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Design and Construction of Five Channel Data Logger: Analog to Digital Error Converter Form

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A B S T R A C T

As the need for record keeping has become imperative in electrical engineering field, maintenance engineers has been finding it difficult to adequately carry out proper routine maintenance on equipment due to lack of record keeping and this has resulted to breakdown of equipment in various fields and it has also cause theft in most location due to inadequate records keeping. Therefore the introduction of Five Channel Data Logger is to help collate this information electronically over time with relation to their various location and it will help in monitoring major electrical parameters for analysis and evaluations and this work will change the narrative on most industries for effective data analysis on their various operation field via real-time logging.

Keywords: Analog, Data logger, Digital, Error converter form

1. Introduction

A data logger has been described as electronic device for recording data over time. Nowadays, data loggers are microcontroller based technology. Most of them are usually portable battery-operated devices with internal storage and some incorporate sensors to measure physical quantities such as temperature, pressure, voltage, current, power in watt, flow of liquid, humidity, displacement, frequency, and so on.

Preventive measure rather total repair of equipment breakdown is a key feature in present day engineering. There is therefore need for performance monitoring via data logging so as to know when systems/equipment are efficient or failing. Besides, power engineering trends changes issues become more important, engineers need to have data to argue their case. Whether you believe in operational changes or not, it's only by systematic collection of hard data that we will enable one to figure out changes in the operational process. The key to this is a versatile data logger. Having a platform like this will facilitate the step towards understanding some great operational performances. Thus, it is required for a more robust way for fault finding and performance monitoring.

The objective of this paper is to design a system that will monitor electrical quantity in real time using data logger. The deliverables include to eliminate problems associated with sudden breakdown of power generating plant via routine logging, to monitor the flow of pressure in a pipeline via real time logging, to monitor system performance by taking sample of electrical parameters e.g. temperature voltages frequency etc., and to log and store data for analysis and evaluation.

Nomenclature

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2. Literature Review

There are basically two groups of data logger: computer interface data loggers and standalone data loggers.

Standalone data loggersare the type that can be employed on their own, without requiring other devices for data collection and storage. Standalone data loggers have large internal non-volatile memory. They may also have real time clock chips. The data that is collected can be saved in the memory with time stamping. The data collected in a standalone data logger is usually analyzed offline. A data loggerof the standalone type, is usually configured and then left at site where it is required to collect data. At the end of the data collection period the device is connected to a personal computer (PC) and the collected data is read and analyzed with the PC. Some standalone data logger are dedicated for specific measurements, for example temperature, pressure, voltages, fluid, frequency. The Thermo Recorder TR-5 Series is a temperature data logger of the standalone type. This data logger has LCD output, and it can take up to 16,000 readings with time intervals from one second to one hour and the battery life is quoted as four years. Of all the disadvantages of standalone data loggers, one is of it is to ensure that the devices are checked at consistent intervals to make sure that the memory is not full, or the battery is not flat. This may sometimes cause problems since the device may be located at a remote location or at a place not easily reachable or accessible.

Computer interfaced data loggers are employed only to capture the data. These devices do not have large internal memories and are normally linked to a personal computer. The captured data are then stored in a PC for storage or for analysis. The data can either be analyzed offline or online. A disadvantage of computer interfaced data loggers is that the devices cannot be used on their own as another device (e.g., a PC) is required to store the captured data. The Pico Technology is a typical interface data logger that is linked to a PC to transfer the captured data. The device has built in sensors for light, sound and temperature measurements. Some computer interface data loggers have wireless capabilities. Usually a transmitter-receiver pair is used: the transmitter captures the data and sends it to the receiving device using wireless communication. The receiving device usually has large internal memory and stores the received data.

There are previous designs regarding data logger such as the one done by Saha et al. [1], which is multi-channel data logger of a low cost. Dedrick et al. [2] designed a Microprocessor-Based Data Logging System. It uses PIC16C73A, 8-bit microcontroller (Microchip Technology, Inc), which is well suited for an inexpensive data logger. Segregating host communications functions into the reader:

- Reduces the number of components and complexity of the logger thus reducing each logger cost.
- Allows the operation of the data logger at the lower power.

