Different Modulation Spreading Techniques for Spread Spectrum, DSSS, FHSS and THSS

Different SS techniques are distinguished according to the point in the system at which a pseudo-random code (PRN) is inserted in the communication channel. This is very basically illustrated in the here below RF front end schematic :

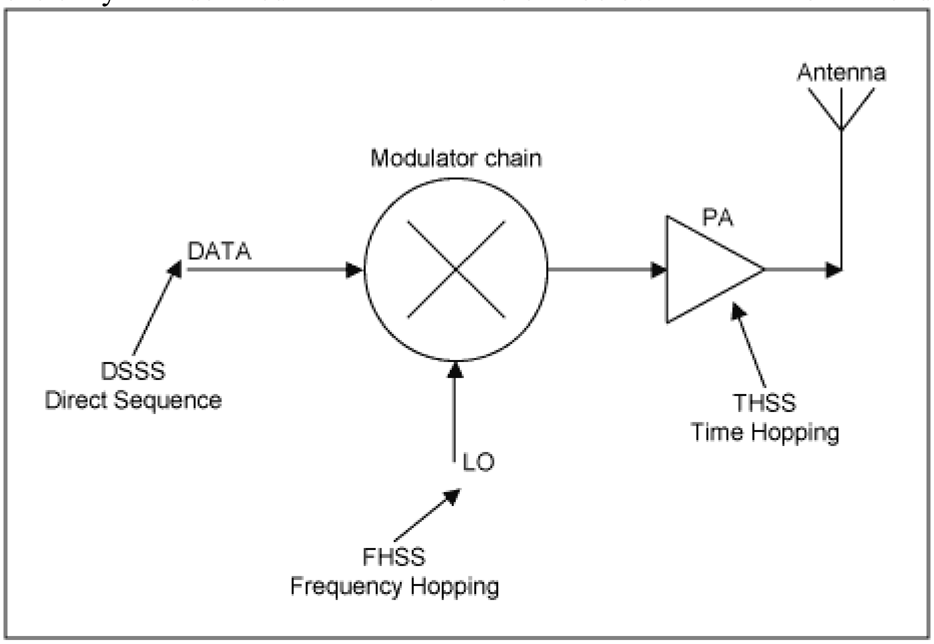

Figure 12.

If the PRN is inserted at the data level, we have the direct sequence form of spread spectrum (DSSS). (In practice, the pseudo-random sequence is mixed or multiplied with the information signal, giving an impression that the original data flow was "hashed" by the PRN.) If the PRN acts at the carrier-frequency level, we have the frequency hopping form of spread spectrum (FHSS). Applied at the LO stage, FHSS PRN codes force the carrier to change or hop according to the pseudo-random sequence. If the PRN acts as an on/off gate to the transmitted signal, we have a time hopping spread spectrum technique (THSS). There is also the chirp technique, which linearly sweeps the carrier frequency in time. One can mix all the above techniques to form a hybrid SS technique, such as DSSS + FHSS. DSSS and FHSS are the two techniques most in use today.

Direct Sequence Spread Spectrum (DSSS)

In this technique, the PRN is applied directly to data entering the carrier modulator. The modulator therefore sees a much larger bit rate, which corresponds to the chip rate of the PRN sequence. The result of modulating an RF carrier with such a code sequence is to produce a direct-sequence-modulated spread spectrum with $((\sin x)/x)^2$ frequency spectrum, centered at the carrier frequency.

The main lobe of this spectrum (null to null) has a bandwidth twice the clock rate of the modulating code, and the sidelobes have null-to-null bandwidths equal to the code"s clock rate. Illustrated below is the most common type of direct-sequence-modulated spread spectrum signal. Direct-sequence spectra vary somewhat in spectral shape, depending on the actual carrier and data modulation used. Below is a binary phase shift keyed (BPSK) signal, which is the most common modulation type used in direct sequence systems.

