Review Class #2 Fri, March 5, 2010

EE 450 Midterm 1 June 25
Summer 2009
Nazarian

Name__________________________________ **Lecture 8 A.M.**
Time: 115 minutes **Score: ____/105**

100 is a perfect score (5 points are extra credit points)
Closed Book; One 8.5 by 11 inch sheet is allowed (both sides fine)

Part A (52.5 points) Part A includes True/ False questions, multiple choice questions (only one item is correct,) as well as some short questions.

1) Processing delay is the dominant latency component of nodal delay in satellite communications. T / F

False dprop

2) Transmission delay is dependent on the distance between the sender and receiver nodes. T / F

False

Kbits → into 1 signal

3) When a digital signal is converted to analog (using a carrier signal to modulate based on the digital signal) the output rate or the rate of the analog signal in baud ~~rate~~ is equal to or smaller than the rate of the digital signal. T / F

(baud)

$R = k R_{baud}$ 00 ... 11 → $R_{baud} = 1/2 R$ R (bps) → R_{baud}

signal => $R_{baud} = k R$

4) A 32PSK has an output signal rate (R_{baud}) of 20K signals/sec. Each signal represents the following number of bits (k) and the bit rate of the original digital signal (R):
a) 32, 20Kbps b) 64, 100Kbps c) 5, 100Kbps d) 5, 20Kbps

2^k FSK, PSK, ASK, QAM $R_{baud} = 20K$

5) The bandwidth-delay product defines the number of bits that can fill the link. T / F

True

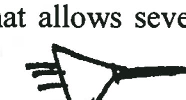
6) Multiplexing is the set of techniques that allows the transmission of multiple signals across a single data link. The transmission is simultaneous. T / F True

7) FDM (Frequency Division Multiplexing) can be ~~directly~~ applied to multiple digital signals. T / F

False

8) TDM (Time Division Multiplexing) is a multiplexing technique that allows several high rate channels to be combined into one ~~low rate~~ channel. T / F

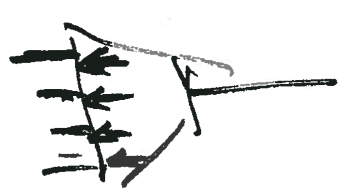
False



9) In TDM the digital channels overlap in frequency but interleaved in time. T / F True

10) TDM multiplexing can happen either at bit level or blocks of bits. T / F

True



$1\text{ msec} = \frac{1 \text{ bit}}{1\text{Kbps}} = \text{bit duration} = d_{trans-one bit} = T_{bit}$

11) In a TDM with 4 inputs each with an identical bit rate of 1Kbps, it takes a certain amount of time for channel 1 to generate one bit of information and write it into the buffer. The multiplexer will visit channel 1 at some point, pick up that one bit and transmit it through the medium. The time it takes to transmit that one bit is:
a) 1msec b) 4msec c) 250μsec d) transmission delay can be ignored in this case, so theoretically the time it takes to transmit one bit is zero

12) The bit rate of the Mux (and also the bit rate of the medium) in the synchronous TDM is greater than or equal to the summation of the bit rates of the input channels. T / F
True

13) In ~~statistical~~ TDM the time slots are pre-assigned, therefore the time slots for the idle inputs are going to be empty. T / F
False

14) Synchronous TDM is more suitable for streamy traffic, whereas statistical traffic more fits bursty type of data. T / F
True

15) IP address of a NIC card should be globally unique, therefore it is burnt into the NIC during manufacturing T / F
False

16) What is the first piece of information the sender node needs to know about the destination?
a) Destination's MAC address
b) Destination's IP address
c) The IP addresses of the immediate router
d) Destination's port address

1st
2nd: subnet masking result
3rd MAC from MAC dest.

17) There are 10 routers along the link between nodes A and B. Transport layer of $\boxed{A}$ uses a set of rules. Which OSI layer will interpret those protocols to understand what they are all about?
a) Session Layer of A
b) Network Layer of A
c) Transport layer of B
d) Application Layer of A
e) Transport layer of ~~the~~ immediate router to A
f) ~~Transport layer of the immediate router to B~~
d) Transport layer of all node throughout the ~~route from~~ A to B

18) Assume both sender and receiver nodes are connected to a shared network (bus topology.) This is shown in Figure 1. The sender divides the message into frames and sends them on the bus. The receiver will find out that a certain frame is destined to it by processing the frame and checking that its MAC (Medium Access Control) address and the destination MAC address in the frame are identical T/F
True

19) Referring to the previous problem, nodes other than the sender and the receiver nodes (the ones that the frames are not destined to) will process the frame up to layer 3 to find out that in fact the frame is not destined to them. T / F
False

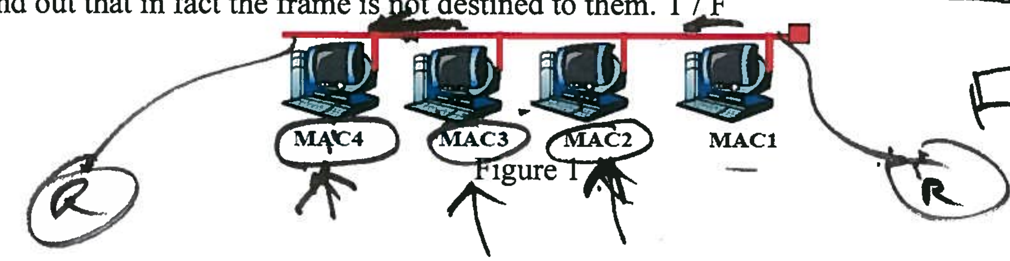


Figure 1

ARP

IP → MAC

20) In Figure 2, nodes know the $\boxed{\text{MAC}}$ address of their immediate routers because this information is configured into them through the service of DHCP (Dynamic Host Configuration Protocol.) T / F

False

21) In Figure 2, node 2 (with MAC2, IP2) wants to email node 9 (with MAC9, IP9.) How does it get the IP address of node 9?

a) Contacting a DNS (Domain Name System) server

b) Using the ARP (Address Resolution Protocol) protocol

c) Nodes 2 and 9 are connected to the same router, so they know each other's IP through initial configuration by the network administrator

d) Using the DHCP service

22) Referring to the previous question, layer 2 of node 2 needs to encapsulate a packet into a frame by adding its own MAC address, MAC2, as the sender's MAC address as well as

a) MAC9 b) MAC11 c) MAC12 d) Broadcast (all 1s)

23) Referring to the previous question when the default router of node 8 receives the frame, it processes the frame up to its 2nd layer (Data Link layer) and figures out that the frame is not destined to it. T / F

True

24) Referring to the previous question when Node 9 finally receives the frame it finds out that the sender of the frame is node 2 after

a) its Physical layer receives the unstructured bits and looks at the physical (MAC) address

b) its Data Link layer receives the frame and looking at the MAC addresses it finds out that node 2 is the sender

node c) its Network Layer receives the packet and looking at the IP addresses it finds out that node 2 is the sender

d) its Transport Layer receives the datagram and looking at the port addresses it finds out that the sender is node 2