Moghavvemi et al. [3] presented a remote temperature and relative humidity sensing device for data acquisition of a low cost. Remote sensing of temperature and humidity is achieved by the system combining logic circuits together with programming technique to control the hardware. The sensor circuit converts the relative humidity and temperature into an analog signal, which will be applied to a microcontroller based data logger for storage purpose. This is transferred to the computer through RS232 standard serial port. The system can be real time and offline. In Kanukurthy et al. [4] a data acquisition device for an implantable multi-channel optical glucose sensor was presented. This new technology relies on the unique optical characteristics of glucose in a near infrared spectrum. The sensor element will be implanted in the subcutaneous tissues of the human body. Optical data are acquired by the data acquisition unit from the sensor and converts it into spectral data for processing.

Moon et al. [5] Microcontroller based Data Logger System. The system is based around ATMEGA 128 microcontroller. This has anin-built analog-to-digital converter (ADC) with a conversion accuracy of 12-bits in addition to memory. The interface program was implemented as software adoptable for graphical user interface environment using Visual C++.The newest of this work is that it has Five (5) channel, which can be stored in memory and this information generally can all read at the same time making maintenance easy and data information safe. According to [6], as an electrometrical device, electrical or mechanical input trend are recorded onto a piece of paper by chart recorder. They appeared in three different types, the strip, circular, and roll types. As shown in Fig. 1, the strip chart recorders have a long strip of paper ejected at the side of the recorder.

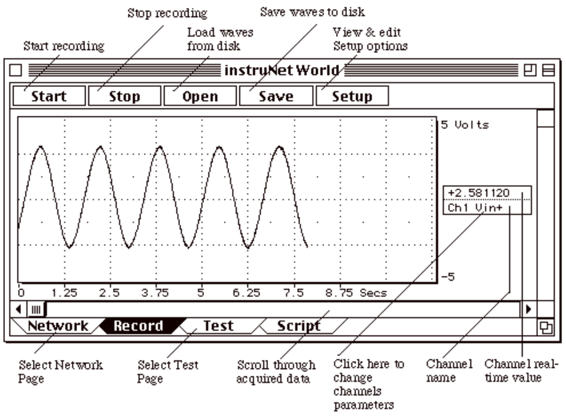


Fig. 1 - ***A typical strip chart recorder [7]***

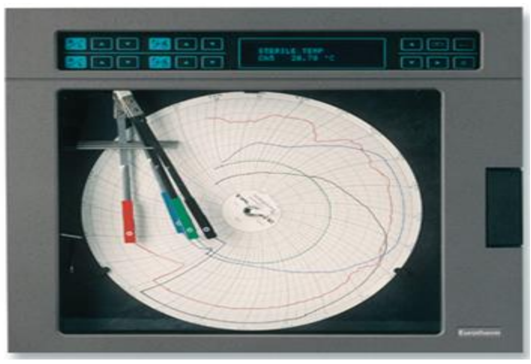


Fig. 2 - Circular chart Recorders [8

Figure 2 shows a circular chart recorder. It has rotating disc of paper, and are more compact and amendable meanwhile are like strip chart recorders apart from the fact that the unit is fully enclosed and data recorded is stored on a round roll.

3. Methodology

Evaluation of Fig. 3 highlights that the memory device is used by both modules. In order to increase the functionality of the system the memory device was designed as an independent unit which could be transferred between modules when required. To create the required system three separate units were designed and constructed, namely: Measurement Unit, Memory Unit and PC interface Unit. The Measurement Unit in conjunction with Memory Unit forms the Measurement Module. The PC Interface Unit connected to the Memory Unit in conjunction with a PC forms the PC Interface Module.

For reasons of simplicity the functional unit performing the task of measurement and data storage will be known as the measurement module while the functional unit performing the tasks of data download and data processing will be known as the PC Interface module.

The implementation of these two functions could be achieved in a single physical device. Such an implementation would be cost effective as manufacturing, housing and materials costs would be reduced. However, since both functions can be done independently, physically separating the functions provides advantages that are undoubtedly superior. These benefits are now discussed with reference to Fig. 4.

