

AD A094831

(12)

NOSC

NOSC TR 631

LEVEL II

NOSC TR 631

Technical Report 631

REMOTE MEDICAL DIAGNOSIS SYSTEM (RMDS): EVALUATION OF THE AN/FTA-28 TELEPHONE TERMINAL INTERFACE

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Final Report: 1 December 1980

Prepared for

Naval Medical Research and
Development Command

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ADMINISTRATIVE INFORMATION

This report is one in a series of reports for the Remote Medical Diagnosis System (RMDS), NOSC Work Unit CM38, sponsored by the Naval Medical Research and Development Command. This document reports on an evaluation of the AN/FTA-28 telephone terminal as an interface between the Remote Medical Diagnosis System (RMDS) shore site terminal and a Naval communication station. This evaluation was performed at the NOSC Bioengineering Laboratory between April and July, 1978. Principal investigators were I. Stevens (NOSC) and J. West (WESTEC Services, Inc., Contract N00123-77-D-0458/7N30), under the direction of W.T. Rasmussen, Head, Bioengineering Branch.

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
NOSC Technical Report 631 (TR 631)	AP-A094831	(15) NOSC TR-631
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED	
Remote Medical Diagnosis System (RMDS): Evaluation of the AN/FTA-28 Telephone Terminal Interface,	Final TR Report - April - July 1978	
6. AUTHOR(s)	7. PERFORMING ORG. REPORT NUMBER	
W.T. Rasmussen, I. Stevens, NOSC J. West, WESTEC Services, Inc. ✓	(15) N00123-77-D-458/7N30	
8. PERFORMING ORGANIZATION NAME AND ADDRESS	9. CONTRACT OR GRANT NUMBER(s)	
Naval Ocean Systems Center San Diego, CA 92152	(16) N00123-77-D-458/7N30	
10. CONTROLLING OFFICE NAME AND ADDRESS	11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Naval Medical Research and Development Command, National Navy Medical Center, Bethesda, MD 20014	64771N, M0033-PN 512-CM38	
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. REPORT DATE	
	1 Dec 1978	
	14. NUMBER OF PAGES	
	18	
	15. SECURITY CLASS. (of this report)	
	Unclassified	
	16a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
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)		
18. SUPPLEMENTARY NOTES		
This is one of a series of reports on the RMDS.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Biomedical Engineering, Remote Diagnosis, Medical Data Transfer, TV Communications, Telephone Terminal Interface		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
As one of a series of reports on the application of the Remote Medical Diagnosis System (RMDS) to improve medical diagnosis at remote sites, this Technical Report evaluates the use of the AN/FTA-28 telephone terminal interface to solve a signal amplitude variation problem between a shore-site RMDS terminal and a Naval communications station. This report concludes that the AN/FTA-28 does not meet RMDS requirements and recommends the design and development of interface equipment for the RMDS.		

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EDITION OF 1 NOV 68 IS OBSOLETE
S/N 0102-LF-014-6601

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391108

OBJECTIVES

Evaluate the AN/FTA-28 telephone terminal as a potential interface between a shore-based RMDS terminal and a NAVCOMSTA. A permanent and reliable interface between the shore terminal and the NAVCOMSTA is required for operational use of the RMDS in order to maintain the required signal levels without a feedback.

RESULTS

1. Transmissions of RMDS video data in a digital format via the AN/FTA-28 were unsuccessful.
2. The 1.3 kHz tone notch filters in the AN/FTA-28 caused a severe signal phase distortion which resulted in unsuccessful digital transmissions.
3. Transmissions of RMDS video data in an analog format via the AN/FTA-28 were unsuccessful due to added noise by the AN/FTA-28 amplifiers.

CONCLUSIONS

As presently configured, the AN/FTA-28 telephone terminal does not meet the requirements of an acceptable interface for the transmission of digital or analog video data between an RMDS shore-site terminal and a NAVCOMSTA via commercial telephone lines for half-duplex transmissions.

RECOMMENDATIONS

Recommend a more simplified piece of equipment be designed and developed specifically as an interface between the shore-site RMDS terminal and the NAVCOMSTA.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

The mission of the Remote Medical Diagnosis System (RMDS) is to improve medical diagnosis at remote sites. This is accomplished by transmitting medical data and diagnostic information between remote ship or shore sites and full-capability medical centers. The RMDS will enable the medical personnel at a remote site to contact a physician at a diagnostic center (ashore or shipboard) and transmit a visual and auditory presentation of the medical data needed for diagnosis, such as patient history, laboratory tests, ECG tracings, x-ray images, images of a patient injury, heart-lung sounds, and verbal descriptions. By return link, the physician will be able to send diagnosis and treatment information. The communication requirements for this are satisfied by any two-way, voice-grade, narrowband communication channel such as telephone line, hf or uhf radio, or satellite links.

The system as a whole consists essentially of the Remote Medical Diagnosis Terminals (RMDTs), user personnel, and existing voice-grade communication links which can be used to interconnect the terminals. All the hardware which is unique to the system is contained in the terminals, including a TV camera, TV monitor, x-ray light box, electronic stethoscope, ECG monitor, audio tape recorder, and audio handsets; and the electronics package, consisting of signal modulator, demodulator, and modems.

Shipboard feasibility tests of an early RMDS were completed during FY-75/76. This testing showed that the concept was feasible and that equipment could be developed to meet the requirements using available technology. Advanced Development Models (ADMs) were specified, and procured in September 1977.

