Portable Data Acquisition Unit for Process Control and Monitoring Applications

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Abstract: The contribution deals with portable data acquisition unit which was developed at our department. The device is designed with respect to possible battery operation which in conjunction with laptop computer enables process measurement in areas where power source is not available. Its hardware design is adopted to fulfill high reliability and immunity against industrial environment, high precision and compact dimensions. Communication using standard RS232 serial interface makes it fully platform independent and thus suitable for connecting with any system, not only personal computer. Device has implemented ASCII - based communication protocol provides very effective way to communicate with number of software environments which are used in process control and monitoring tasks. In order to improve development of new software applications with this device a support program libraries for Visual C++, Control Web and Matlab/Simulink was created. Developed program libraries and data acquisition device were verified by control of educational time-delay heating plant model which is used in Automatic Control theory lessons.

Key-Words: Data acquisition, process control, Control Web, program libraries

1 Introduction

Process measurement is one of the most important tasks in the whole control system. It is determined by the fact that control accuracy is fully dependent on how preciously measuring chain works. Present-day there is available number of devices performing data acquisition tasks – standard cards for PCI or ISA bus which are suitable for standard personal computers and its industrial versions and modules for industrial automation usually equipped with RS485, CAN and other interfaces. Independent category is formed by smart sensors incorporating sensor, converter to unified signal and data acquisition device in one embedded system with very compact dimensions and low power consumption. They have number of advantageous features such as automatic diagnostic and calibration, high accuracy and immunity against electromagnetic interference due to short signal paths. On the other hand lower operating temperature range reduces their usage to laboratory applications, automotive and aircraft industry where compact dimensions and low weight are crucial. Quite often occurred situations when it is necessary to measure data in terrain where it is not possible to use standard computer equipped with DAQ card. In these cases laptop computer equipped with portable data acquisition device may be very advantageous.

This contribution describes multi-channel portable data acquisition device based on low cost general-purpose 8-bit microcontroller Freescale 68HC908GP32, which was developed in our department mainly for control and monitoring educational laboratory models. In order to improve development of new software applications with this device it is very important to equip it with supporting program libraries and utilities for Visual C++, Control Web and Matlab/Simulink.

2 Data acquisition device

2.1 Hardware overview

Hardware design of the DAQ device is fully adopted to support 16 analog inputs with 12-bit resolution, 8 digital inputs and outputs and one analog output with 12-bit resolution with stress on low power consumption enabling long operation when battery supply is used. The core of the DAQ device is 8-bit general-purpose Motorola microcontroller 68HC908GP32 with Von-Neumann architecture which is fully up-ward compatible with the 68HC05 family. On the chip is integrated timer interface with input capture and output compare functions, 8-channel analog-to-digital converter with 8-bit resolution, up to 33 general-purpose I/O pins, clock generator module with PLL, serial communication interface and serial peripheral interface. M68HC908GP32 has implemented several protective and security functions such as low-voltage inhibit which monitors power supply voltage, computer operates properly (COP) counter and FLASH memory protection mechanism preventing unauthorized reading of the

user's program. Internal RAM memory has capacity of 512B and FLASH memory 32KB. Internal clock frequency can be 8MHz at 5V operating voltage or 4MHz at 3V operating voltage. Microcontroller supports two low-power modes: wait and stop mode [1].

Analog-to-digital conversion is performed by external 12-bit A/D converter Linear Technology LTC1298 with very low power consumption. It is equipped by 3-wire synchronous serial interface enabling fast and effective way to communicate with microcontroller [2].

Digital-to-analog circuit utilizes 12-bit D/A converter Burr-Brown DAC7611 with internal 2.435V reference and high speed rail-to-rail amplifier. Output voltage is amplified to unified range 0 to 10V by general purpose operational amplifier. Digital I/O buffers protects microcontroller inputs against electrostatic discharge which may occur during handling and connecting DAQ device to the measured object and boosts output current from microcontroller pins and protect them against overload or short-circuit. Power supply circuits provide stabilized voltages for each functional block; +5V for digital circuits, +18V and -9V using DC/DC converter for analog output amplifier from one 9V single supply. Photograph of the prototype unit is in the Fig.1.
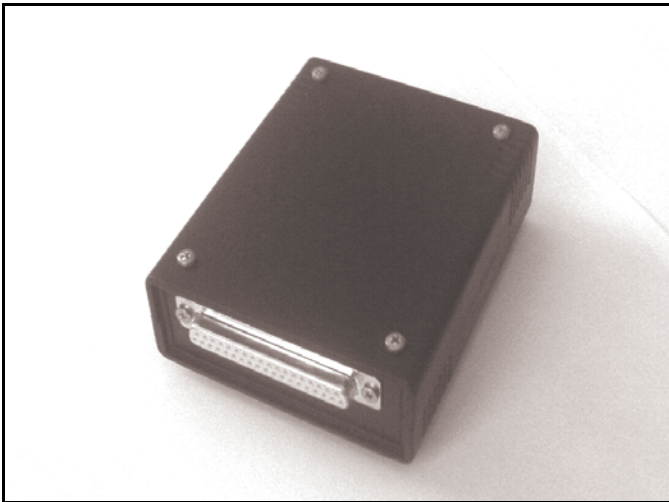