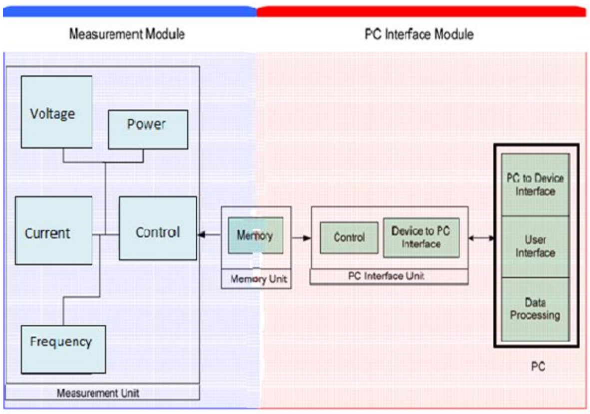


Fig. 3 - ***Block Diagram of System Modules***

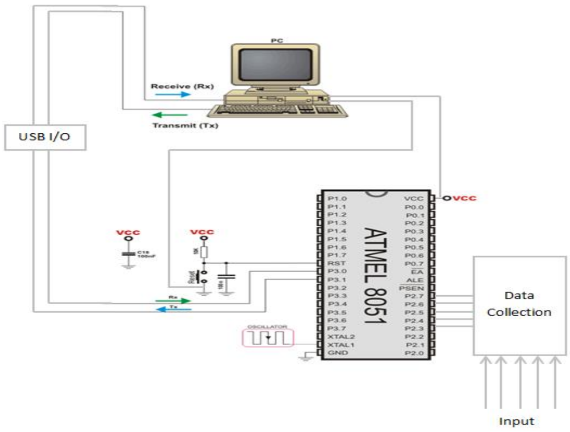


Fig. 4 Block Diagram of the Data Logger

3.1 Block diagram description

Microcontroller Unit (MCU)

In this design, the microcontroller forms the core of the system, meaning that all mathematical and logical operation of the system is executed from within it. The configuration is shown in Fig. 5. As shown on the previous picture, the 8051 microcontroller has nothing impressive at first sight:

- 4 Kb program memory is not much at all.
- 128Kb RAM (including SFRs as well) satisfies basic needs, but it is not imposing amount.
- 4 ports having in total of 32 input/output lines are mostly enough to make connection to peripheral environment and are not luxury at all.

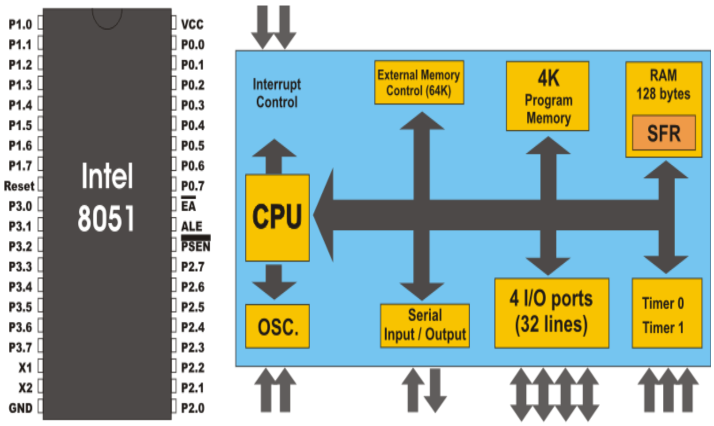


Fig. 5 - ***Pin Configuration of Microcontroller***

Microcontroller's Ports

Port 0: It is specific to this port to have a double purpose. If external memory is used then the lower address byte (addresses A0-A7) is applied on it. Otherwise, all bits on this port are configured as inputs or outputs. Another characteristic is expressed when it is configured as output. Namely, unlike other ports consisting of pins with embedded pull-up resistor (connected by its end to 5 V power supply), this resistor is left out here. This, apparently little change has its consequences:

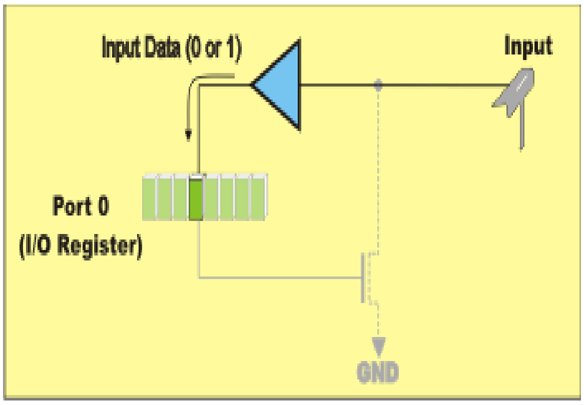
If any pin on this port is configured as input then it performs as if it "floats". Such input has unlimited input resistance and has no voltage coming from "inside".

