A MODULAR APPROACH
TO DATA ACQUISITION SYSTEMS

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ABSTRACT

A description of a unique approach for construction of modular data acquisition systems using a family of standard thick film hybrid circuits. Each module is described in terms of its universal function and examples of various system constructions are explained. Demonstrating the advantages of this approach in offering minimum size, weight, and high reliability, with reasonable cost for various program applications.

INTRODUCTION

In 1975 Aydin Vector designed and developed the first hybrid thick film data acquisition system (Model: MMP-600). The system was completely modular such that modules could be assembled in various configurations to meet the users requirements. One or more multiplexer modules, each equipped with a 37 pin microminiature connector and providing up to 32 analog channels or 30 bi-level channels could be stacked with the basic modules to form a complete PCM system. The advantages of this system are that a user could expand or change the system configuration by simply adding or deleting modules by plugging them into the stack. (See Figure 1)

The basic modules for all systems consists of a power supply, timer, formatter, programmer, sample and hold and analog to digital converter and end plate. Located under an access cover on the end plate is an EPROM which can be removed without disassembly of the module stack or desoldering. The PCM format can be re-programmed in the field providing the user with an additional option of changing the sampling rates by super commutation or sub-commutated frame formats.

Additional custom modules could be added to the stack providing specific applications such as differential analog inputs, low level amplifiers, Quad filters, delay shift registers,
serial data multiplexing, and counter modules. These modules further expand the capability of the MMP-600 PCM unit.

In 1980 Aydin Vector elected to update the MMP-600 design by using a CMOS EPROM with a larger memory (256 x 16). This new system became the MMP-900 Series which provides the same advantages as the MMP-600 unit except that the modules could be manufactured in stack up or hermetic sealed units. (See Figure 2)

The 900 Series modules provide the user with additional capabilities such as 64 combinations of gains and offsets can be provided from one programmable amplifier, single ended or differential analog inputs can be programmed in the same analog multiplexer, and the channels can be programmed to any location in the format by re-programming the EPROM address and control circuits. This product improvement allows the user to change gains, offsets, and channel locations by changing the EPROM or re-programming the unit.

The advantages of using the modular data acquisition system are that the modules can be mass produced thus reducing cost and delivery time. User flexibility is also provided by adding modules to the stack to expand the system capability and re-programming the EPROM’s provide additional formats, pins, offsets or single and differential input modes of operation.

MANUFACTURING AND TEST TECHNIQUES

The modules which make up the MMP-900 and MMP-600 systems are manufactured completely by well proven reliable processes and materials of hybrid thick film technology. The construction meets the requirements of MIL-M-38510, Class B with the exception of the non-hermetic sealed modules which cannot meet the leak test requirements of MIL-STD-883.

The integrated circuits, transistors, diodes, thin film resistors, and monolithic capacitors are bonded and interconnected on multilayer screened ceramic substrates which also contain screen printed thick film resistors. Manufacturing process travellers define the process steps required to completely build and test each module. Each individual operation is controlled by a detailed process specification which describes the operation in sufficient detail for the operators to follow. These details assure increased reliability of the end product.

The standard modules are manufactured in groups or lots thus reducing the cost of the systems. This approach allows the manufacturer to use automatic and or semi-automatic manufacturing equipment for wire bonding, chip mounting, and substrate screening. Set-up
time is amortized over the lot size and economic lot buys for material also help lower the overall loss of producing the modules.

Each module is individually tested to written procedures by using automatic or semi-automatic test equipment. The first module test occurs at the completion of the assembly prior to covering or sealing of the module. A second test occurs prior to burn-in and final test is completed after burn-in. The non-hermetic modules are burned in at the system level while hermetic modules are burned in individually prior to installation in the system. Process screening tests are conducted on all modules prior to burn-in or system integration, in accordance with MIL-STD-883 as applicable. The process screening tests consist of: stabilization bake, thermal cycling, hermetic seal test, acceleration, and burn-in.

**MODULE FUNCTIONS 900 SERIES (Refer to Figure 3 for Basic System Block Diagram)**

The power supply module provides the supply voltages required to operate the entire system. The nominal input voltage is +28 Vdc. A crystal dock circuit is also provided within the power supply module for synchronization and control of the PCM unit. External inputs can be provided for external synchronization to other equipment such as computer data or timing circuits. The DC/DC converter in the power supply is synchronized to the data clock to reduce system noise for low level inputs.

The programmer modules work in conjunction with the EPROM’s and generate the major frame sync, minor frame sync, addresses, controls, and frame counter functions for the entire system. The addresses and controls are sent from the programmer to the multiplexers, amplifier, formatter, and timer modules at two (2) times the system bit rate, enabling the addresses and controls to be latched in one-half the word time.

The analog multiplexer module accepts the input signals from the measurement sensors, adjusts the input for single ended or differential operation, depending upon the instruction code received from the programmer module, and forwards the measured data, in the sequence requested by the programmer address, to the programmable amplifier.

