

COMPARISON OF DIGITAL SIGNALING METHODS

<i>TYPE OF SIGNALING</i>	<i>MINIMUM TRANSMISSION BANDWIDTH WHERE R IS THE BIT RATE</i>	<i>PROBABILITY OF ERROR</i>
Unipolar	$0.5 R$	$Q \left[\sqrt{\frac{E_b}{N_o}} \right]$
Polar	$0.5R$	$Q \left[\sqrt{2 \left(\frac{E_b}{N_o} \right)} \right]$
Bipolar	$0.5R$	$\frac{3}{2} Q \left[\sqrt{\frac{E_b}{N_o}} \right]$
OOK (<i>coherent detection</i>)	R	$Q \left[\sqrt{\frac{E_b}{N_o}} \right]$
BPSK (<i>coherent detection</i>)	R	$Q \left[\sqrt{2 \left(\frac{E_b}{N_o} \right)} \right]$
FSK (<i>coherent detection</i>)	$2DF + R$ where $2DF = f_2 - f_1$ is the frequency shift from data 0 and 1	$Q \left[\sqrt{\frac{E_b}{N_o}} \right]$
DPSK (<i>coherent detection</i>)	R	Not used in practice
QPSK (<i>coherent detection</i>)	$0.5R$	$Q \left[\sqrt{2 \left(\frac{E_b}{N_o} \right)} \right]$
MSK (<i>coherent detection</i>)	$0.667R$	$Q \left[\sqrt{2 \left(\frac{E_b}{N_o} \right)} \right]$

- Notes:
- E_b/N_o is the signal-to-noise ratio, where E_b is the energy of the signal and N_o is PSD of the noise.
 - Coherent detection for carrier systems.
 - Noncoherent detection possible for OOK, FSK and DPSK.

Where:

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} \exp\left(-\frac{\alpha^2}{2}\right) d\alpha$$

For $x > 2$:

$$Q(x) = \frac{1}{x\sqrt{2\pi}} \left(1 - \frac{0.7}{x^2}\right) \exp\left(-\frac{x^2}{2}\right)$$

Probability of Error using Noncoherent Detection:

$$\text{OOK: } P_e = \frac{1}{2} \exp\left\{-\frac{1}{2}\left(\frac{E_b}{N_o}\right)\right\}, \left(\frac{E_b}{N_o}\right) > \frac{1}{4}$$

$$\text{FSK: } P_e = \frac{1}{2} \exp\left\{-\frac{1}{2}\left(\frac{E_b}{N_o}\right)\right\}$$

$$\text{DPSK: } P_e = \frac{1}{2} \exp\left\{-\frac{E_b}{N_o}\right\}$$

$$\text{MSK: } P_e = \frac{1}{2} \exp\left\{-\frac{1}{2}\left(\frac{E_b}{N_o}\right)\right\}$$