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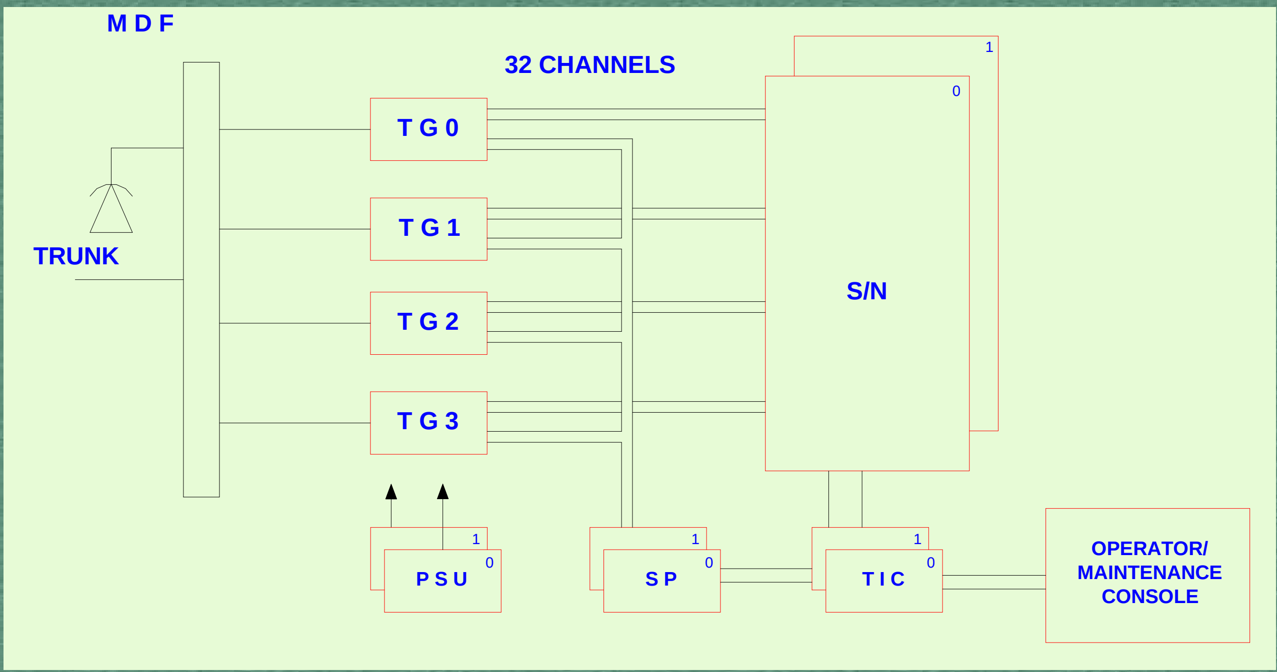
DIGITAL EXCHANGE C-DOT



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INDIAN RAILWAYS INSTITUTE OF SIGNAL ENGINEERING & TELECOMMUNICATIONS, SECUNDERABAD - 500 017

Issued in January 2014

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Edition No	**02**
No. of Pages	**53**
No.of Sheets	**28**

CHAPTER 1

INTRODUCTION

1.0. INTRODUCTION

C-DOT (Centre for Development of Telematics) 128P RAX is a Telephone exchange designed to meet the telecommunication needs of small sized rural areas. These exchanges are also suitable for Indian Railway applications where the telephone line capacity is less than 100. Provision is made in the design to expand the line capacity up to 400 subscriber.

C-DOT is a Central Government Organization of India, set up to develop the necessary equipment suitable for Indian climate and environmental conditions.

The system is designed to offer uninterrupted services by using duplicating methods for control and power supply circuits.

1.1.0 Functional blocks

There are four terminal groups in one 128 port RAX. For Terminal Group there are 32 terminations or ports. Thus from four Terminal groups or 16 terminal interfaces we get 128 ports which are connected to the switching network.

The port configuration of 128 port C-DOT RAX is as shown in the table 1.1

SNo	Type of Connection	No. of Ports/ No. of cards	No. of Ports/ No. of Cards	No. of Ports/ No. of cards
1	Subscriber Lines	80/10	88/11	96/12
2	Trunk lines – E&M/Loop	24/03	16/02	08/01
3	TGD function	16/02	16/02	16/02
4	Conference	08/01	08/01	08/01
	Total	**128/16**	**128/16**	**128/16**

Table 1.1 Port Configuration of 128 Port C-DOT RAX

The system architecture is shown in the Fig. 1.1

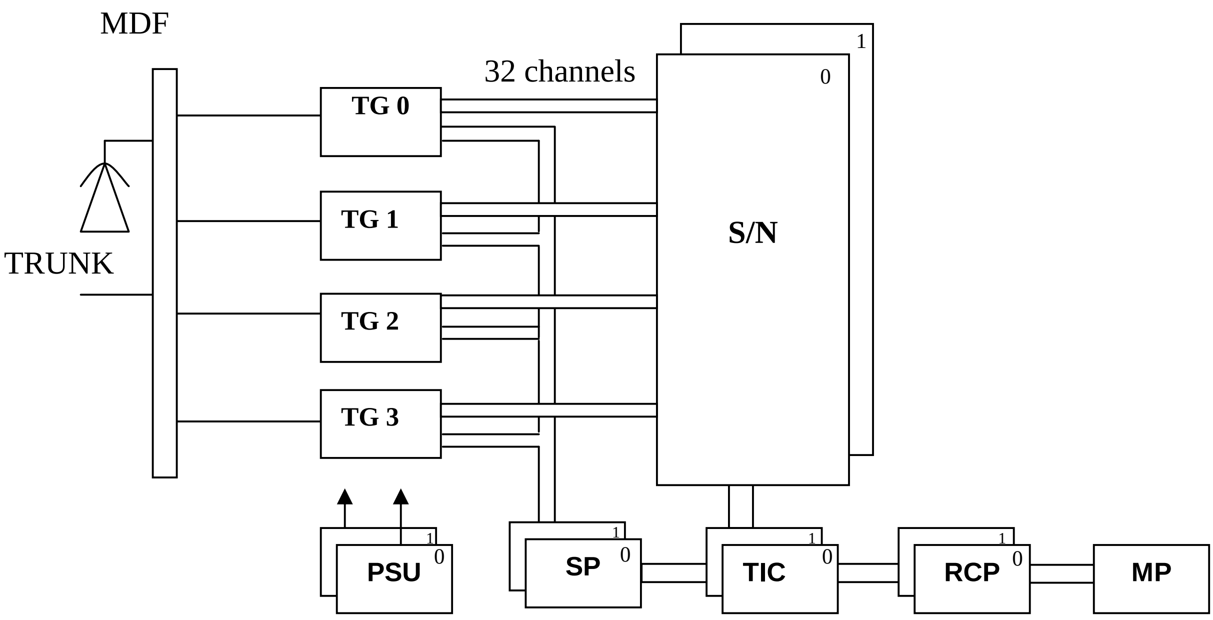

Fig 1.1 – System Architecture of C- DOT 128 Port RAX

1.1.1 Terminal Group :

It is a group of four peripheral cards/ service cards. All the subscriber lines are terminated on the line circuit card (LCC) and trunk lines are terminated on the trunk card (Two way trunk circuit card or E&M trunk circuit cards depends on the type of trunk) respectively. These terminal interfaces are generally known as **peripheral** cards. Tones like dial tone, busy tone etc are generated and interfaced with the subscriber lines and trunks by TGD circuit card. Conference among the subscribers is achieved by Conference circuit card. The conference and TGD circuit cards are known as **service** cards.

There are four peripheral/service cards in one **Terminal group.** There are eight terminations/ports in each terminal (peripheral/service) card.

1.1.2. SP (Signalling Processor) Card: (Duplicated)

It detects the Loop extended by line circuits and trunk circuits. It receives the digits when calling subscriber dials the called subscriber number. It also drives the ring feed relay of the called party. It has memory, to store the scanned information.

1.1.3. TIC/SN (Terminal Interface Controller/Switching Network): (Duplicated)

This card comprises of switching and interfacing between SP and RAX Control Processor (RCP). Multiplexing, demultiplexing of terminal groups takes place here. Switching between calling and called party is established here. It (TIC) also controls the output of TGD (Tone Generator and Diagnostics) to be fed to peripheral cards (Line/Trunk cards). This card also has internal bus with RCP. This card uses 65C02 Micro Processor with 16K RAM and 32K EPROM.

1.1.4. RCP (RAX Control Processor): (Duplicated)

This card uses 65C02 Micro Processor with 12K RAM, 48K/16K EPROM & memories. This contains the information pertaining to peripheral cards, metering and administrative functions. Maintenance panel is connected directly to RCP by which changes can be made (adding, deleting, modifying of subscriber or trunks etc.) in the exchange.

1.1.5. Common Control cards:

The SP, TIC/SN & RCP are called **common control cards** and are duplicated. These cards monitor each other’s health and act accordingly. Normally SP0, TIC/SN0, RCP0 form one group and SP1, TIC/SN1, RCP1 form another group. These groups are known as copy 0 and copy 1. When copy 0 is active copy 1 is in passive mode. If any card of a particular copy goes faulty the system changes over to other copy, and exchange works on this copy till the faulty card is repaired and the copy becomes active.

1.1.6. Power supply Unit (PSU) card : (Duplicated)

The input voltage is –48+/-4V. RAX system requires various internal working voltage sources. PSU card generates the following voltages for internal working.

1) ± 5V-8A – For microprocessor and logic gates.
2) –9V-0.5A – Codec
3) +12V-1A – Relays and speech
4) 75V≥ ~/25Hz – For ringing

1.1.7. Hardware Architecture:

C_DOT 128P RAX is housed in a cabinet containing one equipment frame.

The frame has 26 slots to guide the circuit cards. However a maximum of 24 printed circuit cards can be housed in the system. These PCB’s are jacked in to the mother board using Euro connectors. The cabling to the MDF is extended from the rear side of the mother board using similar euro connectors.

The equipment frame is as shown in fig 1.2.

PSU	PSU	TGD	CONF	TRK	LCC	LCC	LCC	LCC	LCC	TIC/SN	SP	RCP	RCP	TIC/SN	SP	LCC	LCC	LCC	LCC	LCC	LCC/TRK	LCC/TRK	TGD	PSU	PSU
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Fig 1.2 Equipment frame of C-DOT 128 port RAX.

The PSU card occupies two slots due to its width. So two PSU cards occupies four card slots. That's why it is a 26 slot and 24 card arrangement. Slots numbers 22 and 23 are optional for trunk or LCC.

1.1.8 Maintenance Panel: MP is connected to the RCP through RS232C for the system administration and maintenance. Microprocessor 65C02 is used to perform the above functions.

1.1.9 Special features of this exchange are :

- Single frame terminal unit capable of 128 ports.
- Stored program control.
- Modular in design and hence expandable.
- Man machine communication through console.
- Low power consumption.
- No air conditioning is required.
- No single fault affects more than 8 terminations
- Reliable, dependable.
- The digital switching system of C-DOT technology will offer 100% **non blocking** voice and data network, which means in a 96 line configuration system 48 people can be connected to 48 others or each line will be provided a free line at any time irrespective of the system status.
- Easy system start-up.
- Faults are indicated through the maintenance panel in the form of audio visual alarms.
- Calling party release
- Called party release (affected after 60 sec)
- Automatic system alarms in case of duplicate unit failure, battery low and power supply unit failure.
- Remote testing facility to check system status.

1.2.0 Accessories for Maintenance :

1.2.1 Line Test Unit : LTU is also connected to exchange through D25 pin connector. Any subscriber or Trunk line can be connected to line test unit by giving suitable command through maintenance panel. When line is connected to this unit, different tests on subscribers line or on subscribers telephone can be conducted. After tests are completed on subscribers line/telephone, a release command has to be given, otherwise the line continues to get connected to line test unit and subscriber cannot access exchange.

1.2.2 Total Failure Alarm Unit: This unit is optional and connected to one of the ports in the exchange, normally to port No. 80. This port is a nominated port for this purpose .If this alarm is installed, port No. 80 cannot be used for connection of any other equipment or subscriber. It gives an audible and visible alarm to maintenance staff in case of total failure of the exchange. This equipment is connected to the exchange through D25 pin connector.

1.3 Technical Specifications:

1. Switching	:	Digital PCM 'A' law CCITT standard non blocking
2. Control	:	Microprocessor based stored program control (SPC)
3. Capacity	:	Upto 96 subscribers with 8 trunk circuits
4. Line loop resistance	:	Max.1000 ohms
5. Ringing	:	75V 25Hz
6. Primary power	:	-48V +/- 4V, 6 Amps
7. Temperature	:	0° C to 45° C
8. Relative Humidity	:	5 % - 95 %

1.4 Summary :

The C-DOT RAX is housed in a cabinet and equipped with the following cards:

1. Power Supply Card (Duplicated)
2. Tone Generator and Diagnostic Card (Duplicated)
3. Signal Processor Card (Duplicated)
4. Terminal Interface Controller/Switching Network Card (Duplicated)
5. RAX Control Processor Card (Duplicated)
6. Conference Card
7. Line Circuit Card (Max. 12 Cards)
8. Trunk cards (Min. 1, Max. 3)
   (Trunk Cards are of two types TWT and E & M. TWT is 2 wire and E & M is 6 wire)

Objective:

Fill in the blanks

1. One terminal group contains 4 nos. of peripheral cards.
2. Every peripheral card is designed for 8 ports.
3. PSU, TGD, RCP, SP, TIC/SN cards are duplicated in RAX.
4. RCP, SP, TIC/SN is the control cards in RAX.
5. TGD, CNF are the service cards in RAX.

Subjective:

1. Draw C-DoT RAX 128 Port architecture?

CHAPTER 2

POWER SUPPLY UNIT

2.0 POWER SUPPLY UNIT (PSU) - CARD

2.1.0 Introduction: The PSU card used in RAX is a DC-DC converter cum-ringer unit working on -48V DC supply. They are duplicated for redundancy. The output from both the PSUs are made common and given to the load via change over diodes. In case of fault in any one unit the other unit will instantly take over the full load of the RAX system.

The - 48V is filtered and fed to a DC - DC converter wherein it is chopped at 20 KHz using a switching unit.

The resulting square wave is fed to an isolation step-down transformer and the secondary voltage is rectified and filtered to produce the low voltage DC.

In order to regulate the output load, it is monitored and a portion of it is fed back into the control logic circuit (PWM (Pulse Width Modulator) controller chip). Which in turn compares this voltage to a reference voltage and adjusts the conduction period of the switching element.

The RAX system requires the following voltages:

1) + 5V - 8A
2) - 9V - 0.5A
3) + 12V - 1A
4) - 5V - 0.1A
5) 75V ~ 25Hz

2.1.1 BASIC BLOCKS: PSU comprises the following basic blocks:

1. Switcher A 2. Switcher B
3. Ringer (switcher stands for switched mode DC-DC converter).

Switcher A converts -48V DC input to

(a) +5V - 8.0 A regulated.
(b) -9V - 0.5A unregulated.

