WIRELESS MONITORING OF REMOTE SHP STATIONS

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

ALTERNATE HYDRO ENERGY SYSTEMS

By

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CANDIDATE'S DECLARATION

I hereby certify that the work which is presented in this Dissertation entitled, "Wireless Monitoring of Remote SHP Stations ", in partial fulfillment of the requirement for the award of the degree of Master of Technology in "**Alternate Hydro Energy Systems**", submitted in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee** is an authentic record of my own work carried out during the period from July, 2009 to June, 2010 under the supervisions of **Shri. S.N.Singh**, Senior Scientific Officer, **Alternate Hydro Energy Centre** & **Dr. Vinod Kumar**, Professor & Head Of Department, **Electrical Engineering Department , Indian Institute of Technology Roorkee.**

I have not submitted the matter embodied in the Dissertation for award of any other degree.

Date: June 30, 2010

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CERTIFICATE

This is certified that the above statement made by the candidate is correct to best of my knowledge.

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Satyaprakash

Date : 30-06-2010 (SATYA PRAKASH SARASWAT)

ABSTRACT

In this Dissertation Report we have developed a System for Wireless Monitoring of Remote SHP Stations for continuous monitoring of various parameters of SHP stations with the help of LabVIEW Programming. Developed system is cost effective & reliable for Monitoring of Small Hydro Power Projects. The monitoring of SHP means to collect the system information of its current status i.e. Power generation , Power Factor & Frequency of Power, phase current & phase voltage in all three phases, water level of upstream & downstream, Flow & discharge , various Temperatures , Efficiency Of Turbine & Noise Level in the Power House etc.

In this experiment work the following parameters of Remote Small hydropower station unit are monitored

(a) Electrical parameters such as Voltages, Current of all the three phases as well as all other parameters such as power generation (kW), KVA, KVAr, frequency and power factor, Power Angle .

(b) Non electrical parameters such as of speed of turbine, discharge, inlet head, outlet head, temperature of bearings and gate valve position, Noise Level in Power House & Efficiency of Turbine.

Effective plant monitoring & control strategies are essential to maintain efficient plant operation. The technology of parameter monitoring has evolved over the last decade from simple failure notification to the delivery of data about a wide range of different conditions. As the network technology, communication protocols increased, merger of system capabilities made it possible to improve the system reliability.

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INTRODUCTION & LITERATURE SURVEY

1.1 BASICS OF SHP STATIONS

Small hydro power installations have, historically, been cheap to run but expensive to build. That is changing now, with smaller, lighter, and higher speed turbine equipment, lower cost electronic speed and load control systems, and inexpensive plastic piping. Capital investments are still higher than investing in diesel equipment of comparable capacity; but the long life and low operating costs of small hydro make it an attractive investment for many applications. For installing a SHP we have to just evaluate the potential of a small hydro site; - lay out the site; - apply for necessary licences and permits; - get financing; - select and install equipment and - understand the equipment, so that you can operate and maintain the system yourself. Hydropower is being used widely all over the world. Small hydropower, which is renewable energy source, is getting more attention in present world situation comprising of rapidly depleting fossil fuels, increasing power problems and environment problems.[1]

1.2 BENEFITS OF SMALL HYDRO POWER PLANTS

Potential benefits of small hydro units are listed as follows:

i. Small hydro is a reliable source of energy with a very long life-cycle (usually 50-75 years).
ii. It is highest energy density renewable resource and easy to harness
iii. The limited impact of small hydro to a river's ecosystem is often offset by its pollution-free and environmentally benign attributes.
iv. The technology is manufactured to last 50 or more years.
v. Small hydro is an inflation-proof source of energy that requires minimal maintenance. This factor makes small hydro an economically attractive renewable source.
vi. Small hydro systems operated in parallel with the utility grid can serve as reliable back-up power.

vii. Micro, mini, and small hydro plants typically have short construction schedules and are easily built compared to other forms of energy.

The most significant environmental impact of small hydro development is positive in that small hydro plants generate electricity without the type of emissions associated with conventional power stations.

They require control and monitoring systems to limit the huge variation in input flows expected in rivulets over which these are established to produce a constant power supply.

A Power Plant Monitoring System is extremely important for assuring normal operation of the whole power plant as well as initiating alarms to avoid further development of unattended fault within the power generating system. The task of monitoring a power plant is to detect faults at an early stage and avoid damages to the major components of the plant e.g. turbine, generator. There are many parameters of monitoring in a power house. Like generations, instantaneous voltage or generating voltage, current, power factor, temperature, revolutions per minutes of generator shaft because of frequency should be matched with the grid and it should be precisely monitored, KVA generations, load factor, KVAR generations. So knowing of current status of various parameters in system, the monitoring of all quantity is necessary. It helps for controlling of all equipments.[1],[2]

1.3. Maintenance Parameters of Hydro power stations & its Monitoring & control

The maintenance of system parameters like frequency, voltage, etc., within certain limits is essential for proper operation and efficient use of power produced. The system frequency can be maintained constant by eliminating the mismatch between generation and load.Aconventional speed governor with supplementary integral control can be used to maintain the frequency constant both for grid connected and isolated mode operation. In general the generation control mechanism is not used due to prohibitively high cost; therefore, frequency is maintained by load management. A complete mathematical model for an improved load controller when applied for a micro/mini hydro, wind, diesel electric system are discussed in detail in refs. In a standalone small-hydro generation system due to non-availability of storage facility, the total input has to be converted into electrical energy. Any variation in power demand is controlled by a resistive load called dump load. Since the input to the generator is essentially constant, the excess power due to decrement in load is dumped into the dump load . One of the main reasons for non-exploiting isolated small-hydro power systems in the higher capacity range is due to the limitation on the size of the available dump loads . It is also one of the reasons onthe existing systems that the resources are not used to the fullestavailable capacity.[3]

In most of the sites of small-hydro plants it has been observed that the primary requirement of the local community is water for irrigation of agricultural land as their survival depends upon it. But if electricity is available, it will enhance the living standards by helping in better education, hospital, communication, facilities,

etc. Once water enters the stream from tailrace, it requires power for pumping to the fields. Therefore, if surplus water is available before the entry to the penstock it can easily be diverted to the fields. In general, the load factor of small-hydro plants is less than 50%. Therefore, more than 50% water can be available as surplus if proper generation control strategies are employed instead of using dump load.Anewcontrol scheme is proposed in this paper by which the dump load is eliminated and frequency is maintained at the desired level. In the proposed control scheme, the penstock flow is regulated through two longitudinal small sections of pipes as shown. One pipe is fitted with on/off control valve with 50% of flow rate under maximum rated load conditions in on state.

The second pipe is fitted with a valve, which is controlled by a servo motor. The flow rate in the second pipe is continuously controlled by controlling the input signal to the servo motor. The first control valve is either fully open or closed depending upon the loading condition. When the load is less than 50% of the rated maximum load, on/off control valve will remain closed and the servo motor controlled valve will take care of the deviation in frequency due to load variation. Whenever there is disturbance in load, the servo motor controlled valve changes the flow rate so as to maintain the system frequency constant. The water head is maintained constant by overflow of excess water through spillway and diverting to the fields through a channel for irrigation. This method therefore eliminates the conventional frequency control by additional load management, i.e. dump load. The decision of the time for on/off the control valve, when the load increases or decreases plays a vital role in the system dynamics. To study the dynamics, a transfer function model is developed for the system along with the servo motor and on/off controller. Transient responses are shown for different loading conditions and for low, medium and high head installations.[4,5]

Figure 1.1 Shows SHP turbine generator setup & Load Controller

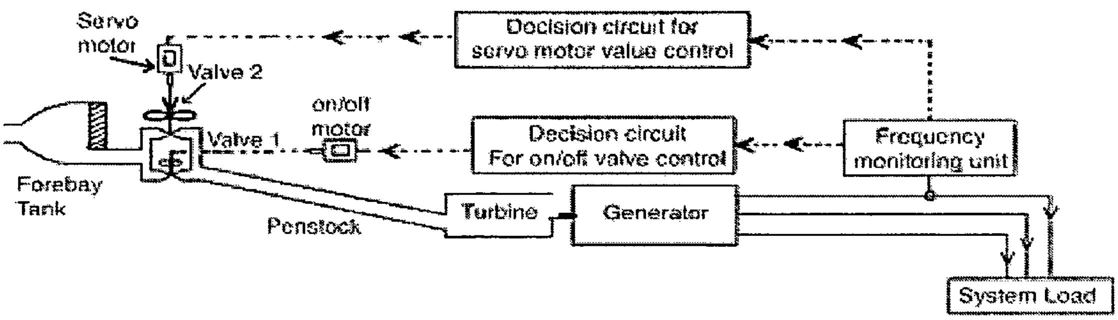


Fig.1.1 SHP turbine generator setup & load controller[5]

1.4 INTRODUCTION TO WIRELESS TECHNOLOGY

Wireless Data transfer technology used in industries is one of the fastest changing areas, with related services and applications having enormous and immediate impact on diverse aspects of the almost every industry i.e. power, manufacturing etc. In this respect the development of reliable and robust yet flexible and future proof infrastructure capable of real-time, secure and cost effective delivery of data is of utmost importance to increase the user's perceived quality of life by facilitating human-to-human as well as human-to-machine communication.[2] **Wireless communication** is the transfer of information over a distance without the use of enhanced electrical conductors or "\wires The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications). When the context is clear, the term is often shortened to "wireless". Wireless communication is generally considered to be a branch of telecommunications.

We has to make a decision to finalize communication system keeping in view the following.

i. Life cycle cost
ii. Equipment acquisition, O&M ,growth and expansion
iii. Facilities, user/operator training
iv. Regulatory issues
v. Time required to replenish the outage
vi. Integration with existing equipment
vii. Availability of support services.

1.4.1 Need of wireless communication

Usually, there are number of sensors in a power plant for measurement purpose, such as, pressure transmitters, flowmeter, temperature transmitters, level transmitter, and so on. Until now, wired networks are used to connect sensors to transfer sampled process data to control systems. Wired networks are very reliable and stable communication systems for instruments and controls. However, the cabling engineering necessary is very costly. Therefore, recently costless wireless networks are more and more strongly required by customers, for example, temporary instrument networks and/or some non-critical permanent sites [4,5].

Wireless networks are more complex, extending towards ubiquitous communications, and providing a broad range of other services and applications, from remote managing of an intelligent and to advanced real-time monitoring systems. In spite of the increased complexity, these are easily maintainable and their capabilities are continuously improved and upgraded by relying as little as possible on human intervention [4].

1.4.2 Advantages of wireless technology

Although there are many industrial networks installed in factories, plant data not accessible, because the cabling engineering is very costly. With wireless communication technologies we can make so far such un-accessible data visible easily, and especially the following applications of industrial automation are expected.

Field Instrument Maintenance

The most of current field instruments are so-called smart modules, which microprocessors are built in. There is a lot of information in a smart instrument besides a measurement value, such as settings, operational status and so on. However, to read out such maintenance information, plant operators usually have to connect cables to the terminators manually. If such information can be accessible by a wireless network, it should be great helpful.

i. Temporary installation

In order to judge the necessity of new instrument engineering, temporary installations are desirable to get some process data before permanent installations. Since the cabling engineering, which is necessary for conventional wired network, is quite costly, it is almost not impossible to do these. But with the wireless network, which no cabling engineering needed, we can make the temporary installation very easily to get the process data we require.

ii. Flexible Engineering

Cabling engineering costs us much money and time. However we may have to re-cabling these signal lines and power supply lines to fit production line layout changes frequently. Conventional wired networks could not be flexible enough to meet such change demands.

On the other hand, there are many applications with difficult wiring by the conventional wired network. For example, rotations, big tanks, or hundreds of measuring points is required. In such cases, if a wireless network is available, conventionally immeasurable data can also be connected with the network.

(iii) Monitoring

In general speaking, the reliability and latency for monitoring process data is not so important compared with control. Monitoring applications are easier to adapt wireless networks than control applications.[6],[7]

In power station monitoring it is very essential to know about current status of the power station as well as for controlling of parameters. Fig 1.3 shows the communication between different instruments in field and PC [7].

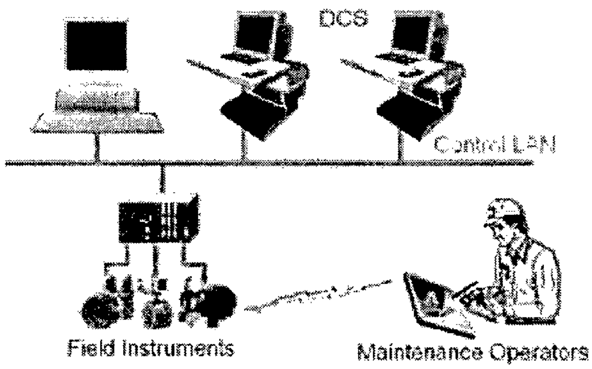


Fig. 1.3 LAN for field instrument measurements [7]

1.5 INFORMATION OF SETUP

In this dissertation work we have done Wireless Monitoring of remote SHP stations with the help of LABVIEW programming for make the system more physically reliable compare to other monitoring techniques. In that we have first sensing the different parameters with help of various sensing equipments which are discussed in next chapters & after sensing data from the setup we have further collect & processing that data with the help of different data acquisition modules & after the data acquisition we have to display that data on computer with the help of RS232 & RS485 Modules & after that we are further processing that data on the LABVIEW Window & retransmit that data to the control panel with the help of web publishing tool available in LABVIEW . It can also connected through LAN or wi-fi network for transferring data to other PC. Here we installed different instruments separately for measuring different parameters, which considered in this experiment. All instruments have analog/ digital outputs for interfacing with computer or other display devices.

There are already software's available with some instruments for measurement on PC, but common problem is different instrument has different software, because these are supplied by their manufacturers. So it is not possible to see all instrument output to a single PC as well as same window. NI LabVIEW graphical programming has revolutionized the development of test, measurement, and control applications. Regardless of experience, engineers and scientists can rapidly and cost-effectively interface with measurement and control hardware, analyze data, share results, and distribute systems.

Here we used the software LabVIEW for solve this problem, using this we can monitor all parameter on same window as well as we can get them in desired form. This can be further transmitted by Radio modem or connected through internet for remote monitoring.. This software is made by National Instruments like PS-CAD, MATLAB and its special feature it is user friendly and virtual display. To connect instrument with LabVIEW window in PC, we used 7000 series modules, manufactured by ICP CON [6].

CHAPTER-2

EXPERIMENTAL SETUP

2.1 SCHEMATIC BLOCK DIAGRAM OF TEST SETUP

The Whole Experiment Setup of our Dissertation work is done in the Hydro-Mechanical Lab present in Our AHEC deptt. The experiment setup consists of a pump which creates the necessary head and discharge for the turbine which is coupled to the Generator . In its suction is a water tank wherein water is drawn by the impeller and pumped into a turbine. The water flow to the turbine can be adjusted by means of a manual control valve or an electrical valve. The Generator is coupled to the turbine by means of a shaft. The generator terminals are in turn connected to load (bulb load) through the Load control circuit. Here we use ICP-DAS modules for data acquisition and for data display we used LabView. [8]

2.1.1 Construction

This setup is situated in our AHEC, Hydro mechanical Laboratory. As shown in Figure 2.1, there is a water tank where water is drawn by the impeller system and pumped into a turbine..

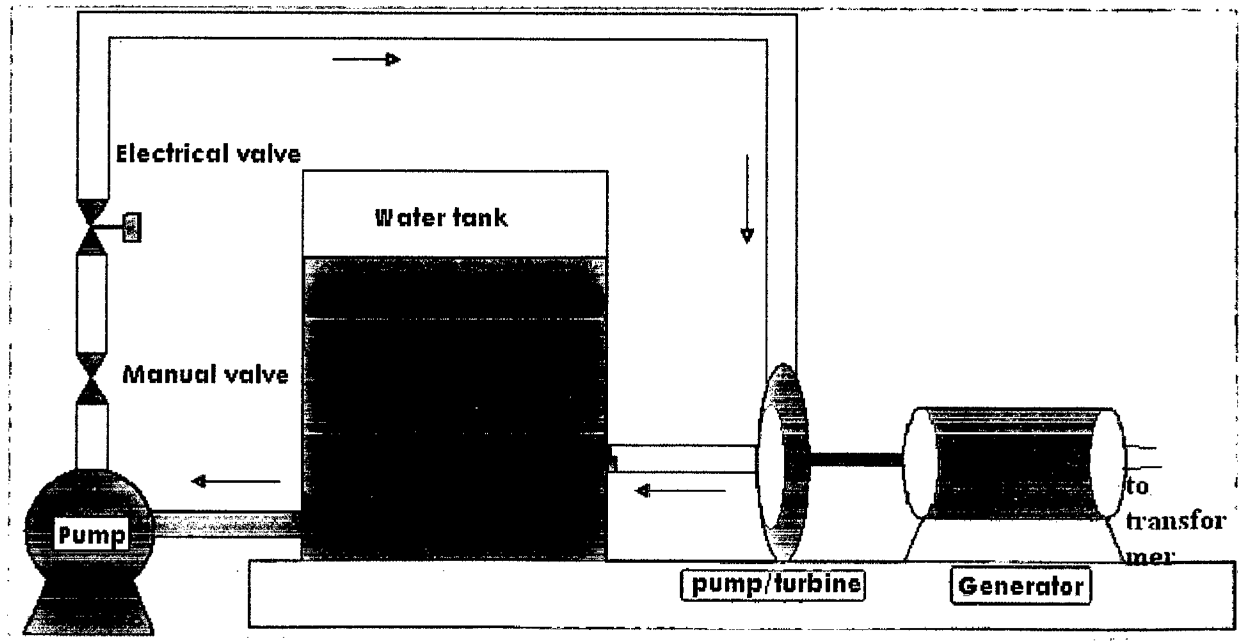


Fig. 2.1 Experimental Test setup unit

We use a pump to create the necessary head and discharge for the turbine which is an impeller and act as pump as turbine (PAT). The flow of water to the hydro turbine can be adjusted by means of a manual control valve as well as an electrical valve. Both are present, but only electrical valve is used because of it consists of potentiometer system. In our test we kept manual valve fully open and that electrical control valve is used.[9,10]

The Generator is coupled to the turbine by means of a shaft arrangement. The generator output terminals are connected to load, and it also connected through control panel.

The resistive load of the generator consists of 5 rows of lamps with 3 lamps in each row and they are arranged such that all the 5 bulbs in each column which are connected to a phase, as the generator is of three phases all the lamps are accommodated by that system. Figure 2.2 is an arrangement of load system which is connected through R, Y, B phases.

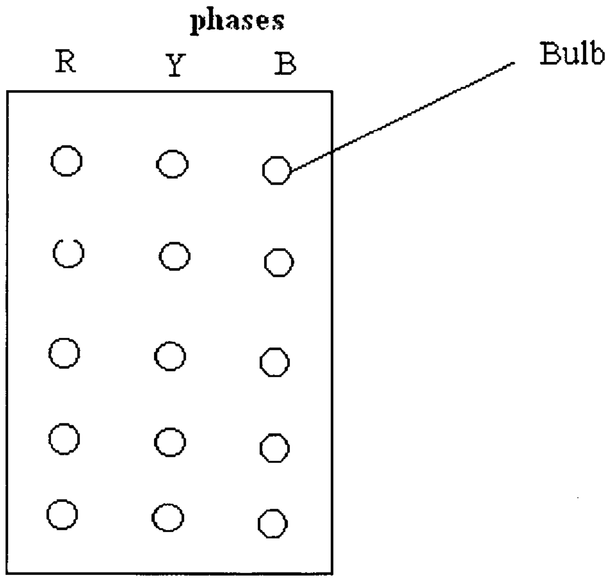


Figure 2.2: Arrangements of load system.[9]

2.1.2 Specifications

(i)Water Lifting Pump

Total head: 32.8 meters

Flow rate: 14.5 liters/sec

Pump input: 8.18kW

Speed: 1450 rpm

The input pump is a constant speed motor pump of 30 H.P and can produce a maximum head of 60 meters and maximum flow of 24.0 Litters.[8]

ii) Generator

Type Synchronous

Terminal voltage: 415V

Reactive power: 12.5 KVA

Active power: 10 kW

Power factor: 0.8

Frequency: 50 Hz

Speed: 1500 rpm

Excitation: 23.5V DC, 2.32 Amps

2.2 MEASUREMENT OF PARAMETERS

In this test set we consider following parameters

i. Electrical Parameters-Voltage, Current, kW, KVAr, KVA, Power factor, Frequency
ii. Non-electrical parameters- Speed, Temperature, Pressure, Discharge, %of gate valve opening

For measurement purpose we used following instruments

(i) Ultrasonic Flowmeter
(ii) Power Analyser
(iii) Infrared Temperature Gun
(iv) Pressure Transmitter
(v) Speed Sensor
(vi) Electric valve

2.3 DATA TRANSFER TO PC

In this section, data received by instruments is to be transferred to PC in desired form, so we use I-7000 series modules, all the data is communicated to these specific module through a channel.

The I-7000 series is a family of network data acquisition and control modules, providing analog-to-digital, digital-to-analog, digital input/output, timer/counter and other functions. The modules can be remotely controlled using a set of commands, which we call the DCON protocol. We used three modules of this family as I-7080(Frequency counter module),I-7019(Analog input module) ,I-7520 (Signal convertor)

i. 7080-Frequency counter module

The I-7080 is a cost-effective, compact and robust 2-channel counter/frequency input and 2-channel digital output module. Each module is addressable allowing up to 256 units to be linked together via a two-wire RS-485 connection with a baud rate up to 115.2 kbps.

ii. 7019- Analog Input module

The I-7019 is an 8-channel voltage, current, and thermocouple input module, with the ability to connect various types of inputs to a single module.

iii.**7520- Signal Convertor**

The 7520, RS-232 to RS-485 converter, equips a "Self Tuner" inside, therefore it can detect the baud rate and data format automatically and control the direction of the RS-485 network precisely. Therefore we can connect all this equipment to the same RS-485 network. This method will greatly reduce system cost and increase reliability. Figure 2.3 , 2.4 shows the picture of module I-7019 and I-7520 [7,8].

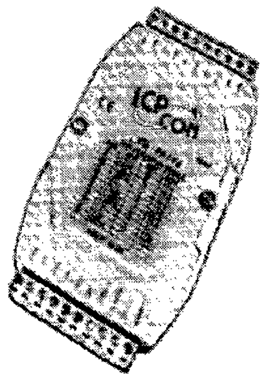


Fig 2.3 Module 7019 [11]

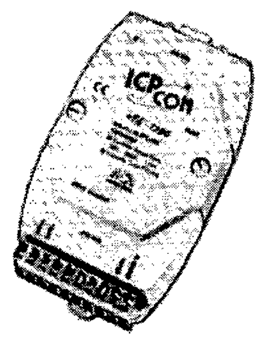


Fig 2.4 Module 7520 [11]

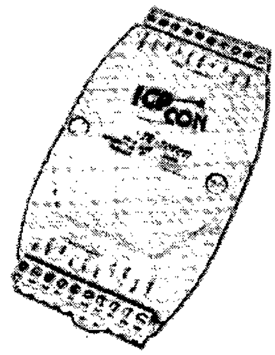


Fig.2.5 module 7080 [11]

Here we used 2 Analog Input Modules, frequency counter and one convertor module. Each analog input module has 8 channels. All the modules are connected in series with the I-7520 i.e. signal convertor module. Frequency counter module is used for speed sensing with necessary circuit and analog input module is taking electrical parameters data.

The 7000 Series RS-485 Network: The 7000 RS-485 network is the most powerful and flexible two-wire RS-485 networks in the world. It is a multiple baud rate and multiple data format network system. That is to say, all the remote modules mentioned above, PLCs and weight scale equipment share the same RS-485 network. The 7520, RS-232 to RS-485 converter, equips a "Self Tuner" inside, therefore it can detect the baud rate and data format automatically and control the direction of the RS-485 network precisely. Therefore the user can connect all this equipment to the same RS-485 network. This method will greatly reduce system cost and increase reliability.

Diagram of setup connection is shown in Figure 2.6 [12]

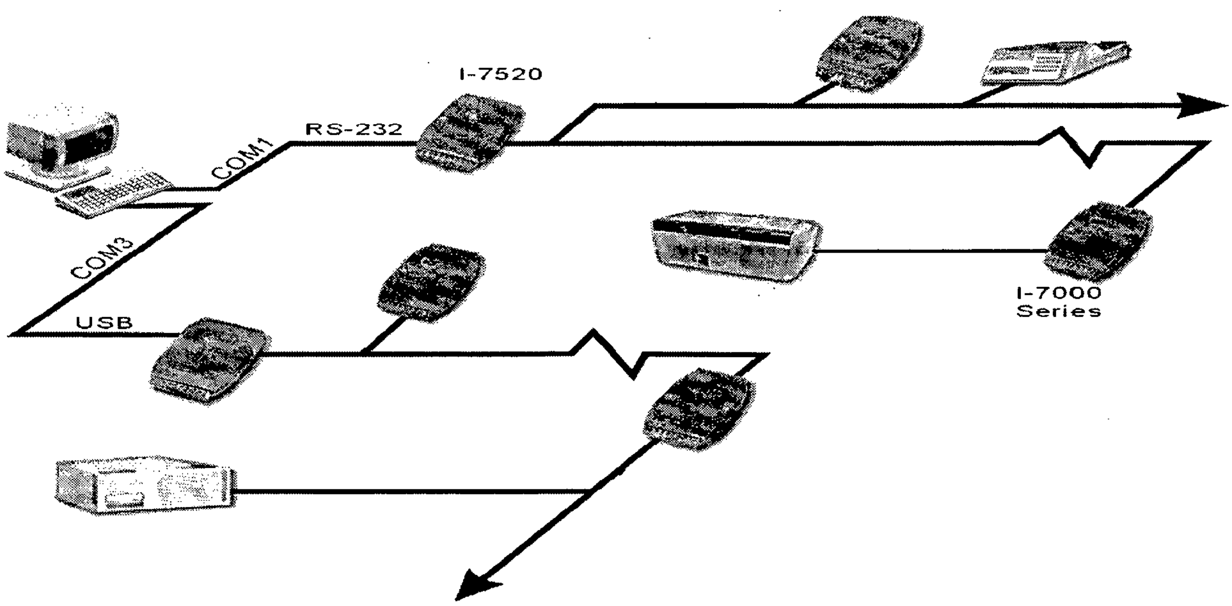


Fig. 2.6 Data Transmission and connections [11,12]

2.4 DATA REPRESENTATION

LabVIEW (**Lab**oratory **V**irtual **I**nstrumentation **E**ngineering **W**orkbench) is a platform and development environment for a visual programming language from National Instruments. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS. LabVIEW is a graphical programming environment used by millions of engineers and scientists to develop sophisticated measurement, test, and control systems using intuitive graphical icons and wires that resemble a flowchart. LabVIEW offers unrivaled integration with thousands of hardware devices and provides hundreds of built-in libraries for advanced analysis and data visualization.

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The last is used to represent the VI in the block diagrams of other, calling Vi [13].

The *front panel* is the face that the user of the system sees. It contains *controls* and *indicators*. LabVIEW has a very rich selection of both (you can even design your own) and this permits a wide range of options to the designer.

Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument. However, the front panel can also serve as a programmatic interface. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program. Demonstration of a few of the controls is shown in Figure 2.7 [14]

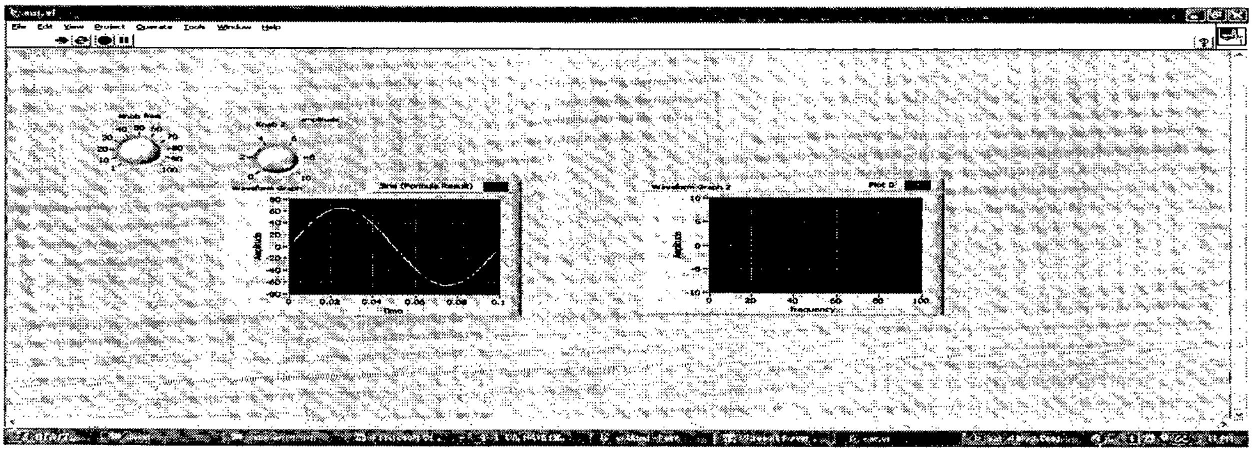


Fig. 2.7 Front Panel of LabView and Controls[14]

Benefit of LabVIEW over other development environments is the extensive support for accessing instrumentation hardware. Drivers and abstraction layers for many different types of instruments and buses are included or are available for inclusion. These present themselves as graphical nodes [13],[14].

2.5 FINAL DISPLAY

With the help of LabView we designed the screen for monitoring of desired parameters of existing setup, which shown in Figure 2.8

This screen shows the display for voltage & current in all three phases, kW, KVA, KVAr, power factor, frequency, discharge, temperature of bearings, pressure, % of electric valve opening, speed, Efficiency of Turbine , Power angle , Sound Level in Power House.

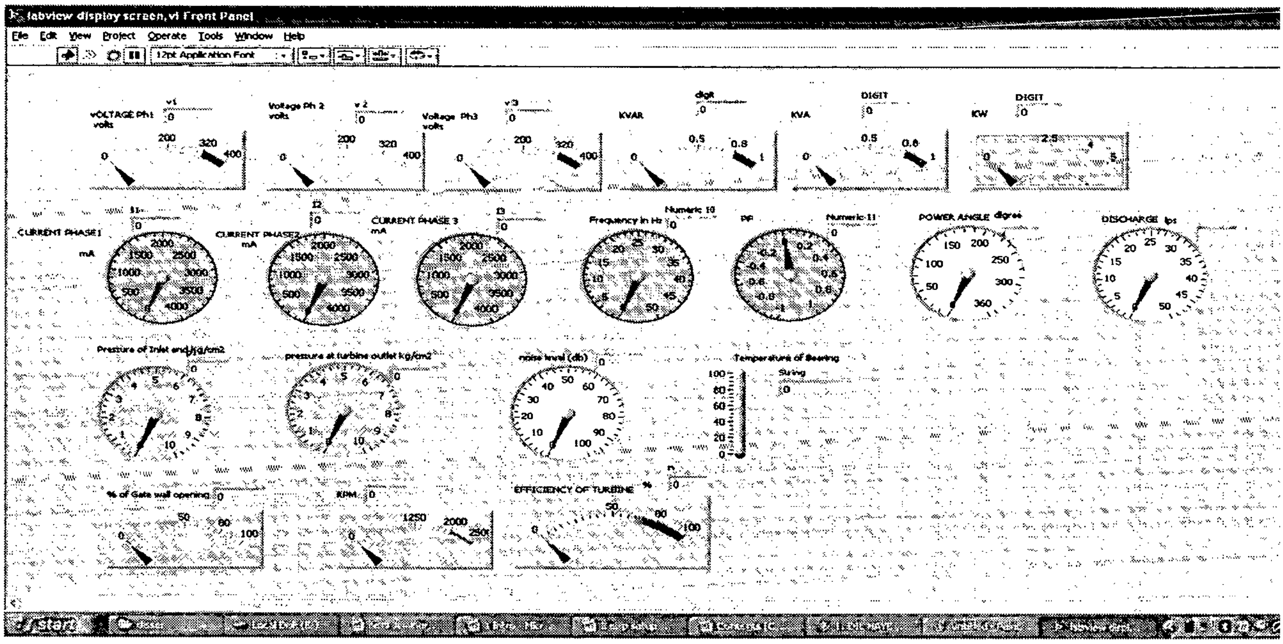


Fig. 2.8 Final Display Screen for monitoring

2.6 CONNECTION AND BLOCK DIAGRAM

Here all the instruments are giving analog output to the modules which further transmitted in RS485 to RS232 convertor for communication with PC.

Module-1(I-7019), taking data from power analyser

Module-2(I-7019),taking data from flowmeter, IR temperature gun, Pressure sensor ,Electric valve, Sound Analyser.

