Military College
of
Electrical and Mechanical Engineering

FACULTY OF ELECTRONICS

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DISSERTATION

161p.

ON

Mobile Communication Through Satellite and its Possible Military Application

Guide :

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SYNOPSIS

1. Success in a Modern warfare depends to a great extent upon an effective communication system. Mobile communication is very important for any Army, since it has to move from one place to another during war/exercise. Mobile communication through satellite has made it possible for a subscriber to communicate from any where to any where in the world. There is a scope of utilising this mobile communication facility through satellite by interlinking it with existing communication setup of Indian Army.

2. The Army has got its own static communication system (Army Static Communication Network-ASCON) and a mobile communication system called Plan AREN (Army Radio Engineered Network). For satellite interlinking, one must understand the existing communication system thoroughly. The dissertation has covered the working Principles of Plan AREN communication system in detail . This includes frequency of operation, power input/output, impedance and other important technical parameters of main equipments used in Plan AREN.

3. The thesis brings out the disadvantages of the existing system which gives rise to the need to introduce satellite terminals. Satellite terminals of various capacities are proposed , keeping in view the echelon of fighting formation and amount of communication traffic estimated.

4. To study the feasibility of proposed satellite terminals, the thesis covers few commercially available satellite terminals of varying capacities, which are being manufactured in India. These terminals are compared with proposed ones in order to find out the feasibility of proposed terminals, to be manufactured and introduced in the Army.

5. Lastly, it covers the advantages and disadvantages of introducing the Satellite Communication System in existing Communication System of Indian Army.

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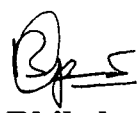

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CERTIFICATE

Certified that this is a bonafied report of the dissertation work done by **Captain B Brhiksha Pathy** during the year **1998** in partial fulfilment of the requirement for the award of the Degree of Master of Technology in Electrical Engineering by the Jawaharlal Nehru University , New Delhi.

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CONTENTS

INTRODUCTION

1.1 Communication plays a very important role in any military operation. Modern warfare completely depends up on an effective mobile communication system to a great extent . Mobile communication, the communication on move , is very important for any Army, since it has to move from one place to other during exercises and war. A mobile communication system requires a repeater station placed at a height in such a position to receive /transmit signals from its subscribers.

1.2. A communication satellite is essentially a microwave link repeater. It receives the energy beamed up at it by an earth station and amplifies and returns to earth at a frequency at about 2 GHz away. Communication satellites appear to hover over given spots above the equator. This makes them geostationary and appear to be stationed at one spot over the earth. A satellite in circular orbit ,35800 Km away from earth , will complete a revolution in 24 hrs, as does the earth below it. That is why the satellite appears stationary.

1.3. The advancement in satellite communication made it possible for a subscriber to communicate from any where to any where in the world. This global communication on move makes it very important to be implemented in military applications.

1.4. To study the applications of satellitte communication in Army , one must understand the existing communication system of the Army.

AIM

2.1 The aim of this project is to study the existing communication system of Indian Army, satellite communication system existing in the commercial field and interlinking the satellite communication with existing system for effective communication of the Army in war/exercises.

REQUIREMENTS

3.1 The requirements of this project are :-

(a) To understand the existing communication system of the Army.

(b) To study characteristics of equipments used for communication in the Army.

(c) To study the satellite communication systems available in the commercial market.

(d) To study important characteristics of equipments used in the satellite communication system.

(e) To study the feasibility of interlinking satellite communication system with the existing communication system of the Army.

(f) To suggest suitable satellite terminals of various capacities to be included in the existing communication system for effective communication of the mobile Army.

METHODOLOGY

4.1 Methodology adopted for completion of the dissertation is as under :-

(a) To study in detail the working principles and important characterstics of equipments employed in the existing communication system.

(b) To bring out the need of satellite communication in the Army.

(c) To propose satellite terminals of various capacities keeping in view the organisation and requirements of Indian Army.

(d) To study few satellite terminals available in commercial market within India with a view to find out feasibility of proposed satellite terminals.

(e) To highlight advantages and disadvantages of introducing satellite terminals.

EXISTING COMMUNICATION SYSTEM OF INDIAN ARMY

5.1 Two types of communication systems are existing in Indian Army which are owned, established and maintained by themselves :-

a) Static communication : The Army has got its own static communication network (Army Static Communication Network - ASCON) based on microwave repeaters using VHF frequencies.

(b) Mobile communication : Plan AREN (Army Radio Engineered Network) communication system is being used in Indian Army for mobile communication. Complete communication system is vehicle mounted and can be moved and established within hours.

EQUIPMENTS USED IN PLAN AREN

6.1 The list of important equipments used in Plan AREN communication system (shown at Fig 1) are as under :-

(a) Exchange Telephone Automatic (TIDEX)

(b) ADM MUX (Multiplexing equipment)

(c) Blue Star (Encryption equipment)

(d) Radio Relay RRD

(e) Automatic Electronic Switch (AES)

(f) Radio Local System (RLS)

(g) Local Switch (LS- 20)

(h) Radio Trunk System (RTS)

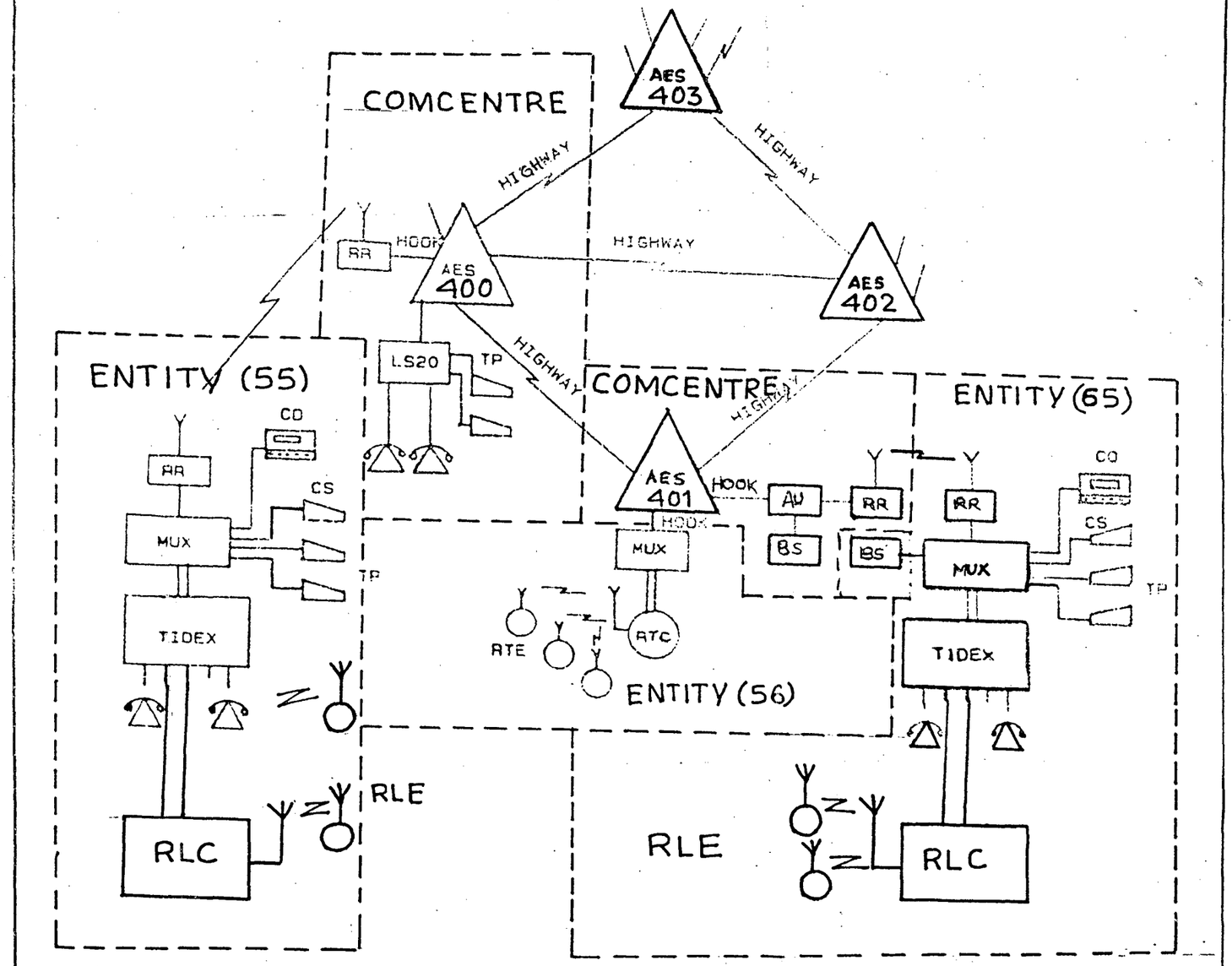


Fig . 6.1 — Plan AREN Communication System

TIDEX

6.1.1 Exchange Telephone Automatic (TIDEX) is a microprocessor controlled TDM exchange. It provides automatic switching for subscribers, Grid Trunks and Universal Junctions. It is a communication switching equipment for use at various formation levels in the forward areas. TIDEX is designed for 40 subscribers +12 trunk lines (40+12) and can be expanded to (80+24) or (160+48) in stages. This equipment provides a full availability switching.

CAPACITY

6.1.2 TIDEX can be configured to have an initial capacity of 40 subscribers, 6 Grid Trunks and 6 Universal Junctions. This can be expanded in similar steps up to 160 subscribers, 24 Grid Trunks and 24 Universal Junctions. TIDEX provides a full availability switching .

SPEECH PATH

6.1.3 TIDEX provides Time Division Switching ,i.e., the speech path within the exchange is time shared between the calls in the system . This is accomplished in TIDEX by first converting the incoming analog speech signals from lines in to digital signals by Adaptive Delta Modulation (ADM) . These signals representing sampled speech are written in to a high speed memory in sequential locations . To connect two lines ,the sampled speech of one line is read out from the memory at an appropriate time and made available to the other line . These digitalsignals are converted back to analog form and transmitted to the line. Time Division Switching offers a number of advantages such as simple and reliable hardware, compatibility with digital communication system etc.

PROCESSOR

6.1.4 TIDEX has dual microprocessor sub system for control . The two microprocessors operate sharing the processing load. The control programs reside in Read only Memory (ROM) of the sub system whereas the data pertaining the calls resides in Read Write Memory (RWM). Input - output circuits provides interface between the microproessor and other subsystems such as time division switch, signalling ports, operator console, etc. The processor subsystem continuously monitors line status of all lines and take appropriate action like collecting dialled digits, connecting/disconnecting tone, speech path, ring and loop relays, etc.

FACILITIES

6.1.5 TIDEX provides the following facilities :-

(a) Priority on all types of calls.

(b) Time out on incomplete dialling, excessive inter-digit pause and busy tone.

(c) Enquiry and call transfer.

(d) Ring transfer for selected pairs.

(e) Unconnected line indication.

(f) Trunk access barred for selected subscribers.

(g) Conference of any five lines.

(h) Field selectable signalling for universal junctions.

(j) Operator assistance for all types of calls.

(k) Simple fault diagnosis from Operator Console.

(l) Status scanning of selected group of lines from the operator Console.

(m) Traffic statistics collection and display.

(n) Optional 'Assistant Telephone' to distribute operator load.

SWITCHING TECHNIQUE

6.1.6 The following switching techniques are employed in TIDEX :-

(a) Adaptive Delta Modulation at 32 KB/S for speech digitisation.

(b) Single stage memory multiplexer Time Division Switch providing full availability and non blocking switching.

(c) Digital service tone generation.

SPEECH CHARACTERISTICS

6.1.7	(a) Voice Frequency Bandwidth	: 300HZ to 3400HZ
	(b) Insertion loss (TE)6 at 800 Hz	: -1 $\pm$ 1 dB
	(c) Signal to Quantisation Distortion	: Better than 20 dB
	(d) Cross talk	: Better than -60 dB

POWER SUPPLY

6.1.8 TIDEX is designed to operate from 230v, 50Hz mains supply or with secondary battery 48 v.

CONSTRUCTION

6.1.9 TIDEX is built up of functionally partitioned sub units. Mechanical design and fabrication of the sub units conforms to the standards specified for the communication equipment for field use.

OTHER DETAILS

6.1.10 Other details of eqpuipment TIDEX are mentioned at Appendix 'A' to this dissertation.

ADM MUX

6.2.1 ADM MUX is a multiplexing equipment. This may be of 6/12/24 channel as per the requirement of the system.

6.2.2 6 Channel MUX shall provide 6 speech channels , 9 Teleprinter Channels and one computer data channel . The communication media are cable or radio.

6.2.3 12 Channel MUX shall provide 12 speech channels, 18 Teleprinter Channels and two computer data channels . Two 6 Channels Terminals are interconnected to form one 12 Channel MUX system.

6.2.4 24 Channel MUX shall provide 24 speech channels , 36 Teleprinter channels and four computer data channels. Four 6 channel terminals are interconnected to form 24 channel MUX. 24 channels MUX is also capable of working with 6 channel and 12 channel MUX.

6.2.5 **BIT RATE**

System	Full Bit Rate	Reduced Bit Rate
(a) 6 Ch MUX	288kB ± 10B/Sec	144 kB ± 5B/Sec
(b) 12 Ch MUX	576 kB ± 20B/Sec	288 kB ± 10 B/Sec
(c) 24 Ch MUX	1152 kB ± 40B/Sec	576 kB ± 20 B/Sec

6.2.6 **SAMPLING RATE**

(a)	Speech Channel and Computer Data Channel	: 32 or 16 kB /Sec
(b)	T.P. Channels	: 2 or 1 kB /Sec

6.2.7 **SYNCHRONISATION**

15 bit Pseudo Noise sequence is adapted for synchronisation fail recognition . A guard time of 10 ms for normal bit rate and 20 ms for reduced bit rate is provided.

6.2.8. **CLOCK**

Clock Stability $\pm$ 25ppm.

When a TTL compatible external clock at 1152 kB/Sec is connected, the local clock will automatically get disabled. In case, the external clock fails when the terminal is working on external clock, the MUX will automatically switch over to the internal clock . Also a switch is provided to select either local clock frequency or external clock frequency.

6.2.9 **SIGNALLING**

(a)	Magneto	: 25V to 80 V, 15Hz to 50 Hz
(b)	Ringer	: 75V, 17Hz to 35 Hz

6.2.10 VOICE FREQUENCY (VF) CHARACTERISTICS

(a) V F Band Width : 0.3 to 3.4 Khz

(b) V F Termination : 2Wire/4Wire

6.2.11. INTERFACE WITH RADIO RELAY

(a) Output to RRD from MUX : Logic 'O' - 1.5 ± 10%
Into 50 ohms Logic '1' 0.0V to -0.3V

(b) Input from RRD to MUX : Logic 'O' - 1.5V ± 10%
Into 50 ohms termination Logic '1' 0.0 V to - 0.3V

6.2.12 POWER SUPPLY

(a) Input

(i) AC mains 180V to 265V, 47 to 63 Hz

(ii) Battery - 21 V to -29 V DC

(b) Output

(i) Multiple supplies + 5V, ±15V, ± 12V, -6V and -24 V .

(ii) Ringer 20Hz , 75 V to 90V .

6.2.13 OTHER DETAILS

For other details please see Appendix 'B' to this thesis.

BLUE STAR

6.3.1 The purpose of Blue Star is to provide protection to communication from unauthorised interception. This equipment contains purely digital encryption and decryption circuits leading to secured communications. The equipment can be used on any of the bit rates 144 kB/s , 288 kB/s, 576 kB/s and 1152 kB/s.

6.3.2 This equipment is provided with a multi pin connector for interfacing with ADM MUX. This equipment has facilities for self testing , working in non secured or secured mode of operation.

6.3.3 Power Supply

This equipment can work with 220V, 50 Hz AC mains or - 24V DC supply With both mains and battery connected , " No break " automatic change over is provided from mains to battery and vice versa.

6.3.4 OTHER DETAILS

For other details please see Appendix 'C'.

RADIO RELAY RRD

GENERAL

6.4.1 RADIO STATION, RRD is a UHF communication equipment, designed for operating as a multichannel Radio Station in duplex mode. It is capable of transmitting and receiving, through line of sight radio path, signals supplied by a 6/12/24 channel Time Division multiplex equipment using Adaptive Delta Modulation (ADM). The radio equipment is provided with an analog service channel.

6.4.2 The Radio frequency bands of the equipment are 225 to 399.875 MHz and 610 to 960 MHz, with channels tunable in steps of 125 KHz. The equipment can be powered from mains 220 V ac or from 48 V storage battery.

6.4.3 The equipment with a suitable TDM/ADM equipment can be set up as a mobile station mounted in a vehicle, or as a static ground station. The RF output of the Radio Station, RRD can be set to intermediate levels between 2 W & 15W by six to ten discrete steps. With two stations, set to 6/12 ch mode of operation radio communication can be established between two line-of -sight geographical locations, approximately 30 km apart. If, no line-of-sight exists between the locations, as reffered to the antennae of the two stations, one or more relay stations, each comprising

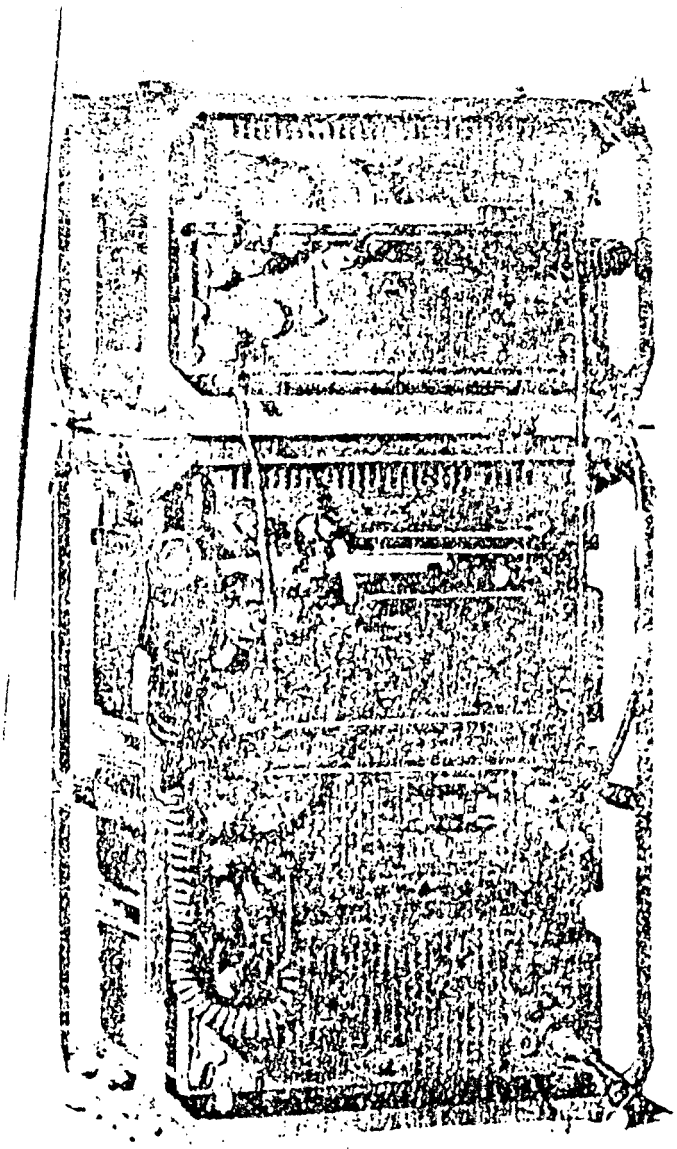


Fig . 6.2 Radio Relay RRD

of two numbers of RADIO STATION, RRD in tandem, may be interposed between the two locations to obtain communications.

EQUIPMENT AND ACCESSORIES

6.4.4 Equipment and important accessories required for setting up a single Radio Station RRD is given below:-

(a) Power supply unit.

(b) System unit.

(c) Amplifier Radio frequency 610 to 960 MHz.

(d) Amplifier Radio frequency 225 to 399.875 MHz.

(e) Antenna Array dipole 610 to 960 MHz.

(f) Reflector Antenna Corner 225 to 400 MHz.

(g) Antenna mast 15.8 m

6.4.5 **WEIGHT**

(a) Equipment - Approximately 150 Kg

(b) Antenna with mast - Approximately 300 Kg

6.4.6 IMPORTANT SPECIFICATIONS FOR TRANSMITTER

(a) Frequency Range : 610-960 MHz & 225 - 399.875 MHZ.

(b) RF Channel Setting : 125 kHz.

(c) RF Output power : Not less than 15 W reducible to at least 2 W

(d) RF bandwidth : Maximum 1380 KHz in 24 channel
Maximum 960 KHz in 12 channel

(e) RF output impedance : 50 ohms (nominal).

(f) Type of modulation : Frequency modulation.

(g) Frequency of TDM Signal : 144 ± 0.2 kHz.

(h) Frequency deviation for Data : 360 KHz ± 10%.

(j) Accuracy of transmitted frequency : ± 20 kHz.

(k) Base-band input level : 0.5 to 3 V peak to peak

(l) Service Channel Frequency : 0.3 to 3.4 kHz.

6.4.7 IMPORTANT SPECIFICATIONS OF RECEIVER

(a) Frequency Range : 610-960 MHz and 225-399.875 MHz

(b) RF Channel setting : 125 kHz.

(c) RF input impedance : 50 ohms (nominal)

(d) Noise Figure : Better than 6.5 dB

(e) Image frequency rejection: 60 dB min.

(f) IF Rejection : 60 dB min.

(g) Base-band data rate : 288/576/1152 k bits/sec

(h) Base band output level :1.5 V $\pm$ 10% peak to peak.

(j) Service channel frequency :0.3 to 3.4 kHz.

6.4.8 TRANSMITTER & RECEIVER WORKING TOGETHER

(a) Duplex frequency spacing : $\geq$ 36 MHz.

(b) System Gain : 6 ch operation $\geq$ 131 dB.

: 12 Ch operation $\geq$ 131 dB.

: 24 ch operation $\geq$ 121 dB.

6.4.9 SPECIFICATION FOR POWER SUPPLY

(a) AC mains voltage : 180 to 250 V, 47-63 Hz/ single phase.

(b) Mains drain : 600 VA max.

(c) Battery voltage : 42 to 58 V.

