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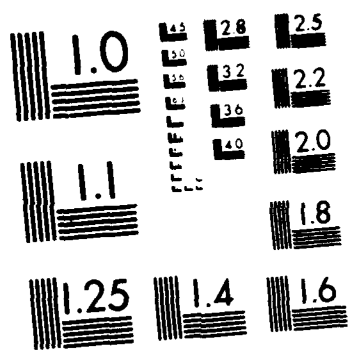

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A practical VLF/LF radio test system designated as the "AN/URM-212, Test Set, Radio" is a recent development of the Naval Ocean Systems Center working in conjunction with industry.

The mission of the AN/URM-212 is to verify the operational readiness of VLF/LF receive communication systems installed in submarines, Navy aircraft, and tenders from antenna to printer. The AN/URM-212 tests processor-controlled VLF/LF receive components (e.g., VERDIN), in a quantitative manner and tests non-processor controlled VLF/LF receive components (e.g., receivers, antennas and associated couplers) in a qualitative manner. The AN/URM-212 is used to test all receive components of the VLF/LF communications system by measuring small performance degradations not discovered by automated performance monitoring, self test or other preventive maintenance procedures.

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PRACTICAL VLF/LF RADIO TEST SYSTEM

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INTRODUCTION

A practical VLF/LF radio test system designated as the "AN/URM-212, Test Set, Radio" is a recent development of the Naval Ocean Systems Center working in conjunction with industry.

The mission of the AN/URM-212 is to verify the operational readiness of VLF/LF receive communication systems installed in submarines, Navy aircraft, and tenders from antenna to printer. The AN/URM-212 tests processor-controlled VLF/LF receive components (e.g., VERDIN), in a quantitative manner and tests non-processor controlled VLF/LF receive components (e.g., receivers, antennas and associated couplers) in a qualitative manner. The AN/URM-212 is used to test all receive components of the VLF/LF communications system by measuring small performance degradations not discovered by automated performance monitoring, self test or other preventive maintenance procedures.

TEST REQUIREMENT

It had been suspected that in time VLF/LF systems slowly degrade due to misalignment or age of analog components. Each component equipment (i.e., demodulator) might lose a small amount of performance too small to be detected by the equipment's own built-in test equipment. The sum of these small individual losses by each component of the system can amount to a measurable value. Since there was no general purpose equipment available to check overall system performance, it was necessary to design a special purpose test system. This test system was developed after the units to be tested were deployed, thus presenting a challenge to the test designers to come up with a low cost and practical test unit.

PRINCIPAL OF OPERATION

The AN/URM-212 consists of five major components: (1) TS-4151/URM Test Unit, Radio, (2) VLF Antenna Interface Set, Aircraft, (3) VLF Antenna Interface Set, Submarine, (4) VLF System-resident Software, and (5) technical manuals and test procedures.

As shown in figure 1, the basis theory of operation is for the test unit to send a canned message (e.g., "QUICK BROWN FOX....") modulated at the desired radio frequency and mixed with a predetermined amount of noise (within the test unit). The resultant mix is routed through the coupler, antenna, and multicoupler to the receive terminal. In the example shown, the receive terminal is the "VERDIN" or AN/WRR-7, Receiver Set, Digital Data. The receive terminal has a stored canned message in memory that is compared to the incoming message. The errors are counted by the unit under test and, the resultant error rate is compared to a known function of signal-to-noise ratios to determine an estimate of noise degradation. The error rate and degradation is printed for operator review. An unusual feature of the test system is that the system brain, namely the resident system software, is in the unit under test.

The test unit also contains the ability to test the noise figure of the receive terminal via a special noise source described later.

RADIO TEST UNIT (RTU)

The block diagram for the Radio Test Unit (RTU) is shown in figure 2. A picture of the unit is shown in figure 3.

The RTU generates the signals and noise required to verify the proper operation of VLF and LF receiving equipment. It is capable of producing the following signals:

- Frequency Shift Keying (FSK) at 50 baud
- Compatible Shift Keying (CSK) at 50 baud
- Minimum Shift Keying (MSK) at 100, 200, 800, or 1600 baud
- Continuous Wave (CW)
- Broadband Gaussian noise

The RTU contains two Z80B microprocessors. Each microprocessor has associated with it 8 Kbyte of erasable programmable read-only memory (EPROM) and 8 Kbyte of random-access memory. Both EPROMs contain the same program and data tables. In routine operation the operator selects from the front panel the modulation and the mode desired. The modulation switch indicates the modulation rate and type used. The mode switch indicates if the RF output is to be noise, signal, or signal mixed with noise, and whether the normal or special data pattern is to be used.