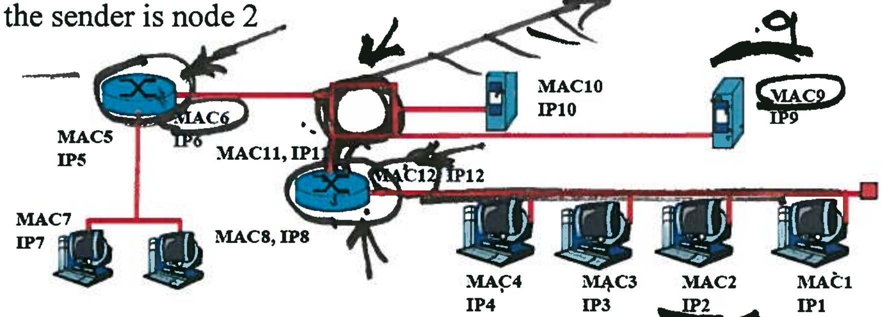


Figure 2

25) ARP is a protocol that gives service to IP (Internet Protocol.) IP gives the IP address of a local node (end system or router) and asks for the MAC address of that node. ARP service is provided by a server which is referred to as the ~~ARP~~ server. T/F

IP ↔ MAC

26) When the actual IP packet is being created ARP service is required to get the MAC address of the local node. The ARP request packet is broadcasted. The nodes in the local network which are not the destination of the ARP packet will only process the message up to

a) their 1st (Physical) layer   b) their 2nd (Data Link) layer
c) their 3rd (Network) layer   d) their 2nd (Transport layer

IP ↔ MA

27) ARP request packet is a broadcast packet. This is not desirable at all, because it wastes some amount of time from all the nodes in the local network, while we know only one of the nodes will finally respond to ARP request by a ARP reply packet which will be unicasted. One practical solution to avoid the broadcast issue has been to create an ARP cache that saves some of the IP addresses and their MAC address. T / F

True

28) Neda wants to connect her new desktop computer to the Internet. The first piece of information her desktop needs to know before being part of the Internet network is

a) the IP address of its default router
b) the IP address of the DHCP server
c) the MAC address of the DHCP server
d) its own MAC address

29) Referring to the previous question, in response to the discovery phase DHCP request by Neda's computer, the DHCP responds in the offer phase by a DHCP offer packet that has 0.0.0.0 as its destination IP address. Even in the request phase by Neda's computer the source IP address is still 0.0.0.0. What does this imply?

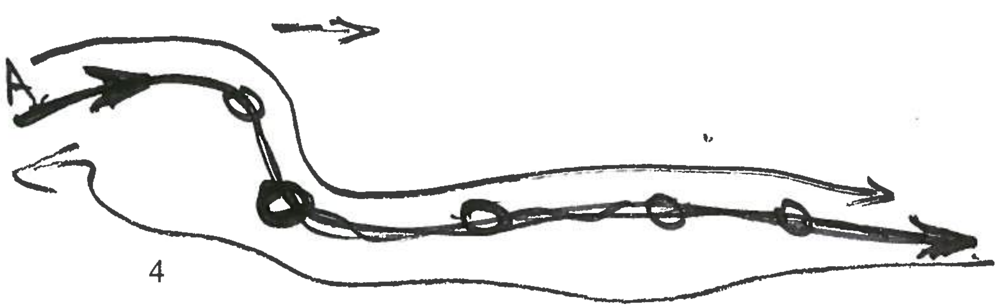
255.255.   IP Packet

0.0.0.0 IP addr. source

30) A Synchronous TDM supports three channels A, B, and C, with bit rates RA = 1 Kbps, RB = 2 Kbps, and RC = 3 Kbps. The number of time slots in each cycle, NA , NB, and NC are:

a) NA=1, NB =2, NC=3   b) NA=3, NB =2, NC=1
c) N_A=1, N_B =1, N_C=1   d) depends on idle channels

31) Virtual circuit switching (aka connection-oriented packet switching) uses the concept of storing and forwarding the packets. However unlike connectionless packet switching, packets here are not delivered out of order. Explain why.

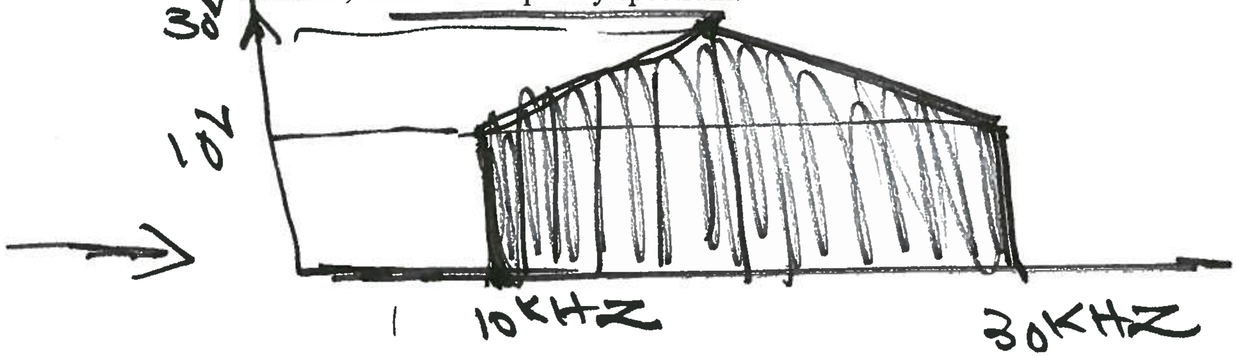


32) If the bandwidth of the channel is 5 Kbps, how long does it take to transmit a frame of 100000 bits out into the channel?

$$d_{trans} = \frac{100000 \text{ bits}}{5000 \text{ bps}} = 20 \text{ sec}$$

amplitude

33) A non-periodic composite signal contains frequencies from 10 to 30 KHz. The peak amplitude is 10 V for the lowest and the highest signals and is 30V for the 20KHz signal. Assuming that the amplitudes change gradually from the minimum to the maximum, draw the frequency spectrum.



34) The attenuation of a signal is -10dB. What is the final signal power if it was originally 5W?

$\left(\frac{P_2}{P_1}\right)$

SNR

$P_1 = 5$ Watts

$P_2 < P_1$

$$-10 \text{ dB} = 10 \log_{10}\left(\frac{P_2}{P_1}\right)$$

$$-1 = \log_{10}\left(\frac{P_2}{P_1}\right)$$

$$\frac{P_2}{P_1} = 10^{-1} \qquad P_2 = 0.5 \text{ Watts}$$

Part B (26 points) 25

a) What is the total delay (latency) for a frame of size 5 million bits that is being sent from a sender node with bit rate R=5 Mbps to a receiver node through a link which includes 10 routers each having a queuing time of 2μsec, a processing delay of 1μsec and negligible transmission delay. The length of the link is overall 2000Km. The speed of light inside the link is 2×108m/sec.

b) Which component of the total delay is dominant? d_{trans}

c) Calculate the bandwidth-delay product (R×total delay) in bits. We know this represents the maximum number of bits that can fit the link at any time. Now what is the width of each of those bits?

d) Suppose the receiver sends an ACK message (1500 bits) back to the sender with a rate of R=15 Mbps and using the same link with the 10 routers each with queuing time of 3μsec, a processing delay of 1μsec and negligible transmission delay. Calculate the RTT (Round Trip Time) and the throughput.

d) RTT = 1.01003

$\underbrace{40\mu s}_{d_{queue+proc}} + \underbrace{10^{-4}sec}_{d_{trans}} + \underbrace{10^{-2}sec}_{d_{prop}}$

$= ~~1.0~~2017 sec$

Throughput = 4.95

$\frac{5000000}{RTT} = 4.95$ Mbps

a) $d_{proc} = 10 \times 1\mu s = 10\mu s$

$d_{queue} = 10 \times 2\mu s = 20\mu s$

$d_{trans} = \frac{5000000}{5 \times 10^6} = 1s$ Source

$d_{prop} = \frac{2000km}{2 \times 10^8} = 0.01s$ total_s to D

Total end_to_end delay = 0.000010 sec + 0.000020 + 1 + 0.01 = 1.010030 sec

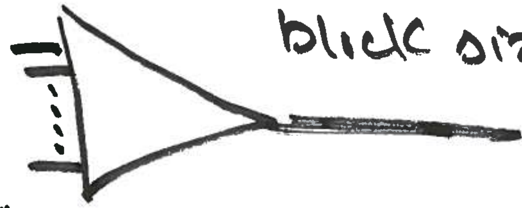
2000 km

b) transmission delay here! packet size is huge!