6.4.10 SPECIFICATION FOR THE SERVICE CHANNEL

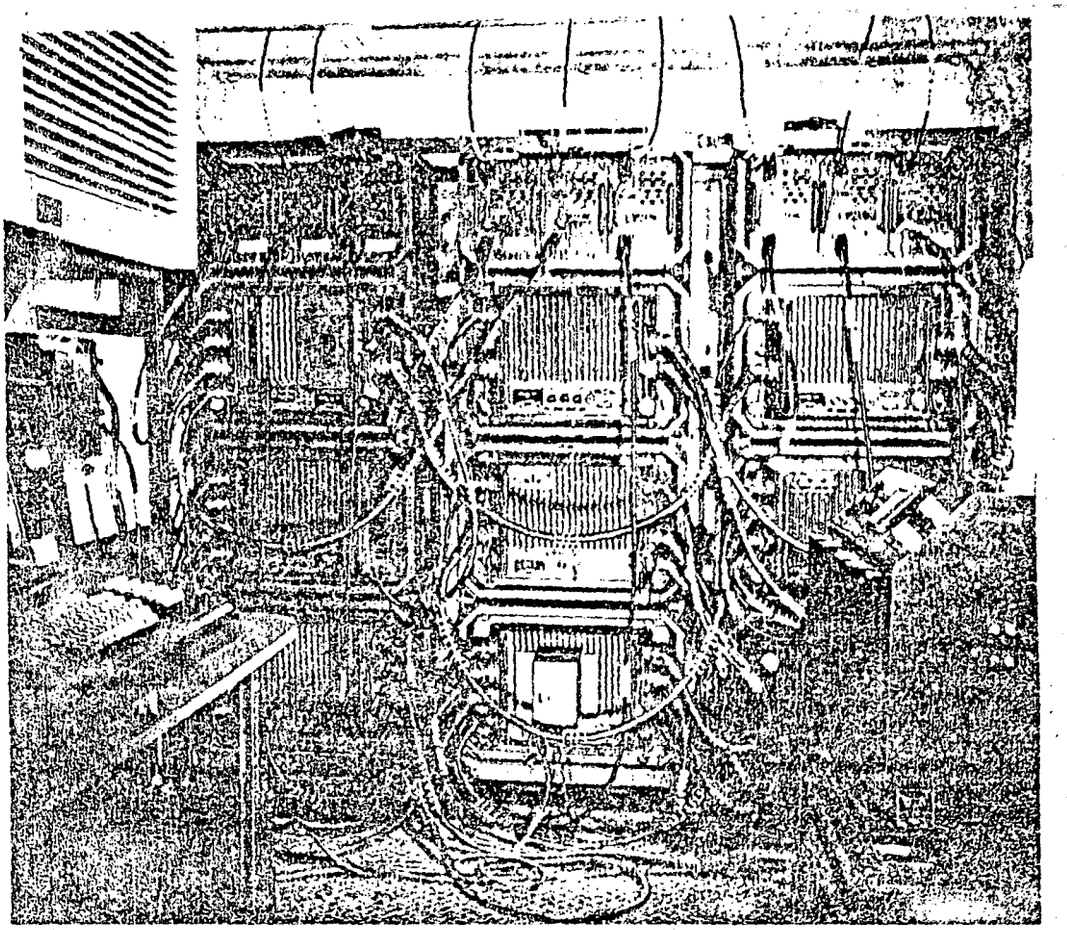
(a) Ringing signal frequency modulated on to the carrier. : 1600 $\pm$ 16V

(b) Service channel signal to noise ratio : 20 db min

(c) Frequency deviation due to service channel : 65 KHz $\pm$10%

6.4.11 OTHER DETAILS

For other details please see Appendix 'D'.



AES SHELTER (INSIDE VIEW)

Fig . 6.3 Automatic Electronic Switch (AES)

AUTOMATIC ELECTRONIC SWITCH (AES)

6.5.1 Automatic Electronic Switch (AES) is a stored program trunk exchange used as Node Switch in an Area Grid Tactical Communication Network which provides the army with automatic, fast, secure and reliable Communication. AES provides automatic trunk switching facilities for voice, teleprinter and computer data. It is designed to operate under field conditions as a vehicular station.

SYSTEM COMPOSITION

6.5.2 The functions of the AES have been devided into a number of tasks. Each task is carried out by a sub-system. The sub systems are as under:-

1) Synchroniser I (SYNG I)
2) Synchroniser II (SYNG II)
3) Front End processor (FEP)
4) Digital Switch (DS)
5) Central Processor Unit I (CPU I)
6) Central Processor Unit II (CPU II)
7) Hot Standby Controller (HSC)
8) Cassette Unit (CASS)
9) Local Switch 20 (LS-20)

6.5.3 A teleprinter, a visual display Unit (VDU) and a system monitor console are provided for the operator to monitor the overall function of the system and configure the system for a particular requirement.

FUNCTIONAL CHARACTERISTICS

6.5.4 AES is deployed in the network as shown in Fig. 1. The AESs are interconnected in the from of a grid through links called highways. The terminal local exchanges namely TIDEX, and RTS are connected to the AES via ADM MUX . LS-20 is connected directly to AES. The link between ADM MUX and AES is called Hook. The links (Highway/Hook) which are established normally through RR can be secured by the use of MID equipments.

6.5.5 **SYSTEM CONFIGURATION FLEXIBILITY**

(a) **System Flexibility**

The AES system can be operated in four configurations designated as 1A, 1B, 2A and 2B `A' type configurations operate with single CPU, `B' type configurations use two CPUs in hot-stand-by mode. The minimum configuration 1A meets the requirement to utilise the full capacity. Each higher configuration provides some additional facility.

(b) **Port Flexibility**

The AES provides flexibility in the use of ports for carrying either trunk traffic or local traffic or both to its maximum capacity . Further, Ports

could be used for carrying 6/12/24 channel group in a mix up to its maximum capacity. A total of 24 ports have been provided.

(c) **Half Bit Rate**

AES provides the facility to configure the system for operation at half gross bit rate by means of switches, then the whole net work goes in for half bit rate working.

(d) **50/100 baud**

Facility of 50/100 baud working of teleprinter is provides. which setting selects the baud rate.

(e) **Dual Processor control**

To ensure call processing integrity and to minimise processor down-time, Dual processor control operating in hot-stand by configuration has been incorporated in the AES system.

TH-7235

(f) **Self Check**

AES includes self check and monitor circuits to diagnose and isolate faults up to card level. Faults are reported on system monitor console.

(g) **System Maintainability**

AES provides the facility of running on-line and off-line diagnostics to diagnose and isolate faults up to card level.

(h) **Operator Facility**

An operator facility has been provided in the AES system to facilitate operational control, configuration changes, subscriber assistance and over all supervision of system operation.

TECHNICAL DESCRIPTION

6.5.6 **Capacity**

(a) No of voice channels	192
(b) No of Teleprinter Channels	256
(c) No of Data channels	32
(d) System availability	Full

6.5.7 **Channel Characteristics**

(a) Sampling Rate	:16/32 kbps
(b) Grouping	:6/12/24 Voice Channels, 8/16/32 Teleprinter Channels and 1/2/4 Data Channels.
(c) Gross Bit Rate	: 144/288, 288/576, 576/1152 Kbps for 6/12/24 Voice Channels groups at 16/32 kbps sampling rate respectively.

6.5.8 **Terminations**

(a) Hooks	: 6/12/24 Channel Groups
(b) Highways	: 12/24 Channel Groups
(c) No of ports	: 24
(d) Maximum No of Hooks	: 24
(e) Maximum No of Highways	: 08
(f) I/O Impedance	: 50 Ohms unbalanced

6.5.9 **Signalling**

(a) Hooks (Voice)	: Loop calling & Loop dialling
(b) Hooks (TP and Data)	: Key board calling
	Key board dialling at 50/100 bauds
(c) Highways	: Common Channel with block
(Voice ,TP & Data)	check and ARQ

Networking

6.5.10 AES provides the facility of connecting TIDEX, RTS and LS-20 through Hooks to enable intra node call routing. Each AES may be connected to up to 24 such terminal Equipment. It provides facility for interconnecting other AESs through highways to enable networking in a grid from. Each AES may be connected to up to 8 other AES. It may be connected up to 4 other AES in neighbouring grids.

Synchronisation

6.5.11 Network synchronisation is achieved by employing a technique that allows autonomous node operations. Each AES is thus provided with its own high stability oven controlled master clock. On hooks ADM MUXs are slaved to AES clock. On highways bit slippage technique is employed using elastic buffers to achieve synchronisation.

Signalling

6.5.12 On hooks AES Accepts dialling at 10 ips for Voice Channels. Common Channel Signalling is employed on highways. For teleprinters and data channels, 50 or 100 baud signalling is accepted.

Routing

6.5.13 AES provides the shortest available route for transit traffic. The routing algorithm adopted in AES takes cognizance of not only the link status in terms of occupancy and operational characteristics but also the priority status of the disconnecting a lower priority call if not available otherwise.

Gypsy Subscribers

6.5.14 Gypsy subscribers have a four or five digit fixed number irrespective of their physical location in the network. The AES keeps trace of these subscribers allowing their affiliation to any of the terminal exchange

OTHER DETAILS

6.5.15 For other details please see Appendix 'E'.

RADIO LOCAL SYSTEM(RLS)

ROLE

6.6.1 Radio Local System(RLS) is a part of the AREN communication network. RLS extends the facilities of TIDEX to radio subscribers (RLEs) over the normal terrain and also where laying of telephone cable is very difficult and the communication is to be set-up in a short period of time. The subscribers can move up to a distance of 5 Kms from the exchange and this range is extendable up to 15 Kms using range extension kit at RLE.

DEPLOYMENT

6.6.2 RLS provides secured duplex communication links to a maximum of 10 RLEs through TIDEX. A Radio Local Central(RLC) which is connected to TIDEX through ten subscriber lines, functions as a concentrator for all the calls from RLEs and provides all necessary interface between the Radio System and TIDEX. RLC is capable of providing communication to four of the ten RLEs simultaneously without any interference.

TRANSPORTATION

6.6.3 RLS shall be carried in a Truck 3 Ton Shaktiman with house type body / aluminum shelter.

SALIENT FEATURES

6.6.4 The system provides a number of facilities to improve the overall efficiency of the communication network and consistent with the role. Some of the major facilities are briefly described below.

(a) **Multi access**:- The RLS system provides telephone communication service up to 10 remote radio subscribers(RLEs) using only 4 RF channels at RLC. Four simultaneous incoming or outgoing calls are possible, thus providing a high grade of service

(b) **Duplex Operation** :- RLS is a full duplex voice communication system. A single antenna is used at RLE for transmission as well as reception while two different antennas are used at RLC, One for all four transmitters and another for all five receivers(including priority receiver).

(c) **Secrecy** :- The system is fully compatible with DIPA (Digital Secrecy Unit). The change over(from clear to secret or vice versa) at the RLC is automatic and at RLE, it is manually selectable.

(d) **Priority** :- One additional receiver is provided at RLC to enable the priority radio subscribers to have an access into the system when all the four radio channels are busy. The priority allocation of

two RLEs is software programmable at RLC. However the above feature is only RLS priority and not AREN Grid priority.

6.6.5 TECHNICAL DATA SUMMARY

(a) Frequency Range : 80 -100 MHz

(b) Operation : Duplex

(c) Range : 5 Kms (Normal)
15 Kms (Extended)

(d) Max. Simultaneous RF links : 4

(e) No of RF channels : 70 Duplex Channels

(f) Channel BW : 50 KHz

(g) No of channels used per RLC : 5

(h) Frequency separation between Receiver and trasmitter : 10 MHz

(j) Modulation : FM

(k) Priority : Any 2 out of 10 RLEs programmable)

(l) Exchange compatibility : TIDEX or any auto exchange operating on 10 ips signalling RLC can be us closely located in the same TIDEX vehicle.

6.6.6 RECEIVER PARAMETERS

(a) Frequency range	: 80 -90 MHz (RLE) 90 - 100 Mhz (RLC)
(b) Sensitivity	: 0.5 uV for 12 db SINAD
(c) Audio out put	: 120 mV (rms)across 24 ohms resistive load at 1KHz modulating signal with ± 5.6 KHz deviation
(d) IF	: 1st 37.25 MHz 2nd 450 KHz
(e) RF Impedance	: 50 Ohms

6.6.7 ANTENNA (RLE)

(a) Frequency Band	: 80 -100 MHz
(b) VSWR	:2:1 (Typ)
(c) Power Handling	: 10 Watts
(d) Polarization	: Vertical

6.6.8 ANTENNA (RLC)

Power Handling : 25 Watts (TX Antenna)

6.6.9 **TRANSMITTER PARAMETRS**

(a) Frequency : RLE 90 -100 MHz
RLC 80 - 90 MHz

(b) power : 33 dBm (Typical)

(c) Deviation : ± 5.6 KHz Maximum at 1 KHz modulating signal

(d) Transmission BW : Clear 18 KHz,
Coded 30 KHz

(e) Modulation BW (3 dB) : 20 Hz -10 KHz

(f) R F Impedance : 50 ohms

6.6.10 **ANTENNA MASTS**

(a) **RLE**: (i) 3 M telescopic(Normal range)
(ii) 7.5 M Hand Crankable (Extended range)

(b) **RLC**: 15 M Hand Crankable
(Both for Tx & Rx)

6.6.11 **POWER SOURCE**

(a) **RLE** (i) 12v, 10 AH Ni cadmium (or)
(ii) 12v, 75 AH Sec. Battery

(b) **RLC** (i) 230 V,50 Hz AC Mains
(ii) 24 v, 140 AH Secondary Bty

6.6.12 **POWER CONSUMPTION**

(a) **RLC at 24V DC**

(i) Receive mode : Less than 2.0 A per channel

(ii) Transmitted mode : Less than 8.0 A per channel

(b) **RLE at 12V DC**

(i) Receive mode : Less than 1.0 A

(ii) Transmit mode : Less than 3.0 A

6.6.13 **OTHER DETAILS.**

For other details, please refer Appendix 'F'.

LOCAL SWITCH - LS 20

6.7.1 LS 20 is an automatic Exchange cattering to the communication needs of local subscribers. It is a microprocessor controlled exchange working on TDM principle. It provides facility for connection of 20 voice subscribers, 1 data terminal and 6 trunks. It is capable of multiplexing 6 voice trunk channels, 2 teleprinter channels and 1 data channel into a bitstream format same as that of a 6 channel MUX at full bit rate of 288 kbps or half bit rate of 144 kbps. It can be directly conected to AES without the aid of an ADM-MUX/DTU equipment. It is a full availability switch providing connection facility for a maximum of 13 simultaneous voice calls. It has the following facilities.

(a) Capacity

(i) No of voice channels : 20

(ii) No of trunks : 06

(iii) No of TP Subscribers : 02

(iv) No of data subscribers : 01

(v) No of simultaneous calls (Voice) : 11

(b) Switching : Single stage TDM switch

(c) Sampling Rate : 32/16 kbps

(d) Multiplexed Truck Bit Streams rate : 288/144 kbps

(e) Numbering Scheme : Voice Subscribers are numbered from 200 to 219.

(f) Priority : The subscribers have4 four level of priority as indicated below :-

P1 : 201, 211

P2 : 202, 212

P3 : 203, 213

P4 : 200 and 204 to 219

(g) Call Transfer : LS provides the facility to transfer calls on incoming/outgoing trunks.

(h) Time out : LS provides the facility of automatic time-out during dialling. Dialling pause of about 15 seconds cause time out.

(j) Affiliation/Deaffiliation : It has switches to register the addition or deletion of subscriber lines.

(k) Facility Digits : LS has the following facility digits.

Digit `2' : Priority Exercise Code

Digit `3' : Call Transfer Code

Digit `4' : Auto call back

Digit `5' : Trunk Access Code

(l) Camp-on Busy : LS is capable of connecting called busy subscriber to the calling subscriber automatically if the calling party waits for 12 seconds, provided the called subscriber becomes free .

(m) Auto Call Back : When the calling subscriber found the called subscriber busy, the clling party can dial 4 and can replace the hand set to get auto call back ring provided both parties are local .

(n) Tones : LS provides tones as listed below -

1. Dial Tone
2. Ring back tone
3. Busy tone
4. NU tone
5. Priority warning tone.

(o) LS can be removed from AES shelter and operated independently.

WORKING PRINCIPLES OF PLAN AREN COMMUNICATION

7.1 Plan AREN communication system is basically a voice and teleprinter communication. In addition , it caters for limited data communication. Block diagram of the Plan AREN communication system is shown at Fig 1.

7.2 First stage of voice communication is an exchange. Equipment TIDEX is a 40 lines exchange. It's subscribers can be connected through line or radio (RLS). Each voice channel speech is digitised using Adaptive Delta Modulation at 32 KB/Sec. Equipment TIDEX provides 40 subscribers lines, 6 Grid Trunks and 6 Universal Junctions. 40 subscribers lines and 6 Universal Junctions cater for communication among local units where as 6 Grid Trunks are there to cater for communication with external world.

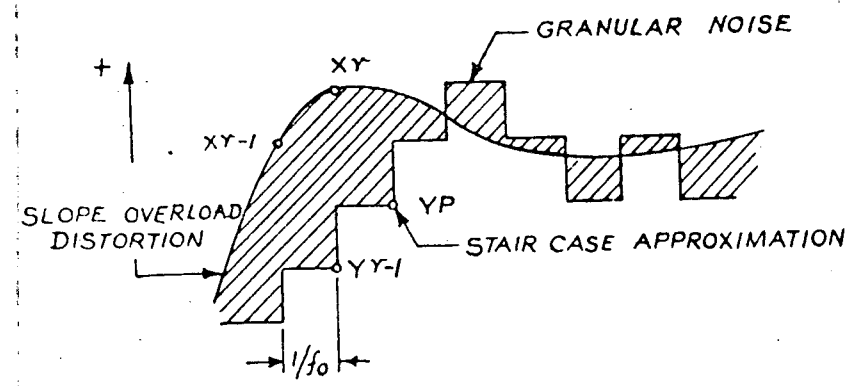
7.3 Out of the 40 lines of TIDEX, 10 subscribers can be on Radio Local System. These mobile subscribers are provided with all the facilities of TIDEX like any other subscriber. Advantage is, they are mobile being linked to TIDEX via a radio trans receiver. At a time 4 out of 10 RLS subscribers can communicate with TIDEX and there by to external world.
7.4. The 6 Grid trunks lines are connected to equipmemt ADM MUX 6 Channel. Each 6 channel ADM MUX provides for multiplexing of 6 speech channels, 9 teleprinter channels and one computer data channel.

Each speech channel and computer data channel are sampled at the rate of 32 KB/Sec and each teleprinter channel is sampled at the rate of 2 KB/Sec. This makes a multiplexed data of 288 KB/Sec which includes signalling information and synchronisation data.

7.5 ADM MUX can be used to work at half bit rate also to produce 144 KB/Sec. Half bit rate facility is used when channel is more noisy. This reduces the effect of noise and error free communications is made possible.

7.6 Adaptive delta modulation used in ADM MUX equipment is derived from Linear Delta Modulation technique. In linear delta modulation, the input is sampled at a frequency which is much higher than Nyquist frequency and a staircase approximation to the input is constructed as shown in fig 7.1. At the instant of sampling, if the approximated staircase value is less than the input signal, a logic '1' is coded and a logic '0' , if otherwise. Thus the output of the LDM is a series of '1's and '0's at the sampling rate depending upon the difference between the input and derived staircase approximated signal.

7.7 The speech signal can be recovered by a simple process of integration. But the recovered signal has distortion due to slope overload and granularity. Slope overload occurs when the step size is too small to follow a steep segment of the input function. Granularity refers to a situation where the staircase approximation tries to follow a flat segment of input with step size that is too large relative to the input slope characteristics. Hence small values of step size accentuates slope overload while large values increase granularity . This drawback is



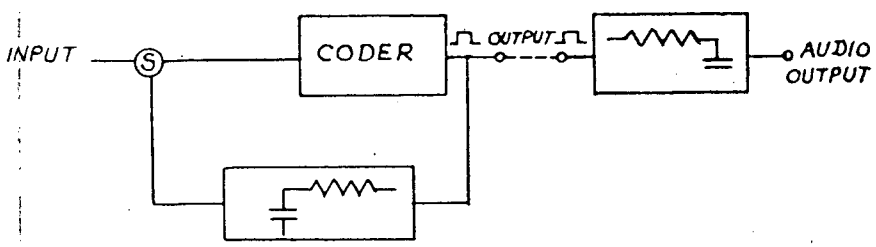


Fig . 7.1 Linear Delta Modulation

overcome by improving the dynamic range of LDM by varying the step size depending on the input slope i.e. adopting the step size in relation to the input. This is called " ADAPTIVE DELTA MODULATION" (ADM). In ADM the variable step size increases during a steep segment of input signal and decreases when the Delta modulator is quantising a slowly varying input signal. There are many ways of implementing the adaptation; one such method, "Two Loop ADM System" is used in development of MUX 6/12/24 Ch System.

7.8 ADM MUX 6 channels can be combined to make 12 channel MUX or 24 channel MUX and can be employed as per the requirements of the system. . Multiplexed output data (288 KB/Sec or 144 KB/Sec) can be transmitted over line radio relay. In Plan AREN communication system the output of the ADM MUX is fed the Radio Relay RRD. The output of ADM MUX can be a plain data explained above or it can be encrypted data using equipment Blue Star.

7.9 Equipment Blue Star in 'coded mode' provides protection to communication from unauthorised interception. This is purely digital system with adequate complexity to provides secured communication. Blue Star can be used on any of the bit rates 144KB/Sec, 288 KB/Sec, 576 KB/Sec or 1152 KB/Sec. The equipment can also be operated in 'clear mode' or can be operated exclusively for speech channels keeping TP Data and computer data in clear mode of working . Signalling

information and synchronisation pattern from ADM MUX always passed without encryption. Synchronisation of this equipment is automatic in either direction. During transmission the Blue Star generates noise sequence of unpredictable nature by a digital circuitry which is programmed by using the external key board on the front panel. As per the code selected the noise sequence is generated which is added to bit stream coming from ADM MUX. During Reception the digital noise is subtracted and original plain data is regenerated. The secrecy equipment Blue Star is connected to ADM MUX. Depending on the mode of operation plain/encoded data output of ADM MUX is fed to Radio Relay RRD for further transmission.

7.10 Radio Station RRD is a UHF communication equipment designed for operating as a multi channel radio station in duplex mode. It transmits/receives through a line of sight path. This equipment operates over a frequency band of 225 to 399.875 MHz and 610 to 960 MHz. It provides more than 4000 communication channels spaced at 125 KHz. This equipment is a FM trans receiver. The base band signal from ADM MUX forms the modulating signal. This equipment transmits the multiplexed data of ADM MUX to Communication Center (AES) through another radio relay equipment RRD (receiver). Separation required between transmitter and receiver frequencies of RRD should be grater than or equal to 36 MHz. Frequency deviation of the equipment is $\pm$ 360 KHz p-p $\pm$ 10%. The equipment is capable to operate at a bit

rate of 144 KB/Sec, 288 KB/Sec, 576 KB/Sec or 1152 KB/Sec corresponding to 6/12/24 Ch TDM signal from ADM MUX in half/full bit rate mode. Equipment RRD provides a service channel for engineering staff with a speech frequency ranging from 0.3 to 3.4 KHz. It has got an elaborated BITE facility for ease of operation/ maintainance.

7.11 Automatic Electronic Switch (AES) is the heart of Plan AREN communication system. . It is a stored program trunk exchange used as a node switch. It provides automatic trunk switching facilities for voice, teleprinter and computer data. Functional block diagram of the AES is shown at Fig 3 . The AES has the following important sub systems.

(a) **Synchroniser I (Sync I) and Synchroniser II (Sync II)**
Synchroniser Interfaces the (AES) system with the TDM trunks from ADM MUX equipments and from other AESs. Sync I and Sync II are identical units. Each Unit caters for 12 ports. One unit is designated as Master and the other as Slave. The two Sync units combined together provides 24 ports. A port can be of 6/12/24 Channel Capacity. When Master port is of 24 Channels, Slave can not support any more channels . Synchroniser receives TDM bit stream, extracts clock from the bit stream and regenerates the data using that clock. It detects synchronisation bit pattern and start of the frame and locks on to it. Sync unit aligns all the bit streams from different ports by writing the bit streams first and reading them using master clock of AES.

7.11.2 Sync unit converts 6/12/24 Channels data stream into the 16 data streams of 12 channels format which are called highways. These synchronised internal highways are sent out on System Data Bus for the Front End Processor (FEP) and Digital Switch (DS) for further operation.The output hardware of sync receives back the switched outgoing internal highways from FEP & DS. These 16 data streams carry the switched channels from the DS and outgoing signalling information from FEP. The Sync unit injects sync pattern and converts back the internal highways into 6/12/24 channel data.

7.11.3 System Monitor portion of Sync, monitors the healthiness of each sync card and generates Sync fail alarms namely, Local sync fail (LSF), Remote sync fail (RSF) and High bit error rate (HBR) . The processor communication (Procom) circuit forwards port status (connected/disconnected) and 6/12/24 channel status to Central Processor unit (CPU).

