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APPLICATION OF SIGNAL PROCESSING WORKSYSTEM ™ SIMULATION TO INTERFERENCE ANALYSIS

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ABSTRACT

Radio communication system performance can be degraded by inadvertent interference in nearby channels or by intentional jamming in the transmit/receive frequency band. The effects of interference and jamming depend on many factors and several techniques can be used to mitigate their impact. Simulation provides a means of quantitatively evaluating the impact of combinations of interferers, jammers and mitigation schemes on a given radio communication system. Using minimum shift keying (MSK) system models developed on Signal Processing WorkSystem™ (SPW) simulation software, we examined the effects of MSK jammers, tone jammers and co-channel frequency shift keying (FSK) interference. The models were used to predict the effectiveness of antenna isolation, spread spectrum, error detection and correction (EDAC) and signal processing methods for mitigating interference. This paper briefly describes our simulation methodology and highlights signficant results. Further details are provided in the associated poster session presentation.

1 SIMULATION METHODOLOGY

SPW models are used to simulate communications systems from end-to-end (i.e., transmitter, channel, and receiver). In our SPW models, the transmitter consisted of an MSK modulator and bit source, the channel consisted of an interference source and addition block, and the receiver consisted of an MSK demodulator and bit decoder.

In our simulation bit error rate (BER) is used as the figure of merit for predicting and comparing system performance against various interference sources. BER is determined by comparing the received bits with the originally transmitted bits. Each simulation run is executed until one-hundred bit errors are measured.

2 SPW SIMULATION DEVELOPMENT

Three versions of an MSK modulator/ demodulator (modem) are used to model various systems. The first is a radio frequency (RF) MSK modem, which applies the MSK modulation and a carrier frequency to the transmitted bits. The second is a complex baseband modem, which models I and Q channels as a real and imaginary signal at baseband. The third modem is a spread spectrum complex baseband MSK pair which applies MSK modulation to chips utilizing direct sequence pseudonoise spread spectrum encoding techniques.

The modems are used to simulate communications systems subjected to various interference environments. The environments are created by adding the output from an interference functional block to the output of the modulator. Four types of interference sources are used: additive white gaussian noise (AWGN), FSK co-channel interference, constant wave (CW) jamming, and MSK jamming.

To illustrate tradeoff analyses for mitigating interference effects, two EDAC codes and a signal processing technique are implemented. The EDAC codes are soft decision Wagner (6,5) coding and hard decision Hamming (15,11) coding. The signal processing technique is used for the excision of narrowband interference and involves the use of prediction error (PE) filters with a least-mean squares (LMS) tap update algorithm [1]. A simulation for such a filter is readily implemented, enabling the necessary trade-off analyses.

3 INTERFERENCE ANALYSES

This section contains examples of co-channel interference, coding gain, intentional jamming and counter jamming analyses using SPW simulation.

3.1 Co-Channel Interference Analysis

Co-channel interference occurs when a co-located transmitter transmits in or near the frequency band to which a receiver is tuned and causes degradation in the receiver performance. Antenna isolation is a common method used to mitigate its effects. To estimate minimum required antenna isolation, we modeled an MSK signal subjected to an FSK interferer 1 Hz away. Our simulation results indicate that a signal to jammer ratio (SJR_{req}) of 28.5 dB is needed to acheive a 10% BER. Using simulation results, the required antenna isolation can be estimated by $I = J - S - SJR_{req}$ [dB] for a known J and S.

3.2 Error Correction Coding Analysis

Error correction coding is often used to increase the robustness of a communications system. System models are developed using one of two EDAC schemes, a Wagner (6,5) code and a Hamming (15,11) code. The performance of these two systems in AWGN is determined by simulation. Our results (as expected) show the Hamming scheme is more effective, having achieved a BER that is equal to or less than that achieved by the Wagner scheme at a given E_b/N_0.

3.3 Counter Jamming Techniques Analysis

To illustrate jamming effects, the Hamming encoded system is subjected to a CW tone jammer with a range of SJRs. E_b/N_0 is set to 7 dB, which results in a BER of 10^{-3} without coding and in the absence of any other interference. In all jamming scenarios the center frequency of the jammer is 1 Hz away from the center frequency of the MSK transmit/receive system. Our results show that when the SJR is less than 11.15 dB the encoded system BER is greater than 10^{-3}. This indicates that EDAC techniques alone are insufficient to counter CW tone jammers.

Instead of using coding to counter the CW jammer, a direct sequence spread spectrum MSK system is used. A spreading factor of 10 chips per bit is chosen. This factor provides some spreading gain while maintaining a reasonable data throughput. This scenario is evaluated for a range of SJR values. Even with spread spectrum, the tone jammer is able to defeat the system when the SJR is 12.5 dB. To counter the stronger jammer, the PE filter described previously is incorporated into the receiver. The signal processing acts as a filter, effectively excising the jammer. This results in a situation in which the receiver is limited by the noise levels and BER stays at about 10^{-3} regardless of SJR. Thus the PE filter is an effective countermeasure against CW jammers.

To illustrate another scenario, an MSK jammer is used in place of the CW jammer that the PE filter defeated. In order to evaluate a worst case scenario, the bit rate of the MSK jammer is the same as the system chip rate and the jammer is perfectly in phase with the MSK signal at the receiver. The PE filter is unsuccessful in predicting the MSK jammer waveform because the waveform is not repetitive. As a result BER increases with jammer power, and at a SJR of 17.5 dB the BER exceeds 10^{-3}.

The simulations show that the system with the PE filter is sufficient to counter a CW jammer, but cannot counter an MSK jammer. Therefore, to counter an MSK jamming threat, a higher spreading factor or an improved signal processing algorithm must be used.

4 SUMMARY

The analyses illustrated simulation of MSK communication system performance in jamming environments. Simulation results were used to perform tradeoff studies of various interference mitigation techniques. The SPW blocks used in these analyses are part of a library of functions that can be used to analyze the performance of many communications systems.

5 REFERENCES

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