c) 5 Mbps × 1.010030 sec = 5050150 bits

Bit width = $\frac{2000km}{5050150}$ bits = 0.396 m or 39.6 cm

$20 \times 1 = 21$ bits 100 Kbps



block size = 1

21 frames

Part C (26.5 points)

We need to use synchronous TDM and combine 20 digital sources each with 100Kbps bit rate. Each output slot carries 1 bit from each digital source but one extra bit is added to each frame for synchronization. Answer the following questions:

a) What is the size of an output frame in bits? 21 bits

b) The Mux should be fast enough to transmit the frame at the same time each channel is writing one bit into its buffer. This means the frame duration is the same as the bit duration. What is the bit duration in seconds for each channel (which is the same as the frame duration at the output of the mux?)

~~20~~/21

c) What is the output frame rate in frames per second?

d) What is the efficiency of the system (ratio of useful bits to the total bits?)

block duration

duration

$\frac{1 \text{ bit}}{100 \text{ Kbps}} =$

a) $20 \times 1 + 1 = 21$ bits

b) $\frac{1}{100\text{Kbps}} = 10 \mu\text{sec}$

$\frac{1}{100K}$ sec

Frame duration $= 10 \mu\text{sec} = \frac{1}{10^5 \text{ sec}}$

c) frame rate ~~same as bit rate of~~ $= \frac{1}{\text{frame duration}} = 10^5$ frames/sec

10^5 frames/sec

$\frac{21 \text{ bits}}{1/100K \text{ sec}} =$

$= 2.1$ Mbps

21×10^5 bps $= 2.1$ Mbps

21 bits/frame

bit/sec: 21 bits/frame $\times$ frame rate $= 2.1$ Mbps

d) $20/21 = 95\%$

or $\boxed{2 \text{ Mbps}}$

2.1 Mbps

4 FSK

00 →

01 →

10 →

11 →

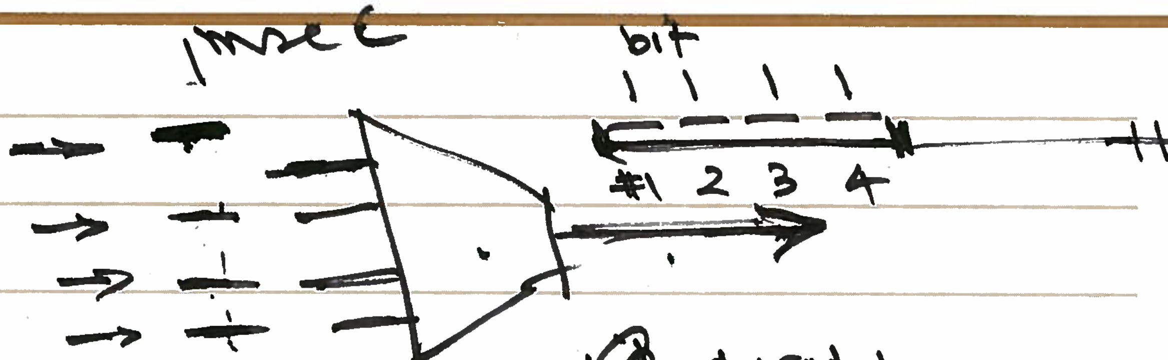
32 $\boxed{\text{PSK}}$ $\boxed{00000}$ →

2^5 - PSK

$R_{baud} = 20K\ Bd = R/5$ 11111 →

$K = 5$, $R = 100$ Kbps

1 msec

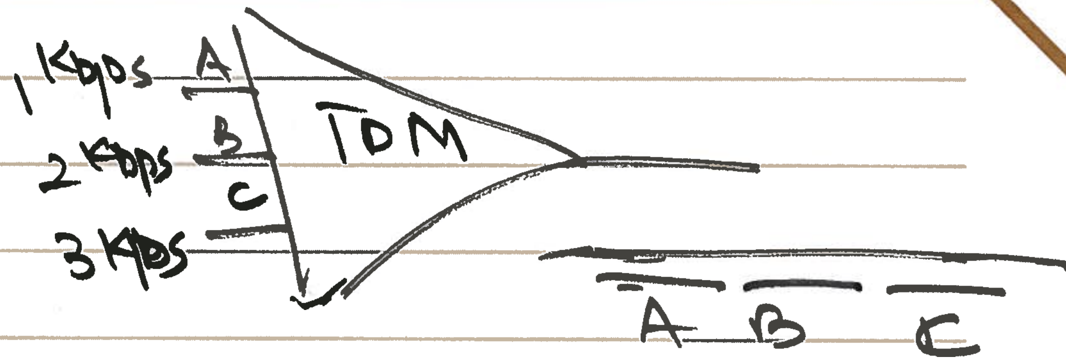


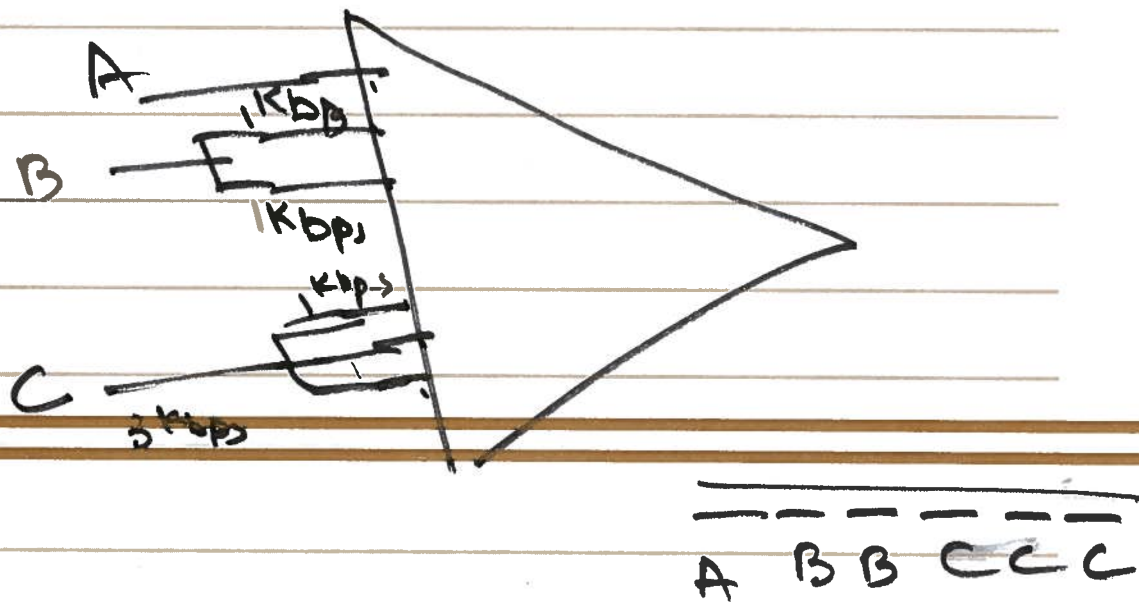
block ~~bit~~ duration = frame duration

1 msec = frame duration ⇒ 1/4 frame has to take $\frac{1\text{ msec}}{4} = 250\ \mu\text{sec}$