Module-3(I-7080), taking data from speed sensor

Module-4(I-7520) ,Converts the data from RS-485 to RS-232

Figure 2.9 & figure 2.10 shows the connections between modules and instruments

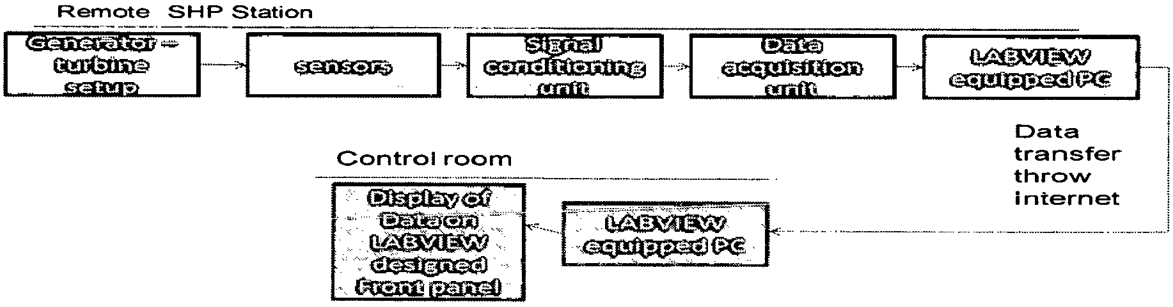


Fig. 2.9 Block diagram of connections

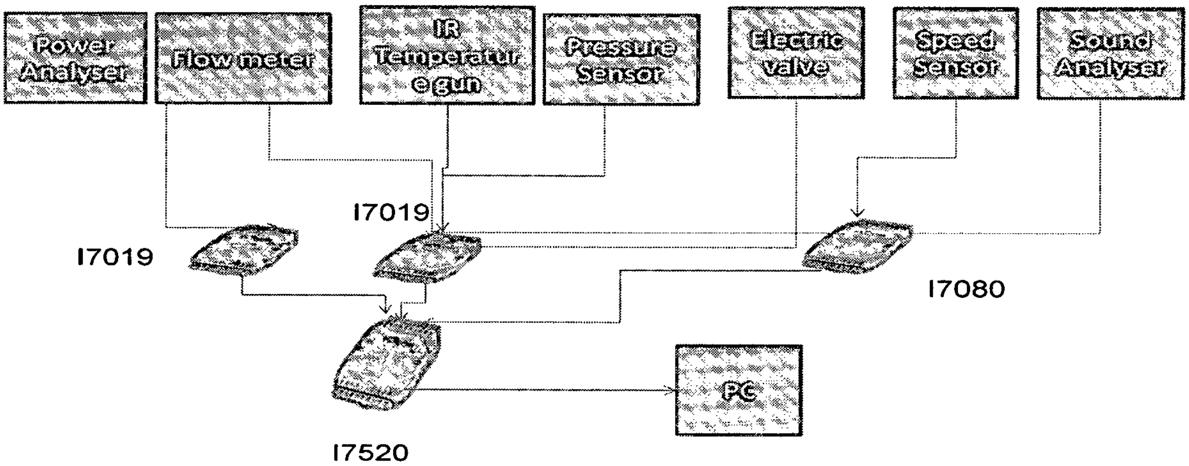


Fig. 2.10 block diagram of experimental setup

2.7 CONCLUSION

The whole Experiment setup is performed in the Hydro Mechanical Lab present in AHEC department with the help of instruments & connections described in this chapter and after completion of whole experiment setup system is ready to perform the required functions .

CHAPTER 3

INSTRUMENTS AND MEASUREMENT METHODS

3.1 INTRODUCTION

In this Chapter we have discussed the details & specifications of the Instruments used to perform the whole experiments, all the instruments discussed in this chapter have been arranged from the Instrumentation Lab of Alternate Hydro Energy Centre & some of them are arranged from Electrical Department.

3.2 INFRARED TEMPERATURE GUN

Infrared temperature sensors absorb ambient infrared (IR) radiation emitted by a heated surface. They are used in a variety of applications where direct temperature measurement is not possible. With noncontact infrared temperature sensors, incoming light is converted to an electric signal that corresponds to a particular temperature. Although many different types of products are available, noncontact infrared temperature sensors can be thought of as belonging to general categories based on design and application. This category criteria attempts to distinguish unpacked devices that can be used as part of a larger sensor from, say, a gauge which can be read by simple examination. Categories for noncontact infrared temperature sensors include sensor elements or chips, sensors or transducers, gauges or indicator and instruments or meters.[15]

The OS530E/OS520E series Handheld Infrared (IR) Thermometers provide non-contact temperature measurements up to 4500°F. They offer effective solutions for many non-contact temperature

3.2.1 Applications

The IR Temperature Gun provides information at a glance custom backlit dual digital LCD displays bothcurrent and minimum, maximum, average or differential temperatures. This versatile instrument provides

i. Measurable target distances from 5 inches to approximately 100 feet

ii. Emissivity adjustable from 0.1 to 1.00 in 0.01 steps provides ease of use when measuring a variety of surfaces.

iii. Built-in Laser sighting in Circle & Dot configurations.

iv. Thermocouple input available.

Laser Specifications-

Wavelength (Color): 630-670 nanometers (red)

Operating Distance: Laser Dot 2 to 40 ft.

Laser Circle 2 to 15 ft.

Fig.3.1 shows Infrared Temperature Gun

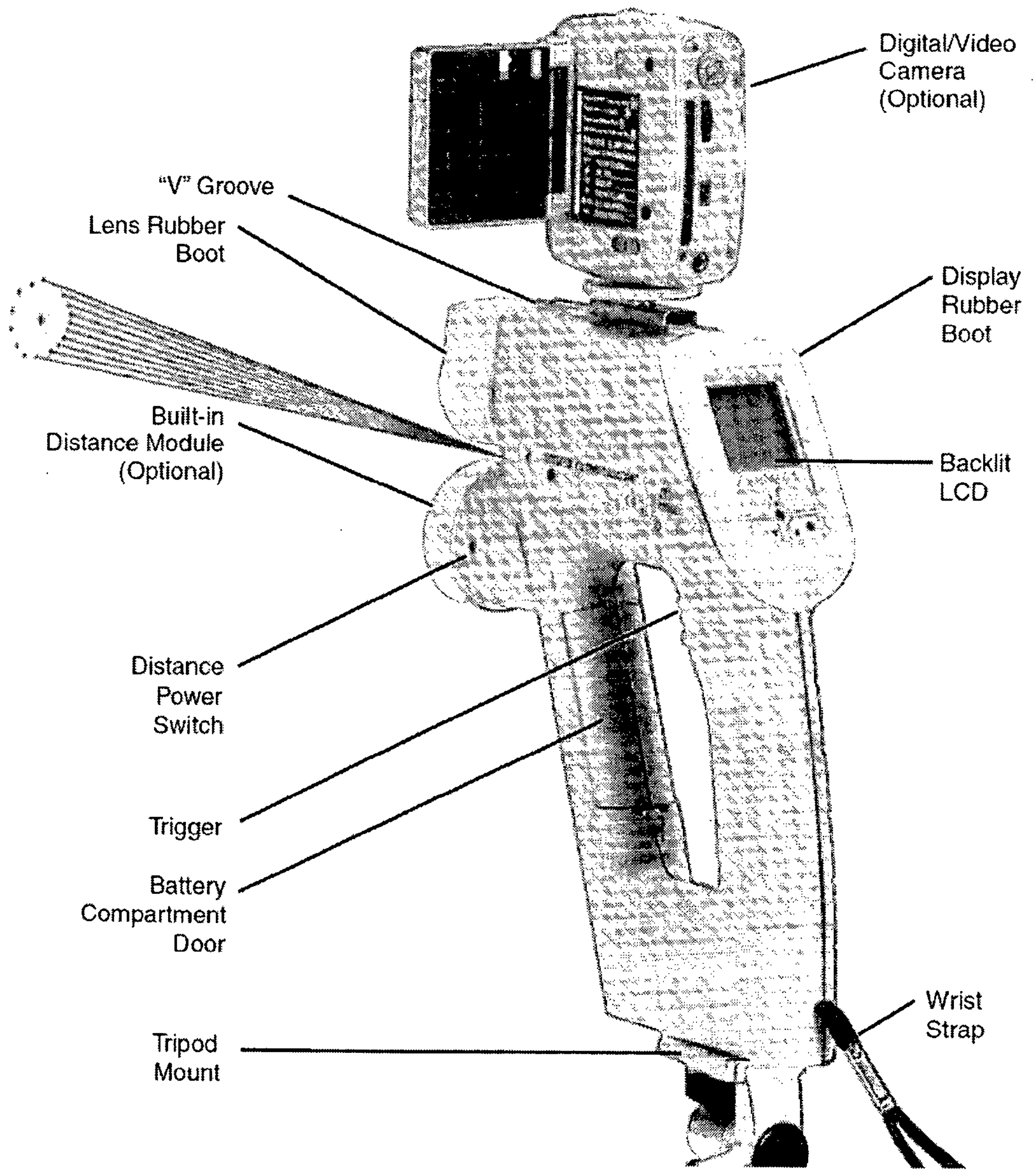


Fig.3.1 infrared temperature gun[15]

3.2.2 Operating

i. Set the laser power switch to the ON position

ii. Aim at the target and pull the trigger.

iii. The laser beam and the red power indicator LED will turn on

Depending on the model, the laser dot/circle switch allows the user to switch between laser dot and laser circle. The laser dot provides visibility at longer distances.
shows the two different laser configurations. The laser Dot indicates the center of the field of view of the thermometer.
The laser Circle indicates the perimeter of the thermometer's field of view.
The visibility of the laser beam depends on the ambient light levels fig 3.2 shows two laser configuration

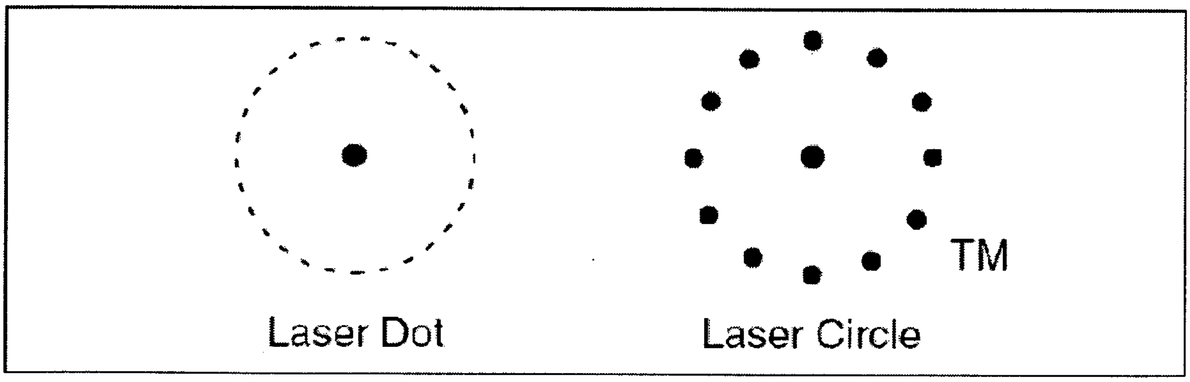


Fig.3.2 Two Laser Configurations[15]

3.2.3 How Infrared Thermometry Works

Heat is transferred from all objects via radiation in the form of electromagnetic waves or by conduction or convection. All objects having a temperature greater than absolute zero (-273°C, -459°F, 0 K) radiate energy. The thermal energy radiated by an object increases as the object gets hotter. Measurement of this thermal energy allows an infrared thermometer to calculate the object's temperature if the emissivity (blackness) is known.
Generally, it is convenient to measure the amount of radiated energy in the infrared part of an object's radiation spectrum. Figure A-1 shows a block diagram of an infrared radiation thermometer. Energy from the object is focused by the lens onto the detector. As the detector

heats up, it sends out an electrical signal, which in turn is amplified and sent to the circuitry of the thermometer. Fig 3.3 shows block diag. of infrared temperature gun.[11]

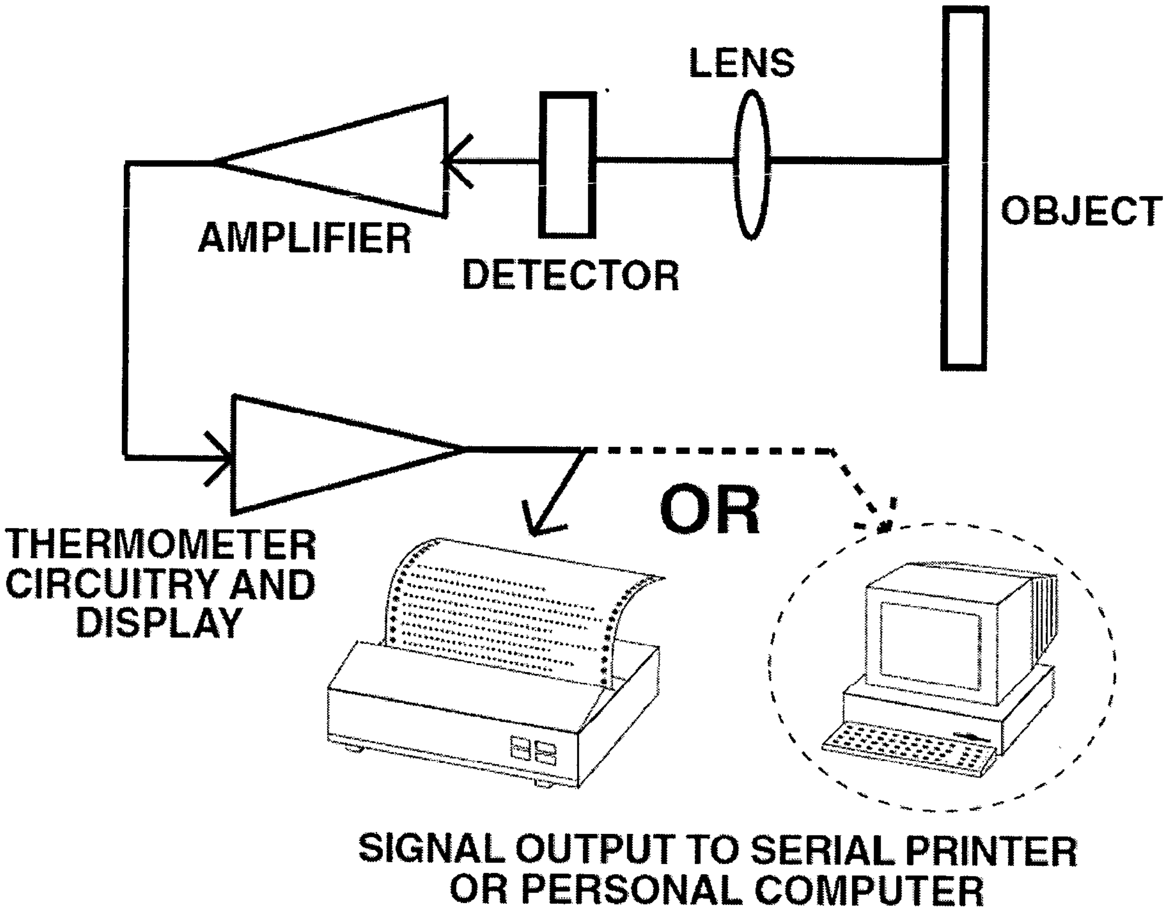


Fig3.3 Infrared Thermometer Block Diagram [9]

When thermal radiation falls on an object, part of the energy is transmitted through the object, part is reflected and part is absorbed. A blackbody is defined as an ideal object that absorbs all the radiation incident upon it. Emissivity is defined as the ratio of energy radiated by an object to that of the energy radiated by a blackbody. By definition, the emissivity of a blackbody is 1. Most objects are considered *gray objects* with an emissivity between 0 and 1. The net thermal power radiated by an object has been shown to depend on its emissivity, its temperature and that of the ambient temperature around the object. A very useful equation known today as the Stefan-Boltzmann Law has been shown both theoretically and empirically to describe the relationship. I = thermal power in watts/meter2

T = temperature of object in Kelvin

Ta = temperature of ambient surroundings in Kelvin

3.3 ULTRASONIC FLOW METER

An **ultrasonic flow meter** measures the velocity of any liquid or gas through a pipe using ultrasonic transducers. The results get slightly affected by temperature, density or viscosity of the flowing medium. Maintenance is inexpensive because there are no moving parts. Some may be able to measure liquid level as well. With the level measurement and pipe size, flow rate and total discharge can be calculated.

Ultrasonic flow meters work with at least three different types:

i. Transmission (contrapropagating transit-time) flowmeters
ii. Reflection (Doppler) flowmeters
iii. Open-channel flowmeters

Transmission flowmeters can be distinguished into:

i. In-line flowmeters (intrusive, wetted)
ii. Clamp-on flowmeters (non-intrusive)

There are two types of Ultrasonic meters, the transit time/time of flight and Doppler models, both of which have unique equations representing the principles behind them. The basis for these meters is monitoring ultrasonic waves in fluid passing through a pre-configured acoustic field. These meters are based on the technique of sound waves that change [16].

3.3.1 General Purpose Transit-Time Flowmeters

The most commonly used ultrasonic flowmeter is the transit-time flowmeter which is used for liquids and gases. Transit-time flowmeters work by measuring the time of flight difference between an ultrasonic pulse sent in the flow direction and an ultrasound pulse sent opposite the flow direction. This time difference is a measure for the average velocity of the fluid along the path of the ultrasound beam. By using the absolute transit time and the distance between the ultrasound transducers, the current speed of sound is easily found. The measuring effect can be adversely affected by many things including gas and solid content. By using at least 3 transducers, an "ultrasonic anemometer" measures wind speed and direction in open air, with no moving parts.[11,16] Fig.3.4 transit time ultrasonic flow meter[16].

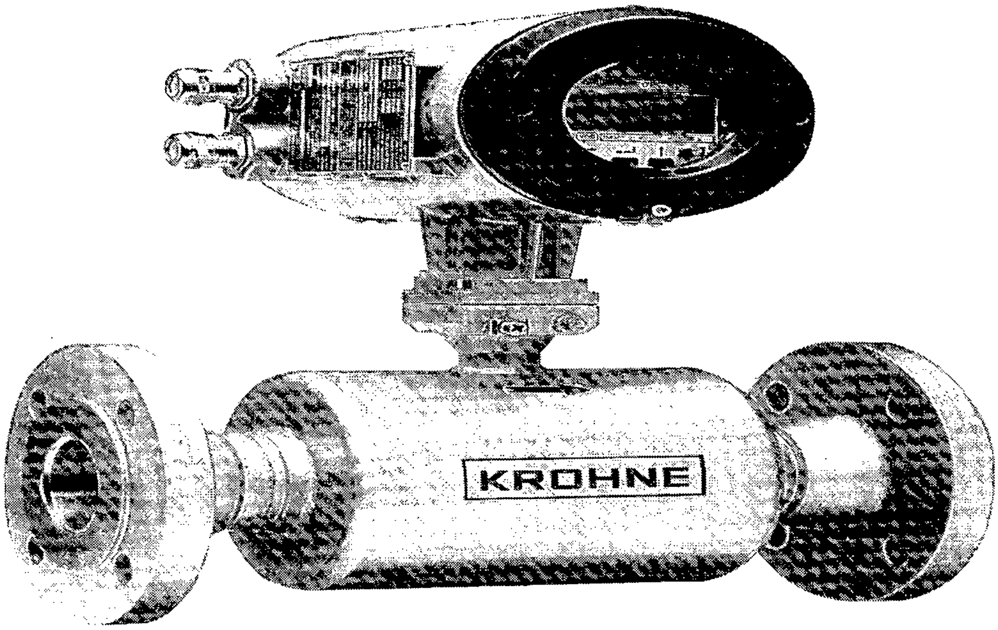


Fig.3.4 transit time ultrasonic flow meter[16]

Transit time meters have two opposing transducers outside of the pipe to measure the time of a signal sent from a transducer upstream to a transducer downstream and vice versa.fig 3.5 shows working of transit time flow meter .

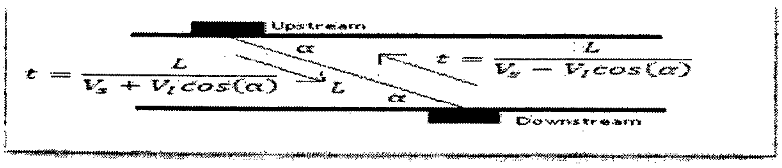


Fig3.5 working of transit time flow meter

Eq3.1 allows the average velocity and hence the flow rate, Q, to be determined.

$$Q = K\left(\frac{\pi d^3 tan\alpha}{8}\right)\left(\frac{1}{t_{UD}} - \frac{1}{t_{DU}}\right) \quad ....3.1$$

where d is the diameter of the pipe, α is the angle between direction of the flow and the pipe, t_{UD} is the time for the signal to reach downstream transducer from the upstream transducer, and t_{DU} is the time for signal to reach upstream transducer from the downstream transducer.

With the Time of Flight Ultrasonic Flowmeter the time for the sound to travel between a transmitter and a receiver is measured. This method is not dependable on the particles in the fluid.

Fig 3.6 shows mathematical calculations of transit time flow meter

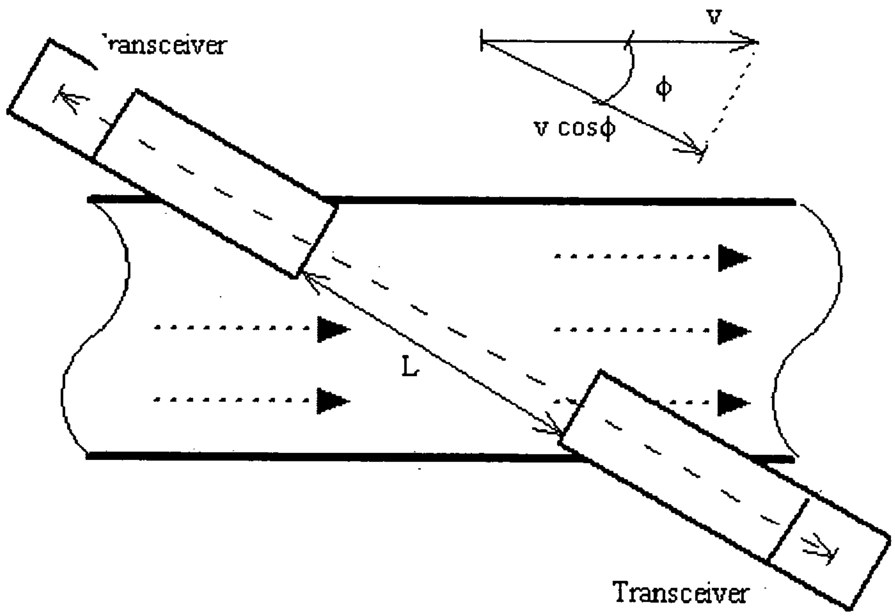


Fig.3.6 mathematical diag of transit time flow meter[16]

Two transmitters / receivers (transceivers) are located on each side of the pipe. The transmitters sends pulsating ultrasonic waves in a predefined frequency from one side to the other. The difference in frequency is proportional to the average fluid velocity.

Downstream pulse transmit time can be expressed as in Eq.3.2

td = L / (c + v cosΦ) 3.2

where td = downstream pulse transmission time L = distance between transceivers

Downstream pulse transmit time can be expressed as in Eq.3.3

tu = L / (c - v cosΦ) 3.3

where tu = upstream pulse transmission time

Since the sound travels faster downstream than upstream, the difference can be expressed as in Eq.3.4

t = td - tu t = 2 v L cosΦ / (c2 - v2 cos2Φ) t = 2 v L cosΦ / c2 ....3.4

(since v is very small compared to c) [8,16]

3.3.2 Doppler type Ultrasonic Flow Meters

Doppler meters use the frequency shift of an ultrasonic signal when it is reflected by suspended particles or gas bubbles (discontinuities) in motion. The Doppler Effect Ultrasonic Flowmeter uses reflected ultrasonic sound to measure the fluid velocity. By measuring the frequency shift between the ultrasonic frequency source, the receiver, and the fluid carrier, the relative motion are measured. The resulting frequency shift is named the *Doppler Effect.* figure 3.7 shows Doppler Type Ultrasonic Flowmeter;

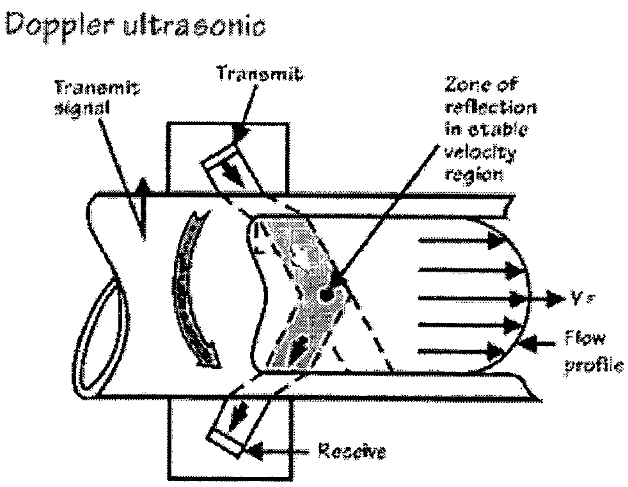


Fig.3.7 doppler ultrasonic flowmeter

Figure 3.8 & 3.9 shows working of Doppler ultrasonic flowmeter

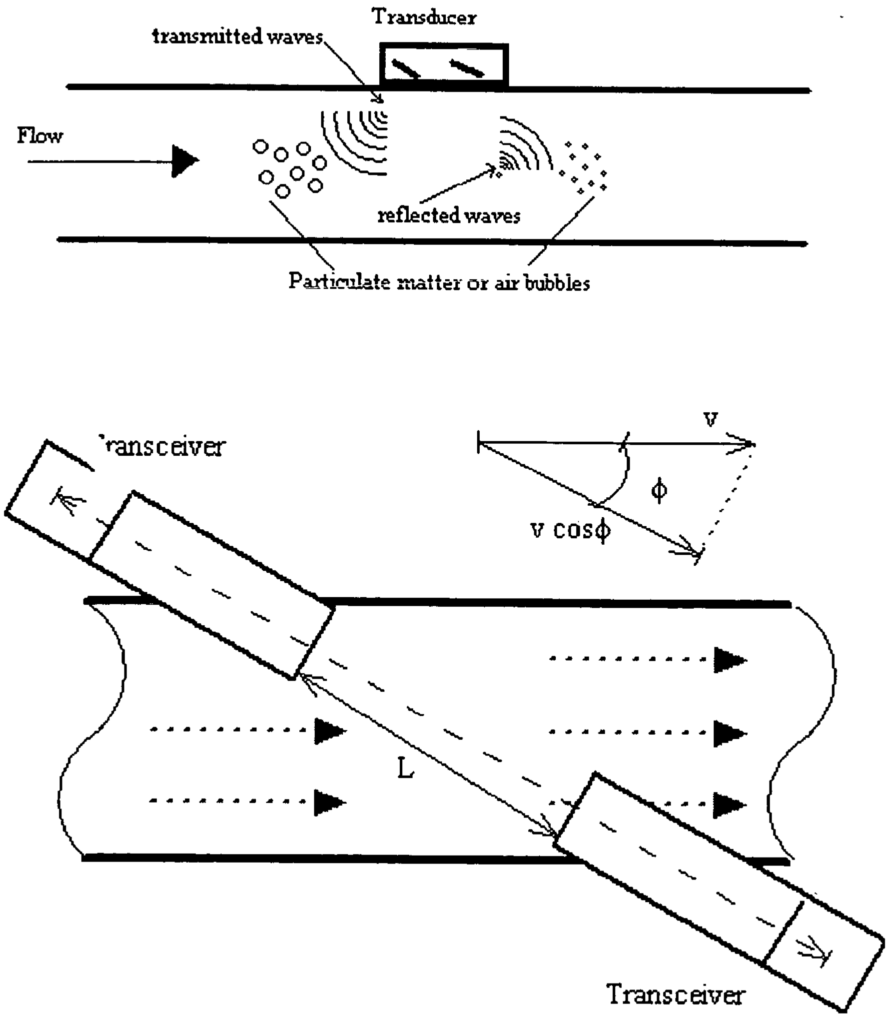


Fig. 3.8 & 3.9 working of Ultrasonic Flowmeter

These reflected signals travel at the velocity of light & is given by Eq.3.5

$$V_f = \frac{V_s \Delta f}{2 f_{actual} cos\alpha} \quad \ldots\ldots\ldots\ldots\ldots 3.5$$

where f is the actual frequency and Δf is the change in frequency or frequency shift.

The fluid velocity can be expressed as in Eq.3.6

v = c (fr - ft) / 2 ft cosΦ 3.6

where

fr = received frequency

ft = transmission frequency

v = fluid flow velocity

Φ = the relative angle between the transmitted ultrasonic beam and the fluid flow

c = the velocity of sound in the fluid

This method requires that there are some reflecting particles in the fluid. The method is not suitable for clear liquids. [16,17]

3.3.3 Advantages with the Doppler Effect Ultrasonic Flowmeter

Doppler meters may be used where other meters don't work. This could be in liquid slurries, aerated liquids or liquids with some small or large amount on suspended solids. The advantages can be summarized to:

i. Obstruct less flow

ii. Can be installed outside the pipes

iii The pressure drop is equal to the equivalent length of a straight pipe

iv Low flow cut off

v Corrosion resistant

3.3.4 Limitations with Doppler Effect Ultrasonic Flowmeters

i. Doppler flowmeters performance are highly dependent on physical properties of the fluid, such as the sonic conductivity, particle density, and flow profile.

ii Non uniformity of particle distribution in the pipe cross section may result in a incorrectly computed mean velocity. The flowmeter accuracy is sensitive to velocity profile variations and to the distribution of acoustic reflectors in the measurement section.

iii Unlike other acoustic flowmeters, Doppler meters are affected by changes in the liquid's sonic velocity. As a result, the meter is also sensitive to changes in density and temperature. These problems make Doppler flowmeters unsuitable for highly accurate measurement applications.

3.3.5 Benefits with Ultrasonic Flowmeters As A Whole

ii. Obstruction less flow
iii. Pressure drop equal to an equivalent length of straight pipe
iv. Unaffected by changes in temperature, density or viscosity
v. Bi-directional flow capability
vi. Low flow cutoff
vii. Corrosion-resistant
viii. Accuracy about 1% of flow rate
ix. Relative low power consumption

Both meters are effective in measuring open channels and partially filled pipes but are very sensitive to flow conditions and hence should be calibrated with care. Also, there is no pressure drop since there are no obstructions in the flow path.[16,17]

3.3.6 Limitations with Ultrasonic Flowmeters as A Whole

i. The operating principle for the ultrasonic flowmeter requires reliability high frequency sound transmitted across the pipe. Liquid slurries with excess solids or with entrained gases may block the ultrasonic pulses.
ii. Ultrasonic flowmeters are not recommended for primary sludge, mixed liquor, aerobically digested sludge, dissolved air flotation thickened sludge and its liquid phase, septic sludge and activated carbon sludge.
iii. Liquids with entrained gases cannot be measured reliably.

3.4 POWER ANALYSER

Compact light weight Hioki 3165 clamp on power Hi- Tester provides all measurement functions & data processing capability required for electric power supervision.

3.4.1 Features of Hioki 3165 Clamp on Power Hi-Tester

Single Unit Capable Of Measuring Single Or Multi-Phase Power Lines (Up To 3-Phase/ 4-Wire Lines)

i. Wide Measurement Ranges, From 2A To 200A, 200W To 240k
ii. Printer Provides Data And Graph Printing And Analog Recording

3.4.2 Specifications:

i. 10 Display Easy - to - View LCD Screen.

ii. Connectors for 4 Current Sensing Clamps.

iii. 1P2W, 1P3W, 3P3W2M & 3P4W Power Measurement.

iv. True RMS Sensing.

v. Power KW, KVAR, KVA, PF, θ ,Hz, & Energy KWh, KVARh & KVAh Measurement.

vi. Phase sequency indicator function.

vii. Backlight display function.

viii. Manual Data Memory and Read (99 sets).

ix. Data Logging (512KB Memory, 20,000 sets)

x. Programmable Trigger - Points and Start / Stop Time.

xi. RS-232 Optical Interface with three phase voltage / current Waveform display and Harmonic analysis.

xii. Easy - to - use Push - Button Operation.

xiii. Light Weight, Portable Design.

