AN ADVANCED, PROGRAMMABLE DATA ACQUISITION SYSTEM

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ABSTRACT

The MicroDAS-1000 is an airborne Data Acquisition System (DAS) designed to meet the growing needs of airframe manufacturers for extensive test data accumulation, processing and evaluation. As such, the system has been designed with emphasis on modularity, miniaturization and ease of operator usage and expansion. The MicroDAS product line includes a series of components used as building blocks to configure systems of virtually any size. The modular design of these components allows considerable latitude to the instrumentation engineer in configuring systems for simple or complex applications. The modular concept has been extended to the design of plug-in modules for different functional requirements and system applications. All units are under software control to allow rapid reconfiguration and setup as requirements for instrumentation and data gathering change.

KEYWORDS

Data Acquisition System	Telemetry	Software Controlled
Programmable	Instrumentation	Modular

INTRODUCTION

The requirements of aircraft flight test programs have evolved dramatically over the last 30 years. A modern test program must employ instrumentation to process more data while occupying less space on the vehicle. This has forced the need for more compact instrumentation systems.

At the same time that there are pressures for reduced size and weight, there are requirements for more sophisticated

systems. Not only are the number of data channels increasing, but a vast variety of types of data must be addressed. Traditional analog measurements must still be made in approximately the same numbers as before, but there has been an increase in the number of on board avionics and computer buses with information that must be collected and processed. A flight test instrumentation system must be able to deal with all these data types and must be flexible enough to meet new demands as they occur.

Due to the recent trend of reducing defense related spending, the increased sophistication of flight test programs has not been accompanied by greater financial resources to accomplish the mission. Just the opposite is true. There is pressure to decrease budgets on almost all programs. This means that instrumentation systems must be made cost effective. To accomplish this goal, not only must the hardware be economical to procure but it must be reliable, flexible, and easy to learn and use.

The MicroDAS-1000 Data Acquisition System has been developed to address all of these factors. It is a miniaturized, modular system that is easily reconfigurable. Virtually all manual operator adjustments have been eliminated by the incorporation of computer programmability for all system parameters. The bus architecture has been designed to be forward compatible with any new data types that may be encountered in the future.

MicroDAS-1000 SYSTEM OVERVIEW

The MicroDAS-1000 consists of a series of system components that can be configured to form a complete data acquisition system. The major elements are the RMU-1000 Remote Multiplexing Unit (RMU), DCU-1000 Data Combiner (DCU), and the GSC-1000 Ground Support Computer (GSC). The RMU provides the functions of a data collector and PCM Encoder. It contains sixteen (16) slots to accept any Signal Conditioning or Bus Monitor Module in the system. Multiple RMU’s may be combined to form an Airborne Data Acquisition Multiplexer (ADAM). The Data Combiner accepts inputs from RMU’s and selectively sends the data to transmitters, tape recorders or computers. The GSC-1000 is used for all setup and verification of the system.

RMU-1000 Remote Multiplexer Unit Overview

The RMU-1000 and its respective input function cards provide the main platform to which all MicroDAS data inputs are applied. An RMU-1000 is capable of accepting up to sixteen (16) plug-in input modules. The input modules are divided into analog and digital functions and can occupy multiple card slot locations.

The RMU set-up information is downloaded from the system GSC via an RS-232 communication channel. The RS-232 communication architecture is defined by the Microcom proprietary Data Acquisition System Management (MicroDASM) application software. The downloaded data contains all appropriate input and program variable information.

The RMU is designed to be a fully programmable signal conditioning encoder. It conditions signals from various types of aircraft transducers, converts the analog signal voltages into digital representations, and then formats the digital data into an IRIG standard serial Pulse Code Modulation (PCM) data stream.

The MicroDAS RMU is designed to be configured either as a Master or a Slave encoder. As a Master, the RMU can operate “stand alone”, formatting data from 16 plug-in Signal Conditioning cards into a standard PCM data stream with no other hardware attached. If channel expansion is required, the RMU’s can be chained together in a Master and Slave configuration to increase the number of channels in an encoder system. Up to 31 RMU’s can be slaved to a Master RMU. The interface between the Master and slave RMU is designed as a serial address/data bus with RS-485 level signals to allow for communication over large distances (100-500 ft. depending on bit rate) between the Master and Slave units. The result is a distributed PCM encoder architecture where the encoder unit can be located in proximity to the sensors.

