S/X Band Experiment: Zero Delay Device Antenna Location

C. T. Stelzried, T. Y. Otoshi, and P. D. Batelaan
Communications Elements Research Section

Representative data are presented for the original Block 3 and Block 4 zero delay devices as a function of antenna elevation angle. Instabilities on the order of 33 nanoseconds as obtained with the original S-band Block 3 system are reduced by relocation of the zero delay device (ZDD) horn. However, unsatisfactory performance at X-band for the Mariner Venus/Mercury 1973 (MVM'73) S/X experiment ZDD requires a reconfiguration eliminating the horns and associated air path.

I. Introduction

The S/X-band experiment (Ref. 1) requires a zero delay device (ZDD) for routine calibrations and receiving system performance verification tests. The Block 4 ZDD (Ref. 2) developed for the S/X-band experiment is an antenna-mounted transponder that receives an uplink signal of 2113 MHz and reradiates downlink signals of 2295 and 8415 MHz. It utilizes the Mu-2 ranging and Block 4 receiving systems.

This article presents results of some preliminary tests at S-band made to determine the Block 3 ZDD range change sensitivity to antenna tipping and horn location. In addition, the Block 4 ZDD performance at both S- and X-band with antenna tipping is presented. Figure 1 shows the DSS 14 64-m antenna and indicates the various test locations for the ZDD on the dish surface (positions 1-3) and the ZDD installation exterior to the Mod 3 area (position 4).

II. Test Setup

A series of S-band tests was performed on the 64-m antenna at DSS 14 from August 1972 to January 1973 to evaluate the performance of the ZDD. Three test setups were as follows:

(1) The S-band Block 3 ZDD was used and consisted of an open-ended WR 430 waveguide/type N coaxial transition and a mixer diode. The local oscillator (LO) frequency of 181 MHz was supplied by the Block 3 receiver/exciter assembly, and ranging was done with the Mu-1 ranging system. The ZDD was first mounted on the 64-m antenna surface near the base of a quadripod leg (Fig. 1, position 1). This location has been used in conjunction with Mu-1 ranging for previous flight missions. The ZDD was then moved to other locations (Fig. 1, positions 2, 3) and tested. The polarization diversity S-band (PDS) cone diplex system and PDS maser were used for this test setup.

(2) The second test setup involved radiating from the PDS cone and receiving with several types of small antennas at a location exterior to the roof of the Mod 3 level (Fig. 1, position 4). Relative phase was measured with a network analyzer, and range was determined by a frequency variation method.

(3) The third test configuration may be seen in Fig. 2. In this test configuration the Block 4 ZDD is installed at a location exterior to the Mod 3 level, below and near the roof ladder access hatch (Fig. 1, position 4). The ZDD is enclosed in a special RF-shielded welded box with remotely controllable lid for RF noise burst suppression. The location for this configuration was selected on the basis of results obtained in the above test setups. This location has the added advantage that the source of the LO frequencies is physically close to the ZDD from the Mod 3 area, thus resulting in greater phase stability.

III. Test Results

Ranging stability using the Block 3 ZDD was found to be very sensitive to antenna elevation angle. Data were typically taken at 10-deg increments of elevation angle. A summary of the data is shown in Table 1. In addition, a test was performed using the Block 3 translator, which bypasses the transmitter and air path completely. Approximately 1 nanosecond of range change was measured with antenna tipping indicating good stability of the overall maser/receiver system. These data indicate that the location of the ZDD "antennas" is a key factor in determining the magnitude of the instabilities, which are presently assumed to be due to elevation-dependent multipath phenomena.

The comparable results for Tests 1 and 6 are to be noted in that they were made at different times with independent equipment and measurement setups but at the same location (Fig. 1, position 4).

Figure 3 shows the system ranging performance for the dual channel S- and X-band systems using Block 4 receivers and the Mu-2 ranging system with the ZDD mounted in the shielded box (Fig. 1, position 4) and with the S/X reflex feed system installed. Considering the large instability with elevation angle at X-band and the requirement to provide a stable calibration system for the MVM'73 S/X experiment, it was decided to modify the original ZDD block diagram. This was accomplished by bypassing the horns and providing the 2113 MHz from a directional coupler on the transmitter output and injecting the S (2295-MHz) and X (8415-MHz) signals directly into the respective masers via waveguide couplers and semirigid cables. This configuration eliminated the assumed multipath-originated range instabilities (Ref. 4).

IV. Conclusions

Tests for proper location of a ZDD were conducted only at S-band frequency and before installation of the S/X reflex feed mechanisms. These tests indicated that, under those conditions, the location exterior to the Mod 3 level would be satisfactory.

Based on these data, the Block 4 ZDD was installed at the Mod 3 location in the shielded RF box. After installation of the Block 4 receiver/exciter, Mu-2 ranging and the S/X reflex feed, tests showed that the location, while acceptable for S-band, was not acceptable for X-band. This required a reconfiguration eliminating the horns and associated air path.