Fig 3.10 shows the ckt. Of Hioki power analyser

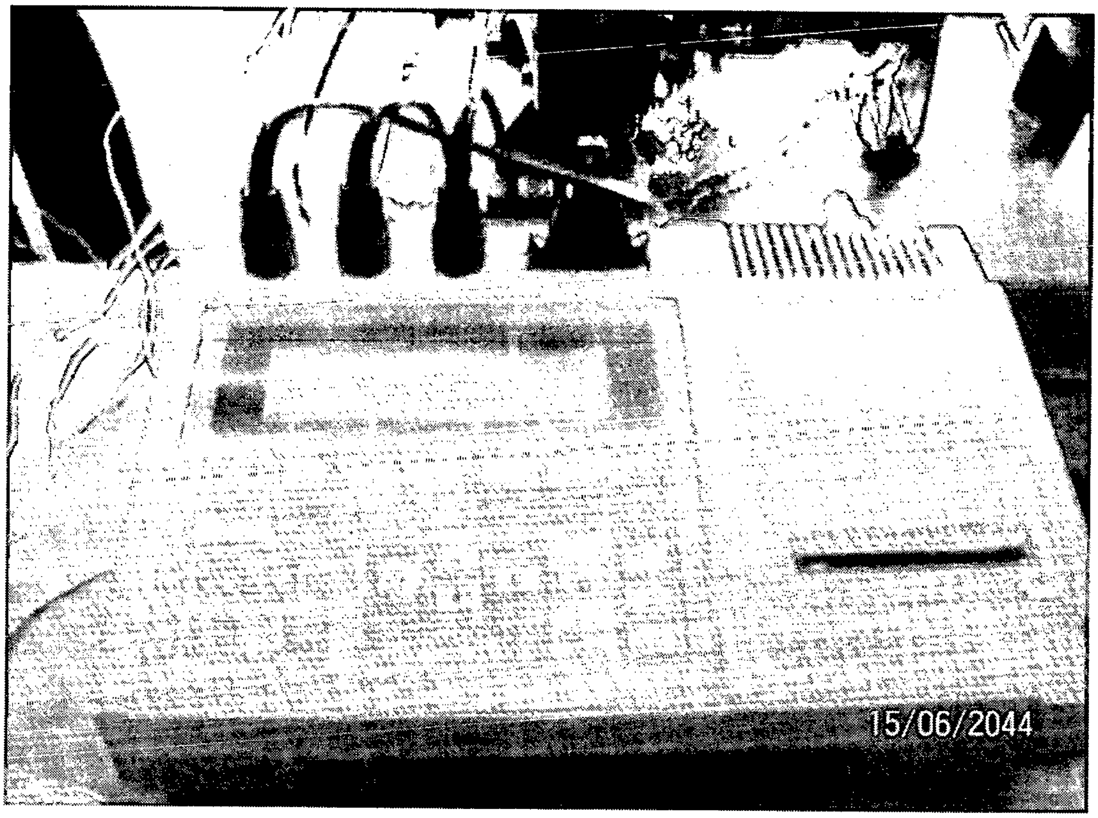


Fig3.10 power analyser lab photograph[20]

3.4.3 Energy saving & Power Supervision throw Power Tester

Fig. 3.11 shows the power supervision

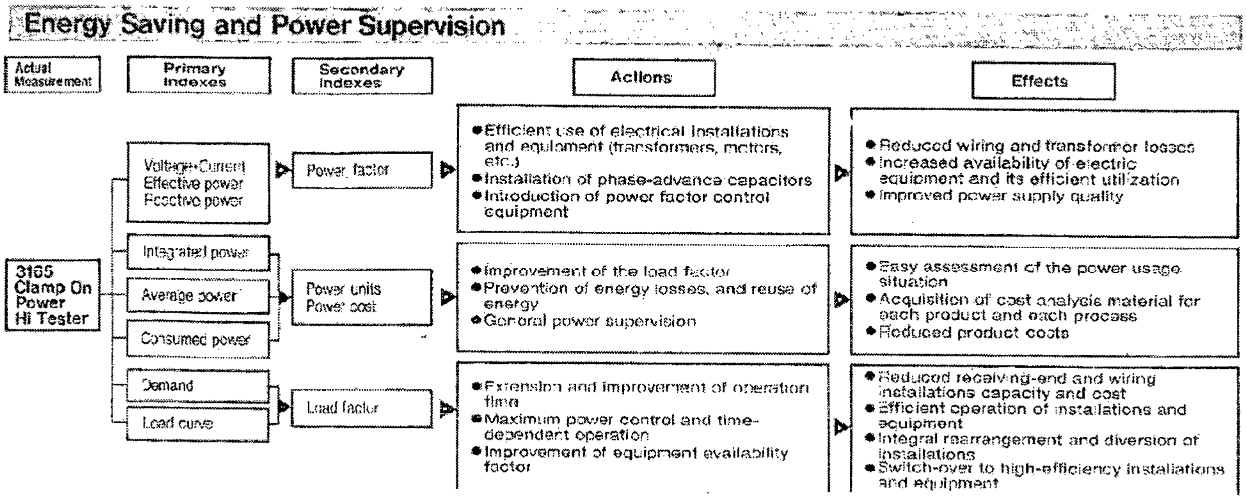


Fig. 3.11 the power supervision[20]

3.4.4 Other Specifications

Designed to help protect you and your equipment against electrical shock and fire, the Fluke 430 Series analyzers, accessories and charger are all certified to meet the stringent safety standards for use in CAT IV 600 V and CAT III 1000 V environments. They are the first tools of their kind to carry the CAT IV rating and therefore can be used at virtually all power connections and outlets in a low-voltage power distribution systems.[19,20]

quality health check on one display A single push of the MONITOR button delivers a single dashboard display of rms voltage, harmonics, flicker, interruptions, rapid voltage changes, swells, unbalance and frequency. The dashboard is updated live, showing compliance of each parameter to EN50160 limits or your own limits. Color-coded bars clearly show which parameters are inside (pass) or outside limits (fail). During a Monitor session, you can easily drill down to more detail of any parameter and view and capture its trends for a report.

i. Records all your necessary values in a three phase system
ii. Highest safety rating in the industry
iii. Four voltage and four current channels
iv. Captures waveform data on all phases simultaneously
v. System-Monitor: Six power quality parameters on one dashboard
vi. Automatic Transient display: Never miss an event
vii. Auto Trend: Don't waste time setting up recordings
viii. Rugged, handheld recorder
ix. Seven hours operating time per charge on NiMH battery pack
x. Transfer data files to you PC for reporting and analysis using FlukeView software

Every time an event or distortion on voltage is detected, the instrument triggers and automatically stores voltage and current waveforms on all three phases and neutral. The analyzer will also trigger when a certain current value level is exceeded. Up to 40 dips, swells, interruptions and transients can be captured this way. You can see voltage transients as high as 6 kV and as fast as 5 microseconds.[19]

3.5 PRESSURE TRANSMITTER:

The differential pressure transmitter LD 301 is suitable for application in the process engineering. Additionally the LD 301 is suited for bidirectional flow measurement. Permissible medias are liquids, vapour or gases, which are compatible with the media wetted materials. Also for higher requirements appropriate materials are available (e.g. stainless steel, Hastelloy or Tantalum). As standard the LD 301 features IS-approvals for "flameproof enclosure" "weather proof" and "intrinsic safety [17].

3.5.1 Operation:

For parameter setting and visualisation of measured value an optional LC display is available. It offers a 4 1/2 digit numerical and a 5-digit alphanumerical display. For the operation a magnetic tool is included in the scope of delivery. Alternatively the LD 301 is programmable via an optional hand terminal or via PC

Fig. 3.12 shows systematic of pressure Transmitter

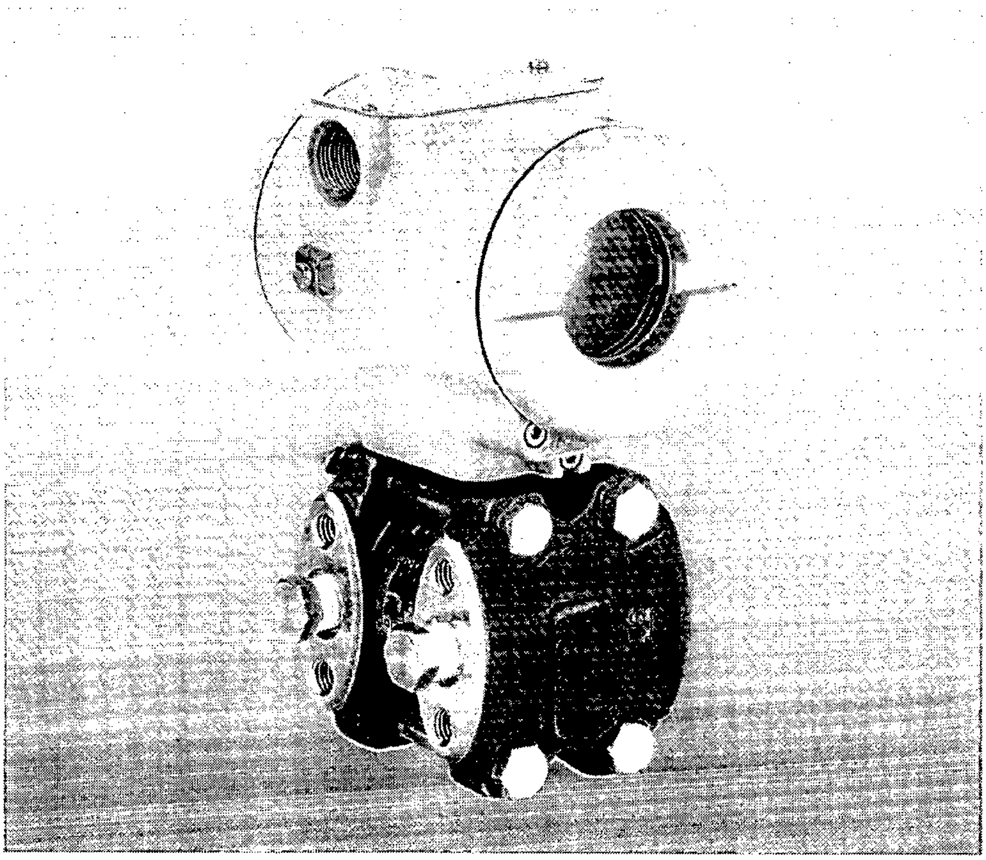


Fig 3.12 systematic of pressure transmitter[17]

3.5.2 Application:

process engineering

i. chemical industry
ii. static overpressure up to 32 MPa
iii. 0.075 % accuracy for range with turn-down 10:1
iv. turn-down of span 120:1
v. offset and span adjustable
vi. 4 ... 20 mA with digital communication ***(HART□-protocol)***
vii. freely configurable 16-point linearization
viii. option: LC-display
ix. failure alarm according to NAMUR NE43
x. Ex-protection:intrinsic safety, flameproof enclosure weather proof

3.5.3 Technical Data: table 3.1, 3.2 & 3.3 shows the technical data of Pressure transmitter

TABLE 3.1

Input pressure range

Differential pressure

Sensor type	D0	D1	D2	D3	D4
Range [kPa]	± 1	± 5	± 50	± 250	± 2500
min. span [kPa]	0.05	0.13	0.42	2.08	20.83
Permissible overpressure / static pressure limits [MPa]	0.5	8	16	16	16
Burst pressure [MPa]	60	60	60	60	60

Differential pressure with high static pressure

Sensor type	H2	H3	H4	H5
Range [kPa]	± 50	± 250	± 2500	± 25000
min. span [kPa]	0.42	2.08	20.83	208
Permissible overpressure / static pressure limits [MPa]	32	32	32	32
Burst pressure [MPa]	60	60	60	60

Output signal / Supply

Standard	2-wire: 4 ... 20 mA with HART®-communication / $V_s = 12 \dots 45\ V_{DC}$

Performance

Permissible load	$R_{max} = [(V_{S} - V_{S\,min}) / 0,02]\ \Omega$ load during HART® communication: $R_{min} = 250\ \Omega$
Turn on time	performs within specifications in less than 5 seconds after power is applied to the transmitter
Damping	0 up to 128 seconds additional damping configurable; time constant of the sensor 0.2 s

Operating performance [1]

Accuracy of output [2]	for sensor types 1, 2, 3, 4:
	0.1 URL ≤ span ≤ URL: ± 0.075 %
	0.025 URL ≤ span ≤ 0.1 URL: ± 0.0375 [1 + 0.1 URL/span] %
	0.0085 URL ≤ span ≤ 0.025 URL: ± [0.0015 + 0.00465 URL/span] % [3]
	for sensor type 5, diaphragm in Tantalum or filling fluid Fluorolube®:
	0.1 URL ≤ span ≤ URL: ± 0.1 %
	0.025 URL ≤ span ≤ 0.1 URL: ± 0.05 [1+0.1 URL/span] %
	0.0085 URL ≤ span ≤ 0.025 URL: ± [0.01+0.006 URL/span] %
	for sensor type 0, diaphragm in stainless steel, filling fluid Silicone oil or Fluorolube®:
	0.2 URL ≤ span ≤ URL: ± 0.1 %
	0.05 URL ≤ span ≤ 0.2 URL: ± [0.025 + 0.015 URL/span] %

Stability	for sensor types 2, 3, 4, 5: ± 0.15% of URL / 5 years, at 20 °C temperature change and up to 7 MPa of static pressure for sensor types 0, 1: ± 0.2% of URL / 12 years, at 20 °C temperature change and up to 100 kPa of static pressure
Temperature effect per 20 K	for sensor types 2, 3, 4, 5: 0.2 URL ≤ span ≤ URL: ± (0.02 % URL + 0.06 % span) 0.0085 URL ≤ span ≤ 0.2 URL: ± (0.023 % URL + 0.045 % span) for sensor type 1: 0.2 URL ≤ span ≤ URL: ± (0.08 % URL + 0.05 % span) 0.025 URL ≤ span ≤ 0.2 URL: ± (0.06 % URL + 0.015 % span) for sensor type 0: 0.2 URL ≤ span ≤ URL: ± (0.15 % URL + 0.05 % span) 0.05 URL ≤ span ≤ 0.2 URL: ± (0.1 % URL + 0.3 % span)
Static pressure effect to zero point	for sensor types 2, 3, 4, 5: ± 0.033 % URL per 7 MPa for sensor type 1: ± 0.05 % URL per 1.7 MPa for sensor type 0: ± 0.1 % URL per 0.5 MPa
Static pressure effect to span	for sensor types 2, 3, 4, 5: correctable to ± 0.2 % of reading per 7 MPa for sensor type 1: correctable to ± 0.2 % of reading per 3.5 MPa for sensor type 0: correctable to ± 0.2 % of reading per 0.5 MPa
Installation position effect	zero shift up to 250 Pa, which can be calibrated in the installation position; no span effect
Power supply effect	≤ ± 0.005 % of span per Volt

[1] *with reference conditions: no deviation of zero point, temperature 25 °C, atmospheric pressure, power supply of 24 V_{DC}, filling fluid silicone oil, diaphragm in 1.4404 (316L SST) and digital trim equal to lower and upper range values (URL upper range limit)*

[2] *including non-linearity, hysteresis and repeatability*

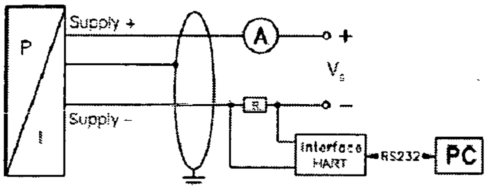
[3] *recommended minimum span for sensor type 1 is 2,5 % of measuring range*

TABLE 3.2

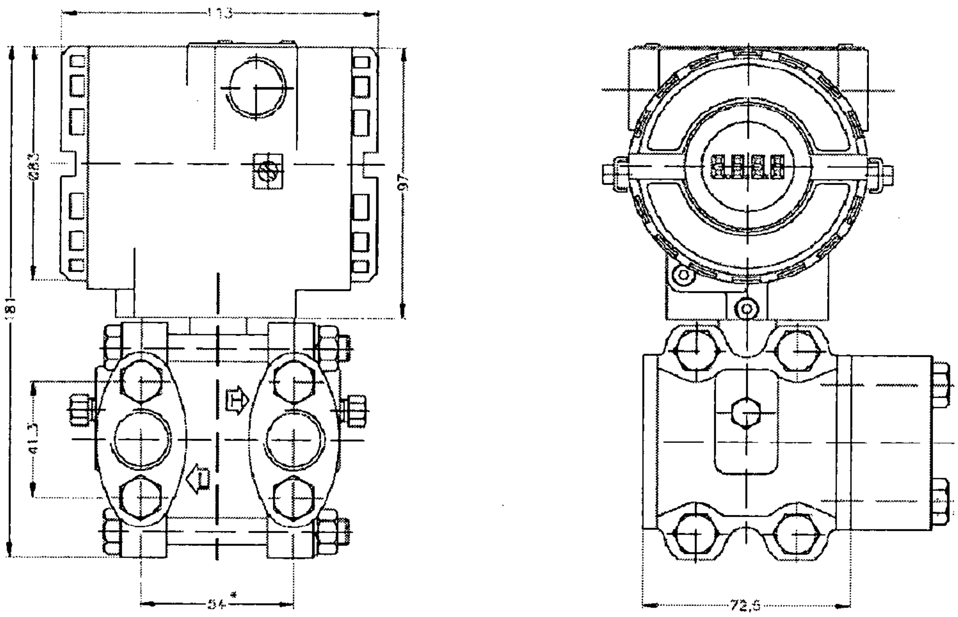
Electrical protection	
Short-circuit protection	permanent
Reverse polarity protection	no damage, but also no function
Electromagnetic compatibility	according to IEC 61000-6-2:1999, IEC 61 000-6-4:1997 and IEC 61326:2002
Ex-protection [a]	intrinsic safety: EEx ia IIC T4/T5/T6 flameproof enclosure: EEx d ICC T6 weather proof: EEx ia I
[a] approved for atmospheric pressure from 0.8 bar up to 1.1 bar	
Permissible temperatures	
Process	-40 ... 100 °C (with Silicone oil) 0 ... 85 °C (with Halocarbon and Fluorolube® filling) -20 ... 85 °C (with Krytox- and Fomblin-oil) -25 ... 85 °C (with Viton® O-ring)
Electronic / environment	without display: -40 ... 85 °C with display: -20 ... 80 °C Ex-protection: without display: -40 ... 85 °C with display: -10 ... 60 °C
Storage	-40 ... 85 °C
Material	
Diaphragm(s)	standard: stainless steel 1.4404 (316L SST) options: Hastelloy® C276, Tantalum
Drain / vent valve screws and flange plug	stainless steel 1.4401 (316 SST), Hastelloy® C276
Flange	C22, stainless steel 1.4401 (316 SST), Hastelloy® C276
O-rings of flange and adapter	Buna N, Viton®, Teflon®, Ethylene-Propylene, Kalrez®
Housing	standard: Aluminium die cast with Polyester-coating option: stainless steel
Filling fluids	standard: Silicone oil options: Fluorolube®, Krytox, Halocarbon 4.2 or Fomblim oil
O-rings housing	Buna N
Screws and nuts of flanges	C 22 or stainless steel
Media wetted parts	diaphragm, drain / vent valve screws and flange plugs, flange, O-rings of flange and adapter
Characteristics of PID-controller	
Proportional gain	0 ... 100
Integral time	0.01 ... 999 min/rep.
Derivative time	0 ... 999 sec.
Action	direct / reverse
Limits	lower and upper output limits
Output rate-of-change limit	0 ... 100 % / sec.
Miscellaneous	power-on safety output antireset windup bumpless auto/manual transfer
Miscellaneous	
Permissible media	fluid, vapour, gas
Humidity limits	0 ... 100 % RH
Display (optionally)	LC display, 4 1/2-digit, numeric and 5-digit, alphanumeric, scalable and configurable; with volumeter function for flow
Configuration	The most functions are configurable in situ by the optional display and included magnetic toll. All functions are available with hand-held terminal and software; non-interactive zero and span adjustment
Alarm signal	In case of sensor or circuit failure, the self diagnostics drives the output to 3.6 or 21 mA (according to NAMUR NE43)
Weight	basic version approx. 3.15 kg
Ingress protection	IP 67

TABLE 3.3

Connections		
Electrical connections	standard: 1/2 - 14 NPT	options: Pg 13.5; M20x1.5; others on request
Process connections	standard: 1/4 - 18 NPT	options: 1/2 - 14 NPT (with adapter); others on request
Wiring diagrams		
2-wire-system (current) HART®		



Dimensions (in mm)



* for sensor type 4: 56 mm
for sensor type 5: 58.3 mm
for sensor type 6: 58.7 mm

3.5.4 Ordering Code Of LD301: table 3.4 shows the ordering code of LD301 differential Pressure Transmitter

TABLE 3.3 [17]

LD 301 □-□□□-□□□-□1□/□

Minimal span / measuring range	(kPa)	Code	
differential	0,05 / ± 1	D0	
differential	0,13 / ± 5	D1	
differential	0,42 / ± 50	D2	
differential	2,08 / ± 250	D3	
differential	20,83 / ± 2500	D4	
differential – high static pressure	0,42 / ± 50	H2	
differential – high static pressure	2,08 / ± 250	H3	
differential – high static pressure	20,83 / ± 2500	H4	
differential – high static pressure	208 / ± 25000	H5	
Diaphragm and filling fluid			
stainless steel 1.4404 (316L SST) and Silicone oil		1	
stainless steel 1.4404 (316L SST) and Fluorolube® [1]		2	
Hastelloy® C276 and Silicone oil [2]		3	
Hastelloy® C276 and Fluorolube® [1,2]		4	
Tantalum and Silicone oil [3]		7	
Tantalum and Fluorolube® [1,3]		8	
stainless steel 1.4404 (316L SST) and Fomblim oil		9	
stainless steel 1.4404 (316L SST) and Krytox oil [3]		D	
Hastelloy® C276 and Krytox oil [2,3]		E	
Tantalum and Krytox oil [3]		G	
stainless steel 1.4404 (316L SST) and Halocarbon 4.2 oil [1,3]		Q	
Hastelloy® and Halocarbon 4.2 oil [1,3]		R	
Tantalum and Halocarbon 4.2 oil [1,3]		S	
Flange(s), adapter(s) and drain / vent valves material			
plated CS with drain / vent valve in stainless steel [4]		C	on request
stainless steel 1.4401 (316 SST)		I	
Hastelloy® C276 (CW-12MW, ASTM-A494) [2]		H	on request
stainless steel 1.4401 (316 SST), with drain / vent valve in Hastelloy C276 [2]		N	
stainless steel 1.4401 (316 SST) with PVDF (Kynar) insert [1,5,6,7]		P	
Wetted O-Rings material			
without O-ring (for remote seal)		0	
Buna N®		B	
Viton®		V	
Teflon®		T	
Ethylene / Propylene		E	
Kalrez® [3]		K	
Drain / vent valve position			
without drain / vent		0	
top		U	
bottom		D	
opposite to process connection		A	
Display			
without display		0	
with LC display		1	
Process connections			
1/4 - 18 NPT (without adapter)		0	
1/2 - 14 NPT (with adapter)		1	on request
1/2 BSP (with adapter)		T	on request
remote seal (welded) [3,5,8]		3	
remote seal, with low volume flange [1,3,5,8]		9	
1/4- 18 NPT , with low volume flange [1,5,8]		6	
low volume flange (welding) for remote seal [5,8,9]		8	
high side:1/2-14 NPT and low side: remote seal (with plug) [3]		B	
high side: remote seal (with plug) and low side :1/2-14NPT [3]		D	
Electrical connections			
1/2 - 14 NPT		0	
M 20 x 1,5		A	
Pg 13,5 DIN		B	
3/4 - 14 NPT (with 316 SST adapter for 1/2 - 14 NPT) [10]		1	
3/4 - 14 BSP (with 316 SST adapter for 1/2 - 14 NPT) [10]		2	
1/2 - 14 BSP (with 316 SST adapter for 1/2 - 14 NPT) [10]		3	
zero and span adjustment, with local adjustments		1	

3.5.5 Working Principle

The **LD301** series uses, as its measuring principle, the wellknown and field proven technique of capacitance sensing, enhanced by a microprocessor based electronics. Designed for process control applications, these 2-wire transmitters generate a 4-20 mA signal proportional or characterized to the applied differential pressure. This signal can be transmitted over a pair of twisted wires through long distances (limited only by the wire resistance and load). Digital communication for remote calibration and monitoring is also provided, superimposing a digital signal on the same pair of wires that carries the 4-20 mA signal. Remarkable features of the LD301 series are its 0.075% high accuracy, 120:1 rangeability, compactness and lightweightiness, PID control capability (optional), etc. The transmitter consists of two main parts. The sensor (a capacitance variation cell) and the electronic circuit. The sensor is schematically shown in the above drawing. A sensing diaphragm **(1)** is shown at the center of the cell. This diaphragm deflects, as a result of the difference between the pressures applied to the left and right sides of the sensor. These pressures are directly applied to the isolating
diaphragms **(2)**, that provide isolation and resistance against process fluid corrosion. The pressure is transmitted to the sensing diaphragm through the filling Fluid **(3)**. The sensing diaphragm is also a moving capacitor plate, and the two metallized surfaces **(4)** are fixed plates. The sensing diaphragm deflection results in a variation on the capacitances between the moving and fixed plates. Fig 3.13 & 3.14 shows the working principle of Pressure Transmitter.

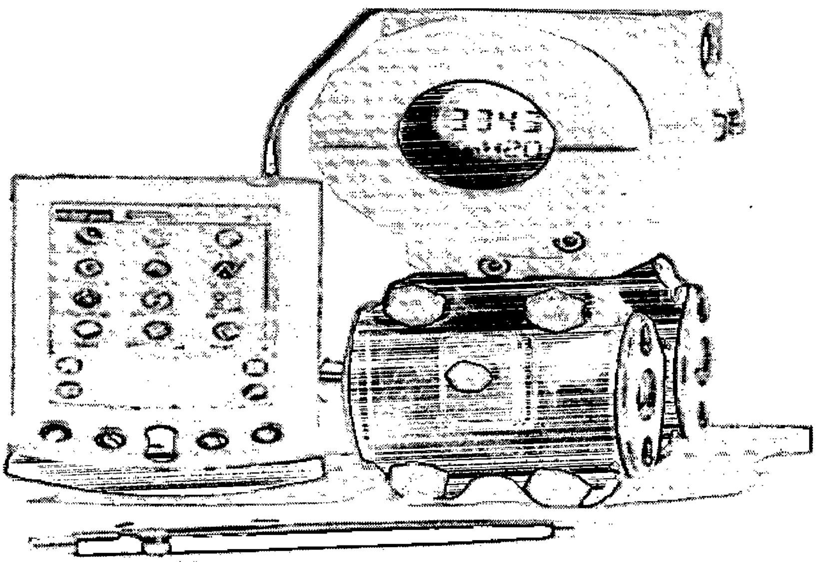


Fig3.13 working of Pressure Transmitter

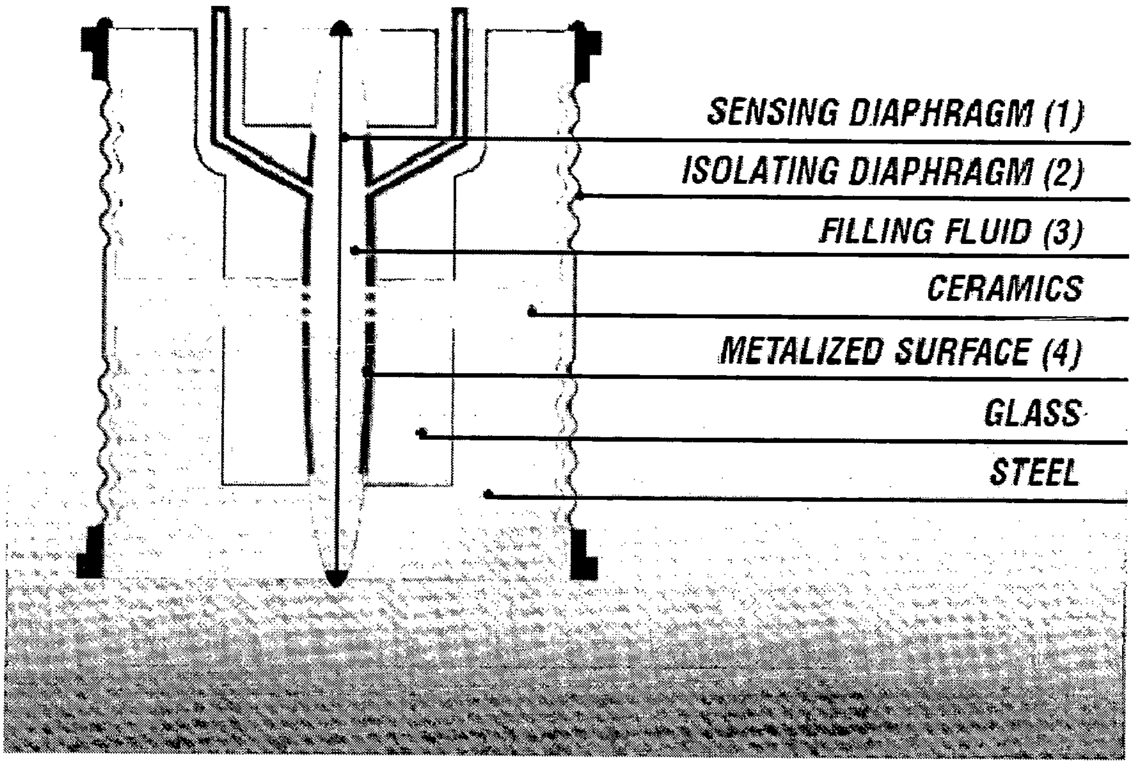


Fig3.14 working principle [17]

3.5.6 Construction : fig3.15 shows the construction of pressure transmitter

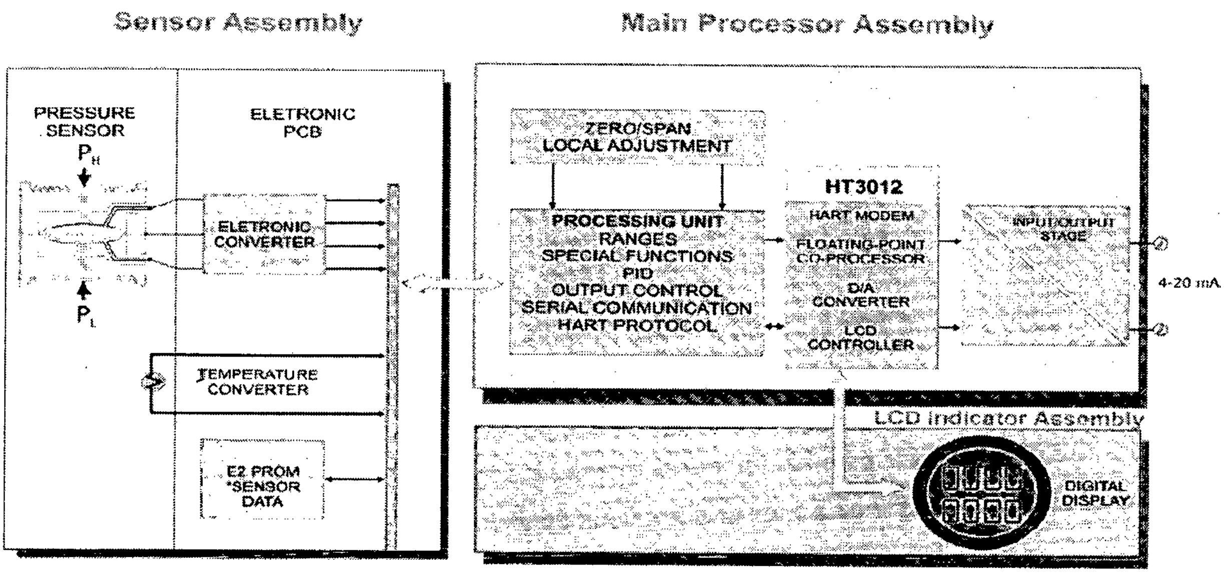


Fig.3.15 Construction [17]

3.6 SPEED SENSORS:

A **wheel speed sensor** or vehicle speed sensor (VSS) is a type of tachometer . It is a sender device used for reading the speed of a vehicle's wheel rotation. It usually consists of a toothed ring and pickup.

3.6.1 Rotary speed sensors :

Many of the subsystems in a rail vehicle, such as a locomotive or multiple unit, depend on a reliable and precise rotary speed signal, in some cases as a measure of the speed or changes in the speed. This applies in particular to traction control, but also to wheel slide protection, registration, train control, door control and so on. These tasks are performed by a number of rotary speed sensors that may be found in various parts of the vehicle.

In the past, sensors for this purpose often failed to function satisfactorily or were not reliable enough and gave rise to vehicle faults. This was particularly the case for the early mainly analogue sensors, but digital models were also affected.

This was mainly due to the extremely harsh operating conditions encountered in rail vehicles. The relevant standards specify detailed test criteria, but in practical operation the conditions encountered are often even more extreme (such as shock/vibration and especially electromagnetic compatibility (EMC) [18]

Although rail vehicles occasionally do use drives without sensors, most need a rotary speed sensor for their regulator system. The most common type is a two-channel sensor that scans a toothed wheel on the motor shaft or gearbox and therefore does not require a bearing of its own.

The target wheel can be provided especially for this purpose or may be already present in the drive system. Modern sensors of this type make use of the principle of magnetic field modulation and are suitable for ferromagnetic target wheels with a module between m =1 and m = 3.5 (D.P.=25 to D.P.=7). The form of the teeth is of secondary importance; target wheels with involute or rectangular toothing can be scanned. Depending on the diameter and teeth of the wheel it is possible to get between 60 and 300 pulses per revolution, which is sufficient for drives of lower and medium traction performance.[18]

This type of sensor normally consists of two hall effect sensors, a rare earth magnet and appropriate evaluation electronics. The field of the magnet is modulated by the passing target teeth. This modulation is registered by the Hall sensors, converted by a comparator stage to a square wave signal and amplified in a driver stage.

