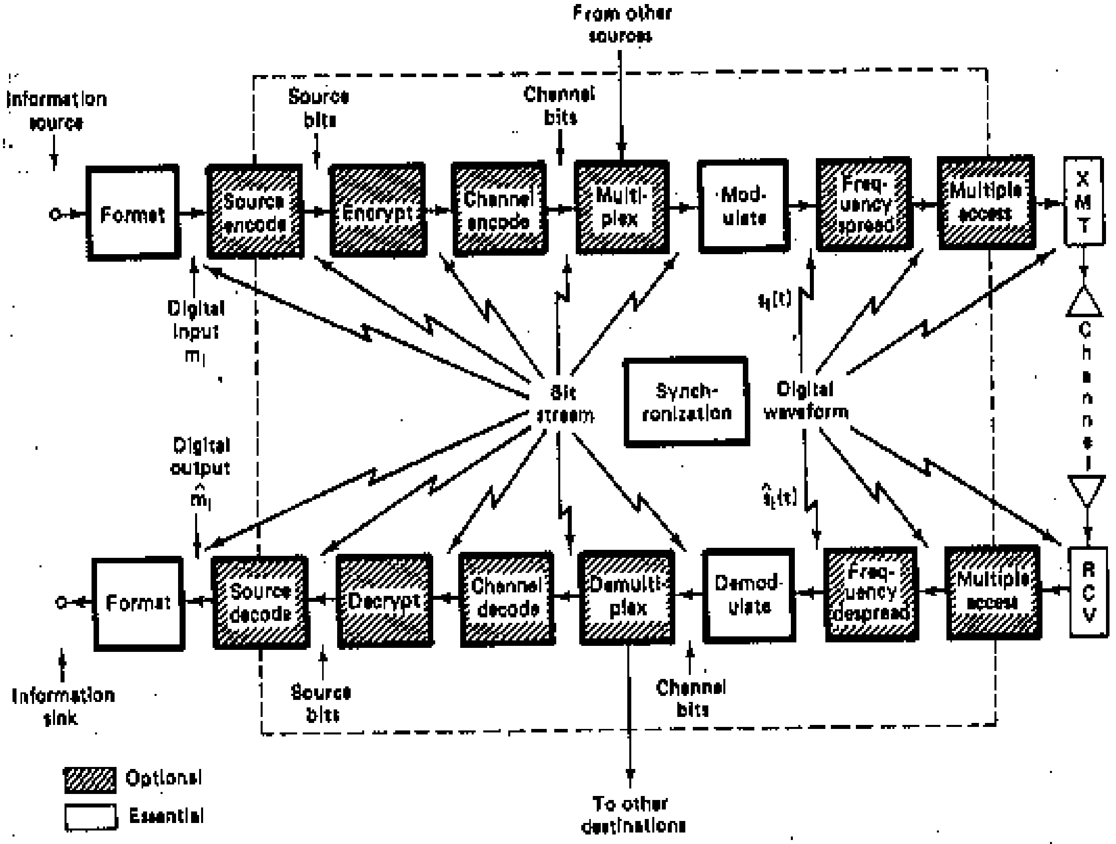
EE 225C

LECTURE #5

INTRO TO RADIO SYSTEMS

READINGS SKLAR 1 & SKLAR 2



Formatting/Source Coding

- Character coding
- Sampling
- Quantization
- Pulse code modulation (PCM)

- Differential PCM (DPCM)
- Block coding
- Synthesis/analysis coding
- Redundancy reducing coding

Bandpass Modulation/Demodulation

Coherent

- Phase shift keying (PSK)
- Frequency shift keying (FSK)
- Amplitude shift keying (ASK)
- Continuous phase modulation (CPM)
- Hybrids

Noncoherent

- Differential phase shift keying (DPSK)
- Frequency shift keying (FSK)
- Amplitude shift keying (ASK)
- Continuous phase modulation (CPM)
- Hybrids

Channel Coding

Waveform

- M-ary signaling
- Antipodal
- Orthogonal
- Biorthogonal
- Transorthogonal

Structured Sequences

- Block
- Convolutional

Synchronization

- Carrier synchronization
- Subcarrier synchronization
- Symbol synchronization
- Frame synchronization
- Network synchronization

Multiplexing/Multiple Access

- Frequency division (FDM/FDMA)
- Time division (TDM/TDMA)
- Code division (CDM/CDMA)
- Space division (SDMA)
- Polarization division (PDMA)

