FROM TRANSDUCER TO DISPLAY IN A WORKSTATION ENVIRONMENT: A REAL TIME DATA ACQUISITION SYSTEM

William D. Wargo
Manager, Microsystems Division

Gill Watt
Applications Engineer

Metraplex Corporation
5305 Spectrum Drive
Frederick, Maryland 21701

ABSTRACT

This paper will address the application of an *end-to-end programmable* PCM telemetry system featuring a modular, programmable data acquisition and encoding system, and a data analysis work station using an IBM PC compatible computer.

INTRODUCTION

The combination of a programmable data acquisition system with a transportable telemetry work station is a revolutionary development in the field of telemetry. It enables the test engineer to perform more efficiently and effectively, both in configuring a data acquisition system and in acquiring the test data.

Together or separately, these two telemetry tools aid the test engineer in designing and implementing data acquisition systems in a minimum time and for a minimum cost.

Using modular plug-in cards in a microprocessor based data acquisition system allows it to be easily reconfigured and reprogrammed for use in the next test program, which decreases capital investment and lead time. Furthermore, the design employs identical signal conditioning cards for all applications, thereby eliminating the need for custom designed signal conditioners.

Recent advances in microcomputer technology now makes it possible to perform real-time telemetry data processing in a low cost, transportable, PC-based system. In addition to its end-to-end system applications, the work station can function as a complete stand-alone system for analyzing PCM telemetry data.

AN END-To-END PROGRAMMABLE PCM TELEMETRY SYSTEM

An *end-to-end programmable* PCM telemetry system enables the test engineer to simultaneously define the frame format, channels, and system configuration for both the encoding and the decoding systems. This eliminates compatibility problems, reduces the time spent entering data, and eliminates time-consuming errors.

Additionally, the work station will automatically track any changes in the configuration of the encoding system made during the course of the test program and will make corresponding changes in the decoding system.

Fully automatic calibration in an end-to-end system permits rapid and accurate checkout of installed instrumentation. As the programmable data acquisition system executes an internal calibration sequence, the work station automatically performs gain checks and linearity checks, and can automatically flag any channels that deviate from the user-programmable performance specifications.

An end-to-end programmable PCM telemetry system can also greatly enhance the operation of a data acquisition system through automatic format switching that allows the user to alter the test parameters and frame format configurations on the fly. This permits the user to maximize bandwidth and channel sensitivity for each specific test. Format switching is initiated in the data acquisition system and is transmitted to the work station through the PCM bit stream to the ground station, which then makes an identical format transition to track the data acquisition and encoding system. This feature allows the test engineer to switch from acquiring data on one set of parameters to another set of parameters in a fraction of a second with no significant loss of data. For example, a flight test engineer could perform two separate tests on a single flight with only one set of instrumentation, greatly increasing the efficiency and effectiveness of the flight test program.

A PROGRAMMABLE DATA ACQUISITION SYSTEM

Individually, the various components of an end-to-end PCM telemetry system can be used to enhance productivity and accuracy of testing programs. The modular, programmable data acquisition system has three main benefits.