The USS ENTERPRISE (CVN-65) was designated as the test ship for the at-sea tests of the RMDS ADMs. The at-sea tests were performed in February and March 1978. One of the terminals was installed in the sickbay area on board the USS ENTERPRISE. The second terminal was located at the Naval Ocean Systems Center (NOSC), San Diego, California.

These at-sea tests of the RMDS revealed problems at the interface between the shore-site terminal and the Naval Communication Station (NAVCOMSTA). The RMDS shore-site terminal achieves access to the NAVCOMSTA telephone switchboard via a commercial telephone line and a hybrid directional coupler, and is then patched through to the transmitter and receiver, both operating at the same radio frequency (half-duplex rf link). Thus, the RMDS-NAVCOMSTA link is essentially a two-wire telephone line connected to a half-duplex radio circuit.

1.2 PROBLEM STATEMENT

A major problem arose with the above link configuration. The signal levels from the RMDS terminal to the NAVCOMSTA were subject to amplitude variations and were

often too low for proper keying of the transmitter. Adding gain at the NAVCOMSTA to boost the incoming RMDS signal to the required keying level resulted in feedback (as shown in figure 1) and reception of a "singing" signal at both the shore- site and ship-board RMDS terminals. The feedback was theorized as occurring in the telephone switchboard and hybrid directional coupler. Further discussion of this problem can be found in reference (1), Section 2.3.4.

1.3 OPERATIONAL REQUIREMENT

A permanent and reliable interface between the shore terminal and the NAVCOMSTA receiver/transmitter is required for operational use of the RMDS with a half-duplex rf communications link. This interface system must maintain the required RMDS-to-NAVCOMSTA signal level without causing "singing" (feedback).

1.4 CANDIDATE SYSTEM

A candidate interface system which was identified to potentially solve the above-mentioned problem was the AN/FTA-28 telephone terminal. The AN/FTA-28 was tested between the RMDS terminals at the Naval Ocean Systems Center (NOSC) and the NAVCOMSTA, San Diego, in order to determine its potential applicability as a telephone line interface between the RMDS and a NAVCOMSTA. In actual application, the NOSC RMDT would be located at a shore Navy medical facility.

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1. NOSC Technical Report (to be published), Remote Medical Diagnosis System (RMDS): Advanced Development Model At-Sea Test Report.

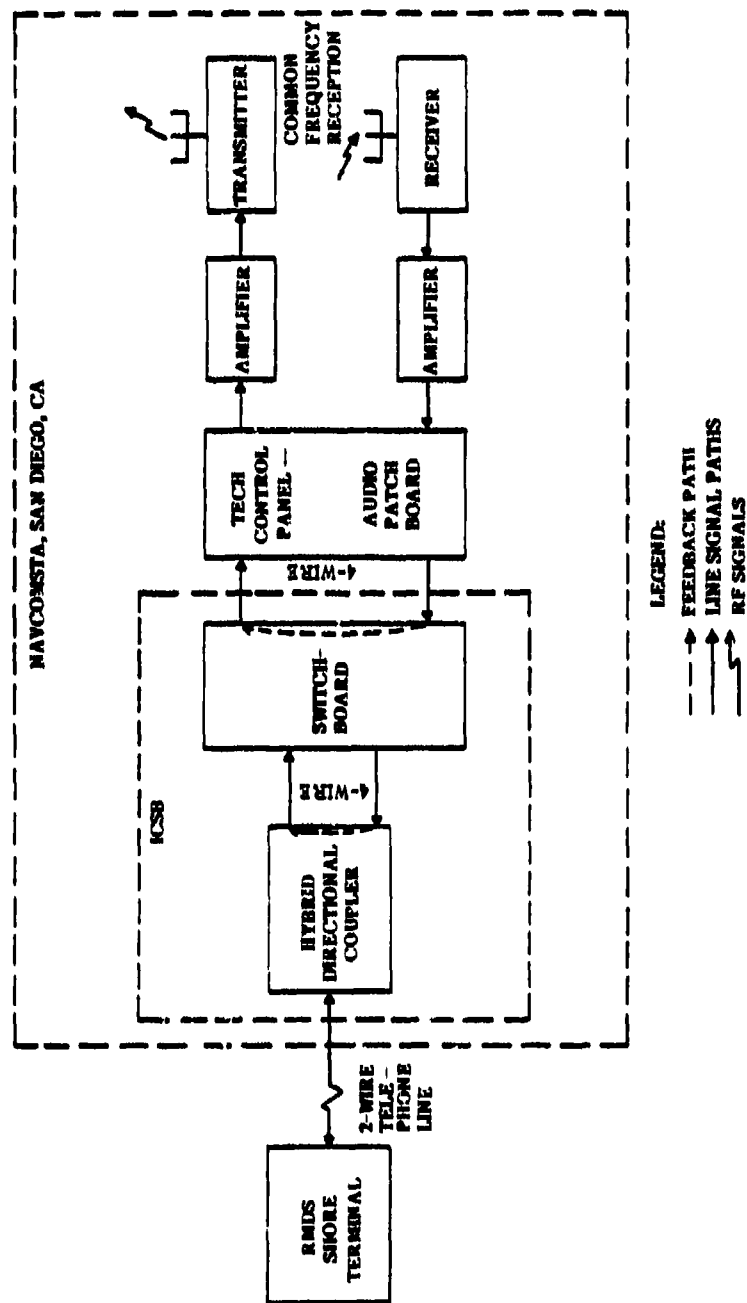


Figure 1. RMDS half-duplex communications configuration with sources of signal feedback.

