TECHNICAL ANALYSIS

OF
SYNTHESIZED ISB RECEIVER SYSTEM

DDR-11

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SYNTHESIZED ISB RECEIVER SYSTEM

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NORTHERN RADIO

EQUIPMENT DESCRIPTION

The equipment proposed for this requirement is of proven design and is currently in operation at commercial and military stations throughout the world. As described in the section on "General Concepts" and in the Technical Description that follows this introduction, the equipment represents the state of the art in both circuit design and component technology. All circuits including power supplies are solid state with all functions of the receiver and control system DC switched. No electro-mechanical motors or ledex devices are used in the receiver.

The equipment proposed consists of the following:

Model	Description
DDR-11	Synthesized Dual-Diversity Receiving System complete with: 2 each GPR-110B Communications Receivers 1 each DVC-10 Diversity Voice Combiner 1 each CFA-4 Diversity F/S Converter 1 each AF/DC Patch Panel 1 each Auxiliary Power Panel 1 each Five-foot Cabinet with Operating Shelf

The DDR-11 synthesized, dual diversity receiving system is designed to receive CW, AM, AME, USB, LSB, two-channel ISB and FSK/FAX signals in the frequency range 100kHz to 30MHz. The receiving system uses two Model GPR-110B triple-conversion communication receivers in conjunction with a diversity F/S converter and a diversity voice combiner. The receiving system permits space diversity operation as well as frequency diversity operation. For space diversity reception, a pair of diversity antennas are required. Frequency diversity reception requires only one antenna capable of receiving the two signals of different frequency that are transmitted.

The modular units of the DDR-11 are as follow:

HF Receiver, Model GPR-110B. The receivers are general purpose synthesized receivers operating in the 100kHz to 30MHz frequency range. In the DDR-11 system the (two) receivers can be used in the RTTY or voice mode of operation.

Frequency Shift Converter, Model CFA-4. The FSK converter accepts the frequency shifted audio output signal from two GPR-110B receivers. The audio tones of each channel are separately limited, demodulated and then combined to provide DC pulses suitable for operating TTY printers. One converter is required for each set of diversity audio frequency shift signals processed.

Diversity Voice Combiner, Model DVC-10. The combiner accepts two channels of a voice signal in the 250-3100Hz range, segments each into four segments, selects the better segment, and recombines them into a high quality audio output signal. One combiner is required for each set of diversity 3kHz sidebands processing voice signals.

AF/DC Jackfield. The AF/DC jackfield is a system patch panel which provides audio tone and DC loop outputs of the component units within the DDR-11 system. The jackfield provides maximum flexibility for patching.

Power Control Panel. The power panel receives the primary power input and provides control of the AC power to the DDR-11 system by means of a front panel circuit breaker. The control panel also includes a main power indicator lamp and fused AC utility outlets.

The frequency stability of each receiver is one part in 10^8 per day, synthesized. Frequency control is accomplished by internal synthesizers located within the GPR-110B chassis. This high degree of stability eliminates the need for a separate master oscillator or for interconnecting the receiver standards within the system.