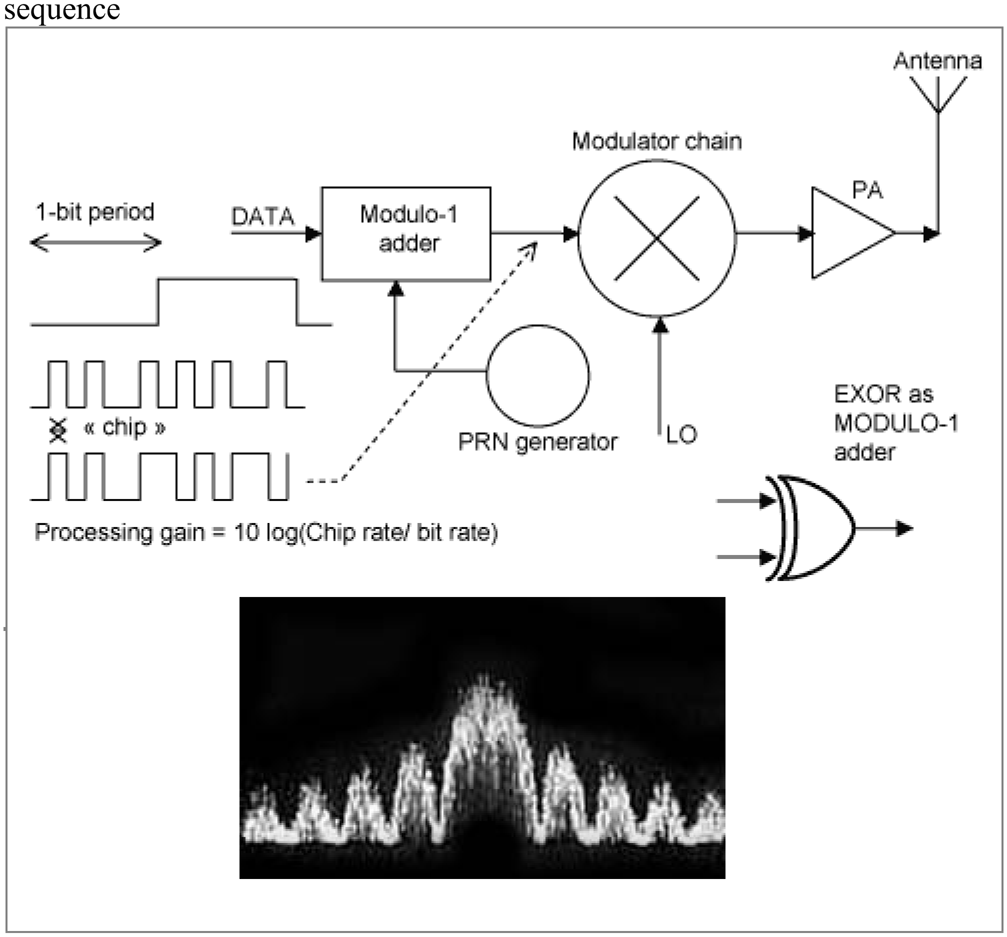

Figure 13. Spectrum-analyzer photo of a direct-sequence (DS) spread-pectrum signal. Note the orginal signal (non-spread) would only occupy half of the central lobe.

Frequency Hopping Spread Spectrum (FHSS)

This method does exactly what its name implies, it causes the carrier to hop from frequency to frequency over a wide band according to a sequence defined by the PRN. The speed at which the hops are executed depends on the data rate of the original information, but one can distinguish between Fast Frequency Hopping (FFHSS) and Low Frequency Hopping (LFHSS). The latter method (the most common) allows several consecutive data bits to modulate the same frequency. FFHSS, on the other hand, is characterized by several hops within each data bit.

The transmitted spectrum of a frequency hopping signal is quite different from that of a direct sequence system. Instead of a $((\sin x)/x)^2$-shaped envelope, the frequency hopper's output is flat over the band of frequencies used (see below). The bandwidth of a frequency-hopping signal is simply N times the number of frequency slots available, where N is the bandwidth of each hop channel.

