EP 3-78 RI

DEFENSE COMMUNICATIONS ENGINEERING CENTER

AD A128952

ENGINEERING PUBLICATION NO. 3-78 RI

DCS TECHNICAL CONTROL ENGINEERING CRITERIA

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DCEC EP3-78R1	2. GOVT ACCESSION NO. AD-A123892	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DCS Technical Control Engineering Criteria		5. TYPE OF REPORT & PERIOD COVERED Engineering Publication (Rev1)
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Members, Engineering & Technical Panel, Tech Control Improvement Program Phasing Group (Basic Pub) & Computer Sciences Corp. (Rev 1)		8. CONTRACT OR GRANT NUMBER(s) DCA100-78-C-0053
9. PERFORMING ORGANIZATION NAME AND ADDRESS Defense Communications Engineering Center Systems Engineering Division, R700 1860 Wiehle Ave., Reston, VA 22090		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Same		12. REPORT DATE MAY 1981 (Rev 1)
		13. NUMBER OF PAGES 365
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Same		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

Review Relevance 5 Years from Submission Date

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Technical Control
Technical Control Facilities
Technical Control Configuration
Patch and Test Facility
Time Division Multiplex
Time Slot Interchange
Testing of Digital Subscriber Loops and Devices
Engineering Criteria

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This publication provides guidelines for engineering of Technical Control Facilities for the Defense Communications System. The criteria are intended to aid the transition of the DCS from an analog system to a predominantly digital system using digital transmission and switching technologies.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ENGINEERING PUBLICATION NO. 3-78R1

DCS TECHNICAL CONTROL ENGINEERING CRITERIA

MAY 1981

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FOREWORD

The Defense Communications Engineering Center Engineering Publications (EP's) are published to provide engineering guidance to DoD Departments/ Agencies and their contractors engaged in engineering, RDT&E, procurement, installation, testing, acceptance, and O&M of specific DCS Projects and Programs. Before using EP's as, or as part of, procurement specifications, coordination should be accomplished with DCEC or the cognizant DCA Program Office to insure currency and the propriety of the application.

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TO ALL HOLDERS OF ENGINEERING PUBLICATIONS EP3-78

1. DCEC Engineering Publication EP3-78, Technical Control Engineering Criteria (May 1978) is revised as follows:

a. A new Preface, revised Table of Contents and revised List of Illustrations has been provided.

b. Chapter One has been rewritten to include additional material.

c. Chapter Two has been revised and shortened.

d. Chapter Three has been revised and shortened to reflect the January 1980 publication of MIL-STD-188-310A.

e. Chapter Four has been expanded to include descriptions of typical digital switching equipments.

f. Chapter Five has been expanded to include sections on "Digital Switching Considerations" and Future Development Impact on DCS Technical Controls".

g. A new Chapter Six, "Testing of Digital Subscriber Terminal Devices and Loops" has been added.

2. This Revision (EP3-78R1) dated May 1981 supersedes the original publication dated May 1978 which should be destroyed or otherwise removed from use.

3. The citation of trade names and names of manufacturers or commercial organizations in this publication is not to be construed as official Government indorsement or approval of any of the commercial products, organizations or services cited herein.

PREFACE TO REVISION 1

Since the publication of EP 3-78 in May 1978, the explosive growth of digital switching in commercial telephony has had a major impact on military communications.

Digital Switching in AUTOVON will be introduced at Fairview, Kansas and is planned for other AUTOVON locations in the United States including two in Alaska.

In Europe, the first phases of the European Telephone System will introduce digital switching techniques for common user services in 1981.

In the Pacific Theater, the Navy is implementing digital switching at Rizal in the Philippine Islands. The U.S. Army will be implementing digital PBX's in Korea and the U.S. Air Force will begin acquiring digital switches under the SCOPE DIAL plan.

The beginning of the all digital DCS is clearly underway and one of the major subsystems to be impacted by digitization will be the DCS technical controls.

It is obvious that this impact will be far-reaching. Revolutionary changes are occuring in the design and implementation of communications networks and in the types of equipment employed. New acquisitions are being engineered on a "systems" basis as contrasted to the "problem-solving" or "specification" approaches of earlier years. Transmission, switching and tech control are being developed in unison to ensure compatibility and operability of the new networks on a system basis.

The provision of suitable standards during a period of rapid technological change such as now being encountered is inhibited through concern over being too early, too detailed or too restrictive and it is in this context that this revision to EP 3-78 is being issued. It is hoped that this information will prove current and useful to those individuals involved in planning, engineering and implementing military technical controls being influenced by the emerging digital technology and that it will provide them with a better understanding of the developments that continue to transform the DCS.

The Engineering and Technical Panel
of the
Technical Control Improvement Program
Phasing Group

TABLE OF CONTENTS

		Page
A.	Preface	IV
B.	Table of Contents	V
C.	List of Illustrations	X

Chapter 1	INTRODUCTION	Page
1.1	SUBJECT AND PURPOSE	1-1-1
1.2	BACKGROUND	1-2-1
1.3	APPLICABILITY	1-3-1
1.3.1	General	1-3-1
1.3.2	Time Frames and TDM Configuration of Future DCS Programs & Projects	1-3-1
1.3.2.1	Typical Configurations	1-3-2
1.3.2.2	DCS Programs and Projects	1-3-2
1.4	Relation to Existing Standards and Criteria	1-4-1
Chapter 2	TERMS, DEFINITIONS AND ABBREVIATIONS	2-1
Chapter 3	TECHNICAL CONTROL ELEMENT CONFIGURATION	
3.1	GENERAL DESCRIPTION	3-1-1
3.1.1	Diversity of DCS Technical Controls	3-1-1
3.1.2	General Requirements	3-1-3
3.2	TRANSMISSION SYSTEMS	3-2-1
3.2.1	Deleted	3-2-1
3.2.2	Patch and Test Facilities in TDM LOS DCS Stations Prior to 1980, Overseas	3-2-50
3.2.3	Patch and Test Facilities in TDM Satellite DCS Stations	3-2-55

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
3.2.4	Patch and Test Facilities for TDM Leases (CONUS)	3-2-82
3.2.5*	Patch and Test Facilities for TDM Cable Transmission	3-2-84
3.2.6*	Technical Control Facilities in TDM LOS DCS Stations, Second Generation DCS	3-2-85
3.2.7*	Patch and Test Facilities in TDM LOS DCS Stations, Second Generation DCS, Overseas	3-2-86
3.2.8*	Patch and Test Facilities in TDM Tropo Stations	3-2-87
3.2.9*	Patch and Test Facility For HF Radio Facilities	3-2-88
3.3	DCS SWITCHED NETWORKS AND TECHNICAL CONTROLS	3-3-1
3.3.1	AUTOVON and Technical Controls	3-3-1
3.3.2	AUTODIN and Technical Controls	3-3-5
3.3.3	AUTOSEVOCOM and Technical Controls	3-3-8
3.3.4*	Special Purpose Networks, Users and Technical Controls	3-3-18
3.4	ORDER WIRES	3-4-1
3.4.1	Prior to 1980	3-4-1
3.4.2*	Post 1980	3-4-5
3.5	ALARMS, LOCAL AND REMOTE	3-5-1
3.5.1	Prior to 1980	3-5-1
3.5.2*	Alarm Network Post 1980	3-5-12
Chapter 4	EQUIPMENT DESCRIPTIONS	4-1-1
4.1	GENERAL	4-1-1
4.1.1	Content of Equipment Descriptions	4-1-1
4.1.2	Organization of Equipment Descriptions	4-1-2
4.2	TIME DIVISION MULTIPLEXERS	4-2-1
4.2.1	TSEC/CY-104	4-2-1
4.2.2	AN/FCC-97	4-2-8
4.2.3	T1WB1	4-2-19
4.2.4	AN/GSC-24	4-2-26
4.2.5	TD-1220(V)/G and TD-1226(V)/G	4-2-33
4.2.6	AN/FCC-98	4-2-38
4.2.7	TD-1193	4-2-44
4.2.8*	Submultiplexers	4-2-46
4.3	MODEMS AND CODERS	4-3-1
4.3.1	MD-921/G Modem	4-3-1
4.3.2	MD-1002 Modem	4-3-4

* To be furnished later

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
4.3.3	MD-920/G Modem	4-3-7
4.3.4	KY-801 Coder	4-3-9
4.4	ENCRYPTION DEVICES	
4.4.1	Walburn Encryption Device	4-4-1
4.4.2*	KG-81 Encryption Device	4-4-3
4.5	RADIO EQUIPMENT	4-5-1
4.5.1	AN/FRC-162(V)	4-5-1
4.5.2	AN/FRC-165	4-5-6
4.5.3	Digital Tropo Modem	4-5-8
4.5.4*	High Frequency Radio Equipment	4-5-11
4.6	SATELLITE EARTH TERMINALS	4-6-1
4.6.1	AN/FSC-78 Earth Terminal	4-6-1
4.6.2	AN/FSC-9 Earth Terminal	4-6-5
4.6.3	AN/TSC-54 Earth Terminal	4-6-9
4.6.4	AN/MSC-46 Earth Terminal	4-6-13
4.6.5	SCT-21 Earth Terminal	4-6-17
4.6.6	AN/TSC-86 Earth Terminal	4-6-18
4.6.7	AN/SSC-6 Satellite Terminal	4-6-19
4.6.8	AN/FSC-79 Satellite Terminal	4-6-20
4.6.9*	AN/MSC-61 Earth Terminal	4-6-22
4.7*	EQUIPMENT ASSOCIATED WITH AUTOVON	4-7-1
4.8	EQUIPMENT ASSOCIATED WITH AUTODIN	4-8-1
4.8.1	AUTODIN Switch	4-8-1
4.9	EQUIPMENT ASSOCIATED WITH AUTOSEVOCOM	4-9-1
4.9.1	CV-3034 A/D Converter	4-9-1
4.10*	EQUIPMENT ASSOCIATED WITH SPECIAL PURPOSE NETWORKS	4-10-1
4.11	DIGITAL SWITCHING EQUIPMENTS	4-11-1
4.11.1	DMS-100/200 Switch Series	4-11-1
4.11.2	KN-101 Switch	4-11-7
4.11.3	GTD 4600 Digital Switch	4-11-16

*To be furnished later

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
Chapter 5	DIGITAL CONSIDERATIONS	5-1-1
5.1*	GENERAL	
5.2*	TIMING & SYNCHRONIZATION	
5.2.1*	Prior to 1980	
5.2.2*	The Second Generation DCS	
5.3*	TESTING CONSIDERATIONS	
5.3.1*	Voice Channel Testing	
5.3.2*	Digital Signal Testing	
5.4*	TYPE OF JACK, FRAME, CABLE	
5.5*	GENERAL PHYSICAL ARRANGEMENTS AND CONFIGUTATIONS	
5.6*	INTERFACE CRITERIA	
5.6.1*	Conditioning	
5.6.2*	Regeneration	
5.6.3*	Signaling	
5.6.4*	Ancillary Equipment Application	
5.6.5*	TCCF Application	
5.6.6*	Security	
5.6.7*	Growth Provision	
5.6.8*	Host Nation Approval Considerations	
5.7*	DSCS INTERCONNECT ARRANGEMENT	
5.8*	TECHNICAL CONTROL POWER, GROUNDING AND BONDING	
5.9	DIGITAL SWITCHING CONSIDERATIONS	5-9-1
5.9.1	Purpose	5-9-1
5.9.2	Objectives	5-9-1
5.9.3	Problem Areas	5-9-1
5.9.4	Methodolgy	5-9-2
5.9.5	Digital Equipment	5-9-2
5.9.6	Specific Planning/Engineering & Transition Considerations	5-9-3
5.9.7	Guidelines & Criteria	5-9-24
5.9.8	DCS Telecommunication Programs	5-9-25

*To be furnished later.

TABLE OF CONTENTS (Cont'd)

Paragraph	Subject	Page
5.10	FUTURE DEVELOPMENT IMPACT ON DCS TECHNICAL CONTOL	5-10-1
5.10.1	Purpose	5-10-1
5.10.2	Background	5-10-1
5.10.3	Technology Advances	5-10-2
5.10.4	System Development Options	5-10-9
5.10.5	A Look at the Future	5-10-12
5.10.6	Preliminary Criteria Guidance	5-10-16
5.10.7	Summary	5-10-20
Chapter 6	TESTING OF DIGITAL SUBSCRIBER TERMINAL DEVICES AND LOOPS	6-1-1
6.1	GENERAL	6-1-1
6.1.1	Purpose	6-1-1
6.1.2	Background	6-1-1
6.2	EVOLUTION OF SUBSCRIBER AREA TECHNICAL CONTROL TESTING	6-2-1
6.2.1	Historical	6-2-1
6.2.2	Impact of Digitization	6-2-1
6.2.3	Changing Roles	6-2-2
6.3	DIGITAL TERMINAL AND LOOP TESTING	6-3-1
6.3.1	Objectives	6-3-1
6.3.2	Measures of Effectiveness	6-3-1
6.3.3	Candidate Techniques	6-3-1
6.3.4	Problems Associated with Digital Monitoring & Testing	6-3-3
6.4	PRESENT AND PROPOSED PRACTICES	6-4-1
6.4.1	Bell/AT&T	6-4-1
6.4.2	Bell Northern, Canada	6-4-2
6.4.3	Commercial Manufacturers	6-4-2
6.5	TRENDS AND GUIDELINES	6-5-1
6.5.1	Trends	6-5-1
6.5.2	Guidelines	6-5-1
6.5.3	Summary	6-5-2

LIST OF ILLUSTRATIONS

FIGURE	TITLE	PAGE
1.3.2	Time Frames of DCS Programs and Projects	1-3-3
1.3.2.1(a)	TDM Pre-1980 Configuration	1-3-4
1.3.2.1(b)	TDM Pre-1980 Configuration (Special)	1-3-5
1.3.2.1(c)	Post-1980 Configurations (DEB)	1-3-6
1.3.2.1(d)	Digital Switch Interface Examples	1-3-7
3.1.2.2.1	Relationship of DCS Technical Controls (Technical Control Facilities and Patch and Test Facilities) to the major subsystems of the Defense Communications System	3-1-8
3.1.2.2.3	Technical Control Facility/Media Patch and Test Configuration	3-1-9
3.1.2.2.9	Recommended Patching Configuration for Future TDM Tech Controls	3-1-10
3.2.2(a)	Patch and Test Facilities in the Mux and Media Technical Control Facility for PCM Voice Channels	3-2-52
3.2.2(b)	Patch and Test Facilities on Radio Equipment AN/FRC-162	3-2-53
3.2.2(c)	Patch and Test Facilities in the Mux and Media Technical Control Facility for 50 kb/s service	3-2-54
3.2.3(a)	Basic Overall System	3-2-59
3.2.3(b)	Typical DCS TDM Satellite Patch and Test Facility	3-2-60
3.2.3.1.1	VF Maintenance Patch Panel	3-2-61
3.2.3.1.2	TTY Maintenance Patch Panel	3-2-62
3.2.3.1.3	Data Maintenance Patch Panel	3-2-63

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
3.2.3.1.4	IF Patch Panel	3-2-64
3.2.3.2.1	Typical Case I	3-2-67
3.2.3.2.2	Typical Case II	3-2-68
3.2.3.2.3	Typical Case III	3-2-69
3.2.3.2.4	Typical Case IV	3-2-70
3.2.3.3.1(a)	Typical DCS TDM Satellite 2 Wire VF Users Utilizing Existing Echo Suppressor And SF Equipment	3-2-72
3.2.3.3.1(b)	Typical DCS TDM Satellite 4-Wire Users Utilizing Existing Echo Suppressor and SF Equipment	3-2-73
3.2.3.3.1(c)	Typical DCS TDM Satellite 2 Wire VF Users Utilizing ES-3B and TD-1192 for SF Generation	3-2-74
3.2.3.3.1(d)	Typical DCS TDM Satellite 4-Wire VF Users Utilizing TD-1192 for SF Generation	3-2-75
3.2.3.3.1(e)	Typical Quasi-Analog Data Users	3-2-76
3.2.3.3.1.2	Tactical DCS TDM Satellite P & TF	3-2-77
3.2.3.3.2.1(a)	Typical AN/USC-28 NCT/NT User Circuit Block Diagram	3-2-78
3.2.3.3.2.1(b)	Typical AN/USC-28 Digital User Block Diagram	3-2-79
3.2.3.3.2.2	Typical Digital User Circuit Block Diagram	3-2-80
3.2.3.4	Maximum Distance for Various Cables	3-2-81(a)

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
3.2.4	1.544 Mb/s Lease, CONUS to Hawaii	3-2-83
3.3.1.1(a)	Typical Station Technical Control Facility overseas AUTOVON I Original Configuration, FDM Facilities	3-3-3
3.2.1.1(b)	Typical Station Technical Control Facility-Overseas AUTOVON I, prior to 1980, TDM Configuration	3-3-4
3.3.2.1(a)	AUTODIN I and DCS Technical Control Facility Original Configuration - FDM Transmission	3-3-6
3.3.2.1(b)	AUTODIN I and DCS Technical Control Facility-Prior to 1980, TDM Transmission	3-3-7
3.3.3.1(a)	50 kb/s Trunking in the European Theater - Present (Nov 77)	3-3-10
3.3.3.1(b)	50 kb/s Trunking in the European Theater - Before 1980	3-3-11
3.3.3.1.1(a)	Typical Station Technical Control Facility AUTOSEVOCOM I Original Configuration, FDM Facilities	3-3-12
3.3.3.1.1(b)	Typical Station Technical Control Facility - AUTOSEVOCOM I - Prior to 1980, TDM Transmission	3-3-13
3.3.3.1.1(c)	Typical Station Technical Control Facility - AUTOSEVOCOM I Prior to 1980, Hybrid Station	3-3-14

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
3.3.3.1.2.1(a)	Station Technical Control Wideband Secure Voice Channel Patching Arrangements-AUTOSEVOCOM I	3-3-15
3.3.3.1.2.1(b)	Station Technical Control - Wideband Secure Voice Channel Patching Arrangements	3-3-16
3.3.3.1.2.1(c)	Station Technical Control - Wideband Secure Voice Channel Patching Arrangements	3-3-17
3.4.1.1(a)	Voice Orderwire/Communications Circuit - LOS Microwave DCS Prior to 1980	3-4-2
3.4.1.1(b)	Example of Orderwire Configuration Phase I FKV	3-4-3
3.4.1.2	Fault Alarm Status Reporting (FASR) Bandwidth Occupancy	3-4-4
3.5.1.1.1	Alarms monitored at a typical LOS TDM DCS Station	3-5-3
3.5.1.1.2	MCC Terminal Unit - Unmanned Station	3-5-4
3.5.1.1.3	FASR Monitor Point	3-5-5
3.5.1.1.4	Alarm Configuration at a Manned DCS Station Adjacent to Two Unmanned Sites	3-5-6
3.5.1.1.5	Alarm Configuration at an Unmanned DCS Station Adjacent to Two Manned Sites	3-5-7

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
3.5.1.1.6	Alarm Wiring to Alarm Monitor Group and CDF	3-5-8
3.5.1.1.7	Examples of Arrangement on the Alarm Display Unit	3-5-9
4.2.1(a)	TSEC/CY-104 System Block Diagram	4-2-5
4.2.1(b)	VICOM D2 Transmitter Block Diagram	4-2-6
4.2.1(c)	VICOM D2 Receiver Block Diagram	4-2-7
4.2.2(a)	Multiplex Group AN/FCC-97	4-2-13
4.2.2(b)	Assembly Schematic, T1-4000 Multiplexer	4-2-14
4.2.2(c)	Protection Assembly Schematic Layout	4-2-15
4.2.2(d)	AN/FCC-97 Major Subassemblies Interconnection Plan	4-2-16
4.2.2(e)	T1-4000 Multiplexer Simplified Block Diagram	4-2-17
4.2.2(f)	Protection Switch Block Diagram	4-2-18
4.2.3(a)	T1-WB1 Assembly Layout	4-2-22
4.2.3(b)	System Application, the T1-WB1 Wideband Data Terminals	4-2-22
4.2.3(c)	T1-WB1 Transmitter Block Diagram	4-2-23
4.2.3(d)	T1-WB1 Receiver Block Diagram	4-2-24

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
4.2.4(a)	Input/Output Characteristics	4-2-30
4.2.4(b)	Universal Rate Converter Feature of the Rate Comparison Buffer	4-2-31
4.2.4(c)	GSC-24 Applications	4-2-32
4.2.5	Front Panel and Control Layout TD-1220 Multiplexer-Demultiplexer	4-2-36
4.2.6	Schematic Layout of AN/FCC-98(V)	4-2-41
4.3.4(a)	Typical Operating Configuration with BPSK or Other Serial Modem	4-3-11
4.3.4(b)	Typical Operating Configuration with QPSK (2 Bit Parallel) Modem.	4-3-12
4.5.1	AN/FRC 162 Radio Set	4-5-5
4.5.2	AN/FRC 165 Radio Set	4-5-7
4.5.3	Typical Quad Diversity Configuration of DAR IV Tropo Modem	4-5-10
4.6.1(a)	AN/FSC-78(V) Earth Terminal	4-6-3
4.6.1(b)	AN/FSC-78 DSCS Terminal Functional Block Diagram	4-6-4
4.6.2(a)	AN/FSC-9, 20 kW Fixed-Station Terminal, 60-Foot Antenna	4-6-7
4.6.2(b)	AN/FSC-9 Simplified Functional Diagram	4-6-8
4.6.3(a)	The AN/TSC-54, Highly Transportable Terminal, With Cloverleaf Antenna Which Is Equivalent to an 18-Foot Diameter Reflector	4-6-11

LIST OF ILLUSTRATIONS (Continued)

FIGURE	TITLE	PAGE
4.6.3(b)	Typical ETC Using the Satellite Communications Terminal AN/TSC-54	4-6-12
4.6.4(a)	Typical ETC Using the Satellite Communication Terminal AN/MSC-46	4-6-15
4.6.4(b)	AN/MSC-46 Simplified Functional Diagram	4-6-16
4.6.8	AN/FSC-79 Fleetbroadcast Terminal Functional Block Diagram	4-6-21
4.8.1(a)	Major Elements of the Automatic Digital Message Switching Center (ADMSC) -- Overseas AUTODIN Switch	4-8-4
4.8.1(b)	Communication Group of the Overseas AUTODIN Switch (ADMSC) Simplified Block Diagram	4-8-5
4.11.1	DMS-200 Digital Switch	4-11-2
4.11.2(a)	KN-101 Switch, Block Diagram	4-11-9
4.11.2(b)	Peripheral Connections	4-11-14

LIST OF ILLUSTRATIONS (Cont'd)

FIGURE	TITLE	PAGE
5.9.6(a)	Development of Direct Digital Switching & Transmission Concept)	5-9-5
5.9.6(b)	T1 North American PCM Carrier Format	5-9-7
5.9.6(c)	CCITT Recommended Format	5-9-8
5.9.6(d)	A-Law Coding	5-9-10
5.9.6(e)	u-Law Coding	5-9-11
5.9.6(f)	Tandem Portion of Switched Network	5-9-14
5.9.6(g)	Application of Principle of Time-Slot Interchange for Alt-Routing	5-9-15
5.9.6(h)	Digital Interface (typical) Configuration	5-9-17
5.9.6(i)	Digital Interface Using Cable	5-9-18
5.9.6(j)	Digital to Analog DCS Interface	5-9-19
5.9.6(k)	Digital Interface Using Fiber Optics	5-9-20
5.9.6(l)	Digital Interface Electronic Switch/DSCS	5-9-21
5.9.6(m)	Typical Time Slot Interchanger (TSI) Configuration	5-9-23
5.10.3.1	Rome Air Development Center-Digital Channel Efficiency Model (DCEM)	5-10-5
5.10.3.2	Various Transmultiplex Configurations	5-10-6
5.10.5.2	Concept for Small Hybrid Technical Control for the Mid 1980's	5-10-15
5.10.5.3(a)	Composite Interconnection Hybrid Analog/Digital Station of the Future	5-10-17
5.10.5.3(b)	Station Interconnection	5-10-18
6.4.1	Generalized Common Carrier Loop Testing System	6-4-4

CHAPTER 1

INTRODUCTION

1.1 Subject and Purpose - This publication provides engineering criteria and guidelines for the configuration of Technical Control Facilities (TCF) and associated Patch and Test Facilities (PTFs) which will be used in the Defense Communications System (DCS). The configurations, functions, and criteria for the following equipments associated with DCS technical controls are addressed:

a. Patching, Test, and Monitoring Facilities

b. Terminal Equipment, Descriptions of:

1. Multiplexers, with emphasis on Time Division Multiplex. (General descriptions of several other new equipments including transmultiplexers, time-slot interchangers and digital TASI will be found in Chapter 5).

2. Radio and Cable Equipment.
3. Switches, including brief descriptions of several commercial digital switches typical of those finding application in the DCS.

c. Special Purpose Networks and Users

d. Orderwire Equipment

e. Alarm Equipment

1.1.1 The Technical Control Facility (TCF) is that element of a communications network with the necessary physical, electrical, and manpower capabilities to provide technical control, to interface transmission elements of the system, and to interface users with the system. Traditionally the management of communication paths is accomplished at the TCF and subordinate Patch and Test Facilities (PTF).

Technical control activities encompass such diverse functions as technical direction, coordination, technical supervision of transmission media and equipment, quality control, communications service restoral, and status reporting as further defined in DCA Circulars 310-70-1 and 310-70-57.

From an operational standpoint the functions of technical control can be categorized into three major tasks: (1) to monitor the status of the system, (2) to measure the quality of the communication links, and (3) to determine the adequacy of the facility to handle the traffic load.

1.2 Background. Over the years technical control has been variously referred to as wire control, facility control, radio control, fault control and finally telecommunications system control. It is now generally referred to as "Tech Control" by both military and civilian communities.

In the early days of military communications, systems often consisted of only a few circuits and tech control activity was so limited that the functions were generally performed by the facility supervisor as a minor additional duty.

During the period of World War II, the demand for military communications grew enormously and carrier multiplex systems came into use and were installed in the technical control facilities. In this same time frame technical control facilities were gradually formalized by the military departments and operated by personnel under job specialties peculiar to that function. The controllers were provided with limited test equipment and monitor printers and keyboards were provided for coordination with distant terminals. The tech controller directed the actions of the maintenance technicians, coordinated frequency changes by the remote transmitter and receiver site attendants and performed limited quality assurance tests.

The 1950's and 1960's were periods of great technological change for military communications. Improved HF, long-haul ionospheric scatter, wide-band microwave and tropospheric scatter systems were introduced. Major systems such as 486L, AUTOVON and AUTODIN were implemented. The DCA was created and strategic communications systems operated by the various military departments were merged as the DCS. Our long involvement in Vietnam with its enormous impact on military communications began.

The above period brought numerous changes to the tech control function. A substantial number of large tech controls were installed in various parts of the world to accommodate the sudden growth of high capacity wideband systems. Tech controllers were confronted with the need to control global switched circuits and the explosive growth of data tranmission at ever higher bit rates. Equal level patching became necessary as the requirement for rapid patching between various systems developed.

In the early tech controls, only limited testing was performed or, in fact, was considered desirable. If a circuit was keying properly or able to pass a test message or voice conversation without gross errors, it was considered acceptable for traffic. Some indications that other tests were required and the need for more rigid quality control and particularly level control discipline surfaced during the 40's and 50's when facsimile transmission came into widespread use. Facsimile was not as forgiving as voice or teletype traffic. Excessive envelope delay and changes in net loss left their imprint on the copy for all to see.

Subsequently, as data transmission rates increased, it was observed that evelope delay and phase jitter were key parameters influencing the rate at which data could be transmitted. Neither of these parameters had previously been significant to voice users or to the transmission of low speed data.

The tech controller began to develop an awareness of circuit parameters that formerly held little importance. Tests grew more numerous, demanding and precise. Such developments accelerated the introduction of specialized conditioning and test equipment into the tech control environment. Quality control programs were expanded and strengthened to assure awareness of degradation trends and to identify and correct faults before the user was impacted.

Deficiencies in standardization of tech control engineering designs and training of tech control personnel were surfaced. DCS Technical Control Engineering Criteria, DCEO Engr Pub H500-12-64, was published in 1964 as guidance to the Military Departments in order to standardize and upgrade Technical Control Facilities and to define interfaces and installation practices for the overseas AUTOVON and AUTODIN switches. Its application extended to major transmission systems such as the Integrated Wideband Communications System for Southeast Asia and the European Wideband Communications System (EWCS). It served as the technical and engineering source document for DCA Circulars DCAC 310-50-3, DCAC 310-50-6, DCAC 310-70-1, DCAC 300-175-1, DCAC 300-175-9, as well as Military Standard 188-310.

Most of this earlier documentation was based on frequency division multiplex analog transmission systems which are now approaching obsolescence as the DCS begins the transition to a digital network. The result of this development is the steady decrease in the inventory of analog assets and a corresponding growth in digital facilities, resulting from, among other reasons, the 1973 Department of Defense policy requiring all future DCS transmission systems to be implemented using Time Division Multiplex (TDM).

The increasing complexity of the communications equipment and the types of services provided by the networks are testing the ability of tech controls to effectively control and maintain the system. Tech control manpower has grown more intensive and costly in recent years and the requirement for near-real-time response in restorals, reroutes and reconfigurations has expanded. In an effort to meet these challenges, the systems engineer is resorting to automation and centralization of various control and maintenance functions. These trends will lead to networks wherein switching, transmission and tech control gradually lose their separate identities as they merge together. Unfortunately, this transformation will not appear suddenly. The process will be evolutionary and spread over many years. A transition period of 20 years is frequently mentioned.

Meanwhile, it is essential that technical control facilities be designed to support the future digital systems as well as the remaining analog systems. The future tech controller will continue to perform many of the same functions now performed, but it is clear that he will rely heavily on automation to accomplish many tasks that now require manual intervention. Several of the areas where automation will likely prove productive are:

- In testing: Automation can drastically reduce the manpower assigned to this task. It can also, through redirection of the human element, improve the quality of the tests performed.

- In fault isolation: Rapid fault isolation depends on the ability to collect information on the health of the network; to analyze the information obtained and to remotely control the state of equipment concerned - all on a near-real-time basis. Clearly, a complex world-wide military system will need automated surveillance and control to satisfy these requirements.

- In circuit restoral; link rerouting or reconfiguration. All of these actions are time-sensitive. Manual restoral is often difficult to accomplish quickly because of coordination difficulties between tech controls. Automation can limit manual intervention and sharply decrease the time required for restoral or rerouting action.

- In network management; the DCS traverses many countries and different time zones. In order to maximize the utilization of limited facilities, a high degree of network management is essential.

- In report preparation, the operation and maintenance of a large, complex communications network generates a wide variety of reports. Many of these are manpower intensive and repetitive in nature.

- In data base updating; the DCS is higly dynamic and appropriate automation could significantly reduce the manual effort involved in maintaining a current data base.

None of the above involve technological breakthroughs; rather it is a process of improving existing techniques to achieve their full potential and pulling together the technology into a system tailored to the DCS requirements.

The introduction and rapid spread of digitization in the DCS has opened up new means for accomplishing tech control functions. This document discusses some of the new hardware and architectures that will shape future tech controls and the effect on the DCS network. The document is intended to be a source publication for new standards and to provide installation guidance, equipment descriptions and other engineering and technical material related to updating of older technical controls through introduction of digital equipments or to the installation of new technical controls in a predominantly digital environment. The impact of digital switches on technical control is addressed and illustrative examples are provided wherein integration of transmission, switching and technical control are examined.

1.3 Applicability. The applicability of this publication is discussed in general terms and in terms of the time frames of future DCS programs and projects.

1.3.1 General

1.3.1.1 The criteria and guidance specified in this publication are applicable as guidance during the design, engineering, and installation phases of DCS Technical Control and Patch and Test Facilities. Applicability to maintenance and operation of these facilities will be addressed in other documentation although it is intended that this publication will be a source document for updating the technical and engineering considerations of maintenance and operation.

1.3.1.2 The criteria specified in this publication are applicable for a completely BLACK TCF or PTF. The inclusion of any RED provision in the TCF requires additional compliance with current RED/BLACK Engineering Installation Criteria, conforming to MIL HDBK 232. Criteria governing the provision of RED facilities within a Technical Control Facility to meet teletypewriter orderwire security objectives will be developed separately and will be compatible with the criteria specified herein. This document also covers tentative physical security criteria for bulk encrypted TDM.

1.3.1.3 The information and guidance provided in this publication apply equally to Patch and Test Facilities required for monitoring and control of a transmission path for service to users end-to-end and also to other Patch and Test Facilities (such as those serving terminal or switching equipment not specifically covered in this publication), unless criteria for these facilities are specific ally provided in other documents.

1.3.1.4 This publication does not imply or propose that existing tech controls or PTF's be immediately modified to conform with the criteria and guidance contained herein. It does propose that new facilities and those undergoing major modifications or rehabilit ation should comply with these criteria insofar as feasible and practical. New and changed circuits, trunks, equipments and facilities should be in accordance with this publication whenever manpower, standardization and cost limitations permit. The contents of this publication are not directive in nature. Where differences occur with the appropriate MIL-STDs the provisions of the MIL-STD shall apply. Since MIL-STDs for digital technical controls are still largely under development, this publication attempts to provide beneficial preliminary information, criteria and guidance to the planners, engineers and implementors associated with the transitional DCS tech controls that will play an essential role in the development and growth of the future digital DCS.

1.3.2 Time Frames and TDM Configurations of DCS Programs and Projects.

This publication generally addresses two time frames of DCS programs and projects. The time periods are a) Pre 1980 and b) Post 1980.

Figure 1.3.2 depicts the programs and projects segregated by transmission or switched networks and by CONUS or overseas categories. The key programs and projects are discussed briefly in the paragraphs which follow.

1.3.2.1 Figures 1.3.2.1(a) through 1.3.2.1(d) present typical system level configurations of TDM elements and hierarchies associated with the Pre 1980 and Post 1980 major DCS programs (not including technical controls). These include:

Pre 1980 Configurations

Figure 1.3.2.1(a)

- FKV
- DEB I
- EWCS-SLI
- DSCS

Figure 1.3.2.1(b)

- WAWS Special Network
- Leased Carrier (1.544 Mb/s)

Post 1980 Configurations

Figure 1.3.2.1(c)

- DEB II through IV
- Pacific Digitization Program

Figure 1.3.2.1(d)

- Digital Telephone Switch Interface Configuration (typical)

In the figures, TDM elements are shown as triangles. Related digital system elements are shown as rectangles. The equipments are identified by short title nomenclature. For detailed information on the major equipments, refer to Chapter 4 of this document.

1.3.2.2 DCS Programs and Projects Prior to 1980

1.3.2.2.1 Overseas - Prior to 1980, Phase I of the Digital European Backbone (DEB I) was implemented by the U.S. Air Force. This project introduced a TDM line-of-sight microwave system over the Alps between Italy and the Federal Republic of Germany. The European Wideband Communications System - Selected Link Improvement Program (EWCS-SLI) was implemented by the U.S. Army in the same general time frame. EWCS-SLI expands TDM operation to Central and Northern areas of the Federal Republic of Germany. The Naples-Lago Di Patria-Ischia (NLDI) bypass system, which converts NAVCAMS MED DSCS interconnection to TDM operation, was implemented by the U.S. Navy. The TDM configuration of DEB I, EWCS-SLI and NLDI digital transmission systems is similar to the TDM configuration shown in the upper half of Figure

		TIME FRAME	
FUNCTION	LOCATION	PRE 1980	POST 1980
TRANSMISSION	OVERSEAS	FKV DEB I EWCS–SLI DSCS II	DEB II, III, IV DSCS III, DOCS
	CONUS	WAWS 1.544 Mbps LEASE	LEASED DIGITAL TRANSMISSION
SWITCHED NETWORKS	OVERSEAS	AUTODIN I (Q/R, & FAX) AUTOSEVOCOM (50 kbps TRUNKS) AUTOVON	AUTODIN II SVIP AUTODIN/DIGITAL AUTOVON ETS
	CONUS	AUTODIN I AUTOSEVOCOM AUTOVON	AUTODIN II SVIP DIGITAL AUTOVON

Figure 1.3.2. Time Frames of DCS Programs and Projects

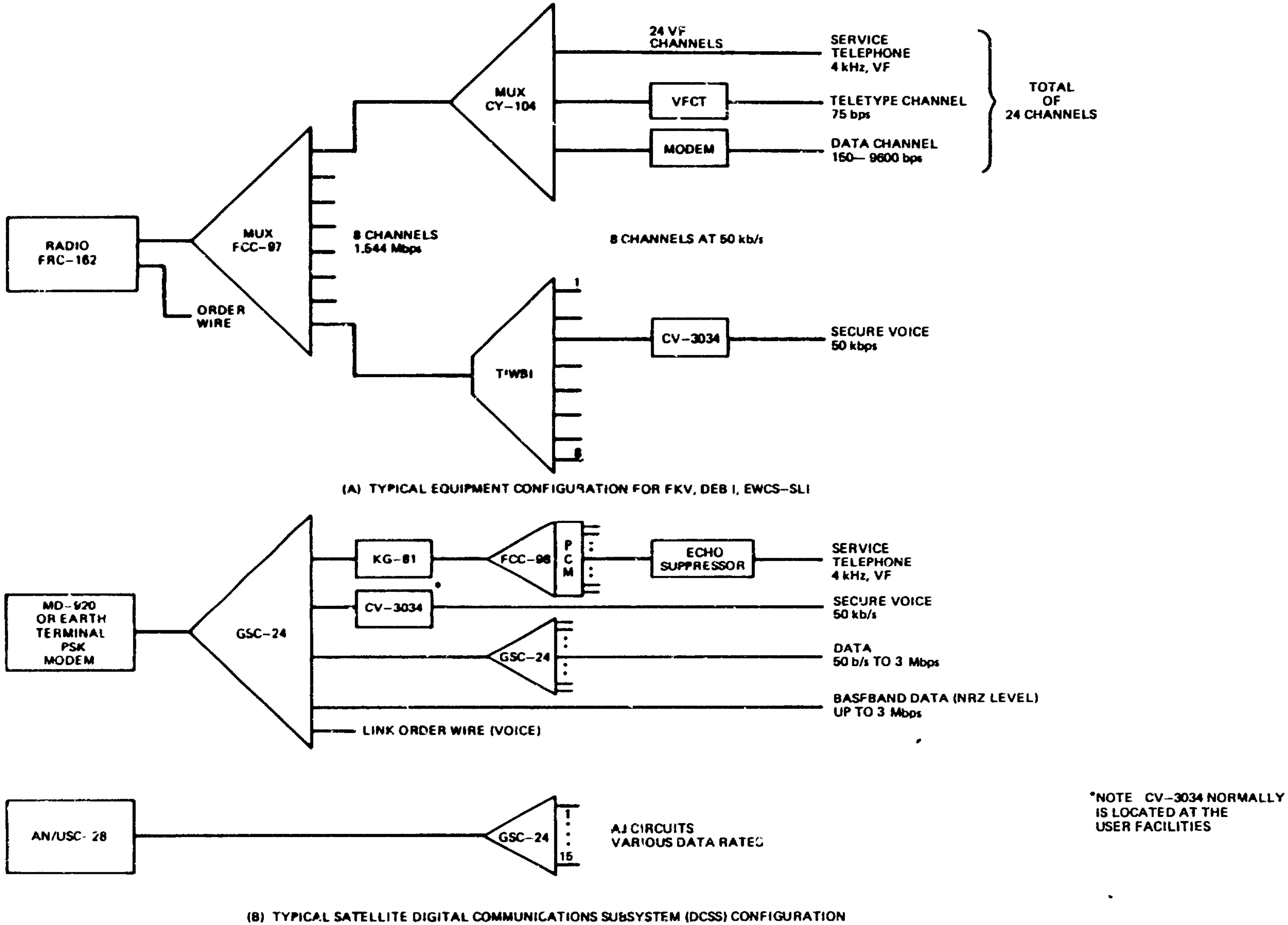
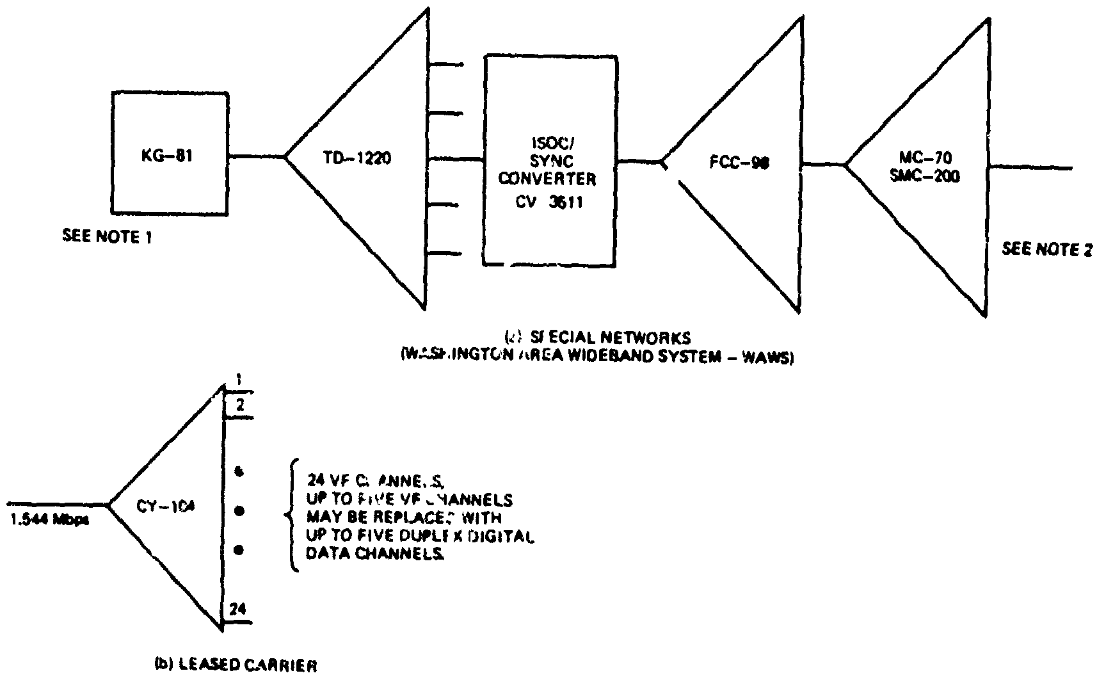


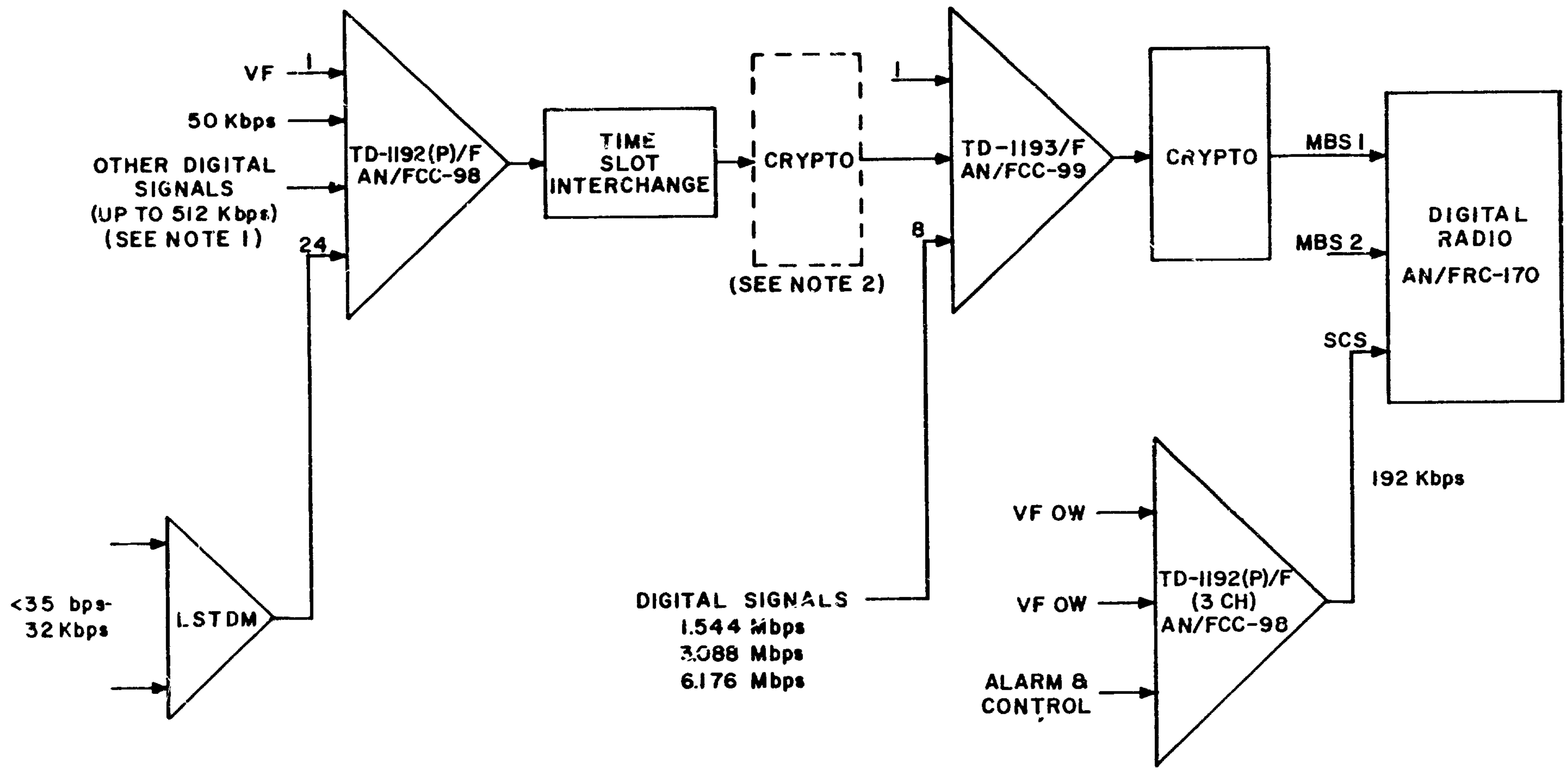
FIGURE 1.3.2.1 (a) TDM PRE-1980 CONFIGURATIONS



NOTES

1. KG-81 TYPICALLY INTERFACES TO DMX-A3 COMMERCIAL MULTIPLEX AND THENCE TO RADIO
2. COMMERCIAL MULTIPLEXER

Figure 1.3.2.1(b). TDM Pre-1980 Configurations (Special)



NOTE 1 DATA INTERLEAVING CARDS ARE USED WITH DIGITAL SIGNALS.

NOTE 2 ENCRYPTION CAN BE ACCOMPLISHED AT THIS LEVEL INSTEAD OF AT MBS LEVEL. IF USED AT THIS LEVEL, ENCRYPTION MUST OCCUR ON THE OUTPUT OF ANY TIME SLOT INTER-CHANGE DEVICES.

FIGURE 1.3.2.1(c) POST-1980 CONFIGURATIONS (DEB)

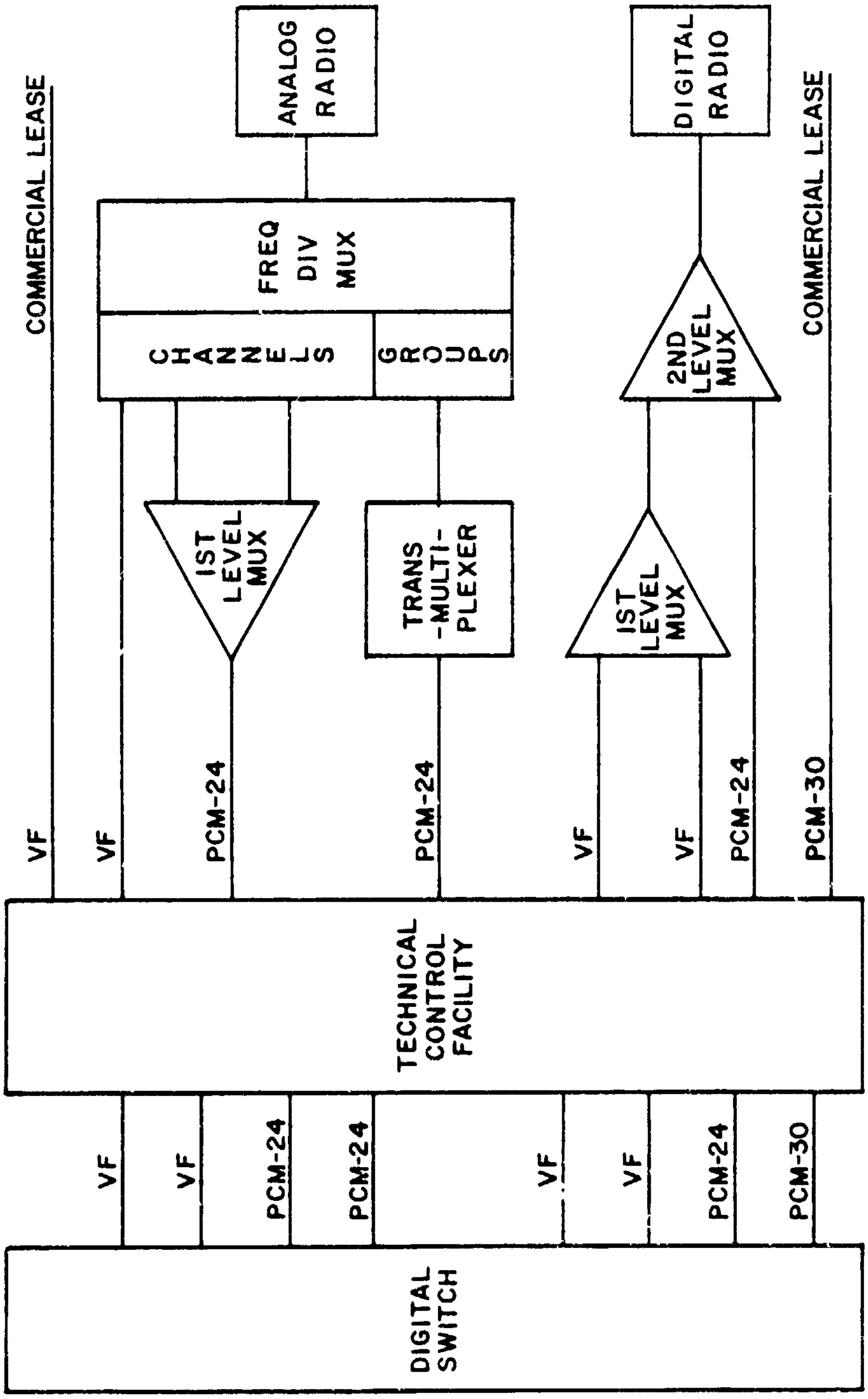


FIGURE 1.3.2.1(d). DIGITAL TELEPHONE SWITCH INTERFACES (EXAMPLE)

1.3.2.1(a). The lower half of this figure shows a simplified TDM configuration of the Digital Communications Subsystem (DCSS) of the Defense Satellite Communications System (DSCS) Phase II which was introduced overseas and in CONUS during the pre-1980 time frame.

1.3.2.2.2 CONUS and Hawaii - Before 1980, a special high-capacity digital network was implemented in the Washington, D.C., area. This network, known as the Washington Area Wideband System (WAWS) employs the TDM hierarchy and configuration shown in the upper half of Figure 1.3.2.1(b). This basic approach for providing digital transmission facilities is also being planned for a number of other areas, including Norfolk, Virginia, Hawaii and areas of California. It is anticipated that these additional digital implementations will have equipment configurations similar to the WAWS.

There are also 1.544 Mb/s leased carrier TDM configurations linking Hawaii and CONUS (Stockton-Wahiawa, McClelland-Hickam) which use the configuration depicted in the lower half of Figure 1.3.2.1(b). This form of lease is relatively new to the DCS, but other 1.544 Mb/s leases are under consideration and it is expected that their numbers will increase as the commercial carriers expand digital services.

1.3.2.3 Post 1980

1.3.2.3.1 Overseas

In the post 1980 period, the Digital European Backbone, Phases II, III and IV (DEB II, III, IV) and the Pacific Digitization Program will be implemented utilizing hardware developed under the Digital Radio and Multiplex Acquisition (DRAMA) program. The hierarchy and configuration of this system are shown in Figure 1.3.2.1(c). A typical digital telephone switch interface/configuration is shown by Figure 1.3.2.1(d).

1.3.2.3.2 CONUS and Hawaii - After 1980, leased digital transmission will gradually become a major carrier of DCS traffic. Commercial use of digital switching is growing very rapidly and so too is the amount of digital transmission. It has been estimated that by 1995 the core trunking network will be digital across the entire country. In terms of DCS switched networks this period will see AUTODIN II become operational; the Secure Voice Improvement Program will augment and eventually replace the AUTOSEVOCOM system; and a digital AUTOVON system will replace the existing analog AUTOVON network. Video conferencing and highspeed digital facsimile will likely become widespread.

1.4 Relation to Existing Standards and Criteria - This publication supplements and updates but does not supersede the standards and criteria listed below with respect to time division multiplexed systems. Where differences occur with applicable MIL-STD's the provisions of the standard shall apply.

Military Standards

MIL-STD-188-310A	Subsystems Design and Engineering Standards for Technical Control Facilities (14 Jan 80). (To be replaced by MIL-STD-188-154 when issued.)
MIL-STD-188-100	Common Long Haul and Tactical Communication System Technical Standards.
MIL-STD-188-114	Electrical Characteristics of Digital Interface Circuits. (The electrical characteristics for the digital interfaces discussed in this publication should be in accordance with MIL-STD-188-114. Normally, a balanced 124 OHM configuration is preferred).
MIL-STD-188-120	Military Communication System Standards Terms and Definitions.
MIL-STD-188-124	Grounding, Bonding and Shielding.
MIL-STD-188-311	Equipment Technical Design Standard for Multiplexers.
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.

Military Handbooks

(C) MIL-HDBK-232	RED/BLACK Engineering Installation Criteria (U)
MIL-HDBK-411	Power and Environmental Control for Physical Plant.
MIL-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (May 1980)

DCA Circulars

DCAC 310-50-6	Defense Communication System Orderwires.
DCAC 310-70-1	DCS Technical Control.
DCAC 300-175-9	Operating - Maintenance Electrical Performance Standards.
DCAC 310-70-57	DCS Quality Assurance Program.

CHAPTER TWO

TERMS, DEFINITIONS, AND ABBREVIATIONS

AAT - Automatic Analog Tester. A functional subelement of the TRI-TAC Communications Nodal Control Equipment.

A AND B LEADS - Those leads associated with direct current connections which are derived from the midpoints of a 2-wire line or circuit (or each pair of a 4-wire line or circuit). The A and B leads are usually derived through use of a retard coil, repeating coil, or a 4-wire terminating set.

ABSOLUTE DELAY - The total time, usually measured in microseconds, for a signal to be transmitted from point A to point B of a circuit.

ADMS - Automatic Digital Message Switch. (Term used in AUTODIN).

ADMSC - Automatic Digital Message Switching Center. Term formerly associated with AUTODIN. Now called ASC for Automatic Switching Center.

ADT - Automatic Digital Test. A functional subelement of the TRI-TAC CNCE.

ACCESS - (1) A point of entry or a means of entry into a circuit. (2) The action of entering or connecting to a circuit. To connect to a circuit.

ACCESS LINE - A circuit between telephone or PBX and the switching center which serves them. Modern designation for "subscriber's loop" and "PBX trunk".

TERMS, DEFINITIONS, AND ABBREVIATIONS

ADAPTIVE MULTIPLEXER	-	A multiplexer in which the output rate is manually or automatically variable depending on the input and whose output rates are close to the sum of the input rates.
ADJACENT-CHANNEL INTERFERENCE	-	Interference caused in one communication channel by a transmitter operating in an adjacent channel.
ALPHA FLUNK	-	Relative measurement (on-line) of performance of digital RF links containing error detection and correction equipment, i.e., KY-801 Viterbi CODEC.
ANALOG SIGNAL	-	A nominally continuous electrical signal that varies in amplitude or frequency in response to changes of sounds, light, heat, position, pressure, etc.
AN/FCC-18	-	A type of frequency division multiplexing equipment used in the present DCS. Also called TCS-600.
AN/FCC-32	-	A type of frequency division multiplexing equipment used in the present DCS.
AN/FCC-97	-	The second level multiplexer which consists of two OB-79(V)/FSD (TI-4000) multiplexers, one normal and one backup, with an automatic transfer feature to switch from normal to backup upon failure of the normal unit.
AN/FCC-98	-	The first level PCM multiplexer (TD-1192) used in the DEB.
AN/FCC-99	-	The second level TDM multiplexer (TD-1193) used in the DEB.

AN/FRC-80	-	A type of microwave radio equipment used in the present DCS. Also called the MR-300.
AN/FRC-162	-	A microwave radio equipment providing space-diversity, full duplex, transmitting and receiving operation. It operates on fixed frequencies between 7125 MHz and 8400 MHz, with a nominal output power of 1 watt. (See Equipment Description).
AN/FRC-163	-	A line of sight microwave radio set associated with the DRAMA procurement used in DEB II, III, and IV.
AN/FRC-165	-	A 5-watt version of the AN/FRC162.
AN/FRC-170 to 173	-	Drama digital radio configurations differing in frequencies and diversity.
AN/FSC-9	-	A large, fixed satellite communications terminal employing a 60-foot parabolic antenna. Used in Defense Satellite Communications System.
AN/FSC-78	-	A large, fixed satellite communications terminal employing a 60-foot parabolic antenna. Used in Defense Satellite Communications System.
AN/FTC-31	-	A four-wire, BLACK digital circuit switch used in AUTOSEVOCOM for automatically switching wideband interswitch trunks and access lines.

AN/FYQ-42(V)1 through AN/FYQ-42 (V)12 and AN/FYQ-42(V)II	-	Military nomenclatures associated with AUTODIN. Automatic Digital Message Switching Centers.
AN/GSC-24(V)	-	A time division multiplexer used in the Defense Satellite Communications System (DSCS). It provides asynchronous time division, multiplexing and demultiplexing of digital signals from 50 bits per second to 3 megabits per second per channel and includes a capability to MUX/DEMUX up to 15 full duplex channels. The total output/input rate may be up to 10 Mbps.
AN/GSC-39	-	A medium, transportable satellite communications employing a 40-foot parabolic antenna used in the DSCS.
AN/MSC-46	-	A moveable satellite communications earth terminal used in the Defense Satellite Communications System. It is mounted in four air transportable wheeled vans and utilizes a 40-foot parabolic antenna which is mounted on a transportable pedestal and contains the low noise receiver.
AN/TSC-54	-	A transportable satellite communications earth terminal used in the Defense Satellite Communications System. The antenna, with an effective 18-foot diameter, uses a cloverleaf arrangement of four parabolic dishes with can be folded for aircraft transport and can be wheel mounted for road travel.

AN/TTC-39 - A circuit switch with both a time division matrix and a space division matrix for switching both analog and/or digital interswitch trunks and access lines to be used in TRI-TAC.

AN/USC-26 - A group data modem (GDM). It provides a 60-108 kHz standard FDM group interface for digital data used in AUTOSEVOCOM for 50 kb/s service although it is capable of higher rates. It has two modes of operation, FULL GROUP or HALF GROUP. In the latter mode, only the center 24 kHz are used for data while six voice channels may be serviced with the remainder of the group spectrum.

AN/USC-28(V) SSMA SATELLITE COMMUNICATIONS SET - A modem used in the Defense Satellite Communications system utilized when necessary to counter link jamming.

ASC - Automatic Switching Center. Term associated with AUTODIN.

ASCII - American Standard Code for Information Interchange.

ASSC - AUTODIN Station Supervisory Console.

ASR - Automatic Send and Receive (Teletypewriter).

ASYNCHRONOUS SYSTEM - A system employing start and stop elements for individual synchronization of each information character, or each word or block. The gaps between characters or words may be of variable length.

ATTENUATION	-	The action by which, or the result in which, the power of an electrical signal is decreased, expressed in decibels.
AUTODIN	-	Automatic Digital Network. A DCS switched network for record/data traffic employing store and forward switches.
AUTODIN II	-	Second generation AUTODIN. A DCS switched network for record/data and computer to computer interactive service employing packet switching.
AUTODIN IST	-	AUTODIN Interswitch Trunk. A four-wire data channel connecting AUTODIN switches.
AUTOSEVOCOM	-	Automatic Secure Voice Communications. A DCS circuit switched network for secure voice service, both 50 and 16 kb/s trunks and access lines and narrowband trunks and access lines at 2.4 kb/s or 9.6 kb/s.
AUTOSEVOCOM IST	-	A four-wire circuit or time division multiplexed circuit connecting two AUTOSEVOCOM SWITCHES for narrowband or wideband service.
AUTOVON	-	Automatic Voice Network. A DCS circuit switched network providing a variety of telephone and data services on a common user basis with special features for important subscribers and users.
AUTOVON IST	-	AUTOVON Interswitch Trunk. A four-wire circuit connecting two AUTOVON four-wire switching centers and designed for zero-dB loss.

AUTOVON SUBSCRIBER	-	An individual, installation, or activity having a direct four-wire connection or access to an AUTOVON switch.
AUTOVON SUBSCRIBER LINE	-	A four-wire circuit connecting an AUTOVON subscriber to an AUTOVON four-wire switch.
AUTOVON USER	-	An individual, installation, or activity having access to the AUTOVON switch through a local switchboard (PBX or PABX).
AVAILABILITY	-	The fraction of time that the system is actually capable of performing its mission.
AVAILABILITY FACTOR	-	The ratio of the time a piece of equipment is ready for or in service to the total time interval under consideration.
BACK-TO-BACK CONNECTION	-	The connection together of (1) two radio system, baseband-to-baseband, or (2) two carrier systems, group-to- group or channel-to-channel, or (3) two selecting switches such as line finder and connector, from jacks-to-jacks.
BALANCED CIRCUIT (Signal-Transmission System)	-	A circuit in which two branches are electrically symmetrical with respect to a common reference point, usually ground.
BALANCED LINE	-	A two-conductor transmission line with both conductors having electrically equal reference to ground.
BANDWIDTH	-	A range of frequencies between upper and lower limits. Two methods of specifying are in common use: (a) between the high and low frequencies where the power level is 3 dB below that at midband, and (b) 25 dB below.

BANK - An aggregation of similar devices connected together and used in cooperation. For example, carrier multiplex terminal channel bank or group bank.

BASEBAND - The total composite signal formed by the aggregate of all the information signals used to modulate a carrier. (PCM/TDM or FDM). Also used to describe DC level digital signal operating into wirelines to differentiate from diphase.

BAUD - The unit of modulation rate. One baud corresponds to a rate of one unit interval per second. The modulation rate is expressed as the reciprocal of tne duration in seconds of the shortest interval. For example, if the duration of the unit interval is 20 milliseconds, the modulation rate is 50 bauds.

BAY - (1) One or more racks or frames on which equipment panels or shelves are mounted. (2) One unit of an antenna array.

BCI - Bit Count Integrity. A situation where the number of bits in a system or subsystem is constant.

BEAT FREQUENCY - A new wave which is created when two different frequencies are combined. Its frequency is the sum or difference between the two combined frequencies.

BIPOLAR - A form of digital signal coding.

BIT - Acronym for "binary digit". See baud.

BITE - Built-In Test Equipment.

BIT ERROR RATE (BER) - The number of erroneous bits divided by the total number of bits over some stipulated period of time. The two types are: Transmission BER - number of erroneous bits received divided by the total number of bits transmitted; and Information BER - number of erroneous decoded (corrected) bits divided by the total number of decoded (corrected) bits. The BER is usually expressed as a number of a power of 10 (e.g., 2.5 erroneous bits out of 100,000 bits transmitted would be 2.5 in 10^5 or as 2.5×10^{-5}).

BIT RATE - The speed at which digital information is transmitted, usually expressed in bits per second.

BLACK - Refers to the type of transmission facility, type of signal, or area which contains either (a) encrypted classified information, or (b) unclassified information.

BSY - Busy.

BULK-ENCRYPTED - Describing information on several channels which are encrypted simultaneously by a single encryption device. A typical arrangement would employ a multiplexer to combine several channels into a single channel for encryption.

BYTE - A group of binary digits which is the smallest addressable unit of information in a memory.

CA - Cable.

CARRIER - A wave suitable for modulation by the intelligence to be transmitted over a communications system.

CARRIER SYSTEM - A system for transmitting intelligence by modulating it on a carrier at one point and recovering the intelligence in the original form at another point by demodulation.

CAU - Crypto Ancilliary Unit.

CCIS - Common Channel Interoffice Signaling.

C/kT - Carrier-Power-To-Noise Power Density Ratio. Measurement of performance of Wideband RF systems.

CDF - Combined Distributing Frame. This is a wiring frame which provides a means of cross connecting switch and technical control equipment.

CHANNEL - (1) The smallest subdivision of a trunk by which a single type of communication service is provided; that is, voice channel, teletypewriter channel, data channel, etc. (2) A one-way transmission between two points.

CHANNEL BANK - A channel bank forms a part of a carrier multiplex terminal. It performs the first steps in modulation and/or in coding and decoding in transmitting voice frequencies into a higher frequency division multiplex (generally 60 to 108 kHz) or into a pulse code modulated 1.544 mb/s bit stream in time division multiplexing. The channel bank generally consists of 12 channels in FDM; 24 in TDM.

CIRCUIT - A communications path between two or more points. A circuit is also a group of components, which together to perform a specific function.

CIRCUIT, CLOSED - A program circuit, radio or video, between two points, not for broadcast use. A completed electrical circuit.

CKT - Circuit.

CLEAR TEXT - Digital or analog communications signals which are not encrypted and from which the information can be easily extracted.

CLOCK - (1) A device that generates periodic signals used for synchronization. (2) A device that measures and indicates time. (3) A register whose changes at regular content intervals in such a way as to measure time.

CNCE - Communications Nodal Control Element. A shelter-mounted technical control facility for communications nodes for TRI-TAC.

COMMON-USER CIRCUIT - A circuit allocated to furnish communications to a number of users each of whom accesses it through a switching facility.

COMPARATOR - A circuit for performing value comparison between two or more variables and a constant.

CONDITIONED DIPHASE - A form of digital signal coding.

CONDITIONING EQUIPMENTS	-	Equipment necessary to match transmission levels, impedances, and rates. In analog facilities it provides equalization. In digital facilities, these include buffers, modems, drivers, shapers, isolators and digital signal processors.
CRF	-	Channel Reassignment Function. A functional subelement of the TRI-TAC Communications Nodal Control Element (CNCE).
CROSS-CONNECTION	-	Easily changed or removed wire that is run loosely between equipment terminals to establish electrical paths.
CSU	-	Customer Service Unit. A commercial unit used on leased lines for use with American Telephone & Telegraph's Digital Data System (DDS).
CUTOVER	-	The replacement of existing communications services with newly operational facilities without curtailing existing services.
CUTOVER DEVICE	-	A device which is wired into a circuit to permit the rapid transfer of a circuit from its present to a future termination. Facilitates pre-cutover testing and the actual cutover.

CV-3034/G	-	A device for interfacing a single four wire analog or asynchronous 50 kb/s digital channel to a digital multiplex or PSK. The unit is transparent to 50 kb/s digital signals and converts analog inputs to a 50 kb/s signal with automatic recognition of the input mode. It is primarily used for analog/digital conversion of analog signaling and supervision signals over 50 kb/s trunks in AUTOSEVOCOM I.
CV-3511	-	Isochronous/Synchronous Converter (Pulse Stuffer) used in the WAWS.
CVSD	-	Continuous Variable Slope Delta Modulation.
CXR	-	Carrier.
DAMA	-	Demand Assigned Multiple Access.
dB	-	Abbreviation for "decibel". A unit expressing the ratio of two voltages, currents, or power levels. It is equal to 20 times the common logarithm of the two voltages or two currents, and 10 times the common logarithm of the ratio of the two power levels.
dBa	-	"Decibels adjusted". A noise meter having FIA weighting will read 85 dBa when the input is 1000 Hz at a level of one milliwatt. While noise limited to 300-3400 Hz will give a reading of 82 dBa.
dBa0	-	A reading of noise power in dBa at a test point, corrected to the equivalent noise power at the zero level transmission reference point.

dBm	-	Decibels referred to a power of one milliwatt, employed in communications as a measure of absolute power values. Zero dBm equals one milliwatt.
dBm0	-	The power in dBm measured at or referred to a point of zero relative transmission level.
dBr	-	"Decibels relative level". Used to define transmission levels at a point in a circuit with respect to the level at the zero transmission level reference point.
dBrn	-	(Decibels Above Reference Noise). Weighted noise power in dB referred to 1.0 picowatt. Thus, OdBrn = 90 dBm. Use of 144-line, 144-receiver or C-message weighting, or flat weighting shall be indicated in parenthesis as required. NOTE: 1. With C-message weighting, a one milliwatt 1000 Hz tone will read +90 dBrn, but the same power as white noise, randomly distributed over a 3 kHz band will read approximately +88.5 dBrn, (rounded off to +88 dBrn), due to the frequency weighting. 2. With 144 weightings, a 1 mW, 1000 Hz tone will also read +90 dBrn, but the same 3 kHz white noise power will read only +82 dBrn, due to the different frequency weighting.
dBrnc	-	Weighted noise power in dBrn, measured by a noise measuring set with C-message weighting.
dBrnc0	-	Noise power in dBrnc referred to or measured at a zero Transmission Level Point (OTLP).
DCEM	-	Digital Channel Efficiency Model

DCS REFERENCE CIRCUIT	-	A hypothetical circuit defined in MIL-STD 188-100. It is used as a reference for overall transmission objectives in long-haul communications systems.
DCSS	-	Digital Communications Subsystem.
DDS	-	Digital Data Service. A tariff offering of the Bell System for data transmission at rates up to 56 kb/s.
DEB	-	Digital European Backbone. A four-phased DCS program which will convert many frequency division multiplexed analog transmission systems to time division multiplexed digital transmission systems.
DEBUG	-	To examine or test a procedure, routine, or equipment for the purpose of detecting and correcting errors.
DELTA MODULATION	-	An A/D conversion technique by which a change in input information, an increase or decrease of the signal level from a previous sample, is transmitted.
DEM	-	See Demodulation. When used as an abbreviation, signifies the receive side of a carrier circuit.
DEMODULATION	-	The act of recovering from a modulated wave the signal with which the wave was originally modulated.
DEMULTIPLEXER	-	A device that reverses the action of a multiplexer, and derives a group of separate channels from the complex multiplex signal.

DFSU	-	Dual Frequency Signaling Unit.
DI-GROUP	-	Used in PCM/TDM systems to describe the processed combination of 24 analog voice channels into a single 1.544 Mb/s digital channel (T1). The PCM/TDM counterpart of an FDM group.
DIPLEX OPERATION	-	The simultaneous transmission or reception of two signals using a specified common feature, such as a single antenna or a single carrier.
DISTORTION, AMPLITUDE VS FREQUENCY	-	The distortion caused by the non-uninform attenuation, or gain, of a transmission system with respect to frequency, under specified terminal conditions.
DISTORTION, BIAS	-	Distortion affecting a two-condition or binary modulation in which all the significant intervals corresponding to one of the two significant conditions have uniformly longer or shorter duration than the corresponding theoretical durations.
DISTORTION, CHARACTERISTIC	-	Distortion caused by transients which, as a result of modulation, are present in the transmission channel and depend on its transmission qualities.
DISTORTION, DELAY	-	That distortion (of a transmission system) caused by the difference between the maximum transit time and the minimum transit time of frequencies within a specified band. (Also called time delay distortion and phase distortion.)

DIU	-	Digital Interface Unit. The components located in a digital electronic switch that provides interface from the switch to the digital data user lines or T carrier trunk lines. It may contain all conditioning equipment needed for the interface.
DMX-A3	-	Multiplexer which combines three 12.928 Mbps streams plus three 1.544 Mbps streams into one 44.736 Mbps stream for feeding one part of the WAWS 90 Mbps radio.
DOWN TIME	-	The period during which a system or device is not operating due to internal failures, scheduled shut down, or servicing.
DRAMA	-	Digital Radio and Multiplex Acquisition
DROP SIDE	-	That portion of patch bay that looks toward the subscriber facilities, or towards a cable facility normally associated with the primary patch bay.
DSCS	-	Defense Satellite Communications System.
DSVT	-	Digital Secure Voice Terminal.
DTMF	-	Dual-Tone Multifrequency - A signaling method employing set combinations of two specific frequencies, of which one frequency is selected from a group of four low frequencies. It is used by subscribers and PBX attendants, if their switchboard positions are so equipped, to indicate telephone address digits, precedence ranks, and end-of-signaling.

D2 CHANNEL BANK - A channel bank which time division multiplexes and pulse code modulates 24 voice frequency signals (including signaling) into a single 1.544 mb/s bipolar pulse stream. Its military nomenclature is TSEC/HY-12.

DX SIGNALING UNIT - A DX signal unit is used to extend E&M leads when the connecting conductor resistance exceeds 25 ohms. The DX signal unit accepts DC pulsing and/or supervising signals from the cable pair and extends these as E lead signals to the trunk circuit. It also accepts M lead DC signals from the trunk circuit and extends these as DC pulsing and/or supervisory signals to cable pair. It also transmits and receives the DC signals on the same cable pair as the talking path, and is capable of simultaneously transmitting signals in both directions.

DUPLEX OPERATION (GENERAL) - The operation of transmitting and receiving apparatus at one location in conjunction with associated transmitting and receiving equipment at another location, the processes of transmission and reception being concurrent.

E&M LEAD SIGNALING - An arrangement whereby communication between a trunk circuit and a separate signaling unit is accomplished over two leads: an M lead which transmits battery or ground signals to the signaling equipment, and an E lead which receives open or ground signals from the signaling unit.

E_b/N_o	-	Energy-Per-Bit-to-Noise-Power Density Ratio Measurement of performance of digital systems. (Similar to Signal-To-Noise-Ratio.)
EBCDIC	-	Extended Binary Coded Decimal Interchange Code. An extension of the Binary Coded Decimal (BCD) code to eight binary bits to allow it to handle control character codes. Used by IBM.
EC	-	Extra Control Lead. This lead is used to accomplish supervisory and signal functions for AUTOVON switch.
ECHO	-	A signal derived (for example, by selection) from a primary signal which returns to the source or the primary signal with sufficient magnitude and delay to be distinctly recognizable.
ECHO CANCELLER	-	An equipment which cancels echo by digital means.
ECHO SUPPRESSOR	-	A device which detects speech signals transmitted in either direction on a four-wire circuit, and introduces loss in the direction opposite to the direction of transmission for the purpose of suppressing echos.
ECHO SUPPRESSOR, SPLIT-CONTROLLED	-	In a split-controlled echo

suppressor system, an echo suppressor is placed at each end of the 4-wire line in which the delay occurs. With one talker speaking, full suppression is inserted in the other direction of transmission; with both talkers speaking, partial echo suppression is inserted in both directions of transmission. Thus, neither talker controls the communications channel in the sense of inserting full suppression which the other talker is unable to remove.

EMS-8-KN SWITCH - European Digital Telephone Switch. Siemens PCM Switching System. (see KN-101 Switch)

ENVELOPE DELAY - The maximum difference in transmission time (absolute delay) between any two frequencies in a specified frequency band expressed in microseconds.

ES-3B ECHO SUPPRESSOR GROUP - Equipment which provides suppression of echo in a synchronous satellite communications system without speech chopping during two-talker operation.

EQ - Equipment (when used as an abbreviation signifies the equipment side of a circuit).

EQL - Equalizer. Used in the process of reducing frequency and/or phase distortion of a circuit by the introduction of networks in order to compensate for that difference in attenuation and/or time delay that occurs at the various frequencies in the transmission of bands.

EQUALIZER, DELAY - An equalizer inserted in a line to delay the higher frequencies, so that all useful frequencies will have almost equal delay, and therefore the minimum delay distortion.

EQUIPMENT SIDE - In reference to a patch bay, the equipment side of a jack is that side which is electrically closer to the in-station equipment than to the ingress to or egress from the facility.

ESC - Echo-Suppressor Control Lead.

ET - Earth Terminal.

EYE PATTERN - An eye pattern is defined by all the possible bit states at the point in the demodulator just before bit decisions are made. The eye pattern is visualized by superimposing all the bit states on the same time scale. An ideal eye pattern will result in an eye pattern voltage of 1 (normalized) at the sample time for every bit. Eye pattern degradations are defined as those effects present in a practical (non-ideal) system that cause reduction in the eye voltage at the same time for some of the bits. Such effects include inter-symbol interference, errors in the phase of the carrier recovery and errors in the clock sampling time.

FAS - Fault Alarm System. It provides for remote monitoring and control on transmission systems.

FASR	-	Fault Alarm Status Reporting System. An orderwire system used in FKV to transmit alarm data from potentially unmanned sites to adjacent manned FKV sites.
FDM	-	Frequency Division Multiplex.
FG	-	Flat Gain (amplifier). A device having uniform gain characteristics over a specified frequency range.
FILTER	-	A frequency selective network which selects signals of desired frequencies while greatly attenuating all other frequencies.
FIRST LEVEL MULTIPLEX	-	The level in the time division multiplex hierarchy that accepts voice frequency, nominal 4 kHz channels, and provides analog-to-digital conversions, time division multiplexing and E&M signaling for 24 channels.
FKV	-	Frankfurt-Koenistuhl-Vaihingen. Abbreviation usually used to denote a time division multiplexed system installed as a test bed in the European Theater. In the actual overall FKV program, analog elements were also installed extending to Frankfurt.
FM	-	See FREQUENCY MODULATION
FORM-C	-	A single pole double throw set of contacts in a relay.
FREQUENCY MODULATION	-	A form of modulation in which the frequency of the carrier wave is varied in accordance with the instantaneous value of the modulating wave.

FREQUENCY DIVISION MULTIPLEX (FDM)	- A method of deriving two or more simultaneous, continuous channels from a transmission medium connecting two points by assigning separate portions of the available frequency spectrum to each of the individual channels.
FREQUENCY SHIFT KEYING (FSK)	- A form of frequency modulation in which the modulating signal shifts the output frequency between predetermined values and in which the output signal has no phase discontinuity.
FSK	- Frequency Shift Keying.
FULL-DUPLEX OPERATION	- A type of operation in which simultaneous 2-way conversations, messages, or information may be passed between any two or more given points.
GCM	- Group Cable Modem. A TRI-TAC modem that accepts an NRZ format group input and outputs either conditioned diphase or a bipolar bit stream at rates of 72 kb/s to 4.6 Mb/s over a coaxial cable up to 3.2 kM in length without repeaters.
GDM	- Group Data Modem. A modem which provides high speed digital channels (e.g., 50, 56, 128 kb/s) through an FDM group 48 kHz channel.
GN	- Gain.
GP	- Group.
GPC	- Group Pilot Control (See PMB).

GROUP - A number of voice channels, either within a supergroup or separately, which normally comprise up to 12 voice channels occupying the frequency band of 60-108 kHz. (Also see BANK).

HALF-DUPLEX OPERATION - A circuit designed for duplex operation; however, because of the nature of the terminal equipment, signals are transmitted alternately in either direction.

HAMMING CODE - A code which introduces a hamming distance sufficient to accomplish error detection, correction, or both.

HARDEN - To construct communications facilities in such a manner that they will survive and be operable following a nearby bomb blast.

HARMONIC - A sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency.

HF - High Frequency

HP-5061A CESIUM BEAM FREQUENCY STANDARD - A frequency standard equipment used in the Defense Satellite Communications System capable of absolute accuracy, intrinsic reproducibility and absence of any perceptible long term drifting or aging, which assures that the output frequency is always within the specified accuracy.

HYB - Hybrid.

ICF - Interconnect facility. A facility associated with the Defense Satellite Communications System (DSCS) for providing the necessary interface elements between the earth terminal equipment and the TCF.

IF - Intermediate Frequency.

INTELLIGENT - A term applied to equipment which can use logic to make decisions and/or display information in a more useful form. Usually applied to microprocessor-controlled equipment.

INTERBAY TRUNK - Trunks connecting and terminated at test positions for testing and patching between test boards and patch bays within the technical control facility.

INTERFACE - The place at which two subsystems or two parts of one system interconnect. The specification of an interface includes the types and functions of the interfacing circuits, e.g., impedances and signal levels and forms, and the nature and coding of the information exchanged.

IST - Interswitch Trunk.

ISOCHRONOUS - That characteristic of a periodic signal in which the time interval separating any two corresponding transitions is theoretically equal to the unit interval or to a multiple of the unit interval.

JITTER	-	Abrupt and spurious variations of a signal such as interval duration, amplitude of successive cycles, or in frequency or phase of successive pulses.
KG-81	-	Bulk encryption equipment to be used in the Defense Satellite Communications System and the Digital European Backbone, Phases II-IV.
KN-101 SWITCH	-	The ETS Switch (See EMS-8-KN Switch
KY-801( )/GSC	-	Equipment used in the Defense Satellite Communications System which provides coding and decoding functions to improve the reliability of transmission of digital data over satellite communications links.
KEYSHELF UNIT	-	A shelf attached to a testboard or patch bay that has mounting for keys, cords, lamps, and test meters arranged to enable the technical controller to talk and perform a variety of tests all circuits appearing in that testboard or patch bay.
LDDS	-	Local Digital Distribution System.
LED	-	Light Emitting Diode.
LEASED FACILITIES	-	Cable pairs or channels derived from systems which are owned privately or by foreign government agencies and which are leased.
LEASED SERVICE	-	Communications Equipment or Services which are leased.

LIFE CYCLE	-	A test performed on a material or device to determine the length of time before failure. Conducted in a controlled, sometimes accelerated environment.
LINE FILTER	-	A filter associated with a transmission line, such as a filter used to separate speech frequencies from carrier frequencies.
LINE SIDE	-	In reference to a patch bay, the line side of a jack is that side which is electrically closer to the facility transmission media, except where the media is cable, the cable side may be labeled "EQUIP" side.
LINK	-	(1) A portion of a communication circuit. (2) A channel or circuit designed to be connected in tandem with other channels or circuits. (3) A radio path between two points, called a radio link; the resultant circuit may be undirectional, half-duplex, or duplex.
LIST	-	Listen (see MON). In a telegraph testboard, a jack permitting communication on a circuit bay patching a teletypewriter.
LOCAL VOICE PARTY LINE ORDERWIRE	-	A permanently connected voice circuit between the technical control facilities and adjacent patch and test facilities.
LONG HAUL	-	A term of indefinite meaning describing circuits spanning considerable distances and requiring special techniques, such as repeatering, echo suppression, etc.

LOOP ANNULER	- A device which continually monitors the signals from a loop. It disconnects the loop from the main circuit when an open condition exists for more than a predetermined period of time in order to prevent interruption to traffic on the main circuit.
LOW	- Link Order Wire.
LPG	- Loop Patching. An abbreviation of the jack on the telegraph testboard.
LSTDM	- Low Speed Time Division Multiplexer
LTG	- Line Termination Group (Electronic switch)
LTU	- Line Termination Unit. (Electronic switch).
MD-920/G	- An Interconnect Facility (ICF) Modem that provides a means of interfacing digital data with a Digital Data-Phase Shift Keying MD-921/G Modem in a remotely located satellite communications terminal, used in the Defense Satellite Communications System (DSCS).
MD-921/G	- A PSK Modem which provides a means of interfacing and transmitting digital data over satellite communications.
MD-1002 ( )/S	- A quadraphase/biphase PSK modem designed for interfacing and transmitting digital traffic over satellite communications links used in the Defense Satellite Communications System (DSCS).

MASTERGROUP	-	Ten carrier supergroups, or 600 FDM channels.
MB	-	Make Busy.
MBLP	-	Make-Busy Lamp. A lamp to indicate that a circuit has been made busy by testboard or other action.
MBS	-	Mission Bit Stream.
MCC	-	Maintenance Coordination Circuit. The maintenance orderwire used in FKV and DEB-I.
MEAN TIME BETWEEN ERRORS (MTBE)	-	The average time between the generation of a single false code of a given set.
MEAN TIME BETWEEN FAILURES (MTBF)	-	The average time (preferably expressed in hours), between failures of a continuously operating device, circuit, or system.
MEAN TIME TO REPAIR (MTTR)	-	On a particular item or system, the total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.
MICROCOMPUTER	-	A computer employing a microprocessor. Usually small in size.
MICROPROCESSOR	-	An arithmetic, logic or control unit usually constructed of a single LSI chip.
MOD	-	Modulator (when used as an abbreviation signifies the transmit side of a carrier circuit).

MODEM	-	A contraction of modulator-demodulator. An A/D converter that converts digital data to a quasi-analog signal suitable for transmission via analog media, and D/A converter that reconverts the quasi-analog signals into digital signal.
MON	-	Monitor. Jacks on testboards or patch bays for monitoring and testing audio tones or visual display on a circuit without disrupting or degrading transmission.
MONITOR JACK	-	A monitor jack provides access to communications circuits for the purpose of observing the conditions on the circuit signal without interrupting the service provided by that circuit.
MR-300	-	A type of microwave radio equipment used in the present DCS. Also called the AN/FRC-80.
NON-RETURN TO ZERO (NRZ)	-	A digital code form having two states termed one and zero, and no neutral or rest condition.
OFF-HOOK	-	The condition that indicates the active state (closed loop) of a subscriber of PBX user line (busy interswitch circuit).
OFF-HOOK-SERVICE AUTOVON	-	The automatic establishment of a connection between specified subscribers as a result of lifting the handset.
OFF-THE-SHELF	-	(1) Said of an item that has been manufactured in quantity, has been proven in use and does not require further research or development. (2) Said of an item which is available from stock on hand.

ON-HOOK	-	The condition that indicates the idle state (open loop) of a subscriber or PBX user line (idle interswitch circuit).
ORDERWIRE	-	Voice or data circuit utilized by technical control and maintenance personnel for coordination and control actions relative to activation, deactivation, change, rerouting, reporting and maintenance of communications systems and services.
OS	-	Out-of-Service Lead. A lead OS that removes a trunk from use by a specific operation at the testboard (jack).
OUT-OF-BAND	-	See SIGNALING, OUT-OF-BAND.
OW	-	Orderwire
PABX	-	Private Automatic Branch Exchange. A local switching machine in which calls are completed by subscriber action, such as dialing, without operator action.
PAD (ATTENUATING PAD)	-	A nonadjustable passive network that reduces the power level of a signal without introducing appreciable distortion.
PARTIAL RESPONSE	-	A modulation technique used to shape a binary signal for transmission over an FM analog radio. In FKV and DEB I this shaping results in a three-level signal using two filters and has the effect of reducing the bandwidth required for the signal.

P&T	-	Patch and Test.
PATCH AND TEST FACILITY (PTF)	-	An organic element of a station or terminal facility that functions as a supporting activity under the technical supervision of a designated TCF. NOTE: It performs functions such as quality control checks and tests on equipment and links, circuits, etc.; troubleshooting; activation, changing, and deactivation of circuits; technical coordination; reporting; etc.
PATCH BAY	-	An assembly of hardware so arranged that a number of circuits (usually of the same or similar type) appear on jacks for monitoring, interconnectivity, and testing purposes.
PATCH BAY, BASEBAND	-	A Patching Facility where baseband level composite signals can be monitored and patched.
PATCH BAY, CABLE	-	A Patching Facility that provides the first technical control facility appearance of external cable pairs on jacks for monitoring, testing, and patching. In military communications, this is often called Primary Patch Bay. see PATCH BAY, PRIMARY.
PATCH BAY, CIRCUIT	-	A patching facility for terminating, monitoring and patching VF circuits, and signaling and control conductors. This terminology is used in technical control facilities which were installed during the implementation of AUTOVON. At facilities installed in accordance with MIL-STD 188-310, this is called the Equal Level

Patch Bay, although the functions are not completely identical in every detail.