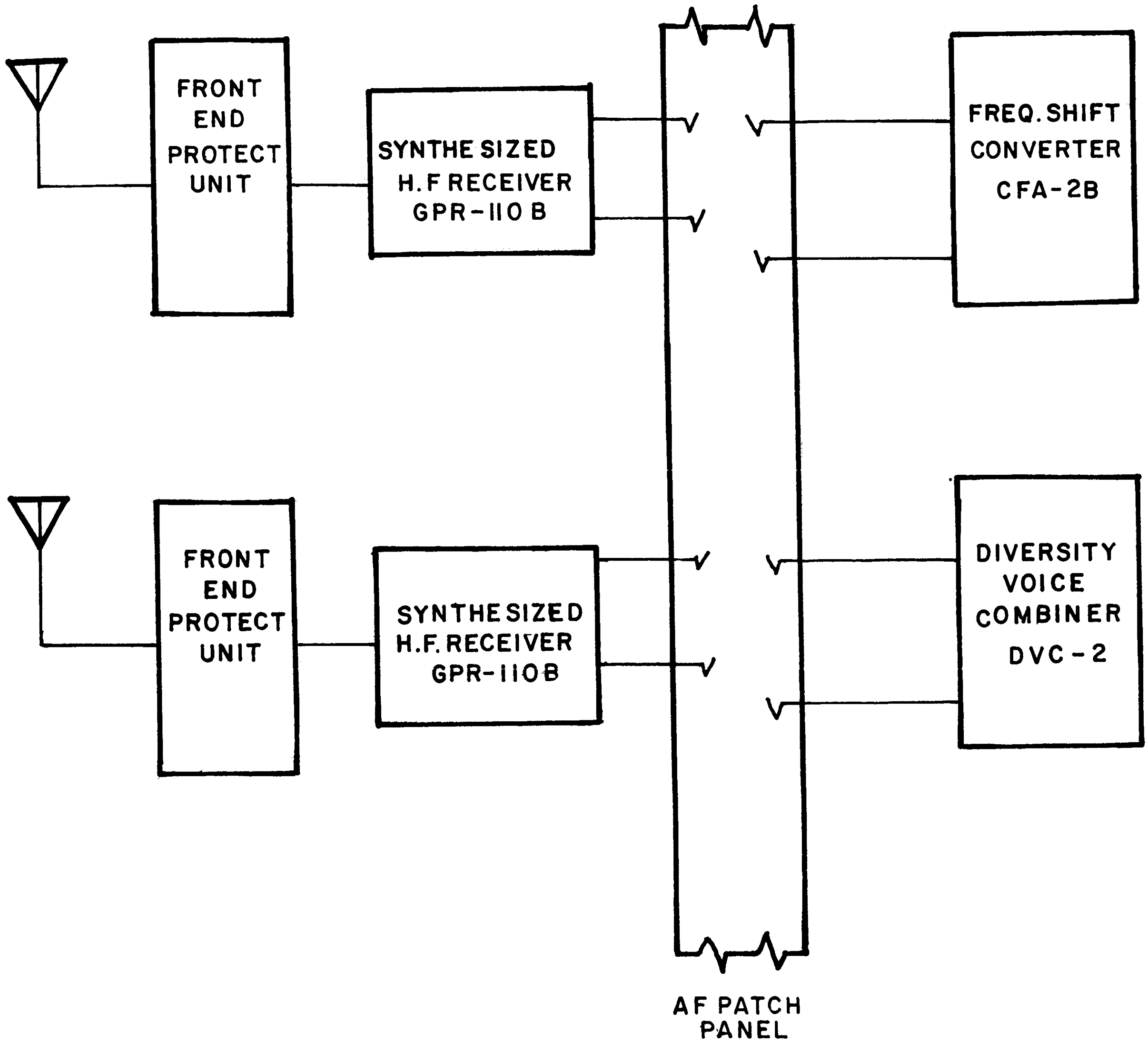
The figure on the next page illustrates the interrelation of each receiver with the FS converter/voice combiner combination in the DDR-11. An audio patch panel is used to process the audio output through the proper equipment. The patching is determined by the type of signals detected by the two receivers in each of their respective sidebands. The frequency shift converter, Model CFA-4, is capable of processing frequency shifts of 10 to 1000Hz at 30 to 340 baud. The DC output signal produced is ±8 volts at 20ma for polar operation and 80 volts at 60ma for neutral operation. Both outputs are sufficient to drive any standard teleprinter.

The diversity voice combiner, Model DVC-10, operates in conjunction with the audio output from both receivers. It processes both receiver outputs at the same time and produces a combined output that represents the best combination of both received signals. The processing is done by sampling four segments of the received audio output, comparing each segment to obtain the S/S+N ratio that is best, and recombining each segment to produce the best combination of the received signals.

