Switching

Q1.

(1) Explain the major components of a telephone exchange and explain their limiting factors

Basic components of a Telephone Exchange

(i) Switching unit ⟶ To connect an input to a output. Limiting factor is number of connections (erlang).

(ii) Control unit ⟶ To handle all controlled functions. Limiting factor will be number of call attempts per unit time.

(iii) Peripherals units ⟶ The supporting equipment. No specific limitations

(iv) Software ⟶ Instructions and methodology to process a call has been written. Limiting factor will be the time taken to process a call.

(2) Explain the difference between Strict and Wide sense of Non Blocking.

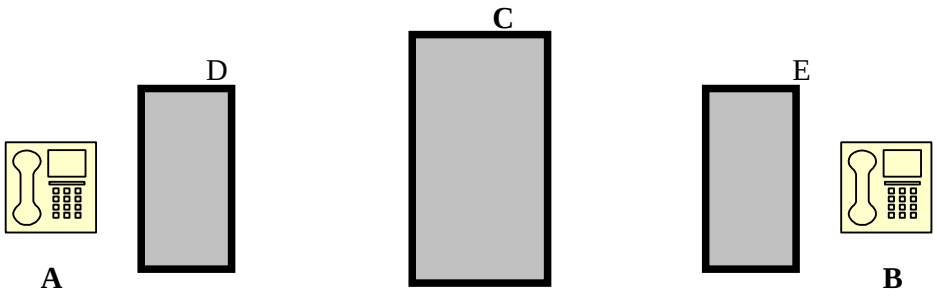
Strict Sense of Non Blocking- To achieve non-blocking without using any rule.

Ex: Close Circuit

Wide Sense of Non Blocking- To achieve non-blocking with using a rule.

Ex: Ben's Rule

(3) A 'T' switch will connect two subscribers in two different locations as follows.



'T' switch

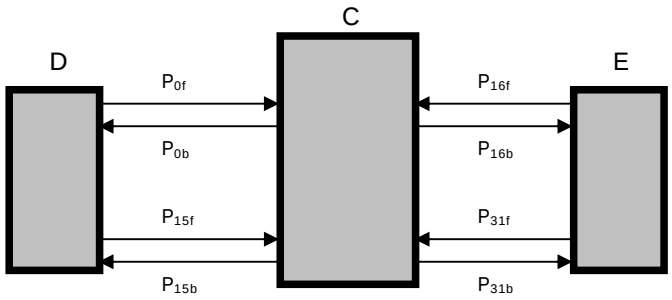
C is the Master Switch, where as D and E are Remote Switches. Each remote switch will connect to Master Switch by 16 PCM systems namely P_0 to P_{31}. A is speaking with B on P_0 TS8, where as B is speaking to A on P_{18} TS20.

(i) Explain clearly how A and B is in conversation with respect to the Master Switch.

(ii) Assuming only these RSU are connected to this MSU, calculate the maximum traffic that this switch can handle.

TS = Time Slot

1.



