tion: BPSK, QPSK, DQPSK

Modulation

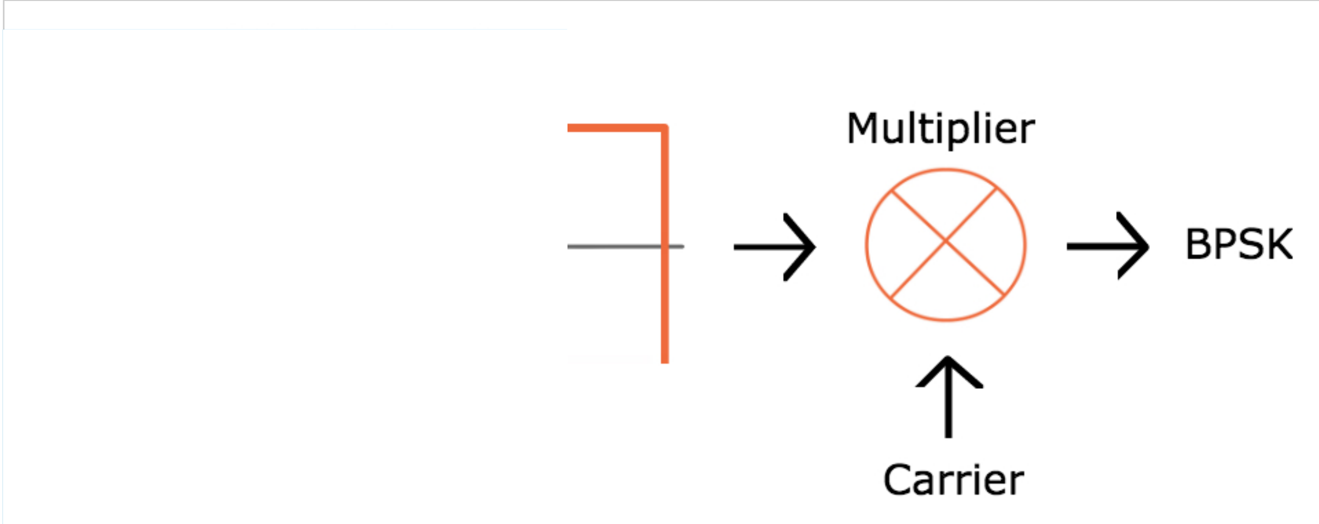
ely used method of wirelessly transferring digital data.

iscrete variations in a carrier's amplitude or frequency as a way of no surprise that we can also represent digital data using phase; this

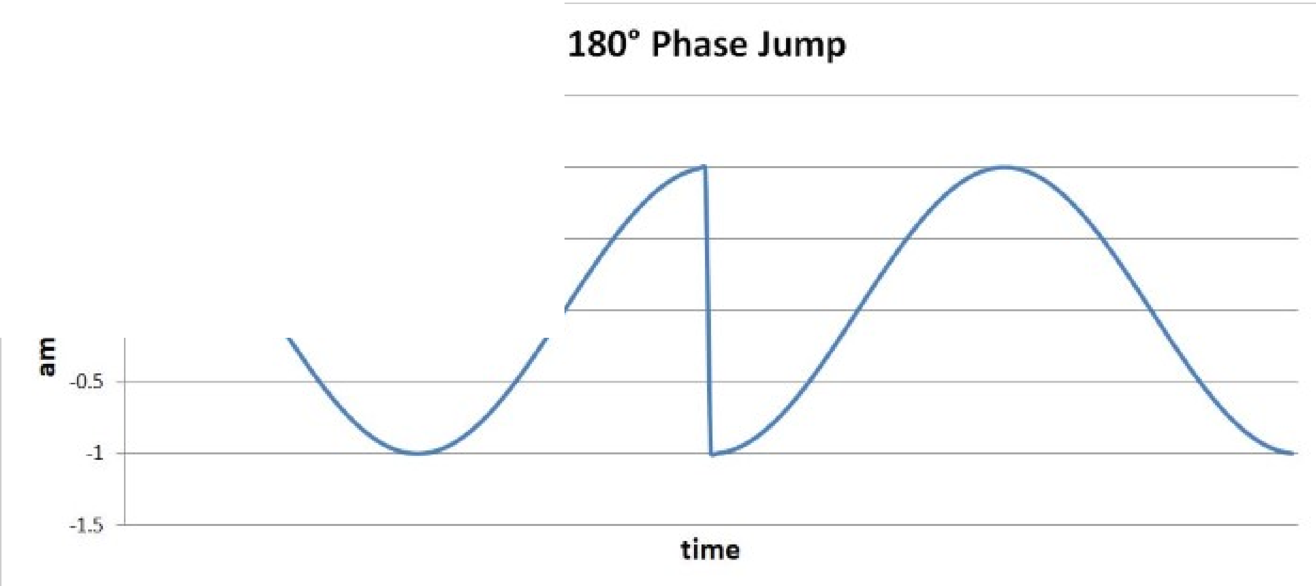
The most straightforward type of PSK is called binary phase shift keying (BPSK), where "binary" refers to the use of two phase offsets (one for logic high, one for logic low).

