Direct Sequence Spread Spectrum (DSSS)

DSSS is the modulation method used for wireless LAN and ZigBee. DSSS transmissions multiply the data being transmitted by a “noise” signal. This noise signal is a pseudorandom sequence of 1 and -1 values, at a frequency much higher than that of the original signal. This noise-like signal can be used to exactly reconstruct the original data at the receiving end, by multiplying it by the same pseudorandom sequence. This process is known as “de-spreading.”

Transmitter

The information signal undergoes primary modulation by phase shift keyed (PSK), frequency shift keyed (FSK), or other narrowband modulation and then secondary modulation with spread-spectrum modulation. Spread spectra are obtained by multiplying the primary modulated signal and the square wave, called the PN sequence. Alternatively, as in commercial radio, there are cases where spread modulation is applied to the data first, and narrowband modulation, such as PSK or FSK, is applied afterwards.

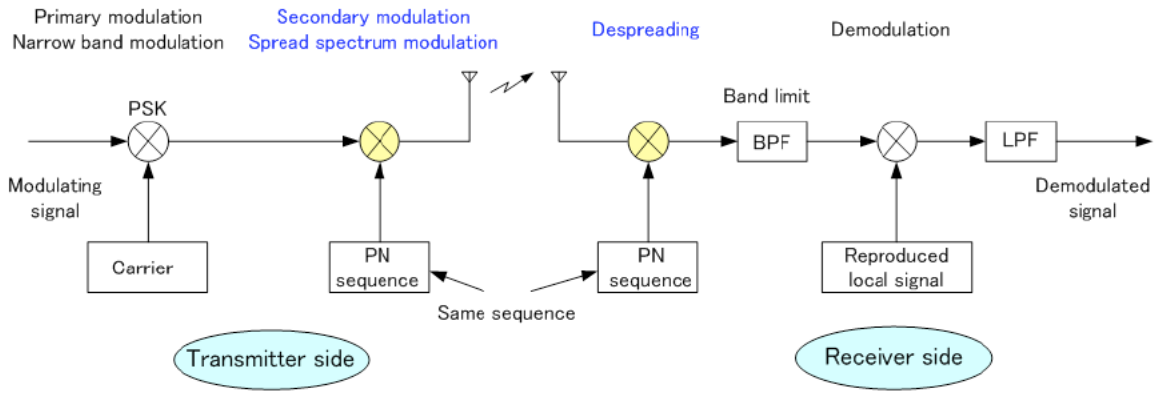

Figure 2: Spread spectrum modulation and demodulation using PSK for primary modulation.

Receiver

If despreading is applied to the received diffuse wave, it returns to the PSK or FSK modulated wave resulting from primary modulation. Then, as with narrowband demodulation, if the despread wave and local signal are multiplied, and appropriate low pass processing is applied, the information signal can be retrieved. Despreading involves multiplying the same PN code as that used at the transmitting end for the receiving wave. It is necessary to synchronize the receiving wave and PN code.

There are two processing methods on the receiving side, demodulation of the information signal after despreading, and obtaining a positive and negative PN code by multiplying the local signal by the receiving wave and despreading using correlation detection. With the former there is process gain but the problem of synchronization

remains. With the latter, the spectrum density of the receiving wave itself is low, and regeneration of the local carrier for performing synchronous detection is a problem. Commercial SS radio equipment uses the latter, but it requires considerable power and has a short communication range.

Despreading

The signal that enters the antenna of the receiver includes outside interference waves and noise. If this signal is despread, the signal component returns to a narrowband modulated wave and the interference components are diffused, expanding the spectrum infinitely so that its power density falls. Therefore, by inputting the signal with frequency band restricted using a band-pass filter, the interference component power that falls into the demodulation frequency band is reduced. The occurrence of errors is calculated using a stochastic process, so ultimately, using spread spectrum results in fewer errors, and thus spread-spectrum communication is resistant to interference.

Demodulation

Demodulation is normal narrowband demodulation. The local signal is regenerated from the receiving wave and after multiplication by the receiving wave, unnecessary components are eliminated with a low-pass filter. Primary modulation uses PSK, so synchronous detection is necessary.

PN sequence

The PN sequence is switched at a far faster speed than the symbol rate of the information signal and its spectrum covers a wide band. For this reason, the spectrum of the modulated wave after primary modulation also covers a wide band.

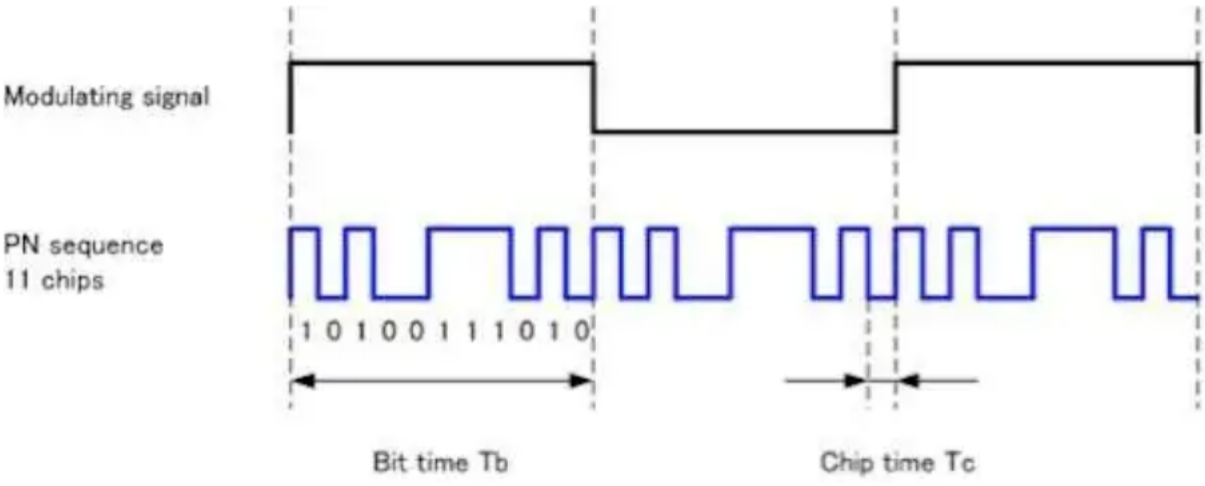

Figure 3: PN sequence

Advantages of DS-SS System

1. This system is the most effective at detecting and preventing deliberate interference (jamming).

2. For multipath signals, this system has a very high level of discrimination. As a result, the multipath interference is successfully reduced.

3. When compared to other systems, the DS-SS system outperforms them in the presence of noise.

Disadvantages of DS-SS system

1. The output rate of the PN code generator must be high. The length of such a series must be sufficient to ensure that it is genuinely random.

2. The acquisition time using the serial search method is too long. As a result, the DS-SS system is sluggish.

3. The varying distance between the transmitter and receiver affects synchronization.

4. The DS-SS signal is ineffective in the case of broadband interference.

Applications of DS-SS system

1. Anti-jamming application — protecting a jamming signal.

2. Signal transmission with low detectability - the signal is intentionally delivered at a very low power level. As a result, the signal is known as an LPI signal since it has a low probability of being intercepted (LPI).

3. Supporting numerous simultaneous signal transmissions on the same channel, such as with Code Division Multiple Access (CDMA) or spread spectrum multiple access (SSMA).