SECTION 2

AN/FTA-28 TELEPHONE TERMINAL

2.1 DESCRIPTION AND SPECIFICATIONS

The following description and specifications are excerpted from reference (2).

2.1.1 General

The AN/FTA-28 provides facilities for connecting various types of two- and four-wire telephone equipments into a full-duplex radio circuit. The AN/FTA-28 is compatible with equipments using various signaling options and various types of voice-controlled modes of operation. The different applications are outlined in paragraphs 2-2, 2-3, and 2-4 of reference (2).

2.1.2 Voice Operation

The AN/FTA-28 voice circuits counteract fading, reduce noise interference, and incorporate an antisinging feature. Also, one operating mode provides continuous radio-link status monitoring by use of in-band control tones. Both the send and receive circuits can be set by a screwdriver adjustment to provide an output level anywhere between +3 dBm and -15 dBm. The output level will be maintained within +1 decibel (dB) of its setting for any input level between +10 dBm and -45 dBm. With the noise-reduction circuits in use, radio noise during periods of no speech transmission is reduced at least 20 dB. The noise-reduction circuits will result in reduced gain for weaker signals, without clipping or distorting the signal. The antisinging feature, a directional switch that locks out the send circuit while the unit is receiving, is operated either by in-band signaling tones or by the transmitted speech itself, depending on the operating mode used. When using tone control, the AN/FTA-28 transmits a 1225 Hz tone when in standby and a 1310 Hz function tone when sending speech. Reception of the 1310 Hz tone switches the distant terminal to the receive state and locks out its sending circuits. The use of tones allows continuous monitoring of the radio-link status, with an outage alarm provided to indicate the condition in which neither tone is detected by the AN/FTA-28. When desired (as in relay applications), the operation of the directional switch can be defeated through the tandem control, a circuit closure to ground that causes a relay to operate in the AN/FTA-28.

-
2. Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual Including Repair Parts and Special Tool Lists; Terminal, Telephone AN/FTA-28; TM 11-5805-443-15/NAVSHIPS 0967-292- 8010/TO 31W1-2FTA28-1; Departments of the Army, the Navy, and the Air Force, September 1968.

2.1.3 Signaling Options

The AN/FTA-28 provides a variety of signaling options for compatibility with different equipments. In response to a 20 Hz ring-in signal from the telephone equipment, a circuit closure to ground, or E- and M-signaling, the AN/FTA-28 can supply any one of the following signals to the radio circuits: 1000 Hz keyed on and off at a 20 Hz rate (hereafter designated the 1000/20 Hz signal), 1600 Hz, or a 2150 to 2450 signal frequency shifted at a 69 Hz rate. The AN/FTA-28 can also process pulse dial signals up to a maximum rate of 14 pulses per second (pps), for which the AN/FTA-28 supplies a pulsed 2150 to 2450 signal frequency shifted at a 240 Hz rate. In response to incoming ringdown signals received over the radio circuits, the AN/FTA-28 can supply any of the following ring-out signals to the telephone equipment: 20 Hz, 1000/20 Hz, 1600 Hz, or a circuit closure to ground. The ring-in and ring-out signals can be applied to the same line, which can (but need not) be the telephone line for speech, or to separate lines, either or both of which can (but need not) be lines used for speech.

2.1.4 Technical Characteristics

Frequency response

Send level output at 0 dBm $\pm$ 1 dB for 300, 500, 700, 900, 1000, 1600, 2000, 2500, and 3000 Hz input (referenced to 1000 Hz input at 0 dBm)

Inputs from switchboard-telephone circuits:

Voice signals

300 to 3000 Hz

Ring signals:

AC ring

15 to 75 Hz, 50 to 130 volts

Manual ring

Ground applied to remote alarm terminals

Switchboard ring

48 Vdc

Dialing (or switchboard supervision)

M-lead ($\pm$ 24 Vdc or $\pm$ 48 Vdc)

Outputs to switchboard-telephone circuits:

Voice signals

300 to 3000 Hz (1100 to 1400 Hz, reserved for control signals)

Ring signals

20 Hz ring generator, E-lead (dial) $\pm$ 48 Vdc, 1600 Hz, and 1000/20 Hz

4-wire line input and output signals:

Voice	300 to 3000 Hz (1175 to 1375 Hz, reserved for control tone signaling)
Control tone signals:	
Function tone	1310 Hz
Standby tone	1225 Hz
Ringdown signals	2150 to 2450 Hz frequency-shifted at a 69 or 240 Hz rate; 1000 Hz, on-off keyed at a 20 Hz rate; steady 1600 Hz
Receive ringdown input signal levels	-40 to +10 dBm
Input/output impedance	600 ohms ± 10 percent, ungrounded and balanced with a minimum return loss of 26 dB over the speech bandpass
Antisinging control	Accomplished by a directional switch which is controlled by a speech-actuated, in-band frequency-shifted tone generated within the equipment
Automatic gain response	Fast attack on signal increase, slow retreat on signal decrease
Maximum dialing rate	14 pulses per second
Ringdown output level	0 dBm ± 1 dB
Dialing output level	0 dBm ± 1 dB
Control signal output level	Adjustable from +5 to -15 dBm; normal output level 0 dBm for standby tone, -10 dBm for function tone
Noise reduction	Adjustable; between syllables of speech transmission, radio noise is reduced by at least 20 dB
Radio circuit outage alarm	Activated when standby tone or function tone falls below -50 dBm (± 5 dB)

