Data Decoder Assembly Reliability and Status of Test Equipment

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The reliability of the Data Decoder Assembly (DDA), although improved by a series of engineering change orders, continues to exhibit a failure rate higher than desired. During the past year, the major source of intermittent problems has shifted to the interface assembly which includes the couplers that provide the interfacing between the Interdata 4 and other station equipment. A mechanical stabilizer design was implemented in the DSN to inhibit physical movement in the interface assembly. Interdata power supply problems had been involved in an increasing number of failures reported on DDAs. Several modifications have been and will be implemented to correct these problems. The lack of test software has complicated troubleshooting because either operational software had to be used or individual test software programs had to be developed at the stations. To rectify the dearth of test software available, the original test software was revised and updated to help station personnel troubleshoot an assembly in its operational configuration. Several corrective actions are in the process of being developed to prevent loosening of integrated circuits and platforms on couplers, to modify and/or replace computer power supplies, and to improve noise immunity in some coupler circuits. The DDA "halt" problem has been irritating to operations. Although a low level of investigation has been going on for over a year, insufficient information has been provided to identify this "halt" problem. The plan for improving the reliability for Viking support includes the addition of personnel to devote full time to the DDA problems, closer interfacing between operations and engineering to identify and define problem areas, and development of a tester to allow off-line testing of DDAs to isolate hard faults to replaceable modules in the minimum time possible consistent with required Viking support.

I. Introduction

The Data Decoder Assembly (DDA) is part of the Telemetry and Command Subsystem of the Deep Space Station (DSS). In operation, the assembly is capable of performing three mutually exclusive functions: sequential decoding of convolutionally encoded data, block decoding of 32/6 or 16/5 biorthogonal block coded data, or high-rate data formatting of encoded or uncoded data for transmission on the wideband data line with simultaneous recording of the data on magnetic tape.

An Interdata Model 4 (ID4) minicomputer is one of nine assemblies mounted in a standard 205.74-cm (81-in.) equipment cabinet which makes up the DDA.

II. Background

Reference 1 gives a description and history of the reliability problems experienced in the assembly up to that time, the corrective actions that were taken and those which were in process, and additional problem areas which were being investigated.

III. Corrective Action Implemented

Since the last report (Ref. 1), a number of engineering change orders have been implemented in the DSN to correct identifiable problems as described below.

A. Data Decoder Assembly Interface Assembly Stabilizer

A stabilizing framework was designed to stiffen the backplane of the Interface Panel Assembly and to support and stabilize the couplers mounted on that assembly. The Interface Panel Assembly contains the interface backplane, which provides power and ground planes for the couplers, and connector wire wrap terminals for the electrical interconnection of the couplers and the intrarack cabling; the mounting for and the couplers to interface the Interdata Model 4 with the Telemetry and Command Processor, the Symbol Synchronizer Assembly, the Block Decoder Assembly, the Frequency and Timing Subsystem, and the Simulation Conversion Assembly; and the connectors for mating with the couplers and the intrarack wiring. The mechanical design of the Interface Panel Assembly was such that the backplane flexed when the coupler was removed or inserted. In addition, the coupler's connectors could not mate reliably with those connectors mounted on the backplane because of flexing of the backplane. The hold-down hardware for the couplers (guide bars and guide pins) was not capable of solidly holding the couplers so that the mating connectors were immobile. This was due to the flexing of the large backplane and the weight of the couplers on the cantilevered hold-down hardware. Correction was effected by designing a stabilizing bar to clamp the backplane to the Interface Panel Assembly side walls and anchoring the plane to the bar with hardware used to assemble the coupler guide bars, and designing a framework to support the couplers at their upper and lower extremities and clamping these points to the Interface Panel Assembly through the framework. With this bar and framework, the Interface Panel Assembly backplane is rigid and the couplers are immobile. Implementation of this interface assembly stabilizer is in process in the network.

B. Computer Power Supply Fuse Relocation

After the Data Decoder Assembly was operating in the network, it was noticed that in some cases the 30-A fuse in the 5-V portion of the power supply blew periodically. This fuse was located on the heat sinks also mounting the series regulator transistors for the 5-V supply. Upon investigation, it was apparent that the heat generated by these regulator transistors was sufficient to cause the solder to melt in the fuse and cause deterioration of the fuse resulting in failure. Electrically, the fuse is designed to protect the raw dc power supplied to the 5-V regulator circuitry.

The solution was to relocate the three fuses mounted internal to the power supply (including the 5-V 30-A fuse). The new location is external to the power supply envelope well away from any heat source and readily accessible should replacement become necessary. In the original design, replacement of this fuse was inconvenient because of its location internal to the supply on the heat sink with no available access hole. Modification kits have been distributed to the DSN and the installation of the relocating hardware is in process.