PATCH BAY, COAXIAL - The TCF area where signals requiring distribution via coaxial cable can be patched, monitored and tested. Signals which require a Coaxial Patch Bay include supergroups, baseband, and high speed time division multiplexing. However, the electrical characteristics of the various signals of different terminal equipment must be carefully considered in designing these facilities.

PATCH BAY, "D" TYPE - A patching facility designed for patching and monitoring of unbalanced data circuits at rates up to 1 Mb/s.

PATCH BAY, DATA - A patching facility where digital data circuits can be patched, tested and monitored. May apply to any data rate circuit.

PATCH BAY, DC - A patching facility where low level digital data circuits can be patched, monitored, and tested. Normally associated with low speed (TTY) data circuits.

PATCH BAY, EQUAL LEVEL - An analog patching facility, either voice frequency or baseband frequency, at which all circuits appear at a uniform level both input and output, (usually 0 dBr), to facilitate patching without transmission adjustments.

PATCH BAY, IF - A patching facility associated in the DCSS which provides patch jack access to the interface between the DCSS modem and the earth terminal radio subsystem.

PATCH BAY, "K" TYPE - A patching facility designed for patching and monitoring of balanced data circuits at rates up to 1 Mb/s.

PATCH BAY, "M" TYPE - A patching facility designed for patching and monitoring of digital data circuits at rates from 1 Mb/s to 3 Mb/s.

PATCH BAY "MM" TYPE - A patching facility designed for patching and monitoring of digital data circuits at rates exceeding 3 Mb/s.

PATCH BAY, PRIMARY - A patching facility that provides the first appearance of local user circuits in the TCF. The primary patch bay may provide patching, monitoring and testing for VF circuits as well as high and low level dc circuits. Signals will have varying levels and signaling schemes, depending on the user terminal equipment.

PATCH BAY, SUPERGROUP/ GROUP - A patching facility which provides jack appearances for the on-line (regular) and spare carrier multiplex equipment. These jacks are provided for testing, patching, and transmission measurements and include appearances for channel bank inputs and outputs; group bank inputs and outputs; and supergroup inputs and outputs.

PATCH BAY, VF - A patching facility that provides monitoring and patching between the multiplex equipment and terminal circuit equipment. This patch bay is found at overseas AUTOVON Switches and technical controls installed in the late 1960's.

PATCH BAY, WBSV - Wideband Secure Voice Patching (WBSV) Facility that provides the capability to monitor patch WBSV signals at all inputs/ outputs of the special WBSV modems (AN/USC-26) and Analog-Digital Converters (CV-3034).

PATCH BOARD - See PATCH BAY.

PBX - Private Branch Exchange (generally manual). The concentration of user lines with the capability to access each other or remote users.

PBX ACCESS LINE - A trunk into the AUTOVON switch that terminates at a PBX.

PCM - Pulse Code Modulation.

PCM-24 - A 24 channel PCM used in North America with an output line rate of 1.544 Mbps. Uses a "mu" law companding technique.

PCM-30 - A nominal 30 channel PCM used in Europe with an output line rate of 2.048 Mbps. Uses an "A" law companding technique.

PERFORMANCE CHARACTERISTIC (DEVICE) - An operating characteristic, the limit or limits of which are given in the design test specifications.

PERFORMANCE INDEX (SYSTEM) - The system function or objective to be optimized.

PHASE MODULATION (PM) - Angle modulation in which the phase angle of a carrier is caused to depart from its reference value by an amount proportional to the instantaneous value of the modulating function.

PHASE-SHIFT KEYING (PSK) - The form of phase modulation in which the modulating function shifts the instantaneous phase of the modulated wave between predetermined discrete values.

PILOT (TRANSMISSION SYSTEM) - A signal wave, usually a single frequency, transmitted over the system to indicate or control its characteristics.

PILOT CHANNEL - A channel over which a pilot is transmitted.

PILOT LAMP - A lamp that indicates the condition of an associated circuit.

PLR - Pulse Link Repeater.

PMB - Pilot Make Busy. In the event of a carrier failure, the trunk circuit relay equipment associated with the AUTOVON switch would be made busy under control of a signal from the carrier pilot, to prevent false seizure of switch equipment during fades.

POLAR - A type of telegraph or data transmission signal with current flowing in one direction during the marking interval and reverse current flowing during the spacing interval. Generally defined as transmission in which the sending impedance is the same during marking or spacing intervals.

PORT - Entrance or exit (input or output) of a multiterminal device, such as a multiplexer or processor. Any of several terminals of a multiterminal network.

PSK	-	Phase Shift Keying.
PTF	-	Patch and Test Facility.
PTT	-	A term used to denote Public Telephone and Telegraph companies usually run by overseas governments and from which facilities are leased by the U.S.
PULSE AMPLITUDE MODULATION (PAM)	-	A form of pulse modulation in which the amplitude of pulses is varied to represent amplitude variations of an analog signal.
PULSE CODE	-	(1) A pulse train modulated so as to represent information. (2) Loosely, a code consisting of pulses such as Morse code.
PULSE CODE MODULATION (PCM)	-	A modulation process for the conversion of a waveform from analog to digital form by means of quantizing the analog information into a series of pulse codes.
PULSE LINK REPEATER (PLR)	-	An arrangement of apparatus used in telephone signaling systems for receiving pulses from one E&M signaling circuit and retransmitting pulses into another E&M signaling circuit.
PULSE MODULATION	-	(1) An A/D conversion technique whereby an analog signal is converted to various forms of digital pulses. (2) Modulation of a carrier by a pulse train. (3) Modulation of one or more characteristics of a pulse carrier.
PULSE REGENERATION	-	The process of restoring a series of pulses to their original timing, form, and relative magnitude.

PULSE REPETITION FREQUENCY (PRF)	-	The number of pulses per unit of time in a system using recurrent pulses.
QUANTIZATION (TELECOMMUNICATION)	-	A process in which the continuous range of values of an input signal is divided into nonoverlapping subranges, and to each subrange a discrete value of the output is uniquely assigned. Whenever the signal value falls within a given subrange, the output has the corresponding discrete value.
QUANTIZED PULSE MODULATION	-	Pulse modulation that involves quantization.
RADIO FREQUENCY INTERFERENCE (RFI)	-	Impairment of the reception of a wanted radio signal caused by an unwanted radio signal or a radio disturbance.
REC	-	Receiving (indicates direction of transmission)
RED	-	Refers to a type of transmission facility or area approved for containing clear text classified information.
RED/BLACK CRITERIA	-	Criteria which specifies the electrical and physical isolation required between unencrypted RED and encrypted BLACK communications circuits.
REGEN	-	Regenerative Repeater (telegraph or data).
REPEATER	-	A combination of apparatus for receiving either one-way or two-way communications signals and delivering corresponding signals that are either amplified, reshaped, or both.

RING	-	See TIP and RING.
RPTR	-	Repeater
SCATTER, TROPOSPHERIC	-	A type of scatter propagation of radio waves which depends upon scatter in the troposphere below 30,000 feet altitude. Uses frequencies of 350-8000 MHz and is useful for covering distances of 40-400 miles.
SCES	-	Split-Controlled Echo Suppressor.
SCS	-	Supervisory Control Subsystem.
SCT	-	Satellite Communications Terminal.
SECOND LEVEL MULTIPLEX	-	The level in the time division multiplex hierarchy that accepts several signals (typically 8) at 1.544 Mb/s and time division multiplexes these into a single bit stream (typically at 12.6 Mb/s) to be combined or connected to the radio equipment or connected to a higher level of multiplexing.
SF SIGNAL UNIT	-	Single Frequency signaling units convert dc supervisory signals and/or dc signaling pulses (that cannot be transmitted by the carrier-multiplex equipment) into a single in-band tone for transmission from the local station to a distant station.
SG/GR	-	Supergroup/Group.
SIG	-	Signal.
SIGNAL CONVERTER	-	A device in which the input and output signals are formed according to the same code, but not according to the same type of electrical modulation.

SIGNALING, IN-BAND - Signaling that utilizes frequencies within the voice or intelligence band of a channel.

SIGNALING, OUT-OF-BAND - Signaling that utilizes frequencies within the guard band between channels. This term is also used to indicate the use of a portion of the channel bandwidth provided by the medium, such as the carrier channel, but denied to the speech or intelligence path by filters. It results in a reduction of the effective available bandwidth.

SIMPLEX OPERATION - A method of operation in which communication between two stations takes place in one direction at a time.

SIXTEEN KBPS VF MODEM - A VF modem that provides the capability to transmit 16 kb/s digital signals through a standard nominal 4 kHz voice channel.

SMARTS - A term used to denote intelligence within a unit usually by means of a microprocessor.

SP - Spare. Any unit or facility not normally assigned to a specific service, but available for use, when required.

SPECIAL GRADE - An AUTOVON interswitch trunk or 4-wire subscriber line that is given special treatment (equalized for amplitude versus frequency and delay distortion) in order to have better than voice-grade transmission characteristics. This is done for the purpose of handling high-speed data transmission.

SSMA	-	Spread Spectrum Multiple Access.
SUBSCRIBER LOOP	-	The transmission, (usually a pair of wires), from the subscriber's telephone to a switch.
SUPERGROUP	-	A subdivision of a carrier multiplex system. A supergroup normally consists of 60 voice channels derived from five groups with 12 channels each. When first formed and just before being broken into groups, a supergroup occupies the frequency band from 312 to 522 kHz.
SW	-	Switch.
SWITCH SM	-	Switch submultiplexer. Usually used in terms of the submultiplexer in the AN/TTC-39.
SYNCHRONOUS	-	Describing a device whose speed of operation or rotation is controlled by other devices, such that they operate at the same speed.
SYNCHRONOUS OPERATION	-	A method of on-line transmission of telegraphic or encrypted signals in which the sending and receiving terminal equipments are kept in step by a timing device, whether traffic is being passed or not.
TASI	-	Time-Assignment Speech Interpolation.
TCF	-	Technical Control Facility.
TDM	-	Time Division Multiplexer.

TD-968( )/U	-	A time division multiplexer with data interleaving capability that converts 3, 6, 12, or 24 four-wire frequency channels to a time division multiplexed, pulse-code-modulated signal.
TD-1192	-	A first level time division multiplexer which accepts voice channels or data (with the use of cards inserted into voice channel ports and interleaved with data for voice channels) and combines them into a 1.544 Mb;s bit stream for transmission. Part of the DRAMA procurement. (See AN/FCC-98).
TD-1193	-	A second level time division multiplexer which accepts several Tl channels at 1.544 Mb/s and combines them into higher rates for transmission. Part of the DRAMA procurement (See AN/FCC-99).
TD-1220	-	Time Division Multiplexer used in the WAWS.
TECHNICAL CONTROL FACILITY (TCF)	-	A physical plant, or a designated and specially configured part thereof, containing the necessary distribution frames and associated panels, jacks, and switches; monitoring test,

and conditioning equipment; and orderwire communications to enable Telecommunications Systems Control personnel to exercise the essential operational control over communications paths and facilities, make quality analyses of communications and communications channels, monitor operations and maintenance functions, recognize and correct deteriorating conditions, restore disrupted communications, provide requested on-call circuitry and otherwise take or direct such actions as may be required and practicable to ensure the fast, reliable, and secure exchange of defense information.

TED - Trunk Encryption Device.

TERMINAL - A Government-owned or contract facility excluding unattended relays, where channels may be tested, rerouted, or dropped out, or through which express through-channels pass (a commercial circuit tie point or cable head at the point of ingress of egress to or from a country).

TERMINAL EQUIPMENT - The terminal equipment when used in a reference to technical control includes all the equipment within the technical control office that interfaces with the technical control facility but is not considered part of it. It includes trunk relay equipment, signal conditioning equipment, and multiplex and radio interface equipment. When used in reference to subscribers and users, terminal equipment refers to four-wire telephones, two and

		four-wire local switchboards, consoles, facsimile machines and data subsets serving subscribers and users.
THROUGH-GROUP	-	In carrier telephone transmission, a group of 12 voice channels which goes through a carrier repeater point as a unit, without being broken down to voice frequency.
TIME DIVISION MULTIPLEX	-	Multiplex arrangement where several message channels share a single transmission facility, each having its own time slot.
TM & NM	-	Transmission Measuring and Noise Measuring.
T1-4000	-	An asynchronous, time division multiplexer capable of multiplexing up to eight channels of 1.544 Mb/s (T1) bit streams into a single 12.5526 Mb/s bit stream. In FKV, accepts these channels from T1WB1 multiplexers and CY104 PCM/TDM terminals.
T1WB1	-	A full duplex, time division multiplexer, with a 1.544 Mb/s, bipolar pulse stream output (T1). In FKV, accepts eight separate channels for multiplexing; each channel can be an asynchronous bit stream with bit rate between 0 and 50 kb/s.
TLT	-	Telegraph Loop Terminal. An assembly of jacks to permit access and testing of telegraph circuits at a terminal point.
TIME SLOT INTERCHANGE	-	Time-Slot Interchange Action. Action employed in a digital electronic switch for routing PCM carrier-based channels through the switch at assigned

times. Employed in a digital electronic switch for routing PCM carrier-based channels through the switch at assigned times.

TONE DISABLING - A method of controlling the operation of communication equipment by transmitting a selected tone over the communications path.

TRANS-MULTIPLEXER - A modem that converts analog groups or supergroups to digital format usually one or more digroups at 1.544 Mbp/s (T1) rate and back.

TRANSMISSION LEVEL POINT (TLP) - At any point in a transmission system, the ratio in dB of the power of a test signal at that point to the power of the test signal at the reference point. For example if a -10 dBMO signal is measured at a test point having a -2 TLP, the measured value will be -12 dBm.

TRSG - Transmitting. (Indicates direction of transmission)

TRUNK - (1) One telephone communications channel between (a) two ranks of switching equipment in the same central office, (b) between central office units in the same switching centers. A trunk is for the common use of all calls of one class between its two terminals. (2) The DCS term meaning "trunk group." (3) A single or multichannel communications medium between two successive terminal facilities (except unattended relays) with DCS access, where channels may be tested, rerouted, dropped out, or switched to another route.

TSEC/CY-104	-	A type of first level multiplex used in the DCS which accepts voice frequency, nominal 4 kHz channels, provides pulse code modulated analog-to-digital conversions, time division multiplexing, E&M signaling, and bulk encryption for 24 channels. It may also multiplex digital signals other than pulse-code modulated voice channels by insertion of cards into its ports.
TSEC/HN-74	-	Signal interface and control unit used in the TSEC/CY-104.
TSEC/HY-12	-	A channel bank which time division multiplexes and pulse code modulates 24 voice frequencv signals (including signaling) into a single 1.544 Mb/s bipolar pulse stream. Also called D2 cnannel bank or VICOM D2 channel bank. This equipment is part of the TSEC/CY-104.
TSEC/KG-34(A)	-	Key generator used in the TSEC/CY-104.
TSI	-	Time-Slot Interchange
TTY	-	Teletype.
T1	-	Digital group carrier at bit rate of 1.544 Mbps.
T1C	-	Digital group carrier at bit rate of 3.152 Mbps.
T2	-	Digital group carrier at bit rate of 6.312 Mbps.
T3	-	Digital group carrier at bit rate of 44.73 Mbps.
T4	-	Digital group carrier at bit rate of 274.16 Mbps.

UNBALANCED LINE	-	A transmission line, the two sides of which are electrically unlike.
VFCT	-	Voice Frequency Carrier Telegraph (VFCT). A metnod in which one or more dc telegraph channels are multiplexed into a composite nominal 4 kHz voice frequency channel for further processing through a metallic or radio network.
VIA	-	Signifies the condition of a telecommunications trunk when in a switched connection.
VOCODER	-	A device which converts analog voice signals to serial binary digital signals, and on the receiving end of the circuit converts the digital signals to reconstructed intelligible analog speech.
VOICE FREQUENCY TERMINAL EQUIPMENT	-	Devices within a Technical Control Facility which interface the VF channel with the subscriber's equipment. These include Single Frequency (SF) Units, conditioning equipment pads, amplifiers, etc.
VOICE GRADE	-	Said of a communication channel which is nominally 4000 Hz wide and capable of passing speech signals in the band 300 - 3400 Hz.
VOICE ORDERWIRE (VOW)	-	Voice Circuit between Stations for maintenance purpose.
VOW	-	Voice Order Wire.
VZ-12	-	A type of frequency division multiplexing equipment used in the present DCS.
WAWS	-	Washington Area Wideband System.

WBSV	-	Wideband Secure Voice.
2-WIRE LINE	-	A two conductor circuit used for 1-way or 2-way transmission.
4-WIRE LINE	-	A 2-way transmission circuit utilizing four conductors (two conductors are used for the transmitting direction and the other two conductors are used for the receiving direction).

CHAPTER THREE

TECHNICAL CONTROL ELEMENT CONFIGURATION

3.1 GENERAL DESCRIPTION - This chapter discusses the configuration of DCS Technical Control elements including:

- Patching, Testing and Monitoring Facilities
- Multiplexing elements with special emphasis on Time Division Multiplex
- Interfacing elements of Radio and Cable equipments
- Interfacing elements associated with DCS Switched Networks
- Interfacing elements associated with Special Purpose Networks and Users
- Orderwires and Critical Communications Networks for System Control
- Alarms and Status Monitoring.

3.1.1 Diversity of DCS Technical Controls - Because of the diversity in functions performed by DCS stations throughout the world, DCS Technical Control Facilities and associated Patch and Test Facilities cannot be configured identically at all locations. The factors that must be considered in engineering DCS Technical Control Facilities may be classified as follows:

3.1.1.1 Geographical

3.1.1.1.1 CONUS - In the Continental United States, much of the DCS is leased and most of the functions of the technical control facility and technical controllers are provided by the major American carriers. However, in areas where the major unified and specified commands are located, and at various posts, camps, stations and bases, DCS technical controls are operated by the Military Departments. The requirements specified in this publication apply to the latter. Nevertheless, the considerations for these facilities are sufficiently different form those overseas that configuration differences are clearly labeled in the text or diagram.

3.1.1.1.2 Overseas - Although some circuits are leased in the overseas DCS, the DCS backbone consisting of switches and transmission facilities is owned by the United States Government and operated by the Military Departments of the Department of Defense. The Technical Control Facilities associated with U.S. Government-owned DCS Stations are the major consideration of this publication.

3.1.1.1.2.1 The European Theater - Within the European Theater, certain unique technical features and characteristics must be considered in the design of technical controls. These include:

- Interface requirements of the civil carriers where leased facilities enter the Technical Control and Patch and Test Facilities.
- Interface requirements of NATO systems and Allied Host Nation military systems.
- Unique characteristics of U.S. military systems.

These considerations will be incorporated into revisions of this publication.

3.1.1.1.2.2 The Pacific Theater - The uniqueness of the Pacific Theater include:

- Interface requirements unique to Hawaii and Alaska.
- The relatively heavier emphasis on satellite transmission and leased submarine cable and satellite transmission facilities due to the sheer size and ocean expanse of the Theater.
- Unique characteristics of U.S. military systems in the Western Pacific.

3.1.1.2 Functional - Technical Control Facilities and Patch and Test Facilities are also configured differently depending on the main function of the station where it is located. These functions may be organized as follows:

3.1.1.2.1 Transmission - Technical controls are configured differently depending on whether the station is primarily a satellite facility, an HF facility, a tropo or diffraction facility, a line of sight microwave relay or terminating point, a terminating point of leased transmission or cable facility. Each of these variations is addressed in paragraph 3.2.

3.1.1.2.2 DCS Switches - Technical controls are configured differently at locations of AUTOVON, AUTOSEVOCOM, and AUTODIN switches as well as at the locations where subscribers and users are located. These variations are considered in paragraph 3.3.

3.1.1.2.3 Special Purpose Networks and Users - Special purpose networks, as well as other non-DCS common user networks, required unique arrangements. These variations are considered in paragraph 3.4.

3.1.1.3. Time Frame of Application - The time frame of application in this publication is divided into two general periods: (1) prior to 1980 and (2) The Second Generation DCS. The evolving nature of the DCS makes this an important consideration in the engineering of Technical Control Facilities. At locations where equipments associated with AUTOSEVOCOM II are programmed for implementation, provisions should be made for later modifications and additions. This publication and subsequent revisions will clearly indicate the technical characteristics of the unique requirements as they become available.

3.1.2 General Requirements of DCS Technical Controls

3.1.2.1 Conceptual Objectives for Engineering DCS Technical Controls

3.1.2.1.1 DCS Technical Control and Patch and Test Facilities will be configured and engineered to enable the technical controllers to utilize the full capabilities of the equipment and personnel resources, through the efficient performance of the daily functions of coordination, quality assurance, technical direction, technical supervision, service activation, restoral and status reporting.

3.1.2.1.2 In addition to these traditional engineering objectives, the next generation of DCS technical controls should be engineered in close coordination with the engineering of transmission systems in order to exploit the potential for increasing the MTBF and decreasing the MTTR offered by time division multiplexing and digital systems. The technical controls should be engineered such that the extensive degree of coordination and alignment required to maintain system availability and reliability will be simplified for future technical controllers. Integration of multiplexing and patching areas/capabilities is a preferred method of achieving this

3.1.2.1.3 The effective accomplishment of the functions of DCS technical controls requires a well designed critical control and orderwire communications network between Technical Control Facilities, and between Technical Control Facilities and subordinate Patch and Test Facilities.

3.1.2.1.4 These facilities will be designed to achieve standardization of equipment in terms of layout and procurement specifications, operating procedures, training, manning guidelines, and technical control functions.

3.1.2.1.5 These facilities will be designed to enable the technical controller to exercise effectively the following responsibilities:

a. Know the status of designated transmission links, groups and di-groups, channels, circuits and communications equipments under his technical direction or supervision.

b. Take immediate action on any deterioration or failure of communications systems or equipment causing degradation to or loss of service to the users.

c. Expeditiously restore service to users by proper means in accordance with established National Communications System (NCS) restoration priorities.

3.1.2.2 General Configuration Description

3.1.2.2.1 The relationship of DCS Technical Control Facilities and Patch and Test Facilities to the major subsystems of the overall Defense Communications System is depicted in Figure 3.1.2.2.1. As stated in paragraph 3.1.1, the diversity in functions of a technical control would indicate that no single technical control would be related to all of the subsystems shown in the diagram. Nevertheless, the diagram is meant to depict the diverse relationships in a single simplification. The single heavy line between transmission subsystems and the technical controls is meant to signify the very close nature of technical controls and transmission systems. In fact, technical controls of the future should be designed as an integrated part of the transmission system and physically collocated wherever local conditions permit.

3.1.2.2.2 The separate lines between technical controls and AUTOVON, AUTODIN, AUTOSEVOCOM and Special Purpose and other users depict areas which have traditionally been less tightly coupled to Technical Control Facilities. Patch and Test Facilities associated with these DCS switched networks and special purpose users have in the past been engineered separately and treated as "subordinate" facilities from the standpoint of status and control reports. One of the challenges of engineering technical controls in the future will be the integration of digital switches, with digital transmission in such a manner that restoral of service to DCS users will be a matter of switching to available resources automatically. Switches and PBX's of the future should be physically collocated with Technical Control Facilities wherever local conditions permit. The reduction of size in both transmission and switching equipment should make these objectives easier to attain in engineering future facilities.

3.1.2.2.3 Figure 3.1.2.2.3 depicts the relationships between Technical Control Facilities and Patch and Test Facilities in greater detail. The traditional Operating Area of a Technical Control Facility is enclosed by the solid line and shown in the center of the figure. The operating area includes:

- Patching, testing and monitoring facilities for voice frequency (VF) multiplexed channels and circuits and for multiplexed digital channels and circuits.
- Orderwires and intercoms for communicating with distant technical controls and local Patch and Test Facilities.
- Terminals for reporting to the DCA Operations Control Complex (DOCC).
- Alarms, both remote and local, for monitoring the status of terminal equipments.

3.1.2.2.4 The patching, monitoring, and testing facilities in the Operating Area of the Technical Control Facility include:

- Equal Level Patch Bay (VF)
- Primary Patch Bay (VF)
- DC Patch Bay
- Primary Patch Bay (DC)

3.1.2.2.5 Connected to the elements noted above are VF terminal equipments, and the Voice Frequency Carrier Telegraph (VFCT) equipment both of which are discussed in paragraph 3.2.1. These equipments are shown outside the boundary of the solid line because, although their performance is monitored by the technical controller, the repair and alignment is normally done by others. Eventually, when the repair and alignment becomes a simple matter of changing cards, or these functions are either automated or eliminated, the arbitrary boundary will be unnecessary.

3.1.2.2.6 The Mux and Media part of the Technical Control Facility will vary according to its function, as discussed in paragraph 3.1.1, and covered in detail in paragraph 3.2. In general, the Mux and Media Technical Control Facility includes the following:

- Patch and Test Facilities for Time Division Multiplexers.
- Patch and Test Facilities for radio equipment and associated modems, optical fiber cables and leased facilities and megabit rates. (This is not to be confused with the DC Primary Patch Bay. The considerations for patching, testing and monitoring at megabit rates are very different from b/s teletype and data.)

3.1.2.2.7 The Mux and Media Patch and Test Facilities are enclosed by dashed lines in Figure 3.1.2.2.3, to the left of the Operating Area. The multiplex, radio, cable and optical fiber equipments are shown outside the dashed lines because, historically, the repair and alignment of these equipments have been performed by maintenance personnel rather than technical controllers. The design of modern equipments allows these functions to be simplified to card replacement. It may be possible to allow the technical controllers to perform these functions.

3.1.2.2.8 The Patch and Test Facilities for AUTOVON, AUTODIN, AUTOSEVOCOM, and Special Purpose Networks and Other Users are shown in simplified form in Figure 3.1.2.2.3. At present, these Patch and Test Facilities are not located adjacent to the Operating Area of the Technical Control Facility and are not conveniently accessible to the technical controllers. However, "subordinate" technical controllers will continue reporting status of their equipments to those at the Technical Control Facility. In the future, when digital switches, PBX's and console terminating equipments are placed physically adjacent to the Technical Control Facility, the older distinction of separate functional facilities will change. The linkage between what is designated as Patch and Test Facilities for DCS Switched Networks and the Technical Control Facility are discussed in greater detail in paragraph 3.3. Special Purpose and Other Users are discussed in greater detail in paragraph 3.4.

3.1.2.2.9 Patching Arrangements for TDM Systems - In future TDM and hybrid TDM/FDM tech control facilities, one type of patch and test facility will not be satisfactory for all ranges of data from low speed to multi megabit rates. This is due to the variation in electrical characteristics of these signals over the range of bit rates. Based on the different electrical characteristics of these signal over this range of bit rates the following patching desigrations (shown in figure 3.1.2.2.9) will apply:

1. MM Patch - Circuit elements carrying bit rates above 3 Mb/s will interface via the Multi Megabit (MM) patch which is normally built into the equipment itself. An actual separate patching facility will be required only to accommodate multi-megabit users as testing and monitoring of the baseband signal can normally be done directly on the equipment. For baseband type patching, an interbay facility will normally suffice. The high speed output of the multiplexer can go directly to the radio thereby minimizing cable runs. This is very important in reducing the distortion of these high data signals, which could occur if a separately placed patch and test board were implemented between the multiplexers and radios.

2. M Patch - Circuit elements carrying bit rates between 1 and 3 Mb/s will interface via a megabit (M) patch bay. This patch bay will be utilized at large stations where alternate routing and restoration can be accomplished (a station having more than two links emanating from it). In smaller stations where alternate routing and restoration are not feasible, the patching facilities built into the multiplex equipment will be used for monitoring and testing. Here again it is of utmost importance to avoid long cable runs between multiplexers and patch bays. If a separate patch bay is required the cable runs should be less than 100 feet.

3. K Patch - Circuit elements carrying balanced signals at bit rates less than 1 Mb/s will interface via a kilobit (K) patch bay. Since future services will emphasize balanced signal levels, this patch bay must be provided to accommodate them.

4. D Patch - Circuit elements carrying unbalanced signals at bit rates less than 1 Mb/s will interface via a dc (D) patch bay. This patch bay will be used to accommodate the large number of subscribers in the current system who require unbalanced service. It is to be emphasized that this service will be phased out in the near future.

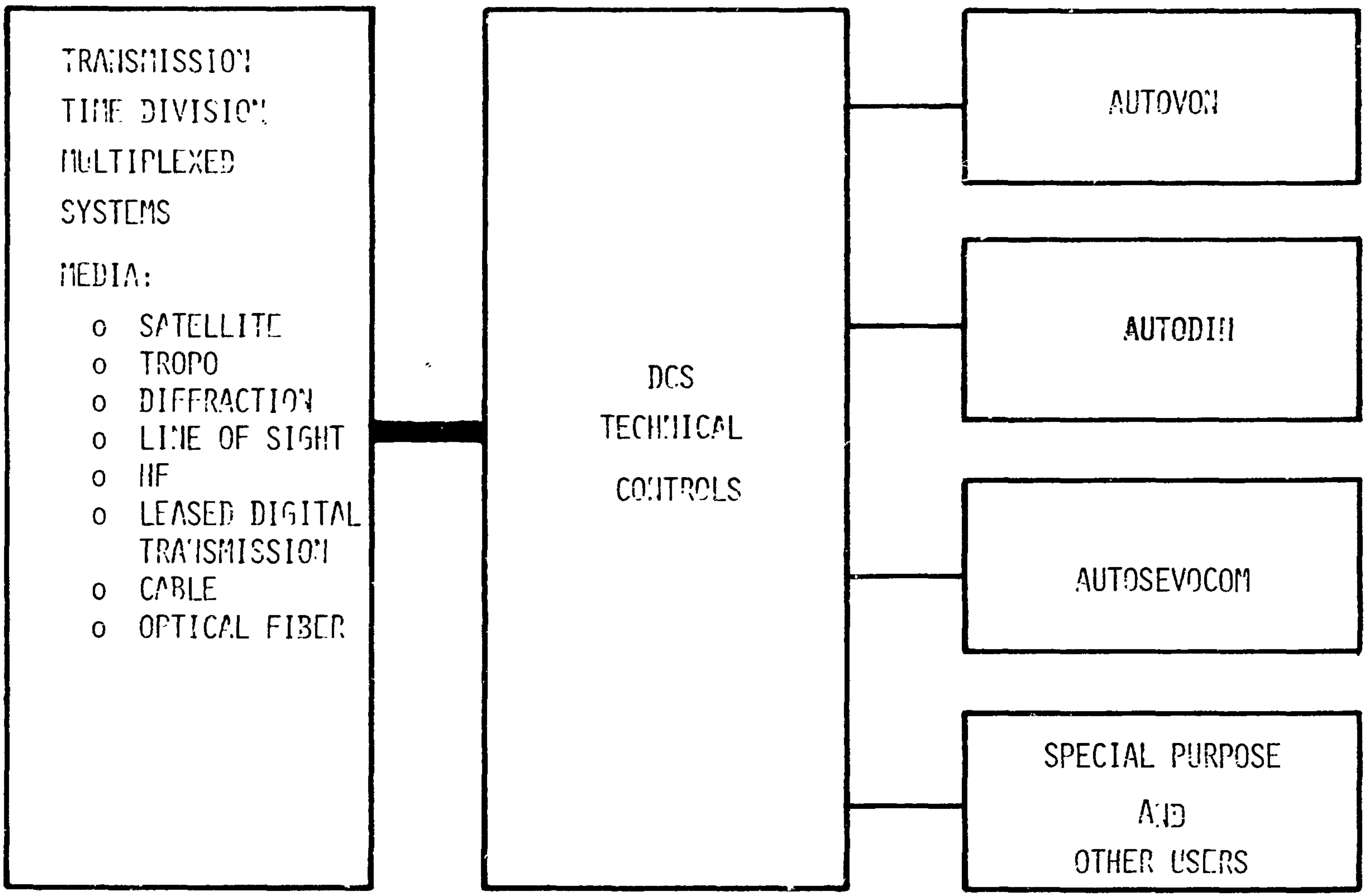


Figure 3.1.2.2.1 Relationship of DCS Technical Controls (Technical Control Facilities and Patch and Test Facilities) to the major subsystems of the Defense Communications System.

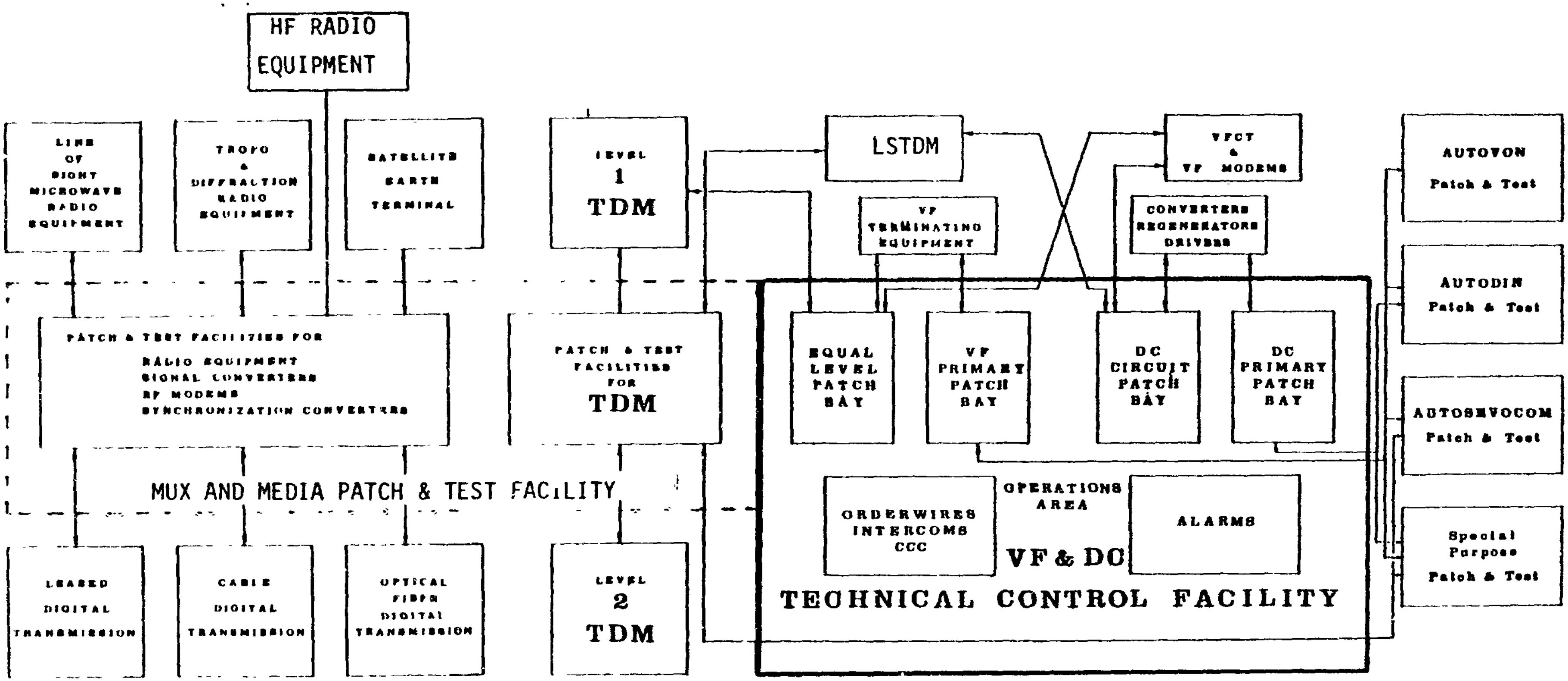


Figure 3.1.2.2.3 Technical Control Facility/Media Patch and Test Configuration

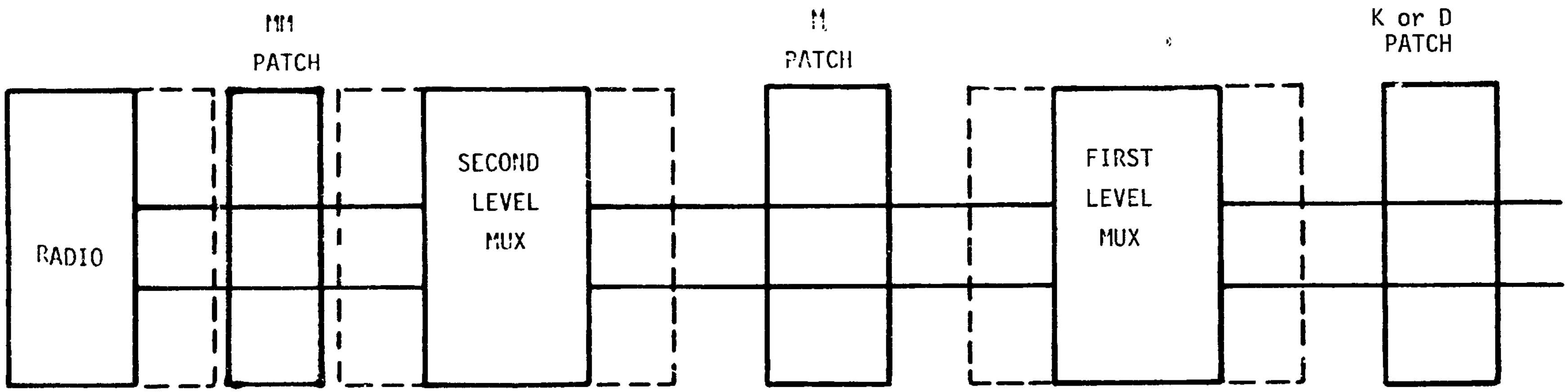


Fig. 3.1.2.2.9 Recommended Patching Configuration for Future TDM Tech Controls

Note: Dotted lines indicate patch jack access which may be provided on the equipment.

3.2 TRANSMISSION SYSTEMS

Paragraph 3.2 discusses the following topics:

TIME DIVISION MULTIPLEXED SYSTEMS

PRIOR TO 1980

- Technical Control Facility in TDM LOS DCS Stations, Prior to 1980, Overseas (See Note 1).
- Patch and Test Facilities in TDM LOS DCS Stations, Prior to 1980, Overseas (See 3.2.2).
- Patch and Test Facilities in TDM Satellite DCS Stations, (See 3.2.3).
- Patch and Test Facilities in TDM Cable Facilities (See 3.2.4).
- Patch and Test Facilities in TDM Leases (See 3.2.5).

SECOND GENERATION DCS

- Technical Control Facility - Second Generation DCS (See 3.2.6).
- Patch and Test Facilities in TDM LOS DCS Stations, Second Generation DCS, Overseas (See 3.2.7).
- Patch and Test Facilities in TDM Satellite Stations, Second Generation DCS (See 3.2.8).
- Patch and Test Facilities in TDM Tropo Stations, Second Generation DCS (See 3.2.9).

NOTE 1: Paragraph 3.2.1 (pages 3-2-2 through 3-2-49) are deleted in this revision. The Contents of paragraph 3.2.1 have been superseded by the appropriate portions of MIL-STD-310A. (Jan 1980).

3.2.2 Patch and Test Facilities in TDM LOS DCS Stations, Prior to 1980, Overseas
This paragraph deals essentially with the MUX and Media Technical Control Facility configuration of the FKV subsystem, the DEB I system and digital segments associated with the EWCS SLI Project. Figure 3.2.2(a) depicts the Patch and Test Facilities for a PCM Voice Channel.

3.2.2.1 At the extreme left of Figure 3.2.2(a) is the patch panel (jackfield assembly) associated with the AN/FRC-162 radio equipment. This patch panel is shown in greater detail in Figure 3.2.2(b). The dashed line indicates the jack arrangements for normal operation. Note that the radio set uses full duplex space diversity techniques and provides reliable communications over the same LOS patch via dual receivers. This Patch and Test facility is all that is needed in a DCS Station for radio equipment. Signal characteristics may be tested on the input to the standby transmitter when required. However, in testing received signals at the baseband, it should be noted that the sensor/logic/switch unit automatically provides for space diversity reception from the two receivers.

3.2.2.2 The next patch panel shown from the left is the section enclosed in dashed lines on the T1-4000 Level 2 Multiplexer. The signal at this point is in three-level partial response format. Note that loopback and other test may be performed on the redundant unit without interfering with the on-line signal and other external patch bays are not required. It is extremely important to engineer the cable run from this point to the radio as short as possible because it has been filtered for best operation for FM modulation. Additional cable lengths and patch jacks can only add distortion and low pass filtering, thus degrading performance at this multi-megabit rate. (12.5526 Mb/s) The partial response format is implemented by frequency domain filtering, with half of the filtering done in the transmitter output and the other half in the receiver input.

The use of partial response coding significantly reduces bandwidth requirements as compared to NRZ, and it is important that this format is not distorted by unnecessary cables and patching terminations.

3.2.2.2.1 The transmit and receive filters are similar in form, consisting of a transistor circuit containing a low pass LC filter. The transmitter output is ac coupled, eliminating circuit dc as well as the dc components of the baseband data.

3.2.2.2.2 The theoretically correct filtering for duobinary is a frequency spectrum having the shape of a cosine function with the zero crossing at a frequency of one-half the bit rate. This frequency spectrum corresponds to the total effect of transmitter filter, cables, transmission media, and receive filter. This function does have a dc component. The output of the transmitter is a Darlington pair, emitter follower transistor amplifier with output impedance set at 75 ohms by a series output resistor. The amplitude of the output signal is controlled by selecting a resistor in the output filter.

3.2.2.2.3 The interpretation of three level partial response signals at the receiver is complicated by the intersymbol interference and distortion introduced in the cable runs, the transmitter and the media. In particular, of the three levels received, only two are unique. The third level requires knowledge of the binary level previously received to decode properly the bit in question. Because of this, a bit error due to transmission anomalies can be propagated to several errors in the receiver.

3.2.2.2.4 A technique called precoding can be employed in the transmitter so that each receive level is unique, thereby eliminating error propagation. Precoding is not employed in the VICOM unit, and therefore propagating errors will occur, which is another reason why the conditioned diphase signal must be kept distortionless as possible. No external patching and monitoring facilities shall be added to this point. This is an unconditional requirement.

3.2.2.3 The next patching and testing facility depicted on Figure 3.2.2(a) is shown enclosed in a dashed line labeled the VICOM PCM ACCESS UNIT. T1 channel connections are made to the multiplexer through back panel wiring to the PCM Access Unit. This unit provides for patching and monitoring of the T1 signals through front panel phone jacks. Insertion of the plug disconnects the signals from the multiplexer making signals available for use in other equipment. The input T1 bipolar signal is unaffected by the PCM Access Unit. The transmit signal is buffered by the unipolar converter of a resistor network in parallel with the primary of a transformer, and presents 100 ohm, balanced input impedance. These patching facilities are adequate for any DCS nodal station with two or less links emanating from that station and with no other operational requirement for a Wideband Digital Patch Bay. Under no circumstances should cable lengths from this point to the first level multiplexers (CY-104 or T1WB1) be permitted to exceed 150 feet including the cable runs to and from the Wideband Digital Patch Bay.

3.2.2.4 The Wideband Digital Patch Bay enclosed in solid is the next patch and test facility shown on Figure 3.2.2(a). This patch bay shall be installed only where there is an operational requirement for it. Interface requirements for this patch bay are presented in Chapter 5.

3.2.2.5 The remainder of the patch and test facilities shown on Figure 3.2.2(a) are located on the CY-104 first level multiplexer. It is imperative that the cable length from the CY-104 to the T1-4000 be kept less than 150 feet.

3.2.2.6 Figure 3.3.3(c) is identical to Figure 3.2.2(a) except for the T1WB1 multiplexer and CV-3034 analog/digital converter.

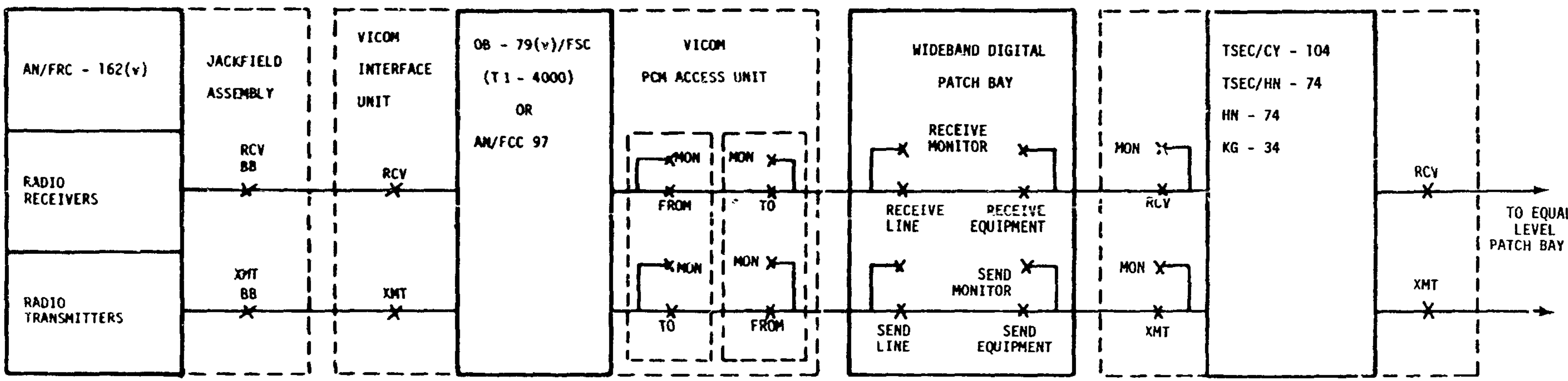


FIGURE 3.2.2 (a) Patch and Test Facilities in the Mux and Media Technical Control Facility for PCM Voice Channels. (LOS TDM Prior to 1980,Overseas)

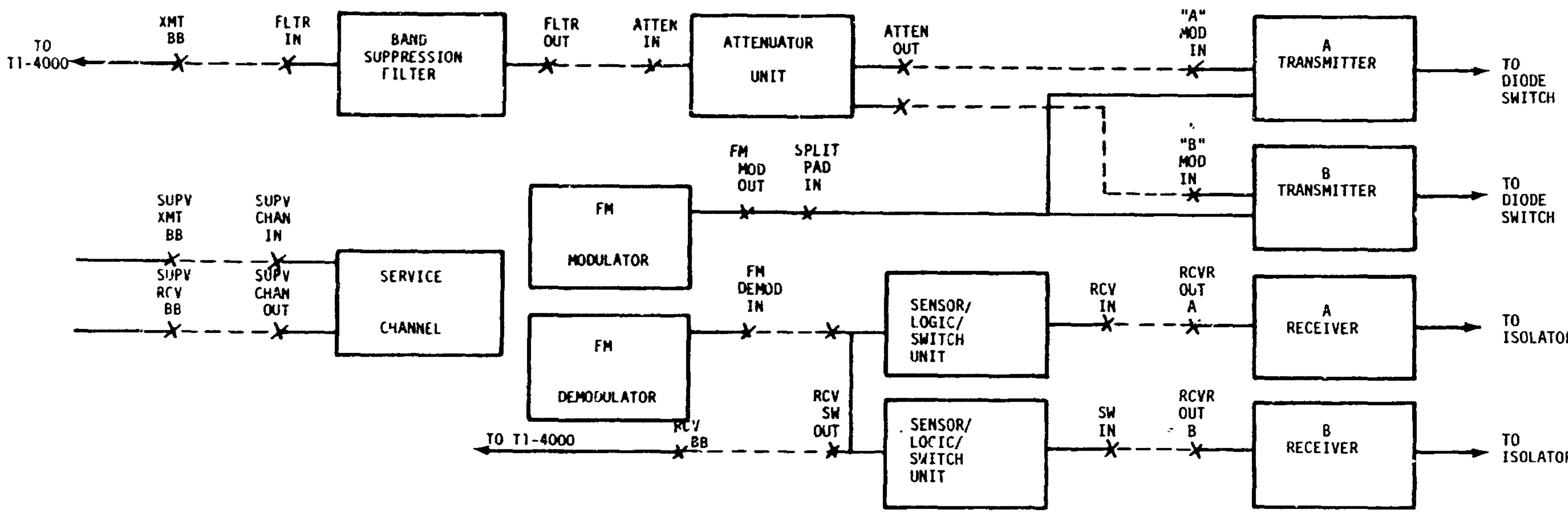


Figure 3.2.2 (b) PATCH AND TEST FACILITIES ON RADIO EQUIPMENT AN/FRC-162

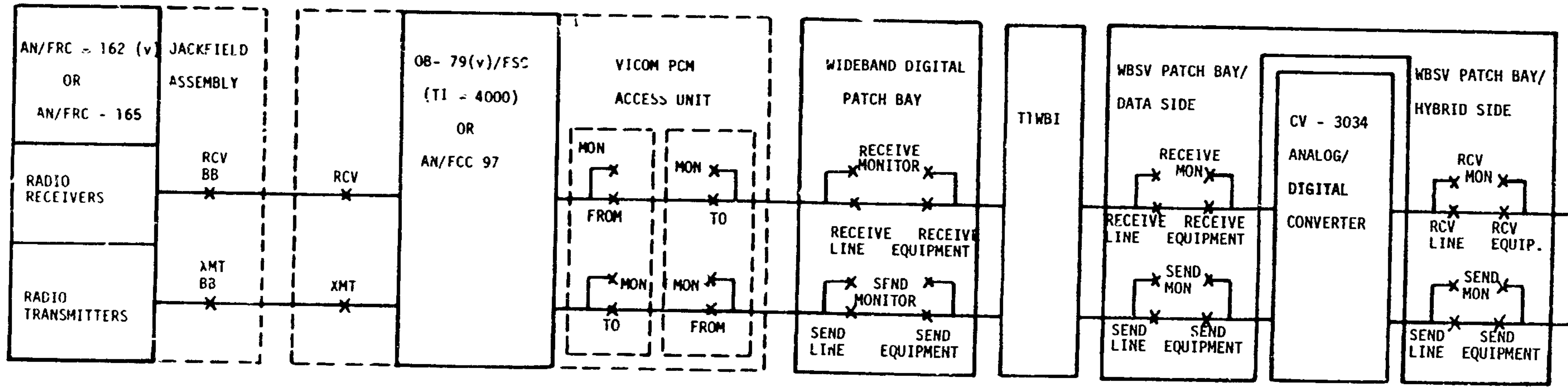


FIGURE 3 2.2 (c) Patch and test facilities in the Mux and Media Technical Control Facility for 50 Kb/s service (LOS TDM prior to 1980,Overseas)

3.2.3 Patch and Test Facilities in TDM Satellite DCS Stations (DCSS)

In the DCS Digital Satellite Stations, the ideal configuration would be to collocate and incorporate Terestial Digital Transmission Equipment and their built-in patch and test features as part of the TCF. This configuration would be of considerable importance in the technical controlling of wideband digital signals which can be seriously degraded when transmitted over unnecessary wirelines and patches. Figures 3.2.3 (a) and (b) show the relationship of the DCSS, user, and the existing P&TF. Tech-controlling of wideband digital circuits on TDM systems will be much more complicated than VF or dc circuits, especially on systems where satellite power and spectrum must be critically conserved. Such limitations on power and spectrum preclude configuration of the AN/GSC-24 TDM with many spare or idle channels to which a circuit of the same bit-rate can be patched. It should be noted that the DCSS was designed to interface with an existing TCF, rather than serve as a TCF substitute. Only in exceptional cases should the TCF/DCSS functions be interspersed.

3.2.3.1 Patch Panels

Four types of patch panels are utilized: A VF patch, a TTY patch, a data patch and an IF patch. Each of these patching functions is separated and contained in its own respective rack.

3.2.3.1.1 VF Patch Panel

The VF maintenance patch panel provides the input/output patch points for the orderwire circuits, VF circuits, and E & M leads for operational and maintenance functions. The VF patch is the only means to access the AN/FCC-98 Multiplexer. Figure 3.2.3.1.1 depicts this panel.

3.2.3.1.1.1 E & M and VF Miscellaneous Patch

The primary purpose of these jacks is to enable breaking an existing circuit and cross-patching the equipment. On-line monitoring of signals can be accomplished with parallel jacks but not without first breaking the line.

3.2.3.1.1.2 VF Patch

The VF patch jacks are configured in a LINE/LINE MON/EQPT/EQPT MON manner. The monitoring jacks provide capability for monitoring LINE and EQPT signals without breaking into the circuit.

3.2.3.1.1.3 Transmission Test Set

The transmission test set consists of an Audio Signal Generator SG-967/U, a true RMS Voltmeter AN/USM-224(A), and a Patch Panel CN-947B/USM-181 which contains matching transformers and a variable attenuator. This equipment is used primarily for troubleshooting VF circuits.

3.2.3.1.2 TTY Patch Panel and Orderwires

This panel provides terminations to be used for maintenance of TTY channels and "on-call" O/W functions. It also provides the input/output patch points for the AN/USC-28, the system teletype circuit (AN/UGC-77), the VFTG keyers and converters, and the teletype users. Other functions normally associated with the teletype circuits, such as cut keys and lights, are not provided. The panel is shown in Figure 3.2.3.1.2.

3.2.3.1.2.1 DC Patch

The jacks are configured in a LINE/LINE MON/EQPT/EQPT MON manner. The LINE and EQPT jack allow circuit patching while the MON jacks provide circuit activity monitoring without breaking the line.

3.2.3.1.2.2 SG-1054/G Signal Generator

This test set generates a wide variety of telegraph test signal patterns having predetermined and controllable characteristics and parameters. It is used in conjunction with associated data measuring equipment to test and evaluate the performance of TTY systems.

3.2.3.1.2.3 TS-3378/G Telegraph Data Analyzer

This analyzer measures bias and bit errors present in data signals of any standard level with bit rates up to 9600 bauds.

3.2.3.1.2.4 TD-201F (KY-798(P)/TCC) Frequency Shift Keyer

The purpose of this keyer is to convert dc TTY signals to FSK tones for transmission to distant stations. The TD-201F accepts 20 or 60 volts neutral, high-level polar (20 milliamperes), or low level (+6 volt dc) polar inputs, as selected by strapping option. These inputs are converted to FSK tone signals on any one of 16 narrowband channels having center frequencies from 425 to 2975 Hz (at 170 Hz intervals). Output frequency is determined by two crystal-controlled oscillators and a bandpass filter (plug-in unit).

3.2.3.1.2.5 TC-301F (CV-3116(P)/TCC) Frequency Shift Converter

The purpose of this converter is to convert FSK TTY tones to a dc TTY signal for driving teletypewriter machines on the test set. It converts FSK input signals on any one of 16 narrowband channels having center frequencies from 425 to 2975 Hz (at 170 Hz intervals) to either ±6 volts (low level) or ±60 volts (high level) dc polar inputs, as determined by strapping option. The low level output is produced using either an internal or external voltage source. Operating frequency is determined by an input bandpass filter/discrimator network (plug-in unit). In addition to the low or high level output, the TC-301F simultaneously provides a ±12 volts dc polar output.

3.2.3.1.2.6 AN/UGC-77 Teletypewriter Model 28

The AN/UGC-77 compact keyboard send-receive (KSR) teletypewriter set is designed to provide normal teletypewriter service in mobile and fixed stations where minimum equipment size is a prime requisite. The KSR originates and monitors messages in a telegraphic network. Signal level is +6 volts for Mark and -6 volts for Space. Signal input and output points are extended to the dc patch panel.

3.2.3.1.3 Data Patch Panel

The DCSS Data patch panel is capable of accepting rates up to 10 Mb/s and will provide the termination for all data users from 75 b/s to 10 Mb/s. It should be noted that the DCSS was engineered prior to publication of this document. Therefore the DCSS Data Patch Panel cannot be classified according to the Digital Patch Panel categories defined as D, K, N. or M.

All of the equipment terminations and users are wired directly to the patch panel to maintain short lines and will not utilize the conventional cross connects for rerouting.

The data patch panel serves as an interface between digital users and digital equipment within the DCSS. The rack contains eight patch panels and a Digital Communications Test Set TS-3642(V)I/G, an error-bit analyzer which is capable of operating at various clock and data rates. It serves as the primary tool for testing digital circuits. Figures 3.2.3.1.3 depicts the data patch rack.

3.2.3.1.3.1 Data Patch Panels A4 Through A8

These patch modules are normally used to connect wideband digital signals developed within the DCSS such as the FCC-98 PCM serial output to inputs of other wideband digital devices within the DCSS such as the AN/GSC-24 TDM. Each panel contains 128 triaxial 78-ohm jacks of which 120 are used for communication circuitry. The remainder are used as three paralleling circuits, one 78-ohm termination, and two reversing jacks.

3.2.3.1.3.2 Data Patch Panel A9

This patch panel contains 64 jacks of which 32 are for VF use and 32 are for digital use. The appearance of VF signals at the data patch is required to enable patching of VF signal into the AN/GSC-24 whose inputs and outputs appear on the previously mentioned data patch panels.

3.2.3.1.3.3 Data Patch Panels A10 and A11

Connections to/from external digital users are accomplished at sub-panel A14 vice the MDF. Panel A14 is internally connected to panels A10 and A11. Appearance of external digital users on A10 and A11 enables further routing within the DCSS, typically to the TDM AN/GSC-24.

3.2.3.1.3.4 Data Patch Logic

The jack logic shall provide the capability to accomplish the following functions to balanced and unbalanced digital and analog signals up to 19 Mb/s.

a. Provide a "normal through" (no patch cord used) connection for data, timing and other signals traversing these patch panels. A reliable and economical 10 Mb/s digital signal switching matrix is the preferred method. The non-normal through patch panel may be employed until replacement assets are available.

b. Provide ability to patch any user to any line equipment appearing on the panels.

c. When required, provide "mark" hold battery to receive equipment when the line is purposely interrupted.

d. When required, provide a patchable 78 ohm terminating resistance to signal sources when the normal terminus is removed.

3.2.3.1.4 <u>IF Patch Panel</u>

An IF patch panel is provided for the termination of all 70 MHz and 7000 MHz input/output patch points. It provides terminations for the AN/USC-28, MD 1002, MD-921, FM MOD/DEMO where applicable, and the up and down converters. Figure 3.2.3.1.4 shows the IF patch panel.

The panel contains 70 and 7000 MHz IF equipment patch facilities, and test equipment including an HP-141T/8553B/8552B Spectrum Analyzer, and a TS-3580( )/G modem test set and space for a possible future installation of an HP-5061A and an associated power supply, HP-5085A.

Primarily, the spectrum analyzer is used to view the IF frequencies into and out of the modms. The TS-3580 is an off-line test set which accepts 70 MHz signals from the modem and automatically returns the 70 MHz carrier plus noise signal of a predetermined dialed-up value.

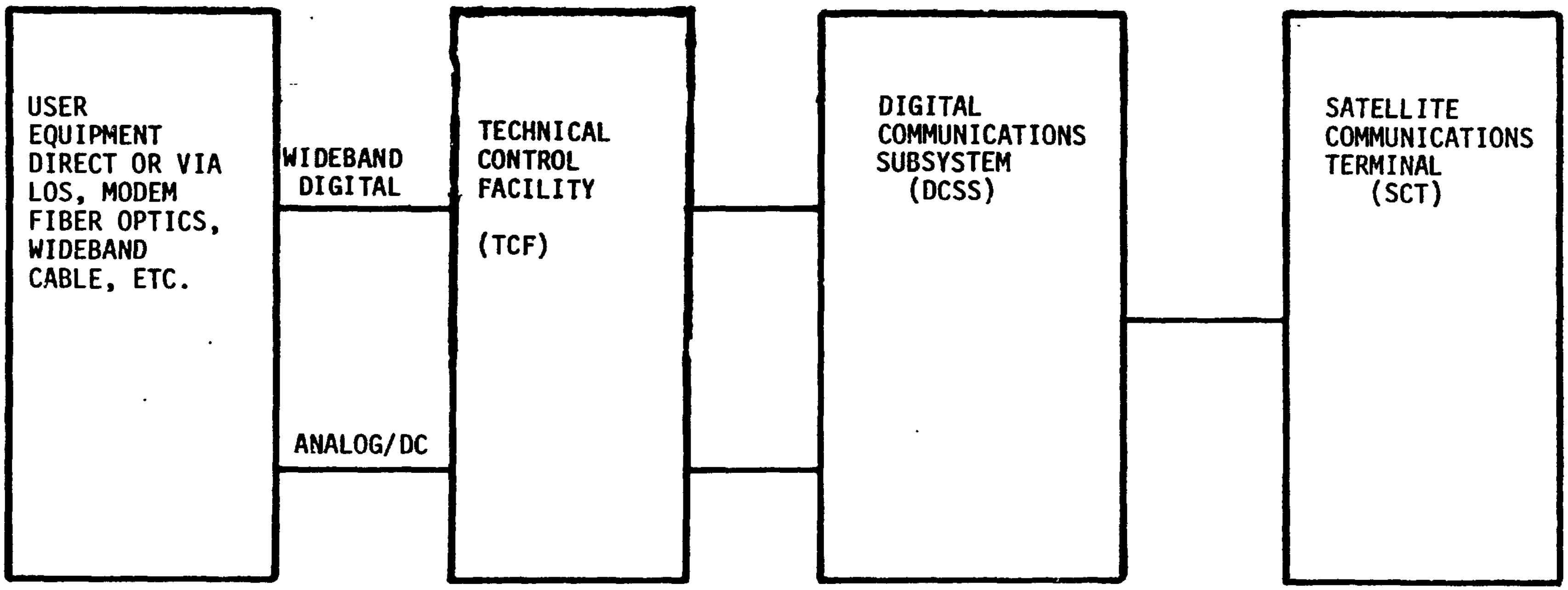


FIGURE 3.2.3(a) Basic Overall System

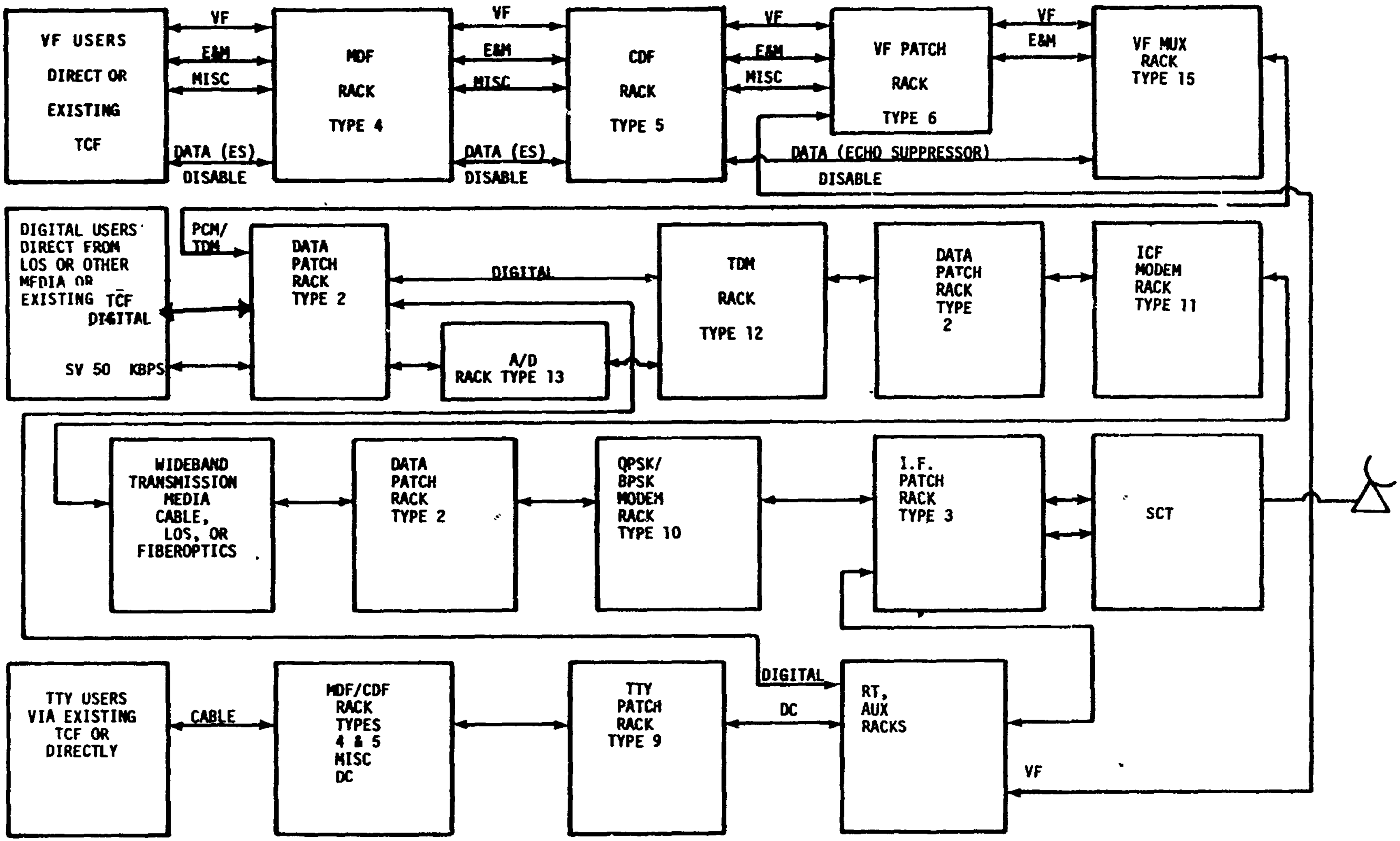
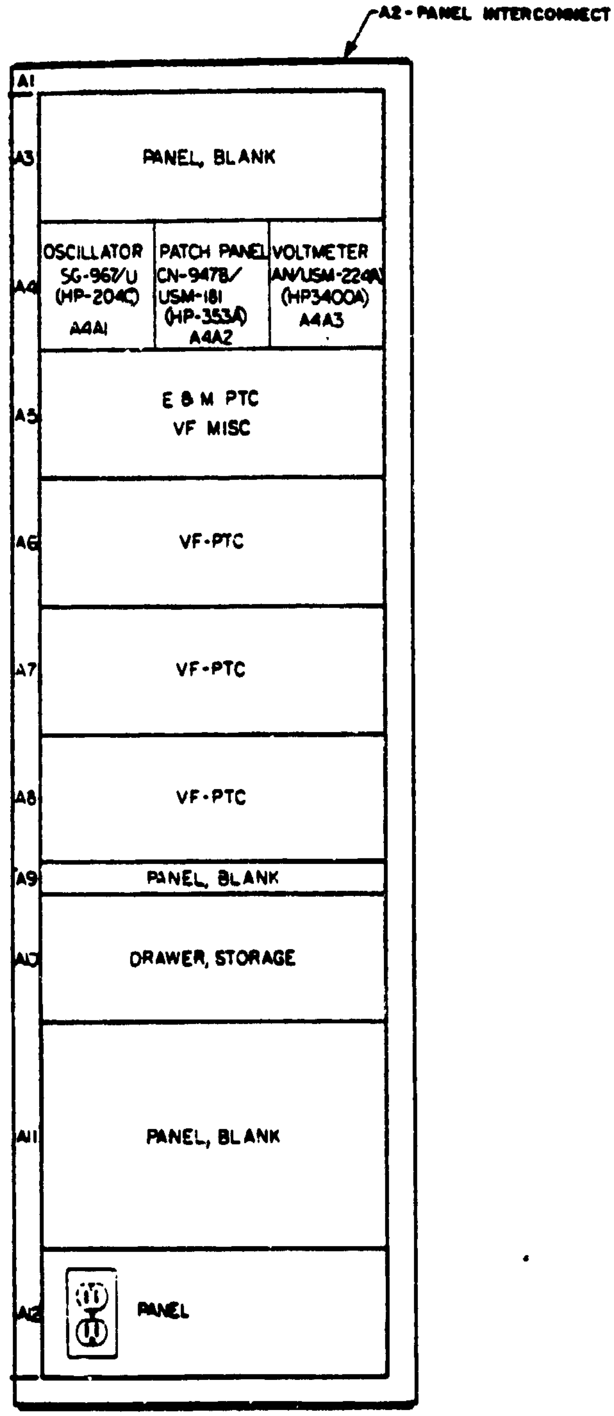
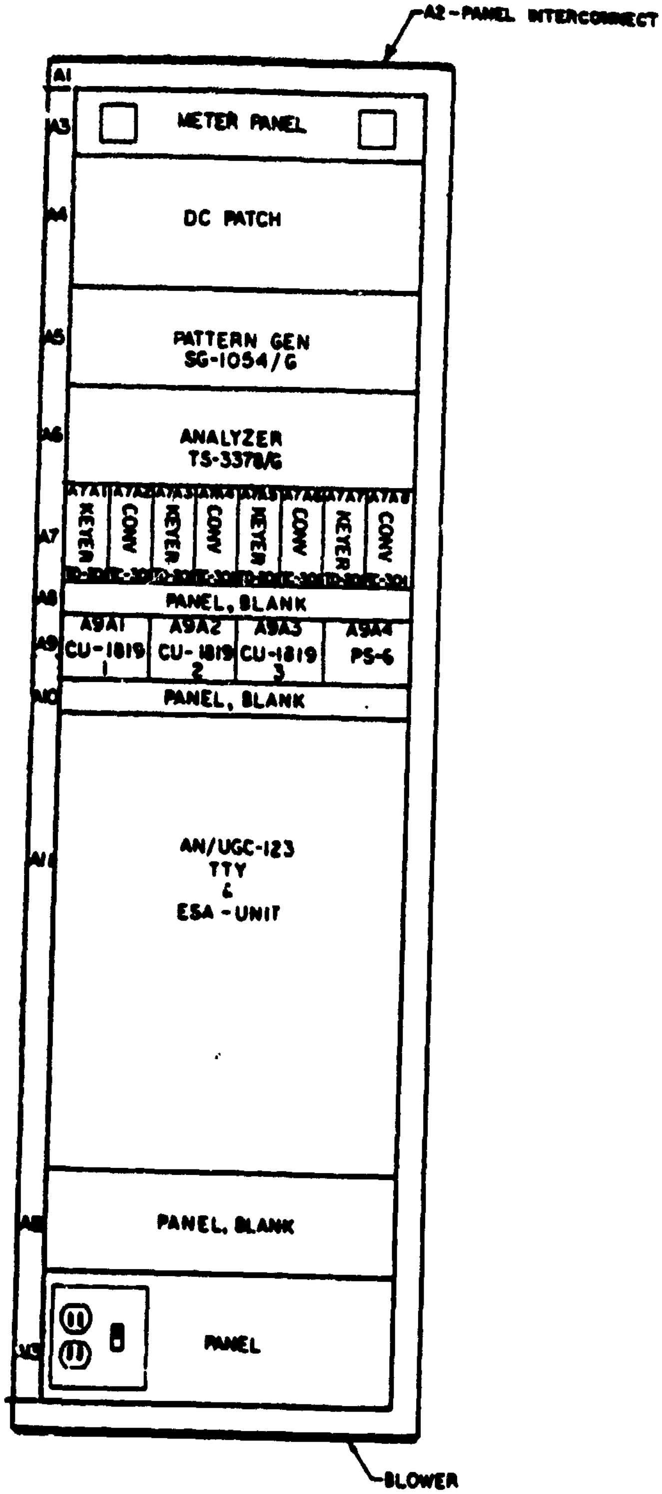


Figure 3.2.3.(b) TYPICAL DCS TDM SATELLITE PATCH AND TEST FACILITY



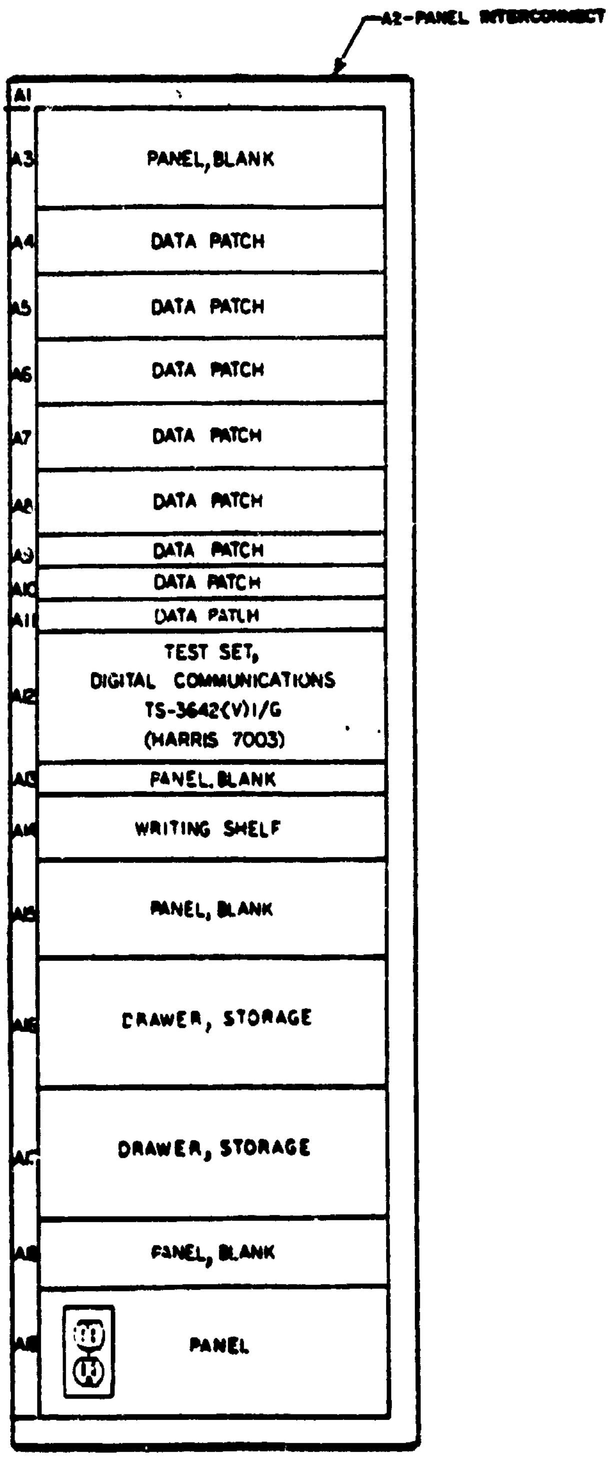
TYPE 6

Figure 3.2.3.1.1 VF Maintenace Patch Panel



TYPE 9

Figure 3.2.3.1.2 TTY Maintenance Patch Panel



TYPE 2

Figure 3.2.3.1.3 Data Maintenance Patch Panel

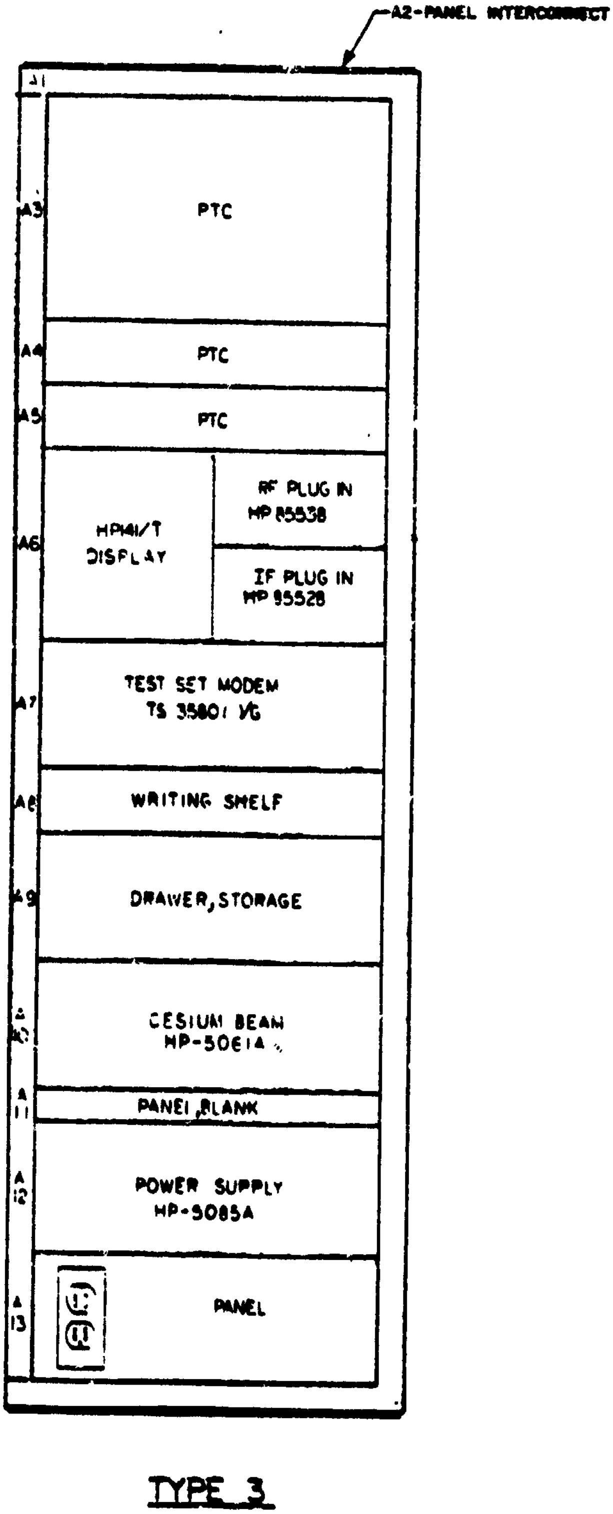


Figure 3.2.3.1.4 IF Patch Panel

3.2.3.2 TCF and Satellite Earth Terminal Connection

Four generic cases are considered of the interconnection of Technical Control Facilities and Satellite Earth Stations. These are depicted in Figure 3.2.3.2.1 to Figure 3.2.3.2.4

3.2.3.2.1. Case I.

Figure 3.2.3.2.1 depicts a typical Case I where the ET and the TCF are located near each other, but in separate buildings/ vans, and the modulation and multiplex equipment is located with the ET. Circuits will be routed on an individual basis from the TCF and will be multiplexed at the DCSS located at the ET. Line conditioning if required, will be provided at the TCF. Use of multipair cable will normally be used for circuits up to 50 kb/s, while coaxial cable will be required for circuits above 50 kb/s. The mix of clear analog voice and digital data circuits traversing the ICF dictates, at most sites, use of cable that provides shielding between those pairs handling digital data and those handling voice.

3.2.3.2.2 Case II

Case II is employed where the ET and TCF are located in separate buildings, some distance apart, and must be interconnected by microwave radio. The link multiplex equipment is located in the TCF and the link modems are at the ET. Multiplex equipment will be used in the ICF to combine the various links into a baseband stream, which will be connected through an MD-920 to the ICF radio. Figure 3.2.3.2.2 shows a typical Case II. Where used, AN/GSC-24 part of the DCSS being fabricated at the Tobyhanna Army Depot (TOAD). In addition, certain Case II locations might present a problem in combining the unprotected (PSK links) and protected (SSMA links) for transmission over the ICF. Therefore, it is imperative that the configuration for each Case II ICF be coordinated between the O&M MILDEP, DCA and USASATCOMA.

3.2.3.2.3 Case III

A typical Case III is shown in Figure 3.2.3.2.3 where the ET and TCF are collocated such that an interconnect facility (multipair cables, coax, fiber) is not required between the two. If the TCF and ETC-PTF are located in different rooms of the same building, multipair cables will have to be run between the ETC-PTF room and the TCF room. In this case, the configuration will be similar to that shown in Figure 3.2.3.2.1.

3.2.3.2.4 Case IV

Figure 3.2.3.2.4 depicts a typical Case IV. The multiplex equipment is located at the TCF and the modems are at the earth terminal. The circuits making up each link baseband will be combined in the TDM equipment at the TCF and transmitted to the earth terminal via coaxial or fiber optic cable. The multiplex cable shall also include an appropriate number of interstitial pairs which will be used for low data SSMA circuits and orderwire channels. Test results indicate that the length of cable should be restricted to 500 feet for driving 10 Mb/s signals. (750 feet for 5 Mb/s. This distance increases to 2500 feet (3750 feet for 5 Mb/s) if an ICF Modem MD-920/G is used. Fiber optic cable can be used for longer distances. A bit synchronizer or modified MD-920/G is required to be used with fiber optics system to recover clock which is required for the demultiplexing on AN/GSC-24. Use of two fiber optical cables per line (one for data and one for clock) to eliminate the requirement of MD-920/G or bit syncronizer for clock recovery is under investigation.

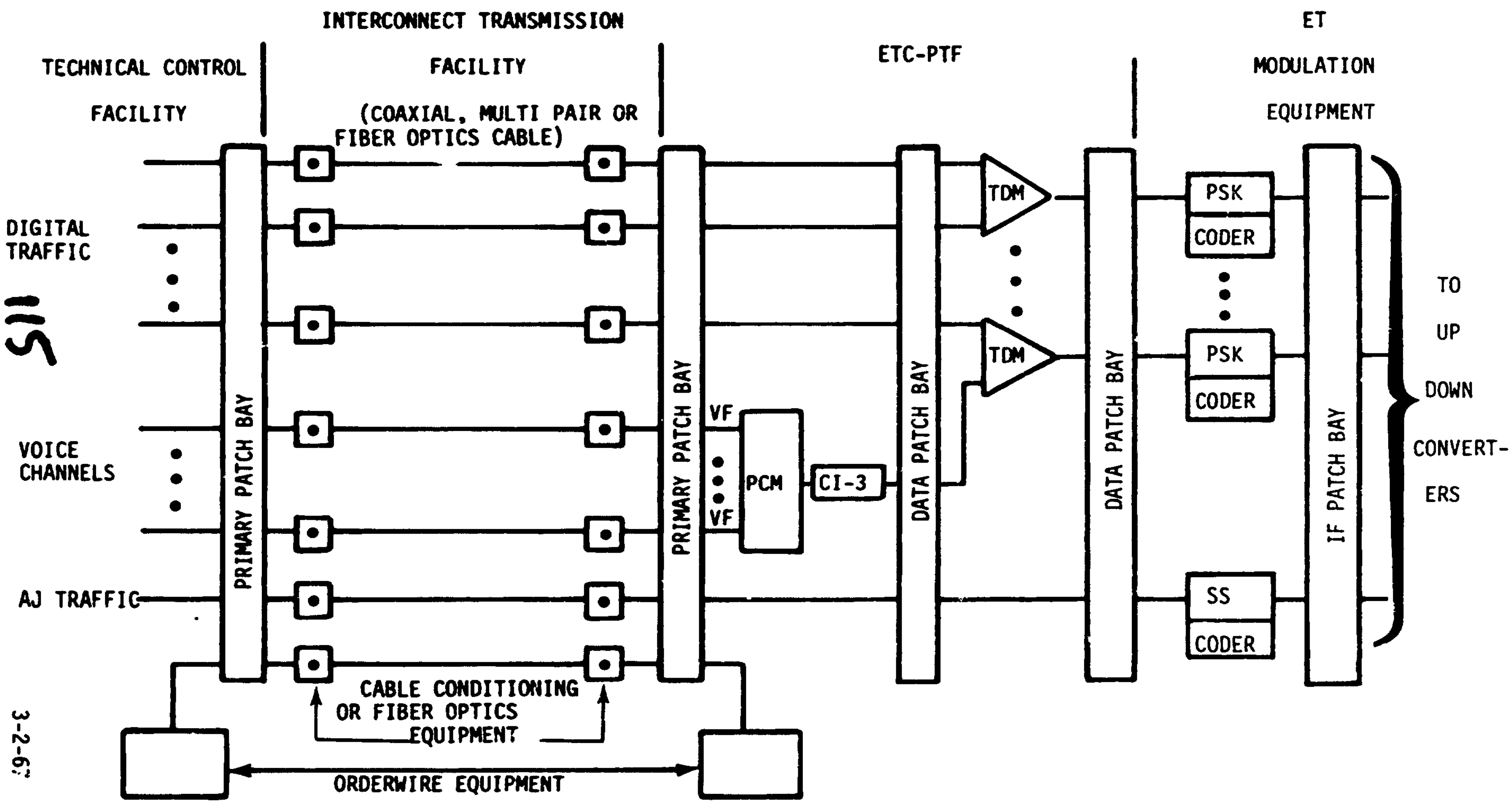


FIGURE- 3.2.3.2.1 Typical Case I

115

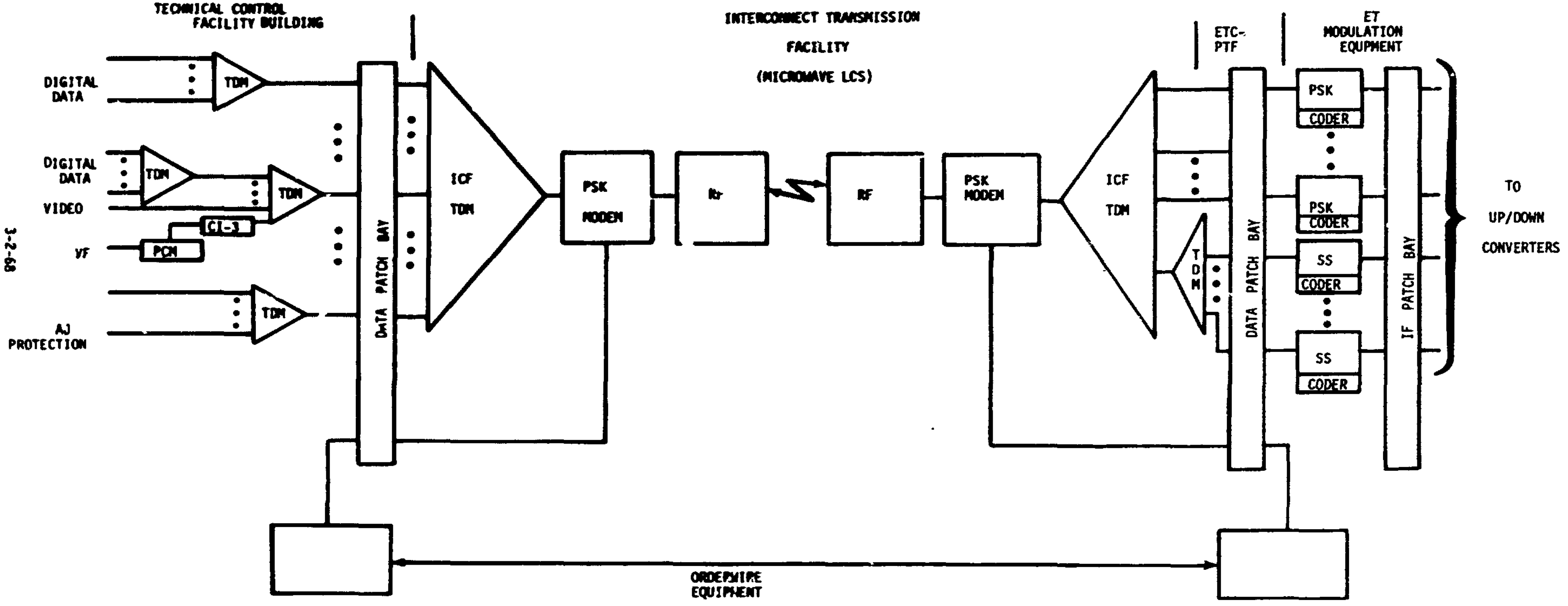


FIGURE 3.2.3.2.2 Typical Case II

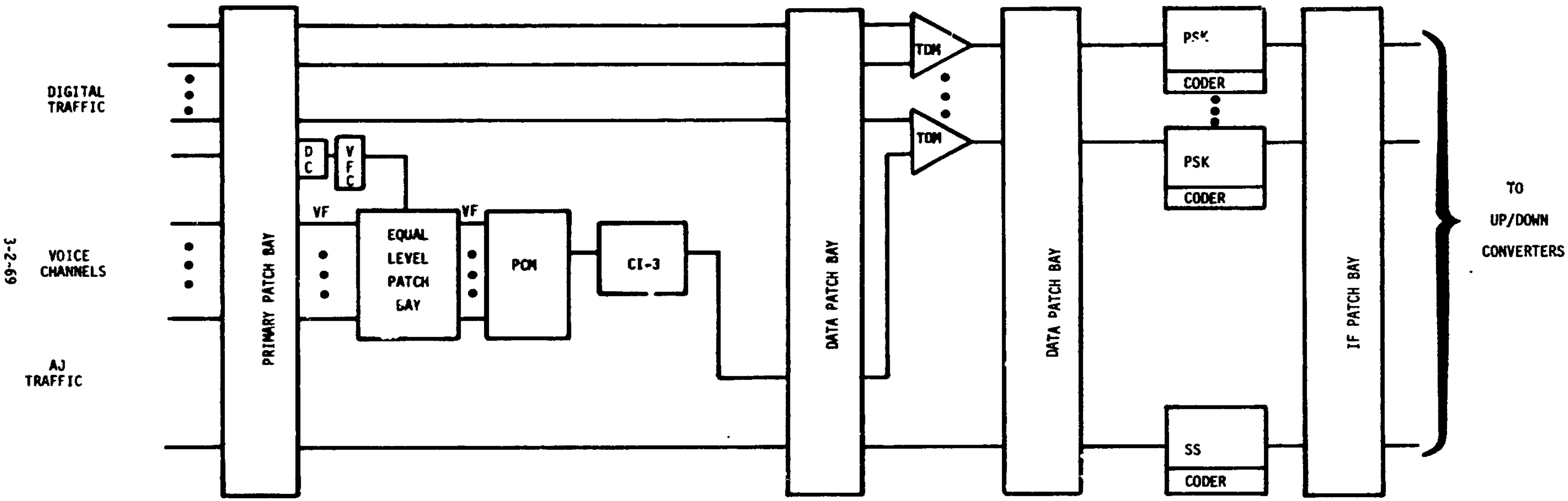


FIGURE 3.2.3.2.3 Typical Case III

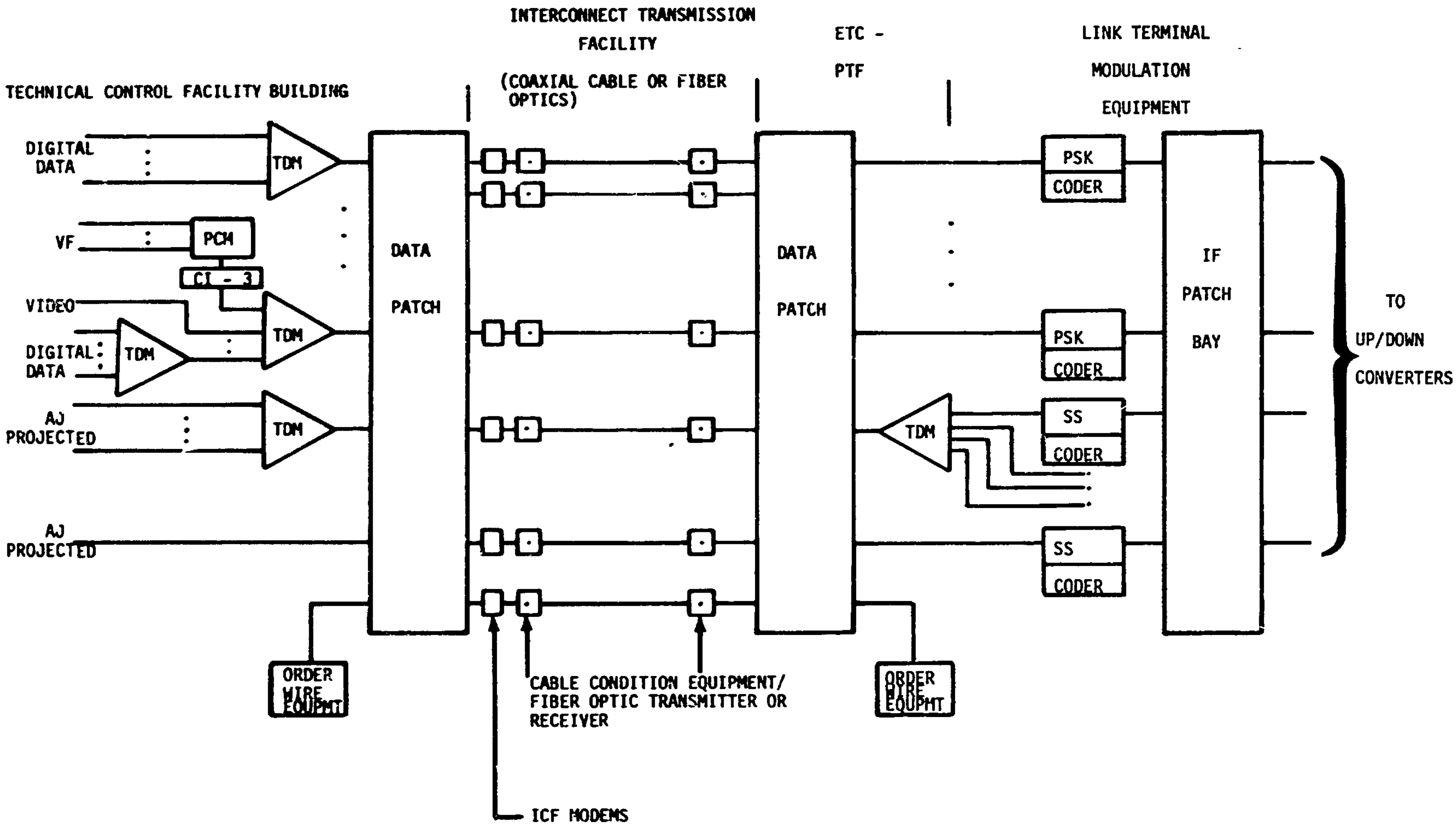


FIGURE 3.2.3.2.4 Typical Case IV

3.2.3.3 Signal Flow

3.2.3.3.1 Analog Signals
The DCS TDM Satellite P&TF will service the analog signals defined in MIL-STD-188-100, paragraph 4.2. These signals should enter and leave this P&TF via 600 ohm balanced wire-pairs at approximately the same level relative to each other to permit patching into a spare echo suppressor/PCM channel without the need for equipment gain adjustments.

