





Data Encoding/Modulation Evaluation Factors	
•	Signal Spectrum
	<ul> <li>Lack of high frequencies reduces required bandwidth</li> </ul>
	- Lack of dc component is desirable, i.e. it should be avoided
	<ul> <li>Concentrate power in the middle of the bandwidth</li> </ul>
•	Clocking, i.e. synchronizing transmitter and receiver
	<ul> <li>External clock</li> </ul>
	<ul> <li>Sync mechanism based on signal</li> </ul>
•	Error detection
	<ul> <li>Can be built into signal encoding</li> </ul>
•	Signal interference and noise immunity
	<ul> <li>Some codes are better than others</li> </ul>
•	Cost and complexity
	<ul> <li>Higher signal rate (&amp; thus data rate) lead to higher costs</li> </ul>
	<ul> <li>Some codes require signal rate greater than data rate</li> </ul>
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Phase Shift Keying
<ul> <li>Phase of carrier signal is shifted to represent data</li> </ul>
Two-level (Binary) PSK
<ul> <li>Two phases represent two binary digits</li> </ul>
Differential PSK
<ul> <li>Phase shifted relative to previous transmission rather than some reference signal</li> </ul>
<ul> <li>Four-level (Quadrature) PSK - QPSK</li> </ul>
<ul> <li>More efficient use by each signal element representing more than one bit</li> </ul>
– e.g. shifts of $\pi/2$ (90°) and each element represents two bits
<ul> <li>In the presence of noise, bit error rate of PSK and QPSK are about 3dB superior to ASK and FSK</li> </ul>
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## Analog Data → Digital Signal

- Digitizing of analog data (e.g. voice) is conversion of analog data into digital data which can then be transmitted using some digital encoding (codec) or analog modulation.
- Pulse Code Modulation PCM used for voice encoding
- PCM is based on "Sampling Theorem":
  - If a signal is sampled at regular intervals at a rate higher than twice the highest signal frequency, the samples contain all the information of the original signal
- Those are analog samples (Pulse Amplitude Modulation, PAM)
- Each sample is then assigned digital value by rounding or truncation
  - Quantizing error or noise introduced
- Approximations mean it is impossible to recover original exactly
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DVD and High Quality Music
What does DVD acronym stand for?
– Digital Video Disc or
– Digital Versatile Disc
DVD disc capacity:
<ul> <li>Single side/single layer = 4.37Gbytes</li> </ul>
• DVD–A (audio) characteristics (different from DVD–V (video)):
<ul> <li>– 6 channels (instead of 2 in stereo music))</li> </ul>
- 24 bits per sample (instead of 16)
<ul> <li>– 96k samples per sec (instead of 44.1k)</li> </ul>
- Max bit rate = $6 \times 24 \times 96 \times 10^3 = 13.824$ Mbps
<ul> <li>– DVD specification limits max rate to 9.6Mbps</li> </ul>
– MLP (Merdian Lossless Packing) compression used, where
(uncompressed) PCM goes through an additional step
Super Audio CD (SACD): an alternative to DVD-A
HD DVD and Blue Ray disk with capacity over 20 Gbytes
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