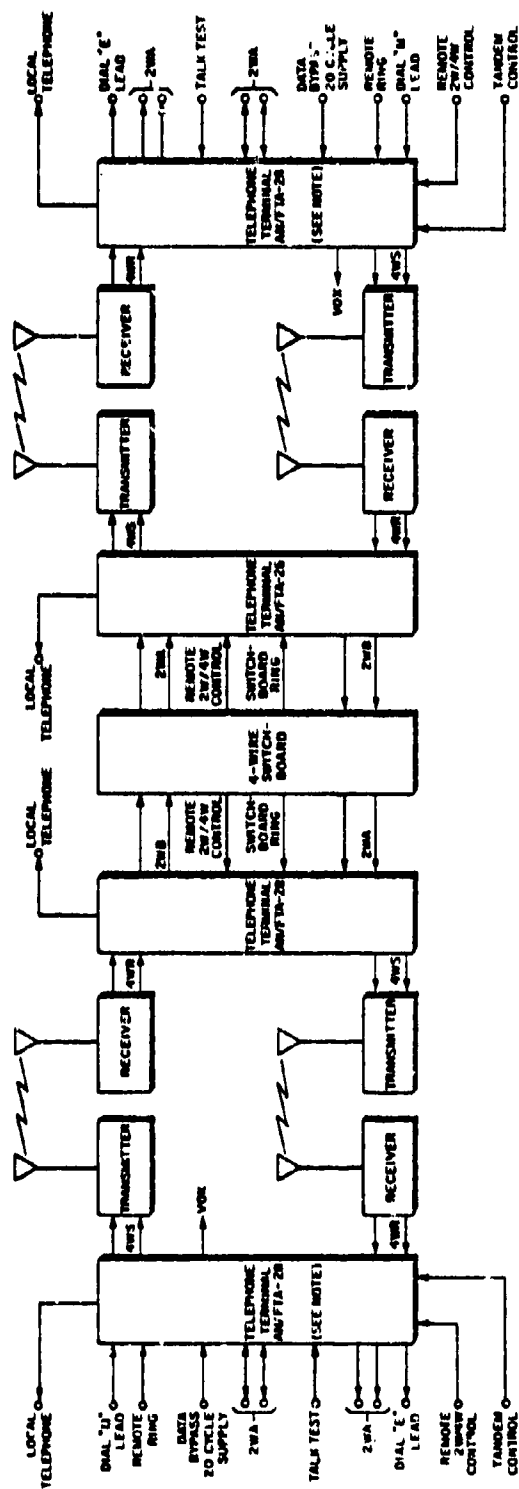
Telephone connections	Double-jack receptacle provides connection for 2-wire telephone-switchboard operation, 4-wire radiotelephone operation, and 2-wire local telephone (party line) 4-wire radio operation
Input power requirements	115/230 volts (± 10 percent) ac; 47 to 440 Hz
Power consumption	30 watts, maximum
Semiconductor devices:	
Number of transistors	102
Number of diodes	90
Temperature range:	
Operating	0°C to 50°C
Nonoperating	-62°C to 71°C
Elevation:	
Operating	Up to 10,000 feet above sea level
Nonoperating	Up to 50,000 feet above sea level

Figure 2 shows the AN/FTA-28 in a system application, and figure 3 is a block diagram of the AN/FTA-28 voice circuits which would be used for both voice and data in the RMDS-to-NAVCOMSTA link. These figures are taken from reference (2).

2.2 IMPLEMENTATION

2.2.1 Half-Duplex Link

The AN/FTA-28 is essentially designed for operation with a full-duplex communications link. The AN/FTA-28 controls feedback (singing) primarily by turning off the drive signal to the transmitter whenever it senses an incoming signal from the receiver. The primary problem in using the AN/FTA-28 for RMDS applications lies in adapting it to a half-duplex communications link operation. The essential difference between half-duplex and full-duplex, with respect to the AN/FTA-28, is that in a half-duplex application the AN/FTA-28 cannot distinguish between a signal transmitted by a remote station and one from its own transmitter. In fact, the proximity of the transmitter and receiver used with the AN/FTA-28 guarantees that the AN/FTA-28 would sense its own transmitted signal as a "received signal," thereby turning off the transmitter in anticipation of an arriving signal. Then, after a short lag period with no other signal present, the AN/FTA-28 would revert to the transmitting mode, thereby again generating the receive signal which would turn the transmitter off. This feedback



NOTE:
ALL CONTROL FUNCTIONS OF TELEPHONE
TERMINAL AN/FTA-28 ARE NOT INDICATED
IN THIS DIAGRAM

Figure 2. AN/FTA-28 system application.