3.2.3.3.1.1 Fixed Station Installation
For fixed stations, conditioning of signals will be accomplished by the existing TCF prior to processing by the digital P&TF equipment. The recommended input and output levels should be the same as that at the equal level patch minus or plus the cable loss, respectively. Figure 3.2.3.3.1(a) through 3.2.3.3.1(e) depict signal flows for various user types.

3.2.3.3.1.2 Tactical or Maneuverable Installations
For this type of installation, the user must provide all conditioning and interfacing equipment necessary to interface the DCSS which is not equipped with two-wire/four-wire hybrids. Figure 3.2.3.3.1.2 depicts typical users which are acceptable to the DCSS.

3.2.3.3.2 Digital Signals
There are several types of digital signals which are processed through the P&TF. The path of E and M signals has been shown in paragraph 3.2.3.3.1, as well as analog and quasi-analog data signals which are digitized for processing through the digital satellite transmission system. Except for the AN/USC-28 TTY circuits and the DCA orderwire TTY circuits, all TTY users will be wired to a subpanel of the data patch rack.

3.2.3.3.2.1 AN/USC-28 Control and Digital Users
These users, usually control and orderwire between the Network Control Terminal (NCT) and the Network Terminal (NT) are shown in Figure 3.2.3.3.2.1(a). Figure 3.2.3.3.2.1(b) depicts typical AN/USC-28 digital users which are Time Division Multiplexed by the AN/GSC-24.

3.2.3.3.2.2 Digital Users
Digital users serviced by the DCS TDM satellite range in rate from 50 b/s to 3 Mb/s. Figure 3.2.3.3.2.2 is a block diagram showing some of the users.

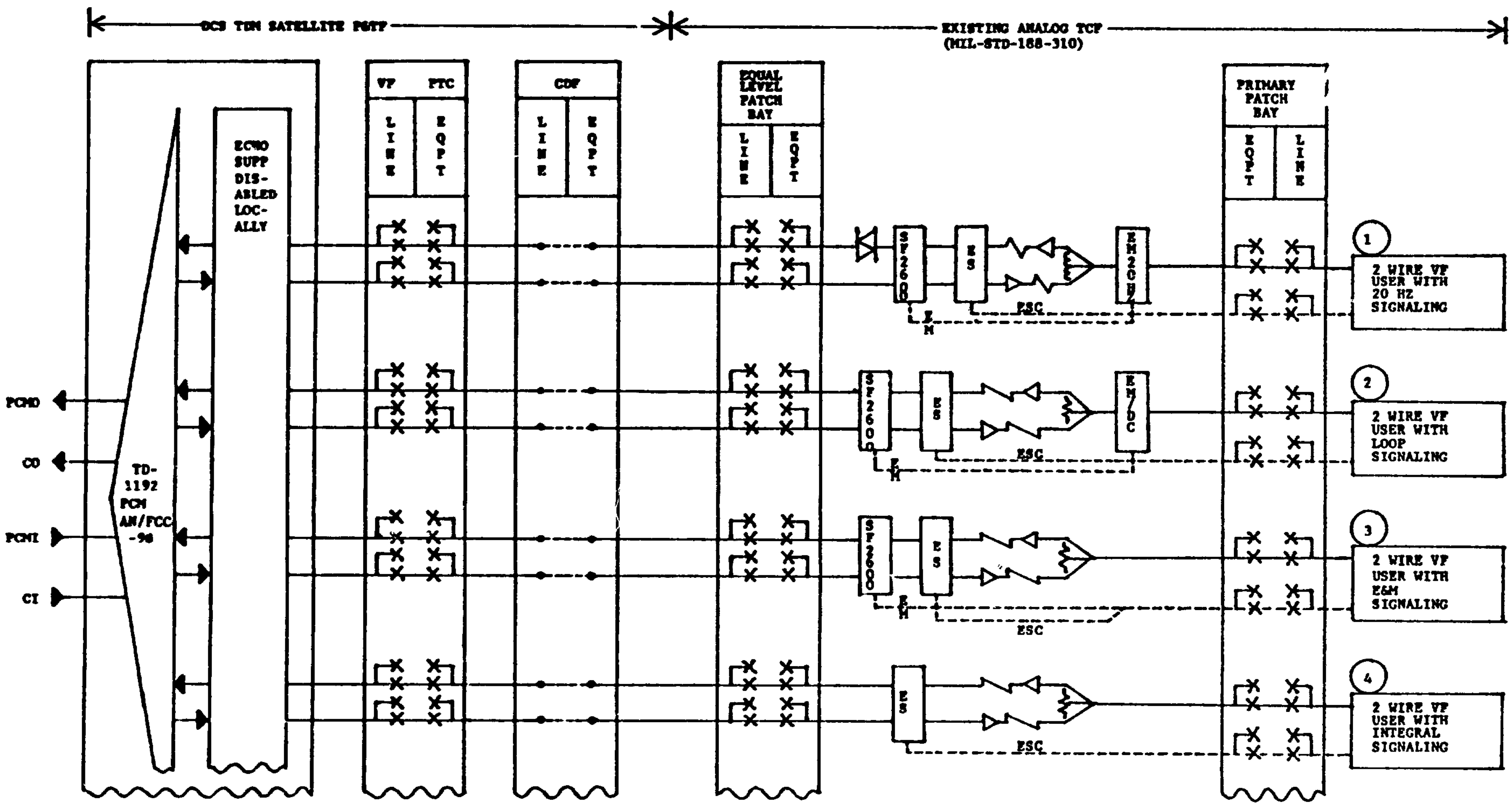


FIGURE 3.2.3.3.1.(a) TYPICAL DCS TDM SATELLITE 2 WIRE VF USERS UTILIZING EXISTING ECHO SUPPRESSOR AND SF EQUIPMENT

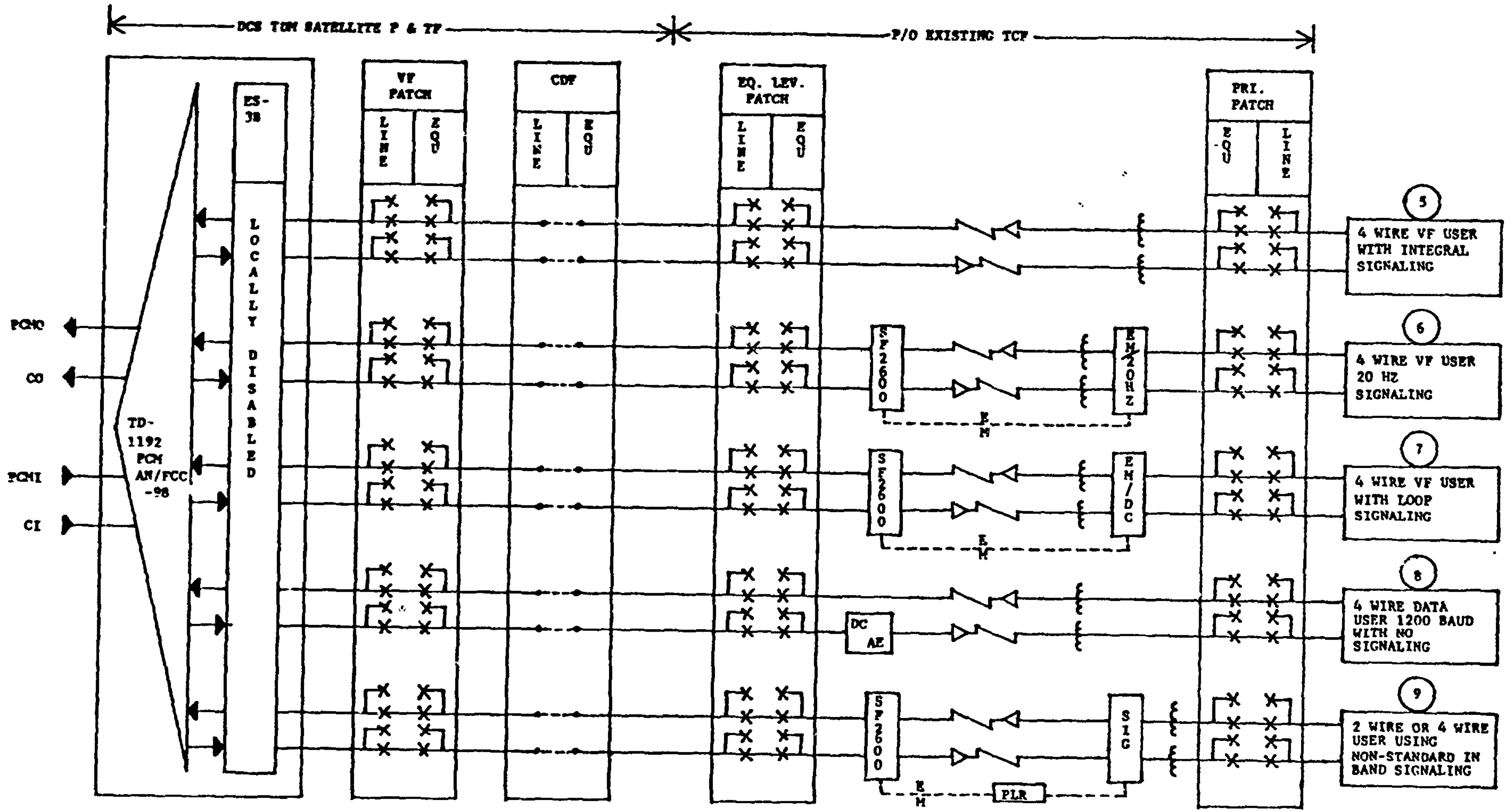


FIGURE 3.2.3.3.1.(b) TYPICAL DCS TDM SATELLITE 4-WIRE USERS UTILIZING EXISTING ECHO SUPPRESSOR AND SF EQUIPMENT

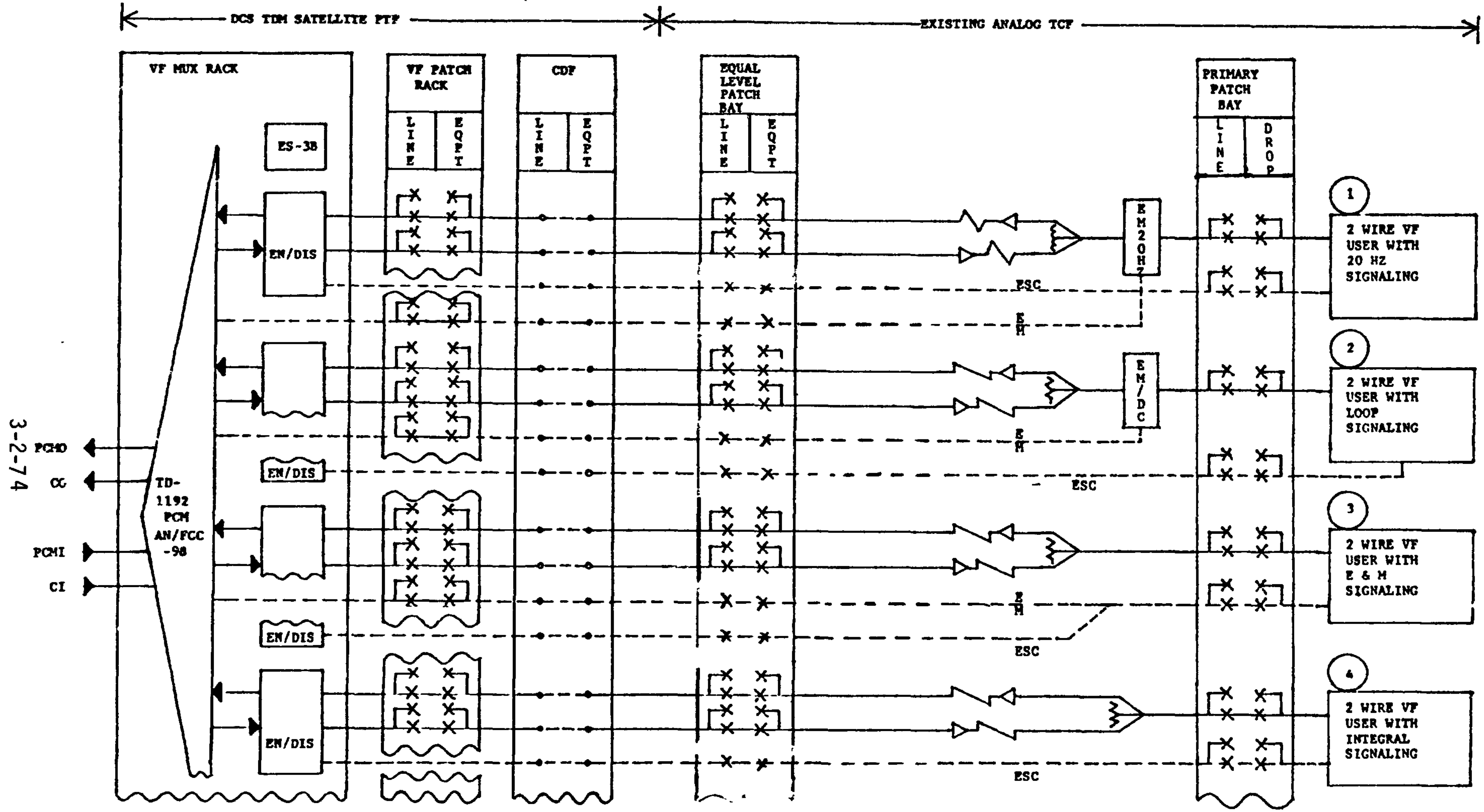


FIGURE 3.2.3.3.1.(c) TYPICAL DCS TDM SATELLITE 2 WIRE VF USERS UTILIZING ES-3B AND TD-1192 FOR SF GENERATION

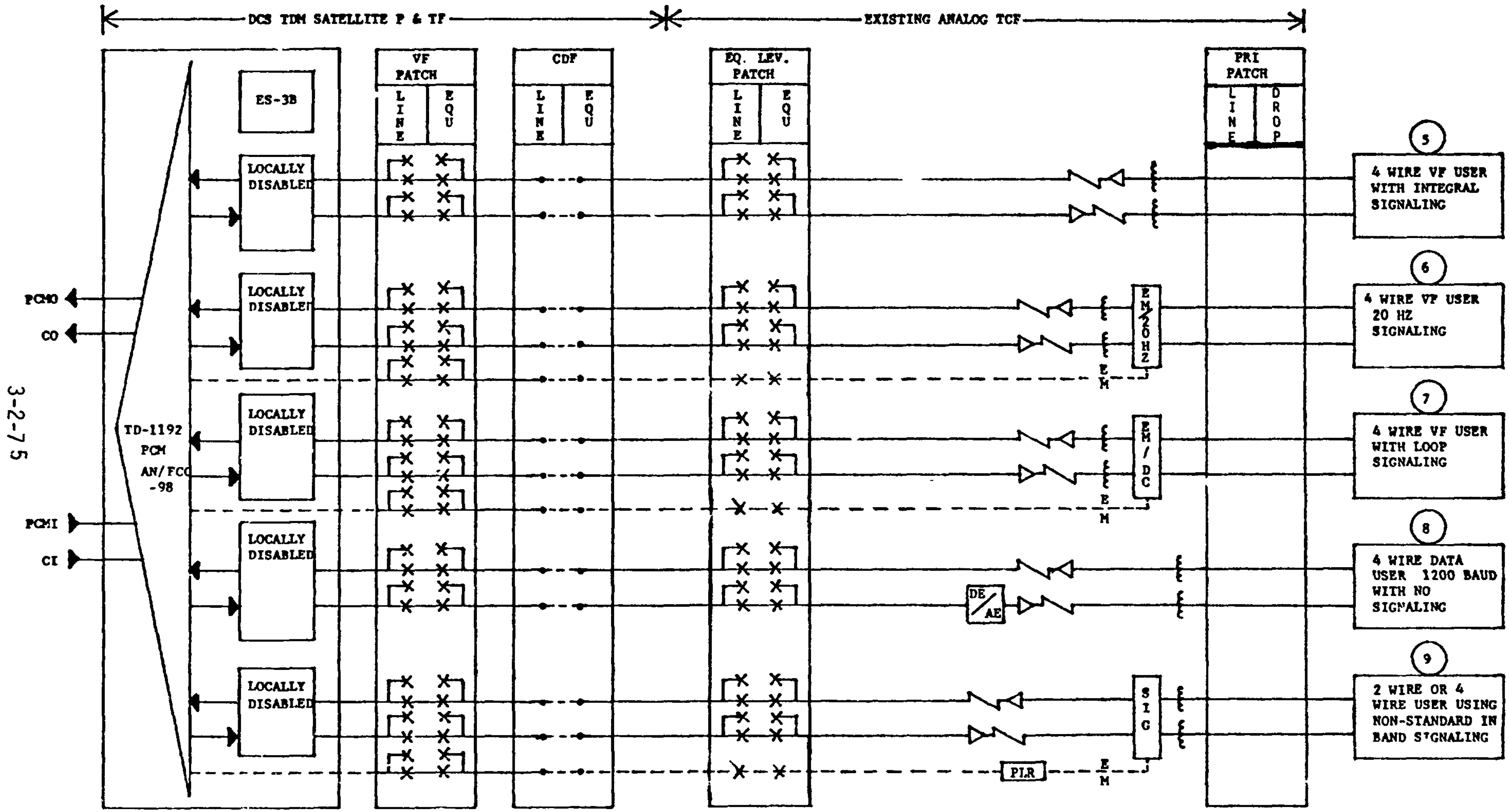


FIGURE 3.2.3.3.1 (d) TYPICAL DCS TDM SATELLITE 4-WIRE VF USERS UTILIZING TD-1192 FOR SF GENERATION

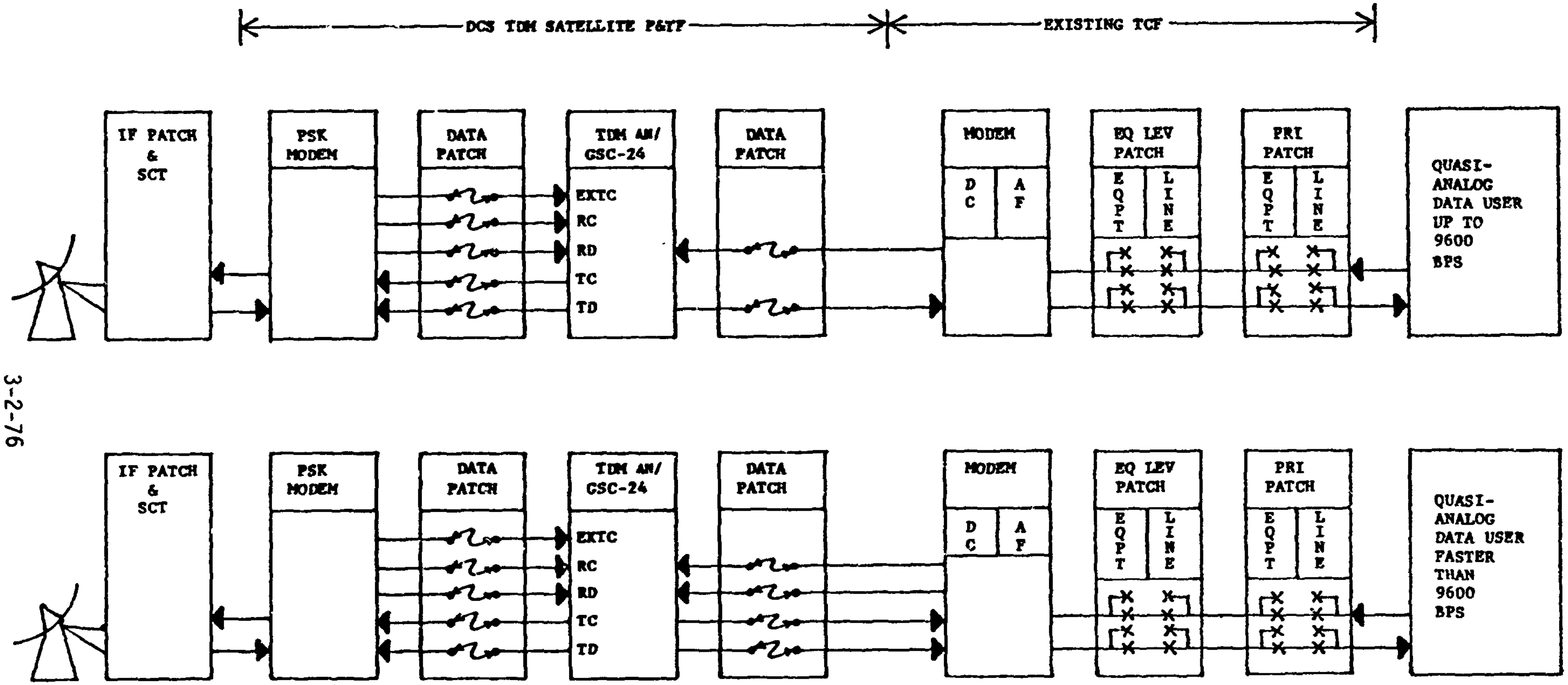


FIGURE 3.2.3.3.1.(e) TYPICAL QUASI-ANALOG DATA USERS

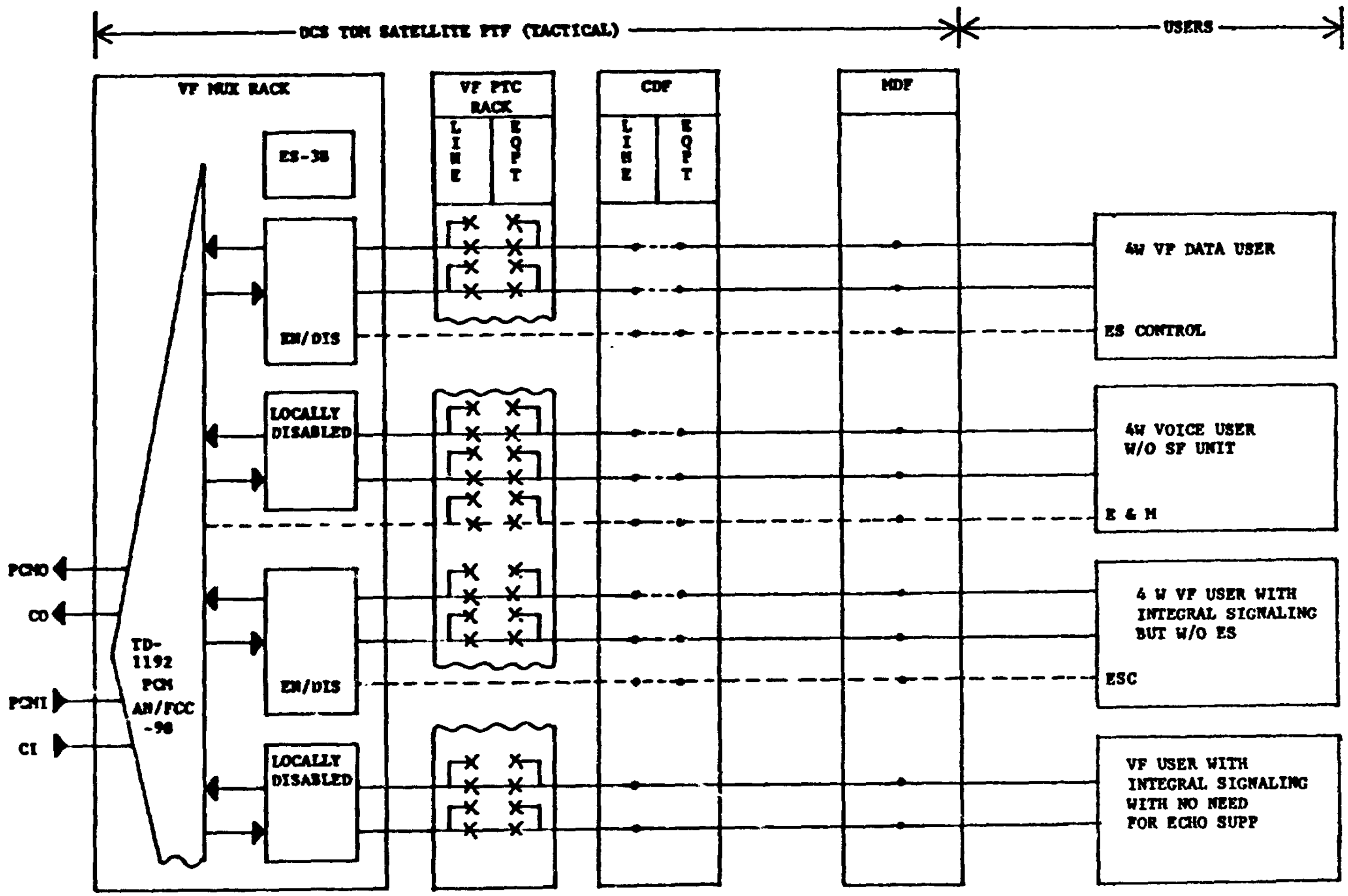


FIGURE 3.2.3.3.1.2 TACTICAL DCS
TDM SATELLIT: P & TF

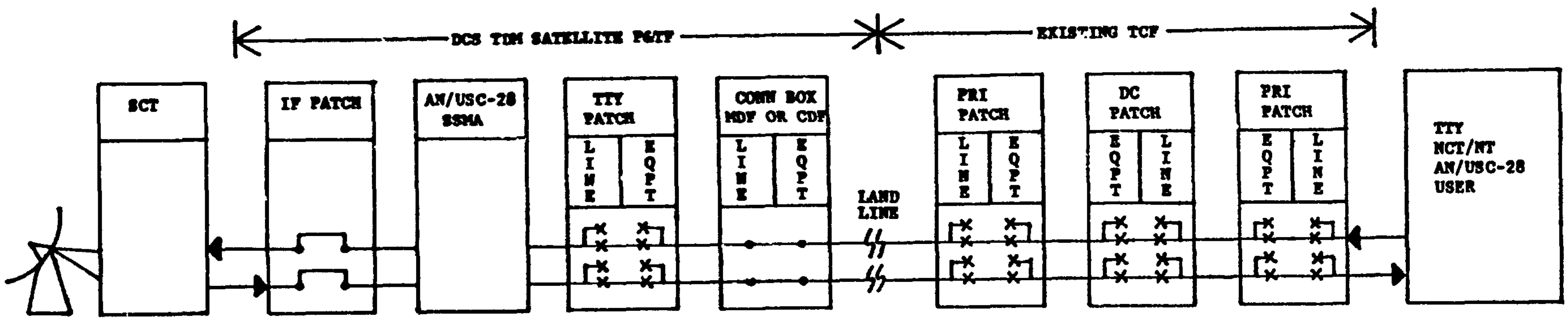


FIGURE 3.2.3.3.2.1.(a) TYPICAL AN/USC-28 NCT/NT USER CIRCUIT BLOCK DIAGRAM

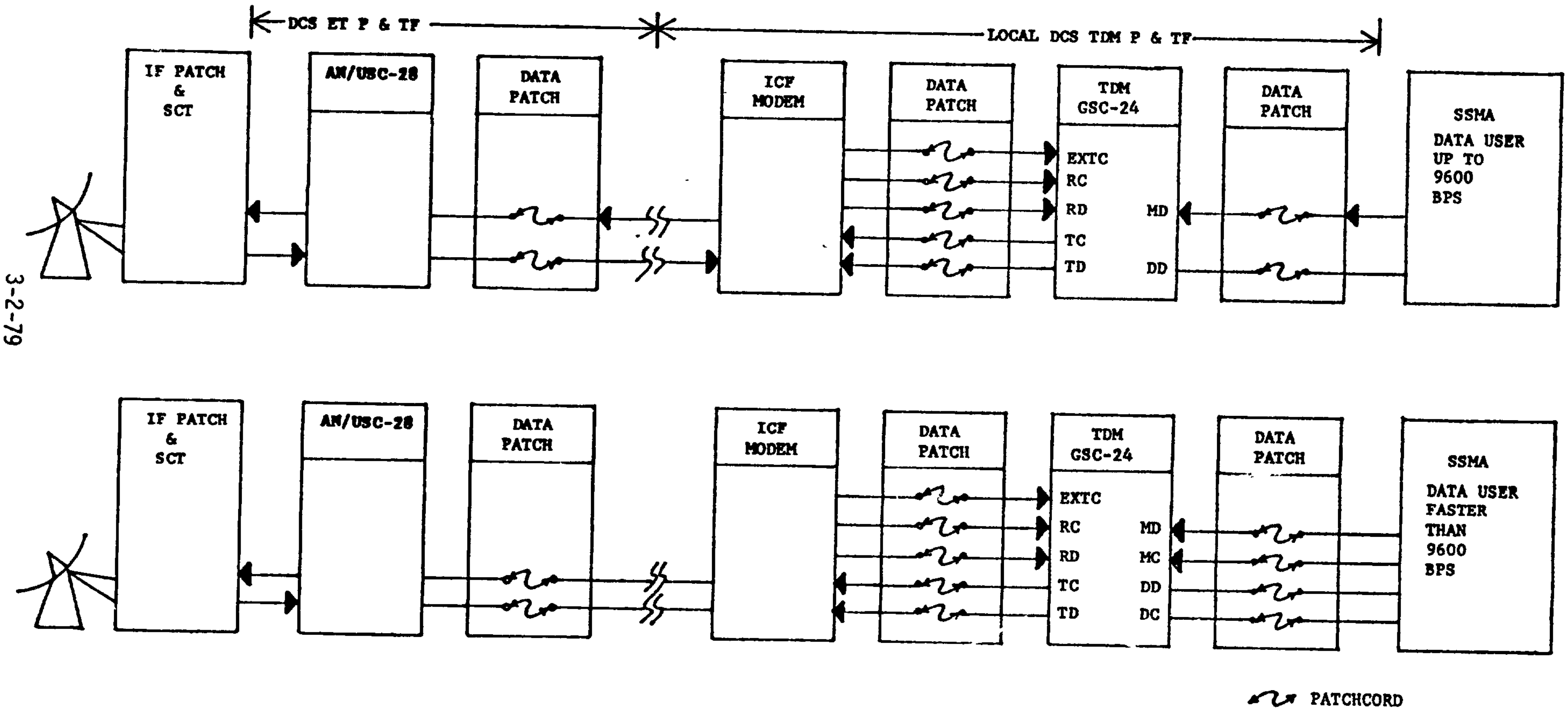


FIGURE 3.2.3.3.2.1.(b) TYPICAL AN/USC-28 DIGITAL USER BLOCK DIAGRAM

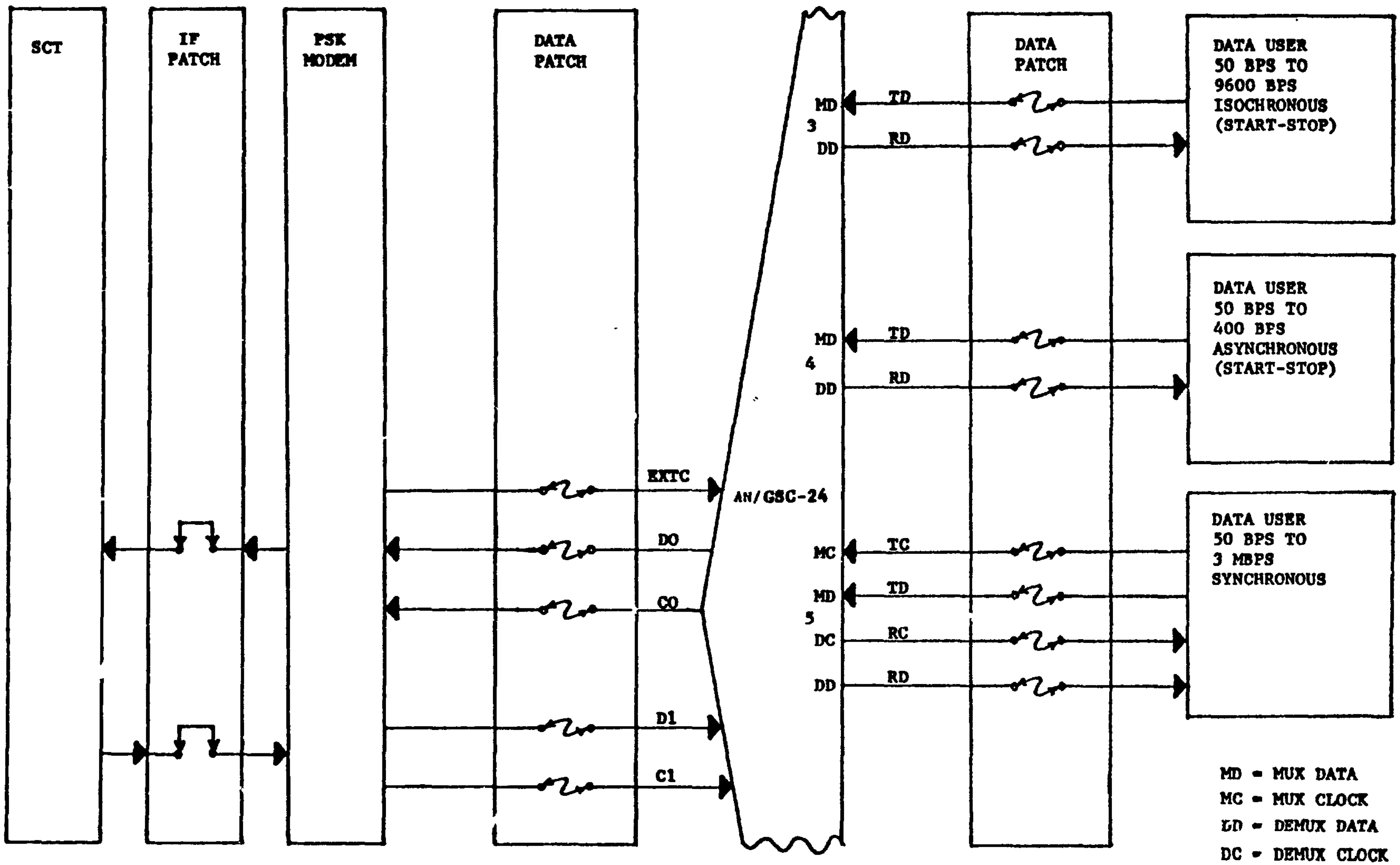


FIGURE 3.2.3.3.2.2 TYPICAL DIGITAL USER CIRCUIT BLOCK DIAGRAM

3.2.3.4 Digital Cabling

There are many types of digital data circuits and signal formats which are utilized within the DCS TDM Satellite P&TF. The types of cables and wires will be selected, and connections made, to preclude unnecessary degradation of signals. Figure 3.2.3.4 shows the maximum distance that data should be run over certain types of cable as a function of data rate without regeneration. This is an approximate chart and does not take into account signal degradations which may be caused by frame cross-connects, patch jacks, or splices.

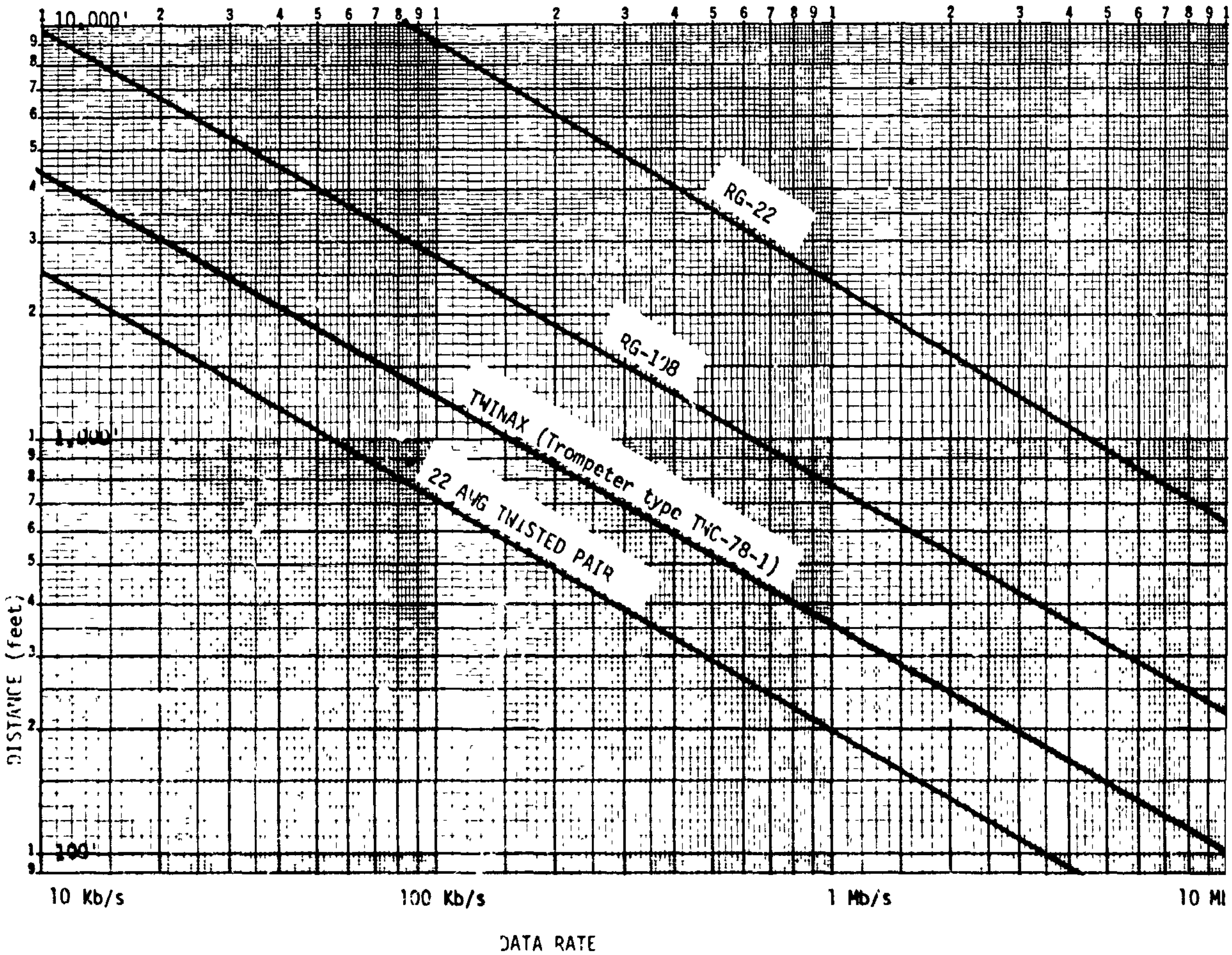
3.2.3.4.1 Low Speed Signals (< 1 Mb/s).

These circuits will maintain a balanced status throughout this P&TF except when transmitted by an unbalanced source or terminated in an unbalanced load. TTY signals interfacing this P&TF shall be balanced in accordance with paragraph 5.1 of MIL-STD-188-114. This is necessary in order to accommodate signals not sensed per paragraph 5.1.1.1 of MIL-STD-188-114. The P&TF TTY signal monitor device shall likewise be balanced and normally wired to measure TTY signals appearing between the Tip and Ring of the wire pair or monitor jack.

The signal sense, level, and impedance of this type of signaling will be maintained in accordance with MIL-STD-188-114.

3.2.3.4.2 High Speed Signals ($\geq$ 1 Mb/s)

These circuits must accommodate signaling speeds up to 10 Mb/s. These circuits must also accommodate various impedances such as 78 ±10% ohms balanced, 75 ±10% ohms unbalanced, 50 ±10% ohms unbalanced, 135 ohms balanced, 100 ohms balanced, 600 ohms balanced, and unbalanced. Since the lengths of cables associated with the P&TF are relatively short, they will provide transparent impedances at low symbol rates (<64 kb/s). At high symbol rates, balanced signaling will be utilized; therefore, balanced cables and hardware should be used whenever possible. For the sake of standardization within the DCS TDM Satellite P&TF, cables and ancillary hardware such as connectors and tools, shall be the same as those utilized in the DCSS built by Tobyhanna Army Depot.



Graph indicates the maximum distance that MIL-STD-188-100 low level interface can be extended over various types of cable without regeneration. Distances refer only to 7 OHM BALANCED ±3 VOLT sources operating into 75 OHM BALANCED receivers with minimum sensitivity of ±0.5 VOLTS.
(source: "TECHNICAL DESCRIPTION, Digital Communications Satellite Subsystem" NOV 76)

FIGURE 3.2.3.4

MAXIMUM DISTANCE (MIL-STD-188-100) FOR VARIOUS CABLES

3.2.4 Patch and Test Facilities for TDM Leases (CONUS)

The configuration for the 1.544 Mb/s leased circuit from California to Hawaii is shown in Figure 3.2.4. Since at present only one 1.544 Mb/s circuit is leased extensive technical control facilities are not required. Even though the CY-104 has test terminal points, it was decided to add a digital patch board to test the line from the CY-104 to the earth station.

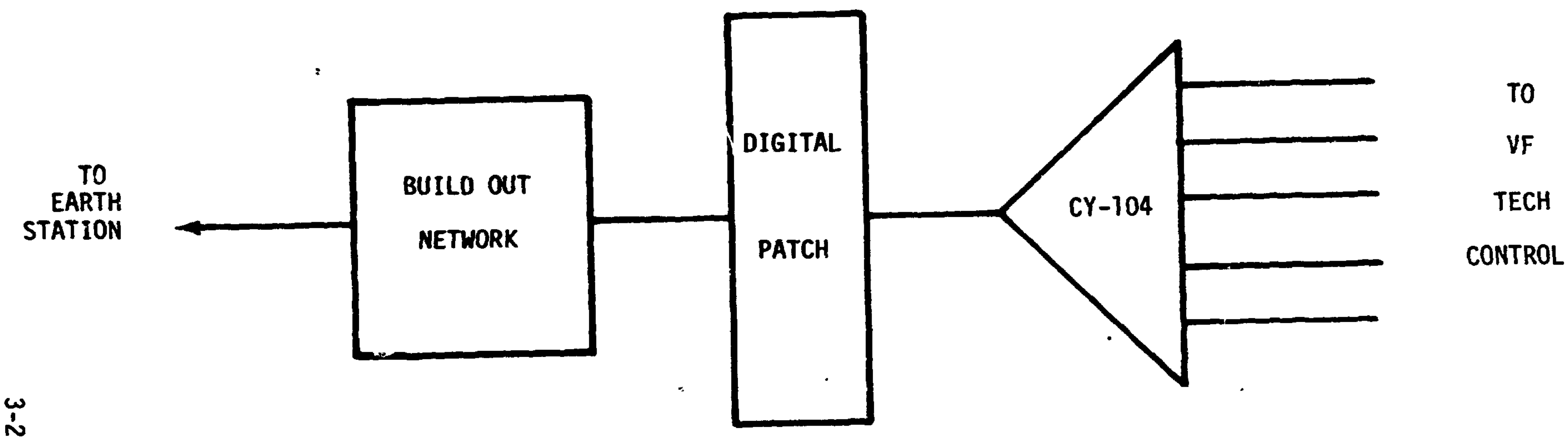


FIGURE 3.2.4 1.544 Mb/s LEASE, CONUS TO HAWAII

3.2.5 Patch and Test Facilities for TDM Cable Transmission

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.2.6 Technical Control Facilities in TDM LOS DCS Stations, Second Generation DCS

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.2.7 Patch and Test Facilities in TDM LOS DCS Stations, Second Generation DCS, Overseas

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.2.8 Patch and Test Facilities in TDM Tropo Stations

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.2.9 Patch and Test Facilities for HF Radio Facilities

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.3 DCS SWITCHED NETWORKS

3.3.1 AUTOVON and Technical Controls

The configuration of Technical Control Facilities for AUTOVON switching centers is described in two time frames: AUTOVON I (the existing AUTOVON network) and AUTOVON II. As of the time of publication of this document, the AUTOVON II architecture is largely undefined. Therefore, we need to concentrate on the interface between AUTOVON I and the new generation of digital transmission systems.

3.3.1.1 AUTOVON I and Technical Controls - The configurations described herein apply primarily to the technical control facilities serving Overseas AUTOVON Switching Centers as they exist today and as they will be reconfigured to accommodate TDM transmission.

Figure 3.3.1.1(a) shows the typical technical control facility configuration over FDM and HF facilities during the original installations.

In terms of patching and monitoring facilities, a VF patch bay was employed at the Channel Modulator Inputs and Channel Demodulator Outputs of the frequency division multiplexer. All channels were considered equivalent at this point regardless of the use or application. This assumption is valid for telephone application but is less valid when data transmission is considered because in actual fact, the channel frequency response and delay distortion exhibit less variation in PCM systems than in FDM systems.

The levels prescribed at this point are - 16 dBr for Channel Modulator input and +7 dBr for Channel Demodulator Output, based on traditional application of FDM equipment. The differences in the levels at this point required the use of 23 dB padding for back-to-back testing and patching. Although this arrangement is common in commercial systems, military communicators have historically preferred equal level patching. It should also be noted that DCS military use of equal level patching negated the purpose of these standard commercial levels, which was to eliminate the need for amplifiers to make up for hybrid losses in 2-wire interfaces.

The circuit patch bay was required for interfacing the AUTOVON switch, at the -2 dBr level. This was in keeping with the Net Loss Design of AUTOVON, but this "equal level" patch was convenient for testing and monitoring and for other applications, such as alternate routing. However, all channels were not identically configured at this point so that it was not a universally convenient patch for alternate routing.

The DC Patch (labeled Telegraph Testboard on Fig 3.3.1.1(a) is used for patching and for monitoring the distortion of teletype signals.

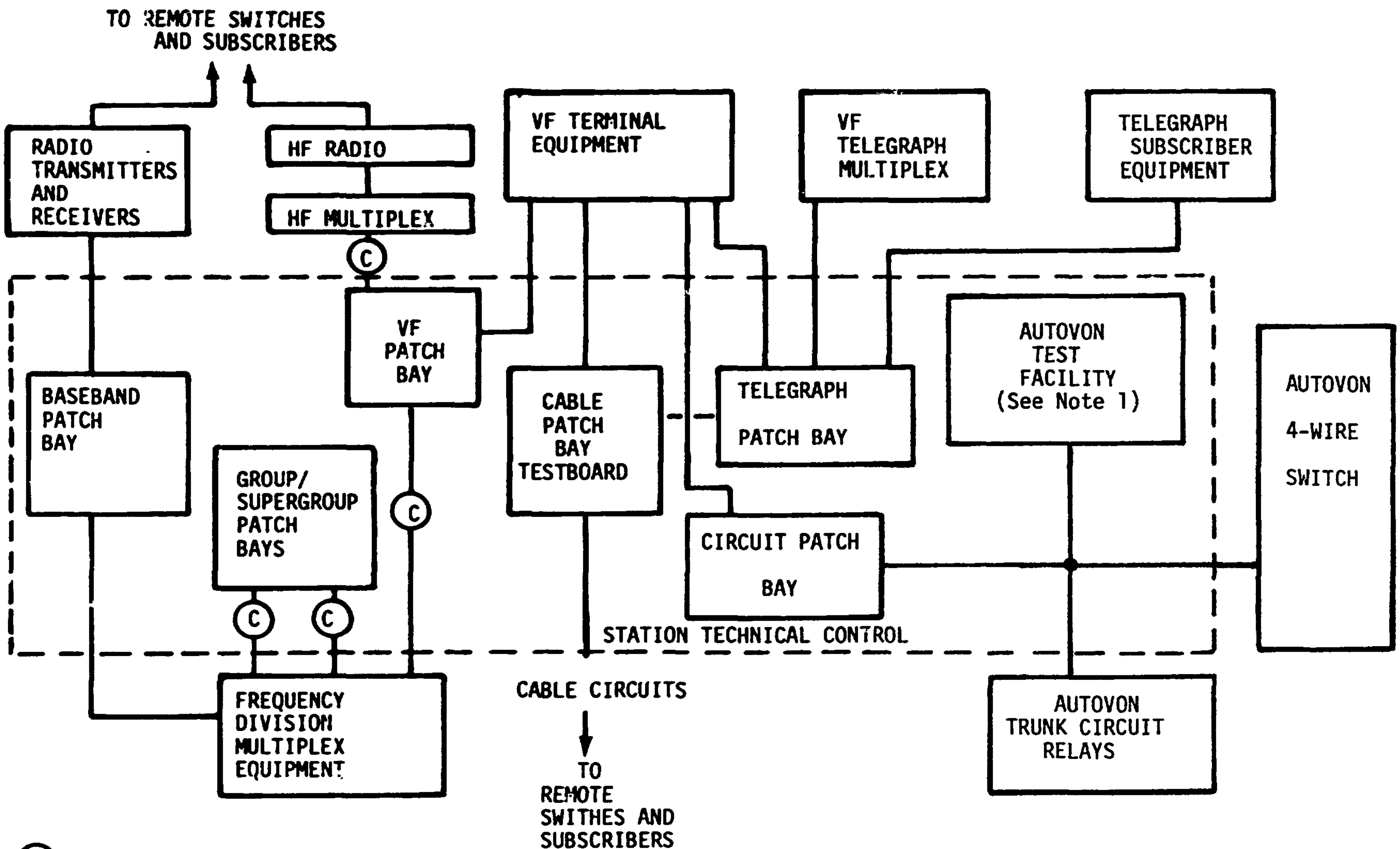
The group, supergroup and baseband patch bays were also incorporated for patching, testing and monitoring the FDM facilities. Group patching could be performed with Group Interconnect filters at the Group Patch Bay, although this capability is rarely used at present. Supergroup and Baseband Patching capabilities are virtually never used for alternate routing. These patch bays are used more frequently for checking levels of individual channels as they are translated to/from the higher levels of multiplex.

Figure 3.3.1.1(b) shows a typical technical control facility configuration for an Overseas AUTOVON switch served by digital transmission.

At the time that MIL-STD 188-310 was published, it was decided that the Equal Level Patch is sufficient for serving the functions of both the VF Patch and the Circuit Patch, thus eliminating one patch bay from the configuration. Conditioning equipment (equalizers and echo suppressors) are connected between the Equal Level Patch and the Primary Patch. Thus the Equal Level Patch Bay can be used universally for alternate routing.

The old cable patch bay was the test and monitor point for cable runs (outside plant) entering the tech controls and the interface point for switches. This patch function is now integrated into the VF and DC Primary Patch Bays.

The interfaces between the time division multiplexers are via data patch bays of the M or MM type defined previously.



(C) = CONDITIONING EQUIPMENT AS REQUIRED

Note 1: Formerly called AUTOVON Technical control Board/secondary Board

FIGURE 3.3.1.1(a) Typical Station Technical Control Facility overseas AUTOVON I original Configuration, FDM Facilities

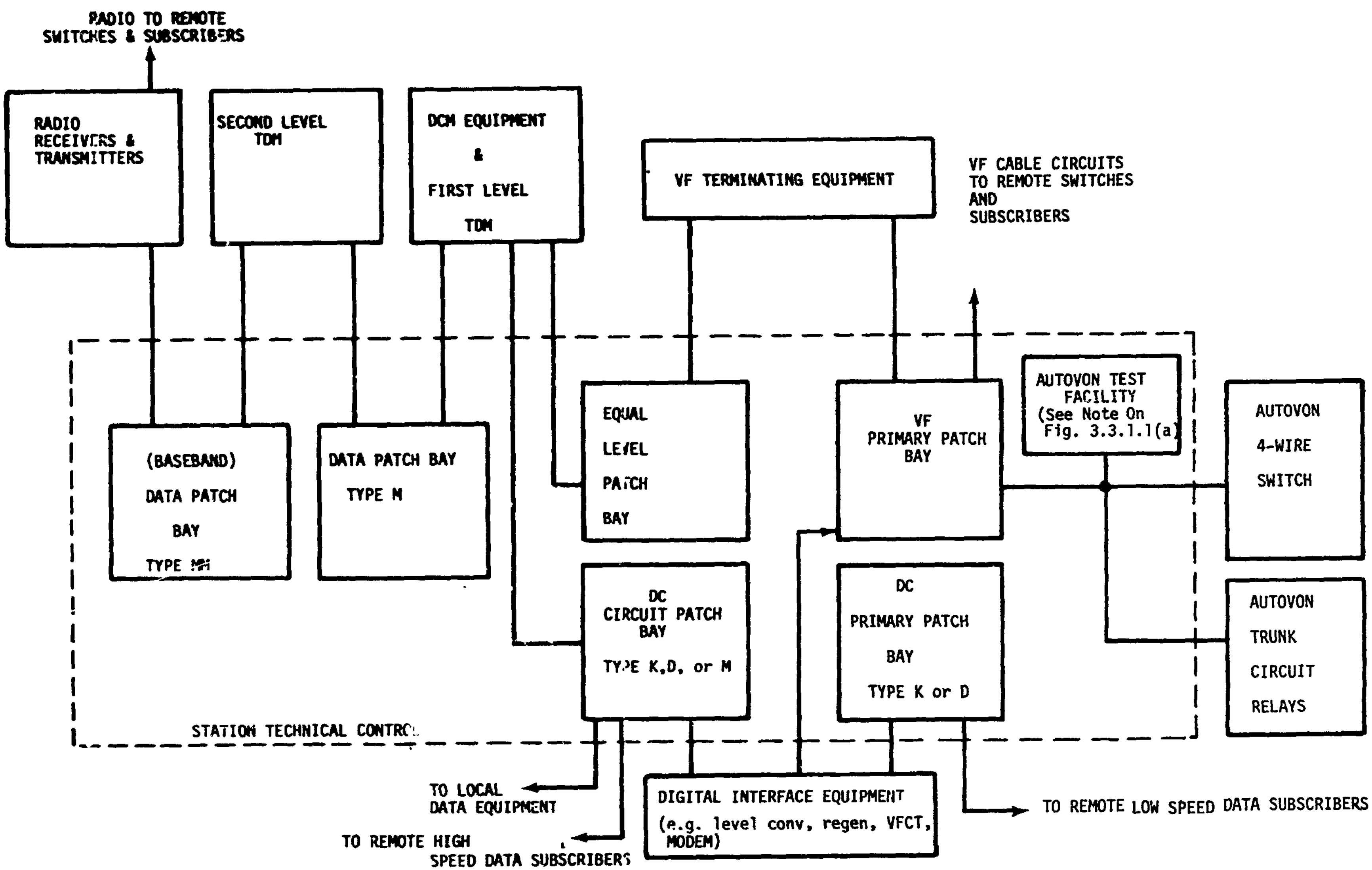


Figure 3.3.1.1(b) Typical Station Technical Control Facility-
Overseas AUTOVON I, prior to 1980, TDM Configuration

3.3.2 AUTODIN and Technical Controls. The configuration of technical control facilities serving AUTODIN switches is discussed in terms of the existing AUTODIN I Communications and Technical Control element.

3.3.2.1 AUTODIN I and Technical Controls

Figure 3.3.2.1(a) shows a typical configuration of an AUTODIN switch served by FDM Transmission. The communications and Technical Control Element of an AUTODIN switch serves as a complete Patch and Test Facility for the COMSEC related functions of AUTODIN circuits. The existing AUTODIN I interfaces with the DCS TCF primarily at the VF analog level. Some low speed dc circuits which do not require long-haul (carrier) routing are passed to the TCF on a dc basis.

As the analog DCS transitions to the digital DCS, it will be difficult to predict how much of the analog/digital conversion function (MODEM) now performed within the AUTODIN PTF will be eliminated in favor of direct digital interface. Figure 3.3.2.1(b) shows a possible configuration of a DCS TCF/AUTODIN I PTF served by digital transmission. Note the provision for dc/dc conversion; e.g., logic levels, regeneration, etc.) at either the DCS TCF or the AUTODIN PTF.

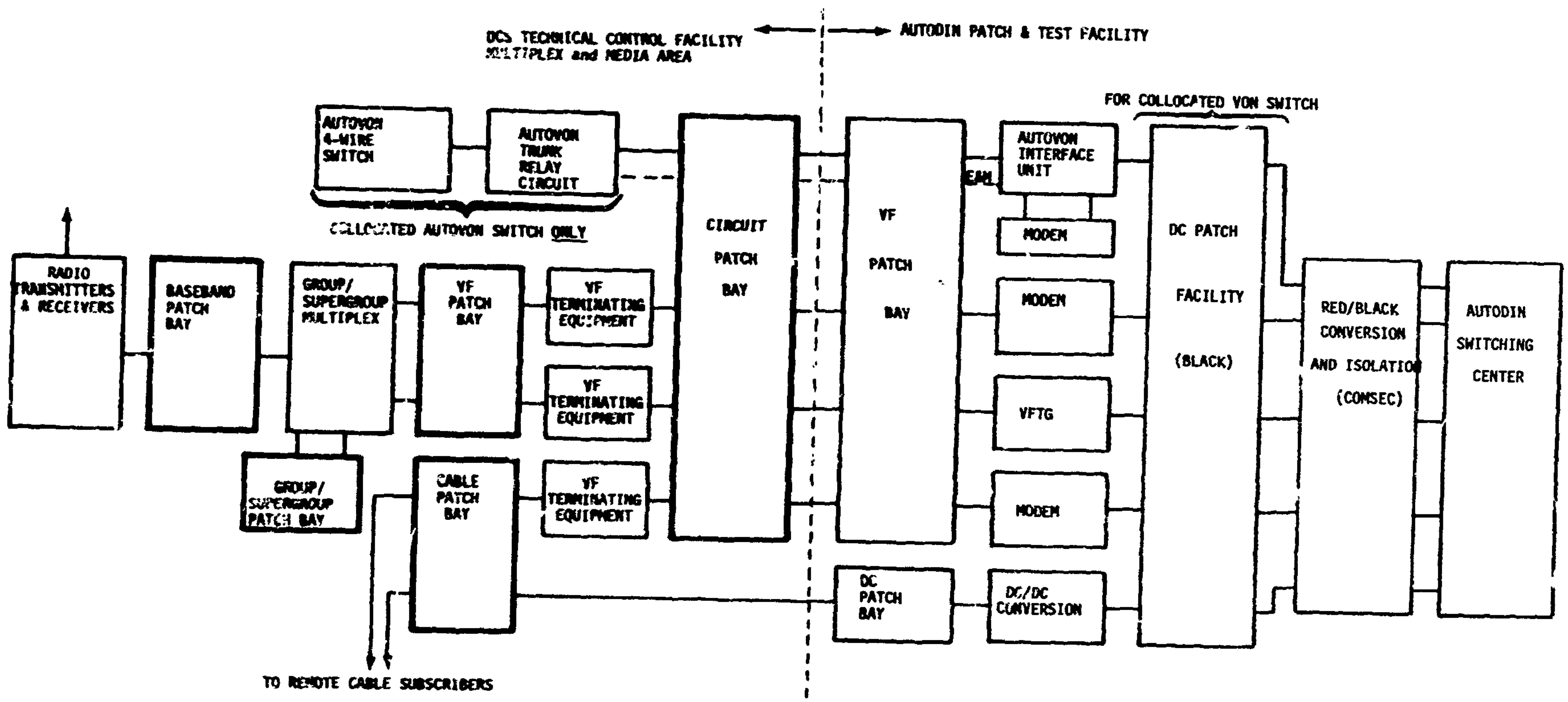


Figure 3.3.2.1(a) AUTODIN I and DCS Technical Control Facility Original Configuration- FDM Transmission

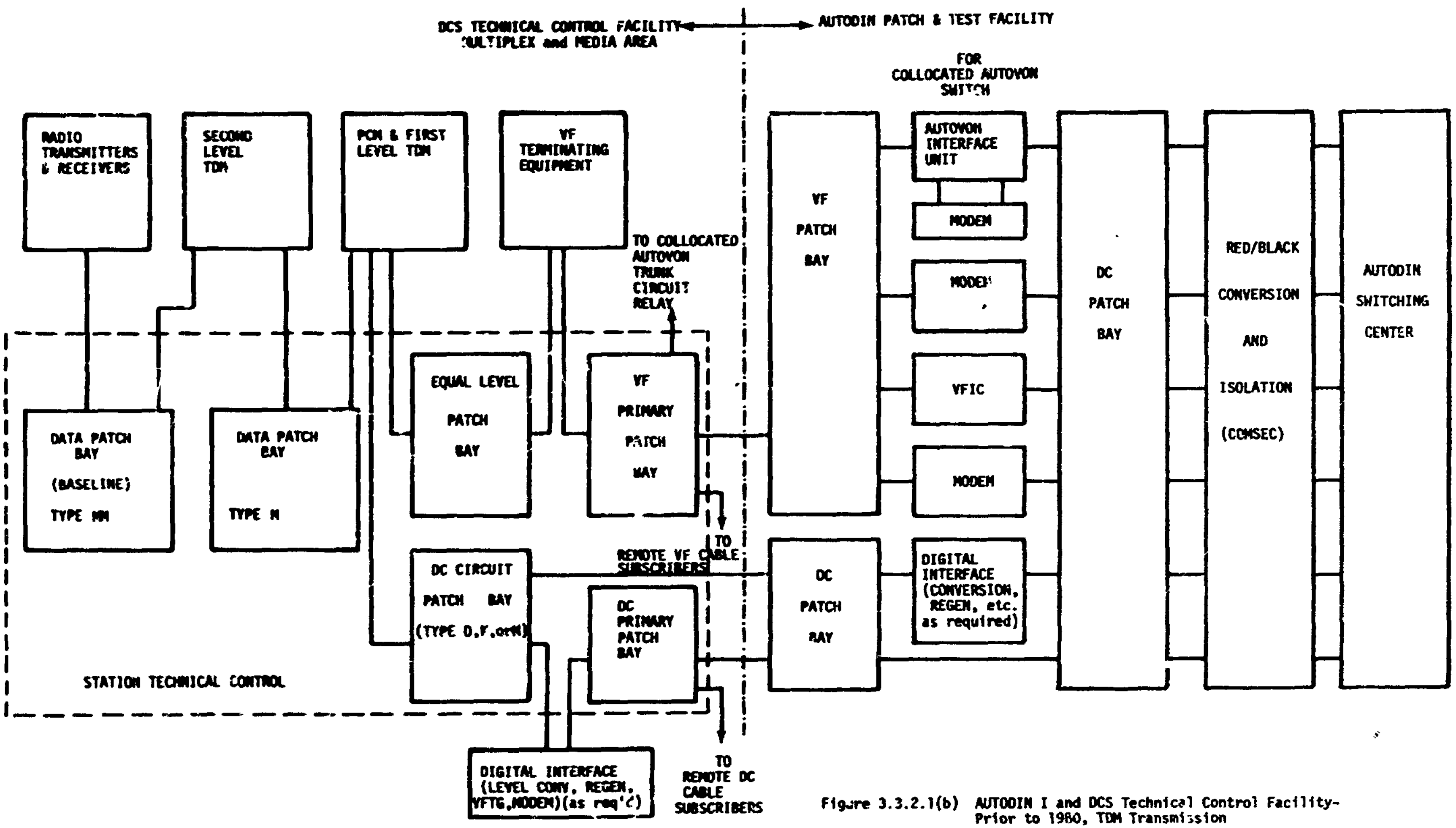


Figure 3.3.2.1(b) AUTODIN I and DCS Technical Control Facility-Prior to 1980, TDM Transmission

3.3.3 AUTOSEVOCOM and Technical Controls - The configuration of technical control facilities and patch and test facilities is discussed in two time frames: AUTOSEVOCOM I and AUTOSEVOCOM II. As of the time of publication of this document, the AUTOSEVOCOM II architecture has not been fully developed. This section will therefore discuss the interfaces between the AUTOSEVOCOM I network (including projected improvements prior to 1980 and technical control facilities.

3.3.3.1 AUTOSEVOCOM I and Technical Controls - AUTOSEVOCOM I, the single, long haul, secure voice network of the DCS, was originally implemented using wideband (50 kb/s) trunking for local subscriber communities and narrowband (2.4 kb/s, 9.6 kb/s) for long-haul trunking. The long-haul trunking was via both dedicated circuits and the common-user Voice Network, AUTOVON. Recently the Wideband Secure Voice (WBSV) program has installed many long-haul 50 kb/s trunks to supplement Narrowband Service and to provide very high quality secure voice service. WBSV has been so well accepted by the AUTOSEVOCOM users having access to it, that the initial network is scheduled for marked expansion prior to 1980. To illustrate the magnitude of expansion, Figure 3.3.3.1(a) shows the present WBSV network in the European area, and Figure 3.3.3.1(b) shows what this network will look like by 1980.

3.3.3.1.1 Technical Control Facility Configuration for AUTOSEVOCOM I - Figure 3.3.3.1.1(a) shows the typical configuration of a technical control facility serving an AUTOSEVOCOM community which is itself served by FDM and/or HF transmission.

In all cases the "narrowband" secure voice traffic accesses the TCF as a normal analog signal by means of modems. Therefore, the TCF handles these circuits just as any other analog circuit.

The local (50 kb/s) wireline loops are provided from the cable patch bay.

However, a unique TCF configuration is required to serve the new WBSV (Wideband Secure Voice) long-haul trunks since they must, in most cases, be properly interfaced with long haul carrier systems. Thus, there is the need for a special WBSV patdh bay, analog/digital conversion equipment, and a special modem to interface with a GROUP level analog path.

For technical controls served by newer TDM facilities, the VF Patch Bay has been eliminated, and the EQUAL LEVEL Patch Bay and Primary Patch Bay are substituted as shown in Figure 3.3.3.1.1(b). The arguments for this reconfiguration are the same as for AUTOVON technical control facilities addressed in paragraph 3.3.1.1. The WBSV patch bay need not be a "physically" separate entity with TDM systems. The function can be integrated into the primary patch bay on the Subscriber side.

Figure 3.3.3.1.1(c) shows a typical layout for those DCS stations which must provide AUTOSEVOCOM I service via mixed media (HYBRID) transmission facilities, including PCM/TDM, FDM, and/or HF. In this configuration, the VF Patch Bay could be eliminated if so desired to equal the TDM configuration of Figure 3.3.3.1.1(b). This figure also shows how a WBSV trunk would be "tandemed" through the facility with a conversion from TDM to and from an FDM carrier system.

3.3.3.1.2 Patch Bay Jack Arrangements for WBSV Circuits - Figure 3.3.3.1.2(a), (b), and (c) show details of the WBSV patch panel and related equipment. They are for WBSV circuits at technical control facilities served by FDM, TDM, and HYBRID media respectively.

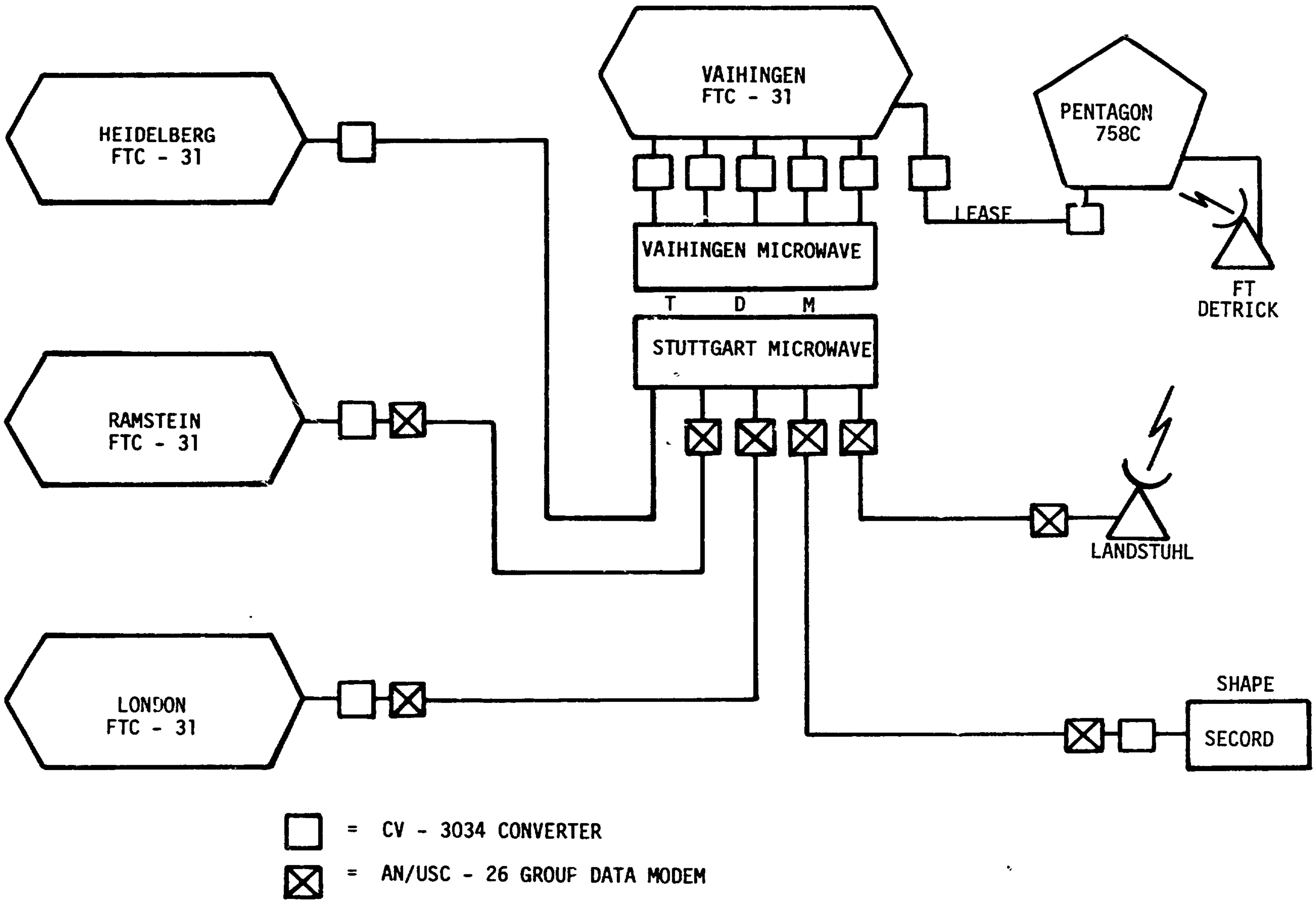


Figure 3.3.3.1(a) 50 Kb/s Trunking in the European Theater (Nov 77)

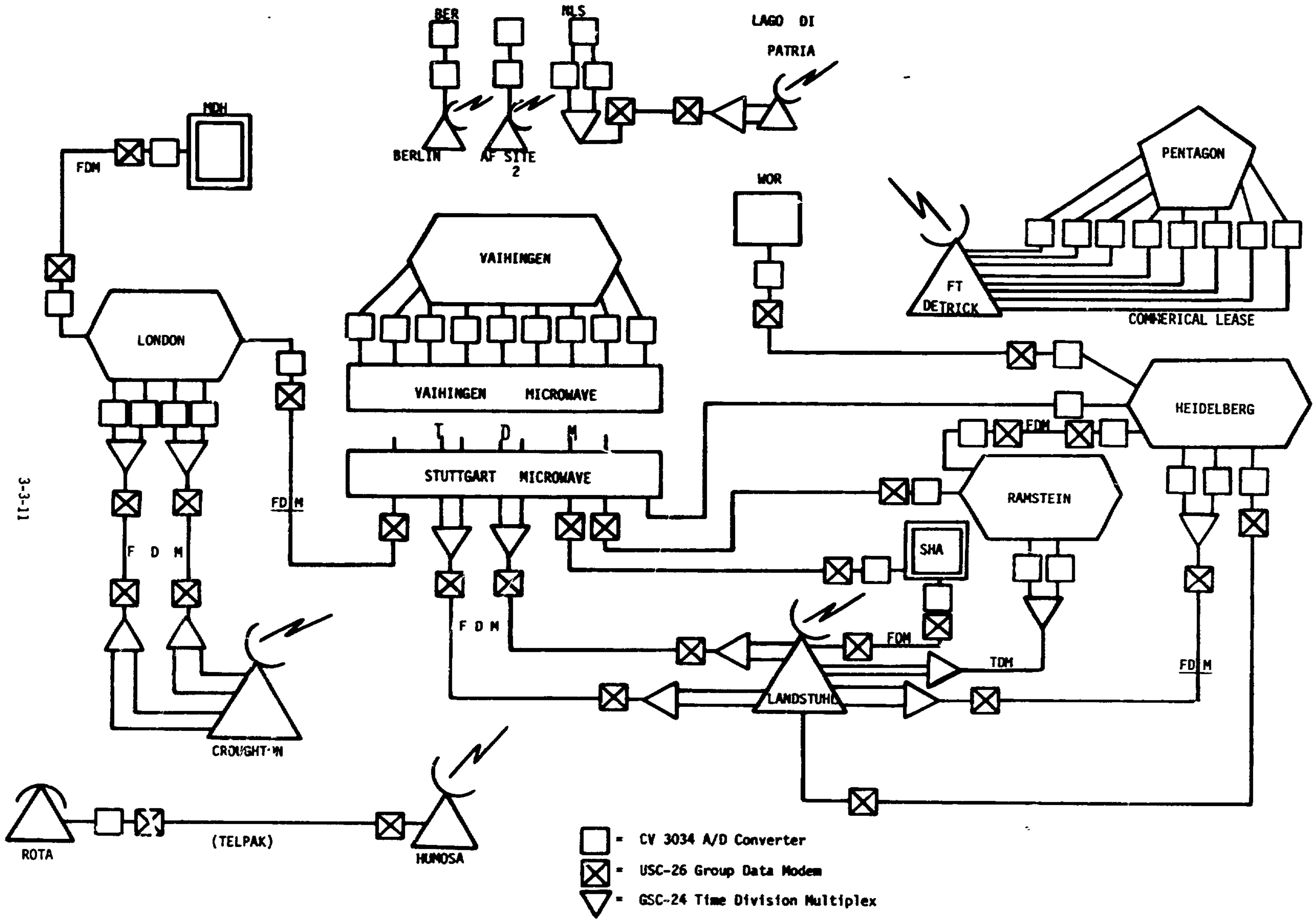


Figure 3.3.3.1(b) 50 Kb/s Truncking in the European Theater- (Before 1980.)

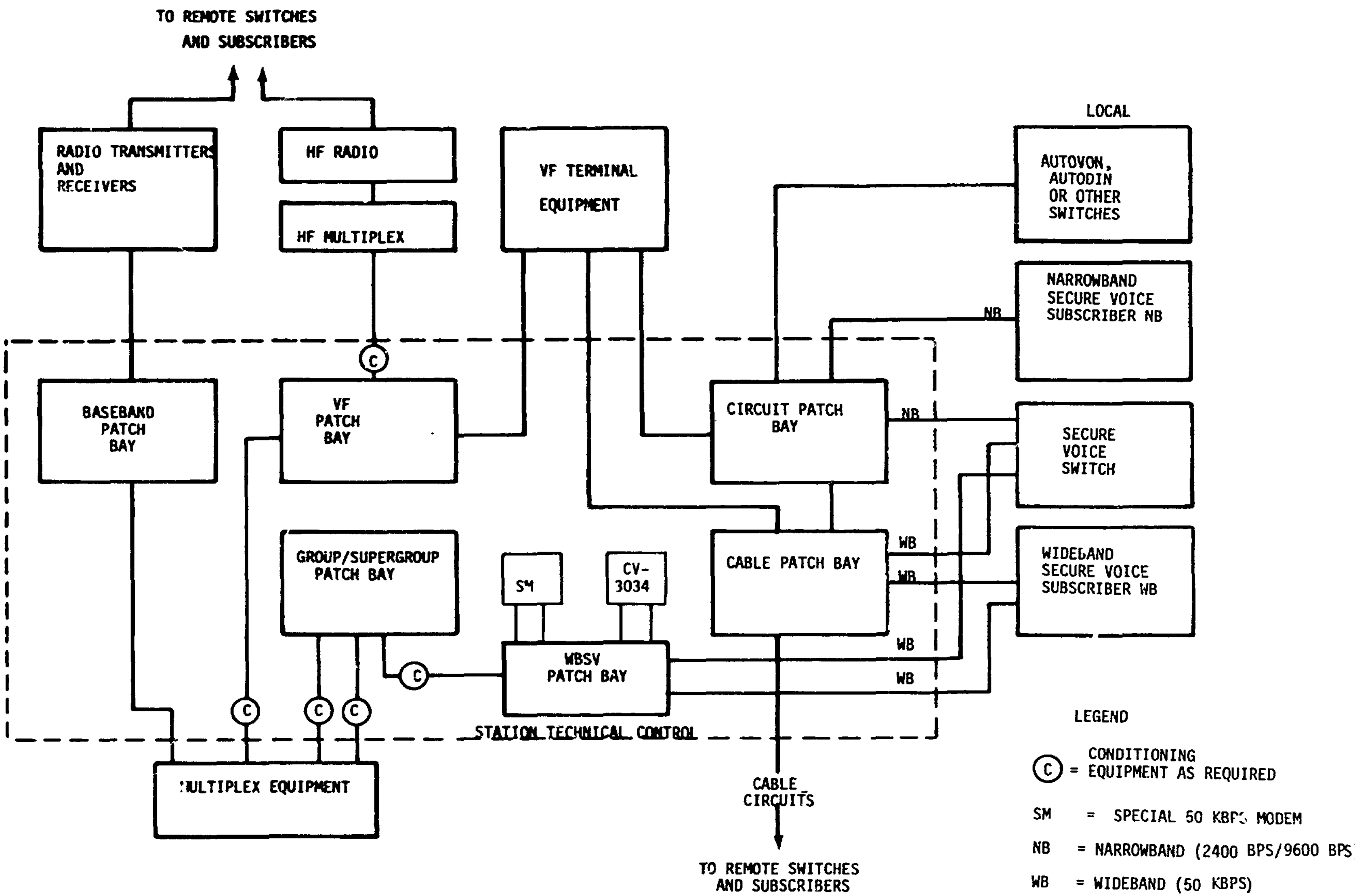


Figure 3.3.3.1.1(a) TYPICAL STATION TECHNICAL CONTROL FACILITY AUTOSEVOCOM I ORIGINAL CONFIGURATION, FDM FACILITIES

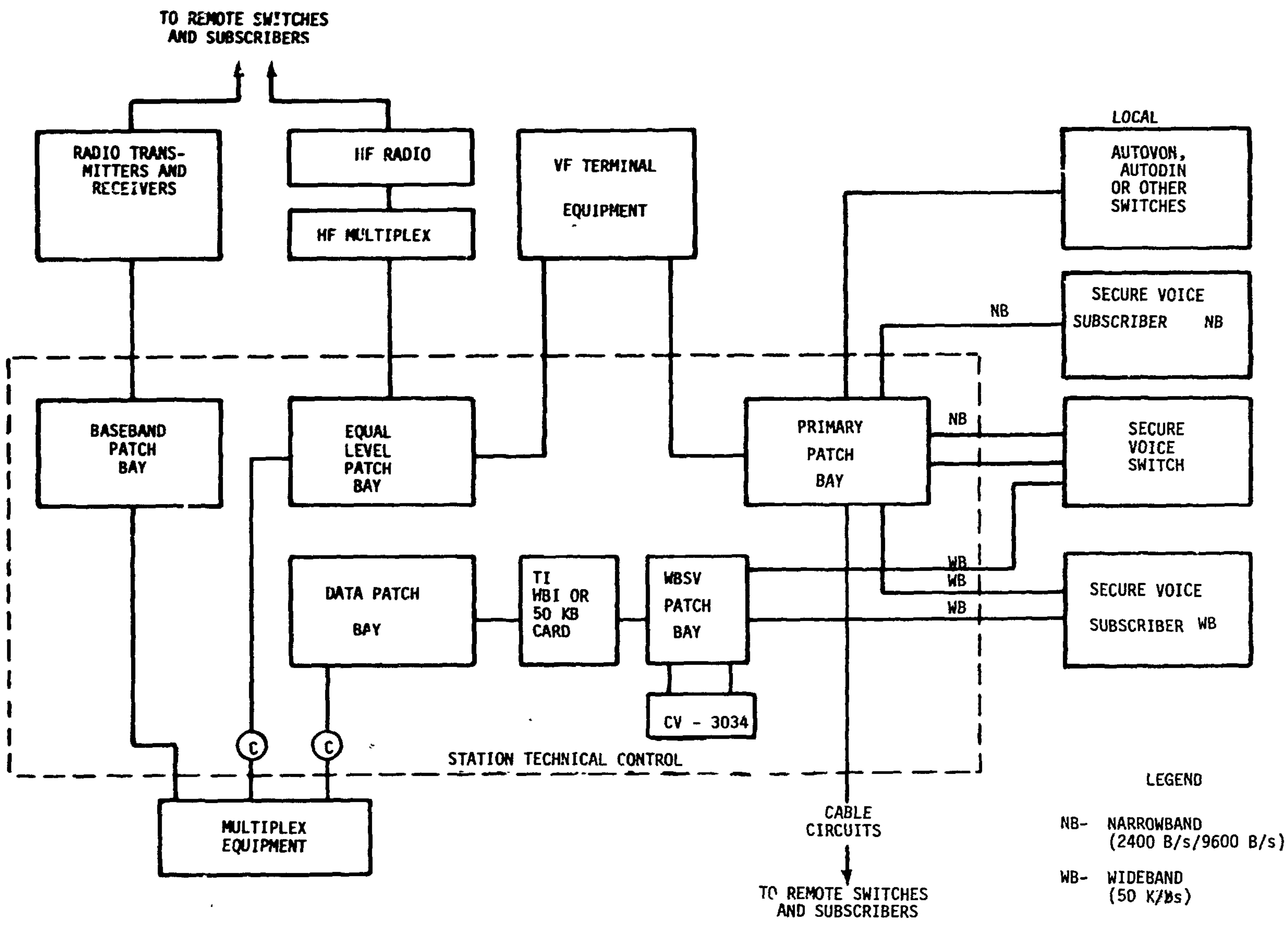
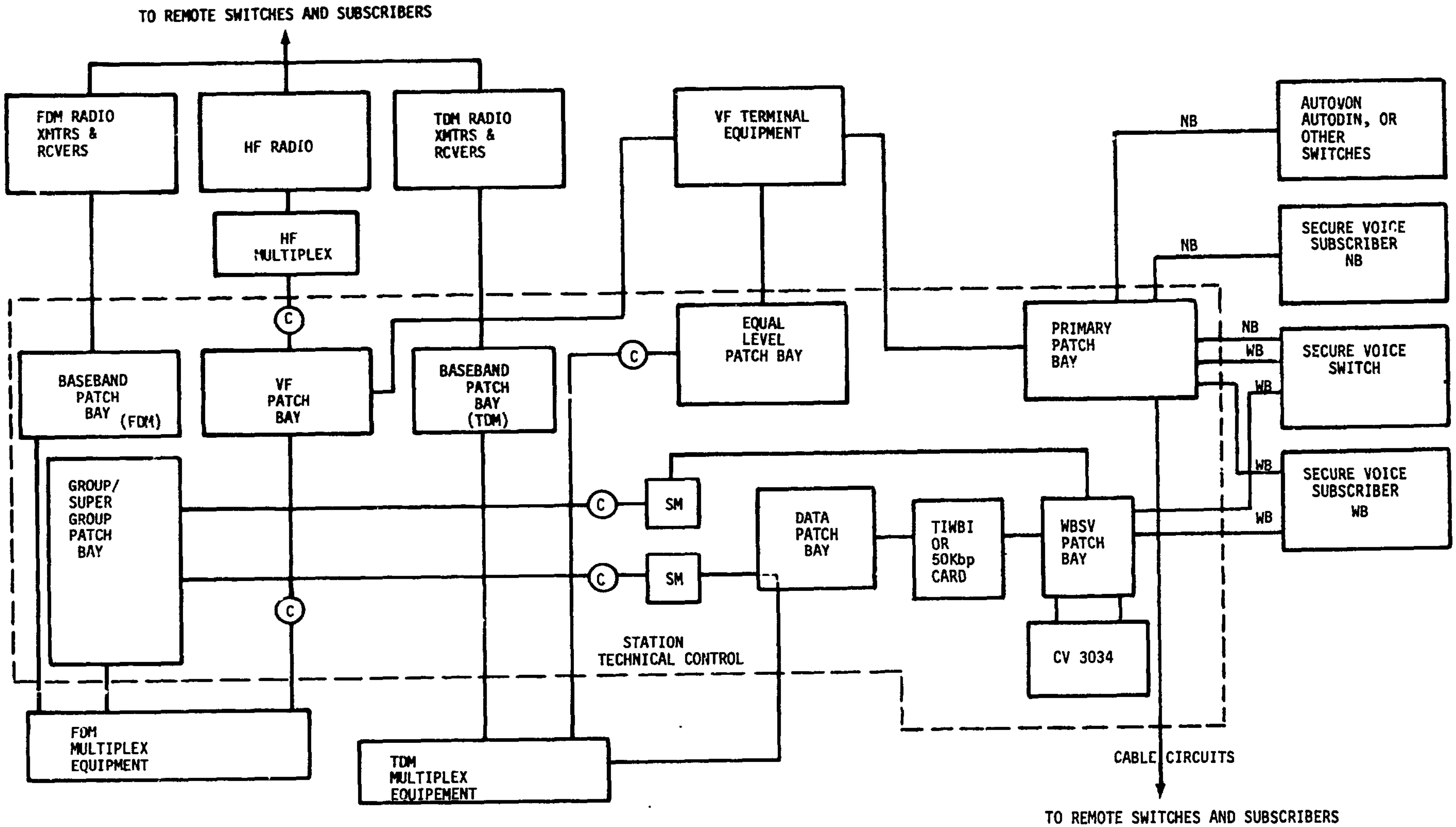


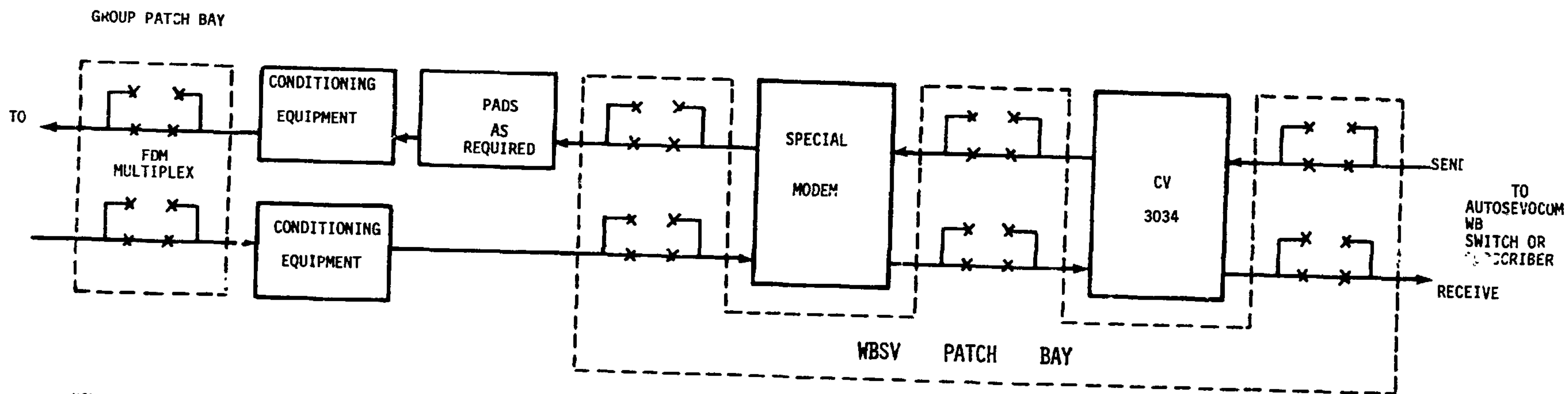
Figure 3.3.3.1.1(b) TYPICAL STATION TECHNICAL CONTROL FACILITY-



C = CONDITIONING EQUIPMENT

SM = SPECIAL MODEM

FIGURE 3.3.3.1.1(c) TYPICAL STATION TECHNICAL CONTROL FACILITY-AUTOSEVOCOM I PRIOR TO 1980, HYBRID STATION (FDM & TDM TRANSMISSION)



NOTE 1: WBSV SHALL NORMALLY BE CONFIGURED TO BYPASS THE TCF PRIMARY PATCH BAY FOR PRE-DRAMA TECHNICAL CONTROL FACILITIES.

