Synchronized Behavior of FHSS against External Interference

Othman Sidek [1] and Abid Yahya [2]
Collaborative MicroElectronic Design Excellence Center
Universiti Sains Malaysia, Engineering Campus

E-mail:,[1]othman@cedec.usm.my and [2]abidusm@gmail.com

Abstract:

This paper demonstrates the execution and performance of frequency hopping spread spectrum (FHSS) in hostile jamming surroundings as correspond to conventional system. The system in this paper is confined to the merest assessments establish on the power ratio between the signal and entire interference. In scheming an antijam FHSS system, the spread bandwidth, W_{ss} , is by and large fixed at the start, and repeatedly with the usable bandwidth. Two rectangular bandpass signals have been diagrammed and the observance matrices are incurred by adding signal to jammer, arranging the jammer amplitude at 6 with matched filter output. From the simulation results it has revealed that plain signal is entirely masked by the jammer and is not noticeably ascertained at the filter output, the FHSS is the one, time constricted by the matched filter, is evident uniquely.

1. Introduction

There is enormous number of jammer types, to foresee their corrosive consequence special steps are claimed as a rule.

FHSS communicates short radio bursts on one frequency then haphazardly hops to another for the next short burst. The carrier signal commutes frequency in a practice way which can be recognized to both transmitter and receiver. The transmission generator and target must be matched, so they are concurrently on the same frequency.

In FHSS, the transmitter actuates just about a nominal centre frequency in an explicit hopping sequence. Hopping sequence is achieved by employing a pseudorandom spreading code to imply arbitrary in emergence which is consistent by settled means. At receiver the reproduction of the spreading code is enforced to retrieve the required information signal. Additional FHSS transmissions with unlike hopping sequences are eliminated by the narrow band IF filter, together with the content of any broad band signal or noise. In IEEE 802.11 FHSS systems, hopping classically occurs at centre frequencies 2402.0-2480.0 MHz with l MHz spacing over 79 channels.

Theoretically FHSS provides 26 orthogonal hopping sequences for numerous 26 collocated networks sharing the band at nominal interference. The block diagram of FHSS is revealed in Fig.1.

Another way for intentional jammer to cover a wider spectrum is to haphazardly hop the transmitted frequency of the information symbol on a symbol-by-symbol ground. Resultantly, this spreads the spectrum consecutively instead of at once. Acquiring that the jammer will determine to spread its energy across the whole frequency hopped spectrum, the possible accessible processing gain is then given by

Processing gain = 10 log [hopped bandwidth/information bandwidth]

Nevertheless, the jammer may take an action in order to concentrate on just a small indefinite amount of the hopped frequencies, acquiring that it is more effectual to seek to crusade errors in only some of the information bits rather than the entire length of information.

To combat against jamming is the prime concern of FHSS system because it is comparatively trouble-free to function over very large spread bands. Nevertheless, under certain condition FHSS has been competently jammed by follower jammers, where the jammer intercepts the transmitted signal, examines to establish the frequency of the hop, and then brings forth jamming in a narrow range about this frequency. This paper demonstrates the execution and performance of frequency hopping spread spectrum (FHSS) in hostile jamming surroundings as correspond to conventional system. In scheming an antijam FHSS system, the spread bandwidth, W_{ss} is by and large fixed at the start, and repeatedly with the usable bandwidth. In practical useful systems fixed hop rates, or, at most, a few selectable hop rates are employed. The only object which is permitted to vary by altering jamming levels is the data rate. The selection of the specific fixed hop rate, R_h, is established on a number of tradeoffs [1].

The jammer desires to establish, which segment comprises the frequency hop but it's cumbersome for jammer to ascertain which segment carries the frequency hop. In [2-4], the classical energy detector is employed for each segment which comprises of a band-pass filter of width W, a square-law device and an integrator that integrates over a time T . They have measured T , $T_h / 2$ ', which entails that half a hop period has been employed barely in shaping the frequency. In [4], a frequency estimator is counted. Once again, it has been mentioned that the time consumed to do precise estimation can be too elongated to attain practical follower jamming.

