Field Interface Module for Antenna Control Assembly

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This paper describes the hardware aspects and capabilities of the Field Interface Module developed for monitor and control function in the Antenna Mechanical Subsystems of the DSN and in the Technical Facilities Controllers for the various complexes. The FIM is capable of monitoring and responding to a range of analog and digital inputs and controlling external elements. The flexibility of the design makes it applicable to other control needs, using software developed for those specific applications.

I. Introduction

The Field Interface Module (FIM) is a packaged, microcomputer-based controller designed to provide controls for and monitoring of the antenna mechanical functions of antennas in the Deep Space Net. The flexibility of the monitoring capabilities, software, and communications makes the FIM adaptable to monitor and control functions in other subsystems.

The FIM uses control and computational modules (CCM) standard components, is modular in construction, and is connectorized for quick replacement of the "Least Replaceable Element" (LRE). It is designed to minimize efforts for system hookup, diagnostics and operation.

II. General Characteristics

The FIM has the following monitor/control capabilities:

(1) Input channels for monitoring functions.
  - (a) 32 differential analog input channels of which three are used for internal tests.
  - (b) 16 isolated input ac binary channels.
  - (c) 16 isolated dc input binary channels.

(2) Output channels for control functions.
  - (a) 16 isolated ac output channels.
  - (b) 16 isolated dc output channels.

(3) Communications
  - (a) An RS232C serial communication link.

(4) Internal memory.
  - (a) 4K RAM (on the central processor board).
  - (b) 8K PROM (on the central processor board).
  - (c) 16K nonvolatile memory.

A. Self-Test

Self-test diagnostics are performed for the following purposes:

(1) To validate the status of hardware unique to the FIM.

(2) To isolate or identify faults or failures to the LRE level.

(3) To verify that the H/W and application S/W of the FIM are functioning correctly.

The diagnostics are performed in two independent modes: Remote and Local. The diagnostics included at the present are the following:

(1) A checksum of the program.

(2) A/D board reference voltages (ground, 2.5 volts and 5.0 volts).

(3) A/D board channel sequence check.

(4) Parallel I/O board check.

The following tests, which are to be standardized for CCM controllers, will be included when available:

(1) CPU test.

(2) RAM integrity test.

When the FIM is in the Remote mode, diagnostics are performed as part of the FIM's operation automatically.

A Local diagnostics capability is provided to allow operation and test of the necessary functions and the communication link of the FIM. This is accomplished through a Field Interface Diagnostics Assembly (FIDA), a device that enables the FIM to perform self-diagnostics in the Local mode, independent of the uplink computer. Basically, the FIDA will allow the FIM to perform the same diagnostics that are performed while the FIM is operating in real-time, with the status displayed on the FIDA.

In order to go into Local mode, the FIM must be powered and the Local button pressed. When the FIM is in the Local mode, a message is sent to the uplink computer notifying that the state is changed and the FIM is no longer in touch with the uplink computer. The FIM will remain out of the communication link until the operator presses the Remote button.

B. Housing

The FIM assembly is contained in a Hoffman EMI/RFI shielded NEMA type 12 enclosure which is oil-tight, dust-tight, and has a strong and rigid construction. The size of the enclosure is 36 X 30 X 10 inches.

III. Architecture

The block diagram of the Field Interface Module is illustrated in Fig. 1. The primary blocks are as follows:

(1) Multibus microcomputer including card cage and circuit cards.

(2) Power supply.

(3) DC/AC interface board.

(4) AC power panel.

A. Multibus Microcomputer

1. **Card cage.** The card cage is an AM95/6440 standard cage with six multibus compatible card-slots mounted in a rigid metal enclosure. The cooling fan is mounted so that it blows air into the card cage but can also be reinstalled to function as an exhaust fan. This card cage contains the CPU board, I/O expansion board, expansion memory board and A/D converter board. As presently configured, five of the six slots are used in the final assembly, with the sixth slot reserved for a floppy disc controller used in system testing.

2. **The CPU board.** The heart of the FIM is the National Semiconductor BLC 80/204 single board computer (Intel 8080A-2). The single board computer contains 8K of RAM, 4K of ROM, Serial I/O interface, parallel I/O interface, interrupt controller, H2818 system bus controller and programmable interval timer.

