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TEST AND EVALUATION OF SOLID-STATE DOPPLER VERY HIGH FREQUENCY OMNIDIRECTIONAL (DVOR) DISTRIBUTOR ASSEMBLY

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PROJECT PLAN

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1. INTRODUCTION.

1.1 OBJECTIVE.

The objective of this project is to evaluate the performance characteristics of a solid-state Doppler very high frequency omnidirectional range (DVOR) distributor assembly. The evaluation will be accomplished through a series of comparative tests with a standard mechanical distributor. The course deviation indicator (CDI) outputs from several VOR receivers will be used to measure course bearing error with respect to accurate bearing data from the Extended Area Instrumentation Radar (EAIR) facility during orbital and radial flights. Ground check error measurements will also be made using the DVOR monitor. Data obtained from the tests using the solid-state distributor will then be compared with baseline data from identical tests using the standard mechanical distributor.

The questions which will be answered by this activity are:

a. How does the ground check error using the solid-state distributor compare to the error generated by the current mechanical distributor, and how does it compare to the standard?

b. How accurate a course bearing does the VOR radiate when using the solid-state distributor, and how does it compare to the radiated course bearing generated by the mechanical distributor?

c. With the solid-state distributor installed, how do specific VOR system parameters compare to the standards handbook?

1.2 BACKGROUND.

The Double Sideband (DSB) DVOR facility has been adopted as the Federal Aviation Administration (FAA) standard. In support of this effort, the Airway Facilities Service (AAF) has a current contract, DOT-FA78WAI-940, with Henderson Industries (8A) to build the solid-state distributor. Edo-Aire, the subcontractor, is providing the engineering development and the technical support to test the prototype and first production article.

The AAF has requested validation tests be conducted at the FAA Technical Center's experimental DVOR Testbed facility to ascertain that the design approach is consistent with performance requirements. The breadboard prototype Doppler VOR Distributor Assembly (DVDA) will be tested first and if the distributor performance data is acceptable, the first article solid-state DVDA will be constructed. The same tests will be repeated on the first article DVDA to provide distributor performance data prior to subsequent production article procurement. Ground measurements will be repeated weekly on the first article DVDA for a period of 6 months to determine performance/stability.

1.3 REFERENCE DOCUMENTS.

The primary documents that will be used in this effort are:

a. Federal Aviation Administration, "Double Sideband Doppler VOR Installations Standards Handbook," 6790.12, July 20, 1981.

- b. "United States Standard Flight Inspection Manual," OP 8200.1, August 1972.
- c. Edo-Aire, "Doppler VOR Distributor Assembly Equipment Manuals" (to be supplied with the equipment).
- d. Federal Aviation Administration, "Doppler VOR Distributor Assembly," Specification FAA-E-2589, February 15, 1974.
- e. Willey, Virgil E., "Development and Evaluation of a Double Sideband and Doppler VOR System with High Level Reference Modulation," Federal Aviation Administration, Report FAA-NA-71-36, June 1971.

2. SYSTEM/EQUIPMENT DESCRIPTION.

The equipment to be evaluated is a solid-state (nonrotating) distributor assembly which operates over the frequency range of 108.0 to 118.0 megahertz (MHz). A functional block diagram of the DVDA is shown in figure 1. The unit to be tested includes the functions of a distributor, goniometer, and audio generator. The distributor provides sequential switching of the sideband transmitter outputs to a circular array of 50 antennas at the rate of 30 hertz (Hz). The goniometer produces 30-Hz upper and lower sidebands of the carrier transmitter frequency. The audio generator produces a 30-Hz sinusoidal output. Timing and phase coherency between the distributor, goniometer, and audio generator outputs are provided by a master generator.