Unfortunately, the Hall effect varies greatly with temperature. The sensors' sensitivity and also the signal offset therefore depend not only on the air gap but also on the temperature. This also very much reduces the maximum permissible air gap between the sensor and the target wheel. At room temperature an air gap of 2 to 3 mm can be tolerated without difficulty for a typical target wheel of module m = 2, but in the required temperature range of from 40°C to 120°C the maximum gap for effective signal registration drops to 1.3 mm. Smaller pitch target wheels with module m = 1 are often used to get a higher time resolution or to make the construction more compact. In this case the maximum possible air gap is only 0.5 to 0.8 mm.

For the design engineer, the visible air gap that the sensor ends up with is primarily the result of the specific machine design, but is subject to whatever constraints are needed to register the rotary speed. If this means that the possible air gap has to lie within a very small range, then this will also restrict the mechanical tolerances of the motor housing and target wheels to prevent signal dropouts during operation. This means that in practice there may be problems, particularly with smaller pitched target wheels of module m = 1 and disadvantageous combinations of tolerances and extreme temperatures. From the point of view of the motor manufacturer, and even more so the operator, it is therefore better to look for speed sensors with a wider range of air gap.[18,19]

The primary signal from a Hall sensor loses amplitude sharply as the air gap increases. For sensor manufacturers this means that they need to provide maximum possible compensation for the Hall signal's physically induced offset drift. The conventional way of doing this is to measure the temperature at the sensor and use this information to compensate the offset, but this fails for two reasons: firstly because the drift does not vary linearly with the temperature, and secondly because not even the sign of the drift is the same for all sensors.

For a new sensor generation it was therefore necessary to find another way: an integrated signal processor now corrects the offset and amplitude of the Hall sensor signals. This correction is so effective that one can almost double the maximum permissible air gap at the speed sensor. On a module m = 1 target wheel these new sensors can tolerate an air gap of 1.4 mm, which is wider than that for conventional speed sensors on module m = 2 target wheels. On a module m = 2 target wheel the new speed sensors can tolerate gap of as much as 2.2 mm. It has also been possible to markedly increase the signal quality. Both the duty cycle and the phase displacement between the two channels is at least three times as stable in the face of fluctuating air gap and temperature drift.

In addition, in spite of the complex electronics it has also been possible to increase the MTBF for the new speed sensors by a factor of three to four. So they not only provide more precise signals, their signal availability is also significantly better.

These new sensors, still with the familiar appearance, thus open up whole new possibilities for the designers of drives for rolling stock. The sensors are attractively priced and operate without wear and tear.

3.6.2 Magnetic Speed Sensors:

The principle used in scanning a ferromagnetic measuring scale magnetically does not exhibit these deficiencies. During many years' experience of using magnetic encoders there have been occasions when a seal has failed and a pulse generator has been found to be completely covered in a thick layer of brake dust and other dirt, but such pulse generators still functioned perfectly.

Magnetic scanning systems were previously simply too expensive to use, but recently a multichannel pulse generator became available that is not only fundamentally superior to previous pulse generators in its robustness and resistant to dirt, but also sets a new standard for flexibility. Here, for comparison, are a few of its key features:

i. from one to eight channels, instead of the previous one to four
ii. up to three different pulse values per revolution from a single encoder, instead of the previous two
iii. from 1 to 400 pulses per revolution, instead of the previously achieved 200
iv. voltage output, current output, signals with a 7 V idle voltage, instead of only a voltage output as previously [19]

There is now a new variant with a maximised hysteresis of ± 90° relative to a signal period. When installed under unfavourable conditions and exposed to severe vibration this variant suppresses any extraneous pulses while the vehicle is at a standstill.

Altogether, these innovative pulse generators offer new features that also open up entirely new possibilities for system integrators.

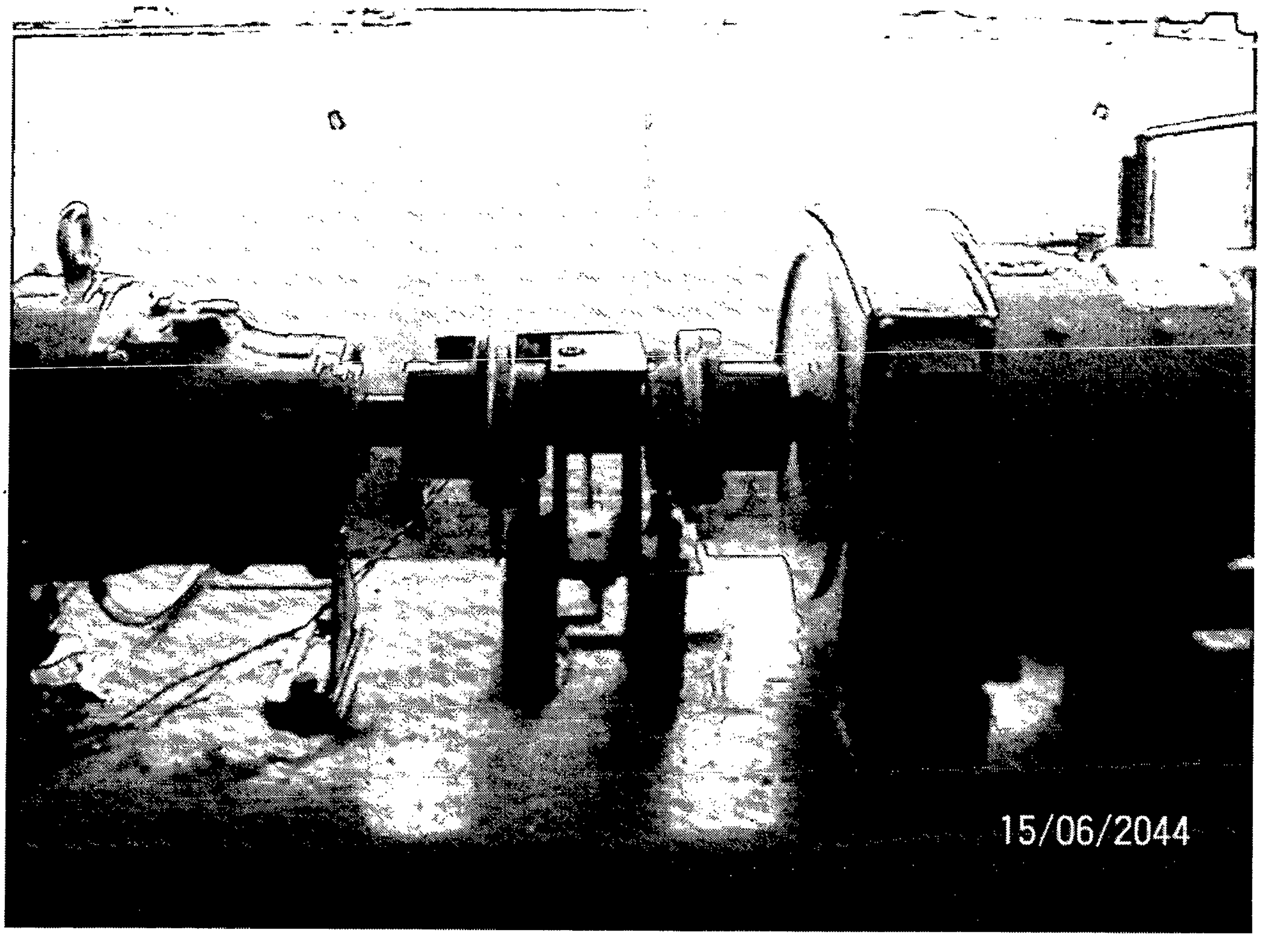
It is possibly to supply significantly more subsystems with independent, electrically isolated output signals. And naturally installation compatible pulse generators can be configured for all the usual previously marketed products.

The magnetic measuring principle and optimised bearing technology increases the pulse generators' reliability, not only increasing maintenance intervals but also significantly reducing maintenance costs.Pulse generators constructed in accordance with this principle have been successfully field tested by several rail operators since the beginning of 2005. The type test specified in EN 50155 has also been successfully completed, so that these pulse generators can now be delivered.

3.6.3 OptoeeElectric Speed Sensors:

1-250,000 RPM. Extremely versatile and able to work over long distances (up to 25 feet). The ROLS-W (tinned wire termination) and ROLS-P (1/8" phone plug termination) are threaded stainless steel remote optical sensors with a visible red laser light source. All these sensors have the "on-target" green LED indicator.

Fig.3.16 shows the diag of Speed sensor & disc



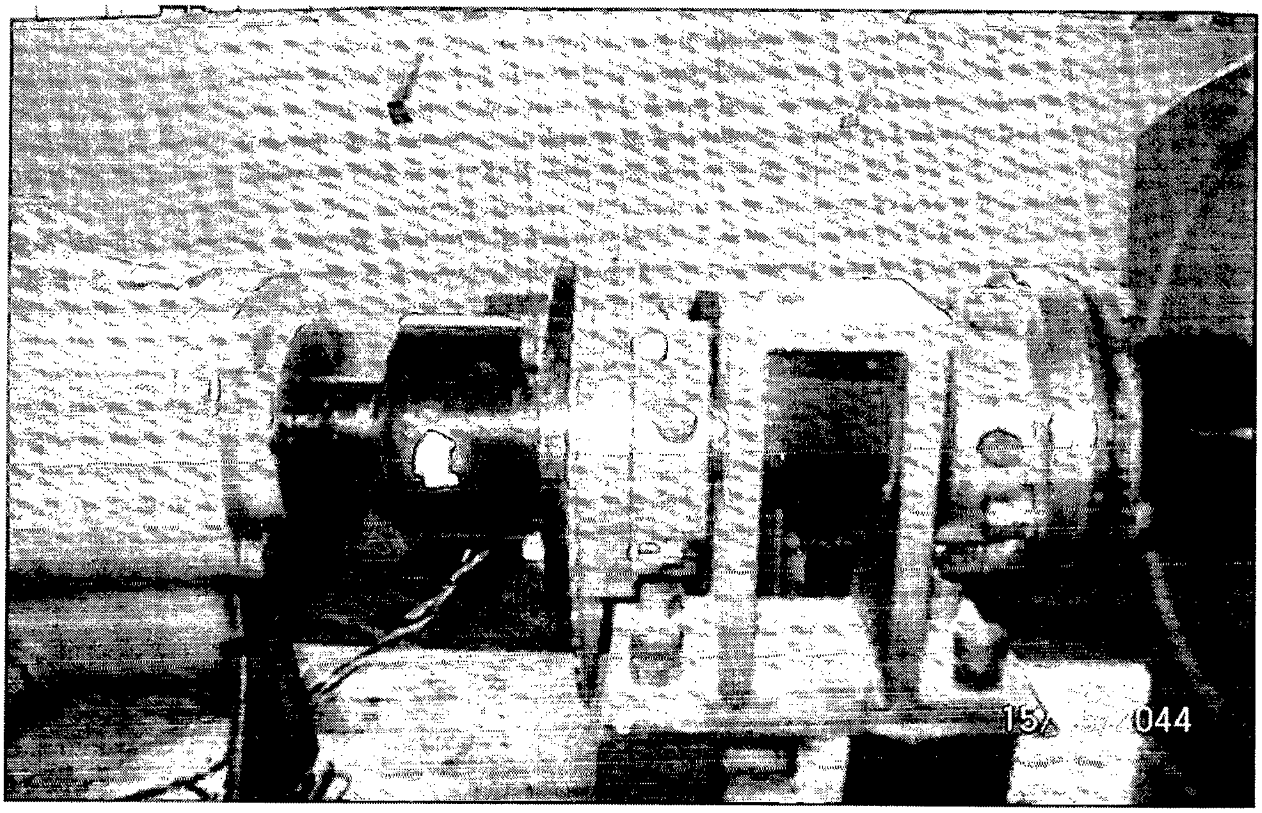


Fig 3.16. Photograph of speed sensor & disc

3.7 ELECTRICAL VALVE:

The AVCON makes 2- way motorized control valve & is most commonly used Electric Actuator EA-21 are primary designed to be In the field with Low Cost, but High Performance Actuators. The maximum torque of actuator is 20 Nm. Electric Actuator housing 'is of Moulded Plastic Nylon 66 with 30% glass, giving extreme strength for the desired torque rating. Metallic inserts are Incorporated In the mounting studs. Design on conforming to IP-65, as per IS 13947 Part I Adjustable Limit switches are Incorporated to cut off supply at the end of travel. Additional Two Auxiliary limit switches can be provided for Individual adjustments.

Actuator houses CE approved, permanent magnet type Synchronous motor. Fuses and Manual Override are incorporated as a Safety features .A terminal block suitable for connecting 14-wires is incorpated in the PCB.

The actuator is suitable for operating AVCON Ball Valve upto and inclusive of 1½" (40 MM) size Full Bore, Rubberlined Butterfly Valves upto 2"(50 MM) size, Plug Valves upto 1" (25 MM) size and low Leakage Type Butterfly Valves upto 6" (150 MM) size. Actuator can be mounted in any direction.

3.6.1 GEARS: Actuator is fitted with induction hardened gears and pinions which will give minimum back lash. Fig..17.shows working of Electrical Valve.

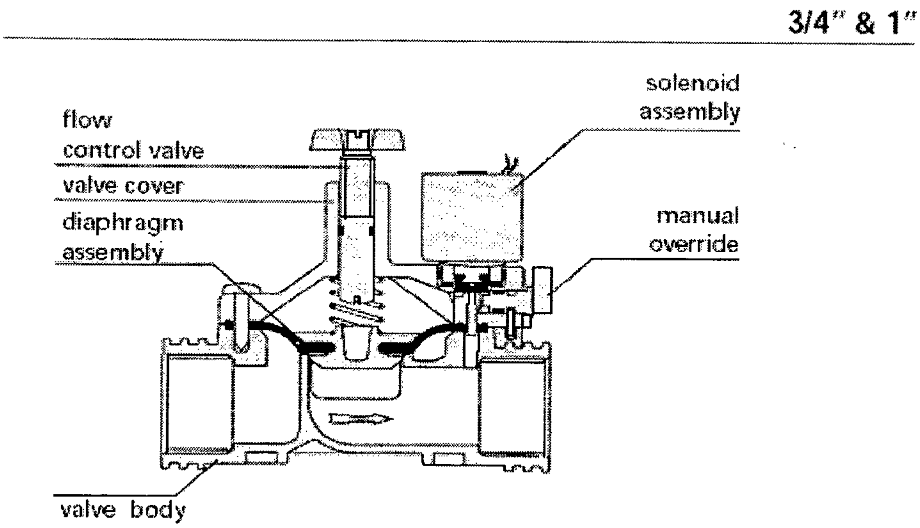


Fig.3.17 working of ELECTRICAL VALVE

Fig. 3.18 shows the Electrical Valve Setup Present In LAB

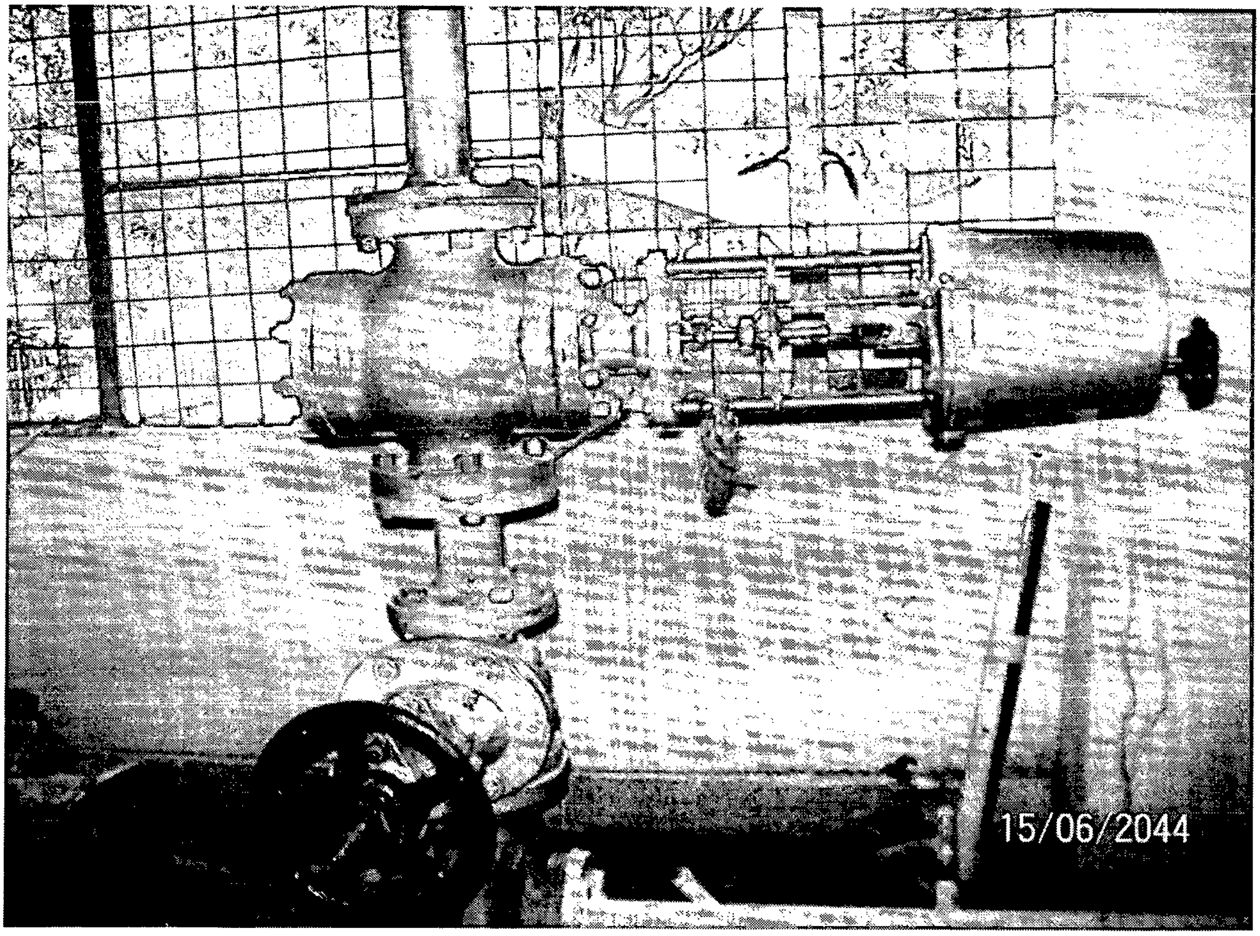


Fig. 3.18 shows the Electrical Valve Setup Present In LAB

3.8 SOUND ANALYSER :

3.8.1 Introduction to Sound Level Analyser :

With the introduction of the precision handheld sound analyser Nor140, Norsonic set a new standard for sound level meters, covering the widest range of applications. The Nor140 is packed into the smallest real time analyser featuring sound recording present on the market today.

Norsonic's philosophy has always been to cover all possible applications within one modular instrument platform. We were the first company introducing software options. This enables functional expansion to take place when you need it and not necessarily at the time you purchase the instrument. The design is based on years of experience making intuitive and easy to use field instrumentation. The Nor140 is Norsonic's second generation of handheld sound level meters featuring sound recording.

The Nor140 covers a wide range of applications, making the instrument a natural choice for every professional user of sound level meters.

Fig.3.19 shows a Sound Analiser

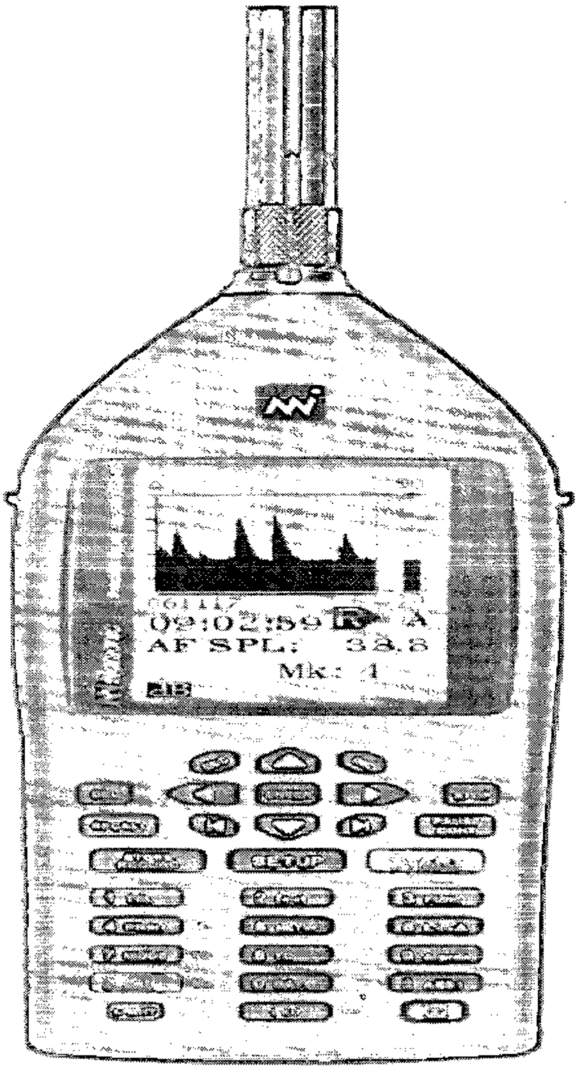


Fig3.19 sound analyser[19]

3.8.2 Applications:

i. Sound recording

ii. Environmental noise
iii. Building acoustics
iv. Noise source identification
v. Industrial hygiene
vi. Product development
vii. Quality control
viii. Sound power
ix. Speech intelligibility - STIPA
x. Vibration measurements

3.8.3 Features:

Handheld real-time 1/1- or 1/3-octave frequency analyser

i. Measurement of A-weighted levels simultaneously with either C- or Z-weighted levels
ii. Parallel detection of SPL, Leq, Lmin, Lmax, LE and Lpeak
iii. 120 dB dynamic range giving a "one-range" instrument
iv. Measures Lpeak levels up to 140 dB
v. Parallel detection of F, S or I time constants
vi. USB 2.0 and High-speed RS-232 serial interface (115 kbaud)
vii. SD memory card and large high speed internal memory
viii. Sound recording in 8, 16 or 24 bit format with 12 or 48 kHz sampling
ix. High-resolution graphical backlit display
x. Manual or automatic storage of results
xi. Automatically repeated

3.8.4 Interfaces and connectors:

The instrument has one USB 2.0 high-speed data interface and one high speed RS232 interface. The multi I/O socket additionally contains several digital I/O ports for different control applications such as remote start/stop of the measurement process or audio recording and Go/NoGo signals for qualitycontrol applications. Two analogue outputs are available.

One is dedicated to the signal generator output, the other for playback of recorded signals or AC output of the measured signal. A separate connector is available for RPM signals.

The microphone input connector is a traditional 7 pin Lemo connector. This standard was invented by Norsonic in the early nineties, now widely adopted by most of the world's sound measuring equipment manufactures. In Nor140 we have added two useful features to this standard, improving its original functionality. Firstly ICP® power is added therby allowing the use of signal line powered sensors such as accelerometers and electret microphones with ICP® preamplifiers. This removes the need of expensive adaptors or cables when connecting them to the instrument. The second feature is the built-in calibration oscillator for verification of outdoor microphones that will be a great advantange on long term noise monitoring projects.

3.9 Conclusion

Whole experiment setup of Wireless Monitoring have been done & sensing of various parameters have been done by the Instruments discussed in this chapter & send these parameters to the wireless modules which are further discussed in the next chapters .

CHAPTER-4

DATA ACQUISITION MODULES

4.1 INTRODUCTION

After sensing data from the different sensing Instruments discussed in chapter 3 ,this data is further processed in Data Acquisition Modules in order to process that data in computer . This is done by various Data Acquisition modules Discussed in this chapter.
The I-7000 series is a family of network data acquisition and control modules, providing analog-to-digital, digital-to-analog, digital input/output, timer/counter and other functions. The modules can be remotely controlled using a set of commands, which we call the DCON protocol. Communication between the module and the host is in ASCII format via an RS-485 bi-directional serial bus standard. Baud Rates are software programmable. This I-7000 modules provide cost-effective protection and conditioning for a wide range of valuable industrial control signals and system. It includes sensor-to-computer, computer-to-sensor, digital I/O, timer/ counter, RS-232 to RS-485 converter, RS-485 repeater, man machine interface, data display and application software.
Conventional Two-Wire RS-485 Network: The conventional two-wire RS-485 network uses a DIP SWITCH selectable converter to convert host RS-232 or USB signals to a two-wire RS-485 signal. The baud rate and data format must be set to a fixed value for the whole network. For example, the user can choose baud rate=9600 and data format=10 bit per character. This limitation is inconvenient for some real world applications.[11]

The 7000 Series RS-485 Network: The 7000 RS-485 network is the most powerful and flexible two-wire RS-485 networks in the world. It is a multiple baud rate and multiple data format network system. That is to say, all the remote modules mentioned above, PLCs and weight scale equipment share the same RS-485 network

4.2 COMMON FEATURES OF THE I-7000 SERIES

Isolation voltage: 3000 VDC

4.2.1 Communication

i. Asynchronous half-duplex 2-wire RS-485 network
ii. Max. Distance without repeater= 1.2km

iii. Speed=1200,2400,4800,9600,19200,38400,57600,115200
iv. Connecting 256 modules in one RS-485 bus without repeater
v. Multiple baud rate and multiple data format can share the same RS-485 bus (7520/7510)
vi. Different baud rate and the same module address can share the same RS-485 bus
vii. Connecting 256*8=2048 modules max. In one RS-485 bus with repeater.
viii. 7000 series data format=1 start + 8 data + 1 stop + no parity = 10-bit
ix. Two extra checksum bytes can be enable/disable
x. Built-in transient voltage suppresser and PTC protector
xi. Sharing the same RS-485 bus with the RS-485 or RS-232 device, which communicates in multiple data format (not 10-bit) and multiple bauds Rate. (Use 7520 to convert RS-232 to RS-485) [22]

4.2.2 Power requirement

i. Unregulated +10V dc ~ +30V dc.
ii. Power reverse protection, Over-voltage brown-out protection

4.2.3 System

i. Dual watchdog inside, power-on start value and safe value for host failure
ii. Operating temperature: -25 to 75°C (14 to 185°F)
iii. Storage temperature: -25 to 80°C (-13 to 185°F)
iv. Humidity: 5 to 95%, non-condensing [30]

4.3 MODULE I-7019

The I-7019 is an 8-channel voltage, current, and thermocouple input module, with the ability to connect various types of inputs to a single module.[19]

4.3.1 Specifications

Analog Input	
Input Channels	8 differential
Input Type	mV, V, mA (jumper selectable)
Thermocouple Type	J, K, T, E, R, S, B, N, C, L, M, LDIN43710
Sampling Rate	8 samples/sec
Bandwidth	5.24Hz

Accuracy	±0.15%
Zero Drift	10μV/°C
Span Drift	25ppm/°C
CMR@50/60Hz	86dB min
Input Impedance	2MΩ
Current Impedance	125Ω, 1/4W
Voltage overload Protection	±240V
Isolation	3000V DC
Open Wire Detection	Yes
Individual Channel Configurable	Yes
Modbus RTU	M-7019R
Power	
Requirement	+10 to +30V DC
Consumption	1.2W
Temperature Range	
Operating	-25°C to +75°C
Storage	-30°C to +75°C

[30]

4.2.2 Schematic of I-7019

Fig 4.1 shows the schematic of module I-7019

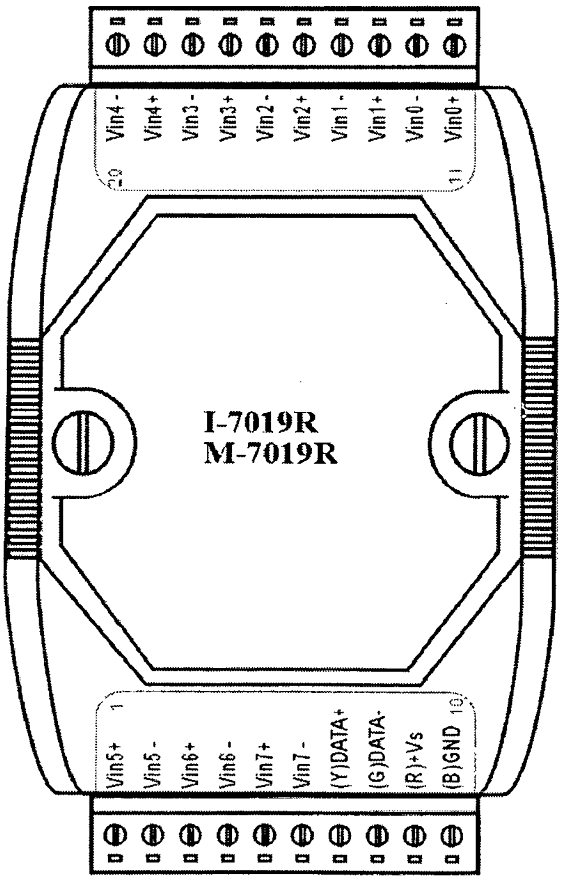


Fig.4.1 Schematic of I-7019 module [21]

4.3.3 Features 7019 Module

The common features of the I-7019 are as follows:

i. 3000V DC isolated analog input
ii. 24-bit sigma-delta ADC to provide excellent accuracy
iii. The I-7019is an 8-channel voltage and current input module. The I-7018 is an 8-channel voltage, current and thermocouple input module. The I-7019 is an 8-channel voltage, current, and thermocouple input module, with the ability to connect various types of inputs to a single module.
iv. The I-7019 has the following variations:
v. □ I-7019F: added support for fast mode, 75 samples/second
vi. □ I-7019C: used for current input only, with no external resistor required
vii. □ I-7019R: added high voltage overload protection, 240Vrms.
viii. □ I-7019RC: used for current input only, with no external resistor required. Added high voltage overload protection, 240Vrms
ix. The I-7018 has the following variations:
x. □ I-7018P: added support for two additional thermocouple types, L and M
xi. □ I-7018BL: added thermocouple wire opening detection
xii. □ I-7018R: added thermocouple wire opening detection and high voltage overload protection, 240Vrms
xiii. The I-7019 has the following variation:
xiv. □ I-7019R: added high voltage overload protection, 240Vrms [21,23]

4.4 MODULE I-7520

The 7520, RS-232 to RS-485 converter, equips a "Self Tuner" inside, therefore it can detect the baud rate and data format automatically and control the direction of the RS-485 network precisely. Therefore the user can connect all this equipment to the same RS-485 network. This method will greatly reduce system cost and increase reliability [20].

4.4.1Pin Assignment and Specifications:

7520: RS-232 to RS-485 Converter

i. Protocol: Differential 2-wire half-duplex RS-485
ii. Connector: plug-in screw terminal block
iii. Speed: "Self Tuner" inside, auto switching baud rate, from 300 to 115200 bps
iv. 256 modules max in one RS-485 network without repeater
v. 2048 modules max in one RS-485 network with repeater
vi. Isolation voltage: 3000V
vii. Isolation site: RS-232
viii. Repeater request: 4,000 feet or over 256 modules
ix. Power requirements: +10V dc ~ +30V dc
x. Power consumption: 0.05A@24V; Max [21'23]

4.4.2 Schematic of Module I-7520

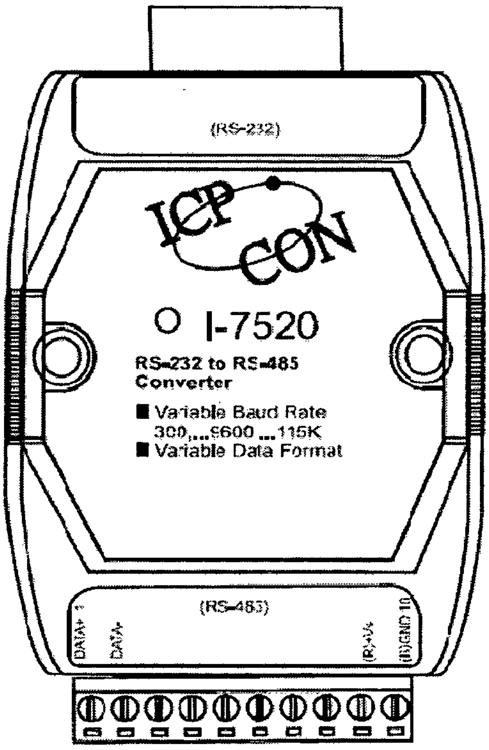


Fig. 4.2 Schematic of I-7520 [20]

4.5 MODULE I-7080

The I-7080 is a cost-effective, compact and robust 2-channel counter/frequency input and 2-channel digital output module. Each module is addressable allowing up to 256 units to be linked together via a two-wire RS-485 connection with a baud rate up to 115.2 kbps.

The I-7080 provides 3000V isolation between the module and the RS-485 communications network [21].

4.5.1 Specifications:

A. Counter input

i. Channels: Two independent 32 bit counters, counter 0&1.

ii. Input Signal: Isolated or non Isolated Programmable.

iii. Isolation Input levels: Logic level 0: +1 V max, Logic level 1 : +3.5 to

iv. +30 V.

v. Isolation voltage: 3750 V rms.

vi. Non-isolation Input threshold level: programmable; Logic level 0: 0 to +5 V (default 0.8 V); Logic level 1: 0 to +5 V (default 2.4 V).

vii. Maximum Count: 32 bit (4,294,967,295).

viii. Programmable digital noise filter: 2 μs to 65 ms.

ix. Alarming: Alarm on Counter 0 or Counter 0&1, Programmable.

x. Counter preset value: Programmable.