The programmable amplifier receives the data from the analog multiplexer and adjusts its offset and gain for the particular input to a pre-determined range as instructed by the address from the programmer module under memory control. After the data is offset and amplified, as required, the amplifier module forwards the result to the pulse amplitude modulation (PAM) output.

The sample/hold and analog-to-digital converter module accepts the PAM output from the programmable amplifier, takes a sample of the analog data, holds the sample and converts
the analog sample to 8, 9 or 10 bit digital data as required by the system and transfers the
digital data to the formatter module.

Bi-level or discrete input data is accepted by a bi-level multiplexer in three (3), eight (8),
or ten (10) bit words. (Each bit represents one input). The bi-level multiplexer forwards
this data directly to the formatter module in the sequence and time required by the
programmer addresses. The formatter module accepts the analog and bi-level data, formats
the data as instructed by the programmer module and generates the NRZ-L data which is
forwarded to the timer module.

The timer module generates the word clock, sample pulse, and bit clock from the power
supply crystal clock. These clocks and pulses are provided to the programmer, formatter,
analog to digital convertor and programmable amplifier for control of the system timing.
The NRZ-L output from the formatter module is accepted by the timer module and
transformed into any of the following outputs: NRZ-L, NRZ-M, NRZ-S, Bi-ϕ-M, Bi-ϕ-S,
Bi-ϕ-L, or Miller Code. A pre-modulation filter is also available in the timer module if
required.

**SPECIAL APPLICATIONS**

In addition to the standard features described so far, the modular data acquisition system
can be adapted to accept digital or analog data from guidance computers, autopilots,
seekers and 1553 Data Busses. Inputs of more than one type can be formatted within the
same encoder. Digital signals of all types can be accommodated through the utilization of
standard and custom modules.

Analog or bi-level inputs may be signal conditioned in various ways with the addition of
hybrid thick film signal conditioning modules and or discrete electronic parts. The signal
conditioning is virtually unlimited, bridge conditioners, strain gauge conditioners, thermo
couple conditioners, charge amplifiers and many more can be accommodated within the
encoder package.

With additional interface modules, remote units can be added to the system configuration.
The master unit will supply the address and control lines to the remote units, and the
output data can be read out thru the master unit. The interface modules utilize line driver
and line receiver devices in CMOS or TTL type circuits. The line drivers allow the remote
units to be placed in locations hundreds of feet from the master unit.
SYSTEM CONSTRUCTION

The MMP-600 and MMP-900 Series systems are packaged in the stack up style frames shown in Figure 1. These systems consist of non-hermetic sealed modules and are the smallest and lightest weight data acquisition systems available at the present time.

The MDS-900 Series systems are packaged on printed circuit boards using hermetic sealed modules. These systems fully meet the requirements for high reliability aerospace applications. The systems can be designed to fit into a variety of different areas by changing the shape of the system housing. The MDS-900 units can be used in airborne or ground environments. Figure 2 illustrates two different packaging styles.

RELIABILITY

All data acquisition systems are manufactured and tested to strict process control procedures. The Quality Assurance Department reviews and approves all process and test documentation prior to implementation. In-Process Inspection, Process Monitoring, and Final Test are accomplished by Quality Control personnel and periodically monitored by Quality Assurance Engineers to assure compliance to the specifications and processes. The electronic design utilizes the latest in CMOS devices available, thereby reducing power and heat dissipation and increasing the calculated mean time between failure rates. The mechanical part layouts and module attachment have been qualified and tested to withstand high shock and vibration environments, 15,000g at 2 milliseconds and 109 G rms random vibration to 7000 Hz.

SUMMARY AND CONCLUSION

The modular approach to manufacturing data acquisition systems, described in this paper, allows the user and manufacturer to design and construct the smallest and lightest weight systems available today be utilizing hybrid thick film circuits. The overall program costs are reduced by using the standard circuits, which are already available. Manufacturing in large lots can reduce the material, manufacturing, and test costs. Additional custom modules can be directly interfaced with the standard modules to provide additional system capabilities. Overall system reliability is enhanced by the utilization of proven hybrid thick film technology and the latest in CMOS devices to reduce power and heat dissipation. The electrical design characteristics also allow the user to reduce the amount of signal conditioners required by using the available gains and offset provided in the programmable amplifier. In conclusion the modular data acquisition system can reduce the design and development costs for the user and manufacturer and provide the smallest, lightest weight, most reliable, and most cost effective systems available today. User design and
development time is significantly reduced by the utilization of standard and custom modules. Changes in the system configuration can be accommodated by the programming or adding additional modules without significant costs.

FIGURE 1
MMP-600 STACKABLE MODULES
FIGURE 2
SERIES SYSTEMS & HERMETIC SEALED MODULES
FIGURE 3
BLOCK DIAGRAM
900 SERIES, BASIC DATA ACQUISITION SERIES