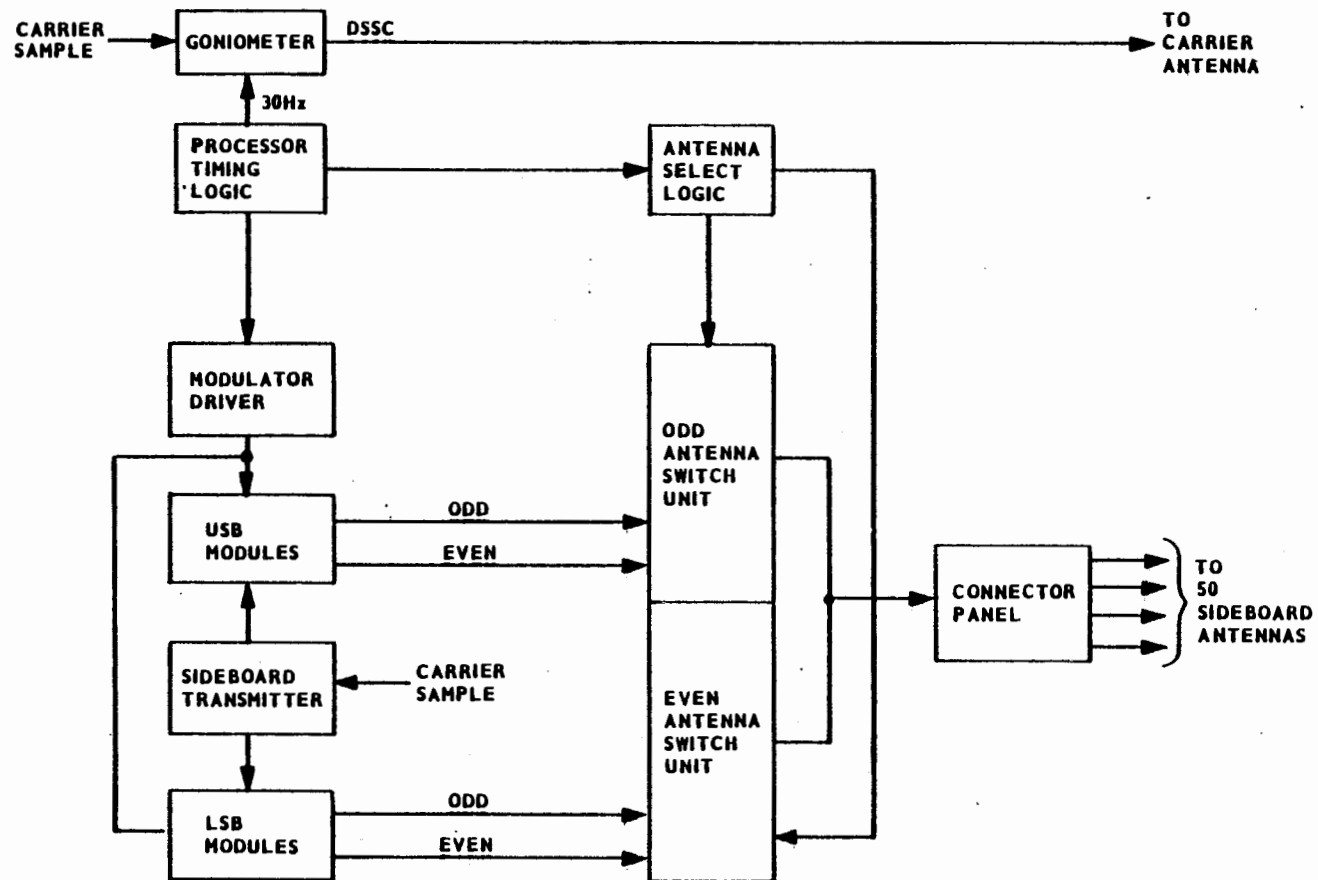
3. DATA COLLECTION.

3.1 GENERAL.

The DVDA tests will be accomplished at the FAA Technical Center utilizing the experimental Doppler VOR site, building 188. This facility provides a means of rotating the entire antenna array for ground check error measurements. The DVOR ground equipment used in the test will include: a TV-19 transmitter, an FA-5644X carrier modulator, an FA-9453 sideband transmitter, an FA-5226 station monitor, a CA-1628 VOR test generator, a Jansky and Bailey modified DSB mechanical distributor, and the new solid-state DVDA. Operational site frequency will be 114.25 MHz. The existing DSB DVOR mechanical distributor will be tested before the new DVDA is installed for comparison of test results.

Assembly and initial testing on the solid-state DVDA will be performed jointly by contract and Technical Center personnel to assure proper installation and operation. Tests on the breadboard prototype will be conducted over a 2-month period to determine DVDA performance. Tests on the first production article will be conducted over a 6-month period to determine stability as well as performance.

Reference documents "a" and "b" (in section 1.3 of this report) provide the technical guidance and standardized test procedures which will be utilized during the Technical Center's test phase. The ground and flight test effort is primarily concerned with the comparative operational performance of the mechanical distributor and the new solid-state DVDA.