1 Kbps → 1 K frames/sec

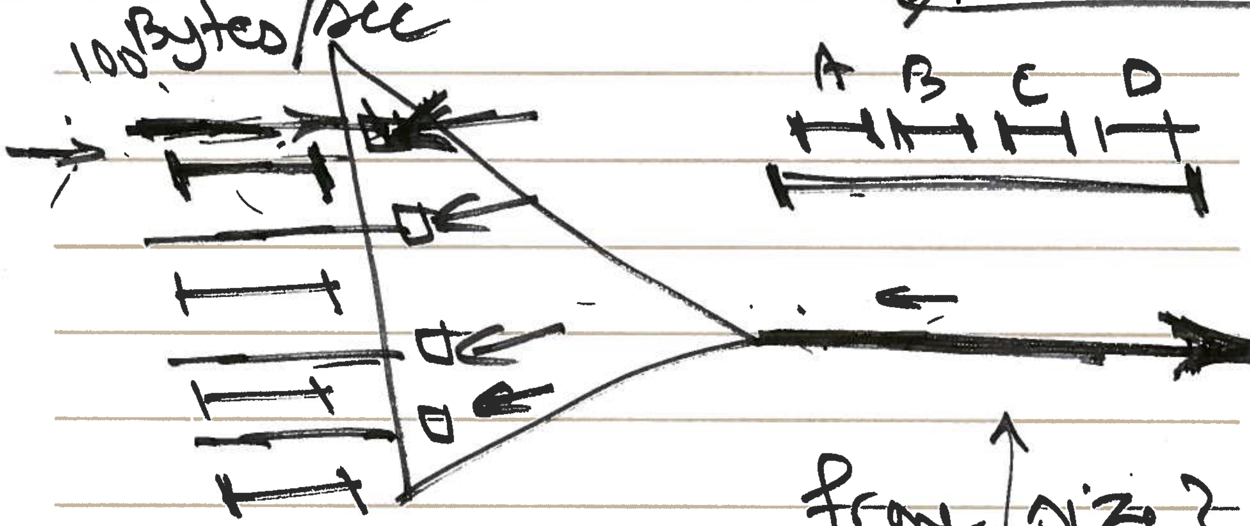
1 bit / 4 Kbps = 250 μsec 4 Kbps


1 Kbps
A
2 Kbps
B
C
3 Kbps
TDM
A B C


A
1Kbps
B
1Kbps
1 Kbps
C
3 Kbps
A B B C C C

(3)

→ $\boxed{\text{frame\_size} = 4 \text{ Byte}}$



Block = byte

frame size? rate?

data rate of MUX or TDM-ed Channel?

one byte

$\boxed{\text{block}}$-duration $= \dfrac{1 \text{ byte}}{100 \text{ Bytes/sec}}$

frame duration?

bit duration?

10^{-2} sec

Frame size = 32 bits

$$R_{MUX} = \frac{\text{Frame-size}}{10^{-2} \text{ sec}} = \frac{32 \text{ bits}}{10^{-2} \text{ sec}} = 4 \text{ Bytes}$$

$$R_{MUX} = \boxed{3200 \text{ bits/sec}}$$

data rate

4

$R_{mux} = 3200 \text{ bps}$

each frame = 32 bits

$R_{mux} = 3200 \cancel{b}ps / 32 \cancel{bit}/\text{frame}$

$\boxed{100 \text{ frame/sec}}$

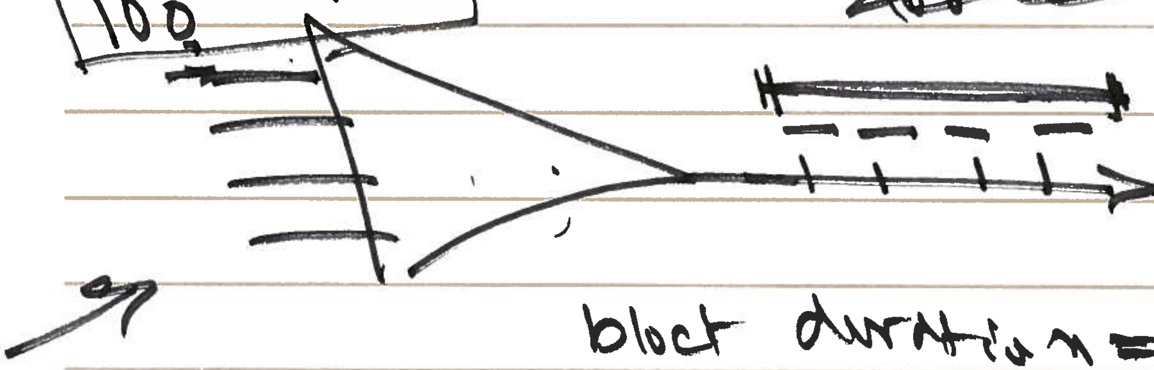
bit duration $= \dfrac{1 \text{ bit}}{R_{mux}(\text{bps})} = \dfrac{1 \cancel{bit}}{3200 \cancel{b}ps}$

1 bit duration $= \dfrac{1 \text{ bit}}{R_A = R_B = R_C = R_D} = \dfrac{1 \cancel{bit}}{100 \times 8 \cancel{b}ps}$

