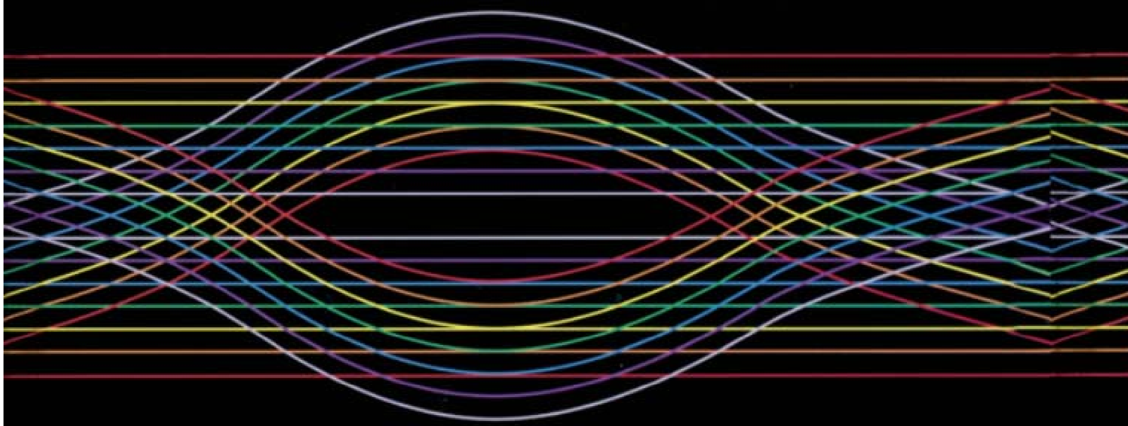

Transceiver and System Design for Digital Communications

Scott R. Bullock

Second Edition

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reflected back to the source and not delivered to the load or antenna. The standing wave is minimized by making the impedances equal so that there are virtually no reflections (VSWR 1:1).

2.7 Spread Spectrum Transmitter

Many systems today use spread spectrum techniques to transport data from the transmitter to the receiver. One of the most common forms of spread spectrum uses phase shift keying and is referred to as *direct sequence* (DS). The data is usually exclusive-or'd with a pseudo-random or *pseudo-noise* (PN) code that has a much higher chipping rate than the data rate. This produces a wider occupied spectrum in the frequency domain (spread spectrum).

DS systems use *phase shift generators* (PSG) to transfer data (plus code for spread spectrum systems) by phase-shifting a carrier frequency. There are several ways to build a PSG depending on the waveform selected. Detailed description of phase shift keying modulation is provided. Other forms of spread spectrum including frequency hopping, time hopping, chirped FM, and ways to manage multiple users are included.

Phase Shift Keying

Phase shift keying (PSK) is a type of modulation where the phase of the carrier is shifted to different phase states by discrete steps using a digital sequence. This digital sequence can be either the digitized data or a combination of digitized data and a spread spectrum sequence. There are many different levels and types of PSK. This discussion will be limited to a maximum of four phase states. However, the principle can be extended to higher order PSK.

Binary Phase Shift Keying (BPSK)

The basic PSK is the binary-PSK or BPSK (see Figure 2-2). This is defined as shifting the carrier 0 or 180 degrees in phase depending on the digital waveform. For example, a +1 gives 0 degrees phase of the carrier, and –1 shifts the carrier by 180 degrees. To produce the digital waveform, the data or information signal is digitized, encoded, and sent out in a serial bit stream, (if not already), and modulo 2 (exclusive-or) added to a PN sequence. The end result is a serial modulating digital waveform. The output of the modulo 2 adder (exclusive-or) contains 0 and 1 and needs to be changed to ± 1 for the mixer to operate. However, certain forms of hardware can bypass this step and modulate the mixer directly. *Emitter-coupled logic* (ECL) contains differential outputs and can be connected directly to the mixer. ECL is also capable of driving 50 ohms directly without an additional driver. A dual input mixer is required in order for the ECL logic to connect directly.

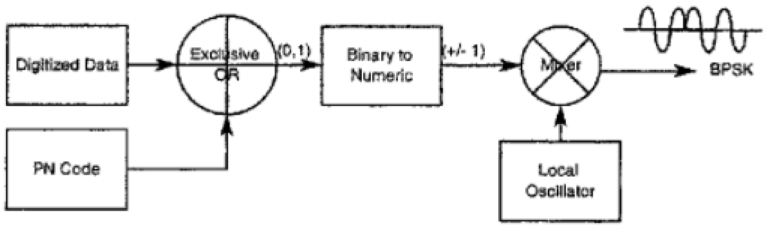

Figure 2-2 *BPSK generator.*

Applying minus voltage to the mixer reverses the current through the balun of the mixer and causes the current to flow in the opposite direction to create a net 180 degree phase shift of the carrier. Therefore, the carrier is phase- shifted between 0 and 180 degrees depending on the input waveform. A simple way of generating BPSK is shown in Figure 2-2. The LO is either multiplied by a +1 or a –1 from the digital sequence producing a 0 or a 180 phase shift.

Other devices such as phase modulators or phase shifters can create the same waveform just as long as one digital level compared to the other digital level creates a 180 degrees phase difference in the carrier output.

Differential Phase Shift Keying (DPSK)

The BPSK waveform above can be sent out as absolute phase, i.e., a 0 degree phase shift is a "1," and a 180 degree phase shift is a "0." Another way to perform this function is to use differential PSK (DPSK), which monitors the change of phase. A change of phase then (0 to 180 or 180 to 0) represents a "1" and no change (0 to 0 or 180 to 180) represents a "0." This scheme is easier to detect because only the change of phase needs to be monitored. The absolute phase does not need to be determined. Differential mode can be applied to various phase shifting schemes and higher order phase shift schemes. Differential results in about one dB of degradation compared to coherent PSK It is, however, dependent on the *S/N* level and the operating position on the probability of error curve. Note that differential can be applied in higher order PSK systems, such as *differential quaternary phase shift keying* (DQPSK) and *differential eight phase shift keying* (D8PSK).

Quaternary Phase Shift Keying (QPSK)

The LO is quadrature phase-shifted so that four phasors are produced on the outputs of the two mixers, 0 or 180 degrees out of one mixer and 90 or 270 degrees out of the second mixer. The phasor diagram shows the four phasors (see Figure 2-3). The two BPSK systems are summed together, which gives four possible resultant phasors, 45, 135, 225, or 315 degrees, all are in quadrature, as shown in Figure 2-3.