Direct-Sequence Spread-Spectrum Communications

Introduction

As spread spectrum techniques become increasingly popular, electrical engineers outside the field are eager for understandable explanations of the technology. There are many books and web sites on the subject but many are hard to understand or describe some aspects while ignoring others (the DSSS type, for instance, with extensive focus on PN-code generation).

The following discussion covers the full spectrum.

Definitions

Different SS techniques are available, but all have one idea in common: the key (also called code or sequence) attached to the communication channel. The manner of inserting this code defines precisely the SS technique in question. The term "spread spectrum" refers to the expansion of signal bandwidth, by several orders of magnitude in some cases, which occurs when a key is attached to the communication channel.

The formal definition of SS is more precise: Spread spectrum is an RF communications system in which the baseband signal bandwidth is intentionally spread over a larger bandwith by injecting a higher-frequency signal. As a direct consequence, energy used in transmitting the signal is spread over a wider bandwith, and appears as noise. The ratio (in dB) between the spread baseband and the original signal is called processing gain. Typical SS processing gains run from 10dB to 60dB.

To apply an SS technique, simply inject the corresponding SS code somewhere in the transmitting chain before the antenna. (That injection is called the spreading operation.) The effect is to diffuse the information in a larger bandwidth. Conversely, you can remove the SS code (despreading operation) at a point in the receive chain before data retrieval. The effect of a despreading operation is to reconstitute the information in its original bandwidth. Obviously, the same code must be known in advance at both ends of the transmission channel. (In some circumstances, it should be known only by those two parties.)

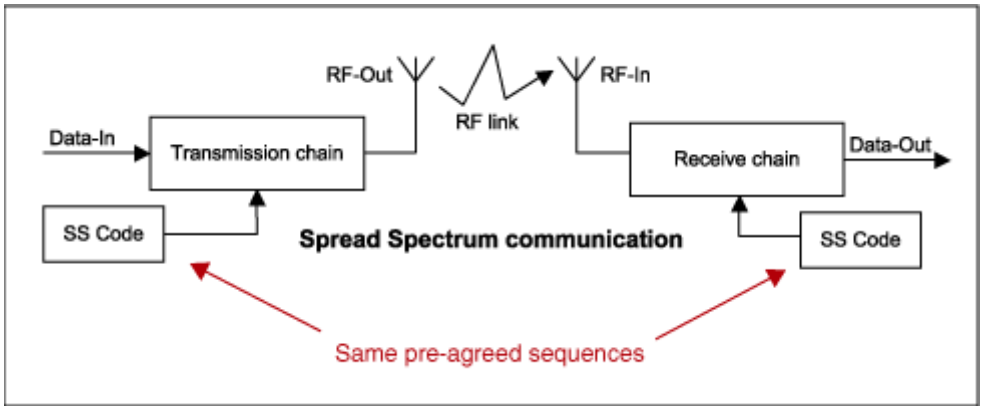

Figure 1.

Bandwidth Effects of the Spreading Operation

The simple drawings below illustrate the evaluation of signal bandwiths in a communication link.

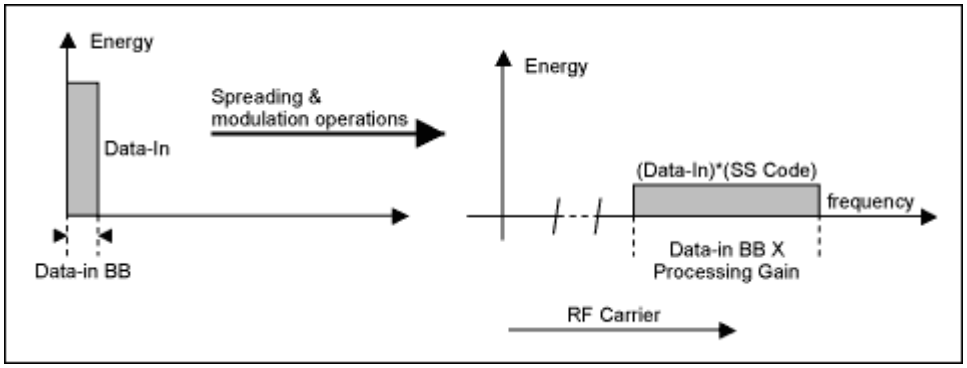

Figure 2.

SS modulation is applied on top of a conventional modulation such as BPSK or direct conversion. One can demonstrate that all other signals not receiving the SS code will stay as they are, unspread.

Bandwidth Effects of the Despreading Operation

Similarly, despreading can be seen as follows:

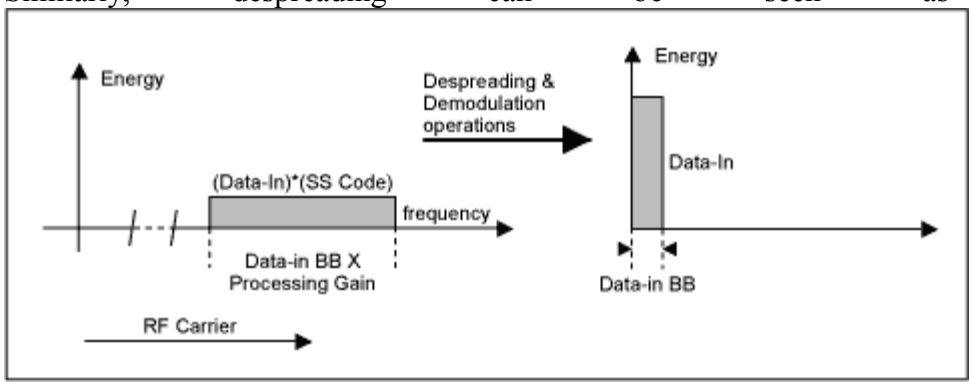

Figure 3.

An SS demodulation has been made on top of the normal demodulation operations above. One can also demonstrate that signals added during the transmission (such as an interferer or jammer) will be spread during the despreading operation!