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Dissertation Abstracts: Performance of Frequency-Hopping Spread-Spectrum Mobile Radio Systems

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Dissertation Abstracts

Raimundo Sampaio Neto, "Spread-Spectrum Code Tracking in the Presence of Interference," Ph.D., Dept. of Electrical Engineering, University of Southern California, Los Angeles, CA 90007, USA, September 1983. Advisor: Robert Scholtz.

This dissertation studies the problem of code-delay tracking in direct-sequence systems operating in an interference environment.

Receiver-noise interference is considered first, and several closed-loop structures for both coherent and noncoherent code tracking are developed, based on the maximum likelihood principle. The structures originated by such development—among which most of the traditional loops were included—are extended via the notion of a generalized correlation, which leads to a unifying approach to the analysis and design of code tracking loops subjected to spectrally white and/or nonwhite interferences.

The generalized correlation is created by introducing arbitrary linear transformations (filtering) of the incoming waveforms and locally generated references prior to the usual correlation operation. Optimal sufficient conditions are derived, based on the minimization of the linearized tracking jitter, which allow the designer to specify the transformations in a suitable way. The fulfillment of the pertinent conditions is shown to yield structures that, simultaneously with minimum-jitter tracking, provide the data detection circuitry with a maximized despread signal-to-interference power ratio.

Expressions for linearized jitter performance of optimal and suboptimal tracking configurations in the presence of arbitrary interference are derived.

The true nonlinear behavior of the tracking systems is described and analyzed in a renewal process framework. General expressions for the stationary distribution of the tracking error process and the mean time to lose lock are obtained in terms of the loop's normalized S-curve and the spectral level of the loop's effective noise. The results are used to investigate nonlinear performance of a selected loop configuration in receiver noise and strong colored interference environments, and illustrate the effects of placing whitening filters, as suggested by the design results, in the loop.

Numerical results illustrating the impact of interference power and bandwidth on different measures of system performance are presented and discussed.

Ramanarayanan Viswanathan, "Performance of Frequency-Hopping Spread-Spectrum Mobile Radio Systems," Ph.D., Department of Electrical Engineering, Southern Methodist University, Dallas, TX 75222, USA, May 1983. Advisor: S. C. Gupta.

This dissertation presents the performance analysis of frequency-hopping spread-spectrum systems for mobile radio. Several receiver configurations for frequency-hopped multilevel frequency-shift keyed (FH-MFSK) systems are analyzed, and some modifications are suggested for improved performance.

Throughout the analysis, the base station to mobile terminal link performance is considered. The number of simultaneous users that the system handles at a specified average bit error (say $P_b \lesssim 10^{-3}$) is the measure of performance used. It is shown that the FH-MFSK system employing a hard-limited receiver accommodates a marginally lower number of users than an ideal likelihood receiver at any finite average signal-to-noise power ratio (SNR). The theoretical considerations also imply an asymptotically (SNR $\rightarrow \infty$) equivalent performance of these receivers. For the FH-MFSK cellular mobile radio system employing a hard-limited receiver, a power control scheme has been suggested to reduce the adjacent cell interference. It is seen that such a scheme recovers much of the performance loss incurred when there is no power control.

In comparing an FH-MFSK system with a frequency-hopped differential phase-shift keyed (FH-DPSK) system, a preliminary analysis shows that burst errors are more likely in the former than in the latter. Finally, the performance of nonparametric type receivers for an FH-MFSK system under mobile environment is discussed. It is found that a receiver based on the maximum rank sum test (MRST) is a possible competitor to the parameter receivers.

Kotikalapudi Sriram, "A Study of Multiplexing Schemes for Voice and Data," Ph.D., Department of Electrical Engineering, Syracuse University, Syracuse, NY 13210, USA, December 1983. Advisor: Dr. P. K. Varshney.

Voice traffic variations are characterized by on/off transitions of voice calls, and talkspurt/silence transitions of speakers in conversations. A speaker is known to be in silence for more than half the time during a telephone conversation. This dissertation studies some schemes which exploit speaker silences for an efficient utilization of the transmission capacity in integrated voice/data multiplexing and in digital speech interpolation.

Two voice/data multiplexing schemes are studied. In each scheme, any time slots momentarily not utilized by the voice traffic are made available to data. In the first scheme, the multiplexer does not use speech activity detectors (SAD), and hence the voice traffic variations are due to call on/off only. In the second scheme, the multiplexer detects speaker silences using SAD and transmits voice only during talkspurts. The multiplexer with SAD performs digital speech interpolation (DSI) as well as dynamic channel allocation to voice and data. The performance of the two schemes is evaluated using discrete-time modeling and analysis. The data delay performance for the case of English speech is compared with that for the case of Japanese speech. A closed form expression for the mean data message delay is derived for the single-channel single-talker case.

In a DSI system, occasional speech losses occur whenever the number of speakers in simultaneous talkspurt exceeds the number of time delay multiplexing (TDM) voice channels. In a buffered DSI system, speech loss is further reduced at the cost of delay. This study proposes a novel fixed-delay buffered DSI scheme. In this scheme, speech fill-in/hangover is not required because there are no variable delays. Hence, all silences that naturally occur in speech are fully utilized. Consequently, a substantial improvement in the DSI performance is made possible. The scheme is modeled and analyzed in discrete time. Its performance is evaluated in terms of the probability of speech clipping, packet rejection ratio, DSI advantage, and the delay.