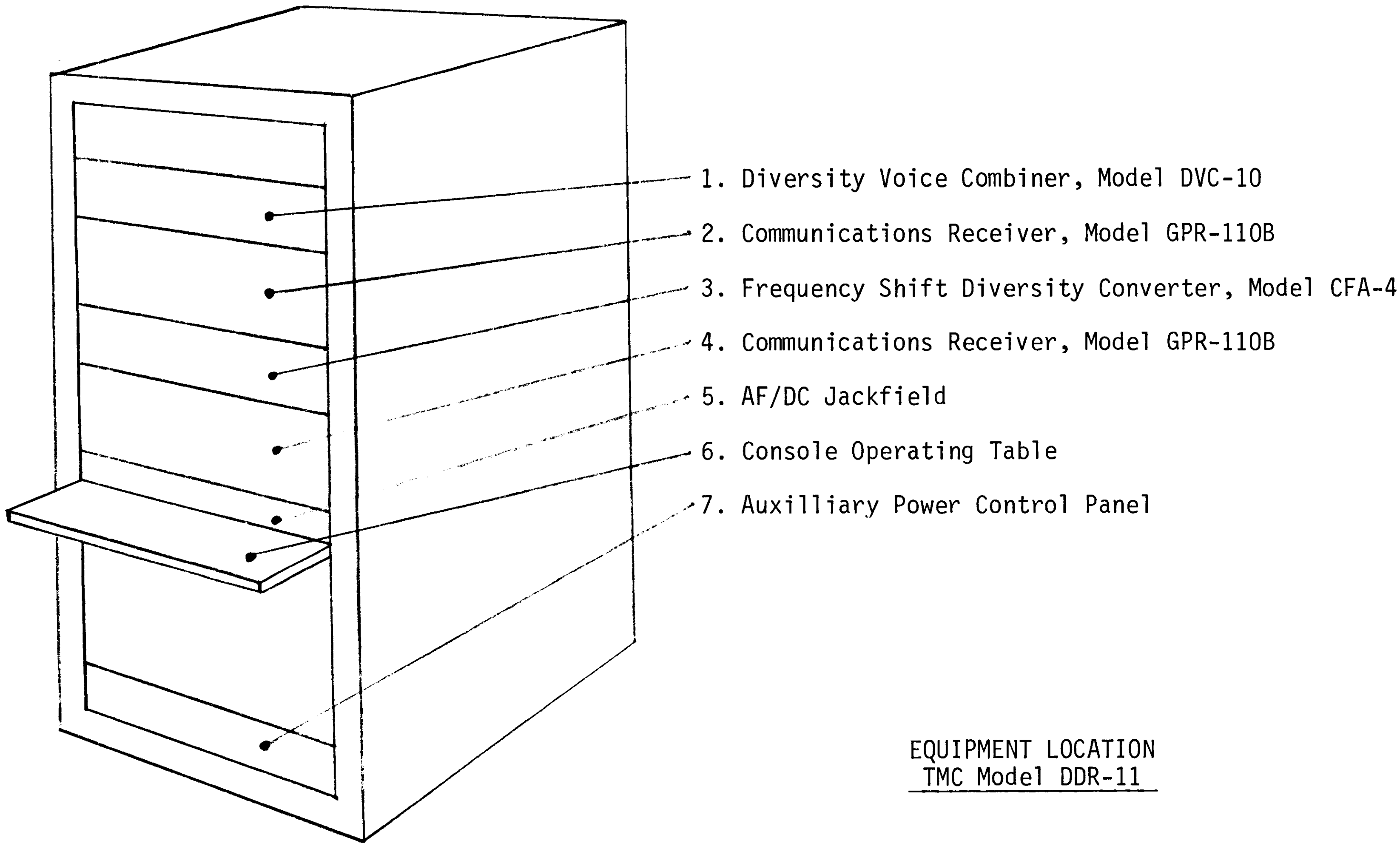
The DDR-11 receiving system is assembled and completely tested at the factory before shipment. The system leaves the factory wired for 230 VAC, 50/60Hz operation; change may be made to 115 VAC, 50/60Hz operation by making minor wiring changes. A minimum number of assemblies, subassemblies, components and hardware are disassembled from the equipment and separately packaged thus reducing the possibility of equipment damage during transit. This method of disassembly and separate packaging also permits realistic equipment handling. Cables, wires and other miscellaneous items that were disconnected during equipment disassembly for shipment are tagged and taped to the equipment. The information on a given tag indicates the designated terminal on a component to which the tagged item will be connected during installation.