References

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Table 1. Summary of DSS 14 zero delay device performance in S-band antenna tipping tests

Test	Description	pk/pk range variation with antenna elevation angles between zenith and 11 deg, ns
1	Test setup 2 (Fig. 1, position 4)	<1
2	Test setup 1, Block 3 ZDD, original position (Fig. 1, position 1)	33
3	Test setup 1, Block 3 ZDD (Fig. 1, position 2)	6
4	Test setup 1 Block 3 ZDD (Fig. 1, position 3), 1.5 panels from antenna edge	15
5	Test setup 1, Block 3 ZDD, Mod 3 location (Fig. 1, position 4)	13
6	Test setup 1, same as Test 5 except pyramidal horn added to Block 3 ZDD	3

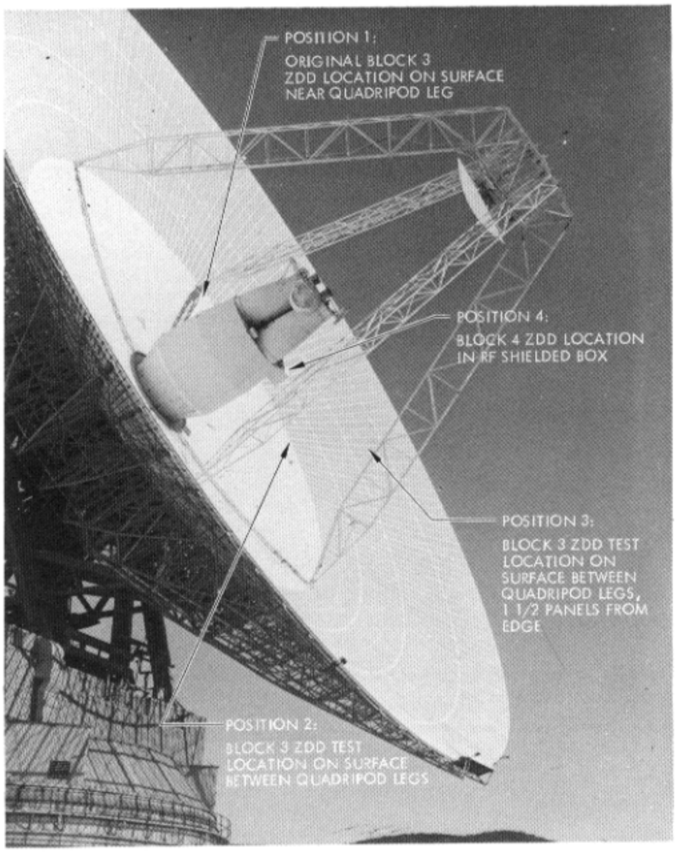

Fig. 1. DSS 14 64-m antenna showing various locations of ZDD test positions (1 through 3) and RF shielded box (position 4) used for the Block 4 ZDD installation

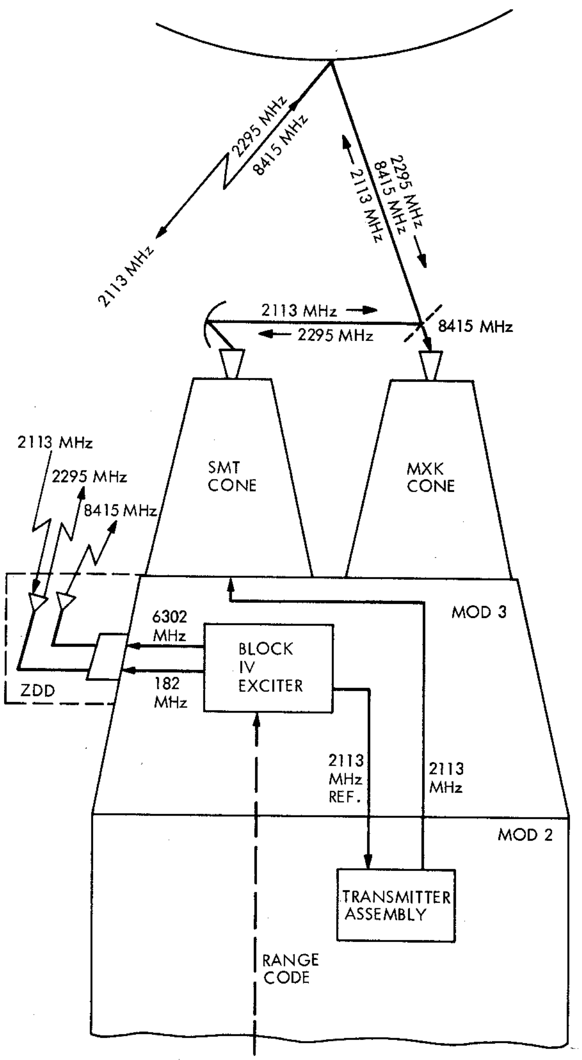

Fig. 2. Simplified block diagram of the original ZDD calibration system for S/X-band experiment

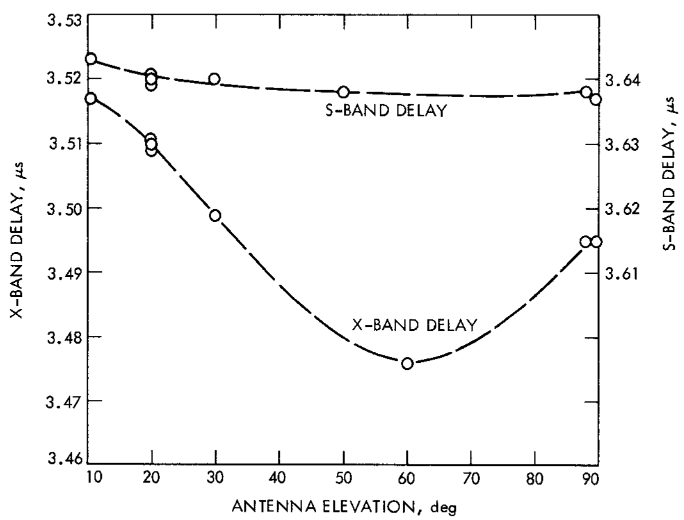

Fig. 3. DSS 14 dual-channel S/X-band ranging on the ZDD as a function of antenna elevation angle using the Block 4 ZDD (Fig. 1, position 4)