THE F-22A QUICK RESPONSE PACKAGE-QRP

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ABSTRACT

The F-22 Quick Response Package was designed to efficiently solve aircraft anomalies in the field. Providing this capability would enhance aircraft combat availability and lower maintenance costs. Using the current F-22 instrumentation flight test system design package as a baseline, a smaller, and much more versatile, version of the system was designed. This new design concept includes a data acquisition and recording system on a single pallet called the Quick Response Package (QRP). The QRP can be installed in any operational F-22 war fighter in a single production shift with no intrusion to the aircraft's systems readiness. The data acquisition and recording capabilities provide a near real-time field solution without excessive downtime or pilot intervention. This paper describes the design requirements, the design concept and packaging details of the QRP.

KEYWORDS

Quick Response Package-QRP, Data Acquisition Recorder

INTRODUCTION

The F-22 program was given the requirement by the Department of Defense to efficiently solve production aircraft anomalies in the field. Providing this capability would enhance aircraft combat availability and lower maintenance costs. Using the current F-22 instrumentation flight test system design package as a baseline a smaller and much more versatile version of the system was designed. This new design concept includes a data acquisition and recording system on a single pallet called the Quick Response Package (QRP).

The QRP can be installed in any operational F-22 war fighter in a single production shift with no intrusion to the aircraft's systems readiness. The data acquisition and recording capabilities provide a near real-time field solution without excessive downtime or pilot intervention. This package is currently in the field at operational bases providing on-site solutions for problems faced by the war fighter.

The top-level requirements for the data acquisition system used by the F-22 QRP are as follows:

- Record at a minimum four channels of Pi-Bus data.
  - The F-22A has six channels of Pi-Bus data, which is a propriety bus on the F-22A.
  - Provide the capability to record all six channels in the enhanced version of the QRP.
- Record at a minimum eight channels of 1553 data.
  - Provide the capability to record twelve channels in the enhanced version of the QRP.
- Provide spare channel recording in the enhanced version.
- Require no pilot intervention for start/stop recording.
- Provide two hour minimum record time.
- Its operation is unobtrusive to the war fighter.

SYSTEM DESCRIPTION

The system architecture for the F-22A QRP is based on the AIM-2004 hardware that is used in the F-22A Instrumentation Data Acquisition System (IDAS). There are only slight differences in the AIM-2005R used on the QRP versus the AIM-2004. The AIM-2005R has a built-in IEEE-1394-based IRIG-106 Chapter 10 recorder, five expansion slots instead of four and a lower maximum-recording rate, 30MBps versus the 100MBps supported by the AIM-2004. The AIM-2005R internal recorder currently has a maximum storage capacity of 128 gigabytes.

The other unit that is part of the QRP architecture is the MCDAU, which is a miniature data acquisition unit, which can be used as a CAIS master and/or slave. In the QRP application the MCDAU is used as the CAIS master for system programming, IRIG time distribution, and as an interface for sampling analog and digital sensors.

The Quick Response Package design architecture can be deployed in two different configurations: basic or the enhanced version. The basic configuration, shown in Figure 1, provides four channels of Pi-Bus data recording. In the enhanced version, shown in Figure 2, that capacity can be raised to six. The enhanced configuration requires the addition of an HSAVDAU-2004 chassis. The HSAVDAU is currently in use as a subsystem of the F-22A instrumentation data system (IDAS). The addition of the HSAVDAU-2004 gives the QRP full data recording capabilities on a small modular plate.

The packaging of the QRP is quite unique. All three data acquisition units are mounted on a plate that fits in the CIP #3 bay on the jet. This bay is a forward unoccupied avionics bay. The QRP wiring is always configured for the enhanced version, so all group "A" wiring is on the plate. When the enhanced version is required, it is only necessary to install the HSAVDAU on the plate, preflight and go fly. There is no additional wiring required. All wiring has permanent stowage plates, so there are no loose harnesses in the basic configuration.

The QRP is powered from a single production 28VDC 10AMP circuit breaker, all three data acquisition units are individually circuit breaker protected. There is no need for a separate power supply on the plate. All aircraft wiring interfaces enter the QRP via circular D38999 series III connectors located on the rear of the pallet. The pre-flight test panel consists of a circular D38999 series III connector for data I/Os and system programming. There is an IRIG time-code jam switch and time lock verification light along with a data recording enable switch and a recording mode verification light. For in-the-field system operation verification, a data valid indicator was created. The data valid indicator indicates that all data packets expected to be recorded are detected and valid. This indicator functions as the equivalent of an "idiot light", providing a quick and reliable method of pre-flighting the QRP without requiring any data analysis tools.

