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Microcontroller Based Control of Devices Using a Sophisticated Control System

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Abstract:-- **In this paper, we design & develop a remote control of equipments using the so called DACS. Microcontrollers are being used for this purpose of control. The experimentation is performed w.r.t. the work taken in this paper & the results show the efficacy of the method developed.**

I. INTRODUCTION

Science and technology are progressing in leaps and bounds today. The growth of industries is opening new avenues for development and innovations. With the advent of automation, industries are looking for cost reduction and restructuring of the development cycle and servicing. In considerations with such changes, the demand for accuracy, data retention capability, data transfer speed is ever increasing. The key to success of any company is its information flow, be it between department to department i.e. human-to-human or machine to human, the costliest possession to any company is information.

Companies are finding various methods and installing new systems, even adopting or completely changing the existing system to be in the race to success. With many new ways and technologies developing every hour to cater this new age transition, the need for systems with high efficiency, retention and simplicity is spiraling in growth. To achieve this the electronics and computer science field are dedicate sources, not only are new standards being developed, but also new branches of engineering are being found in this process, control systems, industrial automation, embedded systems, remote access/sensing, data monitoring and acquisition are few of the examples.

Our research, targets to simulate, design and implement such a device. This device, the data acquisition and remote equipment control is designed to enable the user to control the device from distance. Even if there are a number of devices at different places, the presence of data acquisition and remote equipment control system at each place makes it possible to control over them. The physical variables at these locations can be studied and the devices accordingly controlled, which will efficiently acquire the data and control such remotely, placed equipment. The implemented system will be capable of reading eight 8-bit analog channels and 8 digital channels.

The parameters of the equipment like voltage, current, temperature, etc, that are converted into corresponding voltage values, are read through these eight 8-bit analog channels, while the status i.e., ON or OFF will be read through the 8 digital channels. A provision to control the status of a device (control device) is also provided. The job of data acquisition and control is performed by the micro-controller 89C52, which forms the kernel of the design. To support the job of the kernel, other components like the ADC, Multiplexers, 8255 PPI, EPROM, RAM, Latches, Display, Keyboard, are interfaced. The communication between the remote site and the central control point is done through telephone line via modem. At central control room, data is displayed on the PC using VB graphics.

II. OBJECTIVES OF THE WORK

The objectives of the research work is summarized as follows:

- To design an 89c52 micro-controller based system interface to control and read parameters of equipment. The system has a rs232 port.

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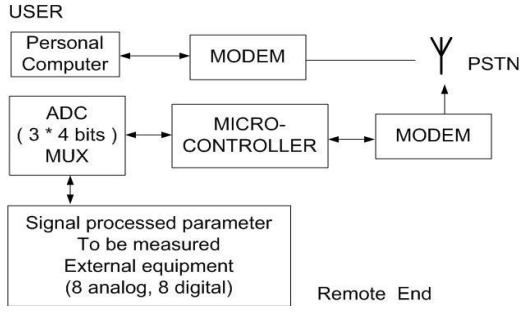
- To design a 10-bit ADC circuit with 8 channel multiplex facility.
- To assemble/solder circuit boards for 6 digit 7-segment display, 89C52 board, an ADC interface board.
- To assemble interface wires/cables for hooking up the circuits to target system
- To design the software in assembly language to achieve the objectives.
- To design the PC end software in VB6.0 to communicate to remote 89C52 via PSTN (Public Switched Telephone Network) at different locations.
- A-D plug in boards are used at the remote end and using multiplexers to multiplex the data lines and the number of control variables/parameters are increased tremendously.
- At The Remote End, Dedicated Controllers Are Interfaced With The Original System, Which Increases The Functionality Of The Present System From Monitoring To Actual Control System**.**
- The implemented design is interfaced with compatible boards to increase the use in accordance with requirement and standards adopted by the industry.
- To make the entire process full automatic.

III. DESIGN OF THE PROCESS

The process begins as follows. Initially a link is established between the remote site and the central control station by dialing appropriate number. After the link is established, the command for reading the analog and digital channels is given subsequently. Then, the values of the channels are displayed on the PC screen, at the central control station. If needed, a change in the state of a device can be made. After the monitoring process is over, the link is disconnected.

The basic block diagram of the process is shown in Fig. 1.



The algorithm designed in Visual Basic VB6 is shown below in Figs. 2 to 6.