We can intuitively recognize that the system will be more robust if there is greater separation between these two phases—of course it would be difficult for a receiver to distinguish between a symbol with a phase offset of 90° and a symbol with a phase offset of 91°. We only have 360° of phase to work with, so the maximum difference between the logic-high and logic-low phases is 180°. But we know that shifting a sinusoid by 180° is the same as inverting it; thus, we can think of BPSK as simply inverting the carrier in response to one logic state and leaving it alone in response to the other logic state.

To take this a step further, we know that multiplying a sinusoid by negative one is the same as inverting it. This leads to the possibility of implementing BPSK using the following basic hardware configuration:

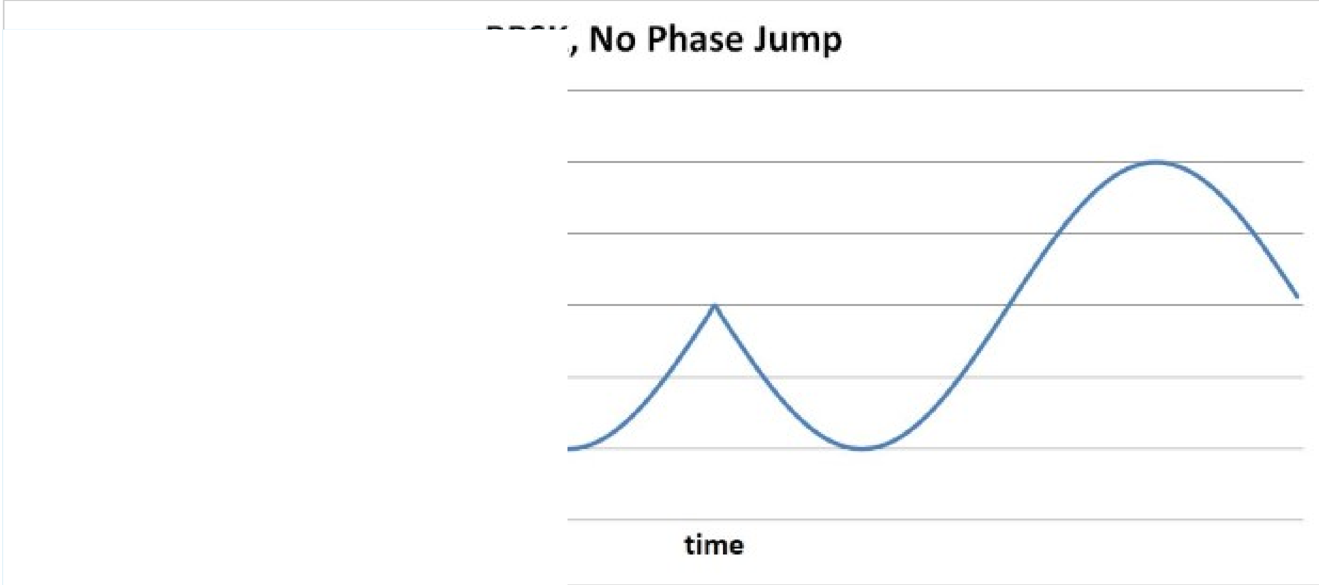


ꞵh-slope transitions in the carrier waveform: if the transition between
ximum value, the carrier voltage has to rapidly move to the minimum



High-slope events such as these are undesirable because they generate higher-frequency energy that could interfere with other RF signals. Also, amplifiers have limited ability to produce high-slope changes in output voltage.

If we refine the above implementation with two additional features, we can ensure smooth transitions between symbols. First, we need to ensure that the digital bit period is equal to one or more complete carrier cycles. Second, we need to synchronize the digital transitions with the carrier waveform. With these improvements, we could design the system such that the 180° phase change occurs when the carrier signal is at (or very near) the zero-crossing.

