APPLICATIONS FOR A PORTABLE PC/104 BASED INSTRUMENTATION CONTROLLER

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ABSTRACT

PC based instrumentation and telemetry processing systems are attractive because of their ease of use, familiarity, and affordability. The evolution of PC computing power has resulted in a telemetry processing system easily up to most tasks, even for control of and processing of data from a very complex system such as the Common Airborne Instrumentation System (CAIS) used on the new Lockheed-Martin F-22. A complete system including decommutators, bit synchronizers, IRIG time code readers, simulators, DACs, live video, and tape units for logging can be installed in a rackmount, desktop, or even portable enclosure.

The PC/104 standard represents another step forward in the PC industry evolution towards the goals of lower power consumption, smaller size, and greater capacity. The advent of this standard and the availability of processors and peripherals in this form factor has made possible the development of a new generation of portable low cost test equipment.

This paper will outline the advantages and applications offered by a full-function, stand-alone, rugged, and portable instrumentation controller. Applications of this small (5.25"H x 8.0"W x 9.5"L) unit could include: flight line instrumentation check-out, onboard aircraft data monitoring, automotive testing, small craft testing, helicopter testing, and just about any other application where small-size, affordability, and capability are required.

KEY WORDS

PC/104, Flight Test Instrumentation, Data Acquisition

INTRODUCTION

PC/104 modules are small (3.6" x 3.8") boards, designed to be stacked together and interconnected through pin/socket connectors so that no backplane or card cage is required. The PC/104 form factor was originally developed by Ampro Computers in California during the late 1980's. The specification was first published in 1992 and is now

maintained by the PC/104 Consortium. The PC/104 designation is derived from the fact that the processors used are the same as those in standard IBM compatible personal computers and that 104 pins are used to interconnect the modules.

The PC/104 Specification is based on the IEEE-P996 Specification which describes the mechanical and electrical specifications for standard 8-bit PC and 16-bit PC/AT buses. The PC/104 bus signals are identical in definition and function to these standard buses. The PC/104 Specification provides the electrical and mechanical interface for a compact version of the IEEE-P996 bus, optimized for the unique requirements of embedded system applications.

As shown in Figure 1, the PC/104 modules are much smaller than standard ISA modules and, when stacked, form a very compact system. Two module versions are specified, an 8-bit equivalent of the PC bus which utilizes the 64 pin J1 connector, and a 16-bit equivalent of the PC/AT bus which uses J1 plus a 40 pin J2 connector. The absence of a backplane allows the drive current requirements for most bus signals to be reduced to 4 milliamps, which reduces power consumption for most modules to around 1-2watts with resulting reductions in heat dissipation.

The mounting holes at each board corner allow the stack assembly to be bolted together with screws and spacers. The combination of the pin/socket electrical interconnects, the screws and spacers, and the overall small size provides for a compact package with excellent mechanical integrity. Reliability is enhanced over a standard PC bus due to the reduced number of electrical connection points achieved by the absence of the backplane.

Following the publication of the PC/104 standard, an increasing variety of modules began to appear. Over 150 suppliers now manufacture PC/104 products and it is possible to configure a highly capable system for applications where the reduced size, weight and power consumption of PC/104 can be used to advantage. Because of the small size and rugged design, the embedded processors are finding application in a wide range of industrial uses. Because of this, many of the PC/104 modules are available in extended temperature ranges.

In 1995, Terametrix began work on a prototype of a small, portable instrumentation controller using a PC/104 configuration combined with a 6.5 inch TFT flat panel display. The goal was to develop a highly portable, low cost platform that could not only be used for check-out of aircraft instrumentation systems but could also be applied to a wide variety of other applications.

BASIC CONTROLLER CONFIGURATION

With further refinements to the mechanical design, the final unit emerged as a 5.25"H x 8.00"W x 10.5"L package. The package houses a 486DX/4 100 MHz processor board with 16 Mb of RAM, IDE and floppy controllers, TFT display controller, and RS232/422 serial, parallel, and Ethernet I/O ports. A PC/104 card stack of up to six modules mounts to the processor board. An 850 Mb IDE HDD and 1.44 Mb floppy disk as well as a slot for Type I or Type II PCMCIA cards are accommodated. The user interface consists of a 6.5 inch color flat panel display capable of being viewed in direct sunlight and a 17 key keypad with glidepoint mouse. The hinged keypad folds up over the display screen when not in use. A universal power supply provides for power from either AC or DC sources. Recessed, readily customized I/O connectors on the back and side panels as well as front panel BNCs provide for flexible signal I/O. The unit is configured with a Windows 95 operating system and appropriate application software.