Fig.1. Portable DAQ device

2.2 Communication protocol

Data acquisition device communicates with supervision system using standard serial interface RS232 which is fully platform independent. In order to achieve compatibility with many software platforms universal ASCII-based communication protocol was choose. Very advantageous is possibility to send all implemented commands using generic terminal program that is contained in most operating systems. Each command can be divided up to five parts depending on concrete function implementation.

Communication starts with character "~" then must follow command name with fixed length to two

characters (for example "AO" means set analog output). After it is first command parameter with length one character (channel index) next character is space followed by second parameter (value). Command must be terminated by CRLF sequence.

3 Software support

Although communication protocol is very simple and easy to understand it is more comfortable in a control application to call functions which can automatically generate commands for the data acquisition device and consequently process its response. Application developer then does not need to know exact communication protocol and do not need to program it. This simplification is resulting in faster program development and reduction of debugging time. For portable data acquisition device were created supporting program libraries dedicated for Visual C++, Control Web 5 and Matlab 6.5 software environments.

3.1 Support libraries for Visual C and Matlab

Created libraries incorporate all functions implemented in the device including error processing. In order to device testing and diagnosis DAQ test utility was created. This program can test all functions of the DAQ device and may be very helpful for testing wire connections to the monitored or controlled system. Main window of diagnostic utility is depicted in the Fig.2. Matlab 6.5 library has implemented same functions with only one difference – in place of device handle is serial port object. Each function is available in separate m-file, so it is very simple to modify them by user.
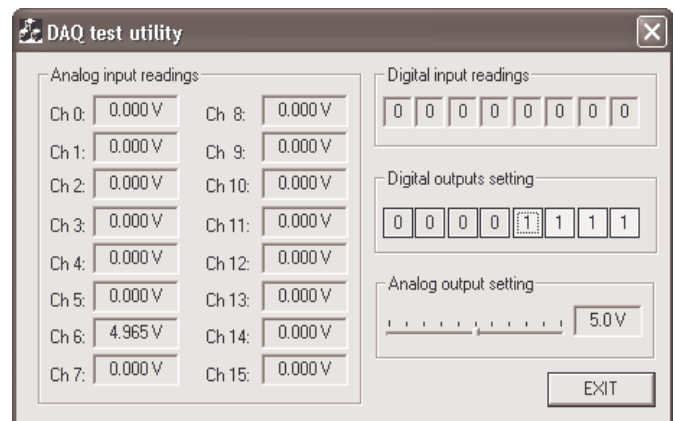

Fig.2. Main window of the DAQ device test utility

3.2 Driver support for Control Web

Application design in Control Web 5 is very fast and comfortable due to integrated development environment, which supports more possibilities how to create new application. The basic idea is to build in graphical editor basic components to the larger block, which can

gradually form whole system. Each component can be configured in sheet editor enabling transparent parameter settings. Because resulting code saved in text form and then compiled there is in parallel also text editor available. Each component can be selected from instruments palette organizing them in subcategories – for example system instruments, flat instruments and so on. Selected category can be expanded if it is possible to next sub trees. Expanded category called Flat Instruments can be seen in Fig. 3. Another type of the object in Control Web is data element. Each data element represents location in system memory, which can save value of the measured quantity, for example [3].
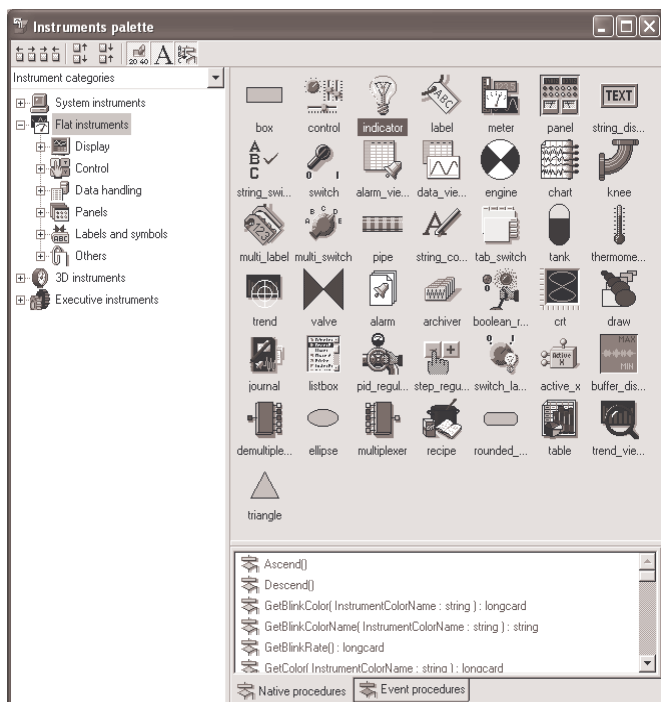