Larger systems can be configured by connecting the Master RMU’s to a DCU-1000, MicroDAS Data Combiner Unit. The MicroDAS DCU accepts up to eight (8) MicroDAS ADAM’s, each containing up to 32 RMU’s, as inputs.

A block diagram of a MicroDAS-1000 is shown in Figure 1. This diagram shows a Master/Slave RMU configuration with typical system inputs and outputs.

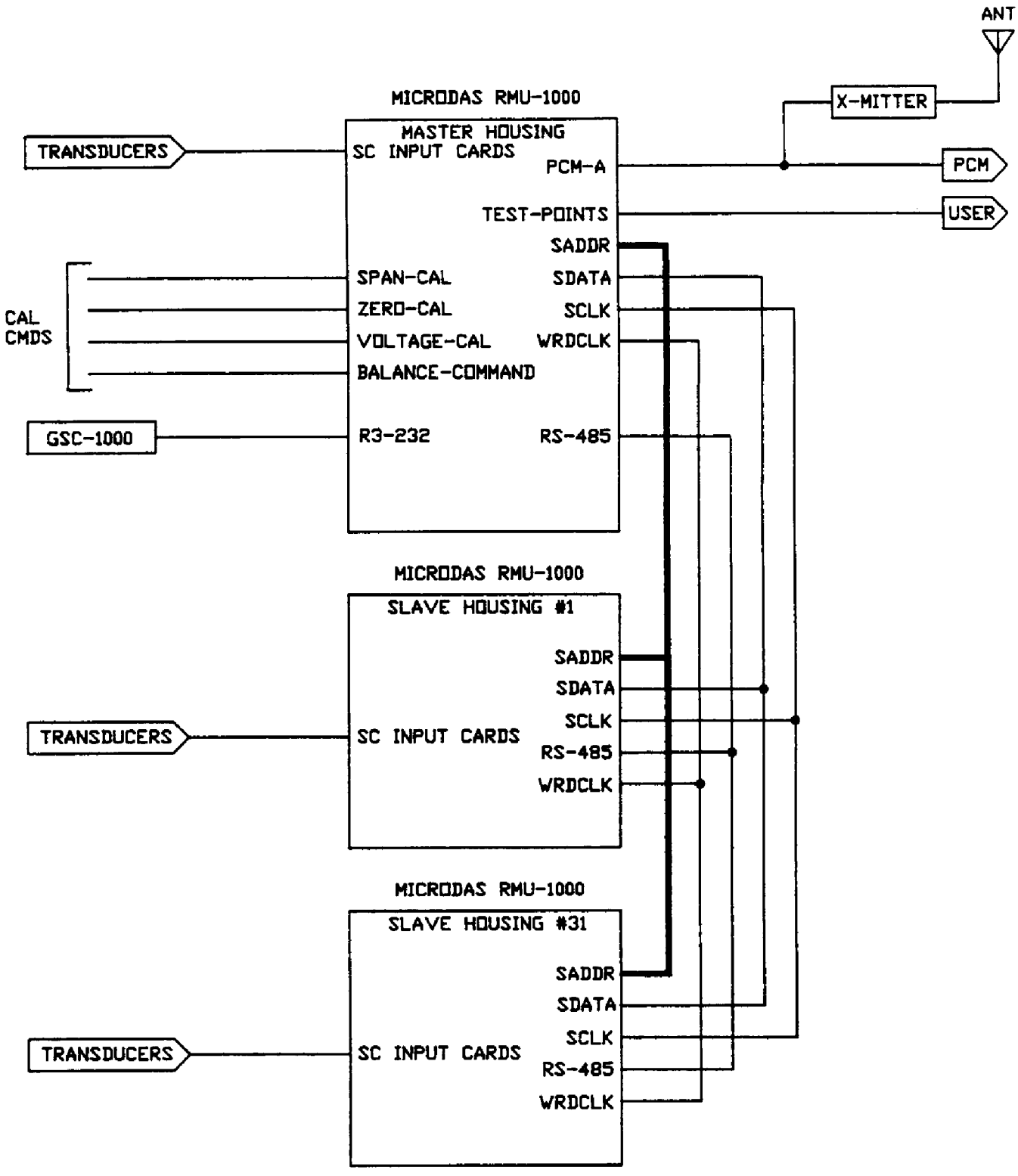


FIGURE 1
MICRODAS-1000 SYSTEM

Signal Conditioner Cards. The Signal Conditioner modules provide all necessary excitation, amplification, offset, and filtering of analog transducers. After being “conditioned”, analog signals are converted into digital signals for conversion into PCM format. A central feature of the MicroDAS RMU-1000 is that Signal Conditioner modules are fully computer programmable. The need to physically access the Signal Conditioning modules and change components or jumper connections is eliminated.

A standard set of MicroDAS Signal Conditioning function cards has been developed satisfying the majority of analog/digital input requirements encountered. Additional functions can be easily implemented as new signal conditioning types. The following list represents the standard set of input conditioning cards.

- MSC-1000-001, Dual Channel Wheatstone Bridge
- MSC-1000-002, Dual Channel Resistor Temperature Detector (RTD)
- MSC-1000-003, Dual Channel Piezo-Accelerometer
- MSC-1000-004, Dual Channel Accumulator
- MSC-1000-005, Dual Channel Synchro to Digital
- MSC-1000-006, 16 Channel Voltage Source Multiplexer
- MSC-1000-007, 36 Bit Discrete/Time Code
- MSC-1000-008, Dual Channel Frequency to Digital
- MSC-1000-009, Dual Voltage Source
- MSC-1000-010, Quad Charge Amplifier
- MSC-1000-011, Customer Specified Signal Conditioner
- MSC-1000-012, MIL-STD 1553 Bus Monitor
- MSC-1000-013, ARINC 429 Bus Monitor
- MSC-1000-014, RS-232 Data Decoder
- MSC-1000-015, Asynchronous PCM Input

