Video Transmission

VID5: Digital Video Modulation

By Prof. Gregory D. Durgin

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Terminology

- CODEC
  - Short for Coder/Decoder (Compressor/Decompressor)
  - Describes baseband processing of a digital signal
- MODEM
  - Short for Modulator/Demodulator
  - Describes transmission of a digital or analog signal
- The previous set of slides briefly described the principles behind digital video CODECs
- This talk describes wireless MODEMs for transmitting CODEC information

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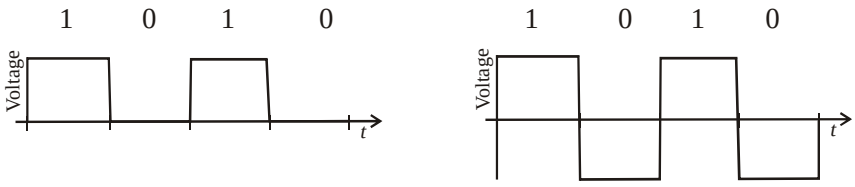
Keying: Digital on Discrete Symbols

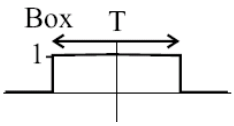
- Digital data of 1 or more bits are encoded on a finite "alphabet" of symbols
  - Differently-shaped symbols
  - Similar symbols with different amplitudes
- This signal then modulated onto an RF carrier



Unipolar Signal

Bipolar Signal

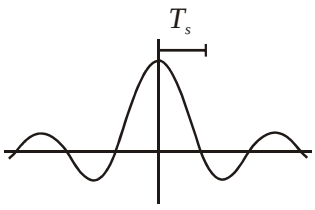
Spectral Content of Pulses

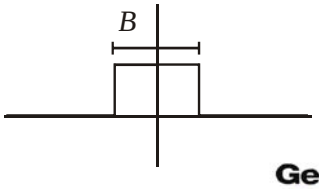


$$\mathrm{u}(\tfrac{T}{2} - |t|)$$

$$T\mathrm{sn}(Tf)$$

Sinc Function $\longleftrightarrow$ Box Function





What About a Random Process?

- Random on-off binary pulses
- Power-Spectral Density (PSD) will, for long sequences, take the shape of a pulse spectrum
- What about binary sequence (50% 1, 50% 0)?
- $S_x(f)$ is PSD, $P(f)$ is pulse spectrum:

$$S_x(f) = |P(f)|^2 + \frac{1}{4}|P(0)|^2 \delta(f)$$

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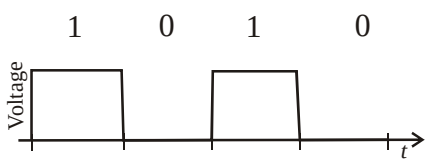
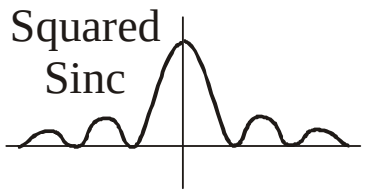
Example PSD





$$S_x(f) = T^2 \mathrm{sn}^2(Tf) + \frac{T^2}{4}\delta(f)$$

Units of Power/Hz

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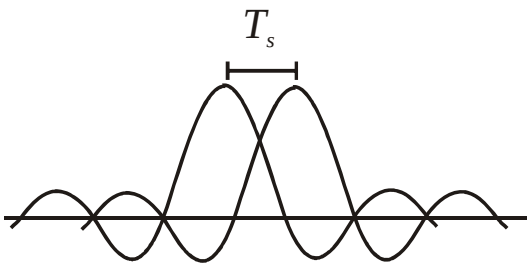
Nyquist Criterion for Overlapped Pulses

- Adjacent pulses must cross zero in integer multiples of the symbol period (*nT*s)
- Can be non-zero for other times
- Requires Matched-Filter receiver



