DIRECT SEQUENCE SPREAD SPECTRUM - PRINCIPLE

Principle of DSSS:

Consider the frequency translation of a baseband message (of bandwidth B Hz) to a higher part of the spectrum, using DSBSC modulation. The resulting signal occupies a bandwidth of 2B Hz, and would typically override the noise occupying the same part of the spectrum. This makes it easy to find with a spectrum analyzer (for example), and so the probability of intercept is high. A local carrier, synchronized with that at the transmitter, is required at the receiver for synchronous demodulation. The recovered signal-to-noise ratio is 3 dB better than that measured at its original location in the spectrum. This 3 dB improvement comes from the fact that the contributions from each sideband add coherently, whereas the noise does not. This can be called a 3 dB 'processing gain', and is related to the fact that the transmission bandwidth and message bandwidth are in the ratio of 2:1.

In a spread spectrum system literally thousands of different carriers are used, to generate thousands of DSBSC signals each derived from the same message. These carriers are spread over a wide bandwidth (much wider than 2B Hz), and so the resulting DSBSC signals will be spread over the same bandwidth.

If the total transmitted power is similar to that of the single DSBSC case, then the power of an individual DSBSC in the spread spectrum case is thousands of times less. In fact, over the bandwidth occupied by one of these DSBSC signals, it would be literally 'buried in the noise', and difficult to find with a spectrum analyzer (for example).

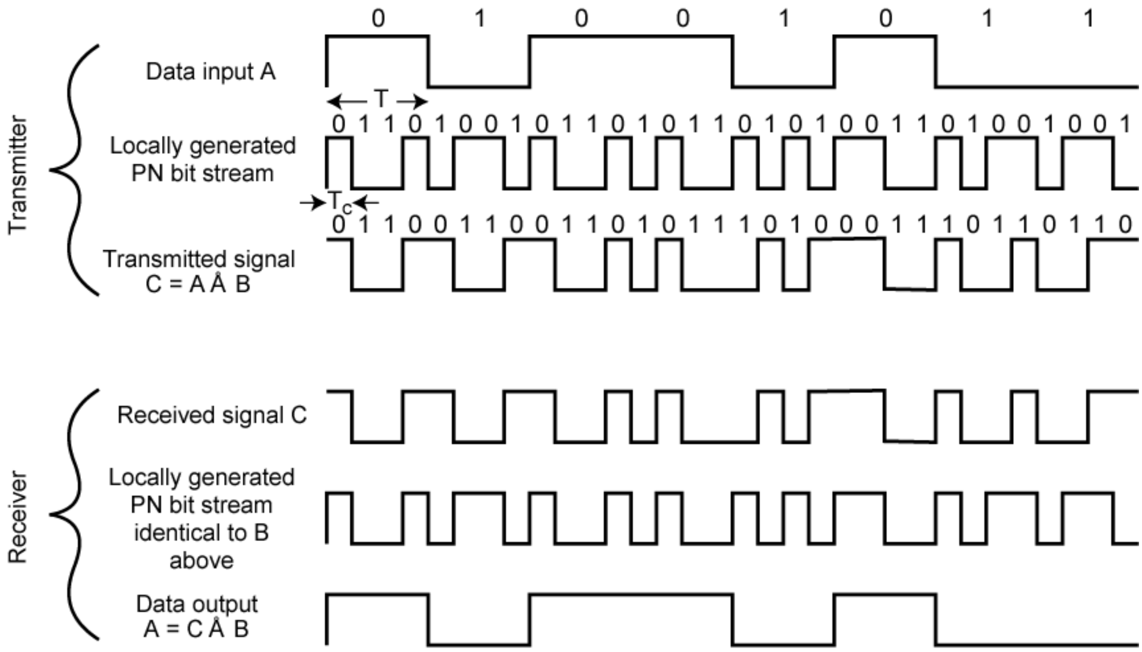
Instead of the total transmitted power being concentrated in a band of width 2B Hz, the multiple carriers have spread it thinly over a very wide bandwidth. The signal-to-noise ratio for each DSBSC is very low (well below 0 dB). To recover the message from the transmitted spread spectrum signal all that a receiver requires is thousands of local carriers, at the same frequency and of the same relative phase, as all those at the transmitter. All these carriers come from a pseudo random binary sequence (PRBS) generator.

