BER Performance of DSSS Technique under Periodic Jamming
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Abstract

For this project we will be studying the performance of 802.11 wireless communication with the use of DSSS while it is being jammed by a periodic jammer. The communications utilizing DSSS will be compared to those without DSSS under different combinations of jamming parameters. These experiments will be performed on testbeds consisting of GNU Radio and USRP2.

Introduction

Radio frequency jamming is the process of transmitting radio signals that disrupt some target communication by decreasing the target receivers' signal to noise ratio. There are two types of jamming: intentional and unintentional. Intentional jamming occurs when an operator transmits on a busy frequency knowing that the said frequency is being used. Unintentional jamming occurs when an operator transmits on a busy frequency without first checking whether it is in use. This could be because the sender does not have the hardware to hear stations transmitting on the same frequency, the sender accidentally radiates a signal using the same frequency by chance, or the sender inadvertently uses too much bandwidth and leaks into some other neighboring frequencies on accident. This concept can be used in wireless data networks to disrupt the flow of information.

One commonly used jamming technique is called periodic jamming. Periodic Jamming can cover a large spectrum with relatively small power consumption. The effective spectrum and energy strength of a Periodic Jammer can be adjusted by changing its duty cycle and pulse width.

Spread spectrum communication systems have an inherent immunity to interference, but it is not difficult to jam such systems either, particularly if the spread spectrum system uses very low power levels for communication. Direct-Sequence Spreading Spectrum (DSSS) technique spreads out the energy of a signal across a much wider spectrum compared to the bandwidth of the original signal.

Theoretical Background

The average BER calculation equation for coherent BPSK [1] is

\[
P_e = (1 - \gamma) Q(\sqrt{2G_p u}) + \gamma Q\left(\frac{2G_p \gamma v}{u + \xi}\right) \quad \text{(Equation 1)}
\]

where

- \(G_p\): Processing gain of DSSS. For Barker Code, \(G_p = 11\).
- \(\gamma\): Duty Cycle of Pulse Jammer. \(\gamma = \text{Pulse\_width}/\text{Pulse\_period}\)
- \(u\): SNR. According to FFT chart, the SNR for our experiments is approximately \(10^4\). This value makes the value of first term small enough to ignore.
- \(\xi\): JSR. \(\xi = \left(\frac{\text{Amplitude\_jammer}}{\text{Amplitude\_signal}}\right)^2\)
- \(Q(x)\): defined as the probability that a standard normal random variable (zero mean, unit variance) exceeds x [3].

The BER for non-coherent DBPSK is

\[
P_b = \frac{1}{2} e^{-\frac{E_s}{N_t}}
\]

approximately double the BER of coherent BPSK [2].

The theoretical BER curves deduced from the equation are shown as following:
In order to show different performance of spreading and non spreading communications, the Periodic Jammer Amplitude for experiments should be set in the range of 0.02 to 0.4 according to this chart.
There is a maximum BER for variable duty cycles. The reason for this is that increasing the duty cycle has two impacts. One effect is on the peak power while the other is on the fraction of effective time. For a fixed average power (fixed JSR) and fixed Processing Gain, the higher the duty cycle, the lower the peak power has to be, and therefore the less effect to the signal being jammed. In the reverse, the higher the duty cycle is, the longer the effective jamming time, and so there should be a balance point or local maximum for the peak power effect vs. effective time. The Effective duty cycle ($\gamma^*$) is metered by:

$$\gamma^* = \begin{cases} 
\frac{0.709}{E_s / N_T}, & E_s / N_T > 0.709 \\
1, & E_s / N_T \leq 0.709
\end{cases}$$
And the calculated BER ($P_e$) is:

$$P_e^* = \begin{cases} 
\frac{0.083}{E_s / N_T}, & E_s / N_T > 0.709 \\
Q\left(\sqrt{\frac{2E_s}{N_T}}\right), & E_s / N_T \leq 0.709 
\end{cases}$$

These parameters can be used in the experiments.

**Experiments Set Up**

1) $\nu(SNR)$ is set to 50dB. This value was chosen by comparing the Noise FFT chart (of test environment) and Signal FFT chart. This value makes the first term of the BER equation (Equation 1) small enough to be ignored.

2) Jammer Amplitude should be varied from 0.02 to 0.4 according to BER vs Jammer Amplitude plot above (Figures 1 and 2).

**Experiments Plan**

Week of 2011/10/28:
1. Deduce theoretical BER vs parameters curves.
2. Determine effective value range and granularity for parameters by performing a few tests. For example, amplitude of Jammer cannot exceed 0.2.
3. Perform experiments with different Jammer parameters, 100 times for each parameter value (about 30 minutes for one parameter value). Record FFT charts and scope charts. Total amount of experiments times depends on number of parameter values. Average of 6 groups (100 times/group) can be done for each day. More experiments need to be done in following weeks.
4. Plot BER vs parameters. Actually, plot PER vs parameters for now, and figure out how to measure BER.

Week of 2011/11/4:
More experiments. Record FFT charts and scope charts. Plot BER vs parameters.

Week of 2011/11/11:
1. Project mid-report, including charts and analysis of experiment results.
2. Maybe there will be some adjustments in the testing data based on previous results, will perform more experiments.

Week of 2011/11/18:
1. More experiments. Record FFT charts and scope charts. Plot BER vs parameters.

Week of 2011/11/25:
1. Experiment report, including charts and analysis of experiments results for no spreading and Barker Code spreading.

**Reference**

