

MICROMINIATURE DISTRIBUTED DATA ACQUISITION SYSTEM

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ABSTRACT

The new generation of advanced tactical aircraft and missiles places unique demands on the electronic and mechanical designs for flight test instrumentation, high bit rates, operating temperature range and system interconnect wiring requirements.

This paper describes a microminiature PCM distributed data acquisition system with integral signal conditioning (MMSC) which has been used in advanced aircraft and missile flight testing. The MMSC system is constructed from microminiature, stackable modules which allow the user to reconfigure the system as the requirements change. A second system is also described which uses the same circuitry in hermetic hybrid packages on plug-in circuit boards.

KEY WORDS (1) Distributed Data Acquisition
(2) Pulse Code Modulation (PCM)
(3) Signal Conditioning
(4) Microminiature

THE CREATION - A Remote Unit for an Advanced Aircraft

The new generation of aircraft (fixed and rotary wing) and missiles places unique demands on the electronic and mechanical designs for flight test instrumentation. Some of these requirements include:

- Small size
- Integral signal conditioning
- Minimum system interconnect wiring
- Wide operating temperature range
- High accuracy
- High bit rate

THE REQUIREMENT

The Advanced Tactical Fighter required a small, lightweight, distributed system to minimize impact on the test aircraft. The MMSC system was created for this requirement. The MMSC (as configured for the ATF application) is a microminiature, modular, remote unit which can be located anywhere in the vehicle. MMSC units were created to accept the following types of input signals:

- Bridge or voltage inputs with 6-pole filter
- Thermocouple inputs
- Bi-level inputs
- Synchro or resolver inputs
- Frequency inputs
- RTD or low impedance sensors

Since the remote units were required to be located in various locations throughout the vehicle significant environmental constraints were imposed on the MMSC remote units:

- a. Operating temp range: -40 deg C to +100 deg C
- b. Shock and vibration consistent with a high performance fighter aircraft.
- c. EMI

The system is controlled through a Programmable Master Unit (PMU). The master unit contains an RS-232 serial communication port to interface with the host computer for programming and verification. The PMU also performs various other functions in the ATF application. These include:

- Time code reader/generator
- Tracksplit

The PMU controls up to 96 remote units located throughout the vehicle. The distributed system architecture is a star structure which is expandable by clustering. The PMU contains 12 remote ports. Each port requires 5 pairs of wires to communicate with a specific location in the vehicle. Up to eight remote units can be clustered at any location to minimize aircraft wiring.

THIRD GENERATION MICROMINIATURE MODULAR SYSTEM

The MMSC is a third generation microminiature, modular, conditioning/encoding product. The first Micro Miniature PCM Encoder (MMP) was originally created in 1973 and has been used in literally thousands of flight test applications. The second generation

microminiature encoder, and corresponding signal conditioning unit (MSC) were created in 1979. In 1980 the MDS was created which used the same circuitry in high reliability hermetic hybrid modules. The MDS is typically used in high reliability applications but has also been used in high shock applications with environments to 13,000 G's.

CUSTOM INTEGRATED CIRCUITS

The MMSC uses semi-custom and full custom integrated circuits to achieve extremely high density. With these techniques circuit functions which previously required up to 4 hybrid modules have been combined into a single module.

USED IN MISSILES AS STAND ALONE CONDITIONER/ENCODERS

The MMSC has been selected for major missile flight test programs since the signal conditioning and encoding unit is extremely small. Three of these applications are as follows:

- Autonomous Guided Conventional Weapon (AGCW)
- Advanced Air-to-Air Missile (AAAM)
- Advanced Medium Range Air-to-Air Missile (AMRAAM)

These applications led to the creation of additional conditioning modules and the stand-alone option which allows the system to operate as a signal conditioner and PCM encoder in a single package. The additional modules are as follows:

- RTD conditioner
- Low impedance accelerometer conditioner
- Bridge or voltage conditioner with 2-pole filter
- Charge amplifier and 6-pole filter

OTHER APPLICATIONS

The MMSC has been selected for various other applications by the following customers.

WRIGHT PATTERSON AIR FORCE BASE
BELL HELICOPTERS
MCDONNELL HELICOPTERS

SUMMARY OF SIGNAL CONDITIONING MODULES

Signal conditioning modules have been created for various types of analog and digital inputs. The signal conditioning is compatible with virtually all types of sensors in use today. As described above the MMSC can contain any or all of the modules described. The complete family of signal conditioning modules is described below:

Signal Conditioning Module 1; this module provides two channels of bridge or voltage signal conditioning. The module provides bridge excitation, programmable amplification, and a fixed frequency six-pole pre-sample filter.

Signal Conditioning Module 3; this module provides one channel of bridge or voltage signal conditioning. The module provides two levels of bridge excitation, programmable amplification, a programmable presample filter, and a sample and hold. The filter contains 7 frequencies which are software controlled plus bypass.