FIGURE 3.3.3.1.2.1(a) STATION TECHNICAL CONTROL WIDEBAND SECURE VOICE CHANNEL PATCHING ARRANGEMENTS-AUTOSEVOCOM I (ORIGINAL FDM CONFIGURATION)

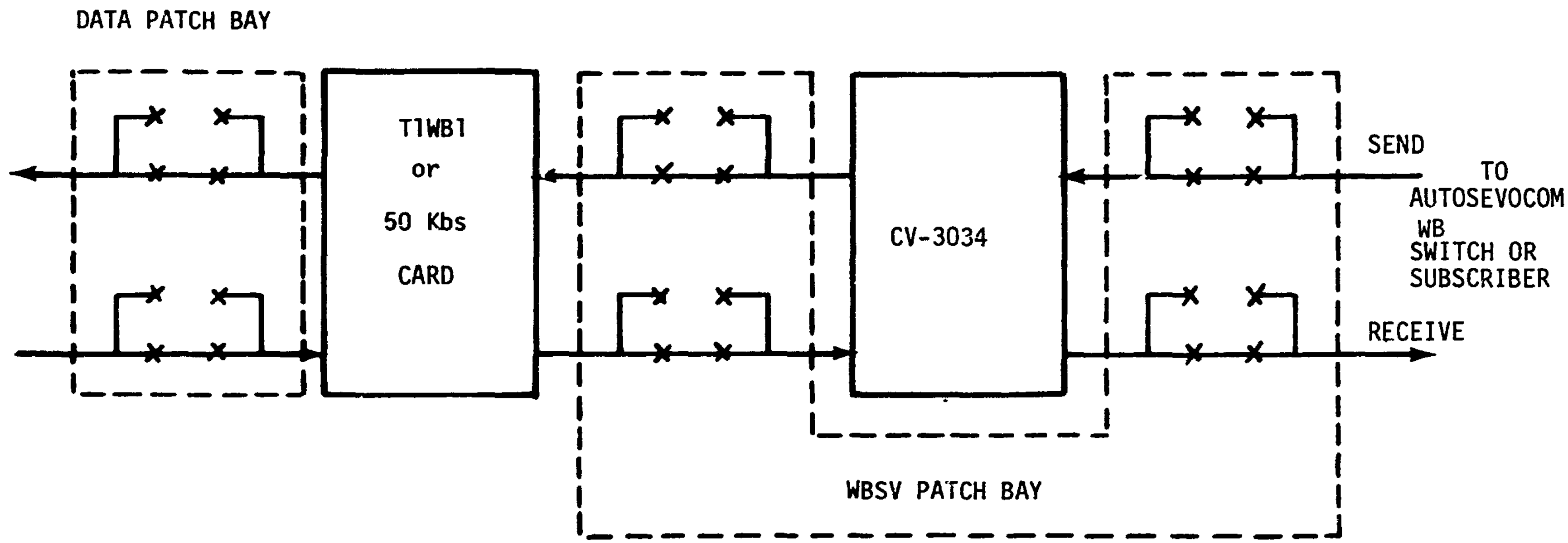
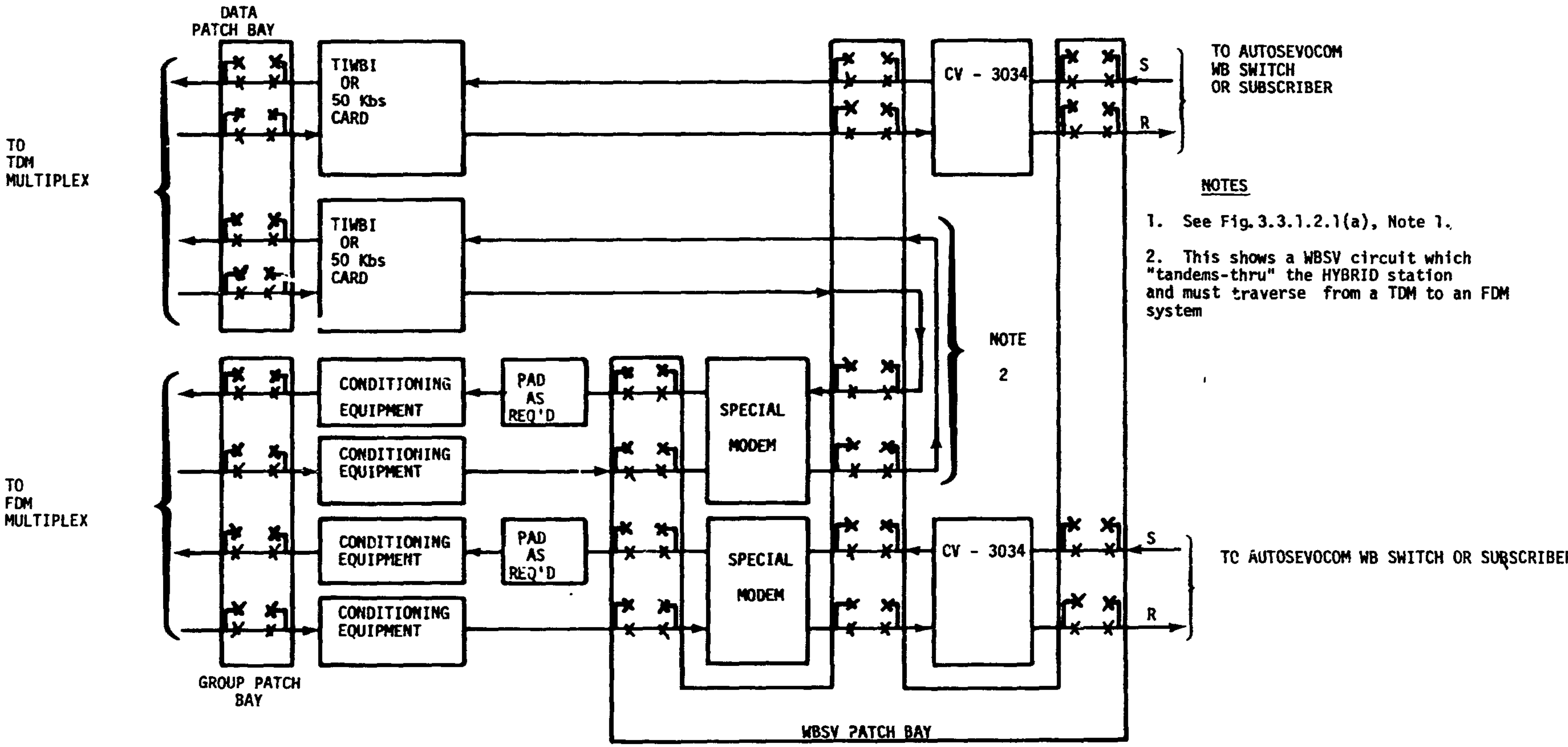


FIGURE 3.3.3.1.2.1(b) STATION TECHNICAL CONTROL - WIDEBAND SECURE VOICE CHANNEL PATCHING ARRANGEMENTS - (TDM CONFIGURATION PRIOR TO 1980).



NOTES

1. See Fig. 3.3.1.2.1(a), Note 1.

2. This shows a WBSV circuit which "tandems-thru" the HYBRID station and must traverse from a TDM to an FDM system

FIGURE 3.3.1.2.1(c) STATION TECHNICAL CONTPOL - WIDEBAND SECURE VOICE CHANNEL PATCHING ARRANGEMENTS (HYBRID STATION)

3.3.4 Special Purpose Networks, Users and Technical Controls

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

3.4. ORDER WIRES

3.4.1 LOS Microwave Order Wires Prior to 1980 - The order wire arrangement discussed in this paragraph is that which has been implemented in the FKV Subsystem and will be implemented in the DEB I and EWCS-SLI project.

3.4.1.1 Between terrestrial LOS stations, two channels are available for voice and data communications. As shown in Figure 3.4.1.1(a), the frequency range can be used for voice communications. This voice channel or Maintenance Coordination Circuit (MCC) is broken out at each LOS radio relay site. At unmanned sites, a bridge is employed such that the MCC is a party line and the MCC at these sites connects to the adjacent manned sites. The sites on both sides of the unmanned sites may communicate with each other directly. These points are illustrated in Figure 3.4.1.1(b).

3.4.1.2 A portion of the upper frequency band from approximately 4400 - 7600 Hz is used to transmit alarm data by means of the Fault Alarm Status Reporting (FASR) system from the SWN and STB sites to the FKV sites on either side of these locations. As illustrated in Figure 3.4.1.2, the FASR employs 60 Hz FSK about the center frequency of 5 or 7 kHz. Hence, the bandwidth from approximately 5300 Hz to 6700 Hz is available for additional telemetry.

3.4.1.3 The actual alarm scanning function is performed by a Pulsecom Datalok-7 Remote Alarm Telemetry Unit. This unit scans the alarms, multiplexes their status into a serial bit stream, and FSK modulates a 5 or 7 kHz carrier as previously discussed. Both the 0-4 kHz channel and 4-8 kHz channel are combined in the radio and then FM modulated on an 8.1 MHz subcarrier before being combined with the partial response signal from the T1-4000.

3.4.1.4 After FM demodulation, the receiver baseband output is simultaneously applied to the overhead channel demodulator and to the receiver T1-4000 input. The output of the FDM overhead channel demodulator is routed to the VOW filter and to the Datalok-7 where FSK demodulation and demultiplexing is accomplished.

3.4.1.5 In addition to the MCC, order wires linking the operating area of the Technical Control Facility must be provided. These order wires will be linked by mission channels. The provision of this order wire as well as the critical communications circuit for the DOCC must be engineered. (Details to be furnished at a later date.)

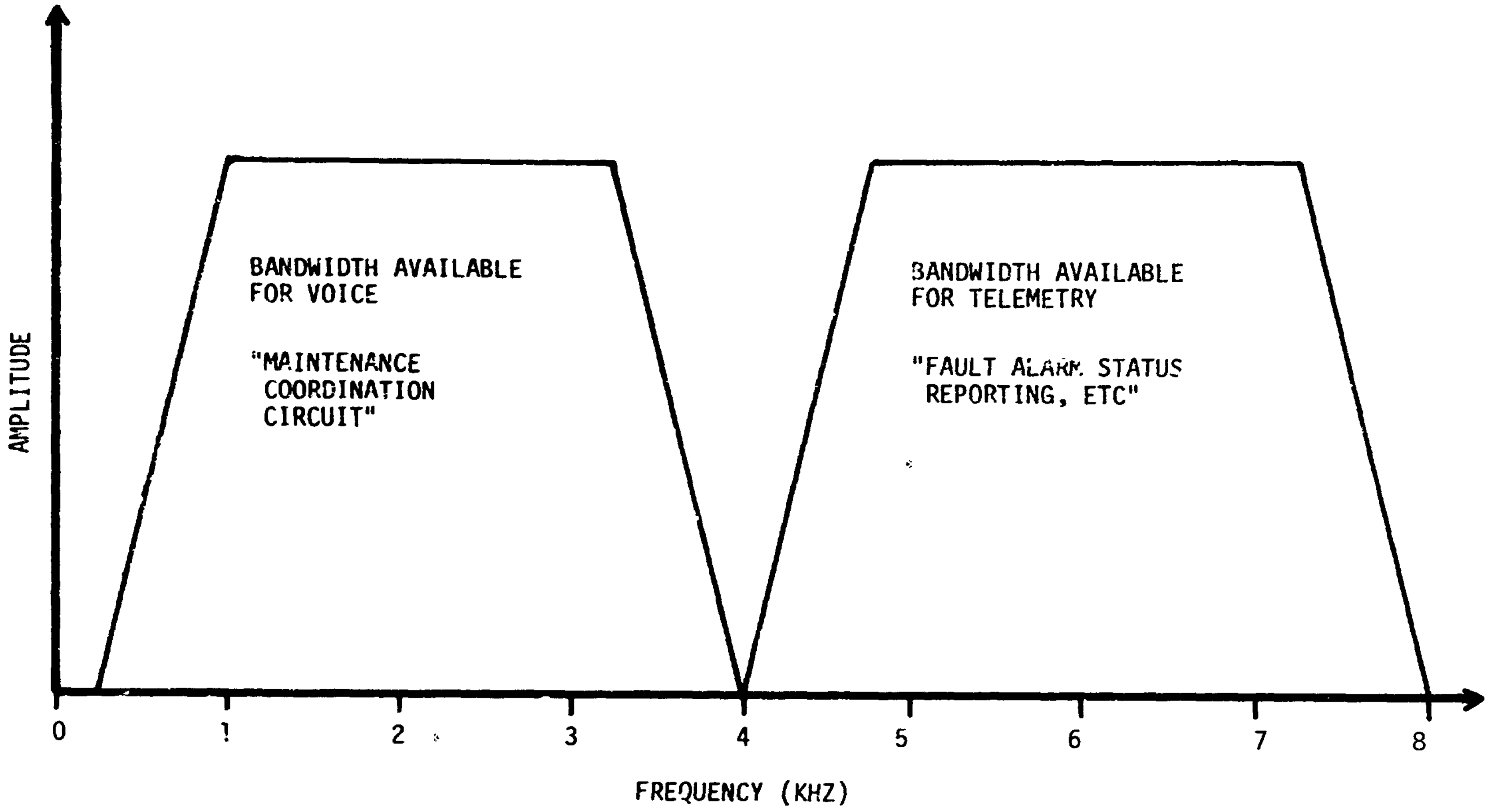
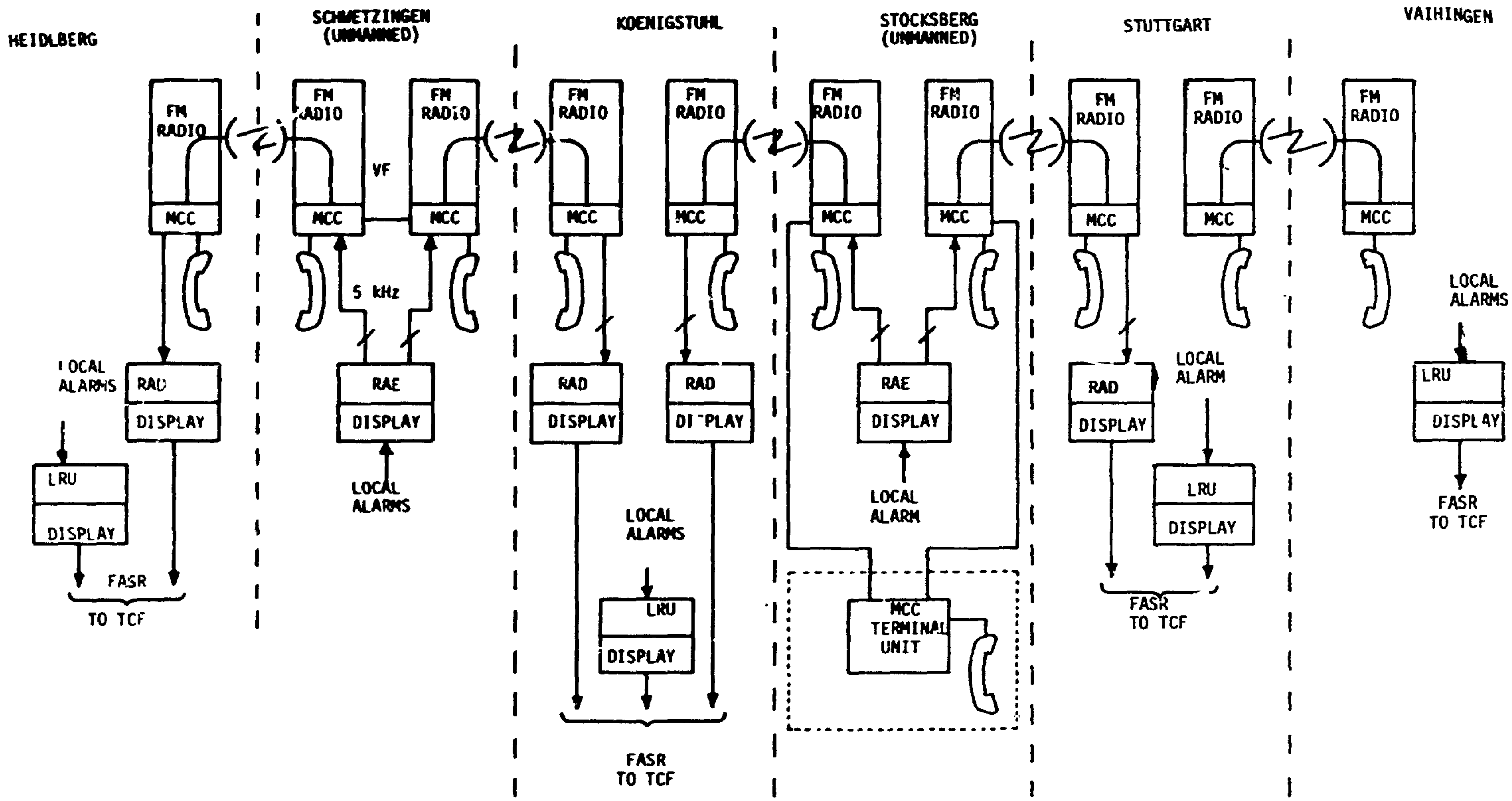


FIGURE 3.4.1.1 (a) VOICE ORDERWIRE/COMMUNICATIONS CIRCUIT - LOS MICROWAVE DCS PRIOR TO 1980



LEGEND
LRU - LOCAL PELAY UNIT
FASR - FAULT ALARM STATUS REPORTING
RAD - REMOTE ALARM DECODER
RAE - REMOTE ALARM ENCODER
MCC - MAINTENANCE COORDINATION CIRCUIT

FIGURE 3.4.1.1(b) Example of Orderwire Configuration
PHASE I FKV
(VOICE CHANNEL AND FAULT ALARM
STATUS REPORTING SYSTEM)

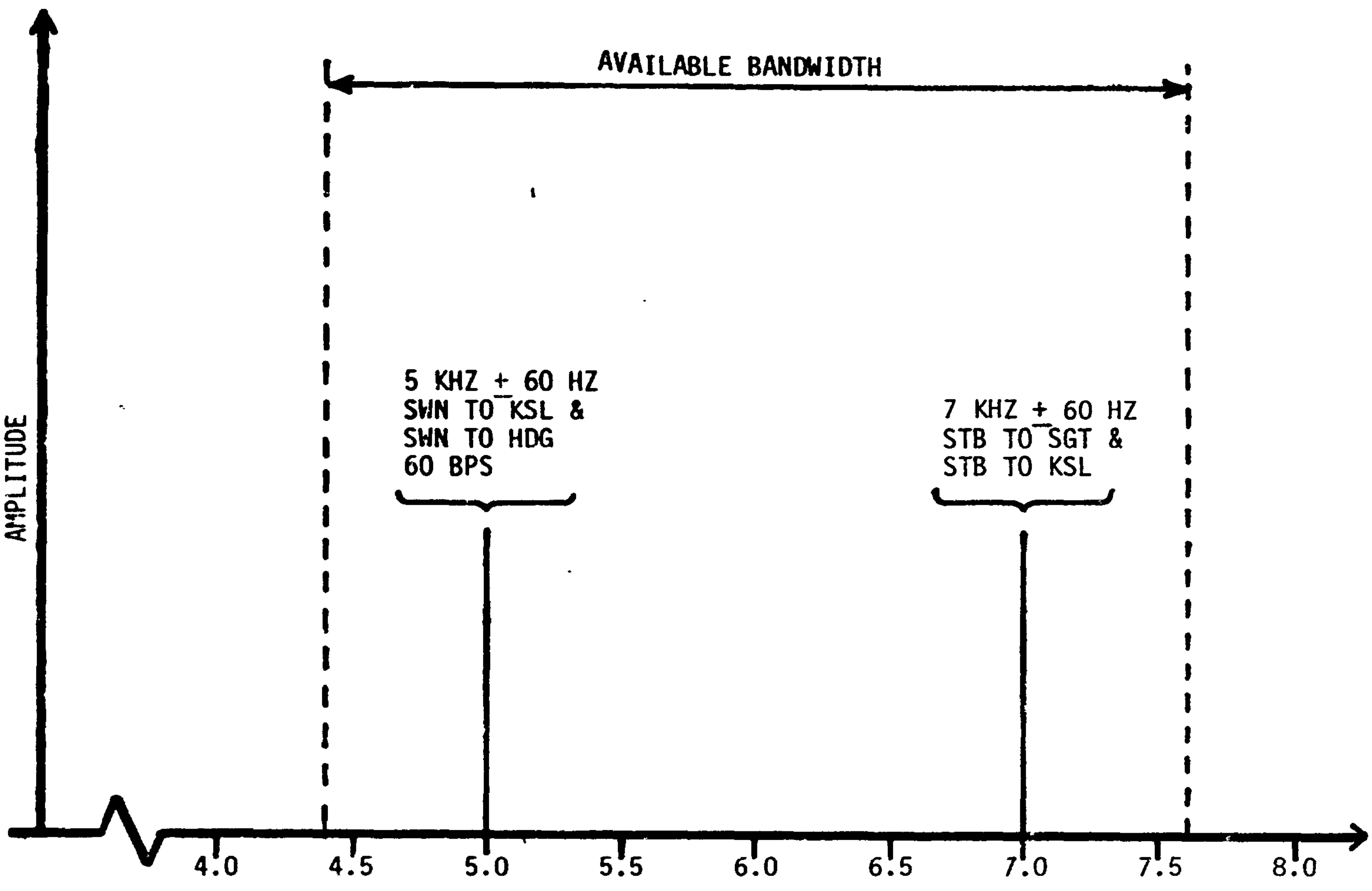


Figure 3.4.1.2 FAULT ALARM STATUS REPORTING (FASR) BANDWIDTH OCCUPANCY

3.4.2 Orderwires - Post 1980

This Section will be furnished later

3.5 ALARMS, LOCAL AND REMOTE

3.5.1 Prior to 1980

3.5.1.1 LOS Microwave (FKV) - The alarm arrangement discussed in this paragraph has been implemented in the FKV Subsystem and will be implemented in the DEB I and EWCS-SLI project. The means of transmission of remote alarms is discussed in paragraph 3.4. The fault alarm reporting system provides local and remote fault and alarm status information for maintenance and technical control personnel. Unattended site alarm and status data are radio relayed to adjacent sites in both directions of traffic flow.

3.5.1.1.1 Figure 3.5.1.1.1 shows the alarms that are monitored in the Alarm Monitor Group at a typical LOS microwave DCS station and those that are remoted via the MCC channel discussed above.

3.5.1.1.2 Figure 3.5.1.1.2 shows the MCC terminal unit highlighting the arrangement with radio equipment and the radio handset for maintenance coordination, for an unmanned location.

3.5.1.1.3 The number of points monitored in the Fault Alarm System Reporting (FASR) arrangement shown on Figure 3.5.1.1.3 is dependent on station configuration. The maximum anticipated usage is no greater than 36 monitoring points at the present. PULSECOM Tx and Rx Display units will be used in installations prior to 1980.

3.5.1.1.4 The alarm configuration at a typical manned relay point with alarms remoted from an unmanned radio site is shown in Figure 3.5.1.1.4. In this particular example, 31 dry contact inputs to the Local Relay Unit represent local fault and status information. A change in status will cause LED and audible indications. The alarm status is presented to the CDF and on to the TCF as dry contact closures.

The two Receiving Display Terminals accept signals remoted from unmanned locations. One, for example, from Station A could demodulate a 5000 Hz signal and present 33 dry contact points to the CDF while the other from Station B demodulates a 7000 Hz signal and connects 33 dry contact to the CDF and the Operations Area of the Technical Control Facility. A dry contact output from each of the CY-104 channel banks is passed to the TCF via the CDF.

3.5.1.1.5 A typical arrangement at an unmanned location is shown in Figure 3.5.1.1.5. Here, the local fault and status information is presented to the Transmit Display. It is then modulated on a 5000 or 7000 Hz carrier. A distribution drawer is provided at the top of the FASR rack to interface outputs and inputs to the rack. A power splitting transformer provides an impedance match from the 600 ohm encoder output to the two

75 ohm radio inputs. The audible alarm for the encoder is also located at this level.

3.5.1.1.6 Figure 3.5.1.1.6 shows in greater detail how alarms are returned to the Alarm Monitor Group and the CDF at a typical manned station.

3.5.1.1.7 Figure 3.5.1.1.7 is an example of the Alarm Display Panel at a particular site (Stuttgart) in the FKV System.

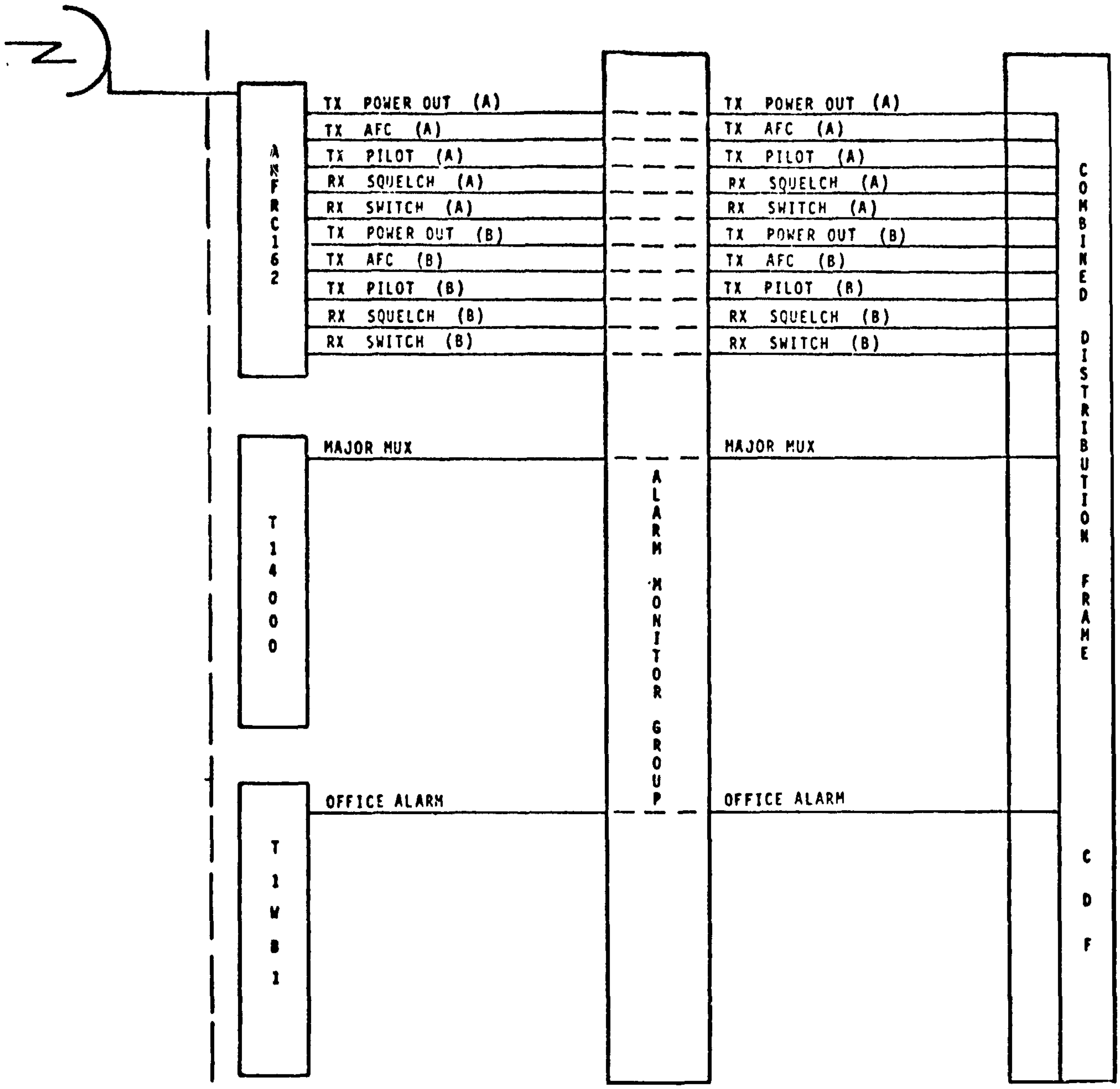


Figure 3.5.1.1.1 Alarms Monitored at a Typical LOS TDM DCS Station (Prior to 1980)

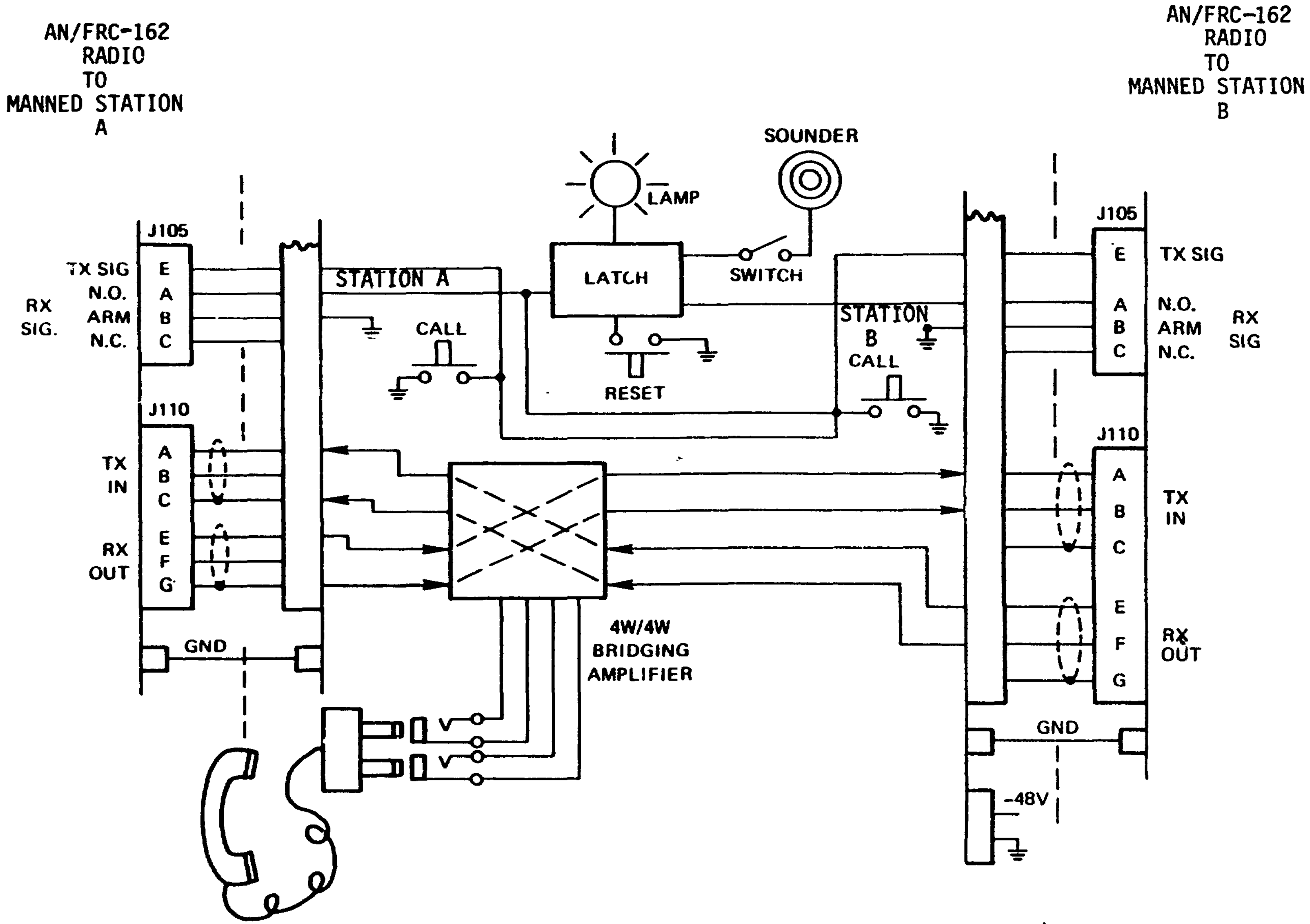


Figure 3.5.1.1.2 MCC Terminal Unit - Unmanned Station

EQUIP	PT	ALARM FUNCTION
AN/FRC-162(V)	1	TX PWR OUT A-E
	2	TX AFC A-E
	3	TX PILOT A-E
	4	RX SQUELCH A-E
	5	RX SW A-E
	6	TX PWR OUT B-E
	7	TX AFC B-E
	8	TX PILOT B-E
	9	RX SQUELCH B-E
	10	RX SW B-E
	11	TX PWR OUT A-W
	12	TX AFC A-W
	13	TX PILOT A-W
	14	RX SQUELCH A-W
	15	RX SW A-W
	16	TX PWR OUT B-W
	17	TX AFC B-W
	18	TX PILOT B-W
	19	RX SQUELCH B-W
AN/FRC-162(V)	20	RX SW B-W
T1-4000	21	MAJOR MUX E RPTR ALM E
T1-4000	22	MINOR MUX E
T1WB1	23	OFFICE ALM E
T1-4000	24	MAJOR MUX W RPTR ALM W
T1-4000	25	MINOR MUX W
T1WB1	26	OFFICE ALM W
FACILITY		BAT CHARGER
	27	ILLEGAL ENTRY
	28	FIRE : GEN
	29	FIRE : BLOG
	30	WATER FLOOD
		BAT CHARGER
	31	FUEL LEVEL
		DC/AC INVERTER
	32	W.G. PRESSURE
	33	W.G. HUMIDITY
	34	TOWER LIGHTS
	35	A.C. POWER
FACILITY	36	BAT. STATUS
		TOTAL POINTS

Figure 3.5.1.1.3 FASR Monitor Point

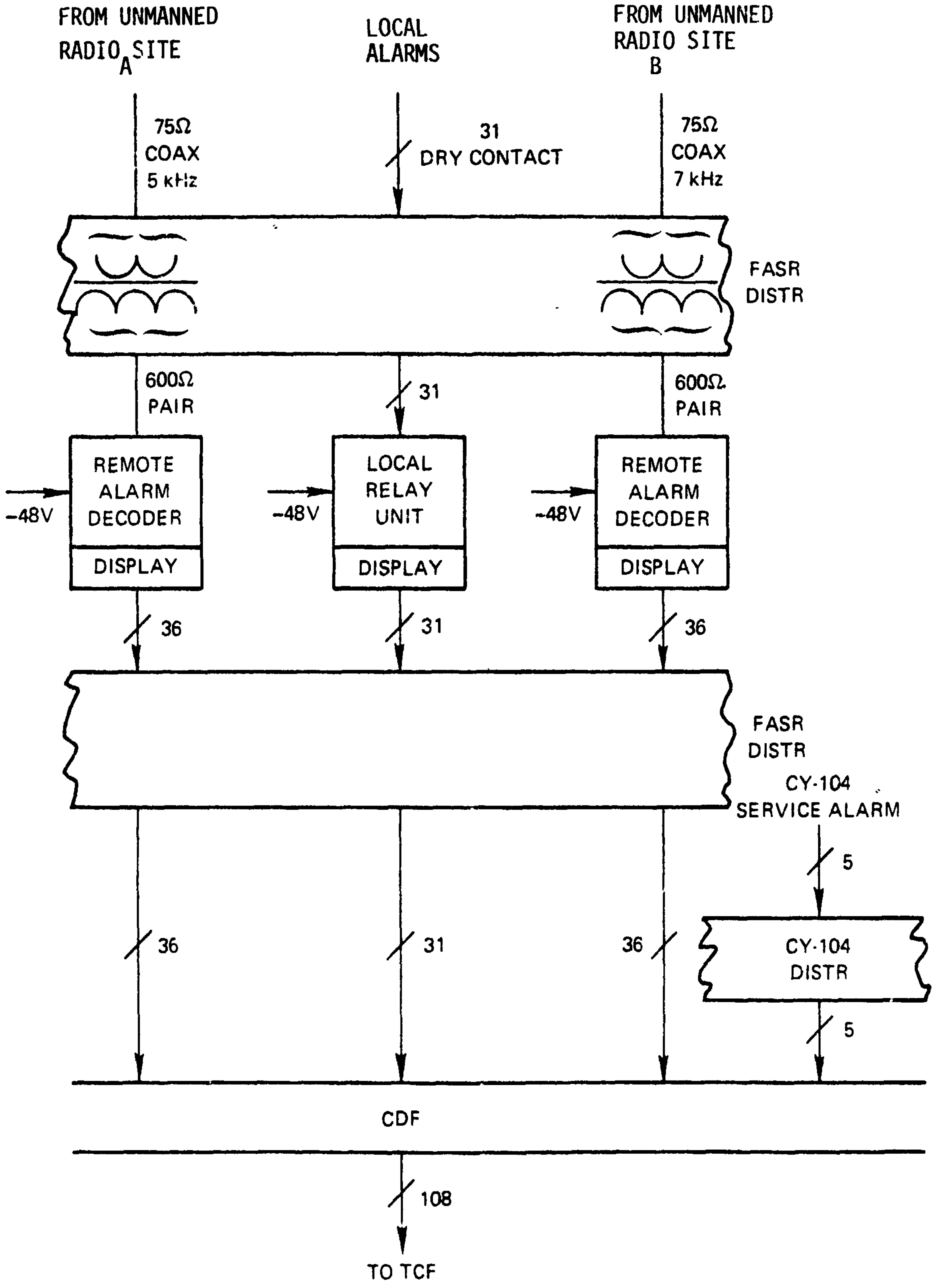


Figure 3.5.1.1.4 Alarm Configuration at a Manned DCS Station Adjacent to Two Unmanned Sites

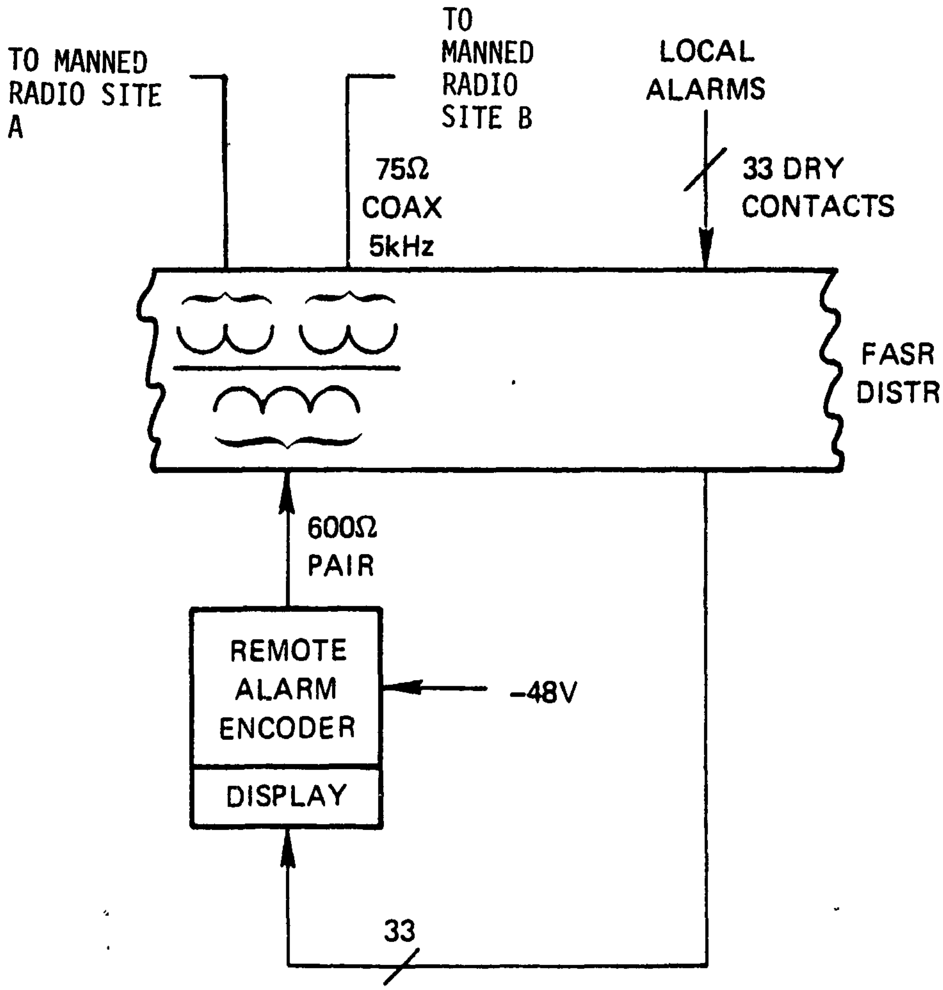


Figure 3.5.1.1.5 Alarm Configuration at an Unmanned DCS Station Adjacent to two Manned Sites.

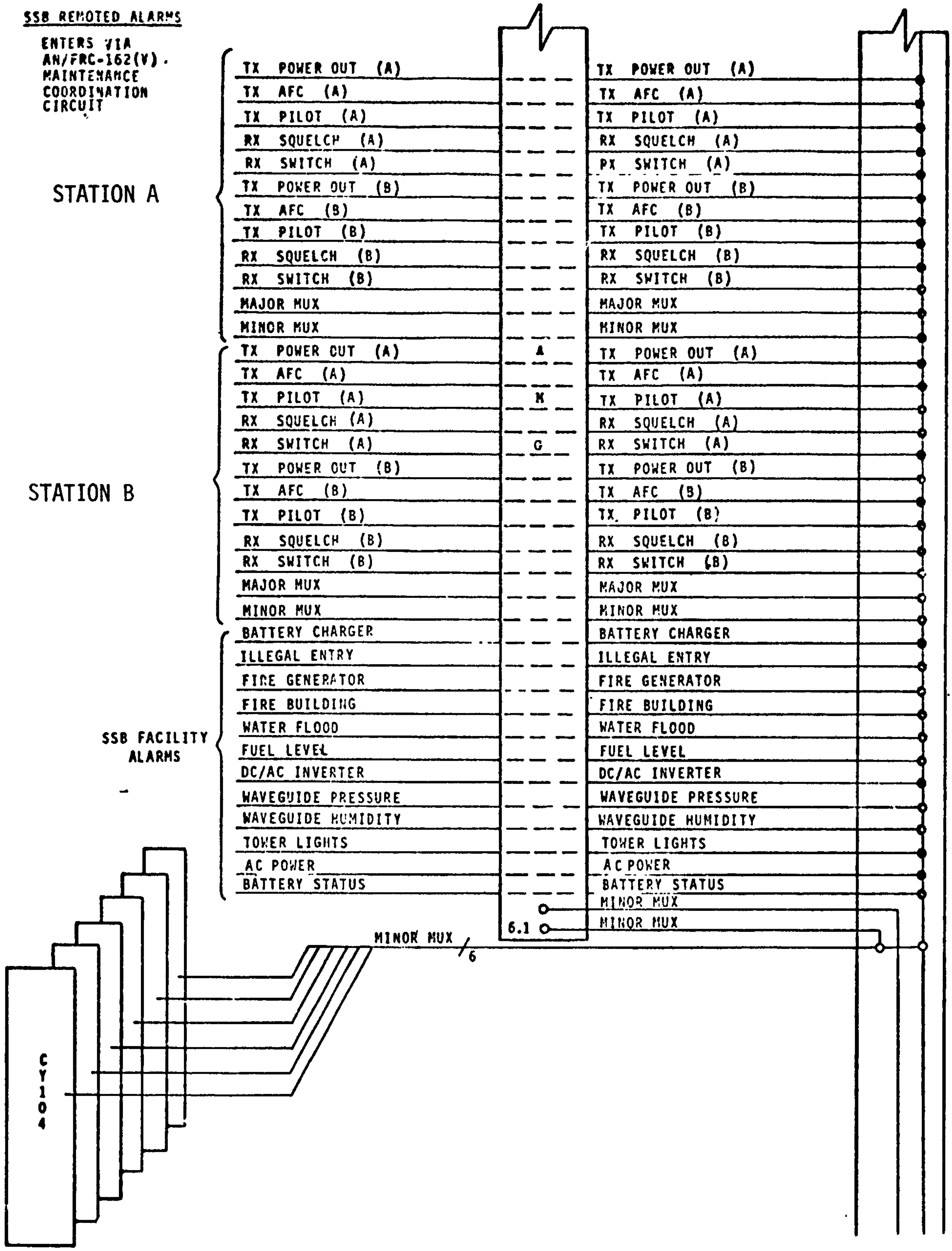
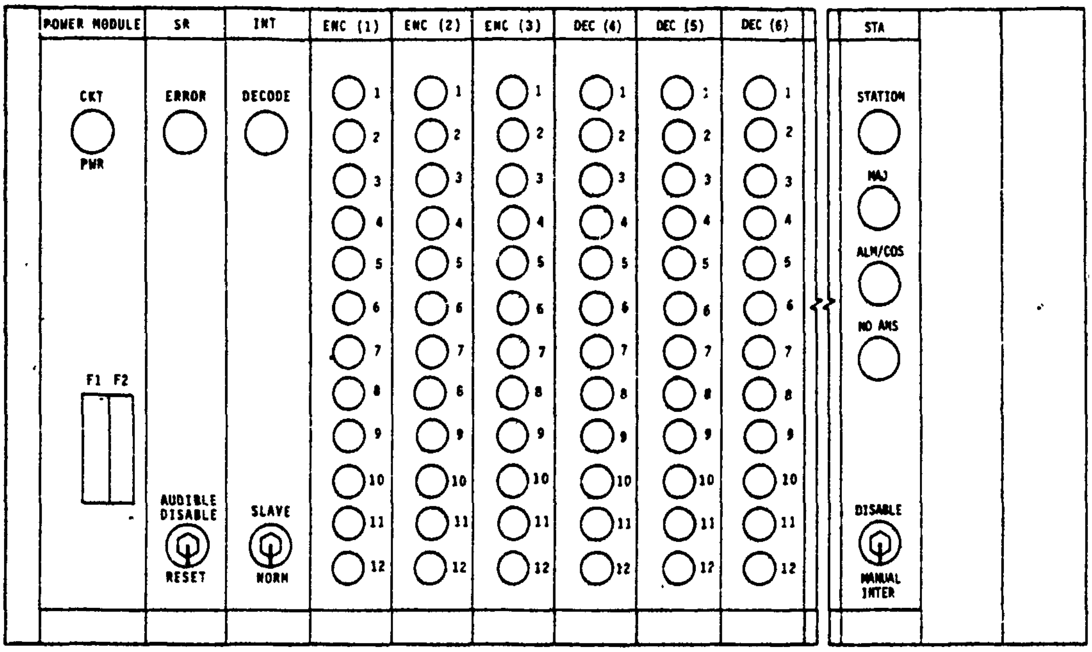


Figure 3.5.1.1.6 Alarm Wiring to Alarm Monitor Group and CDF

ALARM DISPLAY PANEL



ENCODER ALARM DISPLAY PANEL (1)

LIGHT	FAULT	TRANSCEIVER	RADIO
1	XMT POWER	A	SGT to VHN
2	XMT AFC	A	SGT to VHN
3	XMT PILOT	A	SGT to VHN
4	RCV SQUELCH	A	SGT to VHN
5	RCV SWITCH	A	SGT to VHN
6	XMT POWER	B	SGT to VHN
7	XMT AFC	B	SGT to VHN
8	XMT PILOT	B	SGT to VHN
9	RCV SQUELCH	B	SGT to VHN
10	RCV SWITCH	B	SGT to VHN
11	XMT POWER	A	SGT to SSB
12	XNT AFC	A	SGT to SSB

DECODER ALARM DISPLAY PANEL (4)

LIGHT	FAULT	TRANSCEIVER	RADIO
1	XMT POWER	A	SSB to SGT
2	XMT AFC	A	SSB to SGT
3	XMT PILOT	A	SSB to SGT
4	RCV SQUELCH	A	SSB to SGT
5	RCV SWITCH	A	SSB to SGT
6	XMT POWER	B	SSB to SGT
7	XMT AFC	B	SSB to SGT
8	XMT PILOT	B	SSB to SGT
9	RCV SQUELCH	B	SSB to SGT
10	RCV SWITCH	B	SSB to SGT
11	XMT POWER	A	SSB to KSL
12	XMT AFC	A	SSB to KSL

ENCODER ALARM DISPLAY PANEL (2)

LIGHT	FAULT	TRANSCEIVER	RADIO/SYSTEM
1	XMT PILOT	A	SGT to SSB
2	RCV SQUELCH	A	SGT to SSB
3	RCV SWITCH	A	SGT to SSB
4	XMT POWER	B	SGT to SSB
5	XMT AFC	B	SGT to SSB
6	XMT PILOT	B	SGT to SSB
7	RCV SQUELCH	B	SGT to SSB
8	RCV SWITCH	B	SGT to SSB
9	MAJOR MUX		SGT to VHN
10	MINOR MUX		SGT to VHN
11	T1WB1		SGT to VHN
12	MAJOR MUX		SGT to SSB

DECODER ALARM DISPLAY PANEL (5)

LIGHT	FAULT	TRANSCEIVER	RADIO/SYSTEM
1	XMT PILOT	A	SSB to KSL
2	RCV SQUELCH	A	SSB to KSL
3	RCV SWITCH	A	SSB to KSL
4	XMT POWER	B	SSB to KSL
5	XMT AFC	B	SSB to KSL
6	XMT PILOT	B	SSB to KSL
7	RCV SQUELCH	B	SSB to KSL
8	RCV SWITCH	B	SSB to KSL
9	MAJOR MUX		SSB to SGT
10	MINOR MUX		SSB to SGT
11	BLANK		
12	MAJOR MUX		SSB to KSL

ENCODER ALARM DISPLAY PANEL (3)

LIGHT	FAULT	SYSTEM
1	MINOR MUX	SGT to SSB
2	T1WB1	SGT to SSB
3	USC-26	NOT FKV
4	USC-26	NOT FKV
5	USC-26	NOT FKV
6	BLANK	
7	DC/AC INVERTER	NOT FKV
8	BLANK	
9	BLANK	
10	BLANK	
11	BLANK	
12	BLANK	

DECODER ALARM DISPLAY PANEL (6)

LIGHT	FAULT	LOCATION
1	MINOR MUX	SSB to KSL
2	BATTERY CHARGER	SSB
3	ILLEGAL ENTRY	SSB
4	FIRE GENERATOR	SSB
5	FIRE BUILDING	SSB
6	WATER FLOOD	SSB
7	FUEL LEVEL	SSB
8	WAVEGUIDE PRESSURE	SSB
9	WAVEGUIDE HUMIDITY	SSB
10	TOWER LIGHTS	SSB
11	AC POWER	SSB
12	BATTERY STATUS	SSB

Figure 3.5.1.1.7 Examples of Arrangement on the Alarm Display Unit

3.5.1.2 LOS Microwave (DEB) - The monitoring system used in DEB I is similar to the FKV (e.g., equipment manufacturer, modulation techniques). but with several significant differences. These differences will be explained below. The DEB I system monitors relay contact closures controlled by preset threshold detectors available on the radio, multiplex and site equipment. From three to nine analog-to-digital converters (A/D) are included in the FAS to provide the capability to monitor voltages. In the event automatic switching from the disabled primary equipment to backup does not occur, the FAS operator can cause a switch over using the control capability. This allows standby equipment to be manually switched in until maintenance is performed on the deteriorating or failed equipment.

3.5.1.2.1 DEB I FAS Layout - The DEB I monitoring system consists of Master station equipment (for display and control of remote site functions) and Remote station equipment (for gathering site data and providing equipment control functions). Master station equipment will be installed in the Fault Alarm Bay of the large TCFs at Hohenstadt, Coltano, and Aviano. Aviano will be the primary master station and have primary remote control responsibility. Hohenstadt or Coltano, as backup masters, can assume control responsibility should the primary master fail. Remote FAS equipment will be installed in the Radio Miscellaneous Bay at all sites in DEB I, i.e., Zugspitze, Cima Gallina, Paganella, Mt Corna, Mt Cimone, Mt Serra, Mt Venda, Ceggia, Hohenstadt, Coltano, Aviano and Vaihingen. The Remote FAS equipment can also be used as the station common alarm panel for the DEB equipment.

3.5.1.2.2 FAS Operation - The FAS is a polling type reporting system. All master stations have the same transmit frequency with only one master conducting the polling operation at one time, and the remote stations share a single frequency. Each remote station transmits its status upon detection of its individual three-character ID from the polling master station. This status can be decoded by any of the master stations. When an alarm occurs at a site, the remote station latches the alarm, sets a reserved bit in its station code, and encodes the status, including previously existing alarms, for transmission. As the site code is detected by the master station, the bit in the station code is detected, the change of state (CCS) light begins flashing, and the audible alarm sounds. The audible alarm is manually reset and the alarm is answered at each master site by depressing the manual interrogation display switch. When the manual interrogate switch is released, the master station will return to sequential decoding of the status from each remote site. Should a failure occur such that the automatic switchover fails to restore operation, the FAS provides remote control capabilities. Upon detection of this type of problem, personnel at the primary master station can select the appropriate relay control and attempt a switch. For a loss of control capability by the Primary Master (either FAS or link failure), a backup master can be directed to become the primary. This involves only changing the position of the master-slave switch on both masters. Coordination is required to prevent both master stations from transmitting simultaneously on their shared frequency.

3.5.1.2.3 Master Station Equipment - The master station is capable of displaying 108 alarm points, and 36 status points, and of controlling 35 remote functions. The data from the A/D converters cannot be displayed by the master station, but will require a follow-on display device. An 11 bit code similar to ASCII is used for communications between the master and time requirement of between 3 and 5 seconds per remote site to transmit site alarms, status, and data. The master station alarm display includes identification of the remote station being displayed, an indication of major alarms, the status condition of the latching relays, and selected equipemtn status indicators..

3.5.1.2.4 Remote Station Equipment - Remote stations transmit the conditions of up to 108 alarm points, 36 status points, up to nine analog votages, and perform the 35 control functions in reponse to the instructions received from the master station. A remote unit displays the alarm point condition and provides an audible alarm. The audible alarm can be disabled by a switch. An alarm is defined as a condition which requires a response by the operator and will cause the audible alarm to sound at both the TCF and the site. A status indication is a condition which does not require operator action and does not cause an audible alarm but is useful information. In addition, when pulse counting cards become available from the FAS manufacturer, another 5-1/4 inch shelf will be added to each remote FAS unit in the Radio Miscellaneous Bay.

EQUIPMENT DESCRIPTIONS

4.1 GENERAL - This chapter is a collection of equipment descriptions which should provide useful information for planners and designers of DCS Technical Control Facilities with time division multiplexers. It should be noted that these equipment descriptions are provided for convenience and information only. They are reasonably accurate as of the date of this publication. However, for specific applications engineering, the reader should consult the technical documents listed for each equipment.

4.1.1 Content of Equipment Descriptions - Each of the descriptions cover the following aspects of the equipment:

1. Military nomenclature
2. Commercial nomenclature and other names
3. Functional description
   a. Diagram
   b. Discussion of input and output characteristics
4. Intended application
   a. Approved project or program in which it will be used
   b. Theater of application (CONUS, Pacific or European Theater)
5. Interface characteristics
   a. Electrical
   b. Procedural (if required)
6. Date of availability
7. Documentation available for detailed description
8. Discussion of unique characteristics and other items of interest.

4.1.2 Organization of Equipment Descriptions

The description of the equipments is organized as follows. The descriptions are given in the paragraphs shown in parenthesis.

- Time Division Multiplexers (4.2)
- Modems and Coders (4.3)
- Encryption Devices (4.4)
- Radio Equipment (4.5)
- Satellite Terminals (4.6)
- Equipments Associated with AUTOVON (4.7)
- Equipments Associated with AUTODIN (4.8)
- Equipments Associated with AUTOSEVOCOM (4.9)

4.2 TIME DIVISION MULTIPLEXERS

4.2.1 TSEC/CY-104

1. Military Nomenclature: Multichannel Ciphony System TSEC/CY-104.

2. Commercial Nomenclature and Other Names: The TSEC/CY-104 is an equipment assemblage consisting of an HY-12 or HY-12A Channel Bank, an HN-74 Interface Unit, and KG-34 Key Generator. The HY-12 Channel Bank is a VICOM D2 Terminal.

3. Functional Description:

3.1 The TSEC/CY-104 provides for the multiplexing of up to 24 VF 4-wire trunks and associated signaling into an encrypted 1.544 Mb/s binary bit stream. This function is performed by three separate components which mount in shielded cabinets interconnected with conduit. The system block diagram is shown Figure 4-2-1(a).

3.2 The 24 VF trunks are wired to the HY-12 PCM multiplexer (a VICOM D2 Channel Bank housed in a shielded cabinet) which samples each voice channel sequentially at the rate of 8,000 samples per second per channel. The result of this sampling is a TDM data stream composed of 192,000 pulse amplitude modulated (PAM) pulses per second. Each pulse is compared against reference voltages and encoded into an eight bit code word representing a fixed amplitude, one of 128 possible amplitudes above or below zero which corresponds most closely to the amplitude of the PAM sample. The eight-bit words representing samples from all 24 channels are sequentially combined to form a 192 bit frame. A framing bit is added, producing a total of 193 bits per frame, 8,000 frames per second, or 1.544 Mb/s. The 1.544 Mb/s digital stream is in NRZ format, which is fed to the KG-34. The VIDCOM D2 transmitter block diagram is shown in Figure 4-2-1(b).

3.3 Channel signaling information is encoded by preempting the least significant bit of the code word for each channel during every sixth frame. Each VF channel has an E and M signaling capability, built into the channel bank.

3.4 The PAM to PCM encoder/decoder is nonlinear, offering smaller quantizing steps for low level signals and larger steps for higher amplitude signals. This technique minimizes quantizing distortion.

3.5 The KG-34 encrypts the digital stream and passes it to the HN-74 which contains the clock for system timing and provides either a balanced bipolar output or an NRZ output. The HN-74 provides both transmit and receive clocks to the HY-12 and KG-34, provides alarm interfaces, provides power for the HY-12, and controls reframing and resynchronizing functions.

3.6 The receive path is essentially the reverse of the transmit. The HN-74 receives the encrypted bit stream and prepares it for the KG-34 which decrypts the stream and returns it to the HY-12. The HY-12 demultiplexes, decodes, and reconstructs the individual 24 VF channels. The VIDCOM D2 receiver block diagram is shown in figure 4-2-1(c).

3.7 System status is indicated by the service alarm which is activated by local alarm, loop alarm, or remote alarm. Local alarm is initiated by a fuse alarm or by loss of frame synchronization for more than 800 milliseconds. Loop alarm is initiated whenever the terminal is looped back for test/maintenance. The alarm condition is transmitted to the far-end terminal by forcing the second bit of each word to logic zero, for a minimum of 20 seconds. A remote alarm is indicated when the condition has been received for 1.5 seconds.

3.8 In addition to the HY-12, there is an HY-12A channel bank which has the capability of replacing up to five of the 24 VF channels with up to five full duplex digital data circuits. The data rates available are 0-20 Kb/s and 50 Kb/s asynchronous, or 16/32/48/56/64/128 Kb/s synchronous.

4. Intended Application:

4.1 The CY-104 is used at present in the Frankfurt-Koenigstuhl-Vaihingen (FKV) system in the European Theater. It is projected for use in the European Wideband Communications System - Selected Link Improvement Program (EWCS-SLIP). It is also planned for use in connection with the DCS wideband satellite leases between Hawaii and California, DEB I, Korea, Japan link etc.

5. Interface and Performance Characteristics:

5.1 Between HY-12 and Telephone Trunks:

PORT	IMPEDANCE	LEVEL NOM	
XMT T&R	600 ohm Bal	0 dBm	
RCV T&R	600 ohm Bal	0 dBm	
E Lead			On Hook: Open Off Hook: Ground
M Lead			On Hook: Open Off Hook: -48 Vdc

5.2 Between HN-74 and higher level multiplex or T1 transmission path:

PORT	IMPEDANCE		LEVEL
	LOAD	SOURCE	
Bipolar Out			
(w/Office Repeater)	130 ohm	130 ohm	2.9 V P-P
(wo/Office Repeater)*	100 ohm	56 ohm	6 V P-P
Bipolar In			
(w/Office Repeater)	130 ohm	130 ohm	0.9 to 10.0 V P-P**
(wo/Office Repeater)*	100 ohm	100 ohm	2.8 V P-P Min 6 V P-P Nom
NRZ Out	75 ohm	34 ohm (Max P-P)	0-6 V P-P (adjustable)
NRZ In	75 ohm	75 ohm	0.2 V P-P Min 0.25 V to 6 V P-P Nom

*Maximum distance between terminals if 750 feet
**Determined by choice of LBO

5.3 Input Timing to HN-74 if External Clock is Used:

PORT	IMPEDANCE	LOGIC	MIN	LEVEL NOM	MAX
Ext Clk	75 ohm ±10%	0	-3.6 V	0 V	+0.4 V
	75 ohm ± 10%	1	+0.8 V	+3 V	+3.6 V

Waveform: Squarewave
Rate: 1.544 Mb/s
Maximum Rise Time: 100 nanoseconds

5.4 Power Requirements:

HY-12	(supplied by HN-74): (Reg +12, -12, +4 Vdc; Unreg -48 Vdc)	82 Watts
HN-74:	115 Vac ±10%, 50-60 Hz	48 Watts
KG-34:	115 Vac ±10%, 50-60 Hz	48 Watts

5.5 Space Requirements: 36" vertical on 19" rack.

6. Date of Availability: Available now.

7. Documentation for Detailed Description:

TM 11-5820-842-14
TM 11-5820-842-14P
NAG-12/TSEC Security Implementations Manual
TSEC/CY-104 Multichannel System
NAM-12/TSEC Maintenance Manual, TSEC/CY-104 System
NAM-13/TSEC Maintenance Manual, TSEC/HY-12
NAM-10/TSEC Maintenance Manual, TSEC/HN-74 (V-1)/HN-74(V-2)/HN-74
KAM-237/TSEC Maintenance Manual, TSEC/KG-30/30A/33A/34/34A
Volume I - Description, Installation, and Principles of Operation
KAM-238/TSEC Maintenance Manual TSEC/KG-30/30A/33/33A/34/34A
Volume II - Maintenance Procedures and Diagrams
KAM-239/TSEC Maintenance Manual, TSEC/KG-30/30A/33/33A/34/34A
Volume III - Illustrated Parts List
MIL-HDBK-232 Red-Black Engineering-Installation Guidelines

8. Additional Information:

8.1 The major assemblies of the TSEC/CY-104 Multichannel Ciphony Systems with their individual security classifications, short and long titles are shown below:

SHORT TITLE	LONG TITLE	CLASSIFICATION
TSEC/CY-104	Multichannel Ciphony System	NA
TSEC/HY-12	Wideband PCM Trunk Carrier	Unclassified
TSEC/HN-74	Signal Interface and Control	Unclassified
TSEC/KG-34/34A	Key Generator, Electronic, Full Duplex, Shipboard or Fixed Plant Use	Confidential

8.2 TEMPEST considerations impose rigid standards for installation, operation, and maintenance of this equipment. Portions of this equipment are COMSEC controlled and require certain safeguards as detailed in NAG-12/TSEC.

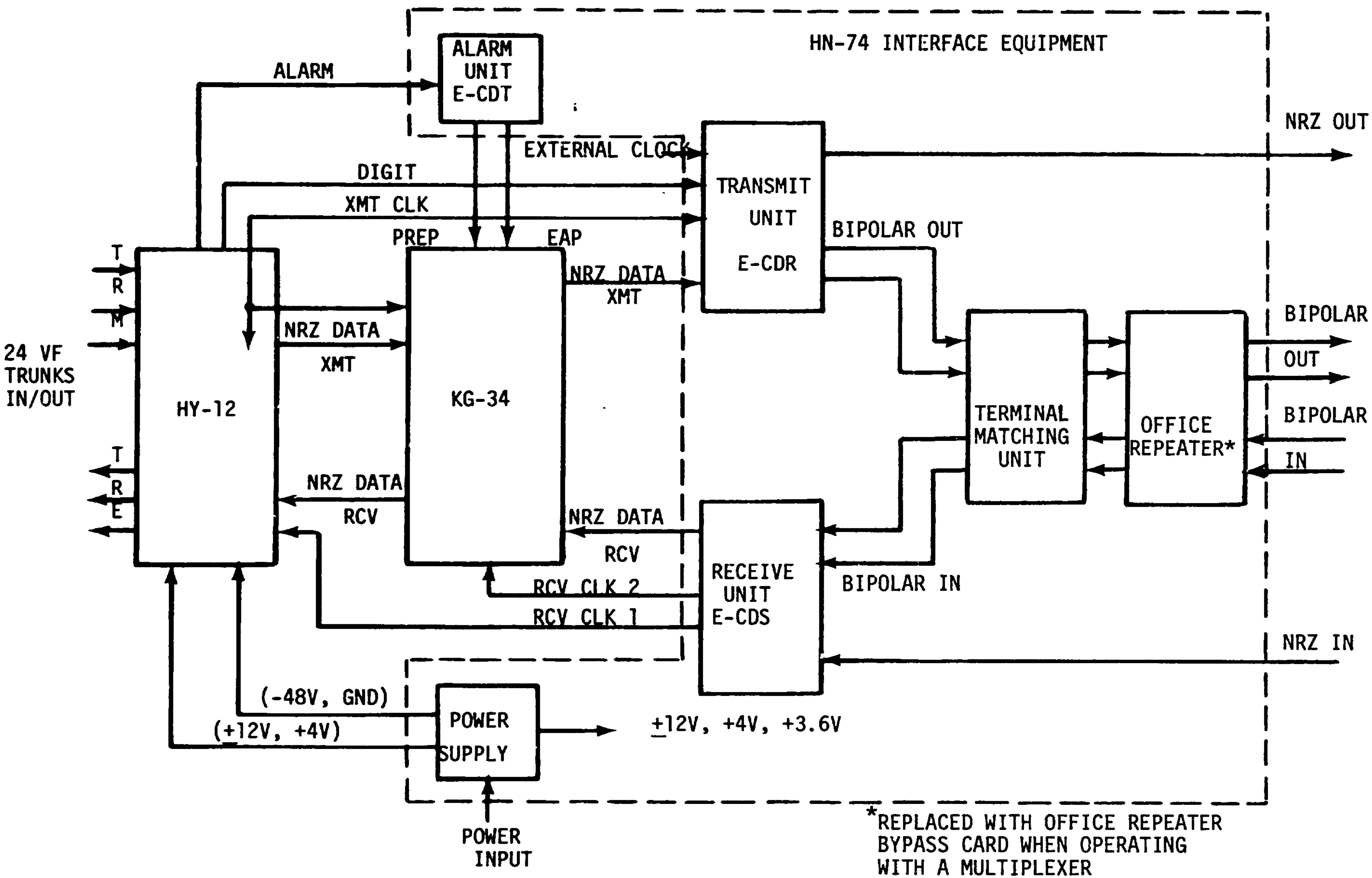


Figure 4.2.1(a) TSEC/CY-104 System Block Diagram

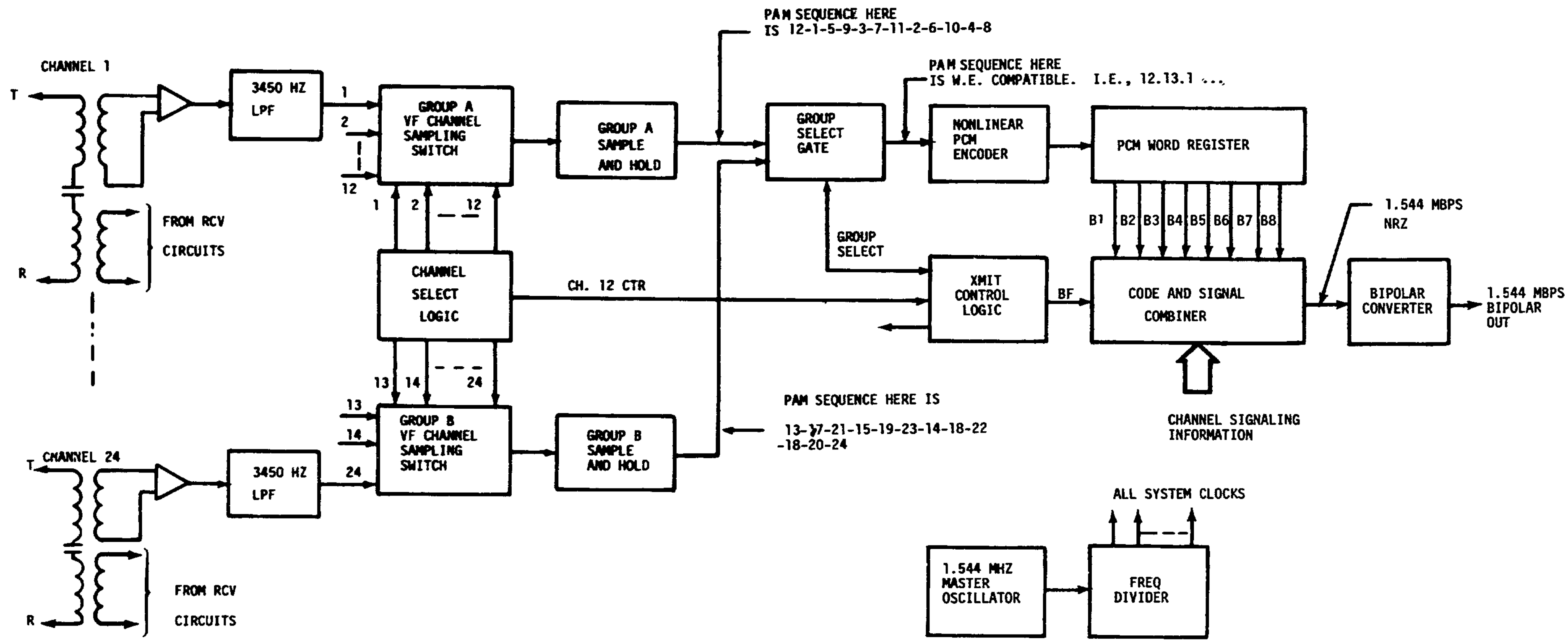


Figure 4.2.1(b) Vicom D2 Transmitter Block Diagram

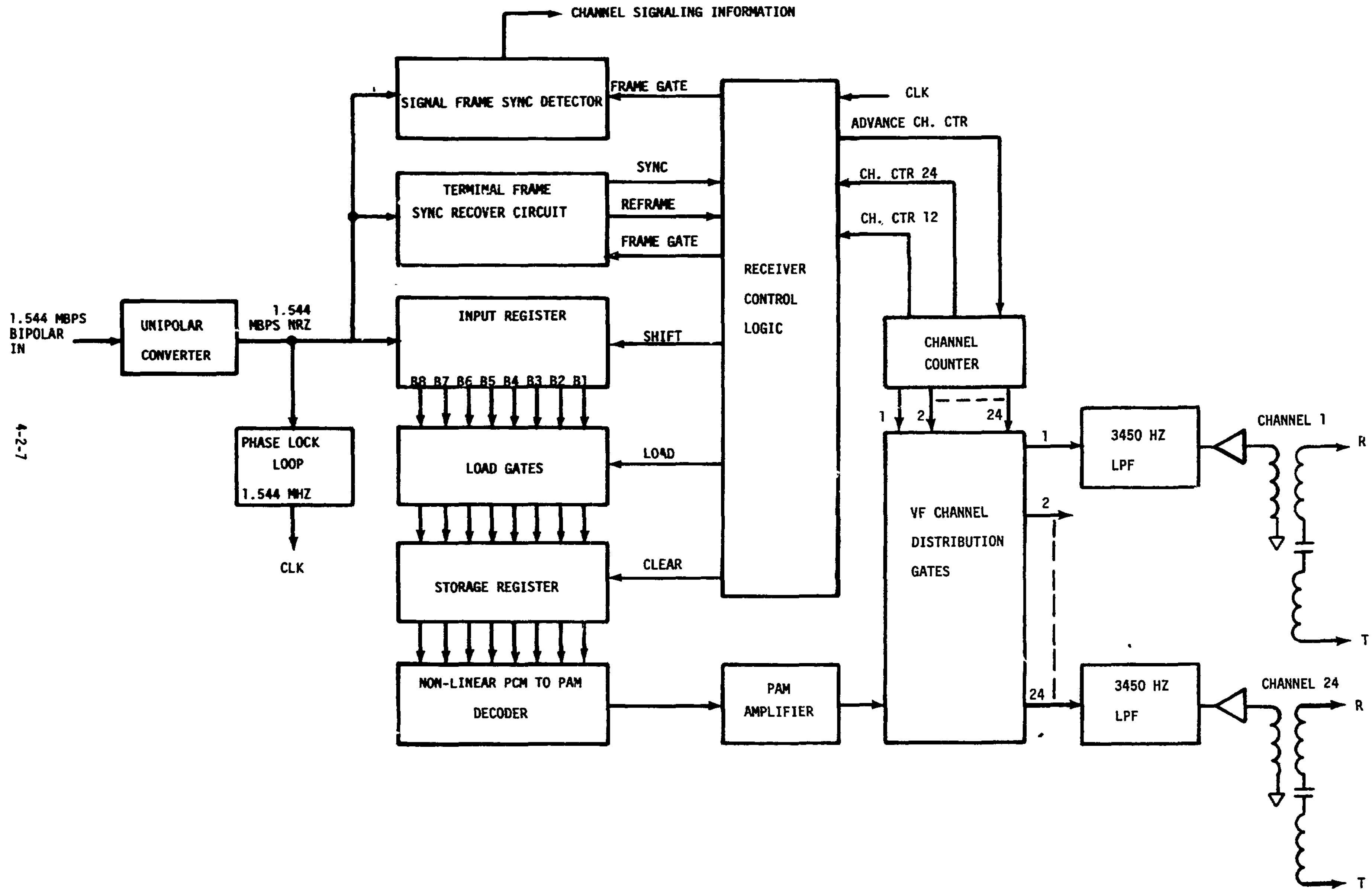


Figure 4.2.1(c) VICOM D2 Receiver Block Diagram

4.2.2 AN/FCC-97

1. Military Nomenclature: Multiplexer group AN/FCC-97

2. Commercial Nomenclature and Other Names: The AN/FCC-97 multiplexer group was once known as OB-79(V)FSC. It consists of two VICOM T1-4000 second level multiplexers and one VICOM 4030 first level multiplexer protection switch mounted in an equipment cabinet.

3. Functional Description:

3.1 The AN/FCC-97 multiplexer group consists of two eight-port T1-4000 multiplexers, the T1 inputs of which are wired in parallel, and the 12.6 Mb/s outputs of which are selected via the 4030 protection switch. The group thus provides redundant multiplexing capable of combining eight 1.544 Mb/s bit streams into a single 12.6 Mb/s bit stream, and back again. The complete equipment assembly is shown in Figure 4.2.2(a). The T1-4000 second-level digital multiplexer subassembly is shown in Figure 4.2.2(b). The multiplexer protection switch is shown in Figure 4.2.2(c). System interconnection is shown in Figure 4.2.2(d).

3.2 T1-4000 Second Level Multiplexer

3.2.1 The T1-4000 is an asynchronous time division multiplexer capable of combining up to eight channels of 1.544 Mb/s, bipolar bit streams into one 12.5526 Mb/s, three-level partial response bit stream suitable for transmission over a digital microwave line-of-site radio.

3.2.2 A simplified block diagram of the T1-4000 is shown in Figure 4.2.2(e). Data enters in the standard T1 format, bipolar RZ at a rate of 1,544,000 +150 -3000 b/s. As the eight inputs are asynchronous and may vary slightly in rate, they must be brought to a common rate before interleaving may take place.

3.2.3 Each T1 channel has an associated set of three plug-in units. The T1 signal enters the PCM access unit (4106-01) which provides patching and monitoring jacks. It passes to the transmit channel unit (4110-01) which recovers clock from the data and converts it from bipolar RZ to unipolar NRZ. The bit stream is serially loaded into an elastic register, the output of which is unloaded at a fixed rate of 1,544,935 b/s. The difference between the buffer input rate of 1,544,000 +150 -300 b/s and the output rate is made up by adding "stuff bits" which contain no information and are discarded at the far end terminal. Circuitry associated with the input buffer determines the need for a stuff bit and requests this bit from the channel buffer control unit.

3.2.4 The 1.544,935 Mb/s streams from the eight channels are in synchronization and are combined in the transmit time base into a single NRZ bit stream. Framing bits and stuffing control bits are added and the composite multiplexer output stream is convolved with a seven bit pseudorandom sequence in order to remove any dc or other predominate spectral components which may have been introduced.

3.2.5 Frequency domain filtering of the output 12.5526 Mb/s bit stream is performed in order to band limit the signal and condition it for the three-level partial response required for transmission by radio. On the receive side, the signal is further filtered to eliminate out-of-band noise and to complete the three-level signal shaping. The use of partial-response coding significantly reduces transmission bandwidth requirements as compared to binary NRZ. An additional benefit is that, since only certain sequences of three-level signal values are allowed, coding violations can be detected.

3.2.6 The receive signal is filtered, amplified and sliced. The original NRZ signal is recovered and unscrambled, while being monitored by a three-level error detector. Framing is recovered and used to produce timing digits which are used to gate NRZ bits into the eight receive channel units. The bit streams enter elastic storage registers and are "de-stuffed" as they leave. The NRZ streams are converted to 50% bipolar RZ T1 format and routed through PCM access units to the eight receive outputs.

3.3 4030 First Level Multiplexer Protection Switch:

3.3.1 The protection switch provides a means of automatically switching either transmit or receive sides of a normal T1-4000 digital multiplexer terminal to an operational standby terminal when a failure occurs in the normal terminal. The protection switch responds to alarm information from the receive sides of the multiplexers. The standby terminal must be functioning normally for the automatic transfer to occur. Manual transfer is also possible.

3.3.2 A simplified block diagram of the switch is shown in Figure 4.2.2(f). The switch consists of a transmit switch unit, a a receive switch unit, a T1 line driver unit, and a set of patch/monitor jacks.

3.3.3 The T1 lines to the normal T1-4000 are bridged onto the standby T1-4000 by the T1 line driver unit. The normal MUX output is connected to the radio through the transmit switch unit. The standby MUX output is connected to the standby receive input so that its operation status can be monitored. The normal receive MUX input is direct from the radio, while the standby MUX receive input is routed through the receive switch unit. Outputs of both receive MUX: are bridged on the PCM access units of the normal MUX.

3.3.4 Automatic switchover will only occur when one of the receive multiplex terminals is unable to frame with the incoming signal. A manual switch capability exists as does a patching capability.

4. Intended Application: The AN/FCC-97 is used in the Frankfurt-Koenigstuhl-Vaihingen (FKV) system in Germany. It is also to be used in the European wideband communications system - selected link improvement program (EWCS-SLIP), and any other application where the CY-104 and AN/FRC-162 are used.

5. Interface and Performance Characteristics:

5.1 Channels: 8 duplex T1 lines
Format: 1,544,000 +150,-300 b/s
± 3 V, 50% bipolar bit stream
Impedance: 100 ohms balanced
BER Objective: 3×10^{-7} maximum
Wiring Distance: MUX to T1 terminal, no more than 150 feet

5.2 Multiplexed Baseband Signal:

Format: Three-level partial response (or by strapping, binary NRZ)
Rate: 12.5526 Mb/s
Impedance: 75 ohms unbalanced
Amplitude Out: 0.5 to 1.0 V P-P
Amplitude In: 1±0.5 V P-P
Stuffing Jitter: Allows standard T1 terminals to operate over a minimum of 8 tandem multiplexer hops.
Signal-to-Noise Ratio: Minimum 28 dB peak signal-to-RMS noise ratio for BER objective.
Transmission Bandwidth: 6.4 MHz (with 8 T1 lines)
Transmit Clock: Square wave, 50±20% duty cycle, 1±0.1 V P-P output into 75 ohms.
Synchronization Clock: 0.5 to 1.5 V P-P square wave or sine wave across 75 ohms.

5.3 Alarms:

Remote Alarm: Indicates outgoing circuit failure, detected at far end and relayed to near end.
Local Alarm: Indicates incoming circuit failure, detected at near end and relayed to far end.
Major Alarm: Failure with loss of service.
Minor Alarm: Failure without loss of service.
Terminal Alarm: A local or looped alarm condition at the multiplexer is transmitted to the near-end T1 terminals and to the far-end multiplex.

5.4 Switching:

Automatic: Transfers operation from normal to standby terminal if fault appears in the normal and the standby is operational.
Manual: Manual transfer available for both transmit and receive sides, independently.
Reset: Manual or by external logic command.

5.5 Power Requirements: 240 watts maximum, from: 115 ±10 Vac 60 Hz; -50 ±6 Vdc; or -25 ±3 Vdc

5.6 Space Requirements: Housed in an electrical equipment cabinet 27 1/2" deep, 25 1/2" wide, and 86 1/2" tall, with doors front and back. Each T1-4000 occupies 15 3/4" of vertical rack space, and the 4030 occupies 5 1/4".

6. Date of Availability: Available now.

7. Documentation for Detailed Description:

TM 11-5805-686-14 & P
VICOM PSB-6018
VICOM PSB-6004
U.S. Army Signal School Publications:
32E2-PROT-IS(1)
32E2-PROT-DIA(1)
32E2-T1-4000-OS(1)
32E2-T1-4000-IS(1)
32E2-T1-4000-DIA(1)
101F6-VICOM-OS(1-3)

8. Additional Information: The 4106 PCM access unit with switch is used to replace the 4105 PCM access unit in the normal first level multiplexer. Standby 4105 PCM access units are not replaced.