The DDR-11 receiving system should be mechanically installed by locating the equipment cabinet in an appropriate site and by installing the components that were removed during disassembly for shipment. The equipment cabinet may be located in any enclosure (room, deck or van) with sufficient clearances and with adequate ventilation. The cabinet dimensions and mounting details are shown on the next page.

A clearance of approximately two feet should be left at the rear and top of the equipment cabinet for ease of access and adequate heat dissipation. In addition to the cabinet depth dimension is the extension of the console table which extends approximately 13-1/2 inches out from the edge of the cabinet.



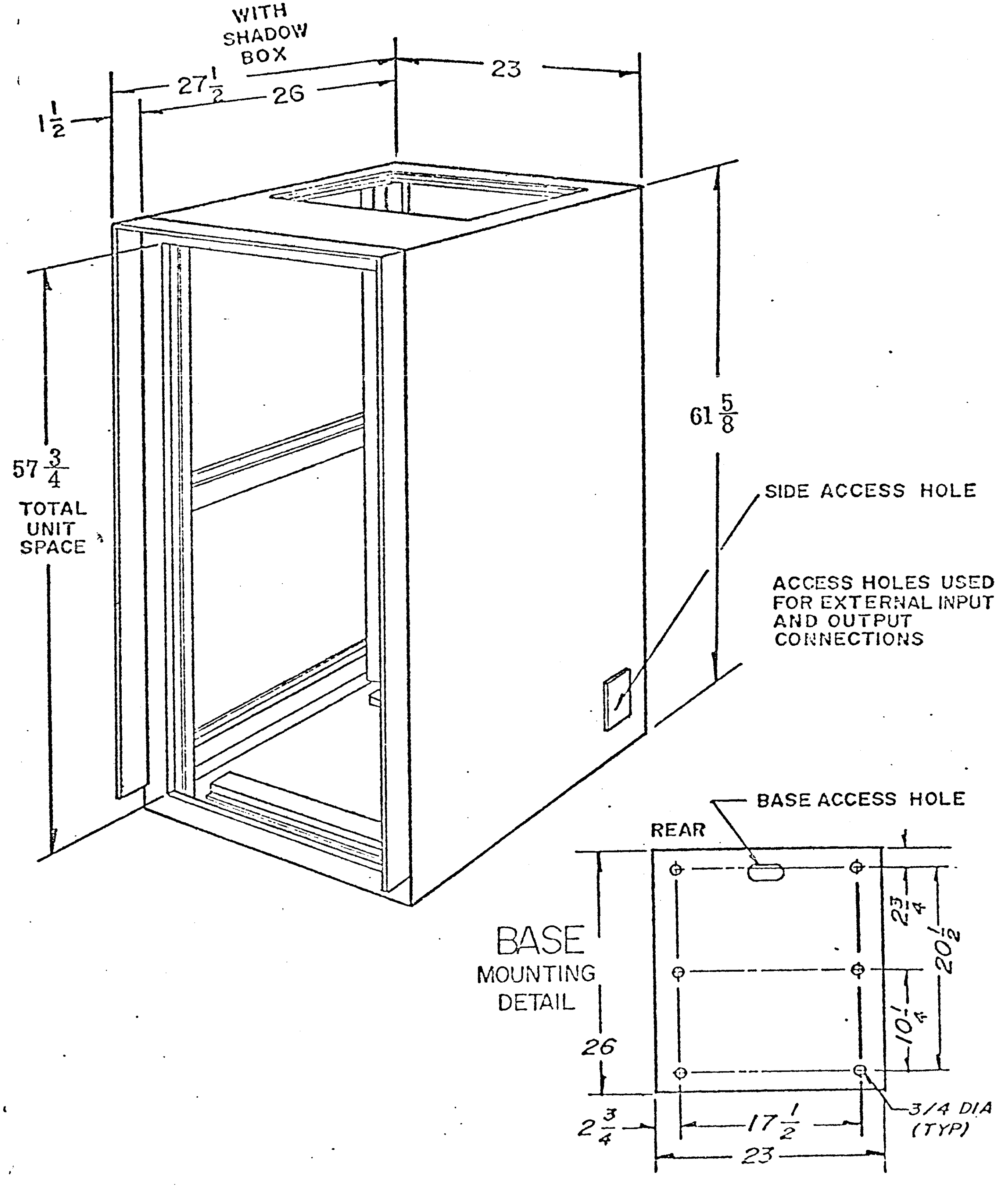
FUNCTIONAL BLOCK DIAGRAM
Model DDR-11



EQUIPMENT LOCATION
TMC Model DDR-11

CRATED WEIGHTS, DIMENSIONS AND CONTENTS

Crate No.	Contents	Gross Weight	Cubic Feet	Dimensions (in.) D	W	H
1	Cabinet and Loose Items	355	30.4	65	26.5	34.5
2	GPR-110B Receiver	100	8.6	25.5	26.5	14
3	GPR-110B Receiver	100	8.6	25.5	26.5	14
4	CFA-4 FSK Converter	55	4.5	31.3	23.2	11.2
5	DVC-10 Voice Converter	75	5.2	31.3	23.2	13


WITH SHADOW BOX
27 1/2
26
23
1 1/2
61 5/8
57 3/4
TOTAL UNIT SPACE
SIDE ACCESS HOLE
ACCESS HOLES USED FOR EXTERNAL INPUT AND OUTPUT CONNECTIONS
BASE ACCESS HOLE
REAR
BASE MOUNTING DETAIL
2 3/4
20 1/2
10 1/4
26
2 3/4
17 1/2
23
3/4 DIA (TYP)

MAINTAINABILITY

Technical Manual

TMC technical manuals perform an important function in successfully maintaining the DDR-11 receiving system. As a minimum, each manual consists of seven sections:

1) General Information
2) Installation
3) Operating Procedures
4) Principles of Operation
5) Maintenance and Troubleshooting
6) Replacement Parts
7) Drawings and Schematics

This breakdown simplifies the maintenance function by providing a ready reference for both operator and technician. Each manual is based on the actual equipment supplied and is updated by addenda sheets as changes in design occur. The manual can also be used as a training guide and as a reference for the ordering of spare parts.

The following pages are extracts from a TMC Technical Manual showing contents, troubleshooting techniques, and simplified schematics. All of these features indicate the ease with which TMC systems are maintained when using the technical manual.

