SPREAD SPECTRUM - 17.3.2006 [1]

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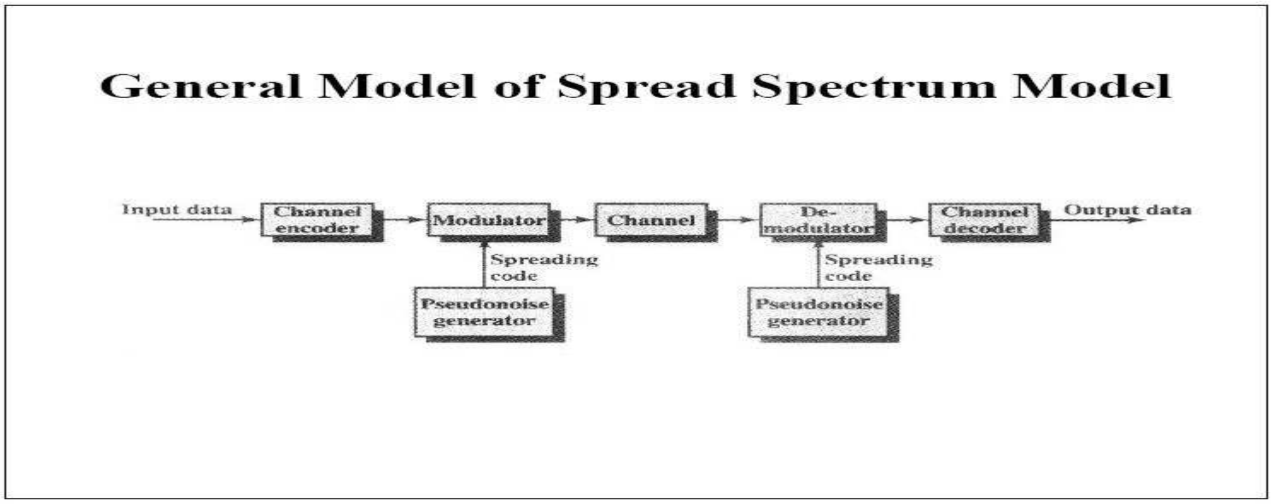
[1]Ref: Data and Computer Communications by William Stallings

- The basic idea of spread spectrum is to modulate the signal so as to increase significantly the bandwidth (spread the spectrum) of the signal to be transmitted.
- General model of Spread Spectrum Digital Communication System.

Frequency Hopping Spread Spectrum

- With frequency hopping spread spectrum(FHSS),the signal is broadcast over a seemingly random series of radio frequencies ,hopping from frequency to frequency at fixed intervals. A receiver ,hopping between same frequencies in synchronisation with the transmitter ,picks up the message .Attempts to jam the signal on one frequency succeed only at knocking out a few bits of it.



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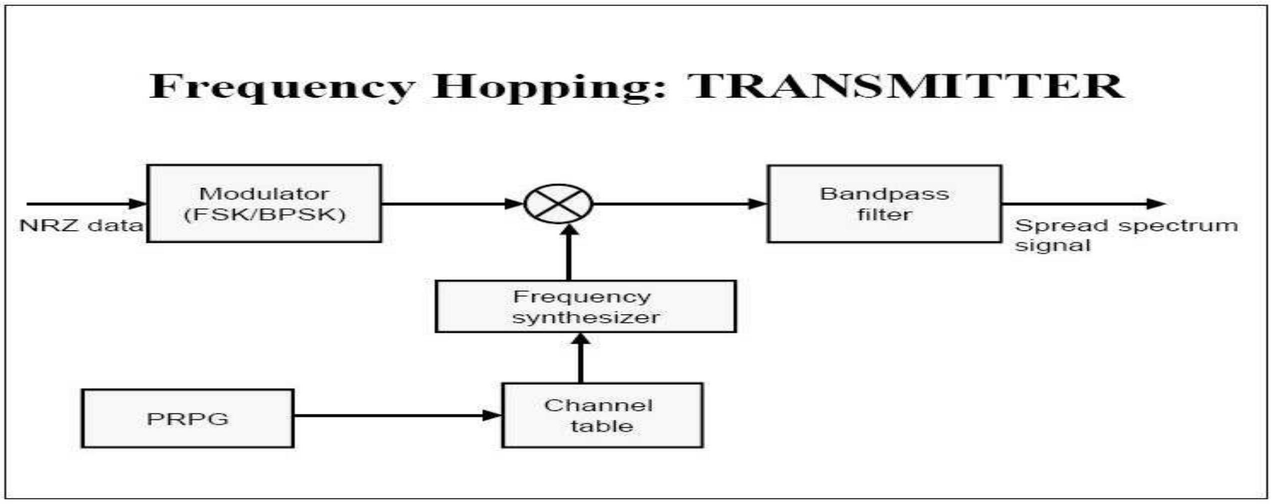
I. Basic Approach

- A typical block diagram of frequency hopping system randomly hops beween different frequencies.
  - At each successive interval a new carrier frequency is selected.This frequency is then modulated by the signal produced by the original modulator to produce a new signal centered around the selected frequency.