The principal objective sought in the design of this controller was to bring significant computing power to an easily handled, easily used package which could be applied to specific instrumentation problems. Limiting the size of the unit to achieve light weight and ease of handling also limits the size of the user interface which can be provided. The 6.5 inch screen limits the amount of data which can be viewed within a single screen and the small keypad and glidepoint mouse are well adapted for set-up and control from menus and lists but are not convenient for entry of large quantities of alphanumeric input.

These constraints define the types of applications for which the unit is well suited. Specifically, where the power of the processor can be utilized to diagnose or monitor large quantities of data and select specific data or results as output. This fits the unit’s intended purpose as a diagnostic test instrument for easy viewing of specific data which led to the product name - QuikView.

FLIGHT LINE INSTRUMENTATION CHECK-OUT

The first application considered for QuikView was for flight line instrumentation and avionics system check-out. As systems and vehicles continue to employ increasing numbers of serial buses to transmit data between units, a typical instrumentation system may output PCM, and interface multiple serial bus types including MIL-STD-1553, ARINC, and others. Simple functional and operational tests or checks on system input and output functions may require a rack of test equipment containing PCM decommutators, bus analyzers, and logic analyzers. QuikView can be configured as a portable test instrument for performing quick diagnostic and functional tests on systems containing one or more serial data bus types for use in laboratory, flight line, and factory floor environments. It is capable of selecting and monitoring PCM data and monitoring and simulating avionics bus

data. The unit may be used in place of complete bus analyzer systems to observe data values and message contents during functional or operational testing and check-out.

To provide for the basic PCM processing, Terametrix reduced all of the basic telemetry signal processing functions to a PC/104 board set. This resulted in a stack of three PC/104 cards - bit synchronizer, frame synchronizer, and data decommutator. In addition, a time code reader card is available and (for users of CAIS) a CVSD Voice Reproduction card is available. The IRIG PCM interface can accept serial NRZ data from 100 bps to 8 Mbps or serial data and clock at up to 24 Mbps.

For quick checks on the input data, a frame data capture mode is provided which captures the entire PCM data frame and performs limit checks against predefined expected values. A limited set of real time displays for viewing behavior of data channels is provided. These include scrolling alphanumeric, EU alphanumeric, and time history trace. The time history data may be logged to disk for later analysis. In addition, a frame map of all channel values may be viewed and scrolled.

If MIL-STD-1553 capability is desired a PC/104 1553 interface card may be added. In bus monitor mode the user may select an individual command, status, or data word from a message and capture the data to memory. Individual data words may be observed in real time as a digital or engineering unit value or as a time history trace. The time history data may be logged to disk for later analysis. A sequential buffer of message data may be captured and the entire message or individual words within the message may be viewed. In simulation mode the unit can function as a Bus Controller or a Remote Terminal. To operate as a BC the user creates data buffers of command messages. A BC message can then be selected for output and, if desired, can be looped on for repeated output. In RT operation, messages can be stored in memory tables to simulate the response given by the simulated RT to Bus Controller commands. Lists of BC and RT messages used for simulation and monitoring may be imported from floppy disk or via the Ethernet port. The messages and data values to be output or captured may be selected from these lists.

If ARINC 429/575 bus data must be monitored, another PC/104 card may be added. The ARINC interface provides one transmit and one receive channel and may be selected to operate at either 12.5 Kbps or 100 Kbps data rates. In receive mode, a label mask is applied to the data to allow selection of only labels of interest. The value of individual data words may be observed in real time as a digital or engineering unit value or as a time history trace. A sequential buffer of data word values for selected labels may be captured and viewed. The time history data may be logged to disk for later analysis. In transmit mode the user can create message buffers which may be selected for one time output or looped on for repeated output. In addition the user may select specific labels and data values for repeated output at specified time intervals. Lists of labels and data values used

for simulation and monitoring may be imported and the labels to be output or captured may be selected from these lists.