Switcher B converts -48V DC input to

(a) +12V - 1.0 A regulated.
(b) -5V - 0. 1 A regulated.

Switcher A : This unit takes -48V DC input, filters, chops to 20KHz square wave passes through a step down transformer which has taps for 5V and 9V. +5V, 8A being a heavy load is generated by forward converter mode. The +5V is monitored by a portion of it being fed back to PWM which regulates the -9V supply is generated by another winding from the transformer.

Switcher B: The -48V DC is filtered, switched to 20 KHz and passed through a stepdown transformer which has taps for 12V and 5V. +12V 1.0A is generated by rectifying transformer. This is being monitored and controlled by PWM chip controller. -5V is derived by inverting another of a winding and regulated through a regulator chip.

Ringer: It is basically a sine weighted PWM inverter whose output is filtered to get 25Hz sine wave. The O/P is distributed on three mutually exclusive phases by means of three Opto - Triacs which are triggered as per the cadence of 0.4 sec on, 2.0 sec. off and this cadence is triggered and controlled by a PROM.

i) **Ringer Generator:** The supply to the ringer generator is +5V. A 8.192 MHz crystal oscillator is used to generate 8.192 MHz signal. 32K byte memory stores the sine wave amplitude in the binary form. The ringer generates the cadence for ringing out put.

The 3 phase sine wave ringing voltage is produced by suitably switching the 3 Opto Triacs at the output stage. The control for these switches is also generated in the ringer generator. Pulse Width Modulator (PWM) pulses needed to produce the sine wave are also produced in this stage.

ii) **Ringer output stage:** The input to this stage is 12.8KHz signal operating one bi-directional switch and a sine wave PWM signal operates another bi-directional switch. The output of the bi-directional switches is pulse width modulated sine wave which is converted to smooth sine wave by means of an inductor. The output stage includes three switches at three phases, which are operated by control signals from ringer generator.

iii) **Change Over Relay:** The relay has 4 contacts. The inputs to 3 of the contacts are 3 phase outputs of the sine wave ringing. The 3 phase outputs are connected to 3 phase ringer bus when the relay contacts are closed. The relay coil is actuated by relay drive signal. The relay drive signal is controlled by TIC (Terminal Interface Controller) card. At a time, only one copy of PSU can supply ringing since the closing of one relay contracts necessarily opens the contacts of the relay on the other copy.

iv) **RELAY DRIVE CIRCUIT:** The TIC signal, duplicate PSU error signal, and self PSU error signal are used to control the closing or opening of the relay contacts.

2.1.2. ERROR MONITORING AND PROTECTION: Error monitoring circuits within the card provide for the monitoring the following:

1) Low Battery.
2) +5V, +12V absent or under/ over voltage.
3) Ringer fail.

1) **Battery low condition**: This consists of resistor network R 42 and R 43 sensing the input -48 V, the value of R 42 and R 43 are so chosen that the voltage across R 43 is always.2. IV or more to drive a transistor Q2 (3440) to its saturation value, Q2 will be deprived of the minimum base drive at a value of < -44V input.

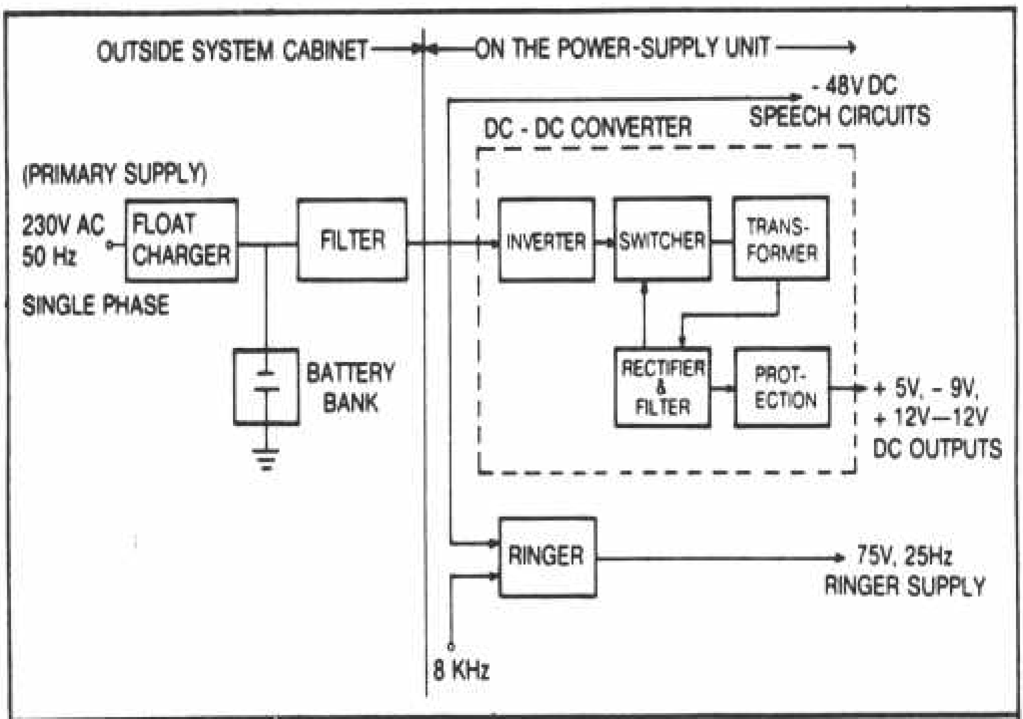

Fig. 2.1 POWER SUPPLY CARD

When the input voltage goes below -44V, Q2 will not turn ON. With the result Q3 will be ON and hence the opto coupler switches ON and the signal take OFF point is pulled high and this signal is extended to the Terminal Interface Controller Card.

2) **+5V, +1 2V Under / Over Voltage or absent:** A quad comparator, out of which two are used for detecting over voltage and the other two for detecting under voltage.

A 2.5V reference voltage from PWM (pulse width modulator) controller serves as one input to all the four comparators. +5V and +12V are adjusted by resistor and capacitor networks suitably at the other input to all the comparators so as to keep the output of the comparator "high”.

In the event of any one output getting low / high or absent, the output of the corresponding comparator goes low which in turn saturates an output transistor to pull the output low. This low output gives as one input of AND gate and the output goes low which is inverted and given as an "active high" PSU (power supply unit) error signal to "TIC" (Terminal interface Controller) card. A crow bar circuit is also present which gets activated during high voltage condition and shorts the output.

3) **Ringer Fail:** The input at this stage is single phase sine wave ringing out-put. It is given to an AC/ DC to digital opto isolator. Its output is used as master reset for a parallel in serial out shift register. Absence of ringer output gives a "high" signal at the output of the shift register.

2.1.3 Pulse Width Modulated Controller (PWM) SG-3524.

Majority of present switch mode power supply systems are of PWM type, which varies the conduction time of the switching element during the ON period to control and regulate the output voltage to a predetermined value.

The role of SMPS (Switch Mode Power Supply) is two fold. It has to provide a well regulated output voltage and also high input-to-output isolation protects the user and the equipment from shock hazards due to high voltage or leakage current.

An Op. Amp compares the feed back signal from the output of the power supply to a fixed reference voltage. The error signal (if any) is amplified and fed into the inverting input of a comparator. The other input of the comparator is connected to a saw tooth wave with a linear slope, generated by a fixed frequency oscillator. The oscillator output is also given to toggle a flip -flop producing a square wave. The comparator square wave output and the flip flop output are both used to drive the AND gate, enabling the output when both inputs to the gate are high. The result is a variable duty cycle pulse train.

Now the output pulse width is modulated when the error signal changes its amplitude.

CHAPTER 3

RAX CONTROL PROCESSOR (RCP)

3.0 INTRODUCTION:

The main functions of RCP are **Call processing, Administration and Maintenance**. The functional block diagram is shown in fig 3.1.

3.1.1 FUNCTIONAL BLOCKS :

a) Processor and Memory.
b) Clock Generation.
c) Address Decoder and Read/Write Generator.
d) Asynchronous Communication and Timer.
e) Error Monitor.
f) EEPROM and Real Time Clock.
g) High Level Data Link Control (HDLC).

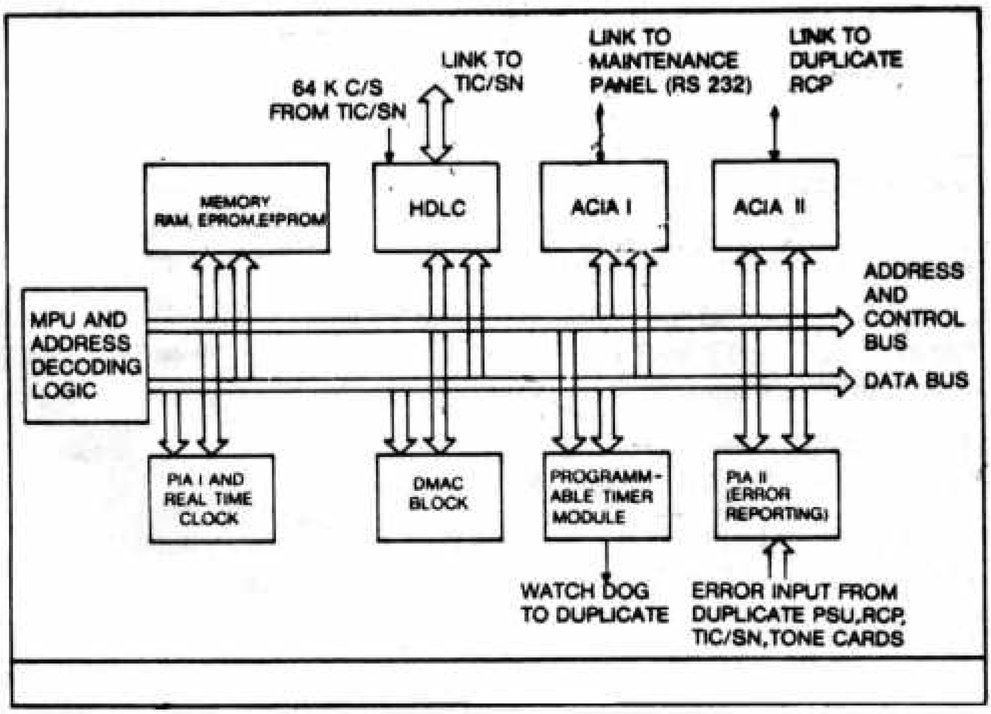

Fig.3.1. Functional Block diagram of RCP card

PROCESSOR AND MEMORY: This is the main control processor, **65C02** micro processor chip is used for this purpose. The frequency of the processor clock is fixed at 1.8432MHz. Processor will get interrupted by all devices within the RAX Control Processor circuit card. External buffers are used for addressing memory and for transferring data.

Clock Generation: 1.8432 MHz clock is generated by using clock generation logic. Pulse Time Modulation of 128 KHz and 64 Hz is used to drive High level data link controls.

Address decoder and Read/ Write Generator: The buffered address bus driven by processor is decoded to drive chip select of memory and devices. All the devices are accessed by processor. The address space allowed for devices is 1K. At that time Device selection logic selects one of the devices except high level Data Link Control where it is selected by processor address bit. Read/Write control signal for memory and program timer module is generated by using processor clock.

Asynchronous Communication and Timer: (ACIA) Asynchronous Communication Interface Adaptor is used within RAX control processor card. There are 3 ACIA links. 2 ACIA links are used between RAX control processor and maintenance panel through RS 232C driver. Third one is used between 2 copies of RAX control processor (This third ACIA link is not buffered by a RS-232C driver to reduce one interface error because this link is vital for communication with RAX control processor).

Error Monitoring: PIA (Peripheral Interface Adaptor) is used to monitor all system errors and self RAX control processor error. All the error signals from Terminal interface controller and switching network, Tone generator with Diagnostics, Power Supply Unit, other copy of RAX control processor and maintenance panel will be terminated and buffered. Finally they are connected to the port pins of PIA. PIA interrupts processor on NMI (Non Maskable Interrupt) to give priority for the system failures.

EEPROM and RTC (Real Time Clock) Interface: (PIA) Peripheral Interface Adaptor 1 is used to interface EEPROM and Real Time Clock. Processor can address upto 64 K but EEPROM or EPROM (12 K) and RAM 48 K covers almost all the locations out of 64 K. So to address EEPROM, 2 separate 8 bit registers are used and it is also used to select one out of 2 EEPROMs at a time Reading/Writing from /to EEPROM is controlled by Peripheral Interface Adaptor.

Real time clock (RTC) is used to provide day and time of the day with the alarm capability. RTC is also controlled by PIA 1 and RTC interrupts processor by using PIA 1.

(HDLC) High level data link control: HDLC is used for synchronous communication with the other processor in the system. Pulse Time Modulation provides clock for HDLC. High level data link control (RCP) RAX control processor receives its serial message from the HDLC of Terminal interface controller and Switching network (TIC/SN). Where RCP and HDLC converts this message into 8 bit parallel data to the processor for processing. After processing, the processor transfers the data to TIC/SN in the message format by using HDLC to the HDLC of TIC/SN.

3.2.0 CALL PROCESSING: RCP processes the information received and gives appropriate message through a synchronous message link (HDLC) to the TIC/SN for further action.

3.2.1 Out Going Call (Local):

1. Subscriber on-hook (free idle).
2. Subscriber goes off-hook (Calling).

3. TIC sends a message to RCP that line low has come on a port.
4. RCP then checks that whether the same port has a valid directory number in the port of directory translation table.
5. If invalid directory number then RCP informs TIC to send NU Tone on that port and state of the port remains same.
6. If valid directory number then RCP informs TIC to feed dial tone.
7. The status bit for this port is changed to busy.
8. The state of the subscriber is changed in the port table to dial begin state.
9. The first dialled digit may be 2 (if local call) otherwise 0,9,8. Once the calling subscriber dials the first digit TIC inform to RCP and RCP instruct TIC to disconnect dial tone.
10. If first digit dialled is not 0,2,9,8 then NU TONE is fed to calling subscriber and status of subscriber is changed to Busy / NU state.
11. The digit arrived from the calling subscriber is stored in the digit space available in the corresponding port table and the digit counter is incremented.
12. Since local call is of total 3 digits only RCP translates *2nd* and 3rd digit into port number. If the port number is not valid, then NU TONE is fed to the calling, subscriber, and state of the calling subscriber is changed from dialling state to NU/ Busy state.
13. If the port is a valid one then RCP checks if the called port is free. If it is not free then RCP informs TIC to feed busy tone to the calling subscriber and state is changed to busy state.
14. If it is free then RCP informs TIC to feed ringing voltage to the called port and RBT (Ring Back Tone) to calling port and state of the calling is changed to RBT state and status *of* the called port is changed into busy state.
15. Once the called port goes off-hook TIC informs RCP line low on that port and then RCP informs Terminal interface controller to connect two ports (calling and called) and state of the subscriber is changed to conversation.