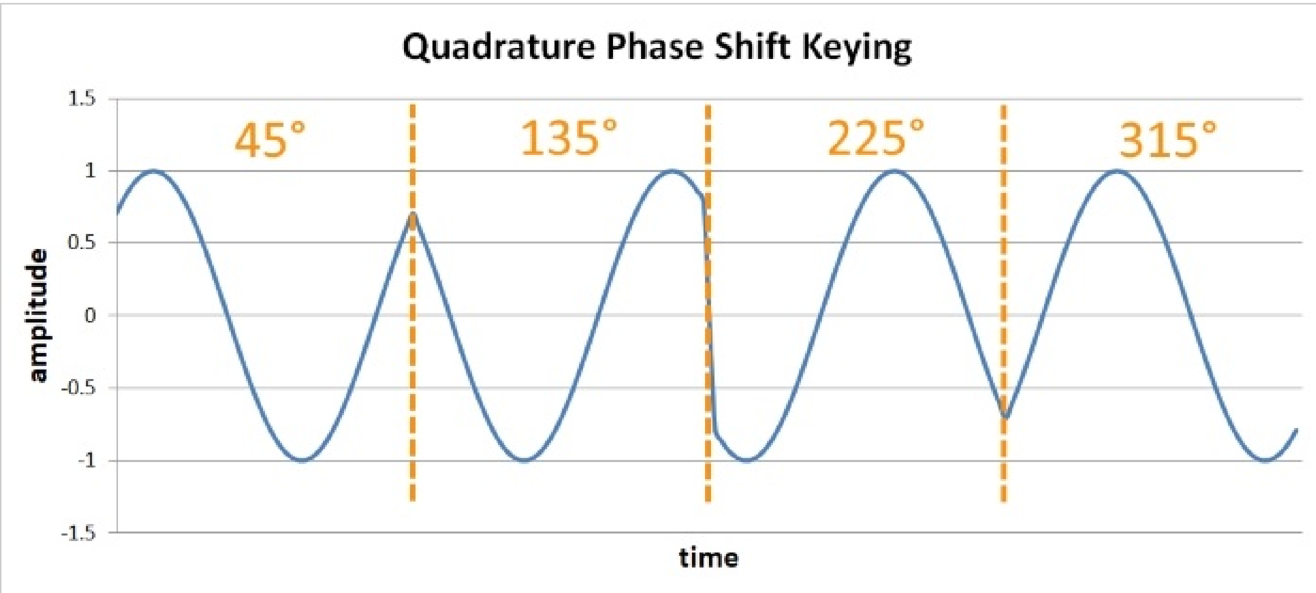


hat we're accustomed to so far. Everything we've discussed with
he carrier signal is modified according to whether a digital voltage is
ucts digital data by interpreting each symbol as either a 0 or a 1.

g (QPSK), we need to introduce the following important concept:
r only one bit. It's true that the world of digital electronics is built
extreme or the other, such that the voltage always represents one
using *analog* waveforms to transfer *digital* data, and it is perfectly
log waveforms are encoded and interpreted in a way that allows one

symbol to transfer two bits of data. There are four possible two-bit
need four phase offsets. Again, we want maximum separation
between the phase options, which in this case is 90°.

Scroll to continue with content



The advantage is higher data rate: if we maintain the same symbol period, we can double the rate at which data is
ide is system complexity. (You might think that QPSK is also
BPSK, since there is less separation between the possible phase
you go through the math it turns out that the error probabilities are

me. But it can be improved.

bol-to-symbol transitions will occur; because the phase jumps can be
he 180° phase jumps produced by BPSK modulation.