2. A speaks on P_0TS8

   B speaks on P_{18}TS20

3. When A speaks to be the following two actions will occur

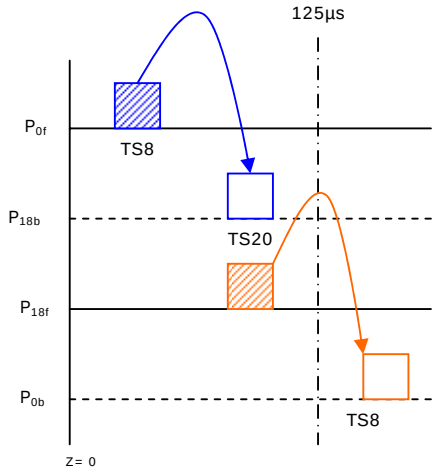
   3.1 P_{0f}TS8 → P_{18b}TS20

   A^{Hello} →

   3.2 P_{18f}TS20 → P_{0b}TS8

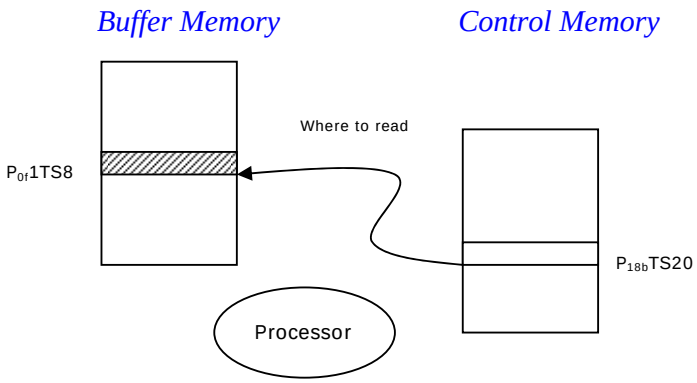
   B^{Hello} →

4. What happens at C (overview)



5. The above transactions will be realized in the following way

There are 3 components in a T Switch. Assuming output Control T Switch all forward PCM timeslots will be stored in the Buffer memory cyclicly by the forward PCM in the Buffer Memory. The output PCM are cyclicly addressed the control memory and the contents will give the word number of the Buffer memory to be read. In a give 125us, the control memory has to be refreshed two times by the Processor.



Q2.

i. Explain the basic elements of a fixed telephone network.

The following are the basic elements of a fixed telephone network

1. Geographical location of the customer.
2. Local Exchange (maximum distance a local exchange will serve is around 10km)
3. Access Network (Connection between above 1 and 2)
4. Domestic Transport Network (interconnection between all local exchanges)
5. International Gateway
6. International Transport Network (Interconnection between all international gateways of each country for each operator)

ii. Basic demarcation of telephone network can be categorized as follows.

Out-side plant
Switching
Transmission

Explain the physical demarcation of each of the above and the functions that we have to achieve from the each above.

Out-side Plant- The demarcation will be a telephone exchange MDF (cable side) to the geographical location of the customer. Technical function that has to be achieved will be to reproduce the electrical signal generated from the customer premises telephone to the MDF (Main Distribution Frame).

Switching- When customer dials a telephone number B switching will connect to the B (B can be any telephone in the world). In general switch will capture all answered calls details for the customer billing.

Transmission- The demarcation will be from one switch to another switch (normally through a MDF or DDF-Digital Distribution Frame). The technical functionality to be achieved is similar to Out-side Plant.

In general OSP is distributed according to the customer's location and involve in high cost in the case of Copper network. Transmission is converged from one point to another point and much technology is deployed to enhance many channels into a single bearer. Switching carry major intelligence of the networks and it provides online computers.

iii. A digital telephone exchange contains a single stage 'T' switch, which can accommodate 512 PCM systems. Assuming all the 512 PCM systems can be utilized for telephone conversation, what is the maximum traffic in Earlangs that this switch can carry.

The traffic that can be carried:

Number of time slots in the switching system = 512*30*2 (1 PCM system is 2 PCMs)

Number of Time Slots used for a conversations = 4

Number of conversations that can be carried out in the switching system = (512*30*2)/4 = 7680

Hence maximum of 7680 Erlangs can be carried out in this switch.

Two RSUs connected to the exchange are connected with PCM0 to PCM15 to one RSU, while the other RSU is connected with PCM385 – PCM400. Total number of PCMs to the Master switch will be 512 (assume all these PCMs are used for RSUU). Two customers connected from these two RSUU are connected via PCM1 TS5 and PCM386 TS10 to the main switch. If this 'T' switch is working as an output

controlled ‘T’ switch, explain clearly how the ‘T’ switch works when these two customers are in conversation with respect to the elements of buffer memory, controller memory and microprocessor.

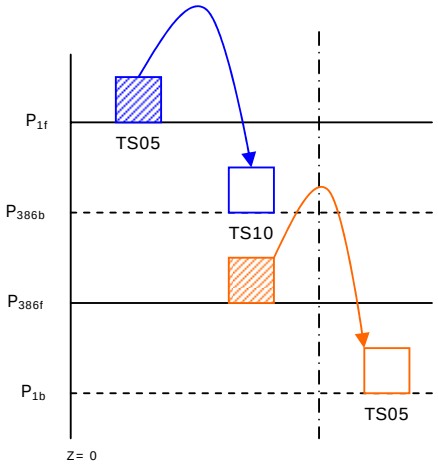
Note: TS = Time Slot

Customer A is speaking on PCM1 TS5 while customer B is speaking on PCM386 TS10. Hence we observe the following switching function at the master switch.