The microprocessors perform the generation of the required signals. For example, if the switches are set at "100 MSK" (modulation) and "SIG + NOISE NORM" (mode), the microprocessors generate a 100 baud MSK waveform from look-up tables (each microprocessor generating alternate samples) representing the normal "QUICK BROWN FOX..." pattern, and digitally mixing within the microprocessor a predetermined amount of noise.

The digital output representations of the selected signal and noise combination are fed via a controlling digital-to-analog converter (DAC) input switching unit to the DAC. A low pass filter is used to remove unwanted spectra from the output of the DAC. An up/down converter consisting of a double balanced mixer, a bandpass filter, and a second double balanced mixer fed by the frequency synthesizer puts the resultant analog output at the desired output frequency.

The test set can also perform self tests of the DAC, the Z80Bs, the RAMs, the EPROMs, and the front panel MODE and MODULATION switches. The test set operator is kept abreast of the progress and results of the tests by means of a teleprinter plugged into the test set's TTY output connector. This teleprinter is needed only when using the self-diagnostic facilities of the test set.

There is a second type of noise source generated by the RTU as contrasted to the RF noise discussed above. When the function switch is in the "NOISE" position, a battery pack in the lid is used to power an encapsulated noise in the RTU. This simple circuit provides a clean noise sources to conduct noise factor tests of receivers. The attenuators are used to adjust the noise supplied to the unit under test until there is a doubling of the power at the receiver. The change is attenuator settings represents the noise factor measured.

INTERFACE SET

There is an interface set designed for aircraft use and one designed for submarines. The VLF Antenna Interface Set, Aircraft is an existing set of couplers designed for a special test unit. The VLF Antenna Interface Set, Submarine is a set of Naval Ocean Systems Center designed "soft" couplers designed to fit the odd shape of submarine antennas. These "soft" couplers provide a low cost method of injecting signals by placing the transmitting potted coils at the exact point of maximum sensitivity on irregularly shaped structures. An example of a coupler for the AT-317 "football" antenna is shown in figure 4. The coils are kept in place by strapping material fasten by hook and pile synthetic webbing.

SYSTEM RESIDENT SOFTWARE

The VLF System resident software has been incorporated into two different VLF/LF receive systems. This software compares incoming signals from the TS-4151/URM to expected patterns and known parameters.

The resident system software performs the following functions: (a) signal synchronization, (b) test message synchronization, (c) comparison to determine errors, and (d) calculation and printout of results. For signal synchronization, the routine resident system synchronization algorithm was used. For test message synchronization, the incoming data is entered into a buffer table. The size and width (number of sub-channels) is determined by the operator indicated modulation rate. After the beginning of the test message is found, errors are detected and counted and the bit error rate (BER) is determined. The BER is compared to a table containing a signal-to-noise value (Eb/No) in decibels and also a test threshold number. If the BER exceeds the test threshold number, the operator will be alerted that the system has failed. The operator is provided a printout of the BER for the test, estimated degradation for the test, a running average BER, and an average running estimated degradation.

APPLICATIONS

The test set is well suited for the application for which it was designed. It also has been used as a test modulator for the Aerostat Supported ELF/VLF Transmitter (ASET) conducted in February 1987.

CONTRIBUTION

Doug Lawrence while at Naval Ocean Systems Center (NAVOCEANSYSCEN), now with Honeywell, did the initial concept design. The system and most of the electronic hardware design was done by Don French of NAVOCEANSYSCEN. The software and initial mechanical design for the AN/URM-212 was done by Computer Sciences Corporation under contract to NAVOCEANSYSCEN. The Resident-system Software was designed by Jeff Greenhill of NAVOCEANSYSCEN and implemented for VERDIN. Wayne Gerth of NAVOCANSYSCEN implemented the Resident-system Software for Enhanced VERDIN. Design of the coupler sets was done by Don French and Eldred Smith of NAVOCEANSYSCEN.

