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Low Cost Ethernet Based Data Acquisition System in Linux Platform

K.Tanveer Alam, B.Rama Murthy, Mahammad D.V, U. Sunitha and P.Thimmaiah

Abstract— This paper reports on the Low cost Ethernet based Data Acquisition System in Linux Platform. Due to the high cost of Ethernet based Data Acquisition Systems (DAQ) in market, an attempt has been made to develop and implement a low cost, high speed, portable and easy make DAQ which suit for general purpose instrumentation systems. In present work Linux operating system, GCC C and g++ compiler used for software development. For hardware, IC MAX197 is interfaced with Personal computers' Parallel port, which works with 12-bit resolution, 8 single ended channels and 100Ksps at 2MHz clock rates. And the temperature sensor LM35Z is connected to zero channel of ADC for evaluation of system performance. Server is the main core to control the DAQ circuitry while Ethernet controller TCP/IP protocol has the responsibility of transmitting data among the client PCs. The system has been tested for different clients and is highly scalable in size and performance.

Index Terms—Ethernet, parallel port, DAQ, server, client, Linux, Qt4, MySQL.

I. INTRODUCTION

DAQ (Data Acquisition) is the process of bringing a real-world signal into the computer, for processing, analysis, storage and data manipulation. Today, most scientists and engineers are using personal computers with ISA, EISA, PCI or PCMCIA bus for data acquisition in laboratory to test and measurement, and industrial automation. Many applications use plug-in boards to acquire data and transfer it directly to computer memory. Others use DAQ hardware by using the Personal Computers (PC) that is coupled via parallel port, serial port or GPIB-Bus. Most PC-based DAQ systems include signal conditioning in addition to the plug-in DAQ board. [1][2][3]. As instrumentation field entering into a fourth generation, i.e. remote controlling based on Ethernet and Internet. It is boon to instrument having such provision for remote controlling. Data Acquisition System (DAQ) plays a vital role in instrumentation where interfacing with PC. Even though availability of such systems in market from different vendors, those are high cost due to usage of commercial build-in hardware boards and software like Microsoft Windows Operating System (OS), Java, Matlab, Turbo C and LabVIEW like High level languages for system software development. The goal of this paper is to provide the low cost Ethernet based DAQ. The proposed DAQ based on Open source OS like Linux, and free C compiler like GCC is used for developing of System software.

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* Correspondence Author (s)
K.Tanveer Alam, Dept. of Electronics, S.K.University, Anantapur, A.P, India.
Prof. B.Rama Murthy, Dept. of Electronics, S.K.University, Anantapur, A.P, India.
Mahammad D.V, Dept. of E&IT, USIC, A.N.University, Guntur, A.P, India.
U.Sunitha, Dept. of Electronics, S.K.University, Anantapur, A.P, India.
Dr.P.Thimmaiah, Dept. of Electronics, S.K.University, Anantapur, A.P, India.

And PC's parallel port used for interfacing of Analog to Digital conversion (ADC) Integrated Chip (IC) MAX197 and LM 35. The proposed DAQ is very useful for the applications where input signal does not vary rapidly, like temperature, pressure, level, and weight measurements. The DAQ has been tested with various applications and compared with standard instruments. It shows good agreement with standard instrument results. .

II. HARDWARE IMPLEMENTATION

The block diagram of the system of DAQ is shown in the above fig.1. The system consists of the following units viz. Temperature sensor (LM 35Z), signal conditioning unit (MAX 197), and Parallel port.

A. Temperature Sensor (LM35)

The LM35 series are precision integrated-circuit temperature sensor. It is three-terminal device produces an electric voltage proportional to degree Celsius (10mv/^{o}C). These sensors are capable to measure temperature below ^{0}C by using a pull down resistor (+1^{o}C from -55^{o}C to +150^{o}C vs. +3^{o}C from -20^{o}C to +100^{o}C). Thus LM35 has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling and not require any external calibration[4]