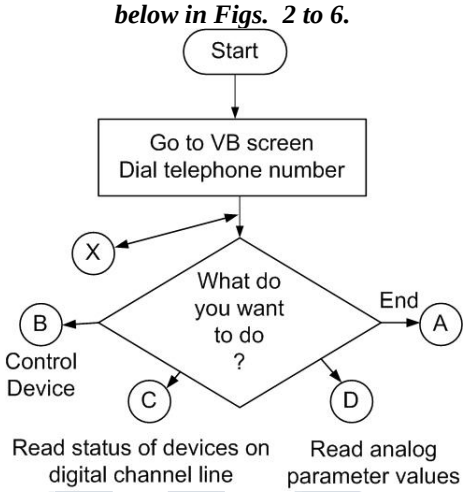


Fig. 2 Flow chart to read status of devices

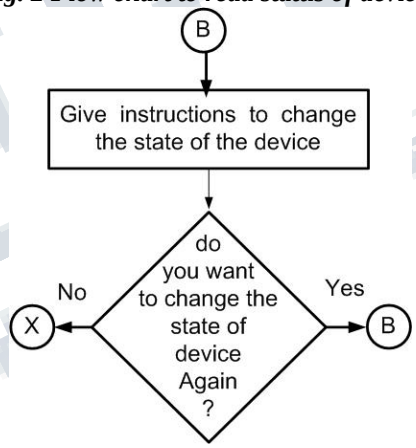


Fig. 3 Flow chart to change the state of the device

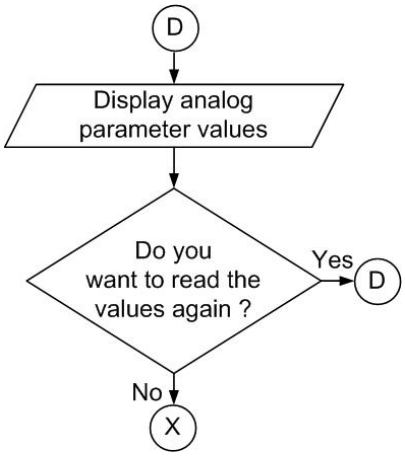


Fig. 4 Algorithm to display parametric values

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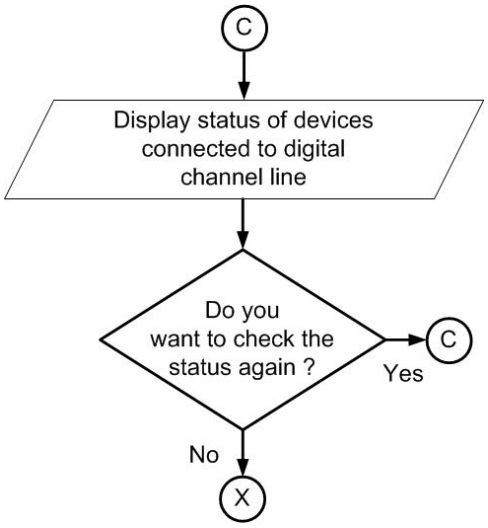

Fig. 5 Algo to check the status of the device

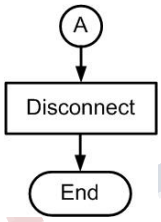

Fig. 6 Flow chart to disconnect the device

The project targets set can be achieved by implementing the block diagram. The overall view of the block diagram is as follows. We get processed 8 analog and 8 digital channels from the equipment. These 8 analog channels are given to the ADC and analog multiplexer. These are then connected to one of the ports of 8255. The digital channels are connected to the other port of 8255.

Microcontroller generates the address and control signal for acquiring data from the equipment or the memory chips. The monitor program will be stored in the EPROM, whereas the data from the equipment will be stored in the RAM. There is a 7-segment display, with 4 fields for address and fields for data. The touch keypad, keyboard is used to send commands or address or data to the microcontroller, which will be displayed on the display during debugging or diagnosis.

The components of the system block diagram are shown in the Fig. 7.