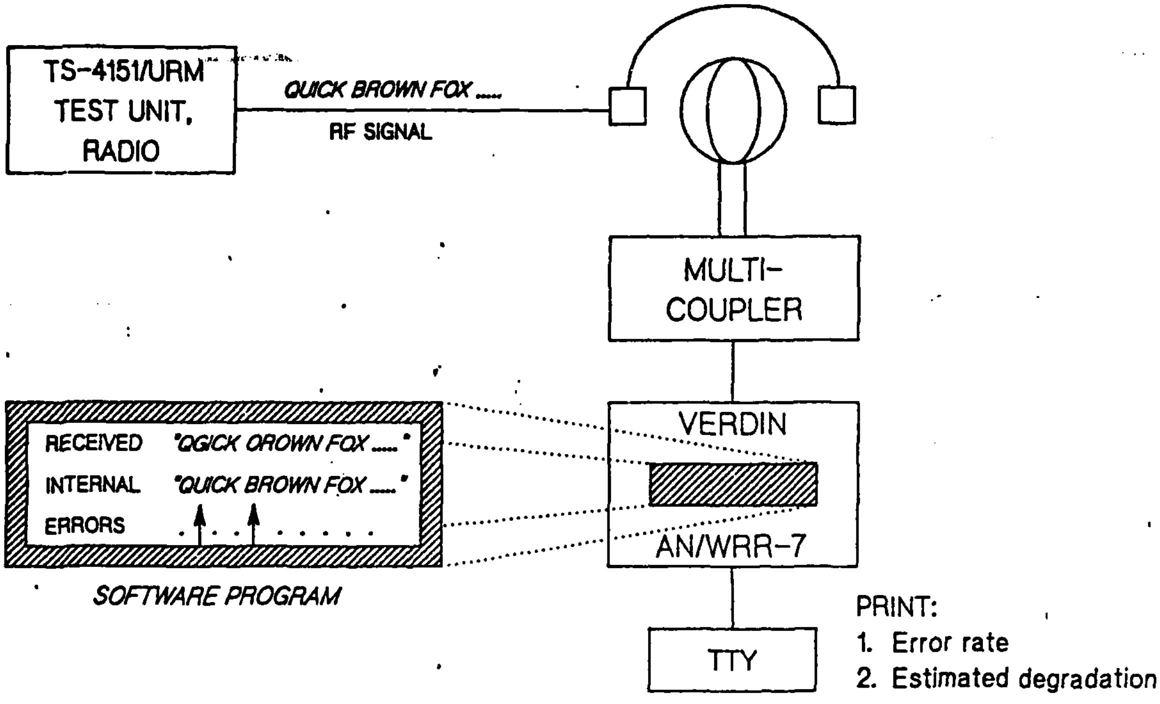

Figure 1. Radio Test Unit (Simplified Operation)

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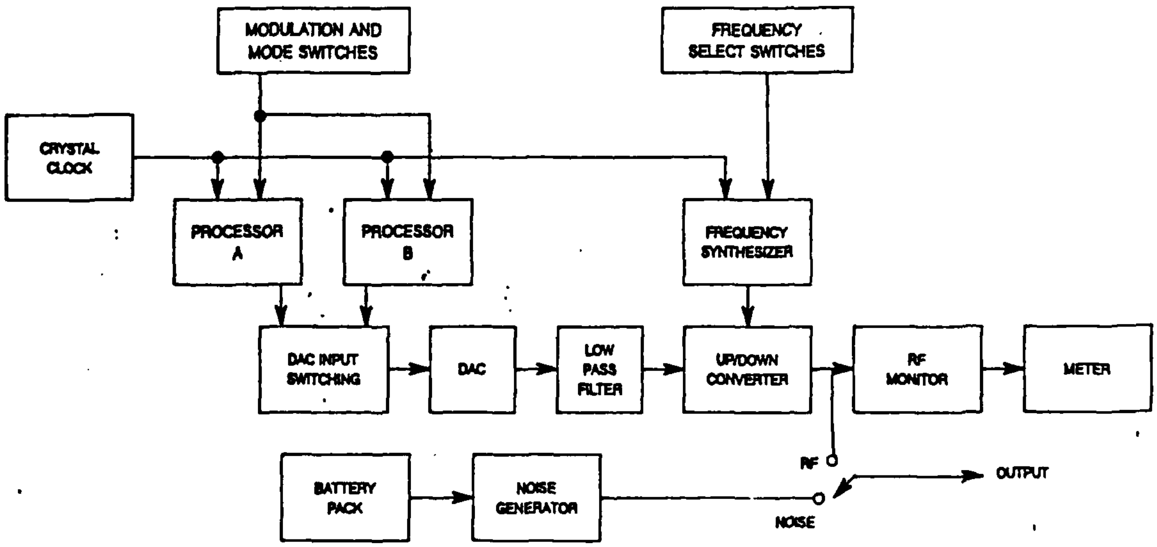