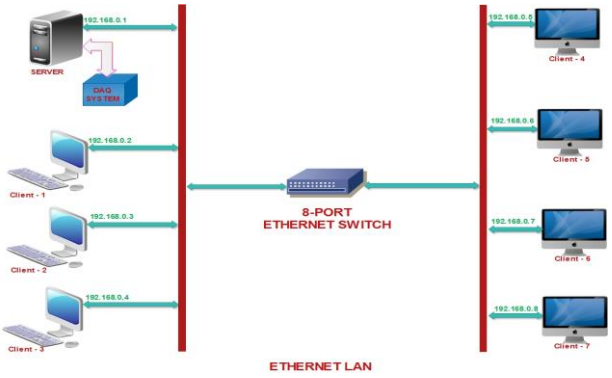

Figure -1. Block diagram of the Ethernet based DAQ

B. IC MAX 197:

Advancement in integrated chip technology brings tremendous changes in simplification of hardware design. Single chip incorporating much integration of required tasks. Maxim has produced a family of high quality and reliable one-chip data-acquisition ICs. The IC MAX-197 is one best among them. The IC MAX197 includes an 8-channel multiplexer, 5MHz track/hold, 12-bit A/D converter and 4.096V reference and features a parallel digital interface that connects easily to most systems like

Microprocessors/microcontrollers or PCs . It is a 28-pin IC, works with 5V supply and having multi-range (0 to 5V, 0 to 10V, ±5V, or ±10V), data acquisition system. Each channel can be independently programmed for one of these standard input ranges. The internal ADC is a successive-approximation type with 12-bit resolution, based on a capacitive DAC whose MSB capacitor doubles as the hold capacitor in a track/hold circuit. The important pins of the device are Pin 2 ($\overline{CS}$), Pin 3 ($\overline{WR}$), Pin 4 ($\overline{RD}$), Pin 5 ($\overline{HBEN}$), Pin 24 ($\overline{INT}$) and input data and output data are multiplexed on a three-state parallel interface which can control through control-byte. The detailed functioning of these pins and control-byte format are given in IC' datasheet. The device can operate with either internal oscillator or with an external clock. In internal clock mode, a capacitor of the order of 100pf placed between CLK (Pin 1) pin and ground sets the internal clock frequency: FCLK = 1.56 MHz which is typical for normal operations[5].

C. Parallel port:

The parallel port is also called as printer port or centronics port. It is found commonly on rear panel of the computer as 25 pin female D-type connector is an inexpensive but yet powerful platform for implementing data acquisition projects. IBM or its clones provide three base addresses for parallel ports: i.e., 0x03bc, 0x0378, and 0x0278. But most of computers have it is 0x0378. The address assignment for a particular machine can be known at ECP printer port (LPT1) properties> Resources. Any printer port consists of three registers – data register (base address i.e., 0x0378, 8 lines, Bi-directional), status register (base address+1, 5 lines, input only) and control register (base address+2, 4 lines, Bi-directional). The printer port working in *Extended Capabilities Port (ECP) mode* [6].

D. Interface circuit:

The proposed DAQ' schematic interfaced circuit is shown in figure-2. The IC MAX-197's parallel I/O lines can easily be interfaced with a parallel port. IC's 8 data lines connected to parallel port's data register (pins D2-D9), and $\overline{CS}$, $\overline{WR}$, $\overline{RD}$, $\overline{HBEN}$ pins are connected to control register (Pins $\overline{D17}$, D16, $\overline{D14}$, $\overline{D1}$) and $\overline{INT}$ pin is connected to status register (pin 13). $\overline{WR}$, $\overline{RD}$ and $\overline{CS}$, control the write and read operations and standard chip selection respectively. When $\overline{CS}$ high, it disables the $\overline{WR}$ and $\overline{RD}$ inputs and forces the interface into a high-Z state. Every conversion is initiated with a write operation of the control byte, which selects the desired input channel, unipolar or bipolar input range and also initiates an acquisition interval or a combined acquisition plus conversion based on the bits selected in control byte. At the end of the conversion a standard interrupt signal $\overline{INT}$, is provided to test by the PC.