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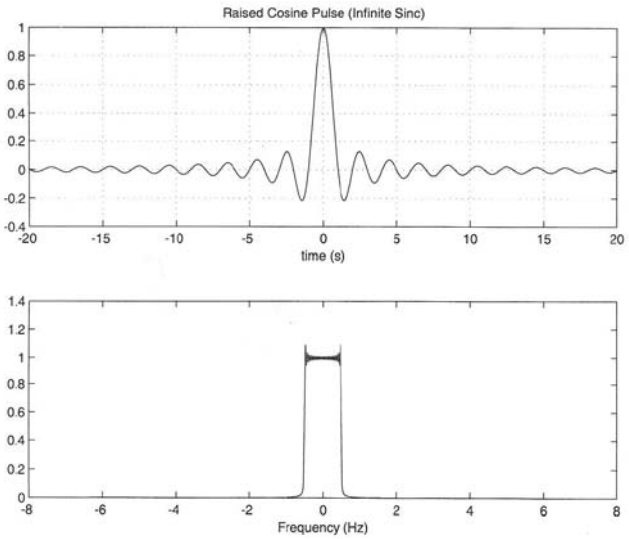
Sinc-Function Pulse Spectrum



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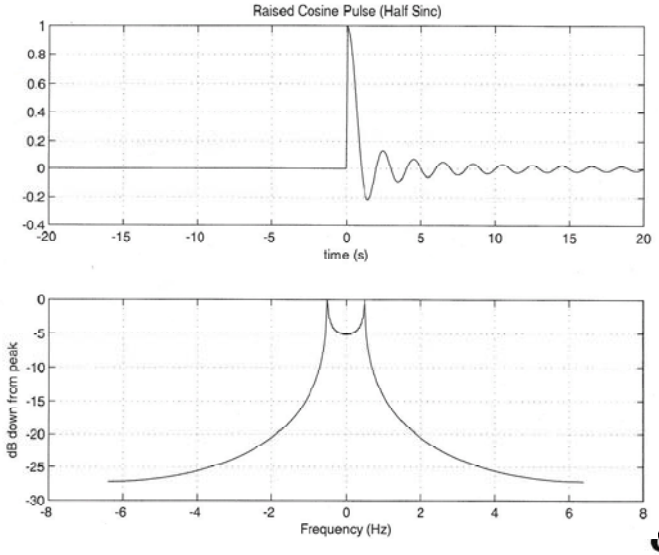
Half-Sinc Pulse?



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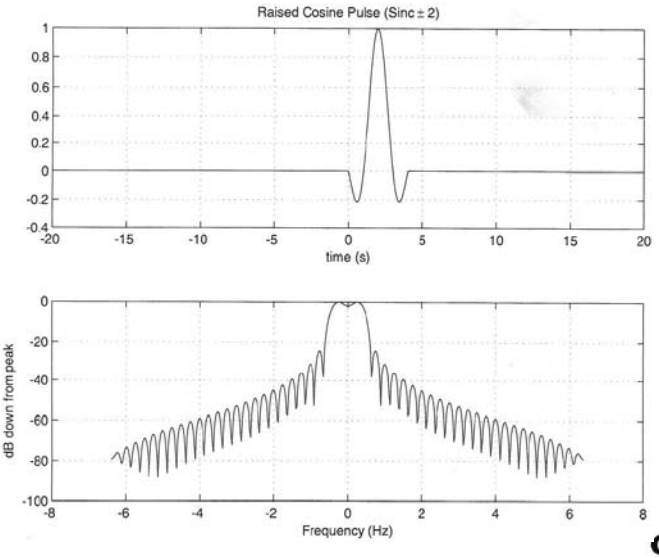
Shifted and Truncated Pulse