Signal Conditioning Module 5; this module provides two channels of constant current excitation and two channels of programmable instrumentation amplifier and a fixed frequency six-pole presample filter per channel.

Signal Conditioning Module 6; this module provides four channels of bridge or voltage conditioning. channel provides a programmable instrumentation amplifier and a fixed frequency two-pole presample filter. A single constant voltage source is provided per module. Modules are available with and without bridge completion.

Charge Amplification Module; this module provides two channels and is designed for use with piezoelectric transducers. It provides charge conversion, a programmable amplifier, and a fixed frequency pre-sample filter.

Analog Multiplexing Module 1; this module provides analog multiplexing of up to sixteen single ended analog inputs. Each channel contains an instrumentation amplifier to eliminate low level multiplexing.

Analog Multiplexing Module 2; this module provides analog multiplexing of up to eight differential analog inputs. Amplifier gain or input attenuation is individually specified per channel.

Thermocouple Signal Conditioning Module; this module provides eight channels of thermocouple signal conditioning. It interfaces with the CJC-808 isothermal reference junction and provides signal multiplexing of the thermocouples and compensation for the reference junction block temperature.

Multiplexer Module; this module provides conditioning for up to 24 (two words) of bi-level (discrete) input signals.

Synchro/Resolver Module; this module provides one channel of synchro or resolver conditioning (user selectable). The module provides a tracking digital conversion with programmable resolution to 16 bits.

Digital Frequency Module; this module provides two channel of frequency-to-digital conversion with input signal conditioning. Each channel has a resolution of 12 bits. Input signals from 100 mv (RMS) to 30 V p-p are accommodated.

OVERHEAD MODULES

Overhead modules in the MMSC consist of the following modules:

- Programmable Offset Module
- Analog-to-Digital Converter Module
- Remote Interface Modules or PCM Formatting Modules
- Power Supply

The signal conditioning modules described above provide either a multiplexed analog signal or a parallel digital output signal. The multiplexed analog outputs are applied to the programmable offset module and analog to digital converter module. The programmable offset module provides programmable offset, the module corrects for parasitic offset to eliminate channel to channel scatter. The A/D converter has a resolution of 12 bits and operates to 167,000 samples per second.

When the MMSC unit is to be operated as a remote unit two interface modules are required to interface with the master unit as follows:

Remote Interface Module; this module accepts the serial digital address information with bit clock and word clock. The address information is converted to parallel and applied to all modules in the unit.

Interface Local Module; this module accepts data from the A/D converter and the digital signal conditioning modules. The data is converted to serial and differentially driven to the master unit. A remote bit clock is also provided.

When the MMSC unit is to be operated as a stand alone conditioning/encoding unit, the following modules are required:

Formatting Module; this module provides the formatting of the data into a serial PCM data stream. Data is accepted from the A/D converter and the digital signal conditioning modules.

Timing Module; this module provides the basic system timing (bit clock and word clock).

The MMSC contains a DC/DC converter which operates from 28 VDC aircraft or missile power. The PS-801 and PF-801 filter module provide up to 700 ma of bridge excitation (which is regulated in the signal conditioning modules) in addition to the power required by all of the modules.

THE FUTURE

Aydin Vector intends to continue to develop additional modules for the system as customer requirements dictate. One module currently in development is described below:

- Automatic Gain Ranging Amplifier; the AGRA module used in the MMSC is currently under development. It is similar to the AGRA-100 which was developed for Wright Patterson AFB and has a successful flight test history when the amplitude of the input signal is unknown.

HERMETIC SYSTEM ON PLUG-IN CARDS

Aydin Vector is currently developing a system which uses hermetic hybrids on plugin circuit boards. The design uses identical modules to the MMSC above and achieves the same outstanding performance. In addition the system contains the following additional features:

- Programmable bridge balance
- Bridge completion
- Zero and shunt calibration

The hermetic hybrid system contains programmable bridge balance in addition to programmable amplifier offset. Each channel employs a 12 bit D/A converter which allows the user software control of bridge balance on preflight.

The hermetic hybrid system contains user configurable bridge completion resistor headers which allow the use with quarter or half bridge devices.

The hermetic hybrid system contains zero calibration and shunt calibration relays for verification of channel integrity. When the conditioning card is used with bridges the user can install the appropriate shunt calibration resistors in the header provided. When the conditioning card is used with voltage inputs, the system can be configured for series (voltage substitution) calibration.

SUMMARY

The MMSC and hermetic hybrid systems provide an extremely accurate, high density solution for current flight test applications. These two products offer the following advantages:

The MMSC is significantly smaller and lighter weight than other unit which performs the conditioning and encoding features described above.

The MMSC and hermetic hybrid system offers an accuracy which is nearly an order of magnitude better than our competition. The accuracy of the bridge conditioning (including excitation) over the operational temperature range of -40 deg C to + 100 deg C is as follows:

Standard accuracy: +/- 0.3%
Optional accuracy: +/- 0.15%