Figure 2. Radio Test Unit Block Diagram

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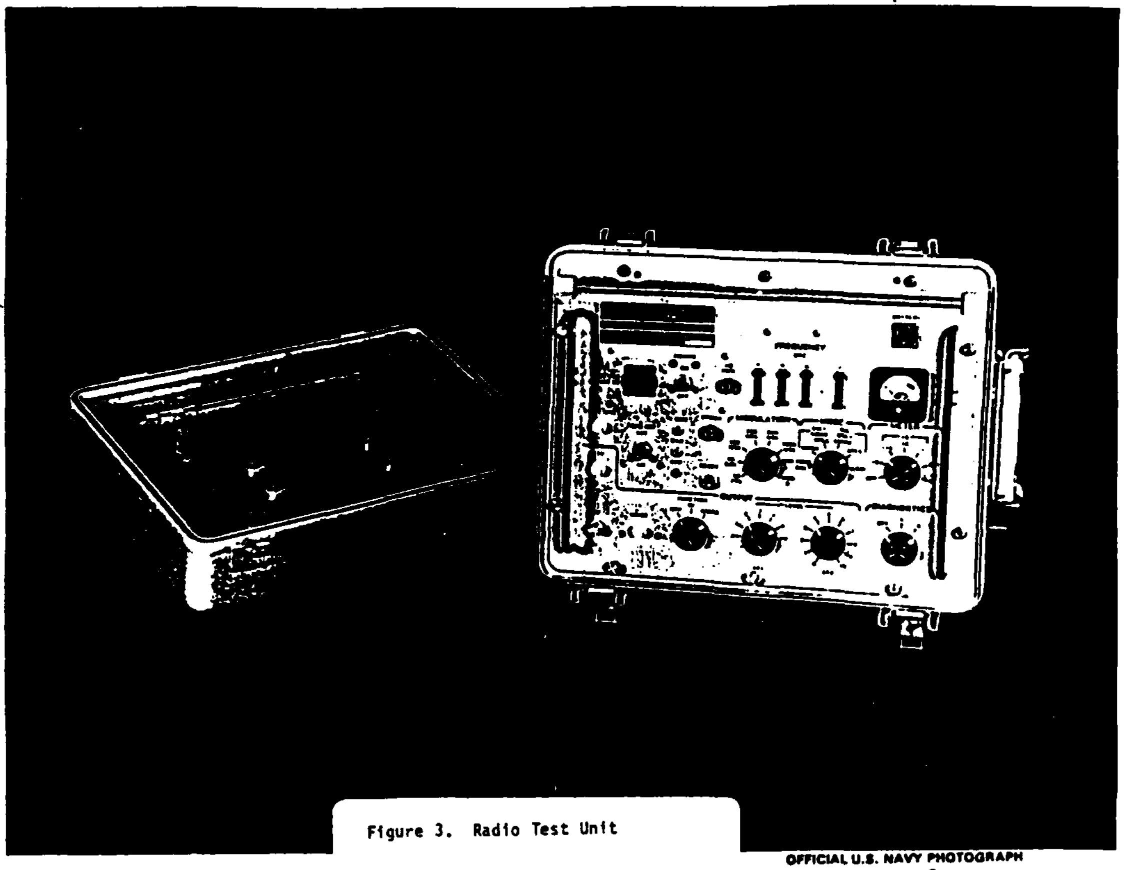

Figure 3. Radio Test Unit

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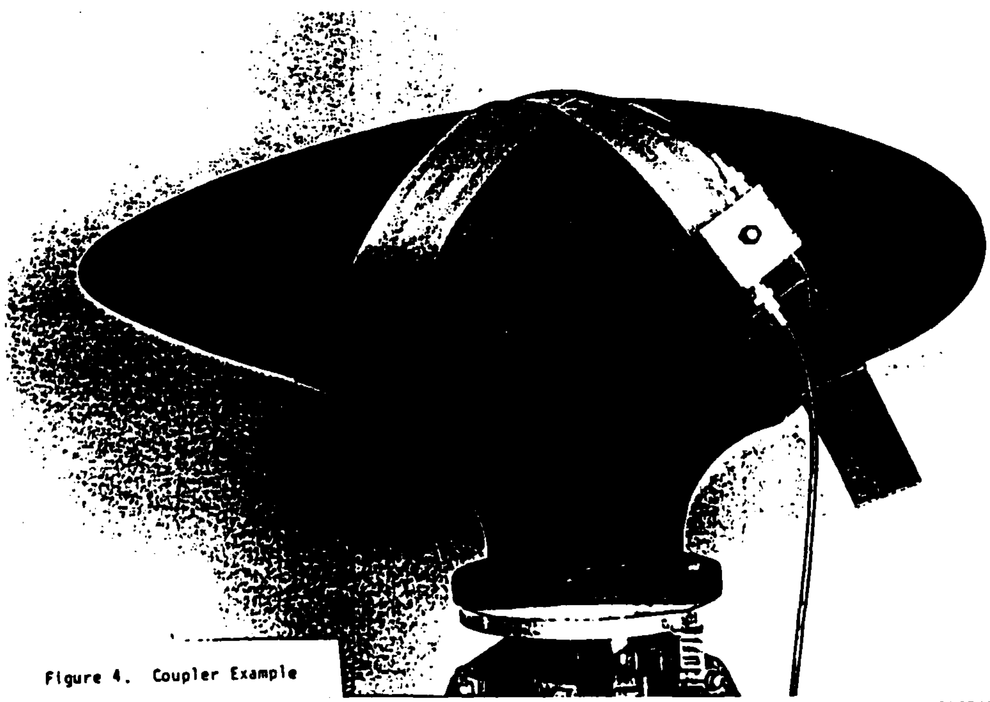

Figure 4. Coupler Example

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