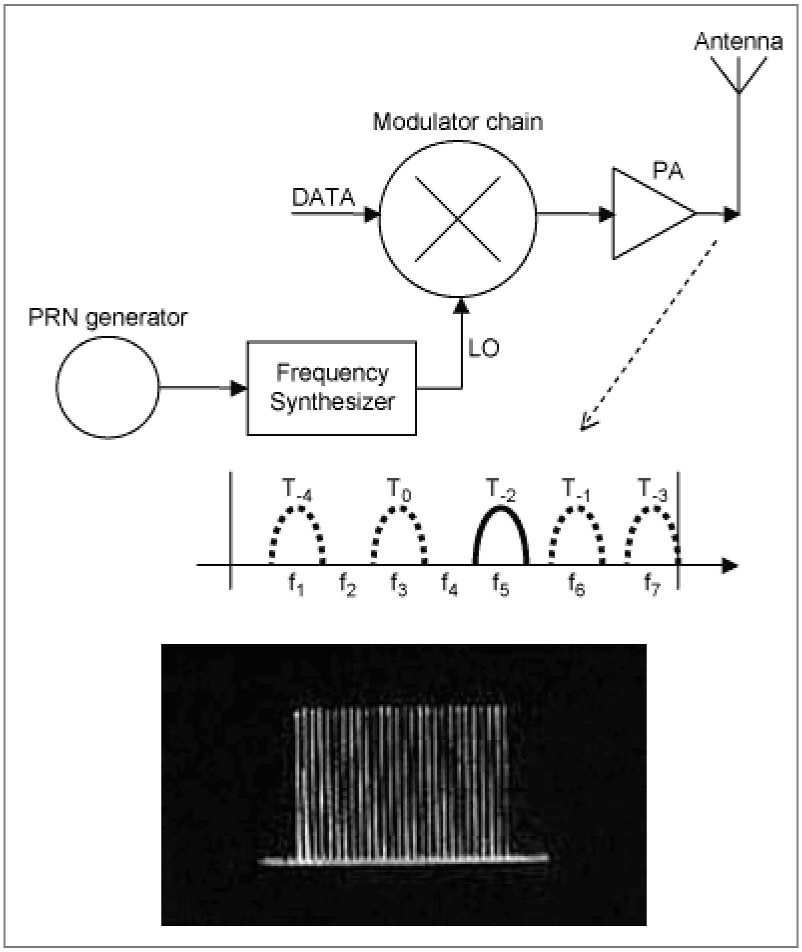

Figure 14. Spectrum-analyzer photo of a frequency-hop (FH) spread-spectrum signal.

Time Hopping Spread Spectrum (THSS)

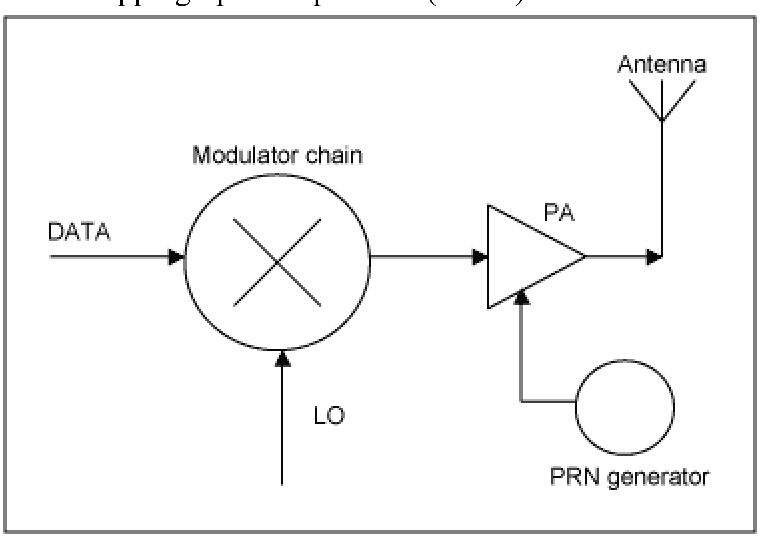

Figure 15.

Here, in a method not well developed today, the on and off sequences applied to the PA are dictated according to the PRN sequence.

Implementations and Conclusions

A complete SS communication link requires various advanced and up-to-date technologies and disciplines: RF antenna, powerful and efficient PA, low-noise, highly linear LNA, compact transceivers, high-resolution ADCs and DACs, rapid low-power digital signal processing (DSP), etc. Though designers and manufacturers compete, they are also joining in their effort to implement SS systems.

The most difficult area is the receiver path, especially at the despreading level for DSSS, because the receiver must be able to recognize the message and synchronize with it in real time. The operation of code recognition is also called correlation. Because correlation is performed at the digital-format level, the tasks are mainly complex arithmetic calculations including fast, highly parallel binary additions and multiplications. The most difficult aspect of today's receiver design is synchronization. More time, effort, research, and money has gone toward developing and improving synchronization techniques than toward any other aspect of SS communications.

Several methods can solve the synchronization problem, and many of them require a large number of discrete components to implement. Perhaps the biggest breakthroughs have occurred in DSP and in application specific integrated circuits (ASICs). DSP provides high-speed mathematical functions that analyze, synchronize, and decorrelate an SS signal after slicing it in many small parts. ASIC chips drive down costs via VLSI technology, and by the creation of generic building blocks suitable for any type of application.

Source : http://nprcet.org/e%20content/cse/ADC.pdf