Data recording is accomplished directly via the backplane of the AIM-2005R. There is a 128 gigabyte ruggedized solid-state drive that resides in a specialized slot in the AIM-2005R. Data recording time is dependent on the number of channels being input; minimum time expected is two hours. Data can be downloaded directly from the AIM-2005R via a built-in IEEE-1394 connection. However, it is recommended to pull the canister from the AIM-2005R and download data directly to a PC due to time and data content.

The block diagrams shown in Figure 1 and Figure 2 define the QRP basic and enhanced system. Each hardware component in this block is discussed in the following paragraphs.

Figure 1: F-22A Quick Response Package Basic configuration

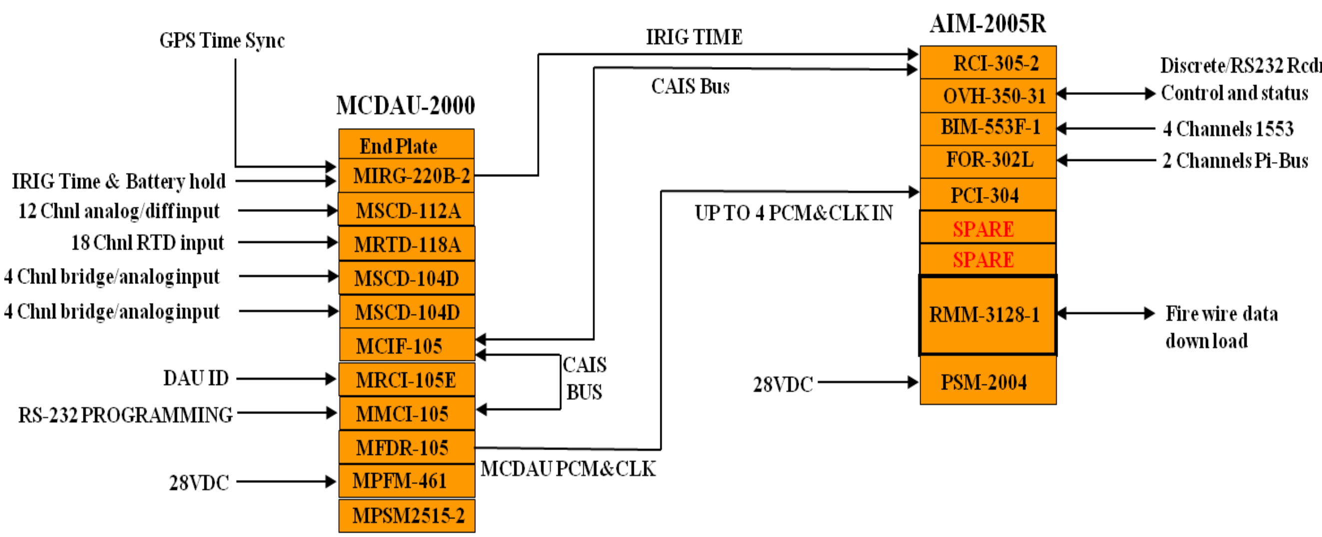

Figure 2: F-22A Quick Response Package Enhanced