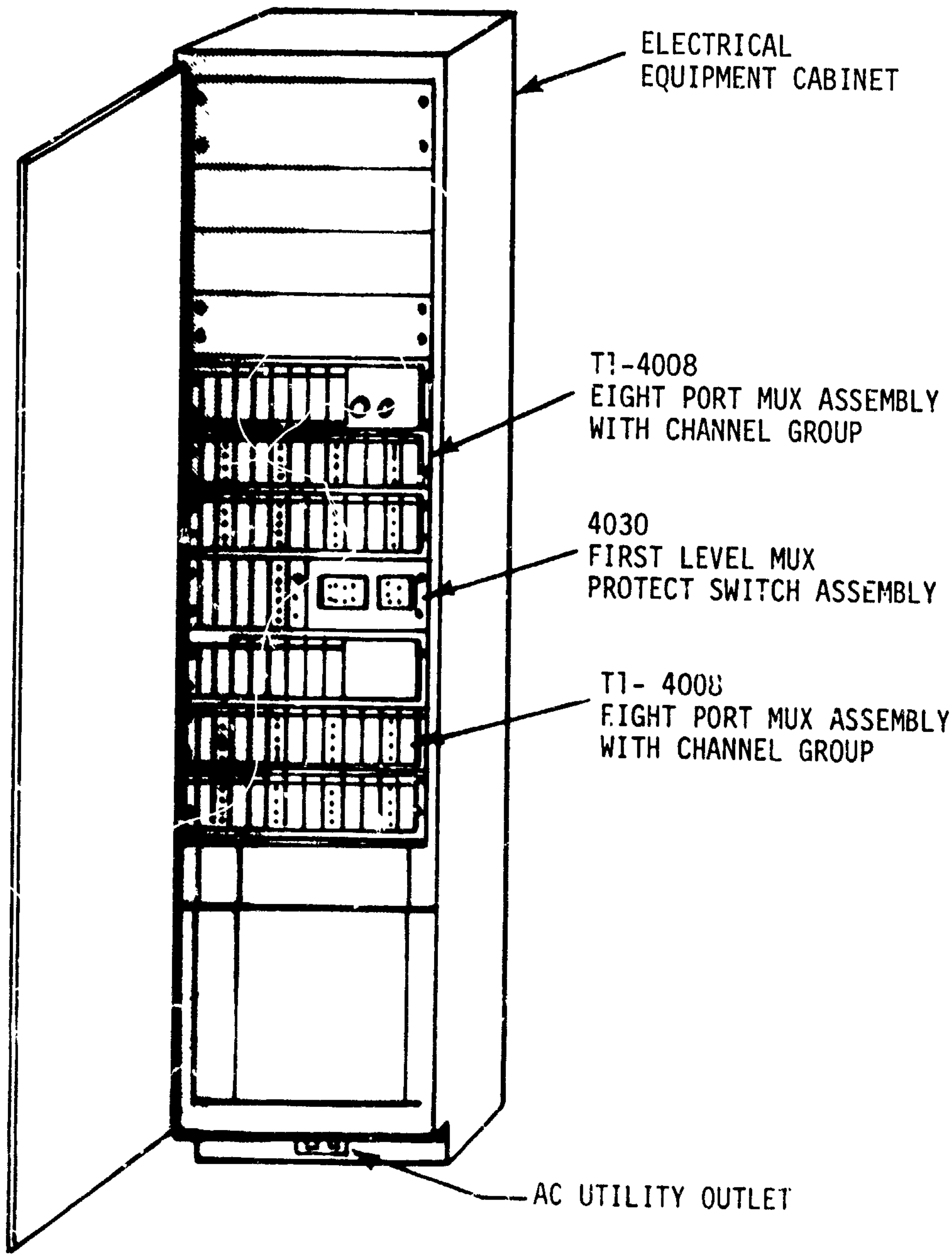


Figure 4.2.2(a) Multiplexer Group AN/FCC-97

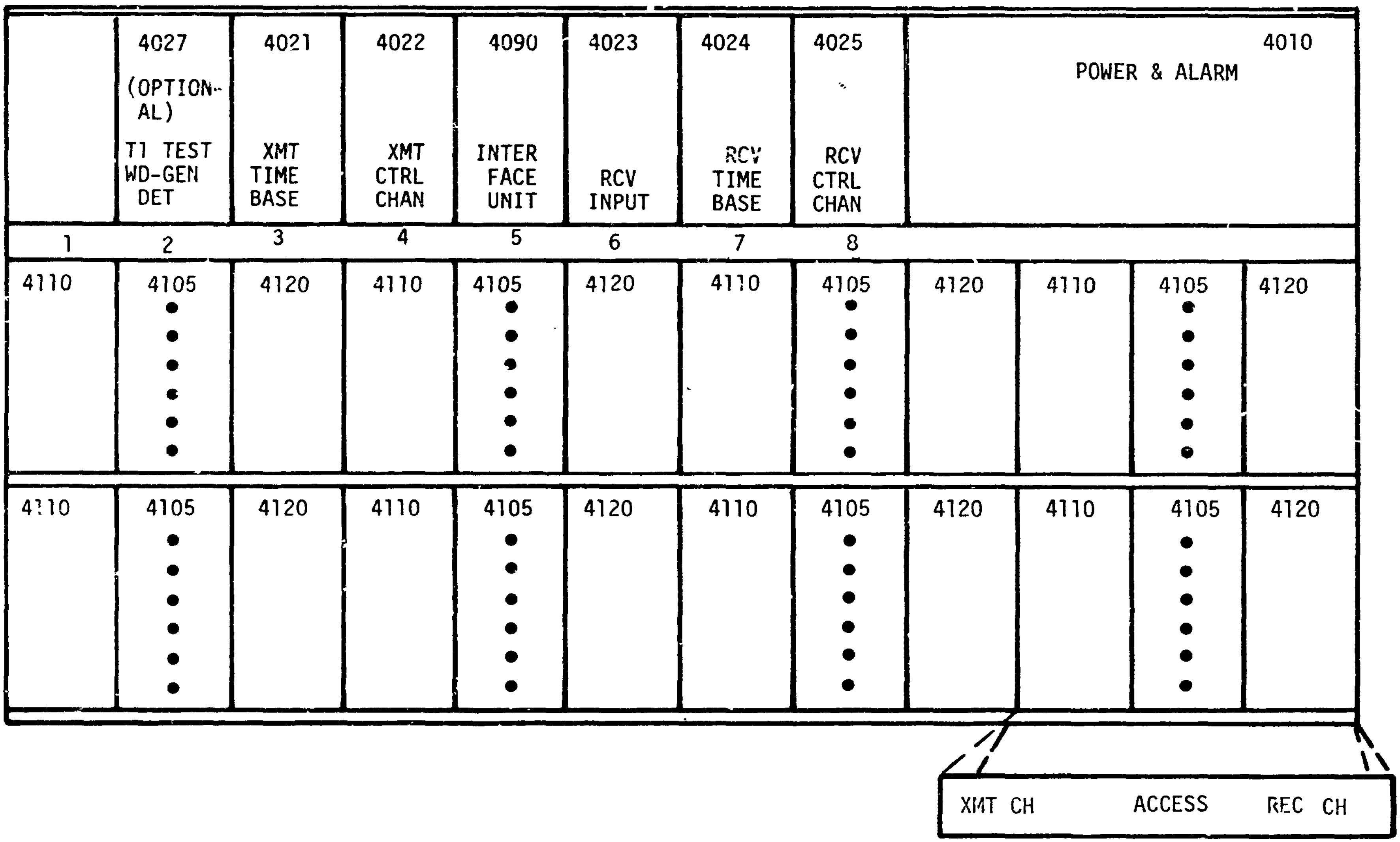


Figure 4.2.2(b) Assembly Schematic, T1-4000 Multiplexer

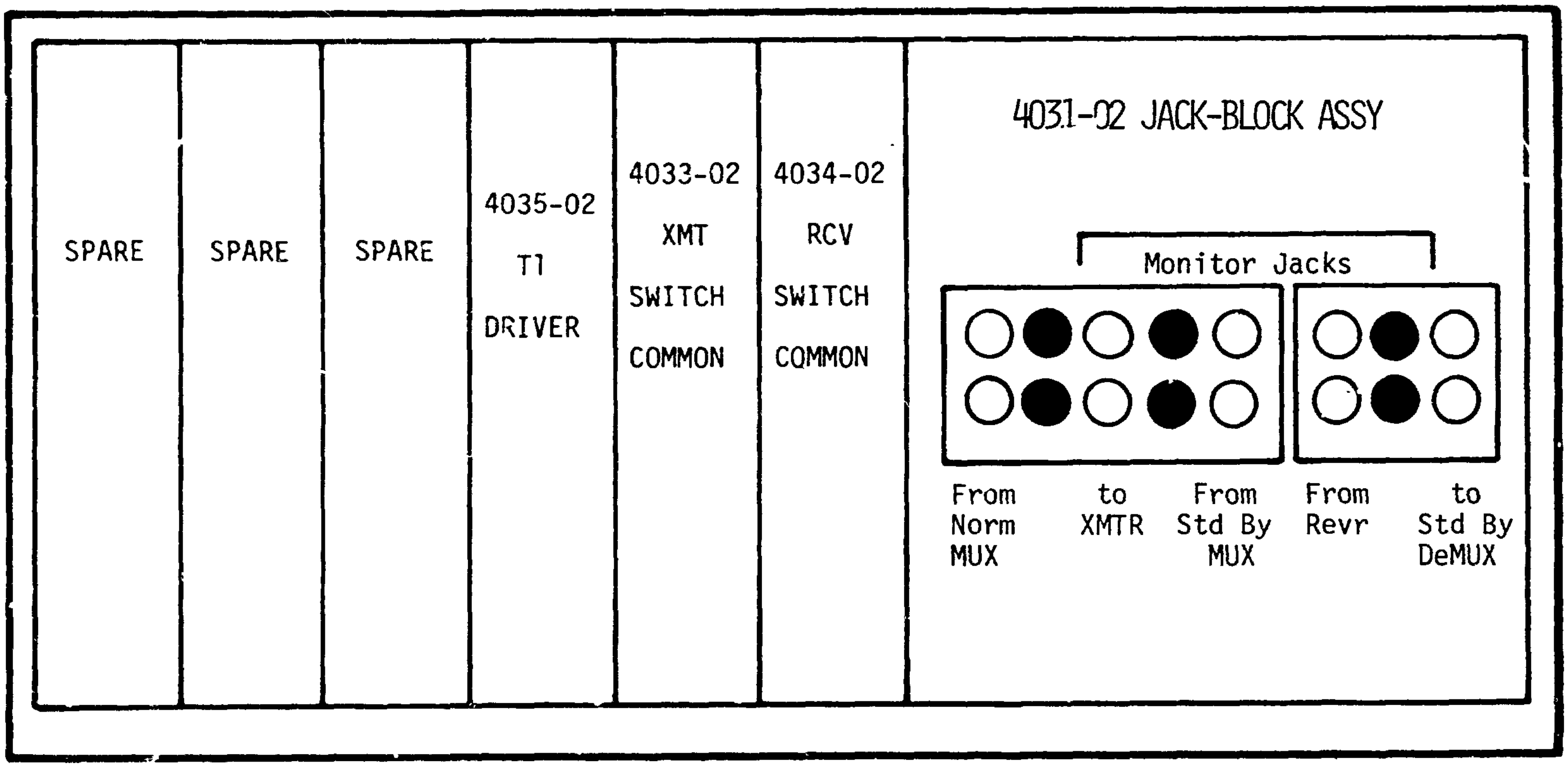


Figure 4.2.2(c) Protection Assembly Schematic Layout

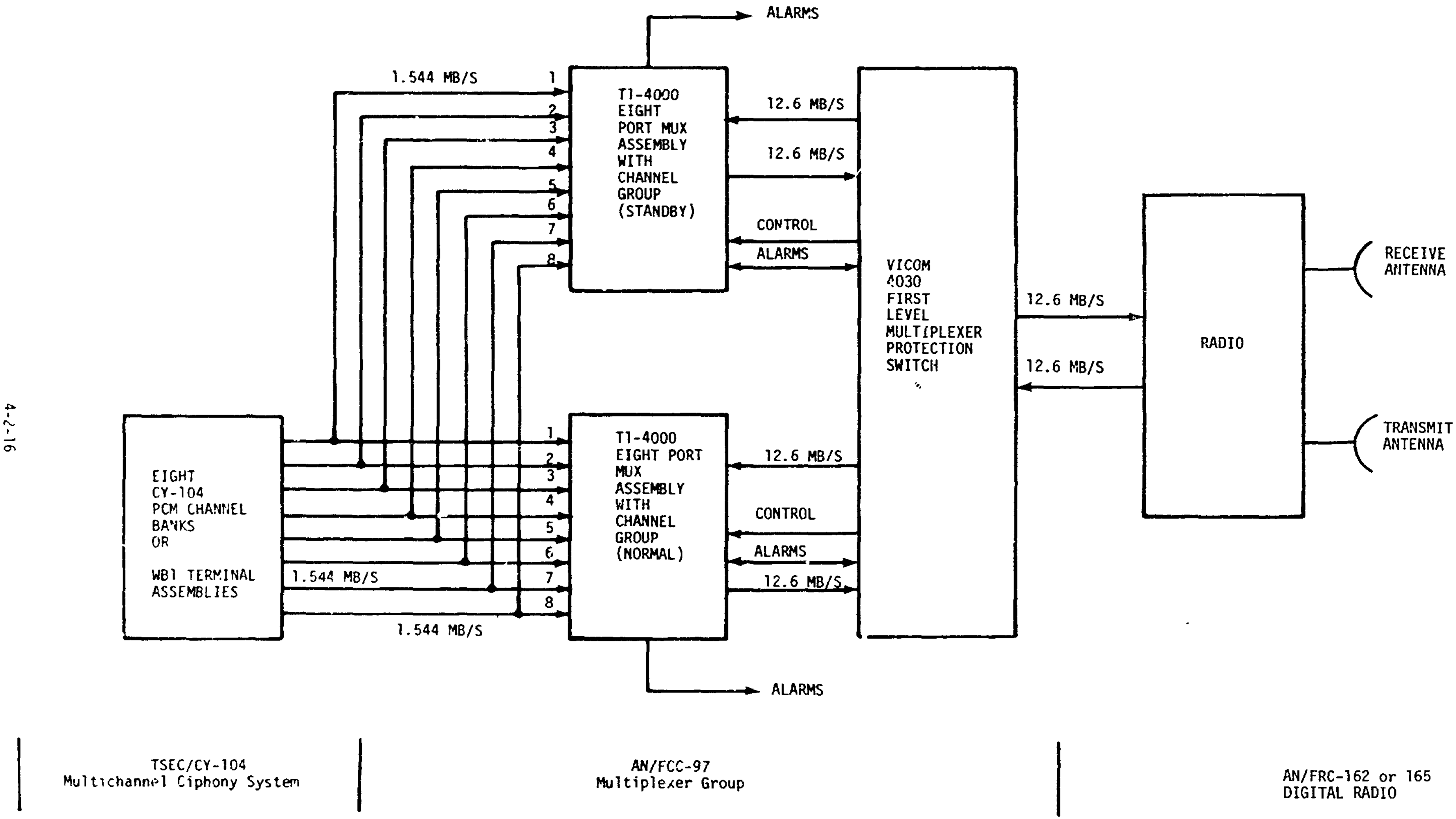


Figure 4.2.2(d) AN/FCC-97 Major Subassemblies Interconnection Plan

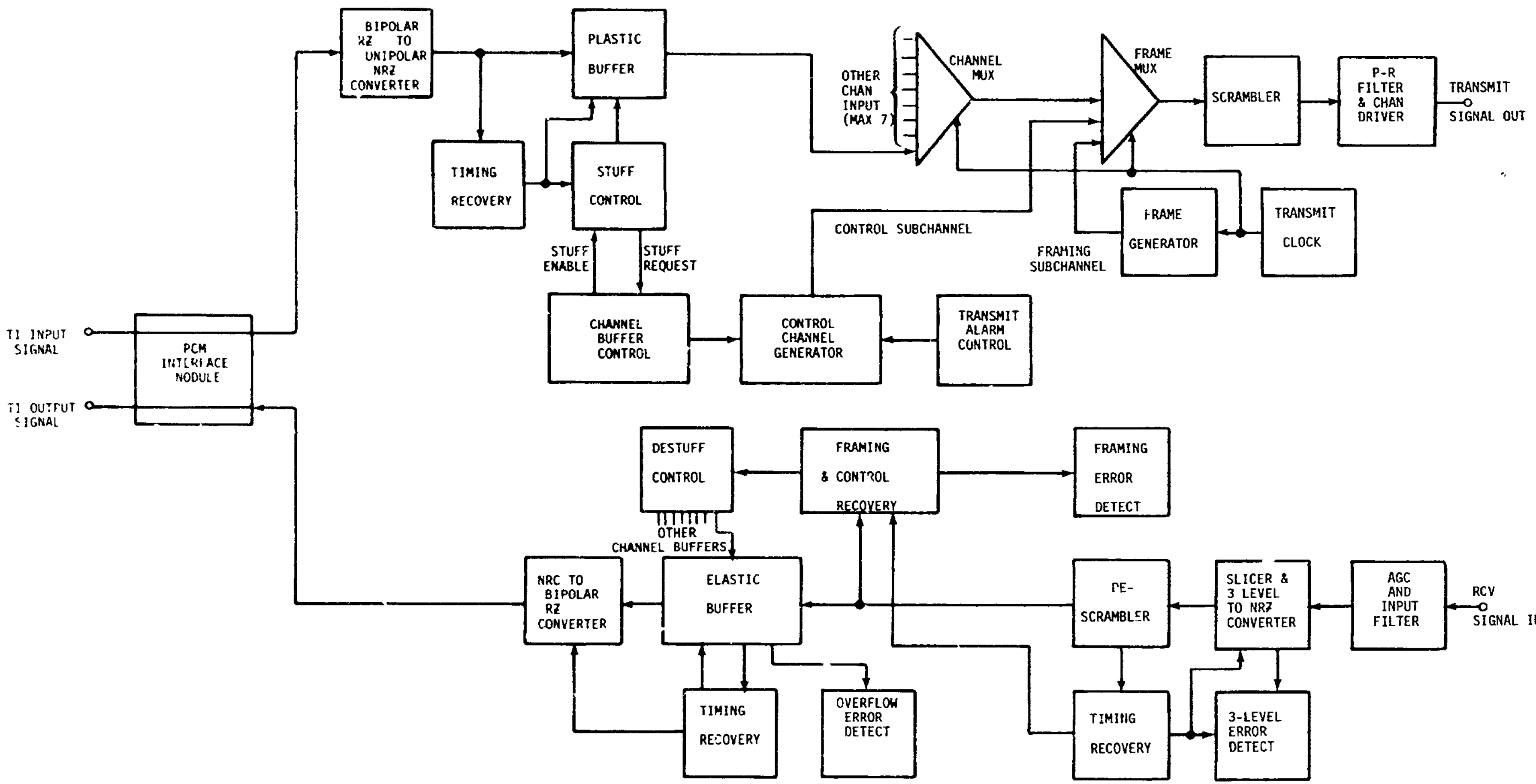


FIGURE 4 2 2 (e) TI-4000 MULTIPLEXER SIMPLFIED BLOCK DIAGRAM

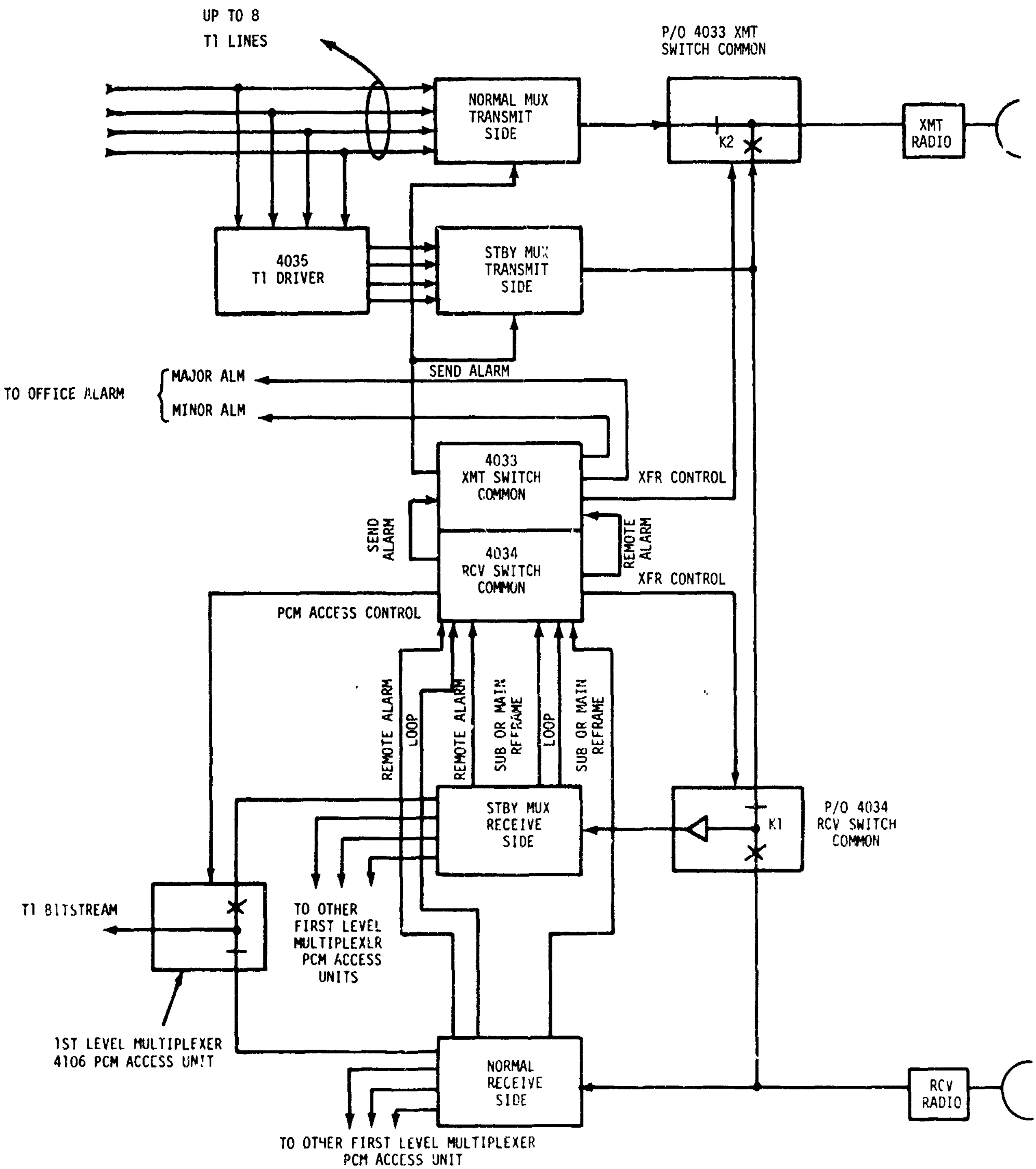


Figure 4.2 2(f) Protection Switch Block Diagram

4.2.3 T1WB1

1. Military Nomenclature: None

2. Commercial Nomenclature and Other Names: VICOM 5200 Series Wideband Data Terminal, T1WB1

3. Functional Description:

3.1 The T1WB1 is a full-duplex, time division multiplexer capable of combining up to eight separate, asynchronous, 0 to 50 kb/s bit streams into a single 1.544 Mb/s bipolar pulse stream (T1). It consists of a single rack-mounted shelf with three common plug-in modules and up to eight individual data channel units. The T1 signal may be applied to a digital radio, a T1 cable link, or a higher level multiplexer. T1WB1 assembly layout is shown in figure 4.2.3(a). System application is shown in Figure 4.2.3(b).

3.2 The T1WB1 uses a transitional encoding technique which converts each transition in logic state for each channel into a three bit code word comprising of an index bit, a quantizing bit, and a state bit. The index bit is transmitted to indicate that a transition occurred. The quantizing bit indicates the phase of the transition relative to two 192 kHz clocks internal to the T1WB1 transmit unit. The state bit indicates the state of the input signal following the transition. It follows that the maximum data rate per channel is actually one-third of the clock rate, or 64 kb/s. This is known as a group rate and is typically used for 50 kb/s service.

3.3 A simplified block diagram of the T1WB1 is shown in figures 4.2.3(c) and 4.2.3(d). All channel units function identically with the exception of their interface characteristics, which are indicated in Table 4.2.3. The channel unit interfaces the common equipment with the data terminal, performs the transition encoding, then passes the words to the transmit unit, where the encoded output code words are held in a register until they are transferred serially into the composite stream.

3.4 In the transmit unit the sequentially sampled three-bit words are combined, a framing bit is added, and the unipolar NRZ bit stream is retimed and converted to 50 % duty cycle bipolar RZ T1 format. The signal is passed through a pad in the power and alarm unit to the output.

3.5 The received T1 signal enters the power and alarm unit where it passes through a span pad and a loopback switch. The bipolar RZ T1 signal is converted to unipolar NRZ in the receive unit. Bipolar coding violations are detected before conversion. The signal is reclocked through noise suppression circuitry, using a phase-locked loop to derive 1.544 MHz from received data. The retimed data is clocked into a buffer register where the framing recovery and clock generator locates the framing bit. A confidence counter is used in the recovery subsystem to increase the reliability of the synchronization process. The system stays in reframe mode until seven consecutive framing bits have been correctly received. The reframe mode is initiated by the reframe error detector whenever 3 out of 10 frames are received with erroneous framing bits. The receive unit passes the received signal to the data channel units, along with clocking which gates the correct channel unit. The three-bit code word is translated into single bits and conditioned to the format characteristics required by the data terminal equipment, depending on the model channel unit.

3.6 The loop switch at the T1 ports of the T1WB1 is used in local terminal alignment and fault isolation procedures. In the "loop" position the output of the transmit unit is switched to the input of the receive unit and a loop alarm indication is generated.

3.7 Alarm indications are generated if the following occurs: (1) a battery fuse fails, (2) one or both terminals are placed in loop mode, (3) receiving terminal cannot sync, or (4) persistent bipolar coding violations are detected. During alarm conditions, the transmit unit inserts an outgoing alarm (OGA) code into the bit stream, which produces a remote alarm condition at the far terminal.

4. Intended Application: The T1WB1 is used at present in the Frankfurt-Koenigstuhl-Vaihingen (FKV) system in the European Theater. It may be used in future programs but 50 kb/s cards available with TD-1192 and CY-104 first-level multiplexers will replace the T1WB1.

5. Interface and Performance Characteristics:

Capacity: Maximum of eight 50 kb/s data channels.

Terminal Carrier Output: 1.544 Mb/s bipolar pulse stream, ±3 volts, with 50% duty cycle. Presence of a pulse is logic "1", absence of a pulse is logic "0".

Bit and Frame Organization: Transitional encoding into 3 bit words, each channel assigned 24 time slots per frame, framing bit inserted every 193rd time slot at rate of 8000 frames/second.

Looped Terminal Transitional Jitter: ±1.3 microseconds.

Data Channel Characteristics: See table.

Power Requirement: -44 to -56 Vdc.

Space Requirement: 5" vertical in 19" rack.

6. Date of Availability: Available now.

7. Documentation for Detailed Description:
TM 11-5805-686-14 and -14P
VICOM PBS-6014

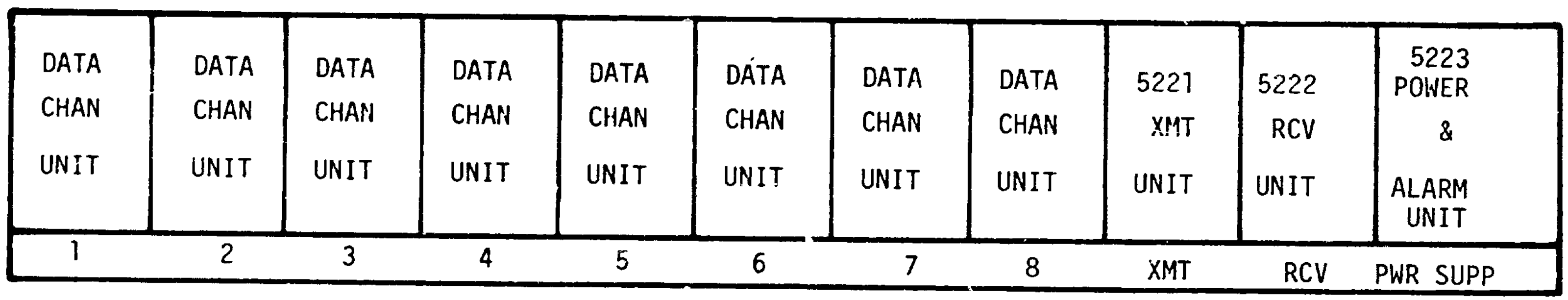


Figure 4.2.3(a) T1WB1 Assembly Layout

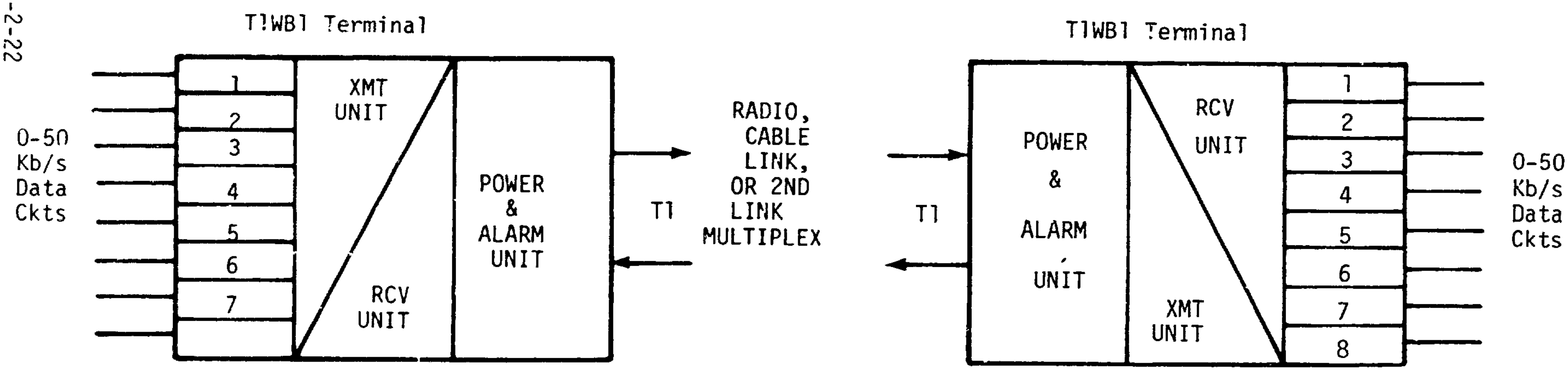


Figure 4.2.3(b) System Application, the T1WB1 Wideband Data Terminals

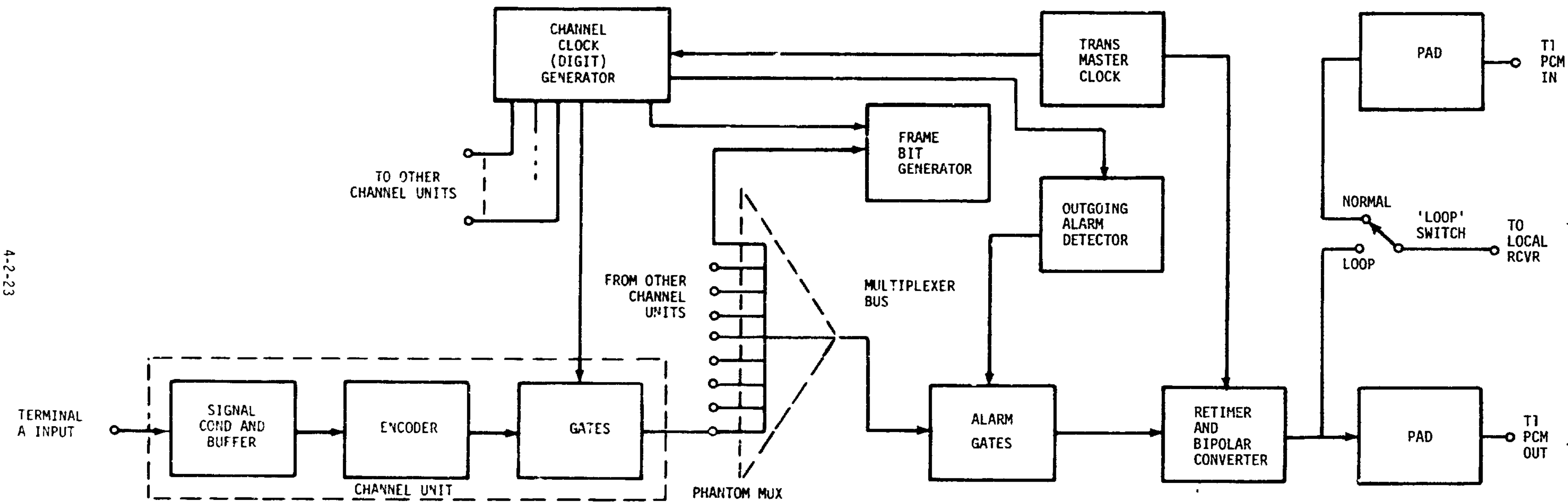


Figure 4.2.3(c) T1WB1 Transmitter Block Diagram

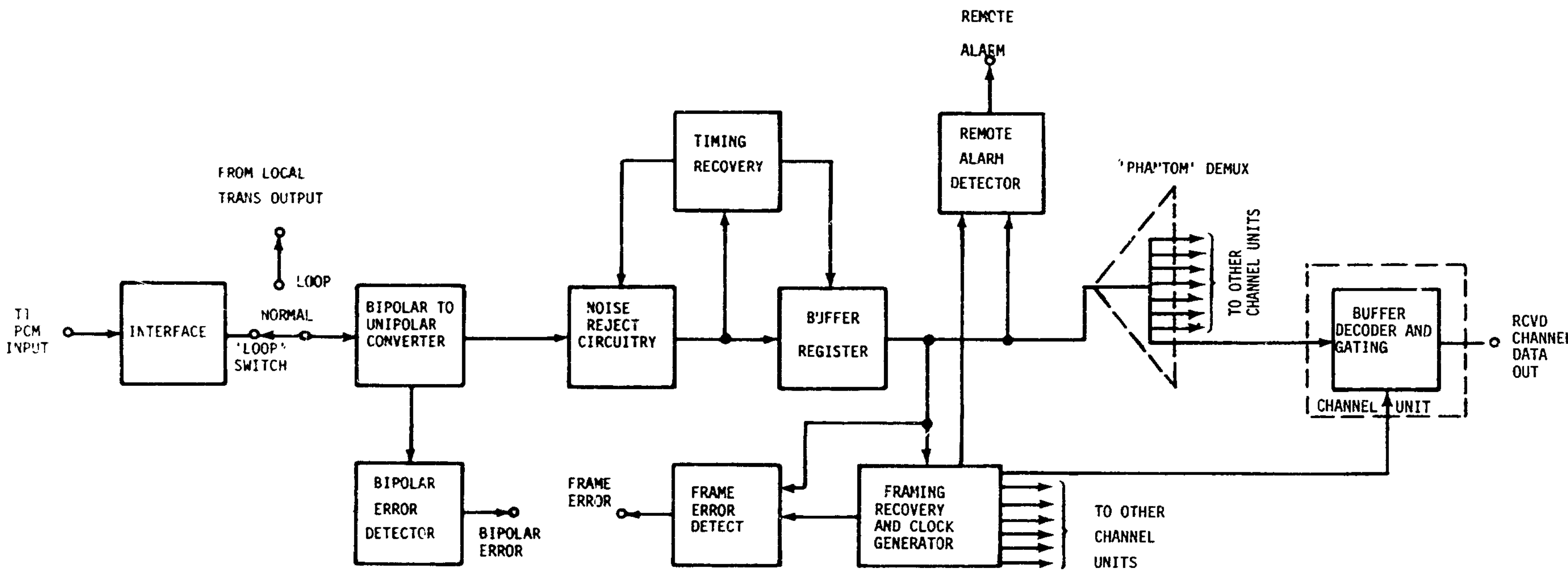


Figure 4.2.3(d) T1WB1 Receiver Block Diagram

TABLE 4.2.3 DATA CHANNEL UNIT CHARACTERISTICS

Model	Input Impedance	Output Impedance	Coupling	Data Format	Input Level	Output Level
5231	135 Ohm ±5%	135 Ohm ±5%	Balanced Transformer	Restored Polar	Adjusted by Attenuator Pad to -7dBm (135 Ohms).	Between +5dBm and -2dBm (135 Ohm), Adjustable via Attenuator Pad.
5232 (Bal)	135 Ohm ±5%	135 Ohm ±5%	Balanced Transformer	Balanced Polar (NRZ)	Adjusted by Attenuator Pad to -7dBm.	Between +5dBm and -2dBm (135 Ohms), Adjustable via Attenuator Pad.
5232 (Unbal)	50 to 600 Ohm Selectable (Normal 135 Ohm)	50 to 135 Ohm Selectable (Normal 135 Ohm)	Direct	Unbalanced Unipolar (NRZ)	Logic "1" level is greater than 1.0 volts, Logic "0" level is less than 0.8 volts	Between 0.5 and 1.5 volts RMS across 135 Ohms Impedance.
5234	Greater than 50K Ohm Between -7 and +7 Volt	Less than or equal to 50 Ohm	Direct	Unbalanced Low level Bipolar (MIL-STD-188c)	Logic "1" is +6 volt ±1 volt Logic "0" is -6 volt ±1 volt	Logic "1" is +6 volt ±1 volt, Logic "0" is -6 volt ±1 volt (Open circuit); 50 MA (Short circuit current). At least 20 MA at ±6 volts.

4.2.4 AN/GSC-24

1. Military Nomenclature: Asynchronous Time-Division Multiplexer Set AN/GSC-24(V).

2. Commercial Nomenclature and Other Names:

3. Functional Description:

The AN/GSC-24(V) is an asynchronous time-division multiplexer that provides a simplex or full duplex (separately configurable) multiplexing/demultiplexing capability. The multiplexer processes 1 to 15 data channels at input data rates of 50 b/s to 3 Mb/s. Various rate families, including C x 75 x 2^N and 8000 N, can be accommodated and intermixed. This is accomplished by an assortment of input/output channel cards including rate comparison buffer and transition encoder/timing recovery. In addition, CVSD voice encoder/decoder cards can be provided for desired efficiency of the configuration required. Full self-checking diagnostics, providing call-out of failed cards to the card level, make possible an MTTR of less than 12 minutes. Logistics and life cycle cost have been reduced by using only 12-15 card types in a fully configured, 15-channel multiplexer/demultiplexer with a total of 40 cards.

Basic to recognizing potential GSC-24 use in a particular application is an understanding of the relationships between input data rate (R) and output rate (R_o). In the example shown in Figure 4.2.4(a), there are 14 user channels (R_i1 to R_i14), a varied strapping configuration (K), 31 ports occupied (N), a port sampling rate (R_p), and an output rate [$R_o=R_p(N=1)$]. Transmission efficiency (input data/output data) is 96.87%. If we assign a port rate (Rp) of 75 b/s, user channels 1 through 7 are 75 b/s (K=1), 8 through 11 are 150 b/s (K=2), 12 and 13 are 300 b/s (K=4), and user channel 14 is 600 b/s (K=8). Output is 2400 b/s, i.e., 75(31+1).

A Universal Rate Converter (URC) is available on each rate comparison buffer (RC_B) channel card to convert user input rate (R_i) to selected port rate (R_p) or a strapped port rate (KR_p) with the constraint that the number of fill bits, F = 899 K $(1- R_i/K\ R_p)$, shall be less than 634 for K = 1 and less than 868 for K > 1.

The appropriate selection of port rate (R_p), use of URC feature of the Rate Comparison Buffer and 31 port (N) capability permit the accommodation of rate differentials between user input channels. An example is shown in Figure 4.2.4(b).

A Transition Encoder (TE) provides a transparent channel, using three-bit transition encoding. Any data rate which is less than one-third the strapped port rate (KR_p) selected may be accommodated by the transition encoder with a maximum of 20 % isochronous distortion. Each transition encoder/decoder card has six strap-selectable rate ranges: 75, 100, 150, 200, 300 and 400 b/s. The corresponding sampling rate, i.e., (KR_p) must be: 225, 300, 450, 600, 900 and 1200 b/s respectively.

Multiplexer reconfiguration can be accomplished within a few minutes by relocation of jumper straps on the channel cards and two control cards. Extra control cards can be acquired and reprogrammed to permit reconfiguration if the operational requirement and reconfiguration warrant this action.

Timing Recovery (TR) does not require external timing input on any channel using a timing recovery card. GSC-24 will accept and properly multiplex both asynchronous and isochronous signals. The timing recovery card is capable of maintaining bit count integrity through 100 consecutive ones or zeros with an input signal containing 40 % isochronous distortion or longer with reduced isochronous distortion and $\pm$250 ppm rate variation.

CVSD Voice Encoder/Decoder permits the insertion of CVSD channel cards for voice interface. These cards will operate at the strapped port rate (KR_p) within a sampling rate limitation of 19.2 kb/s to 300 kb/s, permitting orderwire insertion at the highest level of a hierarchical multiplex structure.

Simultaneous Operation of Type I and Type II Signals (i.e., timing provided and timing not provided) may be handled using available channel cards. Both types may occur simultaneously on different channels.

Accomplishment of these special configuration features entails using the following multiplexer input and demultiplexer output channel cards:

MULTIPLEXER INPUT	USED WITH	DEMULTIPLEXER OUTPUT
RCB (Rate Comparison Buffer)		SB (Smoothing Buffer)
TE (Transition Encoder)		TD (Transition Decoder)
TR (Timing Recovery)		SB (Smoothing Buffer)
VE (Voice Encoder)		VD (Voice Decoder)

Input/output cards can be provided to accommodate all rates between 50 b/s and 3 Mb/s including the C x 75 x 2^N and 8000N rate familites. Positive and negative bit stuffing techniques permit high transmission efficiency. Transition encoding provides for transparent through channels. A voice encoder card permits insertion of voice orderwire at many levels of a multiplexer hierarchy. The universal rate converter feature provides for the conversion of many rates to the selected family rate. Only those input/output channel cards required for a specific multiplexer configuration need be installed in the multiplexer. Figure 4.2.4(c) shows typical examples of GSC-24 applications.

4. Intended Application: The GSC-24 is currently employed in the DSCS program. It is used for the 50 kbps per channel secure voice trunking of AUTOSEVOCOM. It is projected to be used in further expansions of the wideband secure voice network.

5. Interface Characteristics:

Technical Specifications:
- Asynchronous or synchronous data inputs
- 1 to 15 input data channels
- High efficiency:
  - Ports (N) = 15 93.75%
  - Ports (N) = 31 96.87%
- Initial frame-in time (environment of one error per 100 bits)
  - <6.0 x 10^3 bit times for 50% of the time
  - <15 x 10^3 bit times for 90% of the time
- Loss of frame and reacquisition time (environment of one error per 100 bits.
  - <6.0 x 10^3 bit times for 50% of the time
  - <15 x 10^3 bit times for 90% of the time
- Input data rate variation $\geq\pm 250$ Parts Per Million (PPM)
- Accepts input data without any restriction with regard to format, bit sequences, character organization, or error coding.
- Input channel rate : 50 b/s to 3 Mb/s.
- Output rate consistent with input rates:
  - variable to 10 Mb/s
- Mechanical configuration: 19" rack mounting
- Power requirements: 115 volts ±10% 47 to 410 Hz, with 15 channels loaded not over 634 watts.
- Reliability · greater than 3500 hours (MTBF)
- Maintainability :
- Mean corrective maintenance time not over 12 minutes
- Maximum corrective maintenance time not over 36 minutes at the 95th percentile.

GFE Compatibility: Testing has demonstrated that the GSC-24 is compatible with the MD/921 G Modem and CV/3034 Analog-to-Digital Converter, operating in conjunction with the KY-3.

Military Specifications - GSC-24 complies with the following specifications:

MIL-E-4158E	MIL-STD-461A
MIL-E-6051D	MIL-STD-462
MIL-M-38510	MIL-STD-463
MIL-H-46855	MIL-STD-781B
MIL-P-55640A	MIL-STD-810B
MIL-STD-188	MIL-STD-882
MIL-STD-188-100	MIL-STD-883
MIL-STD-189	MIL-STD-1313A
MIL-STD-210A	MIL-STD-1472
MIL-STD-454D	MIL-STD-1495

6. Date of Availability: Available now.

7. Documentation for detailed description:
   AF TO: 31W2-2GSC24-2 Service and Maintenance Instruction AN/GSC-24.

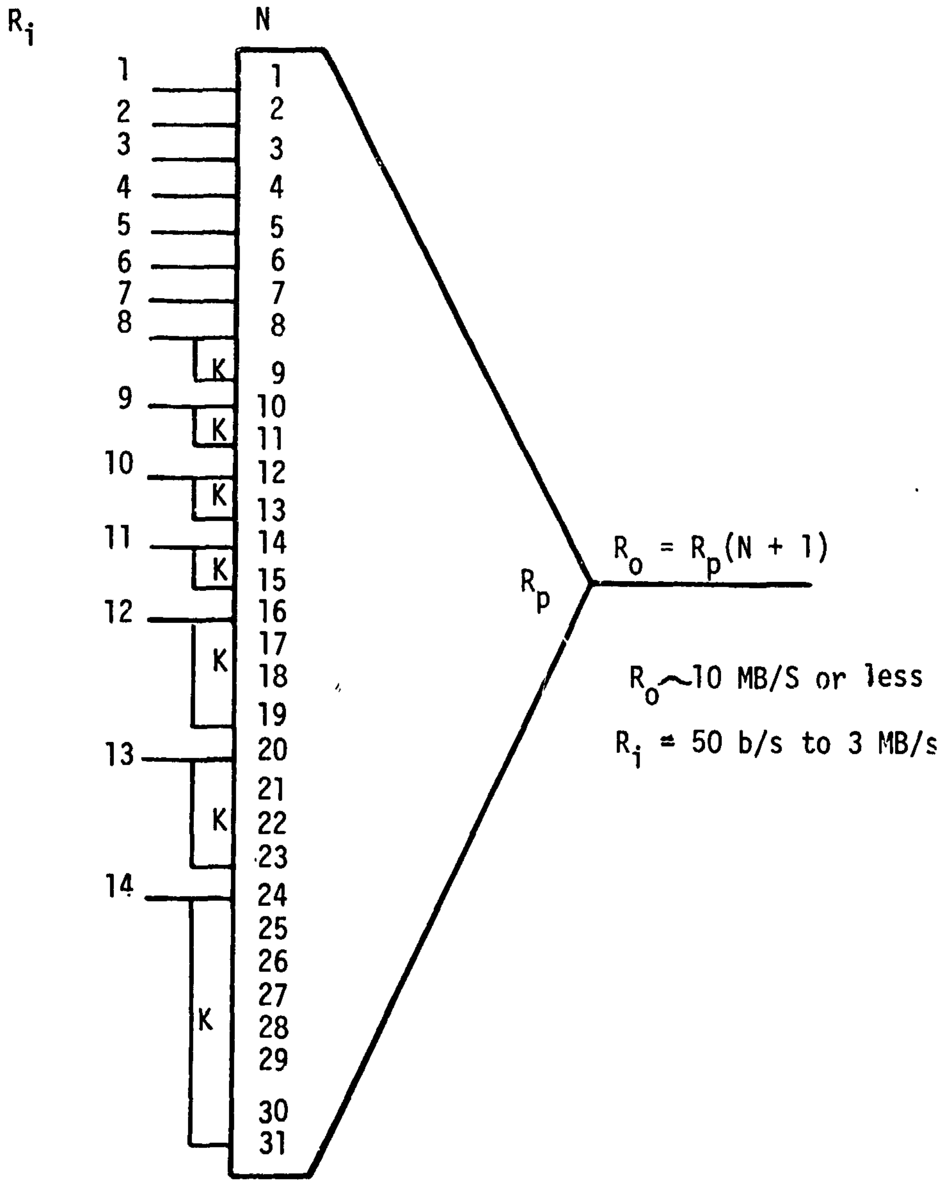


Figure 4.2.4(a) Input Output Characteristics of AN/GSC-24

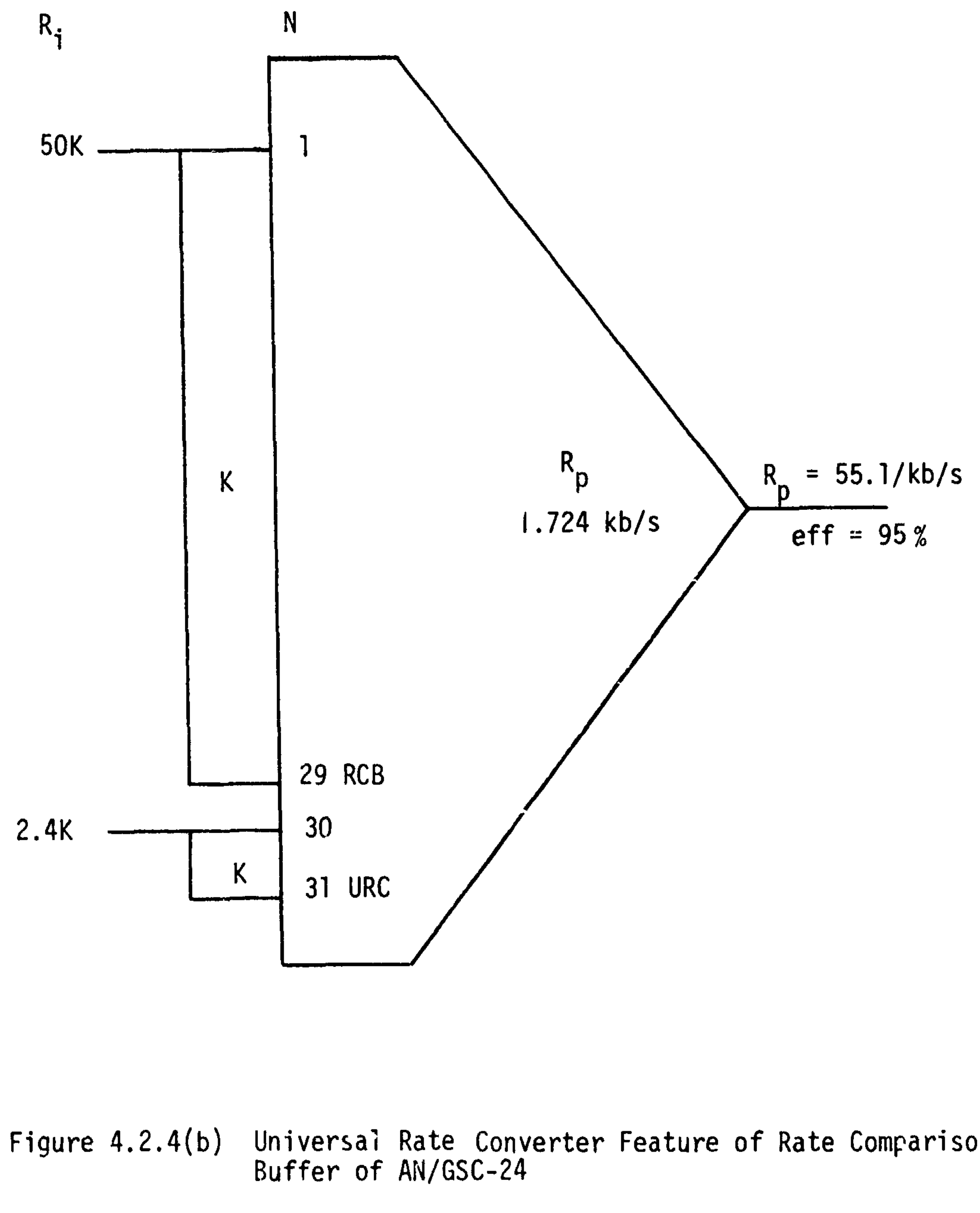


Figure 4.2.4(b) Universal Rate Converter Feature of Rate Comparison Buffer of AN/GSC-24

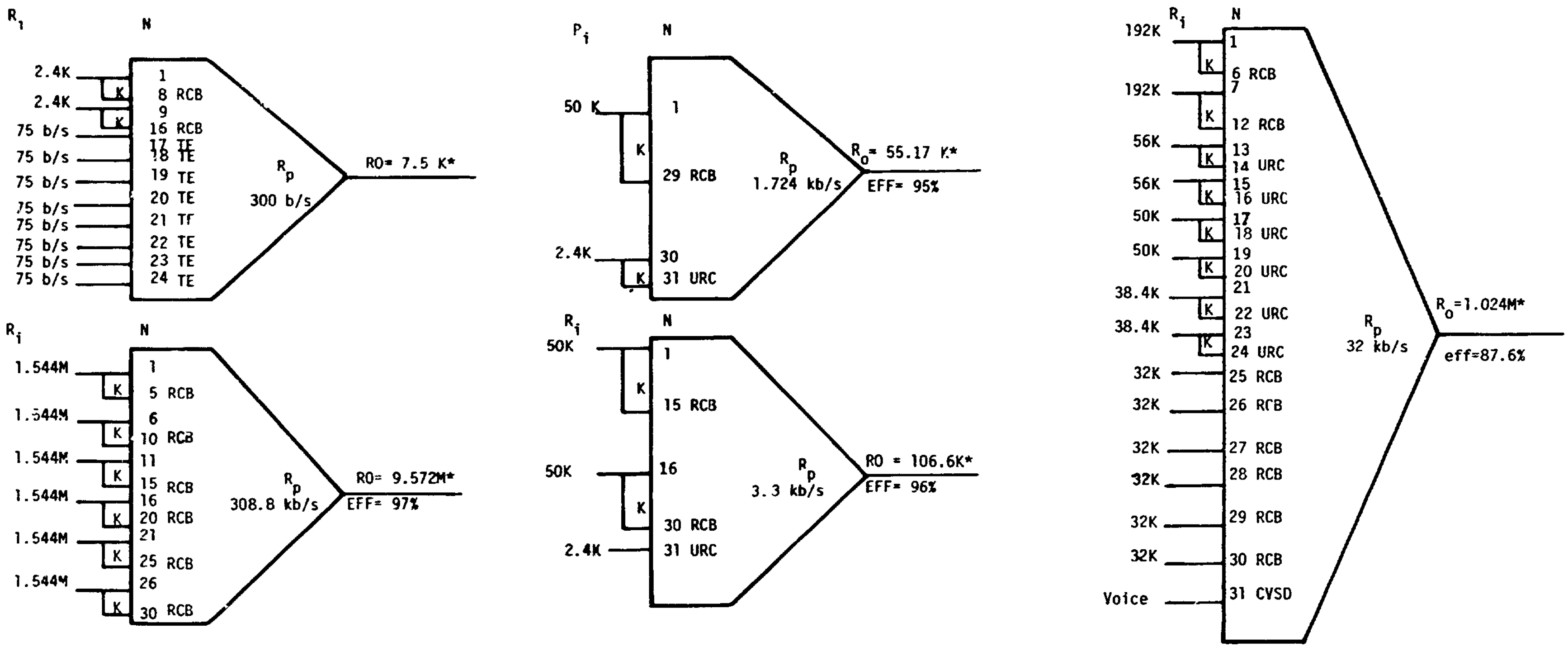


FIGURE 4.2.4(c): AN/GSC-24 APPLICATIONS

* TO MODEM OR GSC-24

4.2.5 TD-1220(V)/G and TD-1226(V)/G

1. Military Nomenclature: Multiplexer-Demultiplexer
   TD-1220 (V1)/G, (V2)/G, (V3)/G, (V4)/G, (V5)/G, (V6)/G
   TD-1226 (V1)/G, (V2)/G, (V3)/G, (V4)/G, (V5)/G

2. Commercial Nomenclature and Other Names: Manufactured by Sperry-Univac.

3. Functional Description:

3.1 The TD-1220(V)/G and TD-1226(V)/G are identical programmable multiplexers-demultiplexers, with the exception of prime power requirements. The TD-1220(V)/G operates on -48 Vdc and the TD-1246(V)/G operates on 115 Vac, 47 to 500 Hz. Table 4.2.5 describes the features of various models. For simplicity, the term TD-1220 shall be used to refer to all units except as noted.

3.2 The TD-1220 is a general programmable digital multiplexer-demultiplexer assembly using time division multiplexer (TDM) techniques to combine up to 12 serial digital data streams into one aggregate mission bit stream. Two independently programmable multiplexers and two independently programmable demultiplexers are included in the TD-1220. (See Figure 4.2.5.) Each MUX/DEMUX is programmable as to the number of channels, channel data rates, and aggregate data rates. In addition to the 12 serial digital data streams, each MUX/DEMUX accepts up to 15 low-speed telemetry or discrete (on/off) signals for remote signaling or monitoring. There are computer network monitoring system (CNMS) inputs. The independent programming also allows the TD-1220 to be used in a combined first and second level multiplexer arrangement.

3.3 The TD-1220 is synchronous, each MUX/DEMUX accepting a master clock at the desired aggregate rate and generating symmetrical channel clocks necessary for the 12 input channels. Advanced programming capability allows each channel rate to be independently selected within the guidelines of the ON230580 programming specification. Clock smoothing techniques are provided on the multiplexer and demultiplexer outputs to insure that channel clock symmetry is maintained.

3.4 Activity monitoring is provided for each individual input and output channel, by means of visual indicators on the front panel and by rear panel remoting connectors.

3.5 Built-in-test-equipment (BITE) provides the capability for internal self test and external loop test, for each multiplexer and demultiplexer. The instantaneous bit error rate is monitored by verifying the sync word originated by each multiplexer. The demultiplexer identifies errors in the sync word and initiates bit error rate alarm. An internally generated pseudo-random sequence may be transmitted by the multiplexer in place of regular data, allowing the demultiplexer to provide an error and clock output for directly reading the BER of the line.

3.6 The TD-1220 is enclosed in a shielded case which occupies 10.5" vertical space on a 19" rack. All assembly controls and indicators are located on the front panel (See Figure 4.5b). All input and output connectors (except for six test connectors on the front) are located on an interface panel located in a shielded compartment at the rear of the TD-1220.

3.7 The multiplexers are controlled by read-only-memories (ROM), which can be programmed for frame lengths of up to 512 bits, including the seven bit sync code. An extended frame of 2048 bits is also available. Each multiplexer requires an external (master) clock input, which is divided internally for channel clocking and synchronization. The output data is a serial stream at the master clock rate. An adjustable delay in the master clock pulse line provides variable phase delay for the output data.

3.8 Each demultiplexer is controlled by a ROM which can be programmed to compliment the multiplexer. Each demultiplexer provides up to 12 data and clock pulse channels which can be connected for differential or single-ended bipolar operation. Clock polarity is reversible as required, with the clock transition centered in the data bit.

4. Intended Application: The TD-1220 is being used in the Washington Area Wideband System (WAWS), and is projected for use in special DoD applications where varieties of data rates and formats require transmission.

5. Interface and Performance Characteristics:

Master clock rate:
Serial numbers 1-14: 8 Kb/s to 10 Mb/s
Serial numbers 15-above: 8 Kb/s to 12.928 Mb/s

Frame length:
Normal: up to 512 bits
Extended: up to 2048 bits

Demultiplexer acquisition time: 100 milliseconds (when BER is less than 10^{-3})

Serial data channels:
Number: 2 to 12 per MUX
Rate: 75 b/s to 6.5 Mb/s
Input Impedance: 75 ohms
Input levels: Differential signals of 25 millivolts or higher, not to exceed 6 volts
Format: Serial binary NRZ
Output impedance: 75 ohms
Output levels: $\pm$1.4 V P-P into 78 ohms

Discrete channels: 15, TTL compatible

Power Requirements:
TD-1220 -48 $\pm$4.8 Vdc at 12.5 A
TD-1226 115 $\pm$10 Vac, 47-500 Hz at 8 A.

Space requirements: 10 1/2" vertical on 19" rack

6. Date of Availability: Available now.

7. Documentation:
Specification: dual independent programmable MUX/DEMUX, purchase description T-1024, dated 23 June 1975, revised 3 March 1976.

Sperry-Univac manual PX-9124, Operation and Maintenance Instructions, TD-1220(V1)/G, (V3)/G, (V4)/G, (V5)/G, (V6)/G; TD-1226(V1)/G, (V2)/G, (V3)/G, (V4)/G, (V5)/G, Multiplexer-Demultiplexer.

Programming specification ON230580, 14 June 1976 (contract #MDA-904-76-C-0222).

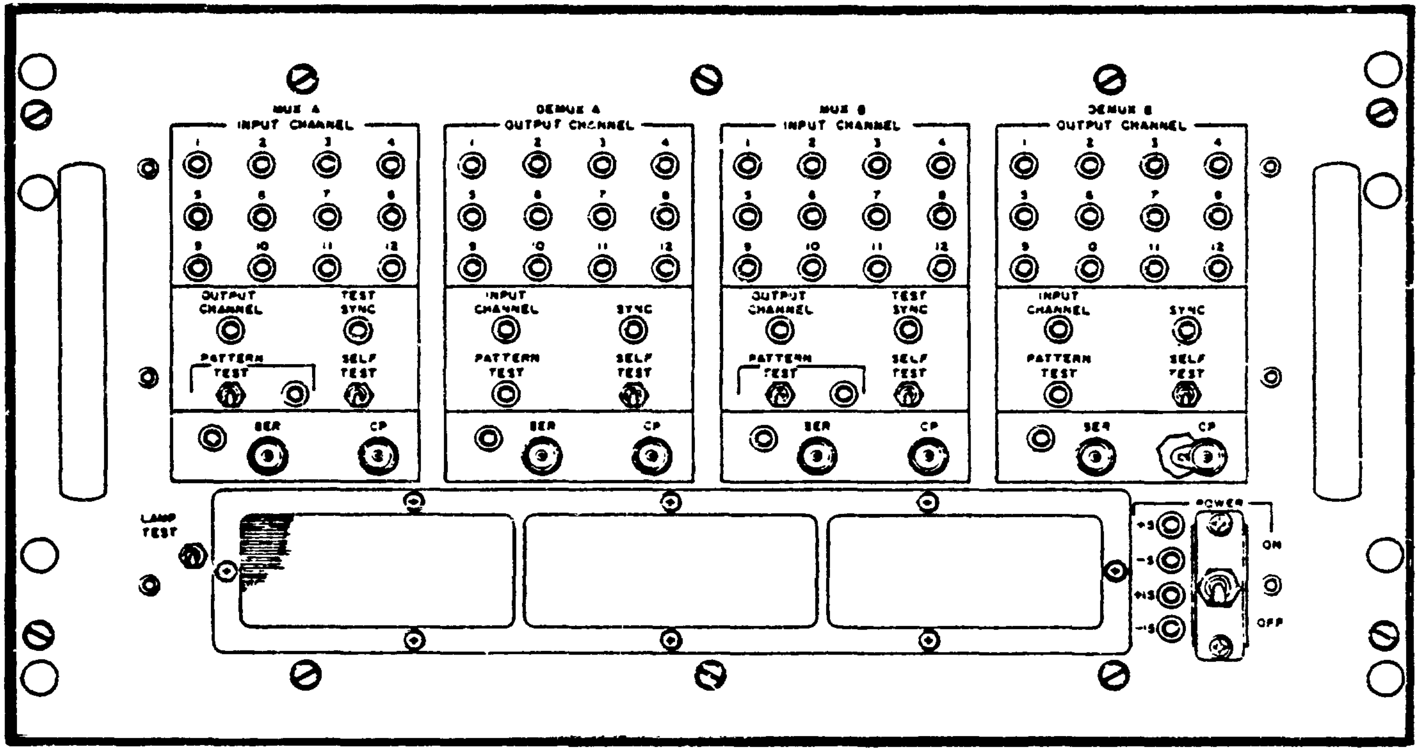


Figure 4.2.5 Front Panel and Control Layout, TD-1220 Multiplexer-Demultiplexer

Table 4.2.5 TD-1220/G and TD-1226/G Model Features

Model(s)	Features
TD-1220(V1)/G and TD-1226 (V1)/G (High Speed)	Provide for high-speed operation at up to 13 MHz master clock rate. Speed of 6.5 MHz is the maximum, however, for any one channel. There is no clock buffering on the V1 model.
TD-1220(V2)/G and TD-1226 (V2)/G (Discrete mux-demux)	Provide the capability of multiplexing and demultiplexing up to 15 discrete data bits on one channel.
TD-1220(V3)/G and TD-1226 (V3)/G (Double buffered clock)	Provide for the generation of two separate families of channel clock pulses.
TD-1220(V4)/G and TD-1226 (V4)/G (Discrete mux-demux and double buffered clock)	See V2 and V3 feature descriptions.
TD-1220(V5)/G and TD-1226 (V5)/G (Low speed - no options)	This is the original design and includes no options.
TD-1220(V6)/G (Low speed, double buffered clock)	Includes the same features as the V5 version plus the double buffered clock.

In addition to the features listed in the Table, four end-of-frame (EOF) signals, two data-out-of-sequence (DOOS) signals, and an over temperature signal are available at connectors on the rear of the V1 through V4 models. These signals are not available on the V5 or V6 models.

4.2.6 AN/FCC-98

1. Military Nomenclature: Multiplexer-Demultiplexer AN/FCC-98

2. Commercial Nomenclature and Other Names: Level 1 Multiplexer, Level 1 PCM Multiplexer, DRAMA Channel Bank. Also known as TD-1192( )(P)/F

3. Functional Description:

3.1 The AN/FCC-98 is a time division multiplexer capable of combining up to 24 channels of VF or data into a single NRZ or bipolar bit stream of 1.544 Mb/s. It is compatible with existing PCM terminals on an end-to-end basis when used in the pure VF version. It has the additional capability of allowing substitution of data channels for VF channels, in accordance with Table 4.2.6(a). The schematic layout of the AN/FCC-98 is shown in Figure 4.2.6.

3.2 Each voice channel of the AN/FCC-98 has E&M signaling included. Channels may be equipped in configurations of 3, 6, 12 or 24 channels, with corresponding output (mission bit stream) data rates of 192, 384, 768, or 1.544 kb/s.

3.3 Various configurations of the AN/FCC-98 are available to meet various requirements. Primary power options include -48 Vdc, or 115/230 Vac, 47 to 435 Hz. Data may be transmitted as NRZ or bipolar. Asynchronous data of 0-20 kb/s and 50 kb/s, or synchronous data of 56, 64, 128, 256 and 512 kb/s may be accommodated, as shown in Table 4.6A.

3.4 The AN/FCC-98 interfaces with the following equipment at the rates stated:

DIGITAL EQUIPMENTS	NOMINAL DATA RATES
KG-81	192, 384, 768, and 1.544 kb/s
AN/GSC-24	192, 384, 768, and 1.544 kb/s
T1-4008	1.544 kb/s
D2 or D3 Channel Bank	1.544 kb/s
HY-12 Channel Bank	1.544 kb/s (HN-74 required)
AN/GSC-26 or CV-3034	50 kb/s (Data Channel)

3.5 The coding technique utilized in the analog-to-digital conversion is typical, each VF channel being sampled at a rate of 8000 times per second and the resulting PAM sample converted to an eight-bit word corresponding to the nearest discrete amplitude of 256 possible values. The compressor/coder has a 15 segment characteristic which approximates a logarithmic law of the MU type with MU=255. Every sixth frame, the least significant bit of the 8-bit word is preempted for the signaling function, each VF channel unit having E&M capability built in. The input/output interface conditions for signaling are as follows:

	E Lead	M Lead
On-Hook	Open	Ground
Off-Hook	Ground	-48 Vdc

4. Intended Application: The TD-1192 will be used in the Digital European Backbone (DEB), Stages II through IV, and the Pacific Digitization Program (PDP). A special version compatible with the AN/GSC-24 will be utilized in the Defense Satellite Communications System (DSCS) Phase II, Stage 1c.

5. Interface and Performance Characteristics:

VF Channels:

Number: 3, 6, 12, or 24
Input/Output Impedance: 600 ohms ±10%
Input Level: 0 dBm or -16 dBm
Output Level: 0 dBm or +7 dBm
Idle Channel Noise: 23 dBrnC0 maximum
Signaling: M-Lead On-Hook Ground, Off-Hook -48 Vdc
E-Lead On-Hook Open, Off-Hook Ground.

Data Channels:

Asynchronous: 0-20 kb/s, 50 kb/s
Synchronous: 56, 64, 128, 356, or 512 kb/s
Format: NRZ Polar Square Wave, Data and Timing
Impedance: 78 ohm ±10% balanced (135 ohms ±10% balanced for the 0-20 kb/s Data Channels)
Input Levels: +0.2 to +7.0 V and -0.2 to -7.0 V
Output Levels: ±6 V ±1 V, open
±3 V ±0.5 V, terminated
Bit Error Rate
(Back-to-Back 50 kb/s): less than 10^{-7}

Multiplexed Output:
Rate: 192, 384, 768, or 1.544 kb/s
(3, 6, 12, or 24 channel configurations)
Format: NRZ Polar Square Wave, Zero Suppression optional. Bipolar operation is optional at the 1.544 Mb/s rate only.
Impedance: 78 ohm ±10% Bal (NRZ)
100 ohm ±10% Bal (Bipolar).

NRZ Output Level: ±3V ±0.5V when terminated
Bipolar Output Level: Logic "1" ±6V ±0.6V
Logic "0" 0V ±0.01V
Input Level: +0.2V to +7.0V
-0.2V to -7.0V.

Power Requirements: -44 to -56 Vdc
115/230 Vac, 47-420 Hz

Space Requirements: 19" vertical on 19" rack.

6. Date of Availability: January 1978.

7. Documentation for Detailed Information: See Table 4.2.6(b).

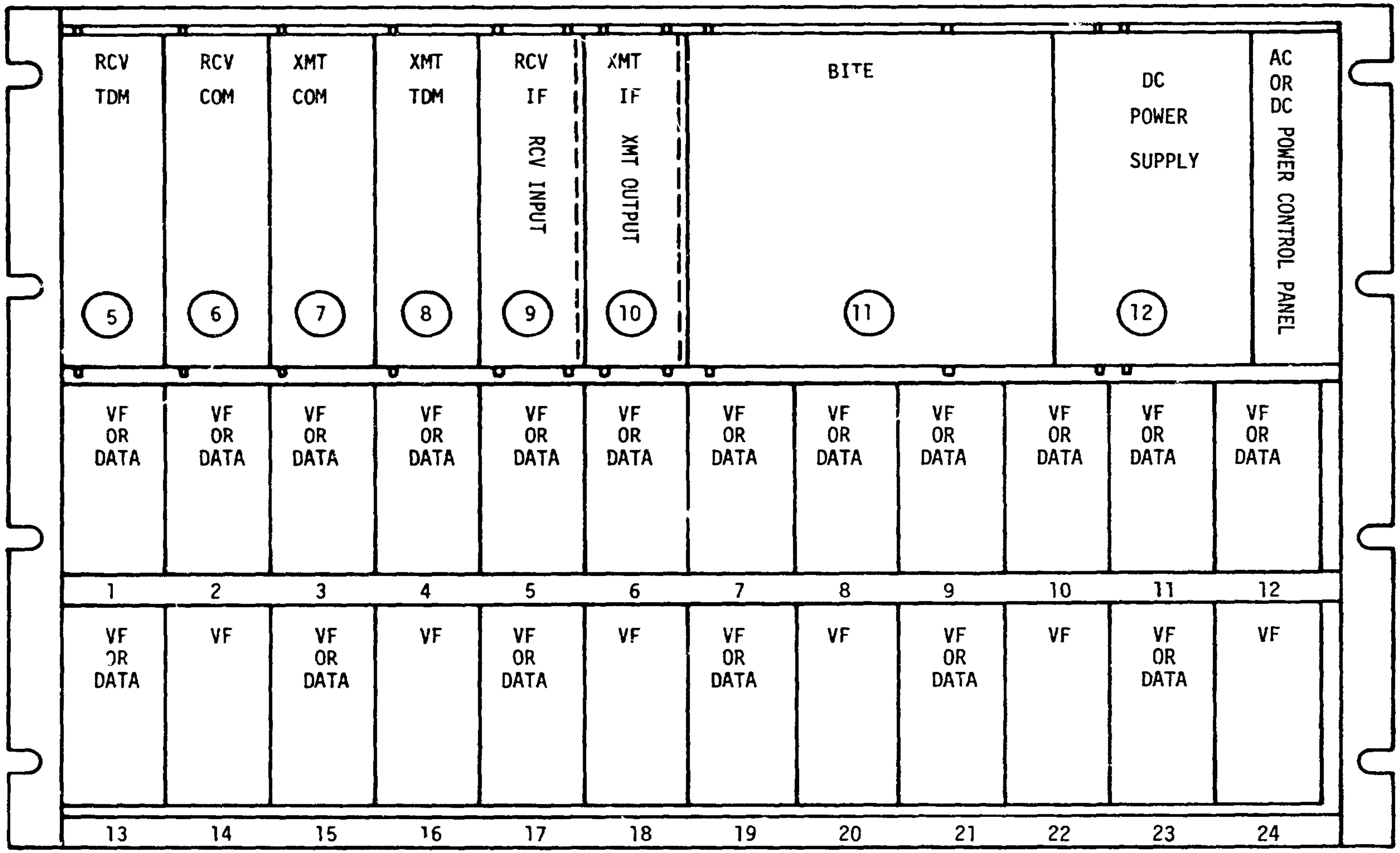


Figure 4.2.6 Schematic Layout of AN/FCC-98(V)

Table 4.2.6(a) Voice and Data Channel Configurations

Consideration	Equipment	Channel Slots			Selectable Options
		Req'd.	Install	Slot #	
Voice/signaling	VF Module	1	24	1-24	Input/output level (high or low)
0-20 kb/s asynchronous	0-20 kbps module	1	18	1-12, 13, 15, 17, 19, 21, or 23	None
50 kb/s asynchronolus	50kb/s module	1	18	as above	Input/ouput balanced or unbalanced.
56 kb/s synchronous	Multirate data module	1	18	as above	Clock source (internal or external) Channel slot (adjacent or alternate)
64 kb/s synchronous	as above	1	18	as above	as above
128 kb/s synchronous	as above	2	9	as above	as above
256 kb/s synchronous	as above	4	4	as above	as above
512 kb/s synchronous	as above	8	2	as above	as above

Table 4.2.6(b) List of Technical Publications

Maintenance Level	Type	Publication Number		
		USA	USAF	USN
Operator's and Organizational/Direct Maintenance	Operation. maintenance	TM 11-5805-711-13	T.O. 31W2-2F-111	Navelex 0967-LP-593-4010
Organizational and Direct Support	Repair part and special tools list	TM 11-5805-711-30P	T.O. 31W2-2F-114	Navelex 0967-LP-593-4040
General Support	Maintenance	TM 11-5805-711-4	T.O. 31W2-2F-112	Navelex 0967-LP-593-5010
	Repair part and special tool list	TM 11-5805-711-45P	T.O. 31W2-2F-124	Navelex 0967-LP-593-5040
Depot Level	Maintenance	TMWR-11-5805-711	T.O. 31W2-2F-113	Navelex 0967 LP-593-6010

4.2.7 TD-1193

1. Military Nomenclature: Multiplexer-Demultiplexer TD-1193 ( )/F.

2. Commercial Nomenclature and Other Names: Level 2 TDM, Second Level TDM.

3. Functional Description:

The Level 2 TDM multiplexer combines or decombines from two to eight nominal 1.544 Mb/s digital bit streams (digroups) into a single combined bit stream. The single digital bit stream at the combined side of the TDM shall be at rates which correspond to 2, 4, 6, or 8 digroups plus necessary overhead. The rates for 4, 6, and 8 digroups shall be 2, 3, and 4 times the rate for two digroups, respectively. For configurations in which 1, 3, 5, or 7 digroups are input to the TDM, the rate of the next higher even number of digroups shall be used. The TDM shall accept digroups whose timing is either synchrounous or asynchronous with respect to the TDM timing. Asynchronous digroups shall have an input bit rate tolerance of plus or minus 200 b/s and shall be transmitted using pulse stuffing techniques. Synchronous digroups shall be transmitted without pulse stuffing. The TDM shall also accept a single 3,088 Mb/s plus or minus 400 b/s stream in place of two digroups or a 6.176 Mb/s plus or minus 600 b/s stream in place of four digroups. The 3.088 Mb/s and 6.176 megabit bit streams shall be capable of transmission in either the syncronous or asynchronous mode.

4. Intended Application:

The TD-1193 will be used in the DEB Stages II-IV and in the Pacific Digitization Program.

5. Interface Characteristics:

INPUT:
- Up to 8 Ports
- 1.544 Mb/s, 3.0888 Mb/s, 6.176 Mb/s
- Synchronous or Asynchronous
- NRZ or Bipolar

OUTPUT:
- 3.232 Mb/s, 6.464 Mb/s, 9.696 Mb/s, 12.928 Mb/s
- Synchronous or Asynchronous
- NRZ or Bipolar
- Source Timing and Clock Signal

DATA HANDLING:
- BER$<10^{-9}$
- Loss of BCI >6 Hours in 10^{-2} BER
- Frame Sync <41 ms in 10-2 BER
- Sync Loss >24 Hours in 10^{-2} BER

ENVIRONMENT:
- 0 to 49°C Operating
- -40 to 68°C Nonoperating
- 0 to 95 Degrees Relative Humidity
- 15,000 Feet MSL
- -44 to -56 Vdc Input Power

6. Date of Availability: October 1979.

7. Documentation:

Specification for Multiplexer/Demultiplexer TD-1193 ( )/F Spec. No. CCC-74048, 1 March 1976.

4.2.8 Submultiplexers

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

4.3 MODEMS AND CODERS

4.3.1 MD-921/G Modem

1. Military Nomenclature: MD-921/G Digital Data Modem, Binary Phase Shift Keyed.

2. Commercial Nomenclature and Other Names: Harris Company Model 5222.

3. Functional Description:

The PSK modem provides a means of interfacing digital data over the Defense Satellite Communications System (DSCS). The modem converts between the baseband data signals required by a digital user and the modulated 70 MHz signals required by a satellite ground terminal. The modem has independent transmit and receive sections which provide the user with the capability of full duplex digital communication. The modem will process data at a rate between 19.200 kb/s and 9.9999 Mb/s. Self test, link test, and on-line fault monitoring functions are built into the modem. INT or EXT rate 1/2 error-correcting coders/decoders can be employed if required to improve the quality of the communications.

The modem employs differentially encoded binary phase shift keying which is coherently demodulated. The modem provides any rate between 19.200 kb/s and 9.9999 Mb/s with a maximum data rate of 4.9999 Mb/s when a rate 1/2 error correction coder is employed. The modem is capable of interfacing with the AN/MSC-46, AN/TSC-54, AN/TSC-86, AN/TSC-90, AN/FSC-9 and AN/MSC-61 class of earth terminals. The MD-921/G modem is interoperable with the MD-1002 (DSCS) and MD-944 (GMF) modems. The modem is designed to interface with an external KY-801 error correction coder and accept inputs from the AN/GSC-24 multiplex and the planned low/medium speed multiplex. For a remote user, the MD-921/G provides an ICF interface for the MD-920/G ICF modem.

4. Intended Application:

The MD-921/G is used in the Defense Satellite Communications System and in overseas terrestrial transmission.

5. Interface and Technical Characteristics:

5.1 Digital User Interface:

a. Direct Interface - via the MIL-STD 188 inputs and outputs of the modem.

b. Remote Interface - via 50 ohm coaxial cable, or 75 ohm balanced cable (requires an MD-920/G ICF modem at user end of cable).

c. Remote Interface - via line-of-sight microwave link (also requires ICF modem at user end of cable).

5.2 IF Interface Characteristics:

1. Modulator:

Power Level:	+10 dBm (terminated)
Impedance:	50 ohms + 10% unbalanced
Frequency Uncertainty:	± 1 kHz at 70 MHz
Frequency Output:	70 MHz center freq, double sideband suppressed carrier
Type Modulation:	Binary Phase Shift Keying (PSK)

2. Demodulator:

Acquisition Range:	± 5 kHz
Power Level:	-20 to -75 dBm and 0 to -55 dBm
Impedance:	50 ohms ±10% unbalanced
Bit Error Rate Performance:	Within 1.3 dB of theoretical differential encoded PSK for any selected data rate from E_s/N_0 = +3 dB to +11.5 dB.

5.3 Line-of-Sight Baseband Interface:

OUTPUT:

Power Level -12 dBm: (terminated)
Impedance:75 ohm ±10%

INPUT:

Power Level:-25 to -35 dBm (terminated)
Impedance:75 ohms ±10% balanced
Data Rate Range: 19.2 kb/s to 5.0 Mb/s.

5.4 Shielded RF Cable Interface

OUTPUT:

Power Level:	+23, +10 and 0 dBm (terminated)
Impedance:	50 ohms, ±10% unbalanced
	75 ohms, ±10% balanced
	75 ohms, ±10% unbalanced.

INPUT:

Power Level:	+ 5 to -15 dBm (terminated)
Impedance:	50 ohms ±10% unbalanced
	75 ohms ±10% balanced
	75 ohms unbalanced
Data Rate Range:	19.2 kb/s to 5.0 Mb/s.

5.5 Direct Interface

LINE DRIVERS AND RECEIVERS

Input/Output Voltage - positive and negative 6±1.5V open circuit (measured between signal pair).

Sense : One state, positive voltage; Zero state, negative voltage.

Source Impedance - 75 ohms ±10% balanced.

Waveshape : With 75 ohms ±10% resistive load, rise and fall times are 20 nanoseconds or less.

LINE RECEIVER INPUT

Impedance : 75 ohms ±10% balanced.

Line Receiver Sensitivity ±0.1 V MAX input required to cause correct shifting.

For the direct digital interface, the MD-921/G will either accept or provide clock to the data source, and provides both data and clock to the data sink.

6. Date of Availability: Available now.

7. Documentation:
   DTM #11-5820-803-12
   DTM #11-5820-802-20P
   DTM #11-5820-803-34
   DTM #11-5820-803-34P.

4.3.2 MD-1002 Modem

1. Military Nomenclature: MD-1002 Digital Data Modem Quadraphase/ Biphase Shift Keyed

2. Commercial Nomenclature and Other Names: Harris Corporation, Model 5228

3. Functional Description:

The Quadraphase/Biphase PSK Modem is designed for interfacing and transmitting digital traffic over a satellite communications link. Independent transmit and receive functions permit operation in NODAL terminals or other applications where send and receive rate and mode would be different. The modem is designed for use with forward acting, rate 1/2 error-correcting coders and provides 3-bit, soft-bit decision decoder interfaces.

The modem is full duplex, employing 70 MHz IF, coherent phase-shift keying with near-theoretical performance. Front panel switches select two-phase or four-phase operation with the QPSK mode utilizing staggered or offset modulation to conserve spectrum. Digital modulation rates are thumbwheel selectable. The modem will accept an input data rate of from 16.000 kb/s to 9.9999 Mb/s in the biphase mode and from 50 kb/s to 9.9999 Mb/s in the quadraphase mode. Differential encoding of digital data is employed. The modem is capable of interfacing with the AN/MSC-46, AN/TSC-54, AN/TSC-86, AN/TSC-90, AN/FSC-78, AN/FSC-9, and AN/MSC-61 class of earth terminals. The MD-1002 is interoperable, with the MD-921/G (DSCS) and MD-944 (GMF) and MD-945 (GMF) modems. The modem is designed to interface with an external KY-801 error correction coder and accept inputs from the AN/GSC-24 multiplex and the planned low/medium speed multiplex. For a remote user, the MD-1002 provides an ICF interface for the MD-920/G ICF modem. A typical BPSK configuration is shown in Figure 4.3.4(a), and a typical QPSK configuration is shown in Figure 4.3.4(b).

4. Intended Application:

The MD-1002 is used in the Defense Satellite Communications Systems and other satellite systems.

5. Interface and Technical Characteristics:

Operating Characteristics Data Rates:	Independent selection of transmit and receive rates 16 kb/s to 9.9999 Mb/s (slightly degraded performance down to 10 kb/s), biphase; 50 kb/s to 9.9999 Mb/s (operation to 19.998 Mb/s at direct MOD/DEMOD ports) quadraphase.
Performance :	At any selected data rate, ES/NO = 3 dB to 11.5 dB within 1.3 dB of theoretical, biphase; within 1.8 dB of theoretical quadraphase.

IF Interface: Staggered/Offset QPSK or BPSK, selectable at 70 MHz IF.

Power Level:

Modulator:	$\geq$+10 dBm into 50Ω
Demodulator:	-20 dBm to -75 dBm and 0 to -55 dBm into 50Ω, selectable.

Frequency Uncertainty:

Modulator:	$\pm$1 KHz
Demodulator:	$\pm$5 KHz or $\pm$25 KHz at 70 MHz, selectable.
Acquisition Time: (E_S/N_O 0 dB)	$\leq$ 45 seconds, biphase $\leq$ 200 seconds ($\pm$5 KHz) or 1000 seconds ($\pm$25 KHz), quadraphase (each mode has automatic sweep).

Baseband Interface:

Standard Inputs and Outputs:	$\pm$3 V balanced into 75Ω, $\pm$6 V open circuit.
External CODEC: (Direct MOD/DEMOD):	T175107A/T175109 (current mode, balanced).
Clock and Data:	Normal or inverted sense via internal switch selection.
Internal Clock:	Data rate clock with 1 in 10^6/s stability at the transmit side selected rate.

Data Accuracy	Accepts up to 250 p/m rate offsets (actual rate compared to dialed-up rate).
LOS/SHIELDED RF Cable Interface (ICF)	
Power Level	
Input:	-25 dBm to -35 dBm,(LOS), +5 dBm to -15 dBm,(Cable).
Outputs:	-12 dBm,(LOS),+23 dBm, +10 dBm, 0 dBm(cable), selectable.
Impedance:	50Ω ±10%, unbalanced 75Ω ±10%, unbalanced 75Ω ±10%, balanced.
Data Rates	16 kb/s to 5 Mb/s

6. Date of Availability: Available now.

7. Documentation:

   Reference Technical Brief I-SS-4103.

1.3.3 MD-920/G Modem

1. Military Nomenclature: MD-920/G Digital Data Interconnect Modem

2. Commercial Nomenclature and Other Names: NONE.

3. Functional Description:

   The ICF modem provides a means of interfacing digital data with a Digital Data-Phase Shift Keying MD-921/G Modem or MD-1002 Modem in a remotely located satellite communications terminal. The ICF modem converts between the baseband data signals required by a digital user and the signal format required for transmission over the interconnect facility link. The modem has independent transmit and receive sections which provide the user the capability of fully duplex digital communications. The modem will process data at any rate between 19.200 kb/s and 5.0000 Mb/s. Self-test and on-line fault monitoring functions are built into the modem. An external error-correcting coder/decoder can be employed if required to improve the quality of the communications.

   The MD-920/G functions as a digital driver for transmission of high rate digital signals over coaxial cable, as well as a means for converting NRZ data streams to a bipolar form for transmission over analog ICF's. The unit will interface, via the ICF, with either the MD-921/G or MD-1002 PSK modems, and on the user side with multiplex such as the AN/GSC-24.

4. Intended Applications:

   The MD-920 is used in the Defense Satellite Communications System and in overseas terrestrial transmission.

5. Interface and Technical Characteristics:

   Digital User Interface:

   Direct interface with a nearby digital user is accomplished via MIL-STD-188 inputs and outputs of the modem.

   Line Drivers and Receivers
   Output voltages - positive and negative 6 ±1.5 V open circuit (measured between signal pair).

   Sense: Zero state, negative voltage.

   Source Impedance: 75 ohms ±10%, balanced.

   Short Circuit Current: 0.1 or less.

Waveshape: with 75 ohms ±10% resistive load, rise and fall times are 20 nanoseconds or less.

Line Receiver Input

Impedance: 75 ohms ±10%, balanced.
Line Receiver Sensitivity: ±0.1 V MAX input required to cause correct switching.