3. **The I/O expansion board.** The parallel I/O expansion board uses four Intel 8255A programmable peripheral interface chips. Together, these devices provide 32-channel input and 32-channel output. This board has an arming function capability to ensure that spurious data will not get in to the data lines. This can be done by entering a specific code into the data line, which will then be compared with the data set in the comparator. If both data are the same, the output of the comparator will be enabled, which in turn will enable the arming function logic. This board is currently wire wrapped and uses two card case slots. If the demand justifies the expense, a printed circuit card will be developed and this will free one card slot for other possible uses.

4. **Expansion memory board.** The expansion memory board is an MCM-8080 microcomputer core memory module made by Ampex Corporation. It has a storage capacity of 16K words with word lengths of 8 bits and is used as expansion memory for the BLC 80/204 single board computer.

5. **The A/D converter.** Data Translation DT1742 analog-to-digital converter card is used in the FIM to provide expandable I/O capability. This board can process up to 32 differential channels of analog data at a throughput rate of 24,000 channels per second and 12 bit resolution.

B. The A/D Signal Conditioning Board

The A/D signal conditioning board is designed to interface the DT1742 A/D converter board to analog sensors (pressure transducers, temperature transducers, etc.). This board can accept up to 32 differential channels. (Three channels are used to check ground, 5 volts, and 2.5 volts reference voltage; 29 channels are available for monitoring analog signals.) This board has a built-in 2.5-volt reference diode, plus compensating circuitry which serves as the reference voltage for the A/D converter card. This voltage reference is monitored by A/D converter via channel 1 of the signal conditioning board. Channels 0 and 2 are devoted to 0 volts and +5 volts respectively.

C. The DC/AC Interface Board

The DC/AC interface board is an iCS 930 ac signal conditioning/termination board made by Intel. It can be configured as input or output for both ac and dc by the type of opto-isolator modules used on the board.

D. The AC Power Panel

The power panel consists of an ac plug, an ac lamp, a 3-A circuit breaker and a power line interference filter (EMI filter).

E. Power Supply

The power supply is a multiple output switching supply having +12, –12 V and +5, –5 V outputs.

IV. Inputs

A. Analog Monitor

The A/D signal conditioning board which is interfaced between the sensors and A/D converter board has a passive single pole filter network for each channel. The A/D converter accepts analog voltages of ±5 V full-scale. Nominal resolution of the A/D converter is 12-bits binary weighted with accuracy of +0.03% and linearity of ±1/2 least significant bit (LSB). The first three channels are used for the reference voltages (0.0 V, 2.5 V, 5.0 V).

B. DC/AC Monitor

The iCS 930 signal conditioning/termination board is used for easy configuration for dc or ac signals. It can be arranged as dc or ac by selection of the opto-isolator modules. For dc use the opto-isolators are Motorola OPTO 22 series. These opto-isolators are capable of accepting digital signals of 4.5 V to 32 V dc and dry contacts inputs. The ac modules (Motorola OPTO 22) can accept voltages of 115 V or 220 V depending on the opto-isolators used in the iCS 930 board. The isolation between input and output of the module is 2500 V rms.

C. Communications

The communication between the FIM and outside world is accomplished by utilizing a standard interface RS 232. All uplink communication will be in 7-bit ASCII and will be used with asynchronous transmission, odd parity, single start/stop bits and transmitting data at a rate of 9600 baud (10 bits per character is 960 characters/second).

V. Output

The interface between the FIM output logic and control components is accomplished by using Intel iCS 930 ac signal conditioning board and opto-isolator modules (Motorola OPTO 22).

VI. External Connections

The following external connections are provided on the FIM housings:

(1) Power connection. Power connection will be through wire in conduit off the antenna 120-V distributions system. Where desired, a power connector cord can be fitted.

(2) Communications. An RS 232C connector is provided for communication to the uplink computer.

(3) I/O ports. The following connectors are provided for I/O functions:

(a) One 32-pin connector for ac signals at 120 or 240 V.

(b) One 32-pin connector for ac controls at 120 or 240 V.

(c) One 32-pin connector for 5 to 24 V dc signals going to the DC-AC interface board opto-isolators.