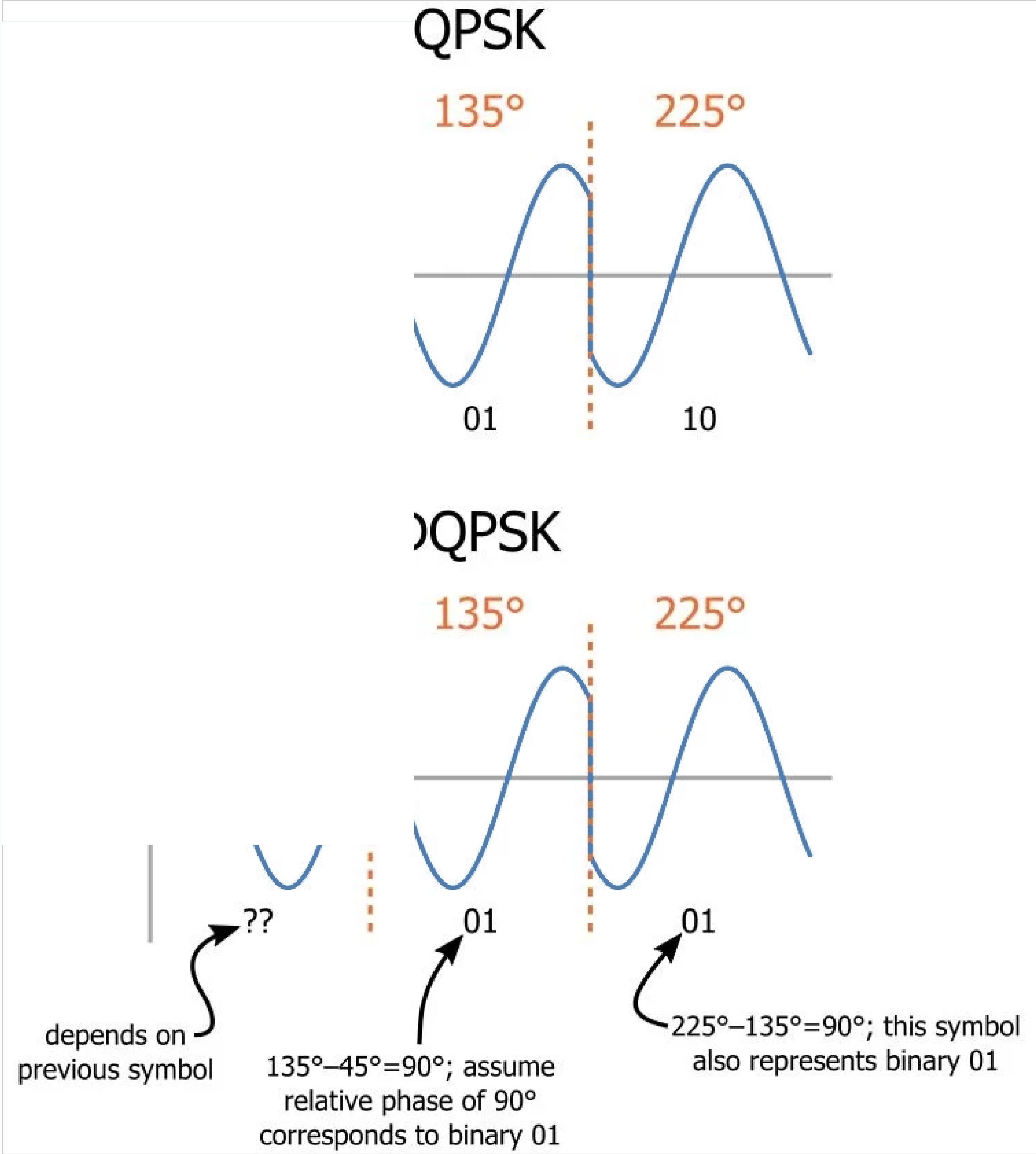
two QPSK variants. Offset QPSK, which involves adding a delay to
lulation process, reduces the maximum phase jump to 90°. Another
um phase jump to 135°. Offset QPSK is thus superior with respect to
s advantageous because it is compatible with differential encoding

scontinuities is to implement additional signal processing that creates
proach is incorporated into a modulation scheme called minimum
vement on MSK known as Gaussian MSK.

SK waveforms is more difficult than with FSK waveforms. Frequency
es can always be interpreted by analyzing the signal variations with
respect to time. Phase, however, is relative in the sense that it has no universal reference—the transmitter generates the phase variations with reference to a point in time, and the receiver might interpret the phase variations with reference to a separate point in time.

The practical manifestation of this is the following: If there are differences between the phase (or frequency) of the oscillators used for modulation and demodulation, PSK becomes unreliable. And we have to assume that there will be phase differences (unless the receiver incorporates carrier-recovery circuitry).

Differential QPSK (DQPSK) is a variant that is compatible with noncoherent receivers (i.e., receivers that don't synchronize the demodulation oscillator with the modulation oscillator). Differential QPSK encodes data by producing a certain phase shift *relative to the preceding symbol*. By using the phase of the preceding symbol in this way, the demodulation circuitry analyzes the phase of a symbol using a reference that is common to the receiver and the transmitter.



Summary

- Binary phase shift keying is a straightforward modulation scheme that can transfer one bit per symbol.
- Quadrature phase shift keying is more complex but doubles the data rate (or achieves the same data rate with half the bandwidth).
- Offset QPSK, π/4-QPSK, and minimum shift keying are modulation schemes that mitigate the effects of high-slope symbol-to-symbol voltage changes.
- Differential QPSK uses the phase difference between adjacent symbols to avoid problems associated with a lack of phase synchronization between the transmitter and receiver.

- Digital Modulation: Amplitude and Frequency

- Textbook Index

Frequency, and Phase Modulation

:invented

Continue to site
QUOTE OF THE DAY
“
”
-