3.2.2 Outgoing call (STD):

1. Subscriber on hook (free or idle).
2. Off hook (calling).
3. Subs state is changed to dial begin state.
4. The first digit dialled by calling subs is "0” then RCP checks whether subscriber is allowed to make STD call or not.
5. If STD is barred then RCP informs TIC to send NU Tone and subscriber state is changed to Busy / NU Tone.
6. If STD is not barred then RCP searches for free outgoing trunk in the outgoing trunk table for direction "0".
7. If the free trunk is not found in outgoing trunk table then free trunk is searched in both way trunk table.
8. If none of the trunk is free then RCP informs TIC to feed busy tone and subscriber state is changed to busy.

9. If free trunk is found then RCP sends a message to TIC to seize the free trunk and connect it to the subscriber. Now subscriber state is changed to busy state.
10. Trunk state is changed to trunk seized state.
11. In STD call RCP expects minimum 5 digits. Before pulsing out first digit if answer signal (line low) comes on the seized trunk then it is treated as blocking signal in case of outgoing trunk and it is treated as incoming seized in case of Both way trunk.
12. In both cases Busy Tone (BT) is fed and state of the trunk (out going) is changed in blocking state.
13. If there is no error all 5 digits are pulsed out. After pushing out of 5th digit then total time out of 150 sec. is started.
14. TAX (Trunk Automatic Exchange) should give answer signal within this time out else the call is terminated and the calling port is fed with BT and subscriber state is changed to a busy state and clear forward signal is sent on the trunk to remove the seize and the state of the trunk is changed to Release Guard state.
15. If answer signal comes from the TAX within 150 sec. then RCP sends a message to TIC to connect subscribers.
16. The state of subscribers and trunk is changed to conversation.

3.2.3 OUT GOING CALL TO PARENT OR ADJACENT EXCHANGE (8):

1. Subs on hook (idle).
2. Off hook (calling).
3. TIC informs RCP by sending message about line low on that port.
4. RCP checks whether the same port is connected or not by checking in the port to directory translation table.
5. If the port is not connected (invalid directory number) then RCP informs TIC to send NU tone on that port.
6. If the port is valid one, then RCP informs TIC to feed DT (dial tone).
7. Subscriber state is changed to dial begin state and status bit of this port is changed to busy.
8. In this case first digit dialled is "8" then TIC informs RCP. RCP searches free (outgoing) trunk in the trunk table of the direction "8".
9. If free trunk is not found then searching is made in the both way trunk table.
10. If none of the trunks are free then BT is fed and subscriber state is changed to busy state.
11. If free trunk is found then RCP sends message to TIC to seize that trunk and subscriber state is changed to parent state and that trunk is changed to seize state.
12. RCP expects 5 digit under no error condition. During pulsing out an IDP time out of 5 secs is started so that within that time parent exchange must give an answer signal.
13. If no answer signal comes within that time then BT is fed and clear forward signal is fed on trunk .The subscriber state is changed to busy and trunk to release guard state.
14. If answer signal comes from parent or adjacent exchange within 150 secs, then RCP sends message to TIC to connect the subscriber and the trunk. And the state of the calling and trunk is changed to conversation.

3.2.4 OUTGOING CALL TO MANUAL TRUNK EXCHANGE (9)

1. Subscriber on book (idle).
2. Subscriber off hook (calling)
3. TIC sends a message to RCP that line low has come on a port.
4. Subscriber state is changed to dial begin state.
5. In this case the first digit dialled is ’9’.
6. The RCP searches for free trunk in the outgoing trunk table of direction. ’9’ if free trunk is not found then searching starts in both way trunk table.
7. If none of the trunks are free then BT is fed and subs state is changed to busy.
8. If a free trunk is found then RCP sends a message to TIC to seize the trunk and connect it to the calling party. Calling port state is changed to operation trunk seized state, the trunk state is changed to seized state and 60 secs. time out starts for the calling subscriber.
9. If the answer signal does not come within 60 secs, then RCP informs TIC to feed B.T. to calling port and calling port state will be changed to busy.
10. Trunk is fed then clear forward signal to release the trunk and trunk state is changed to release guard state.
11. If the answer signal comes within 60 secs, then RCP informs TIC connect calling subscriber and trunk.
12. Calling subscriber state and trunk state is changed to state of conversation.

3.2.5 INCOMING CALL FROM TRUNK BOARD (DIRECT 9):

1. For an incoming trunk to RAX, a line low will come on that trunk port from the distant exchange. RCP then checks whether the trunk is connected or not to RAX If not connected then N U tone is fed to that trunk.
2. If the trunk is connected to RAX then RCP checks for the direction of the trunk (0,8,9).
3. If it is a direction 9 trunk then a message is sent to TIC from RCP to feed D.T. to that trunk and trunk state is changed to dial begin state.
4. The first digit expected in this case be "2" only. If any other digit comes then RCP informs TIC to feed N.U. tone to the trunk and trunk state is changed to N.U. state.
5. If the first digit is ’2’ then trunk state is changed to dialling state.
6. Then RCP translates last 2 digits into port number (since digit expected are 2XX) if the translated port is invalid then RCP informs TIC to feed N.U. tone and trunk state is changed to N.U. state.
7. If the translated port is valid one, RCP checks for the status of that port free/busy. If busy then RCP informs TIC to feed BT.
8. If the called number is free then RCP informs TIC to feed ringing voltage to the RAX subscriber and RBT to the trunk. The trunk state is changed to RBT state and subscriber state is changed to ringing state.
9. If the calling port answers the call then a message is sent to TIC to connect two ports (both subscriber and trunk) and give a battery reversal to incoming trunk port.
10. The state of Trunk port and called port is changed to conversation.

3.2.6 DIRECT (0) Incoming:

1. The first digit expected is "2". If any other digit comes on it then RCP informs TIC to feed NU Tone to trunk and the state is changed to busy.
2. If the first digit dialled is “2” then trunk state is changed to dialling state.
3. Once the first digit is "2" then RCP translates the last 2 digits to port number. If the port number is invalid then RCP informs TIC to feed NU Tone to the trunk and trunk state is changed to busy.
4. If the translated port is not free then RCP informs TIC to feed BT to the trunk and trunk state is changed to busy state.
5. If the called port is free then RCP sends message to TIC to feed RBT to the calling and ringing voltage to the called port and trunk state is changed to RBT and called port is changed to Ringing state.
6. Once the called party answers then TIC informs RCP about the line low on that port. Then RCP informs TIC to connect incoming trunk and called port. And also informs to send battery reversal to the incoming trunk. Then the status of incoming trunk and called port is changed to conversation state.

TRUNK OFFER: This facility is used for trunk operator in the trunk direction “9” or the trunk from manual trunk exchange on a carrier line. This is to be used when operator finds RAX subscriber is busy. If trunk operator wants the RAX subscriber urgently then over the busy tone, digit 1 is dialled, it is treated as Trunk offer signal and operator is connected to RAX port number through 4 party conference unit. The operator then informs the RAX subscriber about the trunk call.

The MP (Maintenance Panel) is connected to the 2 copies of RCP through serial RS-232C link. The MP does all administration and maintenance function by inputting commands through key board. Communication between MP and RCP is through well defined messages. The messages from MP is filled in transit buffer and transferred to receive buffer in active RCP. After analysing the message the response message is stored in Transmit Buffer in RCP and then transferred to receive buffer in MP.

3.3.0 ADMINISTRATION: Non-volatile storage E E P ROM is used for billing, statistics of the subscriber such as metering status and system information.

Administration function is divided into:

1. Subscriber administration
2. Trunk administration
3. Traffic administration
4. Timing administration

3.3.1 Subscriber Administration: It is done through "Sub" function key when only if the user has logged in with a valid password. The various sub operations are:

1) Addition of subs.
2) Deletion of subs.
3) Change of class of service (COS) of subs.
4) Class of service (COS) of subs.
5) Test Access.

3.3.2. Trunk Administration: It is done through “Trunk” function key when only if user has logged in with a valid password. The various Trunk operations such as:

(1) Adding a trunk.
(2) Deleting a trunk
(3) Display, type of trunk.

The above function can be carried out for all 3 types of trunks (incoming/outgoing/both way).

3.3.3. Traffic Administration:

(a) Traffic Administration is done through TRF function key on MP after logging through valid password.
(b) The following information can be obtained through MP
    (1) Number of call attempts.
    (2) Intra exchange calls.
    (3) Congestion on Trunk direction 0, 8, 9.
    (4) Unused calls
    (5) Number of answered outgoing calls.
    (6) Number of answered incoming calls.
    (7) Number of calls abandoned without dialling.
    (8) Number of Calls abandoned after dialling.
    (9) Number of Calls abandoned due to invalid dialling.

3.3.4. Timing Administration:

(a) The timing administration is done through "TIME" function key.
(b) The following timing operations can be carried out from maintenance panel (MP).
    (1) Setting Date.
    (2) Setting time.
    (3) Setting Traffic Duration time.
    (4) Display current Date.
    (5) Display Traffic direction time.

3.3.5. Misc Administration:

Additional functions like PBX hunt group, status of ports, subscriber /trunk line testing, exchange parameters setting, and password scheme implementation etc, can be done by "MISC" key on MP. Metering information can be obtained by METER key on MP.

3.4 MAINTENANCE:

An RS 232C serial asynchronous communication link is used to communicate with maintenance panel. RCP monitors all the error signals of the system to inform the maintenance panel or for switching over to active / passive state. All the faults detected within the exchange (RCP/TIC/SP/MP) can be known through TEST (7) key on MP. The following details regarding the fault are given on MP.

(a) Fault location (MP/RCP/TIC/SP).
(b) Actual fault identity.
(c) Time and Date of detection of fault.

When fault occurs in MP or RCP, MP generates a beep at every 2 sec. The various hardware functional blocks of MP like LCD, Beeper, LED bank, functional key, functional LEDs and Keyboard can be tested through "TEST" function key.

Objective:

1. Microprocessor 6502 is used in RAX.

Subjective:

1. What are the functions RCP card?
2. Write the functional blocks of RCP card?
3. Write the call processing steps of RAX?

CHAPTER 4

TIC /SN MODULE

4.1 GENERAL DESCRIPTION

The TIC/SN is essentially a generic card. It switches voice between the 128 ports, controls signalling, support diagnostics and duplication under the intelligence of RCP. The signalling of the termination cards is handled by the signal processor (SP) and voice by the Switching Network (SN). Both SP and SN are under the control of Terminal Interface Controller (TIC) which works under instruction from RCP.

4.2 FUNCTIONS:

1) TIC/SN Switches the PCM (Pulse Code Modulation) digital voice information. This is to enable the subscribers to converse with each other and to be fed with different tones at different stages of the call.
2) TIC (Terminal Interface Controller) derives the identities of the calling and called terminals and establishes a path through SN (Switching Network) between these terminals. TIC communicates with RCP on HDLC (High Level Data Link Control) for call related information.
3) (Signalling through SP Processor Card) it receives status indication for all the 128 ports. This information is passed on to RCP. It gets the message from RCP to drive events on terminals and passes the Drive signalling information to signal processor.
4) It keeps on doing periodic diagnostic on the terminal cards including itself and informing RCP through HDLC messages.

TIC/SN Interfaces with:

a. Terminal Cards:

Each termination card caters for 8 ports (subs/trunks). Four such cards form one Terminal Group (TG). There are four time division multiplexed, 32 channel (PCM) voice links working at 2.048 Mbps.

The signals, required to control the multiplexing and demultiplexing these PCM links are generated by TIC/SN. The main clock in TIC is 8.192 MHz and it is used to derive 2.048 MHz PCM clock for the terminations. The same clock is used to derive card select signals and port (subscriber) select signals through counter chain.

Card select signal is used to select one of the 16 cards (in the RAX). Once the card is selected, one of the 8 subscribers is selected by using subscriber select signal.

To support duplication and copy change over, TIC/SN generates control signals towards TGs. There is an exchange of clock, sync, and control signals between two copies of TIC/SN in the system to support change over.

b. Signalling Processor (SP):

The SP is interfaced to TIC/SN processor through the processor bus. When any information is to be conveyed to TIC / SN by any one of the devices (including SP) there is an interruption to TIC / SN on IRQ (Interrupt Request) lead of the microprocessor (65C02). It checks for the interrupt and the device which can be either SP, HDLC, ACIA (Asynchronous Communication Interface Adopter), PIA (Peripheral Interface Adaptor) etc. Interrupt from SP is given highest priority. If it is from SP, then with the help of SP status register, it (TIC) reads the event of the port, transfers the information on data leads and writes into RAM (Data memory) of TIC. When TIC wants to drive SP for some event, then TIC informs SP on R/W (Read Write) leads. If TIC wants to write, it writes the data in the Data Register of the SP. Then SP acts accordingly.

c. RAX Control Processor (RCP)

RCP communicates with TIC/SN through the 64 Kbps HDLC. Whenever, TIC receives information from SP, it writes the information in the RAM (of TIC) in required format. This formatted information is sent to RCP on HDLC. Similarly RCP sends message to TIC on HDLC link and is written in the RAM. TIC acts according to the instructions of RCP.

4.2 SIGNAL GENERATION: For switching purposes TIC/SN generates various control signals to get various voice data from each line. Various signals generated towards termination cards are as follows:

(1) TCS (Terminal Card Select): To select one termination card among four Termination cards (TG) on a TDM link, TCS signals are used. Totally there are four TCS signals. This signal of 8 KHz frequency selects a particular card for about 31.5 (125/4) micro seconds (selects a TG for 125 microseconds).

(2) TA0, TA1, TA2: These are used as Port select (or subscriber select or Terminal select) signals. Since each termination card contains 8 ports, three subscriber select signals are provided for selecting a particular port. A port is selected for 4 microseconds out of 32 micro seconds for a terminal card.

(3) PCLK (PCM CLOCK): PCM clock of 2.048 MHz enables the TIC interface of the terminal card to generate a 32 Channel PCM voice link. But timing information for voice data is given by PCM clock.

(4) Sync: TIC interface generates a "Sync Signal" of 8 KHz required by the CODEC for the voice data sampling. Sync signal indicates starting of the Time slot "0" for 32 time slot PCM (TDM) serial link.

4.3 FUNCTIONAL BLOCKS: Since TIC/SN has to switch voice / Data communication and also control other devices, the hardware can be identified as:

Controller (for interfacing with other devices)
Switching Network (for voice and data communication).

