

Design and Implementation of Multichannel Data Acquisition and Processing (DAQP) System Using LabVIEW

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ABSTRACT

The data acquisition and processing architecture covers the most demanding applications of continuous monitoring in industrial field. The multichannel data acquisition is essential for acquiring and monitoring the various signals from industrial sensors. The problem is that the data storage and hardware size, so the multichannel data obtained is processed at runtime and stored in an external storage for future reference. The method of implementing the proposed design is by using the ARM Cortex M-3 Processor to reduce the hardware size. The Cortex M-3 attains high resolution. A Eight channel data acquisition processing (DAQP) and Controlling was designed, developed using the Lab VIEW graphical programming. The module was designed in order to provide high accuracy, storage and portability. The system designed is not specific for any sensor acquisition, so any sensor having signal conditioning circuit built can be connected to the DAQ (Data Acquisition System). ARM controller is used as heart of the DAQ.

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1. INTRODUCTION

The purpose of a DAQ system is to measure a physical phenomenon such as light, temperature, pressure, or sound. A DAQ system includes the following building blocks transducer, signal conditioning, DAQ device, driver level and application level software. With these building blocks, you can bring the physical phenomenon you want to measure into the computer for analysis and presentation.

Data acquisition systems (DAQ) are devices or software components used to collect information in order to monitor or analyze phenomenon. As electronic technology advances, the data acquisition process has become accurate, versatile, and reliable. Typically, data acquisition devices interface to various sensors that specify the phenomenon under consideration. Most data acquisition systems obtain data from different kinds of transducers that produce analog signals. Many applications require digital signal processing. Therefore, analog signals are converted to a digital form via an analog to digital converter (ADC) to be processed. Simultaneous multi-channel DAQs are employed in numerous applications such as environmental measurements and medical diagnosis.

Multi-channel data acquisition (DAQ) is a crucial component in digital instrumentation and control. It typically involves the sampling of multiple analog signals, and converting them into digital formats so that they can be processed either on-board or externally. In either case, DAQ systems also involve microprocessors, microcontrollers, digital signal processing, and storage devices. Multi-channel DAQs, which utilize some sort of processing for simultaneous input channels, are needed in industrial parameters monitoring systems.

In this Project, a low cost multi-channel analog signal acquisition and processing (ASAP) system is presented. The multi-channel analog signal acquisition system is used to acquire multi-channel analog signals

and then processed and controlled by the microcontroller. In industrial data acquisition and also in case of home health care devices, storage is limited and power consumption need to be minimum. Therefore, fixed sampling rate is not the optimal solution for multi-channel data acquisition. Hence, heterogeneous sampling rates are identified for each channel, and optimized for best data quality with minimal storage requirement and power consumption.

The fidelity of the ASAP system is increased by using reconfigurable chip technology, where flexibility, concurrency and reconfiguration can be achieved in hardware. This in turn decreases the size, the power consumption, and the cost of the system. Implementation of the design in Cortex M-3 brings the system energy efficient, reduction of size and low cost.

2. LITERATURE SURVEY

The ARM Cortex M-3 allows the integration of multiple components on a single chip. In addition, it can have all the acquiring, processing, controlling, input-output capabilities that are needed by a DAQ system.

In some cases the development of a wireless sensor Microsystems containing all the components of data acquisition system, such as sensors, signal-conditioning circuits, analog-digital converter, embedded microcontroller (MCU), and RF communication modules has become now the focus of attention in many industrial and biomedical applications [4]. This paper discusses innovation circuits and system techniques for building advanced smart industrial devices. Low power consumption and high reliability are among the main criteria that must be given priority when designing such wirelessly powered Microsystems. Even though this system is highly wireless based and in advanced applications in industrial and biomedical field.