When the pin is configured as output, it performs as “open drain”, meaning that by writing 0 to some port’s bit, the appropriate pin will be connected to ground (0V). By writing 1, the external output will keep on “floating”. In order to apply 1 (5V) on this output, an external pull-up resistor must be embedded.

Port 1: This is a true I/O port, because there are no role assigning as it is the case with P0. Since it has embedded pull-up resistors it is completely compatible with TTL circuits.

Port 2: Similar to P0, when using external memory, lines on this port occupy addresses intended for external memory chip. This time it is the higher address byte with addresses A8-A15. When there is no additional memory, this port can be used as universal input-output port similar by its features to the port 1.

Port 3: Even though all pins on this port can be used as universal I/O port, they also have an alternative function. Since each of these functions use inputs, then the appropriate pins have to be configured like that. In other words, prior to using some of reserve port functions, a logical one (1) must be written to the appropriate bit in the P3 register. From hardware’s perspective, this port is also similar to P0, with the difference that its outputs have a pull-up resistor embedded.



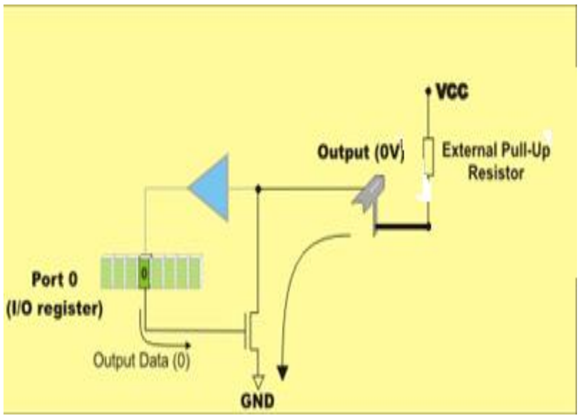


Fig. 6 - ***Micro port input***

Fig. 7 Micro port output

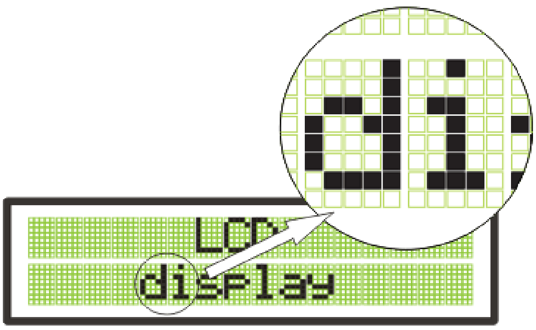
Power Supply Unit

The main supply to the unit is gotten from the USB port of the PC and also an auxillary power supply for backup that run directly from a 9VDC and stabilised down to 5VDC for proper operation of the microcontroller incase the unit is to be operated as a stand alone metering device.

Obviously, all this is about very simple circuits, but it does not have to be always like that. If device is used for handling expensive machines or for maintaining vital functions, everything becomes more and more complicated! This kind of solution is quite enough for the time being

Liquid Crystal Displays (LCD)

These components are “specialized” for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD. In this context, the presented model is based on the HD44780 microcontroller and it is capable of displaying messages in two lines with 16 characters each. It displays all letters of alphabet, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own. Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristic. The LCD screen data command and the pin configuration are shown in Fig. 8 and 9.



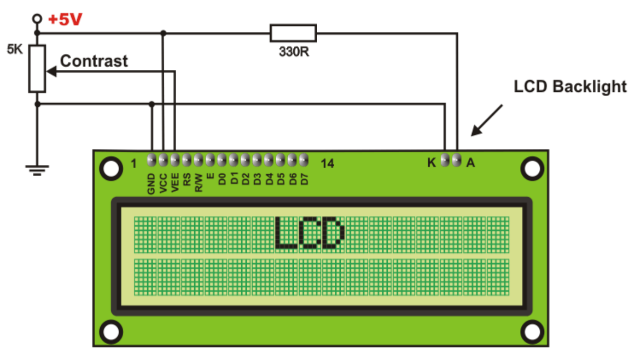


Fig. 8 - ***LCD screen data command***

Fig. 9- Pin Configuration of an LCD

Data Collection Unit

This unit is made up of an Analog-to-Digital Converter **(**ADC**)** is a device which converts continuous signals to discrete digital numbers. Digital-to-Analog Converter (DAC) is used to perform reverse operation and an analogue multiplex.