Fig.3. Control Web 5 Instruments palette

Control Web is in standard installation equipped with several drivers which can be divided to two main categories – for demonstration and testing purposes (Virtual Driver, Model driver, Simulation Driver, Simulating Driver) and general drivers for use in real applications (DDE Client Driver, ASCDRV5 driver, TCP/IP driver). Device driver is independent component in a form of dynamically linked library with standardized interface. During development of the Control Web system gradually originated three versions of the interface. Basic interface was defined for Control Web version 3 and must be implemented in every driver. Newer interface version 4 was created with Control Web 2000 and finally newest version 5 was defined for Control Web 5. Back compatibility is guaranteed by implementation of the basic interface in all higher versions of the interface.

Control web communicates with driver using channels, which must be defined in the driver map file (file with extension dmf). Each channel is defined by number, direction (input, output) and data type (real, boo-lean, string, and others). Driver configuration is stored in the parametric text file (extension par) containing specific information for correct driver initialization. All parameters can be easily viewed and modified using Driver inspector.

On the basis of requirements of the driver interface version 3 device driver for portable data acquisition device was created. It supports all available hardware functions – there are 16 input real channels, 8 boolean input and output channels and one real output channel. For verification of the correct function of the driver and DAQ device test application was created. It enables to manually set output channels and in 0.5 second period reads all input channels. Main window of the test application is in Fig.4.
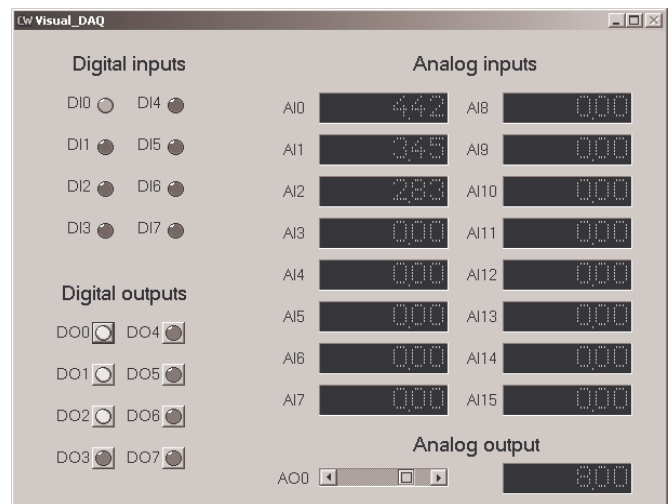

Fig.4. DAQ test utility for Control Web

4 Verification and results

Designed device was tested on laboratory model of heating plant system with four temperature measurement channels and one digital channel for heating element control connected with standard personal computer via serial communications interface.

Educational heating-system model with time delay developed at our institute is based on the principle of transferring heat from source through a piping system using heat transferring media to heat-consuming appliance. The heat transferring fluid is transported using a continuously controllable DC pump 6 into a flow-heater 1 with 750W heat power. The temperature of the liquid leaving the heater is measured using a platinum thermometer T1. Warmed liquid then comes into a thermal insulated coil 2 which is composed of a 15 m pipeline. Here a transport delay between 50 and 200