The system is designed in a modular manner. Each hardware module can operate as an independent gain programmable, level shift adjustable, 16-channel data acquisition system specific to a sensor type [6]. Up to eight such data acquisition modules can be connected to the host PC to realize the whole system hardware. The control of data acquisition and the subsequent management of data is performed by the system's software which is coded in LabVIEW. In the case of input signals with different bandwidths, the hardware real-time adaptive sampling is the best way to optimize the ADC sampling rate. Meanwhile, it also reduces the overall sampling rate that is required, which leads to the reduction of the cost of the required ADC with a large number of channels, particularly in high-frequency inputs.

3. DATA ACQUISITION AND PROCESSING (DAQP) MODULE

A. Multichannel Inputs

The sensors or transducers used to measure the non-electrical signals as electrical signals. Generally in industrial applications the sensors are used in various type to measure heterogeneous parameters such as pressure, temperature, level, velocity, viscosity, friction and vibrations etc., In medical applications by measuring the electrical signals produced by the human body such as ECG, EEG, EMG and etc., since they are the signals which are in analog it should be converted into digital.

These signals are typically waveforms as sine wave or saw tooth wave or cosine wave. Wireless data acquisition system consists of two parts, the part of the data acquisition and the part of the data processing in the host computer. The data acquisition part of the sensor circuit is responsible for receiving the external multi channel signals.

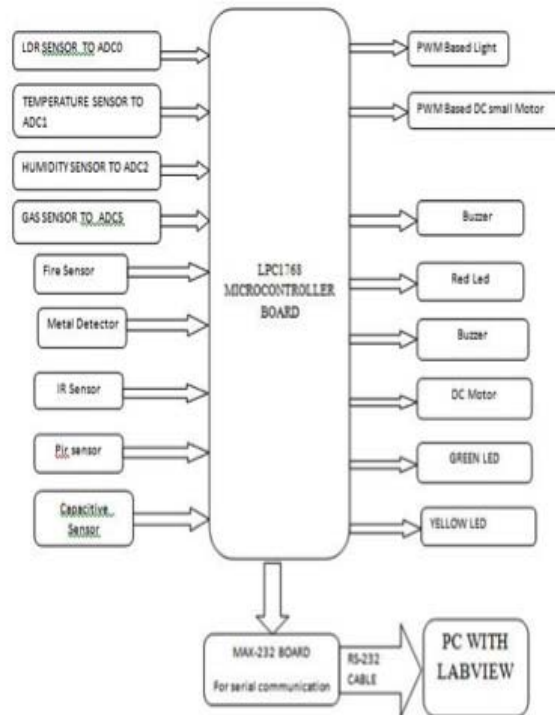


Figure 1. Block Diagram

DAQ has ARM Cortex M3 as a core controller. Computer along with GUI (Graphical User Interface) based software for displaying acquired data by software tool LabVIEW from National Instruments Inc.

B. Host Interface Module

Generally DAQ Function is to acquire the data and convert it to the usable format and this uses ARM Cortex series processor for the acquisition and conversion tasks. The signal will undergo a process of AD conversion through the peripherals of the microprocessor LPC1768, which have a 12-bit high-resolution ADC.

Signal conditioning of the sensor signals are to be carried out before it could be connected to the system. Computer manipulates the data as well as stores values in an Excel file, thus it also does function of data logging.

C. ARM Cortex M-3

This processor is a low-power processor that features low gate count, low interrupt latency, and low-cost debug. It is intended for deeply embedded applications that require fast interrupt response, including microcontrollers and automotive and industrial control systems. In the industrial field, the user requires a faster speed interrupt, so Cortex-M3 is best suited.

Embedded control forms a large part of the market for microprocessors. The embedded controller market has traditionally focused on 8-bit microprocessors, but the growing complexity of many control requirements in sophisticated products indicates a need to move to more powerful processors. The ARM and its variants offer manufacturers the opportunity to move directly to 32-bit controllers at low cost and with a great deal of flexibility for designing custom controllers.