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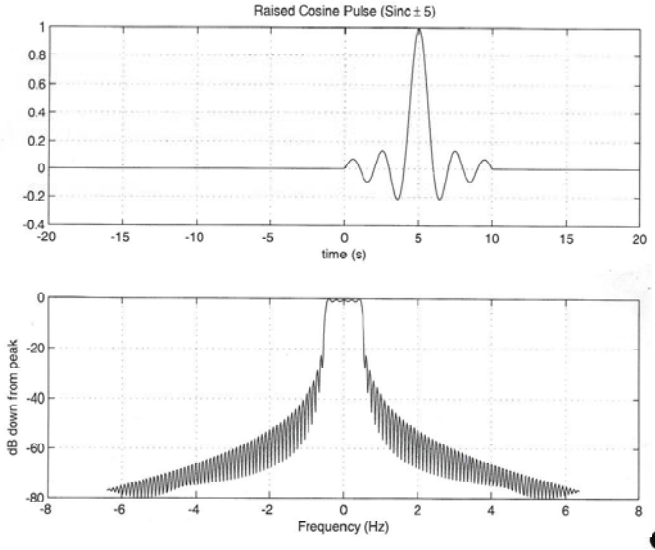
Shifted and Truncated Pulse



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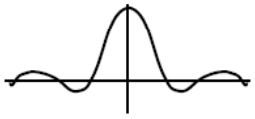
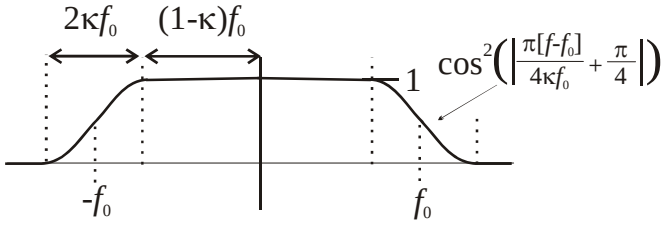
Raised Cosine Pulse and Spectrum

Raised Cosine Pulse



$$\frac{2f_0 \mathrm{sn}(2f_0 t)\cos(2\pi\kappa f_0 t)}{1-(4\kappa f_0 t)^2}$$



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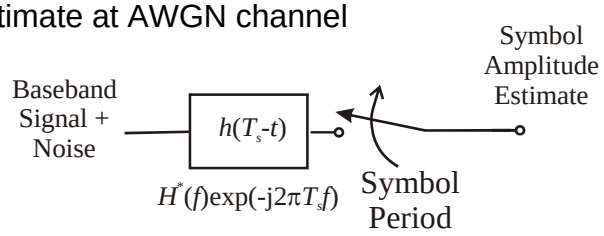
Matched Filtering

- Goal of the matched filter:
  - Provide the best estimate of a signal value *at a specific point in time*.
  - Does not reproduce the best possible signal shape
- Mathematically, the best way to produce a symbol estimate at AWGN channel



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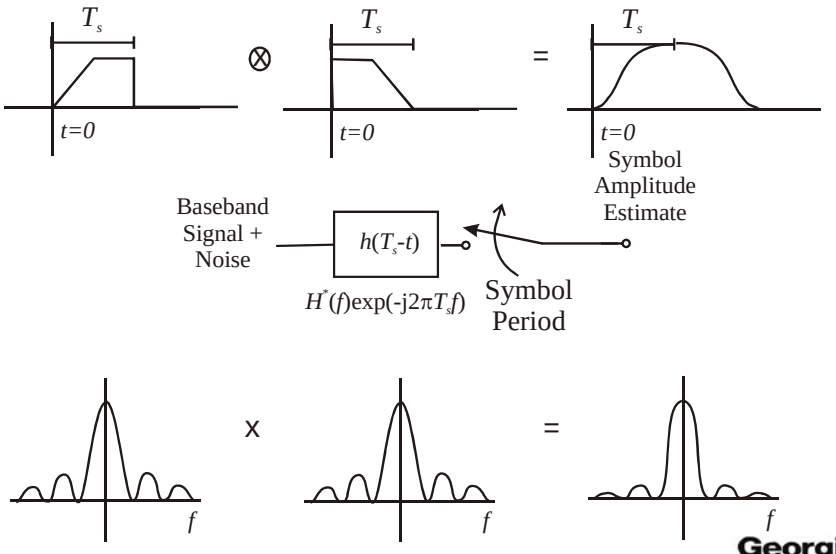
How a Matched Filter Works