$P01_f$ TS05 $\xrightarrow{\text{Delay of 19.5µs}}$ $P386_b$ TS10

$P386_f$ TS10 $\xrightarrow{\text{Delay of 105.5µs}}$ $P01_b$ TS05

Timing Chart



In order to achieve the above switching function 3 components are needed i.e.

Buffer memory- To store the forward PCMs TS information
Control memory- Control information to achieve the above switching function
Processor- To carry out the switching operations.

Output Control T switch

Here the output PCMs (Backward PCMs) is cyclically addressing the Control memory and the relevant word pertaining to output TS will provide where to read from the Buffer. Storing of input PCM TS information is cyclic at the Buffer memory.

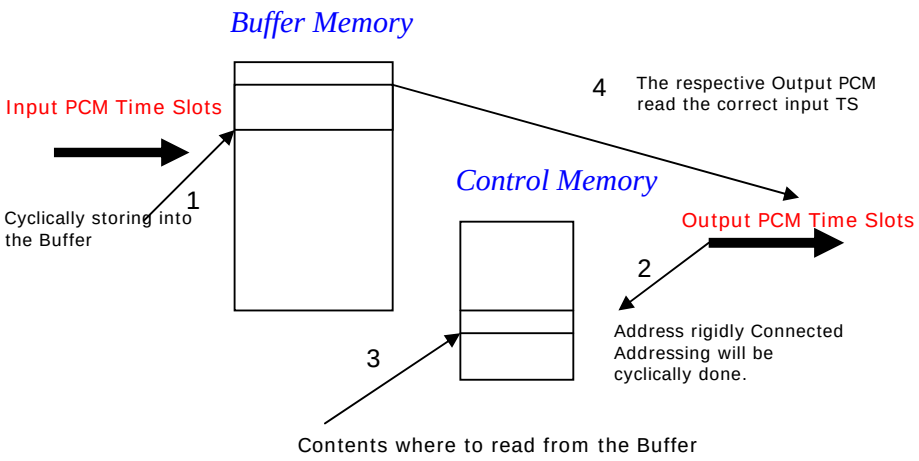
Input Control T Switch

Here the input PCMs (Backward PCMs) is cyclically addressing the Control memory and the relevant word pertaining to input TS will provide where to store the relevant

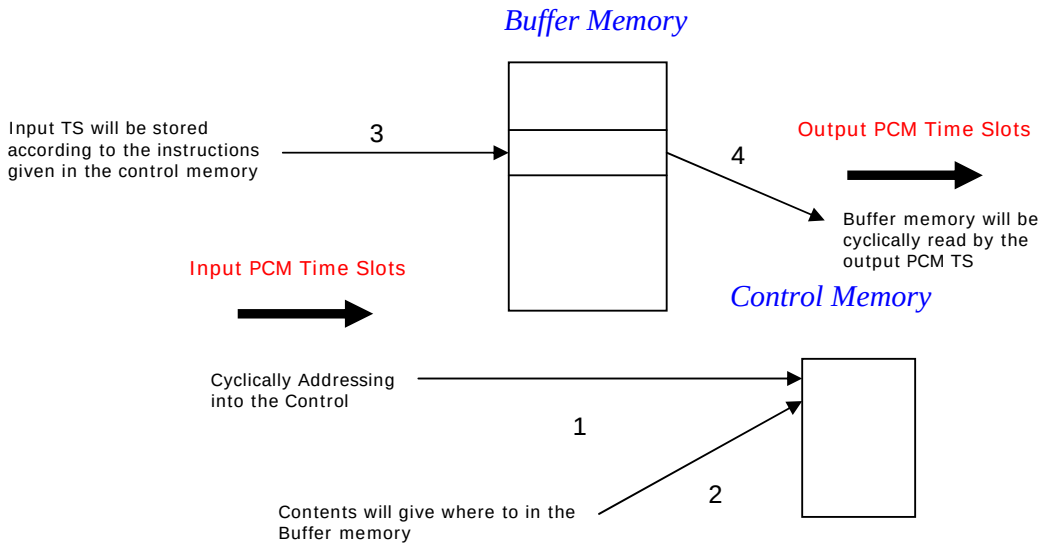
input PCM TS information (which is according to the above switching equation). Reading of output PCM TS information is cyclic at the Buffer memory.