B. Display

i. LED Indicator: 5 digit readout, Channel 0 or Channel 1.

C. Frequency measurement

ii. Input frequency: 1Hz to 100 KHz max.

iii. Programmable built in gate time: 1/0.1 sec.

D. Digital output:

i. 2 channels open collector to 30V, 30mA max load.

ii. Power dissipation: 30mW.

E. Power

i. Power requirements: +10 to +30 V (non-regulated).

ii. Power consumption: 2.2W.

Fig 4.3 shows the schematic of module I-7080

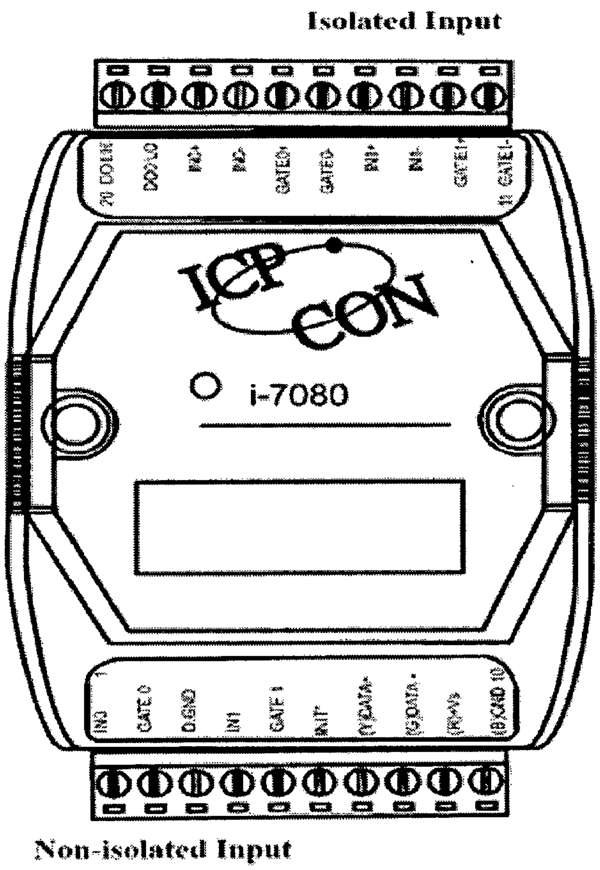


Fig. 4.3 module I-7080 [21, 30]

4.6 CONNECTIONS OF MODULES

Fig 4.4 shows the connection of modules in RS-485 network,here it is shown that we can connect 256 modules in series without repeater,for more than that we need a repeater [20].

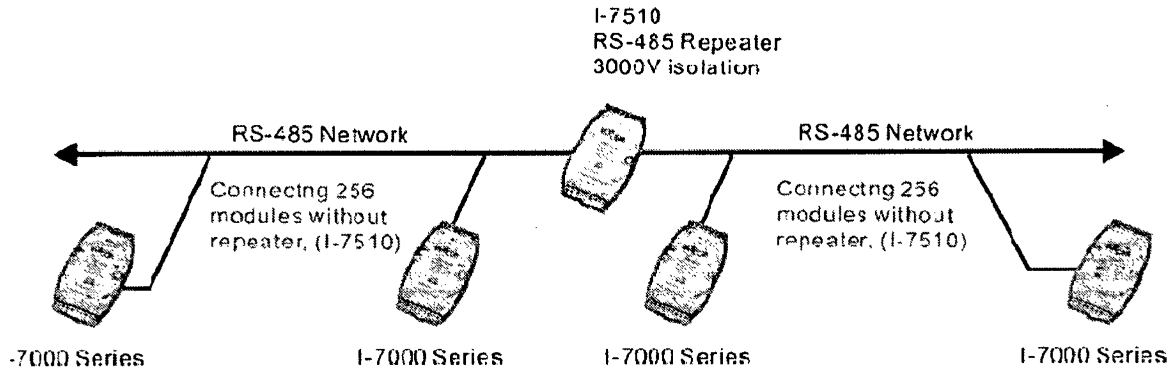


Fig. 4.4 connecting no. of modules [30]

Fig 4.5 shows the connection of single modules with PC,here a converter is applied for RS-485 to RS-232 conversion.[23]

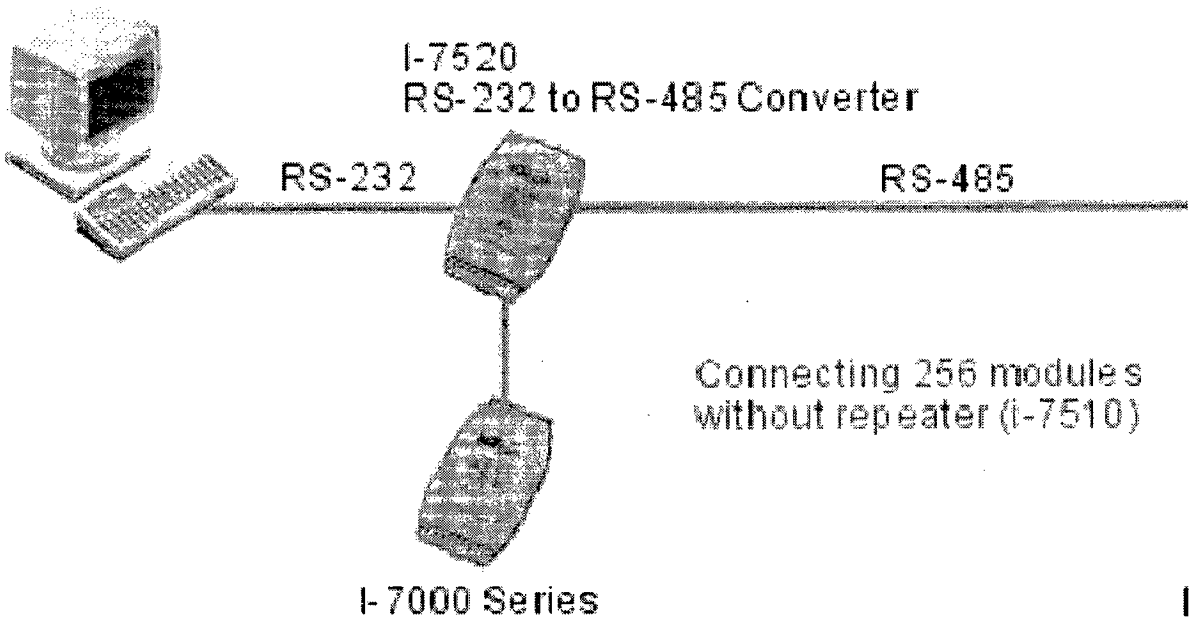


Fig. 4.5 Connection of modules [22]

4.6.1 Operation

i. The host PC sends out commands via COM1 or COM2.

ii. The 7520R module converts the RS-232 signal to RS-485 signal.

iii. All the modules connected to the RS-485 network receive command at the same time. Then all the modules will begin extracting the destination address and compare it to its local module address.

iv. The module with the matched address will continue to execute the host command while other modules will bypass it.

v. After executing the host command, the destination module will send the result back to the RS-485 network. The host PC will interpret the result and take necessary action [21].

4.6.2 Circuit Diagram

Fig 4.6 shows the connection ports between I-7019 and I-7520

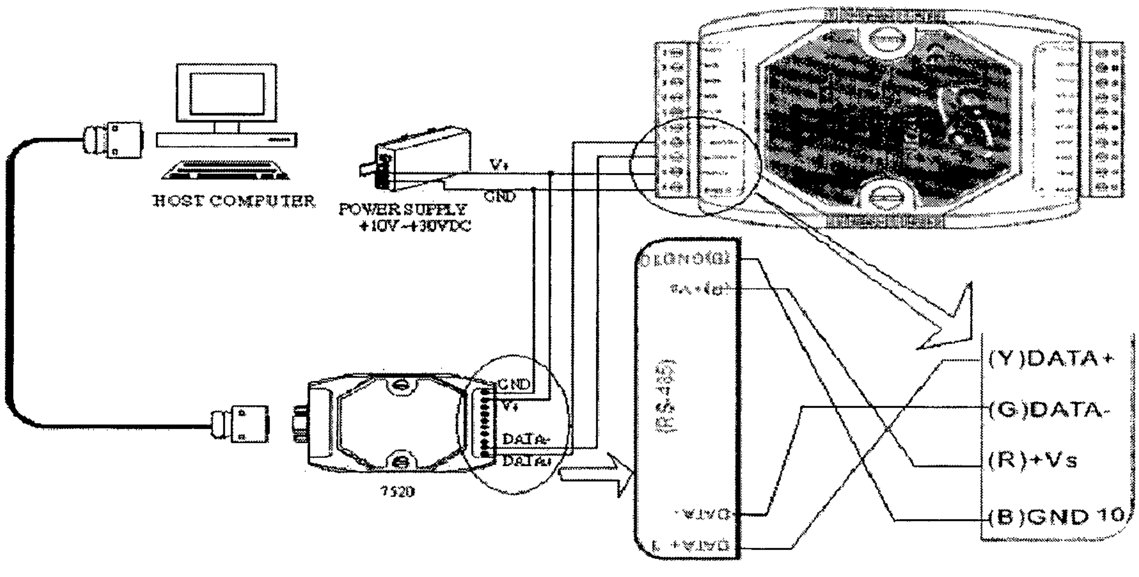


Fig. 4.6 Connection between I-7019 and I-7520[20]

4.7 DCON UTILITY SOFTWARE

The DCON Utility is a toolkit that help user to search the network, easily to configure and test the I/O modules via the serial port (RS-232/485) fig 4.7 shows connectivity DCON software

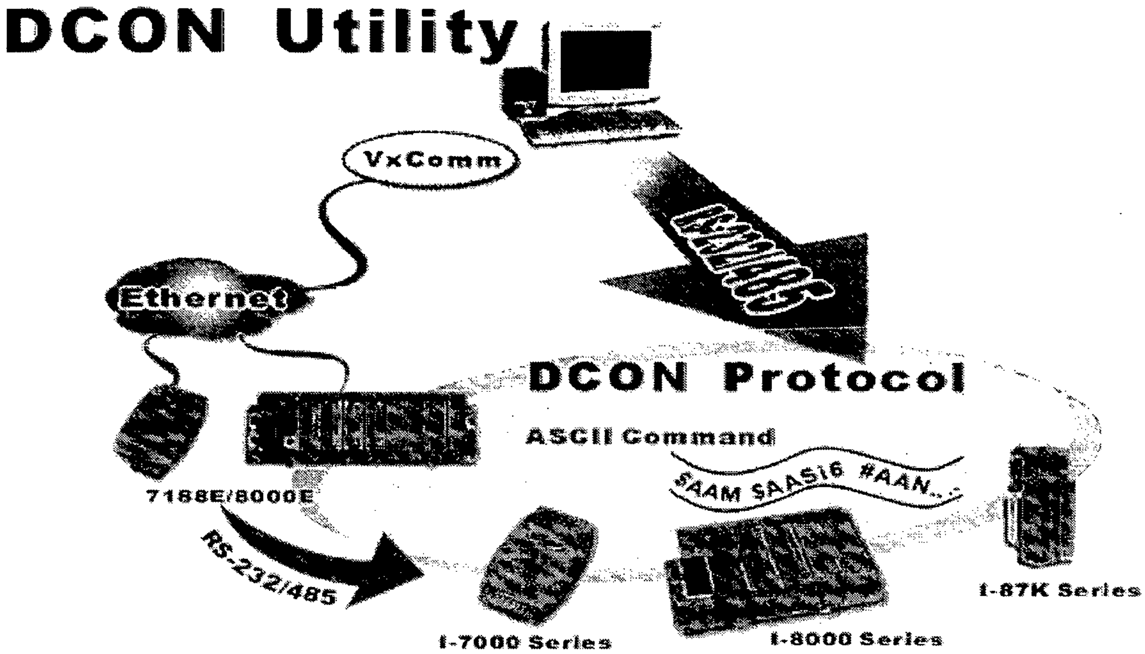


Fig 4.7 connectivity of DCON SOFTWARE [27]

4.7.1 Search I/O modules:

DCON Utility is a program based on COM port interface, it can search DCON Protocol and Modbus RTU Protocol modules and support checksum disable and enable. Fig 4.8shows the screen for selecting a baud rate and com port for searching a module.

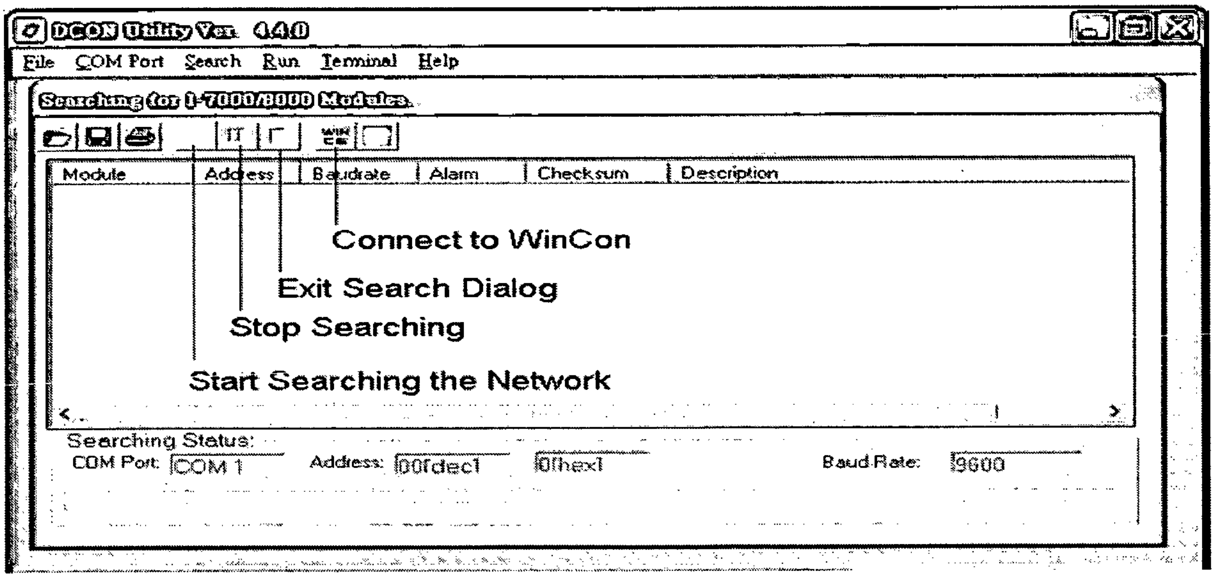


Fig. 4.8 Different icons and their functions [23]

4.7.2 Steps for Searching and Configure the modules:

Following steps for searching and configure the modules.

Step 1. Make sure the wirings are correctly connected.

Step 2. Search and configure the modules one by one.

If the modules are new or unknown, they may have the same communication settings, and if there are two modules with the same communication settings, it will get an unexpected search result. So they must be searched and be configured one by one [22].

Step 3. Check the COM Port Setting.

Choose the COM port of Host PC that will connect to the module and select the searching parameters as shown in fig 4.9

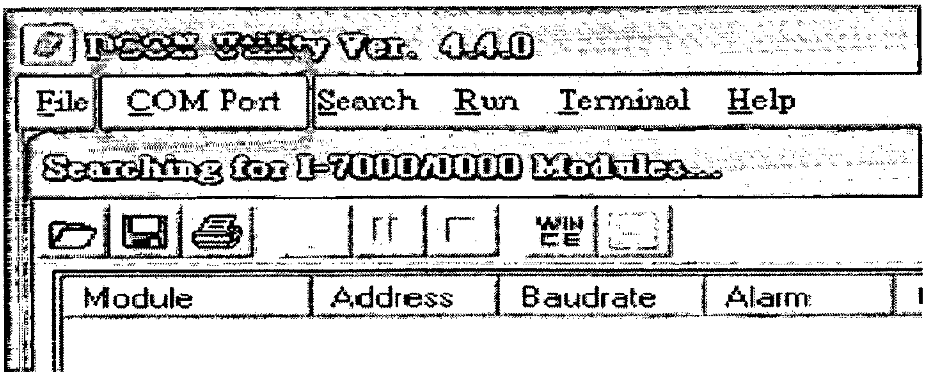


Fig 4.9 Searching a COM port

Step 4. Clicks to start searching,as shown in fig 4.10

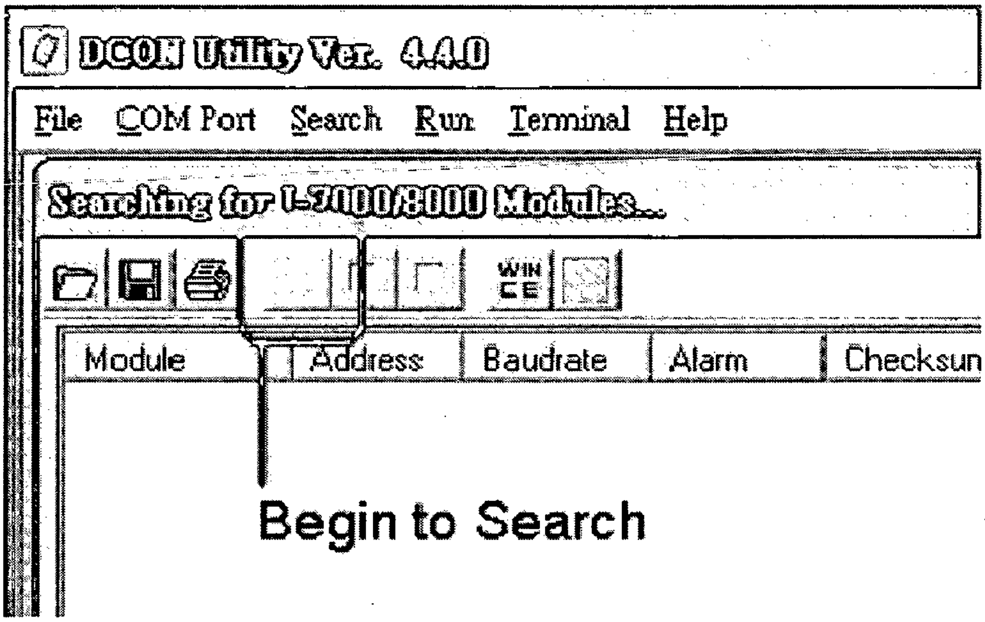


Fig. 4.10 Display screen when system is searching a COM port [23]

Step 5. Click Searched ID to enter the configuration form as shown in fig 4.11

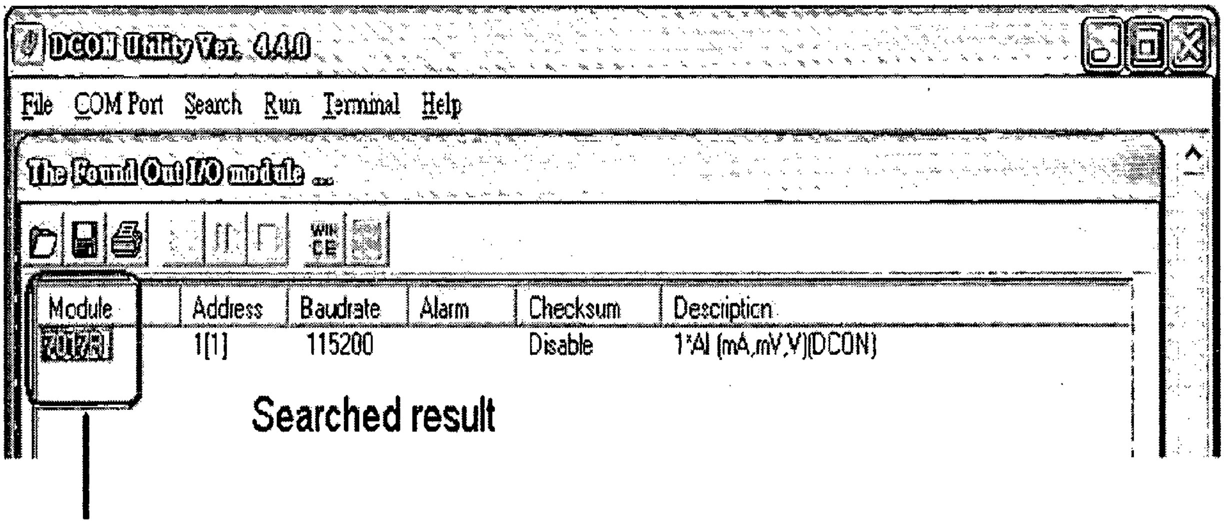


Fig. 4.11 Screen showing the search results for module[23]

After configuration all the modules we have to connect these to LabView blocks or .vi files should be prepared for taking display of parameters. Configuration of module is shown in fig 4.12

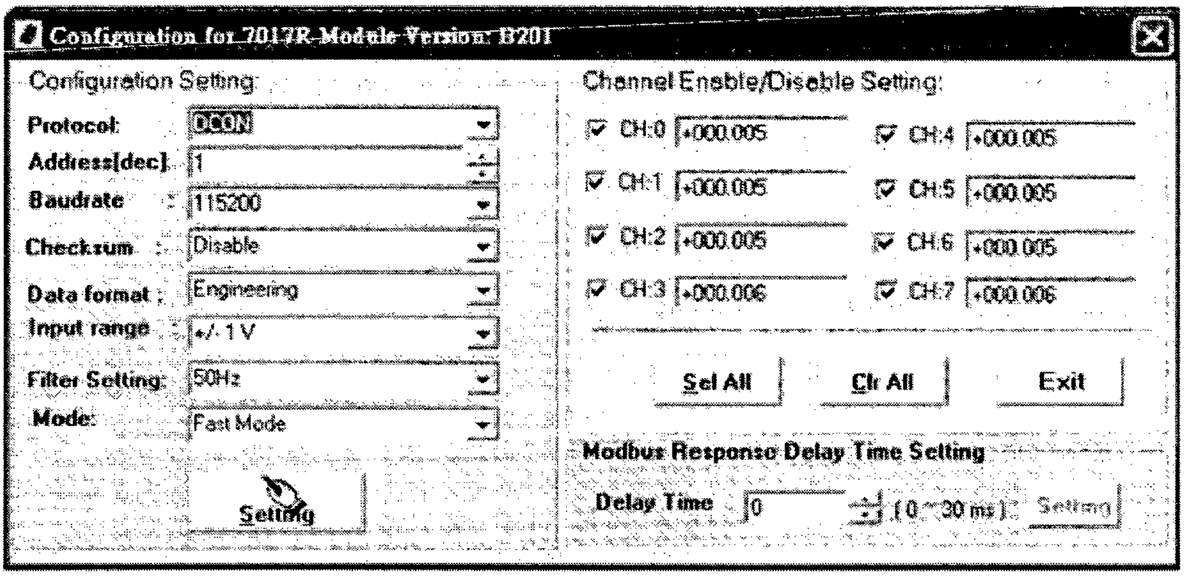


Fig. 4.12 Configuration of modules [26]

4.8 CONCLUSION

After sensing data from the sensors the data further processed in Data Acquisition Modules discussed in this chapter and after data acquisition this data is send to the computer in which this data is again processed & represented in LabVIEW screen which is discuss in the next chapter.

CHAPTER 5

LabVIEW AND ITS APPLICATION IN EXPERIMENT SETUP

5.1 INTRODUCTION

After Data Acquisition the data is further processed & visualize in form of digits in LabVIEW window ,the introduction of LabVIEW & how it is used in our system is discussed as follows.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution. In LabVIEW, you build a user interface with a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart. You can purchase several add-on software toolsets for developing specialized applications. All the toolsets integrate seamlessly in LabVIEW. Refer to the National Instruments Web site at ni.com for more information about these toolsets. [13,14]

LabVIEW is an entirely graphical language which looks somewhat like an electronic schematic diagram on the one hand and a 1950's vintage style electronic instrument on the other -these are the concepts of the block diagram and the front panel. LabVIEW is heirarchical in that any virtual instrument that we design (any complete functional unit is called a virtual instrument and is almost always referred to as a "VI") can be quickly converted into a module which can be a sub-unit of another VI. This is entirely analagous to the concept of a procedure in conventional programming.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution. In LabVIEW, you build a user interface with a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.

We can also write a LabVIEW module using LabVIEW and present it as a VI to be used in other programs (re-usable code) or can also write modules which interface with LabVIEW in other languages such as C and C++. These are known as "sub-VIs" and are no different from VIs except that the interface has been defined to the next level. Sub-VIs in C or C++ are very useful if we have a complex numerical procedure to perform on the data which is not covered in a standard LabVIEW routine.

Virtual instrumentation is defined as combining hardware and software with industry-standard computer technologies to create user-defined instrumentation solutions. National Instruments specializes in developing plug-in hardware and driver software for data acquisition (DAQ), IEEE 488 (GPIB), VXI, serial, and industrial communications. The driver software is the programming interface to the hardware and is consistent across a wide range of platforms. Application software such as LabVIEW, LabWindows/CVI, ComponentWorks, and Measure deliver sophisticated display and analysis capabilities required for virtual instrumentation.

We can use virtual instrumentation to create a customized system for test, measurement, and industrial automation by combining different hardware and software components.If the system changes, we often can reuse the virtual instrument components without purchasing additional hardware or software.[13,14]

5.1.1 LabVIEW Virtual Instruments:

LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers. LabVIEW is an integral part of Virtual Instrumentation because it provides an easy-to-use application development environment designed specifically with the needs of engineers and scientists in mind. LabVIEW offers powerful features that make is easy to connect to a wide variety of hardware and other software. Hence, finally some of the chief features of Virtual Instruments can be summarized as:

i. Graphical Programming
ii. Connectivity and Instrument Control
iii. Open Environment

iv. Reduces Cost and Preserves Investment
v. Multiple Platforms
vi. Distributed Development
vii. Analysis Capabilities
viii. Visualization Capabilities
ix. Flexibility and Scalability -- Key Advantages

A VI contains the following three components:

i. **Front panel**—Serves as the user interface.

ii.**Block diagram**—Contains the graphical source code that defines the functionality of the VI.

iii.**Icon and connector pane**—Identifies the VI so that you can use the VI in another VI. A VI within another VI is called a subVI. A subVI corresponds to a subroutine in text-based programming languages. [14]

5.1.2 Front Panel

You build the front panel with controls and indicators, which are the interactive input and output terminals of the VI, respectively. Controls are knobs, push buttons, dials, and other input devices. Indicators are graphs, LEDs, and other displays. Controls simulate instrument input devices and supply data to the block diagram of the VI. Indicators simulate instrument output devices and display data the block diagram acquires or generates. Figure 5.1 shows design of a front panel.

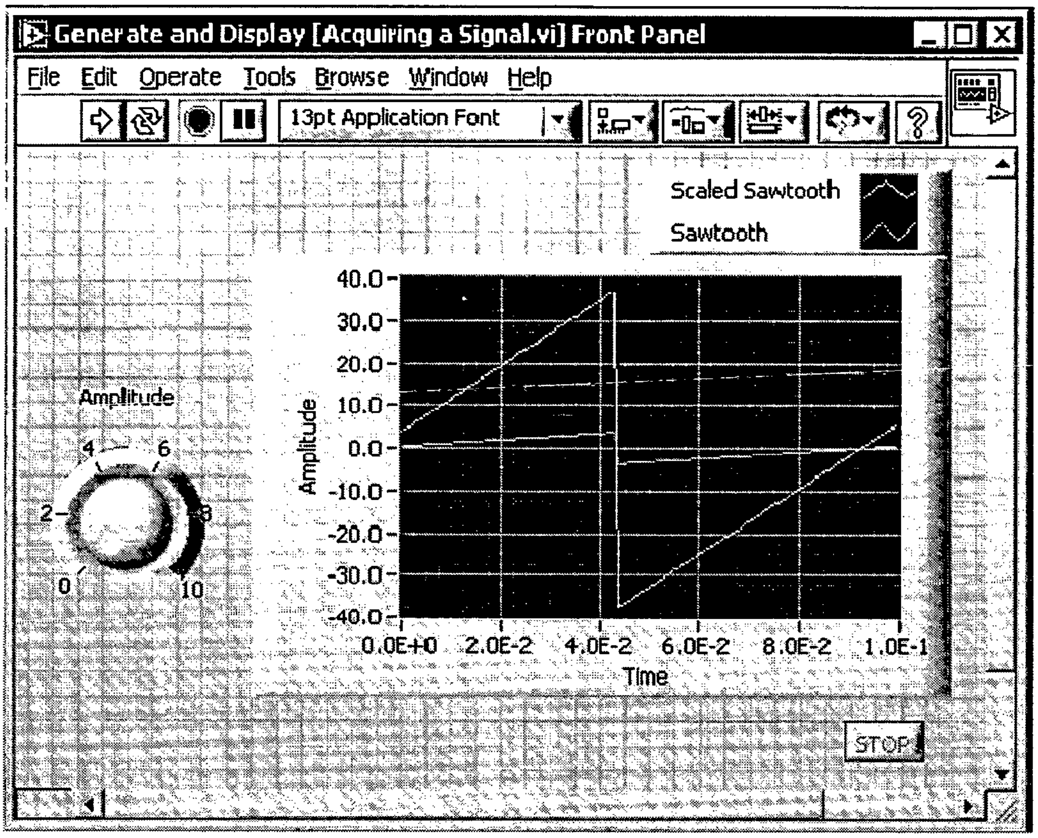


Fig 5.1 labview front panel [14]

5.1.3 Block Diagram:

After you build the front panel, you add code using graphical representations of functions to control the front panel objects. The block diagram contains this graphical source code. Front panel objects appear as terminals on the block diagram. Figure 5.2 shows Example of a Block Diagram and Corresponding Front Panel

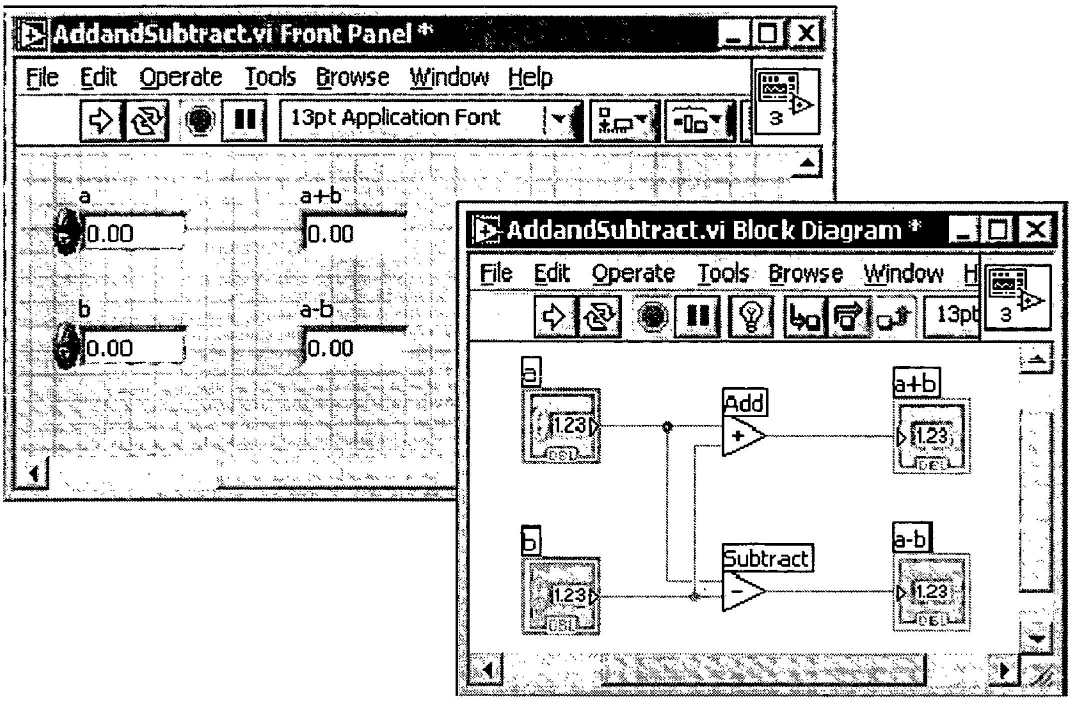


Fig. 5.2. Example of a Block Diagram and Corresponding Front Panel [14]

5.1.4 Terminals

The terminals represent the data type of the control or indicator. You can configure front panel controls or indicators to appear as icon or data type terminals on the block diagram. By default, front panel objects appear as icon terminals. For example, a knob icon terminal shown at left, represents a knob on the front panel. The DBL at the bottom of the terminal represents a data type of double-precision, floating-point numeric. A DBL terminal, represents a double-precision, floating-point numeric control or indicator. Measurement devices, such as general-purpose data acquisition (DAQ) devices and special-purpose instruments, are concerned with the acquisition, analysis, and presentation of measurements and other data we acquire.

Acquisition is the means by which physical signals, such as voltage, current, pressure, and temperature, are converted into digital formats and brought into the computer. Popular methods for acquiring data include plug-in DAQ and instrument devices, GPIB instruments, VXI instruments, and RS-232 instruments. Data analysis transforms raw data into meaningful information. This can involve such things as curve fitting, statistical analysis, frequency response, or other numerical operations. Data presentation is the means for communicating with your system in an intuitive, meaningful format.