Remote Site Interface:

a. Interface with a remotely located MD-921/G PSK modem via 50 ohm or 75 ohm coaxial cable, or 75 ohm balanced cable.

b. Interface with a remotely located MD-921/G PSK modem via a line-of-sight microwave link.

LINE-OF-SIGHT BASEBAND INTERFACE:

OUTPUT

Power Level:	-12 dBm (terminated)
Impedance:	75 ohms ±10%, unbalanced.

INPUT

Power Level:	-25 to -35 dBm (terminated)
Impedance:	75 ohms +10%, unbalanced
Frequency Range:	19.2 kb/s to 5.0 Mb/s.

SHIELDED RF CABLE INTERFACE

OUTPUT

Power Level:	+23, _10 and 0 dBm (terminated)
Impedance:	50 ohms ±10%, unbalanced.

INPUT

Power Level:	+5 to -15 dBm (terminated)
Impedance:	50 ohms ±10% balanced and unbalanced
Frequency Range:	19.2 kb/s to 5.0 Mb/s.

6. Date of Availability: Presently available.

7. Documentation:

DTM #11-5820-804-12
DTM #11-5820-804-34
DTM #11-5820-804-34P.

4.3.4 KY-801 Coder

1. Military Nomenclature: KY-801/GSC Encoder-Decoder

2. Commercial Nomenclature or Other Names: Linkabit LV 7017.

3. Functional Description:

The encoder-decoder provides coding and decoding functions to improve the reliability of transmission of digital data in satellite communications links. The encoder is connected to the modulator which produces two binary phase-shift keyed signals for each information bit input to the encoder. The decoder accepts the demodulator outputs, corrects errors in the output and generates one decoded information bit for each pair of received binary phase-shift keyed signals. The encoder-decoder provides full duplex digital communication and will process data at any rate from 0 b/s up to 10 Mb/s. The encoder-decoder has built-in test equipment for on-line and off-line self-tests. The encoder-decoder also generates a test signal which may be used for end-to-end testing.

The encoder-decoder employs a constraint length 7 convolutional encoder and Viterbi 3-bit soft decision decoder.

The encoder is capable of operation in three different satellite multiple access environments. The three modes are all programmable by use of soldered jumper wires:

1. Frequency division multiple access

2. Time division multiple access

3. Spread spectrum multiple access.

The encoder-decoder is also capable of operation with binary phase-shift keying modems, quadraphase-shift keying modems, or offset quadraphase-shift keying modems.

Specifically, the encoder-decoder will interface directly with the MD-921 BPSK and MD-1002 QPSK DSCS Modems, the AN/USC-28 SSMA DSCS Modem, and the projected PN/TDMA DSCS Modem.

4. Intended Application:

The KY-801 is used in the DSCS and in overseas terrestrial transmission.

5. Interface and Technical Characteristics:

The encoder-decoder and modem are interconnected accomplished via 75 ohm shielded, twisted-pair cables carrying balanced current mode signals. Driver and receiver circuit types and characteristics are as follows:

LINE DRIVER:	SM-A-699713-5 (Texas Instruments Type SNC55109J00)
Output Drive Current:	6 mw, typical
Source Impedance:	75 ohms, nominal
LINE RECEIVER:	SM-A-699713-4 (Texas Instruments Type SNC5510AJ00)
Input Sensitivity:	3 mw, typical
Input Impedance:	75 ohms, nominal
Data Rate Capability:	Any data rate from 0 to 10 Mb/s
Clock Signals:	Nominally one and zero for equal periods of time.

Required inputs to the encoder are data at rate R and clock at rate 2R. Outputs from the encoder are encoded data at rate 2R and synchronous clock at rate 2R. The decoder will accept either hard (1 bit) or soft (3 bit) decision data and clock at rate 2R and provide decoded data and synchronous clock at rate R.

6. Date of Availability: Presently available.

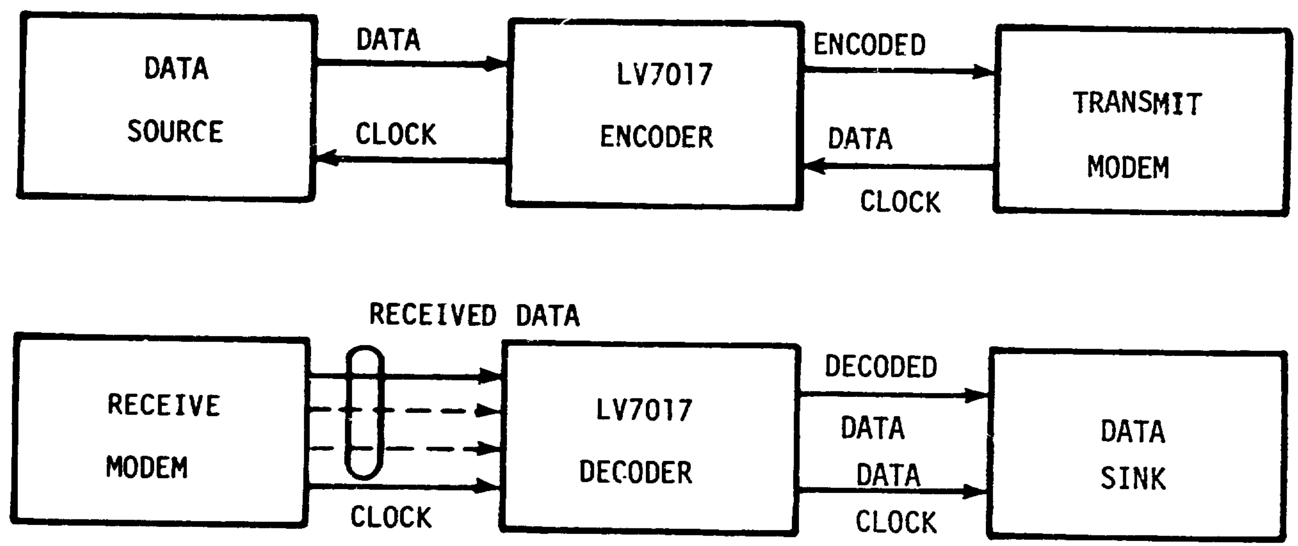


Figure 4.3.4(a) Typical Operating Configuration with BPSK or Other Serial Modem

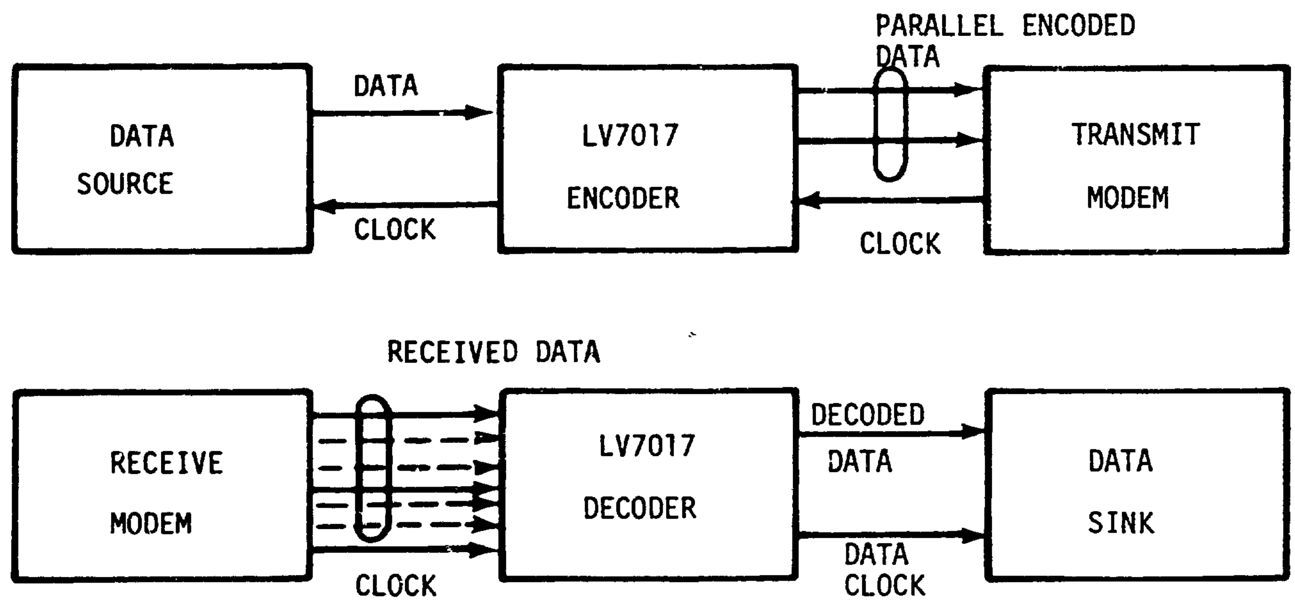


Figure 4.3.4(b) Typical Operating Configuration with OPSK (2 bit Parallel) Modem

4.4 ENCRYPTION DEVICES

4.4.1 Walburn Encryption Device

1. Military Nomenclature: TSEC/CI-3 (Walburn) Bulk Encryption Devic

2. Commercial Nomenclature or Other Names: NONE.

3. Functional Description:

Each TSEC interfaces with multiplexer, demultiplexer, and modems by means of eight pairs of wire. Three of the pairs are red, and are designated transmitter plain text (TPT) (i.e., MUX data to TSEC), receive plain text (RPT) (i.e., TSEC data to MUX), and receive plain text (RPTC). The remaining five (5) pairs are black. The five pairs are designated transmitter cipher text (TCT) (i.e., TSEC data to the trunk modem), transmitter cipher text clock (TCTC), receiver cipher text (RCT) (i.e., trunk modem data to TSEC). Receiver cipher text clock (RCTC), and black station clock (clock from the switch equal to the trunk data rate).

The receive section of the TSEC operates on the receive cipher text clock (RCTC) from the receive station of the trunk modem. This clock is used to sample the received cipher text (RCT) and after black/red buffering it clocks out the received plain text.

The transmit section operates from the black station clock (Trunk group rate). This clock is supplied as an output TCTC in phase with the transmit cipher text (TCT to the transmit section of the modem). The station clock is also supplied to the multiplexer so that it can produce transmit plain text (TPT) at the same frequency as the TSEC transmit clock. Because of the different path delay from the clock source to the multiplexer and then from the multiplexer to the TSEC, the TSEC contains a provision for selecting an optimum sampling point on the incoming PT data. If a sampling point is ambiguous relative to the time at which the data changes, it is possible to select a sampling point 180 away.

4. Intended Applications:

The TSEC/CI-3 is intended for the DSCS and for terrestrial transmission.

5. Interface and Technical Characteristics:

The data and clock signals have identical requirements for voltage levels, impedances, rise and fall times.

Data Rates:	9.6 kb/s to 7.68 Mb/s
Data and Clock Drive Signals (Output)	
Balanced Lines:	78Ω twisted pair
Voltage Levels:	A logic one or logic zero is defined by a differential voltage of at least 300 m. A polarity reversal of the differential voltage indicates a change in logic status. A logic one level is a positive differential voltage when measured with respect to the positive terminal.
Termination Impedance:	78Ω $\pm$10% (non-center tapped)
Capacitive Load:	$\leq$ 15 pF (on each of the two lines with respect to ground)
Rise and Fall Times:	$\leq$ 15 ns (when measured between the 10% and 90% levels of the signal).
Data and Clock Input Signals:	
Balanced Lines:	78Ω twisted pair terminated transmission line (RG-108A/U or equivalent).
Voltage Levels:	Same as output levels
Termination:	Same as output
Rise and Fall Times:	Same as output

6. Date of Availability: Presently available.

7. Documentation:

TT-A3-9002-0017A, Appendix III.

4.4.2 KG-81 Encryption Device

(TO BE FURNISHED AT A LATER DATE)

4.5 RADIO EQUIPMENT

4.5.1 AN/FRC-162(V)

1. Military Nomenclature: Radio set, AN/FRC-162(V)(1-5).

2. Commercial Nomenclature and Other Names: Similar to Collins MW-518 but modified to accept Quasi-analog baseband instead of FDM. Modification of the pilot frequency, removal of baseband filters, and translation of the service channel with inclusion of associated filters were the major changes.

3. Functional Description:

3.1 The radio set is a space diversity, dual channel, full-duplex, microwave line-of-sight transmitting and receiving radio terminal, operating on fixed frequencies in the 7125 to 8400 MHz super high frequency (SHF) band with a nominal 1 Watt RF output. The radio accepts a quasi-anlaog baseband signal known as three-level partial response, biternary, or duo-binary, at a rate of 12.5526 Mb/s, plus order wire and pilot signals. Figure 4.5.1 shows the schematic diagram of this radio set.

3.2 The AN/FRC-162 is configured to accept a baseband of up to 192 voice channels, or a combination of data and voice, at a rate of 12.5526 Mb/s in three-level partial response form. Specifically a multiplexer group OB-79(V) 1/FSC is used to combine the T1 outputs of up to eight TSEC/CY-104 multichannel ciphony systems, or T1WB1 wideband terminals, in any combination.

3.3 All radio sets AN/FRC-162 are functionally identical except for those components that determine the operating frequency band and associated filters, oscillators, and isolators.

3.4 The radio uses two complete transceivers, configured with either transmitter on-line and the other in hot standby. Transmitter switching can be initiated in three ways: Manually, by remote control, and automatically on occurrence of fault. Both transmitters and one of the receivers use one antenna, while a second antenna is dedicated to the second receiver, providing space diversity. The receiver outputs are compared and the best baseband signal is selected. Receiver switching can be initiated manually, by remote control, or automatically on occurrence of fault or comparative degradation of the on-line receiver.

3.5 The service channel is separate from the mission bit stream and is frequency modulated on an 8.1 MHz subcarrier. This signal and the 8.5 MHz radio pilot frequency are then mixed with the three-level partial response data stream (the 12.5526 Mb/s requires 6.3 MHz bandwidth) which has been band suppressed and attenuated. The combined signal modulates the 2 GHz oscillator, the output of which is amplified before being multiplied by two independent doublers, which brings the modulated carrier to the transmit RF frequency. Diode switches are used to select the output of one transmit filter, by attenuating the undesired transmitter. The transmitter switch output interfaces with a circulator to the antenna.

3.6 The receiver buffers the RF input with a preselect bandpass filter and an isolator, before combining it in the mixer/preamplifier with the local oscillator frequency to produce a 70 MHz IF. After equalization, amplification, and AGC action, the detected baseband is applied to one of a pair of sensor/logic/switch units (S/L/S). The basebands of the two receivers are compared and the better of the two signals is selected. The service channel is detected from the selected baseband.

3.7 The radio set is designed for permanent installation inside an equipment room and is housed in a single cabinet with access doors front and rear.

4. Intended Application:

The AN/FRC-162 is used at present in the Frankfurt-Koenigstuhl-Vaihingen (FKV) System, the European Wideband Communications System-selected link improvement program (EWSC-SLIP), the Bremerhaven-Garlstaat System (Brigade 75), and other systems in Germany. It will also be used in phase one of the Digital European Backbone (DEB) System being installed by the U.S. Air Force.

5. Interface and Performance Characteristics:

Frequency range:	7125 to 8400 MHz
Frequency stability:	0.0005%
Deviation:	
Pilot:	140 kHz rms
Supervisory:	700 kHz peak
Data:	3.14 MHz peak
Transmit Output Power:	
AN/FRC-162(V) (1-5):	+27 dBm minimum
AN/FRC-165(V) (1-4):	+37 dBm minimum
Return loss circulato our:	32 dB
Receive noise figure:	10 dB nominal, 12 dB maximum
Image rejection:	130 dB maximum
IF:	70 MHz
IF Bandwidth:	

Bandwidth	Loading:	Bit Error Rate at -71 dBm RSL
25 MHz	12.6 Mb/s	1 in 10^7

Baseband Levels	
Input:	
TDM:	$+2.5 \pm 0.5$ dBm
Supervisory:	-35 to -10 dBm
Output:	
TDM:	$+2.5 \pm 0.5$ dBm
Supervisory:	-15 ∓ 0.5 dBm
Pilot (TX in):	-24 dBm0
Service channel	
Input:	-15 to 0 dBm
Output:	-15 to 0 dBm

Impedance:	
TDM:	75 ohms, unbalanced
Supervisory:	75 ohms, unbalanced
Service Channel:	600 ohms, balanced
Return loss:	
Supervisory & TDM Baseband:	26 dB
Supervisory & TDM Baseband:	
Service:	20 dB

Frequency response

350 to 3000 Hz ± 3 dB (service channel)

300 Hz to 8 KHz ± 3 dB (supervisory)

300 Hz to 6.4 MHz ± 1.5 dB

Pilot:	8.5 MHz
Input Power:	
ac	120/240 V, 47 50 63 Hz
dc	44 to 56 V

Power Consumption:	AN/FRC-162(V)(1,3,4, or 5)	4 A @ 115 Vac
	AN/FRC-162(V) (2)	300 W (48 Vdc)
	AN/FRC-165(V) (3 or 4)	14 A @ 115 Vac
	AN/FRC-165(V) (1 or 2)	1000 W (48 Vdc)
Floor Space Required:	AN/FRC-162(V)(*)	24" x 25 1/2"
	AN/FRC-165(V)(*)	48" x 25 1/2"
	Maintenance Clearance	4' front, 3' rear

6. Date of Availability: Available now.

7. Documentation for Detailed Description:

TM-11-5820-836-14
TM-11-5820-836-24P.

8. Unique Characteristics:

8.1 The various configurations of the AN/FRC-162 differ in primary power option, cabinet size, and sensor/logic/switch functioning, according to the following matrix:

CONFIGURATION	PRIMARY POWER	CABINET SIZE	S/L/S
AN/FRC-162(V)(1)	ac	66"	Old
AN/FRC-162(V)(2)	dc	66"	Old
AN/FRC-162(V)(3)	ac	84"	Old
AN/FRC-162(V)(4)	ac	66"	New
AN/FRC-162(V)(5)	ac	84"	New

8.2 System changes in operational frequency alter the radio set configuration. A limited frequency change is possible by component replacement in the following ranges:

7.125-7.445 GHz
7.445-7.525 GHz
7.525-7.750 GHz
7.750-8.000 GHz
8.000-8.070 GHz
8.070-8.400 GHz.

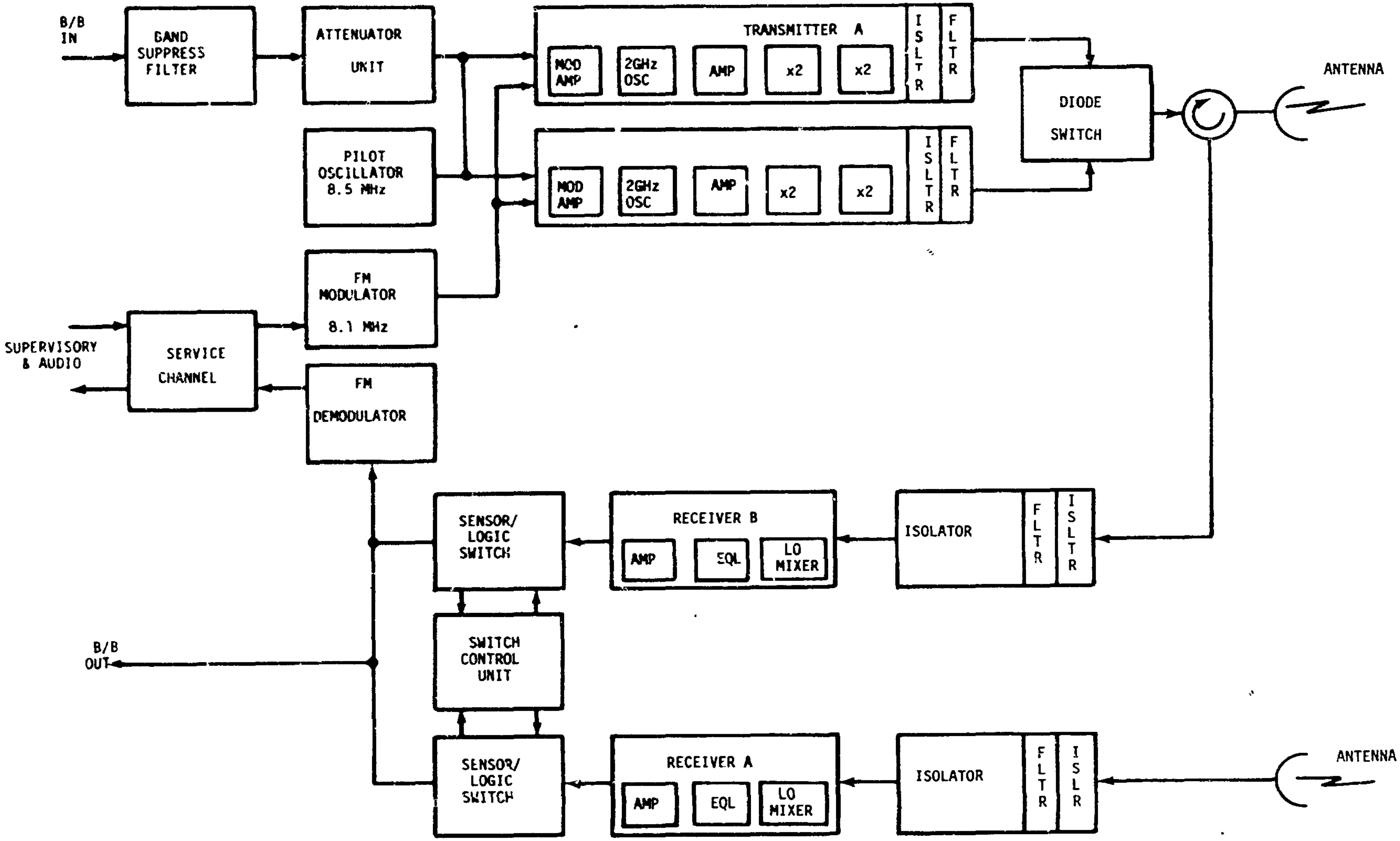


Figure 4.5.1 AN/FRC 162 Radio Set

4.5.2 AN/FRC-165

1. Military Nomenclature: Radio Set AN/FRC-165(V)( ).

2. Commercial Nomenclature and Other Names: None.

3. Functional Description:

3.1 The AN/FRC-165 radio set consists of an AN/FRC-162 radio set and an additional cabinet housing two 5 watt TWT amplifiers and related power supplies. It functions in the same way as the AN/FRC-162, with the addition of the TWT amplifiers to the transmit paths. The receive path is unaffected. The schematic diagram is shown in Figure 4.5.2.

3.2 The various configurations of the AN/FRC-165 offer optional AC or DC primary power source and either 84" or 66" cabinet height, in accordance with the following matrix:

CONFIGURATION	PRIMARY POWER	CABINET	S/L/S
AN/FRC-165(V)(1)	dc	66"	New
AN/FRC-165(V)(2)	dc	84"	New
AN/FRC-165(V)(3)	ac	84"	New
AN/FRC-165(V)(4)	ac	66"	New

4. Intended Application:

The AN/FRC-165 is intended for use in all applications listed for the AN/FRC-162, whenever additional output power is required for increased path reliability.

5. Interface and Performance Characteristics: (see Figure 4.14d).

6. Date of Availability: Available now.

7. Documentation for Detailed Description:

TM-11-5820-836-T4
TM-11-5820-836-24P

8. Additional Information:

8.1 The actual waveguide switch used in the AN/FRC-165 is different from the one used in the AN/FRC-162.

8.2 The 1 watt outputs of the A and B transmitters of the AN/FRC-162 are attenuated 20 dB before they are applied to the A and B TWT amplifiers.

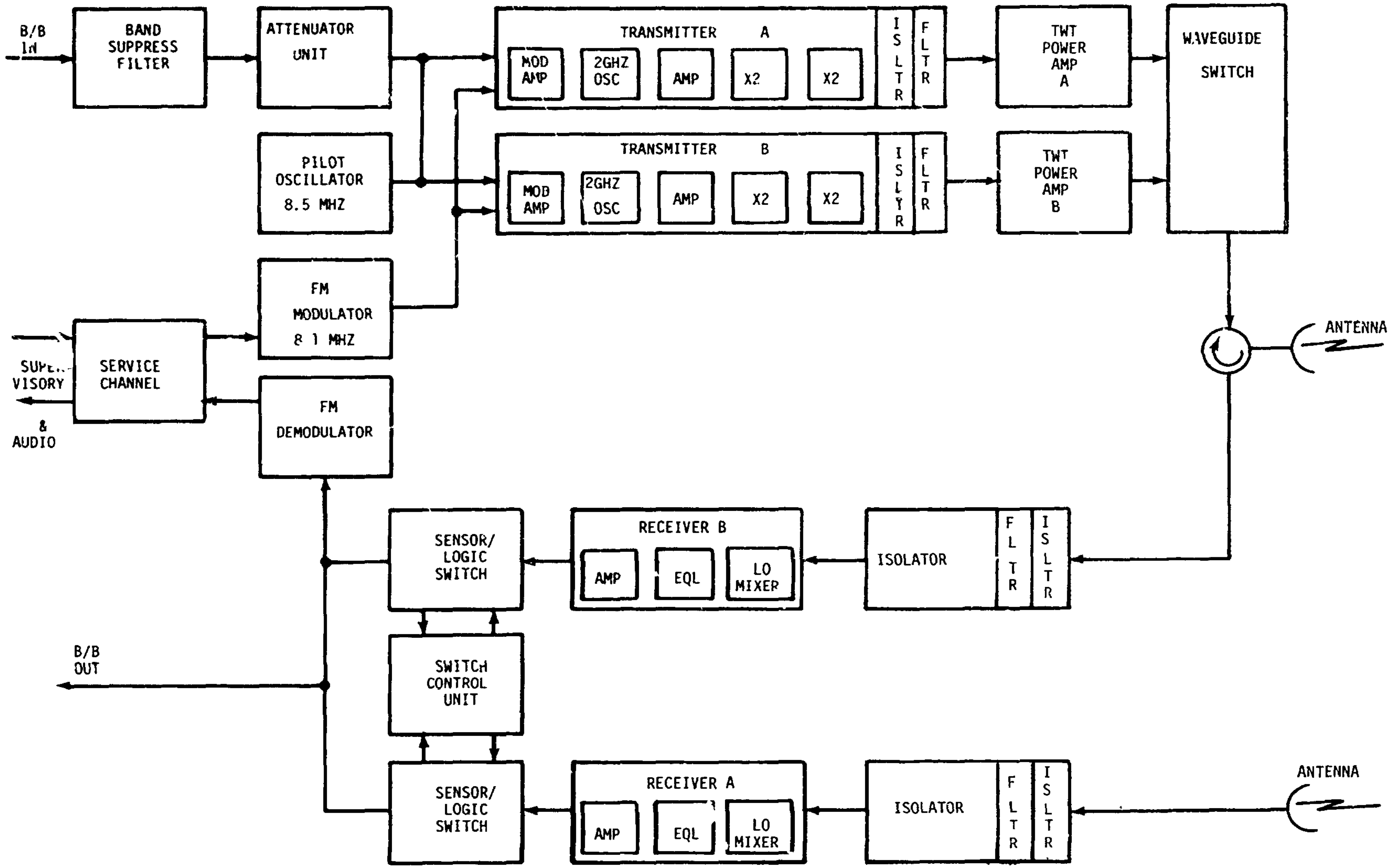


Figure 4.5.2 AN/FRC 165 Radio Set

4.5.3 Digital Tropo Modem

4.5.3.1 Model DAR IV

The all solid state Digital Tropo Modem provides low complexity, efficient, high speed data transmission over dispersive channels. Outstanding performance is achieved utilizing a new technique called Distortion Adaptive Receiver (DAR). Compatible with both tactical and strategic Troposcatter systems, it offers a variety of standard data rates and all diversity configurations.

4.5.3.2 Features:

1. Simple as line-of-sight modem yet provides optimum performance on most troposcatter systems.
2. Utilizes multipath distortion to enhance performance.
3. Integral maximal ratio diversity combining only one circuit board per diversity channel.
4. Coherent adaptive matched filter detection for optimum receiver efficiency.
5. All modular construction.
6. High capacity digital service channel.
7. Switch-selectable data rates from 256 kb/s to 2048 kb/s or 1.544 Mb/s to 6.3 Mb/s.
8. Built-in performance monitoring and rapid fault alarm and status indicators for ease of maintenance.

4.5.3.3 Application:

The DAR-IV is designed for use with existing or new troposcatter systems and provides a simple yet highly efficient means of high speed data transmission capability. Will accommodate any order of diversity channels by simple addition of a single module. Because of the unique nature of the matched filter detection, substantial in-band diversity gain is obtained. Quadraphase shift keyed (QPSK) waveform is used for high bandwidth efficiency. Typical Quad Diversity configuration is given in Figure 4.5.3.

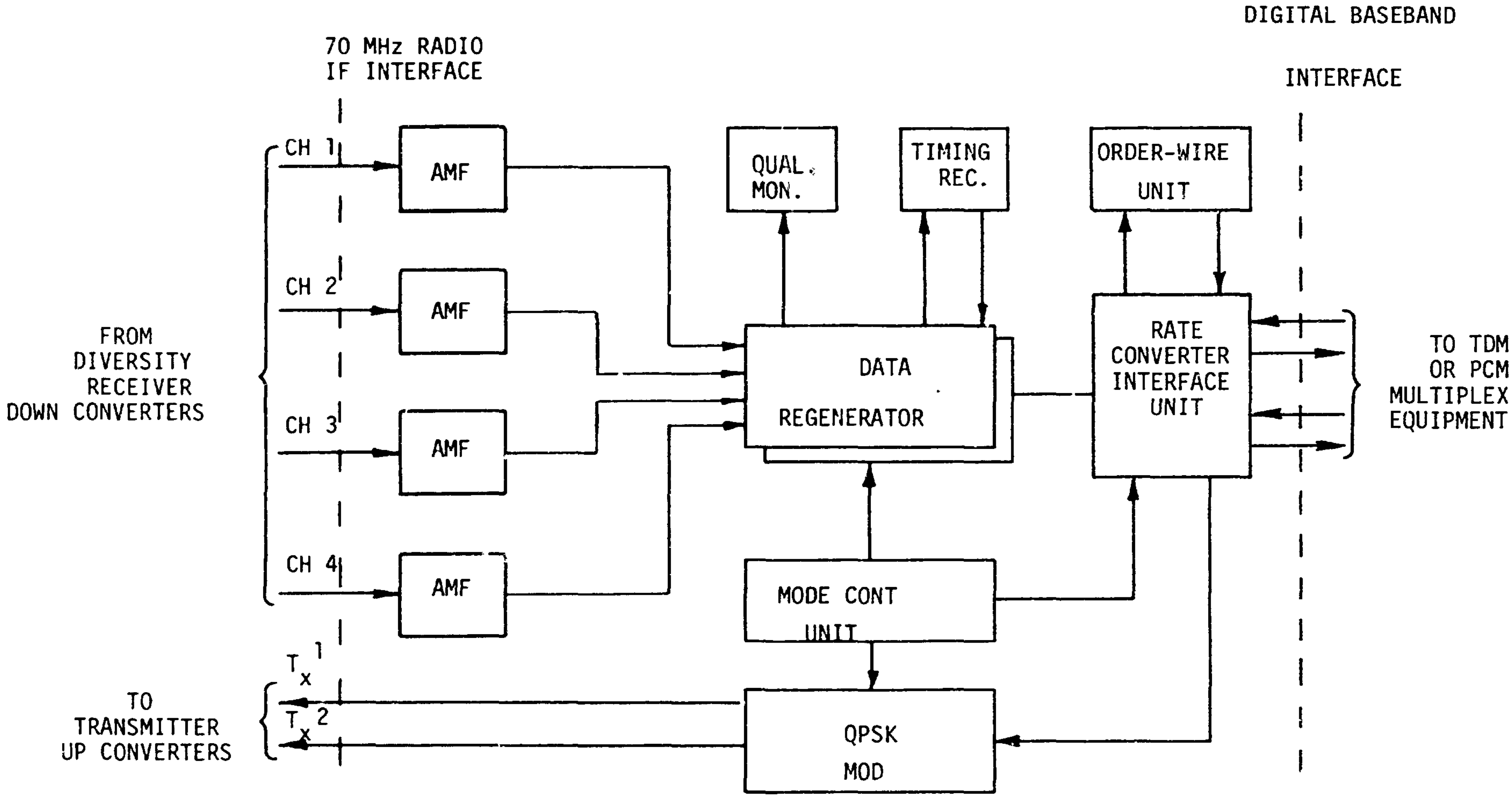
5. Interface and Performance Characteristics:

4.5.3.4 Specifications

Data Rates	256 Kbps to 6.3 Mbps, switch selectable, expandable to 12.6 Mb/s in parallel transmission mode.
Fade Rates	0.1 Hz to 100 Hz rms, doppler spread
Acquisition	Automatic
Diversity	Any order is practical
BER Performance	Back-to-back error rate better than 10^{-9}
Adaptive Dispersion Range	Up to two baud intervals with adaptive feedback equalizer
Data Interface	Syrchronous, TTL compatible
Received IF Signal	
Frequency	70 MHz nominal
Impedance	50 ohms
Level	-70 dBm to -20 dBm
Transmitter IF Outputs	
Frequency	70 MHz nominal
Level	0 dBm into 50 ohms
Waveform	Time gated QPSK (duty cycle variable for optimization for specific path dispersion)
Mounting	Rack mounted - standard 19"
Prime Power	210 W
Weight	70 pounds

6. Date of Availability: Available now.

7. Documentations for Detailed Description:



AMF = Adaptive Matched Filter Module

Figure 4.5.3 Typical Quad Diversity Configuration of DAR IV Digital Tropo Modem

4.5.4 High Frequency Radio Equipment

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

4.6 SATELLITE EARTH TERMINALS

4.6.1 AN/FSC-78 Earth Terminal

4.6.1.1 Military Nomenclature: AN/FSC-78(V) Satellite Communications Terminal.

4.6.1.2 Commercial Nomenclature and Other Names: Heavy Transportable

4.6.1.3 Functional Description:

The AN/FSC-78(V) is of fixed installed design with recovery (disassembly/reassembly) capability. The total weight of the AN/FSC-78(V) is approximately 425,000 pounds. A typical installation is shown in Figure 4.6.1(a).

The antenna subsystem consists of a parabolic type reflector 60 feet in diameter. The subreflector is a circular contoured, aluminum structure seven feet in diameter and supported by a quadripod assembly 18 feet above the antenna feed point.

The terminal is equipped with redundant cooled parametric amplifiers to provide a G/T of 39 dB. Also included are redundant interfacility link amplifiers (IFL) which are solid state and utilize Gallium Arsenide FET devices. Included in the recieve path is a power divider, a tracking converter, and up to 15 signal down converters. In the transmit direction, as many as nine up converter RF outputs are combined and amplified by redundant IFL amplifiers to feed redundant 5 kW, 500 MHz bandwidth TWT power amplifiers for an ERP of +124 dBm. Provision is made to combine the outputs of these amplifiers to obtain power equivalent to an 8 kW amplifier and an ERP of +127 dBm.

The AN/FSC-78(V) terminal can be wired to accept up to 15 down converters and nine up converters. Various sites differ only in the number of up/down converters actually supplied. The receive and transmit carrier capability for each site is tailored according to site mission.

Through the use of advanced design for performance, coupled with extensive selftest, redundancy, and automatic fault location, this terminal is able to achieve a high degree of operational availability, reliability, and ease of maintenance. A functional block diagram of the terminal is shown in Figure 4.6.1(b).

4.6.1.4 Intended Application: The AN/FSC-78(V) is used in overseas theaters and in the USA as part of the Defense Satellite Communications System.

4.6.1.5 Interface and Technical Characteristics:

Receiving System Figure of Merit, G/T:	39 dB
Reflector, Pedestal:	60 feet high efficiency Az-EL
Receive Frequency Band:	7.25 - 7.75 GHz.

Transmit Frequency Band:	7.9 - 8.4 GHz
Polarization:	Receive-LHC, Transmit-RHC
Simultaneous Communications Carriers:	9 max transmit, 15 max receive
Beacon CArrier:	3 max receive; only one is useable at a time
ERP:	+124 dBm, normal mode +127 dBm, high power mode
Intermediate Frequency:	70 MHz and 700 MHz
Amplitude Response:	70 MHz: ± dB/10 MHz ± 2B/40 MHz 700 MHz: +1 dB/60 MHz +2 dB/125 MHz
Phase Linearity:	70 MHz: ±0.25 rad/40 MHz +0.15 rad/60 MHz 700 MHz: ±0.15 rad/60 MHz +0.4 rad/125 MHz
Tunability:	500 MHz (1 kHz increments)
Redundancy:	All subsystems except antenna
Fault Location:	Automatic
Frequency Control:	Atomic (cesium) standard derived, synthesizer controlled
Carrier Power Level Control:	Automatic or manual
Multiple Access Capability:	FDMA, SSMA, TDMA
IF Interfaces (transmit and receive)	70 MHz (40 MHz bandwidth), 700 MHz (125 MHz bandwidth)
Transmitter:	
Power Amplifiers:	Redundant 5 KW TWT's. Combinable for high power operation
Receiver:	
Low Noise Preamplifier:	Redundant, cryogenically cooled, 500 MHz bandwidth paramps
Prime Power Requirements:	230 KVA, 280/120V, 50/60 Hz

Frequency Conversion (Up/Down Converters:
Up to nine up converters
Up to 15 down converters.

Redundant Switchover:	Automatic <250 ms
Life Expectancy:	15 years
MTBF:	1000 hours
MITTR:	1 hour

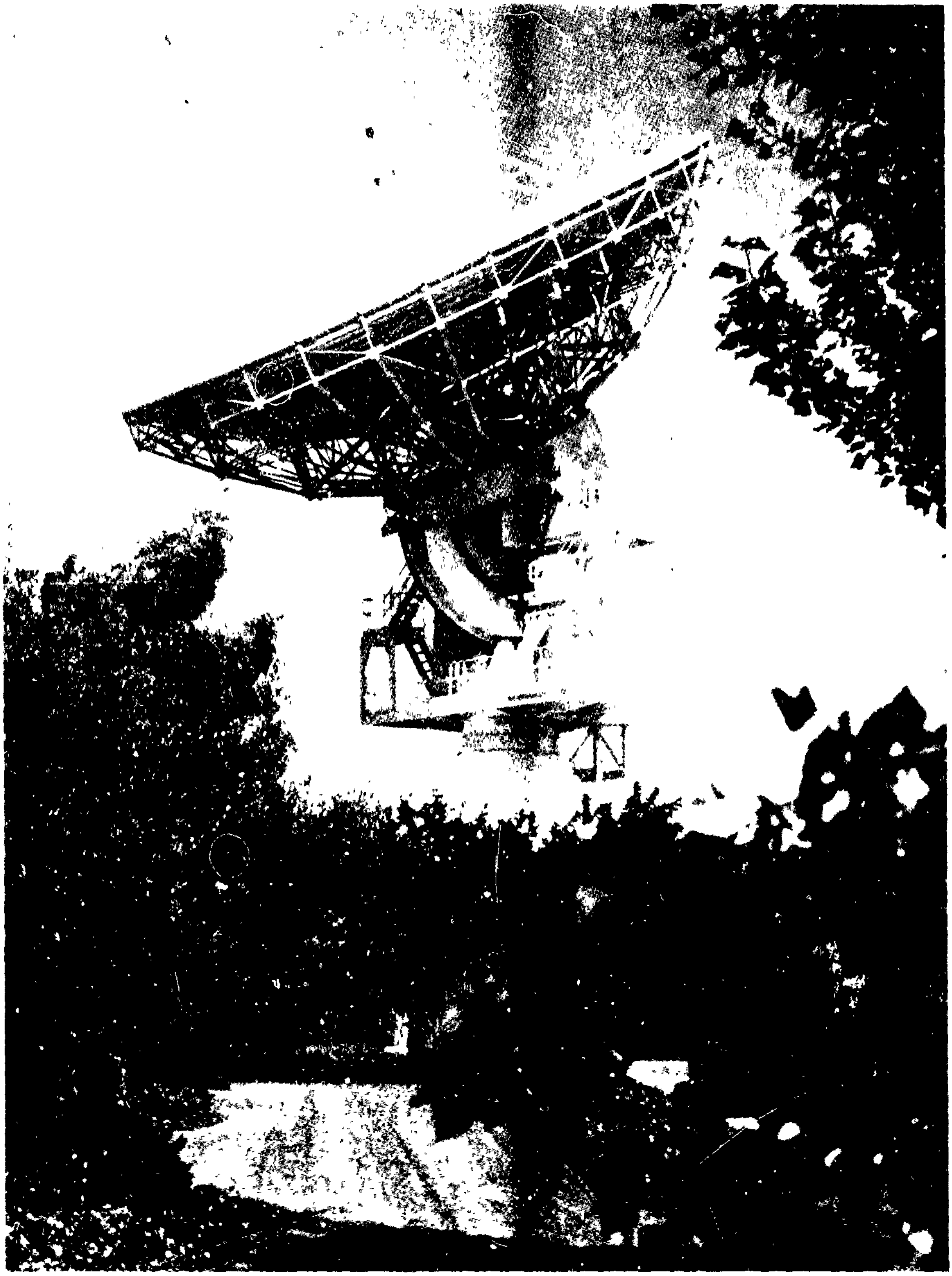


Figure 4.6-1(a) AN/FSC-78(V) Earth Terminal

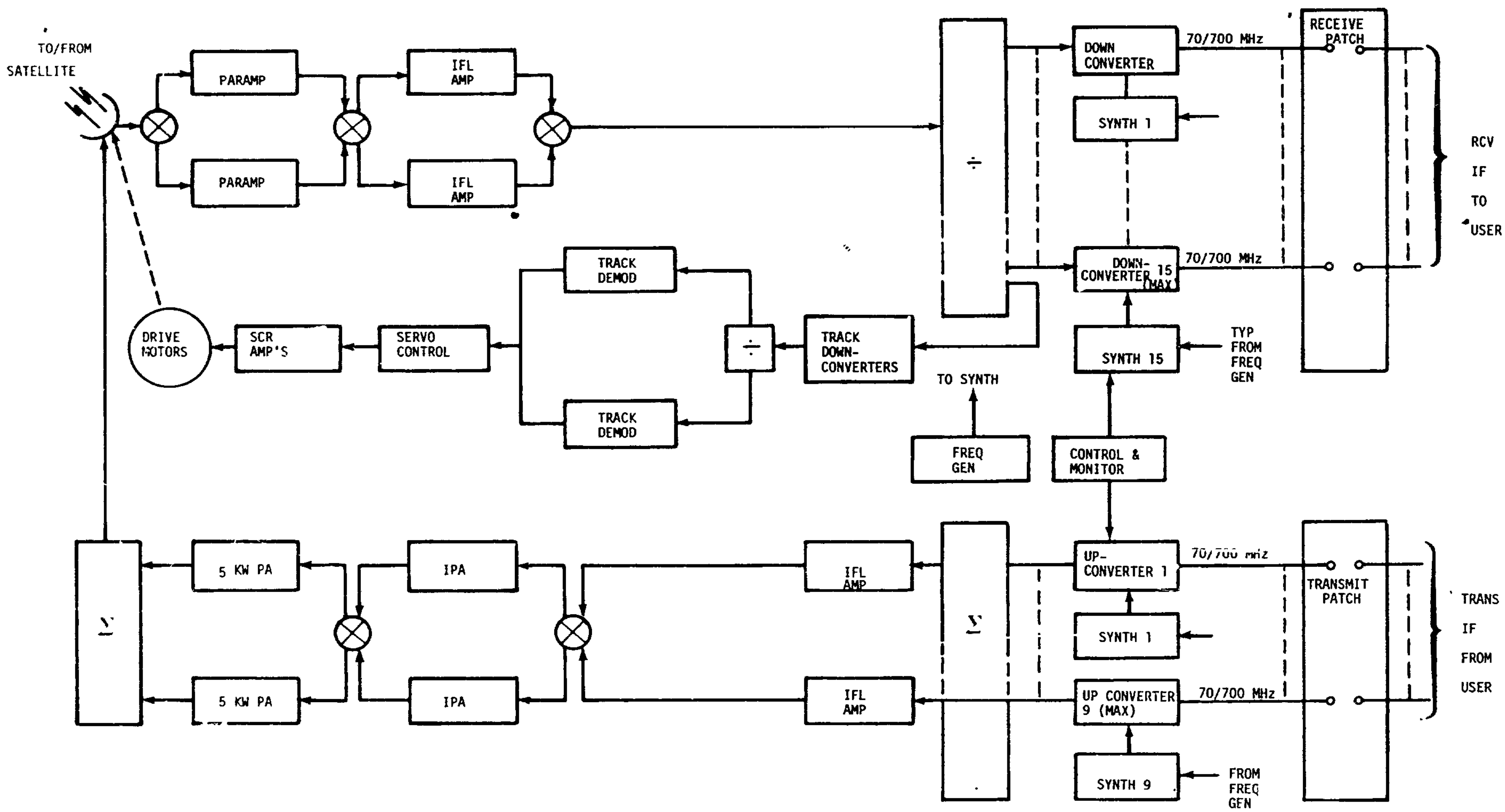


FIGURE 4.6.1(b) AN/FSC-78 DSCS TERMINAL FUNCTIONAL BLOCK DIAGRAM

4.6.2 AN/FSC-9 Earth Terminal

4.6.2.1 Military Nomenclature: AN/FSC-9

4.6.2.2 Commercial Nomenclature and Other Names:

4.6.2.3 Functional Description:

The AN/FSC-9 is a large, fixed satellite communications terminal which employs a 60 foot parabolic antenna. There are two existing terminals of this type, one located at Fort Dix, New Jersey and the other at Camp Roberts, California. An installation is shown in Figure 4.6.2(a).

The RF transmitter consists of from one to six up converters, exciter (TWT driver), and a power amplifier (Klystron). A 70 MHz input signal from the terminal equipment is converted to X-band and amplified to a power output of up to 11.5 kW.

The microwave receive subsystem consists of a cooled low noise preamplifier and from 1 to 15 down converters to provide signals to demodulators and beacon receivers for the generation of communications and tracking signals. The tracking and servo system provides acquisition and automatic tracking capability.

The terminal equipment provides both the modulation and demodulation functions. The AN/FSC-9 is equipped with both FM and spread spectrum (psuedonoise-PN) modulation equipment. A total of 12 incoming user voice channels can be accepted by the multiplex equipment for operation in the FM mode. Four voice channels and a digital signal of up to 4800 bps can be provided using the PN equipment. A functional diagram is shown in Figure 4.6.2(b).

4.6.2.4 Intended Application: The AN/FSC-9 is used in the Continental United States (CONUS) in the Defense Satellite Communications System.

4.6.2.5 Interface and Technical Characteristics:

Receiving System Figure of Merit, G/T:	36.5 dB
Effective Radiated Power, ERP:	126 dBM
Antenna:	60 foot diameter parabolic reflector with Cassegrain feed. No random is used.
Transmitter:	
Frequency Range:	7.9 GHz to 8.4 GHz (limited by Klystron tuning range)
Bandwidth:	125 MHz
Maximum Output Power:	5 kW

Receiver:	
Frequency Range:	7.25 GHz to 7.75 GHz
Bandwidth:	50 MHz (down converter); 500 MHz (paramp)
Prime Power Requirements:	700 kW, 60 Hz

4.6.2.6 Date of Availability: Available now.

4.6.2.7 Documentation: Digital Communications Subsystem, Appendix A, 1 July 75, United States Army Satellite Communications Agency.

Figure 4.6.2(a) AN/FSC-9, 20 kW Fixed-Station Terminal, 60-Foot Antenna

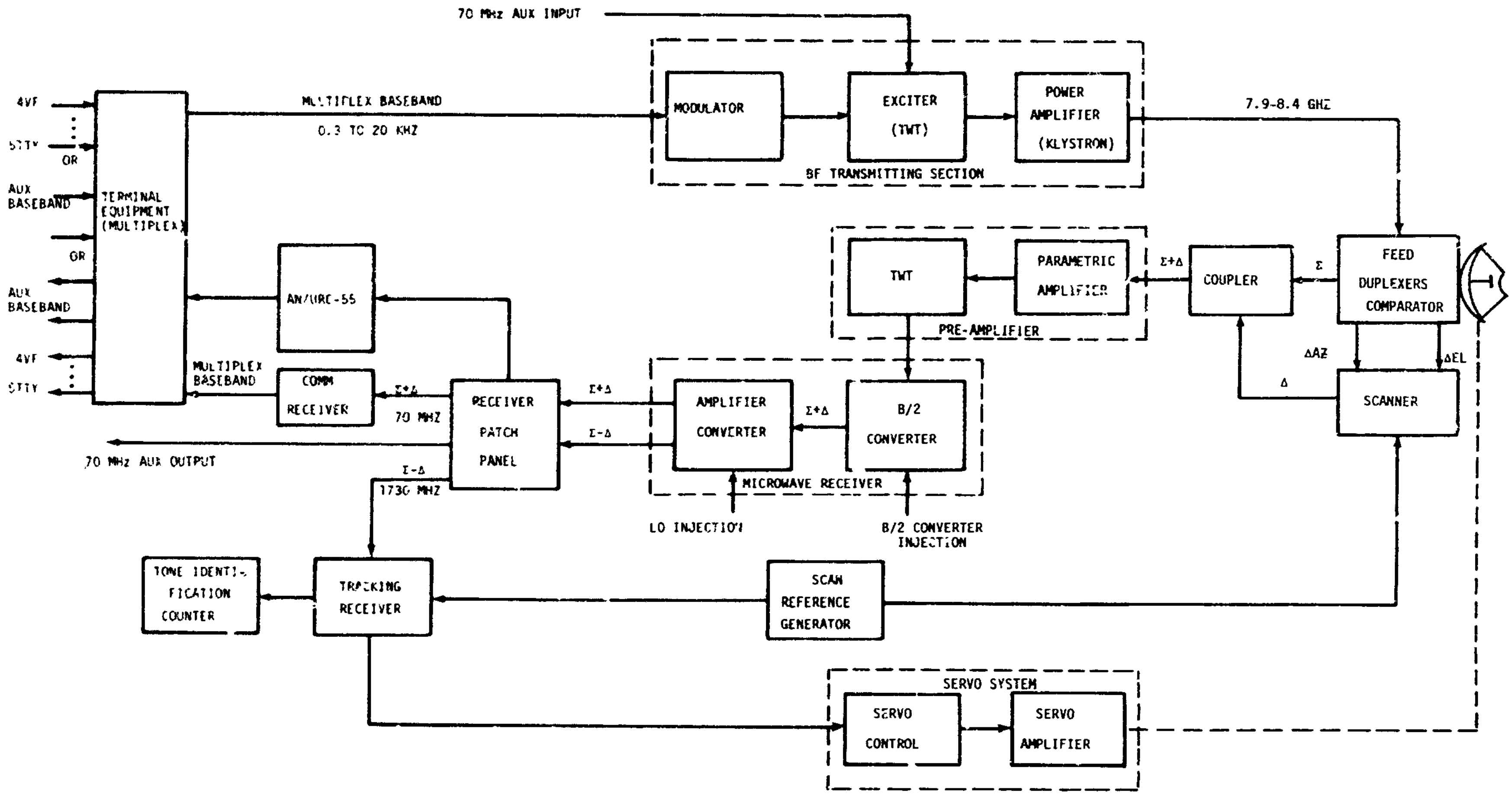


FIGURE 4.6.2(b) AN/FSC-9 - Simplified Functional Diagram

4.6.3 AN/TSC-54 Earth Terminal

4.6.3.1 Military Nomenclature: AN/TSC-54

4.6.3.2 Commercial Nomenclature and Other Names: NONE.

4.6.3.3 Functional Description:

The AN/TSC-54 is a transportable satellite communications earth terminal. The terminal equipment includes an antenna structure which houses the RF components of the terminal, and a van which houses support communications and control equipment and the operating personnel. The antenna, with an effective 18 foot diameter, uses a cloverleaf arrangement of four parabolic dishes. The antenna can be folded for aircraft transport and can be wheel mounted for road travel. The AN/TSC-54 is shown in Figure 4.6.3.(a) and a typical ETC using this earth terminal is shown in Figure 4.6.3(b).

The RF interface with the van is at 70 MHz transmit and 70 MHz receive. The transmitter consists of from 1 to 3 up converters, a TWT exciter and a klystron high power amplifier. The receiver consists of a low noise preamplifier and from 1 to 3 down converters for the generation of communications and tracking signals. The tracking and servo system provides acquisition and automatic tracking capability.

The AN/TSC-54 terminal can be equipped with both FM and spread spectrum (pseudonoise-PN) equipment. The AN/TSC-54 can handle in contingency mode 12 voice channels with provisions for up to 72. In the PN mode one voice channel plus one PSK TTY orderwire, or one 16 channel TTY package, or digital data up to 4800 b/s can be accommodated.

4.6.3.4 Intended Application: The AN/TSC-54 will be used overseas in the Defense Satellite Communications Program.

4.6.3.5 Interface and Technical Characteristics:

Figure of Merit, G/T:	26 dB
Effective Radiated Power, ERP:	118 dBm
Antenna and Radome:	18 foot effective diameter cloverleaf arrangement. Rigid radomes are used at some locations.
Transmitter:	
Frequency Range:	7.9 to 8.4 GHz
Instantaneous Bandwidth:	50 MHz (Power Amplifier)
Maximum Output Power HPA	8 kW
LPA	1.3 kW.
Receiver:	
Frequency Range:	7.25 to 7.75 GHz
Bandwidth:	500 MHz.

4.6.3.6 Date of Availability: Available now.

4.6.3.7 Documentation: Digital Communications Subsystem, Appendix A, 1 July 75, United States Army Satellite Communications Agency.

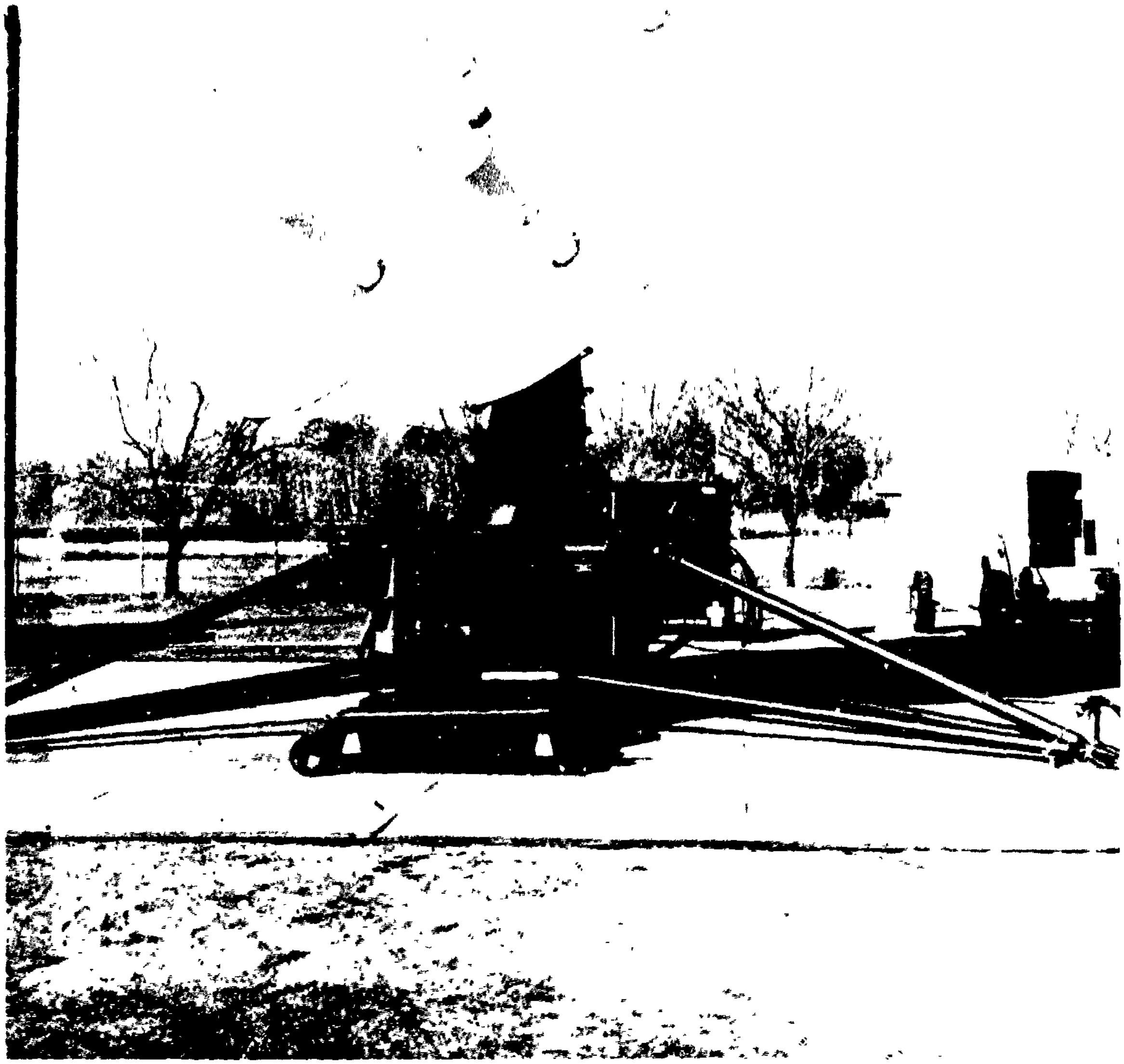


Figure 4.6.3(c) The AN/TSC-54, Highly Transportable Terminal,
With Cloverleaf Antenna Which Is Equivalent to an 18-Foot Diameter Reflector

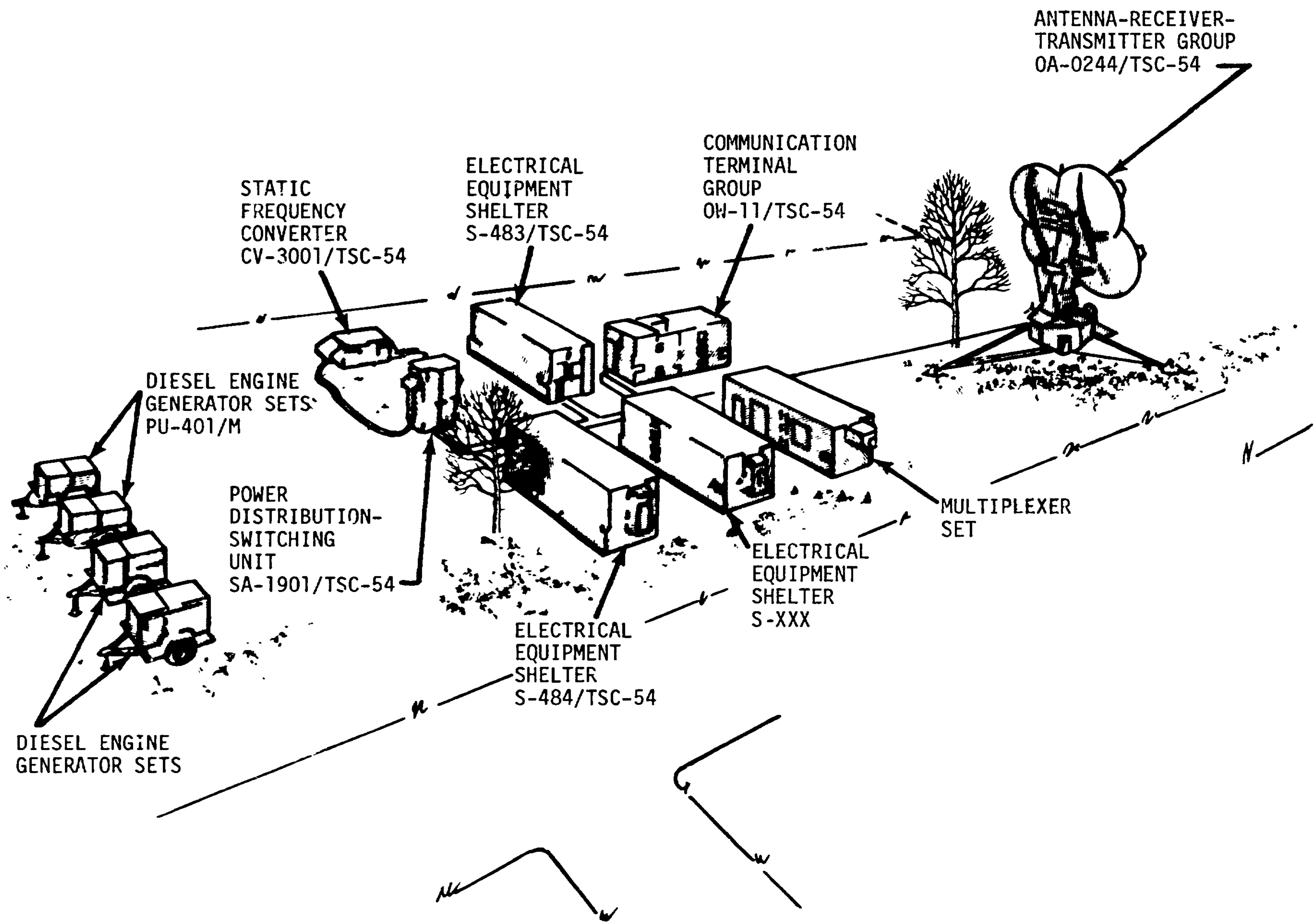


Figure 4.6.3(b) Typical ETC Using the Satellite Communications Terminal AN/TSC-54

4.6.4 AN/MSC-46 Earth Terminal

4.6.4.1 Military Nomenclature: AN/MSC-46

4.6.4.2 Commercial Nomenclature and Other Names: None

4.6.4.3 Functional Description:

The AN/MSC-46 is a movable satellite communications earth terminal. It is mounted in four air transportable wheeled vans. A 40 foot parabolic antenna is mounted on a transportable pedestal and contains the low noise receiver.

The RF transmitter consists of from 1 to 6 up converters, intermediate power amplifier, and the low power amplifier or high power amplifier. A 70 MHz FM or spread spectrum pseudonoise (PN) signal from the modulation equipment is up converted to X-band, amplified and applied to the antenna. The receive section consists of a cooled low noise preamplifier and from 1 to 15 down converters to provide signals to the demodulators and beacon receivers for the generation of communications and tracking signals. The tracking and servo system provides aquisition and automatic tracking capability.

The AN/MSC-46 terminal may be equipped with both FM and spread spectrum (pseudonoise-PN) modulation equipment. In the non-nodal configuration, the terminal can handle 12 channels with provisions for 24. In the nodal configuration, the terminal can handle 60 channels. The PN equipment processes a baseband of up to four voice channels and digital signal of up to 4800 b/s.

4.6.4.4 Intended Application: The AN/MSC-46 is used overseas in the Defense Satellite Communications System. A typical installation is shown in figure 4.6.4 (a).

4.6.4.5 Interface and Technical Characteristics:

Figure of Merit, G/T:	33 dB (with Radome)
Effective Radiated Power, ERP:	124 dBm
Antenna and Radome:	40 foot diameter reflector with a Cassegrain feed system which uses dielectric loading between the feed horn and the subreflector to improve efficiency.
Transmitter:	
Frequency Range:	7.9 to 8.4 GHz
Bandwidth:	125 MHz (with high power amplifier); 500 MHz (with low power amplifier)
Maximum Power Output:	8 kW (HPA); 2 kW (LPA)
Receiver:	
Frequency Range:	7.25 to 7.75 GHz
Bandwidth:	500 MHz

4.6.4.6 Date of Availability: Available now.

4.6.4.7 Documentation: Digital Communications Subsystem, Appendix A, 1 June 66, United States Army Satellite Communications Agency.

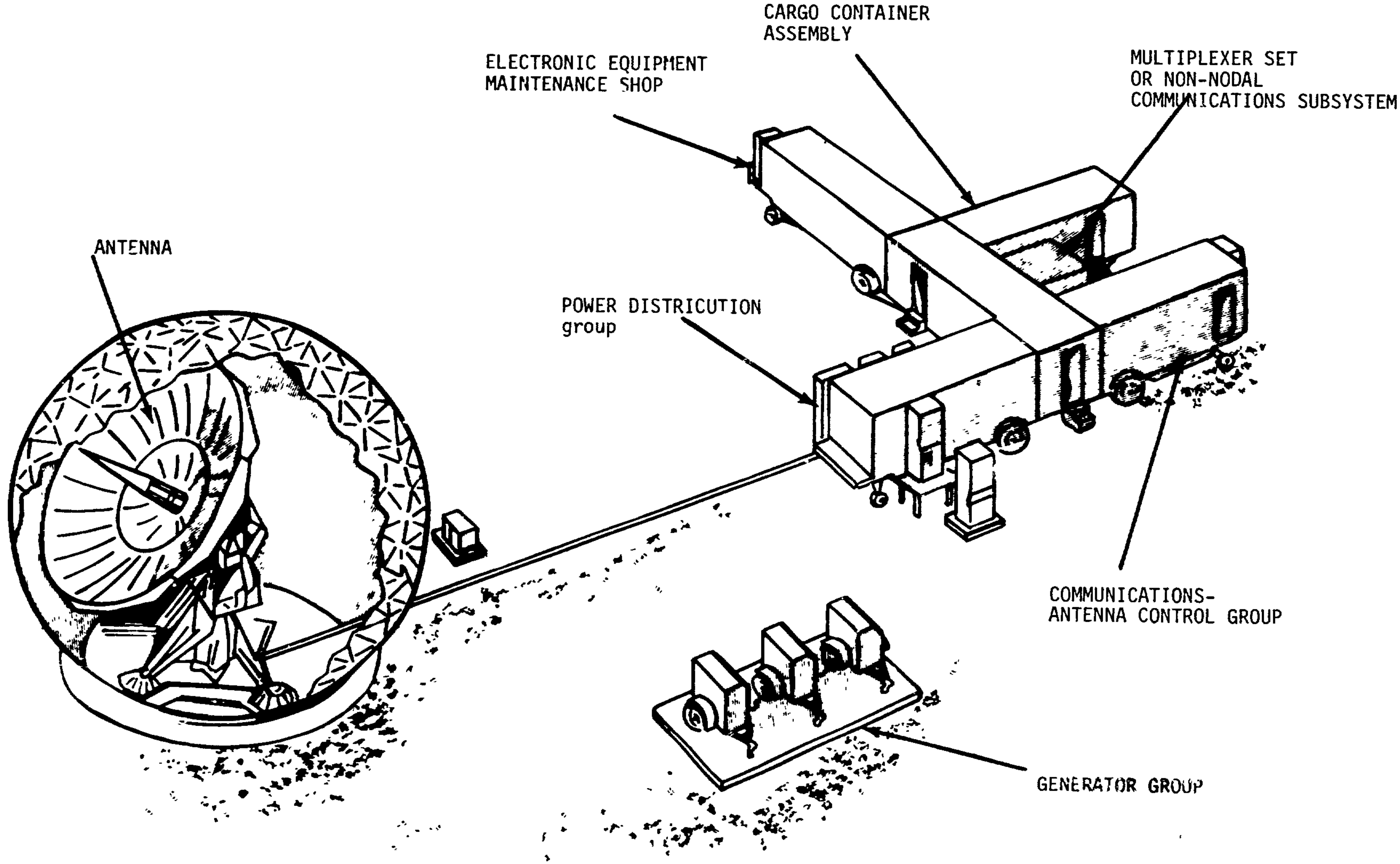


Figure 4.6.4(a) Typical ETC Using the Satellite Communication Terminal AN/MSC-46
(Nodal and Non-Nodal)

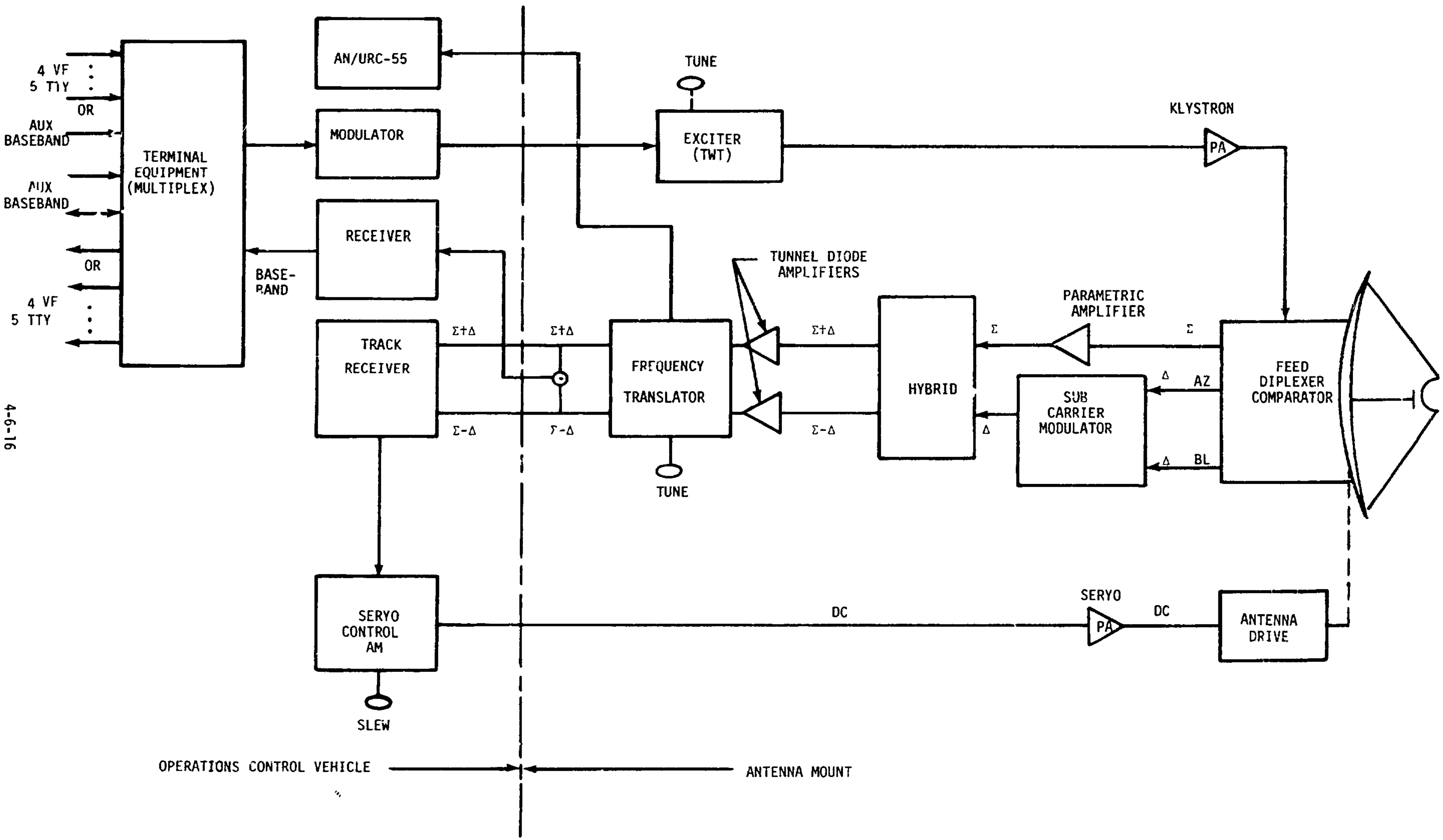


Figure 4.6.4(b) AN/FSC-46 Simplified Functional Diagram

4.6.5 SCT-21 Earth Terminal

4.6.5.1 Military Nomenclature: None

4.6.5.2 Commercial Nomenclature and Other Names: SCT-21

4.6.5.3 Functional Description:

The SCT-21 is a transportable satellite communications earth terminal. It is commercial, non-militarized and intended for non-militarized use.

The terminal is capable of accepting 4 kHz analog voice channels, 2400 b/s data channels modulated onto a 4 kHz channel wire line and TTY channels from up to 20 user lines and provides a minimum compatibility to relay up to four of the 4 kHz channels including two TTY channels, up to 50 kb/s of digital data on a single carrier frequency.

4.6.5.4 Intended Application: The SCT-21 will be used overseas in the Defense Satellite Communication program.

4.6.5.5 Interface and Technical Characteristics:

Figure of Merit, G/T:	31 dB/^{o}K
Effective Radiated Power:	
Antenna and Radome:	24 ft Cassegrainian
Transmitter:	
Frequency Range:	7.9 to 8.4 GHz
Bandwidth:	40 MHz
Maximum Power Output:	5 kW
Type:	Klystron
Receiver:	
Frequency Range:	7.25 to 7.75 GHz
Bandwidth:	500 MHz

4.6.5.6 Date of Availability: Available now

4.6.5.7 Documentation: SATCOM Reference Handbook, July 1972.

4.6.6 AN/TSC-86 Earth Terminal

4.6.6.1 Military Nomenclature: AN/TSC-86

4.6.6.2 Commercial Nomenclature and Other Names: Light Transportable (LT), LT-2.

4.6.6.3 Functional Description:

The Satellite Terminal AN/TSC-86 is a lightweight, transportable satellite earth terminal designed for rapid deployment during contingency situations and for fixed station operational missions. The AN/TSC-86 is capable of providing: satellite extension and restoral communications, low capacity nodal communications, civil defense and humanitarian services and special user services. The operational usage for the AN/TSC-86 will be similar to the present application of the Satellite Terminal AN/TSC-54, which is being used as both a contingency facility and fixed facility. The AN/TSC-86 is designed to be used in the Defense Satellite Communications System (DSCS) Phase II, Stage 1C program.

4.6.6.4 Intended Application: The AN/TSC-86 will be used in the Defense Satellite Communications Program.

4.6.6.5 Interface and Technical Characteristics:

Receiving System, Figure of Merit, G/T:	LT = 18 dB/^{o}K LT -2 = 26 dB/^{o}K
Reflector, Pedestal:	LT = 8 feet diameter LT-2 = 20 feet diameter
Receive, Frequency Band:	7.25 to 7.75 GHz
Transmit, Frequency Band:	7.9 to 8.4 GHz
Polarization:	Receive LHC, Transmit RHC
Simultaneous Communication Carriers:	3 uplink with 20 ft ant 1 uplink with 8 ft ant
Effective Radiated Power:	109 dBm with 20 ft 103 dBm with 8 ft
Intermediate Frequency:	70 MHz
Transmitter Power:	1 kW
Transmitter Type:	Klystron
Transmitter Bandwidth:	40 MHz

Date of Availability: Unknown.

Documentation: SATCOM Reference Handbook, July 1972.

4.6.7 AN/SSC-6 Satellite Terminal

4.6.7.1 Military Nomenclature: AN/SSC-6

4.6.7.2 Commercial Nomenclature and Other Names: Major Ship Satellite Terminal (MASST)

4.6.7.3 Functional Description:

The AN/SSC-6 is a shipboard SATCOM terminal for use aboard flagships and other combatants. The terminals will provide high speed data, voice and teletypewriter connection between ship and shore, and ship and ship via the DCS Phase II Satellite.

4.6.7.4 Intended Application: Shipboard

4.6.7.5 Interface and Technical Characteristics:

Figure of Merit:	14 dB/^{o}K
Effective Radiated Power, ERP:	110 dBm
Antenna and Radome:	6 foot Cassegrain shipboard, Radome not required.
Transmitter:	
Freouency Range:	7.9 to 8.4 GHz
Bandwidth:	125 MHz
Maximum Power Output:	11.0 kW
Receiver:	
Frequency Range:	7.25 to 7.75 GHz
Bandwidth:	500 MHz
Type:	Uncooled paramps

4.6.7.6 Date of Availability: Unknown

4.6.7.7 Documentation: SATCOM Reference Handbook, July 1972.

4.6.8 AN/FSC-79 Satellite Terminal

4.6.8.1 Military Nomenclature: AN/FSC-79(V)

4.6.8.2 Commercial Nomenclature and Other Names: FLEETBROADCAST (FLTBCST) Terminal

4.6.8.3 Functional Description:

The basic FLTBCST terminal serves as a single carrier terminal. While it is capable of operating anywhere in the 500 MHz transmit and receive frequency bands, normal operation will be at a single fixed transmit frequency. The receive frequency will be that of the satellite SHF beacon for automatic antenna track purposes. The AN/FSC-79(V) is very similar to the AN/FSC-78(V) DCS Satellite communications terminal with significant deletion of components. The AN/FSC-79 looks similar to the AN/FSC-78, shown in Figure 4.6.1(a). The functional block diagram is shown in Figure 4.6.8.

4.6.8.4 Intended Application: Transmit 16 encrypted 75 baud information time-division-multiplexed into a 1200 b/s serial stream for processing by spread-spectrum modulation. The output of the modulation is up-converted and transmitted to the FLTSAT.

4.6.8.5 Interface and Technical Characteristics:

Reflector, Pedestal:	60 ft high efficiency AZ-EL
Receive Frequency Band:	7.25 to 7.75 GHz
Transmit Frequency Band:	7.9 to 8.4 GHz
Transmit:	Redundant 8 kW Klystron
Transmitter Bandwidth:	125 MHz Instantaneous
Polarization	Receive LHC; Transmit RHC
Simultaneous Carriers	One transmit, one receive (Beacon)
G/T:	28 dB
ERP:	+127 dBm
Intermediate Frequency:	70 MHz or 700 MHz
IF Bandwidth:	40 MHz or 125 MHz
Amplitude Response:	±1 dB/10 MHz, ±2 dB/40 MHz
Phase Linearity:	±0.1 rad/10 MHz ±0.2 rad/20 MHz
Tunability:	500 MHz (1 kHz increments)
Redundant Switchover:	Automatic <250 ms
Life Expectancy:	15 years
MTBF:	1200 hours
MTTR:	1 hour

4.6.8.6 Date of Availability: Available now.

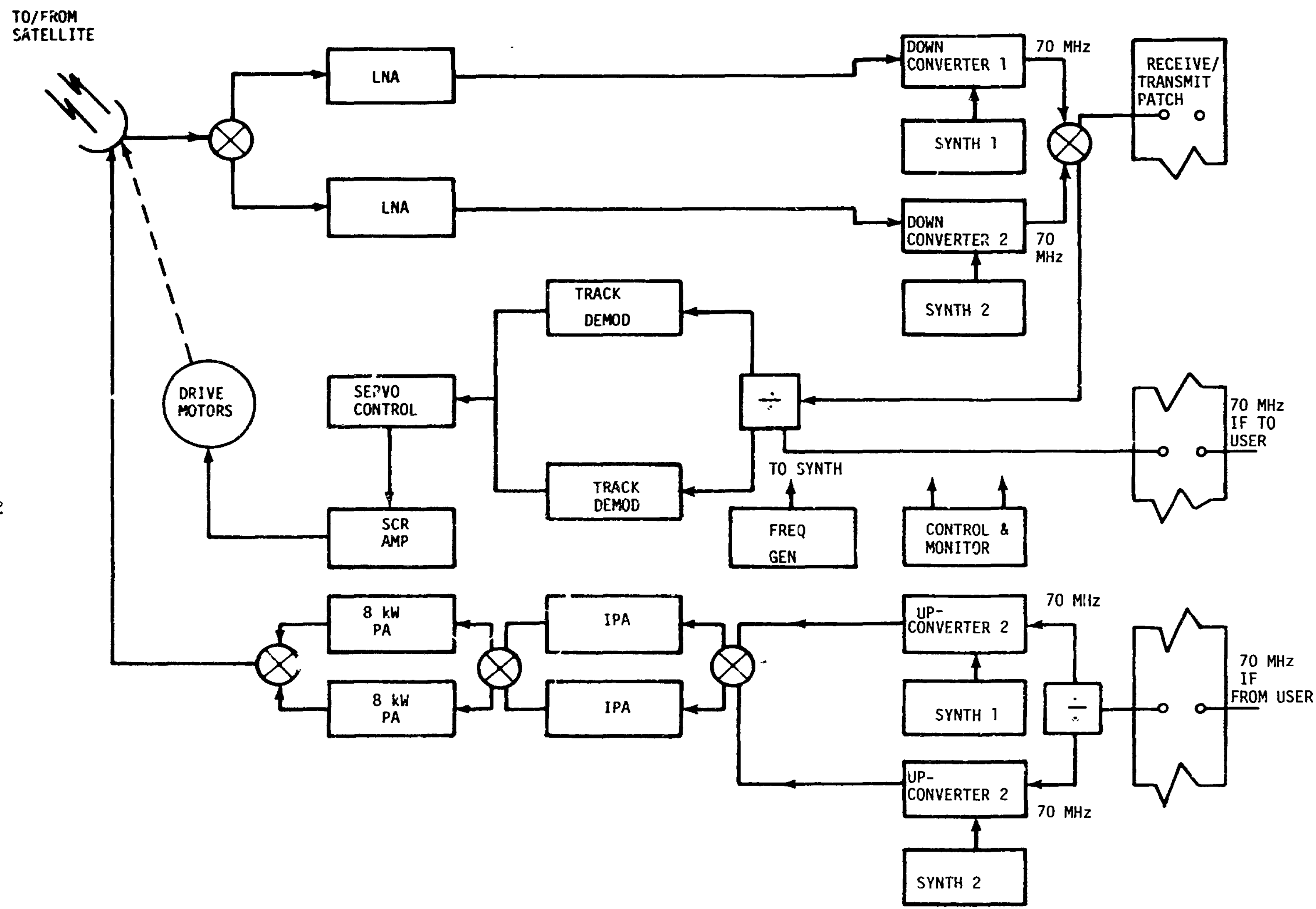


Figure 4.6.8 AN/FSC-79 Fleetbroadcast Terminal Functional Block Diagram

4.6.9 AN/MSC-61 Earth Terminal

(THIS SECTION WILL BE FURNISHED AT A LATER DATE)

4.7 EQUIPMENTS ASSOCIATED WITH AUTOVON

This section will be furnished later

4.8 EQUIPMENTS ASSOCIATED WITH AUTODIN

4.8.1 AUTODIN Switch

4.8.1.1 Military Nomenclature: AN/FYQ-42(V)1 through AN/FYQ-42(V)12 and AN/FYQ-42(V)T1

4.8.1.2 Commercial Nomenclature and Other Names: AUTODIN Switch, ASC, ADMSC, Automatic Switching Center, Automatic Digital Message Switching Center.

4.8.1.3 Functional Description:

The Automatic Digital Message Switching Center (ADMSC) is a major element within AUTODIN. An ADMSC includes: a technical control facility (or a patch and test facility in the terminology of this document), power generating and distribution equipment; station timing source and distribution; modems; cryptographic and crypto-ancillary equipment; maintenance facilities; and Automatic Digital Message Switch (ADMS), and the building, primary and emergency power and environmental equipment. An ADMSC handles both encrypted and unprotected digital message traffic while performing necessary transmissio and message switching functions. An ADMSC provides necessary monitoring, supervision, and control required to maintain continuous service.

The major elements of an ADMSC include a programming package of required routines to accomplish the required message switching functions and three major technical elements, illustrated in Figure 4.8.1 (a), as follows:

(1) Uninterrupted Power Supply (UPS)
(2) Communications and Technical Control
(3) Automatic Digital Message Switch (ADMS)

For the purpose of this document, only the Communications and Technical Control element of the Switching Center is discussed. The signal flows through the Patch and Test Facility at the AUTODIN Switching Center and the serving Technical Control Facility at the nearest transmission system are discussed in Chapter 3.

4.8.1.4 Communication Group Description (Figure 4.8.1 (b),

- General
  The communications and technical control portion of the ADMSC provides facilities for termination of the external communications lines and interface the ADMS; the function of technical control is to maintain continuity of service over the communications lines while monitoring the status of supporting areas, including power and station timing.

- Nomenclature

The communications and technical control portion of the ADMSC is Communications Group AN/FYA-11 through AN/FYA-22, and AN/FYA-T1.

- Shield Point Isolation Facility:

The facility provides radio frequency interference (rfi) filters on all lines entering or leaving the ADMSC. For a detailed description of the shield point isolation facility, refer to TM 11-5895-410-15.

- System Distribution and Patching Facility:

The system distribution and patching facility contains five types of patch bays and four types of distribution frames, each performing a specific function at the ADMSC. For detailed descriptions of the system distribution and patching facility equipments, refer to TM 11-5895-414-15. The major components of the system distribution and Patching Facility are:

Black dc patch bay
Black distribution frame
Entrance distribution frame (af)
Entrance patch bay (af) Cabinet 1
Entrance patch bay (af) Cabinet 2
Entrance distribution frame (dc)
Entrance patch (dc)
Red dc patch bay (secure)
Red dc patch bay (unsecure)
Red distribtuion frame

- AUTODIN Station Control Console (ASCC), Monitor Test Console

The monitor test console (MTC) provides the AUTODIN station control console operator with the capability of monitoring and testing semiautomatically any one of the red group or black group duplex teletype channels. Panel-mounted controls and indicators provide for selection of channels to be monitored, visual identification of channel number, speed and routing, selection of test equipment to be connected to the channel under test, and indication of test results. A selected channel is switched to the MTC via remote switchers associated with the red group and black group of channels. Interlocks within the control circuitry prevent cross over in the system between red and black lines. For a detailed description of the monitor test console, refer to TM11-5895-417-15.

- AUTODIN Station Control Console (ASCC), Channel Status Display Cabinet

The channel status display cabinet (CSDC) provides visual and audible-alarm indication of the status of the AUTODIN duplex communications channels. Each channel is identified on the CSDC front panel with an indicator lamp which flashes when a failure is detected by ADMSC equipment associated with the channel. A common alarm indicator panel is then used to identify the type of fault that has occurred. Audible alarm indication is also given during fault conditions and continues until the operator responds to fault indication. For a detailed description of the channel display cabinet, refer to TM 11-5895-527-15.

o Station Timing Subsystem:
The station timing subsystems supplies all external time bases required by the synchronous and asynchronous data equipments located within the ADMSC. The timing system consists of an oscillator section, a frequency synthesizer section used to generate the desired timing rates, and a distribution section to provide output timing signals to the various equipments within the ADMSC. In addition, a chronometer section is incorporated to drive wall-mounted and ceiling-mounted clocks to provide time-of-day information to station personnel. In addition to timing system components necessary to generate and distribute timing signals, a frequency comparator equipped with a digital readout enables local standard oscillator frequency comparison measurements between individual oscillators to be made by the operator; further, a vlf receiver/phase comparator is used to permit comparison of locally generated standard frequencies with that of an external standard. For a detailed description of the station timing subsystem, refer to TM 11-5895-413-15/1, TM 11-5895-413-15/2, and 11-5895-413-15/3.