In Summary

Output Control T Switch



Input Control T Switch



Generally Output Control T switch widely applicable due to less errors experienced. Nevertheless for short hauls Input Control T switch can be used.

Where to store in the Buffer memory of the following forward PCM

$P01_f$ TS05

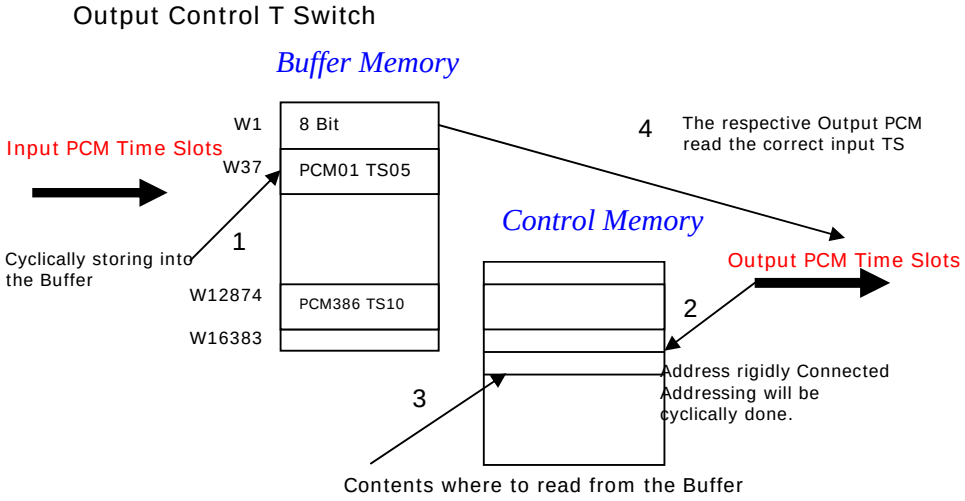
$P386_f$ TS10

Total of 512 PCM are available to store in the Buffer memory. Hence the Buffer memory size has to be 512 *32 words of length and width will be 8 bits.

To define a word in the Buffer memory we need 14 binary bits where 9 major significant bits are for the PCM number and the least 5 significant bits are for the TS number.

$P01_f$ TS05 = $0000000001,00101_2$ = 0025_H= 37_{10}

$P386_f$ TS10 = $1,1001,0010,01010_2$= $324A_H$= 12874_{10} (386_{10}= 192_H= 1,1001,0010)



In the Control memory word number 37 will be addressed by $PCM01_bTS05$ and the contents is to read the Buffer memory in the word number 12874. Similarly word number 12874 is addressed by the $PCM386_bTS10$ and the contents of the control memory is to read word number 37. The size of the control memory is 14 bit word and 16384 words. The Processor deployed to carry out the instructions of the switching equation given above should have cycle time better than (125/512)*30*2 µs.

Q3.

1. Explain the difference between Analogue & Digital switching.

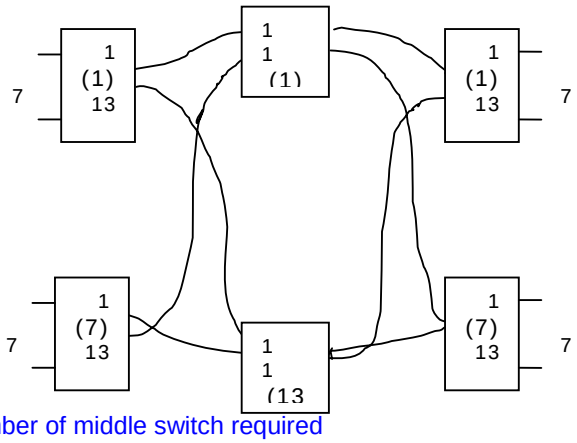
In the switching module one can see all the voltages with respect to time which is generated in the telephone is called analogue switch, whereas in the digital switch you can see only samples or equivalent of samples.