Given a stable clock, and a long sequence, it may be shown that the spectrum of a pseudo random binary sequence generator is a good source of these carriers. A second PRBS generator, of the same type, clocked at the same rate, and appropriately aligned, is sufficient to regenerate all the required local carriers at the receiver demodulator.

In the spread spectrum context the PRBS signal is generally called a PN – pseudo noise - signal, since its spectrum approaches that of random noise.

Having the correct sequence at the receiver means that the message contributions from each of the thousands of minute DSBSC signals combine in phase – coherently - and add up to a finite message output. Otherwise they add with random phases, resulting in a (very) small, noise-like output.

Direct Sequence Spread Spectrum Example:

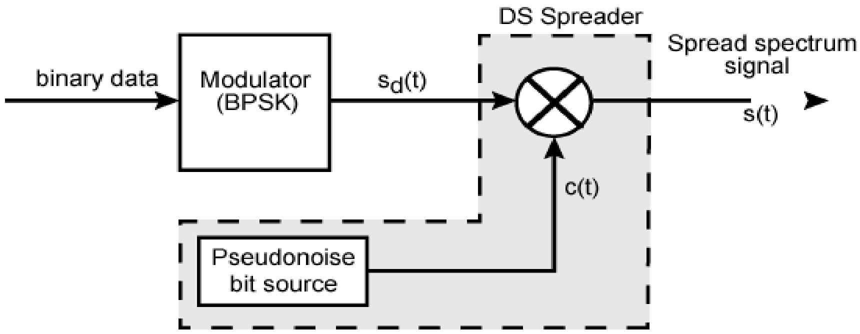


Direct Sequence Spread Spectrum Transmitter/receiver:

To generate a spread spectrum signal one requires:

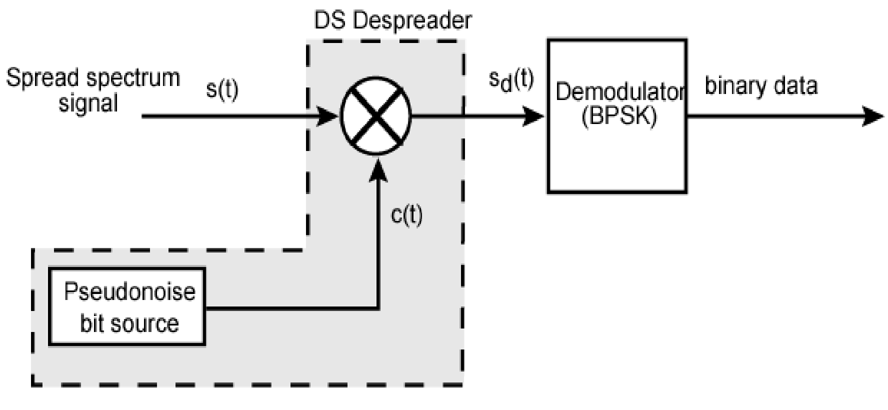
1. A modulated signal somewhere in the RF spectrum
2. A PN sequence to spread it

There are two bandwidths involved here: that of the modulated signal, and the spreading sequence. The first will be very much less than the second. The output spread spectrum signal will be spread either side of the original RF carrier (ω_0) by an amount equal to the bandwidth of the PN sequence. Most of the energy of the sequence will lie in the range DC to ω_s, where ω_s is the sequence clock. The longer the sequence the more spectral components will lie in this range. It is necessary and usual that $\omega_0 >> \omega_s$, although in the experiment to follow the difference will not be large. The modulated signal can be of any type, but typically digitally-derived, such as binary phase shift keyed - BPSK. In this case the arrangement of Figure 1 can be expanded to that of Figure 2. A digital message is preferred in an operational spread spectrum system, since it makes the task of the eavesdropper even more difficult.