4.3.1 Controller:

(1) Micro processor (65C02) with Data Memory (RAM)and programme Memory (EPROM):

This is also known as processing kernel. Along with 8 bit processing unit (65C02), program memory (EPROM) and data memory (RAM) forms the processing kernel. This is the controlling unit for the card and main microprocessor for processing the information. On any interruption from any of the associated devices or SP, it takes appropriate action like informing RCP through a massage. It informs SAM (Switch Address Memory) for switching the appropriate ports depending upon the information it received from RCP. Also from the data received from RCP after proper analysis, it writes into SP for further action (if any)

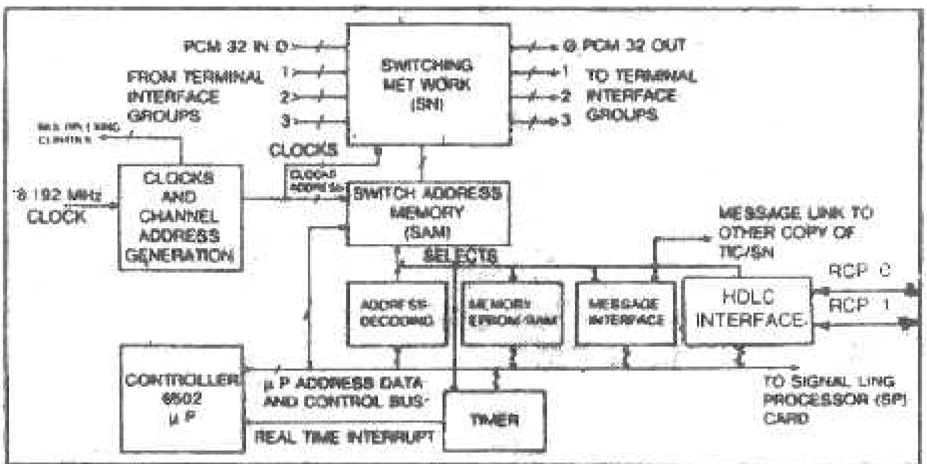

Fig. 3.1 TIC/SN CARD

4.3.2 Support Device such as PIA, HDLC, ACIA and timer.

i) Peripheral Interface Adapter (PIA): To enable control over the switch, microprocessor has PIA. It has programmable I/O ports and two interrupts for ports A and B respectively. It provides to monitor the error signals from all peripherals like TGD, CONF.

ii) Advance/High Level Data Link Controller (ADLC/HDLC): This is a bidirectional data communication link between the TIC and RCP and works at the rate of 64 Kbps. This is a synchronous communication link which works on 2 MHz clock. The clock to this ADLC/HDLC is supplied by RCP. The data to be transmitted is first stored in a transmit buffer. When the link is free, it transmits the data on the link.

iii) Asynchronous Communication interface Adapter (ACIA): This is used to programme the data flow at a desired rate. There are two types of ACIA which can be accessed by different addresses. In RAX, ACIA is used as a monitor and also as a debugging aid.

iv) Timer: This has three input clock for three independent 16 bit counters. Clock 1 is a 2MHz. With this, counter 1 is programmed to generate the 16 bits/sec. clock which is used as ACIA input clock for transmitting and receiving sections.

Second timer gets the output of the first timer as its input clock. With this, counter 2 is programmed to generate real time clock signal i.e. interrupt requests (IRQ).

Clock 3 is a 2 KHz. With this, counter 3 is programmed to generate Watch Dog signal. This Watch Dog (WD) signal is used for monitoring the supply of the MPU. The watch Dog error signal will indicate failure of processor.

4.3.3 SWITCHING NETWORK (SN): SN consists:

(i) Information Memory (IM): The incoming bit streams from termination cards are multiplexed and given out as one 128 channels (time slots) PCM link. The output of multiplexer goes to IM. This Memory will hold voice information (PCM or digital data) of 128 subscribers for one sample at a time.

There are two information Memories each of 1 K capacity. Each information Memory is divided into two portions - one for reading and other for writing, on alternate cycles of 2 ms. The other information Memory is identical to the earlier one. One of the two information Memories is located in trans path, and the other in the receive path.

The 128 time slots are divided into ports as 0-31, 32-63, 64-95 and 96-127.The messages from the 4 line/trunk cards, which forms the PCM link of 32 time slots are allotted to the ports accordingly. The message which are multiplexed are stored in sequential order so that the messages of port numbers and time slots are identical.

In the IM, one location is allotted per subscriber/port. Thus while writing, it is written in the sequential order of subscriber port numbers. A counter is used to generate address for Information Memory.

(ii) Switch Address Memory (SAM): To control switching, SAM is provided under the control of processor which will write port numbers of subscribers to be switched, into this SAM. The actual switching of voice information between the time slots is done in SAM. This information of switching is available to (65C02) TIC processor (which gets instruction from RCP).

The switching is done during the Read cycle of Information Memory, which holds the sample of the subscriber to be switched, has to be addressed as per switching requirement.

In order to provide address information for reading the information Memory, there is a separate Memory which has locations for each subscriber. This Memory is called switch address memory (SAM). This will get address information (of Information Memory) from counters to identify the proper subscriber time slots.

The data coming out from Information Memory is now a switched information. This bit stream is again converted into four 32 channels PCM links by a Demultiplexer.

(iii) Multiplexer and Demultiplexer (MUX and DEMUX): There are four 32 ch. PCM links which carry data to and from termination cards. Each link work at the rate of 2.048 Mbps. These four 32 ch. PCM links of 2.048 Mbps are multiplexed by a multiplexer to form one 128 ch. PCM link of 8.192 Mbps. The message available here is written sequentially in the Information Memory.

Similarly after being read sequentially from Information Memory the message on 128 ch. PCM link of 8. 192 Mbps is demultiplexed by the Demultiplexer to form four numbers of 32 ch. PCM links of 2.048 Mbps.

(iv) Counter Chain (circuit) Logic: This logic is used to derive the number of clock pulses(periods) for different purposes. The frequency of the main clock is 8.192 MHz. Using the dividers it is divided to derive various clock pulses. From these clock pulses card select, subscriber sleet (port - select) and synchronous signals are derived.

Objective:

1. In RAX 128P the main block is of 8.192 MHz.
2. TCS terminal card select signal selects one of the sixteen cards.
3. SCS-subscriber card signal selects one of the eight ports.
4. One TG is selected for 125 micro second
5. One terminal card is selected for 32 micro second.
6. One port is selected for 4 micro second.
7. In C DoT 128P exchange the basic PCM data rate is 2.048 mbps.

Subjective:

1. What are the functions of TIC/SN card?

CHAPTER 5

TONE GENERATOR/DIAGNOSTICS CARD (TGD)

5.1 INTRODUCTION: Tone Generator card is used to generate call supervisory and test tones. It has the capability to diagnose the tones it produces and there by can conform sanity check of the voice path.

(a) A tone is a simple audio signal having distinct frequency or set of frequencies (usually a voice frequency i.e. between 300 Hz to 3400KHz).

(b) A tone may be continuous or may have cadence i.e. signal has certain ON - OFF period.

(c) A tone consists of one or more tone components.

(d) A tone component may mean a single frequency signal (400 Hz) or a modulated frequency signal (400 Hz modulated by 25 Hz) or it can be an addition of two sine waves of different frequencies as well.

(e) These tone components which contain the PCM samples of a particular frequency or group of frequencies reside in a bank of memory called tone memory.

(f) Each bank of this tone memory consist s one tone component.

(g) When a tone consists of more than one tone component the second tone component may be just silence (regarded as unaudible d. c. signal).

(h) If in a tone (like RBT) there is one tone component followed by silence then the tone is said to have cadence.

5.2.0 AN EXCHANGE ENVIRONMENT: When a subscriber goes off-hook, the exchange should respond to the subscriber's request for the access to the system. It indicates the subscriber that the exchange has registered his request and it is ready to accept his digits. Similarly the other response of the exchange include a Busy Tone if a called party is busy, RBT if a called party is free.

How does the exchange produce such responses? An exchange is a switch. It can basically switch the subscriber voices. It is little wonder than to expect the exchange to switch these responses to the subscriber in need of such responses henceforth referred to as tones.

5.2.1 TONES AS SUBSCRIBERS: The tones are available at certain termination for the exchange to the subscribers in need of them. In what aspect the exchange will look at the TGD, which produces such tones as a termination card, giving the voices of 8 special subscribers called tones.

The TIC /SN card (which has the switch and the controller embedded in it), interfaces with the TGD in much the same way as with a line card.

5.2.2 TYPES OF TONES:

1. Dial Tone (DT)
2. Busy Tone (BT)
3. NU. Tone (NUT)
4. Ring Back Tone (RBT).
5. Conference idle Tone (CIT)
6. RAX Test Tone (RTT)
7. Idle (Silence) Tone (IT)
8. Not used.

5.2.3 HOW ARE TONES PRODUCED:

Let us take a typical tone called RBT. It is made of a tone component with a sine wave of frequency 400 Hz modulated by 25Hz as one tone component and silence as the other. This tone is such that 400/25 Hz tone component is ON for 400 ms, OFF for 200 ms ON for 400 ms and OFF for 2 sec. This tone component (400/25 Hz) is stored in PCM samples in a tone bank. During the OFF period silence tone is sent. The PCM bit stream sent continuously produces the effect of silence and this tone is called silence tone. This silence tone is also stored in tone memory in one of its banks.

TONE ROM (Tone Memory): The tone of 25 Hz (320 samples) and 400 Hz (20 samples) are stored in a PROM, called tone ROM (6K X 8). This PROM is divided into 16 banks and each bank contain tone components. To select any one of the 16 tones to be switched to 16 channels, we store the address of Banks in BAM (Bank Address Memory). Each location of BAM corresponds to a channel.

A computer addresses this memory to give the series of samples stored in consecutive locations of the bank of memory. Since any voice sample is to be sampled at 8 KHz rate, all tone samples are read out from a bank of tone memory once in 125 µs and put on a channel to form a tone.

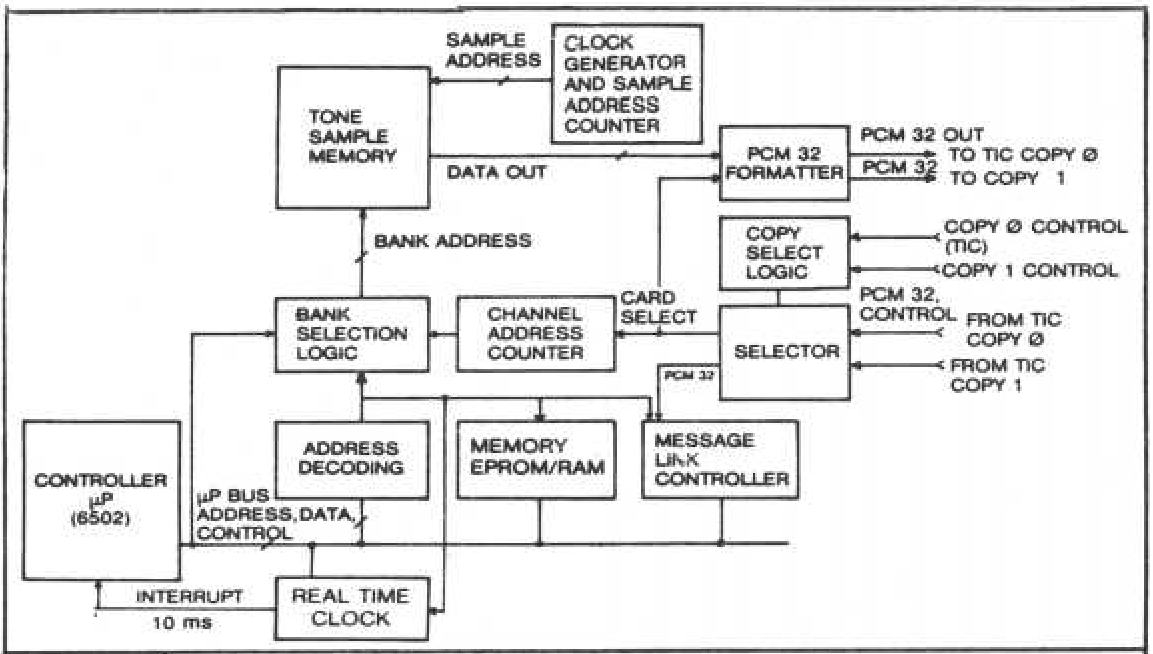

Fig. 5.1 TONE GENERATOR CARD

In fact the same tone memory can be read several times in the 125 μs period to give samples pertaining to the other channels as well. In TGD 16 samples are read from various banks of tone memory and put on 16 consecutive channels of PCM highway.

Each of these channels are the time slots on the PCM highway in a period of 125 μs. Since the PCM highway is (125/32) apprx. 4 μs duration. Each sample from tone memory is read once in 4 μs and converted into serial and transmitted at 2.048 MHz on PCM link during the next 4 μs.

5.2.4 BANK ADDRESS MEMORY (BAM): An eight location RAM called as BAM gives the address of the bank of tone memory in a particular channel. So which bank of memory has to be read out in which channel is automatically taken care of by writing that bank address in the corresponding location of BAM.

Once all the channels have given the address to the tone memory one after another in 125 μs period and thereby read out their corresponding sample on the PCM highway, the tone memory automatically gets updated (by 8 KHz clock) to next sample in each of the banks. In each bank there are 320 such samples after which there is a wrap around in the bank's samples.

5.2.5 CADENCE GENERATION: Any tone component can be sent on any channel by writing into the corresponding location of Bank address Memory, the particular tone component's address (Bank address). Each location in BAM thus corresponds to a channel and thus holds the tone component Bank address from where the samples have to be read out in the channel.

Now if periodically the tone components address in BAM can be changed to put different tone components on the channel thereby producing cadence on the channel. The processor in TGD card takes care of the changes in BAM location to ensure the cadences of the tones on all 16 channels.

5.2.6 CLOCK STRETCHING: The Bank Address Memory is generally read by the counter to produce the Bank address for a channel. This reading is continuous and therefore BAM is always being accessed by the counter. However the processor has to write occasionally (wherever there is need to change the cadence of a tone) different Bank address in different location of Bank Address Memory.

To ensure that with processor and counter access Bank Address Memory in different times, the processor clock is stretched and synchronized with the counter clock so that processor writes into Bank address Memory soon after the counter has read from BAM, when the need arises for the processor.

5.2.7 SANITY CHECK OF TONES: The tones produced by TGD are duplicated and sent to the controller (TIC/SN). TIC, in turn, switches them to the needy subscriber. However there has to be a provision for the TIC to test the sanity of tones. To ensure that, the tones and hence the TGD are sane enough, the TIC/SN switches back the tone output of TGD to itself. The diagnostics on TGD tests this tone input and informs the TIC/SN if the tones are in fact correct. If any tones are bad, the TGD asserts a signal towards TIC called TGERR. (Tone Generator Error).

5.2.8 THE DIAGNOSTICS: The incoming PCM stream can be made parallel. The processor extracts a particular channel from the Pulse code Modulation (PCM) stream and compares the sample on the channel with idle pattern. This comparison signal indicates if that channel has tone or silence at that particular time.