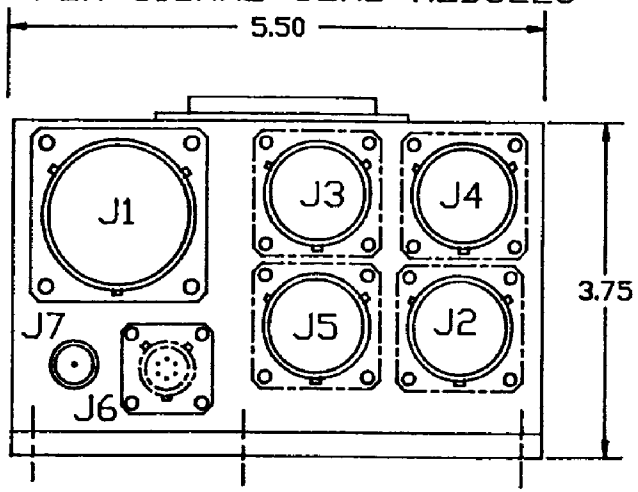
RMU-1000 Technical Description

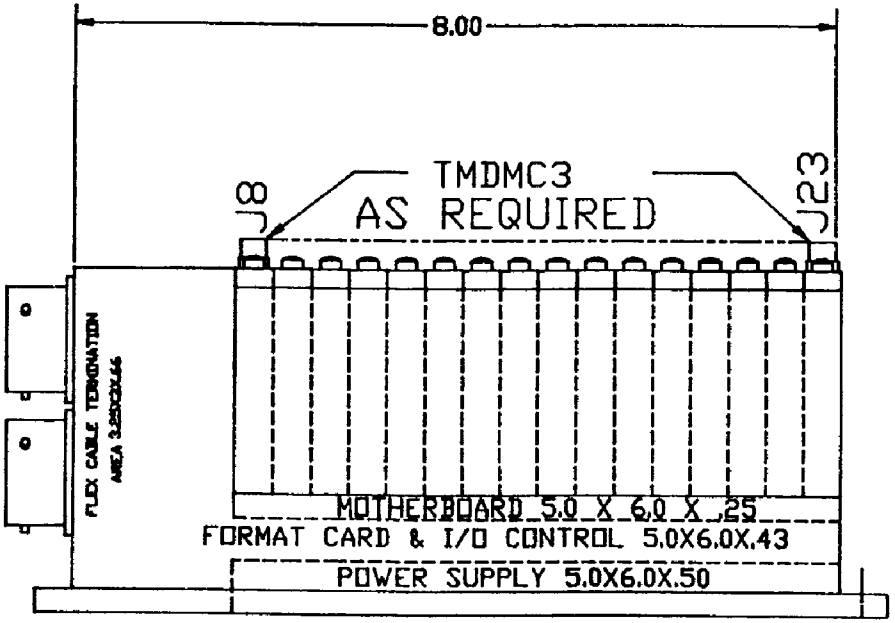
The RMU PCM Encoder Unit (Figure 2) is designed for data acquisition from avionic bus inputs and/or analog transducer inputs. Each RMU contains a Power Supply card, Formatter card, and a sixteen (16) card slot backplane. A signal conditioning card can plug into any available card slot in the RMU backplane. The Backplane, Power Supply, and Formatter cards are built into the base of the unit. Salient features of the RMU-1000 include.

- Simultaneous S/H, all system channels
- A/D conversions, per channel or card basis

J1 D38999/20FJ35PN
J2 D38999/20FE35PN
J3 D38999/20FE35PA
J4 D38999/20FE35PB
J5 D38999/20FE35PC
J6 D38999/20FB98PN
J7 M39012/19-0101
J8 THRU J23 TMDMC3-37P AS REQD
FOR SIGNAL COND MODULES

SYSTEM VOLUME 165 CU. IN.
SYSTEM WEIGHT <5 LBS





RMU-1000

FIGURE 2

- One power supply per housing
- Internal Microprocessor Control
- Master and Slave interface circuitry in each unit
- Serial communication circuitry
- EEPROM for program setup information storage
- Power watchdog circuit. Resets RMU after power loss
- Alternate or External Clock for RMU Synchronization

Programmed values from the Ground Support Computer are stored in EEPROM on the RMU Formatter card and are loaded into the Signal Conditioning channel cards upon power-up or reset.

The following paragraphs describe the operation and characteristics of the Signal Conditioning modules used in the RMU.

MSC-1000-001, Dual Wheatstone Bridge Conditioner. The Wheatstone Bridge Signal Conditioner Module is a two (2) channel, fully programmable module designed to interface between Wheatstone Bridges (between 120 and 5 Kohms) and a data bus. A block diagram of the Signal Conditioner is shown in Figure 3.