(b) **FRONT END PROCESSOR (FEP)**

7.11.4 FEP is a program controlled, time shared processor that monitors TDM trunks in real time and reports status change to the processor. It comprises of Hooks Processor and Highways Processor. The connecting system from ADM MUX to AES is called the Hooks and between AES to AES is called a highway. The hooks carrying signalling at 10 ips for voice

subscriber and 50/100 bauds for TP and data subscribers and scanned by hook processors at regular intervals for detecting status changes (new call, disconnection, etc,.) and collecting digits and addresses . Common Channel Signalling with Block check and Automatic Repeat Request facility is provided for communication between nodes (AESs) . Highway Processor provides common channel singalling interface.

(c) **DIGITAL SWITCH (DS)**

7.11.5 Digital Switch is used for switching the channels. Various tones (Busy tone etc) are generated and switched by DS.

(d) **CENTRAL PROCESSOR UNIT (CPU)**

7.11.6 It is a general purpose mini-computer to exercise control over the system operation. The two processors CPU I & CPU II and used in Hot Standby Mode. Hot Standby Controller (HSC) allows one of the CPUs to have control on the system at any instant.

7.12 In addition to the above equipments Radio Trunk Center (RTC) is used to connect Radio Trunk Extension (RTE) subscribers to AES through ADM MUX . RTEs are also known as Gypsy subscribers who can communicate while on move .

7.13 Auxillary Unit (AU) is an interfacing equipment between RRD , AES and Blue Star . The data received from RRD is deciphered before feeding to AES .

7.14 Similarly, 50 AESs can be connected to form a Grid .Communication between subscribers is very simple like STD facility. Any subscriber on the Grid can communicate with any other by direct dialling .

7.15 Plan AREN communication system is also linked with the static communication system ASCON by using a gate way Hook . With this facility a subscriber of AREN can also dial ASCON subscriber directly and vice-versa.

REQUIREMENTS OF SATELLITE COMMUNICATION IN THE ARMY

8.1. There are certain disadvantages in the existing communication system of the Army as given below which can be overcome by using Satellite communication :-

(a) Plan AREN communication system is based on the technology of almost 30 years old compared to the latest technologies used in modern satellite communication.

(b) Plan AREN communication system is based on UHF (Microwave) repeaters to be established after every 20 to 30 KM distance. Establishment of these repeaters is cumbersome and time consuming. Establishment of these repeater in the enemy area makes it more difficult. Where as satellite is a repeater station already established and stationary. Communication can be established with lesser time and lesser manpower. Also, repeater stations (Radio Relays) are required to be placed at a height to provide line of sight communication. At times, it becomes very difficult to find out such heights and establish repeaters in enemy territory/operational area. Satellite being conveniently placed at a height solves this problem.

(c) Plan AREN caters for a low speed (9.6 KB/Sec) data communication. In future the requirement of high speed data communication would be more (appx 64 KB/Sec) and can be fulfilled using satellite communication.

8.2. Video communication/ Video conference are possible with satellite communication.

8.3. Satellite communication will provide more effective point to point mobile communication and enhance flexibility of communication network.

8.4. Satellite communication is more reliable and survivable.

ORGANISATION OF FIGHTING ARMY

9.1. This paragraph is included for the benefit of non-defence personnel reading this thesis. Indian Army is devided in to five Commands. Each Command has number of Corps which are basic fighting formations. The organisation of a Corps is shown at Fig 9.1 which is self explanatory.

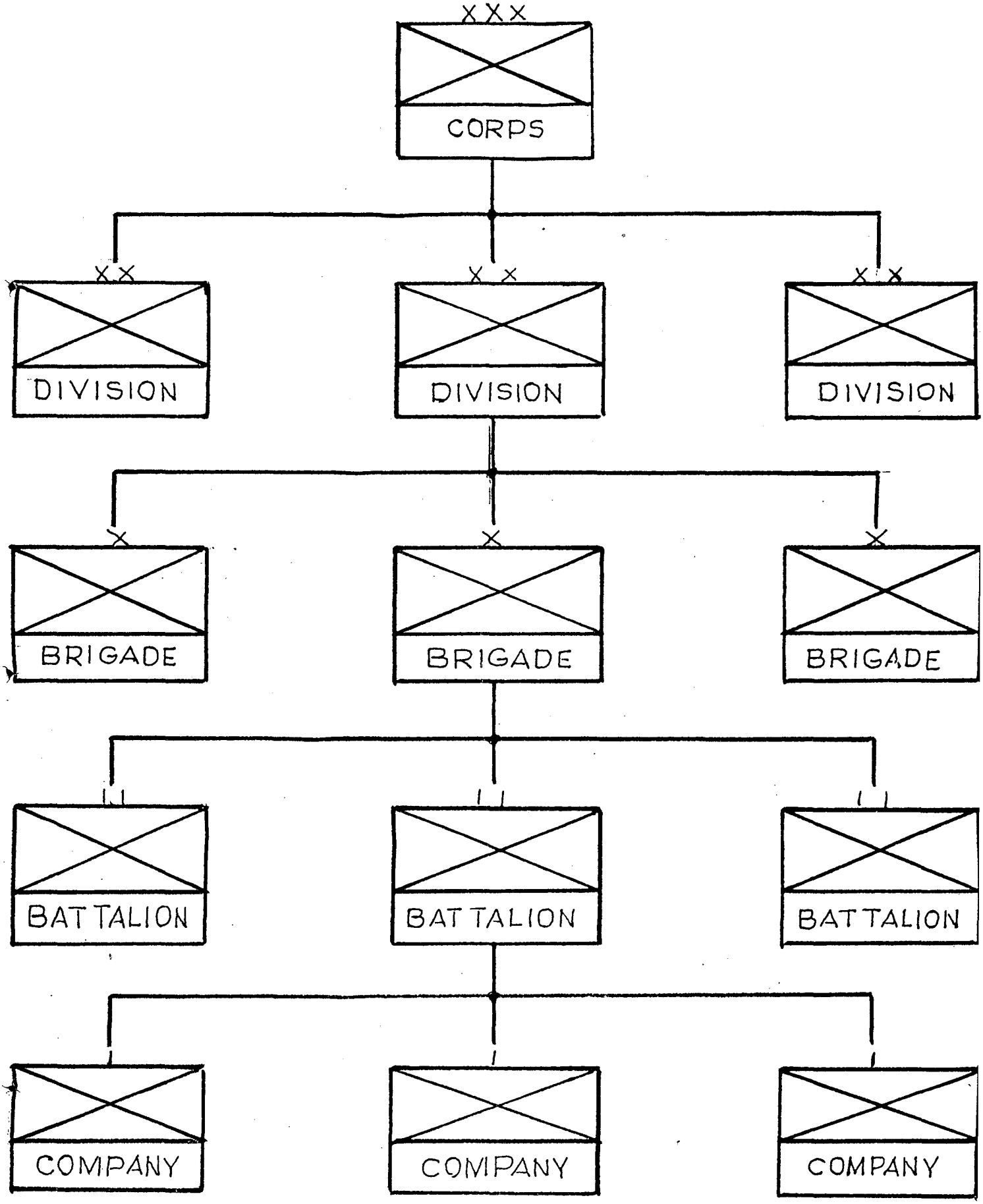


Fig . 9.1 Organisation of a Corps

SATELLITE TERMINALS PROPOSED TO BE LINKED WITH EXISTING COMMUNICATION SYSTEM

10.1 Being proposed for communication system of Indian Army, the satellite terminals should be based on INSAT series of satellites of India. All these terminals should be vehicle based, to be mobile .The satellite terminals proposed are devided into five categories based on their data handling capacities . Layout of these satellite terminals is shown at Fig١٥.١ .

(a) Gypsy subscriber terminal (GST)

10.2.1 During war / exercises Commanders of higher headquarters , officers on Observation post (OP) duties and Field Commanders (Company Commanders) are required to move frequently from one place to another . They should be in continuous communication with their troops and higher headquarters .There is an essential requirement of man-pack/ hand-held radio set with these subscribers . VHF trans-receivers are being used at present for this purpose . Communication range of these equipments is limited to 25 to 30 KMs. Radio Repeaters are being used to increase the range up to 60 KMs . For beyond this range number of repeaters are required . With each repeater noise increases considerably, limiting number of repeaters permitted . Secondly, VHF trans-receivers can not be used for point to point communication only . Trunk dialling is not possible. These problems can be solved with Hand-held/Man-pack Satellite terminals.

10.2.2 These subscribers on move are called Gypsy Subscribers . Satellite terminals proposed for them are called Gypsy Subscriber Terminals (GSTs). These terminals should be Single Carrier Per Channel (SCPC) terminals providing two way voice communication of one channel. Complete equipment , including antenna, should be carried on body of a man or mounted on a Gypsy vehicle . One GST may be provided with each subscriber mentioned above . In addition , one GST may be provided for each Battalion , with Unit Exchange ,for trunk connectivity where line layout is not possible.

(b) **VERY SMALL APERTURE TERMINAL (VSAT)**

10.3.1 To cater for number of voice , teleprinter (TP) and data channels multiplexing equipment ADM MUX is being used in Plan AREN. Radio Relay RRD is there for communication between ADM MUX and COMCENTRE (AES) . A VSAT with matching capacity of ADM MUX , i.e, 6 speech, 8 TP and 1 Computer data channels, is proposed to be introduced . If possible the VSAT should cater for about 3 data channels instead of one channel provided by ADM MUX .

10.3.2 This implies that VSAT should be multi channel per carrier (MCPC) terminal . For connectivity through satellite the 6 trunk lines of TIDEX may be connected to the VSAT. The equipment may be mounted on Gypsy / Jonga vehicle to cater for mobility .Some selected Battalions and each Brigade may be provided with a VSAT to be employed with TIDEX (40+12).

(C) SMALL SATELLITE TERMINAL (SST)

10.3.1 This terminal may be employed with selected Brigade / Divisional headquarters where communication is more and TIDEX (80 + 24) is being used at present .This terminal should cater for 12 voice trunks ,16 TPs and about 6 data channels .

10.3.2 ADM MUX 12 Ch works at 576 Kbps at Full Bit Rate and 288 Kbps at Half Bit Rate . In ADM MUX each voice / data channel is sampled at 32 Kbps . With improvement in technology a good quality of speech is being reproduced even when sampled at 16 Kbps . Therefore , a satellite terminal about 512 Kbps data handling capacity may be adequate to be used as a SST being proposed .

10.3.3 This SST may be mounted on a vehicle to be mobile along with a generator mounted on second vehicle .

(d) MEDIUM SATELLITE TERMINAL (MST)

10.4.1 This terminal may be employed with selected Division / each Corps headquarters where TIDEX (160 + 48) is being employed at present. This terminal should cater for 24 voice trunks , 32 TPs and 12 data channels . 24 voice trunks of TIDEX (160 + 48) may be connected to the MST. A terminal of 1 Mbps data handling capacity is adequate for this purpose .

10.4 .2 The MST may be mounted on two vehicles along with a generator on third vehicle .

(e) **LARGE SATELLITE TERMINAL (LST)**

This terminal may be employed with selected Corps headquarters / COMCENTRES / ASCON Gateway . The data handling capacity of the terminal should about 2 Mbps . This may employed for trunk connectivity for more than 24 voice trunk channels or as a high way RR between two COMCENTRES .This MST may be mounted on three or four vehicles to cater for mobility along with a generator set .

10.5.2 The layout of these satellite terminals is shown at Fig 6.1. As shown in the figure these satellite terminals will provide a parallel mobile communication system with Plan AREN . At a later stage , all equipments of Plan AREN beyond TIDEX , ie , ADM MUX ,RRD and AES may be replaced completely by the satellite communication system when each headquarters is provided with a satellite terminal of requisite capacity .

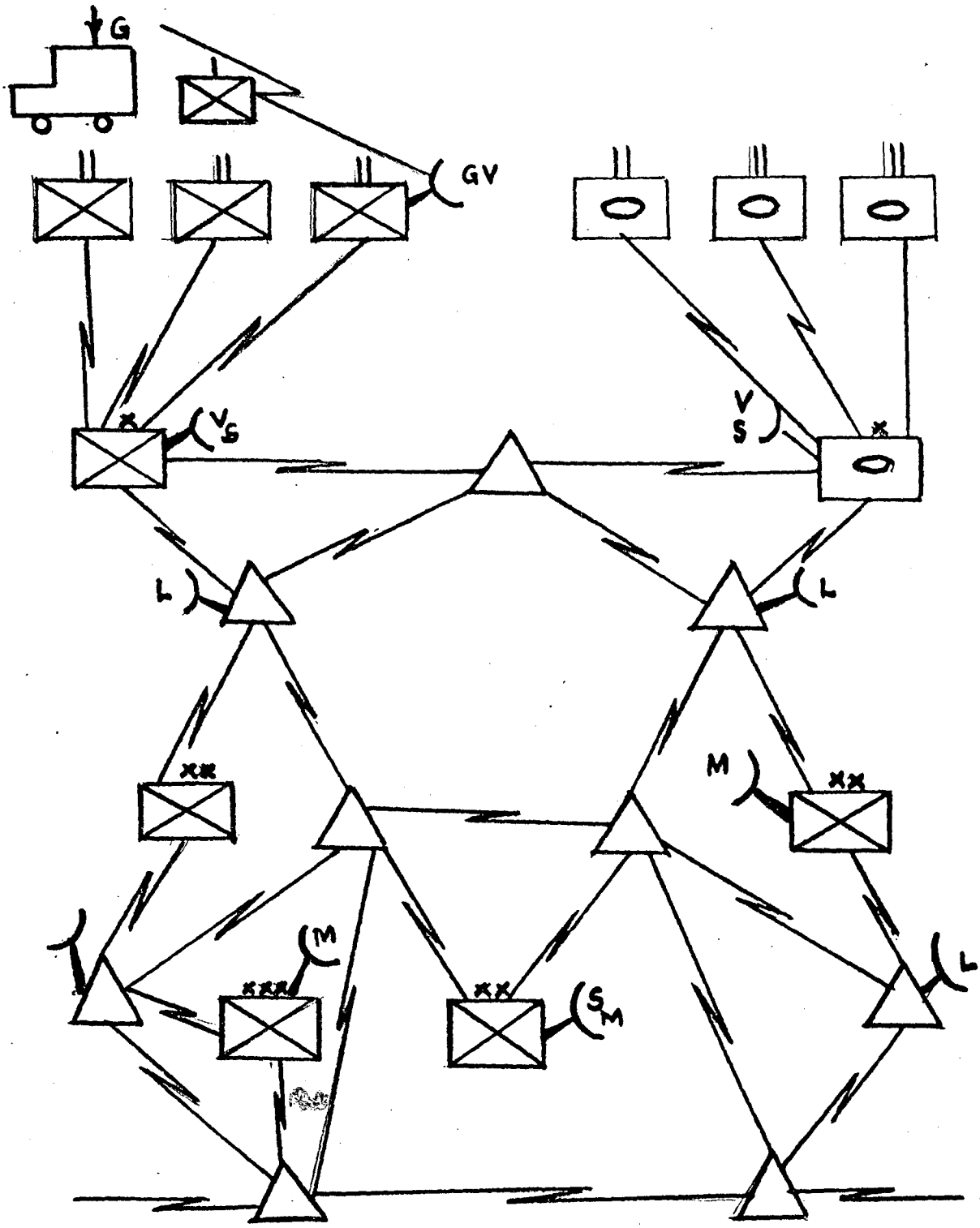


Fig . 10.1 Layout of Proposed Satellite Terminals

CHARACTERISTICS OF INSAT2C AND EARTH STATION TERMINALS AVAILABLE INCOMMERCIAL MARKET OF INDIA

11.1 This chapter brings out important technical characteristics of INSAT 2C and few satellite earth station terminals available in commercial market to study the feasibility of satellite terminals proposed to be introduced in Indian Army .

INSAT 2C

11.2.1 Indian National Satellite INSAT 2C was launched on 07 Dec 95 . This satellite is designed and manufactured by India and launched from French Guiana . It caters for mobile communication in S band ,transponders in C band and Ku band .

11.2.2 INSAT 2C has got 24 transponders . 12 transponders are operating in C band . Out of these 12 , two transponders are of 50 watts capacity, 7are of 10 watts, 3 are of 4 watts capacity . 6 transponders are operating in extended C band comprising of 2 x 10 watts transponders and 4 x 4 watts . In Ku band it has 3 x 20 watts transponders . besides it has a Ku band beacon ,Broadcast Satellite Services (BSS) operating in C band . The satellite provides 45000 two way speech channels through 119 earth stations and 600 VSATs deployed in remote areas .

11.2.3 IMPORTANT DATA OF INSAT 2C

(a) Manufactured by : ISRO (India)

(b) Expected life : 10 years

(c) Body size : Dia - 2.38 m

Height – 2.82 m

(d) Weight : 2050 Kg

(e) Solar cells

(i) Area : 20.5 Sq m

(ii) DC Power : 2000 Watts

(f) Assigned Frequency

(i) Up link frequency in C band : 5925 – 6425 MHz

(ii) Down link -do- : 3700 - 4200 MHz

(iii) Up link frequency in Ku band : 14 - 14.5 GHz

(iv) Down link -do - : 11.7 - 12.2 GHz

(g) Band width

(i) C Band : 500 MHz

(ii) Extended C Band : 300 MHz

(h) Channel Spacing

(i) C Band : 40 MHZ

(ii) Extended C Band : 72 MHz

(j) Cost

(i) Cost of Satellite : 125 crores

(ii) Cost of launching : 200 crores

SATPHONE - SP 1600

11.3.1 Satellite phone SP –1600 is a portable satellite trans- receiver fitted in a brief case . The SATPHONE is a SCPC terminal based on INMARSAT system and being used by international business travelers , Radio & TV reporters and Relief & Rescue Organisations etc. This equipment is having the facility of automatic dialing in the world-wide telephone network in duplex mode . The SATPHONE is shown at Fig. 11.1.

11.3.2 **TECHNICAL FEATURES**

(a) Frequency range : 1530 - 1660.5 MHz

(b) Modulation : PSK

(c) Type of communication : Voice , Data & FAX

(d) Channel spacing : 10 KHz

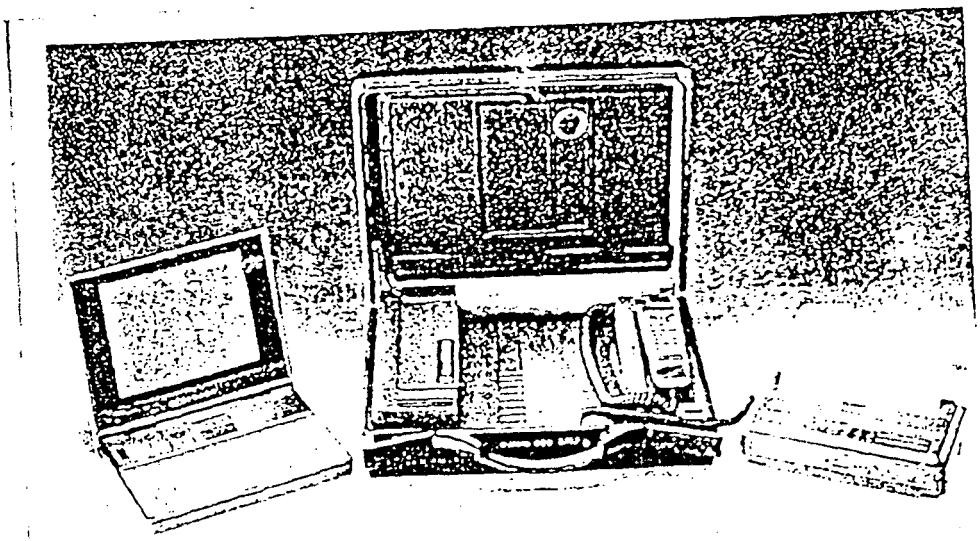
(e) Transmission mode : Duplex , Forward error corrected

(f) Transmitted Power : 16 Watts approximately

(g) Receiver sensitivity : - 139 dbm

(h) Voltage required : 110/220 V AC or 10.5 – 32 V DC

(j) Power consumption : 120 W during transmission



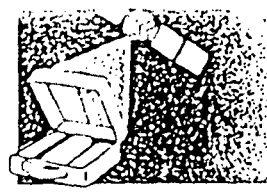


Fig . 11.1 SATPHONE : Briefcase Version

(k) Temperature range : - 25 *C to 55 *C

(l) Standard interfaces

(i) Voice : Coded as per IMBE algorithm

(ii) DAX : CCITT standard Group III

(iii) Data : RS 232 / 2 .4 Kbps

(m) Weight : 10.5 Kg

11.3.3 SATPHONE SP – 1600 is ideal to be used as Gypsy subscriber Terminal (GST) proposed . At present this type of terminals are not being manufactured in India . But they are being used and likely to be manufactured in near future .

ARCANET PERSONAL COMMUNICATION SYSTEM

11.4.1 This SCPC portable satellite terminal is using CDMA technology and fitted in a suitcase . The equipment is shown at Fig.11.2 . ARCANET was developed in collaboration with European Space Agency .

11.4.2 **TECHNICAL CHARACTERISTICS**

(a) Coverage : International

(b) Space segment : INTELSAT

(c) Frequency : Ku band

(d) Modulation : QPSK

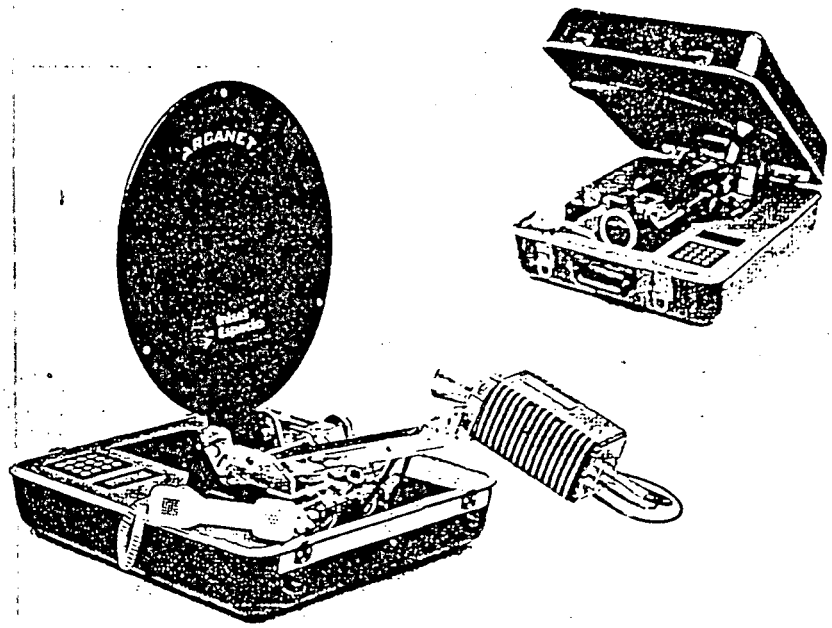
(e) Services

(i) Telephone : Full duplex at 16 Kbps or Backup mode at 8Kbps

(ii) FAX : Full duplex G- III at 4.8 Kbps

ARCANET

Personal Satellite Communication System



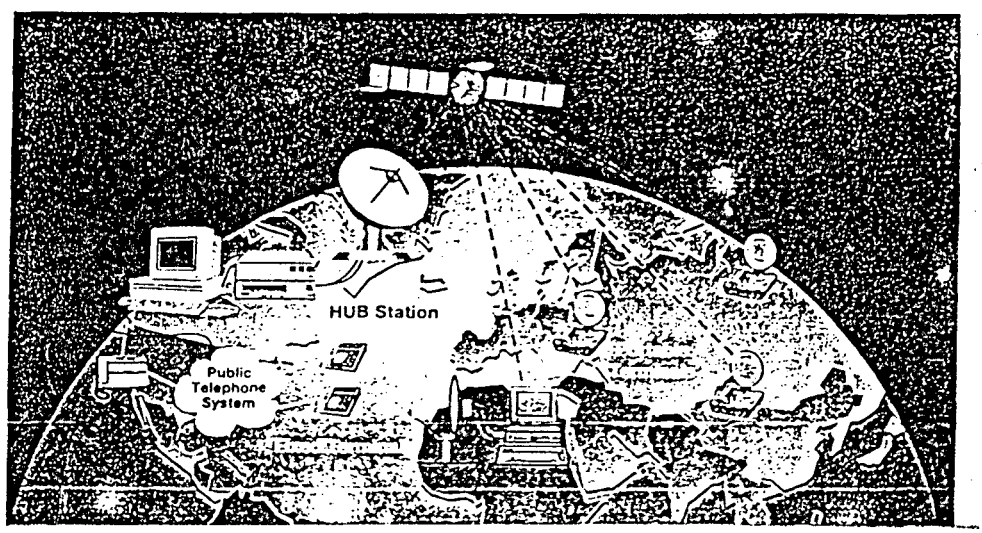


Fig . 11.2 ARCANET Personal Communication System

	(iii) Data	:	Full duplex at 4.8 Kbps or simplex broadcast mode
(f)	Antenna	:	4.5 Cm Dia , Auto pointing
(g)	RF Power	:	2 Watts
(h)	Size	:	55 x 50 x 20 Cms
(j)	Weight	:	13 Kg
(k)	Temperature range	:	-10 *C to +50 *C
(l)	Set up Time	:	Less than 5 minutes
(m)	Power input	:	220 V AC / 12 V DC

11.4.3 This type of terminal can also be used as Gypsy Subscriber Terminal (GST) proposed to be introduced in the Army .

MCPC VSAT

The Multi Channel Per Carrier (MCPV) Very Small Aperture Terminal (VSAT) is manufactured by M/S BE Bangalore and offered to National Thermal Power Corporation (NTPC) of India. The VSAT is designed to carry three voice channels and one data channel to traffic in addition to one voice channel for engineering service channel (ESC) and one data channel for network maintenance and control (NMC). The data rates for each channel can be programmed for operation from 5.33 Kbps to 32 Kbps. Group III FAX can also be transmitted/received on any of the voice channels.