(d) One 32-pin connector for 5 to 24 V dc control signals.

(e) Two 32-pin connectors for ±5 V dc signals to the A/D processing board. One connects to channels 0-15; one connects to channels 16-31.

The I/O connections will require external junction boxes to collect cables from individual sensors or control points for concentration and transmission to the FIM. This arrangement will vary for each application.

VII. Typical Implementations

A. 64-M Antenna Monitor and Control

In the 64-m Antenna Monitor and Control (ACM) (Fig. 2) a single microcomputer is used as a central point for monitor and control of all Antenna Mechanical Subsystem functions. A number of FIMS will be placed in specific locations on the antenna to gather data and to perform control functions. This arrangement will control the start/stop functions of the servo system precharge and high pressure pumps, the hydrostatic bearing precharge, high pressure and accumulator pumps, and the gear drive lubrication pumps. It will also monitor operational parameters for each assembly such as oil temperatures, oil levels, pressures, and motor controller status. The FIMs serve as data collection points and as points for evaluation of performance parameters in terms of standards and limits downloaded from the supervising computers.

B. Typical Hydraulic System Controller

Figures 3 and 4 show a possible application in which a FIM is used to control and monitor a typical hydraulic system, including an oil reservoir, precharge and high pressure pumps and actuators. This system can, on command, validate oil reservoir level, start the low pressure and then the high pressure pump, cause actuator movement, sense completion of actuator movements, and monitor oil pressures and temperatures and differential pressures across filters and take appropriate defensive actions as required. Note that the system as shown uses only five analog input channels, four digital binary input channels and four digital output channels. The same FIM could be used to monitor and control other similar assemblies or could be arranged to perform additional data processing of input or operational parameters, based on the specific software developed for the application.

References

1. Hardware Reference Manual, Pub. No. 420305521-001C, BLC 80/204 Board Level Computer, National Semiconductor Corp., April, 1979.
2. Hardware Reference Manual, Pub. No. 9800802A, iCS 930 AC Signal Conditioning/Terminator Board, Intel Corp., 1978.
3. User Manual for Data Translation, DT1742 Analog to Digital Converter, Data Translation, Inc. 1978.