Spreading

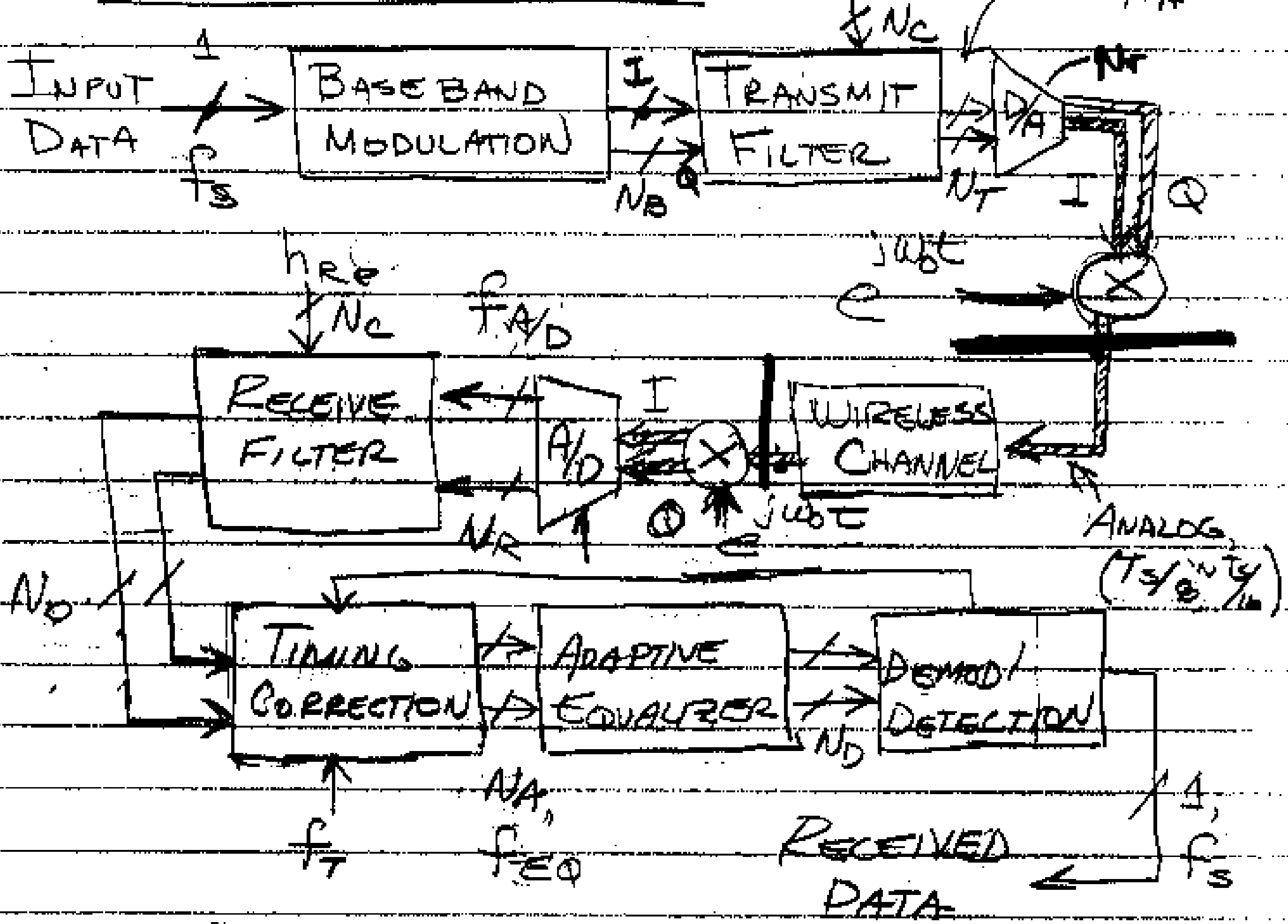
- Direct sequencing (DS)
- Frequency hopping (FH)
- Time hopping (TH)
- Hybrids

Encryption

- Block
- Data stream

FIRST VERSION

DIGITAL RADIO



DESIGN PROCEDURE:

ASSUME: MODULATION, T_S, BANDWIDTH SPECIFIED

1) ALGORITHM DESIGN:

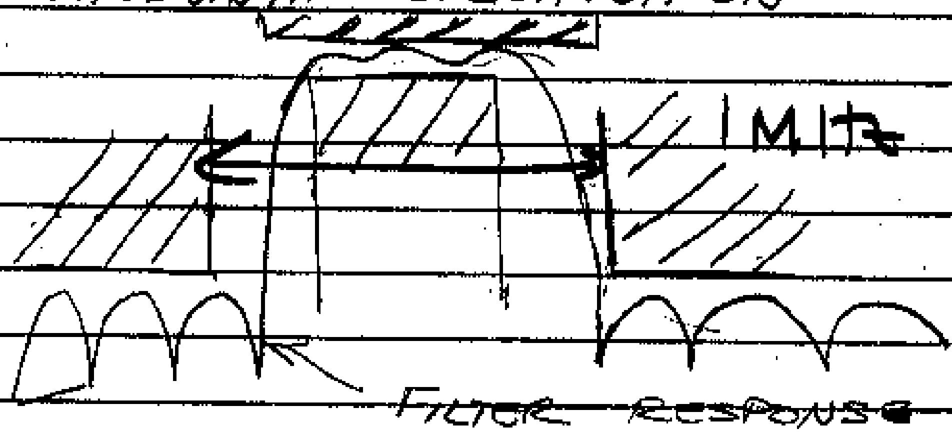
1) TRANSMIT / RECEIVE FILTERS
2) MODULATOR
3) DEMODULATOR
4) DETECTOR
5) TIMING CORRECTION
6) ADAPTIVE EQUALIZER