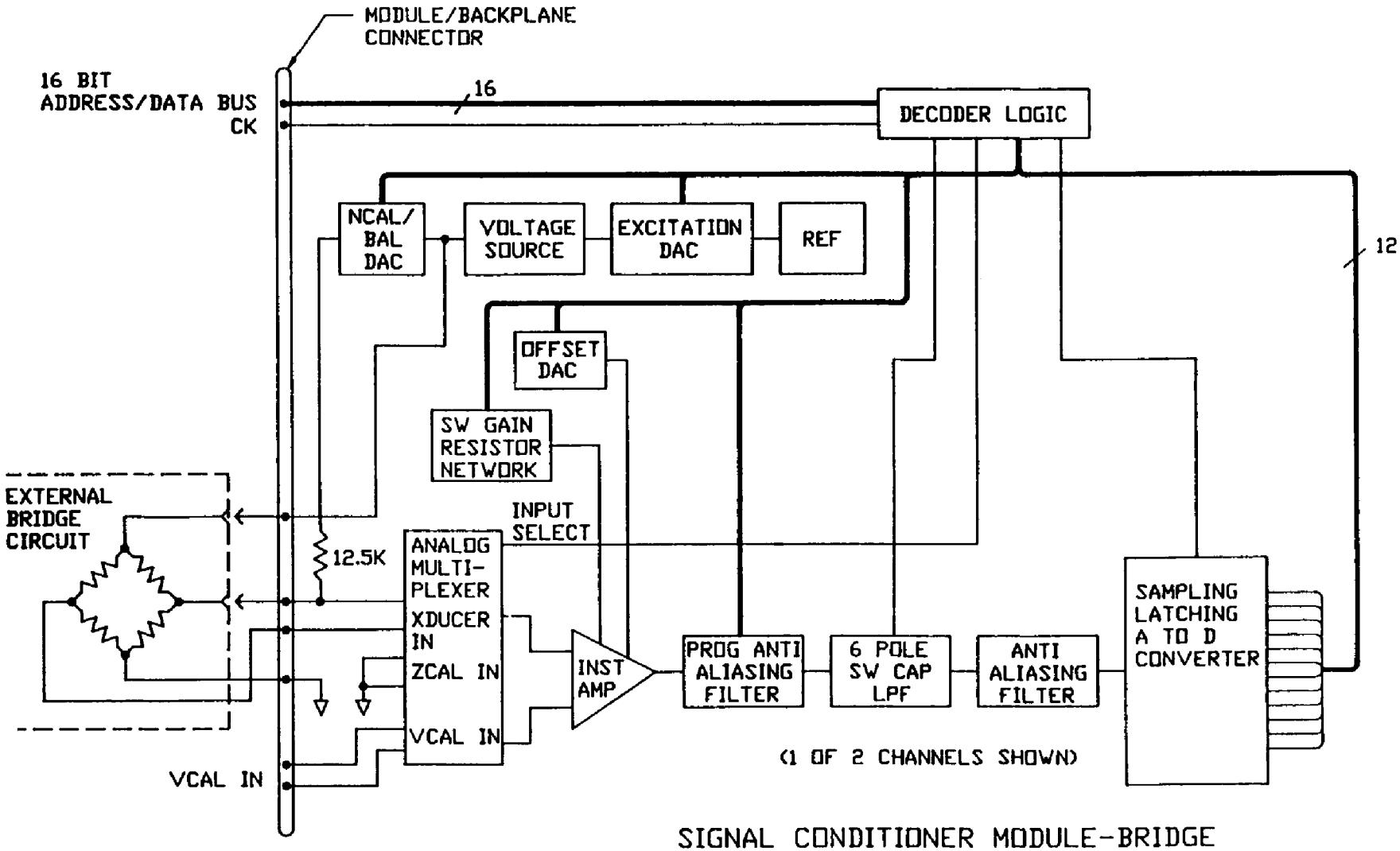
The following are the salient programmable features:

- Excitation, 0 to 1OVDC, 12 bit, current limited.
- Gains in range of 1 to 1000, 12 gains per channel.
- Offset, 13 bits resolution, (balance) and adjustable ±10V.
- 6-Pole Pre-Sample Filter, 5Hz-3000Hz, 16 cut offs per chan.
- Responds to system S/H command.
- Zero, Voltage and Shunt calibration capability.

MSC-1000-002, Dual Channel RTD Conditioner. The RTD Signal Conditioner is a 2 channel fully programmable module designed to interface between RTD sensors (of between 40 and 3K ohms) and a data bus.

The following are the salient programmable features:

- Excitation, 1 to 16 ma, 12 bits.
- Gains in range of 1 to 1000, 12 gains per chan.
- Offset, 13 bits resolution, (balance), range through ±10V.



SIGNAL CONDITIONER MODULE-BRIDGE
MSC-1000-001

FIGURE 3

- 6-Pole Pre-Sample Filter, 5Hz - 3000 Hz, 16 cut offs per chan.
- Responds to system S/H command.
- Zero and Voltage calibration capability.

MSC-1000-003, Dual Piezo-Accelerometer Conditioner. The Piezo Accelerometer Signal Conditioner Module is a 2 channel fully programmable module design to interface between Piezo Accelerometers and a data bus.

The following are the salient programmable features:

- High Pass Filter Input, 10% cutoff at 5 Hz
- Excitation, 1 to 16 ma, 12 bits compliance voltage of 2OVDC
- Gains in range of 1 to 1000, 12 gains per chan.
- Offset, 13 bits resolution, (balance), range through ±10V
- 6-Pole Pre-Sample Filter, 5 Hz - 3000 Hz, 16 cut offs per chan.
- Responds to system S/H command
- Zero, Voltage and shunt calibration capability

MSC-1000-004, Dual Accumulator Conditioner. The Accumulator Signal Conditioner Module is a two (2) channel fully programmable module designed to interface between discrete input occurrences and a data bus.