D

$\boxed{100 \text{ Bytes/sec}}$

~~100 bytes~~



block duration = frame duration

block rate = frame rate

$\boxed{100 \text{ bytes/sec}}$ ~~= 800 bps~~ 100 Block/sec

~~800 frames/sec~~

~~data rate = 800 x 32 bits~~

$\boxed{\text{output frame rate}}$ = input block rate

100 Blocks/sec

output rate $\boxed{100 \text{ frames/sec}}$

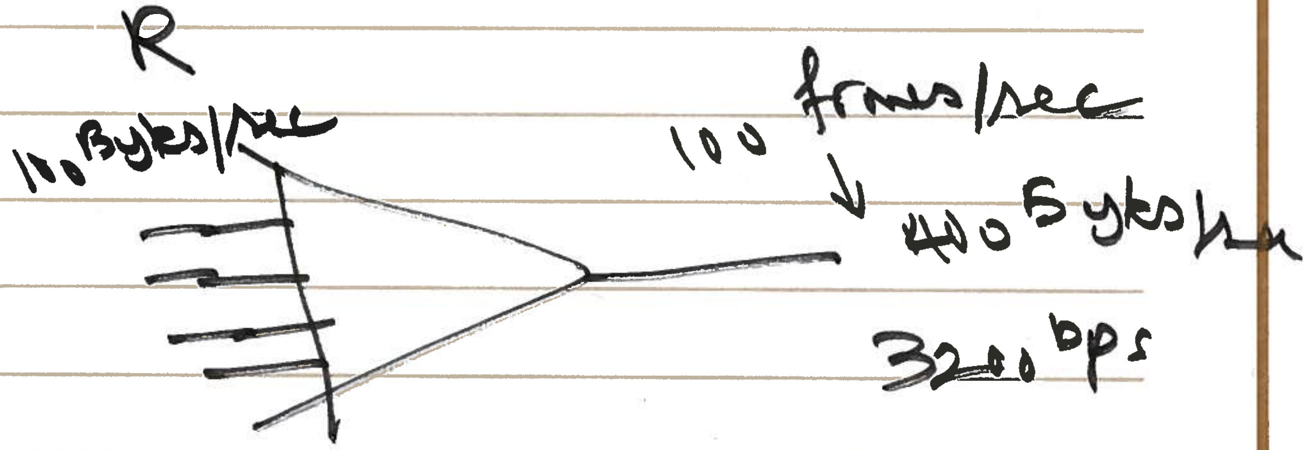
100 frames/sec x 32 bits/frame

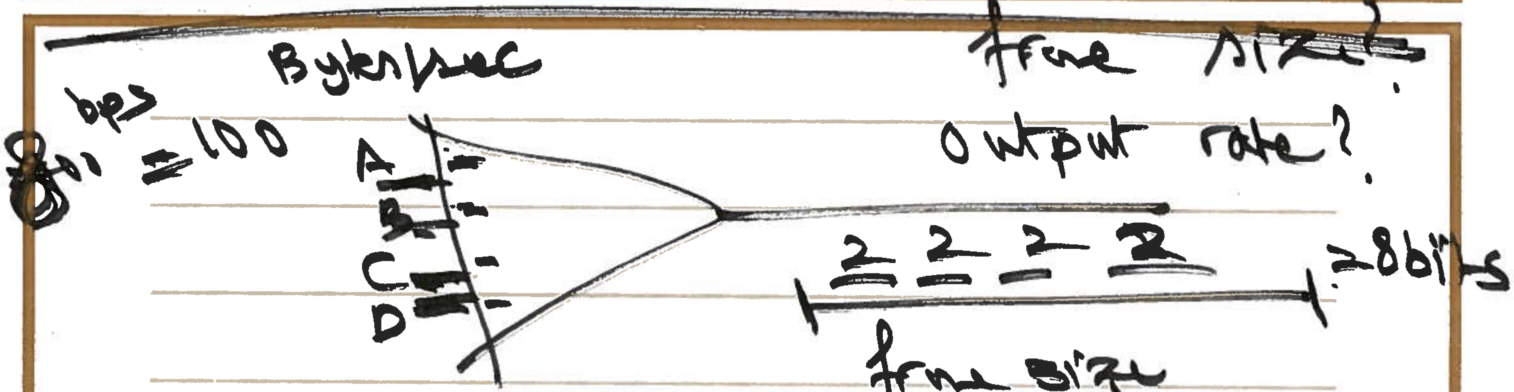
3200 bps

6

100 ~~frames~~/sec × 4 Bytes/~~frame~~

output rate = 400 Bytes/sec





2^{bits} Block size = 2^{bits}

block duration = $\frac{2 \text{ bits}}{800 \text{ bps}} = \frac{1}{400}$ sec

frame duration = $\frac{2}{800} = \frac{1}{400}$ sec

7

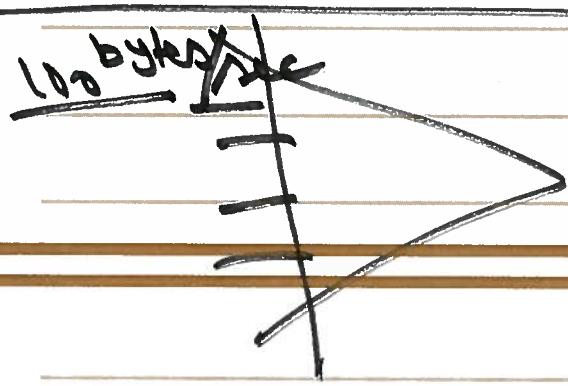
$\boxed{\text{frame duration}} = \frac{1}{400}$ sec

8 bits

_ _ _ _

2 2 2 2

$R_{output} = R_{min} = \frac{8 \text{ bits}}{1/400 \text{ sec}} = 3200$ bps



2 2 2 2

block rate $= \frac{800 \text{ bps}}{2 \text{ bits/block}} = 400$ blocks/sec

= frame rate

$\boxed{400 \text{ frames/sec}} \rightarrow$ 8 bits/frame

3200 bps

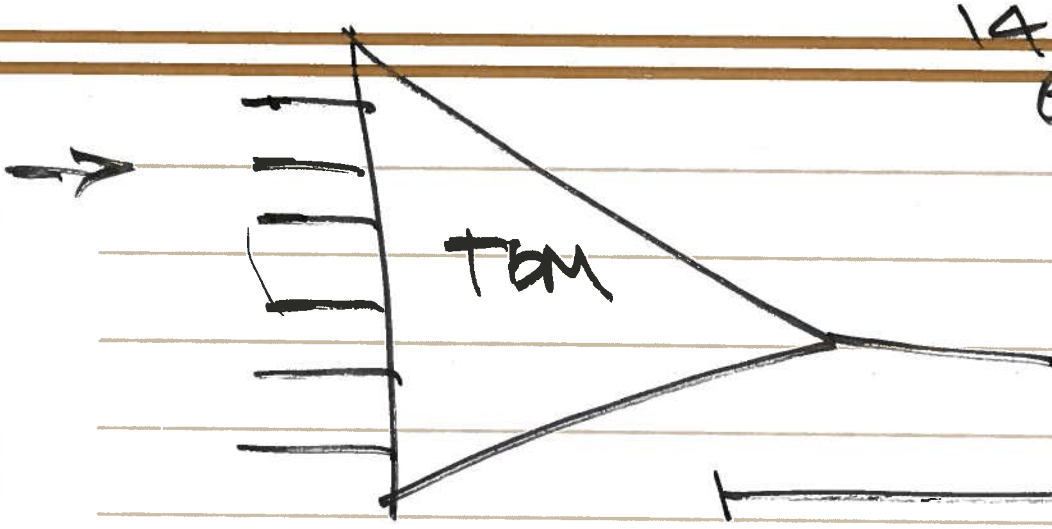
$$\frac{21 \text{ bits}}{10\,\mu\text{sec}} = \frac{2.1}{} \text{ Mbps}$$

$$2.1 \text{ Mbps} \,/\, 21 \text{ bits/frame} = 0.1 \text{ Mframes/sec}$$

$$10^5 \text{ frames/sec}$$

14 channels

6 active



8 + 4

12 bits

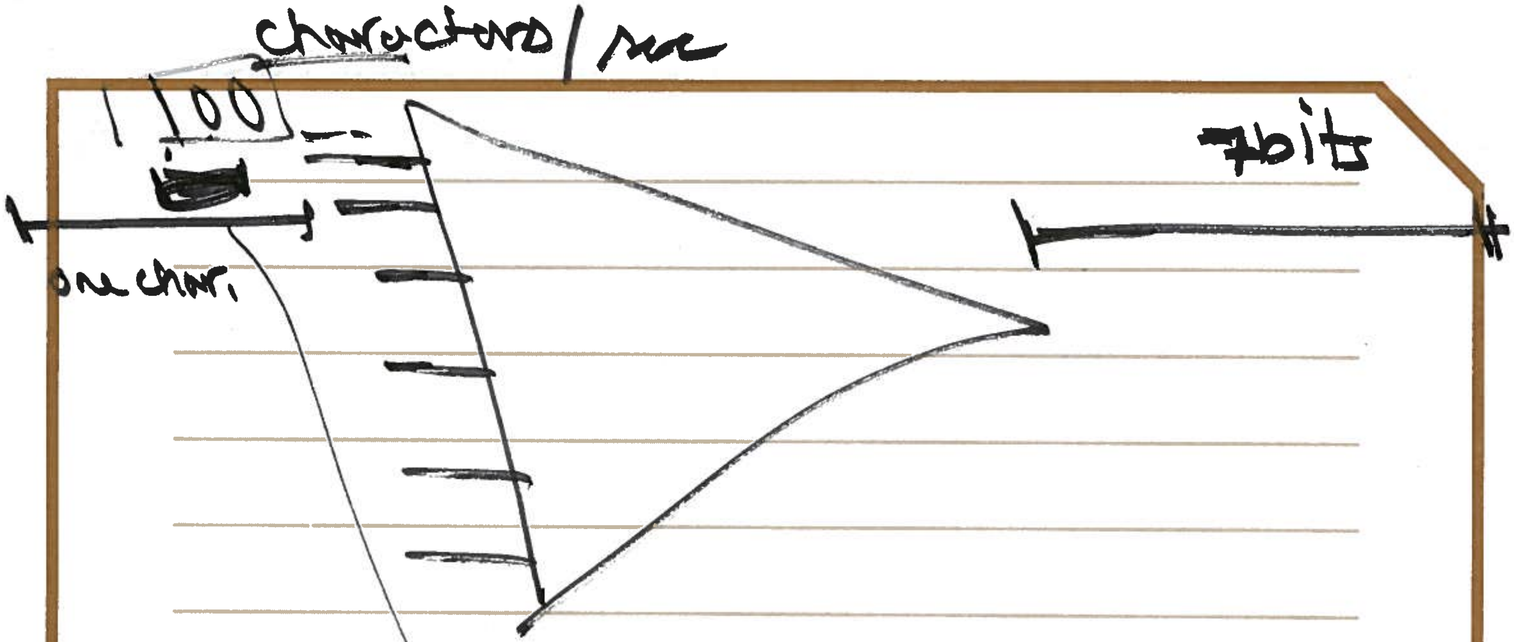
$\boxed{8 \text{ bits} + 4 \text{ bits}}$