DESIGN PROCEDURE (CONT.) ②

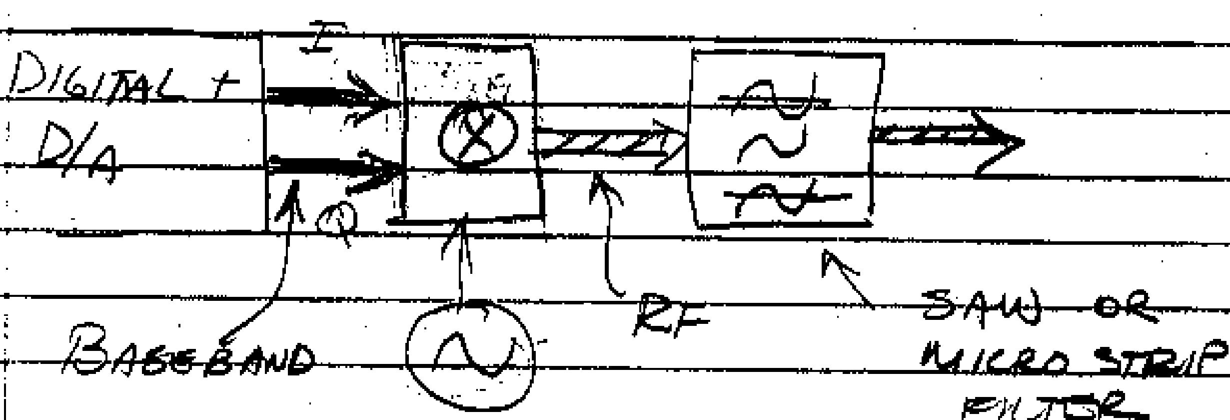
2) IMPLEMENTATION ARCHITECTURE
3) WORD LENGTH OPTIMIZATION
4) HARDWARE MAPPING

TRANSMIT / RECEIVE FILTERS

BANDWIDTH SPECIFICATION

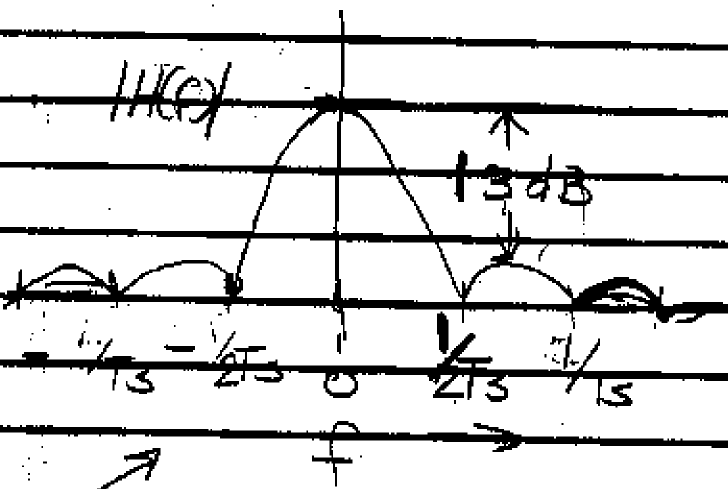


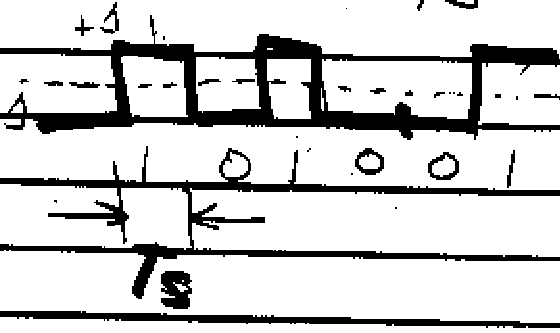
ACTUALLY A CONCATENATION OF THE DIGITAL T/R FILTERS & RF FILTERS



FILTER DESIGN

SYMBOL RATE = f_s BITS/SEC. = $\frac{1}{T_s}$





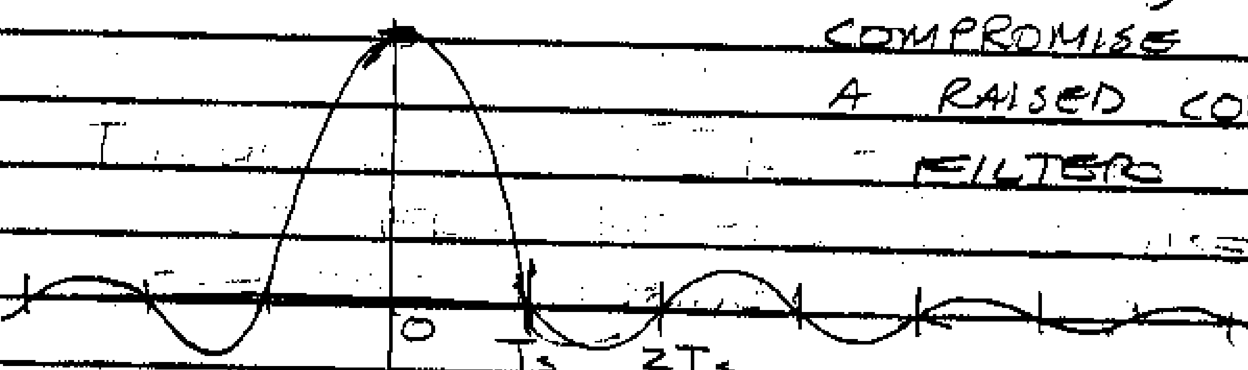
FREQ. RESPONSE OF 1 PULSE (REAL)