The ARM processor is always differed from other commercially available RISC processors in that it is intended to meet a price/performance ratio rather than to be the most powerful processor available. ARM processors offer an extremely good price/performance ratio compared to other processors.

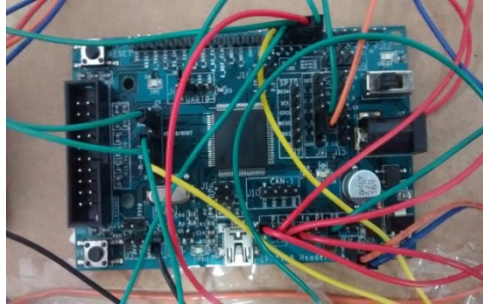


Figure 2. LPC1768 Microprocessor

The Cortex-M3 processor design has some innovative and much improved features and capabilities when compared with the ARM7TDMI processor. Since the Cortex-M3 processor can finish a task quicker, the architecture uses Thumb-2 technologies, which use 31% less memory, which reduces system overhead in comparison with the pure 32-bit code. At the same time it provides 38% higher performance than the existing technology solutions based on Thumb.

The ADC collects sample data by using a programmable sequence-based approach. ADC acquisition supports single-ended and differential-input configurations.

The start of the conversion can be controlled by various triggering's such as Controller (software), Timers Analog Comparators, PWM and GPIO. The GPIO module supports 5-42 programmable input/output pins.

D. Data Storage and Processing Unit

In the data storage and processing unit the digital data that obtained from ADC through the multichannel input signals are stored in a data storage unit that is in flash memory. Data storage plays an increasingly essential role in data monitoring, control, and safety protection. Analog data storage is subject to deformation with time and poor privacy protection. On the other hand, digital instrumentation technologies are known for high processing capabilities, which allow them to perform intelligent onboard computing that supports functionality such as universal data storage. In addition, they also provide improved accuracy, flexibility, and easier data protection [3]. This is because the conversion from various analog signal types to a digital format simplifies universal data archiving and unifies data protection and communication schemes.

While designing the data storage block, our main purpose was to provide continuous data-acquisition capability along with random access to selected blocks of acquired data. The solution we have chosen consists of building a large block of memory, addressed circularly, where acquired data are directly saved under the responsibility of control logic contained in the data storage block. This control logic also answers the host requests by fetching the required blocks of data. The only other intervention of the host processor in the process is the initial programming of the desired mode of operation of the data storage block.

E. User interface module (Display unit)

A virtual instrumentation user interface module is designed for the display of raw data and waveforms. This module has controls and indicators for controlling and monitoring, which is developed using Lab VIEW platform. The data log module is designed to record measured data into data files for further use.

4. DESIGN IMPLEMENTATION

The experimental setup of this system was designed under Lab VIEW National instruments (NI) and DAQ board. The design consists of Cortex M-3 board, which acts as the DAQ card for interfacing the sensors for acquiring the signals and NI SD memory storage module used for storing the acquired signal values, shown in Figure 3.

The NI Educational Laboratory Virtual Instrumentation Suite (NI ELVIS) is a hands-on design and prototyping platform that integrates eight industrial sensors in this project. Based on NI graphical system design software, NI ELVIS, with USB plug-and-play capabilities, offers the flexibility of virtual instrumentation and allows for quick and easy measurement acquisition and display. This NI ELVIS II has analog input channels of 8 differential or 16 single ended, ADC of 16 bit resolution, input frequency up to 50 to 60 Hz.

We used the LPC1768 Microprocessor as the host controller, which has 144 pins. The processor has a FSMC controller, whose data and address lines are separated. The FMSC controller can easily read and write the NAND FLASH.