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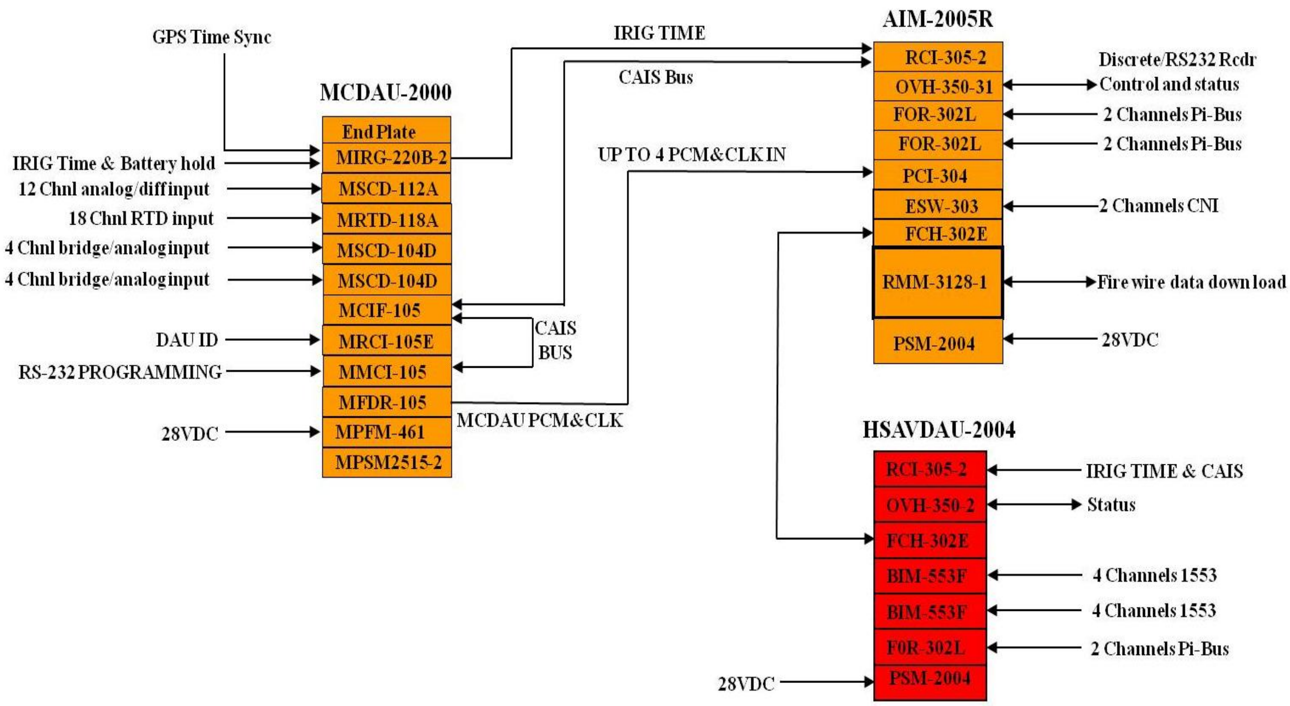
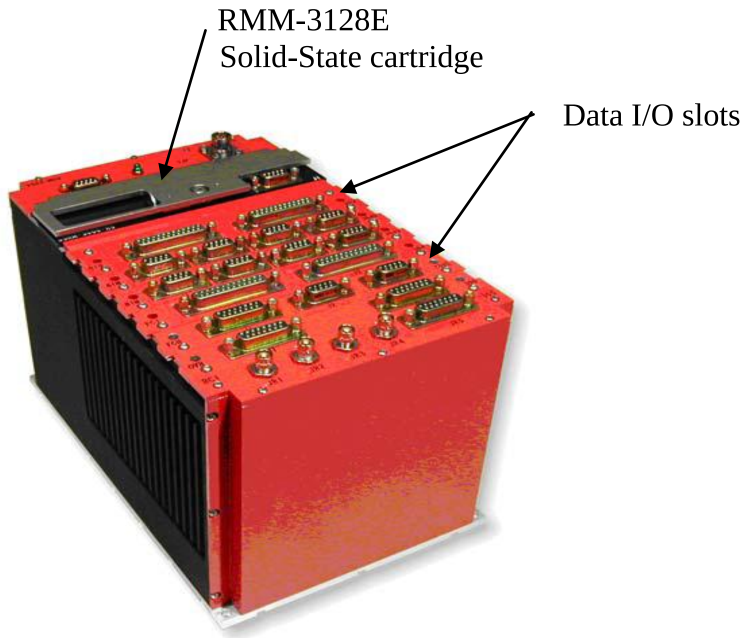


AIM-2005R DATA ACQUISITION UNIT

The AIM-2005R is an enhanced version of the Airborne Instrumentation Multiplexer (AIM) that is based on the design of the AIM-2004. The AIM-2005R accepts data from a variety of input sources, including PCM, 1553, and other data sources and formats the data per IRIG-106 Chapter 10 requirements, for recording on the internal RMM-3128E storage cartridge, shown in Figure 3. The AIM-2005R has an internal power supply, PSM-2004 for aircraft power conversion and regulation. The PSM-2004 accepts +28VDC ±4VDC power, and generates the voltages necessary for AIM-2005R operation. The AIM-2005R unit houses an overhead card assembly and up to five data interface cards.