IV. MICROCONTROLLER DESIGN

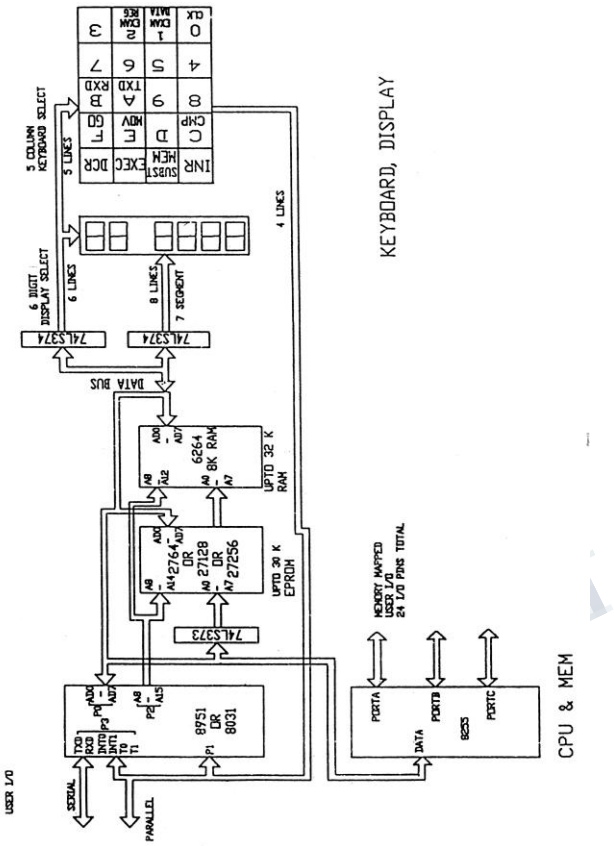

Fig. 7. Microcontroller system design

Microcontroller 89C52:

The microcontroller 89C52 forms the central block of the device. There are other components like 8255, memory chips, keyboard and display interfaced to the micro controller, for supporting it's job. The microcontroller is used for regulating the working of these components. These analog channels read are multiplexed after converting to digital form and given to 8255. The microcontroller 89C52 reads these analog channels and the digital channels on it's data bus through 8255. It generates the control signals and sends address for processing of data form the equipment. Serial communication between the control station and the remote site takes place through TXD and RXD lines (serial port) of 89C52. The data bus from 89C52 is used for scanning the 7-segent display and the keyboard alternately.

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Display and Keyboard:

The scanning of the display and keyboard is done alternately at a very high speed. There are two 74LS374 latches used for this purpose. The data bus of 89C52 is the input for these two latches. One of the latches is used to select a particular field out of the 6 fields i.e. 4 address fields and 2 data fields. The other latch contains the data to be displayed on the corresponding selected field. For selecting a particular field, 6 lines of the data bus is latched, whereas, for displaying the data 8 lines are latched. When one of the latches selects a particular field, the other latch sends out the data to be displayed. Thus, all the 6 fields are read in this manner, one after the other.

Although one field is displayed at a time, all the fields seem to be displayed together due to the persistence of the vision as the scanning is done at a very high speed. After the display scanning, the keyboard is scanned. The keyboard is of 5 columns and 4 rows. The latch used for selecting one of the fields, also gives out 5 lines for each of the 5 columns of the keyboard.

These 5 columns are selected consecutively and when any key is pressed of the corresponding is pressed, it is read on the 4 lines connected to the port of the microcontroller. This is how the data is read from the keyboard. The display and the keypad are used during diagnosis and debugging. In case there is some malfunctioning in the running of the programs, by reading the contents of the address on the display, the cause of the error can be found i.e. debugging. By using the keypad the detected error can be rectified.

8255 PPI :

The analog and digital channels are read on the data bus of 89C52. Since both these channels cannot be directly connected to the data bus of 89C52 , 8255 is used as an intermediate between the channels and microcontroller 89C52. One of the ports of 8255 is utilized for reading the 8 analog channels through ADC and analog multiplexer. The other port is used for reading the 8 digital channels. Each bit of the digital channel represents the state of the digital channel being 8 bit. Thus, there are 8 devices interfaced to the 8255.

***EPROM*:**

External EPROM of 4kB is used for storing the monitor program. It is electrically erasable ROM. EPROM chip is used for storing the programs necessary for the working of the circuit.

***RAM*:**

External RAM of 32kB is used to store the relevant data acquired during the working of the circuit. The data stored in Ram chip is volatile.

***Latches*:**

The 74LS373 address latch is used for latching the address from the multiplexed address data bus AD0-AD7 of 89C52. The ALE signal from 89C52 is used for enabling latching. Two 74LS374 latches are used to latch the data bus alternately. One of the latches is used to latch the data to be displayed on the 7-segment display. The other latch is used to turn on one of the 6 corresponding fields. The same latch is also used to scan the 5 columns of the keyboard.

Multiplexer:

4051 is a CMOS, analog, 8:1 multiplexer. 8 analog channels are given to the multiplexer which are selected by the 3 select lines from 8255. One of the ports of 8255 is dedicated for reading the analog channels. Out of the 8 lines of this port, 3 lines are given to select input of the multiplexer for selecting one of the 8 analog channels, whereas, the 5 lines are given to the ADC.