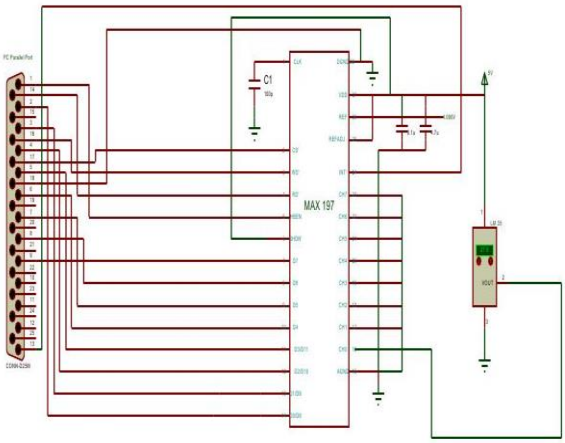

Figure.-2 Schematic diagram of the DAQ

III. SOFTWARE DEVELOPMENT

Software plays very important role in any Ethernet based instrumentation system, as it includes all tools which a developer needs to build and execute applications. The software selected for the present Ethernet based DAQ should support the necessary hardware and allows the programmer to develop various Instruments that can be used for the measurement and control of various parameters like temperature, level and pressure etc. Though, these types of programs can also be developed using any text and graphical (called G-language) languages like turbo C, C++, Pascal, Visual Basics, Visual C and LabVIEW, Agilent VIEW, Bridge VIEW respectively, but require considerable cost to implement system software in windows environment. But, it can be implemented very low price with this Linux OS and GCC C compiler as this software instantly available as Open Source from Free Software Foundation. Linux owes its existence to the cooperative efforts of a large number of people. The operating system kernel itself forms only a small part of a usable development system. Commercial UNIX systems traditionally come bundled with applications that provide system services and tools. For Linux systems, these additional programs have been written by many different programmers and have been freely contributed. The Linux community supports the concept of free software, that is, free from restrictions, subject to the General Public License (GNU). Although there may be a cost involved in obtaining the software, it can thereafter be used in any way desired and is usually distributed in source form. The GNU Project has already provided the software community with many applications that closely mimic those found on UNIX systems [7] [8].

A. TCP client server programs:

Both Client and server programs runs on GNU/ LINUX Operating Systems. To compile these programs using the GCC C and C++ compilers these are free tools in GNU/LINUX operating system [9]. The client and server programs are written accordingly to the flowchart of figure–3 and figure- 4 using GCC C and C++ compilers in Linux platform. It includes various functions like initiating PC's Parallel port, controlling of ADC, controlling of server program and TCP client side program.

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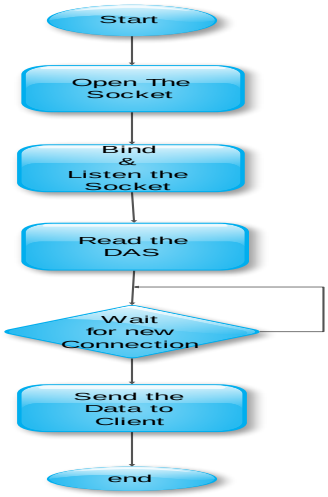

Figure-3 Flow chart of the Server program and DAQ System

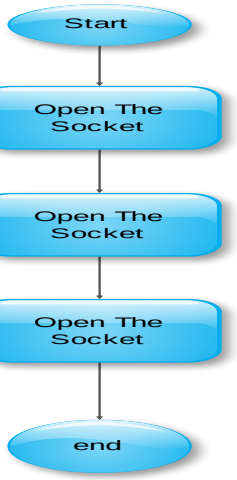

Figure -4 Flow chart for Client program

B. TCP Client GUI program:

Client Program written in C++ using GUI is Qt which is Open Source Edition for the development of Free and Open Source Software. Qt is a multi-platform C++ GUI toolkit provides application developers with all the functionality needed to build applications with State-of-the-art. Qt is fully object-oriented and easily extensible. It allows true component programming. The client program receives the data from the server and stored in MySQL database which is most popular Open Source SQL database. The Source code of client program is written in C++ using GUI Programming with Qt4 and MySQL Database is shown in figure- 5.