11.4.2 The out door unit consists of the following:-

(a) 3.8 meters Antenna.

(b) C-Band RF trans receiver with 10W output consisting of:-

(i) RF driver unit.

(ii) Power supply unit.

(iii) Solid state power amplifier (10W).

(iv) C-Band feed.

(v) Low noise convertor.

(vi) Transmit reject filter.

11.4.3 The Indoor unit consists of:-

(a) VSAT rack comprising of:-

(i) Variable data rate MODEM.

(ii) Multiplexer.

(iii) Satellite monitor and controller processor.

(b) Digital switch.

(c) 2 KVA UPS.

11.4.4 Block diagram of the MCPC-VSAT is shown at Fig 11.3. 230 V AC and DC Btys 48 V are connected to the input of UPS system which supplies power to different stages of the VSAT. The EPABX is 24 line exchange with eight trunk lines. Three out of these eight trunk lines are connected to the input of MODEM through termination pannel and MUX rack. The MUX rack receives one data (Traffic) channel and one data (NMC) to produce a composite bi-directional stream of digital data. The IF output of MODEM, which can be set in step of 100 Hz in the IF band of 52 to 88 MHz, is coupled to the input of the Up-convertor. (RF Trans receiver). The IF is then converted to the required transponder frequency of 5925 to 6425 MHz in 2.5MHz steps. The output of up-converter is then fed to solid state power Amplifier of 10 W out put. Then the output is coupled to the antenna for transmission to the satellite. During reception, reverse process is carried out to get the desired voice/data signal. For other details of MCPC-VSAT please see Appendix '**5**'.

11.4.5 This terminal may be used as VSAT terminal mentioned at para 10.2 (b) above. This terminal may be modified to suit for few additional number of voice channels and data channels.

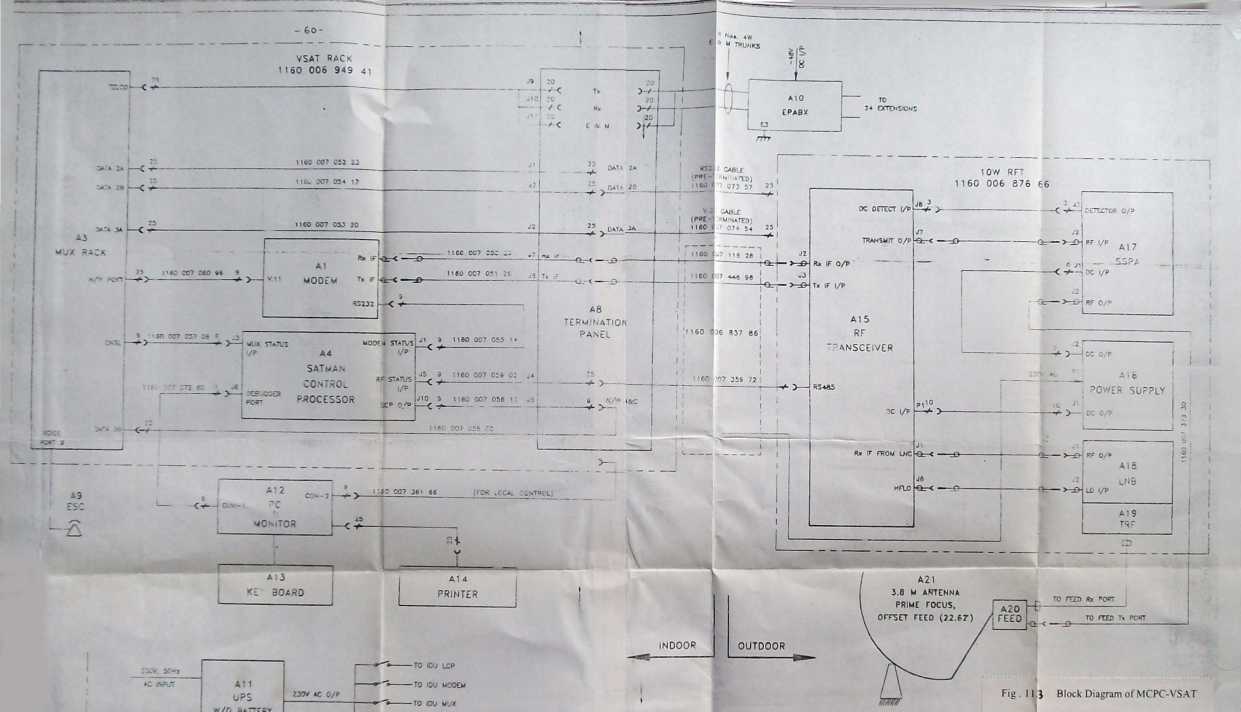


Fig. 11.3 Block Diagram of MCPC-VSAT

01	ORIGINAL						
NO.	CH. NO.	DATE	CHANGE	DD	CHCK	APPRD	NUMBER
MATERIAL		FINISH		PROJECTION			NEXT ASSEMBLY
DRAWN	CHECKED	ENGINEER	DWG. SCALE	TITLE	MCPC VSAT (UNCHAHAR)		
DATE	DATE	DATE		DOC. CODE	NUMBER	SHEET	ISSUE
				BD	1160 007 283 09	01	01
				BANGALORE		NO. OF SHEETS	01

C-BAND UP LINK EARTH STATION XU 464

GENERAL

11.5.1 C Band up link earth station XU 464 is manufactured by M/S Bharat Electronics, Bangalore and being used by Doordarshan India as mobile earth station as well as static earth station. This terminal is basically used for video transmission alongwith one radio channel. Although five video inputs and ten audio inputs can be connected to the input, only one channel each can be transmitted/received. Block Diagram of Earth Station is shown at Fig. 11.4 .

EARTH STATION PERFORMANCE SPECIFICATION

11.5.2. **Input signal**

(a).(i)	Number of video inputs	: Five
(ii)	Video frequency range	: 25 Hz to 5 MHz
(iii)	Video input level	:1 V pk to pk
(iv)	Impedance	: 75 ohms unbal
(v)	Return loss	: 20 dB
(vi)	Base band	: 5 MHz
(b) (i)	Number of audio inputs	: Ten
(ii)	Audio input level	: + 9dBm
(iii)	Audio frequency range	: 25 Hz to 10 KHz
(iv)	Impedance	: 600 ohms bal

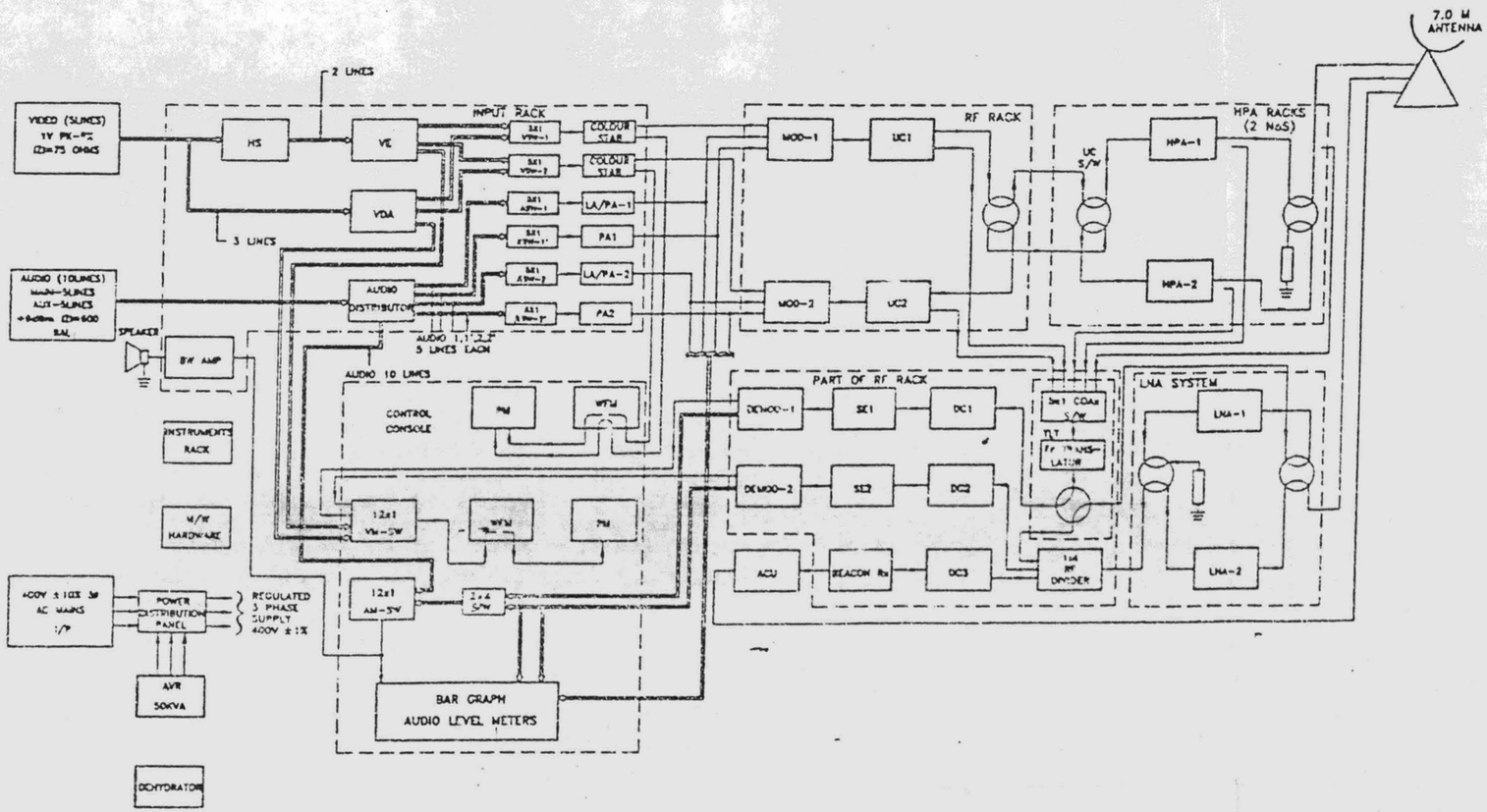


Fig . 11.4 Block Diagram of C Band Uplink Earth Station XU 464

11.5.3 **Modulation Format**

(a) Modulation	: FM
(b) Composite baseband frequency	:25 Hz to 5.9 MHz
(c) Video peak deviation	: 12 MHz
(d) Audio subcarrier frequencies	: 5.5 MHz & 5.75 MHz
(e) Audio subcarrier modulation	: FM
(f) Audio subcarrier peak deviation	: 75 KHz
(g) Audio subcarrier bandwidth	: 200 KHz

11.5.4 **Transmitter Performance (C-Band Transmit)**

(a) Earth Station EIRP : 83 dBW (max)

(b) Frequency band : 5.85 to 6.425 GHz
6.725 to 7.025 GHz
(Extended C-Band)

(c) Frequency selection : HPA tuned to one of 12 transponder frequencies while Up-converter can be selected in 125 KHz step size

(d) Frequency stability : 1 PPM/day

(e) Output level stability : ±0.5 dB/day

11.5.5 **Receiver performance**

(a) Earth station G/T : 27 + 20 log F/4dB/K

(b) Frequency band : 3.625 to 4.2 GHz

4.5 to 4.8 GHz (extended C-Band)

(c) LNA system noise temperature : 90 K (max)

(d) LNA gain : 50 dB (min)

(e) Output Characteristics

(i). Video : 1 V pk - pk

(ii). Response : ± 0.5 db over 25 Hz to 5 MHz

(iii). Audio subcarrier Frequencies : 5.5 & 5.75 MHz

(iv). Audio out put level : + 9 dBm

11.5.6 **Performance Checks**

These checks are carried out at 15 dB C/N simulated by adjusting input to LNA.

(a) **Video performance**

(i) Video frequency response : ± 0.5 db over DC to 5 MHz

(ii) S/N weighted for peak deviation of 12 MHz : 50 dB

(b) **Audio performance**

(i). Audio distortion : < 1 %

(ii) Audio frequency response : ± 3 dB
(50 Hz to 10 KHz)

(iii) S/N Ratio : 55 dB

11.5.7 **Intermediate Frequency (Modem)**

(a) IF Range : 70 ± 18 MHz

(b) IF Band with : 17.5 MHz, 23 MHz, 30 MHZ (switch selectable)

(c) Mod/ Demod Linearity : < 3 %

(d) Peak to peak deviation : ± 12 MHz (max)

11.5.8 **Antenna**

(a) Antenna Type : 7.0 m parabolic reflector

(b) Feed system : Cassegarin, 2 port liner, with 4 port linear 4 circular as an option

(c) Antenna gain : Tranmit 51.1 dB
: Receiver 47.6 dB

(d) Antenna travel elevation : 5 to 90* continuous

(e) Azimuth : 180* continuous

(f). Polarisation : Linear horizontal/vertical

11.5.9 **Power Supply**

(a) Supply voltage : 415/380 VAC, 50 Hz 3 Phase

(b) Consumption : 40 KVA

11.5.10 **Mechnical Details of Equipment**

(a) **Dimensions**

(i) Station Equipment racks (Overall) : (H) 2200 mm x (W) 3000 mm x (D) 800 mm

(ii) Control Console : (H) 1040 mm x (W) 1560 mm x (D) 1170 mm

(iii) Power Distribution Panel : (H) 1600 mm x (W) 1200 mm x (D) 600 mm

11.5.11 Weight

(a) Overall Equipment : 1740 Kg

(i) Station Equipment racks (Overall) : 1450 Kg

(ii) Control Console : 110 Kg

(iii) Power distribution panrl : 180 Kg

(b) Antenna : 2500 Kg

Conditions of usage

11.5.12 The equipment is designed for static operation, working in shaded and protected environment, and installed upright. It is designed for continuous operation. Permissible operating temperature and environment conditions for satisfactory operation are :-

(a) Temperature range : 0 to 50* C
(b) Relative humidity : 95% at 40*

11.5.13. This terminal transmits a modulating frequency up to 5.9 MHz Instead of this modulating frequency digital multiplexed data can be transmitted after suitable modification to the equipment . This equipment is operating in C Band with an antenna of 7 Meters in size. The size of the antenna can be reduced using a higher carrier frequency.

INTELSAT F3 EARTH STATION

11.6.1 The INTELSAT F3 Earth Station Equipment XU 465 is manufactured by M/s Bharat Electronic Bangalore, India. It is used for digital transmission of telephone and data through INTELESAT Satellites. These Earth Stations can support both IDR (Intermediate Data Rate) and IBS (International Business Service) Carriers. The present F3 Earth Station are equipped for IDR carrier up to 6312 Kbps data rate. The Earth Station operate in the transmit frequency band of 5.85 to 6.425 GHz and in the receive frequency band of 3.625 to 4.2GHz . The Earth Station is configured in (1+1) redundant mode with facility to expand up to (5+1) carrier. Equipment layout of F3 Earth Station is shown at Fig. 11.5.

11.7.2 EQUIPMENT CONFIGURATION

The Earth Station Consists of the following equipments: -

(a) 9.2 meter Antenna with 4 port circular polarised feed and equipped with step track facility.

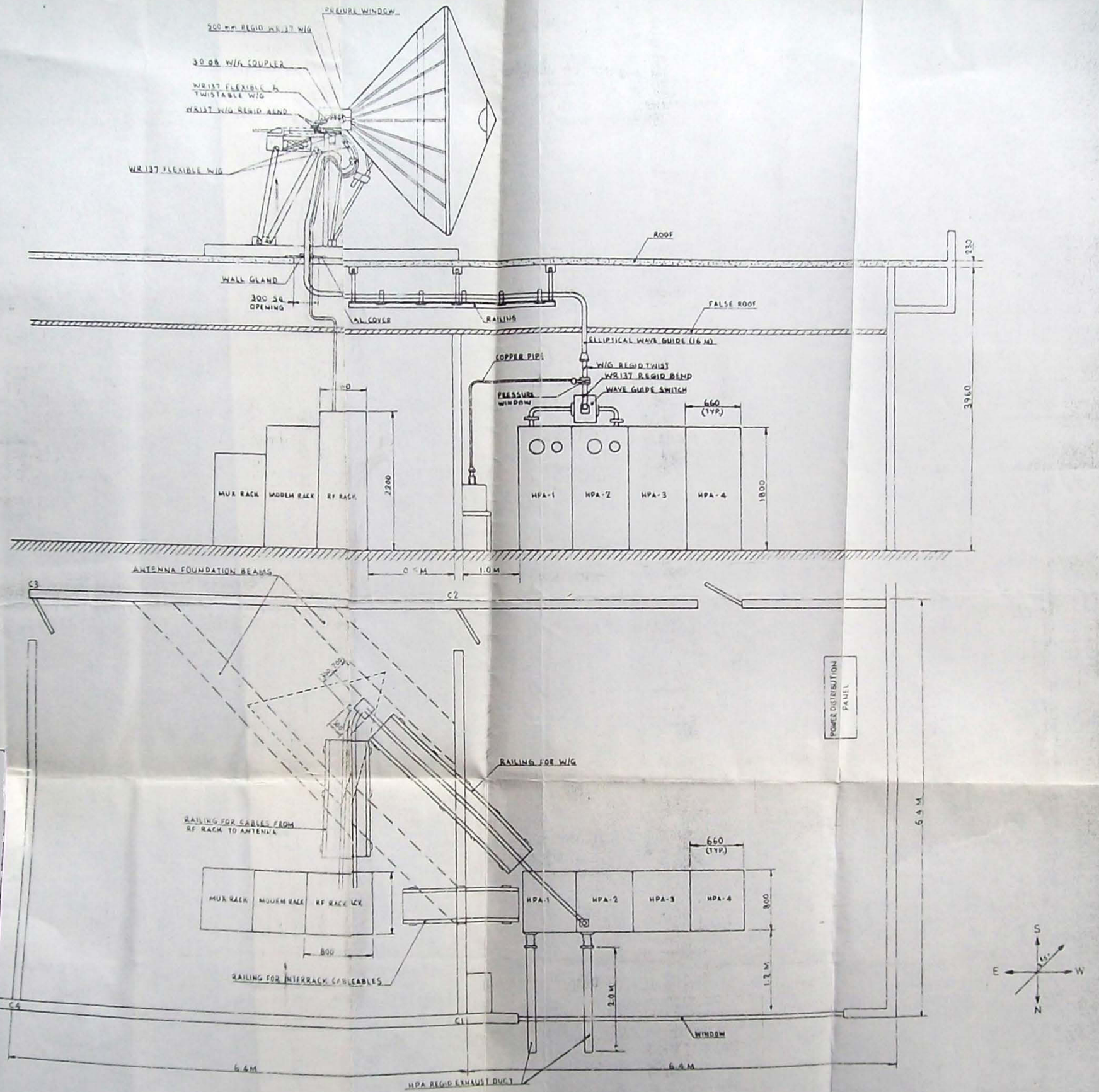
(b) 1.5 KW Klystron high power Amplifier in (1+1) redundant configuration.

(c) (1+1) Low Noise Amplifiers.

(d) RF Rack consisting:

(i) (1+1) up converters with system equalisers.

(ii) (2+1) Down converters with system equalisers.



NOTE : HPA3 AND HPA4 ARE SHOWN FOR REFERENCE ONLY AND MEANT FOR FUTURE EXPANSION.

Fig . 11 .5 Equipment Layout Diagram of F3 Earth Station XU-465

(iii) Control unit for LNA and HPA.

(iv) Beacon Down converter & Beacon receiver.

(f) IDR modulators and demodulators.

(g) Test instruments

(h) Microwave hardware for interconnecting Antenna & HPA.

11.7.3 Apart from these a power distribution panel, Automatic voltage regulator and Uninterrupted Power Supply (UPS) would be provided the LNA is mounted in the Hub of Antenna, which is located on top of the building. The other equipments are located inside the building .

EQUIPMENT DESCRIPTION

Transmit Section

11.7.4 The incoming IDR carrier at 6312 Kbps data rate from digital 2nd order MUX is devided in to two streams and connected to MOD 1 and MOD 2. The MOD 1 and MOD 2 or working in (1+1) hot stand by mode with a switching unit to switch over the traffic automatically during the failure of Modulator. The modulator accepts 6312 Kbps data rate and adds the required over head bits and introduces. Forward Error Correction Code (FEC) and QPSK modulates the signal of IF carrier. The IF carrier can be selected depending on the available slot in the transponder, in steps of 22.5 KHz by a frequency synthesizer in the frequency band of 52 to 88 MHz. The modulated IDR signal is then taken through the top of the MODEM rack to the RF rack.

11.7.5 In the RF rack the modulated signal is again divided and connected to Upconverter 1 and Upconverrter 2.. The Upconverters are working in (1+1) hot stand by mode. The Upconverter converts 70 MHz modulated signal to the required to transponder frequency. The signal is first converted to 1115 MHz signal and then using a microwave frequency synthesizer the signal is Upconverted to the required transponder frequency. By this type of double conversion it is possible to select any transponder frequency without changing any component in the Upconverter. The synthesizer can operate in the step size of 125 kHz to give an RF frequency band of 5.85 to 6.425 GHz. The signals from the two Upconverters are selected in the changeover unit. The changeover takes place automatically depending upon the status of the two Upconverters. A manual over ride facility is provided in the change over unit.