Analog to Digital Converter [ADC]:

CA3162 ADC features a dual slope A to D conversion. It gives the output in the BCD form. The 5 lines of the 8255 comprises of: 4 for BCD output and 1 for indicating a new BCD value. The digitized output of the analog channels is of 3 nibbles which are in BCD form. Therefore the minimum and maximum which can be represented are 0-999 which in this case is 0-999 mV. Therefore 1000 readings can be read. These 1000 readings can be approximated as 1024 i.e. 2^{10}. Thus the resolution of ADC used is 10 bit.

***Display and keyboard*:**

The display logic uses 6 nos. 7 segment display modules that display the data at a rate/second far more than persistence of vision. The data is latched into an 8 bit 74LS374 latch IC2. The common anode 7 segment displays are powered using 6 PNP transistors BC557. These transistors are driving the 7 segment displays with another 74LS374 Latch IC3 where CPU writes a word to select one such display at any instant. Thus CPU writes respective data to be displayed into latch IC2 and then writes control word in latch IC3 to switch on the respective transistor in order to illuminate the LED's. CPU sacrifices two port addresses 7900 and 7A00 for this purpose. It is interesting to note that both the latches must be written to

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get a display module activated. This feature allows you to disable the display altogether by writing FF in IC2. Now you can write a word in IC3 to enable scanning of the 5 x 4 matrix keyboard where data written in IC3 latch allows selection of only one of the 5 rows of switches. The four switches in the row can be scanned for key closer by a user.

The data can be read in higher order data pins p1-4-p1-7 of the CPU. The keyboard can be thus scanned for the remaining rows also. The scanning of all 7 segment display and keyboard keys occurs at a faster rate as stated above. The timer T0 of the CPU is programmed at initialization to call the display and keyboard routines in interrupt driven mode.

You must note that if '1' has to be displayed on a seven segment then B and C of the display must be powered on. This needs different data to be output on the latch IC2 for a given value to be displayed. This is easily achieved using a table in software for correct conversion. A similar table is also required in case of KB scanning logic.

ADC BOARDS DESCRIPTION:

CA3162 is used as ADC chip in this board. It can measure from –99 to 999 mV in terms of 3 nibbles of 4 bit per reading. It works with two selectable speeds 4 or 96 readings per second. Interface board has one CD4051 analogue multiplexer for 8 channel inputs. The selection of a channel is possible through 3 address lines in the chip.

V. DESIGN OF COMMUNICATION SYSTEM

The remote control is actually the transmitter, receiver and the interface cards all put together. Transmitter transmits the pulses coded according to the button that is pressed. At the other end, the receiver IC decodes the information and any one of it pin goes to logic high depending on the button number that is pressed. The remote control is used to teach the robot how to do a particular task. Once taught, it can playback all the stored instructions. Keeping in view the enormous energy saving afforded by LCD over LED, especially for battery powered applications, a oriole display module which is dot matrix LCD that is capable of displaying alphanumeric, kana (Japanese) characters and symbols is used. The ODM is interfaced to the controller card through the 8255-2. The ADC cards provide the 8-bit equivalent of all the positions of left wheel, right wheel, arm base, shoulder, elbow, roll and gripper movements at its o/p depending upon ADC channel selected.