seconds originates depending on the pump speed. Heat exchanger 3 represents a heat-consuming appliance by releasing the thermal energy from the heat transferring fluid to the ambient air. The heat consumption can be set using two fans 4, 5 with adjustable speed. The temperature of the fluid entering and leaving the heat exchanger is measured by thermometers T2 and T3. Expansion tank 7 compensates for the thermal expansion effect of water. Schematic of the model is depicted in Fig.5.
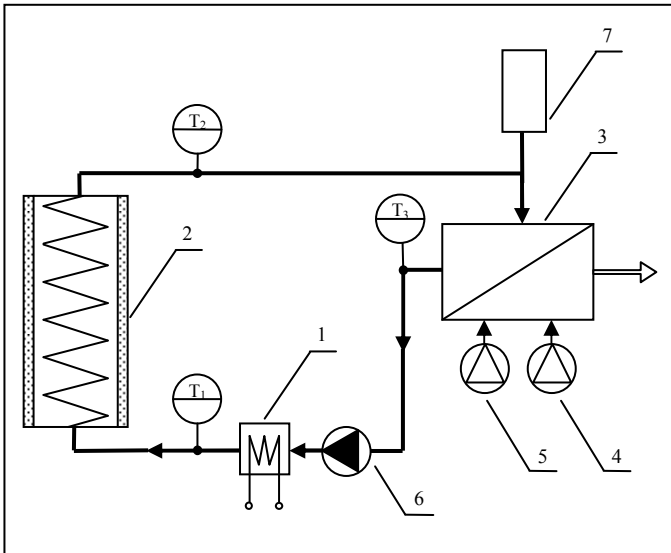

Fig.5. Schematic of the time-delay model

Main window of the developed control application in Control Web 5 is depicted in Fig.6 and Fig.7. The left part of the window contains simplified technology schematic with two control components for pump speed and demanded temperature setting.
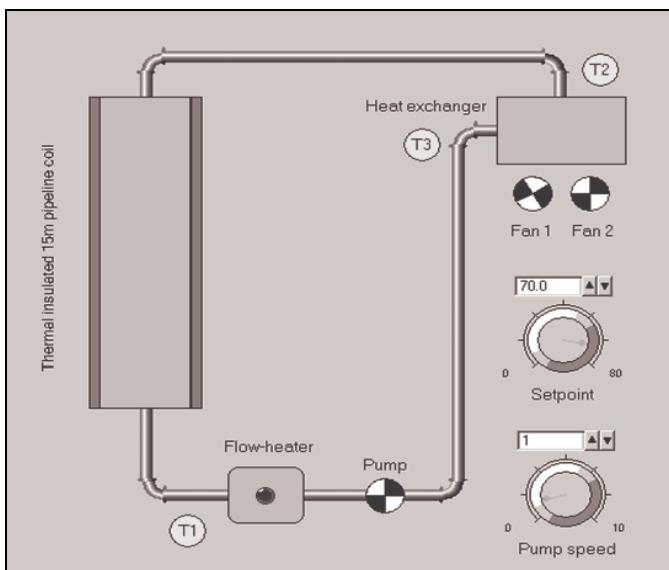

Fig.6. Time-delay model control application – left part of the window

The right part of the window visualizes all monitored values – temperatures in 3 important parts of the model, controller actuating signal and demanded temperature value. All these values are stored in graph with history of 1000 values.
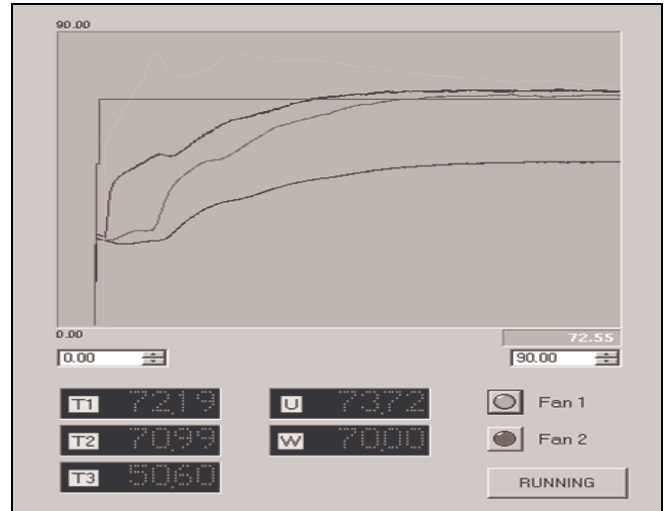

Fig.7. Time-delay model control application – right part of the window

5 Conclusion

The contribution deals with portable data acquisition unit which was developed at our department for control and monitoring related tasks. The device is designed with respect to possible battery operation enabling measurement in areas where power source is not available. Communication with supervision system is realized by standard RS232 serial interface which makes DAQ device fully platform independent. In order to improve development of new software applications with this device a support program libraries for Matlab/Simulink, Visual C++ and Control Web 5 were created.

6 Acknowledgment

References:
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 [3] Moravian Instruments. *Control Web 5 documentation*, Moravian Instruments, Inc., Zlín, 2005.