By monitoring this signal (Tone or silence signal) for a particular channel, the processor can have an estimate of the cadence of tone. By doing such checks regularly on several channels, the sanity of tones can be ascertained. Any irregularity can be reported to TIC/ SN through TGERR.

In fact the TIC / SN can test the functioning of diagnostics on Tone Generator Diagnostic by creating an error or switching wrong tone back into one of the slots of TGD. An assertion of TGERR for this test from TGD will ensure proper functioning of diagnostics logic itself.

There is a provision on the TGD card to collect samples of a particular channel and compare or calculate the check sum of the samples to ensure correct tones.

Objective:

1. In C-DoT 8 tones are generated.
2. Dial tone frequency is 400 Hz.
3. RBT frequency is 400/25 Hz.
4. In C-DoT 128P tones occupies 16 ports.

Subjective:

1. Write short note on tones in C-DoT RAX?

CHAPTER 6

MAINTENANCE PANEL/CONSOLE (MP)

6.1.0 Main Functions:

1. Subscriber Administration.
2. Trunk Administration.
3. Subscriber Metering.
4. System Monitor and Fault Directory.

This unit consists of 2 cards.

(a) Keyboard and Display card.

(b) Operator Console Controller (OPR) card.

This OPR card interface with the keyboard and display card for accepting key commands and displaying information with the RCP for signalling and switching.

All signalling information on the operator console unit is detected by appropriate key closures and sent to the RCP through RS 232C link.

6.2.0 Functional Blocks:

The OPR card interfaces with the keyboard and display card for accepting keyboard commands and displaying the related information. Commands are formatted into messages and communicated to the RCP through an asynchronous serial interface, messages from the same are displayed on the LCD or LED displays. The functional blocks constituting the OPR card are:

1. MPU (Microprocessor unit) Logic.
2. Asynchronous Communication Interface.
3. Keyboard Interface and Control.
4. Command LED Drivers and LCD display drivers.
5. Diagnostic LED Driver Interface.
6. Buzzer Driver.
7. Power Supply.

6.2.1. MPU Logic:

The clock input to the MPU of the console is 1.8432 MHz and it is generated in the card itself. The MPU logic consists of 8 bit Microprocessor with 8 K / 32 K bytes of program memory and 2 K bytes of RAM (depending upon the system requirement). Address decoders are provided to divide the processor address space of 64 K bytes into blocks of 8 K bytes each and to derive the select signals for memories, peripherals and LED Drivers.

6.2.2. Asynchronous Communication Interface (65C51)

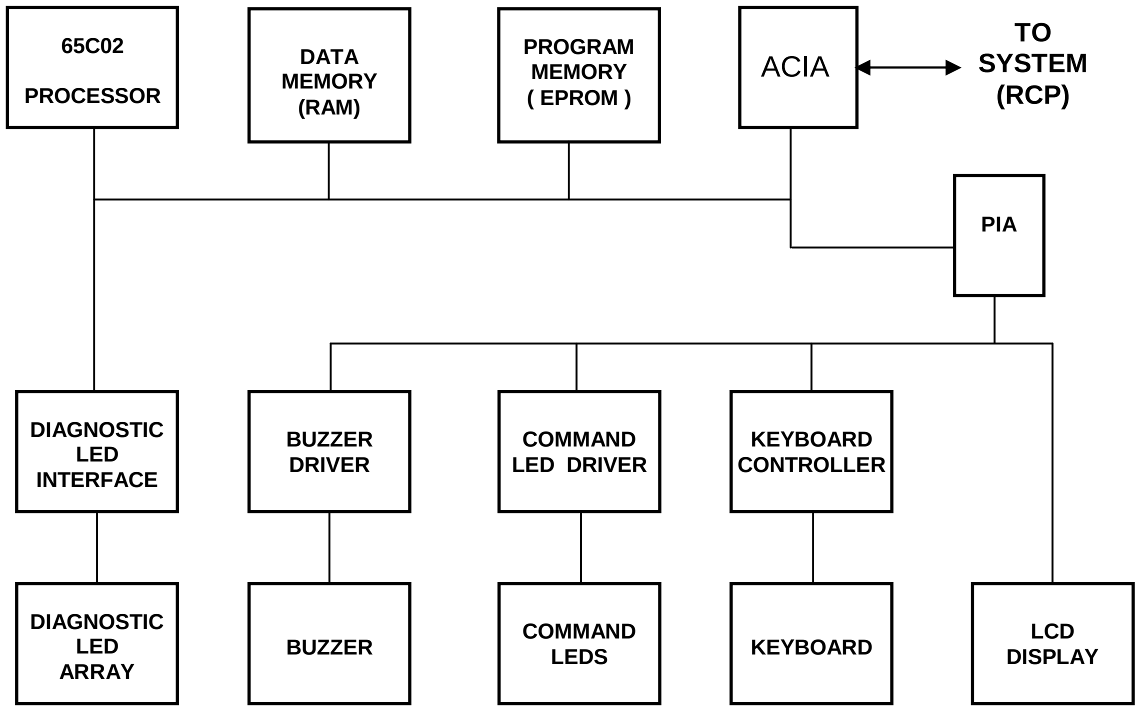

Fig. 6.1 MAINTENANCE PANEL BLOCK DIAGRAM

The console communicates with the RCP via a standard serial asynchronous RS-232C link. Messages that are generated by the MPU are formatted and transmitted by means of an asynchronous communication Interface Adapter (ACIA) which is programmed to operate at 1200 baud, 8 bit word length and 2 stop bits. The ACIA indicates the presence of data received from RCP through an interrupt line to the MPU. The MPU on recognising this signal receives the data and processes it.

6.2.3. Keyboard Interface and Control:

The keyboard has an array of 23 keys. Ten of which are for selecting the digits and rest are being command function keys. A dedicated keyboard interface controller scans the keyboard via scan lines S1-S8 and drivelines D1 - D5. When key closure is detected, it interacts with the MPU through a peripheral I/O Controller (PIAT). The keyboard interface has a data available (DA) line which goes low when a key is depressed. This line then initiates an interrupt signal to the MPU through the PIAT. The MPU obtains the code of the key pressed by the help of encoder, to take further action.

6.2.4. COMMAND LED DRIVERS -74LS374:

To indicate the acceptance of a command a LED is provided in every command key. Each LED has an associated latch and a driver which is controlled by the MPU through the PIAT which generates the necessary LED Device select signal.

6.2.5. LCD DISPLAY DRIVER - PCIM 200:

A display driver circuitry for 16 character DOT Matrix display is provided. The display interfaces through 8 data lines, 3 control signals.

6.2.6. DIAGNOSTIC LED DRIVER INTERFACE:

There are 24 cards and 3 states of the system. Active, passive and fail (condition of the card). Correspondingly 3 rows of 24 LEDs each (total 72 LEDs). Diagnostic related data received by the MPU is stored in the LED Drive RAM. A bi-directional buffer enables the CPU (Central Processing Unit) to access data in the RAM (Random Access Memory) by means of a diagnostic enable signal. When MPU does not access the RAM, the data is in the "READ" mode and the information is displayed on the diagnostic LED.

6.2.7. BUZZER DRIVER:

This provides audio feedback to draw the attention of the operator by giving an audio signal on the buzzer.

6.2.8. POWER SUPPLY:

The console obtain its supply from the system. A 3 pin voltage regulator provides the on board supply. In addition - 5V supply is also obtained for operating the RS 232-C interface.

6.2.9 INTERACTION BETWEEN DIFFERENT BLOCKS:

To initiate a command, a key has to be pressed. By means of an appropriate scanning logic, the keyboard interface and control logic senses this key closure and responds by setting the Data Available line low. The Data available signal sent by the keyboard interface and control logic is sensed by the PIAT which indicates this to the MPU by asserting the Interrupt Signal. The MPU (through the PIAT) accesses the keyboard controller by asserting the keyboard select signal. The firmware analyses this event and accesses the ACIA interface to transmit this information to the call handling processor. It also writes (through the PIAT) suitable information into the display.

On receiving a response from the system the ACIA interface interrupts the MPU by asserting the interrupt signal. The MPU reads the information from this device by asserting the appropriate device Select Signal. The firmware analyses this message and takes suitable action. This may include lighting up a particular LED by asserting the LED device select or writing suitable information into the display. It may also initiate a trigger pulse through the PIAT to active the buzzer. If a diagnostic massage is received, it writes this information into the LED RAM by asserting the appropriate Device select signal.

Subjective:

1) What are the functions of maintenance console?

2) Write the functional blocks of maintenance console

CHAPTER 7

SIGNAL PROCESSOR (S.P) CARD

7.1.0 Introduction:

Signal processor exchanges signalling information between Termination cards and Terminal interface controller. The SP card acts as an interface between the terminal cards and Terminal interface controller cum Switching Network (TIC / SN) card. This interface is primarily for supervisory, control and data signal.

7.1.1 Main functions:

The Signal processor card performs the following functions:

(a) Receiving supervisory signals such as on - hook/off - hook/hook switch flash and decadic (dial) pulses from termination and also for transient validation (noise rejection).

(b) Controlling ringing towards subscriber and providing automatic ring trip when the called subscriber goes off - hook.

(c) Controlling metering signals.

(d) Recognising incoming ring from incoming junction calls.

(e) Controlling outpulsing towards junction calls.

(f) Channel associated signalling on digital trunks.

In order to support all the functions given above, the card has four scan points (or buses) viz., A,B,C and D and four Drive points A,B,C and D.

On scan A, both level and pulse transmissions (including decadic pulses) from terminals can be detected. Other scan buses B, C and D have the capability to validate level signalling, only when the Bus A has completed an event. The detection time for signalling validation (on - hook, off - hook status) is software programmable. On Drive A, both level and pulse transmission (including decadic pulses) can be driven towards terminals. Drive B also supports level and pulse signalling. Drive C is used for diagnostics. Drive D is used to control test access for terminations. Diagnostic facilities are also provided in the card. Diagnostics can be achieved by looping back the drive signals to the scan side on any termination. The card also has built in self synchronization facility and it can synchronize itself with the duplicate copy of the signalling processor.

7.1.2 SP INTERFACE with Terminal cards and TIC/SN :

The signal processor card acts as an interface with the termination card (TCs) on one hand and both the copies of Terminal interface controller and Switching Network (TIC/ SN) card. For interfacing with termination cards, the SP card is capable of scanning and driving 128 terminations. The SP card interfaces with the TIC/SN card via a time multiplex bidirectional bus. The received signalling information from the terminations is given to the TIC through a standard 6502 bus interface. The TIC also programmes the SP drive functions through this interface.

The SP card is duplicated for fault tolerant system operation. Each copy (copy 0 and copy 1) is interfaced with the corresponding copy of the TIC i.e. copy " 0 " of SP to Copy " 0 " of TIC and copy " 1 " of SP to copy 1 of TIC.

7.1.3 SIGNAL GENARATION:

In order to achieve scan and drive signalling information for all 128 terminations in 2 ms, SP generates the following signals towards the terminal cards.

a. Subscriber card select (SCS) signal:

The signal processor generates 16 card select signals SCS 1 to SCS 16 for 16 Terminal cards (TC 1 to TC 16). SCS 1 goes to TC 1,SCS 2 goes to TC 2 and so on. The card select signals are generated by decoding four counter output bits. This is done by using 4 to 16 decoder in SP. Whenever SCS connected to a TC, is low (active), that particular TC is selected for a duration of 125 μs. (2 ms/16 = 125 μs).

b. Port or termination select signal (SA0, SA1, SA2):

Each line card caters for 8 subscribers. The SP supplies three bits-A0, A1 and A2 towards the TIC card. Through these signals eight terminal circuits of TC (Terminal Card) are selected one by one i.e. one subscriber out of eight subscribers is selected. Each terminal circuit is selected by SP for 15.6 micro sec. (125 μs /8=15.6 μs). These signals are decoded by a 3 to 8 decoder which is positioned in the line card.

c. SP DIR, (Signal Processor Direction):

This signal from SP to terminal cards control Drive/Scan logics (periods). Every terminal is processed for 15.6 μs. Out of 15.6 μs (time a port or terminal is selected by SP) first 3.6 μs are allotted by SP, for driving the events on terminal and during this period the signal processor direction goes high to drive signals from SP to Termination card (ring/test access/diagnostic to particular termination from signal processor). The last 12.0 μs (out of 15.6 μs) are allotted for scanning the events from the terminal. During this period of 12.0 μs SP DIR goes low to scan subscriber status and to report to Signal Processor.

To distinguish between scan and drive operation a S/D signal (scan/drive signal) is generated at the line card. Four data signals are used for signalling purposes. These signals are time multiplexed and bidirectional. They are called as:

SCAN A Drive A.

SCAN B Drive B.

SCAN C Drive C.

SCAN D Drive D.

Therefore each terminal circuit exchanges signalling information with SP on bi-directional ABCD lines. Depending on scan and Drive period, the ABCD lines change direction from Terminal Cards to SP for scan and SP to Terminal cards for Drive operation.

d. Direction clock (DCLK):

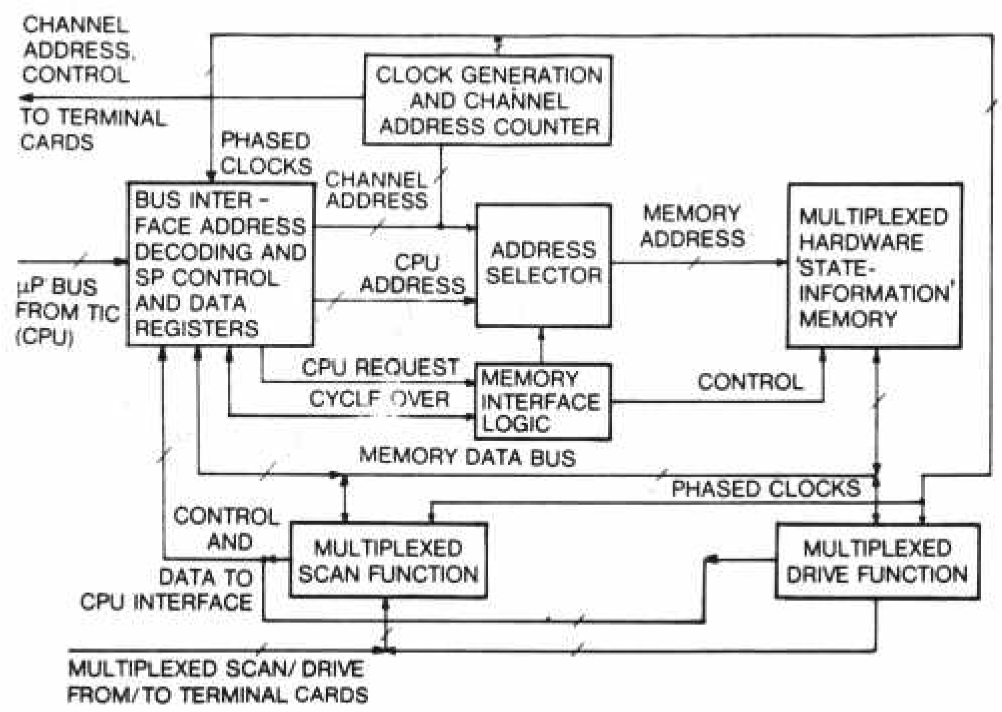

Fig. 7.1 DIRECTION CLOCK

This latches the drive information. It is active for 500 nano sec.