Preventive Maintenance

A key factor in the successful operation of this receiver system is the degree to which preventive maintenance is performed. Dust, dirt or other destructive elements can cause the equipment to fail if conditions are allowed to continue over an extended period of time.

At periodic intervals, the equipment should be pulled out on its slides for internal cleaning and inspection. The wiring and all components should be visually inspected for accumulations of dirt, dust, corrosion, grease and other harmful substances. Removal of these elements by dusting or treating with a solvent is essential to extending the useful life of the equipment.

RELIABILITY

Equipment and Circuit Design

Designed into all TMC products is quality. From the time a circuit is first sketched on a drafting table, meticulous attention is given to minimizing the number and density of components while maximizing the functions performed. Whenever possible, solid-state components including large scale integrated (LSI) circuits are used. All of the modern TMC equipment is solid state except for the final tube circuits in the higher power linear amplifiers (1KW and above). This includes such sub-systems as the exciter, driver amplifiers, power supplies, and control circuits as well as such accessory equipment as frequency shift keyers and test generators. Maximizing the use of solid state components increases overall reliability by reducing the number of components needed to perform a given function and reducing the power requirement (stress) on the system. This improvement in reliability is reflected in a higher MTBF value (see below). Costs also decrease as the overall reliability improves since downtime, maintenance and the requirement for spare parts are all reduced. With each proven advance in modern technology, TMC modifies its designs to reduce cost and improve reliability while maintaining compatibility with older systems. Consequently, the reliability of TMC equipment, already well-known, improves with age as modern technologies are incorporated in designs. This attention to designing reliability into its receiver systems is one reason why TMC equipment is selected more often to perform the most demanding jobs.