11.7.6 The output of the selected Upconverter is connected to the 8 Klystron High Power Amplifier (KHPA) switch. This connects the signal to the selected Klystron Amplifier. The Klystron amplifier is tuned to each one of the 12 transponder frequencies of INTELSAT. The amplifiers has a1 dB band width of more than 45 MHz. The KHPA amplifies the Upconverter signal to the required power output. The KHPA has a gain of 80 dB in the frequency band of 5.85 to 6.425 GHz. The output of the amplifier is taken through a waveguide switch which selects the output of

the traffic carrying KHPA. The KHPA output is taken through flexible elliptical wave guide to the antenna.

Antenna

11.7.7 The antenna operates in the transmit frequency band of 5.85 to 6.425 GHz and receive frequency band of 3.625 to 4.2 GHz. This is a 9.2 m antenna using 4 port reuseable feed. The antenna has a 53.5 dB gain at 6 GHz and 50 dB gain at 4 GHz. A step track system is used for pointing the antenna towards the satellite. The step track system consists of a Beacon Downconverter, Beacon Receiver, Antenna control unit and a motor control unit. The Beacon downconverter is a synthesizer down converter which can receive any one of the beacon signal.

11.7.8 The Beacon downconverter is identical to the down converter used for IDR receivers. The Beacon receiver accepts the 70 MHz signal from Beacon downconverter and gives a DC signal corresponding to the Beacon signal strength. This is a PLL type of receiver which locks on to the incoming beacon frequency. The DC signal corresponding to the signal strength is connected to the antenna control unit. The Antenna Control Unit (ACU) is a PC based system which sends control signals to the motor control unit of the Antenna. The antenna has Azimuth and Elevation control motors. The ACU first peaks the signal in the Azimuth direction. The motor control unit is located near the antenna.

11.7.9 **Receive Section**

The received signal from the antenna feed is connected to a (1+1) Low noise Amplifier Unit. The LNA has a 60 dB gain and 65 K noise figure. The LNA unit is located in the hub of the antenna to reduce the front end losses. The power supply unit and the control unit of LNA are located in the RF rack. The LNA output is taken through a 1/2" foam dielectric low loss cable to the RF rack. The received signal is taken through a 1:8 RF divider to various downconverters. There are four downconverters located in the RF rack. The first downconverter is connected to the beacon receiver. The second and third downconverters are tuned to the required transponders and the fourth downconverter is a standby unit. The down converters employ double conversion and the first local oscillator is a frequency synthesizer with a step size of 125 kHz. The traffic carrying downconverters outputs are taken through a (2+1) Downconverter switch which automatically selects the working down converter.

11.7.10 The 70 MHz output of the downconverter is taken to the IDR demodulators. The demodulators are coherent QPSK demodulators which demodulates 6312 Kbps signals. The demodulators also perform FEC correction to get better bit error rates. The output of the demodulator is 6312 Kbps data. This data is connected to the 2nd order demux located in the Earth Station.

11.7.11 The Earth Station is also equipped with the following test instruments.

a. RF power meter - HP437B with 8481A power sensor.
b. RF frequency Counter - HP 5350B
c. Spectrum Analyser - MS 710C (Anritsu)
d. Microwave system Analyser - 538 L(Anritsu)
e. Digital transmission Analyser - MD 6420 (Anritsu)

These test instruments are used for monitoring and aligning the Earth Station.

11.7.12 **TECHNICAL FEATURES**

(a) **Terrestrial interface**

(i) IP/OP Interface : G 703/G747
(ii) IP/OP Information rate : 64 kbps to 8.448 Mbps

(b) **Overhead frame structure**

(i) Overall : 96 kbps
(ii) ESC voice channels (two) : 32 kbps
(iii) Digital ESC : 8 kbps
(iv) Frame/Multiframe alignment and alarm : 24 kbps signal

(c) **Intermediate Frequency**

(i) IF Frequency Range : 70 + 18 MHz

(ii) IF Frequency Step size : 22.5 KHz

(iii) Modulation : QPSK

(iv) Frequency Stability : 1 PPM

(v) IF Output level : 0 to -15 dBm

(vi) IF Input level :-25 to -45 dBm(with ALC)

(vii) Acquisition time : 3 Sec (Max)

11.7.13 **Transmitter Performance (C band transmit)**

(a) Earth Station EIRP : 80.5dBW

(b) Frequency band : 5.85 to 6.425 GHz

(c) Frequency Selection

HPA : 12/24 Channels

Upconverter : 125 KHz Step size

(d) Frequency Stability : 0.003 rpm/Day

(e) Output Level Stability(HPA) : ±0.5 dB/Day

(f) Instantaneous band width : 36 MHz

(g) IF/RF Gain (Upconverter) : 20 dB±0.5 dB

(h) RF/IF Gain (Down Converter) : 50 dB(Minimum)

11.7.14 **Receiver Performance (C bans Receive)**

(a) Earth Station G/T : 29.5 + 20 Log F/dB/K

(b) Frequency band : 3.625 to 4.2 GHz

(c) LNA System Noise Temp : 90 Degree K (Max)

(d) Individual LNA Noise Temp : 60 Degree K (Max)

(e) LNA Gain : 60 dB (Minimum)

11.7.15 **Antenna**

(a) Antenna Type : 9.2 Mtr Parabolic Reflector with Elevation over Azimuth type mount

(b) Feed System : Cassegrain 4 Port Linear
(4 port Circular as an option)

(c) Antenna travel

Elevation : 5 to 90 Degree continuous

Azimuth : 0 to 180 Degree continuous

11.7.16 **Power Supply**

(a) Supply voltage : 415/380 V AC 50Hz 3 phase

(b) Consumption : 40 kVA (MAX)

11.7.17 **Other Details**

For other details of the earth station please refer Appendix `H' of this dissertation.

11.7.18 This equipment has a handling capacity of 6 Mbps against our maximum requirement of 2 Mbps . This is basically designed for static role. Movement of 9.2 meter antenna will be difficult some times . Therefore, this terminal, as it is ,may not be suitable. Terminals of lesser capacity working on the same principle will be having lesser size of antenna. Antenna of about 3 meter size will be ideal for mobile purposes. However , there are mobile tropo terminals in Army, with big antenna , terminals in mobile role .

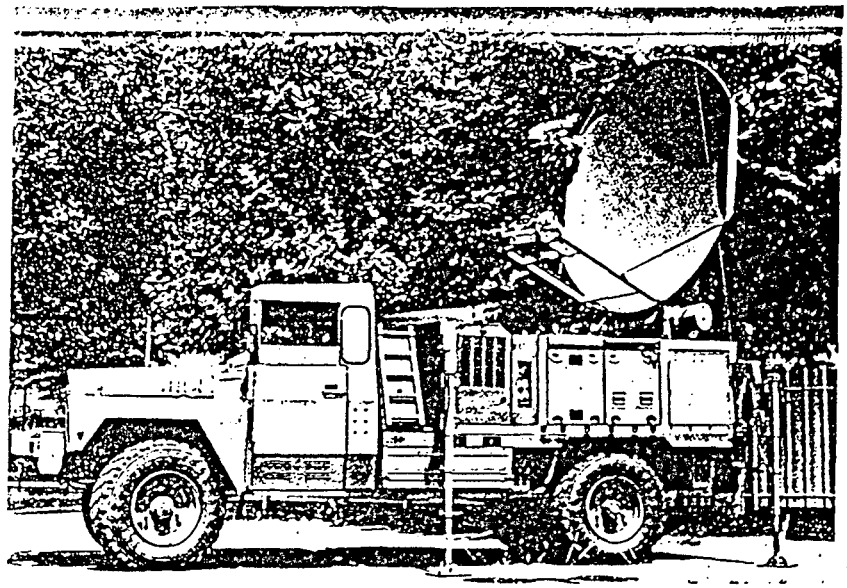
TITANS

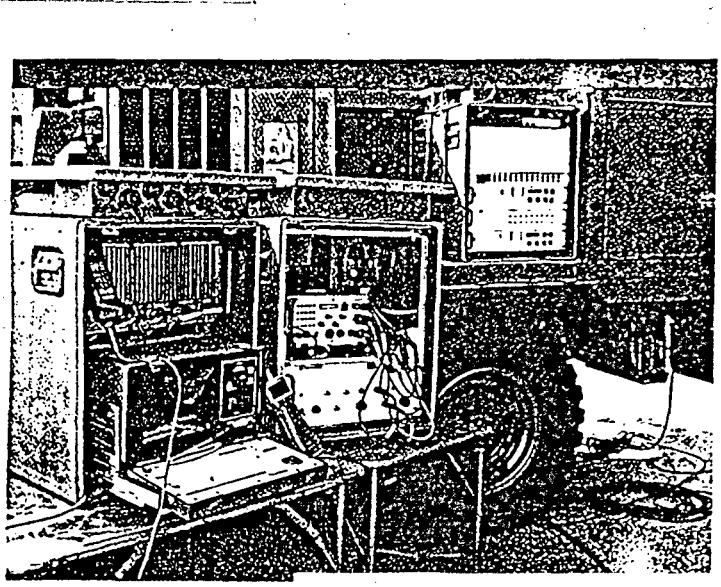
11.8. 1 TITANS stands for Totally Integrated , Tactical And Autonomous Nodal SATCOM and provides solution for a variety of communication needs through military and commercial satellites . This equipment is manufactured in France . TITANS is a vehicle mounted equipment . It is operating in C , X , Ku frequency bands . It supports multi carrier transmission and multi data rate applications such as voice , FAX ,Data and Video conference .The Equipment mounted on a vehicle is shown at Fig.11.6 .

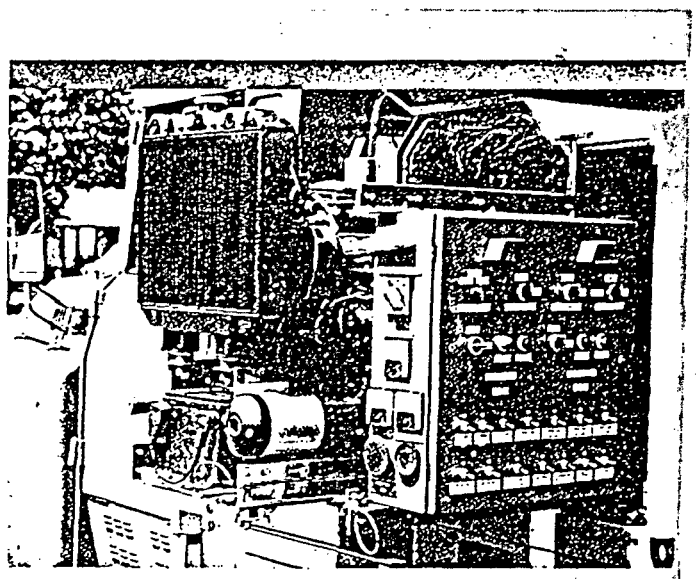
11.8.2 **TECHNICAL CHARACTERISTICS**

(a) **Frequency**

	Band	Transmit	Receive
(i)	C Band	3.625 - 4.200 GHz	5.850 – 6.425 GHz
(ii)	X Band	7.250 - 7.750 GHz	7.900 - 8.400 GHz







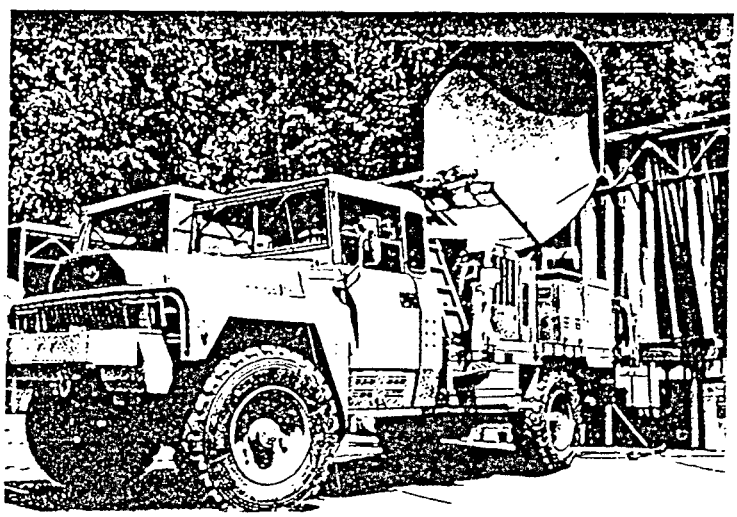


Fig . 11.6 Vehicle mounted Earth Station : TITANS

(iii)	Ku Band	10.950 – 12.750 GHz		14 – 14.5 GHZ
(b)	EIRP	:	65 dbw	
(c)	MODEM Data rate	:	2.4 Kbps – 9.216 Mbps	
(d)	Modulation	:	BPSK,QPSK	
(e)	Temperature range	:	-25*C to +50*C	
(f)	Weight	:	2500 Kg	
(g)	Setup time	:	20 min for 2 trained persons	
(h)	Antenna	:	2.4 M dia ,Auto pointing	
(j)	Internal Energy	:	2 x Diesel Generators of 220 V, 12 KVA	
(k)	Power consumption	:	10 KVA max	

MINOS

11.9.1 MINOS , stands for MODULAR Integrated Nodal SATCOM , is designed to meet the emergent requirement of countries equipped with civil or military satellite resources which have to rapidly implement telecommunication links . MINOS is tactical three band (C, X , Ku)station for satellite communication . This equipment is manufactured by France . It offers multi-carrier , multi-rate links . The equipment supports digital transmission , secured or not , Voice , Data , FAX , Video conferencing ,etc .MINOS is transportable in cases and easy to install . the layout of equipment is shown at Fig. 11.7 .

TECHNICAL CHARACTERISTICS

(a) **Frequency**

Band	Transmit	Receive
(i) C Band	3.625 – 4.200 GHz	5.850 – 6.425 GHz
(ii) X Band	7.250 – 7.750 GHz	7.900 – 8.400 GHz
(iii) Ku Band	10.95 – 12.75 GHz	14.00 – 14.50 GHZ

(b)	EIRP	:	60 to 68 dbw
(c)	MODEM data rate	:	9.6 Kbps to 9.216 Mbps
(d)	Modulation	:	BPSK , QPSK
(e)	Temperature range	:	-25*C to +50*C
(f)	Weight	:	350 Kg (in 5 cases)
(g)	Power input	:	110 / 220 V , 1.6 KVA
(h)	Antenna	:	2.4 M dia
(j)	Set up time	:	30 min for 2 trained persons

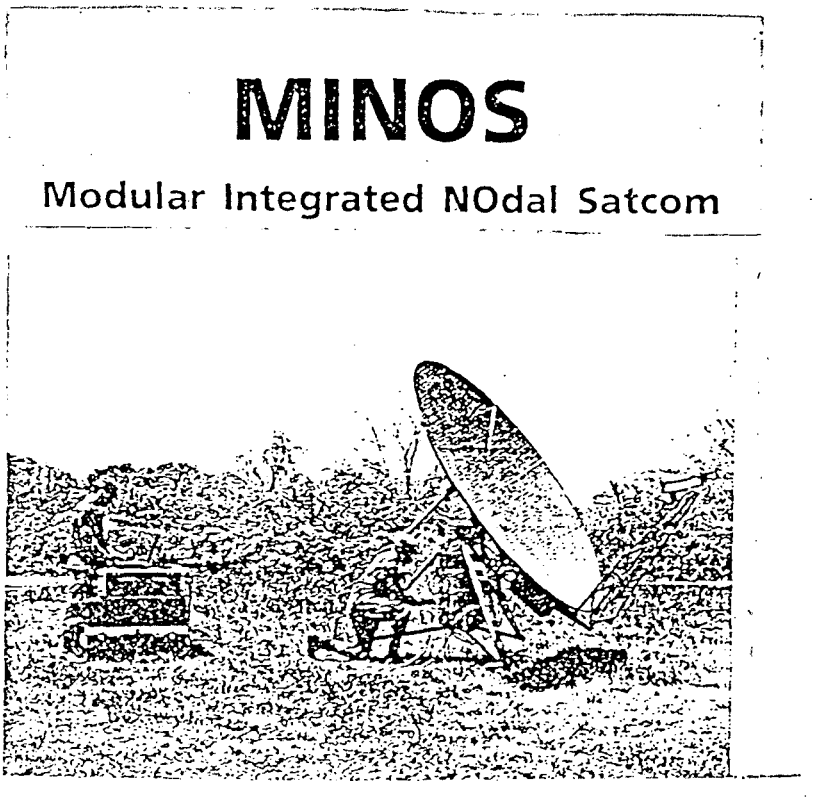


Fig . 11. 7 Transportable Earth Station : MINOS

FEASIBILITY OF SATELLITE TERMINALS PROPOSED TO BE INTRODUCED

12.1.1 As the system has been proposed to be based on INSAT series of satellites , this Dissertation has brought out the important technical characteristics of INSAT -2C , operational at present . Since INSAT 2D has been abandoned by ISRO and not in operation , it has not been included in the Dissertation . INSAT-2E has been planned to be launched in 1998 which will provide all the facilities provided by INSAT-2C .

12. 1.2 Five types of satellite terminals were proposed to be introduced as per the requirements of the Army. This chapter brings out the feasibility of these satellite terminals to be introduced into the Army, considering the following:-

a) Whether the technology of manufacturing the satellite terminals is existing in India / else where in the world .

b) Whether the satellite terminal is being manufactured in India / can be manufactured in India .

c) Whether the satellite terminal can be interfaced with existing equipment in the Army .

d) Any modifications required .

GYPSY SUBSCRIBER TERMINAL (GST)

12.2.1 The technology required for this mobile terminal is available . SATPHONE SP-1600 and ARCANET Personal Communication System are available in the commercial market . India has not manufactured any

such satellite terminal so far. M/s BE Bangalore, ECIL Hyderabad which are manufacturing VSAT terminals are capable of manufacturing the GSTs proposed. These terminals working in 'S' Band, can be based on INSAT-2C. Indian Railways are also planning to introduce this type of terminals in all important passengers trains. If Indian Army also putsup its demand, one of the above manufacturer can supply them in one or two years time.

12.2.2 Regarding interfacing, since the input to this equipment is analog voice signal their will not be much of problems. Signalling and synchronisation system should be designed to make it compatible with INSAT series of satellites. CDMA/DAMA system may be incorporated to cater for more no of subsribers on same frequency.

12.2.3 In view of the above reasons, the GST may be treated as feasible to be manufactured and introduced in the Army.

VSAT

12.3.1 MCPC-VSAT terminal discussed in chapter – is being manufactured and being used with INSAT-2C. The no of voice and data channels can be increased if required by modifying the equipment. Interfacing with TIDEX (40+12) will be possible. The six trunk lilnes of TIDEX can be directly coupled to the VSAT. Since coupling is again an analog voice signal, there will not be any interfacing problems. To connect the required no of TPs and computers, the multiplexing equipment employed in the VSAT needs modification , which will be feasible.

12.3.2 Since the MCPC VSAT is already being used, signalling and synchronisation problems with satellite will not arise. Therefore the VSAT terminal is feasible to be manufactured and introduced in the Army.

SST, MST AND LST

12.4.1 Small Satellite Terminal (SST), Medium Satellite Terminal (MST) and Large Satellite Terminal (LST) have been proposed to cater for data handling capacities of 512 Kbps, 1024 Kbps and 2048 Kbps respectively. Since Earth Station XU464 and XU465 with data handling capacity Mbbs are designed and manufactured by India .This brings out that design and manufacturing of the proposed SST, MST and LST are possible in India. It is brought out the all Satellite Terminals discussed in chapter - , other than Briefcase version and VSAT offer data handling capacity of about 6 Mpbs. Therefore same Satellite Terminal may be used as SST, MST and LST. But multiplexing equipments, whose output is to be coupled to these Satellite Terminals, will be of varying capacities as per the requirement. The multiplexing equipments should be designed keeping in view the signalling and synchronisation system of INSAT 2C/2E.

12.4.2 The details discuss above brings out that the Satellite Terminals are feasible to be manufactured in India. Multiplexing equipment should be designed such that they have no interfacing problems with the satellite terminals.

OTHER IMPORTANT POINTS TO BE CONSIDERED

13.1 Chapter 12 has brought out that the satellite communication system is feasible to be introduced in the Army. In induction stage, the satellite terminals may be used for parallel communication with Plan AREN. Once fully inducted. i.e. at least one satellite terminal connected with each exchange (TIDEX), the equipments ADM MUX,RRD, AES of Plan AREN may become redundant. By the time this Satellite Communication System is inducted fully, all existing equipments would have out lived their life and will be in discard stage. Therefore, the cost of new equipment in lieu of old equipment to be replaced ,can be utilised to purchase to Satellite Terminals proposed.

Secrecy Equipment Blue Star

13.3 Blue Star has been designed to function with ADM MUX . The multiplexing equipment proposed to designed should be based on protocals of INSAT. Secrecy equipment also required to be designed accordingly to function along with multiplexing equipment.

Switching at Transponder

Switching of speech , TP and Data channels at the transponder is to be carried out on plain data. Encrypted data may be required to be decrypted first before switching and encrypted once again after switching is carried out. Accordingly a transponder may have to be designed to cater for

Military Communication, including Ciphering equipment. Satellite terminals with encryption facility (Over the air rekeying, crypto key roll over) are already existing in France. Otherwise Satellite Terminals utilisation will be restricted to work as a Radio relay in place of RRD.

Non availability of Satellite Services

13.5 During Eclipse period the satellite services may not be available. Although this phenomenon occurs only for a brief and predicted period, alternate arrangements may be required to cater for vital military communications. Secondly, though the satellite services are very reliable, one can not rule out the possibility of failure. INSAT-2D has been abandoned due to a short circuit triggered electrical problem. To cater for essential Military communication a standby Satellite is inescapable. Keeping the fast developments in space programme of India, it is possible to have at least two INSATs working simultaneously to cater for unexpected problems.

ADVANTAGES OF INTRODUCING SATELLITE COMMUNICATION IN THE ARMY

1. Communication will be based on latest technology making it possible to utilise modern Value Added Devices (VADs) such as G3 FAX, Video Conference and ISDN facilities in future.

2. Number of UHF repeaters(Radio Relay Systems) and AESs being used and aging can be replaced by utilising the services of already existing INSAT services and thereby saving economic resources.

3. Establishment of communication will be easier and time saving compared to establishment of UHF repeaters at every 30 Km distance.

4. More reliaable communication compared to UHF repeaters system.

5. Wider bandwidth is available for communication to cater for increasing high speed data communication requirement.

6. Flexibility of communication network increases many fold.

7. Satellite communications are more survivable from enemy threat compared to UHF repeater system.

DISADVANTAGES

1. Equipments required being more complex ,it demands highly skilled manpower for operation and maintenance. This will lead to more training requirements.

2. Initial cost of satellite terminals will be higher.

3. Being based on single satellite, complete communication may be disrupted when lonely satellite fails.

4. Transportation of Large satellite terminals from one place to another during exercises/war will be more difficult.

CONCLUSION

1. Outcome of a Modern warfare depends , to a great degree on the effectiveness of communication system used . Gulf war has proved the efficacy of effective electronic warfare system.

2. Satellite communication is very essential for any modern Army. Besides the advantages mentioned in earlier paragraphs, Satellite Communication can form the back bone of the modern electronic warfare.

3. The dissertation has brought out that introduction of satellite terminals in the existing communication system is feasible.

4. Sooner Indian Army opts for Satellite communication, the better it will be.

5. Let us hope that India enters 2000 AD with an effective satellite communication for Defence Services.

LIST OF APPENDICES

Appendix 'A'

(Refer to para 6.1.10 of thesis)

TECHNICAL DETAILS OF EXCHANGE TELEPHONE AUTOMATIC (TIDEX)

1. Exchange Telephone automatic (TIDEX) is a microprocessor controlled TDM exchange . TIDEX provides automatic switching for Subscribers, Grid Trunks and Universal Junctions. TIDEX is a communication switching equipment for use at various formation levels in the forward areas. TIDEX is designed for modular expansion from an initial capacity of (40 + 12) lines to (160 + 48) in stages.