2. What are the basic components of a Telephone exchange explain the functions of each.

Basic components of a Telephone Exchange

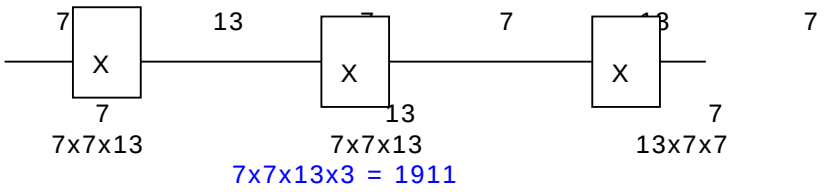
(i) Switching unit ⟶ To connect an input to a output
(ii) Control unit ⟶ To handle all controlled functions.
(iii) Peripherals units ⟶ The supporting equipment.
(iv) Software ⟶ Instructions and methodology to process a call has been written.

3. Design 3-stage strict sense of non-blocking 49 inputs, 49 outputs. How many middle switches you use? Prove the total number cross points are 1911.



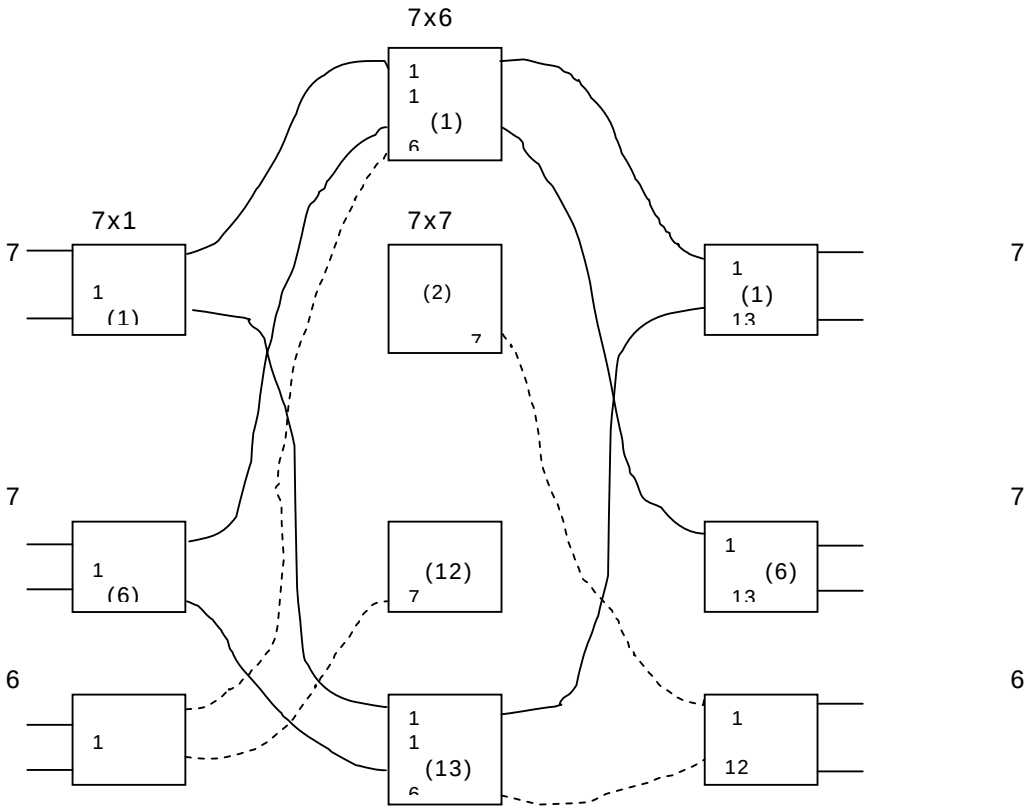
The number of middle switch required
= 7 x 2 – 1 = 13

Total number of cross points;



7x7x13x3 = 1911

4. If you have to design 48 input 48 out 5 stage switching Network, how do you design to obtain minimum number of cross points? Calculate the number of cross points in that network.



Number of switches from 6 i/p or i/p should access = 7+ 6 - 1 = 12

In order to obtain minimum Number of cross points, the links from i/p small switch has to be transpose with o/p small switch which is shown in the diagram.