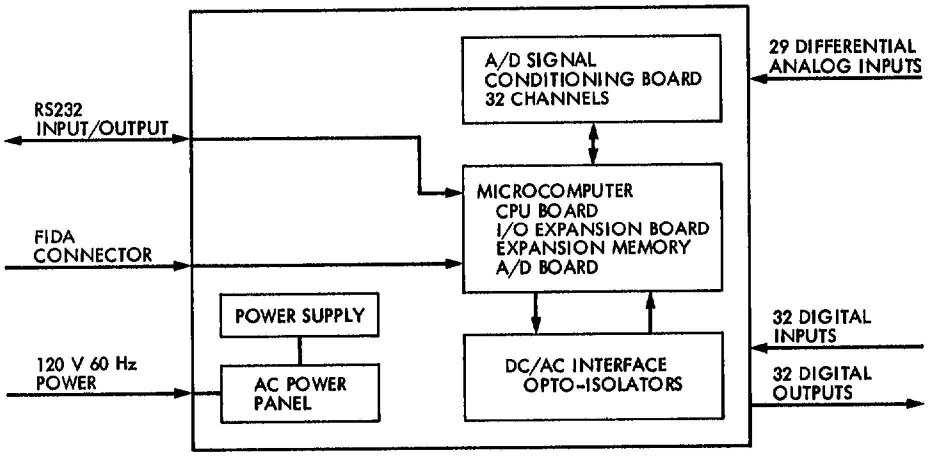

Fig. 1. Field interface module block diagram

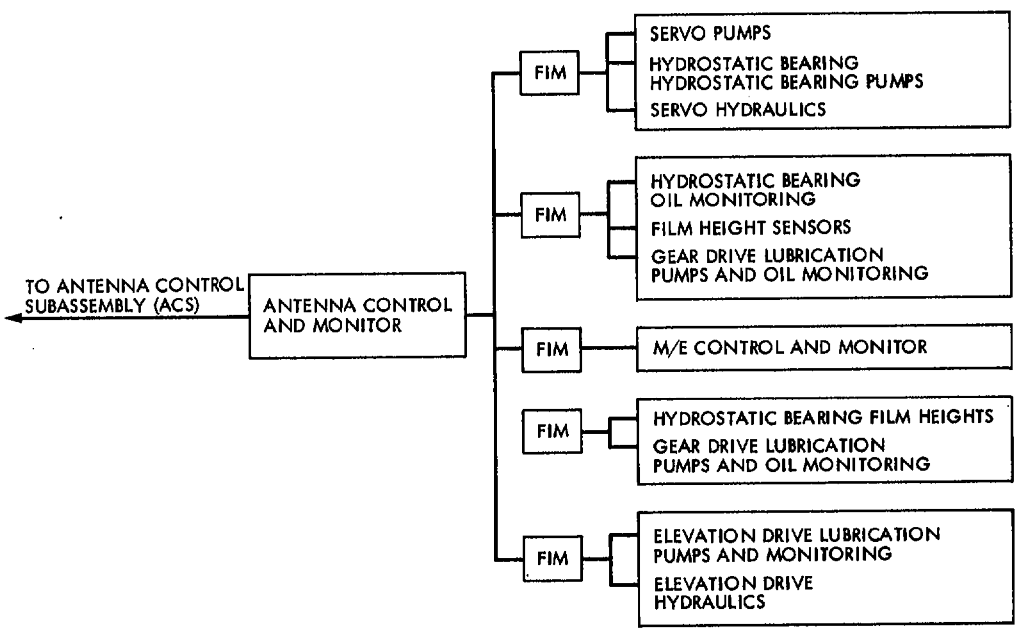

Fig. 2. 64-m antenna monitor and control block diagram (proposed)

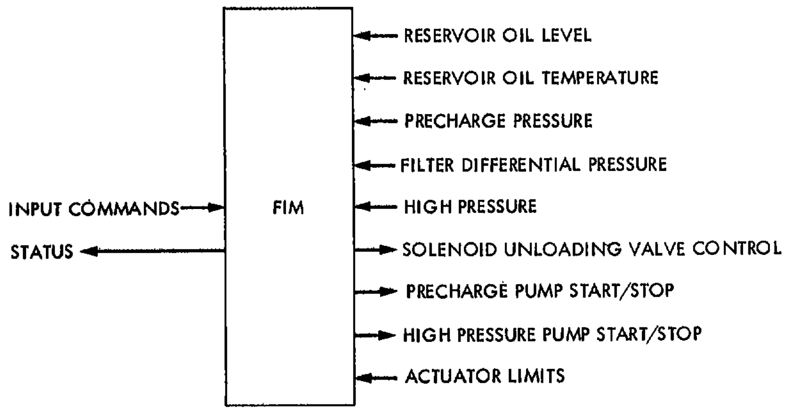

Fig. 3. Typical hydraulic system control and monitor functions

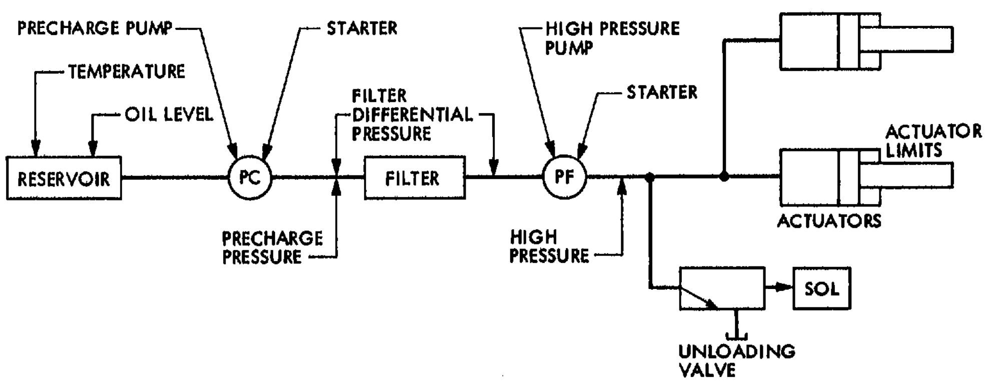

Fig. 4. Typical hydraulic system