HIGH SPEED AVIONICS DATA INSTRUMENTATION SYSTEM (HADIS)

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ABSTRACT

SAIC, under contract with the Air Force Wright Laboratory, has developed and demonstrated a prototype High Speed Avionics Data Instrumentation System (HADIS). The HADIS system is designed to operate in both the laboratory and in an airborne environment. This paper briefly describes the features of the system including its ability to collect and record data at up to 13.25 MBytes per second, its ability to provide real-time processing of the data, and its ability to rapidly reconfigure its interfaces based on field programmable gate arrays. The paper discusses the need for multiple data paths within the system to allow parallel operations to take place, the need for dedicated access to the recorder subsystem, and methods for allowing selective recording based on the information content of the data. The effort was sponsored by the Test Facility Working Group to provide a common data collection system for Air Force logistics and test and evaluation facilities. The design is owned by the government and may be cost-effectively used by any government agency.

INTRODUCTION

This paper presents the concept for a High Speed Avionics Data Instrumentation System (HADIS). The system provides the capability to collect and record 48 GBytes of data from multiple data sources at an aggregate, sustained rate of up to 13.25 MBytes per second. The system also provides the capability to display selected information in real time. The system's data acquisition interface capability is based on reconfigurable gate arrays which provide significant interface flexibility. Figure 1 provides a block diagram of the complete system showing the configuration for instrumenting a fighter aircraft.