data 4 bits

time slot

1 2 6

$6 \times 12 \text{ bits} = 72 \text{ bits/frame}$



block duration = char. duration = frame dn

$$\frac{1 \text{ char}}{100 \text{ char/sec}} = \frac{1}{100} \text{ sec} = \text{frame dur.}$$

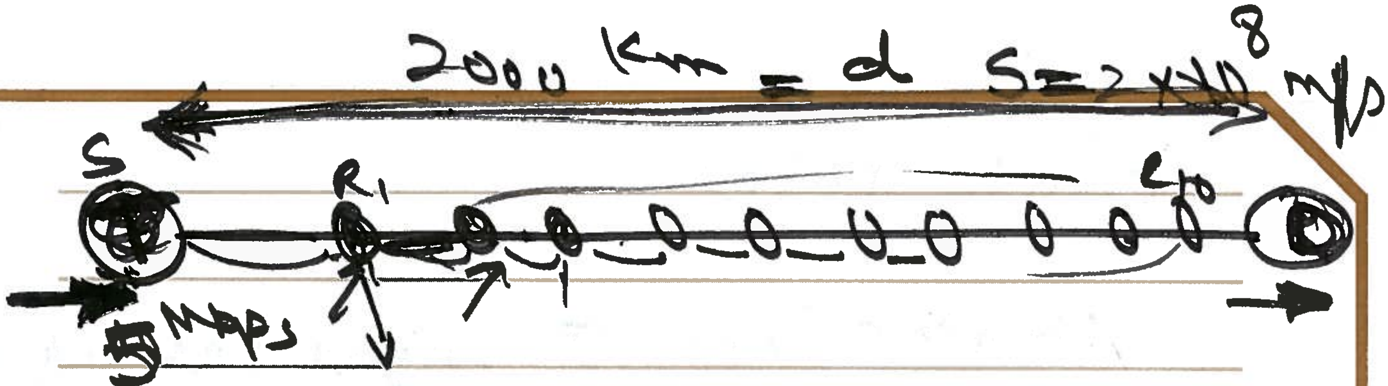
→

$$\frac{72 \text{ bits}}{1/100 \text{ sec}} = \boxed{7200 \text{ bps}}$$

$$\frac{7200 \text{ bps}}{72 \text{ bits/frame}} = 100 \text{ frames/sec}$$

block rate = 100 char./sec = 100 frames/sec

→ 72 bits/frame × 100 frames/sec = 7200 bps



$\rightarrow d_{queue} = 2\,\mu sec$

$\rightarrow \boxed{d_{proc} = 1\,\mu sec}$

$\boxed{d_{trans\_routers} = 0}$

total-delay = end-to-end-delay

$= d_{trans} + d_{proc} + d_{queue} + d_{prop}$

size of frame = 5 million bits

$d_{trans-S} = \frac{5\text{ M bits}}{5\text{ Mbps}} = 1\text{ sec}$

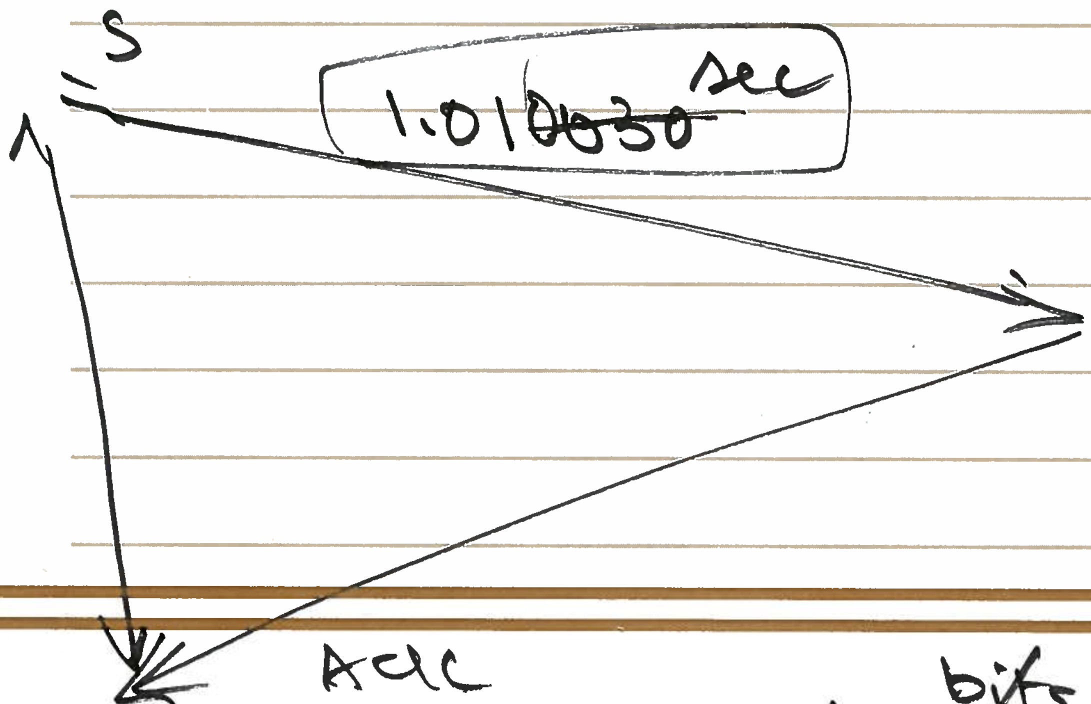
Total delay $= d_{trans-S} + 10\times(2\,\mu sec + 1\,\mu sec) + 0.01\text{ sec}$