C. ID4 Power Supply Over-Stressed Component

For the second buy of 15 Interdata computers, the manufacturer changed power supply vendors. Acme power supplies were provided with the nine latest DDAs and the six new Planetary Ranging Assemblies (PRAs) for the Viking update. After part of a regulator circuit of one of these power supplies was damaged by fire, investigation showed that the four series resistors (part of the 5-V regulator circuit) were being continuously over-stressed in all but the PRA application. These 5-W resistors were being subjected to approximately 6.5 W each in the DDA Configuration II at the 64-m stations. Higher wattage replacement resistors for all of the Acme supplies have now been installed in the equipment.

D. High Error Rate Under Strong Signal Conditions

It was found that cross-coupling of signal information from the clock line to the data inputs into the Symbol Synchronizer Assembly (SSA)/DDA Coupler for both the inputs from the SSA and Block Decoder Assembly (BDA) was causing unrealisticly high error rates in many DDAs. To correct this problem, small capacitors were connected across the difference amplifier inputs to the data line receivers and the clock signal receivers in the SSA/DDA Coupler. The capacitor on each mentioned input was sufficient to preclude the previously noted marginal operating condition. Filtering was necessary to slow down the speed response of the receiving amplifiers and eliminate spurious signals cross-coupled in the cables. This problem has been corrected.

E. DDA Test Software

A test software package was developed and delivered with the initial implementation of the DDA in the DSN, but this software was not updated with each engineering change implemented in the assembly. Because of the need for more effective testing of the assembly in the operational configuration, the test software was updated and distributed throughout the network.

IV. Corrective Actions in Process

A. Questionable Retention of a Few Integrated-Circuit Sockets

A number of complaints have been received concerning integrated circuits becoming loose in their sockets or falling out of their sockets. On close inspection, it was found that a few of the older coupler boards contain some white sockets with a lighter-than-standard-gauge bronze material in the individual pin receptacles. It was also noted that, because of the positioning of the receptacles in relationship to the socket, some integrated circuits cannot be pushed into the socket until the package bottoms on the plastic body of the receptacle. This condition is caused by the shoulder of the integrated-circuit pins spreading the receptacle clip before the package body bottoms, and when the clip spreading is limited by the walls of the socket, it prevents a stable bottomed insertion of the integrated circuit. This characteristic of itself does not appear to cause electrical problems nor a permanent offset in the bronze receptacle clip. Further study indicated inserting a probe, as might be done in conjunction with scope troubleshooting, does cause permanent spreading in these and the standard bronze clips. After having been given a permanent offset, the clips can be bent back individually to give their original aperture and tension characteristics.

A coupler with the suspect type receptacles was filled with typical integrated circuits and platforms and taken for a shake test in the Environmental Testing Laboratory. The coupler was given a shake test along several axes, including the direction of insertion and removal. A detailed report is not yet available, but the coupler was given a shake of several g's over a frequency range including that expected at a DSN station. No integrated circuit or platform came out of its socket, and none was loosened during these tests.

A pull test was performed on integrated circuits inserted in all types of receptacles used in DDA coupler boards. The retention strength of the questionable white receptacles (on Interdyne boards) was measured to be from 4.45 to 8.90 N (1 to 2 lb) of pull to remove integrated circuit, while those in the standard Interdyne-manufactured board and Viking-manufactured boards required from 8.90 to 22.24 N (2 to 5 lb) of pull for removal (Viking 8.90 to 17.79 N (2 to 4 lb); Interdyne 13.34 to 22.24 N (3 to 5 lb)).

Based on the investigation so far, it would appear that the loosening of integrated circuits is not due to vibration but probably or more likely due to handling, especially while removing or installing a coupler. It is easy to hit the coupler against other couplers or cables while installing or removing it. Therefore, at least a protective plate should be mounted on each coupler to prevent accidental knocking against integrated circuits or platforms causing loosening of one of these components. In the event some hold-down mechanism is needed to insure the seating of integrated circuits, etc., one method of holding down these chips and platforms is being tested. This design can possibly cause heating for the itegrated circuit, and so some testing in both CTA 21 equipment and the prototype DDA is in progress to study the heat rise involved to determine if it would be a problem. An engineering change will be implemented to at least provide a protective plate for the integrated circuits and platforms.

