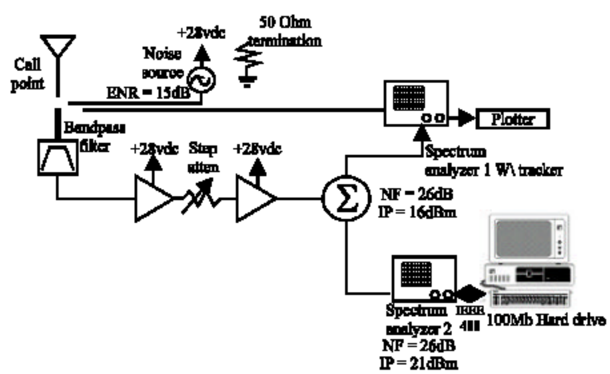

Fig. 1: Suggested CDMA noise floor measurement system

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The output of the final amplifier is then split using a two-way splitter. The two equal outputs of the splitter are used as inputs to two spectrum analyzers[9]. Spectrum analyzer 1 operates in the manual mode. This spectrum analyzer is equipped with a tracking generator, which is used for the System gain calibration. This spectrum analyzer is also used to make noise floor plots and to investigate the nature of interference as it appears on the screen. Spectrum analyzer 2 is under computer control. Measurement traces are collected with this spectrum analyzer and are stored to disk for later processing. A hard drive with at least 100 Mb of storage space is recommended. Up to two-spectrum analyzer traces per second can be recorded for the described system[10]. The noise source is used to measure the system noise figure. The measured system noise figure is used when processing the collected data into the desired cumulative distribution plots.

Test system calibration: The test system gain and noise figure must be measured before data collection begins. The measured gain and noise figure are used to make adjustments to the collected data, during the data analysis operation. The system gain is measured using the tracking generator provided in spectrum analyzer 1. The system noise figure is determined by first measuring the noise floor with the system Calibration Point (input) terminated in 50 ohms and then measuring the noise floor with the system Calibration Point connected to the calibrated noise source[11]. The noise figure is then calculated from the two measurements and the noise source ENR rating as follows:

$$NF=10Log[ENR / (Pon / Poff - 1)]$$

Where,

ENR = the equivalent noise ratio of the calibrated noise source (linear ratio)

P on = the noise floor measurement with the noise source connected to the system input (Watts)

P off = the noise floor measurement with the system input terminated in 50 ohms (Watts)

NF = the collection system noise figure (dB)

TEST PROCEDURES

It is expected that the CDMA trial systems and many CDMA commercial systems will be deployed in areas where analog coverage currently exists[12]. Two methods of co-existence between analog and CDMA systems have been proposed. One implementation is to clear all analog co-channels within the CDMA band on a system wide basis. Another possibility is to only clear the analog co-channels from cells, which are near the CDMA cells. Analog co-channels to the CDMA band are then re-used at distant analog cells. Before noise floor testing can begin, analog co-channel clearing, per the chosen implementation plan, must be completed[13]. This is necessary because analog channels within the CDMA band will appear as interference in the collected data. Once the system has been cleared of analog co-channels, noise floor testing can proceed. For best results, the data should be logged at various times of the day and night at each cell site. This is necessary because varying traffic patterns throughout the day will affect the noise levels present at the cell site.

DATA ANALYSIS

The collected data must be scaled to account for the measurement system gain, noise figure, and bandwidth before the statistical analysis is performed. Once the data is properly scaled, a statistics software package can be used to calculate the average noise floor rise and cumulative distribution functions. The noise floor rise cumulative distribution plots can then be used to make a judgment on the effect of background interference to CDMA performance at each cell site[14]. Plots can also be produced which show the amplitude and frequency of interferers as a function of time. These plots can be used to help identify the source of interferers, which can lead to methods of interference reduction.

CONCLUSIONS

System interference, or in particular, the noise floor, directly impacts CDMA capacity and quality[15]. Due to the nature of CDMA, capacity alone will influence the noise level, therefore, it is imperative that noise is kept to a minimum and that procedures are in place to monitor the system for spurious emissions.

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