7.2.0 FUNCTIONAL BLOCKS:

The Signal processor card has the following functional blocks.

7.2.1 (1) CLOCK GENERATION AND CHANNEL ADDRESS COUNTER: Each signal processor receives its clock from the main clock corresponding to the copy of TIC. Copy ’0’ of SP receives its clock from copy 0 of TIC and similarly copy 1 - SP gets its clock from copy 1 - TIC.

If the clock circuitry in the SP fails then there is a need to select the duplicate copy of the clock supplied from duplicate copy of TIC. Self clock and Duplicate clock are given to 2 to 1 selector where selection of the clock is controlled by the control register. Fifth bit of the control register (CLK SEL) controls the select (S) input of 2 to 1 selector where this (fifth bit) being written by TIC. If duplicate copy is selected, the synchronization between the active and passive copy is done by synchronisation logic.

Signal processor keeps a track of the time elapsed from the start of a signalling event viz on hook, off - book, hook switch flash, decadic pulses etc. A periodic pulse of 16 ms of 2 ms width (high) is used for scan time count operations. In addition to this, a periodic clock of 32 ms. With 2 ms. Width (high) is used for drive operations.

Signal processor accesses the memory for processing and updating signalling information. In order to facilitate this, the memory address has to be generated. A 1.024 MHz clock forms the basis for SPs operation. This clock drives a synchronous counter chain and the outputs of this chain provide the memory address during SPs internal processing.

Each port in the line card circuit is allocated with 8 bytes within State Information Memory. 10 bits of address is required to address state information - where first 3 bits are used to select one out of 8 bit allotted to each channel (port) and remaining 7 bits are to select one out of 128 channels (port).

Each termination is scanned once in every 2 ms and the state of hardware for that channel (port) is saved in the memory. This information is restored to the hardware at the beginning of channels (port) in next time slot and operations continue. The memory is accessed by the CPU (TIC) to update the drive and timing information.

16 card select signals, each of 125 μs width (8 ports x 15. 6 μs per port = 125 μs) are generated by decoding four counter output bits. This is done by using 4 (binary bits 0000 to 1111) to 16 (decimal) decoders in signal processor.

Each line card caters for 8 subscribers. Signal processor supplies three counter bits – A0, A1, and A2 for selecting one out of eight subscribers. These signals are decoded by a 3 to 8 decoder which is positioned in the line card.

State information memory receives address from signal processor and TIC at different phases.

TIC's address is selected only during 16th phase.

7.2.2 Phase generation: Each port is scanned for a period of 15.6 μs which is divided into 16 phases each of approximately of 1 μs duration. Those 16 phases are generated for synchronous hardware operations. In each cycle of 1 μs, only 500 ns are used for validation. Out of 16 phases, first eight phases are used as Read phase from state information memory (for loading) into the various registers, counters, filp-flops, latches etc. for processing. During next seven phases i.e. phases 9 to 15 writing or updating of the processed signalling information into the SIM through buffer takes place. For example information read during the 9th phase is written back into SIM after processing during 0 phase through allocated buffer.

Sixteenth phase is exclusively used either for transferring the address and memory contents of the TIC to SP's SIM for write operations or for transferring the address and memory contents from SP's SIM to the TIC for read operations. In other words 16th phase is used for TIC/SN Reading/Writing operation. Both these read/write operations are done ' through SP 's programming interface.

To disable SP's internal processing, phase generation can be stopped by a control signal called SP - Reset.

7.2.3 SCAN FUNCTION:

The scan function includes the following:

- receiving on / off hook, hook switch flash signals.
- receiving various signalling conditions on E & M trunk e.g. seizure.
- receiving decadic dial pulses and framing these into 4 - bit BCD code.

Signal processor scans all 128 terminal circuits in 2 ms. Thus it allots 15.6 μs (2/128) to each terminal circuit. Whenever a terminal circuit reports any new signalling event on ABCD bus, Signal processor validates the timing for that event. A signal transition is valid only if the last three successive samples pertaining to a particular channel (termination) are of the same level and are different from the stable state which is signified by the previous valid level. Timings for different events are programmable. After validating the signalling event, if the new event meets the timing requirement, signal processor stores the event for that terminal circuit with terminal circuit number in its register. At the same time, signal processor gives interrupt to the TIC card. Terminal interface controller on getting signal processor interrupt, reads signal processor register through the data bus provided between Terminal interface controller and signal processor and knows the event reported by the particular terminal.

7.2.4 DRIVE FUNCTION:

Encoded information towards the Terminal interfaces is used to control functions like ringing on subscriber lines and outpulsing on trunks.

Whenever Terminal interface controller has to drive any event on a particular terminal, Terminal interface controller writes the drive information in signal processor register along with terminal circuit number. Signal processor decodes this information and places the corresponding drive ABCD value on ABCD bus towards the terminal circuit in the timeslot allotted for that particular terminal circuit.

7.2.5 STATE INFORMATION MEMORY (SIM):

Each channel (port) is processed for 15.6 μs in every 2 ms. Therefore to store the status of each channel, a set of registers is required. This is organised as an 8 byte memory for each channel (termination or port). The 128 terminations therefore require 1024 bytes of memory. This memory (SIM) is accessed both by signal processor and TIC at different phases and can be addressed externally and internally. The signal processor access the state information memory internally for processing and updating signalling information. The Terminal interface controller accesses the SIM externally via the micro processor interface for memory initialisation.

The State information memory holds the status of each port (subscriber) in a particular memory location. Each port is allocated with 8 bytes within state information memory. Therefore 128 terminations (subscribers) are allocated with 1024 bytes (128 x 8 bytes or 1024 x 8 = 8192 bits) of memory.

The memory is accessed by a ten bit address. First three bits are used to select one out of 8 bytes allocated to each channel (port) and remaining 7 bits to select one out of 128 channels (port).

Out of 8 bytes allocated for each channel, first 3 bytes are allocated for drive and remaining 5 bytes for scan. Drive bytes are written by the Terminal interface controller during the 16tb phase by using Data Write Register.

Each termination is scanned once in every 2 ms and processed for 15.6 μs. In other words each byte is accessed for about 2 μs (15.6 μs /8) i.e 1 μs for Read and 1 μs for write. Out of 1 μs Only 500 ns are used for validation. The state of hardware for the processed termination (for 15.6 μs) is saved in the memory. This information is restored to the hardware at the beginning of channels (terminal or port) in next time slot and operations continue.

The memory (SIM) is accessed by the CPU (TIC) to update the drive and timing information. Memory access is controlled by 16 phases as discussed in the Phase Generation.

7.2.6 PROGRAMMING INTERFACE:

Memory address and memory data buses are available on various registers in order to enable the Terminal interface controller access signal processor's SIM for initialisation and for controlling drive or loop back operations on bidirectional buses A,B,C and D. This helps in the transfer of data to and from state information memory (SIM) during the 16th phase.

This interface contains address decoding for CPU (TIC) access to signal processor's control, status and data registers. Terminal interface controller reads from and writes into state information memory (SIM) by using registers.

There are totally 9 registers for accessing the memory. These registers are addressed by using A0, A1 and A2 address signal (three address bits) with qualified, processor control signals. Out of these 9 registers 4 are write only and 5 are Read only registers. These registers are 8 bit wide.

(a) Memory Write Registers (4 nos.): There are four types of write registers**.**

1) **Address Register (AR) - Port Selection:** This register selects one out of 128 channels during TIC interfaces with SP. From this, TIC reads the memory data and also writes the memory data in it.

2) **Memory Control Register (MCR):** (Byte selection and Read and write control) This register is used for addressing (selecting) one of the 8 memory locations i.e. selects one byte since each channel (subscriber) is allocated 8 bits within SIM. Three bits from the byte address.

   The fourth bit in (MCR) memory control register called (R / W) Read / Write bit is used to control read and write operations of state information memory. When this bit is set (1) Memory is in Read mode, where as the same bit is reset, the memory is in write mode. The memory can be read from the data bus or written into the data bus of microprocessor during 16th phase.

3) **Control Register (CR):** This register is used to control the reporting through interrupts, of events like parity error and completion of scan / drive operations to the terminal interface controller.

Through this register, the terminal interface controller (CPU) can selectively enable interrupts to , initialise signal processor etc. The different interrupts are:

i) SDIE: Interrupt due to scan and drive.
ii) RWI E: Interrupt due to read or write memory.
iii) PIE : Interrupt due to parity error

4) Data Write Register(DWR): Data in the form of bits is written by the microprocessor. What is to be written into the particular memory location during the 16'h phase, is first written into this register by addressing this register. This memory is addressed by memory control Register and address Register.

(b) **Memory Read Register:** There are 5 types of Read Registers

(i) **Data Read Register (DRR):** Data from the internal memory is made available on the micro processor bus using Data Read Register during the 16th phase by addressing Data read register. Memory control Register and Address Register provide the address of memory location from where data is read into Data Read Register.

(ii) Scanner Termination Number Register (STNR): This register gives the data (bits) loaded from the counter output after completion of scan signalling event of a particular channel (port or subs). The data represents the address of the channel on which scan signalling event is completed. By addressing this register the data is available on microprocessor bus.

(iii) Drive Termination Number Register (DTNR): This register gives the data (bits) loaded from counter output after completion of Drive signalling event of a particular channel. The data represents the address of the channel on which Drive signalling event is completed. By addressing this register, the data is available on micro - processor bus.

(iv) Status Register (SR): This register reflects the occurrence of events within signal processor.

(v) Scan Data Register (SDR): The scan data is made available on this register. This register contains the four bus conditions A, B, C and D and digit collected on the termination, which completed a signalling event. The data represent the stable state attained by the A, B, C, D. buses required for call processing.

Subjective:

1. What are the functions of SP card?
2. SCS means subscriber card signal?

CHAPTER 8

LINE CIRCUIT CARD (LCC)

8.1.0 Introduction:

Line circuit card is one of the termination cards and It is the first link in the chain of cards comprising the exchange.

Line circuit card (LCC) is the direct interface between the exchange and subscriber. Each card has 8 identical circuits on which it receives 8 pairs of subscriber telephone wires. Each of these circuits does the following function.

8.1.1. MAIN FUNCTIONS:

1. DC feed to subscriber for signalling and energising handset microphone.
2. Detects the status of the corresponding subscriber telephone handset i.e. on – hook or off – hook.
3. Enables the voice of the subscriber to reach a point within the exchange for onward transmission to the called party or vice-versa.
4. Through control logic, subscriber line card (SLC) performs a diagnostic check on the basic health of the card.
5. It has provision to operate from any of the two sets of the input signals i.e. copy - 0 or copy - 1(copy selection).
6. The subscriber line card communicates with the Terminal Interface Controller & Switching Network (TIC / SN) for voice switching.
7. The subscriber line card communicates with signal processor card (SPC) for signalling data.
8. Operates Test Access Rely for a particular subscriber line

The basic function of Line Circuit Card is collectively termed as BORSCHT an acronym for-

B	-	Battery Feed.
O	-	Over Voltage Protection.
R	-	Ringing.
S	-	Supervision.
C	-	Coding & Decoding
H	-	Hybrid Conversion (2 / 4 wire conversion)
T	-	Testing.

Battery Feed: -48v battery With current limiting circuit is supplied to subscriber loops for signalling and energising the Microphone of the handset. Maximum current is limited to 35 ma by current limiting circuit to prevent excessive current on short loops.

Over Voltage Protection: A Hybrid transformer in the line circuit with back to back Zener diodes suppress the voltage transferred to the secondary even though surge arrestors across the lines (GD Tube) provide protection against surge voltage. It (over voltage) may be carried through the subscriber line to the exchange before the GD (Gas Discharge) tube in the MDF(Main Distribution Frame) is activated i.e. during the response time of the GD Tube.

Ringing: Ringing is extended to subscriber circuit under the control of TIC & SP. Each subscriber line circuit has independent ringer relay.

Supervision: Three opto-couplers are used to sense the line status and detect the signalling events, such as on/off hook detection, dialling, ring trip, seizure, digits reception, clear forward etc.

Coding: To provide for speech path, Analog / Digital (A/D) and Digital/Analog (D/A) conversion is done by CODEC (Coder and Decoder) in the line circuit card. Coding refers to encoding of analog voice to digital form (8 bit, A - law PCM) through a coder/decoder. Outputs of 32 codecs of each TG, are time multiplexed to form a 32 channel PCM link of 2.048 Mbps. For every line circuit, separate Codec is used. This reduces the phenomenon of cross talk.

Hybrid Conversion (2/4 Wire Conversion): The transformer Hybrid circuit does 2 to 4 wire conversion to give two unidirectional speech paths.

(i) Towards exchange before coding for A/D conversion.

(ii) Towards subscriber after decoding for D / A conversion.

Testing: In order to perform various routine and other tests, metallic access to lines is provided through Test Access Relay in each and every line circuit.

There are essentially two types of information flowing over the analog lines (1) Voice Information, and (2) Signalling information. The analog circuitry has to cater for both.

The line circuit card interfaces with TIC card for voice information and with SP card for signalling information.

8.2.0 TERMINAL INTERFACE CONTROLLER:

In order to get voice data from each line, various signals are generated by TIC towards the line card. Those are as given below:

(i) T C S (Terminal/Subscriber Card Select): To select one line card (termination card from a group of four cards (TG) on a TDM (Time Division Multiplex) link, TCS signals are used. Totally there are 4 TCS signals. This signal of 8 KHz frequency selects a particular card for about 32 micro seconds. (selects a TG for 125 micro seconds.)

(ii) TA0, TA1, TA 2 (Subscriber /Port/Terminal Select Signal): (TIC) Terminal interface controller generates these three signals TA0, TA1, and TA2 for selecting a particular port (subscriber) in the selected card (4 micro seconds per port out of 32 micro seconds per card).

(iii) P CLK (PCM CLOCK): PCM clock of 2.048 MHz from Terminal Interface Controller enables interface of the line card to generate a 32 channel PCM link.

(iv) SYNC: TIC interface generates a Sync. signal of 8 KHz required by the codec for voice data sampling. Sync signal indicates the starting of time slot "0", for 32 time slot PCM serial link.

8.2.1 SIGNAL PROCESSOR:

Signalling information like on - hook, off hook, Ring Trip is detected by the signal processor when there is a change in the subscriber line status.