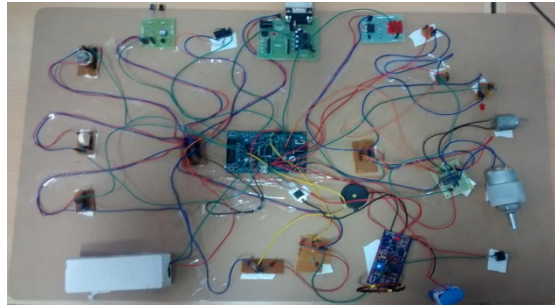


Figure 3. Data Acquisition System

Designed DAQ consists of total eight sensors as shown in the block diagram. Whenever there is a limit crosses in particular predetermined sensor values then they will be controlled and all the sensor values are represented in Lab view software sent through RS-232 cable or through Zigbee module wirelessly.

MicroVision, the popular IDE from Keil Software, combines Project Management, Source Code Editing, Program Debugging, and Flash Programming in a single, powerful environment.

5. EXPERIMENTAL RESULTS

The design for the Monitoring section is designed and developed using Lab VIEW block diagram panel window and the results are monitored with Lab VIEW front panel window. The following Figure shows the block panel design of multichannel data acquisition, processing and retrieval. First the signals are acquired from sensors using DAQ with necessary time limits and clock frequency and the task was created for continuous data acquisition and the task get ended. After the end of this task the data is stored and retrieved using TDMS file viewer where this function will store the individual signal performance values with respect to time and it was stored in an excel sheet. Then the data can be stored in a removable SD memory module. The sensors are circuited to Cortex M-3 board to collect the signals. The system will run continuously until the user stop the process.

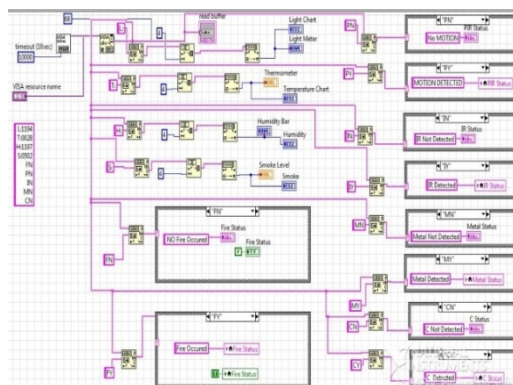


Figure 4. LabVIEW Design for Multichannel DAQ

The Following figures Shows the front panel window of the multichannel data acquisition and processing system, shows the scope of all the individual channel output. The sensor outputs of all channels are collected in a storage file for future reference in an excel sheet. The each column stores the performance with respect to time. Here the TDMS file viewer will store the acquired signals in terms of .xml file format this will be both human and machine-readable.

The Acquired data is represented instantaneously as graphical representation in LabVIEW software on PC. The below Figure shows the result of temperature measurement using thermistor. The change of temperature values is monitored in a front panel window of Lab VIEW

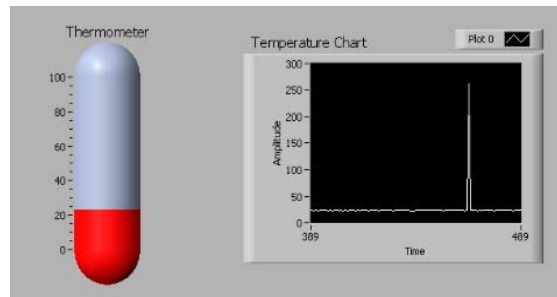


Figure 5(a). Output Waveform of Temperature Sensor

The Second signal acquired is the Smoke or gas level indication obtained by using the MQ-6 Gas sensor provide the level of indication with respect to time as shown in the Figure 5(b).