The Signal conditioner is designed to operate in one (1) of four (4) modes.

- Accumulator - A 32 bit counter maintains a running count of conditioned input data.
- Frequency Measurement - The data input is fed to the counter while the on-board time base is fed to a register.
- Period Counter - The data is fed to a latch while a high speed clock is fed to the counter.
- Special Functions - Special functions can be implemented for various totalizer, timer functions, and presently undefined functions via firmware changes.

MSC-1000-005 Dual Channel Synchro to Digital Conditioner. The Synchro to Digital Conversion Signal Conditioner Module is a fully programmable 2-channel module designed to interface between various synchro angular position transducers and a data bus.

The Signal Conditioning Module is designed to accept an 11.8 Vrms or input signal from 360 to 440 Hz.

The Synchro Input line-to-line input impedance is 100 Kohms minimum. The Reference Input line-to-line input impedance is 250 Kohms minimum and operates in two ranges. Low range is defined as 26 Vrms, and high range is defined as 115 Vrms.

Static accuracy is 5 arc-minutes maximum, over the specified input voltage, frequency and temperature ranges.

MSC-1000-006, 16 Channel Voltage Source Mux Conditioner. The 16 Channel Analog Multiplexer Signal Conditioner module is a fully programmable module designed to interface with voltage signals of up to 100 Vpeak and a data bus. The Signal Conditioner Module contains four (4) excitation sources +28Vdc, +15Vdc, -15Vdc, and +5Vdc which are short circuit protected.

The following are the salient programmable features:

- Gain, 12 per channel over a range of 1 to 1000.
- Offset, 13 bits resolution (balance), range through ±10V.
- Zero and Voltage Calibration Capability.

MSC-1000-007, 36 Bit Discrete/ Time Code Conditioner. The Discrete Signal Conditioner Module is a fully programmable module designed to interface between digital transducers and a data bus. Input logic “Hi” ranges from 2.7 to 32 volts, input logic “Lo” ranges from 0 to 1.5 volts. Floating inputs are designated as logic “Hi”. Provisions are included to interface the discrete inputs to a Time Code Generator.

MSC-1000-008, Dual-Frequency to Digital Conditioner. The Frequency to Digital Signal Conditioner Module is a fully programmable module designed to interface between rotary tachometer signals and fluid flowmeters and a data bus. The operation and optional configurations are similar to the Accumulator Signal Conditioner Module.

MSC-1000-009, Dual Voltage Source Conditioner. The 2 Channel Voltage Source Conditioner Module is a fully programmable module designed to interface between differential voltage signals of less than 5V peak and a data bus. The Module provides excitation of 0 to 10V which is short circuit protected.

The following are the salient programmable features:

- Gain, 7 per channel, over a range of 1 to 1000.
- Offset 12 bits resolution (balance), range through ±5.
- Filter 8 selections per channel, 10 to 3000 Hz.
- Balance VCAL and ZCAL.
- Responds to system S/H command.

The output of each channel is an analog 0 to 5 volt signal, converted into 12 parallel data bits upon receipt of the S/H command. One A to D converter is allocated to each channel.

MSC-1000-010, Quad Charge Amplifier Conditioner. The Charge Amplifier Signal Conditioning Module is a 4-Channel fully programmable module designed to interface between piezoelectric or charge output accelerometers and a data bus.

The following are the salient programmable features:

- Filter, 16 selections per channel, 5 to 3000 Hz.
- Gain, selectable per channel 0.5,1,2,4, for input charge ranges from 0 to 20k pCp-p.
- Zero and Voltage Calibration Capability.

MSC-1000-012, MIL-STD 1553 Bus Monitor Conditioner. The 1553 Bus Monitor has the capability to recognize and capture up to 256 message blocks from a dual redundant 1553 bus. In addition, time tag information and data status words, which indicate overflow or underflow conditions are generated on the bus monitor and are available. Any data word within this block can be selected to be inserted into the PCM data stream via menu driven software. 1553 data can be included along with analog and other digital data in a PCM stream.