II. Basic Approach Contd..

- Figure after the slides show that the two signals are multiplied . For example let BFSK be the data modulation scheme. We can define FSK input to the FHSS system as Sd(t) =

  Acos(2*pie(fo + 0.5(bi +1)/ f)t) for iT ¡ t ¡ (i+1)T where A = amplitude of the signal fo = base frequency bi = value of the ith bit of data (+1 for binary 1,-1 for binary 0) / f= frequency seoaration T = bit duration ;data rate = 1/T Sd(t)=Data Signal



III. Basic Approach Example

- In this example during the ith bit interval ,the frequency of data signal is fo or fo + / f depending on data bit being 1 or -1 respectively.
- Assuming the duration of one hop is the same as the duration of one bit we have the product signal during the ith hop as $p(t) = sd(t) * c(t) = Acos(2 * pie(fo + 0.5(bi + 1)/\ f)t) * cos(2 *$

$pie * fi * t)$

p(t) = product signal c(t) = chipping signal(spreading signal) Sd(t)= Data Signal fi = frequency generated by frequency synthesizer during the ith hop

- Using cos(x)cos(y)=(1/2)*[cos(x+y) + cos(x-y)] we have $p(t) = 0.5Acos(2 * pie(fo + 0.5(bi + 1)/\ f + fi)t) + Acos(2 * pie(fo + 0.5(bi + 1)/\ f - fi)t)$

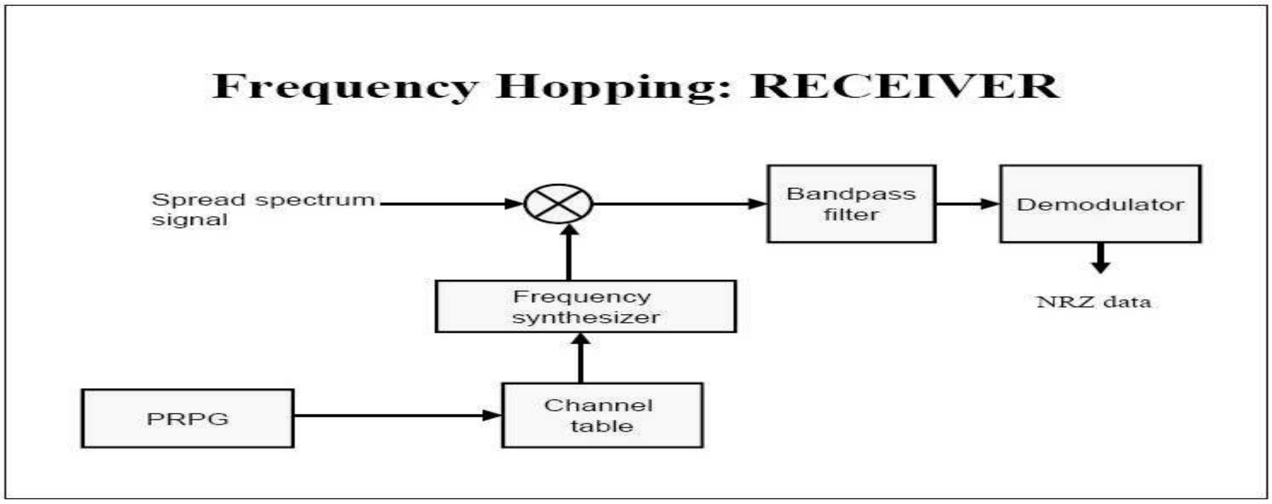
- A band pass filter blocks the difference frequency & passes the sum frequency ,yielding $s(t) = 0.5Acos(2 * pie(fo + 0.5(bi + 1)/\ f + fi)t)$ In this example during the ith bit interval ,the frequency of data signal is fo + fi or fo + fi + / f depending on data bit being -1 or +1 respectively.

IV. Basic Approach Example (Receiver side)

- At the receiver end s(t) will be received(see figure) .It is multiplied by a replica of c(t) to yield $p(t) = sd(t) * c(t) = 0.5 * Acos(2 * pie(fo + 0.5(bi + 1)/\ f + fi)t) * cos(2 * pie * fi * t)$

- Using $cos(x)cos(y) = (1/2) * [cos(x + y) + cos(x - y)]$ we have $p(t) = sd(t) * c(t) = 0.25 *$

  $Acos(2 * pie(fo + 0.5(bi + 1)/\ f + fi + fi)t) + 0.25 * Acos(2 * pie(fo + 0.5(bi + 1)/\ f)t)$
- A bandpass filter is used to block the sum frequency & pass the difference frequency, yielding a signal of the form of sd(t) as $0.25 * Acos(2 * pie(fo + 0.5(bi + 1)/\ f)t)$



V. FHSS using MFSK

- A commom modulation technique used in conjunction with FHSS is multiple FSK.The transmitted signal is of the form $si(t) = Acos(2 * pie * fi * t) where 1 <= i <= M$ where $fi =$

  $fc + (2 * i - 1 - M) fd$ fc = denotes the carrier frequency fd = denotes the difference frequency M = number of different signal elements = 2^L

- For FHSS, the MFSK signal is translated to a new frequency every Tc seconds by modulating the MFSK signal wih the FHSS carrier signal. The effect is to transalte the MFSK signal into the appropraiate FHSS channel.For a data rate of R,the duration of a bit is T=1/R seconds and the duration of a signal element is Ts=LT seconds.If Tc ¿= Ts spreading modulation is referred as slow frequency hop spread spectrum otherwise fast hop spraed spectrum.