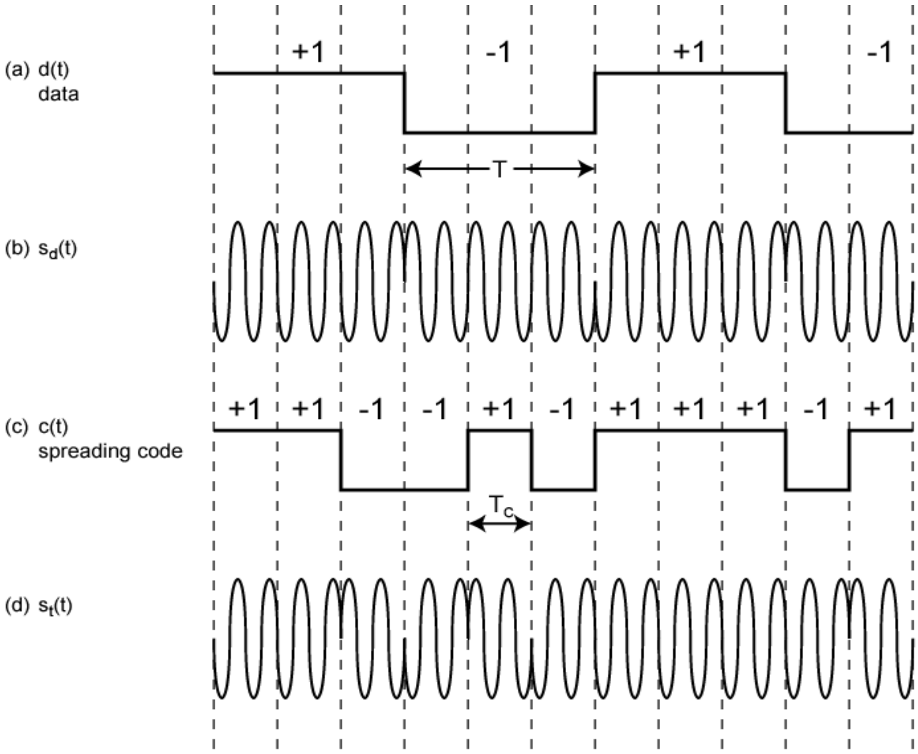
The input multiplier performs the de-spreading of the received signal, and the second multiplier translates the modulated signal down to baseband. The filter output would probably require further processing - not shown - to ‘clean up’ the waveform to binary format.

The PN sequence at the receiver acts as a ‘key’ to the transmission. It must not only have the same clock and bit pattern; it must be aligned properly with the sequence at the transmitter.



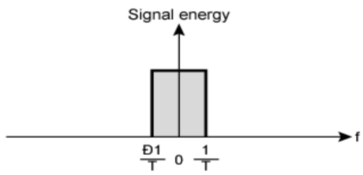
Processing gain:

To achieve most of the claims made for the spread spectrum it is necessary that the bandwidth over which the message is spread be very much greater than the bandwidth of the message itself. Each DSBSC of the DSSS signal is at a level below the noise, but each is processed by the synchronous demodulator to give a 3 dB SNR improvement. The total improvement is proportional to the number of individual DSBSC components. In fact the processing gain of the system is equal to the ratio of DSSS bandwidth to message bandwidth.

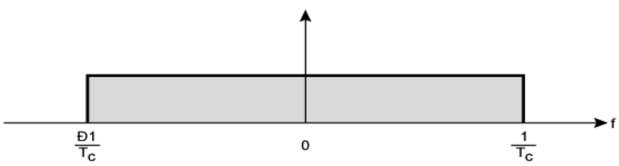


Direct Sequence Spread Spectrum Using BPSK Example

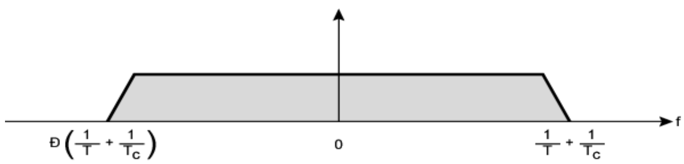
Approximate Spectrum of DSSS Signal:



(a) Spectrum of data signal



(b) Spectrum of pseudonoise signal



(c) Spectrum of combined signal

Source : http://msk1986.files.wordpress.com/2013/09/wlc-unit1.pdf