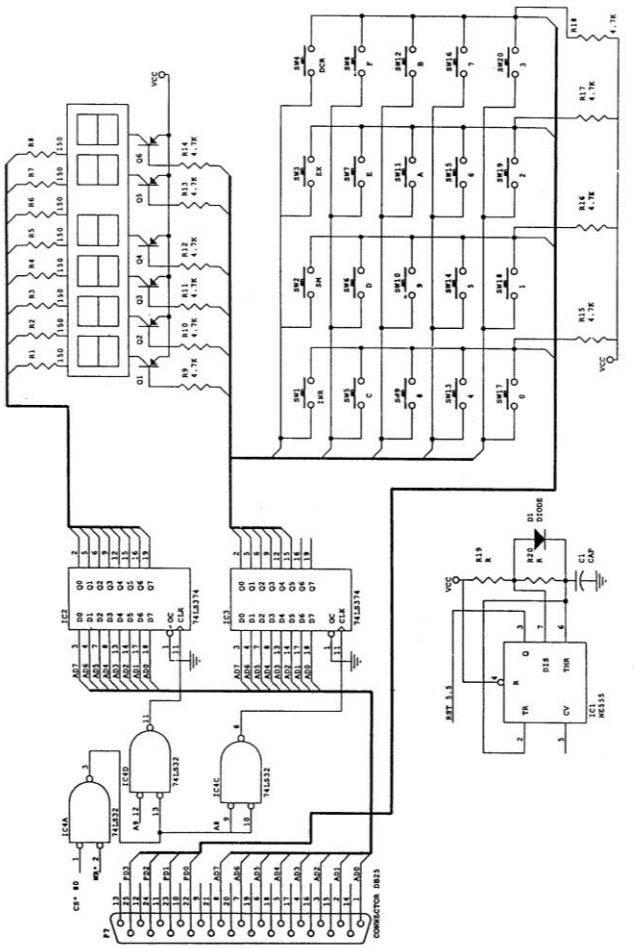

Fig. 8 Display and keyboard design

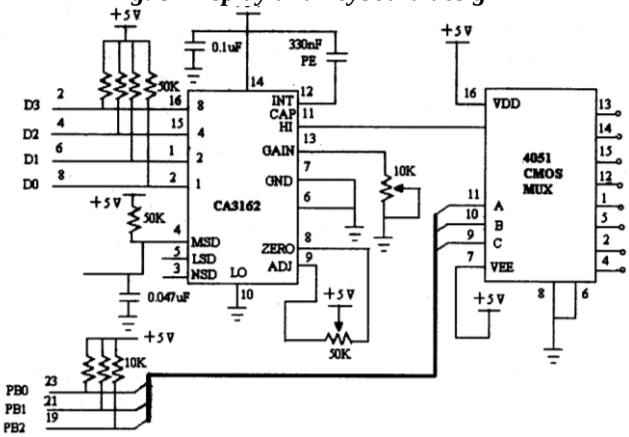

Fig. 9 Analog to Digital Conversion board design

In commercial establishment, its activities may not be concentrated at a particular place, but widespread.

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These widespread units need to be periodically monitored, to ensure their proper functioning. Provision of manpower for each of these units is not profitable and dispensable. So to economize, a central control station is set up for monitoring these remotely located units. To regulate the functioning of these unmanned units, the data from these units is needed to be acquired at regular intervals as they have chances of failure. For the data acquisition and controlling to be successfully implemented, a device needs to be placed, at the remote site, which will act as a bridge between the main control station and the remote site.

VI. APPLICATIONS

The Data Acquisition and Remote Equipment Control System can be used in applications where process parameters at remote place are to be monitored. The parameters which are continuously changing or which may change discretely. In any case the Data Acquisition and Remote Equipment Control System give the reading which is average of several readings. Thus the readings are taken number of times and then they are averaged to get the value which reflects the true status of the process parameters.

It is also possible for Data Acquisition and Remote Equipment Control System to provide the real time reading but it might not always give the correct value. For example if a reading is takes when there is influence of noise (spike) on transmission line from process to the Data Acquisition and Remote Equipment Control System then such reading will be incorrect and thus will falsely prompt to take a corrective action which could disturb the stable process environment on the other hand averaging procedure take only those readings in account for averaging which are in specific range.

Thus such noisy reading will be eliminated. This minimizes the effect of such noise spike. The monitoring is done by operator who is at originator end. The operator gets the readings and analyses the situation and takes corrective action further if required. Thus abnormal changes in process parameters are detected and corresponding action can be taken.

Thus the Data Acquisition and Remote Equipment Control System finds applications in diverse fields such as chemical, metallurgical, electrical etc to name a few. The data acquired by the system can be used for testing purposes or it can used to get the snapshot of the process at a particular moment. This can also be used for research purpose. One of the main advantages of Data Acquisition and Remote Equipment Control System is the physical area that can be covered by it.

The communication medium between originator and Data Acquisition and Remote Equipment Control System is telephone line. The telephone network is well established over the years and it has reached almost every corner of the world. Thus in case of Data Acquisition and Remote Equipment Control System connectivity is global. The speed of data transmission through the telephone line is also sufficient for applications where Data Acquisition and Remote Equipment Control System are used. Since telephone network is already established there is no investment required for setting up the communication network for originator and Data Acquisition and Remote Equipment Control System.

The only cost is that of using the telephone line, which is very less, compared to the cost of setting up a network. The connectivity will also be limited only to the network if private network is established. Thus these features also add to the low cost feature of Data Acquisition and Remote Equipment Control System.