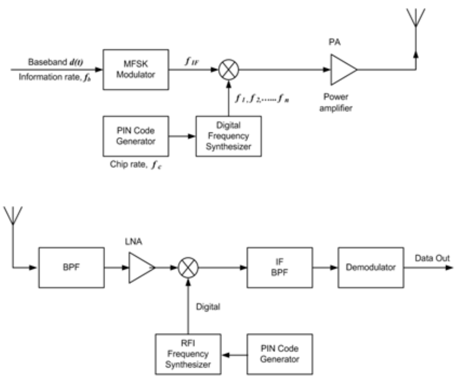


Figure.1 Structure of the transmitter and receiver of FHSS system

2. Jammers

We are familiar with the communication over a channel interrupted by additive white Gaussian noise (AWGN) channel. AWGN has infinite power, spread consistently over all frequencies. With the presence of interfering noise of infinite power, effectual communication is conceivable because only the finite power noise components in the signal can do several destructions. Consequently, we can gain a power advantage over the noise by concentrating the transmitter power to a finite-dimensional signal space, which is being employed in jamming situation.

In order to conceal the transmitted signal from jammer, unlike dimensions has been used that jammer can't focus its power to the same dimensions.

As declared in [5-9], that the signal's dimensionality counts on bandwidth and signals' duration in the space. Let us consider W_{ss} as the bandwidth of the spread spectrum and the data rate $R_b = 1/T_b$, then the transmission of a packet of P information bits will take roughly T_p seconds, where

$$T_p = PT_b = \frac{P}{R_b} \tag{1}$$

A signal space with time-limited to T_p seconds and band-limited to W_{ss} Hz spans dimensions. Consequently, to transmit one bit information the number of usable dimensions is

$$N_d = \frac{N_p}{P} = 2\frac{W_{ss}}{R_b} \tag{2}$$

A feature of a spread spectrum system is that ratio $\frac{W_{ss}}{R_b}$, which is large enough to constitute the processing gain of the system.

If the jammer is unaware of the subset of the N_d dimensions that is employed for the transmission, it may choose to spread its power uniformly and evenly over all dimensions. The jamming signal can then be considered as a noise waveform having flat power spectrum over the system bandwidth, the spectral altitude of the jamming signal is referred as $\frac{N_J}{2}$, where

$$J = 2W_{ss}\frac{N_J}{2} \tag{3}$$

$$= W_{ss}N_J \tag{4}$$

This nature of jamming is addressed as broadband noise jamming. Practically, a lot of endeavor is plant into the design of spread spectrum systems to compel the jammer into this jamming strategy.

Narrowband (or tone) interference and wideband noise both have at large, correspondent jamming efficiency against Pseudonoise signals. Nevertheless, it would be very aboveboard for the receiver to make use of a narrow-band interference elimination filter in order to get rid of complete jamming signal without severely degrading the receiver reaction to the preferred signals.

2.1 Narrowband Jammer

This kind of jammer is very distinctive of positions where some side systems have no aggressive purposes as compared to the practical system and generate a jammer merely resulting normal functioning.

A jammer is being named as narrowband only to emphasis that its bandwidth W_J is smaller than the signal band width W and there are some areas where uncorrupted signal spectrum is exhibited.

The filter communicates a jammer to the output without any alteration of its power J, the filtered AWGN power turns to $N_o W$.

The output peak of the signal is portrayed after passing through a matched filter

$$A_{out} = \int_{-\infty}^{\infty} |\tilde{s}(f)| d \tag{5}$$

$$= = 2W\tilde{s} \tag{6}$$

where $\tilde{s}(f)$ corresponds the amplitude spectrum of the utile signal

By employing Parseval's theorem the signal energy can be accounted as

$$E = \int_{-\infty}^{\infty} |\tilde{s}(f)|^2 dt \tag{7}$$

$$= 2W\tilde{s}^2 \tag{8}$$

The power signal interference ratio (SIR) at the matched filter output is demonstrated by $Q^2{}_I$

$$Q^2{}_I = \frac{A_{out}}{J + N_0 W} \tag{9}$$

$$= \frac{4W^2\tilde{s}^2}{J + N_0 W} \tag{10}$$

$$= \frac{2E}{N_0 + J/W} \tag{11}$$

where $\frac{N_0}{2}$ represents the two-sided power spectral density

The equation (11) demonstrates irrespective of a particular jammer bandwidth W_J, the matched filter output SIR conducts as if the jammer power were evenly spread over the non-jammed signal bandwidth W, producing an additional AWGN with the power spectrum J/W.

The correlator and matched filter are devices characteristically employ to actually analyze correlation and parameter $Q = \sqrt{\frac{2E}{N_0}}$ is the signal to noise ratio (SNR) at the correlator output.

$$Q^2{}_J = \frac{2E(1 - W_J/W)}{N_0} \tag{12}$$

$$Q^2 = (1 - W_J/W) \tag{13}$$

The antijamming capability of spread spectrum communication, particularly FHSS is clearly demonstrated in equations (11) and (12). In order to accomplish a higher narrowband jamming immunity with no increase of signal energy or peak power, to broaden the spectrum of signal duration severally, is the prime solution that is to employ the spread spectrum technology.