Figure 3: AIM-2005R



Interface Cards

OVH-350 Overhead Card

The OVH-350 card is a new design that provides major enhancements over the OVH-300 previously deployed in earlier AIM/HSAVDAU-200X systems. The OVH-350 uses an embedded processor capable of up to1600 Dhrystone 2.1 MIPS at a clock rate of 800 MHz. This card contains 256 MB of double data rate SDRAM with a memory bandwidth of about 2.1 GBps peak. The card also provides 64 MB of non-volatile memory storage for the operating system and configuration data. In addition to higher processor performance, the major improvement to the card over the OVH-300 is the incorporation of two 1000BASE-T Ethernet interfaces and one 10/100BASE-T Ethernet interface.

The OVH-350 executes an embedded real-time Linux operating system, various hardware-specific drivers, and application software. It stores software executables and AIM programming information in its flash file system. It terminates an IP stack to support standard Ethernet protocols and TCP and UDP, and can communicate with other data acquisition systems.

RCI-305 Remote CAIS Interface Card

The RCI-305-2 provides a remote CAIS bus interface and a time code reader/generator. It is a mezzanine card that connects to the mezzanine port on the OVH-350 and is functionally identical to the existing RCI-305-1 card used with the older OVH-300 card. A new layout is required to mate to the OVH-350.

FOR-302L Two-Channel Fiber Optic Receiver Card

The FOR-302L card is a fiber optic receiver card for the AIM-200X and HS-AVDAU 200X product lines that supports two Fiber Optic Receiver (FOR) receive channels at 400 Mbps line rate per channel. It employs a Xilinx Spartan 3 FPGA plus Dual-Port SRAM to terminate the F-22A fiber optic protocol and buffer inbound data. FOR-302L provides accurate data time-tagging. The card interfaces to multi-mode 100/140µm fiber optic cable at the faceplate using an optical D-subminiature connector. It interfaces with the host chassis on a modified Compact PCI Bus backplane. Two FOR-302L cards can be installed in a single AIM/HS-AVDAU chassis.

BIM-553F Four Channel Mil-Std-1553 Bus Monitor Card

The BIM-553F is a four-channel 1553 Bus Monitor Card for use in the Airborne Instrumentation Multiplexer (AIM) and High-Speed Avionics Data Acquisition Unit (HSAVDAU) products. The BIM-553F card has four dual redundant 1553 channel inputs. Each channel is individually programmable for enable/disable, 1553B or 1553A, direct or transformer coupled, and response-time time-out. Data acquired by the BIM-553F card is transported to the overhead card memory via a customized high-speed CompactPCI® Bus where data can be stored on a data recorder. The card can be programmed to filter out data based on specific command words. One hundred percent of the input data message traffic (minus any filtered data) is recorded.

ESW-303 Three Port Ethernet Switch Card

The ESW-303 is an Ethernet switch card used in the Airborne Instrumentation Multiplexer (AIM) and High-Speed Avionics Data Acquisition Unit (HSAVDAU). It provides time tagging on incoming data. The ESW-303 is equipped with three interfaces on its front panel, two optical 100BASE-FX Ethernet interfaces and a single copper gigabit Ethernet interface. A serial RS-232 port is included for engineering test and debug. The two 100BASE-FX ports interface to the aircraft network, and the single 10/100/1000BASE-T port can interface to Ground Support Equipment (GSE).

PCI-304 Four-Channel PCM Interface Card

The PCI-304 is a four-channel PCM input card for use in the Airborne Instrumentation Multiplexer (AIM) and High-Speed Avionics Data Acquisition Unit (HSAVDAU) products. The PCI-304 card has four independent channel inputs, each of which accepts either single-ended or RS-422 differential inputs at standard rates up to 20 Mbps on a per-channel basis. All incoming data is buffered on the card, formatted as embedded PCM words, and sent to the overhead card for word selection and eventual telemetry transmission or storage on the recorder unit. The aggregate data rate output can be up to 80 Mbps.

FCH-302E Dual-Port Electrical Fibre Channel Interface Card

The FCH-302E board is designed to provide a Dual Electrical Fibre Channel interface board in both the Airborne Instrumentation Multiplexer (AIM) and High-Speed Avionics Data Acquisition Unit (HSAVDAU) products. The FCH-302E board provides two 'Fibre Channel Industry Association'-compliant electrical interfaces, each capable of data rates up to 1.0625 Gbps. The two Electrical Fibre Channel interfaces are accessible at the FCH-302E faceplate via two 9-pin D-subminiature receptacles (DB9). Each DB9 connector corresponds to a single Electrical Fibre Channel interface. The Fibre Channel interfaces are initially intended to be utilized for HSAVDAU to AIM communications and for connection to Fibre Channel capable flight recorders. One or more FCH-302E boards can simultaneously reside in the AIM and HSAVDAU chassis'.