2. TIDEX consist of the following sub units in different quantities depending on the configuration :

(a) Processor and Switch unit (PAS) with power supply unit

(b) Subscriber Unit (SUA for Initial and SUB for additional) with DC/DC Power Supply Unit (PSU)

(c) Operator Console

(d) Mains Power supply (MP 1 or MP 2)

(e) Junctions Box (JB 1 or JB 2)

(f) Line Termination Box

FUNCTIONAL CHARACTERISTICS

CAPACITY

3. TIDEX can be configured to have an initial capacity of 40 subscribers, 6 Grid Trunks and 6 Universal Junctions. This can be

expanded in similar steps up to 160 subscribers, 24 Grid Trunks and 24 Universal Junctions.TIDEX provides a full availability switching .

SPEECH PATH

4. TIDEX provides Time Division Switching ,i.e., the speech path within the exchange is time shared between the calls in the system . This is accomplished in TIDEX by first converting the incoming analog speech signals from lines in to digital signals by Adaptive Delta Modulation (ADM) . These signals representing sampled speech are written in to a high speed memory in sequential locations . To connect two lines ,the sampled speech of one line is read out from the memory at an appropriate time and made available to the other line . These digital signals are converted it analog from and transmitted to the line. Time Division Switching offers a number of advantages such as simple and reliable hardware, compatibility with digital communication system , etc.

PROCESSOR

5. TIDEX has dual microprocessor sub system for control . The two microprocessors operate sharing the processor load. The control programs reside in Read only Memory (ROM) of the sub system whereas the data pertaining the calls resides in Read Write Memory (RWM).Input - output circuits provides interface between the microproessor and other subsystems such as time division switch, signalling ports, operator console, etc. The processor subsystem continuously monitors lines status of all lines and take appropriate action like collecting dialled digits, connecting/disconnecting tone, speech path, ring and loop relays, etc .

LINE INTERFACE

6. There are three of line interface corresponding to three types of lines. The subscriber lines interface with field telephone with dial attachment. The Grid Trunk have both way interface suitable for loop calling and dialling. Universal Junction (UJ) provides the following types of signalling

a. Loop calling /Dialling

b. A C Ringing

c . E & M Signalling

It is possible to select the required type of signalling for UJs in the field. All lines provides balanced two-wire speech path . Subscriber provides a -48 v battery for loop sensing and energising microphone. Trunk and UJs with loop signalling have a -24V battery for loop, sensing .

CALL PROCESSING

7. TIDEX can handle the following types of calls:

a . Subscriber to Subscriber

b . Subscriber to Grid Trunk and vice versa

c . Subscriber to Universal Junction and vice versa.

d . Subscriber/Grid Trunks/UJ to Operator and vice versa.

e . Trunk to UJ and vice versa.

All these types of calls can be either directly dialled by the line (when allowed/possible) or obtained trough the assistance of the operator.

Line interface circuits provide the signalling information to the processor which analyses it and provides a speech path through the time Division Switch .

FACILITIES

8. TIDEX provides the following facilities :

a. Priority on all types of call

b. Time out on incomplete dialling , excessive inter-digit pause and busy tone.

c. Enquiry and call transfer.

d. Ring transfer for selected pairs.

e. Unconnected line indication .

f. Trunk access barred for selected subcribers.

g. Conference of any five lines.

h. Field selectable signalling for Universal Junctions

j. Operator assistance for all type of calls.

k. Simple fault diagnosis from operator console.

l. Status scanning of selected group of line s from the operator console.

m. Traffic statistics collection and display.

n. Optional assistance telephone to distribute operator load.

CONFIGURATION AND CAPACITY

9. TIDEX is modularly designed such that it can be configured to provide switching facilities in three capacities. These configurations are referred to as (40+12), (80+24) and (160+48).

SWITCHING TECHNIQUES

10. The following switching techniques are employed in TIDEX.

a. Adaptive delta modulation at 32 KB/S for speech digitisation.

b. Single stage memory multiplexer time division switch providing full availability, non blocking switching.

c. Digital service tone generation.

CONTROL TECHNIQUES

11. Dual Microprocessor control in load -share mode is employed in TIDEX.

SPEECH CHARACTERISTICS

12. a. Voice Frequency : 300 Hz to 3400 Hz

b. Insertion loss (TE) at 800 Hz : -1 ± 1 dB

c. Signal to Quantisation Distortion : Better than 20 dB

d. Cross talk : Better than -60 dB

FACILITIES CODE DIGITS

13. a. Priority code : 2

b. Enquiry : 3

c. Conference entry : 8

TONES AND RINGING

14. TIDEX provides the following tones and ringing to indicate the progress of the calls and facilities.

S.No	Tone	Frequency	Ringing
(a)	Dial Tone (DT)	400 Hz Modulated by 25 HZ	Continuos
(b)	Ring Back Tone (RBT)	-do-	0.4 Sec On 0.2 Sec Off 0.4 Sec On 2.0 Sec Off
(c)	Priority Warnning Tone (PWT)	400 Hz interrputed at 66ms ON/33 ms Off.	
(d)	Busy Tone (BT)	400 Hz	0.4 Sec On, 0.6 Sec Off
(e)	Number Unobtainable Tone (NUT)	400 Hz	2.0 Sec On 1.0 Sec Off
(f)	Operator Monitoring Tone (OMT)	1400 Hz	0.2 Sec On, 2.8 Sec Off
(g)	Ringing Current	17 to 35 Hz (Square Wave)	0.4 Sec On, 0.2 Sec Off 0.4 Sec On, 2.0 Sec Off

POWER SUPPLY

15. TIDEX is designed to operate from 230 V, 50 Hz mains nominal (the permissible limit are 180 to 260 V , 47 - 53 Hz or from a-48 V nominal secondary battery (the permissible limits are - 43 V to -54 V). Normal working will be from AC mains; automatic change over to bty takes place when the AC main fails . When the AC mains recover , from under voltage, change over from battery to AC mains is automatic. But when the AC mains recover from over voltage change over is achieved manually by putting off and On AC mains.

CURRENT CONSUMPTION

16. Current consumption of various configuration of TIDEX are follows

S.No	Configuration	Consumption when operating from	
		230 V AC Mains	48V Battery
(a)	40+12	4A	13A
(b)	80+24	5A	12.5A
(c)	160+48	12A	24A

CONSTRUCTION

17. TIDEX is built -up functionally partitioned sub units. Mechanical design and fabrication of the sub unit conforms to the standards specified for the communication equipment for field use .

Appendix 'B'

(Refer to para 6.2.13 of the thesis)

TECHNICAL DETAILS OF ADM MUX

General

1.1 6 Channel MUX shall provide 6 speech channels , 9 teleprinter channels and one computer data channel . The communication media are cable and radio.

1.2 12 Channel MUX shall provide 12 speech channels , 18 teleprinters channels and two computer data channel. The communication media are cable and radio. Two 6 channels terminals are interconnected to from one 12 channels MUX system

1.3 24 Channels MUX shall provide 24 speech Channels, 36 Teleprinter channel s, four computer Data channels . The communication media are cable and radio. Four 6 Channels terminals are interconnected to from 24 channel MUX . 24 channel MUX is also capable of working with 6 channel and 12 channel MUX over line / RRD.

2. BIT RATE

System	Full Bit Rate	Reduced Bit Rate
6 Ch MUX	288 kB ± 10 B/Sec	144 kB ± 5 B /Sec
12 Ch MUX	576 kB ± 20 B/Sec	288 kB ± 10B/Sec

24 Ch MUX	1152kB ± 40 B/Sec	576 kB ± 20B/Sec

3. SAMPLING RATE

(a) Speech Channel and
Computer Channel : 32 or 16 kB/Sec

(b) TP Channels : 2 or 1 kB/Sec

4. SYNCHRONISATION

15 Bit P N sequence is adapated for synchronisation fail recognition. A guard time of 10 ms for normal bit rate and 20 ms for reduced bit rate is provide.

5. Resynchronisation time

(a) Normal Bit Rate : 288kB/Sec Average -3 ms
Maximum -4.5

(b) Reduced Bit Rate : 144kB/Sec Average -6 ms
Maximum -9 ms

6. CLOCK

Clock Stability ± 25 ppm.

When a TTL compatible external clock at 1152 kB/Sec is connected, the local clock will automatically get disabled. Incase, the external clock fails when the terminal is working on external clock, the MUX will automatically switch over to the internal clock. Also switch is provided to select either local clock frequency or extracted clock frequency.

7. **COMPRESSION RATIO**

Compression Ratio of Sylabic Compounder ..... 33 dB

9. **SIGNALLING**

(a) Magneto : 25V to 80 V, 15 Hz to 50 Hz

(b) Ringer : 75V , 17Hz to 35 Hz

10. **VOICE FREQUENCY (VF) CHARACTERISTICS**

(a) VF Band width : 0.3 to 3.4 kHz

(b) VF Termination : 2Wire/4Wire

(c) Return loss : Better than 16dB for 300 to 500 Hz

Better than 20 dB for 500 to 3400 Hz

(d) Over load : 5dB m at 2kHz on full bit rate

11 . **QUANTISATION DISTORTION**

	Level in dBm	**Full Bit Rate**	**Half Bit Rate**
(i)	-5	-22dB	-14 dB
(ii)	-15	-22 dB	-14 dB
(iii)	-25	-22 dB	-14 dB
(iv)	-30	-22 dB	-14 dB
(v)	-35	-21 dB	-11 dB
(vi)	-40	-16 dB	-8 dB

12. **NOISE**

Idle Channel Noise : Better than -65 dbm

(at16/32 kb/sec)

13. **CROSS TALK** : Better than -65 dbm at 16/32 kb/sec

14. **INTERFACE WITH RADIO REILAY**

(a) Out put to RRD/RRA/RRB from MUX /CRI in to 50 ohms : Logic '0' -1.5 +- 10%
Logic '1' 0.0V to -0.3v

(b) Input from RRD/RRA/RRB to MUX /CRI with 50 ohms termination. : Logic 'O' - 1.5V +- 10%
Logic `1' 0.0V to - 0.3 V

15. **CABLE WORKING** : 3V ± 0.5 V base to peak AMI Bipolar

16. **DATA DISTORTION**

(i) T.P	50 Bauds	2.5 % Max	Single hop at
	100 Bauds	5% Max	full bit rate

(ii) Character Error Rate : Less than 1 in 300 for 4 hops at F.B.R (50 Bauds TP). Shall be better than 1 in 3000 .

(iii) Computer Data : (Max 2.4 kB/Sec) 7.5% at full bit rate only.

17. **Power Supply**

(a) **Input**

i) AC mains 180 V to 265V , 47 to 63 Hz

ii) Battery - 21 to - 29V DC

(b) **Out put**

i) Multiple supplies + 5V , ± 15V, ± 12V, -6V and -24V,

ii) Ringer 20Hz, 75V to 90V

18. ENVIRONMENTAL SPECIFICATION

(a) Operating Temperature : -20 *C to 55 * C

(b) Storage Temperature : -30 *C to 75 * C

(c) The equipment is designed to withstand the environmental tests as per Indian Joint Service Specification JSS 55555 Category L2.

19. PHYSICAL DATA

		MUX 6 ch Unit	MUX PSU Unit
(a)	Width	495 mm	495 mm
(b)	Height	250 mm	250 mm
(c)	Depth	375 mm	375 mm
(d)	Weight	27 kgs	36 kgs

Appendix 'C'
(Ref to para 6.3.4 of the thesis)

TECHNICAL DETAILS OF MID

GENERAL DATA

The purpose of 'MULTIPLEXER INTERFACE DIGITAL' equipment briefly referred to as MID is to provide protection to communications from unauthorised interception . This is purely a digital system with adequate complexity leading to secure communications. The same unit can be used on any of the four bit rates namely 144 KB/s, 288 KB/s, 576 KB/s and 1152 KB/s.

FACILITIES

The equipment is provided with a multipin connector (MUX 6/12/24 Ch) for interfacing with MUX.TEST/CLEAR CODE switch(SP-switch) on front panel provides facility for by-passing /coding through MID . In TEST /CLEAR position equipment loop back test facility is available.

(a) Operating media with MUX : The equipement can be used along with MUX for working on Radio Relay (RRD,RRA,RRB),Tropo of M/s BEL (GAD) 4W Cable (WD1) and Carrier Quard.

(b) POWER SUPPLY : In built power supply unit is provided to work off 230v a.c. mains .The in -built power supply can also work on -24 V DC standby source . With both the mains and battery connected , " No Break" automatic changeover is provided from mains to battery and vice versa . Standby battery power source should always be available for equipment memory .

BROAD TECHNICAL CHARACTERISTICS

a. 6 Ch MUX: MID alongwith MUX 6 Ch provides secure communication for 6 speech channels, 9 teleprinter channels of 50/100 bauds speed and 1 computer data channel of 2.4 KB/s speed.

b. 12 Ch MUX : MID alongwith MUX 12 Ch provides secure communication for 12 speech channels , 18 teleprinter channel and 2 computer data channel of speeds mentioned at 'a'above.

c. 24 Ch MUX : MID alongwith MUX 24 Ch provides secure communication for 24 speech channels , 36 teleprinter channels and 4 computer data channel of speeds mentioned at'a' above.

d. T.P. and Data Channels: The equipment can be exclusively operated for 6/12/24 speech channels keeping the T.P. and data channels in clear mode of working .

e. Bit Rate: The gross bit rate for 6 Ch., 12 Ch and 24 Ch MUX system are 288 , 576 and 1152 KB/s respectively for which MID is designed to work. This can also work on reduced bit rates of 144, 288 and 576 KB/s respectively when MUX is used in the relevent configurations.

f. Sigalling: The equipment is so designed to have signalling information always in clear mode of operation.

g. Synchronisation : MUX Sync, pattern is always sent in clear. Synchronisation of MID is automatic.

h. Interfacing: This equipments will be always interfaced through MUX. MUX has facilities to work with Radio Relay equipment and Remote cable working through :

(i) Converter Radio Interface 1A

(ii) Converter Line Interface 1A

respectively.

j. Technical Characteristics : MID does not contribute any deterioration in performance for voice channels , teleprinter channels and computer channels when transmission media is free of errors .

k. Built in Test Facilities : LED indications are provided for the following :-

(1) Incoming bit stream from MUX in trans direction

(2) Outgoing bit stream from MID to MUX in trans direction

(3) Incoming bit stream from MUX in receive direction

(4) Outgoing bit stream MID to MUX in receive direction

(5) Standby - 24V DC power source indication

(6) For 'coded' mode of working indication

(7) Only for pulse fail indication when SP -switch is in TEST/ CLEAR and MUX 6 Ch connected. In normal working of the equipment , the indication of this LED -6 glow is to be ignored.

(8) The above LED is certain configuration provide built in facility.

(9) Neon lamp is provided to indicate AC Power ON - (LP).

(10) Built in loop back test facilities provided on MUX can also be used to checked for the following :-

(a) Correct functioning of speech channels .

(b) Correct functioning if teleprinter channels.

BROAD TECHNICAL SPECIFICATION

a. The equipment is designed to provide digitally scrambled bit stream onward transmission of communications. This digital encryption provides necessary proterction to the communication from enemy access to information .

b. This is common to all bit rate of 6/12/24 channel MUD(288 KB/s, 576 KB/s and 1152 KB/s).

c. Synchronisation of the MID's on either direction is automatic.

d. The equipment performance is satisfactory upto a medium error rate of 1 in 1000. It is possible to have speech, even within error rate well above that specified , though channels go very much noisy.

e. Performance Characteristics :- When interface with 6/12/24 Ch MUX all the tests must confrom to that spdcified for 6/12/24 ch in normal conditions.

f. Power Supply :-

(i) INPUT

A C Mains 180 V to 265V, 47 to 63 Hz

Battery -21 V to -29V DC

(ii) OUTPUT

General +5 $\pm$ 0.5V

For destructions circut -21 to -29 V DC

(Provided by stand by battery source/AC mains voltage rectified)

g. Environmental Specification

Operating temperature : -20 C to + 55 C

Storage temperature : -30 C to + 75 C

The equipment is designed to withstand the environmental tests as per joint service Specification JSS 55555 (Nov 69) category L2 Clause 12.

h Physical Data :

Width : 495 mm

Hight : 260 mm

Depth : 375 mm

Weight : 32 Kg

Appendix 'D'
(Ref para 6.4.11 of the thesis)

TECHNICAL DETAILS OF RADIO STATION RRD

1. GENERAL

1.1 RADIO STATION RRD is a UHF communication equipment, designed for operating as a multichannel Radio Station in duplex mode. It is capable of transmitting and receiving, through line of sight radio path, signals supplied by a 6/12/24 channel Time Division multiplex equipment using Adaptive Delta Modulation (ADM). The radio equipment is provided with an analog service channel.

1.2. The Radio frequency bands of the equipment are 225 to 399.875 MHz and 610 to 960 MHz, with channels tunable in steps of 0.125 MHz. The equipment can be powered from mains 220 V ac or from 48 V storage battery.

1.3. The equipment with a suitable TDM/ADM equipment can be set up as a Mobile Station mounted in a Vehicle, or as a Static Ground Station.

1.4. The RF output of the Radio Station, RRD can be set to intermediate levels between 2 W & 15W by six to ten discrete steps.

1.5. With two stations, set to 6/12 ch mode of operation radio communication can be established between two line-of-sight geographical locations, approximately 30 km apart. If, however, no line-of-sight exists between the locations, as reffered to the antenna of the

two stations, one or more Relay Stations, each comprising of two nos, of RADIO STATION, RRD in tandem, may be interposed between the two locations to obtain communications.

2. EQUIPMENT AND ACCESSORIES

Equipment and important accessories required for setting up a single station of Radio Station RRD is given below:-

(a) Power supply unit.

(b) System unit.

(c) Amplifier Radio freq 610 to 960 MHz.

(d) Amplifier Radio Freq 225 to 399.875 MHz.

(e) Antenna Array dipole 610 to 960 MHz.

(f) Reflector Antenna Corner 225 to 400 MHz.

(g) Antenna mast 15.8 m.

3. WEIGHT

Equipment - Appx 150 Kg

Antenna with mast - Appx 300 Kg

4. SPECIFICATION FOR TRANSMITTER

(a) Frequency Range : 610-960 MHz & 225 - 399.875 MHZ.

(b) RF Channel Setting : 125 kHz.

(c) RF Output power : Not less than 15 W reducible to at least 2 W by six to ten discrete steps Deterioration of maximum 2 W over the input voltage variation from mains or battery.

(d) RF bandwidth : Max 1380 kHz in 24 channel TDM. Max 960 kHz in 12 channels TDM.

(e) RF output impedance : 50 ohms (nominal).

(f) Spurious Radiation : At least 60 dB lower than fundamental component.

(g) Type of modulation : Frequency modulation.

(h) Frequency of TDM Signal for 6/12/24 channels : 144 $\pm$ 0.2 kHz.

(i) Frequency deviation for Data : 360 kHz p-p $\pm$ 10%.

(j) Accuracy of transmitted frequency over the operating temperature range : $\pm$ 20 KHz

(k) Baseband data rate : 288/576/1152 k bits/sec., corresponding to 6/12/24 ch TDM signal.
144 k bits/sec corresponding to 6 ch reduced bit rate operation.

(l) Impedance and Return Loss at Base-band input connector : 50 ohms. (Return loss of 18 dB min.)

(m) Base-band input level : 0.5 to 3 V peak to peak

(n) Service Channel Frequency: 0.3 to 3.4 kHz.

5. SPECIFICATION FOR THE RECEIVER

(a) Frequency Range : 610-960 MHz and 225-399.875 MHz.

(b) RF Channel setting : 125 kHz.

(c) RF input impedance : 50 ohms (nominal)

(d) Spurious radiation : Max. 1uW (-30 dBm) measured at antenna connecting socket, terminated with 50 ohms.

(e) Noise Figure : Better than 6.5 dB over the frequency range 610-960 MHz. Better than 5.5 dB over the frequency range 225-399.875 Mhz.

(f) Image frequency rejection: 60 dB min.

(g) IF Rejection : 60 dB min.

(h) Suppression of spurious response due to local oscillator spurious and harmonics. : Min 60 dB from ±2 MHz to ±15 MHz off the set receiving frequency. Min. 100 dB at ±15 MHz or more off the set receiving frequency.

(i) Receiver frequency setting accuracy : ± kHz as determinated by the accuracy of Receiver local oscillator.

(j) Base-band data rate : 288/576/1152 k bits/sec corresponding to 6/12/24 channel operation.

144 k bits/sec corresponding to 6 channel reduced bit rate operation.

(k) Impedance and return loss at the base band output connector : 50 ohms. (Return loss of 18 dB min).

(l) Base band output level : 1.5 V ± 10% peak to peak.

(m) Clock output level : 1.5 V ± 10 % peak to peak.

(n) Service channel frequency : 0.3 to 3.4 kHz.

6. SPECIFICATION FOR TRANSMITTER & RECEIVER WORKING OGETHER

(a) Duplex frequency spacing : ≥ 36 MHz.

(b) System Gain(possible path) loss for an error rate of 1x10-6 and transmitter power = 15 W)
: 6 ch operation ≥ 131 dB.
12 ch operation ≥ 131 dB.
24 ch operation ≥ 121 dB.

7. SPECIFICATION FOR POWER SUPPLY

(a) AC mains voltage : 180 to 250 V, 47-63 Hz/ single phase.

(b) Mains drains without CRI : 600 VA max.

(c) Battery voltage : 42 to 58 V.

(d) Battery drain without CRI : 7.5 A max (at 48 V).

(e) Supply for CRI at : -24 V ± 1 V, 750 mA.
connector 102

(f) System is protected against accidental mains over voltage in excess of 255 ± 4 V and shut down mechanism cuts off the mains voltage to the input circuits of power supply.

(g) Automatic changeover in case of mains failure and mains over voltage when both AC mains and battery are connected.

8. SPECIFICATION FOR THE SERVICE CHANNEL

(a) Ringing signal frequency : 1600 ± 16 Hz.
modulated on to the carrier.

(b) Ringing signal frequency and level to and from the remote field telephone;

(i) To the remote Field : 35 to 50 Hz/40 +- V across
Telephone 1000 ohms.

(ii) From the remote Field : 16 to 50 Hz/40 to 75V.
Telephone

(c) Service channel signal level to and from the remote Field Telephone.

(i) Outgoing level : -14 dBm ± dB/600 ohms.

(ii) Incoming level : 0 dBm/600 ohms.

(d) Service channel signal level at Handset socket (208)

(i) Incoming level : -6 dBm/150 ohms.

(ii) outgoing level : ±3 dB/300 ohms.

(e) Service channel signal level at the socket (215) provided for interconnecting two Radio Stations for repeater role.

(i) Incoming level : -7.4 dBm/600 ohms.

(ii) Outgoing level : -7.4 dBm +-2 dB/600 ohms.

(f) Service channel frequency characteristics. : Flat within ± dB between 0.3 to 3.4 kHz with respect to 1 kHz.

(g) Service channel signal to noise ratio measured over a simulated link, when a 15 stage PRBS data at Bit rates of 288/576/1152 kbits/sec, is being transmitted and a service channel signal with a level of -6.0 dBm/150 ohms is fed at the handset socket (208) of the transmitter end :- 20 dbm.

(h) Frequency deviation due to service channel with a level of -6 dBm/150 ohms at the handset socket(208) : 65 kHz p-p +- 10&.

9. ALARM & METERING SPECIFICATION

(a) Visual and Aural Alarm.