Application software for the RS232/422 port included on the processor board is designed to provide for capture and simulation of message data in systems utilizing an RS232/422 serial bus for point to point data communications. It may be operated either as a transmitter or a receiver. The user may define the message formats in terms of identifying headers, embedded word count values, fixed word count values, word lengths, error check bits, and message lengths. In monitor mode the user may select messages or specific data words within the message for capture and display. The value of individual data words may be observed in real time as a digital or engineering unit value or as a time history trace. The time history data may be logged to disk for later analysis. A sequential buffer of message data may be captured and the entire message or individual words within the message may be viewed. In transmit mode the user can create message buffers which may be selected for one time output or looped for repeated output.

The result is a portable test instrument equipped to monitor and display PCM, 1553, ARINC, and RS232/422 bus data. All of the interface cards mount on the processor card as a PC/104 module stack approximately 3.5 inches high.

PORTABLE DATA ACQUISITION

QuikView is adaptable to a large number of data acquisition applications where it is desirable to quickly set up a test and monitor existing signals or interface to installed transducers. The unit also lends itself to remote data acquisition and short range telemetry requirements. In data acquisition applications, the primary function of QuikView is to interface to the acquired signals, acquire and log the data, and provide quick-look data monitoring and validation. The acquired data may then be exported in a variety of formats including Excel and DADiSP for further analysis.

PC/104 modules, each including eight channels of universal signal conditioning per module, provide the necessary input interfacing for signals from analog sensors. Each channel has 5 wires available for ±excitation, ±signal, and shield. Screw terminal blocks are provided on the QuikView I/O panels for connection to sensors. Each channel may be individually programmed to interface to a thermocouple, RTD, thermistor, strain gauge, 4-20 ma current loop, or voltage input device. A pulsed constant current voltage provides excitation. Each module has a 16 bit analog to digital converter and can scan the data channels at 110 channels per second.

Modules may be added to provide programmable counter-timer channels for frequency conversion or totalization from pulse type sensors like flowmeters or tach sensors. Additional modules providing parallel or discrete digital inputs or serial inputs may also be added.

Data can be acquired and viewed in engineering units, in real time or playback, using three basic display types. An all channel display provides the current value of each active channel along with a hi/lo limit indicator. Channels can be presented in a scrolling alphanumeric form with hi/lo limit indicators or as a time history trace with limit indicators. Archiving the acquired data is done on the internal disk and can be transferred via floppy disk or over an RS232 or Ethernet port.

The advent of wireless LAN's have made available a wide variety of low cost radios operating in bands at 900 MHz, 2.4 GHz, and 5.8 GHz which can be utilized for low cost telemetry links in certain applications. These links utilize a variety of modulation techniques from FSK to spread spectrum and many operate under FCC Part 15 low power standards and do not require licensing. Communicating over these links is identical to transmitting over wire using RS232 or Ethernet ports.

As an example, a typical low cost radio currently available operates under FCC Part 15 at 900 MHz and can provide a range of 2000 feet outdoors. A data rate of 64 KBaud can be utilized with this radio which is quite adequate for many small data acquisition applications. Its power consumption of only 35 ma at 3V makes it compatible with a PC/104 based system.

A small telemetry system for remote data acquisition can be configured by using two QuikView units and adding a remote access software package. In this configuration, either QuikView could be operated remotely from the other. Alternately, a version of QuikView can be provided without a keyboard or front panel and could be used simply as a slave unit.

This system could be used in a variety of ways. For testing applications requiring limited transmission ranges such as might be found in testing construction equipment, the slave unit can be equipped with signal conditioning and transmit the acquired data to the master unit for storage to disk and quick-look review. Another application would be in an industrial data logging environment where the slave unit could be set-up and left at the data collection point to log low rate data over a long time period. Periodically the unit could be visited and interrogated to dump its data over the telemetry link.

CONCLUSION

The PC/104 standard and the PC/104 modules being brought to market now make it possible to provide small, lightweight low power systems with a level of capability and ease of programming not previously possible. This capability can be conveniently packaged, taken to the field, and applied to problems of testing and test support. The development of PC/104 based test instruments represents one more step in the continuing drive to achieve better test results in shorter times at less cost.