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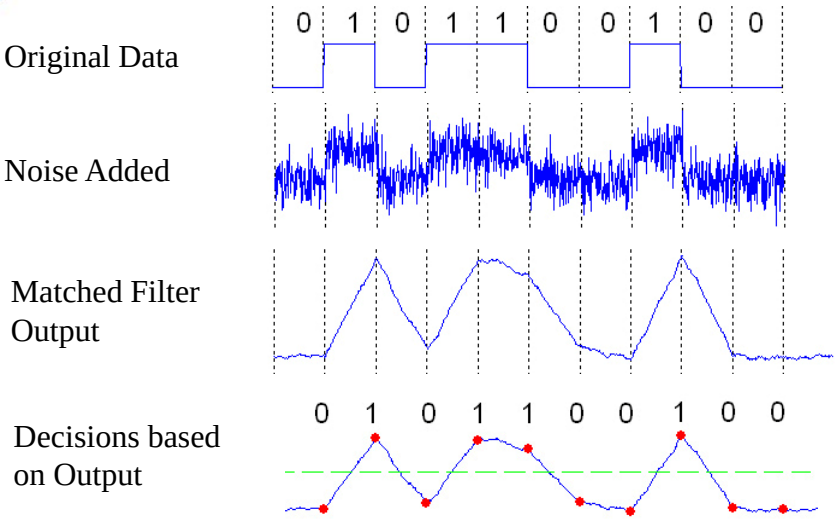
Example of Matched Filter in Action



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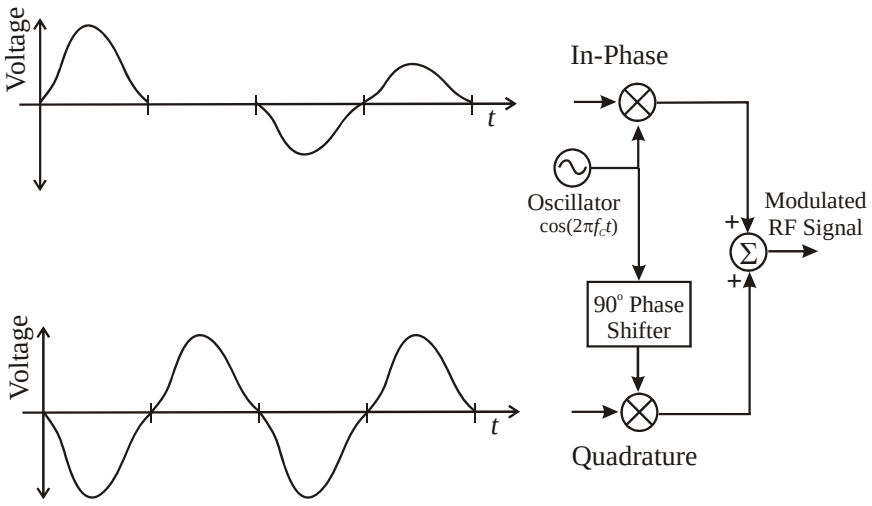
Amplitude Shift Keying (ASK)



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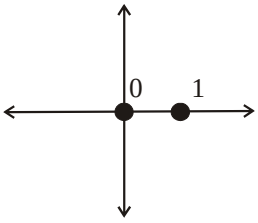
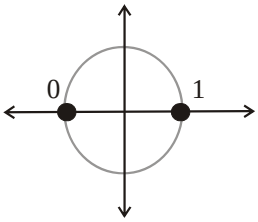
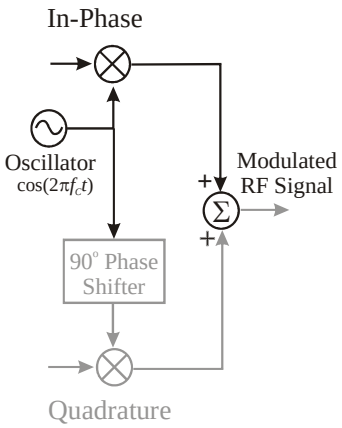
On-Off/Binary Phase Shift Keying