Data Acquisition and Remote Equipment Control System enables user to interact with the different processes taking place at various locations by seating at one place. The job of operator is to dial the number of remote place and then give appropriate commands to get required data.
The versatility of the Data Acquisition and Remote Equipment Control System can be best explored by considering the fields in which this system can be applied to get information and to get much needed control. There are many fields where such situation occurs. The areas of application of Data Acquisition and Remote Equipment Control System thus can be given as follows. The areas of application are

a) Commercial applications.
b) Industrial applications.
c) Security systems.
d) General applications.
e) Research applications.

Let us consider a chemical process in which say pressure, temperature, humidity, concentration of constituents, flow etc. are the critical parameters because changes in these parameters may change the desired course. Therefore any abnormal change or deviation in any of these parameters must be immediately known so that corrective action can be taken. If the section in which the process is taking place is inaccessible due to the corrosive environment or high temperature of process then it is desirable to be able to monitor the process from remote place which is safe.

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The parameter to be monitored is say humidity. In such a case a sensor is required to sense the current value of humidity. For example Lithium Chloride sensor shows a very sharp decrease in electric resistance when it's relative humidity increases. This allows more current to flow thus more heat is generated. This heat is directly proportional to the relative humidity. Thus a temperature sensor would be required.

In order to monitor the process from remote place a communication system would be required with devices to read correctly the process parameters. The Data Acquisition and Remote Equipment Control System have sensors to measure the parameters as well as communication and data acquisition system to collect and store data. Thus the current reading of humidity will be displayed at originators end. The operator can check whether the process environment is suitable for process to continue or any modifications are required.

This is possible without entering the process environment which might be harmful for human being. Thus naturally the Data Acquisition and Remote Equipment Control System are preferred in such situation.

The Data Acquisition and Remote Equipment Control System can be used for commercial applications as well where prime concern involved is money. The digital electric meter reading is such a sector. In digital electric meter reading procedure, the person from electric company has to visit all the subscribed houses. Thus it is not possible for him to visit all houses often. Thus the reading of each house meter is taken once in two months. The other month's bill is predicted from previous reading thus accuracy suffers. The precious working hours are also wasted in just taking the reading because the subscribed houses may be physically at distant locations from each other. Thus traveling gets big share of time needlessly.

The Data Acquisition and Remote Equipment Control System are ideal in such a situation. One microcontroller at each location in a building where the digital electric meters are installed will solve the purpose. Here we will interface the digital electric meter with our microcontroller. This becomes our remote end. Now when we dial from the originator to this remote end we can get the readings of all the meters connected to different ports and thus save on money.

VII SAFETY PRECAUTIONS FOR THE PROJECT DESIGN

Here, We Describe The Intricate Details Which We Have Considered While Design, This Is Done To Achieve Efficient, Safe, Usable, Sturdy Design**.**

a) 8" x 10" Plastic box enclosure for the system.
b) Circuit boards firmly mounted with threaded plastic spacers and screws.
c) Circuit boards interconnections with plug in type connectors.
d) Header connectors with computer grade flat cable used for data lines.
e) D type male and female connectors used for external connections.
f) 6.5 volts regulator with black powder coated heat sink.
g) Membrane Keypad for durable use.
h) 6 digit 7 segment LED used for better visibility.
i) All the chips used in the circuit are socket mounted for better maintainability.
j) CPU & display boards on double sided glass epoxy printed circuit boards with lacquer coating and component layout masked.

The basic system architecture is as stated as below.

- Based on 89C52 microcontroller.
- 4 KB EEPROM program memories.
- 32 KB RAM space.
- 6 digit 7 Segment display.
- Touch switch keyboard.
- 8255 with 24 I/O ports.
- 8 channel 10 bit resolution ADC.

VIII. IMPLEMENTATION AND RESULTS

The implementation and results are, once a system has been completed, it should tested for its reliability. We have successfully implemented our work with the help of MODEMS and telephone lines by simulating conditions by means of potentiometers. The variance in the data at the remote end was successfully displayed on the computer at the user end. The entry to the system is regulated via security checks at both locations, layers of security is introduced, both at the control room end and the counter checked at the remote end by checking for the password string at both ends fed by the user, enabling or disabling the system accordingly.

XI. CONCLUSIONS

On varying the potentiometer, which simulates the analog quantities we find a corresponding change m the readings on the computer after giving the command for data acquisition. The digital values were simulated m the program and displayed on the VB screen. LED used, which

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simulates any on going process at the remote end had been controlled by initiating appropriate command from the user end. In case of any alerting increase in any of the measured data was also indicated at the user end.

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