$= \frac{2000\text{ Km}}{2\times10^5\text{ Km/s}} = 10\text{ msec} = 0.01\text{ sec}$

d_{prop_total}

$RTT = \text{end\_to\_end\_delay}_{S\_D\_frame} +$

" " " $_{D\_S\_ACK}$



$d_{trans\_ACK} = \frac{1500 \text{ bits}}{15 \text{ Mbps}} = 1$

$\frac{10^2}{10^6} = 10^{-4} \text{ sec}$

$0.01 \text{ sec} = d_{prop\_ACK}$

$d_{proc\_ACK} = 1 \mu sec$

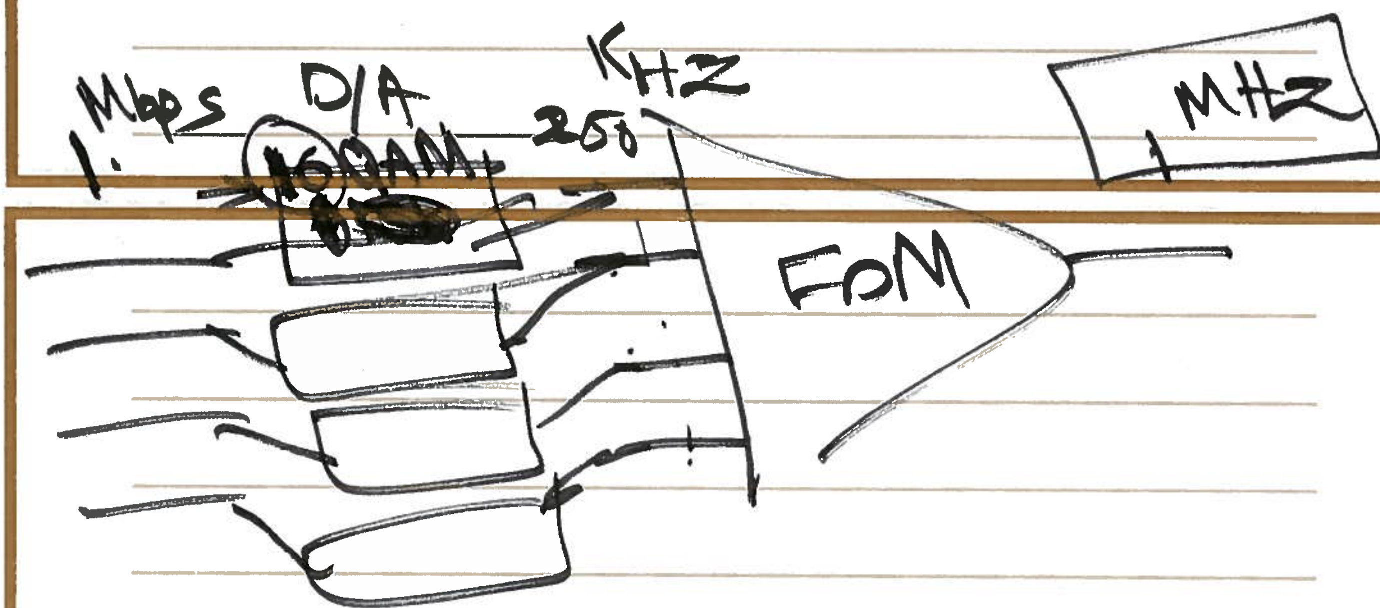
$d_{queue\_ACK} = 3 \mu sec$

1V 8V

16 bits/sample

600 Ksamples/sec × 16 bits/sample

= 9600 Kbits/sec



$R = 1$ Mbps $\quad R_{band} = 250$ KHz

$$R_{band} = \frac{1}{k} R$$

$\Rightarrow$ $k=4$

5 Miles

-0.3 dB/Mile

$10 \text{ miles} \times -0.3 \text{ dB/mile} =$

Attenuation $= \underline{-3 \text{ dB}} = 10 \log_{10}\left(\frac{P_F}{P_0}\right)$

$$\frac{P_F}{P_0} = 10^{-0.3}$$

$P_F = 2 \text{ mV}$

$5 \text{ miles} \times -0.3 \text{ /miles} = \underline{-1.5 \text{ dB}}$

$$\frac{P_F}{P_0} = \underline{10^{-0.15}} = 0.71$$

Nyquist Thm.