It is given under the following conditions :-

(i) Whenever Transmitter output power is 3 to 8.5 dB below the preset value.

(ii) Whenever squelch operates.

(iii) Whenever 1600 Hz incoming ringing signal is received

(iv) Whenever 16-50 Hz incoming ringing signal from remote field telephone is received.

(v) When the duplex frequency setting is less than 13 MHz.

(vi) Whenever the TDM working is out of synchronism.

(vii) Whenever AC mains voltage is low or failed and system operates on battery.

(viii) Whenever Transmitter frequency unlocks.

(ix) Whenever Receiver frequency unlocks.

(x) Whenever data input at terminals 210 is not present.

(b) **REMOTE ALARM EXTENSION**

(i) Fault alarm indication, can be extended to a remote point

(c) **MODULES STATUS INDICATION**

(i) In addition to major alarm parameters listed earlier functional status of important modules in the system are displayed by 'Normally on LEDs' on the front panel.

(d) **ANNALOG METERING**

(i) Analog indication of Transmitter power output, VSWR at output of power amplifier, received strength and mains/battery voltage are also provided on LED bar graphs on the front panel.

10. **REFLECTOR, ANTENNA, CORNER, 225 TO 400 MHz**

(a) Frequency Range : 225 - 399.875 MHz

(b) Gain over isotropic : ≥8 dB

(c) Side lobe attenuation : ≥12 dB

(d) Front -to-back ratio : ≥18 dB

(e) Matching impedance : 50 ohms (nominal)

(f) VSWR : 1.8 : 1

(g) 3 dB Beam width in the main lobe

(i) H-Plane : 56* to 21* decreasing with increasing frequency

(ii) E-Plane : 71* to 36*

(h) Power handling capacity : ≥ 50 W

11. **ANTENNA, ARRAY, DIPOLE, 610 TO 960 MHz**

(a) **SINGLE ARRAY**

(i) Frequency Range : 610 - 960 MHz

(ii) Gain over isotropic : ≥ 15 dB

(iii) Side lobe attenuation : ≥ 8 dB

(iv) Front -to-back ratio : ≥ 17 dB

(v) Matching Impedance : 52 ohms (nominal)

(vi) VSWR : 1.7 : 1

(vii) 3 dB Beam width in the main lobe

(a) H-Plane : 31* to 21* decreasing with increasing frequency

(b) E-Plane : 34* to 22*

(viii) Power handing capacity : ≥ 50 W

(ix) Insulation resistance : 100 M at 500 V

(b) **DOUBLE ARRAY**

Using 2 dipole arrays and coupler, antenna alongwith cable assembly, RF 700 mm long.

(i) Gain over isotropic : ≥ 17 dB

(ii) 3 dB Beam width in the main lobe

(a) H-Plane : 20* to 10* | decreasing with increasing frequency

(b) E-Plane : 18* to 7* |

All other specifications are same as that of Single Dipole array.

Appendix 'E'
(Refer to para 6.5.15 of the thesis)

TECHNICAL DETAILS OF AUTOMATIC ELECTRONIC SWITCH (AES)

Introduction

1 . Automatic Electronic Switch (AES) is a stored program trunk exchange used as Node Switch in an Area Grid Tactical Communication Network which provides the army with automatic, fast, secure and reliable Communication. AES provides Automatic trunk switching facilities for voice, teleprinter and computer data. It is designed to operate under field conditions as a vehicular station.

System Maintainability

2. AES provides the facility of running on-line and off-line diagnostics to diagnose and isolate faults up to card level so that maintenance in the field is reduced to replacement of faulty cards by healthy ones. Identity of the faulty card is indicated on System Monitor console and/or VDU.

3. Operator Facility

An operator facility has been provided in the AES system to facilitate operational control, configuration changes, subscriber assistance and over all supervision of system operation.

Operator Telephone

4. It has been provided to enable operator to make or receive a call from any subscriber in the network. Operator calls are assigned priority level 3 (P5). He can cut in any non priority call.

System Monitor

5. System monitor provides faulty cards indication of each sub-system and also it provides information regarding operational parameters such as port connectivity, ports status, bit error rate and time.

Operator Console

6. Operator console comprises VDU and teleprinter. The I/O devices have been provided to enable the operator to communicate with processor. Operator communicates the configuration changes to processor and gets statistics reports on these terminals.

Operator's Command Mnemonics

7. A set of command mnemonics is provided, to be used by for effecting configuration changes, directory modifications and for getting system status reports and traffic statistics.

8. **Report Generation**

(a) **Traffic Statistics** Engineering statistics regarding offered and carried traffic on system port wise basis, priority option usage, wrong

number dialling e.t.c., are provided at hourly intervals and on 24 hourly basis for the communication engineer to optimise system usage.

(b) **Operational Statistics** Statistics regarding the performance of various ports in regards to syncronisation failures and their duration is provided on 24 hourly basis which aids in analysing the performance of the network.

9. **Power Supply**

Mains PSU accepts AC input from mains or generator and provides 52 VDC out put for modular power supply units. It incorporates protection circuitry and also automatic change over from mains to battery (140 AH). Modular power supplies accept 52 V DC input and generate the logic voltage required by various sub-systems. These voltages are regulated. Protection circuitry is also provided.

10. **Construction**

The AES system has been installed in a fiber reinforced plastic (FRP) shelter which can be slid on to a 3 Ton vehicle and lashed to it. The sub-units are suspended in a matrix frame through shock mounts. The frame it self is mounted on a base frame which is fixed to the shelter floor through shock mounts. The matrix frame is also supported at the top through stabilising shock mounts mounted on wall. This entire frame is situated in the rear portion of the shelter. A VDU, a teleprinter and a system monitor console are mounted on a table which is fixed to

floor with shock mounts. Line terminator unit is located on the left side wall.

11. **Dimension and weight**

The size and weight of the various subsystems of the system shall be as follows :-

	Size (mm)	Weight(Kg)
(a) Synchroniser	516L x 312W x 380D	40 Kg
(b) Front End processor	-do-	40 KG
(C) Digital Switch(DS)	-do-	40 Kg
(d) Processor (CPU)	-do-	40 Kg
(e) Hot-Stand by Controller	-do-	35 Kg
(f) Digital Cassette	-do-	30 Kg
(g) Local Switch Board(LS)	-do-	30 Kg
(h) System Monitor Console	----	03 Kg
(j) Teleprinter	----	35 Kg
(k) Visual Display Unit	----	22 Kg
(l) System power Supply	900L x 460W x 460D	130 Kg
(m) Modular Power Supply Unit	160L x 255W x 400D	11 Kg

12. **Environmental Specification**

(a) Storage temperature : -40 *C to + 70 * C

(b) Operating Temperature : -20 * C to + 55 * C

13. **Humidity**

(a) Damp heat 40 * C 95% RH

(b) Meets Driving Rain Test

(c) Meets Roadability Test

14 . **EMI/EMC Shielding**

The FRP shelter has an embedded mesh to protect the system from EMI/EMC. The cables connecting various subsystems are well shielded to avoid EMI/EMC. Provosion is made to earth the shields.

15 . **Grid connectivity**

AES provides facility for interconnecting other AESs through highways to enable networking in a grid from. Each AES may be connected to up to 8 other AES. A grid may consist of maximum of 32 AES.

16. **Inter-Grid Connectivity.**

AES provides facility for interconnecting other grids through highways to enable inter-grid call routing. AES may be connected upto 4 other AES in neighbouring grids.

17. Facilities

17.1 Switching

AES provides facility for switching deigitised voice, telegraph and field Computer data in real time in response to signalling received over hooks and highways. It is a non-blocking switch, a call is never denied due to lack of switching facilities.

17.2 Priority pre-emption

Entities provide 4 levels of priority. AES provides only two levels of priority in the network and treats P1, P2, and hot line subscribers as priority subscribers and P3 and P4 as non-priority subscribers. There is no priority for teleprinter and data calls.

TH-7235

17.3 Time out

AES provided facility for timing out the non-priority voice call after 10 minutes of call established time elapse. At the end of the timeout period the call will be automatically terminated by the originating AES and the call will be released enroute also. `NU' tone will be extended to both the subscribers for two seconds from the AES 's to which they are connected before disconnecting the call. There is no time-out for priority calls. Similarly AES provides facility for automatically disconnecting teleprinter alls if no conversation takes place for two minutes. This facility is operative during call origination as well as signalling.

17.4 Automatic Sensing

AES provides the facility of sensing automatically whether a teleprinter connected or not connected to the TP channels and the CS (Computer Supervisor) channels. In case the called teleprinter is not connected the NC (Not connected) code is returned to the calling teleprinter in either of the of cases. Here CS channel works as signalling channel for CD call, where as TP channel works as signalling as well as data channel for TP call.

17.5 Disabling Faulty Channels

AES provides facility for disabling any voice, TP and CS (CD) channel on Hook, when it is found to be not working. The disabled channels can be brought back into operation by enabling them. The disabling and enabling is done through appropriate console commands.

17.6 Trunk Booking Position

AES system provides the facility of calling trunks booking position by abbreviated dialling and also the facility to nominate any TIDEX subscriber operator as trunk booking position. On receiving trunk booking position code 90 -98,AES automatically routes the call to nominated subscriber/operator. Even a LS-20 subscriber can be updated as trunk booking/network facility position. Nomination of TBO is the responsiblity of the Grid Manager.

17.7 **Automatic Log-in, Log-off**

AES provi1des the facility of automatic log-in and log-off for RTE subscribers.Code`24'and `25' are used for log-in and log-off respectively AES returns busy tone for login and NU tone for log-out. Logout of RTE subscriber from another RTC is not allowed other than the one from where it logged in.

17.8 **Inter Grid Networking**

AES system provides facility for routing calls to neighbouring grids by dialling codes `20' to `23' or `26' to `29'.

17.9 **Operator Assistance**

AES system provides facility for contacting Home AES Operator by dialling 99 or any other AES operator by dialling AES No followed by 99.

17.10 **Mapping to operator**

99 is home AES operator number. It shall be possible to update a LS subscriber as AES operator. After such updates, all incoming call from operator shall be routed to this LS number. Outgoing call from the AES operator telephone shall be inhibited after such update. Double port connectivity. Using this facility, it is possible to get more channel capacity combining two contiguous ports for a connection of Highway/ASCON-Hook to have better traffic handling capability. The possible combination of Double Port are 24+24, 24+12 and 12+12.

17.11 CD Hunting

AES is giving a provision to hunt for a free CD channel at the far end and establish the call if it is available on issue of a special call request this is to help Data concentrator working in the AREN network in conjunction with AES to provide Data Communication facility for Data subscribers.

17. 12 Integration of AREN & ASCON Networks

AES system is given a provision to integrate AREN and ASCON networks at Analog Trunk level for inter-working between these two networks. Only two types of services have been provided for direct inter-working, namely voice and teleprinter services, and for CD inter-working Data concentrator is required.

17.13 Alarms

AES provides various alarms to user for prompting him to takes necessary actions as and when those events occur by printing them on systems TP.

The alarms can be given while the occurrence of the following events :-

(a) Sync fail and recovery of the updated Hooks and Highways.

(b) CCS link failure and recovery of the updated Highway and Grid connections.

(c) Channel stuck and recovery of the updated Hooks.

(d) When an active entity is automatically become inhibited entity on the reception get a deactivate message.

17.14 Call Statistics

AES system provides consolidated call statistics for all updated Hooks/Highways for a period of 1 hour. This will be printed at every standard clock hour provided if this print-out option is enabled. And it also gives consolidated sync fail information and connectivity log for all hooks and highways updated. AES system also provides current statistics report on demand.

17.15 Codes

AES provides the following codes for indicating progress of Teleprinter and Data calls

(i)	Send address	SA
(ii)	Call being processed code	CP
(iii)	NU Code	NU
(iv)	Bell code (Ringing)	Bell code sent for 5 Sec
(v)	Busy code	BU
(vi)	Precedence disconnect code	PD
(vii)	Not connected	NC

Appendix 'F'

(Refers to para 6.6.13 of thesis)

TECHNICAL DETAILS OF RLS

ROLE

1. Radio Local System(RLS) is a part of the AREN communication network. RLS extends the facilities of TIDEX to radio subscribers (RLEs) over the normal terrain and also where laying of telephone cable is very difficult and Communication is to be set-up in a short period of time. The subscribers can move up to a distance of 5 Kms from the exchange and this range is extendable up to 15 Kms using range extension kit at RLE.

DEPLOYMENT

2. RLS provides secured duplex communication links to a maximum of 10 RLEs through TIDEX. A Radio Local Central(RLC) which is connected to TIDEX through ten subscriber lines, functions as a concentrator for all the calls from RLEs and provides all necessary interface between the Radio System and TIDEX. RLC is capable of providing communication to four of the ten RLEs simultaneously without any interference.

TRANSPORTATION

3 . RLS shall be carried in a Truck 3 Ton Shaktiman with house type body/alluminium shelter. The RLC shall be mounted in such a way as to enable its working without disturbing its fitment in the shelter. The shelter shall also house the RLC antennas, masts, and other accessories and also 6 RLEs. RLE antennas, masts and accessories and batteries needed for the RLEs and standby operation of the RLC.

SALIENT FEATURES

4. The system provides a number of facilities to improve the overall efficiency of the communication network and consistent with the role. Some of the major facilities are briefly described below.

(a) **MULTI - ACCESS**

The RLS system provides telephone only 4 RF channels at RLC. Four simultaneous incoming or outgoing calls are possible, thus providing a high grade of service.

(b) **RADIO SILENCE**

Complete radio silence is observed when no call is in progress, thus providing a complete privacy of communication. RLE tranmitter is ON only when it is locked to a free RF channel and initiates a call or when the RLE receives an incoming call. The RLC transmitter comes ON only when the RF channel is utilised on demand. The signalling takes place in the same channel as the voice channel.

(c) **DUPLEX OPERATION**

RLS is a full duplex voice communication system. A single antenna is used at RLE for transmission as well as reception while two different antennas are used at RLC, One for all four transmitters and another for all five receivers(including priority receiver).

(d) **SYNTHESISED RADIO**

Fully synthesised transmitter and receivers are provided both at RLE covering the whole RF band of 10 MHz. RLE receivers have automatic channel scanning facility while the RLC radios are operated at pre - assigned channels.

(e) **SIGNALLING**

High reliable robust digital signalling is employed. This enables the system to perform satisfactorily even under highly noise operating environment.

(f) **SECRECY**

The system is fully compatible with DIPA (Digital Secrecy Unit). The change over(from clear to secret or vice versa) at the RLC is automatic and at RLE, it is manually selectable.

(g) **PRIORITY**

One additional receiver is provided at RLC to enable the priority radio subscribers to have an access into the system when all the four radio channels are busy. The priority allocation of two RLEs is software

programmable at RLC. However the above feature is only RLS priority and not AREN Grid priority.

(h) **BITE**

Self diagnostic features (BITE) are built in the equipment at RLC as well as at RLE for easy maintenance. The self check at power ON is carried out automatically.

(h) **AUTOMATIC CHANNEL RELEASE FACILITY**

When any radio communication link is continuously busy for pre - programmed call time out duration (which is software programmable), that channel is automatically released at RLC. Also when a TIDEX subscriber initiates a call to RLE, and radio subscriber fails to answer back within one minute, the radio channel is automatically realeased at RLC. Besides, when a RLE lifts handset to initiate a call and does not dial any digit, the channel at RLC is automatically released if no digits are received within one minute after the RF channel is patched

(ii) AUTO CHANGEOVER OF PSU

In case of AC mains failure necessary circuit has been built in the power supply unit at RLC to change over automatically from AC mains to standby secondary battery and vice versa. Besides, when a RLE lifts handset to initiate a call and does not dial any digit, the channel at RLC is automatically released if no digits are recovered within one minute after the RF channel is patched.

5 . **DATA SUMMARY**

(a) Frequency Range	: 80 - 100 Mhz
(b) Operation	: Duplex
(c) Range	: 5 Kms (Normal) 15 Kms (Extended)
(d) Max. Simultaneous RF links	: 4
(e) No of RF channels	: 70 Duplex Channels
(f) Channel BW	: 50 KHz
(g) No of channels used per RLC	: 5
(h) Frequency separation between	: 10 MHz
(j) Receiver and trasmitter Modulation	: FM
(k) Priority	: Any 2 out of 10 RLEs programmable)
(l) Exchange compatibility	: TIDEX or any auto exchange operating on 10 ips signalling RLC can be us closely located in the same TIDEX vehicle.

6. **RECEIVER PARAMETERS**

(a) Frequency	: RLE 80 -90 MHz RLC 90 -100 MHz
(b) Sensitivity	: 0.5 uV for 12 db SINAD
(c) Audio output	: 120 mV (rms)across 24 ohms

resistive load at 1KHz modulating signal with ± 5.6 KHz deviation

(d) Audio response (3 dB) : 20 Hz -10 KHz

(e) IF : 1st 37.25 MHz
2nd 450 KHz

(f) RF Impedance : 50 Ohms

6. TRANSMITTER PARAMETRS

(a) Frequency : RLE 90 -100 MHz
RLC 80 - 90 MHz

(b) Power : 33 dBm (Typical)

(c) Deviation : ± 5.6 KHz Maximum at 1 Khz modulating signal

(d) Transmission BW : Clear 18 KHz,
Coded 30 KHz

(e) Modulation BW (3 dB) : 20 Hz -10 KHz

(f) Protection : Open/short circuit protected

(g) R F Impedance : 50 ohms

8 . ANTENNA (RLE)

(a) Folded dipole (Normal Range)

(i) Frequency Band : 80 -100 MHz

(ii) VSWR : 2:1 (Typ)

(iii) Power Handling : 10 Watts

(iv) Input Impedence : 50 Ohms

(v) Polarization : Vertical

(b) **Yagi (Extended Range)**

(i) Frequency band : 80 -100 MHz

(ii) VSWR : 2.5 : 1 (Max)

(iii) Power handling : 10 watts

(iv) Input Impedence : 50 Ohms

(v) Polarization : Vertical

(vi) Radiation Pattern : Directional

(vii) Gain : Better than 7dB

9. **ANTENNARLC**

0 dB GPA Omni-directional one for all 4 transmitters and one for all 5 receivers

(a) VSWR : 2:1 (Max)

(b) Power Handling : 25 Watts (TX Antenna)

(c) Polarization : Vertical

(d) Impedance : 50 Ohms (Nominal)

10 . **ANTENNA MASTS**

(a) **RLE** 3 M telescopic(Normal range)

7.5 M Hand Crankable

(Extended range)

(b) **RLC** — 15 M Hand Crankable (Both for Tx & Rx)

11. **POWER SOURCE**

(a) **RLE** — 12 V, 10 AH Ni cadmium (or) 12 V, 75 AH Sec. Battery

(b) **RLC** — 230 V,50 Hz AC Mains 24 v, 140 AH Secondary Battery

12 . **POWER CONSUMPTION**

(a) **RLC at 24V DC**

(i), Receive mode : Less than 2.0 A per channel

(iii) Transmitted mode : Less than 8.0 A per channel

(b) **RLE at 12V DC**

(i) Receive mode : Less than 1.0 A

(ii) Transmit mode : Less than 3.0 A

13. **BATTERY LIFE**

(i) RLC :

(a) when all four RF channels are engaged. — 2 hours(Appx)

(b) when two of the four RF channels are engaged. — 6 hours(Appx)

(ii) RLE (Under normal load condition)

(a) Lead Acid Battery 40 hours(Appx)

(b) Ni-Cd Battery 6 hours(Appx)

14. TIDEX INTERFACE

(a) Separation between RLC and TIDEX : RLC shall be located near to TIDEX. However RLC will work satisfactorily upto a separation of 100 mtrs between RLC and TIDEX.

(b) Interface Cable : RLC shall be connected to TIDEX through a suitable single cable with a capacity of 15 pairs.

15. CO-LOCATION WITH OTHER RADIO EQUIPMENT

(a) RLE - Other Radio equipment shall be located beyond 10 meters from RLE.

(b) RLC - Other Radio equipment shall be located 15 meters from RLC.

16 . **SIZE AND WEIGHT**

(a) RLC - 230 KGs exclusive of batteries, Antenna and other Accessories.

(b) RLE - 13 KGs (including DIPA) excluding Batteries and Antenna and other accessories.

(c) RLC Antenna - GP Antenna : 2.5 Kg (Max)

(d) RLE Antenna - (1) Folded dipole : 3.0 Kg (Max)

(2) Yagi Antenna : 9.0 Kg (Max)

Appendix 'G'

(Ref to para 11.1.5 of the thesis

TECHNICAL DETAILS OF MCPC - VSAT

INTRODUCTION

1. The MCPC-VSAT is designed to carry three voice channels for traffic, One voice channel for ESC, one data channel for traffic and one data channel for NMS. The three voice channels are encoded at 16 Kbps using adaptive transform coding (ATC)technique. The voice rates for each channel can be programmed for operation from 5.33 kbps to 32 kbps. The ESC channel operates at 5.33 kbps. Group III Fax can also be transmitted or received on any of the voice channels.

2 The MCPC-VSAT consists of the two sub systems. Out door Unit (ODU) and Indoor Unit (IDU) . Outdoor Unit consisting of :

(a) 3.8 Meter Antenna

(b) C-Band RF Transreceiver (10W including the following:-

(i) RF Driver Unit

(ii) Power Supply Unit

(iii) Solid State Power Amplifier (10 W)

(iv) C Band Feed

(v) Low Noise Converter

(vi) Transmit Reject Filter

and Indoor Units (IDU) Consisting of

(a) VSAT Rack including the following:-

(i) Variable Data rate MODEM

(ii) Multiplexer

(iii) Satman Controller Processor

(b) Digital Switch and

(c) 2 KVA UPS

(d) The station layout is shown in the General Assembly Drawing.

3 The 220 V AC from the source power and the battery input are connected to the UPS system. The UPS supplies power to the ODU (RFT), the multiplexer, the MODEM, the Satman Controller Processor (SCP), the PC and the printer and EPABX. The EPABX is connected to 24 extensions. Voice communication between extension-extension and extension-trunk is possible. The eight trunk lines from the Main Distribution Frame (MDF) of the Digital Switch(EPABX) are connected to the Multiplexer. The digital out put of the Multiplexer is connected to the Modem. The modulator's IF output is available from MODEM.

4. This IF signal is then connected to the RF Transceiver input. The output of the up converter is then fed in to a Solid State Power Amplifier (SSPA) . The output of the SSPA is connected to the feed with a low loss, foam dielectric cable. This signal gets radiated to the satellite. In the receive path, the RF signal is received by the antenna and the signal passes through a Transmit Reject Filter (TRF) and low noise block converter (LNB) to produce first IF signal of 1042.5 $\pm$ 18 MHz. The LNB output then fed into the down converter. The output of the down converter is an IF signal (70 $\pm$ 18 MHz).

5. This IF signal is then connected to the VSAT Rack. This signal gets demodulated in the Modem and demultiplexed in the MUX to finally recover the voice and data signals. The voice signals are connected to the EPABX which is turn are connected to the telephones.

SYSTEM DESCRIPTION

6.. 3.8 m band antenna is a precision, prime focus, 22.62 offset feed, four piece reflector (Polyester glass). The antenna optics are disigned for reduced blockage and low side lobes. The anetenna is also custom disigned to support the RF transceiver. The antenna is designed for 125 mph wind loading and full orbital arc coverage. (Elevation : 0* to 90* and azimuth : 360*). The anetenna has a transmit gain of 46 dB and receive gain of 42.1dB.

C Band RF Transceiver

7. The C Band tranceiver is a modular RF terminal for two way satellite communication in the C Band frequency range. The unit transmits at 5925 MHz and receives at 3700 to 4200 Ghz. A basic RF terminal includes a microwave driver unit, power amplifier unit, low noise block converter (LNB), power supply and interconnecting cables. The terminal works with any 70 or 140 MHz Modem having a data capacity of 9.6 kpbs or higher,and mounted on the antenna.

