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Multi-Channel Datalogger with Programmable Gain

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ABSTRACT: This paper explains the development and implementation of multichannel data logger system that can accept inputs from various sensors amplify using programmable gain amplifier, filter, convert to digital and store it in a memory card is planned. This system will avoid use of long lengths of cable carrying low-level sensor signals that are extremely susceptible to induced noise. The design is fully a real –time `microcontroller-based data logging system to measure the output of various sensors for industrial applications. The system consists of a high-performance low-power PIC microcontroller, LCD monitoring device for channel and gain selection, programmable resistors and programmable gain amplifiers to adjust the gain, ADC for analogue to digital conversion and SD card for memory storage. The designed data logging system has been tested with the application program developed in MPLAB X IDE which can write data into SD card.

KEYWORDS: Data Logger;Microcontroller;.SPI.

I.INTRODUCTION

A data logger is an attractive alternative to either a recorder or data acquisition system in many applications. When compared to a recorder, data loggers have the ability to accept a greater number of input channels, with better resolution and accuracy. Also, data loggers usually have some form of on-board intelligence, which provides the user with diverse capabilities. A data logger is an electronic instrument that records environmental parameters such as temperature, relative humidity, wind speed and direction, light intensity, water level and water quality over time. Typically, data loggers are compact, battery-powered devices that are equipped with microprocessor input channels and data storage. Most data loggers utilize software on a personal computer to initiate the logger and view the collected data. One of the primary benefits of using data loggers is the ability to automatically collect data on a 24-hour basis. Upon activation, data loggers are typically deployed and left unattended to measure and record information for the duration of the monitoring period. This allows for a comprehensive, accurate picture of the environmental conditions being monitored, such as air temperature and relative humidity, pressure etc. Data loggers can also offer advantages over dedicated, computer interface systems. A data logger is a self-contained unit that does not require a host to operate. It can be installed in almost any location, and left to operate unattended.

II.MATERIALS AND METHOD

A.SYSTEM OVERVIEW

The design and development of standalone data logger needs the microSD card and RTC along with the microcontroller.The selection of microcontroller should be given higher priority.

The working of data logger can be operated in 4 stages. The parameter being measured is sensed by an appropriate transducer. The transducer produces an analog electrical signal that relays information about the phenomenon. The output signal from the transducer requires signal conditioning to conform to a standard range and strength. But the overall signal strength is not retained by ordinary data loggers, so programmable resistors and programmable gain amplifiers are introduced to overcome this problem. This analog signal is then converted to a digital signal using an Analog-to-Digital Converter (ADC) .The data is then logged by a processor and at regular intervals the processor takes the digital data provided by the ADC and stores it into memory. The stored data may be

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further interpreted by software such as spreadsheets and other data handling programs. Push buttons are provided for channel and gain selection. The system is so user friendly that the user can select gains required, hence weak signals are given good signal conditioning. Also the portability of the system is maintained using SD cards so that engineers can leave the system unattended.

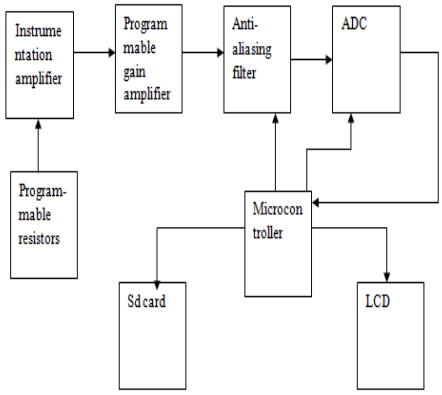

Fig 1 Block Diagram of Proposed System

B. HARWARE DESCRIPTION

- **Input Channels**

The output from a sensor is inputted or connected to a data logger channel. A channel consists of circuitry designed to 'channel' a sensor signal (typically a voltage or current) from the sensor to the data logger processor. A single data logger can have a variety of channel types and from one to many channels (multi-channel data logger) - one channel is required for every sensor signal.

- **Instrumentation Amplifier**

An instrumentation amplifier is a closed-loop gain block that has a differential input and an output that is single-ended with respect to a reference terminal. Most commonly, the impedances of the two input terminals are balanced and have high values, typically 10^{9} ohm, or greater. In this application INA333 is choosen. The INA333 is a low-power, precision instrumentation amplifier offering excellent accuracy. The versatile3-oamp design ,small size ,and low power make it ideal for a wide range of portable applications .A single external resistor sets any gain from 1 to 1000.the INA333 is designed to use an industry-standard gain equation: $G = 1 + (100k\Omega/RG)$.

- **Programmable Resistor MCP42100**

The MCP42100 device is a 256- position, digital potentiometers available in 10 kΩ, 50 kΩ and 100 kΩ resistance versions. The MCP42100 contains two independent channels. This resistor is SPI based and can be programmed. This act at as the external resistor of instrumentation amplifier.