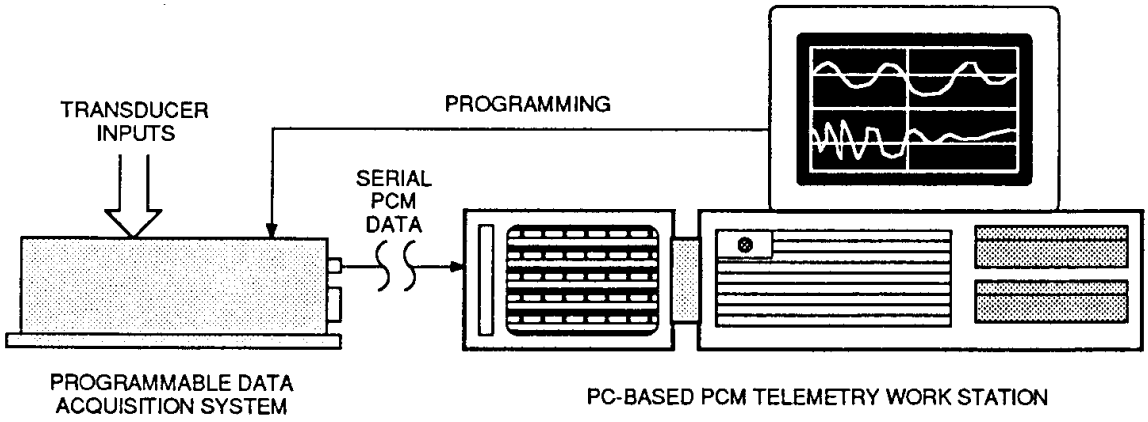

Figure 1. An End-to-End Programmable PCM Telemetry System

Reusable Components

Major test ranges are in a perfect position to take full advantage of the unique capabilities of a modular, programmable data acquisition system. They can confidently purchase a whole library of signal conditioning cards and several housings with the assurance of being able to use them in a variety of future testing programs.

For each test, the hardware can then be selected from stock and configured with the programming software, bypassing the laborious and time consuming tasks of either designing and building the necessary data acquisition equipment or sending a new specification out for procurement. Thus, stocking a library of cards and a set of housings will allow the user to configure a new data acquisition system for a specific test in a few hours instead of weeks or longer. The end result of this operation is a significant savings in time, labor, and materials.

Flexible Configuration

On any major testing program, it is often difficult to precisely determine the test parameters prior to acquiring the test equipment. All too often, the testing requirements change during the course of the testing program, causing schedule delays while reconfiguring, modifying, or purchasing equipment.

The programmable data acquisition system is based on a single bus architecture, with identical housings and completely interchangeable signal conditioning cards. Setting up a new configuration is then as simple as filling a housing with the appropriate cards, downloading the correct program with user-friendly software, and turning on the power.

All major functions of the data acquisition system are programmable, so that system configurations can be quickly created and modified, and multiple formats for a single hardware configuration can be saved on disk and individually downloaded to the data acquisition system within seconds. Additional parameters can be included simply by adding more programmable channel cards. Such flexibility is highly useful in configuring test data acquisition systems because it allows the test engineer to modify the data acquisition system rapidly as test conditions and parameters change.

Small to Large Scale Testing

The configuration flexibility of a programmable data acquisition system makes it equally suited for either small scale testing or large scale testing. For a simple test with a few channels, the data acquisition system can be configured as a complete telemetry system in a single housing, including signal conditioning and encoding. On the other hand, a large scale testing application can take full advantage of the expandability of the data acquisition system. For example, by using multi-housing and merge configurations, over 1000 fully signal conditioned channels can be easily encoded into a single PCM bit stream.

760 SERIES HYBRID DATA MEASUREMENT SYSTEM

Five features of the Metraplex 760 Series make it an ideal modular, programmable data acquisition system: (1) rugged and miniature construction, (2) complete signal conditioning and pulse code modulation (PCM) encoding in a single package, (3) modular and flexible system architecture, (4) full programmability with user-friendly, menu-driven software, and (5) complete automatic calibration of all analog channels.

Ruggedized, Miniature Construction

Vehicle and flight testing require a data acquisition system that can operate accurately through extreme temperatures and shocks. Surface-mount and thick-film hybrid technology make the 760 Series very compact, and the solid aluminum housing with Mil-Std connectors provide a ruggedized system for use in high-environment settings. The complete system is approximately the size and weight of a brick and has been environmentally qualified for extremes in temperature, shock, and vibration. The majority of the system is manufactured on multi-layer printed circuit boards using surface-mount technology while other components, such as the programmable low-pass filter and amplifier on the Programmable Channel Card, are manufactured on a thick-film hybrid substrate.

Complete Signal Conditioning

For simplicity as well as environmental considerations, the 760 Series is designed as a complete microprocessor-controlled data acquisition and encoding system contained in a single housing.

Each housing features 16 identical slots for signal conditioning cards and a PCM encoder consisting of a microprocessor card, a PCM output card, and an analog to digital converter card (Figure 2).