Signal processor generates the following control signals towards the line card (terminal card)

(i)SUBSCRIBER/TERMINAL CARD SELECT (SCS): This signal selects a particular line card (terminal card) at the particular time slot. Signal processor processes 128 ports once in every 2 milli seconds Since one card contains 8 subscribers, signal processor generates 16 SCS signals - one for each termination card which is selected for 125 micro seconds (2 m sec/16). SCS 1 goes to TC1, SCS2 to TC 2 and so on.

(ii) SA0, SA1, SA2 (SUBSCRIBER/PORT/TERMINAL SELECT SIGNAL): These three signals are used to select the particular subscriber (port) within the selected card which is selected for 125 micro sec. So each subscriber gets selected for 15.6 micro sec (125/8).

(iii) (SPDIR) SIGNAL PROCESSOR DIRECTION: This signal from signal processor to terminal cards controls Drive / scan logics (periods).Every terminal is processed by signal processor for 15.6 micro seconds. Out of this period during first 3.6 microseconds,SPDIR goes high to drive signal from SP to Terminal Card (Ring/Test Access/Diagnostics to particular termination from SP). During the remaining 12.0 micro sec., SPDIR goes low to scan subscriber status and to report to signal processor.

Further four data signals are used for signalling purposes. These signals are time multiplexed and bidirectional. They are called as:

SCAN A	DRIVE A
SCAN B	DRIVE B
SCAN C	DRIVE C
SCAN D	DRIVE D

Scan signals carry information about terminations (ports) during scan operation from line card (Termination card) to signal processor.

Drive signal carry the information to drive ringing/test access relay control circuits and come from signal processor to (LCC) Termination card.

(IV) (D CLK) Direction clock: This latches the drive information. It is active for 500 nano seconds.

8.3.0 FUNCTIONAL BLOCKS:

There are 8 identical subscriber line circuits in the line circuit card. The functional block diagram is shown in the fig 8.1.

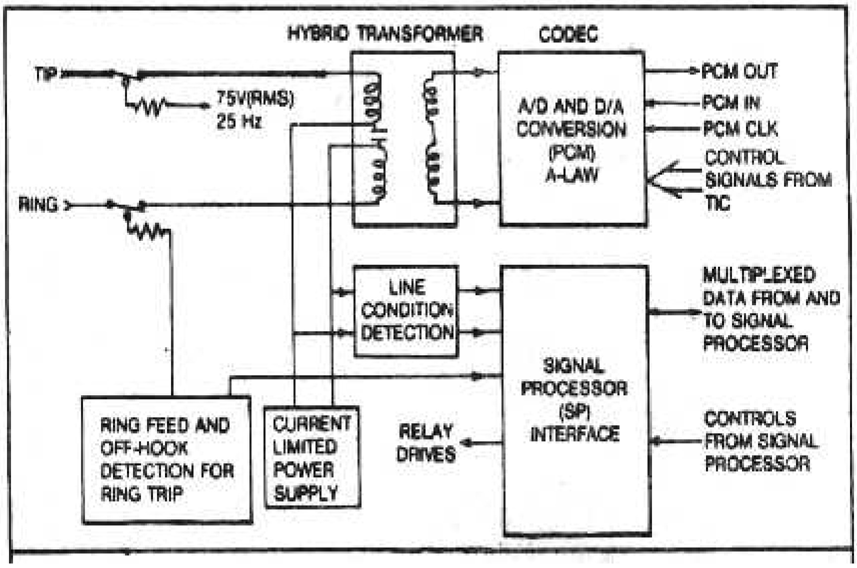

Fig 8.1 Functional block diagram of Subcriber Line circuit card

8.3.1 VOICE PATH:

(a) FROM SUBSCRIBER TO EXCHANGE: Tip and Ring wires coming from the subscriber are connected through the capacitor to the primary of the Hybrid transformer. Here D.C. is blocked and only A.C voice signal is available on the secondary of the Hybrid transformer.

The secondary is connected to 2 to 4 wire converter circuit which uses operational amplifiers to convert bidirectional speech signal into two uni-directional speech signals. The speech signal is then fed to codec which encodes it in 8 bit PCM. The output of 8 different Codecs for 8 different line circuits are given into 8 consecutive time slots and are so as to give a single 8 time slot PCM voice output of the line card. The outputs of 4 lines cards of a Terminal Group (TG) are combined to give 32 time slot PCM voice output at 2 Mbps towards Terminal interface controller.

(b) FROM EXCHANGE TO SUBSCRIBER: The 32 channel (time slot) 2 Mbps PCM voice input coming from TIC to a terminal group is distributed among 4 line cards of the terminal group. Thus each line card will convert digital voice samples for 8 time slots in analog form and give analog voice to the respective subscribers.

The incoming PCM voice (Digital Voice) is given to all the 8 Codecs of the line card but each Codec convert it into analog form in different time slots. The analog voice signal goes to 2 to 4 wire converter to convert the signal from uni-directional to bi-directional. Then the signal is given to secondary of the Hybrid transformer. At the primary of the Hybrid transformer, the voice signal is super-imposed on D.C. level, present on the line and is given to the, subscriber via Tip and Ring wires.

8.3.2 SIGNALLING:

(a) D.C. FEED: Line circuit card (LCC) uses method of D.C. loop signalling. Carbon microphone requires D.C. The -48 V battery is fed across the Tip and Ring through current limiting circuit (CLC) on both the limbs so that the current does not exceed 35 ma even if Tip and Ring are short circuited.

(b) LINE STATUS SENSING: It is done by the LCDC (Line Condition Detection Circuit) which monitors the presence or absence of D.C. (Direct Current) in both the limbs. Line condition detection consists of opto couplers or current sensors which detect 10 - 35 ma as PRESENCE of current and less then 10 ma as ABSENCE of current.

(i) ON - HOOK: During this condition there is only A. C. path as D C path is blocked by capacitor in the subscriber instrument. In other words, it offers a high resistance and no D.C flows across the Tip and Ring. That means there is no appreciable current in the loop so current less then 10 ma is not sensed by the opto couplers (current sensor) and is interpreted as on - hook.

The status of the SCAN - A and SCAN - B for on - hook is

SCAN - A	HIGH
SCAN - B	HIGH

(ii) OFF - HOOK: When subscriber lifts the hand - set (goes off - book),it is signalled by completion of the D.C. loop. Low resistance is offered and D.C. flows across Tip and Ring. So the flow of D.C. of 10 - 35 m a, sensed by the opto - couplers on both the limbs, is interpreted as off - book state.

The status of the Scan A and Scan B line for off - hook is

SCAN - A	Low
SCAN - B	High

8.3.3 RING FEED:

The ring is Fed to a particular subscriber through ringer relay which is operated under control of TIC and SP. Drive B from signal processor drives ring feed relay driver circuit for that particular subscriber. The input of the ringer relay is connected to the ringer bus which carries a 75 V/25 Hz ring signal.

When signal processor selects the line circuit and gives Drive command to feed ring in A, B, C, D form during the drive period, the line circuit closes the ringer relay. This connects Tip and Ring to ringer bus and isolates Tip and Ring from Hybrid Transformer.

Each subscriber line circuit has got independent ringer relay.

8.3.4 RING - TRIP:

In the On - hook state of the subscriber, only AC can flow in the line as. D.C. is blocked by the capacitor in the subscriber instrument.

When subscriber lifts the handset (OFF - HOOK) during ringing the (LCC) line circuit card trips the ring by using signal processor drive information.

During Ring Trip, status of scan- A and scan - B is:

SCAN - A HIGH.
SCAN - B LOW.

On receipt of scan A (high) and scan B (Low),signal processor releases ring feed relay for tripping the ringing current. This OFF HOOK state is detected by LCDC (Line Condition Detection Circuit) 'which removes, ringer bus from Tip and Ring and connects them to Hybrid Transformer.

The capacitor being removed, low resistance is offered allowing D.C. to flow in subscribers instrument.

8.3.5 TEST ACCESS:

For conducting the lines side and exchange side tests, subscriber line is isolated through TA (Test Access) relay. Drive D is used to control the operation of the TA relay. Whenever a line circuit receives a Drive D command in A, B, C, D form from SP, it (line circuit) operates its TA relay. On operating, the TA relay separates out the line and exchange LCC (Line Circuit Card) sides and connects the Tip and Ring terminal of LCC to two points TLC and RLC (Tip and Ring of Line Circuit) in the (LCT) Line Card Tester. Now all line and exchange side tests can be performed. The Line card Tester tests the LCC functions and checks the health of the subscriber lines. There is a separate TA relay in each line circuit but only one line circuit at a time can be tested.

8.3.6 DIAGNOSTICS:

It is desirable to monitor at least some of the essential signals coming on to LCC. So the controller cards which provide service in the system keep on routine their on board logics and informing RCP periodically about their health so that RCP knows whether some card is functional or not. For this a diagnostic circuit is therefore included in the LCC to check for SCS,SA0, SA1, SA2, SP DIR and D CLK signals required for signalling and 2.048 MHz PCM clock (2 MHz) required for synchronization.

A bidirectional multiplexed line, line C (Drive C and scan C) is used for diagnostics. The state of the C bits at any time contains information about the two copies of 2.048 MHz PCM clock, the copy of the TIC / SN card that the LCC has selected, whether or not a PCM loop back is in progress and the general health of the Line circuit card.

8.3.7 COPY SELECTION:

To ensure continued operation of the system in the event of faults in cards other than Line circuit card, all signals to the Line circuit card come from two TIC/SN and two SP cards working in parallel. If either of these two develops a fault, it informs the (LCC) Line circuit card of its fault through its Hardware Error (HE), Active and passive (A/P) and WD (Watch Dog) outputs. The LCC selects the other copy of inputs through its 2 to 1 selector and continues to operate on these (inputs). A copy is selected only if HE, A/P and WD signals are all high for that copy.

Actually all cards except termination cards (Line cards, Trunk cards etc) are duplicated and are termed as copy " 0 " (passive copy) and copy 1 (Active Copy). Both copies will be sending copy selection signals to termination cards but only active copy will be able to select the termination card. Any time active copy fails, passive copy immediately becomes active and selects the termination cards. Thus the service will not be disturbed.

8.3.8 PROTECTION:

In addition to protectors on MDF on - board protection is provided to circuits on the primary and secondary of Hybrid transformer. Battery feed and current limiting circuits are protected using diodes. Moreover the inductance of Hybrid Transformer greatly reduces the voltage surges. Back to back zener diodes are connected across the secondary of the Hybrid Transformer. They do not allow the voltage rise above 5 V and protect the circuits.

The above mentioned protections are provided on all 8 line circuits of the line card.

8.3.9 POWER REQUIREMENTS:

The LCC gets several power inputs from the back plane (generally known as mother board) through connector. These are supplied by the PSU 0/1 card. These are:

+ 12 V, for relay operation,

- 48 V, for Battery feed circuits.

75 V rms, for ringer signal.

- 5 V, for Codecs and Op-Amps.

+ 5 V, for digital logic circuits, codecs and Op-Amps.

The (LCC)Line circuit card receives + 12 v and - 48 v supplies from PSU 1 card of the unit through back plane connector. +5v and - 5v are generated by using 3 terminal voltage regulators from input voltage of + 12 V and - 9 V respectively.

Objective:

1. Subscriber line is connected to <u>LCC</u>.
2. Codec is present in <u>LCC.</u>
3. Hybrid is present in <u>LCC</u>.
4. TCS selects <u>TG.</u>

Subjective:

1. What is the function of LCC?
2. Draw the functional block of LCC?
3. Write the interfacing of LCC with TIC?
4. Write the interfacing of LCC with SP.

CHAPTER 9

INTERCONNECTION BETWEEN EXCHANGES

9.1 Introduction:

Electronic Exchanges being procured from various vendors having different technologies. Normally, different interfacing circuits would be needed to interconnect different exchanges with different signalling systems. eg. loop - no loop, E & M, DTMF, R2MFC, etc. With facilities available in Electronic Exchanges, they can be integrated with other Strowger as well as Electronic Exchanges.

Let us first consider the case of C - DOT 128 P RAX. This exchange is ideal to replace the small intercom exchanges, which remain unmanned and do not require many facilities. These have only two types of trunk connections - 2Wire signalling (loop, no loop) and 4Wire (E & M) signalling.

9.2.0 TWT(Two wire trunk) Card : The block diagram of the TWT card is as shown in fig 9.1

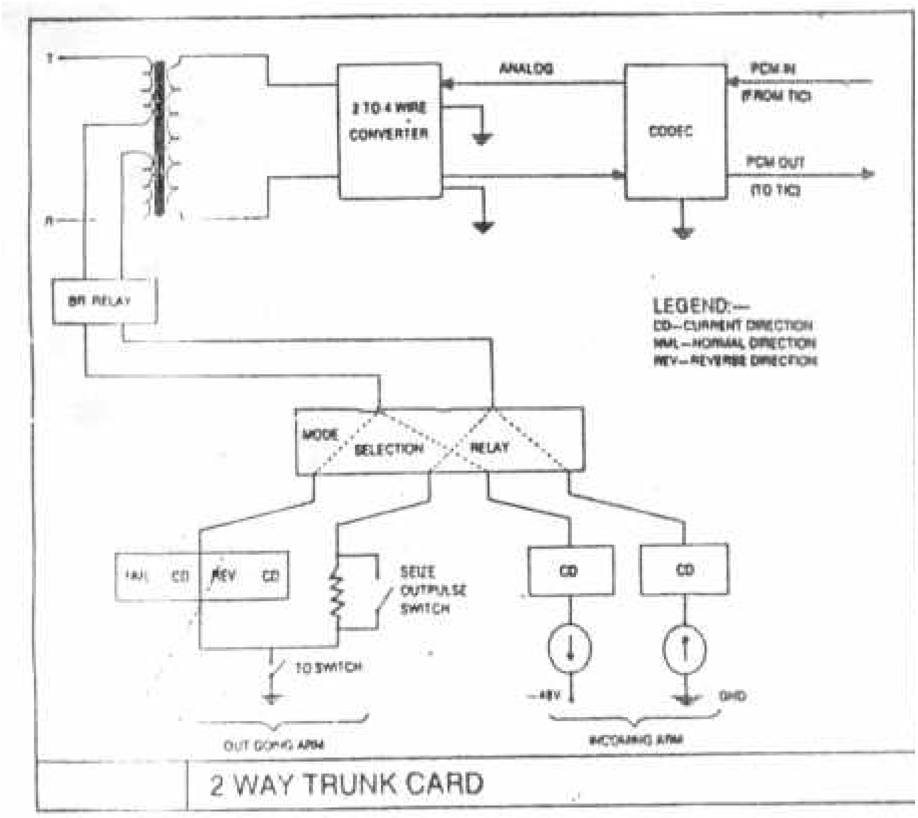

Fig.9.1.The block diagram of Two way trunk card.