The reliability of electronic equipment is defined as the probability the equipment will perform properly for a desired length of time under the conditions (operational and environmental) for which it is designed. There are basic assumptions which underlie the construction of a mathematical model to be used to predict the reliability of equipment:

(1) Part failure rates are constant;
(2) Probability of part survival or part reliability follows a Poisson or exponential distribution;
(3) Parts within a particular equipment or the equipment within a particular system have a series relationship. That is, each part of each equipment must operate properly so that the function for which they are used can be performed.

Mathematically, the reliability of an item of equipment or a complete system is a function of the sum of the failure rates of the parts constituting the equipment or the equipment constituting the system. Normally, failure rates can be predicted for specific parts. However, for equipment in systems, failure rates are less precise since the time interval for which the equipment reliability is being determined is usually not well defined. Mean-Time-Between-Failure (MTBF) is used in this latter case and is equal to the reciprocal of the failure rate for the equipment.

The following steps were taken to calculate the reliability and the MTBF of the receiver system:

(A) A list of all parts used in the design of the receiver was compiled from material lists stored on magnetic disks on an IBM computer system.

(B) The failure rate of each part was determined using MIL-HDBK-217 Reliability Stress and Failure Rate Data for Electronic Equipment. In the case of equipment for which adequate test time was not available, a list of components with typically average failure rates was used. This list appears at the end of this Section.

(C) The predicted failure rate of each part was recorded on a magnetic disk. The summation of these failure rates yielded the failure rate for the entire equipment.

(D) The MTBF was then calculated by taking the reciprocal of the summation of the failure rates. Since the receiving equipment has been operating well over 10,000 hours in the field, failure rates were calculated by computer and then modified to reflect actual performance.

The data for MTBF on the DDR-11 receiver system was derived from actual installations in the following areas:

Madrid, Spain	Iberia Airlines
Ottawa, Canada	Government of Canada
Maynard, MA, USA	US Government, Dept/Defense
Santiago, Chile	Government of Chile
Rome, Italy	Government of Italy

Experienced over a period of 1,000 to 10,000 hours after acceptance, the average failure rates in terms of percent per 100,000 hours of operation is 0.29. The calculated MTBF is 3448 hours. Calculated from a computer analysis of the receiver system using known stress values, the MTBF is 3170 hours.

The difference in values can be attributed to the type of service the receiving equipment is used in. The computer analysis assume 24-hour per day operation under severe environmental conditions. In actual fact, receivers are routinely shut down for periodic maintenance such as cleaning and minor adjustment. This procedure serves to extend the useful life of the system.

Two important factors further affect MTBF values: (1) the age of the equipment, and (2) the degree of preventive maintenance. TMC has found through experience that new equipment (less than one year operating) and old equipment (greater than seven years operating) have more failures than normal for a given period of time. The "burning in" of new parts and the normal wear of old parts are the primary factors which contribute to this condition. Once corrected, the system gives extremely reliable service particularly if the basic preventive maintenance procedures are conscientiously followed throughour the 20-year life of the equipment.

TYPICAL AVERAGE FAILURE RATES*

Components	Estimated Failure Rates % per 100,000 Hours of Operation
Capacitors (general purpose)	0.01 - 0.6
Capacitors (electrolytic)	0.02 - 2.0
Crystal diodes	0.05
RF inductors	0.05
Integrated circuits	0.1
Meters	0.2
Motor/generators	0.04
Potentiometers	0.3
Relays	0.001 - 0.5
Resistors, fixed	0.01 - 0.3
Switches	0.01 - 0.1
Transformers	0.05 - 2.0
Transistors	0.2
Tubes (receiver types)	1.0 - 2.0
Tubes (high power, transmitting)	1.0 - 20.0
Soldered joints (dipped)	0.0001
Wrapped joints	less than 0.0001

*Based on actual performance from TMC field engineering and maintenance records