3. Results and Discussion

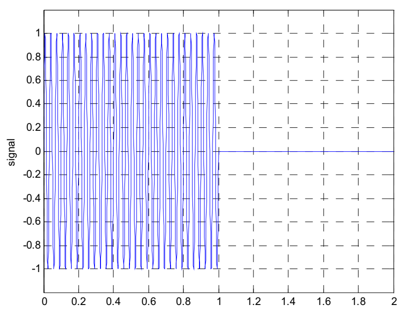
The antijamming characteristics of frequency hopping spread spectrum signal against narrowband jammer has been simulated and equates to the plain signals. When the MFSK subchannels are adjacent, for a jammer it is not appropriate to transmit the jamming in all the subchannels of an MFSK set since only a single subchannel inevitably to be jammed, to case a symbol error. The advanced jammer with cognition of the spectral locations of the MFSK sets can make the system degradation by locating one jamming tone or narrowband jamming signal in each and every set of MFSK.

Two rectangular bandpass signals have been diagrammed that is a plan pulse and a linear frequency modulation (LFM) pulse with some deviation. The matrix of CW jammer has been shaped with 12 rows, each experiencing frequency equal to the signal carrier frequency at 30Hz and random initial phase consistency distributed over (-π, π). The observation matrices are prevailed by adding signal to jammer, adjusting the jammer amplitude 6 as portrays in Fig.3.

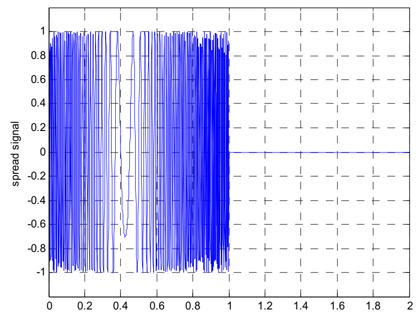
After receiving the signal bit at the matched filter input, it advances down the tapped delay line .The chip chooses “1” goes in the delay line first, accompany by chip “2,” and so on.

The consequence of the matched filter in the receiver is to spread out and diminish in amplitude the interfering uncoded impulses while at the same time establishing up the peak amplitude of the correctly coded information bit. Figure 4 demonstrates that that plain signal is entirely masked by the jammer and is not noticeably ascertained at the filter output, the FHSS is the one, time constricted by the matched filter, is evident uniquely.

We have observed, the fundamental concepts of spread spectrum communications have been offered here in terms of getting over the consequences of redundant external interference. Spread spectrum has much wider practical application merely than that of interference rejection.



(a)



(b)

Figure.2 Linear frequency modulation bandpass (a) Plain signal (b) Spread Signal

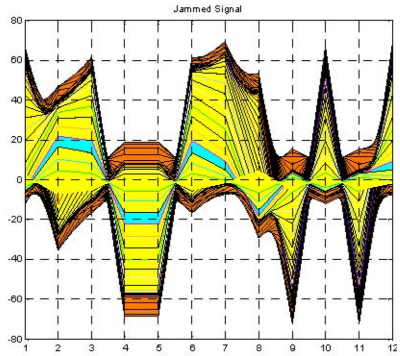
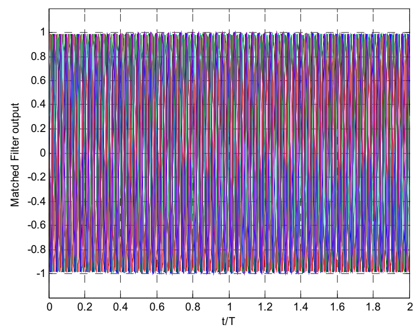
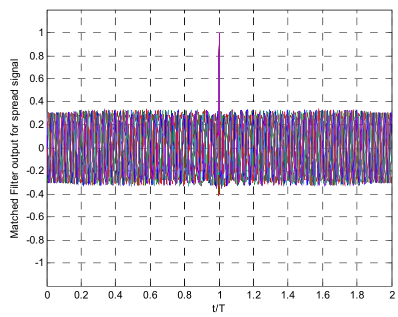


Figure.3 LFM signal after corrupted by Jammer



(a)



(b)

Figure.4 Matched filter output of (a) Plain Signal (b) Spread Signal

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