5.1.5 Control and Indicators

control can take many forms. Many of the forms are themselves "pictures" of real controls used on real instruments - rotary knobs for example. Others are strictly digital in concept. All controls have some form of visual feedback to show the user what state they are in. This helps enormously as you do not have to make explicit allowance to show the state of the controls in our design. A second extremely useful property of controls is that you can specify how they are to react if the input given is unsuitable. To give a specific example - if a control should have an input range of 0 to 10 in integer numbers, we can specify what should happen if the value 3.5 is given or -1 or "zero" as a character string. Since a great deal of time can be consumed in "bullet proofing" a user interface against these sorts of problems, this can be a big timesaver. Figure 5.3 and 5.4 shows the tools and control pallets in Labview. [13]

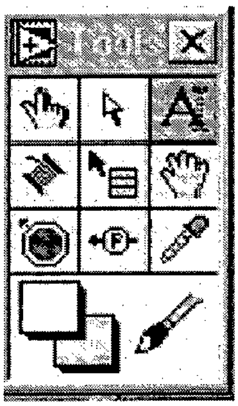


Fig. 5.3 Tools pallets in LabView

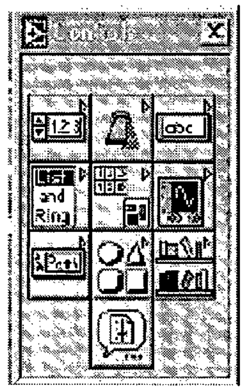


Fig. 5.4 Control pallets in LabView

Indicators take a large number of forms. Again some are "pictures" of real indicators -lights and meters. Some are more designed for the computer screen. The concept of indicator also includes graphs and charts which is a second major timesaver as we do not have to design any of these elements explicitly. Figure 5.3 shows different types of indicators available in LabView.

5.1.6 Adding a Control to the Front Panel:

Controls on the front panel simulate the input mechanisms on a physical instrument and supply data to the block diagram of the VI. Many physical instruments have knobs you can turn to change an input value. Complete the following steps to add a knob control to the front panel. Throughout these exercises, you can undo recent edits by selecting **Edit»Undo** or pressing the <Ctrl-Z> keys.

1. If the **Controls** palette, shown in Figure 1-4, is not visible on the front panel, select **View»Controls Palette.**

You can right-click any blank space on the front panel or the block diagram to display a temporary version of the **Controls** or **Functions** palette. The **Controls** or **Functions** palette appears with a thumbtack icon in the upper left corner. [14]

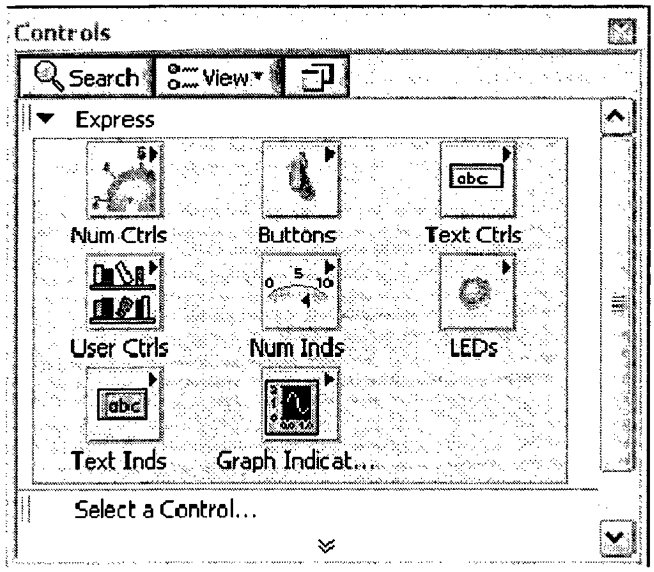


Fig 5.5. Controls Palette [14]

5.1.7 Changing a Signal Type

The block diagram has a blue icon labeled **Simulate Signal.** This icon represents the Simulate Signal Express VI. The Simulate Signal Express VI simulates a sine wave by default.

Complete the following steps to change this signal to a sawtooth wave.

1. Display the block diagram by pressing the <Ctrl-E> keys or by clicking the block diagram. Locate the Simulate Signal Express VI, shown at left. An Express VI is a component of the block diagram that you can configure to perform common measurement tasks. The Simulate Signal Express VI simulates a signal based on the configuration that you specify.

2. Right-click the Simulate Signal Express VI and select **Properties** from the shortcut menu to display the **Configure Simulate Signal** dialog box. **(Mac OS)** Press <Command>-click to perform the same action as right-click.

You also can double-click the Express VI to display the **Configure Simulate Signal** dialog box. If you wire data to an Express VI and run it, the Express VI displays real data in the configuration dialog box. If you close and reopen the Express VI, the VI displays sample data in the configuration dialog box until you run the VI again.

3. Select **Sawtooth** from the **Signal type** pull-down menu. The waveform on the graph in the **Result Preview** section changes to a sawtooth wave. The **Configure Simulate Signal** dialog box should appear similar to Figure 5.6.

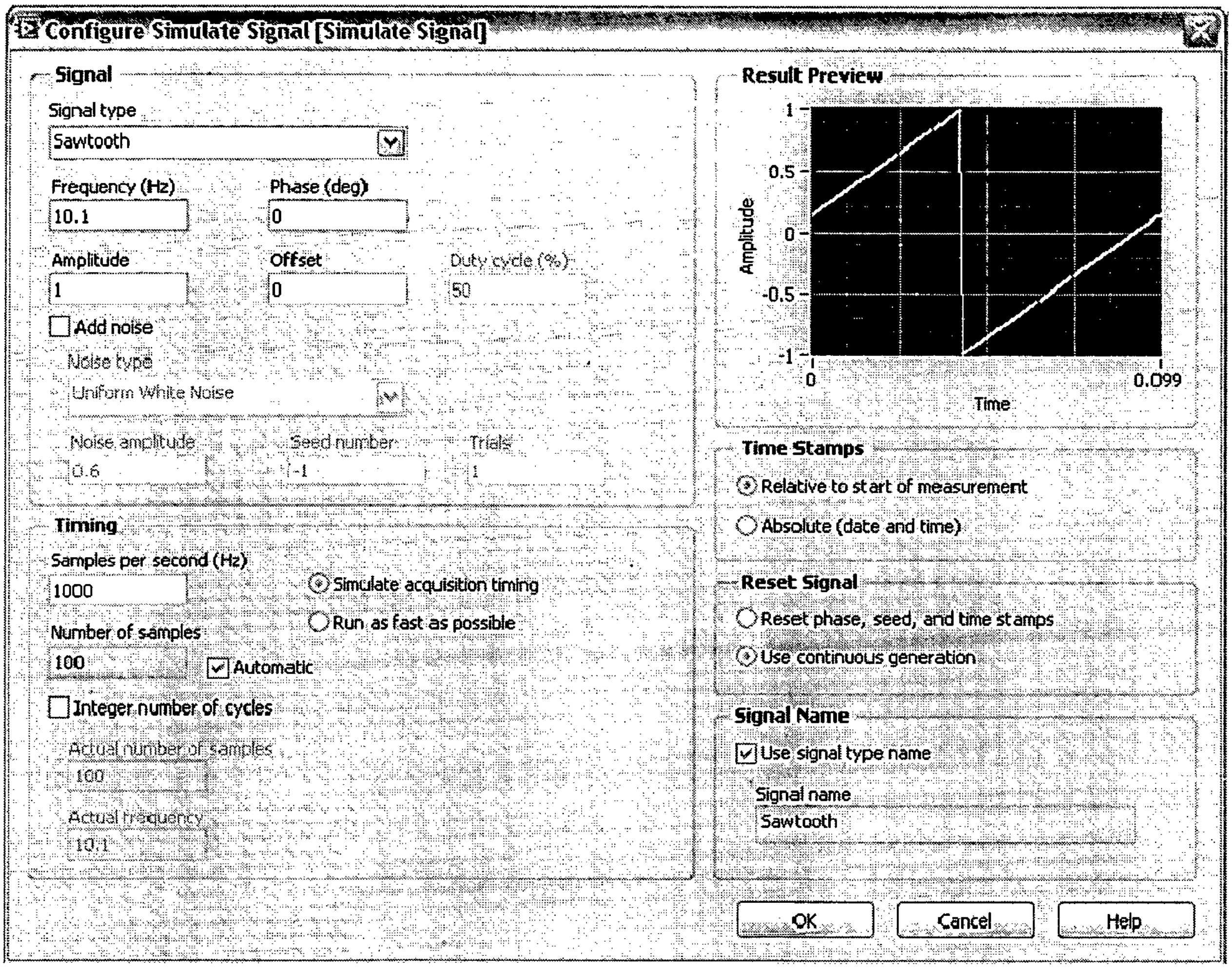


Fig. 5.6. Configure Simulate Signal Dialog Box [13]

4. Click the OK button to save the current configuration and close the Configure Simulate Signal dialog box.

5. Move the cursor over the down arrows at the bottom of the Simulate Signal Express VI. The down arrows indicate you can reveal hidden inputs and outputs by extending the border of the Express VI.

6. When a double-headed arrow appears, shown at left, click and drag the border of the Express VI to add two rows. When you release the border, the Amplitude input appears. Because the Amplitude input appears on the block diagram, you can configure the amplitude of the sawtooth wave on the block diagram.

In Figure 5.6, notice that Amplitude is an option in the Configure Simulate Signal dialog box. When inputs, such as Amplitude, appear on the block diagram and in the configuration dialog box, you can configure the inputs in either location. [13]

5.2 DYNAMIC LINK LIBRARY

Monitoring system is first step before controlling any system, therefore data acquisition is important. The real time parameters can be monitored by means of LabVIEW drivers which are basically responsible for to get the online data into the LabVIEW program .The drivers for the I-7000 Series Modules, provide one or more DLL files (and VXD/SYS files) to be used by higher-level computer languages. The DLL files are written in Visual C++ and provide lots of functions to perform a variety of Analog input/output, Digital input/output, Counter/Timer and RS-232/RS-485 Communication operations with the hardware of the I-7000 Series Modules. The DLL files are in standard Win32 DLL format, and can be used with Windows 95/98/NT/2000. With these functions of DLL files, user no longer needs to process the lower-level hardware controls. The DLL files can be easily used by higher-level computer language. For example, it provides a large variety of demo programs that are written in Visual C++, Delphi, Borland C++ Builder, Visual Basic and LabVIEW. Figure 5.7 shows the architecture of dll files import in LabView [27].

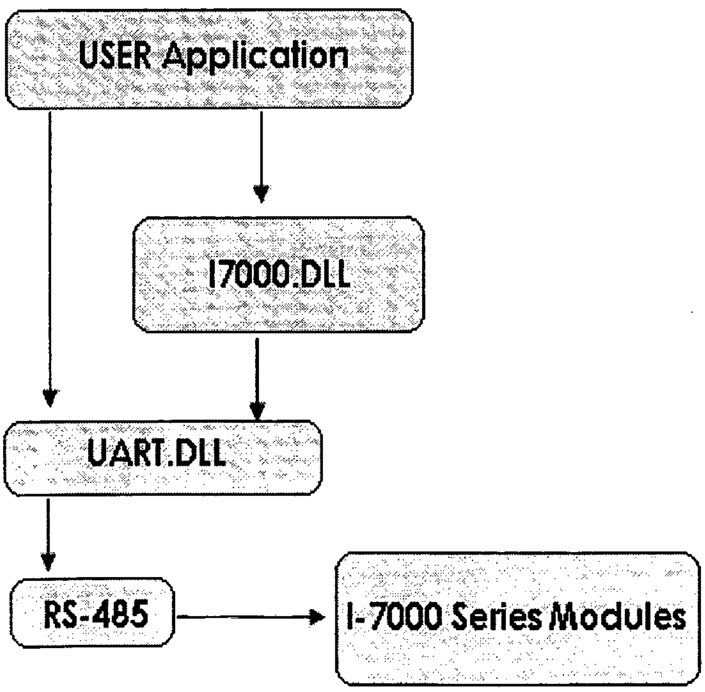


Fig 5.7 use of .dll files[27]

Figure 5.7 shows the schematic of how the dll files are called from the source program in LabVIEW the **UART.DLL & I7000.DLL** are the dynamic linking library (DLL) designed for Windows 95/98 and Windows NT 3.51/4.0/2000/XP applications. The user can use many programming languages as mentioned to develop his application with UART.DLLandI7000.DLL.

5.2.1 Open Com

This DLL will initialize the COM port. This DLL must be called once before the other DLLs are called send received command.

Syntax- Open_Com (char cPort, DWORD dwBaudRate, char cData, cParity, char cStop)

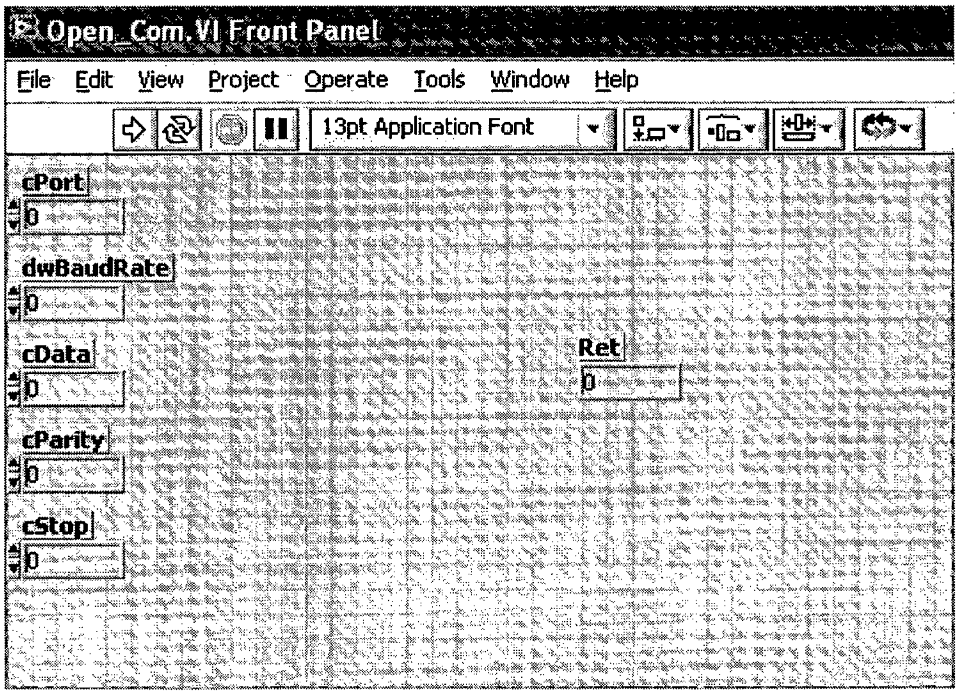


Fig. 5.8: Open_Com[27]

Figure 5.8 shows the front panel of Open_com dll file.

Input Parameter:

cPort: 1=COM1, 2=COM2, ..., 255=COM255

dwBaudRate: 50/75/150/300/600/1200/1800/2400/4800/9600/

19200/38400/57600/115200

cData: 5/6/7/8 data bit

cParity: 0=Non Parity, 1=1.5-stop, 2=2 Stop

Here cData=8, cParity=0,cStop=0 for 7000 series modules.

Return Value: No Error= OK, others= Error refers to I7000.H

5.2.2 Close_Com

This DLL will free all the resources used by Open_Com. This DLL must be called once before exit. The Open_Com will return error massage if the program exit without calling Close_Com function.Figure 5.9 shows the front panel of close_com file.

Syntax- Open_Com (char cPort) [27]

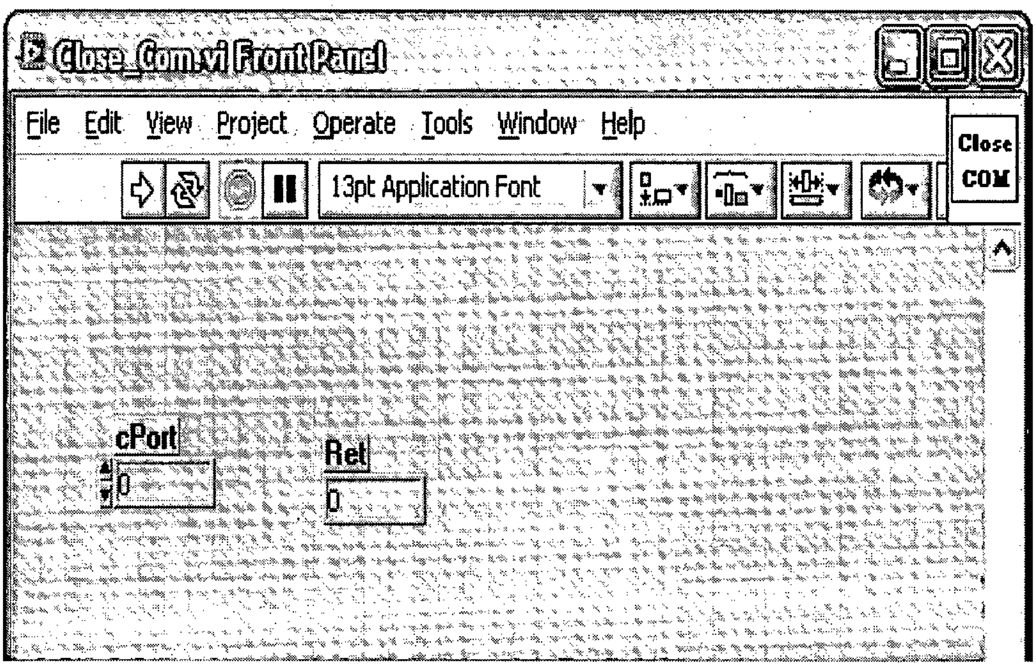


Fig. 5.9: Close_Com [27]

Input Parameter:

cPort: 1=COM1, 2=COM2, …., 255=COM255

Return Value: No Error= OK, others= Error refers to I7000.H

5.2.3 Send_Receive_Cmd

This DLL will send command string to RS 485 Network and receive the response result from RS 485 Network. If wCheckSum=1, this DLL will automatically add two checksum bytes to the command string and check the check sum status of the receiving string. This DLL will add the [0x0D] to the end of the command string , szCmd. The Send_Receive_Cmd is not a multi-task DLL.

Syntax- Send_Receive_Cmd (char cPort, char szCmd[], char szResult[], WORD wTimeOut, WORD wCheckSum, WORD *wt)

Input Parameter:

cPort: 1=COM1, 2=COM2, …., 255=COM255

szCmd: the string address of the input string (terminated with 0)

szResult: the string address of the result string

wTimeOut: constant for time out control , unit=1 ms

wCheckSum: 0=DISABLE, 1= ENABLE

wT: time of send/receive interval, unit= 1 ms

Return Value: No Error= OK, others= Error refers to I7000.H .

5.2.4 AnalogIn

Read the analog input value from 7000 series modules.

Figureure 5.10 shows AnalogIn. VI's front panel

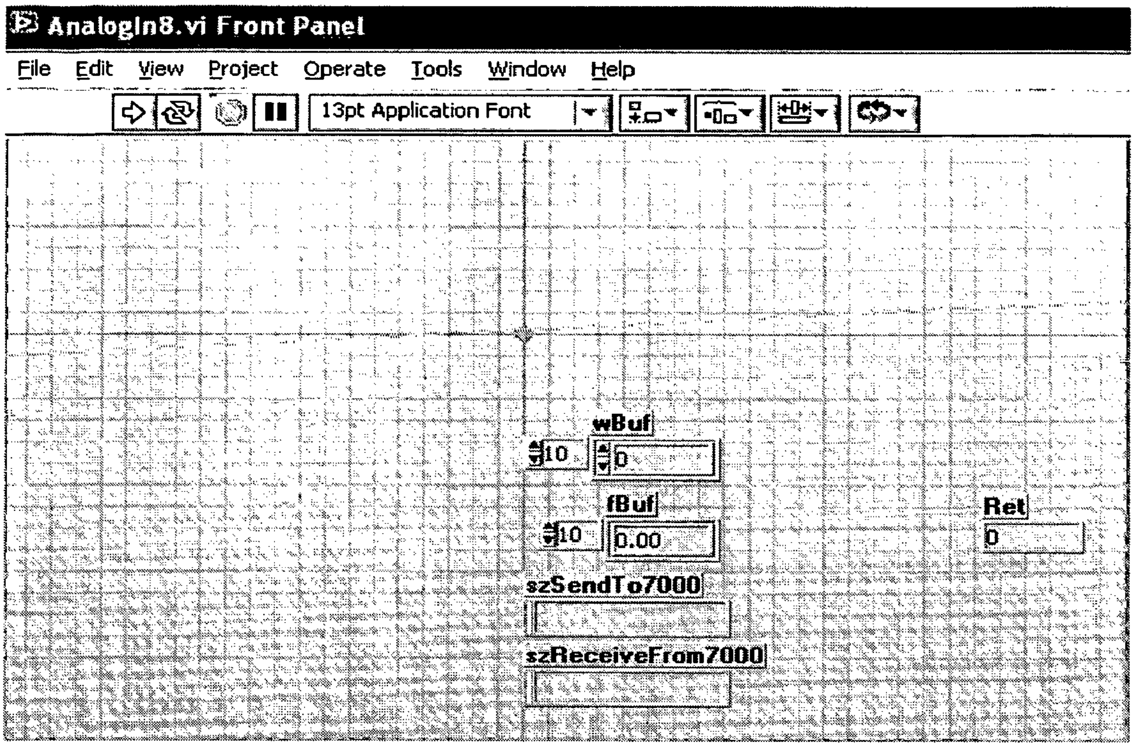


Fig. 5.10: AnalogIn vi's [27]

Syntax- AnlogIn (WORD w7000[], float f7000[], char szsendTo7000[], char szReceiveFrom7000[])

Input Parameter:

w7000: WORD Input/Output argument table

f7000: float Input/Output argument table

szSendTo7000: command string sends to 7000 series modules.

szReceiveFrom7000: result string reads form 7000 series modules.

Return Value: No Error= OK, others= Error refers to I7000.H

5.2.5 CounterIn_7080

Obtain the value of the selected counter in module I-7080.

Syntax- CounterIn_7080 (WORD wBuf[], float fBuf[], char szsend[], char szReceive[])

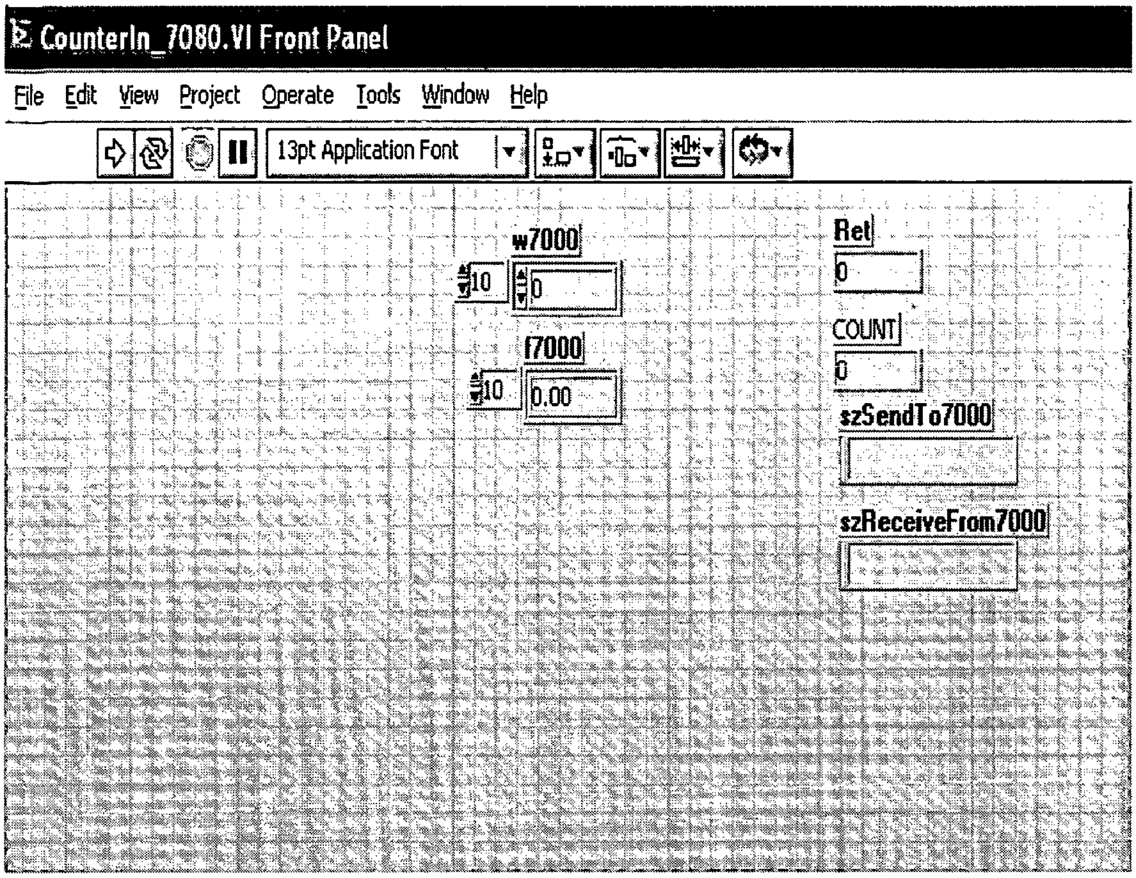


Fig. 5.11: CounterIn_7080 vi's

Figure 5.11 shows CounterIn_7080.VI's. [27]

Input Parameter:

wBuf: WORD Input/Output argument table

fBuf: float Input/Output argument table

szSend: command string sends to 7000 series modules.

szReceive: result string reads form 7000 series modules.

Return Value: No Error= OK, others= Error refers to I7000.H

Figure 512. shows "Call Library Function Node" example with assigned input and output variables connected

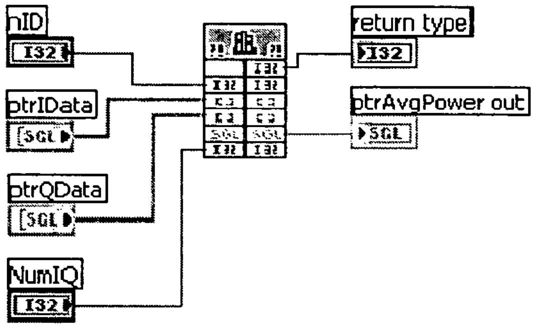


Fig. 5.12"Call Library Function Node" example with assigned input and output variables connected

Figure5.13 . showsCall Library Function Node configuration window

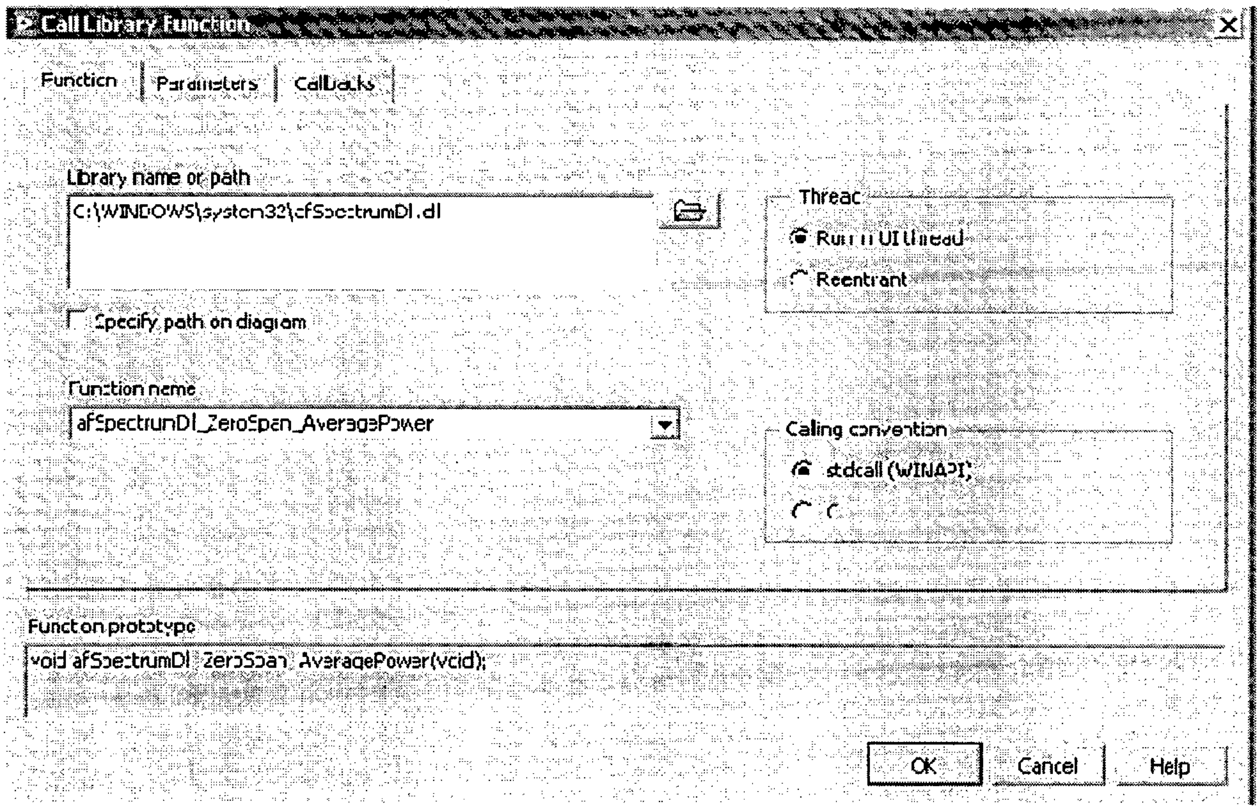


Fig. 5.13 . Call Library Function Node configuration window [27]

5.3 CONFIGUREURING THE DAQ MODULUS USING LABVIEW

In order to acquire data from different I-7000 series modules the drivers of the particular module have to be called into the LabVIEW program. Drivers are nothing but sub VI's in Labview which can be accessed by popping up "select a VI" option in the block diagram. The subVI's are present in a *.llb file such as UART.llb, I7000.llb, and I7080.llb.

5.3.1 ConFigureuring Analog Input module (7019R):

w7000[0]: RS-232 port number ,1/2/3/4

w7000[1]: module address, from 0x00 to 0xFF

w7000[2]: module ID, 7019

w7000[3]: 0=checksum disable, 1=checksum enable

w7000[4]: Timeout constant, normal=100

w7000[5]: channel number (0-3)

w7000[6]: 0: no save to szSendTo7000&szRecieveFrom7000

1: szSendTo7000=Command string send to 7000

szRecieveFrom7000=result string receive from 7000

The module is addressed 1 with module ID 7019, all the input channels data can now be called into the Labview program. [24]

5.3.2 ConFigureuring Frequency/Counter module (7080D):

w7000[0]: RS-232 port number ,1/2/3/4

w7000[1]: module address, from 0x00 to 0xFF

w7000[2]: module ID, 7080

w7000[3]: 0=checksum disable, 1=checksum enable

w7000[4]: Timeout constant, normal=100

w7000[5]: 0: to read 7080's counter 0

1: to read 7080's counter 1

w7000[6]: 0: no save to szSendTo7000&szRecieveFrom7000

1: szSendTo7000=Command string send to 7000

szRecieveFrom7000=result string receive from 7000

w7000[7]: high word of counter value

w7000[8]: low word of counter value

The module is addressed 2 and module ID 7080, the channel 0 is configured for frequency measurement in non-isolated mode using DCON utility. [24]

5.4 MODULES CONNECTIONS

According to requirements modules can be connected. Here two 7019R & one 7080 module are connected for all parameters. Here total parameters are sixteen i.e. V1,V2,V3,I1,I2,I3, kW, KVA, KVAr, pf, f,% of gate valve opening, P,Q, rpm, T, efficiency, noise & power angle. If we connect all modules at a same time it is unable to found out all modules at same time. So connect second after connecting first module. Figure5.14 shows DCON Utility software for searching condition.