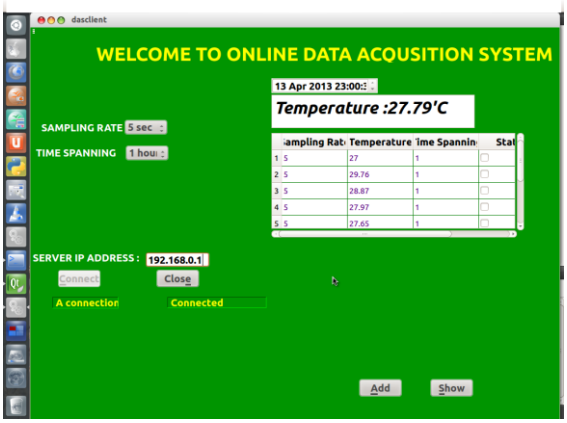

Figure -5 GUI Client program written in C++ with Qt4

IV. EXPERIMENTAL

The measurement and data acquisition system has following blocks:

1. Sensors
2. Signal processing
3. Data transfer
4. Display and signal analysis

A. Data Acquisition Operations

During execution of DAQ program in Server PC, it continuously reading the LM35Z sensor data through the CH0 (channel zero) of the MAX 197 ADC. The total 12-bits are received two times as 8-bit and 4-bit respectively through the data port of the parallel port. And it will be calibrated and stored in float variable. The server program will convert the float variable to ASCII string format and use this variable to send data to multiple clients.

B. Testing of Sensor Recording

To test the main functionality of the present DAQ system, we measured environmental temperature using the developed hardware. The DAQ was set to record sensory data every 5 seconds for a total of one hour. Initially, the DAQ required the user to configure operating parameters which are date, time, recording duration and sampling rate through Ethernet port. During the testing of DAQ, the Server will send the reading data to client systems via Ethernet. The results were recorded in form of Database file. We began our measurement at the room temperature and later we turned ON an air conditioner to change the room temperature. The temperature recording is varied around 28C°and shown in gifure-7. Note that dramatically dropping in temperature to 27.4°C at 12:45:01 showed in figure-7 was caused by the change when we turned ON the air condition. The spanning time of records depends on the sampling rate selected by the user. And this process will run until completion of span time set by user.

V. RESULT AND DISCUSSION

The prototype of the DAQ's photograph is shown in figure-6. The proposed system is designed and tested successfully in laboratory. The performance of the current DAQ is evaluated by comparing its performance with the standard instrument Viz. HP 61/2 digit multi meter model 34401A, which is monitoring through PC. An experiment is performed to measure room temperature by using LM35Zsensor (output voltage 10V / °C) [9]. The Sensor output voltage is acquired through DAQ zero channel. And simultaneously the room temperature is measured using standard PC based 61/2 multi meter. The data of both measurements are shown in figure-7 and stored in database for further analysis.

Figure-6 The prototype of the DAQ System

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This graph show that the device worked satisfactory. We acquired the data for long time and it gives the same results. The repeatability of the hardware is also very good. We tested this hardware for the various other projects like level and pressure monitoring. The DAQ gives the same level satisfactory response for other projects.

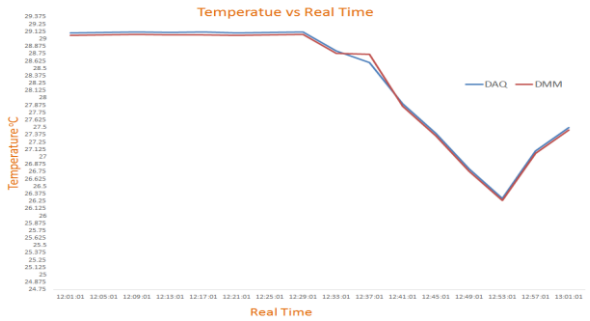

Figure-7 graphical representation of systems measured readings

VI. CONCLUSION

A Low cost Ethernet based Data Acquisition System in Linux Platform has been developed, implemented and evaluated for its functionality with standard instrument.

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K.Tanveer Alam, is doing Ph.D. in the Department of Electronics and communications, Sri Krishnadevaraya University, Anantapur. He also working as a Faculty of Electronics in the Department of Electronics and communications, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India. He has 6 years of teaching experience. His areas of interest are Computer Networks, Data communications, Artificial Intelligence and embedded systems.

Prof.B.Rama Murthy is presently working as a Professor in the Department of Instrumentation & USIC, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India. He is having 20 years of Research & teaching experience. Under His guidance 8 Ph.D & 4 M.Phils are awarded. His areas of interest are Embedded Systems, Network and Mobile Communications, network security systems, Industrial and Bio-medical Instrumentation.

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