MSC-1000-013, ARINC 429 Bus Monitor Conditioner. The 429 Bus Monitor can recognize and capture up to 256 data words associated with selected labels from two 429 buses. Each 32 bit data word can be parsed and inserted into the PCM data stream. Data status words are generated for inclusion into the data stream to signal overflow and underflow conditions.

MSC-1000-014, RS-232 Date Decoder Conditioner. Asynchronous serial data can be inserted into the PCM stream via the RS-232 Bus Monitor. This card accepts any eight bit data with a start bit and at least one stop bit. It is programmable for baud rates from 300 to 19,200 bits per

second. Message blocks of up to 8192 data characters can be accommodated by the system.

MSC-1000-015, Asynchronous PCM Input Conditioner. The PCM Input Conditioner allows the insertion of other PCM data into the output PCM stream. The conditioner requires only NRZ-L PCM data and a clock. Frame synchronization is detected on the card and a buffer is sequentially filled from that location. That data can be inserted into the PCM stream by the same means as the RS-232 Data Decoder card.

DCU-1000 DATA COMBINER UNIT OVERVIEW

The DCU-1000 performs the function of gathering all the data from up to eight (8) ADAM's and selectively routing the data to various devices for recording, analysis and transmission. It also acts as a single point of communication between all the data systems and the Ground Support Computer.

The DCU-1000 can supply four simultaneous outputs, each one containing all or some submultiple of the incoming data. All data can be output by running the bit rate at X number of times each input bit rate, where X is the number of ADAM's in the system.

Each output is programmed independently to contain its desired data words, with the only restriction being that the amount of time necessary to transmit the data is equal to the time for a frame of data on the input. Since there is a total frame of valid data in the buffer being accessed, word assignment in the output frame does not have to follow the sequence of the incoming frame.

Although the synchronous merge system adds a certain amount of complexity to the setup of the individual frames, it increases system performance in several ways. It increases the system sample rate beyond what is possible in a single PCM Encoder of this type available today. This is possible because the A/D converters for the analog channels operate at the rates of the individual ADAM's and not at the output system rate.

Compared to asynchronous methods of merging data, where data samples are input to a "current value" table, or in a command/response system, the synchronous method optimizes the use of bandwidth for analog channels while maintaining the rules of the Sampling Theorem. No oversampling of

channels is necessary because each sample correlates to a specific time interval in the output data. This time interval is also a constant, so no error is produced due to time differences in sample rates. All other techniques either require extra data samples to be taken or do not guarantee a constant time interval between samples.

GSC-1000 GROUND SUPPORT COMPUTER OVERVIEW

The Ground Support Computer (GSC) is a ruggedized, portable, PC compatible and is designed to perform system configuration and diagnostics on the flight line. It consists of an 80386 based PC, an internal Bit Synchronizer and PCM Decommutator, and MicroDASM software. All communications with the MicroDAS System is done via one RS-232 or RS-422 link and a PCM output stream from the system.

MicroDASM software forms the core of the GSC's capability. This software performs the following system functions:

1. Allows full configuration of a MicroDAS system via user friendly, pulldown menus. This includes all channel and gain parameters.

2. Loads setup files into the airborne MicroDAS System either from the Ground Station or from the GSC itself.

3. Performs end-to-end system tests and diagnostics utilizing the built in Bit Synchronizer and Decommutator, and reports any out of tolerance conditions.

CONCLUSION

By taking full advantage of the capabilities of computer integration, the MicroDAS-1000 system offers many desirable features to a Flight Test Engineer. There is no longer a need to physically access the hardware to make adjustments or change settings. Software can run pre-flight calibration and report results back to an operator. Data necessary to program the MicroDAS-1000 system can be integrated into the ground system data base to allow the systems integrator to play an active role in the Flight Test Program.

The MicroDAS-1000 system has been developed to serve the needs of the Flight Test Community. By providing a flexible,

expandable platform and combining it with the latest in computer and software technologies, this system is positioned to not only accommodate the needs of today but to grow with the requirements of tomorrow.