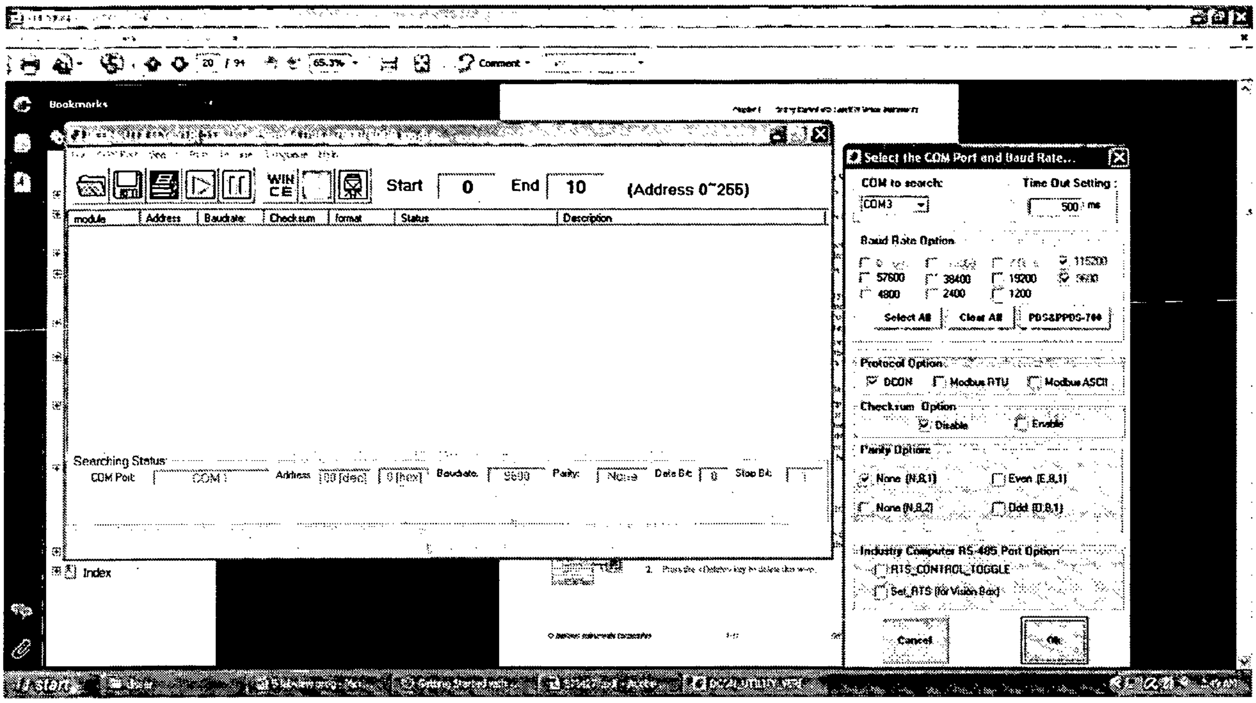


Fig 5.14 Screen when DCON is searching for modules

Figure 5.15, Figure 5.16 is block diagram of entire experiment setup. Here one channel of non isolated node of 7080 is used; four channels are used of second 7019R module out of eight channels and lastly all eight channels are used in the first module. 7080 is a frequency counter module calculated rpm of turbine. 7019R (left from one) is used for temp, pressure, % of gate valve opening, discharge measurement. Another 7019R is connected with all eight electrical parameters such as V1, V2, V3, I1, I2, I3, kW, frequency respectively. [25]

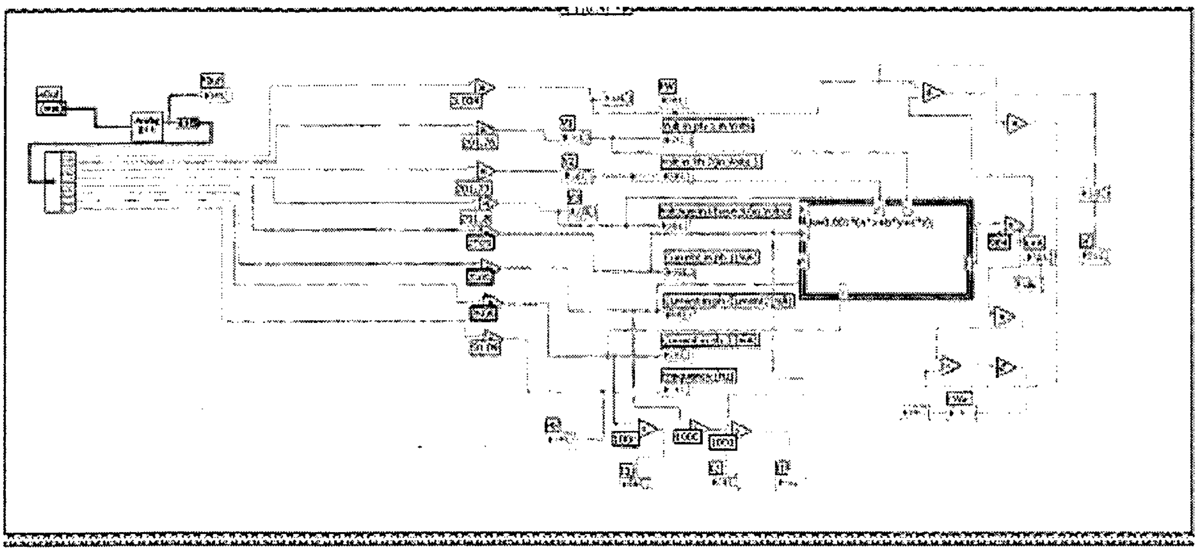


Fig. 5.15 LabView block diagram for front panel of module 1

After develop library function such as Open_Com, Close_Com, Analog IN 8, COUNTER IN 7080 VI's save them into user library. These VI's or UART.dll files are also supplied by the manufacturer. The front panel of VI's contains wBuf, wBuf 2, w 7000 it should be filled by serial port number, address of modules, module ID, no parity bit, as well as stop bits [25].

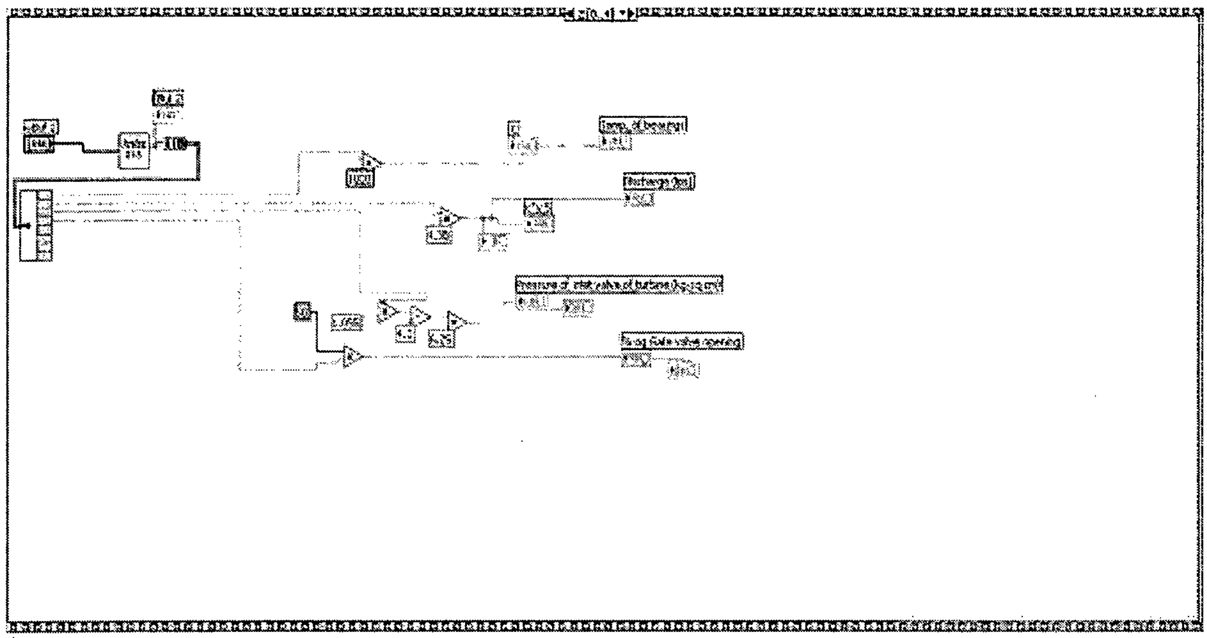


Fig. 5.16 LabView block diagram for front panel of module 2

Now final Display will be as shown in Figure 5.17 when system is not in running mode

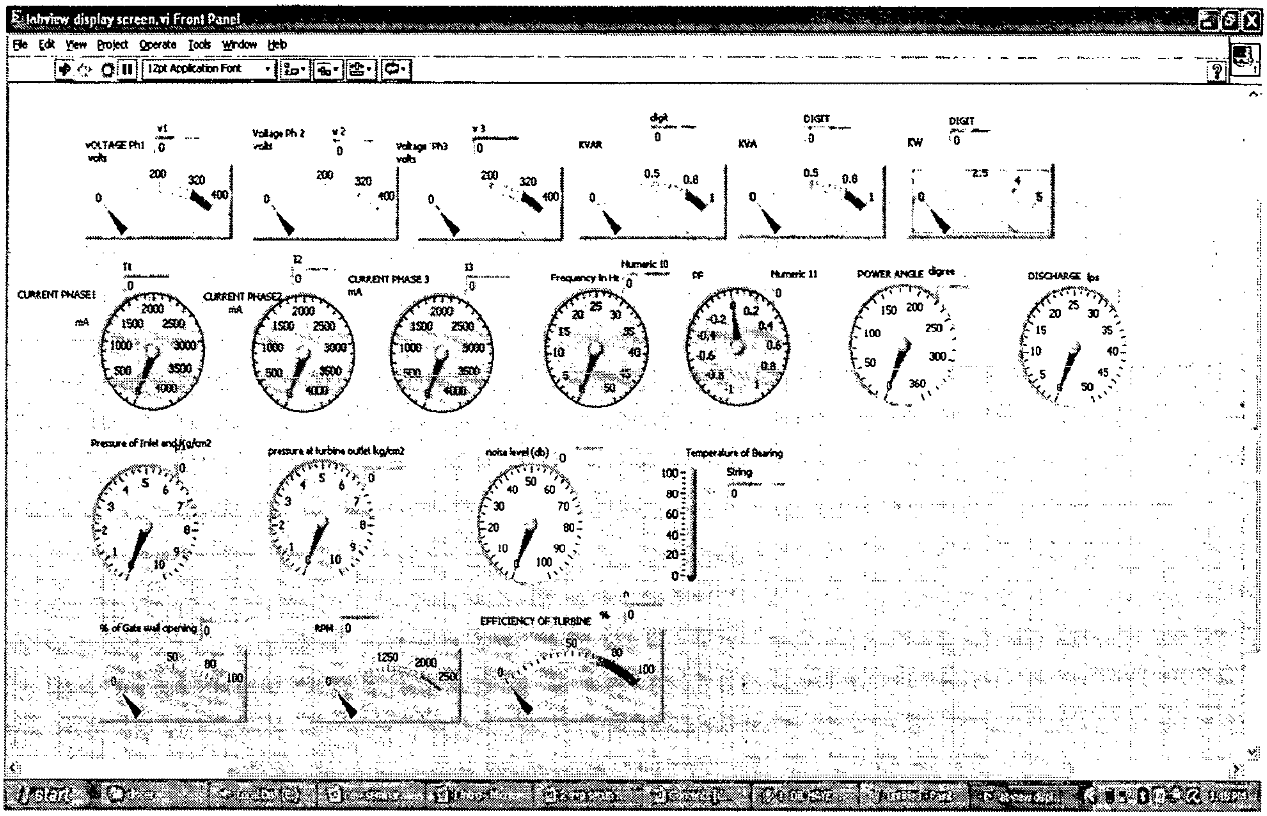


Fig. 5.17 Final display screen

5.5 CONNECTION OF LabVIEW TO INTERNET

connectivity of radio modem apparatus, time consuming for experimenting, even we can't There are several ways for wireless monitoring. Two best way of monitoring either by traditional transmitter and receiver system or connect to internet. Connect to internet is the best method because, reduce cost of apparatus, unreliable get result after trying long effort with transreceiver system. LabVIEW program can be connected through internet. There are few more steps to connect internet.

Select the VI program, next select web publishing tool from tool menu. This tool allows modifying the look of the document in the web browser. Title, Header, and Footer text and the previewing the document in web browser, then click save to disk. This is saved to the .html file to the www directory. Name and save the file then click ok. This will bring up another window giving the URL name of the document for putting in the web browser.[14]

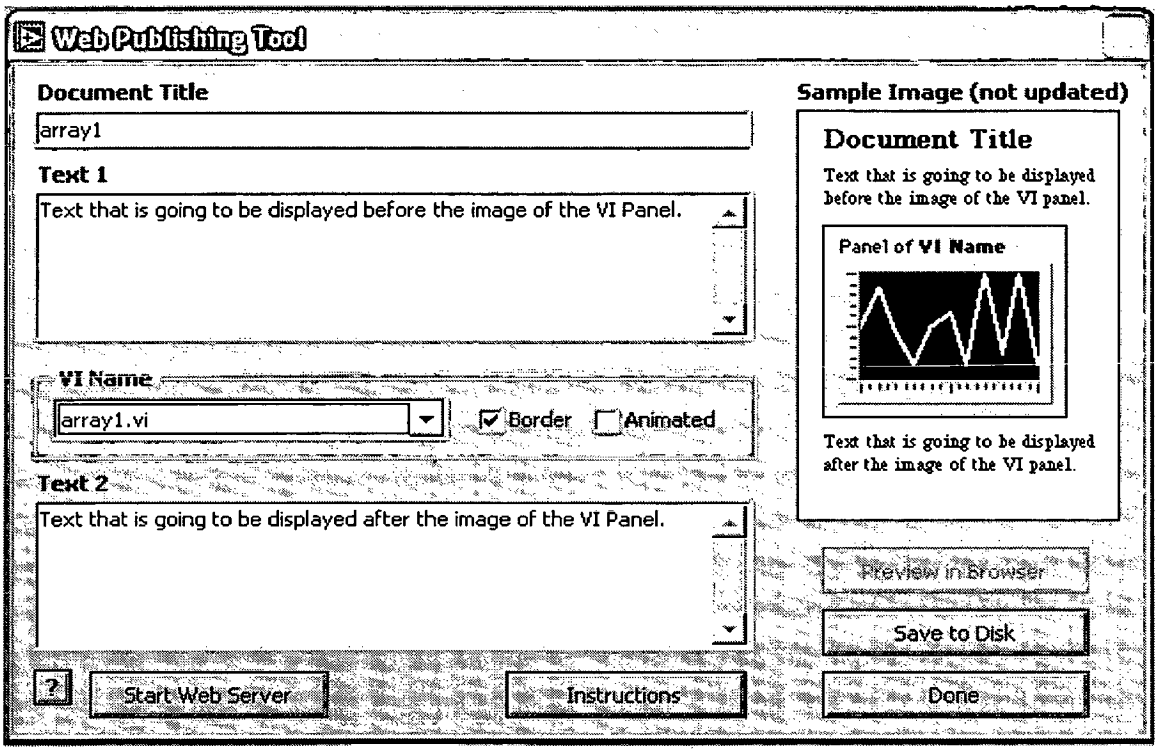


Fig. 5.18: Web publishing tool window[13]

The continuous update is possible in the advanced version of LabVIEW. It is continuous update after every few seconds

It is also possible to run program from a remote PC only required LabVIEW with LabVIEW runtime engine of same version. Runtime engine should be installed in the client PC. It is possible to see window form anywhere by the help of internet. Figure 5.16 is the web polishing tools window .

CHAPTER 6
DATA DISPLAY & RESULTS

6.1 DATA DISPLAY

In this dissertation work the whole experiment is being done for monitoring of different parameters and results are verified through measured reading on meter and monitored reading on Computer & after that we have to calculate the difference between both the readings to analyze experiment data. In ideal condition the value of data on meter (true value) and the value of data on computer (Monitored value) should be same. There are very little deviations in the readings in this experiment results. [9]

In this experiment we measure various parameters as voltages and current in all three phases, Power output, Apparent power, Reactive power, Power factor, power angle, Frequency, Speed, Discharge, %of gate valve opening, Temperature, pressure at inlet of turbine , pressure at outlet of turbine , Efficiency of the Turbine & Noise Level in the experiment lab .

These parameters sre classified as follows

6.1.1 Electrical Parameters

6.1.1.1 Parameters Directly measured by sensors & monitored on display screen (FRONT PANEL)

i. Phase Voltages
ii. Phase Currents
iii. Active Power (kW)
iv. Reactive Power(KVAR)
v. Power factor
vi. KVA Rating
vii. Frequency

6.1.1.2 Parameter manipulated by basic sensed parameters

i. Power Angel

6.1.2 Non Electrical Parameters

6.1.2.1 Parameters Directly measured by sensors & monitored on display screen (FRONT PANEL)

i. Pressure at inlet of Turbine
ii. Pressure at outlet of Turbine
iii. Discharge
iv. Turbine Bearing Temperature
v. Speed in rpm
vi. Noise level in Experiment Lab

6.1.2.2 Parameter manipulated by basic sensed parameters

i. Efficiency of Turbine

This experiment contains results, which we obtained from measuring instruments and monitored values on PC. LabView8.6 is used for monitoring purpose. It has functions so that we can take output in desired form. It contains Dials, Graphs etc. to display the parameters. LabView is programmed to sense change in parameters every second and according to that display on the screen. The screen contains block diagram for each parameter measurement, which can be seen, after stop the program, it shows the virtual form of cable connection and the values of data at each stage of transfer.

Fig 6.1 shows the display screen designed in LabView. Here we use meter for voltage and power monitoring, guage for current, frequency and power factor monitoring, thermometer for temperature monitoring, again meter display for speed and %of gate valve opening. These can be changed and there range also can be modified through LabView programming [27].

Fig. 6.1 and 6.2 shows the display when system is not running, here all the values are on zero value.

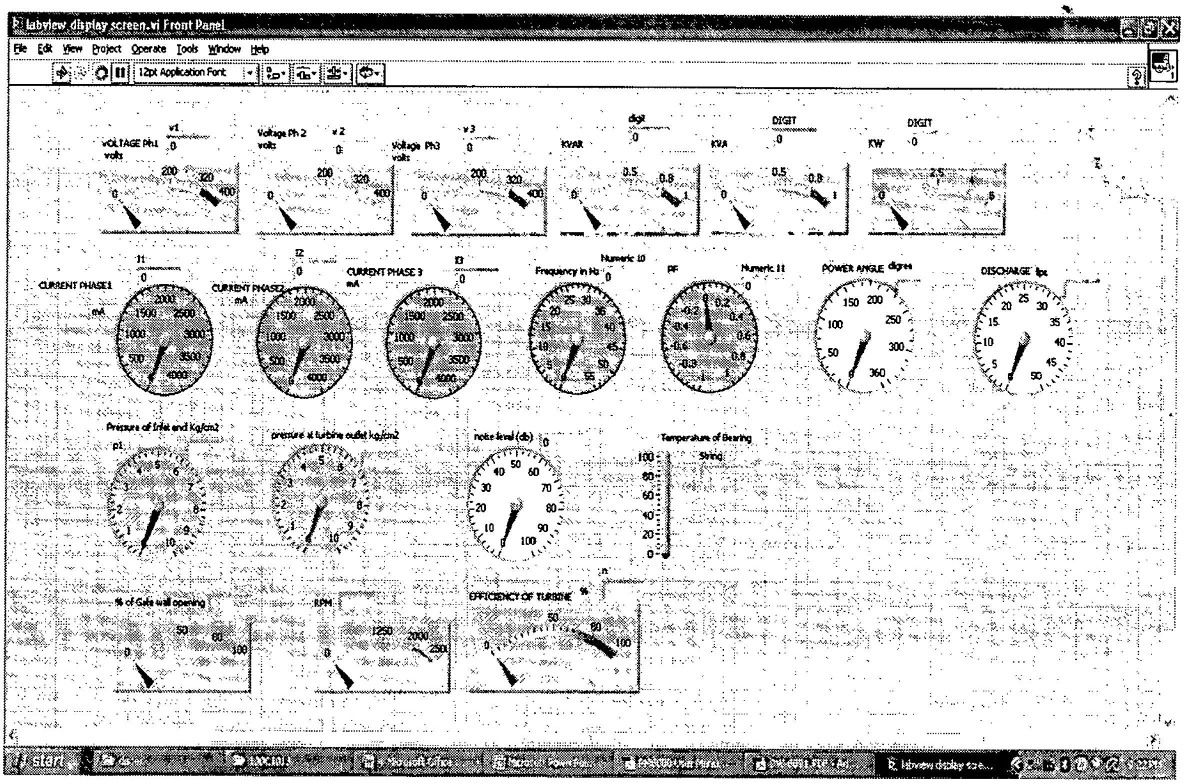


Fig. 6.1: Front panel before starting the program

Fig. 6.2: System before software program

Fig 6.3 and 6.4 shows the screen, when system is in continuous running mode and the parameters are changing their values.

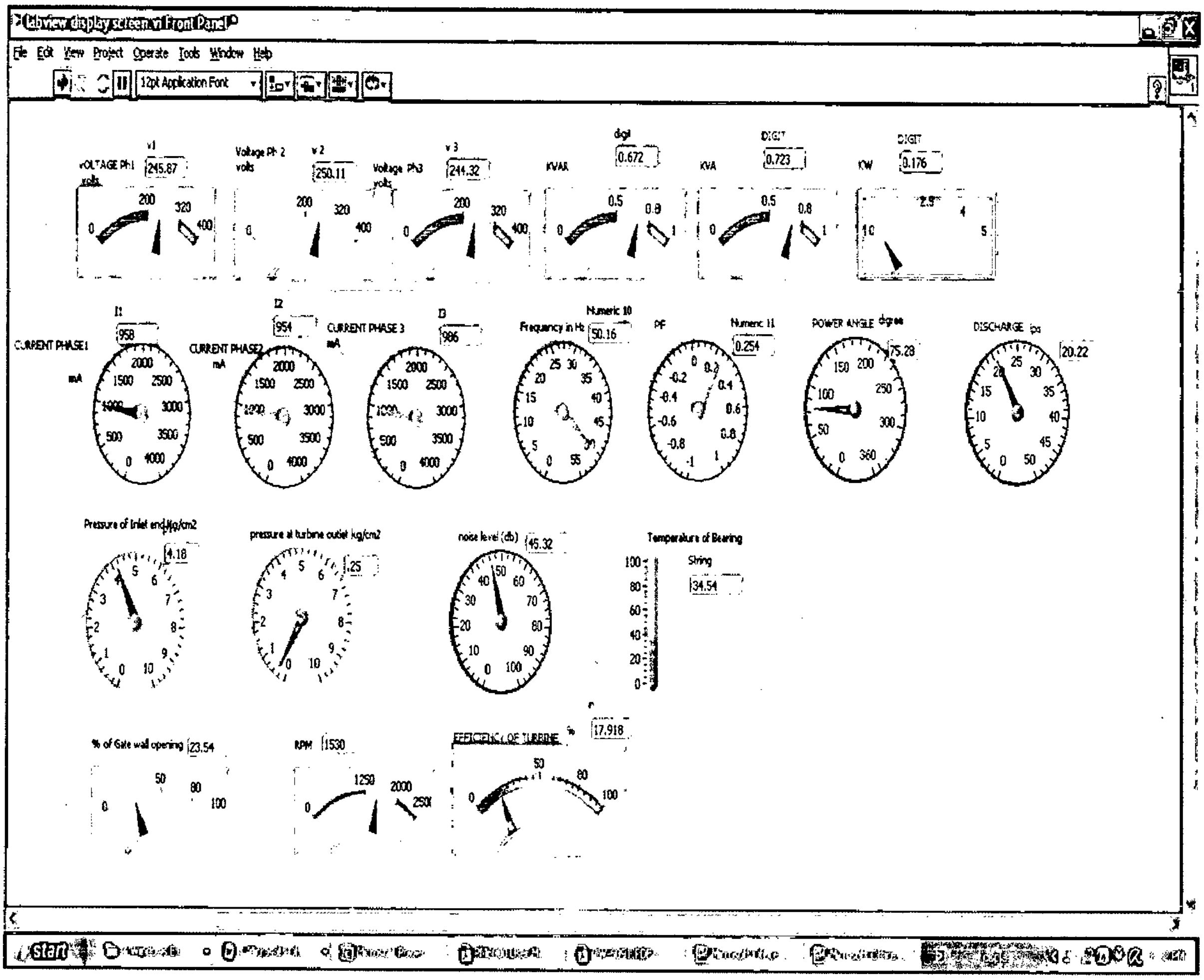


Fig 6.3: Screen after few minutes of the starting System

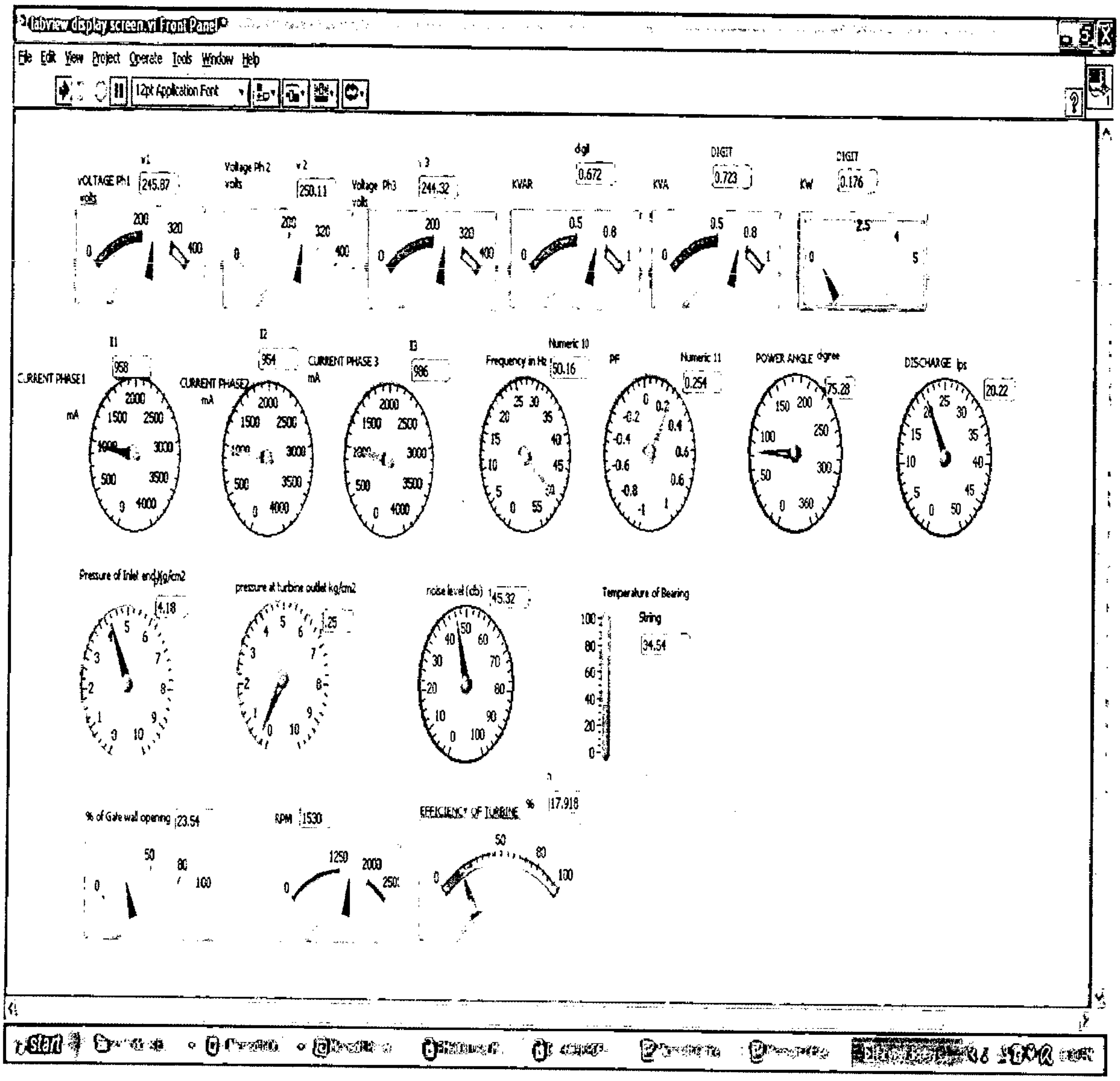


Fig 6.4 system shown in running modeafter some time.

So it is easily seen that change of readings in this monitoring screen is flexile in nature and display is according to parameter value change.

We can also monitor it on any remote desktop as well as laptop which is connected with internet, it is also called remote or online monitoring. The front panel of this program can be seen on the computer screen which is connected through internet facility.

So monitoring can be done at far away place from power plant as shown in fig 6.5, fig6.6 & fig6.7

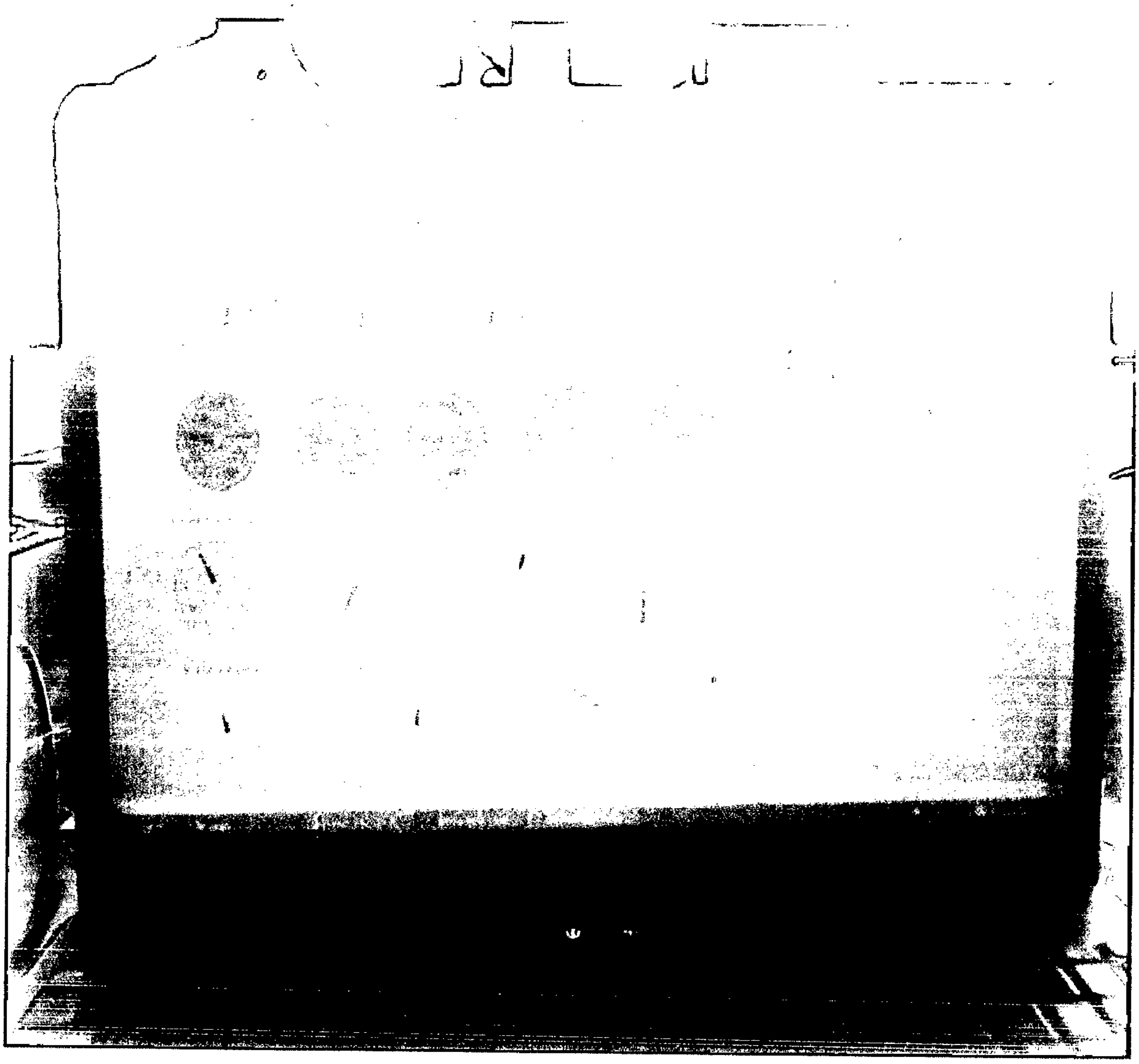


Figure 6.5 Remote monitoring on Laptop under on position of turbine and generator