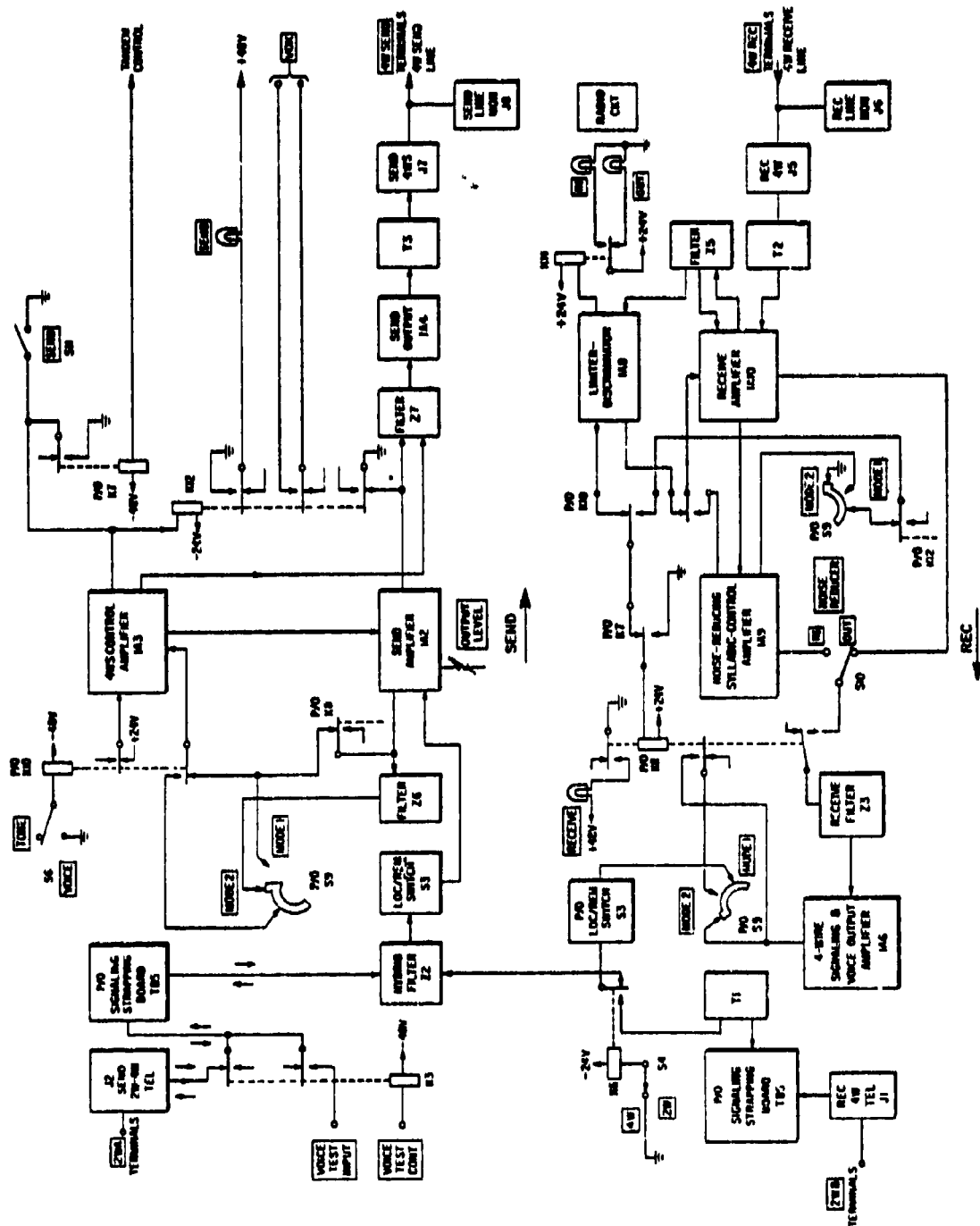


Figure 3. AN/FTA-28 voice circuits.

would continue as long as the RMDS terminal was in the transmit mode. If interfaced with the RMDS in the half-duplex configuration, the AN/FTA-28 would continuously start and stop its own signal.

2.2.2 Transmit Control Tone

The AN/FTA-28 terminal can be operated in several modes, and one of these, the "Voice Mode 2," could provide a possible solution to the half-duplex operation problem indicated above. Figure 4 is a simplified block diagram of the AN/FTA-28 Voice Mode 2. Note that a tone, at the same frequency as the AN/FTA-28 filters, must be mixed with the RMDS-transmitted signal in order to satisfy the AN/FTA-28 Voice Mode 2 requirements. This is an easy, practical and inexpensive modification to the RMDS shore terminal. The AN/FTA-28 would sense the tone transmitted by the RMDS and would switch to its transmit (send) circuit and simultaneously turn off its receive circuit, thereby eliminating the possibility of singing. When not actively transmitting, the AN/FTA-28 would be in the "standby receive" condition.

The transmit tone signal level (from the RMDS) required by the AN/FTA-28 is in the order of 5 mv. After the control tone is received by the AN/FTA-28, it is then filtered out of the transmit circuit, making it unlikely that signal degradation from the tone or its harmonics would occur. Worst-case measurements showed a third harmonic approximately 40 dB below normal data signal levels. A 1.3 kHz tone notch filter is incorporated in the AN/FTA-28 receive circuit to prevent any noise containing the 1.3 kHz tone frequency from triggering the transmit circuit.

Both AN/FTA-28 transmit and receive circuits incorporate amplifiers with automatic gain control (AGC), so that once set to the required level, the signal level is held constant. Additionally, the receive circuit provides optional squelch capability. Figure 5 shows the receive circuit output as a function of input voltage for both squelch and AGC effects.