Typically, an ADC is an electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current. However, such devices like rotary encoders that are partly electronic or non-electronic devices can be regarded as ADCs. Different coding schemes such as binary gray code or two's compliment binary may be used by the digital output.

Its prime function in this circuit is to digitize the analog quantity that is gotten from the transducer (sensor) or the instantaneous voltage that to be logged to the system unit to a form that the microcontroller will easily processed. The accuracy of the converter depends on these factors' resolution, Accuracy, Quantization error, Aperture error, and non-linearity.

3.2 Resolution

The number of discrete values it can produce over the range of analog values is indicated by the resolution converter. Here we have decided to use an 8-Bit Analog-Digital converter for its low cost and simplicity hence at expense of lower performance when it comes to step size or resolution. The storage of the values is commonly done electrically in 1's and 0's (i.e. binary form) such that the expression of the resolution is usually in bits.

The definition of resolution can be electrically, and represented in volt. The ADC voltage resolution is equal to the total voltage measurement range over the number of discrete can be intervals as in the formula:

$$Q = \frac{E_{FSR}}{2^M - 1} = \frac{E_{FSR}}{N} \qquad (1)$$

where Q is resolution in volts per step (volts per output codes less one), E_{FSR} is the full-scale voltage range = 2^M is the ADC's resolution in bits.

4. Results

This design was triggered off by first; trying to figure out how the project can be actualized, getting the desired clue, surfing online to gather more "Intel", and thus the Ideal was achieved. In any given design there must be a set rules and regulation guiding it, in view of this project "industrial data logger with computer" is not left out. The three output circuit, the system user application console and the system logged data. are shown in Fig. 10, 11, and 12.