RMM-3128E Removable Memory Module Unit with Secure Erase.

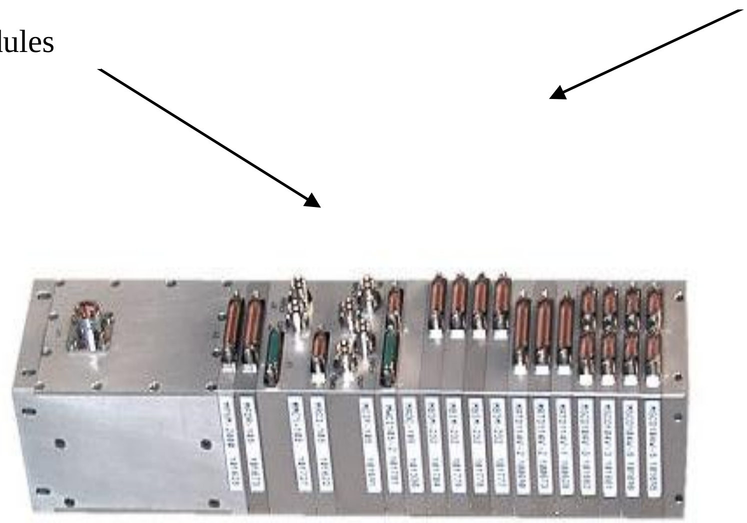
These units are used within the AIM-2005R family of Airborne Instrumentation Multiplexers (AIM) as internal data recorders. The modules support the IRIG-106-03 declassify procedure. The RMM-3128E-1 cartridges support the IEEE-1394b High-Speed Serial Communications Format at data rates up to 400 Mbps. This allows for sustained data-recording rates of up to 30 MBps on the internal solid-state drive.

MCDAU-2000– MINIATURE CAIS DATA ACQUISITION UNIT

The MCDAU-2000 is a miniature Data Acquisition Unit that interfaces with a variety of analog and digital sensors and sources, with the ability to act as a bus monitor. The system is reconfigurable to handle additional channel inputs, or to accommodate other types of data. The MCDAU-2000 can operate as a stand-alone data acquisition unit, or can be configured to operate with other compatible hardware in a master/remote configuration. Channel sample sequences and conditioning parameters are user-programmable and are pre-programmed via a serial RS-232/422 connection to a PC-based computer running TTC's TTCWare software application. Data acquired and encoded by the MCDAU-2000 master unit or stand alone unit is formatted as serial PCM per IRIG-106-96, Chapter 4 requirements. The MCDAU-2000 unit consists of various interconnecting modules including those dedicated to overhead functions, power conversion functions, and signal conditioning and encoding functions. The system is extremely rugged and is suitable for use in harsh environments and over a wide temperature range. All interface signals to and from the system use microminiature style interface connectors.

In the QRP configuration the MCDAU-200 is used as a master to program the system. There is a time code module that is used to jam and generate IRIG B for system time tagging. Also included are various analog and digital modules for transducer monitoring.

Figure 4: MCDAU-2000



HSAVDAU – HIGH SPEED DATA ACQUISITION UNIT ENHANCED QRP ONLY

The HSAVDAU is only used in the QRP enhanced version. It adds more data I/O interfaces and utilizes the same data interface cards as the AIM-2005R. Data is transferred to the AIM-200R via the FCH-302E card.

Figure 5: HSAVDAU-2004

Data I/O Slots

CONCLUSION

The Quick Response Package system development has been a success. Several QRP packages have been deployed to operational bases to solve several war fighter issues on-site. The design is derived from existing F-22A instrumentation system designs which have been proven by past and on-going flight tests. System installation and preflight time has been minimized due to the system design and architecture as detailed in this paper. While it is still early, the value and utility of the solution has been tested in the field and has been found to be effective. We expect the number of deployments to increase as the long-term value of the QRP is demonstrated. The modular architecture of the systems will allow the system to adapt to aircraft upgrades and modifications, keeping the QRP relevant for many years.