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FIGURE 1. DOPPLER VOR DISTRIBUTOR ASSEMBLY BLOCK DIAGRAM

3.2 GROUND MEASUREMENTS.

Measurements of the following standard parameters will be accomplished as indicated in reference 1.3a, unless otherwise stated, and will be recorded during single sideband (SSB) and double sideband (DSB) operation on both the mechanical distributor and the solid-state DVDA for comparison and validation.

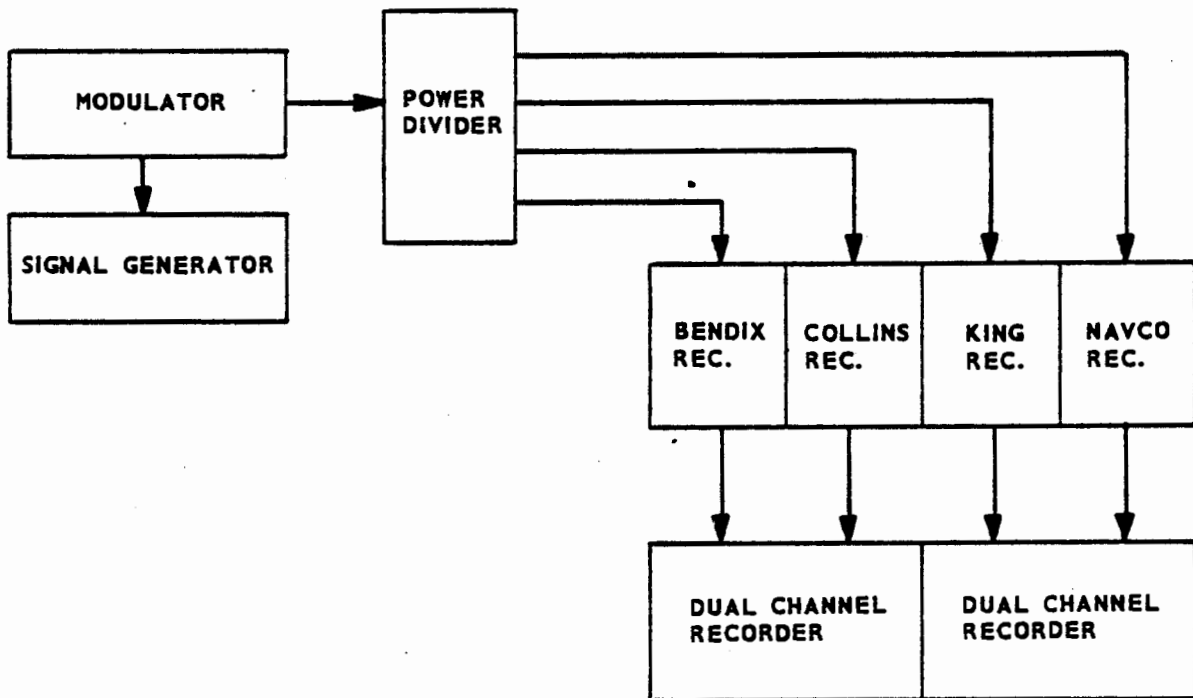
- a. Sideband antenna parasitic current.
- b. Sideband feedline input to distributor voltage standing wave ratio (VSWR).
- c. Carrier feedline VSWR.
- d. Radiofrequency (RF) power levels:
 1. Modulation eliminator (ME) input.
 2. ME output.
 3. Goniometer input.
 4. Carrier antenna input.
- e. Residual ME.
- f. 1,500 Hz level.
- g. Ground check error curves (SSB and DSB operation).
 1. Normal station.
 2. Antenna 37 shorted.
 3. Antenna 37 open.

Ground check error measurements will be conducted by rotating the DVOR antenna array and stopping in 10° increments, as determined by accurately measured marks and a photocell sensor on the edge of the rotating portion of the counterpoise. A yagi antenna, RF amplifier, and amplitude modulation (AM) detector will provide the DVOR monitor with an amplified demodulated sample of the signal being radiated by the facility. The yagi antenna is located atop a 40-foot pole on the 90° radial 500 feet from the center of the DVOR. The phase control of the monitor will be adjusted for a zero course error indication on the monitor bearing error meter. The DVOR signal will then be replaced with a signal of the same amplitude from the VOR test generator. The test generator will be adjusted for a zero course error indication on the monitor. The difference between the indicated angle of the generator and the counterpoise position will be the station error for that bearing. The test results will be plotted to provide a station error curve for each distributor/condition tested.