ACKNOWLEDGMENTS

PC/104 is a trademark of the PC/104 Consortium.
QuikView is a trademark of Terametrix Systems International, Inc.
Windows is a trademark of Microsoft Corporation.

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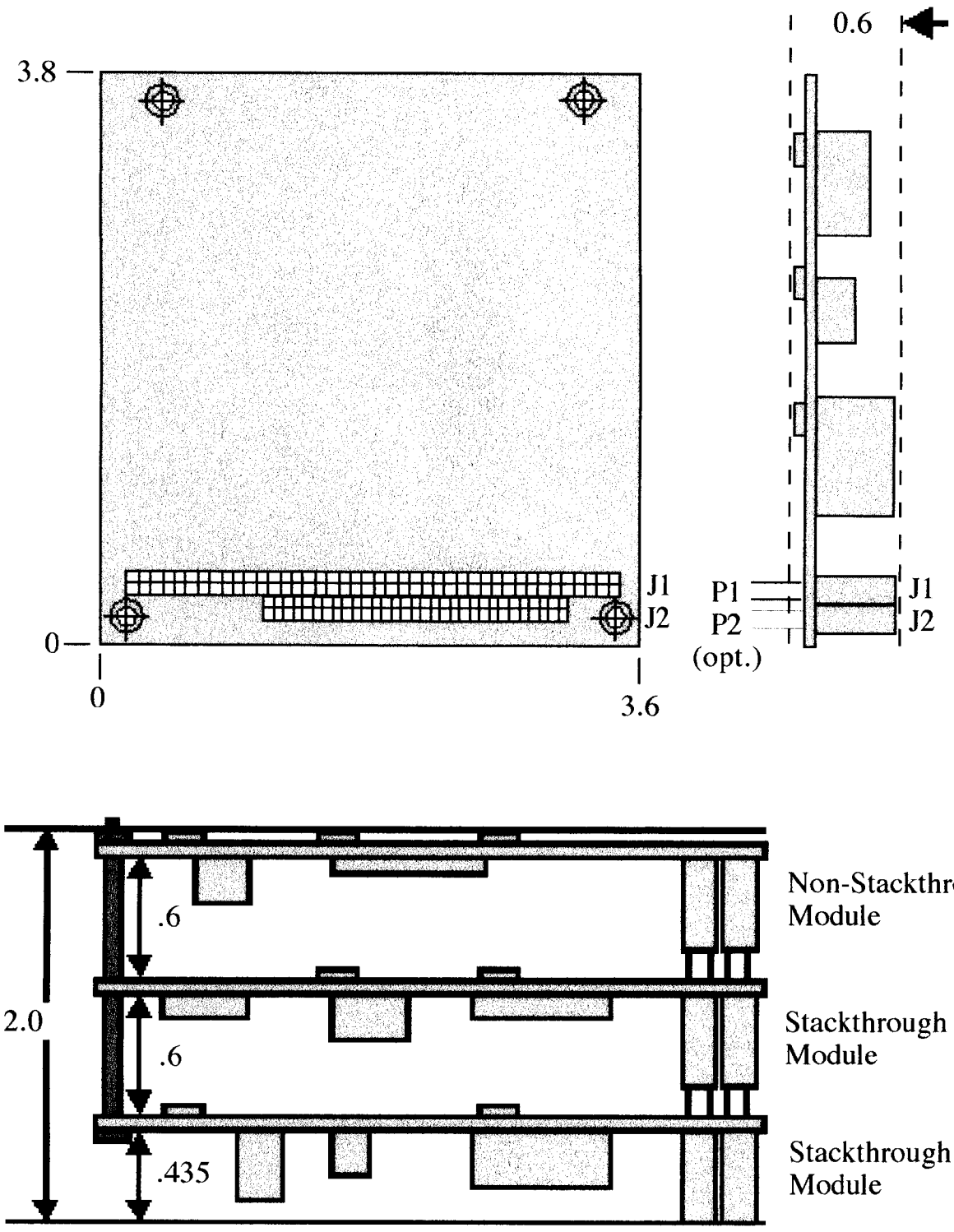

Figure 1 - PC/104 Board and Stack Configuration