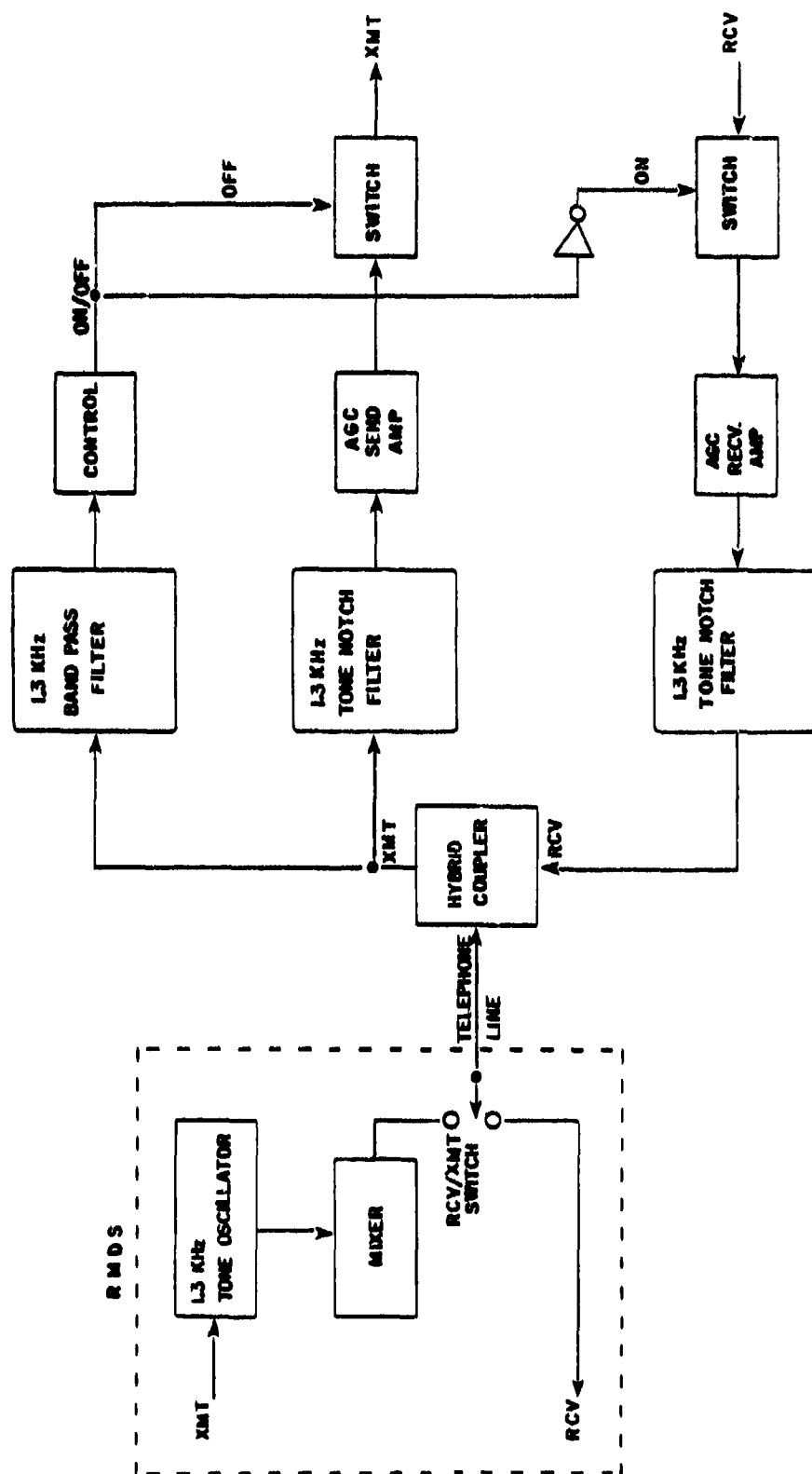


Figure 4. AN/FTA-28 Voice Mode 2.