$\boxed{f_{max}} \longrightarrow 2 f_{max}$

1 KHz $\quad$ 2 Ksamples/sec

a composite signal a BW = $\boxed{200\ KHz}$

What is the sampling rate

Sampling rate = 600 Ksamples/sec

$f_{min} = 100\ KHz$

$f_{max} = 100\ KHz + BW$

$= 300\ KHz$

→ Quantized signal rate =

2.1 V $\quad$ 1.003 V $\quad$ 7.81 V —

↓

2 $\quad$ 1 V $\quad$ 8 V →

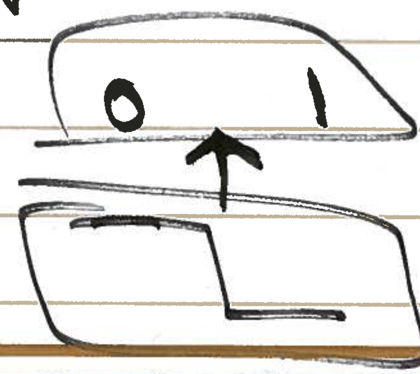
D/D

Line coding

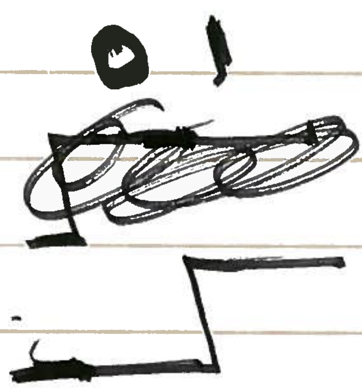
→ Ethernet → +1V, +1V

NRZ-L : 0 → +1V

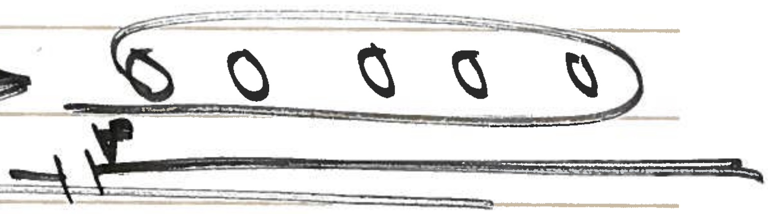
1 → -1V

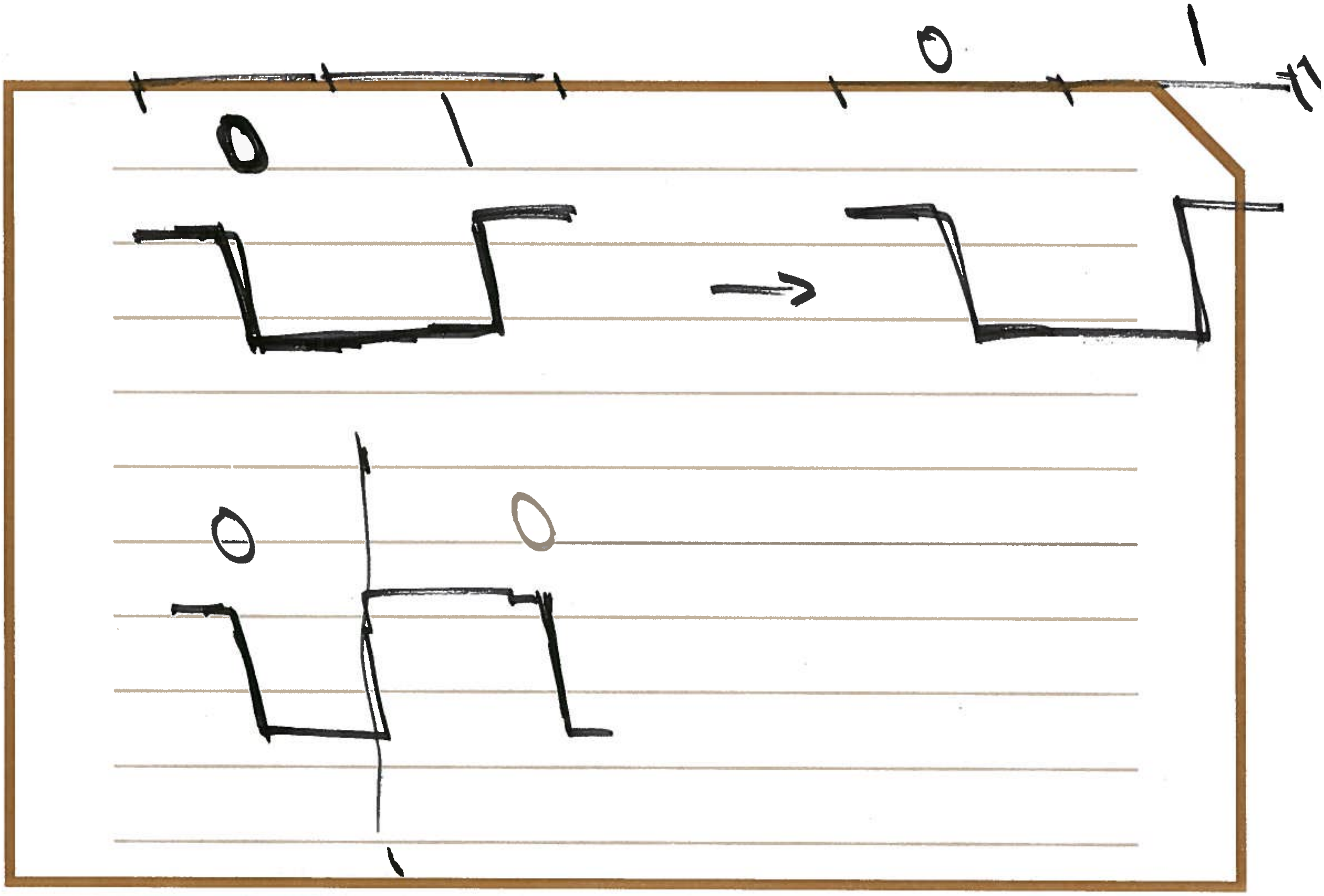


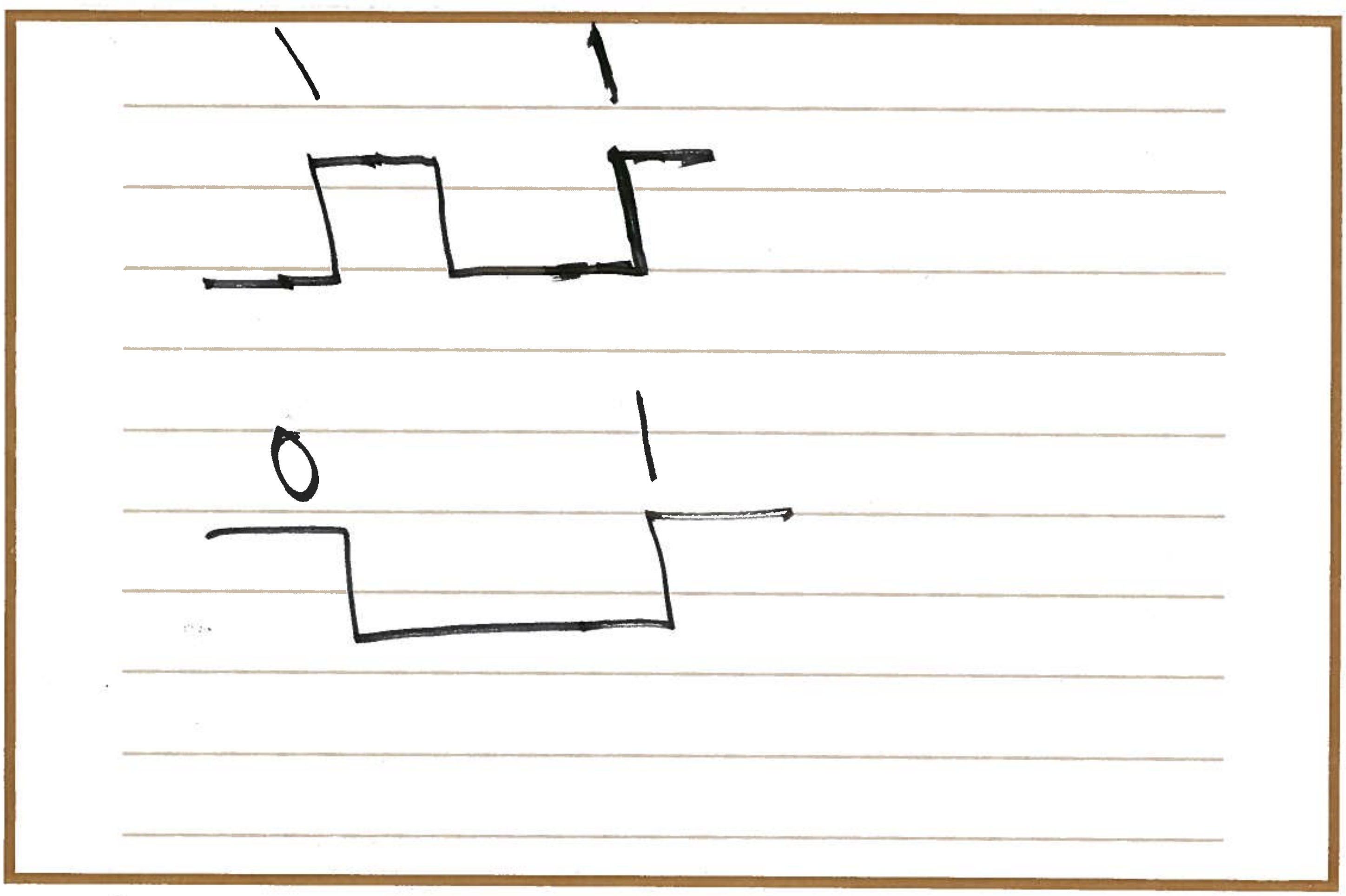
NRZ-I



t=0



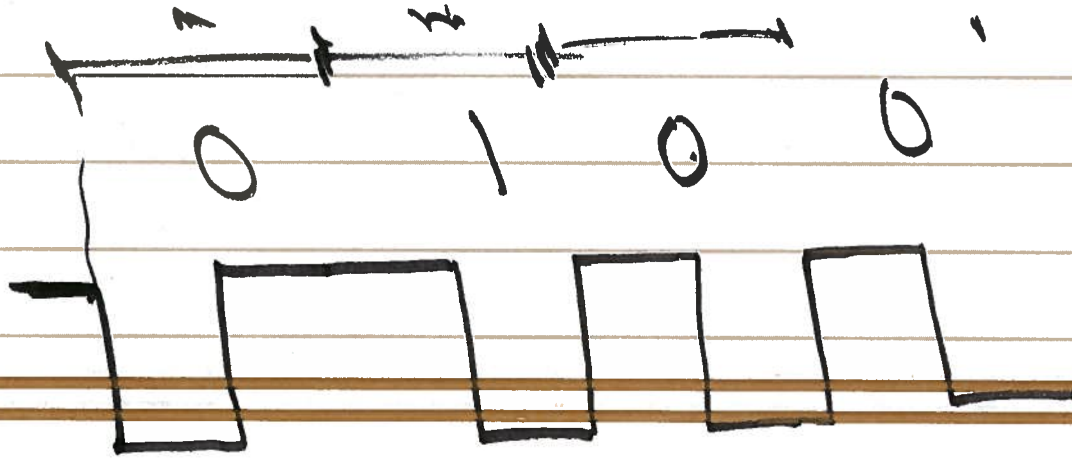

0
1
0
1
0
0


1
1
0
1

0 1

0 1

a transition in the begin cycle



$t=0^-$