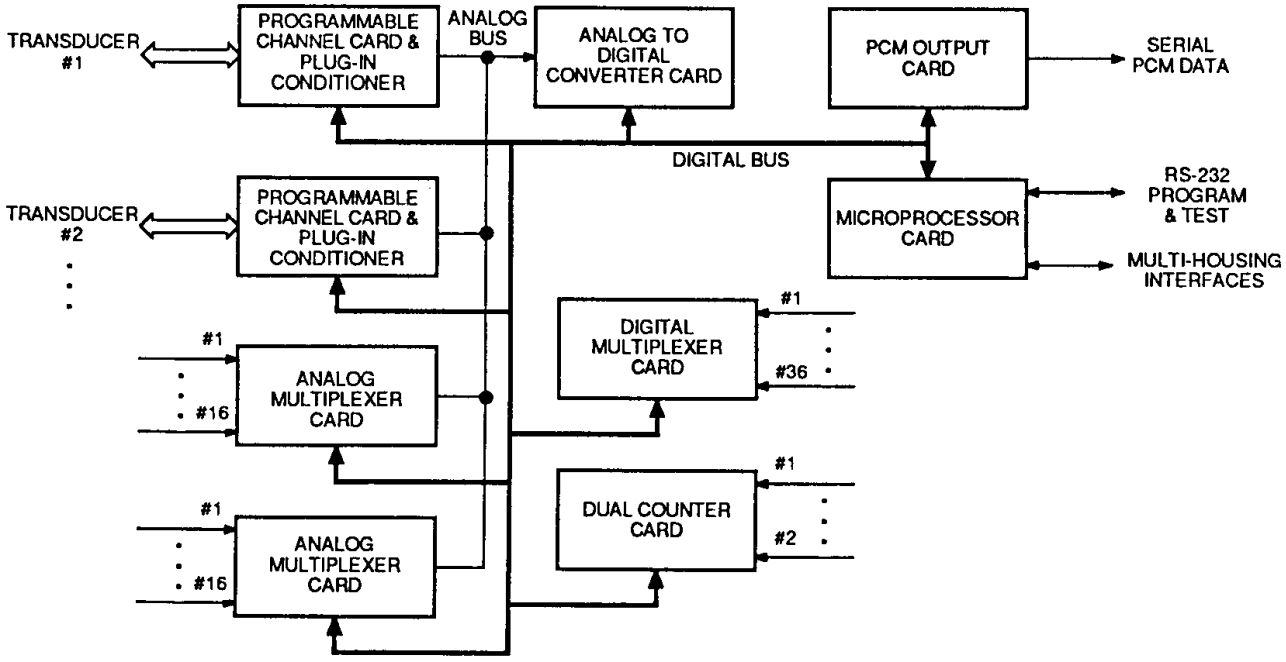

Figure 2. Single Housing Configuration

A full complement of signal conditioning cards are available. The basic card is the Programmable Channel Card, which features plug-in signal conditioning modules for all standard transducers. Each Programmable Channel Card also has an individually programmable transducer excitation power supply.

Other signal conditioning cards are available for multiplexed analog and digital signals, synchro/resolver signals, and frequency signals. The standardized bus architecture of the 760 System has greatly simplified the development and implementation of additional signal conditioning cards for specific customer data acquisition needs.

Modular and Flexible System Architecture

Expanding the data acquisition system is easily implemented by interconnecting two or more housings, using either the multi-housing configuration or the merged PCM configuration.

The multi-housing configuration features a single microprocessor controller with a completely digital interface between housings. Control and data links provide simple and accurate operation of up to eight housings.

The merged configuration can be used for systems that require higher bit rates, even larger numbers of signal conditioned channels, or greater distances between encoders. It is designed to combine multiple serial PCM streams into a single PCM stream. Since each bit stream can be produced by a multi-housing system, the total number of signal conditioned channels available in this configuration is quite high. Another advantage of the merge system is that the possible distances between the individual acquisition and encoding systems are greatly expanded through the use of serial PCM data transmission.

Fully Programmable

To fully utilize this level of hardware flexibility, the configurations of the 760 Series Hybrid Data Measurement System are done almost entirely in software. The HDMS Software is a user-friendly, menu-driven software package that allows the operator to program the signal conditioning parameters and the PCM encoding format. System configurations are created on an IBM compatible computer and downloaded via an RS-232 link to the 760 System where they remain stored even without power.

