

## 23.11: Digital Modulation Summary

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The modulation efficiencies of various digital modulation schemes are summarized in Table 2.9.1. For example, in 1 kHz of bandwidth the  $3\pi/8$ -PSK scheme (supported in 3G cellular radio) transmits 2700 bits.

beta.69: It is critical to control interference in digital radio so that the error in digital transmission is no more than one bit per symbol. Error correction can then be used to provide error-free digital communications.

The modulation efficiency of an actual modulation method is less than the ideal (see Table 2.9.1). With digital modulation wave-shaping at baseband is required to constrain the spectrum of the RF-modulated signal. Thus it will take different times for the phasor to make the transition from one symbol to another; to achieve longer transitions in the same time interval requires more bandwidth than that required for shorter transitions. As a result, the modulation efficiency of modulation methods other than binary methods will be less than the ideal. So in a QPSK-like scheme, 2 bits per symbol are achievable, but the longest transition takes the most time, so the bandwidth needs to be increased so that the transition is completed in time (i.e., in a fixed time equal to one over the bandwidth). Various modulation methods have relative merits in terms of modulation efficiency, tolerance to fading (due to destructive interference), carrier recovery, spectral spreading in nonlinear circuitry, and many other issues that are the purview of communication system theorists.

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