- **Programmable Gain Amplifier**

A PGA, or programmable gain amplifier, is an electronic amplifier (often an op amp), of which the gain can be controlled by external analogue or digital signals. These gains can be set from under 1V/V to over 100V/V .MCP6S28 is used here. MCP6S28 are analogue Programmable Gain Amplifiers (PGA). They can be configured for gains from +1 V/V to +32 V/V and the input multiplexer can select one of up to eight channels through an SPI port.

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- **Analog to Digital Converter**

An analog-to-digital converter is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude. MCP3201 is a successive approximation 12-bit Analog-to-Digital (A/D) Converter with on-board sample and hold circuitry. The device provides a single pseudo-differential input. Differential Nonlinearity (DNL) is specified at ±1 LSB, and Integral Nonlinearity (INL) is offered in ±1 LSB (MCP3201-B) and ±2 LSB (MCP3201-C) versions. Communication with the device is done using a simple serial interface compatible with the SPI protocol. The device is capable of sample rates of up to 100 ksps at a clock rate of 1.6 MHz.

- **PIC Microcontroller PIC18F2520**

The PIC 18 family introduces a 8 bit RISC microcontroller family with a broad peripheral Feature set and enhanced computational performance. The PIC18F2520 family offers a new migration option with enhanced Flash program memory, alternate run modes, multiple idle modes, low consumption etc. It is the central processing unit.

- **Anti-aliasing filter**

An anti-aliasing filter (AAF) is a filter used before a signal sampler to restrict the bandwidth of a signal to approximately or completely satisfy the sampling theorem over the band of interest. Since the theorem states that unambiguous reconstruction of the signal from its samples is possible when the power of frequencies above the Nyquist frequency is zero, a real anti-aliasing filter trades off between bandwidth and aliasing. A Butterworth fourth order filter is used.

- **SD Card**

The SD card is a flash type memory which is designed to provide high capacity, non-volatile rewritable storage in a small size. The memory capacity and speed are increasing all the time. Microcontrollers are relatively memory constrained, e.g., 512K bytes flash, which limits the ability to store large quantities of data either as inputs to or outputs from an embedded program. For example, in a game application it might be desirable to access sound and graphic files or in a data logging application, to store extended amounts of data. In addition, accessing the contents of the flash requires a special interface and software. In such applications it is desirable to provide external storage which the MCU can access while running and the user/programmer can easily access at other times. SD cards provide a cost effective solution which can be accessed by both the processor and user. In practice, these cards have file systems (typically FAT) and can be inserted in commonly available adaptors. Furthermore, the physical interface of most SD cards has a SPI mode.

- **RTC**

The DS1347 SPI-compatible real-time clock (RTC) contains a real-time clock/calendar and 31 x 8 bits of static random-access memory (SRAM). The real-time clock/calendar provides seconds, minutes, hours, day, date, month, year, and century information. A time/date programmable polled ALARM is included in the device. The end-of-the-month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24hr or 12hr format with an AM/PM indicator.

- **LCD**

A 2x16 column LCD is used in the circuit for displaying channel and gain selection.

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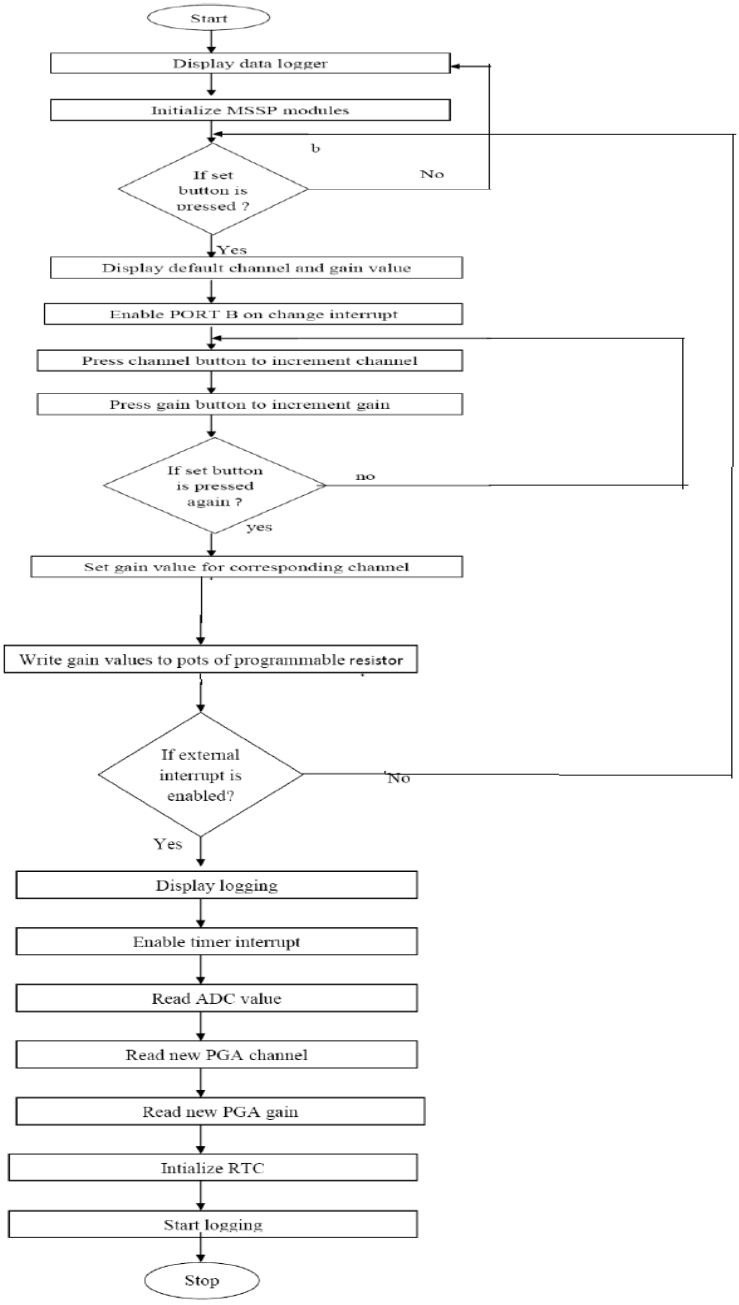
III SOFTWARE DEVELOPMENT