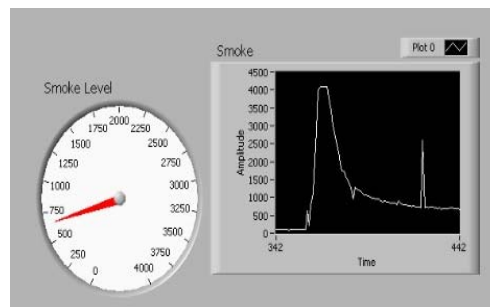


Figure 5(b). Output Waveform of Smoke sensor

The third signal is the Humidity rate measurement shown in figure 5(c), obtained by using the humidity sensor provides the information about the percentage relative humidity present in the environment

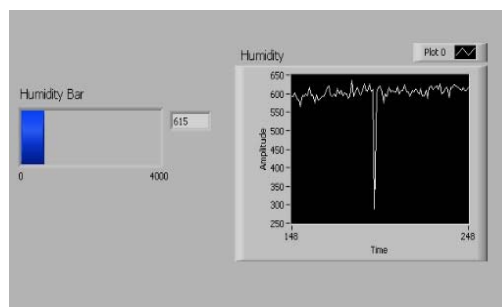


Figure 5(c). Output Waveform of Humidity Sensor

The Fourth signal is the light intensity measurement shown in figure 5(d) obtained by using **photoconductor** or photocell is a variable resistor whose value decreases with increasing incident light intensity.

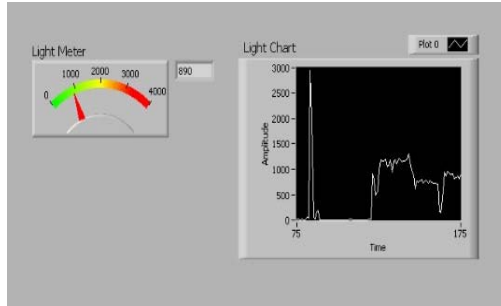


Figure 5(d). Output Waveform of photocell

The fifth signal is the status of detection of the motion using PIR sensor used to detect whether a human has moved in or out of the sensors range shown in figure 5(e).

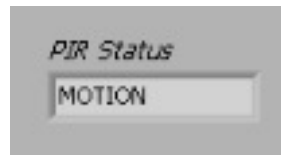


Figure 5(e). PIR Status

The sixth signal is the Fire status indicator as shown in figure 5(f).

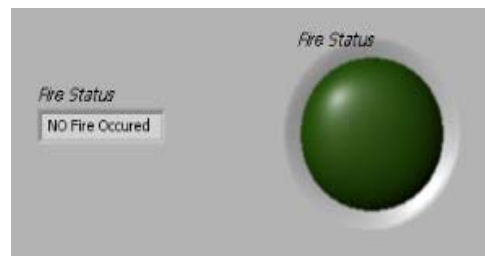


Figure 5(f). Fire Status

The next signals are the Metal detection and Infrared (IR) status as shown in below figures 5(g) and figure 5(h). Metal detectors are used as protection equipment.

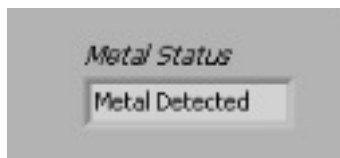


Figure 5(g). Metal Status



Figure 5(h). IR Status

6. CONCLUSION

This paper proposed a technique of multichannel DAQP system to monitor industrial parameters such as Gas, temperature, Fire, light, motion, Humidity and metal detection. The novel aspect of the design is to bring the system into small size, portability, reduced cost, power consumption, and data storage. This is an

enormous improvement over the existing products. This entire system was designed and tested successfully using the LabVIEW tool and Cortex M-3 processor.

The data acquisition designed in this project integrates a DAQ which is designed around ARM Cortex M3 MCU and LabVIEW application. The combination of the two proves very beneficial in solutions related to the automation, acquisition and networking fields. Each of the above has unique peculiarities, which is utilized together to give best performance required.

The low cost MCU based design makes system affordable to the industries. The networking capability enables highly efficient data analysis process and for future references, sensor values saved in an Excel File as database.

7. FUTURE WORK

The design of network control module for transmitting and monitoring the real time data acquired from the DAQ device through Internet is the future work to be progressed

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