No.of cross points = 7x13x6 + 6x12 + 7x6 + (7x7) x11+ 6x7 + 13x7x6 + 12x6
= 1859

Input No.of cross points = 7x13x6 + 6x12 = 618
Middle No.of cross points = 7x6 + (7x7)x11 + 6x7 = 623
Output No.of cross points = 13x7x6 + 12x6 = 618

Total = 1859

Q4.

a. Today the telephone exchanges use packet switching technology, named Next Generation Networks. Explain the basic advantage of utilizing NGN networks.

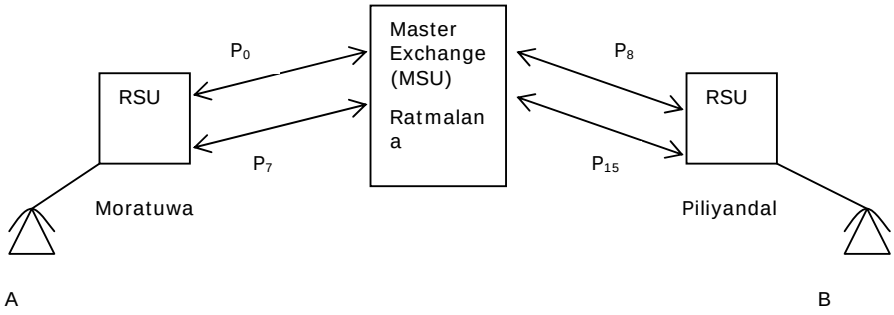
NGN networks will have the following advantages over the normal circuit switch network.

i. Normal circuit switch network when deployed for voice the transmission network will be efficient less than 50%.This was due to the fact that from A to B a bidirectional transmission 2 parts are established for a connection and the voice is such that where both parties not speak simultaneously, when one speaks other person listens resulting the other persons voice channel is not being utilized though it is established. Hence NGN networks transport part is utilized for packet switching for 100% efficiency of the transport network where there is no fixed channels being allocated for A and B.

ii. Similar concept explained above exist in the digital switching network too where circuit switching is used allocating 2 clear channels in the switching network for the communication of A and B. A and B does not talk simultaneously. Hence the efficiency of the switching network too is less than 50% n circuit switching. The advancement of computer and packet switching technologies has helped to migrate a normal circuit switch to a packet switch which is of high efficiency.

iii. In the circuit switching networks integration of services such as Data, IPTV etc. was difficult and have been handled by separate networks by using IP technology for both transport and switching networks in the NGN environment leads to provide unified service to the customer through the already provided access network. Hence more utilization of access network with an unified terminal equipment with high resolution screen, keyboard, speakers will be made available in future.

b. The following is a part of digital switching network deployed in Sri Lanka. Each Remote Subscriber Unit is connected to Master exchange by 8 PCM systems.



i. From the diagram what is your assessment of the number of customers that can be connected to each RSU.

Each RSU is connected with 8 PCM systems i.e. 240 bi-directional Time Slots for voice. Assume a customer will speak (either originate or terminate) 6 minutes in the busy hour. The traffic offered by a customer will be 6/60= 0.1 Erlang. 240 bi-directional circuits can carry 240 Erlangs (assuming there is no loss). 2400 customers for each RSU can be accommodated.

ii. Assuming that there are no customers connected at Ratmalana Master exchange, what is the maximum traffic that the Master exchange can handle. (Assume no other connections from Master exchange to other exchanges and this will work as a closed Switching network.)

The traffic that can be carried:

Number of time slots in the switching system = 16*30*2 (1 PCM system is 2 PCMs)

Number of Time Slots used for a conversations = 4

Number of conversations that can be carried out in the switching system = (16*30*2)/4 = 240

Hence maximum of 240 Erlangs can be carried out in this switch.

iii. If A customer speaking to B customer on P03 TS05 and P14TS10. Clearly explain how digital switching is achieved at Ratmalana Master exchange.

At Ratmalana master switch the following switching function will be achieved.

$P03_f$ TS05 $\xrightarrow{\text{Delay of } 19.5\mu s}$ $P14_b$ TS10

$P14_f$ TS10 $\xrightarrow{\text{Delay of } 105.5\mu s}$ $P03_b$ TS05

In order to achieve the above switching function $P03_f$ TS05 and $P14_f$ TS10 has to be stored in a buffer memory. Lets analyze the buffer memory.