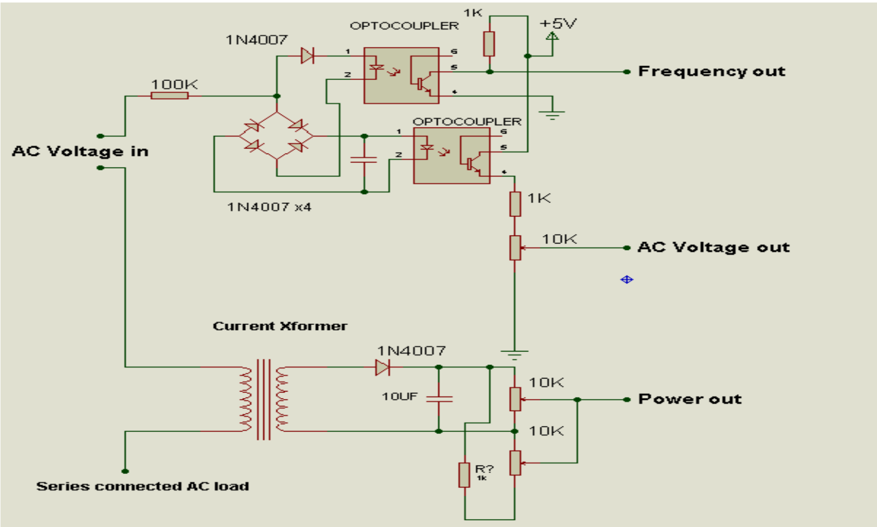


Fig. 10 - ***Three-Input Data logger Circuit Diagram of the Sensor Unit***

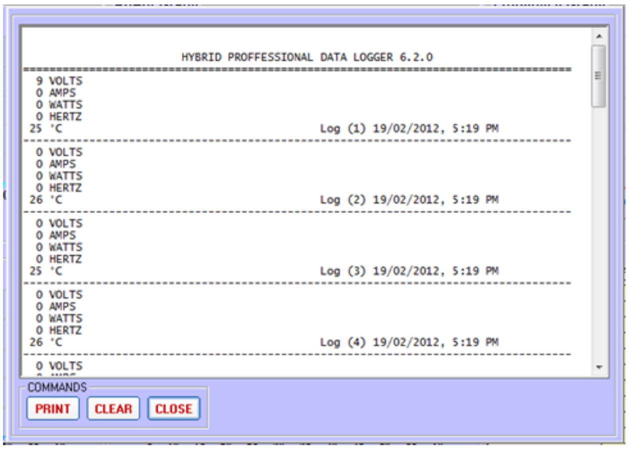


Fig. 8 – ***System user application console***

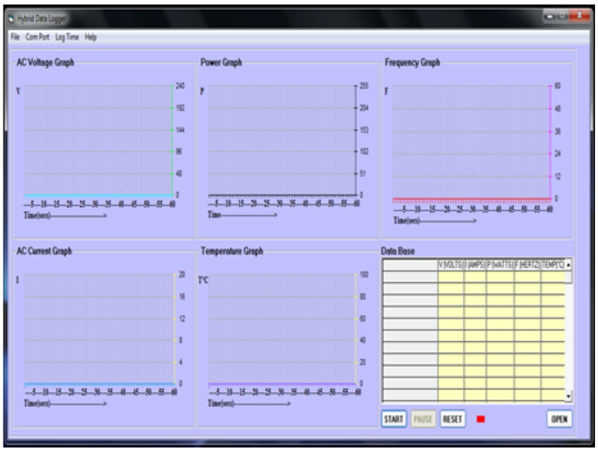


Fig. 9- System logged data

4.1 How It Works

All microcontroller embedded system runs on an internal firmware burnt into the chip or outside the chip in a ROM. This design uses the ever-familiar MCU "microcontroller unit", which is the Atmel semiconductors because of its wider data I/O line for the task. Assembly language, and ASEMW brand of macro cross is us-assembler is used as compiler to finally ensure that the machine is executed. Once the exec file is gotten, it was downloaded it into the MCU internal flash memory from where it is required to be executed using a gadget called a "Programmer".

4.2 Programmers

Programmers are device used to get the executable file that resides in the computer down to the microcontroller for final execution of the program. Below are the modes of operation of the system outlined in a sequential manner in order to aid quick understanding of how the project works. Three buttons are used to control operation of the data logger: START, PAUSE, and RESET.

4.3 Step-by-Step Analysis

1. When the power is "ON", an initialization of the state of the visual display unit to a given state is immediately performed by the microcontroller, and self-resets to a specify status that agrees to the pre-loaded program.
2. A routine is called upon by the controller to clear the visual display unit and also to clear the register'scontent that is employed in storing the converted data that resides in the controller.
3. An instruction is called upon, which checks the serial control line and also to power down the USB controller so that the issue of unwanted logging would be combated. During this sequence of system initialization, the visual display is defaulted to the value of zero.
4. At this point the system is fully initialized. Here it waits for the appropriate command for logging to commence else it will serve as a standalone metering instrument.
5. The data collection unit proceeds to these modes of operation labeled "i thru vi":

i. The number of pulses at the counter input pin if any, is counted by MCU, and then stores the data in a special register employed for its temporary store, and then calls upon a routine that outputs this data onto the corresponding display then jumps to the next step.

ii. At this point, the ADC unit is activated. Here since there are four analogue parameters that are to be measured, the multiplexer unit is automatically enabled as well since the four inputs are concatenated to the multiplexer. Thus, taking us to the next step.

iii. The MCU issues a command to the multiplexer that enables the temperature channel, the analogue value is quickly made available to the ADC input, and the MCU further gives the ADC command to start conversion. Once the conversion is done, data is sent to the MCU for digital processing. Here, data analysis occurs; and the resulting analyzed data is stored in its temporary register, then displayed onto the corresponding indicator. From here the MCU jumps to the next step.

iv. The MCU issues a command to the multiplexer that enables the current channel, the magnitude of the current which has been converted to voltage by the current transformer quickly made available to the ADC input; the MCU further gives a command to the ADC to start conversion. Once the conversion is performed the data is the gated to the MCU for digital processing.

In summary of this work, it is recommended that five channel data logger be used be used for every engineering firm for adequate record keeping and data collection of various variables in every of their field and location, having seen the important of the work, how it reduce unnecessary loss of machine and equipment and how it also helps in information/data storage of various electrical parameter.

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