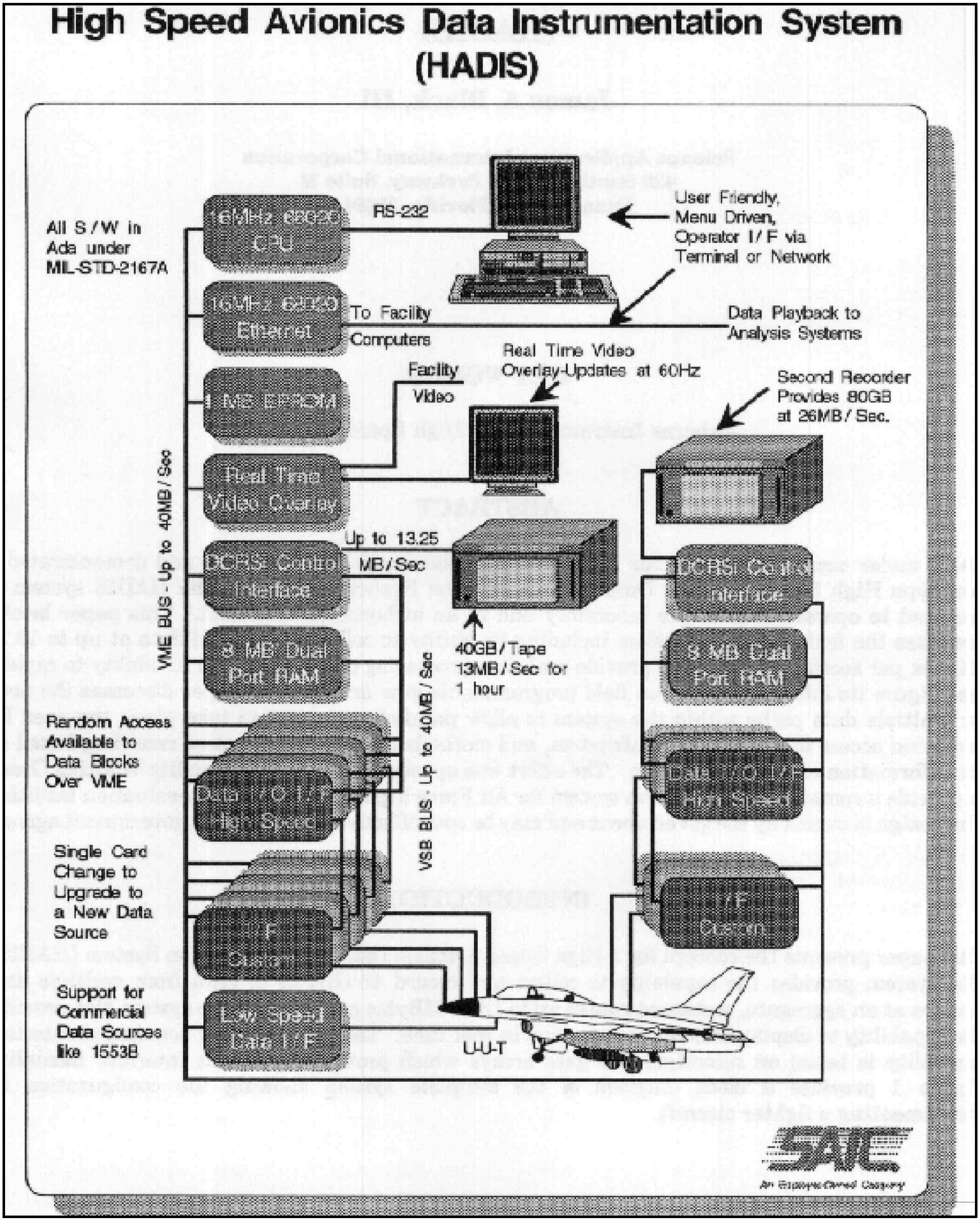

Figure 1 - HADIS Block Diagram

HIGH SPEED AVIONICS DATA INSTRUMENTATION SYSTEM

The HADIS system is comprised of three major subsystems. These include the recording subsystem, the process / display subsystem, and the interface subsystem. Each of the subsystems is described below followed by a discussion of critical design rationale and application of the system to selective data recording.

RECORDING SUBSYSTEM

The recording subsystem is based on the Ampex DCRSi digital rotary head data recorder. Ampex manufactures both laboratory and airborne versions of the recorder. The recorder interface is managed by a Triplex Systems TSC4x4 VME based interface controller which was designed specifically for the DCRSi. The 4x4 provides both control and data communications with the recorder using a simple command initiated, interrupt terminated scheme. This implementation minimizes processor intervention and provides maximum processor availability for the display subsystem.

The 13.25 MByte per second sustained system throughput is limited by the current capability of the recording subsystem. This limit will soon be removed as Ampex has announced a 30 MByte per second recorder. Burst collection rates of up to 20 MBytes per second are provided by a 24 KWord FIFO in the record data path. These FIFOs also provide the capability to record data which was collected prior to an event. This event triggered capability is described further in the Selective Recording section which follows.

Each data block stored on the tape is prefixed with a header which provides information on the data source, the time the data was collected, and several data integrity checks including checksums and sync patterns. The integrity system allows full recovery of readable data in the event of a corrupted directory or damaged tape. This feature is most important in cases where the data collection process is very expensive or when specific test conditions are only available once.

PROCESS / DISPLAY SUBSYSTEM

The HADIS display subsystem provides real-time video presentation of selected portions of the data being collected. The data to be displayed is captured in one of four random access memory buffers at the same time it is being written to the recording FIFOs described above. The memory buffers are constantly updated in a rotating fashion until the display process requests a buffer for display. At that time the last completely filled buffer is taken out of the rotation and the pointer is passed to the display routine. The display task builds the display from the buffer data and passes the image to the display controller. The buffer is then released and falls back into the normal rotation. Data from multiple sources can be accurately integrated by issuing a command to freeze the completely filled buffers on the data collection cards. This process allows displays to be built based on synchronized data from all available sources. The frequency of the display update is limited by the slower of the video display update (30 Hz) or the processor time required to build the display.

The process bandwidth used by the display system can also be used to provide real-time analysis of the data stream. This could include active data monitoring, calculation of values based on several input items, or running calculations such as data filters or smoothers. An 8 MByte dual port memory board is provided to allow access to the recorder. Process or display results can be placed in record buffers in the dual port memory and passed to the recorder as part of the total data stream. Additional processing is implemented by linking new Ada tasks into the system task list.

The HADIS processing system also provides a complete user interface. The interface is a simple menu-driven system which allows multiple operators to control the system from different terminals on a local area network. The system may also be controlled from a local terminal by a single user. The user interface supports access to low-level device drivers for complete control of the system as well as top-level commands for a novice operator. The system also provides an overall or unit-by-unit built-in test.

INTERFACE SUBSYSTEM

The interface subsystem provides the key to the flexibility of the HADIS system. Each of the interface boards is based on Xilinx 3090 reprogrammable gate arrays which are programmed with the interface characteristics necessary for each unit under test. Using these gate arrays, the HADIS system is capable of collecting data from a wide variety of data sources with no hardware changes. This is possible since the gate arrays are programmed by the software each time the system is reset or powered up. The prototype HADIS system has demonstrated the capability to collect data from both F-15 and F-16 radar systems using the same hardware.

This approach is also useful in providing the capability to keep up with changes in a unit under test without having to purchase additional interface hardware.

HADIS provides two digital to analog convertors designed to support visualization of sequential data streams. The data streams currently using this capability are the radar range / doppler matrix streams.

The existing HADIS system is implemented on two 6U VME form factor boards. These are shown in Figures 2 and 3. Each HADIS can support four board sets per recorder.