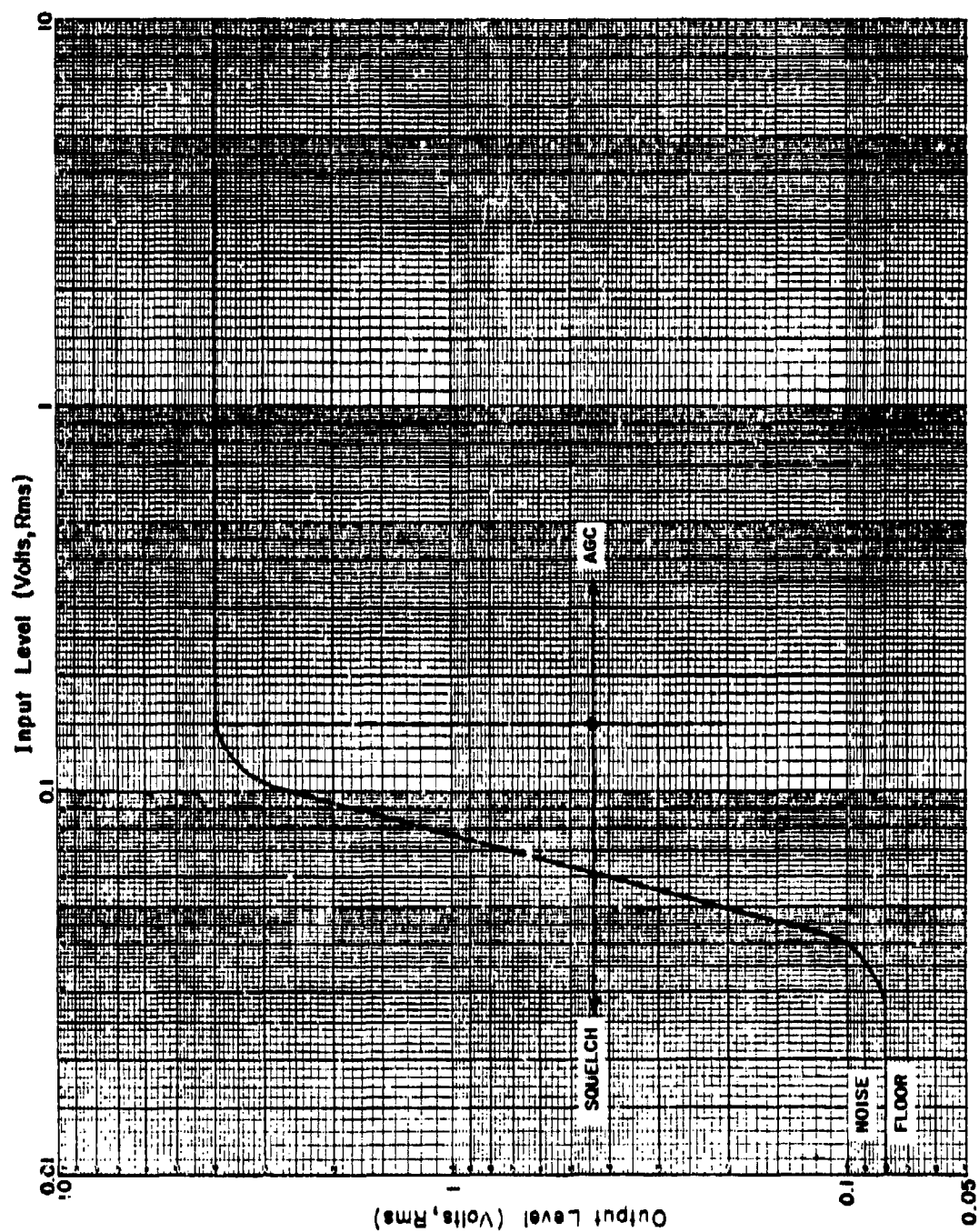


Figure 5. AN/FTA-28 Receive Mode; input signal vs. output signal.

SECTION 3

RMDS-AN/FTA-28 TESTING

3.1 DIGITAL TRANSMISSION RESULTS

Attempts were made to transmit video data in digital format from an RMDS terminal containing the tone oscillator and mixer shown in figure 4. Transmission proceeded via commercial telephone lines terminated in an AN/FTA-28, whose output supplied the signal to a receive RMDS terminal. These attempts were unsuccessful. Specifically, synchronization was disrupted. Analysis of the AN/FTA-28 circuitry indicated that the 1.3 kHz tone notch filters, rather than the AGC amplifiers, switches, hybrid couplers, or other AN/FTA-28 components, were the most likely cause of signal degradation. To test this hypothesis, the tone notch filters were bypassed from the signal path with temporary leads. With the filters bypassed, there was no apparent disruption of the digital video data received at the RMDS terminal.

Figure 6 represents the power spectrum of a digital RMDS video signal. From this figure, it is apparent that the RMDS signal contains important sideband energy in the region of 1.5 kHz. Figure 6 also shows the amplitude and phase characteristics of the tone notch filters used in the AN/FTA-28 terminal for frequencies above the notch filter tuned frequency. The filter response data below the tuned frequency of the notch filter is not shown because there is no RMDS signal power in that portion of the spectrum. It can be seen from these curves that the AN/FTA-28 filters have a significant deleterious effect on the RMDS video signal by causing considerable attenuation of important sideband information, as well as severe phase shift. A 2400 bps modem is part of each RMDS. The data modulates a differential four-phase signal centered on an 1800 Hz carrier. The received differential phase shift keyed (DPSK) signal represents data coded by means of changes in phase. The detected phase changes are then converted into bits, dibits, etc., as appropriate.

This problem can be solved in a practical and economically feasible manner by lowering the frequency of the tone oscillator and the notch filters from the presently implemented 1.3 kHz. A tone frequency between 300 Hz and 1 kHz could be used, provided that the frequency chosen does not have an adverse impact on speech intelligibility. Since the AN/FTA-28 tone notch filters are easily removed and replaced, different filters at a new frequency selected for the RMDS oscillator could be installed in the AN/FTA-28. The lower frequency tone filters would have a negligible effect on the frequencies contained in the RMDS power spectrum. Therefore, an AN/FTA-28 terminal modified for a lower frequency transmission tone would be a suitable interface for digital data transmitted from an RMDS terminal to a NAVCOMSTA via commercial telephone line.

3.2 ANALOG TRANSMISSION RESULTS

The AN/FTA-28 was tested using analog video data from one RMDS terminal to the other terminal via a telephone line. When the AN/FTA-28 was not included in the circuit, an acceptable image was received. However, when the AN/FTA-28 was added