Functions:

- TWT is used to establish connections between two Exchanges.
- TWT Card caters 8 channels
- Each channel is dynamically configurable as either Incoming or Out going or Both ways through software
- Configuration of pins is similar to line card
- TWT interfaces with SP for signalling and TIC for voice switching.

- Two way Trunk means:
  1) It can receive a call when the other exchange seizes the loop to initiate the call – Incoming mode
  2) It can seize the loop to initiate the call – Out going mode
- Both short and long loops can be handled

9.2.1 Functional Blocks :

- 2 to 4 wire conversion
- Coding and Decoding
- TIC interface for voice switching
- Scan and drive interface – Signalling to SP
- Copy selection and diagnostics
- Protection
- Power supply

9.3.0 Working Mode : It is selected by a changeover relay known as Mode change over relay. When this relay is activated the trunk circuit goes into Outgoing mode. Normally it is kept on Incoming mode.

9.3.1 Incoming Mode : Battery is fed through current limiting circuit in each limb.

- It accepts dialled pulses.
- The battery reversal takes place as called party answers.
- Supervision is done by sensing the trunk status like Idle/Seized.

Battery is fed through current limiting circuits in each line. Two Opto current sensors are provided on the DC loop path, one each on ring and tip limbs to monitor the status of the trunk.

9.3.2 Outgoing Mode: It extends loop to seize the incoming selector juncture of the distant exchange. Sends decadic pulses over junction.

In outgoing mode, there are 2 drive points for trunk. The first drive point is meant for offering loop and outgoing pulsing. When the trunk is set to outgoing mode a 30KΩ resistance is introduced in series with the loop. This resistance is by passed by means of a switch, so that full loop current stays flowing, normal current sensor is activated and the loop is seized.

The 2W trunk (TWT) card interconnects C - DOT exchanges with 2 way trunk, working on loop basis and so can directly be connected to a Strowger Exchange or to OKI exchange etc. There are 8 circuits per card, each one of which can be programmed as either incoming, outgoing or both way circuit. Thus the C - DOT 128P RAX can be connected to 4 lines of one Exchange and 4 lines of another exchange by using one TWT card. I/C (incoming) trunk reverses polarity to acknowledge seizure of the trunk.

9.4.0 E and M Trunk circuit card: The block diagram of E&M trunk card is as shown below

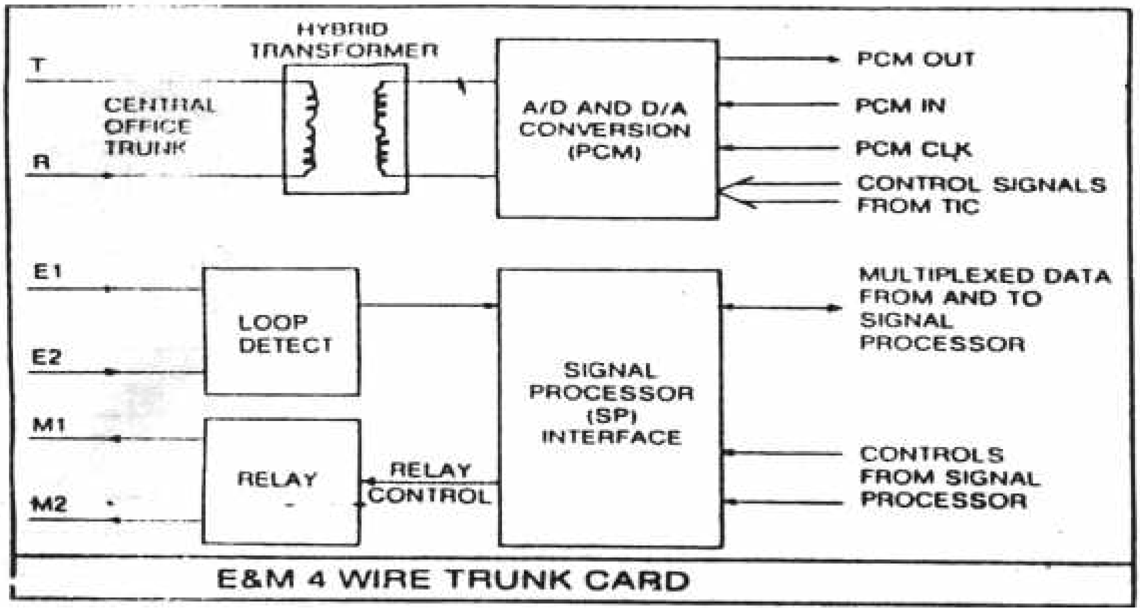

Fig.9.2. Block diagram of E&M 4 wire trunk card.

9.4.1 INTRODUCTION:

The 4Wire (E & M) trunk card is used to interface the RAX to another Exchange through carrier equipment. It can be connected to OKI exchange via ODBWTDE card and ARIA exchange via EMIB card.

- E&M four wire trunk card is an extension interface between the switching system and the E&M trunk lines leading to another exchange.
- It carries the signals of the trunk condition through two different leads called “E&M” (Ear and Mouth)
- “E Lead” carries signals to the switching system.
- “M Lead” sends signals from the switching system to the other exchange.
- The two leads are connected to the trunk lines through a carrier equipment (or trunk signalling equipment) which decodes the DC signalling conditions into out band signalling with a specified (3825Hz) tone.
- The carrier equipments transmit the voice and signalling conditions through a single line.
- One EMF card occupies eight ports of the switching system as it caters for eight E&M 4 wire trunks.

9.4.2 Functions of E&M Trunk Circuit card :

- It receives/sends analog voice and signalling information from trunk side.
- It also receives/sends the digital information (voice) and signalling information’s from the digital switch.
- It gets the required timing and control signals from the TIC and SP.
- The incoming analog voice signal after proper termination is subjected to A/D conversion to give the voice in the form of PCM samples.

- In the same way, the PCM samples after switching are reconstructed into analog voice signal and put on the outgoing lines.
- The digital voice PCM samples of all the 8 lines are multiplexed into a single PCM stream and sent for switching.
- In the same way the switched PCM stream is demultiplexed into individual ports. This is carried out with the help of control and timing signals received from TIC.
- The incoming DC signalling condition (battery or ground) on E wire is sensed and given as a digital level (high or low)
- The outgoing digital level is converted into DC signalling condition (open or ground) to send on M wire.
- The E wire signalling digital data of all 8 lines are multiplexed into a single line data to send to SPC.
- In the same way, the single line signalling data is demultiplexed into individual M wire of the trunk lines. This is carried out with the help of control signals received from SPC.
- In addition to the above basic functions, extra facilities like duplication, diagnostics test access and regulation of power supply are also carried out.

Objective:

1. One 4wire E&M circuit requires 6 pairs.
2. The frequency used for signaling is 3.825 KHz.

Subjective:

1. What is the function of E&M TRK card?

CHAPTER 10

CDOT-128 P PBX

PBX stands for Private Branch Exchange.

This is a telephone exchange as would be used within an office to connect a number of internal users to a (usually) smaller number of outside lines on the public network. They can range in size from very small (two outside lines and maybe eight extensions of PBX) to very large (hundreds of outside lines and thousands of PBX extensions).

The public network lines for a PBX may be local/STD/ISD lines from any PSTN. The extensions may be served by a conventional analogue telephone network.

10.1.1. FUNCTIONAL BLOCKS:

1) TG(Terminal group): C-DOT 128 P PBX has three types of voice terminal interfaces. The interface with extensions also referred to as subscriber line interface, the interface with the central office trunks (CO) also referred as junction line interface and tie line interface used to connect other PBXs. Each terminal card caters to 8 terminations, and has one CODEC per termination. Four cards together put out digital PCM voice onto a 32 channel time multiplexed link. This link terminates onto both copies of the switching network (SN) and represents a **Terminal Group.** The TG consists extension line circuit/tie line circuit/DTMF dialing circuit/Conferencing circuit.

The terminal card performs a set of functions collectively termed as BORSCHT.

2) SP card: The Signal Processor Card performs the function of,

- ♦ Receiving supervisory (on-hook/off-hook/hook switch flash) signals and decadic dial pulses on extension DC loops.
- ♦ Controlling ringing towards extensions and providing automatic ring-trip when extension goes off-hook.
- ♦ Recognizing incoming ring on ring-down Central office trunks (junctions).
- ♦ Controlling out pulsing on outgoing calls.

SP card interfaces with terminal cards and TIC just similar to the SP card in C-DOT 128P RAX.

3) TIC/SN : TIC/SN contains the central control and switching network of the exchange. It is the main processor and the complete exchange data is stored in this card. Switching controls for speech paths are generated here and distributed to terminal cards. A non blocking time switch with stored program control is used to achieve switching.

The TIC/SN performs the function of

- ♦ Voice switching
- ♦ Call processing
- ♦ Administration
- ♦ Maintenance

This TIC/SN card is not similar to the TIC/SN card used in C-DOT 128p RAX. The new versions of PBX refers this TIC/SN card as XSC card (Expandable Switching Control). This card performs the function of both RCP and TIC/SN of C-DOT 128P RAX.

4) PSU card: This is just similar to the PSU card used in C-DOT 128P RAX. This produces different voltages like –48V, +5V, +12V, -9V and 75V AC required for the working of the exchange.

5) Operator/Maintenance Console: The Operator Console performs all the Operator features like call hold, call transfer, call intercept and call release. It communicates with the TIC via a serial data transport RS232C interface for all administration and maintenance functions. The speech path for Operator is provided via the extension line circuit card just like any other extension. Generally the first and the last line ports are reserved for the Operators.

This Operator console is provided with a handset used for voice communication between Operator and system users. No DC signaling is done over this line. All digits and off/on hook signals are simulated via command keys from the key board. The Operator console handset terminates like any extension on the terminal card.

10.1.2 Feature Cards :

1) Conference card: The conference card supports two simultaneous '4' party conferences. It interfaces with the switching network through 8 time slots (ports) on one of the 4 terminal groups (32 channel). This card receives controls signals from the TIC. It can also perform single 6 party conference.

2) RMF (Receive Multi Frequency) card: This card occupies 8 ports and provide DTMF dialing facility to 8 extensions simultaneously. But practically all the extensions may be given tone dialing facility. By providing this card C-DOT 128P PBX offers mixed dialing facility (both pulse and tone) to the extensions. But this facility should be programmed in the Class of Service feature of the extensions.

3) Data card: This is termed as DTA (Data Transmission Adapter) card. DTA card acts as an interface between external data terminals and the terminal interface controller. Any terminal group can be selected from the available 4 terminal groups for the provision of data switching by means of jumpering on the DTA card.

10.2 Exchange Working in Brief:

All terminations (extensions, central office trunks and data lines etc) are interfaced to the Switching Network through terminal interfaces called Terminal cards. It is here that the analog to digital conversion and formation of 64 kbps PCM channels for voice are achieved. A time division multiplexing (TDM) is performed over 32 such (64 kbps) channels to generate a PCM 32 line with a bit rate of 2.048 million bits per second. Four such PCM 32 links representing all the 128 terminations, are connected to the switching network (SN) of the system.

The switching network (SN) consists of a secondary multiplexing of the PCM 32 links (to form a 128 channel link at 8 Mbps), a non-blocking Time slot Interchanger and the demultiplexing of the resultant PCM 128 channel link to (four PCM 32 links which carry switched information back toward the terminals).

The data bits from each terminal form another Time Multiplexed link, on which data from each terminal can exist at 8 kbps. The switching of data bits (between terminals already interconnected for speech) takes place in the Switching Network. Thus, the data path and voice path are established between the same set of terminals at no additional effort on part of the subscriber.

The non-blocking nature of the Switching Network allows for high traffic handling capacity, ie. Every terminal is guaranteed a path to a free destination terminal.

Signaling information (origination detection, dialed digits collection, Central office ring detection, etc) is separated at the terminal cards and is sent to the Signal Processor Card (SPC), on a time multiplexed PCM link. The SPC processes the information and passes it on to the Terminal Interface Controller (TIC).

The TIC is a microprocessor based unit which handles the Call Processing maintenance and administration functions. Signaling information which is formatted by the SPC is analysed by the TIC. The TIC having derived the identities of the calling and the called terminals, establishes a path by connecting the two through Switching Network.

10.3. Physical Description:

C DOT 128 P is housed in a cabinet. The front of the cabinet has a hinged door. The sides of the cabinet are enclosed with lift off panels. The cabinet contains one equipment frame. Each frame has 26 card slot guides. However, a maximum 24 printed circuit boards can be housed in the system. All PCBs have Euro-connectors. Inter-card connections are made by printed circuit traces on the systems back plane called the mother board. External, voice and data connections are made on the Main Distribution Frame (MDF).

The actual cards arrangement in an equipment frame is as shown in fig.10.2

PSU	PSU	TGD	JUN	LCC	LCC	LCC	LCC	LCC	LCC	XSC	SPC	DTA	DTA	XSC	SPC	RMF	TRK	LCC	LCC	LCC	CONF	JUN	TGD	PSU	PSU
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

Fig.10.2 Hardware Architecture of C-DOT 128P PBX

The equipment frame houses the following cards :

- Tone Generator Card (TGD)
- Terminal Interface Controller/Switching Network Card (TIC/SN)
- Signal Processor Card (SPC)
- 14 Termination cards (with provision for one conference card)
- 2 Power Supply units (PSU)
- 1 Data Card (DTA)

The control cards, TGD cards and PSU cards are duplicated for fault tolerant, uninterrupted service.

10.4.0 Facilities offered to the extensions:

- Out calls
- STD calls
- Call if Buffers full
- Room Extension
- Tie line
- Conference
- Public Address
- Call Forward
- DND (others)
- DND (self)
- Conference set
- ISD call
- OG call 'Q'
- Executive
- Admin Allowed
- DTMF facility

10.4.1 System Features:

- Automatic call back – Busy
- Automatic call back – No answer
- Automatic alarm – Wakeup service
- Broker call
- Call Pickup
- Call Transfer
- Data call
- Emergency Reporting
- No call alarm
- Hunt – Busy
- Hunt – No Response

10.5 Technical Specifications:

1. Switching	:	Digital PCM 'A' law CCITT standards non blocking
2. Control	:	Microprocessor based stored program control (SPC)
3. Capacity	:	Upto 96 extensions including line, trunk and special features
4. Line loop resistance	:	Max.1000 ohms
5. Ringing	:	75V RMS
6. Dial tone	:	400 Hz continuous
7. Ring back tone	:	400x25 Hz 0.4 sec ON, 0.2 sec OFF, 0.4 s ON, 2 s OFF
8. Busy tone	:	400 Hz 0.75 sec ON, 0.75 sec OFF
9. Number Unobtainable tone	:	400 Hz 0.28 sec ON, 0.2 sec OFF
10. Primary power	:	-48V +/- 4V, 6 Amps
11. Temperature	:	0 degrees centigrade to 45 degree centigrade
12. Relative Humidity	:	5 % to 95 %