SAMPLE RATE = f_s

BASEBAND BW = $f_s/2$; PASSBAND BW = f_s

IF WE BANDLIMIT TO THE MINIMUM POSSIBLE AMOUNT $\frac{1}{2T_s}$

THEN THE TIME RESPONSE GOES ON FOREVER, SO WE COMPROMISE WITH A RAISED COSINE FILTER

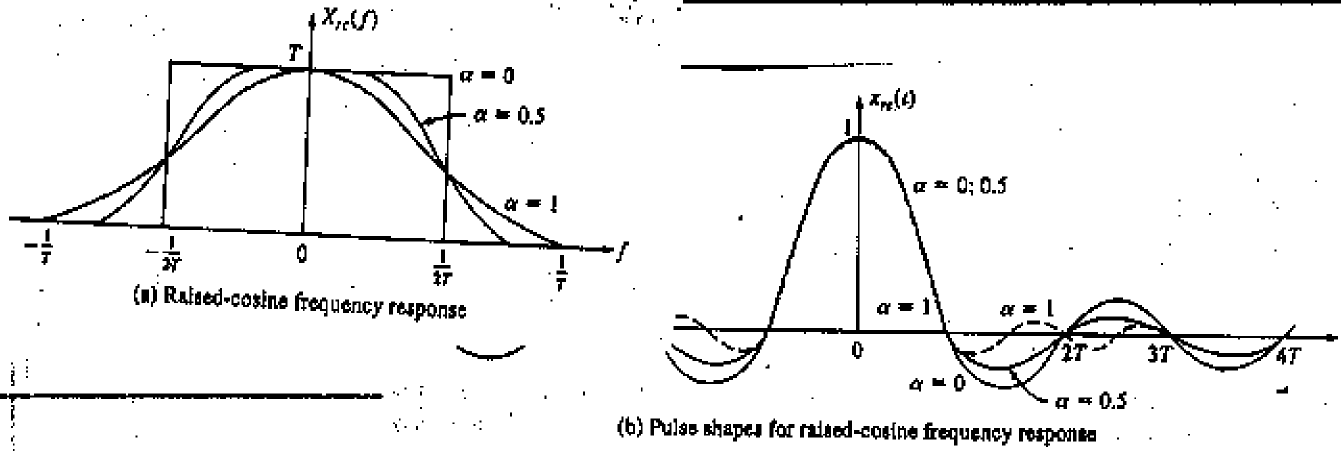


RAISED COSINE FILTER

FREQUENCY RESPONSE

$$H_{RC}(f) = \begin{cases} 1 ; & |f| \le \frac{(1-\alpha)}{2T_s} \\ \frac{T_s}{2}\left[1+\cos\frac{\pi T_s}{\alpha}\left(|f| - \frac{(1-\alpha)}{2T_s}\right)\right] ; & \frac{1-\alpha}{2T_s} < |f| \le \frac{1+\alpha}{2T_s} \\ 0 ; & |f| > \frac{1+\alpha}{2T_s} \end{cases}$$

NO ISI WITH THIS FILTER



(a) Raised-cosine frequency response

(b) Pulse shapes for raised-cosine frequency response

NORMALLY WE SPLIT THE FILTER BETWEEN THE TRANSMIT & RECEIVE

$$H_{RC}(f) = H_T(f)\,H_R(f)$$

OR

$$H_{Tr}(f) = H_{Re}(f) = \sqrt{H(f)}$$

RAISED COSINE FILTERS (CONT.)

TO GET THE SQUARE ROOT FILTER IMPULSE RESPONSE WE CHOOSE A SAMPLE RATE FOR THE FILTER, f_s WHICH WILL BE THE SAME AS THE A/D & D/A SAMPLE RATES, SO IF WE LET $f_{A/D} = f_{D/A} = 4/T_s$ (4 TIMES THE ABSOLUTE MINIMUM).

WE GET:

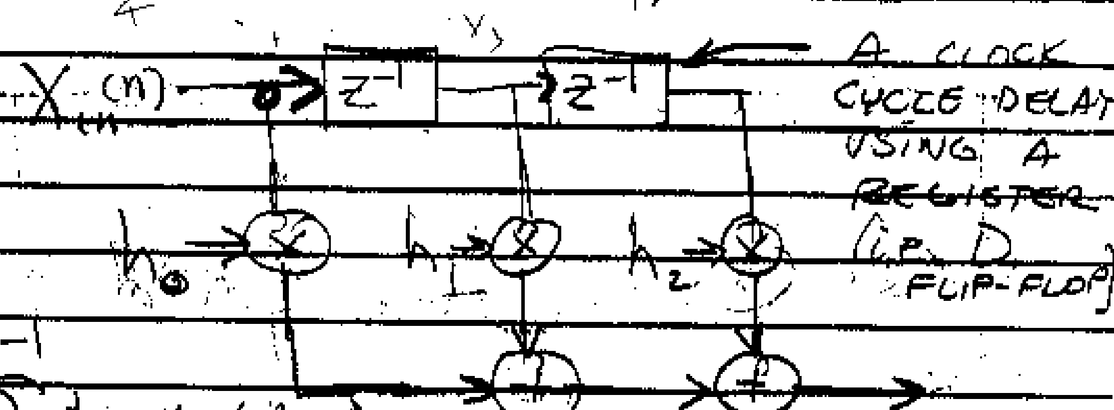
$$h_{Tr}(n) = \sum_{m=-(N-1)/2}^{m=+(N-1)/2} \sqrt{H_{RC}\left(\frac{4m}{NT_s}\right)}\, e^{\frac{j2\pi mn}{N}}$$

$$; \quad -\frac{(N-1)}{2} \le n \le \frac{N-1}{2}$$

NOW TO IMPLEMENT THE FILTER:

FIR $N = 3$ (TAP) $\quad h_n = h_{Tr}(n)$

DRAW THE SIGNAL FLOW GRAPH



$$X_{OUT}(i) = \sum_{n=0}^{N-1} h_n X_{in}(i-n)$$