Summary of Baseband Transmission

- Line Coding
  - On-Off
  - NRZ
  - RZ
  - Manchester
- M-ary baseband signals
  - $r_b = \frac{1}{T_b}$
  - γ bits/symbol (binary case $\gamma = 1$)
  - $T_s = \gamma * T_b$
  - $r_s = \frac{1}{T_s}$ = symbol rate
  - $B_0 = \frac{r_s}{2}$ = minimum baseband bandwidth
- Symbol detection
  - Minimum distance decision algorithm
  - Integrate & dump is the same as filter & sample
  - Decision based on the output of the Integrate & dump (or filter & sample)
  - One symbol error can cause multiple bit errors
- ISI
  - Pulse shaping
  - Criteria for no ISI, $p(0) = 1$ (constant) and $\sum_{\substack{k=-\infty \\ k \neq 0}}^{\infty} p(t - kT_s) = 0$
  - Raised cosine pulse shaping,
  - $B_T = B_0(1+\alpha)$
  - Eye-diagram
- Analog-to-Digital (A/D) conversion
  - PAM
  - PCM
  - $(S/N)_Q \approx 6\gamma$ (dB)

Summary of Time Division Multiplexing

- Time frame
- Time slot & number of time slots/frame
- Number of bits/time slot
- Bit rate = $\frac{\#\,\text{bits/frame}}{\text{Frame Time}}$
- TDMA
- TDD
- Uplink and downlink

Frame synchronization

TDM/PAM

Minimum baseband bandwidth= $\frac{r_s}{2}$

TDM/PCM

Minimum baseband bandwidth= $\frac{r_b}{2}$

Summary of DSB-SC

$x_{DSB-SC}(t) = A_c\, x_{bb}(t) \cos(2\pi f_c t)$

$B_{RF} = 2\, B_{bb}$

In general requires a synchronous (coherent) receiver, carrier recovery is needed

DSB-SC is a linear modulation

ASK is a digital modulation using DSB-SC with a specific digital baseband signal, $x_{ON-Off}(t)$

$B_{RF} = r_b$

Spectral efficiency = (1b/s)/Hz

BPSK is a digital modulation using DSB-SC with a specific digital baseband signal, $x_{NRZ}(t)$

$B_{RF} = r_b$

Spectral efficiency = (1b/s)/Hz

Power in the DSB-SC signal, $A_c x(t)\cos(2\pi f_c t)$, is $P_{DSB-SC} = \frac{A_c^2 P_x}{2}$

Summary of Quadrature Modulation and Multiplexing

Quadrature Multiplexing allows two signals to use (share) the same RF spectrum, one signal on the I-channel and one on the Q-channel

Carrier recovery is required to demodulate quadrature modulated signals

Quadrature modulation is used to transmit digital signals

One baseband digital signal (NRZ or M-ary) transmitted on the I-channel and one on the Q-channel

Constellation (signal-space) diagrams

Minimum distance detection of transmitted symbols-in two dimensions

Transmitter block diagram

Receiver block diagram

Relationships:

γ bits/symbol

Symbol time $T_s = \gamma T_b$

QPSK 2 bits/symbols, γ=2

M-QAM; M= 2^{γ}

M-ary PSK; M= 2^{γ}

Maximum spectral efficiency = γ (b/s)/Hz

Modulation Type	Maximum Spectral Efficency (b/s)/Hz
ASK	1
BPSK	1
QPSK	2
8 – ary PSK	3
16 – QAM	4
64 – QAM	6
256 – QAM	8
1024 – QAM	10

Representations of RF Signals

$y_l(t) = y_c(t) + j y_s(t)$

$\mathrm{Re}(y_l(t) e^{j2\pi f_c t})$

$V(t)\cos(2\pi f_c t + \Theta(t))$

$y_c(t)\cos(j2\pi f_c t) - y_s(t)\sin(j2\pi f_c t)$