B. Additional Computer Power Supply Problems

The power supply originally provided with the Interdata Model 4 computer was manufactured by North Electric. During the original phase for support of Pioneers 10 and 11, the power supplies appeared adequate even though the specification sheet indicated a lower than required capacity (Interdata wrote a letter assuring JPL that the power supply was more than adequate for the application). With the installation of new selector channels throughout the network, and new memories in the 64-m subnet, the logic voltage drain was increased. This condition was intensified in the new Interdata 4 computers for Data Decoder Assemblies because of additional new configuration of some of the motherboards. Problems began occurring in the network, especially with the new ID4's since, in addition to the above-mentioned changes, the computers were delivered with a power supply designed and built by a different manufacturer (Acme). These supplies were designed to supply only 20 A although Interdata performed some modifications ostensibly to increase the power output capability. Investigating the problem in depth showed this new supply marginally adequate for the DDA application and just adequate for the Planetary Ranging Assembly application. Therefore, Interdata is in the process of replacing all of the Acme power supplies with North Electric Supplies. Additionally, they are supplying to JPL modification kits to increase the power capability of the currently used North Electric Supplies (also including this modification in the replacement supplies mentioned above). Along with the equipment that will soon be delivered, Interdata is updating the power supply specification sheet to describe the new power supply capability. The ID4 power supply problem will be solved with installation of the modification kits and replacement supplies during the summer of 1975.

C. Modifications to Improve Noise Immunity in Two Couplers

The input noise immunity in the Interrupt coupler is being improved by substituting the currently used receiver network with that used in the Telemetry and Command Processor (TCP) emulator and also adding a small capacitor across the input to the receiver amplifier to further reduce noise susceptibility. This change is in the modification kit building phase.

Input noise immunity is being improved in the TCP/DDA coupler by adding capacitors to the receiver amplifiers on the command signal lines from the TCP. This change is being implemented in the DSN to make the transfer between TCP and DDA more reliable.

V. Undefined Problems

For some time and for reasons yet unknown, the DDA will stop processing data while tracking a spacecraft. These occurrences are fairly infrequent, with a period of no shorter than once in several days. The problem has been called the DDA "halt" problem although the DDA does not halt but merely stops processing data with the program jumping to a wrong area in core and trying to execute data. A low-level investigation as to what causes the program to get out of step has been in progress for over a year with no real insight as to the origin of this problem. To this end, core dumps have been requested from the station after the computer enters this "halt" condition. A procedure has been given to the stations as to how to perform this dump to avoid loss of the desired information. Analysis of the received core dumps from the network has not provided any suggestion of the source of the problem. A DDA Halt Study was conducted by Dunn (Ref. 2) in 1974. The results of analyses of the core dumps have been described in several memos written to this author.

VI. Plan for Improving DDA Reliability

A. Reliability Survey

Based on an agreement between DSN Operations and DSN Engineering, additional manpower has been acquired for the study and improvement of the reliability of the DDA hardware and software. A survey of the DSN was made in January 1975 to determine the current problems and to receive recommendations for ways of improving DDA reliability. A summary of this survey was completed and published in April. Many of the problems defined will be solved by implementation of engineering change orders already in process.

B. DDA Tester

A tester is being designed for implementation into the network. The design concepts for this tester are to disconnect the DDA from other station equipment for stand-alone testing; to isolate faults to a replaceable module (i.e., Motherboard in the ID4 or coupler in DDA Interface Assembly); to provide simple procedures allowing station operating personnel to perform the tests; and to provide a tester easily understood and usable to complete fault isolation, leading to fault correction in minimum time consistent with Viking requirements.

A study of the unit tester designed and built by Motorola is in process. That tester was used as a debugging and acceptance test unit during the building of the DDAs. The unit is being used as the basis for the design of the current tester.

To better understand the Data Decoder Assembly, the Tester Hardware Design Engineer has drawn a complete set of block diagrams of the DDA which were not provided in the original publication of the DDA Operation and Maintenance Manual. The top sheet of the block diagrams is an overall diagram with reference to ID4 documentation in Technical Memoranda and to JPL drawings of logic diagrams to better tie together the various areas of DDA documentation.

In order to preclude the need for disconnecting subsystem and system cables to connect the tester, a design has been undertaken to incorporate a multiplex switch in the DDA to require one cable connection from the tester and allow switching of the DDA applicable interfaces from the operational configuration to the test configuration. As it is being designed, this 2 to 1 multiplex switch would be capable of being installed in all assemblies by electrically inserting this multiplexer between the intrarack cable connectors and the interface connector panel bulkhead connector and make available the tester connection at the front of the assembly.

The design has been completed for the special test equipment which will be used in the tester to simulate other station equipment that interfaces normally with the Data Decoder Assembly and also to connect with the ID4 in the assembly to provide wrap-around paths for testing of the complete assembly. The prototype special test equipment is in the process of being built and should be checked out by mid-September. The design was done in such a way as to be compatible with the existing unit test programs written by Motorola. This course was taken so that those programs can be used as the basis of the new test software needed to accomplish the design concepts.

A Functional Requirements Document for the tester is in the process of being generated.

The present schedule will provide a tester for each of the nine stations by early 1976.

References

1. Mancini, R. A., "Data Decoder Assembly Reliability Modifications," in *The Deep Space Network Progress Report 42-21*, pp. 92–94, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1974.
2. Dunn, G. L., *DDA Halt Study—Report for Period August 1 through November 18, 1974*, IOM 421E-74-354, Nov. 25, 1974 (JPL internal document).