4.8.1.5 Interface Characteristics:

(to be furnished later)

4.8.1.6 Date of Availability: In Service at Present.

4.8.1.7 Documentation:

TM 11-5895-395-391-15, NAVSHIPS 0967-301-5010, to 31S5-2FYQ42-1, DCA Circular 310-D70. Also, TM's discussed under Functional Description Above

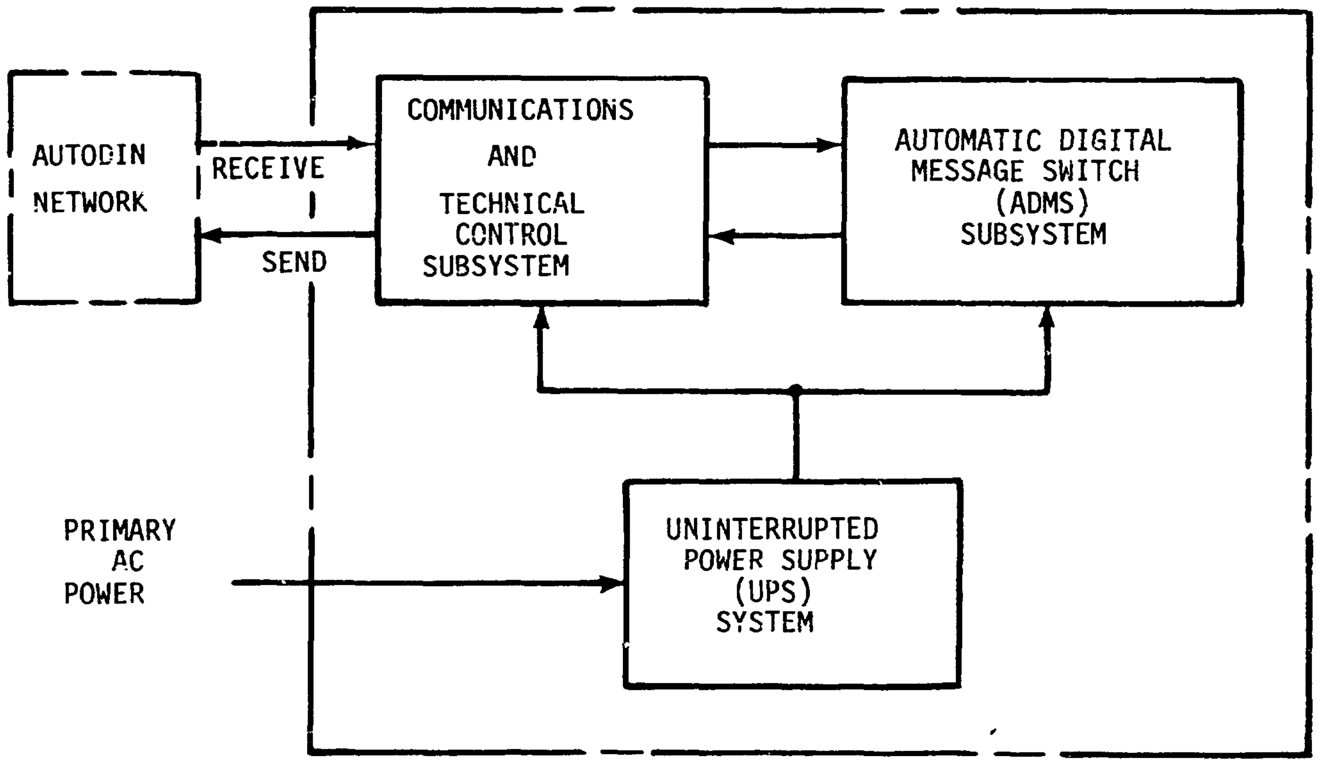


Figure 4.8.1(a) MAJOR ELEMENTS OF THE AUTOMATIC DIGITAL MESSAGE SWITCHING CENTER (ADMSC) -- OVERSEAS AUTODIN SWITCH.

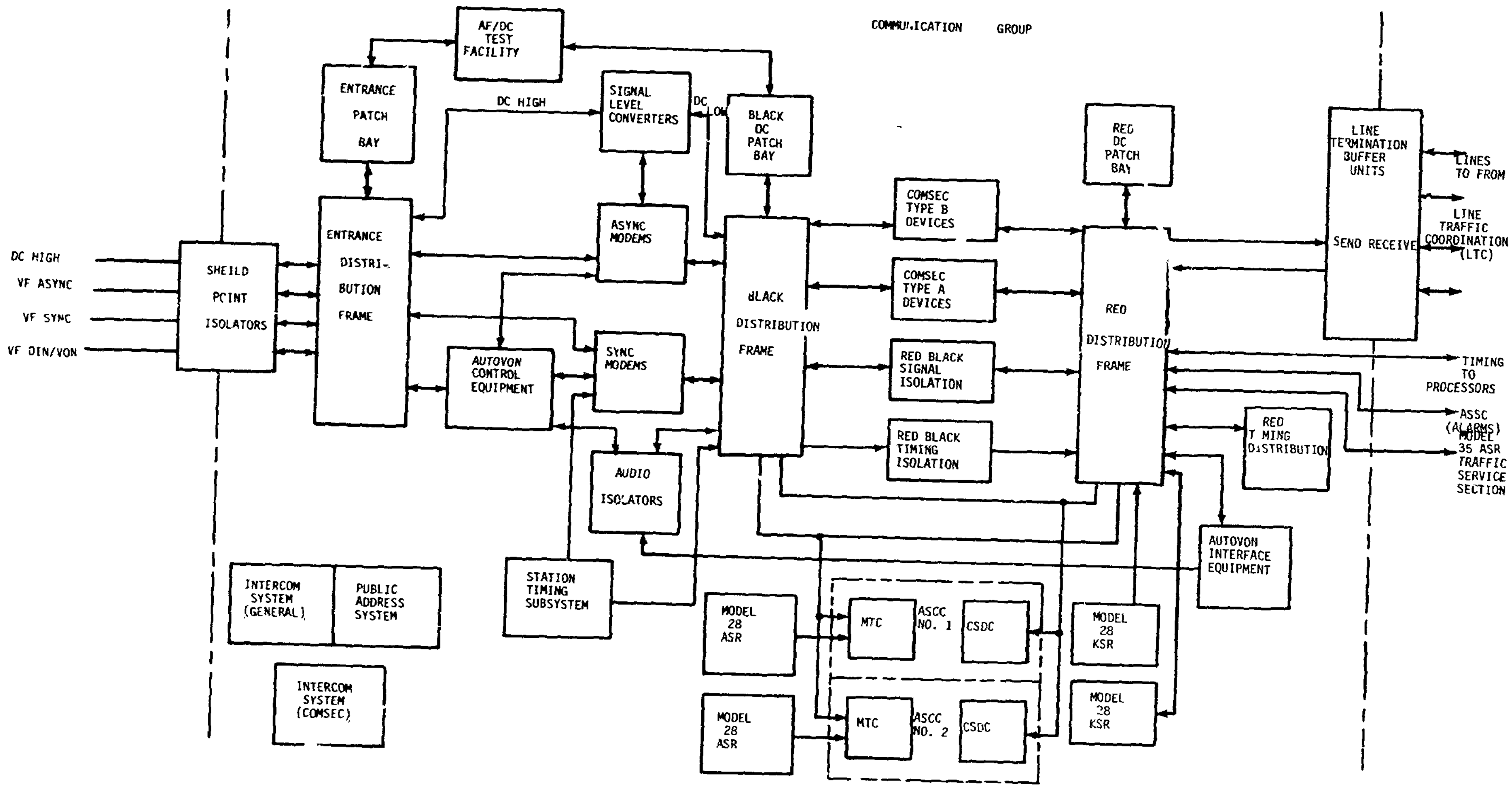


FIGURE 4.8.1(b) COMMUNICATION GROUP OF THE OVERSEAS *AUTODIN* SWITCH (ADMSC), SIMPLIFIED BLOCK DIAGRAM

EQUIPMENT DESCRIPTION

4.9 EQUIPMENTS ASSOCIATED WITH AUTOSEVOCOM

4.9.1 CV-3034 A/D Converter

4.9.1.1 Military Nomenclature: DV-3034/G Analog/Digital Converter.

4.9.1.2 Commercial Nomenclature and Other Names: Magnavox MX-530

4.9.1.3 Functional Description:

The CV-3034/G, A-D Converter interfaces full duplex hybrid analog/digital users with all digital interfaces of the communications subsystems of the DSCS. The unit may service a single channel user having a contingency link terminal, or be multiplexed with other channels working into a high capacity terminal or an interconnect facility.

On the user side, signal sources may be 4 kHz audio channels from a FDM, hybrid signals from a wideband switch, or a wideband secure device. The audio channel carries a voice (analog) signal limited to 3 kHz bandwidth. If the user is a hybrid device, the transmitter will determine if the signal is analog or digital and process it accordingly. Also, the receiver determines automatically if the input is of analog or digital origin. The only input on the user side is the signal input. No clock is provided at this interface.

The converter typically interfaces on the digital side with an AN/GSC-24 TDM or a MD-920, MD-921/G or MD-1002 PSK/ICF Modem. The converter transmitter provides data and clock outputs. In most cases data and clock inputs are provided to the converter receiver. However, if a clock input is not provided, the timing unit can be strapped so as to derive clock signals from the received data. The unit is also compatible with the AN/USC-28 and PN/TDMA modems, as well as the AN/USC-26 group data modem.

4.9.1.4 Intended Applications:

The CV-3034/G is used in the DSCS and in terrestrial transmission.

4.9.1.5 Interface and Technical Characteristics:

Digital User Interface

Transmitter:	Nominal 3 kHz voice band signal
Voice Mode	
Signal Level:	-46 to -16 dBm (low level) -30 to 0 dBm (high level)
Input Impedance:	600 Ohms, balanced.

EQUIPMENT DESCRIPTION

Input Hybrid Mode :	Voice and 50 kb/s Data Signal
Voice Signal Level :	-30 to 0 dBm
Data Signal Level :	-15 to 0 dBm
Input Impedance :	135 Ohms, balanced.
Input Voice Mode :	Nominal 3 KHz voice band signal
Signal Level :	-14 to -16 dBm (low level) -30 to 0 dBm (high level)
Input Impedance :	600 Ohms, balanced
Transmitter Clock :	Free run with voice signal input Locked to data signal frequency with data signal input
Frequency :	7,200,000 ± 200 Hz
Stability :	±60 ppm in free run
Tracking Range :	±500 ppm (±3600 Hz) with data input
Clock Output :	50,000 Hz square wave
Signal Level :	±3V bipolar
Impedance :	75 Ohms, balanced
Transmitter Output :	50 kb/s digital signal
Signal Level :	±3V bipolar
Impedance :	75 Ohms, balanced.
Receiver :	
Input Signal :	50 kb/s digital signal
Signal Level :	±3V bipolar, minimum acceptable ±0.1 V
Impedance :	75 Ohms, balanced
Receiver Clock :	Locked to incoming digital data signal or locked to external clock
Frequency :	7,200,000 ±200 Hz
Stability :	Equal to stability of locking frequency
Tracking Range:	±500 ppm (±3600 Hz)
External Clock Input:	50,000 Hz square wave

EQUIPMENT DESCRIPTION

Receiver Clock :	
Signal Level :	±3V bipolar, minimum acceptable ±0.1V
Impedance :	75 Ohms, balanced
Output Voice Mode :	Nominal 3 KHz voice band signal
Signal Level :	-30 to 0 dBm (low level) or -23 to +7 dBm (high level) each continuously adjustable over +2 to -8 dB range
Output Impedance :	600 Ohm, balanced
Output Hybrid Mode :	Voice and 50 kb/s Data Signal
Voice Signal Level :	-30 to 0 dBm, continuously adjustable over +2 to -8 dB range
Data Signal Level :	0 ±1 dBm
Output Impedance :	135 Ohms, balanced

Line or System Interface :

Transmitter Output :	50 kb/s digital signal
Signal Level :	±3V bipolar
Impedance :	75 Ohms, balanced
Receiver Input :	50 kb/s digital signal
Signal Level :	±3V bipolar, minimum acceptable ±0.1V
Impedance :	75 Ohms, balanced

4.9.1.6 Date of Availability: Available now.

4.9.1.7 Documentation:

IM-5895-797-14.

4.10 EQUIPMENTS ASSOCIATED WITH SPECIAL PURPOSE NETWORKS

This Section will be furnished later

4.11 DIGITAL SWITCHING EQUIPMENTS

This section describes typical digital switches. The ones included, for descriptive purposes only, are those which may be used in CONUS AUTOVON, are proposed for use in the European Telephone System, or are typical of a modern electronic PBX. Their inclusion in this document does not imply endorsement by the military departments or the DCA.

The following paragraphs briefly describe several representative commercial digital switches which are typical of those finding application in the DCS. These switches are examples of what new exists in a highly dynamic industry and in no manner represents a comprehensive or conclusive list.

All of this brief descriptive material has been gathered from published sources and some of the material may have been modified by subsequent releases or changes. Inclusion of a particular switch in this publication implies no preference or support for the item described. It is hoped these illustrative examples will provide some insight into the typical digital switch that will likely be progressively phased into the DCS over the next several years.

4.11.1 DMS-100/200 Switch Series

1. Military nomenclature: None

2. Commercial nomenclature and other names: Northern Telecom DMS-100/200 series and digital switching machines

3. Functional description:

   The DMS-100/200 series represent a family of digital switching machines. These switches utilize versatile stored program control combined with the many advantages of digital switching techniques. They are designed with architectural flexibility so they may be used as a toll, local, or combined local/toll, or as an international gateway switch. Their versatility is attained from a range of software operating programs and different peripheral hardware units: The basic functional blocks of the DMS-200 switch are outlined in Figure 4.11.1.

   Trunks may be connected to DMS-200 in either digital or analog form. Digital trunks appear on the digital carrier module, where signaling information is extracted or inserted. Voice information previously digitized is unchanged. Call progress and multifrequency tones are digitally generated by the digital carrier module and can be applied to the trunk without the need of a network connection.

   The analog trunk module performs the same functions as the digital carrier module and, in addition, converts the analog voice signal into digital format (and vice versa). The analog trunk module also provides facilities for testing and maintaining the analog transmission plant.

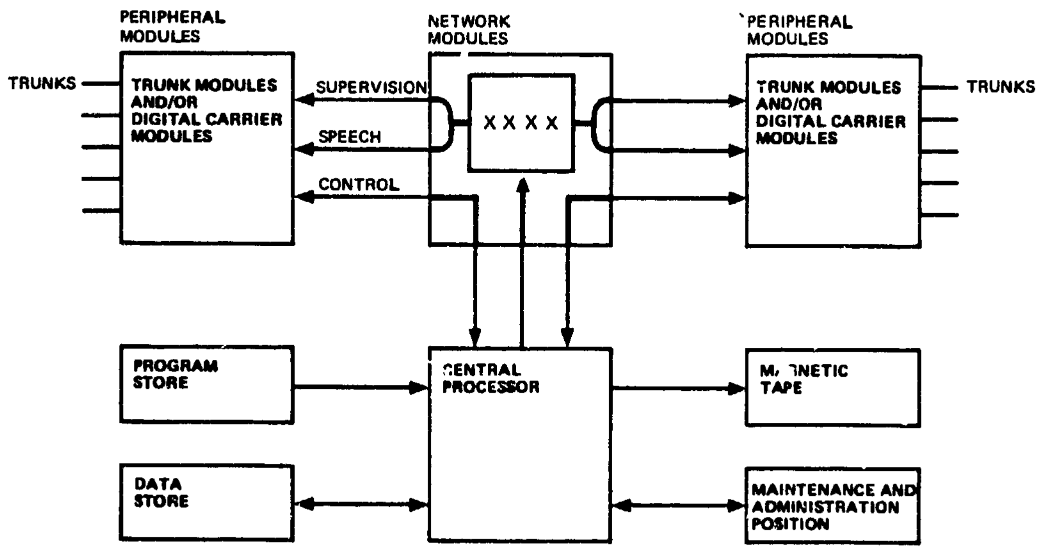


Figure 4.11.1. DMS-200 Digital Switch

The trunk and digital carrier modules are both controlled by individual microprocessors, which are responsible for the simple, repetitive telephony tasks. This distributed structure is an effective way to keep the advantages of stored-program control in smaller systems while retaining the capability to add computing power easily as the system grows. It is also the key to achieving a broad, economical size range.

The central and peripheral processors do not talk to each other directly; they exchange control messages through an intermediate level in the control hierarchy, which is occupied by network modules.

The messages between the levels of the hierarchy flow over the switch's internal pathways at 2.56 Mb/s. On links between the peripheral and network modules, 32 channels are used, of which 30 are for speech signals, and one for internal signaling. One channel is a spare. Two bits, transmitted with each 8-bit speech sample, provide fault detection for the switch path, as well as a direct signaling channel between the two peripheral controllers involved in a connection. Signals that must be exchanged quickly between trunk circuits, such as change of supervision, can use that channel, and bypass the central processor.

Standardization of the physical and logical interfaces between the central and peripheral processors enhances the structured modularity of the DMS - 200 system. Modules can evolve independently and take advantage of rapidly evolving microprocessor and LSI technologies. New modules can be easily added to satisfy future control requirements.

In a digital switch such as DMS-200, calls are connected by a switching network consisting of an assembly of integrated circuits. These connections are electrical pathways from the input to the output of silicon integrated circuits, set up under the direction of signals from a controlling computer. Under the control of the central processor, these circuits can switch bits of information very rapidly. In DMS-200, these contacts are made 2 million times a second, establishing a switching path for a timeslot of 0.4 u/s. This contact lasts long enough to transmit one bit of a speech sample (using standard PCM techniques, each voice signal is converted to voltage sample 8000 times a second, and each sample is then coded as a digital word containing 8 bits).

The DMS-200 employs a common variation of this approach. Instead of switching the bit streams serially (one bit after the other), the machine converts them to a parallel flow and switches all at once. Thus all 10 bits for each sample (the 8-bit code plus the two bits for internal signaling) are switched at the same time by a parallel array of digital switching circuits.

The digital machine uses integrated circuits to perform both space switching (connecting any input to any output, but in the same timeslots) and time switching (moving samples around between timeslots). Thus. a time-space switch is able to transfer a sample on any input in one timeslot to any output in any other timeslot.

The basic building block of the DMS network is an 8 by 8 time-space switch which is physically contained on one circuit pack. The eight inputs to this switch are 32 channel links which are standard throughout the system; the outputs from the switch are eight similar links. The function of the switch is to permute any combination of the 256 input channels and transfer the result to the output links.

Failure of such a switch could affect all the calls passing through it, which could be as many as 256. Calls are protected from this situation in the DMS-200 by duplicating the network.

The DMS-200 network is modular in form, with each module capable of switching 1920 trunk circuits. At its maximum size the network contains 32 such modules, and is capable of switching approximately 60,000 trunks.

4. Intended application:

The DMS-200 to be employed as the AUTOVON switch at Fairview, Kansas and Toledo Junction, Ohio may be used as a toll, local, or combined local/toll switch in the Defense Switched Network (DSN) program. Other potential applications are under study.

5. Interface characteristics:

Major interaction of technical controllers with the DMS-200 would take place at a maintenance and administration position (MAP). This is a freestanding, multifunctional unit. It has a visual display terminal and work surfaces and is used for communication between the controller and the DMS-200. Communication consists mainly of messages passed back and forth via the terminal, whose display is divided into independently standard message links, allowing up to 40 MAP positions if required to be placed wherever they are needed.

A manual mode of testing is available for trouble shooting and for trunk tests in cooperation with distant switching centers which are not equipped for automatic testing. In this mode the controller makes use of the MAP to dial up trunks and connect them to the digital test circuits, to switch in signal generators and filters and to measure the level and frequency of received signals.

Self testing tecnniques have been implemented in the design of the DMS-200 to ensure quick and effective identification and isolation of faults. Links between equipment, for example, are tested every time they are used, with alternate links employed whenever a failure is detected, and failed links are removed from service for scheduled in-depth tests.

Every trunk module or digital carrier module, is connected to both network planes and transmits the same PCM bit streams to both. The digital signals received by the peripheral module from the two network planes contain redundant bits which permit the detection of faulty channels.

Hardware failures in the network are thus detected by the peripheral modules, but no service interruption occurs as the path over the other network plane is immediately ready. The detection of a network fault by a peripheral module is reported to the central processor, which instructs the affected network modules to run a diagnostic test and identify the faulty printed card.

The DMS peripheral modules (PM) interface customer line and long-haul trunks to the DMS digital switching network. Analog and digital speech and signaling information is converted to the 32 channel, 2.56 Mb/s format used by DMS. A message passing system provides for communication between the PM's and Central Control. There are three types of peripheral modules:

- Line Module (LM)
  - interfaces with up to 640 analog subscribers.
- Trunk Module (TM)
  - interfaces with up to 30 analog trunks.
- Digital Carrier Module (DCM)
  - interfaces with up to 5 digital carrier lines.

The Maintenance Trunk Module (MTM), is also provided to accommodate special circuits, for example:

- transmission measuring equipment
- test signal generators.

6. Date of availability: Available Now

7. Documentation available for detailed description:

   Northern Telecom brochures and Operation Course Manuals.

8. A training center for the DMS Series of switches is also in operation at Raleigh, N.C.

4.11.2 KN-101 Switch

1. Military Nomenclature: European Telephone System (ETS) Tandem Switching Center (TSC), Intermediate Switch Center (ISC), End Office (EO).

2. Commercial Nomenclature and other names: EMS-8-KN Switch, Siemens PCM Switching System, KN-101 Switch, KN Switch.

3. Functional Description:

The KN-101 Switch is a stored program digital switching system utilizing a two-level centralized control structure. The central processor level one is overall master and controls the total system. The group processor level two is controlled by the central processor and maintains the status and directs operations in the Line Truck Group. The system is modular and all functions are realized by plug-in modules and memory units. Due to modular construction, the KN switches represent a uniform switching family irrespective of its utilization as a TSC, ISC, EO individually or combined. These PCM switches manage telephone traffic automatically and provide capabilities for alternate routing. For the purpose of this document, only the communications and interface characteristics of the switch are discussed. The system can be subdivided into the following basic components. (Figure 4.11.2(a)

- Line/Trunk Groups (LTG)
- Central Switching Network (CSN)
- Central control (CC).

Line/trunk groups (LTG) and central switching network (CSN) are interconnected via standardized 2048 kbit/s highways handling the speech information. Signaling highways connect the central control to the central switching network and the line/trunk groups.

Line/Trunk Group (LTG): A line/trunk group provides eight line/trunk units (LTU) with 32 ports each, or a total of 8 x 32 = 256 ports. The line/trunk units provide two interfaces to the system:

- One interface with 2048 kbit/s to the group switching network (GSN) for speech information
- Two interfaces at 64 kbit/s to the signal multiplexer (SMX) and thence at 2048 kbits to the Group Processor

Each Line Trunk Unit (LTU) provides four card slots to accommodate peripheral interfaces as follows:

- Subscriber Line Module, Analog (SLMA)
- Subscriber Line Module, Digital (SLMD)
- Trunk Module, Analog (TMA)
- Digital Interface Unit 24 (DIU-24)
- Digital Interface Unit 30 (DIU-30)
- Tone Receiver Cards (TRC)

The LTU is arranged so as to permit plugging any of the above modules into any of the slots with the exception of DIU's - since no more than 4 DIU's shall be connected to any one LTG.

A total of 4,096 ports in the KN switch are assigned to 512 card slots which can accommodate

- SLMA - 8 line circuits per card
- SLMD - 2 circuits per card
- OLMD - 1 attendant console per card
- 4 two wire or 2-four wire trunks per card
- DTMF receivers - 4 per card

Group Switching Network (GSN): The GSN is a non-blocking Memory Time Switch (MTS) with 16 inputs/outputs controlled by the Group Switch Control (GSC) with 32 time slots/highway at 64 kbit/s in each time slot and 2048 kbit/s serial data per highway, non-blocking within the group.

- Conference

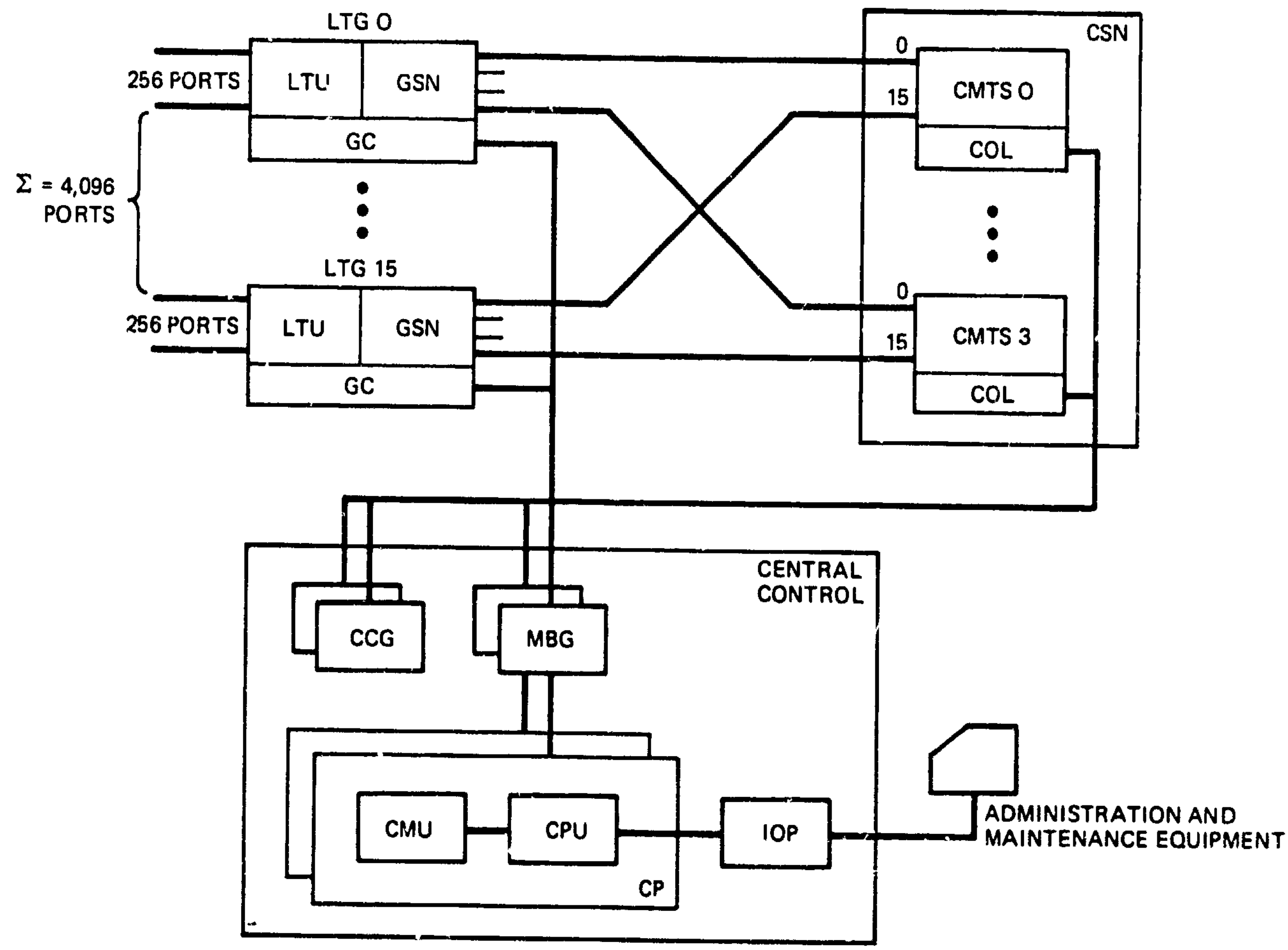
  It is possible to conduct several conferences on digital basis which are independent of each other, simultaneously. The parties to a conference can be connected to different group switching networks.

- Audible Tones or Announcements

  Similar to conferences, connections from a tone generator or announcement equipment to any number of peripheral devices can be established.

- Attenuation

  Each of the 512 channels of the group switching network (GS) can be attenuated individually. The group switching network can be programmed with different attenuations. The attenuation for a certain connection is calculated by program and is signaled to the group switching network to maintain correct amplitude for all signals.



LEGEND:

CSN	CENTRAL SWITCHING NETWORK
LTU	LINE/TRUNK UNIT
GSN	GROUP SWITCHING NETWORK
GC	GROUP CONTROL
CPU	CENTRAL PROCESSING UNIT
MBG	MESSAGE BUFFER GROUP
CCG	CENTRAL CLOCK GENERATOR
IOP	INPUT/OUTPUT PROCESSOR
CP	CENTRAL PROCESSOR
LTG	LINE TRUNK GROUP

Figure 4.11.2(a). KN-101 Digital Switch Block Diagram

Group Control (GC): The group control consists of the following components: (1) Processing unit (PU), (2) Memory unit (MU), (3) Signal buffer (SIB), and (4) Signal multiplexer (SMX).

The control of the line trunk group is provided by the central control. The maximum storage capacity of data and programs is 64 kbytes. The group control (GC) receives state information from the peripheral equipment via the line trunk unit/group control interface.

The signal multiplexer (SMX) receives information, coming from the different line/trunk units and from the group switching network, and transmits them via a signal highway to the signal buffer (SIB). In the opposite direction, the signal multiplexer distributes the signaling information coming from the signal buffer (SIB), to the different peripheral devices and to the group switch control.

The signal buffer (SIB) has to store these signals temporarily on demand, to adapt them to the different processing speeds of the peripheral devices and the group processor (GP).

Depending on the type of the peripheral terminal, the different signals are received in the group processor (GP) which carries out the direct control of the line/trunk group (LTG). These signals are transmitted in a standardized format to the central control via the signal buffer (SIB) and signal multiplexer (SMX). The group processor (GP) receives the instructions from the central control via the SMX.

The group control performs the following functions:

- Call Processing Tasks

  - Scanning
  - Control of line/trunk circuits and group switching network
  - Control of signaling procedure
  - Performing timing operations related to the connections (e.g. for supervision, trunk criteria)
  - Converting external line/trunk signaling information to internal standardized messages for the central processor and vice versa.

Safeguarding Tasks

- Routine testing of line/trunk circuits, tone generators, and code receivers

- Monitoring of switching network functions (continuity check, supervision of the standardized messages to and from the central processor)

- Scanning the alarm indication signals of the PCM-highways

Central Switching Network (CSN): The central switching network (CSN) is, like the group switching network (GSN), a time switch stage with full availability. It consists of one to four identical time switches that are identical with the group switching network, except for the conference memory and the attenuation switch.

The task of the central switching network (CSN) is to set up the connection between different line/trunk groups.

The overall traffic between the different line/trunk groups is distributed over the four time switch units uniformly. Thus, when one time switch unit fails, the connection between the sixteen line/trunk groups via the remaining three time switches is not disabled.

Central Control (CC): The central control consists of the following components:

Central processor (CP)

Message buffer group (MBG)

Central clock generator (CCG)

Input and output processors (IOP)

Cross channel (CCH)

The Central Control performs the following functions:

Call Processing Tasks

- Pooled resource management

- Digital translation

- Path selection

- Attendant console functions

- Administrative functions

- Intergroup switching

- Maintenance functions
- Start-up/restart/recovery
- Call metering control

Administration and Maintenance Tasks

- Man-machine communication administration;
- Assigning/reassigning subscriber lines and trunks changing directory numbers
- changing classes of service

Traffic Tasks

- recording traffic measurement data
- call data registration

Dependability Tasks

- Fault analysis;
- localizing and blocking faulty equipment
- switch to standby unit
- recovery, alarm and fault message
- fault diagnosis
- automatic restart
- testing

4. Intended Application:

The KN digital switch is projected for use in applications of the European Telephone System upgrades in the Federal Republic of Germany.

5. Interface characteristics:

The interface modules listed below can be used in the KN switch in any combination: (Figure 4.11.2(b) depicts peripheral connections to a KN switch.)

- Subscriber line module, analog (SLMA)
- Subscriber line module, digital (SLMD)
- Trunk module analog (TMA)
- Digital interface units PCM 24 & 30

The Subscriber line module, analog (SLMA) provides connection of conventional telephone sets. One module contains eight 2-wire subscriber line circuits.

A digital telephone set would be connected to the switching system via the subscriber line module digital (SLMD) The function of the SLMD is to adapt the speech and signaling from the digital line to the switch.

Analog trunk lines are connected via various types of trunk modules analog (TMA). For example, to interface trunking associated with existing electromechanical switching systems, TMA's accomplish conversion of 600-750-Hz 3-wire, 2280 Hz 4-wire, 50Hz 2-wire and 4-wire E&M signaling schemes to the KN switch digital input.

Digital multiplex trunks (PCM 30 or 24) are interfaced directly via a digital interface unit (DIU). This interface is designed in accordance with CCITT Recommendation G.732 for PCM-30 trunks and G-733 for PCM-24 trunks.

The KN Switch has two separate software organizations resident within the switch. One organization operates the Central Control and the other operates the Line Trunk Group Controls. The LTG's perform all the functions which require direct interface with the ports. These functions include:

- Circuit activity scan
- Digit reception
- Digit output
- Tone output
- Ringing output
- Intra-group switching
- Circuit status monitor
- Call metering Control

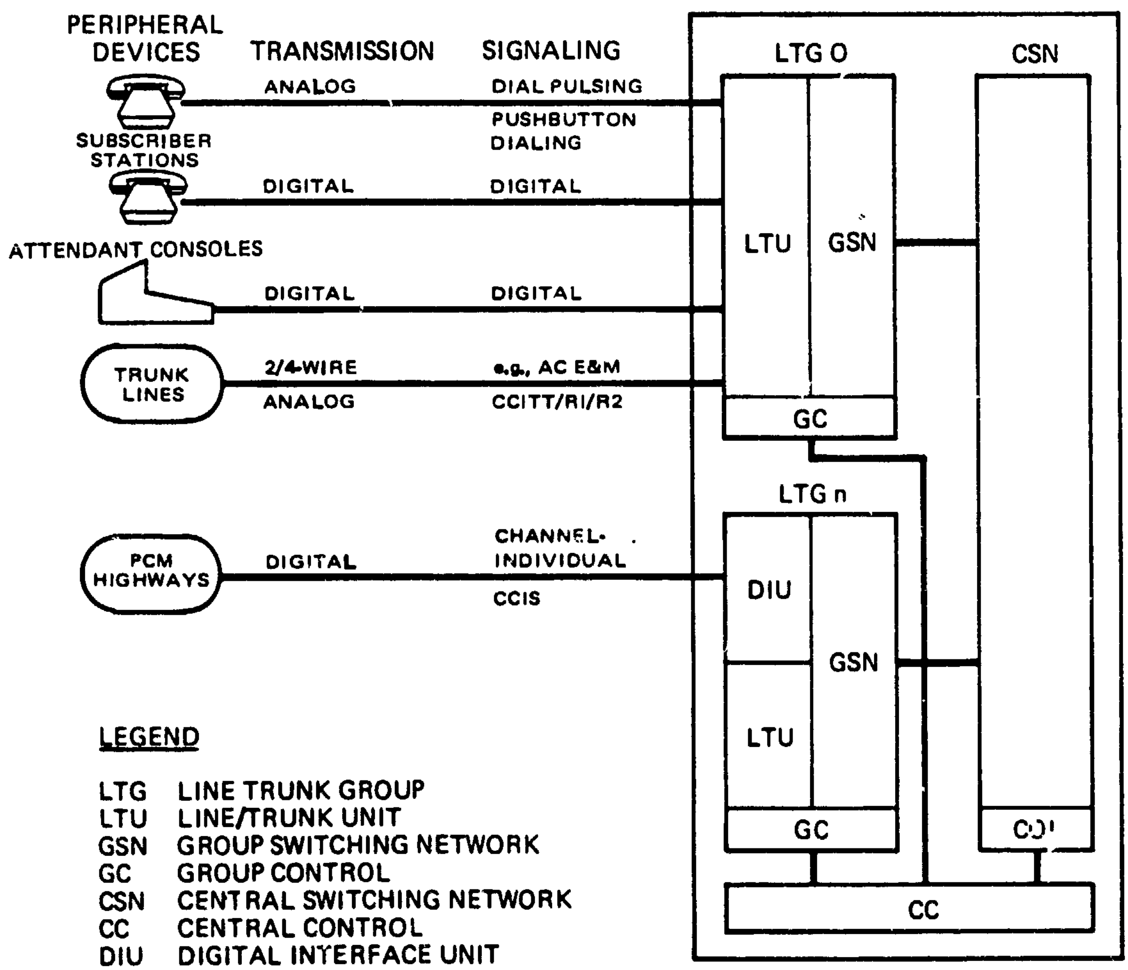


Figure 4.11.2(b). Peripheral Connections

6. Date of availability: Presently available.

7. Documentation available for detailed description:

   - Siemens - Description of KN-101 Switch.

   - European Telephone System Proposal, Vol. II, Part II.

8. Discussion of unique characteristics and other items of interest:

   Specific supervisory and maintenance features to facilitate usage of the KN-Switch by Technical Controllers are contained in the technical documents listed.

4.11.3 GTD 4600 Digital Switch

1. Military Nomenclature: None.

2. Commercial Nomenclature and other names: GTD-4600 Digital Business Service Module; GTD-4600 Digital PABX.

3. Functional Description:

The GTD-4600 Digital PBX is a stored-program controlled switching system which utilizes time division multiplexing (TDM) with pulse code modulation (PCM) format. The GTD-4600 can interface directly to analog and T1 type digital trunks. The common control uses a large central processor sized for the systems operating configuration and features.

The GTD-4600 PBX's practical service range is from 800 to 5000 terminations. The system is implemented around an expandable digital network of 96 time-slots to a maximum of 2304 time-slots. Each 256 line equipment group shares 96 time-slots, whereas trunk equipment groups have dedicated time-slots on a one-to-one basis. Service circuits, such as DTMF receivers, MF receivers, recorder-announcers, customer provided equipment, etc., utilize either a dedicated time-slot or may be concentrated by way of line terminations.

The GTD-4600 is arranged as a modular system. System growth within specified limits is provided by adding line and trunk frames.

All essential equipment is duplicated and operated in a "hot standby" mode to prevent service interruptions. The maximum outage for single faults is 24 channel.. Automatic fault detection, system recovery, and fault localization is provided for all common control equipment, including the digital switching network. Diagnostic software is also provided for routing of all equipment common to 24 channel equipment allocation (A/D, D/A, group multiplexers, etc.).

Overall System Description

Analog station line and trunk interfaces are sampled in a TDM mode at a 8 KHz rate and converted to PAM samples for subsequent conversion by 24 channel PCM codecs. A 24 channel codec is shared for every 64 lines, providing a concentration ratio of 2.67:1.

The switching network is a multistage Time-Space-Time (T-S-T) PCM digital network and is duplicated for high reliability. In its maximum configuration it is comprised of six identical T-S-T mixing stages for a capacity of 2304 time slots. The basic increment of network expansion is a 384 time slot network unit (NU). Each 384 time-slot NU is subdivided into 96 time-slot quadrants to accommodate equipment group terminations for lines, trunks, or service circuits.

- Amplifies and band-limits the audio signals for presentation to the associated Pulse Amplitude Modulation (PAM) bus

- Reconstructs and amplifies the audio signal received as PAM samples over the receive PAM bus

- Provides ringing current and ring trip for the associated telephone.

The codec consists of two circuits: the ATD converter circuit, and the DTA converter circuit.

The ATD converter operates in a TDM mode with a 1.544 MHz clock and a 5.2-microsecond cycle of eight clock pulses. It sequentially serves 24 channels. It accepts the samples from the PAM bus, converts each of them into a digital nonlinear nine-bit code (one bit is for parity), and gates the codes onto a parallel nine-bit digital bus.

The DTA converter operates in a TDM mode and sequentially serves 24 channels. It accepts eight-bit codes from the network and reconverts them to PAM samples that are gated to the appropriate customer lines where they are used to reconstruct the original analog waveforms.

Analog Trunk Group Equipment

The major areas of the analog trunk group equipment subsystem are as follows:

- Analog trunk circuits

- Codec

- Trunk unit controller

- Trunk group controller

- Local Trunk Test Access

The analog trunk circuits provide the interface between various inter-office facilities and the transmit and receive PAM buses. The analog trunk circuits also contain the logic required to enable the sense and control points.

Digital Trunk Group Equipment

The digital trunk group equipment is used as the interface between four DS1-compatible PCM span lines and the system's network. A PCM span line consists of an incoming and outgoing pair on which a serial string of PCM encoded samples are transmitted or received during a 125-microsecond time frame. A time frame consists of twenty-four-bit samples plus a synchronization bit, resulting in a transmission rate of 1.544 MHz.

In the incoming direction, the digital trunk group equipment performs the following:

- Receives the serial 24-channel samples from each span line
- Buffers the serial input stream and converts the samples to a 24-channel 9-bit parallel output (8 bits plus parity).
- Time multiplexes the output samples from 4 line interfaces to provide 96 channels to the network
- Extracts supervisory and synchronization information.

In the outgoing direction, the digital trunk group equipment does the following:

- Receives 96 channels of PCM output from the network
- Demultiplexes and distributes the PCM output samples to four span lines
- Inserts supervisory and synchronization control bits onto the outgoing span line
- Converts parallel PCM and control information to serial bipolar signals and inserts them onto the outgoing span line.

Switch Network

The switching function in the GTD-4600 system is performed by a 3-stage, non-folded (undirectional), Time-SpaceTime (TST) digital network. The three stages are named Originating Time Switch (OTS), Space Switch Multiplexer (SSM) and Terminating Time Switching (TTS).

The basic building block in the network is termed the Network Unit (NU). A full-sized system consists of 6 NU's (NU0-NU5) plus one additional NU (NU6) to provide a 3-port conference circuit. Each of the network units contains the three stages OTS, SSM and TTS. The Space Switch Multiplexer provides the means to connect the OTS of an NU to the TTS of any NU.

The group equipment multiplexes four 24 channel bit streams from the unit equipments into one 96 channel bit stream (there are 24 groups in a full system). Each of the maximum 6 Originating Time Switches then multiplexes four of these 96 channels into 384 channels.

The Network Unit switches 386 channels - referred to as time-slots. To maintain a multiple of the 24 channel T1 type channel rate, only 384 channels per NU are available for peripheral (line and trunks) switching. Thus the maximum peripheral switching capacity of the fully equipped network is 2304 channels (384x6) (the extra two time-slots per NU are used for maintenance purposes.)

Time-slots occur cyclically from 0 to 385 in a 125 microsecond frame. This frame rate is compatible with the T1 type, 193 pulses per 125 micro-second, frame rate resulting in a timeslot duration of 324 ns.

All network units operate in parallel for every timeslot. That is, under control of the network clock circuit, all network units will be operating in the same 1/386 timeslot as defined by the clock circuit time-slot counter. The clock circuit, in addition to synchronizing the operation of all network units also provides timing pulses to the network cards and timing clock to the peripheral equipments.

The seventh NU (i.e., NU6) designated as the Conference Unit, provides 128 circuits of 3-way conferencing using a modified loudest speaker algorithm. This conference unit supplies to the third port the loudest speaker via digital comparison of two other ports.

Interface to the Central Processor (CP) for control of the network paths and for network maintenance is provided by Network Controller circuits.

Part of the network complex is comprised of the Digital Tone Sources (DTS) stored in read-only-memories (ROM). A given tone is dedicated to a particular time-slot in TTS and conference circuit and is available via network switching to the peripheral group equipments.

For reliability, the network, clock, network controller and digital tone sources are duplicated in a second network frame in an active/hot-standby mode with both copies running in synchronization and updated with voice data (PCM Samples) and control path data.

The Information Memory (IM) stores the actual speech (PCM) samples consisting of 8 bits plus a parity bit. The Control Memory (CM) contains the Time Slot Interchange (TSI) data, which is provided by the CPU under software control, and defines the input/output time-slot relationship in the IM. Each input channel is associated with a particular time-slot address while the output channels are selected by the call processing software (OTS only).

All time switch operations are based on a division of the 324 ns time-slot interval into two equal, 162 ns nominally, halves referred to as cycle 1 (CY1) and cycle 2 (CY2) respectively.

Attendant Console

The attendant console is of the release-loop type and contains pushbuttons and Light Emitting Diodes (LED's) that enable the attendant to make or extend calls and monitor or apply the various service features of the system. Additionally, the attendant console contains a call identification display which alerts the attendant to the types of calls being serviced.

The attendant-console interface equipment is not duplicated. In the event of an attendant-console failure, one of two options may be taken. If the system is equipped with more than one attendant console, traffic may be routed to the operational consoles. If no other attendant consoles are available, traffic may be routed to a night-answering facility.

Maintenance and Test Center (MTC)

The MTC is a centralized facility that provides an interface between the system and maintenance personnel. The MTC is made up of the Manual Control Console (MCC), and a TTY (hard or soft copy), and additional Input/Output (I/O) access equipment.

- Manual Control Console

The MCC is a focal point for observing and maintaining overall system operation. The MCC provides a visible status display of system components, an audible indication of alarm conditions within the system and a centralized position from which maintenance personnel can change the configuration or status of the common control units in the system for testing or recovery purposes. The MCC is housed in the Manual Control Console Frame (MCCF).

The MCC is composed of two sections, the display section and the control section.

The display section provides maintenance personnel with a visible indication of the system's status. The display section consists of different groups of lamps that display the status and alarm condition of all the subsystems within the system.

The control section provides maintenance personnel with the ability to control and force control-and-memory-complex configurations. Additionally, maintenance personnel can initiate certain immediate maintenance or recovery tasks. The control section also contains lamps that display the configuration of the control and memory complex and the status of the MCC.

- Teletypewriter (TTY)

The TTY accepts input messages and provides output messages regarding the system's response to various requests, alarms, etc.

4. Intended Applications:

There is currently no firm intended application of the GTD-4600 in the DCS. The brief description is provided as a typical example of one of the numerous digital switches now available from commercial sources.

5. Interface Characteristics

Lines

The system offers the following service options to station lines:

(a) With or without extension telephones.
(b) Dial pulsing or DTMF (may be mixed on a line with extensions).
(c) Loop start or optional ground start.
(d) Automatic Number Identification (ANI) only.
(e) Originating service only.
(f) Terminating service only.
(g) Data Line Security.

Trunks

The analog trunk group equipment can support the following trunk applications:

(a) Central Office
(b) Foreign Exchange
(c) CCSA Loop
(d) DID Loop
(e) CCSA E&M
(f) DOD Loop
(g) CAMA E&M
(h) DID E&M
(i) DOD E&M
(j) TIE Line E&M
(k) TIE Line Loop
(l) TIE Line 4-Wire E&M

The system interfaces directly with digital trunk groups (T1 type, D2/D3 compatible).

6. Date of Availability; The GTD 4600 is presently available

7. Documentation Available for Detailed Description:

GTE Automatic Electric Labs, Inc. Technical Brochures, Technical Manuals, etc.

Chapter 5

DIGITAL CONSIDERATIONS

5.1 General - The transition to an all-digital DCS is underway and one of the major subsystems to be impacted by digitization will be DCS technical control. While many of the specific issues and problems have yet to be resolved, an understanding of the principles involved should lead to an appreciation of the potential improvements that digital technology can bring to technical control. In this light, this chapter is intended to present information on devolpments directly or indirectly related to the technical control area which may have significant impact on technical control. Known problems are indicated along with the potential for improved operation and performance. Many areas have not yet been documented for inclusion in this publication but will be included in the future.

(5.2 through 5.8 to be furnished later.)

5.9 DIGITAL SWITCHING CONSIDERATIONS

5.9.1 Purpose

The DCS is a dynamic network continuously influenced by changing requirements and advancing technology. As the DCS enters the decade of the 1980's, the conversion from analog to digital operation will be the common thread among various subsystem implementations. The purpose of this section is to provide guidance and criteria for planning, engineering, and installation personnel that will assist them in coping with this changing environment as they work to upgrade the DCS technical control capability, particularly with respect to digital transmission and switching.

5.9.2 Objectives

The general objectives for future technical control will remain the same; that is, to assist in providing a reliable communications network for peacetime and for emergency or wartime situations. The tech control assists in this effort by providing flexibility through its primary functions of establishing circuits, monitoring, restoral, repair, control, and reporting.

Advancing technology has greatly impacted these functional areas. The advent of the microprocessor, digital transmission, and digital switching has introduced new equipment and with it new interface problems. However, this technology has also improved capability to facilitate many monitoring, control, and reporting functions that are now performed on a time consuming manual basis. Although the new technology is complex, it is clearly promising in terms of opportunity.

5.9.3 Problem Areas

While the new technology offers the capability for tremendous improvement in monitoring, testing, control, and alternate path routing for critical, time sensitive networks and circuits, the real world of the DCS faces many problem areas in achieving such improvement. Influencing factors include:

- Funding limitations in terms of procurement funds but often more seriously, military construction funds
- Political, legal and organizational constraints
- Training and logistic support based on older technologies
- Roles and mission boundaries based on older technologies
- Policies, procedures, standards and criteria based on older technologies
- Limited interconnectivity of major portions of the network

- Shared use of common paths by critical time sensitive users
- Intermix of analog and digital subsystems during a lengthy transition period
- Mix of different equipments with different operating capabilities and characteristics not all amenable to modification for interoperating with the new digital technology
- Differing commercial and military standards in such important areas as modulation techniques, multiplex hierarchies, signaling and interfacing.
- Major investment in existing facilities in established locations
- Technical and operational need to operate certain facilities from diverse locations based on older technologies
- Division of responsibility for planning, engineering, and implementation of projects between different military departments and agencies.
- Encryption of 1.544 Mbps signals on an end-to-end basis which precludes time slot interchanging at an intermediate point.

Despite these many problem areas, coordinated actions following the guidance and criteria provided below, can utilize current commercial technology to provide cost effective improvements to the DCS operational capability and survivability. The constraints listed above should caution planners that progress will be evolutionary and not all of the guidance provided herein can be utilized in a sudden, revolutionary manner.

5.9.4 Methodology

The remaining portions of this section define equipment, general guidance, and criteria applicable to the planning, engineering, and implementation of new DCS technical control (or patch and test) facilities. Specific illustrations, applicable to Europe and the Pacific, are also provided. The overall emphasis is on digital technology although it is recognized that the transitional DCS will retain a significant analog component for a number of years.

5.9.5 Digital Equipment

New technological advances and manufacturing techniques have made available highly reliable components and equipment that permit establishment of cost effective digital transmission and switching systems. The advent of relatively low priced microprocessors provides a capability for high speed monitoring and testing of circuits and equipment as well as for performing reporting and warning functions. Systems can be designed to perform self-diagnostics, self-replacement (through redundancy), and automated rerouting. LSI and VLSI technology is being applied across the wide spectrum of system design, permitting highly sophisticated intelligence and software to be incorporated in the switching, transmission, terminal and technical control areas. The viability and added value of this new technology is firmly illustrated by the quantity and variety of new communications equipment being introduced.

Digital switching equipment has higher reliability than its electromechanical counterpart. Performance of digital switches and transmission facilities, with their built-in redundancy, is frequently stated at better than one hour downtime in 10 years or less than six minutes per year. The equipment is normally built on a modular basis providing systems that have exceptional diagnostic capability. Thus, the equipment can switch from a defective to a good modular unit and alert the system operator of the action, using the diagnostic tool to isolate the faulty module. With a spare available, the defective module can be manually replaced without interruption of service.

With a proper configuration, the operator can, via his control terminal, instruct the system to cross-connect circuits, replace components, and in general, control, monitor, and test the accessible telecommunications equipment and channels.

However, as with analog systems, there are limitations. Despite the many advantages of digital transmission and switching, improper planning can simply lead to a substitution of old analog problems with a new set of digital problems of somewhat greater complexity.

5.9.6 Specific Planning/Engineering and Transition Consideration

5.9.6.1 Analog-Digital Mix. The DCS is now primarily an analog network, however, major digital subsystems are rapidly being introduced to meet new requirements or to replace aging analog facilities. For at least the next decade, the DCS will be a hybrid analog-digital network. This means analog to digital (A/D) or digital to analog (D/A) conversions will be required where the different systems interface. It is of course desirable that where possible, the circuits should remain digital from end to end. An associated requirement will be for digital technical controls to interoperate with manual patch and test facilities at existing terminals. In all stages of digitization, the new digital facilities must be completely interoperable with older facilities at existing locations.

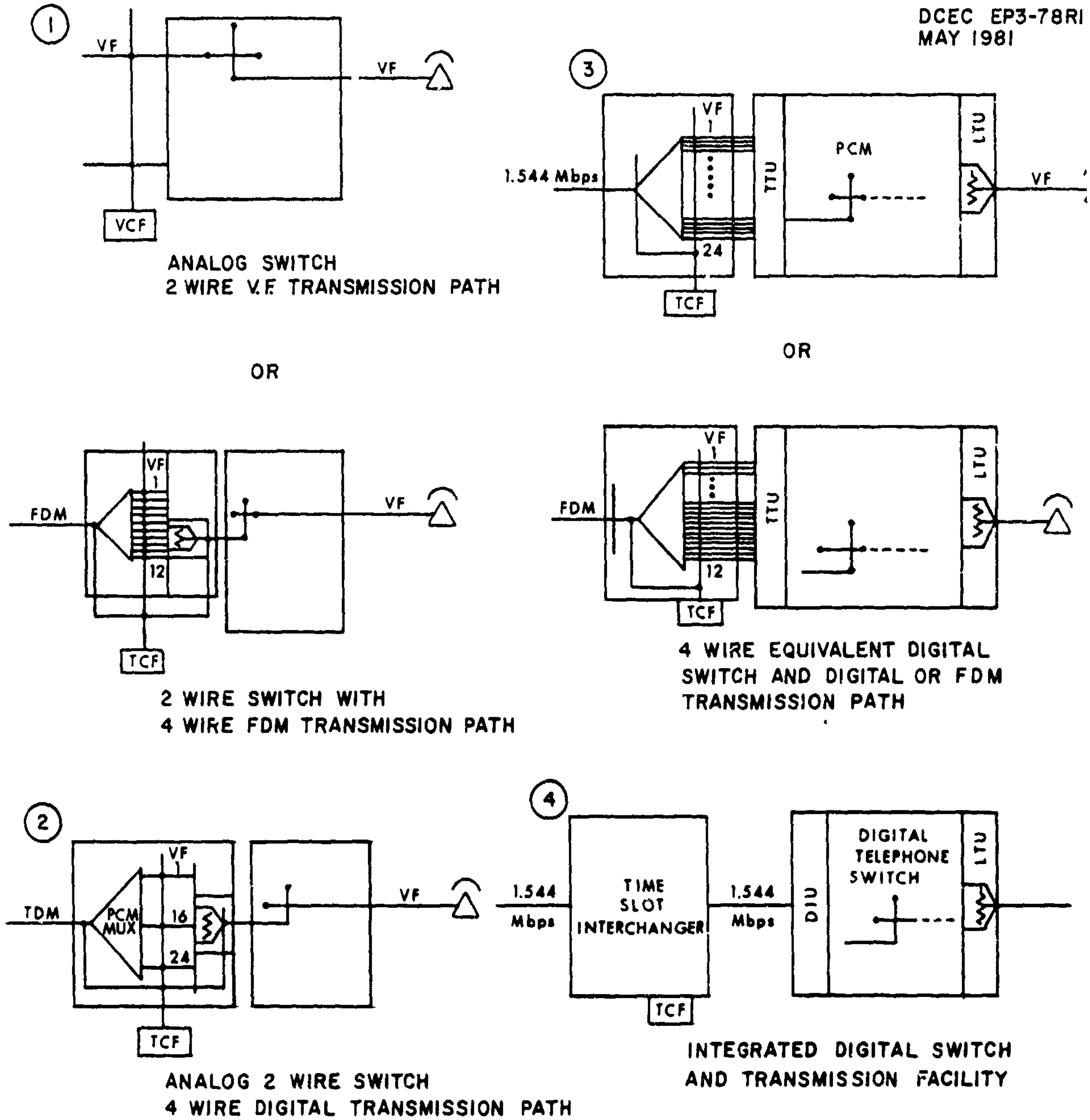
Figure 5.9.6(a) represents the transition stages which are occurring in the DCS as digital hardware replaces the analog switching and transmission facilities. Panels 1 and 2 depict virtually all of the present configurations existing today in the switched DCS. Panel 3 indicates the configuration as digital switches replace the present analog units. As this replacement is implemented, as will be the case in Europe under the ETS Program, the opportunity exists to selectively realize the configuration in Panel 4 without implementing Phase 3. (Paragraph 5.9.6.6 discusses some of the limitations associated with using digital switches for technical control functions.) Since the digital switch Time Slot Interchange Feature switches TDM Channels in a PCM format there is no need to demultiplex the PCM transmission for processing by a digital switch. This opportunity to eliminate channel banks at the switch is a major advantage of the digital switch.

With the introduction of digital multiplexing and switching, much of the line conditioning and level adjusting equipment is eliminated, especially if the channels are not brought to VF level. When the digital switch is employed, line conditioning units, such as 2 to 4 wire hybrids and SF signaling units, are provided as an integral part of the Line Terminating Unit (LTU).

5.9.6.2 Integrated Digital Switching-Transmission System. Integration of digital transmission and switching systems is a logical consideration when these subsystems are utilized in a common communications network. A non-integrated approach to implementation of transmission and switching would process a telecommunications signal in the following unnecessary manner.

- Demultiplex the digital bit stream from a distant node to voice frequency (VF) level
- Interface the VF signal to a digital switch
- The switch digitizes the VF signal to pass it through the matrix
- The VF signal is reconstructed on the output side of the switch
- The VF signal could be digitized again for transmission to a distant switch or terminal.

Since similar digital formats and megabit signaling rates are employed in both switches and multiplexers, the alternative is to maintain the digital signal over the entire digital path and only demodulate to VF level at, or close to, the user terminal. The evolution of this concept is depicted in Figure 5.9.6(a) and is the basis for major redesign of Technical Control Facilities of the future. As the VF interfaces with the switch increase, the patch and test, circuit terminating, and conditioning capability must grow in direct proportion. This situation will increase demand for floor space and associated facilities at tech control locations and increase staffing requirements unless the VF interfaces are avoided.



LEGEND

TCF – TECHNICAL CONTROL FACILITY
FDM – FREQUENCY DIVISION MODULATION
PCM – PULSE CODE MODULATION
VF – VOICE FREQUENCY
DIU – DIGITAL INTERFACE UNIT
LTU – LINE TERMINATING UNIT
TTU – TRUNK TERMINATING UNIT

FIGURE 5.9.6(a).
DEVELOPMENT OF DIRECT DIGITAL SWITCHING AND TRANSMISSION CONCEPT

5.9.6.3 Digital Equipment Compatibility. Digital transmission systems pass encoded data streams resulting from Pulse Code Modulation (PCM) of analog voice signals. The initial step in the encoding process is sampling the analog signal at a periodic rate. The common sampling rate is 8 kHz or once every 125 us. This noncontinuous, periodic sampling produces a stepped or quantized signal. Each quantized step (sample) is assigned a binary 8-bit code to represent it. It is this binary code that is transmitted and used at the distant end to reconstruct the content of the original signal.

The North American PCM system used for transmission multiplexes twenty-four 64 kb/s channels into a single 1.544 Mb/s stream. The "scanning cycle" or frame for the twenty-four channels is 125 microseconds and in each frame, the individual channels are allocated 8-bits to encode the incoming channel signal. Each frame also includes 1 bit for timing information so that the distant receiver can recognize the beginning and end of each frame transmission. The following illustrates this:

8 bits/time slot X 24 channels = 192 bits + 1 bit for framing = 193 bits
193 bits/frame X 8000 frames/sec = 1.544 Mb/s (Figure 5.9.6(b))

Unfortunately, from a global DCS viewpoint, the "North American" format is not a universal standard.

The "European" PCM system transmits 32 channels of 64 Kb/s each, thus providing a standard output rate from the primary multiplexer of 2.048 Mb/s. In the normal configuration, one of the 64 Kb/s channels is used for frame alignment and alarms (channel 0), and a second 64 Kb/s channel (channel 1/) is reserved for signaling. Each voice channel therefore uses full eight bit encoding. (Figure 5.9.6(c))

The incompatibility of the signaling and timing techniques employed in the North American and European digital formats is the greatest obstacle to integration of the Digital European Backbone (DEB) and the European Telephone System (ETS). The signal conversion and timing compatibility considerations are now being reviewed for solutions. The present plan is to do all interfacing at the digital switch because of the flexibility in the software and the compatibility requirements imposed by CCITT on switch manufacturers.

Clearly, the differences in format described above prevent direct interoperability of the two systems. This becomes an issue of deep concern and complexity in the overseas DCS in the European Theater since it will be necessary to provide suitable interfaces. Fortunately, the DCS in the Pacific Theater will largely be spared this interface problem since the T1 format is expected to be used.

5.9.6.3.1 Companding Systems. In addition to the format problem noted above, there is also a difference in the companding technique used in North America and that used in Europe. (They are both CCITT recommendations.)

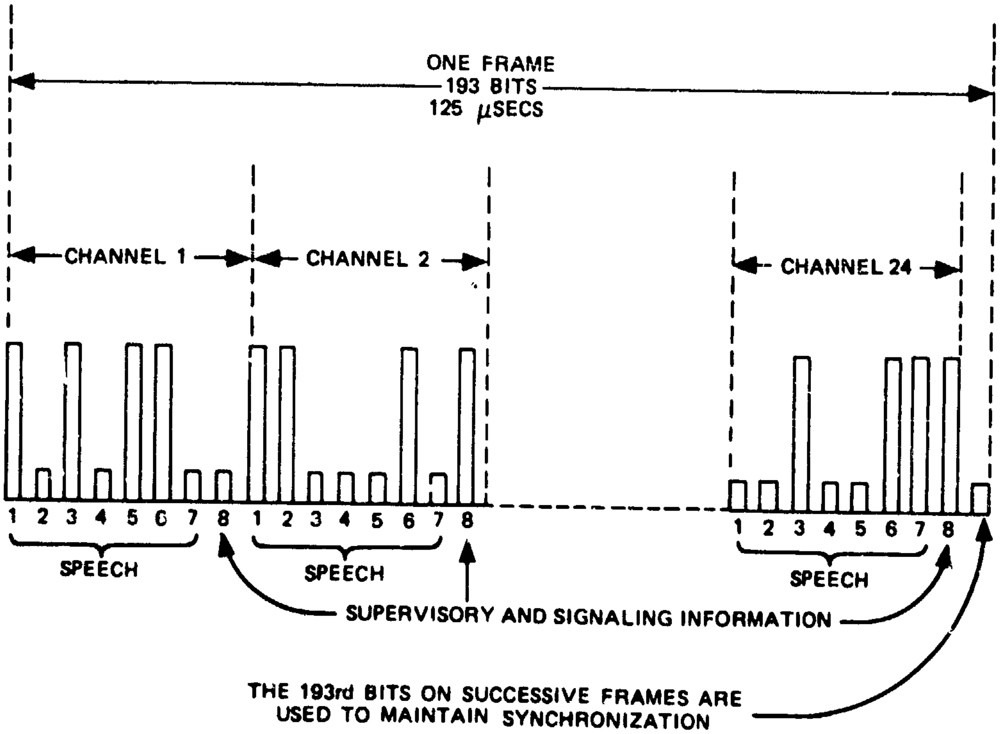


Figure 5.9.6(b). North American T1 PCM Carrier Format

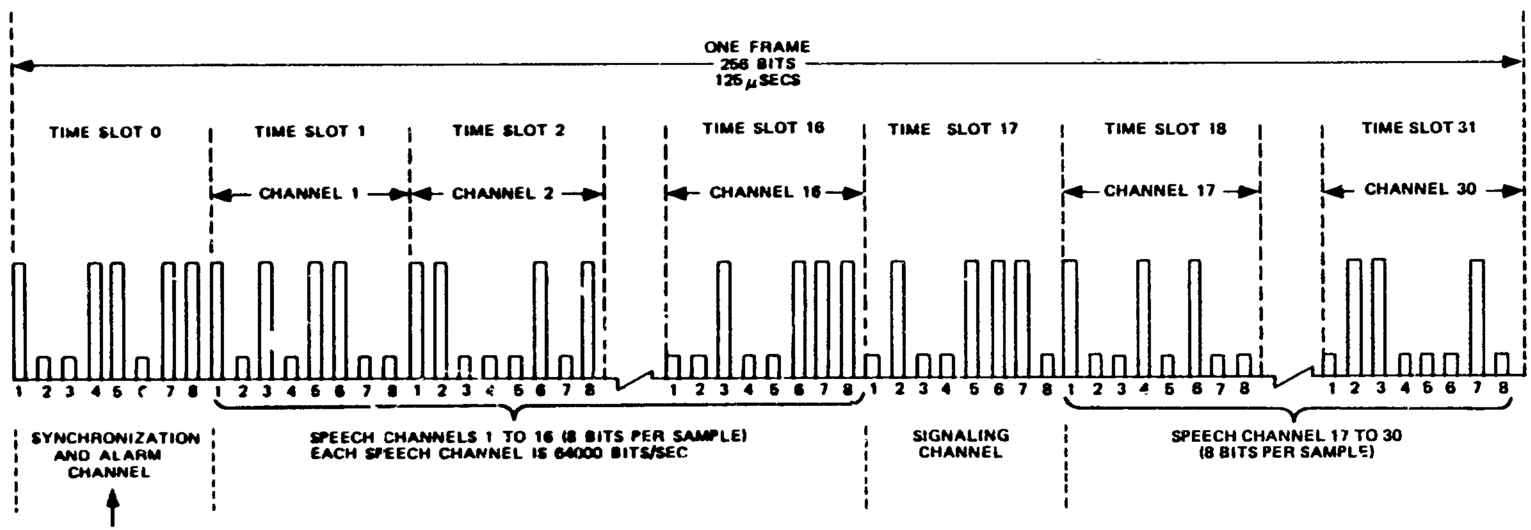


Figure 5.9.6(c). CCITT Recommended Format

Companding is using a non-uniform method of quantizing the signal to be transmitted. It increases the signal to distortion ratio and the dynamic range above that which can be achieved for a linear 8 bit code system. Companding attenuates strong signals and strengthens weak signals; thus, both hard and soft speakers get good transmission.

The North American technique used is known as u-Law (also called u = 255 Law). The European system is the A-Law system. Each system has its own algorithm for converting its established input samples to a desirable output level for signal reconstitution. The algorithms, while generally similar, are not the same; the sampling points/levels are not identical and the 8 bit codes differ. Thus, while both systems have the same objectives, they are not directly compatible. See Figures 5.9.6(d) and 5.9.6(e).

It is obvious that format and companding differences between the "North American" and "European" PCM systems create very special and difficult interface problems. Some potential solutions to these problems are:

- 64 Kb/s "North American" to 64 Kb/s "European" channel. There is no currently available transparent interface between these systems. Demodulation to audio level is the accepted interface procedure. Although conversion between u-Law and A-Law companding is feasible and microprocessor controlled reformatting of the two signals can be accomplished there is, as yet, little economic incentive for the effort.

- 1.544 Kb/s "North American" digroup to 2.048 Kb/s "European" digroup. An equipment such as the RADC Digital Channel Efficiency Model described in paragraph 5.10.3.1 is needed for this type of interface. No separate suitable commercial equipment is available although the Digital Interface Unit component described in paragraph 4.11.2, sub-para 5 is designed to perform such a function.

- 1.544 Kb/s and 2.048 Kb/s digroups to CCITT analog groups. Appropriate transmultiplexers could accommodate this type of interface. As with the digital to digital example above, some juggling of channels would be necessary to avoid penalties in the fill ratio when interfacing from 24 to 30 channels and vice versa. A number of transmultiplexers are available and representative models are briefly described in paragraph 5.10.3.2.

5.9.6.4 <u>Physical Location</u>. The physical location of communications facilities is dictated by various factors. PBXs or COs are normally placed near the majority of the subscribers they serve. This is to minimize the length of the many local distribution lines. Tech controls are normally located separately or adjacent to multiplex and microwave equipment.

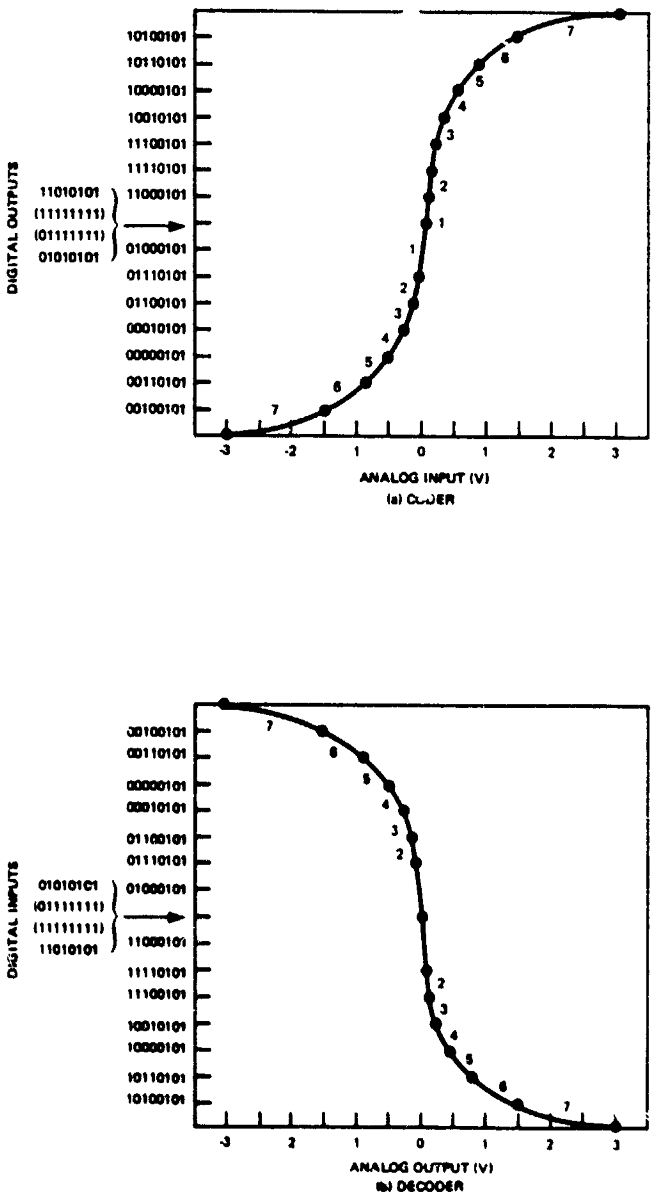


Figure 5.9.6(d). A-Law Coding

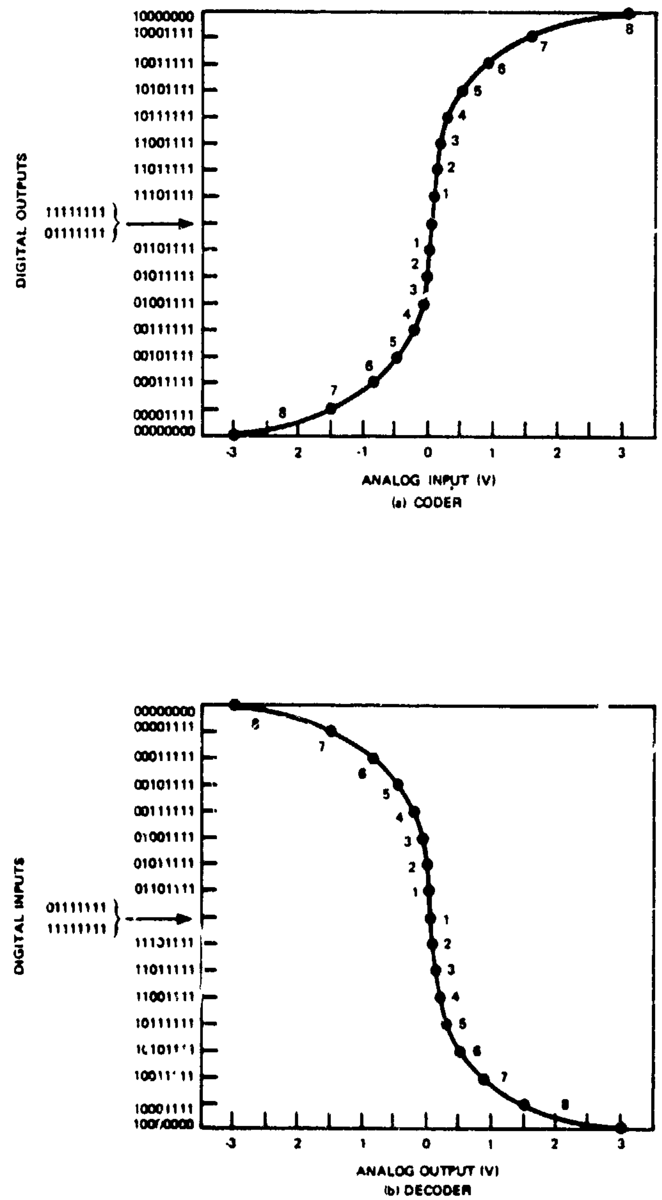


Figure 5.9.6(e). μ-Law Coding

Transmission and AUTOVON tandem nodes are frequently located on mountain/hill tops, at a considerable distance from the nearest PBX/CO. They are so placed to provide good line of sight paths for the radio relay systems.

Transmission terminal facilities are frequently located in different buildings from the PBX/CO. This may be due to prohibition on erecting a large antenna facility or noisy power generator installation near the selected PBX/CO site or may simply be due to lack of available space adjacent to the PBX/CO site. Communications facilities are located in whatever space made available by the post commander.

In some cases, the technical control is located in a building separate from any other major telecommunications element. This separation of facilities is far less than ideal from a manpower, operational, and technical viewpoint and the full benefits of digitization cannot be realized with such arrangements.

With the introduction of digital switching/time slot interchange and transmission systems, the opportunity exists to consolidate these closely related functions. Digital switching/time slot interchange and transmission equipment normally takes less space and has lower power requirements than analog equipment. Furthermore, much of the monitoring, testing, and patching of digital circuits can be accomplished from the digital switch/time slot interchange control terminal. Thus, from operational, economic, and survivability viewpoints, having all of the facilities closely located in a common and protected facility is extremely desirable and advantageous.

If facilities must be separated, the technical control and transmission terminals should be colocated because the technical controllers present, as well as future, patch and test capability is at the multiplex and radio equipment locations.

5.9.6.5 Limited Network Interconnectivity. The survivability of a network such as the DCS, depends, in large part, upon regional subsystems that lack survivability due to the single thread nature of the serving communications links. For a technical control to alt-route circuits, an alternate path must be available between the desired end points and technical controllers at the appropriate locations must have physical access to the circuit or system involved.

Alt-routing within the tandem portion of a switched network such as shown in Figure 5.9.6(f), is simple and commonplace. In completing a call from User 1 to User 2, if the link B-E is not available (busy, or out of service), the call can be completed via alt-routes B-F-E, B-D-E, or B-C-E. However, if any of the single thread links 1-A, A-B, E-G, or G-2 are not available, no altroute is possible. For increased cost, additional connectivity could be provided by establishing links such as A-C/F and G-D/F. Additionally, altroutes could be provided between 1 and A and 2 and G. Care must be taken in establishing alt-routes to ensure that, if possible, they do not traverse the same paths an interconnect points as the circuit being alt-routed. This is frequently the case, even in large networks such as the Bell System where there are large concentrations of circuits at major transmission nodes.

Switched networks inherently have alt-routing capability. The DCS has many hi priority dedicated circuits that presently require manual alt-routing in the event of an outage. With adequate interconnectivity, proper planning, and programming of the new electronic switches/time slot interchanges, dedicated circuits can be automatically alt-routed thereby supplanting the need to manually route around the failed section in the transmission link.

In Figure 5.9.6(g) a circuit connection from Switch A to Switch D with the ability of automatic or operator controlled alternate routing can be redirectec from A to C to D through A-B-C-D or A-B-D by using the automatic alternate routing feature and time slot interchange principle inherent in digital switche

The efficiency of this capability is, however, based on alternate route connectivity between multiple switching nodes but complete flexibility of channel interchange can take place even within a single thread mux between switches. The important points are that:

- There is no constraint to dedicate a particular time slot in a multiple group to any circuit or to group patch entire digroups to reestablish priority circuits within a digroup.
- The switch or timeslot interchanger can make direct connections between channels of incoming and outgoing lines.
- The switch or time slot interchanger can break out a single circuit to the VF level and thus the costly demultiplexing of entire digroups to terminate a few circuits is eliminated at transmission nodes.
- The switch or time slot interchanger can serve as a substitute for carrier terminal equipment at both ends of the digital transmission lin and in addition is capable of alt-routing on a per channel basis.
- The switch or time slot interchanger can pass a digitized telephone typ channel through to any digital multiplexed facility without converting to VF, thereby eliminating the need for back to back multiplexing.
- The switch or time slot interchanger can provide access to any channel for remote digital testing.

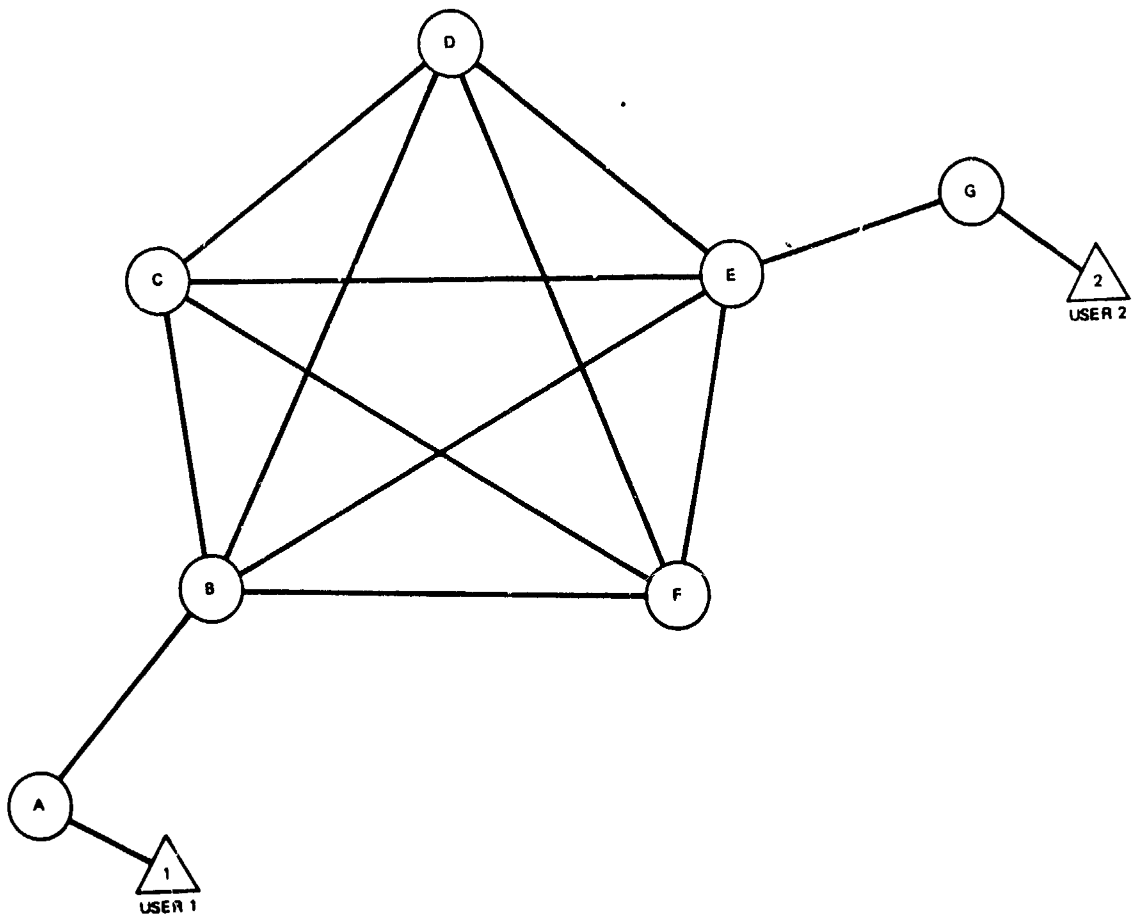


Figure 5.9.6(f). Tandem Portion of Switched Network

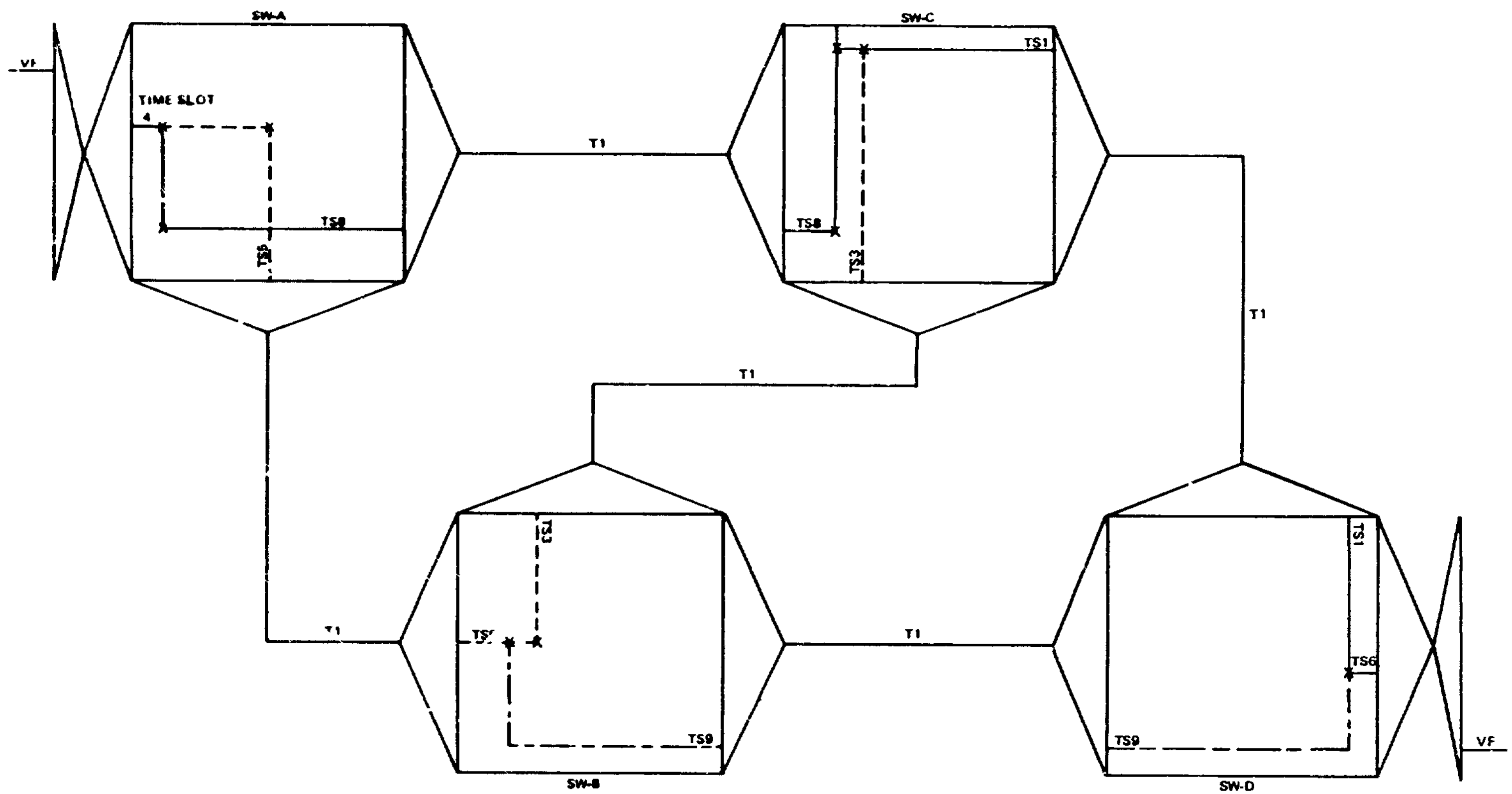


Figure 5.9.6(g). Application of Principle of Time Slot Interchange for Alt-Routing

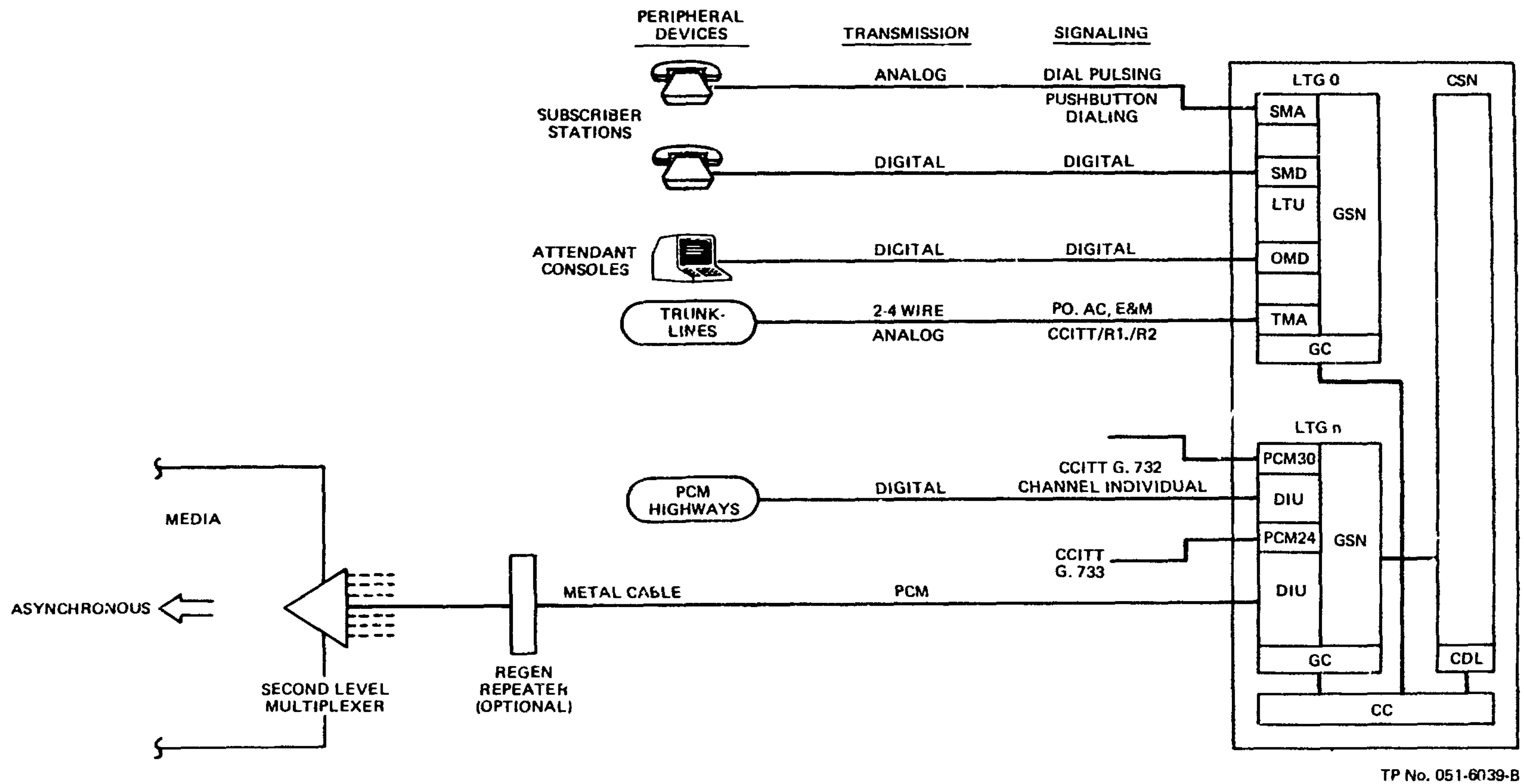
5.9.6.6 Digital Switching Devices for Technical Control Applications. The listed capabilities are synonomous with many of the technical control functions and lead naturally to considerations of a digital switching/time slot interchange device for technical control application. A brief discussion follows:

- The typical digital switch would be practical for only a limited number of technical control functions. If circuits could be "nailed up" it could serve as an electronic patch bay under the control of an operator. If the software were configured correctly, channels could be grouped into the correct digroups or highways and so reswitched as long as the switch was active. Although switch diagnostics are well designed, the station alarms necessary for a functional techical control would still have to be provided. A limited amount of loopback capability could be used between switches but full loopback to subscribers or users would not be available. Digital switches can serve as a source of traffic information and provide a general view of the health of the access lines and trunks associated with the switch. However, their technical control functions and capabilities are as yet too limited to completely replace existing manned TCFs.

- The European Telephone System (ETS) switch, and in fact all digital switches today, have been designed to provide quality transmission and routing for voice frequency (300 - 3600 Hz) telephone circuits. They are not intended for anything other than this. Thus, there are certain circuits which traverse Technical Control Facilities that must continue to be served by the present manual patching and testing methods. These are data circuits of more than 9600 bps whether encrypted or not and terminating voice and data non-telephone circuits. These would be routed to PCM channel banks and then patch and test facilities.