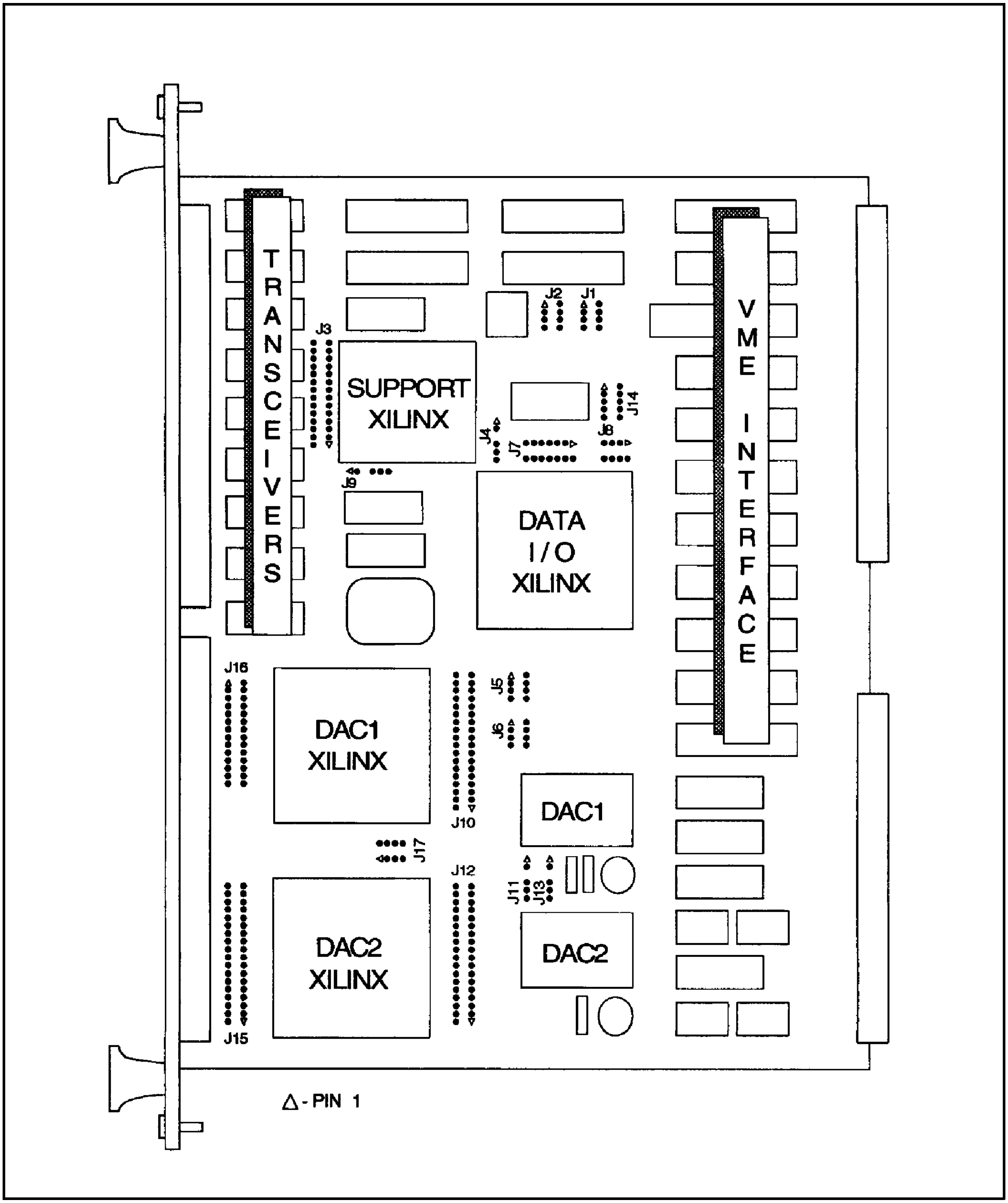

Figure 2 - Avionics Interface Card

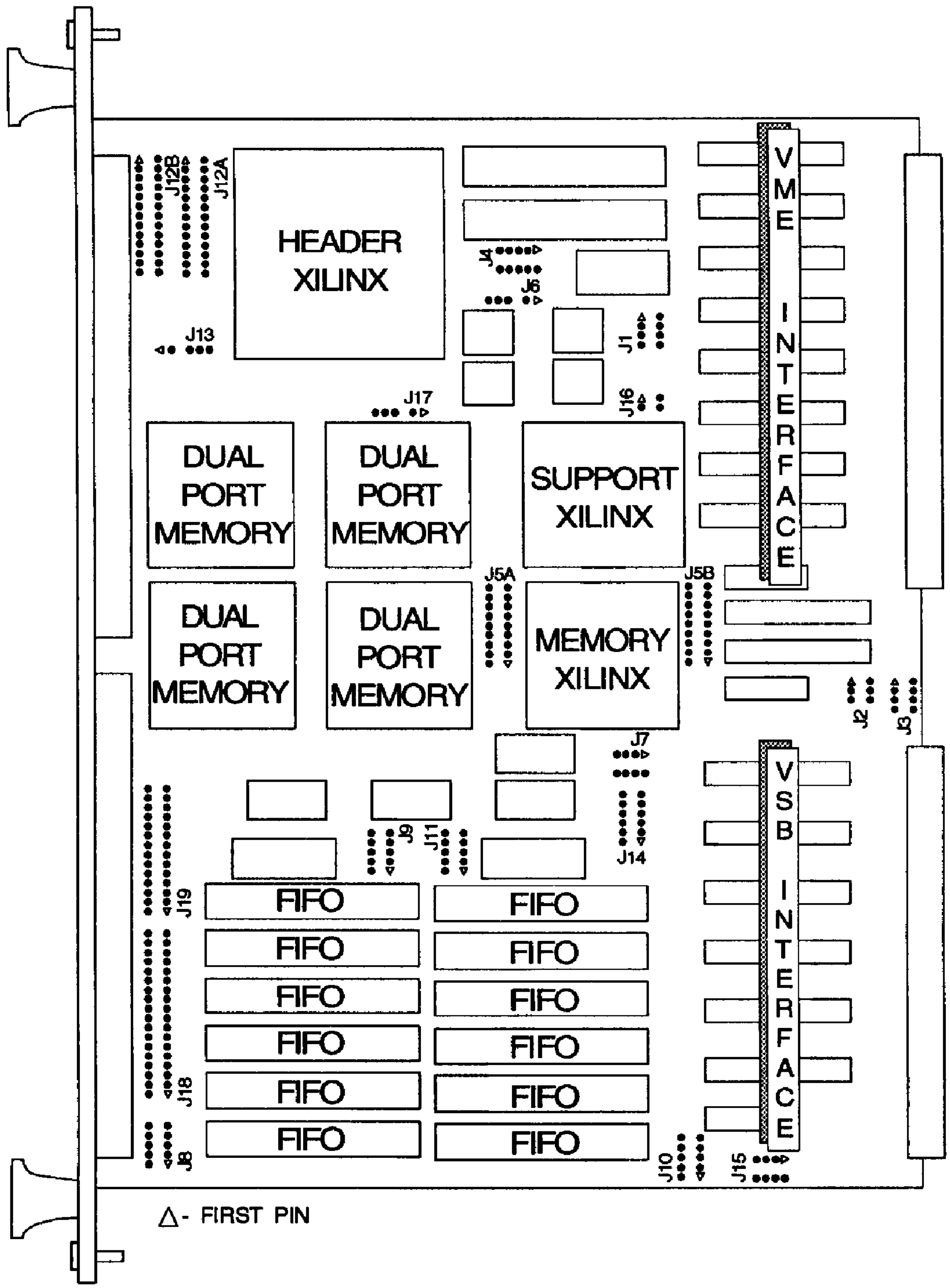

Figure 3 - Data Interface Card

DATA PATHS

The HADIS system provides three completely redundant data paths within the processing system. This provides a dedicated path to the recorder subsystem, a dedicated path to the display subsystem, and an unused path for future capability such as real-time data analysis which is discussed in the next section. The separate data path approach removes all subsystem interdependencies and allows each subsystem to operate at its maximum efficiency. For example, the recording subsystem is not penalized if the display subsystem needs a long time to compute and produce a complex display. The display update rate decreases but the recorder process is still capable of capturing and recording all of the data collected.

SELECTIVE RECORDING

One of the significant problems facing instrumentation systems today is limited recording space and increasing collection requirements. The ability to do selective recording is a promising approach to solving this problem. By using the third data path provided by a HADIS-type system, an additional processor is used to evaluate the performance of the unit under test in real time. When specific events occur, the recording system is enabled and the required data is collected until the event terminates. This recording scheme can be used to collect both planned events as well as anomalous behavior.

The FIFOs mentioned in the Recording Subsystem section provide a 24 KWord pre-event storage capability. When an event occurs, the FIFO contents can be recorded or flushed as required.

CONCLUSIONS

The HADIS system provides the foundation for a common airborne instrumentation system that is flexible and extendable. The system demonstrates a capability to acquire and record data at near state-of-the-art rates and is currently limited only by the recording technology. The system has successfully demonstrated the capability to collect and record data from several different complex avionics systems manufactured by numerous vendors.

The HADIS design was funded by the government and all rights to the design are available to government agencies. This system provides a cost-effective means of collecting and recording high speed data in both laboratory and airborne environments.

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