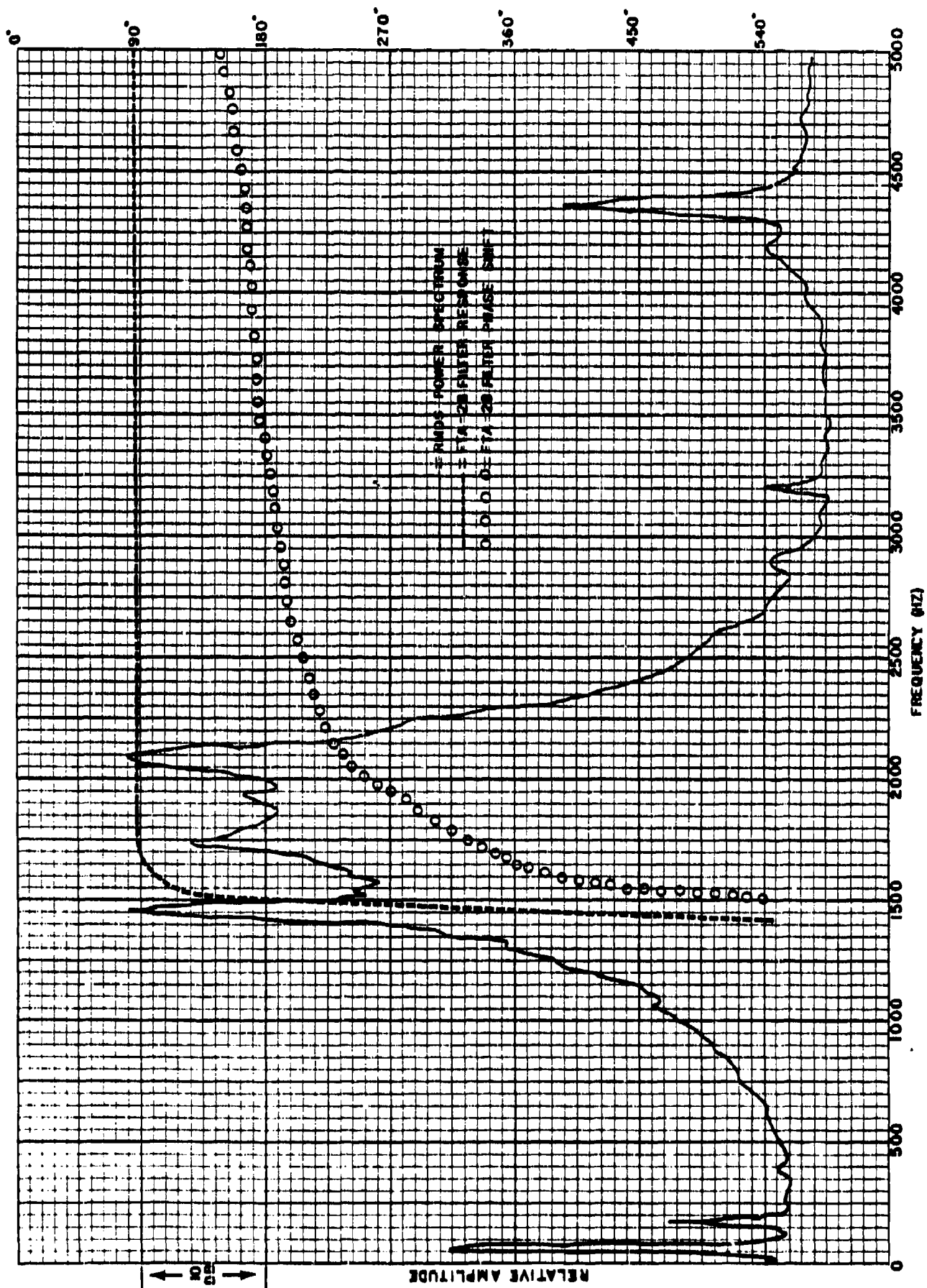


Figure 6. RMS power spectrum and AN/FTA-28 filter response.

to the same telephone line connection, noise added to the received data degraded the signal-to-noise ratio to such an extent that either the receive terminal was not able to receive an image, or if an image were received, it was unacceptable. The most likely sources of the noise were the AN/FTA-28 amplifiers; and, furthermore, the AGC action incorporated in the amplifiers aggravates noise problems. Replacing the existing amplifiers with less noisy ones could alleviate the noise problem observed. Time and monetary constraints precluded any further investigation of noise contribution to analog data transmission by the AN/FTA-28 terminal.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

It is recognized that under most operating conditions, only a half-duplex link between a ship and a NAVCOMSTA will be utilized. The existing interface between a shore-site RMDS terminal and the NAVCOMSTA switchboard, to operate over a half-duplex communication link, results in a loss of signal level. If the signal level is boosted to overcome this drop, feedback problems occur between the NAVCOMSTA transmitter and receiver. It is, therefore, necessary to integrate a permanent interface between a shore-site RMDS terminal and a NAVCOMSTA to eliminate the feedback problems.

As presently configured, the AN/FTA-28 telephone terminal does not meet the requirements of an acceptable interface for the transmission of digital or analog video data between an RMDS shore-site terminal and a NAVCOMSTA via commercial telephone lines for half-duplex transmissions. Furthermore, even if the AN/FTA-28 terminal were modified for this use, it is a much more complex piece of equipment than that needed for the RMDS-NAVCOMSTA interface requirements, because of its many operating modes and multifaceted telephone dialing and signal generating capabilities.

It is recommended that a more simplified piece of equipment be designed and developed specifically as an interface between the shore-site RMDS terminal and the NAVCOMSTA. This interface equipment should be designed to utilize a control tone signal to activate/deactivate the transmit/receive circuitry. The control tone frequencies must be outside the frequency band utilized by the RMDS terminal for slow scan transmissions and must not interfere with the preamble frequencies. It is, therefore, recommended that this interface equipment be designed as an integral part of the Engineering Development Models of the RMDS during the next phase of the RMDS program.