- The employment of a digital electronic switch system is not without some basic problems. These problems appear in the form of unique interface and configuration problems. Some of these problems and some candidate solutions are illustrated in Figures 5.9.6(h) through 5.9.6(l). The model used for illustration is the interfacing of the ETS switch (KN-101) with the DEB transmission media although these same issues apply to any switch/media interface. For example, in the ETS/DEB, conversion from A-Law (PCM-30) to u -Law (PCM-24) must be accommodated. This issue is being addressed by the appropriate organizations. The RADC DCEM described in paragraph 5.10.3.1 and shown in Figure 5.10.3.1 may be capable of being used in this application. These illustrations are intended to depict typical configurations/ interfaces that may be required wherever the digital switches meet with the planned DCS media.

- Because of the limitations of digital telephone switches for technical control functions and the fact that many transmission nodal TCFs in the DCS will not have digital telephone switches on site, it is apparent that the "Technical Controller" who is dealing more and more with digital transmission systems will require a small digital switch or Time



LEGEND

CC	– CENTRAL CONTROL	LTU	– LINE TRUNK UNIT
COL	– CONTROLLER	OMD	– OPERATOR MODULE DIGITAL
CSN	– CENTRAL SWITCH NETWORK	PCM 24	– PULSE CODE MODULATION-24 CHANNEL INTERFACE UNIT
DIU	– DIGITAL INTERFACE UNIT	PCM 30	– PULSE CODE MODULATION-30 CHANNEL INTERFACE UNIT
GC	– GROUP CONTROL	SMA	– SUBSCRIBER MODULE ANALOG
GSN	– GROUP SWITCH NETWORK	SMD	– SUBSCRIBER MODULE DIGITAL
LTG	– LINE TRUNK GROUP	TMA	– TRUNK MODULE ANALOG-INTERFACE UNIT (MANY TYPES)

Figure 5.9.6(h) Digital Interface - (Typical)

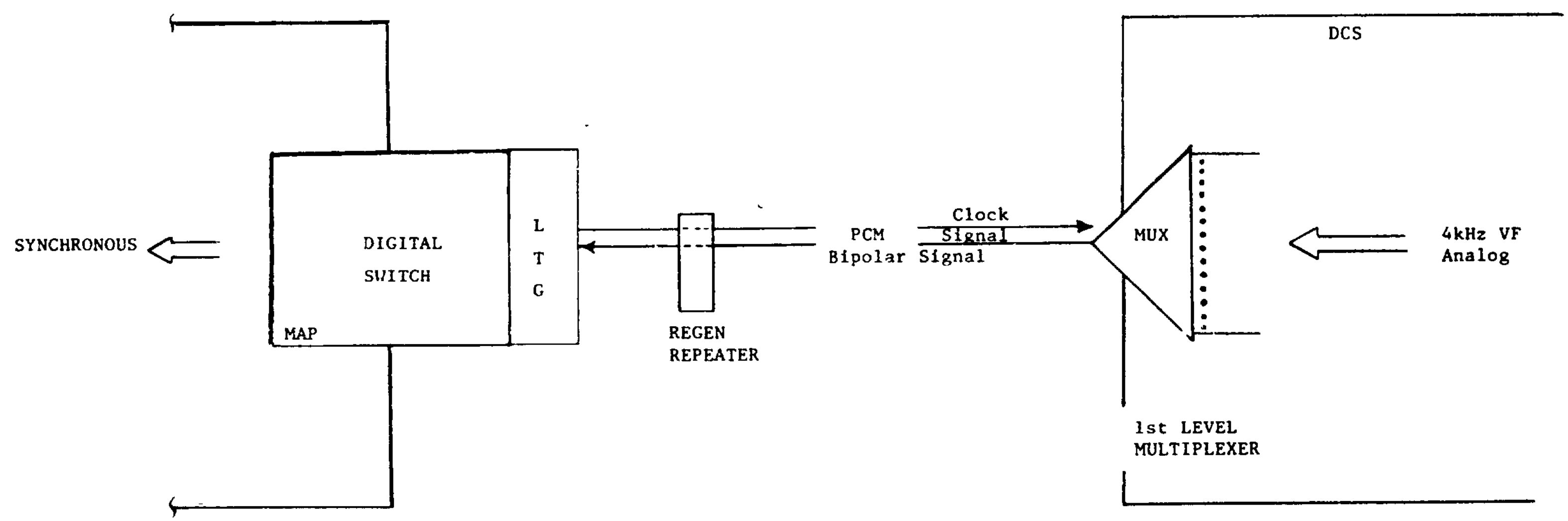


Figure 5.9.6(i). Digital Interface Using Cable

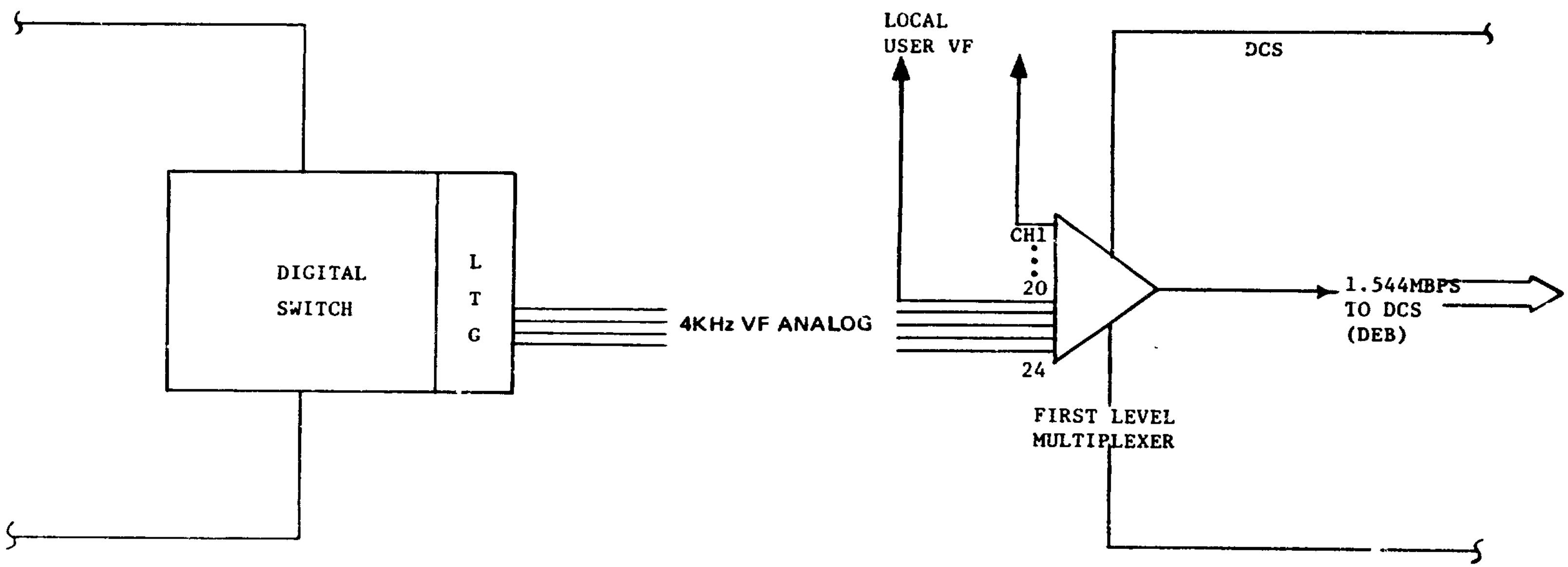


Figure 5.9.6(j). Digital To Analog DCS Interface

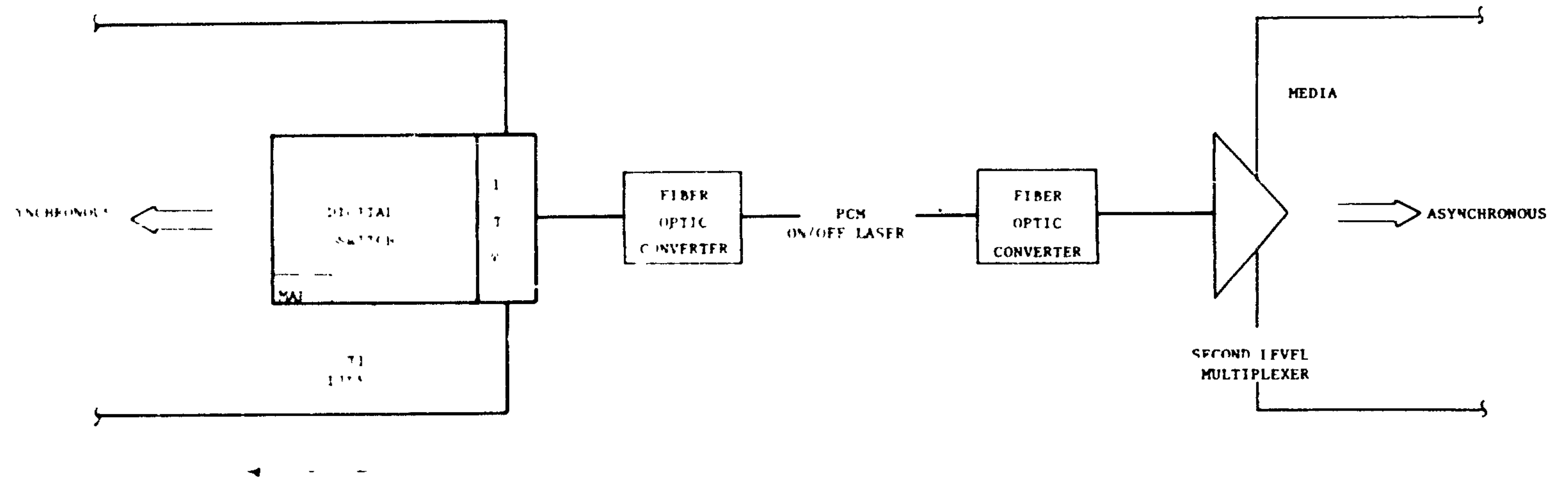


Figure 5.9.6(k). Digital Interface Using Fiber Optics

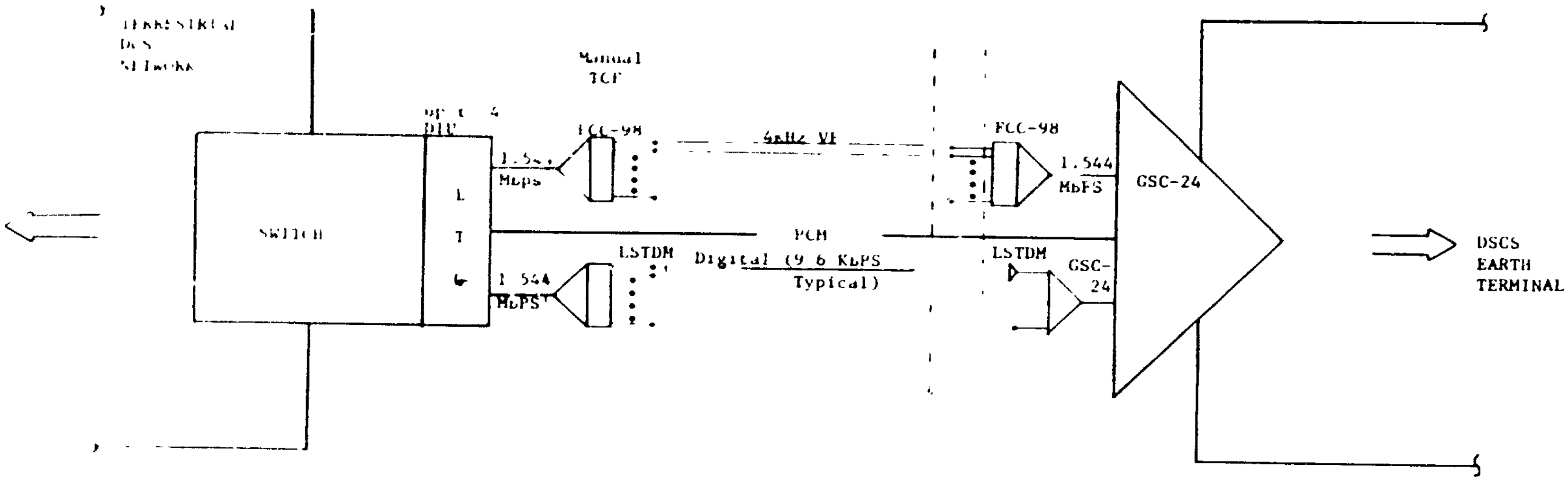


Figure 5.9.6(1). Digital Interface Electronic Switch/DSCS

Slot Interchanger (TSI) designed specifically for technical control functions without all the costly "dial features" inherent in a digital telephone switch. For these reasons a digital Time-Slot Interchanger such as the "Digital Access Crossconnect System" (DACS) developed by Western Electric Co. will likely be utilized at future TCFS and will typically be arranged as indicated in Figure 5.9.6(m). This arrangement not only provides for the access required by a TCF on digital circuits of 1.544 Mbps but also provides full technical conrol of voice frequency and frequency division multiplexed circuits through the use of Digital Multiplexers and Transmultiplexers to convert these types of circuits to digital formats.

- Capabilities of Time-Slot Interchangers such as the Western Electric Co. DACS can provide the Technical Controller with the required capability to technically manage the DCS effectively and at the same time eliminate the tedious and time consuming V.F. patching and testing procedures involved at Technical Control sites today. Among these features are:

  - Rerouting of individual circuits at a digital level (64bps) without the frame wiring required today.

  - Eliminates the requirement for much of the circuit conditioning equipment necessary when a circuit is converted to V.F. level for remultiplexing over some other FDM or Digital transmissiopn link.

  - Provides an immediate report of system status and facility condition.

  - Provides a means of segregating various types of traffic onto exclusive groups.

All functions are provided without having to demodulate to VF level which guarantees a higher quality transmission over greater distances.

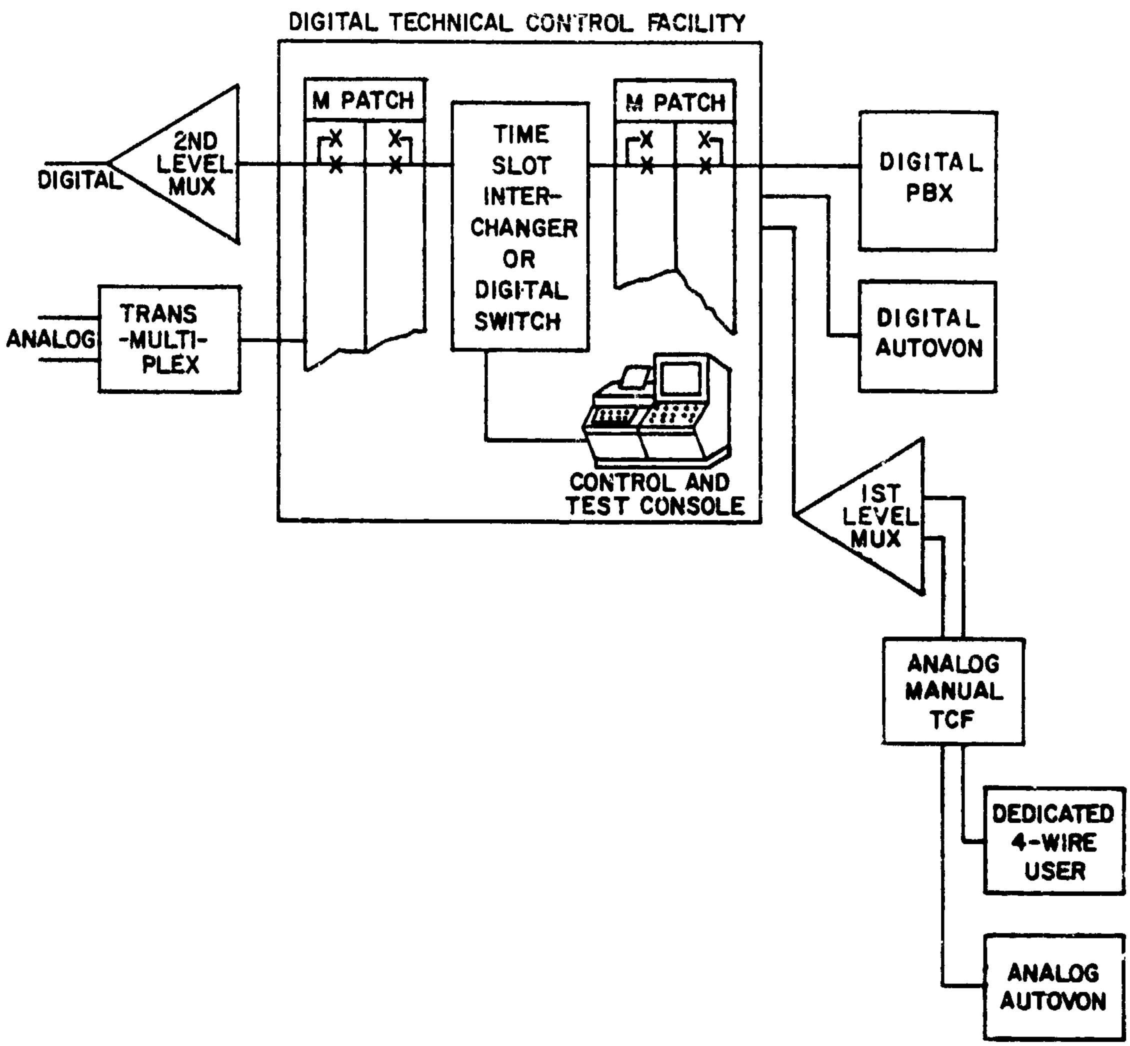


FIGURE 5.9.6(m). TYPICAL TIMESLOT INTERCHANGER/DIGITAL SWITCH CONFIGURATION

5.9.7 Guidelines and Criteria

5.9.7.1 General Guidelines. Technical controls must be prepared to handle both analog and digital circuits during the hybrid analog-digital transition period. Close observance of the following guidelines for technical control implementation or upgrade will enhance the reliability and survivability of the DCS.

5.9.7.1.1 Physical Location. Where feasible, the technical control, switching, and transmission facilities should be located in the same immediate area separated only the minimum distance appropriate for technical and operational considerations.

For survivability and endurability, the telecommunications facilities for critical time sensitive users should be housed in secure structures along with the critical command and control facilities.

In the event the three facilities cannot be colocated, the technical control will normally be colocated with the major multiplex/transmission node. A small digital switch such as a Time Slot Interchanger should be considered to assist in automation of technical control functions.

5.9.7.1.2 Technical Control Automation. Full advantage should be taken of the new automation techniques wherever feasible. These can provide for:

- Automation of system and circuit monitoring
- Automation of system and circuit testing
- Automation of reporting
- Automation of system and circuit alt-routing.
- Automation of circuit provisioning
- Automated routing of channels in selected special service networks.

Essentially all digital switch manufacturers provide these features to varying degrees and some special requirements can be accommodated by software design. New or upgraded technical controls should plan for the of these valuable capabilities wherever feasible. See the discussion in paragraph 5.9.6.6 on limitations of these switches for technical control applications.

5.9.7.1.3 Plans. Plans for technical control upgrades should include the following:

- Provide for the interfacing of analog and digital facilities.
- Provide for allied, tactical, and commercial interfaces.
- Provide for remote control of technical control related digital switc functions in the event the technical control is physically separate f the location of the local area digital switch
- Pass through the communications at the highest level consistent with routing requirements.
- Utilize automated capabilities to accomplish:

  diagnostic programs

  data base maintenance

  trouble isolation

  trouble reporting

  statistical analysis

  report generation

- Provide the capability for rapid manual intervention to bypass failed major elements or to cope with emergencies not foreseen in the non-stressed operating environment.

5.9.8 DCS Telecommunications Programs

The DCS, both overseas and in CONUS, is being modified to a large degree, by several major telecommunications programs that will impact technical control design, planning, engineering, and operations. Among the most significant programs are:

- European Telephone System (ETS)
- Digital European Backbone (DEB)
- Technical Control Improvement Program (TCIP)
- Scope Dial (Air Force Digital Switch Program)
- BASCOP (Army Digital Switch Program).
- Pacific Digitization Program.
- Low Speed Time Division Multiplex (LSTDM) Program.
- Timing and Synchronization Program.

5.9.8.1 In Europe and the Pacific, the ETS, DEB and Pacific digitization programs will constitute a major expansion of digital transmission and switching in the DCS. Many of the transitional problems inherent to a hybrid analog-digital network will be initially encountered and resolved as these large programs become operational.

5.9.8.2 The Technical Control Improvement Program (TCIP) will be increasingly shaped by the growing digitization of transmission and switching facilities. Improvement and refurbishment of analog technical controls will be on a reduced scale. Technical control automation will likely be implemented but as a transitional system pending integration of digital transmission and switching facilities with their intelligent built-in monitoring and testing capabilities. The physical requirements of technical controls will likely diminish as digitization leads to reduced equipment sizes and smaller manning levels.

5.9.8.3 The SCOPE DIAL and BASCOP programs will introduce small but powerful digital switches into the DCS subscriber areas. The capability of using these switches in a distributed network exists.

5.9.8.4 The LSTDM program appears destined for widespread utilization in the DCS as a replacement for analog VFCTS and as a means for interfacing 64 Kb/s PCM channels to secure voice and other users employing 16 Kb/s and 32 Kb/s transmission rates.

5.9.8.5 The Timing and Synchronization Program is part of the overall conversion of the DCS to digital operation. In a digital network, synchronization is a fundamental requirement to insure bit count integrity. Several candidates for network synchronization have been under study and it appears that a combination of Loran-C, and Cesium Clocks will be used to synchronize the DCS. The timing sources will be distributed throughout the network and will therefore require some buffering to compensate for clock differences and variations in transmission delay.

5.10 FUTURE DEVELOPMENT IMPACT ON DCS TECHNICAL CONTROL

5.10.1 Purpose

This section will attempt to look into the future, beyond 1985, and to describe and discuss new military and commercial telecommunication capabilities and propose concepts and design and configuration options for the future DCS. It will review present and proposed commercial and military hardware and practices including a representative sampling of the electronic switching, automatic testing and remote monitoring areas.

5.10.2 Background

5.10.2.1 Chronology. A few decades past, when communications were simple and point-to-point, the notion of control was inherent in the operation of the end terminals. Connections were made by physical wire or high frequency (H.F.) radio. As nets and networks developed, operational control became a necessity, and as general purpose transmission increased, some method of controlling, monitoring and testing that transmission plant, separate from the users with their terminals, became necessary, and thus facility control or technical control came into being. The advent of large switched systems where the switches were part of the backbone network impacted this separation of operational and technical control.

In the commercial world, the long-lines were separate from the operating companies who had contact with the subscribers. In the military, the DCA ran the long-lines, switches and transmission, and the Military Departments ran the "operating companies" and responded to the users. The problem of three "different" military operating agencies were slowly solved as standards were promulgated. Conversion to digital operation initially caused problems because both base plants and backbone plants became hybrid - partially analog, partially digital.

As new developments are coming on the scene and digital techniques are spreading, the line of demarcation between the base and backbone plant is becoming blurred. A "bit" does not indicate whether it is a subscriber bit or a transmission bit. In the pure digital world the effect of the sudden transitions from audio to radio frequency are reduced as the same digital signal is regenerated, time slotted, retrieved and finally delivered. Digital equipments are becoming versatile, small, and highly sophisticated. Technical control can no longer bring signals to its domain, look them over, and send them on their way. Technical control must look for "targets of opportunity". Wherever possible, the job must be done without adding extra equipment, extra routing, extra handling or extra personnel. The challenge is to anticipate these changes rather than have them thrust upon the technical control world. In this section we will discuss many of these recent developments and propose methods for dealing with the future.

5.10.2.2 Transition. In considering how to progress from analog systems through hybrid analog-digital to mostly digital systems, the effect of the transition on technical control functions as they affect procedures and configurations will be considered. An implementation strategy is required that permits digitization to proceed rapidly with minimum disruption to services that depend on the existing network for their communications.

5.10.3 Technology Advances

Modern communications technology is advancing at a tremendous pace. Many of these advances will profoundly affect both communication equipment design and also the design of technical control facilities. Examples of the more important developments are described below.

5.10.3.1 Digital Time Assignment Speech Interpolation (TASI)

TASI equipment is a technique which uses the properties of speech and conversation to carry more conversations over a number of channels than the usual 1:1 ratio.

TASI has not, in the past, found application in the DCS. However, new developments in this area could change the situation. DCS application of digital TASI is under study. Its eventual use would probably be in the area of digital groups such as long haul CONUS-overseas T-1 lines.

The commercial transoceanic transmission submarine cables have used analog TASI for some time to utilize the expensive submarine cable to its maximum. With the advent of digital transmission, many digital TASI's have been developed. Some of these are described below:

- Western Union has developed a microprocessor-run digital speech interpolator for domestic satellite use in which 4-T1 lines (96 voice channels) are reduced to 2-T1 lines (44 voice channels, 4 signaling and overhead channels). Test results have been good with little degradation. This equipment is being refined to include echo suppression.

- Northern Telecom has developed a private line speech interpolator (Model PLC-1) in which digital lines can be reduced from 48 in to 12 out (maximum) down to 9 in to 6 out (minimum) by plug-in cards. This microprocessor run voice concentrator includes signaling capability, contains self diagnostics and alarms, and also computes call and line utilization statistics. A provision is also made to introduce test signals into the system. If power fails the system is bypassed.

- A French company, CIT-Alcatel, has developed a digital TASI system called CELTIC. This system provides a 2:1 reduction and has been tested with the cooperation of AT&T over TAT-6 cable. A dual minicomputer, (one can run the system), controls the connection and operates the system. Two 9600 bps channels transmit signaling information between the end equipments. The equipment can use a digital echo suppressor. The equipment is self-testing. Since two symmetrical ports are used, a failure of one doesn't affect the other. In a general breakdown, CELTIC is automatically bypassed, thus keeping 24 channels in service.

- DCA has evaluated an STC Communications Corporation Model COM2 Voice Concentrator. The equipment was tested on voice grade CONUS-Overseas AUTOVON Trunks. As tested, 17 input channels were converted to 9 trunks. The concentrator is microprocessor-run using digital technology. It uses buffering to allow housekeeping for the reduction. All signaling options are available and echo suppression is included. The equipment is designed to bypass itself in case of failure. Data and facsimile signals are dedicated through. The unit has built-in monitoring capability, and can take lines out of service when excess noise exists and put them back in service when the problem clears. It accumulates traffic data by hours and by channels, and records status and traffic volume. Hourly, it dumps equipment performance parameters. Loop around tests can be performed on a channel or facility basis. The reduction is (2n-1) to (n) where n can vary from 5 to 16. A 300 baud terminal can be plugged in to allow diagnostic reports to be displayed. A display panel is provided so that a field engineer can do detailed trouble-shooting.

- Rome Air Development Center (RADC) is developing a Digital Channel Efficiency Model (DCEM) with many unique features. The unit is designed with two input PCM terminal ports and one PCM line port. Inputs to the PCM terminal ports can be either PCM-24, the North American standard 24 Channel 1.544Mbps T-1 signal using u-law companding or PCM-30, the 30 channel 2.048Mbps A-law European standard. The PCM line port can output the standard PCM-24 signal, the standard PCM-30 signal or a 3.084Mbps signal compatible with the AN/FCC-99 Multiplexer. Internally, the equipment can perform TASI functions, can convert u-law to A-law companding and can translate the HDB3 code used in the PCM-30 to be compatible with the PCM-24 code. It is capable of handling Non Return to Zero (NRZ) polar square wave with associated square wave timing, bipolar signals and ternary signals. By utilizing these features the equipment can convert 48 channels to 24 channels, convert 30 channels to 24 channels; can convert from PCM-24 companding to PCM-30 companding; can be used to send PCM-24 signals over PCM-30 lines and vice versa; and can be used to send PCM-30 signals over DRAMA multiplex equipped DCS facilities. Eight different configurations are specified. See Figure 5.10.3.1. When this equipment is developed and becomes available a large part of the interface problems now confronting the DCS will be alleviated.

- Stromberg Carleson has developed a Digital Trunk Expander (DTX) which uses the TASI principle to reduce the number of channels required to carry voice conversations. It is a digital implemented, microprocessor-run equipment. The minimum size allows 4 trunks to carry up to 6 channels. The maximum size allows 24 trunks to carry 48 channels. Signaling facilities (E&M) are built-in. Faulty channels are blocked and their traffic is internally rerouted through available channels. In the event of a catastrophic failure, the system bypasses itself.

5.10.3.2 Transmultiplexers

In order to reduce equipment costs and complexity when analog systems must be connected to digital systems, a number of transmultiplexers have been developed. These equipments directly accept FDM groups and/or supergroups and convert them to T-1 lines. See Figure 5.10.3.2 for various configurations.

Transmultiplexers will likely find rather extensive application in the DCS during the hybrid transition period. Their use permits elimination of expensive back-to-back channel banks between FDM group equipment and PCM digroups. Savings in equipment costs and floor space in the order of 50 percent are reported. Brief descriptions of several typical transmultiplexer developments follow:

- AT&T has designed a Model LT-1B Facility Connector that connects 4 analog groups (60 to 108kHz) to two T-1 lines (48 channels). The equipment can handle various signaling options; i.e., CCIS, E&M, Loop, DX, Ringdown. Flexible alarm monitoring and carrier failure alarms are built-in. Test and monitor jacks on the digital side can be used by the Digital Access and Cross Connect System (DACS) described in following paragraph 5.10.3.3.

- GTE Lenkurt has developed an FDM/PCM converter Model 4691B. This equipment connects 4 groups (60 to 108kHz) to either a T-1C line (3.152Mbps) or two T-1 lines (1.544Mbps each). Local and remote alarm capability are built-in and include diagnostic and control features. Each digroup may be remotely loopbacked. Carrier failure alarms and normal digital and analog alarms are provided.

- Granger Associates is producing Model TM 7400 transmultiplexer which is a 24 channel equipenc which accepts two 60 to 108kHz groups and outputs a T-1 line. It is a solid state digital converter. It has loopback features, visual and audible alarms including frame synchronization, loss of signal, etc.

- NTT Electrical Communications Laboratory in Japan has developed a TDM/FDM Transmultiplexer which uses a Fast Fourier Transform (FFT) to convert the signal from analog to digital. It can convert two FDM supergroups (312 to 552kHz) to either a 8.192Mbps or to five 1.544Mbps bit streams. The FFT processor is timeshared.

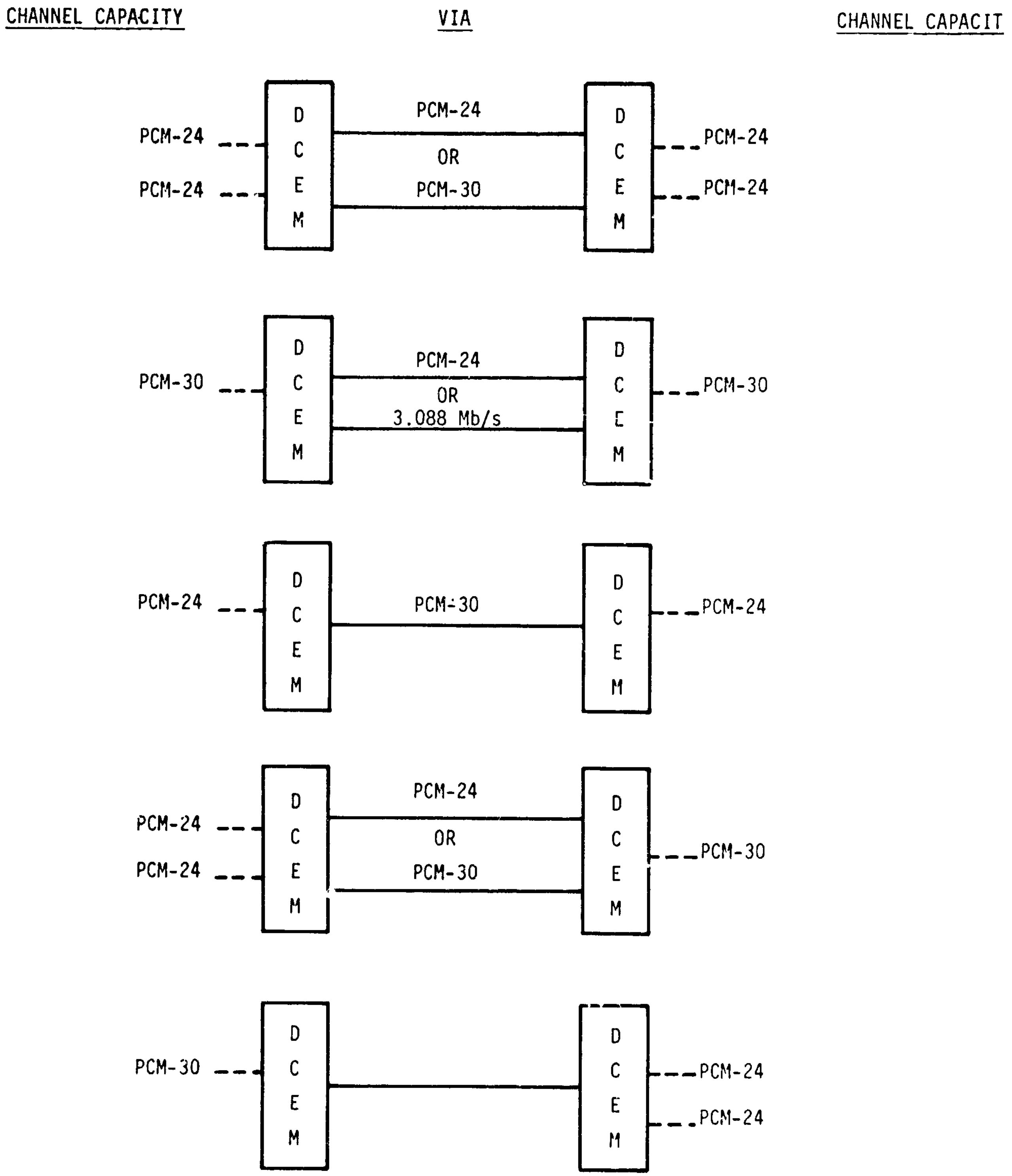


FIGURE 5.10.3.1. ROME AIR DEVELOPMENT CENTER (RADC) DIGITAL CHANNEL EFFICIENCY MODEL (DCEM) TYPICAL CONFIGURATIONS

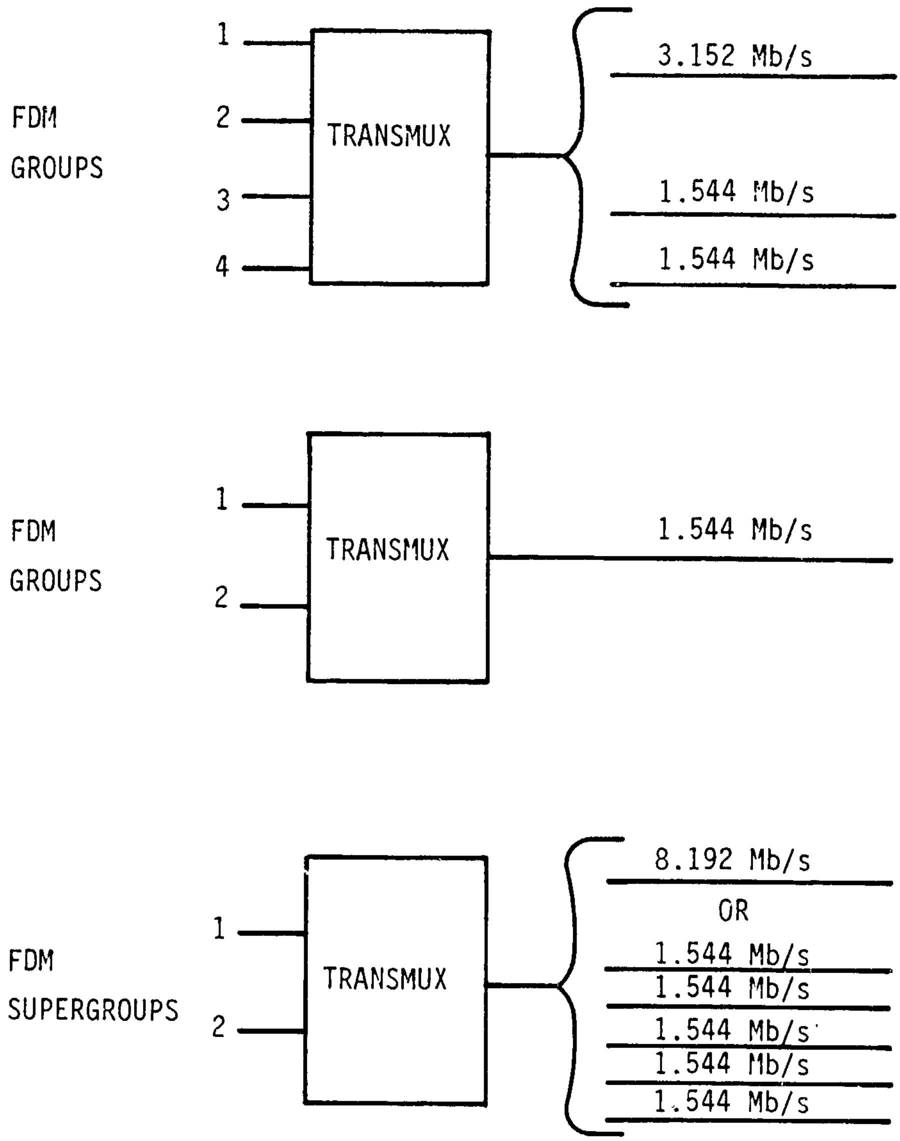


FIGURE 5.10.3.2. TYPICAL TRANSMULTIPLEXER CONFIGURATIONS

5.10.3.3 Time Slot Interchange for Test and Control

A recent development that appears extremely promising for technical control applications is the Time Slot Interchange Unit. This equipment, which is essentially a time-slotted digital switch without call processing capability, offers the possibility to automate many technical control activities that are now accomplished manually. These equipments allow digital channels to be interchanged between trunks, groups and other digital streams.

Review of current literature indicates widespread activity by many organizations in the development and application of time slot interchange units. A program for testing of such a unit is being actively pursued by DCA and the Air Force. Clearly, these equipments will exert a major impact on the design and control of future digital networks. A description of several typical time slot interchangers follows:

- AT&T has developed a Digital Access and Cross-Connect System (DACS). This microprocessor run system allows up to 3048 64Kbs channels leaving or entering the system in 127 T-1 lines to be interchanged within the equipment. In addition, 12 test access ports are available for use in monitoring and testing individual 64kbps channels traversing the system. DACS may be used to collect voice channels with common destinations, to segregate channels by type in order to simplify interconnection and testing arrangements and to provide improved test access to any channel. The use of DACS allows more efficient use of terminals and lines, reduces the requirement for back to back channel banks; reduces distribution frame and patch panel appearances; and allows local and remote rearrangements of digital groups. Group Carrier Alarms and fault isolation to the circuit pack level are built in. The DACS can be controlled by a local teletypewriter or up to four remote teletypewriters. When used with a switch, the transmission function (facility terminal) and a switch-like function (cross connect/test access) can be used for a wide variety of network applications. Major floor savings are made when distribution frames are eliminated through application of the DACS.

- A Channel Reassignment Unit and Automatic Digital Tester has also been developed for use in the TRITAC family of equipments. It is used in the Communications Nodal Control Equipment built by Martin Marietta. This equipment allows channel reassignment for 50 TRITAC groups (up to 1792 TRITAC channels) and insertion or diversion of individual TRITAC channels. It allows subchannel reassignment and insertion or deletion of subchannels. All of this can be done under manual or processor control. Associated with the channel reassignment function is an automatic digital tester which allows for channel and group Bit Error Rate (BER) tests either end-to-end or loop-back using a built-in psuedo random binary sequence generator. It performs an internal self-test, contains built-in test equipment and can:

  (1) Control automatic sequencing of tests.

(2) Compute average BER.

(3) Perform threshold comparison.

(4) Initiate alarms.

(5) Perform trend analysis.

(6) Provide Visual Display Unit (VDU) displays.

- The British Post Office is investigating time slot access to their 2.048Mbps PCM trunks. By accessing the PCM stream using external equipment they see a way to insert and extract data channels at 64kbps and program channels consisting of multiples of 64kbps.

As stated above, there is widespread activity in the time slot interchange field and the brief descriptions provided here only address a few that are currently available or in various stages of development. Clearly, this new and highly versatile equipment will likely play an important role in the digital DCS.

5.10.3.4 Adaptive Multiplexers

Adaptive multiplexers are those in which the output rate is variable depending on the input and which adapt (by manual or automatic means) their output rates closely to the sum of the input rates. These flexible equipments allow maximum use of transmission facilities where the bit bandwidth is limited. These equipments will significantly impact the future DCS technical control functions.

- The Army is procuring a Low Speed Time Division Multiplexer (LSTDM) from Data Products, New England. This is a preliminary description. But initial information indicates the multiplexer allows over 20 different input rates varying from 35bps to 32Kbps encompassing practically all standard rates and those rates expected to be found in the future DCS. The output trunk rate varies from 1.2 to 256Kbps depending on the input rates. Sixteen inputs are available. The equipment will accept NRZ, conditioned diphase, asynchronous, isochronous and synchronous inputs. It is run by dual microprocessors. It may be timed from a station clock, a colocated modem, a higher level mux from received signal or by an internal clock. The unit may be caused to loopback either locally or remotely up to a line rate of 128Kbps. The unit monitors itself on a card by card basis. Alarms are remotable by means of Form C contacts. A not spare channel can be used for test purposes. An in-service bit error rate is determined by counting bit errors in the known frame pattern and frame number. The multiplexer is an 8 bit character multiplexer and can be operated from the front panel. Plug-in cards are used to change port rates. A more comprehensive description is planned to appear in section 4.8.

- Rixon produces a statistical multiplexer model DCX815. It is a microprocessor controlled 4 or 8 channel input. These channels can be from 50 to 9600bps, 5 to 8 bit characters, BAUDOT, ASCII or IBM EBCDIC. The unit uses a buffer large enough to bridge several seconds. This buffer is used for error detection and correction and also for handling peak traffic. ACK's and NAK's are used to retransmi errored frames. An automatic baud rate detector useful up to 1200bps adapts the inputs by analyzing the first data character. The equipmen tests itself at start up and restart and may be locally or remotely looped.

- GTE Sylvania has developed an adaptive multiplexer with 31 input ports. Any mix of 6 synchronous data rates from 2 to 64Kbps in a binary progression may be used. The output rate is 100Kbps to 2.016Mbps automatically calculated by the equipment with an overhead not exceeding 8.5 percent of the total input. The unit includes built-in test equipment and a fault status display. Three lines are used by each port to let multiplex sense connection and port rate.

5.10.4 System Development Options

Maintenance and control systems for the various commercial carrier plant are surprisingly similar. Telephone systems and transmission plant are being converted to digital and are being integrated. Even before the technologies described in 5.10.3 above are being implemented several trends are evident. There are discussed below:

5.10.4.1 Centralization of Control with Distributed Processing

In the analog world the carriers have found it cost effective to centralize their control over the switched network. This is in consonance with the switched network management philosophy of the DCS and allows decisions to be made more rapidly where more information is available. However, in the DCS it is vitally important for the control system to be survivable. This means that each large technical control must be envisioned as the hub of that part of the transmission/switching system that might remain intact after a catastrophe or a military operation. By using multi-processors, the control systems are not subject to the failure of a single unit.

5.10.4.1.1 As an example of this type system, ITT, in their System 1240, has designed a hierarchical control system for a telephone switching system which has a distributed multiprocessor pattern. They base this concept on:

- The decreasing costs of microprocessors and integrated circuit memories.

- Significantly improved node availability.

- Less expensive control element redundancy by use of standby sharing, duplex load sharing control configurations and simple software update.

- Simpler error detection and emergency recovery software.

- No specialized hardware memory compiling of duplex control elements.

- Standard commercial memories with parity and Hamming error detecting and correcting codes. Fault detection objectives can be achieved without building unusual or unique fault detection in control element hardware.

5.10.4.1.2 The distributed processor architecture uses techniques for automatic recovery and maintenance strategy in four areas:

- Provides effective and economical error propagation barriers across control element boundaries.

- Maintains high control element autonomy while distributing maintenance software for most economical use of memory.

- Provides flexible control element and semi-permanent data redundancy without the use of specialized hardware.

- Provides sufficient dynamic data redundancy across processor boundaries to allow rapid takeover of function by standby or spare control element.

Although this particular control system is designed for a telephone switching network, the parallel to a control system for an integrated switching/transmission system is obvious. It is based on a continuous extendable hierarchy of control elements. The lower the level, the higher the number of control elements at that level. The extent of control element redundancy at each level is reduced to match the impact of control element failure on the system.

5.10.4.1.3 As another illustration, AT&T has developed a Telecommunication Alarm and Surveillance System which functionally centralizes and automates alarm surveillance and control. It uses a redundant minicomputer at a centralized point and interfaces to node collection points of alarm information. It handles alarms from central offices, microwave stations, switch control centers, transmission control centers and large switch locations. The system uses existing telemetry systems to both collect information and implement control actions. Both collection and control are implemented by relay closures. Interactive operation, listing logs, system status displays and trouble ticket generation are features of the system. Polling with 12 second updates are used.

AT&T sees trends in maintenance leading to centralization, extensive use of monitoring with telemetry systems, and sophisticated maintenance centrals using minicomputers. They expect this to lead to more effective use of personnel, more frequent monitoring, specific sectionalization, automatic data analysis, and automated management reports.

Each of the separate control, access, and maintenance systems in the Bell System are being integrated into a master system.

5.10.4.1.4 GTE has described a network support system for centralized operations based on a distributed computer network with integrated microcomput minicomputer elements. Communication between the elements is by 2400 to 9600b packet data communication. It is designed to interface existing analog system and present or future digital systems. One single centralized controller performs the functions of network configuration, maintenance, security, accounting and network diagnostics.

5.10.4.1.5 A centralized communication control center is used by Grumman Data Systems Corporation for effective teleprocessing control and maintenance. Thi system allows remote access to six computers of two different manufacturers at different locations. Commercial remote control monitor systems and statistical multiplexers are used. Programmable interactive test systems, uninterrupted monitoring and status keeping are features. Although this system still uses analog transmission, it is an interesting application of a modern centralized technical control built up of commercially available components into an effective and sophisticated control system.

5.10.4.1.6 A similar control system is used by Donovan Data Systems, Inc. Thi network supports about 250 terminals on 65 data lines. Multiple-access switching systems are used for both analog and digital lines instead of normal patch bays. Commercial loopback transponders, remotely controlled, are used to test all parts of the network.

5.10.4.2 Remote Testing

Intimately associated with the concept of centralized control is the use o remote testing tecnniques for controlling the access and testing of remote equipments or equipments at unattended sites.

5.10.4.2.1 One such example is the ADC Products Model 6100 which provides remote access for up to 40,320 circuits. An LSI-11 microprocessor with a flopp disk controls and tests via 300 baud communications lines. Lines are accessed by relay access cards and are tested by test access modules. Up to 8 wires can be switched.

5.10.4.2.2 Cidcomm Telecommunications produces a remote line disconnector for subscriber line testing. The unit allows the subscriber line to be opened, shorted or looped back. A test tone may also be sent back to the test station when so ordered.

5.10.4.2.3 Many tests sets, such as the Hekimian Laboratories Model 3900 are designed to be slaved to a master and perform a full range of tests by remote control. In some cases the line under test is used for communication. In other cases a dial-up connection can be used. These test sets are usually microprocessor controlled.

5.10.4.2.4 AT&T has developed a switched access remote testing system which uses a switched maintenance access system for lines and trunks. Remote controlled test equipment is operated from a central test position. When combined with circuit maintenance systems, automated testing, administration and recordkeeping is provided.

5.10.4.3 Integrated Transmission, Switching and Technical Control.

The combination and integration of transmission multiplexers, switching inputs, and the resultant control of resources and channels as shown in Figure 5.10.5.3(a) has many advantages:

- Reduced system acquisition and operating costs.
- Reduced manning of facilities.
- Rapid alternate routing of time sensitive circuits.
- Improved survivability and availability.
- Improved system reliability.
- Improved performance for the users.
- Improved utilization of equipment by reducing routing constraints.

The commercial world has adopted this idea in different forms. Chapter 6 discusses some of these applications and their benefits. In order to take maximum advantage of the merits of such an integration it appears logical that a policy statement to this effect be issued; that the transmission programs, the switch programs and the technical control programs be reviewed as a whole and made consistent; and that a test bed be assigned to put the integration concept into practical form before complete field implementation is attempted.

The Channel Reconfiguraton Unit described in paragraph 5.10.3.3 planned to be tested in the field as a Time Slot Interchanger should be an integral part of the test.

5.10.5 <u>A Look at the Future</u>

It is obvious from the previous discussion that major transformations and changes are taking place in the world of communications and that fast developing technologies will significantly impact the technical control community. It is now basically a matter of pulling together and exploiting existing technology into integrated systems.

5.10.5.1 System Overview

A review of the current literature indicates the following trends:

- There is a worldwide trend to digital switching and transmission. A marriage between the two leads to an integrated services digital network. This, in turn, brings easier supervision because of the common signal format being transmitted and switched and having the capability of being monitored on the basis of error rate.
- Integrated services digital networks will appear by 1985. A continuing dialogue between carriers and manufacturers is necessary and economics and performance will be a forcing issues for the commercial carriers. We must include vastly improved security when discussing military networks.
- Future planning for new technologies must be interactive between subscriber, local switch, interface facilities, toll switches, and operating services planning.
- There will be more software controlled products. Software is viewed as cost effective and will save manpower. Modular, standardized software will become widespread. Network self knowledge will become high.
- Testing will be centralized and automated. The growth of unattended facilities will accelerate the concept of the "long screwdriver" and will lead to a concentration and centralization of testing and maintenance "smarts."
- Loop testing and trunk testing will be integrated in the same computer system.
- Testing and administration functions will be integrated.
- Line by line limit tests based on traffic recognition and signal analysis will be used.
- Voiceband lines will be continuously monitored.
- Testers will become more programmable and interactive. There will be more measurement capability for the dollar.
- The new testing systems will allow sophisticated tests on complex networks with less experienced personnel performing the tests.
- Analog, digital and protocol testers will be combined in service and control centers for more efficient testing.
- The use of microprocessors will result in better self testing, improved displays, increased overall functionality, data conversion capability, reduced costs, simplified operation and increased operator efficiency.

5.10.5.2 Technical Control Outlook

The use of the appropriate technology advances described in paragraph 5.10.3 will lead to technical controls which will be able to assess the status of communications on more of a real time basis and to control resources remotely. Status, trend, and failure information will be integrated, combined, analyzed and displayed to the future technical controller. Where actions are obvious and preprogrammed, they will either be performed and the controller notified or the controller will be able to review the programmed actions and to approve or disapprove them. Information from terminals, base loop plants, base switches and switching systems will be filtered and integrated into useful information for the technical controller. Most patching and testing will be performed at a console of a digital test position. Logs and reports will be automatically issued with the minimum input by a technical controller. Instead of the physical lines and circuits being brought into the technical control operating area, only the required information will be brought in and displayed. A conceptual illustration of what a small computer controlled technical control could look like is shown by Figure5.10.5.2. This includes TASI, trans-multiplexers, time slot interchangers, modems, crypto, analog and digital orderwires, precision station clock, test equipment, etc.

Obviously, only broad guidance such as provided by the above Figure can be offered at this time concerning the appearance and configuration of future technical controls. Many options are available to the planners and engineers and some of these options such as use of time slot interchanges are only beginning to emerge. However, it does seem reasonably clear that the future technical control will look more like a computer center than the present

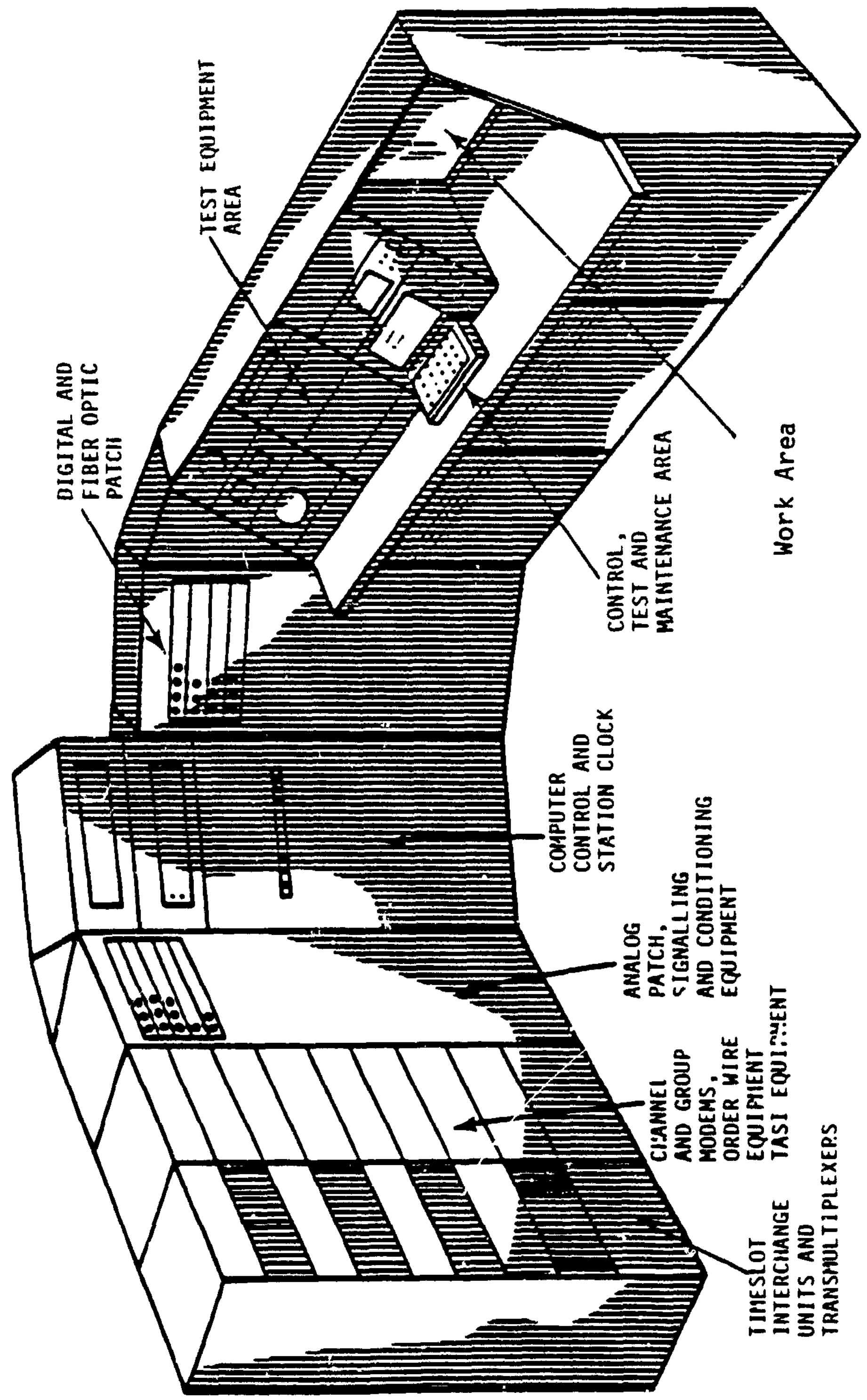


FIGURE 5.10.5.2. CONCEPT FOR SMALL HYBRID TECHNICAL CONTROL FOR THE MID 1980's

collection of patch bays test equipments and order wires. In all probability the space required by a computer run technical control will be less than that now required. However during the transition, there may be more space temporarily required for operating both the old and the new layouts. Therefore careful planning is required to make sure new technical control plans allow for a temporary increase in space during this transition period.

5.10.5.3 Interconnection

Figure 5.10.5.3(a) presents a composite interconnection of a hybrid analog/digital station using some of the equipment and techniques now available. The diagram shows how the TASI equipment, the transmultiplexer and the time-slot interchange equipment may be interconnected at a station. Figure 5.10.5.3(b) shows how the new equipment would serve to interconnect FDM stations with TDM stations. Within the station boxes, the equipment would be interconnected as shown in Figure 5.9.6(g).

5.10.6 Preliminary Criteria Guidance

In order to prepare for the future there are certain actions which can be taken to simplify the impact of new technology and design.

5.10.6.1 Communication Equipment Design

There are many design options which will affect testing, monitoring and fault isolation of future systems. Designs should be reviewed and assessed by technical control designers from the concept stage to the implementation stage. The following can be used as a guide:

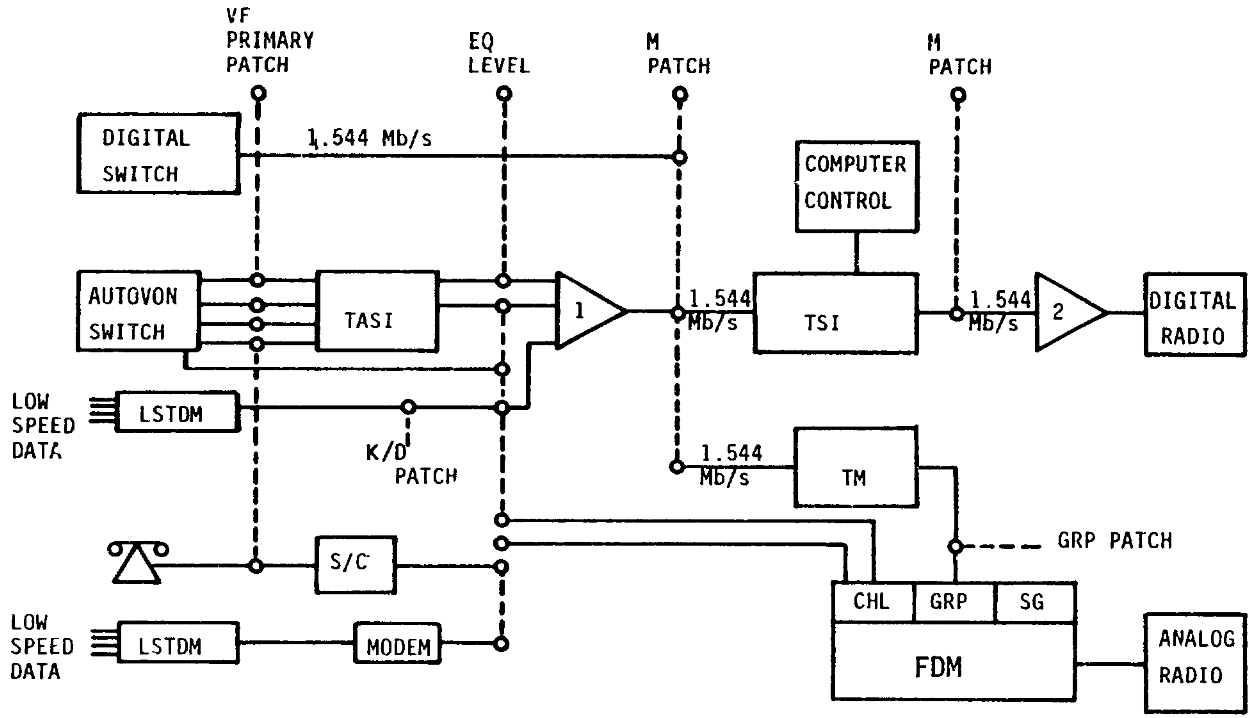
- Build into each piece of equipment the means to monitor its own performance. Output this performance indication locally and remotely either by a relay closure or a variable voltage.

- Build into each important equipment a means to restore performance by redundant equipment, a bypass of nonvital functions, or a by pass of the equipment itself. Design this function so that it may be remotely automated.

- Digital switches should have capabilities for adding network synchronization and common channel signaling so that these features can be used, if/as necessary, for future planned networks.

- All future subscriber concentrators, remote switches, and PABX's should have the capacity for common channel signaling. This form of signaling may be necessary for economic, flexibility and service handling reasons.

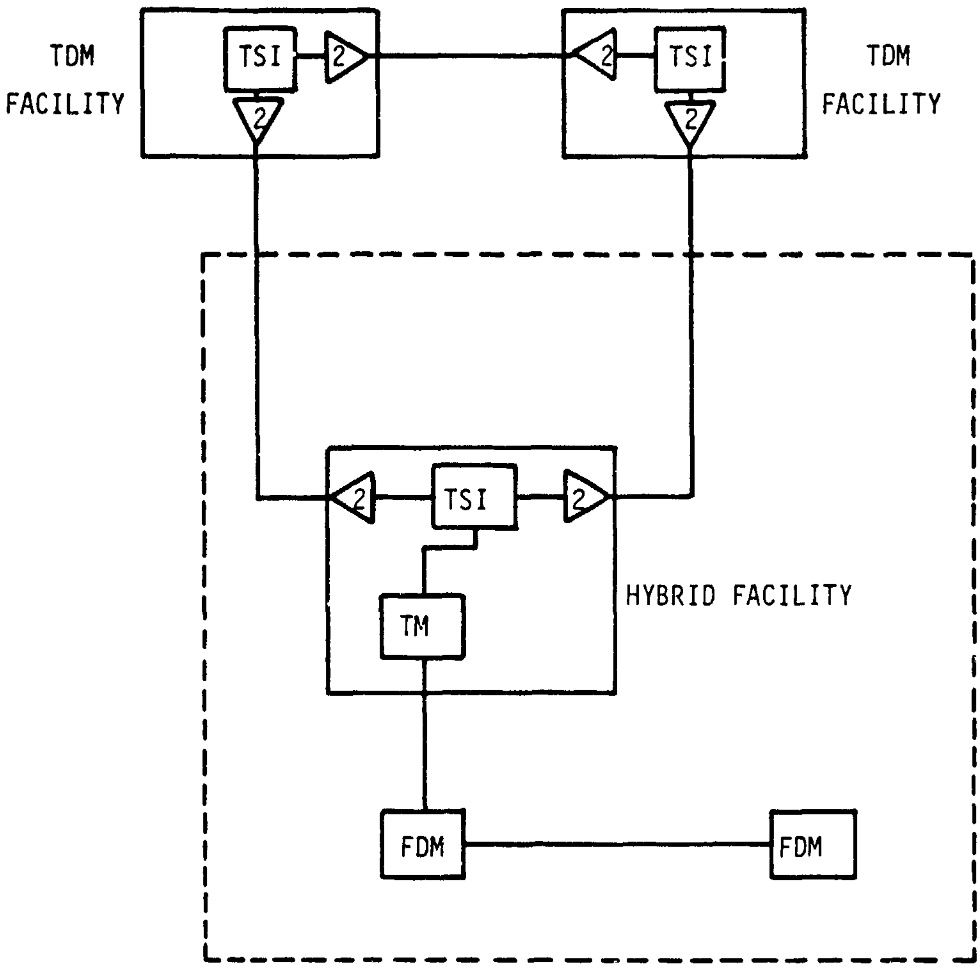
- Nailed-up connections through digital switches should be used for full service channels.



LEGEND

FDM	FREQUENCY DIVISION MULTIPLEX
LSTDM	LOW SPEED TIME DIVISION MULTIPLEX
S/C	SIGNALLING AND CONDITIONING EQUIP
TM	TRANSMULTIPLEXER
TASI	TIME ASSIGNMENT SPEECH INTERPOLATION
TSI	TIME SLOT INTERCHANGE
1	1ST LEVEL MUX
2	2ND LEVEL MUX

FIGURE 5.10.5.3.(a). TYPICAL COMPOSITE INTERCONNECTION, HYBRID ANALOG/DIGITAL FACILITY OF THE FUTURE



LEGEND

FDM	FREQUENCY DIVISION MULTIPLEX
FMR	FM RADIO
TDM	TIME DIVISION MULTIPLEX
TM	TRANSMULTIPLEX
2	2ND LEVEL MUX

FIGURE 5.10.5.3(b). TYPICAL FACILITY INTERCONNECTION

5.10.6.2 Technical Control Equipment and Subsystem Design

- The system engineer should plan a hierarchical based distributed processor control system capable of being operated in segments when communication between nodal facilities are degraded or lost.

- Plan monitoring and control actions down to user and subscriber including all serially connected equipments and transmission lines. Use the control functions built into switching subsystems by remoting and using these functions rather than duplicating them.

- Ensure a sturdy control communications network including error detection and correction ability. Use such other subsystems as are available for control communications and order wires that will include the functional equivalent of orderwires. Make sure alternate paths are planned and are available.

- Use station interface equipments such as the Channel Reconfiguration Unit paragraph (5.10.3.3) for TRITAC and the RADC DCEM paragraph (5.10.3.1) for Allied interconnects at strategic interface points. Make sure status and control capabilities are integrated into the control communications system at all levels. In this respect plans are being made to test the DACS at selected transmission access and technical control nodes. A version of the DACS called a Digital Patch and Access System is being considered for inclusion in the Digital European Backbone Project.

- Technical Controls should be built with rack space near Patch Bays for future Time Slot Interchange Units. Space should be reserved for mini-microcomputer equipment run consoles.

- Operating control doctrine to handle the problems brought up by new technologies must be determined and promulgated. When TASI equipments fail some standard procedures must be followed to take care of lost capacity. This may be an extension of the problem of handling variable rate satellite channels. Adaptive multiplexer characteristics must be carefully reviewed during their introduction to ensure that operating procedures, proper nomenclatures, trunk numbering conventions and rerouting techniques are available.

- Distribution frame growth allowances should be reduced since all indications are that equipments such as transmultiplexers and time slot interchangers will reduce distribution frame requirements in the future.

- Bring technical control functions from other systems into the technical control operating space by extending their console operating capabilities. For example, digital switches which can be controlled for rerouting, loopback of testing purposes should have this capability extended to the technical control.

- Maintain some form of manual intervention capability to assure minimum essential system operation when confronted with unusual or highly stressed circumstances not caused by the normal operating procedures.

5.10.6.3 Technical Control Training

The future technical controller will play a key role in the transition period. He must learn new techniques while operating the present equipment. The switch to hybrid analog-digital will create some new problems which in turn will change when all digital techniques are used. Operating procedures will change slowly at first and more rapidly as newer developments mature. The future technical controller training will likely include:

- Automated patching, testing and monitoring equipment.
- Microprocessor and computer training.
- Digital data circuit analysis and fault isolation techniques.
- Principles of digital communications. Techniques used in TASI, adaptive multiplexers, time slot interchangers, etc.
- New automated test equipment.
- Advanced switching techniques.
- Remote application of fault isolation diagnostics.

5.10.7 Summary

This brief forecast of the technological impact on DCS technical controls conveys a clear impression that the integrated digital network consisting of subscriber access, switching, technical control and transmission is a fast developing reality. The fact that digitization permits all types of information to be translated into a common signal format, thus leading to greater simplicity of network and equipment design; to simplified systems planning; to greater flexibility in signaling and to downward costs in equipments and operations is enormously important to the systems engineer. He must complement the developing technological trends with careful cost-effective planning coupled with progressive implementation to ensure success for the technical controls employing these new developments.

CHAPTER SIX

TESTING OF DIGITAL SUBSCRIBER TERMINAL DEVICES AND LOOPS

6.1 GENERAL

6.1.1 Purpose

A key to efficient network testing is the ability to perform a wide range of remote testing from a centralized technical control. This capability permits testing of remote, unmanned locations, and with sufficient sophistication of the technical control, simultaneous testing at multiple locations can be accomplished.

This chapter will give a brief chronology of technical control testing of subscriber loops and terminal equipment and discuss reasons for the evolution, trends and the impact of digitalization. The effects of "user-to-user" testing, commercial and military practices and experiences will be briefly presented, and the problems arising from the use of various techniques will be included. Minimum requirements for new terminals and subscriber loops will be offered, and considerations for upgrading them will be discussed. Testing techniques based on digital lines and terminals, both in present and future use, will be covered.

6.1.2 Background

Historically, subscriber loops and subscriber or user terminal equipment have been treated differently from long-haul trunks and switches. In the military, base and access area communications have been operated by the military departments rather than by the long-haul or strategic operators. This is especially true of the base telephone plant. In the commercial world, the local telephone company has maintained access lines and instruments while AT&T has operated the long-haul plant.

In the telegraph industry this demarcation was not initially as marked, since metallic facilities were used for both access and long haul. Subscriber trunks and loops consisted basically of metallic circuits called "outside plant" and were usually maintained by a wire chief.

Usually it was the subscriber or user who detected the trouble and notified the operators. At that point testing was performed and the fault isolated. Even after remote tests were completed, it was still often necessary to dispatch maintenance personnel to correct the fault.

6.2 EVOLUTION OF SUBSCRIBER AREA TECHNICAL CONTROL TESTING

6.2.1 Historical

In early communication systems, failures were observed and reported mainly by the customer. Fault location depended on the thoroughness, experience and competence of the repair technicians.

The early metallic subscriber lines or loops were tested from test boards by using DC measurements of insulation, resistance and current. Various bridges made it possible to locate certain types of faults from the test boards. Some measurements required assistance at the customer end to supply the proper terminations. Telegraph loops were monitored by checking for the proper current and measuring the distortion of the signals. Impedance and continuity tests were used in analog testing.

As terminal equipment became more sophisticated and users became aware of the high quality services which were available, the testing became more involved. The frequency response, noise, level and attenuation tests became more important. DC measurements were made from Cable Test Bays, while voice frequency measurements were made from Audio Test Bays. The test equipment became more and more complicated as the types of tests continued to increase. Portable test equipment had to be carried to user locations or to manholes and pole lines for some tests.

With the appearance of carrier telephony on the base areas, simple tests no longer sufficed. Special test sets were developed and used to perform quality control, fault detection and isolation tests. These functions were manpower intensive and costly. High levels of skill and experience were required to determine the needed tests and to operate the test equipments. They required substantial resources and did not, in general, provide an assessment of the access area plant status.

Circuit tests and measurements have been continuously improved and advanced. Modern commercial modems and terminals feature built-in self-testing, remote switching and loopbacks, remotable alarms, and the ability to be tested under remote control. The use of sophisticated remote testing, reducing manpower and time, is becoming more common.

6.2.2 Impact of Digitalization

As the base access area terminal equipment and access lines change from analog to digital techniques, the same factors described in Chapter 5 will affect access area testing. The same kinds of measurements, i.e., bit error rate, phase jitter, clock stability, etc., will be required. The use of Large Scale Integration (LSI) and embedded microprocessors in terminal equipment allowing self-testing and remote control of equipment make feasible the use of remote processors for the quality control, fault isolation and maintenance management of base area systems. These processors, with extensive software capabilities, can provide automated, fast, accurate diagnostics and analysis, and prompting of remedial actions. The processors will also assist in system maintenance by producing required records and analyses for more effective administration. The commercial world is using centralized remote monitoring, diagnostics, and enhanced control of access areas more efficiently and economically as it progresses from the analog to the digital environment. Many of these developments are also finding enthusiastic application in military communications.

6.2.3 Changing Roles

Modern sophisticated communications and data transmission systems require that user-to-user tests be conducted to verify overall performance. Thus, the terminal equipment and subscriber loop at each end of the system would have to be included. The fragmented testing of the backbone on the one hand and the access area on the other is no longer satisfactory as a measure of system performance. In the commercial world, test equipment manufacturers have been presenting equipments which can access both ends of a data circuit and test it end-to-end. These equipments are used in private data systems independent of the common carriers. The demarcation point between the common carrier long lines and the operating company access lines is becoming less defined. Remote units are being designed which access, test and switch at the user end in response to central equipment either at the central office or at a central point in the common carrier structure. As military systems replicate commercial offerings, the same forces will require considerations of similar testing if performance is to be monitored and status displayed on a dynamic real-time basis.

The use of carrier FDM, T-1 repeated digital, and digital coaxial base access facilities requires testing techniques similar to those in use in the backbone systems. By bringing all the monitoring and testing results to a common centralized point, it is possible to localize troubles and, in some cases, quickly diagnose the problem. Since the maintenance and repair of troubles must take place at the site of the trouble, a system-oriented testing and maintenance plan must be formulated. Thus, the roles of base area and backbone technical control and maintenance personnel must be evaluated and made to conform to the realities of modern communications. The result of such coordinated testing and maintenance planning will most likely be to reduce the number of required personnel and/or to allow the present number to service a larger system.

6.3 DIGITAL TERMINAL AND LOOP TESTING

6.3.1 Objectives

The general goals and objectives of digital terminal and loop testing are:

- Improved services to users
- Reduced labor intensive tasks
- Reduced number of user trouble reports
- Faster response to user trouble reports
- Reduced manual quality control
- Reduced call backs

6.3.2 Measures of Effectiveness

Schemes for testing terminals and loops can be compared by the following measures:

- How many reported faults are real faults?
- What proportion of the total faults are located?
- How many faults were detected before a user reported trouble?
- How long before a user report was the fault detected?
- How much of the base access area plant was covered by the monitoring system being considered?
- How often is a circuit, channel, or terminal monitored or tested?
- How efficiently are intermittent faults found?

6.3.3 Candidate Techniques

This chapter will not attempt to cover the present, (1980), manual techniques currently used in the DCS to monitor and test the essentially analog subscriber/user plant. In order to proceed from the present, it will be necessary to examine the change from manual to automated techniques in testing and the digital changes in the subscriber world. In addition, modern test methods in the commercial world are based on centralization outside of the base/subscriber area. The latter considerations are also discussed more generally in Chapter 5.

6.3.3.1 General

In recent years, a number of new techniques independent of whether analog or digital plant is being monitored or tested have materialized. Some of these are:

- Automatic routining
- Automatic control transfer (e.g. spare modem switching)
- Built in diagnostic programs (easier when digital)
- Built in system performance index
- Remote unit testing
- Triggered per call testing
- Loopback - local and remote
- High speed modem speed reduction
- Base plant test results relayed back to control point
- Remote line connectors and switches
- Measurement bypass techniques

6.3.3.2 Techniques Based on Digital Lines or Terminals

- Protocol testers.
- Dynamic debugging.
- Remote diagnostic processor (e.g. in modem).
- Bit error rate monitor (usually framing or sync bits).
- Throughput monitor.
- Information built into data stream.
- Remote traffic analysis of switches/PABXs.

6.3.3.3 Discussion

A search of pertinent literature indicates that maintenance and control of the commercial subscriber plant in this country and overseas has followed a very consistent pattern. Subscriber switching and transmission have slowly merged as digital equipment and lines are put into service. Local switching is being used to access loops. Tests are becoming more sophisticated and automated. Microprocessors are being used to put electronic intelligence in equipment at the subscriber locations. Terminal equipments are getting smarter and can now be controlled remotely. Self diagnostics, automatic loopback and the ability to send alarms are common features of modern digital terminal equipments including modems and multiplexers.

6.3.4 Problems Associated with Digital Monitoring and Testing

In any system where automation is increasing and costs are largely controlled by a reduction in personnel, it is obvious that centralization is an issue. The ruggedness and reliability of modern digital equipment allows many sites to be unattended. The use of redundant and switchable equipment also helps. However, the subscriber plant and the backbone system tend to support one another in the digital world, and it is increasingly difficult to separate operation and maintenance at the traditional dividing point of the Main Distribution Frame. An overall system concept based on user-to-backbone system-to-user must be envisioned. Various terminal equipments must follow some minimum interface specification and include common features for modern techniques to be applied. The question of "who is in charge" must also be answered. A fundmental issue is whether the centralization of subscriber area monitoring and testing should occur in the backbone system or in geograhic areas surrounding the backbone area. In many cases the station at which the subscriber is located is part of the backbone system so even this line of demarcation becomes blurred. As the backbone system is automated, in the future, the question comes up as to what interfaces should be designed between subscriber access test systems and backbone automated systems.

The next section will briefly describe some current and proposed commercial practices which will set the stage for recommendations.

6.4 PRESENT AND PROPOSED PRACTICES

The following paragraphs describe practices which are typical of what is being developed in the commercial world.

6.4.1 BELL/AT&T

AT&T has automated their testing of analog loops using computers, minicomputers, test controllers and mechanized loop testers. The decentralized system of the 1950's progressed to the centralized systems of the 1960's and are now in the process of being transformed to the distributed processing system of the 1980's. The system evolved from a stand-alone system in 1972 to full automation in 1978. As wire line loops were replaced by subscriber loop carriers and T-1 digital lines, the testing problem became vastly more complicated.

Carrier transmission maintenance systems containing minicomputers and program controlled selective detectors determine a transmission performance index and connect with other systems or with telemetry data systems to send information to central points.

An automatic data test system, minicomputer run, performs tests on remote data sets on a time shared basis. The system accesses lines through a switched maintenance access system, also remotely controlled. About 20,000 data sets may be accessed by one system.

A new development uses a DC test path to a final metallic loop bypassing subscriber carrier or T-1 carrier systems (called "pair gain" systems by AT&T), and then tests both the wireline portions of the system, as well as the channel riding the carrier system. The system uses a microprocessor-controlled equipment called a Pair Gain Test Controller.

A digital transmision surveillance system monitors T-1 multiplexers for sync word errors and in-sync/out of sync status. Either separate data channels or the 191st bit is used to send the information to a central control point.

The accelerating trend in maintenance is towards centralization with extensive use of monitoring and telemetry systems. The sophisticated associated maintenance consoles use system minicomputers. This procedure results in more effective use of personnel, more frequent monitoring, automated data analysis and management reports. Figure 6.4.1 illustrates the technical hierarchy of such measurements.

AT&T is also addressing the problem of where the "long lines" end and the "subscriber loops" begin and how the different operating companies can coordinate with AT&T in operation and management on an end-to-end basis.

6.4.2 Bell Northern, Canada

Bell Northern Research has developed and field tested a microprocessor controlled loop test verifier using a unique concept of "triggered" testing combined with a switch-based test head. This concept is applicable to both digital and analog loops. The concept uses "per call" test indications of a potential loop fault as a "trigger" to automatically access and retest a specific line. Previous wholesale routining as a preventive maintenance practice had led to "paper pollution" and a blurred distinction between hard and potential faults. Final statistical results of the test were as follows:

- Efficiency - 88% of fault indications were real faults.
- Coverage - 60% of faults were identified in advance of a customer report.
- Leadtime - 72 hours - Half the faults were identified 72 hours before the customer reported it.
- Found OK Rate - 50% reduction.

A 10 - 12% savings in cost of the loop maintenance function was estimated.

6.4.3 Commercial Manufacturers

Commercial equipment manufacturers now provide equipment and systems that include:

- Remote and local trunk and port bidirectional loopback.
- Continuous self diagnostics.
- Acknowledgement signals to remote originator.
- Remote controlled end-to-end testing using internal test pattern generators.
- Automatic remote fault reporting.
- Dial back-up.
- Spare modem switching.
- High speed modem speed reduction.
- Polled block error rate performance.

- Interface monitoring.
- Equipment self tests.
- Display of erroneous protocol conditions.

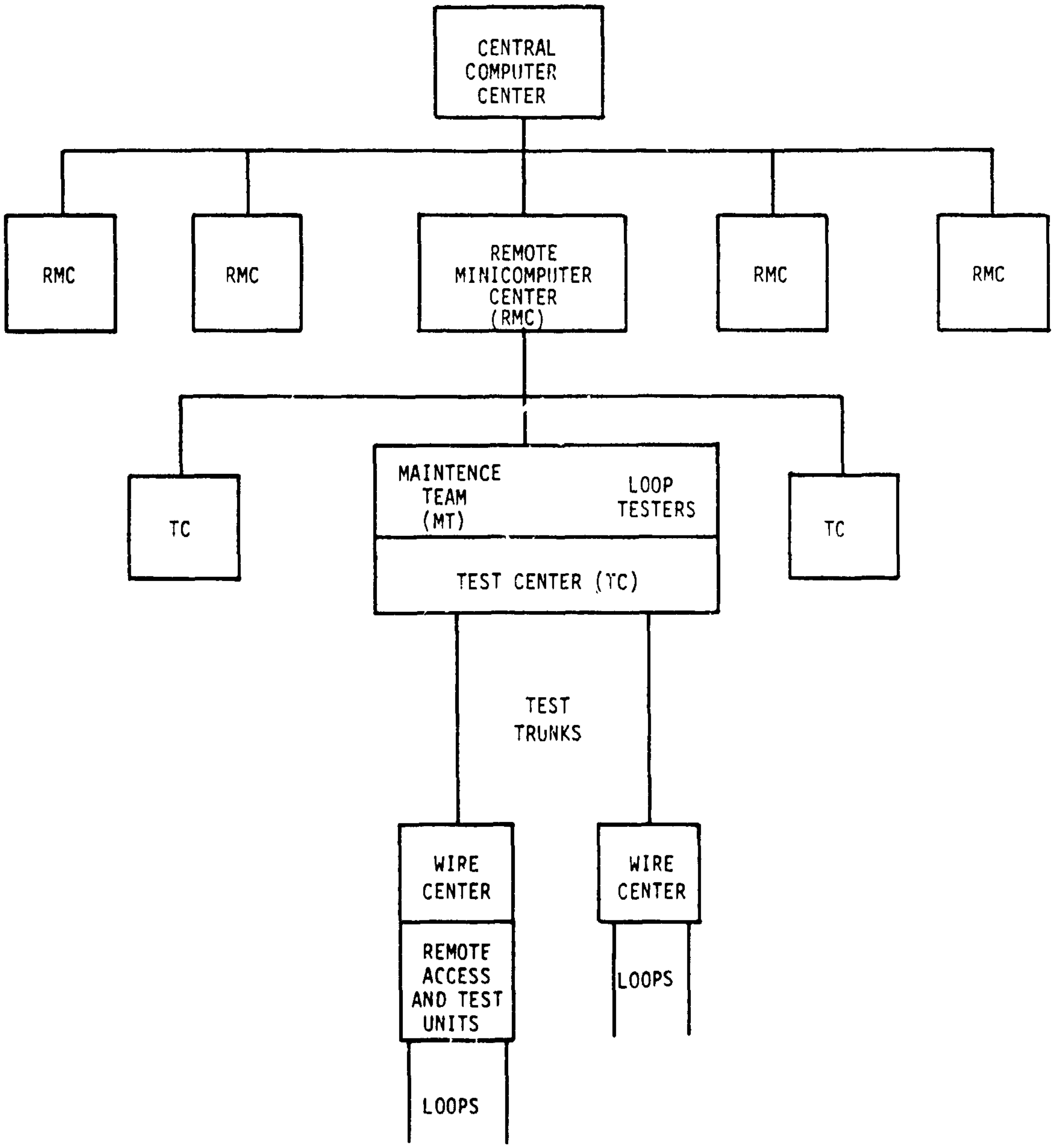


FIGURE 6.4.1. GENERALIZED COMMON CARRIER LOOP TESTING SYSTEM

6.5 TRENDS AND GUIDELINES

6.5.1 Trends

Obvious trend in subscriber access areas are:

- To put intelligence (usually in the form of a microprocessor) into newly designed terminal equipment.
- To include Built-In Test Equipment (BITE) and self-diagnostics into terminal equipment.
- To use remotely controlled redundant modules for important portions of terminal equipment.
- To provide for remote extension of important alarms generated by terminal equipment.
- To combine digital transmission and remote switching.
- To test those portions of access lines which use different transmission techniques both together and separately.
- To use framing and overhead signals to convey information and control, and to make measurements of such parameters as bit error rate.
- To combine results from access line testing and backbone testing in order to fault isolate troubles and monitor circuits on an end-to-end basis.
- To increase the use of digital carriers.

6.5.2 Guidelines

Recommended guidelines for design and testing of subscriber access lines and terminal equipment in the DCS are:

6.5.2.1 Terminals

6.5.2.1.1 Wherever possible include microprocessor control instead of discrete logic in order to provide more easily for:

- Monitoring, diagnosis of troubles, ability to report and to automatically switch in redundant units.
- Responding to remote commands to perform various loop-arounds, to terminate access lines, and to send test signals back or record data as required by the type of terminal involved.

- Keeping traffic records where appropriate and forwarding or displaying them upon local or remote command.

- Downloading of new or revised software where appropriate.

6.5.2.1.2 Build in redundant units where single faults will cause critical degradation or failure of the terminal equipment.

6.5.2.1.3 Make sure that software languages, alarm interfaces, and procedures are consistent with existing or planned overall automated test systems.

6.5.2 2 Access transmission lines and carrier equipment.

6.5.2.2.1 If not already available, build in remote switched access to ends of lines for monitoring and testing purposes.

6.5.2.2.2 Use techniques such as bipolar transmission which inherently allow a measure of errors.

6.5.2.2.3 Use framing and overhead bits to obtain measure of the bit error rate performance.

6.5.2.3 Access systems.

6.5.2.3.1 Design the system so that information generated by terminal and access line portions are useable locally by maintenance teams and globally by trouble finding diagnostic systems.

6.5.2.3.2 Ensure "end-to-end" test equipment interoperability (e.g. Bit Error Rate Testers at each end of the long data circuits must be compatible.)

6.5.2.4 PBX, PABX and Remote Switches.

6.5.2.4.1 Wherever possible provide facilities to the proper technical control facility to make tests and provide switched access without duplicating switch equipment.

6.5.2.4.2 Follow same guidelines as for terminals (6.5.2a, above).

6.5.3 Summary

- The use of software controlled microprocessors is providing a major breakthrough in the design and testing of access systems, PABX's and remote switching.

- The lines are blurring between access systems and backbone systems as well as between switching systems and transmission systems. This leads to simpler technical designs but to new and different operating procedures.

- Automated monitoring and testing of access sytems is practical and cost effective.

- Much of the routine quality control testing, record keeping, report writing and testing can be accomplished and recorded with much less human effort than is now required.

- Historical analysis of terminal and equipment failures plus statistical analyses of types and locations of failures become possible in an automated system in a reasonable time.

- Data testing systems will allow more measuring capability for the dollar.

- Modern test systems will be efficient and programmable and will include analog, digital and protocol measurements. These will be more cost-effective than existing manually operated, manpower intensive systems.

- The networks self knowledge will continue to grow as microprocessor applications increase. This will permit many system level decisions to be made on a near-real time basis.

- Increased network self-intelligence (microprocessor and computer derived) will make possible automated adaptive routing for restoration and reconfiguration of critical circuits in essentially real-time.

6.5.3.1 In the DCS, the implementation strategy for such systems must proceed on an evolutionary basis with a minimum disruption to existing services that depend on the installed plant for their communications needs.

6.5.3.2 Fortunately, the current push in communications system development technology will have an appreciable fall-out for the military community in the form of cost-effective adaption of tested commercial equipments and operational procedures. These fall-outs will, undoubtedly, exert a significant impact on the military implementation strategy.

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1	Operating Location C, Detachment 12, 2140 Communications Group, APO NY 09693
1	Detachment 13, 2140 Communications Group, APO NY 09690
1	Detachment 15, 2140 Communications Group, APO NY 09253
1	Detachment 20, 2140 Communications Group, APO NY 09253
2	2143 Communications Squadron, ATTN: DO, APO NY 09860
1	2164 Communications Squadron, ATTN: DO, APO NY 09755
1	Detachment 1, 2164 Communications Squadron, ATTN: DONP, APO NY 09755
1	2166 Communications Squadron, ATTN: DA, APO NY 09238
2	2168 Communications Squadron, ATTN: CC, APO NY 09194
1	Detachment 1, 2168 Communications Squadron, ATTN: APO NY 09150
1	2184 Communications Squadron, ATTN: DONP, APO NY 09019
1	Detachment 3, 2184 Communications Squadron, ATTN: CC, APO NY 09292
2	2187 Communications Group, ATTN: LGME, APO NY 09293
1	Operating Location J, 2187 Communications Group, APO NY 09221
1	Operating Location K, 2187 Communications Group, APO NY 09221
1	Detachment 25, 2187 Communications Group, ATTN: CC, APO NY 09002
1	Detachment 27, 2187 Communications Group, ATTN: CC, APO NY 09240
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