The system is designed using MPLABx. This version has most advanced features like driver switching, code generation for particular modules of specific series and so on. The MPLAB X IDE also comes with MPLAB IPE that comes in programming of microcontroller from IDE window. The XC8 type of compiler is used to compile the given C coding to binary data.

IV. FLOW CHART



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V.RESULT AND ANALYSIS

The results obtained indicate optimum utilization of processor with embedded C for realizing low cost software for developing the application on embedded boards with least software development effort. Here measurements of multiple inputs are acquired within a less time and high efficiency. The gain values can be changed by push buttons to conform the required signal conditioning strength and range. This standalone data logger is also fast in acquiring data within seconds after the test time due to fast sampling.

Prior to the instrumentation amplifier, programmable resistors are connected that can provide gain through 256 taps in binary steps by SPI programmable .A differential, instrumentation amplifier is then used on the signal to provide a high-impedance buffer and to remove unwanted common-mode noise in the signal. Instrumentation amplifiers are desirable in this application due to their high DC precision, low op-amp noise, high common-mode rejection ratio, and a high input impedance which prevents a significant load being presented to the transducer.

Despite the gain provided by the instrumentation amplifier, additional gain is required in order to bring the signal within full scale range of the ADC. As per the design requirements, the additional gain provide values 1,2,4,8,10,16,and 32 v/v.The MCP6S28 programmable gain amplifier was chosen to accomplish this task. In addition, the MCP6S2 provides the advantage of being able to be calibrated with the ADC in order to reduce the gain and offset errors of the ADC The gain will be programmed by the systems microcontroller prior to use and will not be adjusted during application. the PGA can only be used to bring the signal up to 5 V, to achieve the full range of the ADC.

In this design, it was deemed acceptable (and necessary to meet the 5 kHz passband frequency) to allow aliasing into the filters transition region since the data would be stored and later digitally filtered. To prevent any aliasing, an ADC requires a minimum of 6 dB attenuation per bit at the Nyquist frequency A 12-bit ADC thus requires -80 dB attenuation.

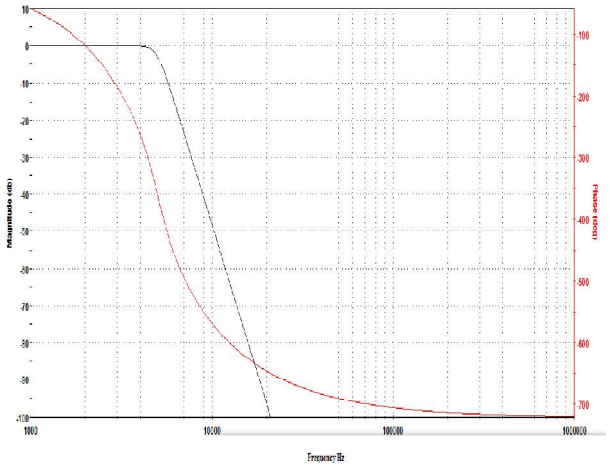

Fig. 2 Butterworth Filter for different Order

VI.CONCLUSION

The concept would entail a system that is completely instrumented, has onboard signal conditioning, analog to digital conversion and memory for storage has the ability to clearly present real time data fetched from sensors and probes. The above system is implemented to monitor the parameters like force, pressure, temperature etc during wind tunnel test time in the industrial application. By realization of the system one can acquire knowledge on embedded system and metering devices. With the advent of portable data logger, the reduction of external cables and cost of operation.

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