All measurements conducted in section 3.2g will be repeated weekly over a 6-month period to determine stability.

3.3 FLIGHT TESTS.

Flight tests will be made using four navigational receivers, representative of a cross section of the air carrier, executive, and general aviation types. Calibration of the receivers will be performed in a laboratory environment utilizing the test configuration shown in figure 2 before and after the flight test series. A Convair 580 (N-49) aircraft will be utilized to obtain flight test recordings of the CDI of the four receivers. After amplification, the CDI voltage of each receiver will be terminated to individual channels of a rectilinear recorder.



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FIGURE 2. RECEIVER CALIBRATION TEST SETUP

3.3.1 Orbital Flights.

Orbital flights around the station will be made under various configurations to obtain a sampling of the course radiated by the DVOR system. Table 1 is a tabulation of the various types of orbits that will be flown during the test program. Reference track for all 20- and 10-nautical mile (nmi) orbits will be provided by EAIR. Distance guidance and 10° azimuth marks, provided by EAIR, will be used for all flights.

3.3.2 Radial Flights.

The 90° and 40° radial flightpaths will be flown at an altitude of 1,500 feet above mean sea level (m.s.l.), and out to a distance of 20 nmi to measure course error with the station configured as per table 1. Two-nmi distance marks and azimuth guidance will be provided by EAIR on all radial flights.

4. DATA REDUCTION AND ANALYSIS.

4.1 GROUND DATA ANALYSIS.

The ground check station error (difference between true angle and indicated angle) as recorded by the station monitor will be plotted for each distributor/condition

tested. The primary significance in the station error curve is the error spread (the separation in degrees between the error in the most positive direction and the error in the most negative direction); therefore, the error spread for each distributor/condition tested should have the same general shape and amplitude when compared to the standard mechanical distributor.

TABLE 1. TABULATION OF ORBITAL FLIGHT TEST CONDITIONS

<u>Type Distributor</u>	<u>Radius (nmi)</u>	<u>Altitude (feet/m.s.l.)</u>	<u>Sideband Antenna</u>
SSB Mechanical	10	1,500	Normal
SSB Mechanical	25	2,500	Normal
DSB Mechanical	10	1,500	Normal
DSB Mechanical	25	2,500	Normal
SSB Mechanical	10	1,500	37 Open
DSB Mechanical	10	1,500	37 Shorted
SSB DVDA	10	1,500	Normal
SSB DVDA	25	2,500	Normal
DSB DVDA	10	1,500	Normal
DSB DVDA	25	2,500	Normal
SSB DVDA	10	1,500	37 Open
DSB DVDA	10	1,500	37 Shorted

The measured values of the parameters from the remaining standard ground measurements will be compared for each comparable configuration and against the standards handbook, reference 3.1a.

4.2 FLIGHT DATA ANALYSIS.

Analog recorders will be used to record the CDI voltages from the four VOR receivers. The data from the recordings will be reduced manually. Orbital and radial data will be plotted on rectilinear paper showing azimuth versus bearing error for each condition tested. Any occurrence of unusual flag conditions will be analyzed. The performance of the DVDA, as recorded by each receiver under various flight conditions, will be compared.

5. INSTRUMENTATION AND FACILITIES.

The four VOR receivers to be used on the flight tests will be calibrated and maintained to meet or exceed manufacturer's specifications. The receivers and recorders will be assembled into an airborne data collection package that will be used throughout the project. Strip chart recorders, Hewlett-Packard model 7402A, will be connected to the standard DVOR monitor for DVDA stability measurements. Major facilities to be used from the Technical Center are: (a) the Doppler VOR (building 188), (b) the EAIR Tracking Radar Facility, and (c) the Convair 580 (N-49).

6. COORDINATION AND AREAS OF RESPONSIBILITY.

a. Systems Test and Evaluation Division, ACT-100, will provide:

1. Instrumentation.
2. Coordinate test flights.
3. Collect raw airborne data.
4. Analyze data.
5. Write final report.

b. Aviation Facilities Division, ACT-600, will provide:

1. Convair 580 (N-49) and pilots.
2. Installation of VOR airborne data collection package.

c. Data Engineering and Development Division, ACT-700, will provide tracking data.

7. SCHEDULE.

The estimated test schedule for each phase of the effort is shown in figure 3.