Each Programmable Channel Card provides individual programming control over the following signal conditioning parameters: pre-sample filter cutoff frequency, excitation voltage, amplifier gain, and amplifier offset.

The PCM encoding format includes the following programmable parameters: bit rate (with automatic pre-modulation filter adjustment), output code, parity, and frame format. The length of the frame format is fully programmable and any channel can be assigned to any location in the frame in order to optimize the sample rates for maximum bandwidth efficiency.

Complete Automatic Calibration

The 760 System is able to perform an internal five-point calibration of all analog channels, and may be initiated either by a single command line or by the HDMS software. The

calibration system fully compensates for all gain and offset variations in each individually programed channel to produce a true transducer substitution calibration. This rapid five-point calibration system can be used to quickly check out the data acquisition system before performing the test and acquiring data.

PC-BASED PCM TELEMETRY WORK STATION

Airborne Monitoring

The small size and portability of a PC-based telemetry workstation make it ideal for use as an airborne monitoring station for telemetry data. Not only can it provide the on-board test engineer with real-time monitoring of telemetry data, but the workstation can supply quick analyses of the data while the test aircraft is still in flight. With these tools, the test engineer can make immediate decisions concerning the current flight test, contributing to more accurate and more effective testing.

To enhance this application, the work station is readily available in a ruggedized configuration that is rack-mountable and capable of withstanding the high environment of the typical flight test aircraft.

Off-Site Testing

Frequently, to obtain the required environmental setting or security, it is necessary to perform vehicle testing away from the usual data reduction facilities. The usual procedure for such testing involves recording the data on analog or digital tape and sending the tape to the data reduction facilities for processing. This procedure involves a great deal of time in shipping the tape, analyzing the data, and returning the analyzed data to the test site. Occasionally, serious problems in the data acquisition system are not detected until the test has ended and the data analysis has begun. It is then necessary to repeat the entire test.

It would be far more efficient to be able to perform some basic data analysis at the test site. The same ruggedized configuration can also be used for off-site testing.

DRAWS PCM TELEMETRY WORK STATION

The DRAWS Data Recording and Analysis Work Station is a complete PCM telemetry work station designed around the IBM PC/AT architecture. This microcomputer based system provides the test engineer with a portable, low-cost PCM telemetry analysis tool to be used for configuring end-to-end telemetry systems, real-time monitoring of analog and bilevel data, digital data recording, and quick-scan viewing and analysis of captured data. In short, the PCM Telemetry Work Station is designed to perform the basic functions of a

PCM Telemetry ground station in a more portable, less expensive, and more flexible package.

Hardware

The work station has both hardware and software components designed specifically for the telemetry field and operates on a IBM PC/AT compatible microcomputer. The front end of the system is a small, high-performance, portable decommutator that contains a bit synchronizer, a frame synchronizer, and a parallel interface to transmit the acquired data to the work station. The microcomputer system is based on a state-of-the-art Intel 80386 microprocessor running at high clock speeds. In addition to the decommutator, the workstation includes uniquely developed IBM PC/AT compatible bus cards that handle the parallel interface with the decommutator, perform preliminary decoding of the data stream, and store selected data in the on-board memory.

Software

The data entry component of the software is designed to allow the user to quickly define frame formats and the individual data parameters. Easy menu-driven screens help the user to program the decommutator and define each analog and digital parameter. Other menu-driven screens allow the user to define trigger points for activating the data capture memory. Context-sensitive help screens exist for every operation, providing the user with the appropriate explanation at the push of a button.

The software also features full-color display screens enabling the user to visualize data quickly and effectively. The work station software displays real-time data for monitoring of analog and digital channels and captures data in memory for rapid reviewing, storage on magnetic media, or detailed computational analysis including magnitude fast Fourier transforms and digital filtering of data.

The software displays analog data in both a meter-like line-marker display and a scrolling waveform display; digital data is displayed as one of its two possible states, with user-definable function names. Quick-scan viewing allows the user to scroll both forward and backward through the captured data and to manipulate the data for more precise analysis by expanding the time scale, scaling and offsetting the data. The work station software displays are meant to allow the user to immediately understand and interpret the data.