OOK Signal Constellation



BPSK Signal Constellation





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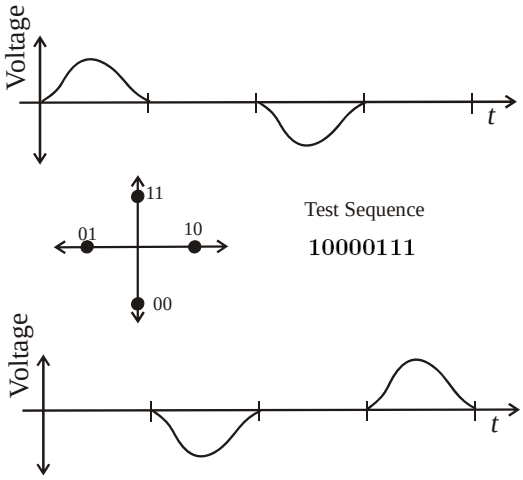
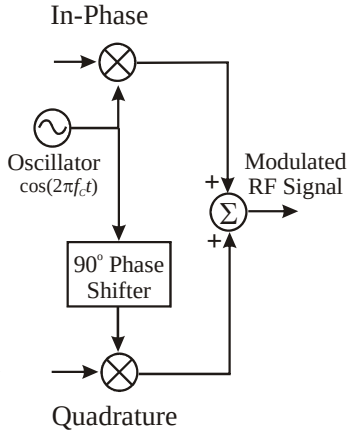
Quadrature Phase Shift Keying





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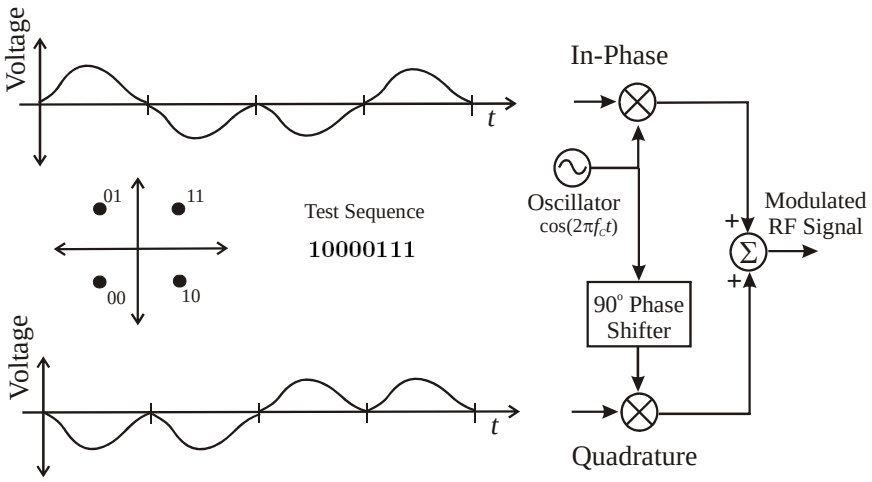
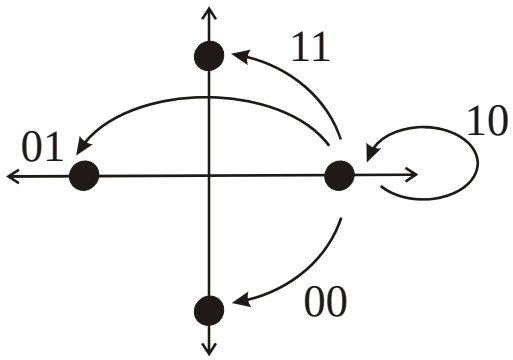
π/4-QPSK



Differential QPSK (DQPSK)



Resistant to Frequency/Phase Rotation errors in the carrier reception