8. The synthesizer is locked to a very stable temperature controlled crystal oscillator in the driver, the synthesizer can tune the transceiver

across the 500 MHz bands in 2.5 MHz steps. Tuning is achieved by selection of DIP switches, or remotely with the Monitor and Control (M & C). Dual conversion bandpass filters and a power amplifier are used by the RF transceiver to convert the 70 MHz or 140 MHz IF signal from the modulator to a 6 GHz tansmit signal. The transmitter is configured as a gain block (fixed gain). The RF signal is amplified by the power amplifier as a final step before transmission. Active bias regulators in the power amplifier perform at the optimum operating point regardless of temperature or environment. The solid state power amplifier incorporates devices that provide highly stable power and gain with minimal intermodulation distortion. The low noise block converter (LNBC) incorporates low noise devices that provide a system noise temperature typically better than 65 K.

9. The transceiver is designed to operate anywhere in the world under the most stressful environmental conditions.

Modem

10. The modem accepts the digital outputs from the MUX. The modem is a variable data rate mode MODEM. The modem consists of a digital modulator, a demodulator, a convolutional encoder, a viterbi decoder and monitor & control facilities. The modem can also be programmed for different data rate (32 - 2084 Kbps). The data rate change in a simple procedure - a few keypad operation, all of which can be done easily in the field. The modem supports BPSK, QPSK, modulation techniques. The modem Tx and Rx. IF frequency can be programmed.

The modulator output level is also programmable from 0 to -26 dBm. The output frequency can be set in steps of 100 Hz in the IF frequency band of 52 - 88 MHz. The M & C facilities are accessed either locally through a key pad and a LCD display or remotely via RS 232C port. The demodulator portion of the MODEM demodulates the received IF signal in to a digital bit stream. The nominal input level to the demod is -30 +10 dBm.

11. Multiplexer

This unit provides 8 voice channels and 4 data channels. It transforms voice, 9.6 Kbps FAX or other analog signals in to their equivalent representations in digital form and combines them with digital information from the unit's data channels and system supervision data to produce a composit bidirectional stream of digital data. The MUX supports loop supervisory signalling. The MUX can be configured to handle voice, or a combination of voice/fax calls. The MUX also accepts data inputs. The ESC channels is a 5.33 Kbps Celp coded digital signal. The MUX also has built in echo cancelers. These voice and data channels are multiplexed into a 128 Kbps digital signal which is available at the network port (V.35) of the MUX.

SATMAN Control Processor (SCP)

12. The SCP is a small computing and interface device designed to facilitate the control and monitoring of VSAT earth station. It is intended to be used as a part of a larger maintenance and control (M & C) system with a central computer directing and co-ordinating SCP's at

remote sites. The SCP's role in such an M & C system is to monitor the health of the remote equipment and to report problems to the central site. SCP is capable of interfacing with and monitoring a wide range of devices. The physical interfaces provided in the LCP include one RS 485 serial port, eight RS 232 C serial port and 37 pin D connector for relay output and contect closure inputs. SCP monitors devices by issuing the appropriate command to the device's M&C interface ports via the RS 485 bus. The SCP stores the last information received from each device and compares with the current information. If the information changes then a change of state (COS) is detected . When COS occurs, the SCP uses its communications path back to central computer to report the occurrence . The central site then communicates with the affected device to retrieve detailed information about COS. This information may be used by operator to take the appropriate corrective action.

13. **Digital Switch**

The digital switch (OMNI 210) comprises of a fully microprocessor controlled private automatic branch exchange. The system is designed on a combat, modular basis and are equipped with extensive software , providing access to a wide variety of feature and functions. This system can be used either as an autonomous PABX connected to the central office network, or as part of a private network of PABXs. The system is designed on a modular basis. All of the electonic circuits of the system are functionally grouped on individual cards, which are inserted into available slots in the cards files provided , according to the configuration required. Each cards files contains 36 slot. Cards are slid into the files slots and plugged into the backplane of connector. A number of card slots

are reserved for the system cards which control the operation of the EPABX. All other card slots are referred to as "universal", meaning that any peripheral card can be inserted, allowing a dialogue between switch and a terminal or a peripheral device.

14. Each EPABX consists of a common equipment module(CEM) and a peripheral equipment module(PEM). The common equipment module consists of system control cards such as the processor, the memory and associated device modules. The peripheral equipment module allows a number of peripheral cards to interface with telephones, operator console, trunk lines and data equipment. The system features include call hold, call transfer, 3 party conference, call forward, executive override, hotline, call waiting and a host of other user features. OMNI 210 is currently equipped with 24 extensions and 8 Nos. of 4 W E & M trunks, The system can be expended to 256 extensions and 128 trunks.

2 KVA UPs

15. The UPS provides uninterrupted power to the equipment. This UPs supplies 1.5 KVA at 220 V AC and 0.5 KVA at -58 Volt DC. The system employes PWM technology resulting in smaller size, better transient performance and lesser distortion. The feature includes auto trip facility for overload, overcharge, battery low, output over voltage and indications like main on/off, inverter on/off, battery low, overcharge and output over and under voltage.

FUNCTIONAL DESCRIPTION

Transmit side

16. The telephone signals from the exchange are connected to the multiplexer unit. The MUX supports 4 wire E & M, 2 wire E & M , DTMF and loop supervisory signalling. Three such telephone channels are be connected to the MUX. Each voice channel can be programmed for different types of signalling. The incoming voice channel is converted into a 16 Kbps digital signal. The digital signal is then coded using CELP (for voice rates-5.33, 8.0 or 9.6 Kbps) or ATC for higher voice rates. The MUX can be configured to handle voice , Fax or a combination of voice/Fax calls. The MUX also accepts data inputs. The ESC channel is a 5.33 Kbps celp coded digital signal. These voice and data channels are multiplexed into a 128 Kbps digital signal which is available on the network port of the MUX.

17 . The MUX output is then connected to a variable data rate MODEM configured for 128 K operation. The modem consists of a digital modulator, a demodulator, a convoluitional encoder, a viterbi decoder and monitor and control facilities. The MODEM can also be programmed for different data rates (32-2048 Kb). The data rate change is a simple procedure -a few keypad operations, all of which can be done easily in the field. The modem provides standard v .11 interface. The modem supports PBSK, QPSK, O-QPSK modulation techniques, 1/2 or 3/4 FEC. The modem TX and RX. IF frequency can be programmed. The modulator output level is also programmable from 0 to -26dBm. The output frequency can be set in steps of 100 Hz in the IF frequency band of

52 - 88 MHz. The M & C facilities are accessed either locally through a keypad and a LCD display or remotely via RS 232 C port. 33. The 70 + 18 MHz output from the modem iis connected to a C - Band transreceiver. This signal is then mixed with a fixed LO of 1112.5 MHz to produced 1182.5 +18 MHz signal. This IF output is then upconverted to the required transponder frequency (5925-6425 MHz) by mixing with a microwave synthesizer. The synthesizer has a 2.5 MHz step size. The fixed LO and the synthesizer are referenced to a 10 MHz oscillator. The output of the upconverter is connected to a 10 W SSPA. The SSPA receives a 5925-6425 MHz RF input from the driver unit.This signal is fed through an isolator for better VSWR and then through several gain stages. Each gain stage uses an active bias to ensure that it is performing at optimum level regardless of temp or environment . The SSPA will then amplify the RF input signal to the required level.

Receive Side

18. The received signal from the antenna in the freq. band 3700-4200 MHz is fed into a Trans reject filter whose output is fed into the Low Noise Block Converter. The LNB incorporates GaAsFET devices to provide a system noise temperature typically better than 65 deg. K. The function of the LNB is to downconvert the receive RF from the satellite to L Band where it is then sent to the driver unit for further downconversion. The incoming RF receive signal passes through a Tx. reject filter. The filtered signal then enters the LNB which contains the first downconverter, a BPF and an amplifier. The output of the LNB is a 1042.5 +18 MHz signal.

19. The output of the LNB is fed to the downconverter (which is a part of the RF Driver). In the down converter, the received 1042.5 + 18 MHz is mixed with the common fixed LO at 1112.5 MHz to give an IF output of 70 + 18 MHz. A screw driver adjust is provided for Rx. level adjust. The downconverter provides a nominal gain of 30 dB. The output of downconverter is fed into the demodulator portion of the MODEM which demodulates the received IF signal into a digital bit stream. The nominal input level to the demod is -30 +10 dBm. This digital signal is then fed into the Demultiplexer which has built in echo cancelers. The output of the demultiplexer which are VF/data signals are connected to the exchange.

Appendix 'H'

(Refer to para 11.6 of the thesis)

TECHNICAL DETAILS OF INTELSAT F3 EARTH STATION

1. The INTELSAT F3 Earth Station Equipment XU 465 is used for digital transmission of telephone and data through INTELESAT Satellites. This Earth Station can support both IDR (Intermediate Data Rate) and IBS (Internation Business Service) Carriers. The present F3 Earth Stations are equipped for IDR carrier up to 6312 Kbps data rate. The Earth Station operates in the transmit frequency band of 5.85 to 6.425 GHz and in the receive frequency band of 3.625 to 4.2GHz . The Earth Station is configured in (1+1) redundant mode with facility to expand up to (5+1) carrier.

EQUIPMENT CONFIGURATION

2. The Earth Station Consists of the following equipments:

(a). 9.2 meter Antenna with 4 port circular polarised feed and equipped with step track facility.

(b). 1.5 KW Klystron high power Amplifier in (1+1) redundant configuration.

(c). (1+1) Low Noise Amplifiers.

(d). RF Rack consisting:

(i) - (1+1) up converters with system equalisers.

(i) - (2+1) Down converters with system equalisers.

(iii) - Control unit for LNA and HPA.

(iv) - Beacon down converter & Beacon receiver.

(e). IDR modulators and demodulators.

(f). Test instruments

(g). Microwave hardware for interconnecting Antenna & HPA.

3. Apart from these a power distribution panel, Automatic voltage regulator and Uninterrupted Power Supply (UPS) would be provided. The LNA is mounted in the Hub of Antenna, which is located on top on the building. The other equipments are located inside the building .

EQUIPMENT DESCRIPTION

Transmit Section

4. The incoming IDR carrier at 6312 Kbps data rate from digital 2nd order MUX is devided in to two streams and connected to MOD 1 and MOD 2. The MOD 1 and MOD 2 are working in (1+1) hot stand by mode with a switching unit to switch over the traffic automatically during the failure of Modulator. The modulator accepts 6312 Kbps rate and adds the required over head bits and introduces 3/4 rate veterbi. Forward Error Correction Code (FEC) and QPSK modulates the signal of IF carrier. The IF carrier can be selected depending on the available slot in the transponder, in steps of 22.5 KHz by a frequency synthesizer in the frequency band of 52 to 88 MHz. The modulated IDR signal is then taken through the top of the modem rack to the RF rack. In the RF rack the modulated signal is again divided and connected to Up-converter 1 and Up-converter 2. The Up-converters are working in (1+1) hot stand by mode. The Up converter converts 70

MHz modulated signal the required to transponder frequency . By this type of double conversion it is possible to select any transponder frequency without changing any component in the Up-converter. The synthesizer can operate in the step size of 125 kHz to give an RF frequency band of 5.85 to 6.425 GHz. The signals from the two Up-converters are selected in the changeover unit. The changeover takes place automatically depending upon the status of the two Up converters. A manual over ride facility is provided in the change over unit .The output of the selected Up-converter is connected to the Klystron High Power Amplifier (KHPA) switch. This connects the signal to the selected Klystron Amplifier. The Klystron amplifier is tuned to each one of the 12 transponder frequencies of INTELSAT. The amplifiers has a 1 dB bandwidth of more than 45 MHz. The KPHA amplifies the Up-converter signal to the required power output. The KHPA has a gain of 80 dB in the frequency band of 5.85 to 6.425 Ghz. . The output of the amplifier is taken through a waveguide switch which selects the output of the traffic carrying KHPA. The KHPA output is taken through flexible elliptical waveguide to the antenna.

Antenna

5 . The antenna operates in the transmit frequency band of 5.85 to 6.425 GHz and receive frequency band of 3.625 to 4.2 GHz. This is a 9.2 m antenna using 4 port reusable feed. The antenna has a 53.5 dB gain at 6 GHz and 50 dB gain at 4 GHz. A step track system is used for pointing the antenna towards the satellite. The step track system

consists of a Beacon Downconverter, Beacon Receiver, Antenna control unit and a motor control unit. The Beacon down-converter is a synthesizer down converter which can receive any one of the beacon signals . The Beacon down converter is identical to the down converter used for IDR receivers, thus reducing the variants in the type of equipment. The Beacon receiver accepts the 70 MHz signal from Beacon downconverter and gives a DC signal corresponding to the beacon signal strength. This is a PLL type of receiver which locks on to the incoming beacon frequency. The DC signal corresponding to the signal strength is connected to the antenna control unit. The Antenna Control Unit (ACU) is a PC based system which sends control signals to the motor control unit of the Antenna. The antenna has Azimuth and Elevation control motors. The ACU first peaks the signal in the Azimuth direction. The motor control unit is located near the antenna.

Receive Section

6. The received signal from the antenna feed is connected to a (1+1) Low noise Amplifier Unit. The LNA has a 60 dB gain and 65 K noise figure. The LNA unit is located in the hub of the antenna to reduce the front end losses. The power supply unit and the control unit of LNA are located in the RF rack. The LNA output is taken through a 1/2" foam dielectric low loss cable to the RF rack. The received signal is taken through a 1:8 RF divider to various downconverters. There are four downconverters located in the RF rack. The first downconverter is connected to the beacon receiver. The second and third downconverters

are tuned to the required transponders and the fourth down converter is a standby unit. The down converters employ double conversion and the first local oscillator is a frequency synthesizer with a step size of 125 kHz. The traffic carrying downconverters outputs are taken through a (2+1) Downconverter switch which automatically selects the working down converter. The 70 MHz output of the downconverter is taken to the IDR demodulators. The demodulators are coherent QPSK demodulators which demodulates 6312 Kbps signals. The demodulaters also perform FEC correction to get better bit error rates. The output of the demodulator is 6312 Kbps data. This data is connected to the 2nd order demux located in the Earth Station.

7. The Earth Station is also equipped with the following test instruments.

(a) RF power meter - HP437B with 8481A power sensor
(b) RF frequency Counter - HP 5350B
(c) Spectrum Analyser - MS 710C (Anritsu)
(d) Microwave system Analyser - 538 L(Anritsu)
(e) Digital transmission Analyser - MD 6420 (Anritsu)

These test instruments are used for monitoring and aligning the Earth Station.

TECHNICAL FEATURES

8. (a) **Terrestrial interface**

(i) IP/OP Interface : G 703/G747

(ii) IP/OP Information rate : 64 kbps to 8.448 Mbps

(b) **Overhead frame structure**

(i) Overall : 96 kbps

(ii) ESC voice channels (two) : 32 kbps

(iii) Digital ESC : 8 kbps

(iv) Frame/Multiframe alignment and Alarm : 24 kbps signal

(c) Coding/ Decoding

(i) FEC :3/4 punctured type convolution code as per IESS- 308 Rev.4

(d) Intermediate Frequency

(i) IF Frequency Range : 70 + 18 MHz

(ii) IF Frequency Step size : 22.5 KHz

(iii) Modulation : QPSK

(iv) Scrambling/Descrambling : CCITT V35

(v) Frequency Stability : 1 PPM

(vi) Spurious Output : -6 dBc in any 4 KHz band

(vii) IF Output level : 0 to -15 dBm

(viii) IF Input level : -25 to -45 dBm(with ALC)

(ix) IF filtering : As per IESS -308 Rev. 4

(x) Acquisition time : 3 Sec (Max)

(xi) BER performance : IESS-308 Rev. 4

(e) Transmitter Performance (C band transmit)

(i) Earth Station EIRP : 80.5dBW

(ii) Frequency band : 5.85 to 6.425 GHz

(iii) Frequency Selection HPA : 12/24 Channels

(iv) Frequency Stability : 3 PPM

(v) Output Level Stability(HPA) : ±0.5 dB/Day

(vi) Instantaneous band width : 36 MHz

(vii) IF/RF Gain (Up-converter) : 20 dB ± 0.5 dB

(viii) RF/IF Gain (Down Converter) : 50 dB(Minimum)

(f) **Receiver Performance (C bans Receive)**

(i) Earth Station G/T : 29.5 + 20 Log F/dB/K

(ii) Frequency band : 3.625 to 4.2 GHz

(iii) LNA System Noise Temp : 90 Degree K (Max)

(iv) Individual LNA Noise Temp : 60 Degree K (Max)

(v) LNA Gain : 60 dB (Minimum)

(g) Antenna

(i) Antenna Type : 9.2 Mtr Parabolic Reflector with Elevation over Azimuth type mount.

(ii) Feed System : Cassegrain 4 Port Linear

(iii) Antenna travel

Elevation : 5 to 90 Degree continuous

Azimuth : 0 to 180 Degree continuous

(h) Power Supply

(i) Supply voltage : 415/380 V AC 50Hz 3 phase

(ii) Consumption : 40 kVA (MAX)

MECHANICAL DETAILS OF EQUIPMENT

9 . (a) **Dimension/weight**

(i) Station equipment (overall) : (H) 2200 mm x (W) 2400 mm (D) 800mm

(ii) Antenna : (Dia)9.2 m x

CONDITIONS OF USAGE

10. The equipment is designed for static operation, working in shaded and protected environment, and installed upright. It is designed for continuous operation. Permissible operating temperature and environment conditions for satisfactory operation are :

(a) Temperature range : 0 to 50*C

(b) Relative humidity : 95 % max. at 40 *C

EQUIPMENT DESCRIPTION

ANTENNA

11. The antenna system consists of 9.2 M parabolic reflector with elevation over azimuth pedestal mount and motorized drive control from 180 azimuth axis travel and 5* to 90 * elevation axis travel. The feed system consist of circular polarised port cassegrain feed and sub reflector assembly. The Tx and Rx gain of the antenna are 53.5 dB and 50.0 dB respectively. With the optional control system it is possible to position the antenna within 0.02* accuracy. The Tx and Rx port of the antenna are WR 137 G and WR 229 G respectively.

KLYSTRON HIGH POWER AMPLIFIER

12 . This is a 1.5 KW Klystron High Power Amplifier in (1+1) redundant configuration with a minimum gain of 75 dB. The KHPA

rack includes the SCR controlled power supply unit, cooling system and the control logic circuits. The equipment is engineered in 23 inch rack . The SCR regulated power supply is located at the bottom of the rack. This power supply unit is mounted on castor wheels, so that unit can be rolled out of the rack for trouble shooting. The filament power supply is located in a tray above the SCR power supply unit. This unit is provided with guide rails into pull out the tray. On top of this tray the klystron tube is fitted. Above the klystron tubes two 300 CFM capacity blowers are fitted to cool the collector of the Klystron. The wave guide arc detector, isolator and monitoring couplers are located behind the cooling blowers. The intermediate power amplifier is located on the side wall near the klystron. The control panel with associated circuits are mounted on the front panel where klystron and cooling system are located.

LOW NOISE AMPLIFIER (LNA) ASSEMBLY

13 . The (1+1) LNA subsystem consists of two numbers of LNAs, coaxial switch, one waveguide switch and a Transmit Reject Filter (TRF). All these items are integrated together on a plate and are located inside the HUB of the antenna. Each of these LNAs provides a minimum gain of 60 dB and typical noise temperature of 65 degrees Kelvin .· These LNAs are specially designed for use with satellite earth stations. Each of the LNAs consists of 6 stages GaAs FET amplifier stages. An integral drop in microchip isolator at the final output ensures good VSWR. The co-axial switch at the output and

wave guide switch integrates two LNAs into 1+1 LNA system. The LNA system is weather proof and has waveguide pressurisation facility. It forms the front end of the satellite earth station receive chain. Two LNAs are configured in (1+1) hot standby mode. This redundant LNA sub system accepts input signals in the 3.625- 4.2 GHz (C-Band receive) frequency range from the antenna feed and amplifies these very low signals (-80 dBm type).

System Equaliser

14. The System Equaliser is used in satellite Earth Station to compensate or the amplitude and phase distortions caused by the Satellite transponder filters in the Uplink chain, and to compensate for the receive system amplitude and phase characteristics in the down link chain. System equaliser consist of number of amplitude and group delay equalisers working in the frequency band 70 $\pm$ 18 MHz. There are 3 parabolic and 6 linear (3 positive and 3 Negetive) amplitude equalisers and 6 linear (3 positive and 3 Negetive), 4 parabolic group delay equalisers. By the combination of positive and Negative linear group delay equaliser group delay in steps of 2.5 nsec can be selected. In the case of parabolic group delay equaliser the step size is 5 nsec. This is an independent unit with built in 230 V AC supply. Details of system equaliser are as under :-

(a) (i) Amplitude equaliser : 3.5 dB in 0.5 dB steps
linear positive

(ii) Amplitude equaliser : 3.5 dB in 0.5 dB steps
linear Negative

(iii) Amplitude equaliser : 1.5 dB in 0.5 dB steps
parabolic

(b) (i) Group delay equaliser: 35 nsec in 2.5 nsec steps
linear positive

(ii) Group delay equaliser: 35 nsec in 2.5 nsec steps
linear Negative

(iii) Group delay equaliser: 55 nsec in 5 nsec steps

Up converter switch

15. The up-converter switch selects the healthy/working transmission chain (Mod and Up converter) of the RF rack for transmission and extends the same to HPA racks. The unit monitors the status of Mod-1 and Mod -2, Up-converter-1 and Up-converter -2 of transmit chain -1 and 2 respectively and switches to the other chain in case of fault in any one of the sub systems of the chain. The RF outputs from the two up-converters are taken through the transfer switch located in the unit. There is provision for manual selection of transmission chain -1 or 2 . The unit is energised by DC supply voltage of the up-converters. This is a 2U height unit with dimensions-88.1 mm x 482.6 mm x 550 mm.

Up-converter

16. The up-converter frequency translates 70 MHz IF carrier to the frequency band of 5.850 GHz to 6.425 GHz. The up-converter has a gain of 20 dB (min) and its output frequency can be adjusted in steps of 125 KHz. There are two up-converters in the RF rack which are configured in the (1+1) hot stand by mode. The up-converter contains filters for suppression of LO leak and spurious products. Equalisers compensate for group delay introduced by the filters and keep amplitude response within specification.

RF Power Divider

17. The 1:8 RF Power Divider is used in the down link receive chain of INTELSAT F3 Earth Stations to split the signal (3.625- 4.200 GHz) received from the LNA sub system into eight equal signals. In the typical arrangement, seven of these signals are fed to seven down converters and the eighth signal is use for monitoring purposes. This indoor unit has N-connectors for RF interfacing and is configured for mounting in 19" rack.

Downconverter

18 . The down converter contains frequency translating circuits which converts input signal to 70 MHz signal, where carrier frequency is in the band of 3625 MHz to 4200 MHz. The downconverter has a variable gain of 35 to 50 dB, with the nominal power output being-12 dB. The down converter contains filters for suppression of local

oscillator(LO) leak and spurious products. Equalisers compensate for group delay introduced by the filters and keep amplitude response within specifications. There are three downconverters configured in 2+1 hot standby mode.

IDR MODEMS

19. The IDR Modems operate over data rates 64 kbps. Two modems are configured in (1+1) hot stand by mode. The IF carrier of the modems can be selected in steps of 22.5 KHz over the IF Band of 52 MHz to 88 MHz. These modems are supplied by M/S ITI Ltd.

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