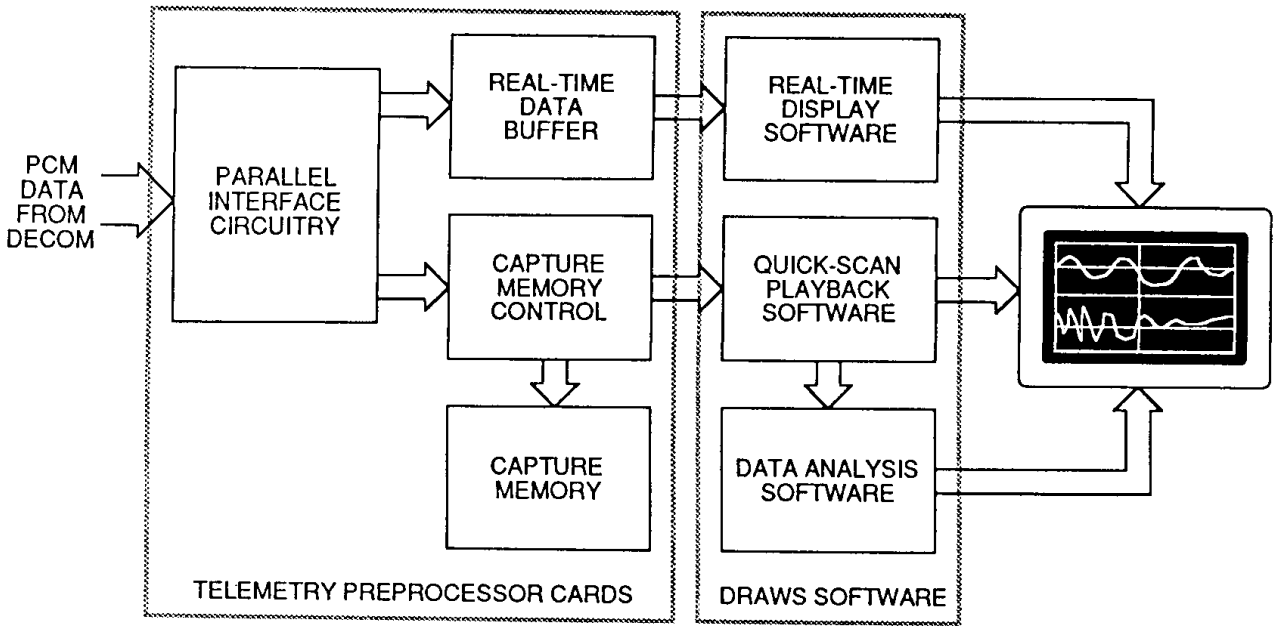

Figure 3. DRAWS PCM Telemetry Work Station

Flexibility

The IBM PC compatible hardware platform is particularly useful in this application, as opposed to a custom-designed machine, because there are numerous hardware and software packages already available to allow the user to expand and customize the system. For instance, a network interface card can be added to the DRAWS Work Station for high-speed data transfer to other computers for more intensive data analysis or for use on a local area network of work stations. It is also possible to add an external or internal hard disk drive with removable high-density cartridges for storing large quantities of acquired test data. Additionally, the DRAWS software includes translation software to transfer the acquired data into standard formats for use with the myriad of data analysis packages that are available to run on MS-DOS microcomputers. All of these customizations and expansions are possible because the workstation is designed on the ubiquitous IBM PC/AT architecture and are able to take advantage of the well established base of available PC hardware and MS-DOS software.

CONCLUSIONS

Technology makes complete end-to-end telemetry systems possible now, and the hardware required to complete this is already available. In the past decade, personal computers have been used to enhance productivity in many fields. Personal computers are now able to increase productivity in the field of telemetry through the use of end-to-end programmable systems. The true value of these systems is in the software support and ease of use. The

application is new and many advancements will be made as users gain experience to further increase the capabilities of these systems. These systems demand a new way of thinking—traditional data acquisition, collection, and analysis delineations are not able to take advantage of the advancements possible with end-to-end systems. A larger, systems approach must be taken towards these new telemetry systems to use them to their fullest abilities.