Buffer memory size- Since there are16 forward PCMs resulting 16*32 = 512. The size of the buffer memory should be 8bit word (time slot information is 8 bits) of 512 words.

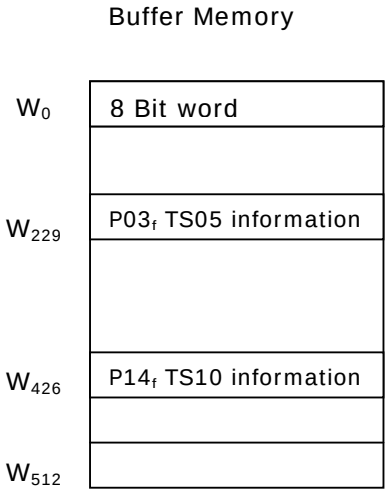
Where to store in the buffer memory? If we assume buffer memory is partition to accommodate 1st PCM then Time Slot a word in the buffer memory can be defined (in binary) as follows

$X_9\,X_8\,X_7\,X_6\,X_5\ldots..\,X_0$ where X_5 to X_9 represent the PCM number and the rest represent the Time Slot number. Hence PCM $P03_f$ TS05 will store in the following word

$00110,00101_2 = 0C5_H = (14*16+5)_{10} = 229$

Similarly $P14_f$ TS10 will store in the following word

$11010,1010_2 = 1AA_H = (1*16^2+10*16+10)_{10} = 426$



How to read the Buffer memory? Reading the Buffer memory will be directed by the control memory. Control memory too will have 512 words since there are 512 Time Slots pertaining to backward PCMs.

If we assume Control memory is partition to accommodate 1st PCM then Time Slot a word in the Control memory can be defined (in binary) as follows

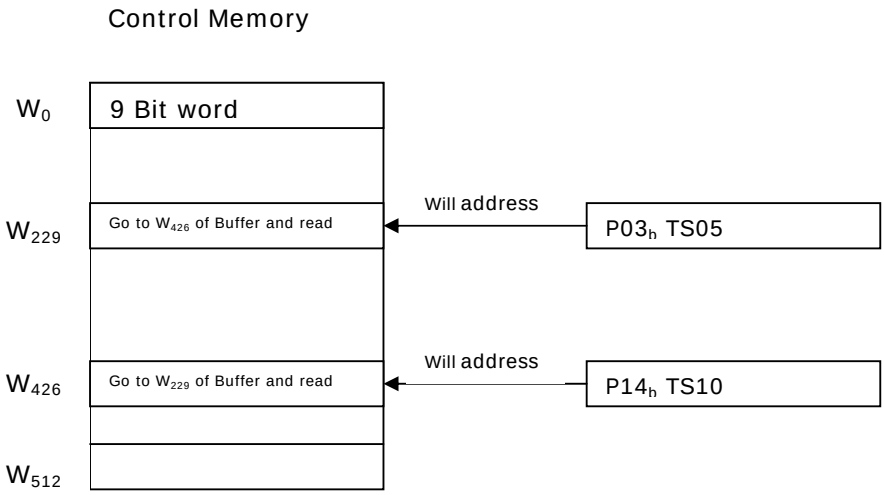
$X_9\ X_8\ X_7\ X_6\ X_5 \ldots\ X_0$ where X_5 to X_9 represent the PCM number and the rest represent the Time Slot number. Hence PCM $P03_b$ TS05 will address the Control memory in the following word

$00110,00101_2 = 0C5_H = (14*16+5)_{10} = 229$

Similarly $P14_b$ TS10 will store in the following word

$11010,1010_2 = 1AA_H = (1*16^2+10*16+10)_{10} = 426$

The Control memory maximum size will be of 512 words where each word will be of 9 bits to indicate from which buffer memory word the output Time Slots should read.



Processor

Processor will control all these functions for every 125µs reading and writing of Time Slots will be managed. Hence if there are 512 Time Slots the processor cycle time has to be better than 125/512 *2µs.

The following timing chart summarizes how the above transactions are visible in the Ratmalana switch.