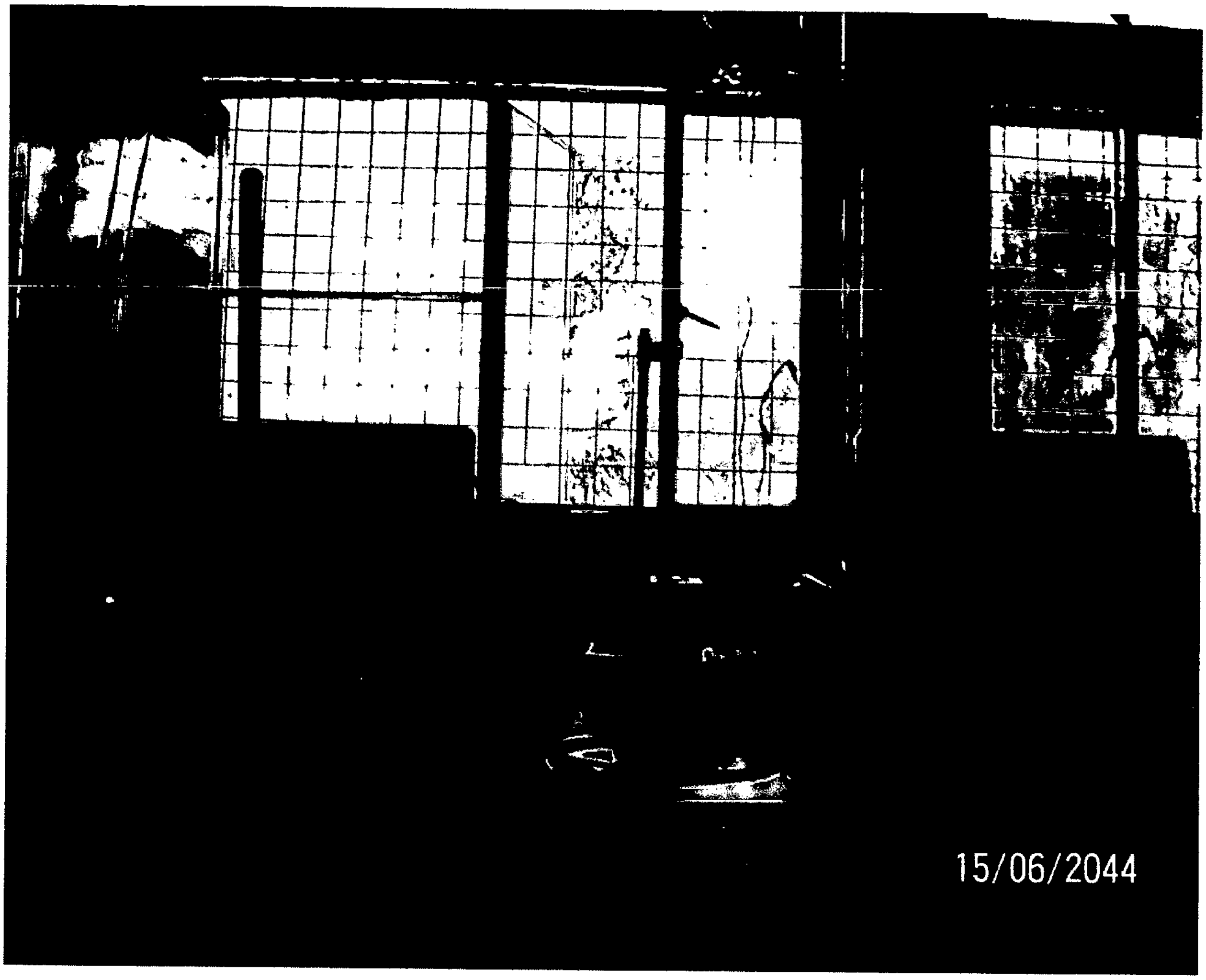


Figure 6.6 Remote monitoring on laptop under running position of turbine and generator

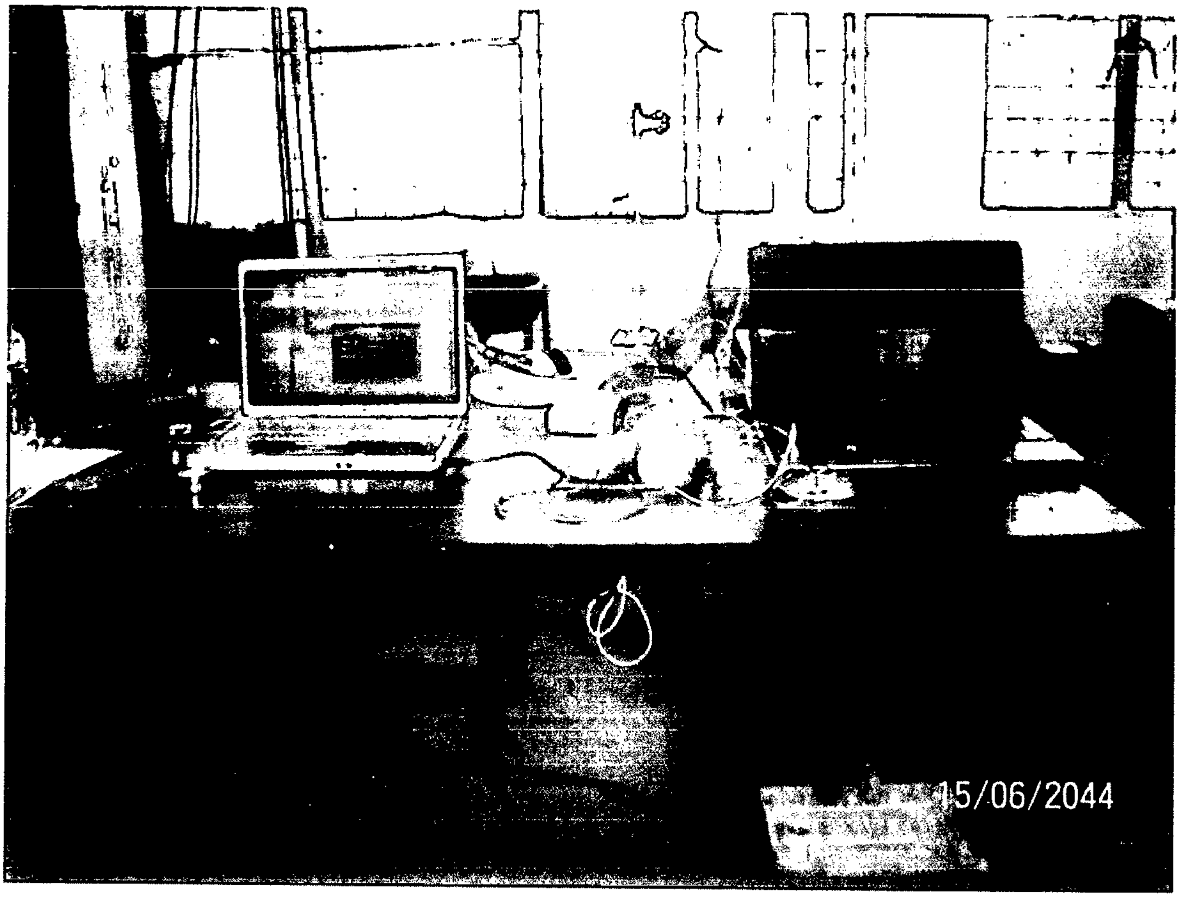


Figure 6.7 Monitoring on PC situated in laboratory

6.2 RESULTS AND DISCUSSIONS

In this section it is shown that readings of all parameters on the meter are almost matched with the monitored readings of this system. The secondary parameters that are desired from one or more primary parameters are almost equal and have very low % of error. The errors are produced due to transducers output raw voltage, current not being in pure ac forms or only root means square form. Formula for measuring electrical parameters according to instruments software system is shown in the table supplied by the manufacturer.

Here V,A are line voltage and current and v,a are phase values.

*values are average values.

Other non electrical parameters such as discharge, temperature of bearings, pressure of inlet valve also have different desired transducer output. The table 6.2 indicates the meter readings and Monitored readings on computer of electrical parameters.

6.2.1 Calibration of parameters

The following tables 6.1,6.2 & 6.3 shows the readings of electrical and non-electrical parameters with readings shown in meter and monitored readings.

Here T.R. - Measured on Meter (True Reading)

M.R. - Displayed on PC (Monitored Reading)

Table 6.1 Voltage and Current readings

S.No.	V1 (Phase-1) In volts		V2(Phase-2) In volts		V3(Phase-3) In volts		I1(Phase-1) In mA		I2(Phase-2) In mA		I3(Phase-3 In mA	
	T.R.	M.R.	T.R.	M.R.	T.R.	M.R.	T.R.	M.R.	T.R.	M.R.	T.R.	M.
1	250	250.9	252.3	251.8	252.1	251.3	968	987	965	979	987	9
2	222.4	227.7	242.9	243.2	239.3	238.9	986	978	969	962	957	9
3	238.3	223.1	222.3	220.3	224.2	221.2	2563	2568	2678	2572	2635	25
4	249.1	232.3	232.3	231.9	232.8	232.5	3654	3651	3623	3629	3627	36
5	241.1	241	239.8	239.6	242.2	241.8	776	778	785	782	745	7

Table 6.2: Others electrical parameter readings

S.No.	kW		KVA		KVAr		Power Factor		1 Frequency	
	T.R.	M.R.	T.R.	M.R.	T.R.	M.R.	T.R.	M.R	T.R	M.R
1	0.179	0.178	0.734	0.742	0.711	0.718	0.247	0.239	50.63	50.8
2	0.799	0.795	1.422	1.419	1.171	1.160	0.553	0.567	49.53	49.7
3	1.185	1.168	1.752	1.721	1.294	1.268	0.674	0.677	52.03	52.1
4	2.291	2.536	2.532	2.818	1.088	1.211	0.903	0.902	49.86	49.9
5	0.417	0.416	0.555	0.554	0.366	0.365	0.752	0.752	51.53	51.5

Table 6.3: Others non electrical parameter readings

S.No.	Pressure(kg/cm^2)		Discharge (m^3/sec)		Speed(rpm)		Temperature(°C)		%of gate valve opening	
	T.R	M.R.	T.R	M.R.	T.R.	M.R.	T.R.	M.R.	T.R.	M.R.
1	4.02	4.12	0.0205	0.0203	1520	1521	35.8	35.4	20	18.76
2	4.03	3.95	0.0211	0.0213	1492	1491	40	39.8	50	15.43
3	4.01	3.91	0.0215	0.0218	1561	1563	41	40.5	80	23.46
4	3.72	3.71	0.0217	0.0217	1496	1499	43	42.5	75	21.06
5	3.92	3.86	0.0225	0.023	1546	1545	36	36.3	25	12.37

Table 6.1, 6.2 and 6.3 shows the parameters and their values when monitored on PC. There is some difference in the readings which is analyzed further.

6.2.2 Comparison of all parameters (T.R and M.R)

Above table shows the difference between true reading and monitored reading, now for calibration of results, here following graphs are shown deviation of readings in experiment. This is a comparison between true readings on meter and monitored values on PC

Here T.R. - Measured on Meter (True Reading)

M.R. - Displayed on PC (Monitored Reading)

Figure 6.8 shows Deviation between readings of voltage (Phase-1)

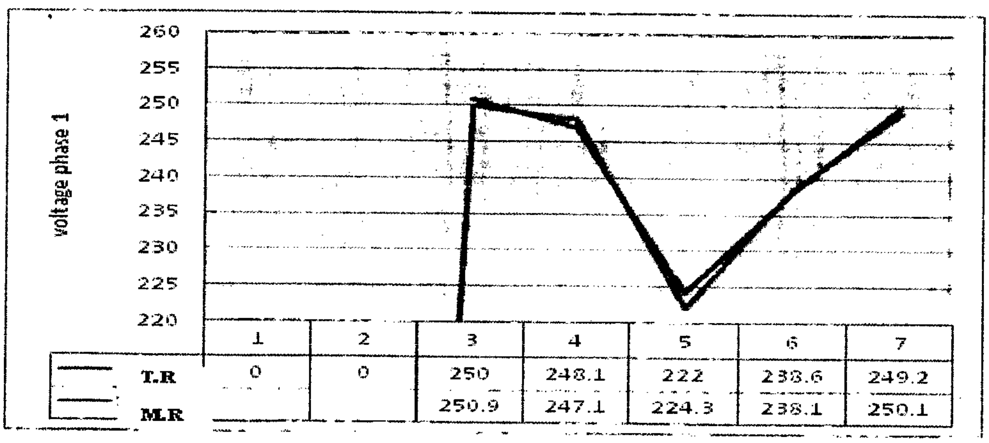
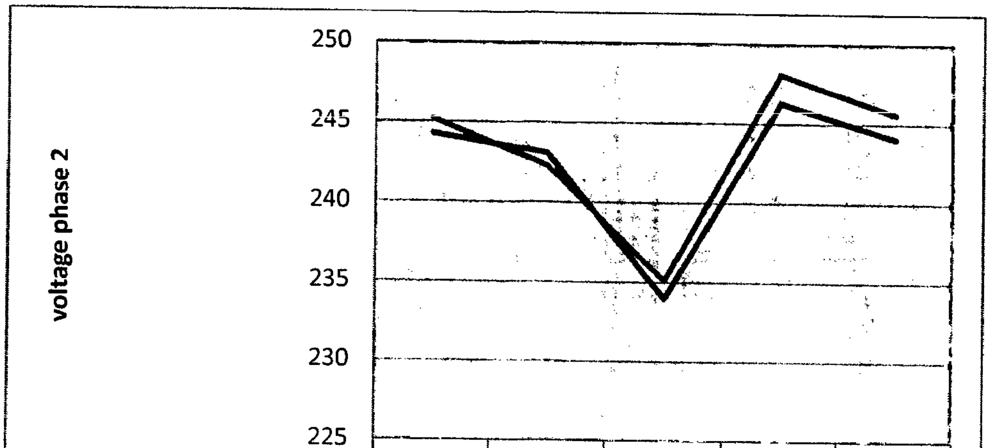


Fig. 6.8 Deviation between readings of voltage (Phase-1)

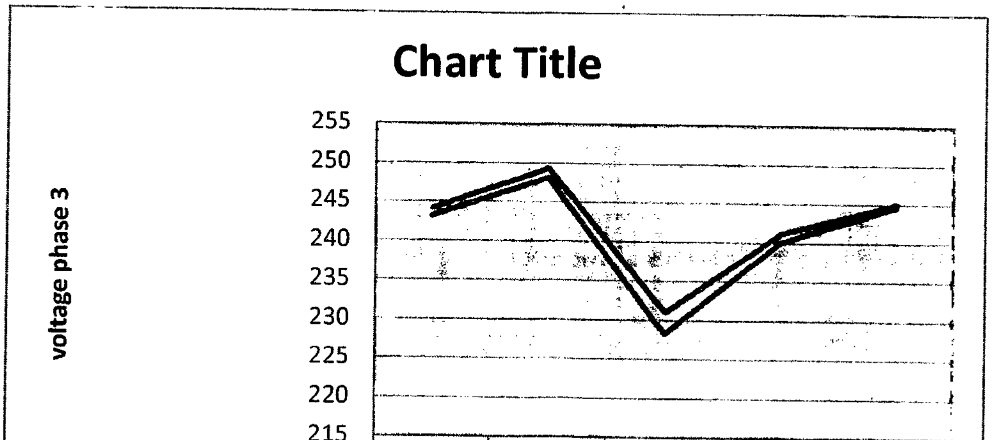
Figure 6.9 shows Deviation between readings of voltage (Phase-2)



	1	2	3	4	5
V2 (Phase-2) volts T.R	245.2	242.3	235.1	248.1	245.6
V2 (Phase-2) volts M.R	244.3	243.1	234	246.3	244.1

Fig. 6.9 Deviation between readings of voltage (Phase-2)

Figure 6.10 shows Deviation between readings of voltage (Phase-1)



	1	2	3	4	5
V3 (Phase-3) volts T.R	244.1	249.3	231	241.2	245
V3 (Phase-3) volts M.R	243.2	248.1	228.3	240.1	244.7

Fig. 6.10 Deviation between readings of voltage (Phase-3)

Fig 6.11, 6.12 and 6.13 shows the deviation in readings of Current (Phase-1, Phase-2,Phase-3) true values vs. monitored values

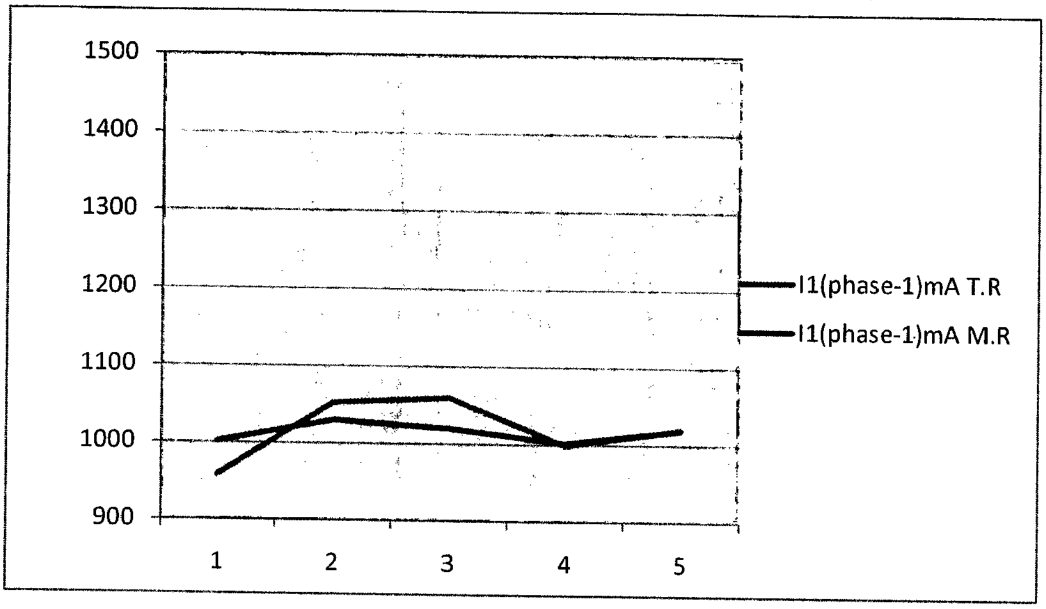


Fig. 6.11 Deviation between readings of Current (Phase-1)

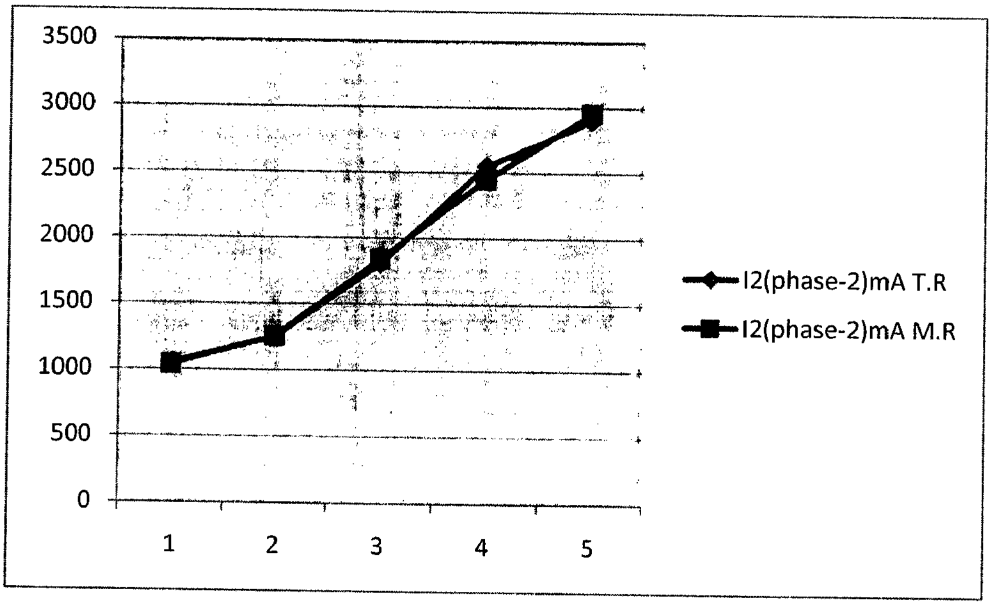


Fig. 6.12 Deviation between readings of Current (Phase-2)

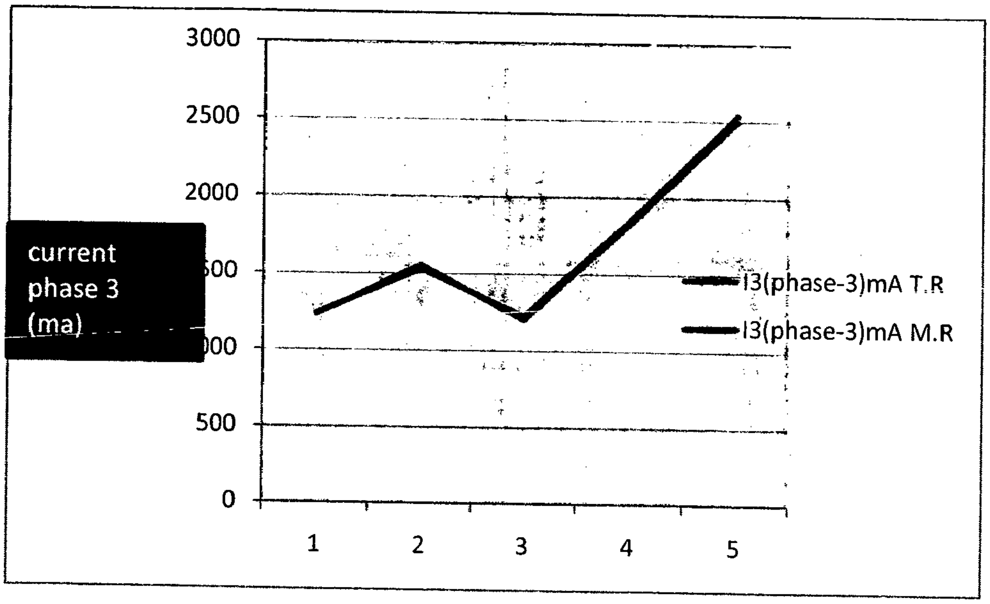


Fig. 6.13 Deviation between readings of Current (Phase-3)

Fig 6.14, 6.15 and 6.16 shows the deviation in readings of power output , Apprent Power & Reactive Power Current true values vs. monitored values.

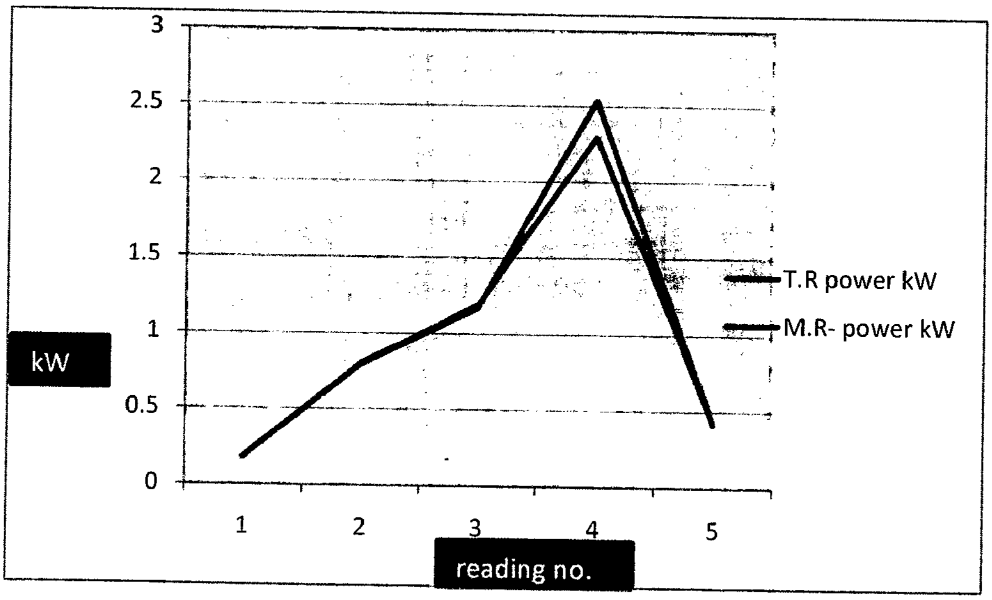


Fig. 6.14 Deviation between readings of Power Output

Fig 6.14 shows the deviation in readings of power output, it can be seen that the difference between both the readings is minor.

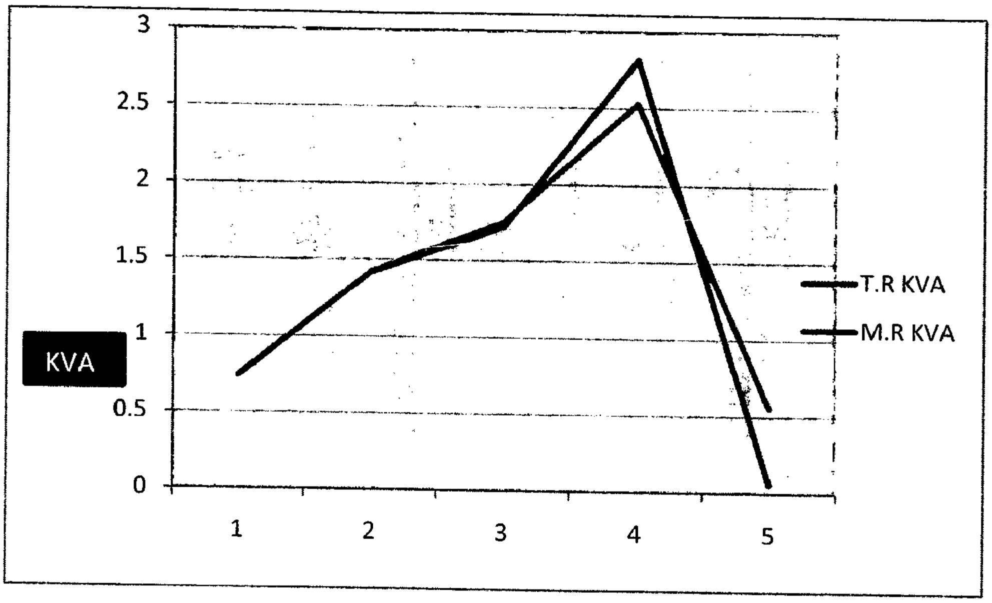


Figure 6.15 Deviation between readings of apparent power

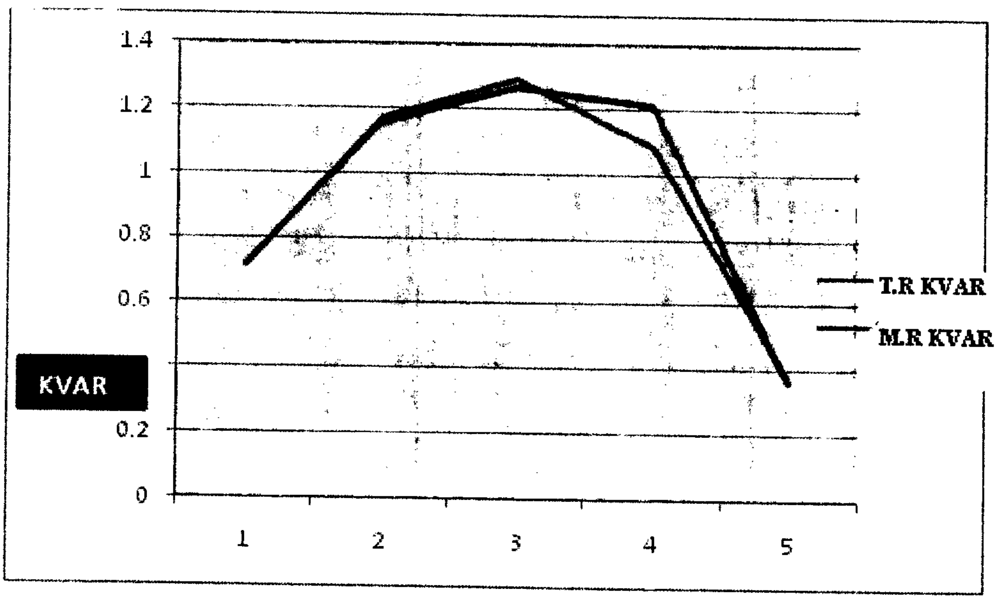


Fig. 6.16 shows the Deviation between the readings of reactive power

Fig 6.17, 6.18 ,6.19 ,6.20 ,6.21,6.22 and 6.23 shows the deviation in readings of power Factor, Frequency, Pressure, Discharge ,Turbine Speed, Turbine Bearing Temperature & % gate opening Apprent Power true values vs. monitored values.

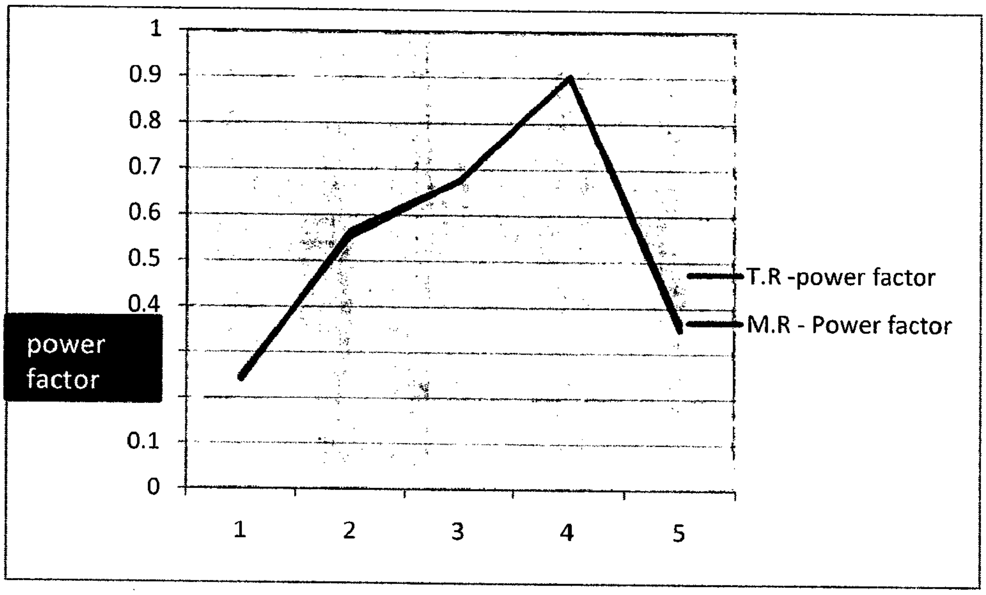


Figure 6.17 Deviation between the readings of power factor

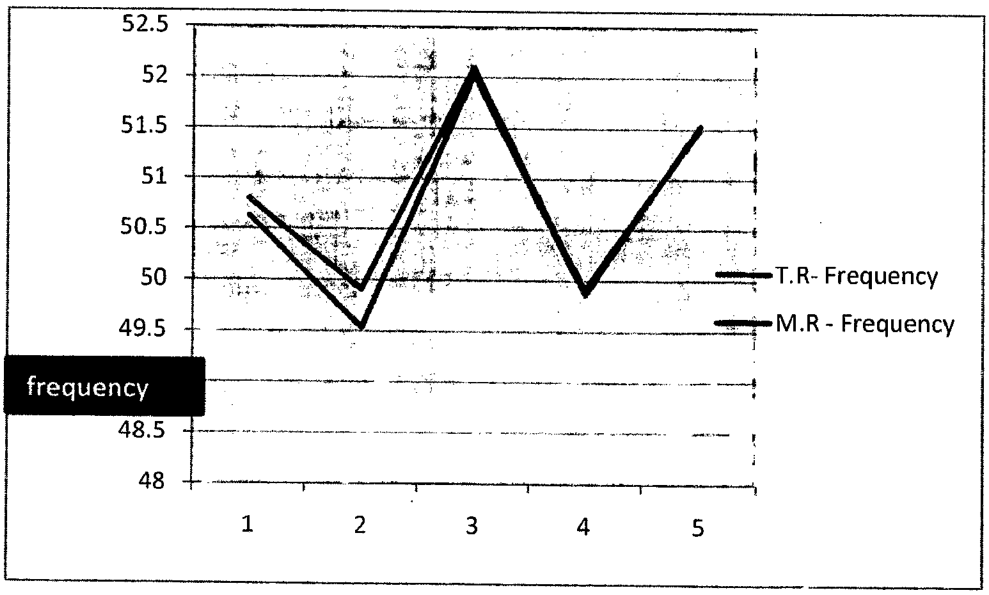


Figure 6.18 Deviation between the readings of frequency

Fig 6.19 shows the deviation in the readings of pressure and fig. 6.20 shows the deviation in the readings of discharge

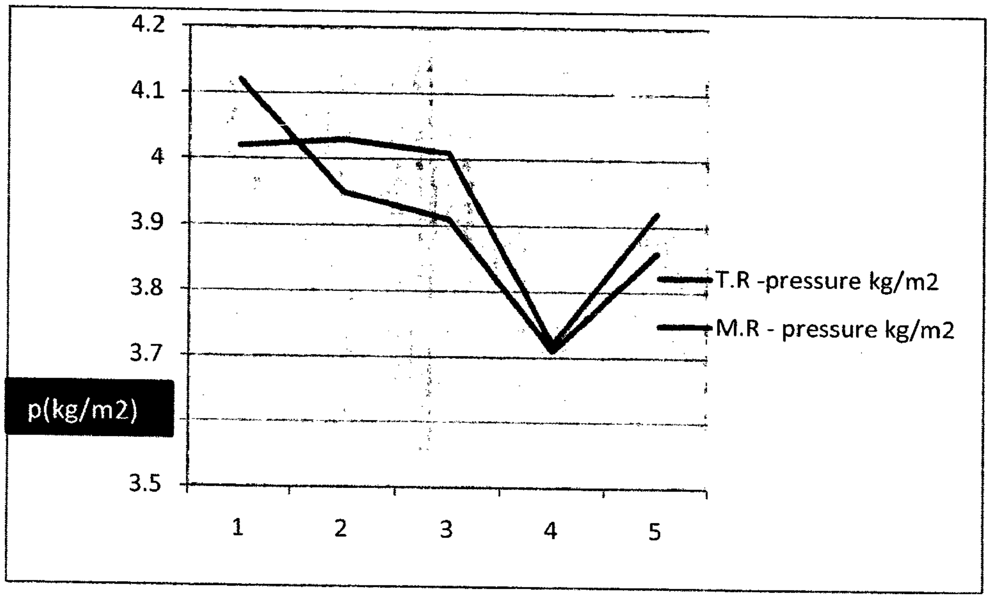


Figure 6.19 Deviation between readings of pressure

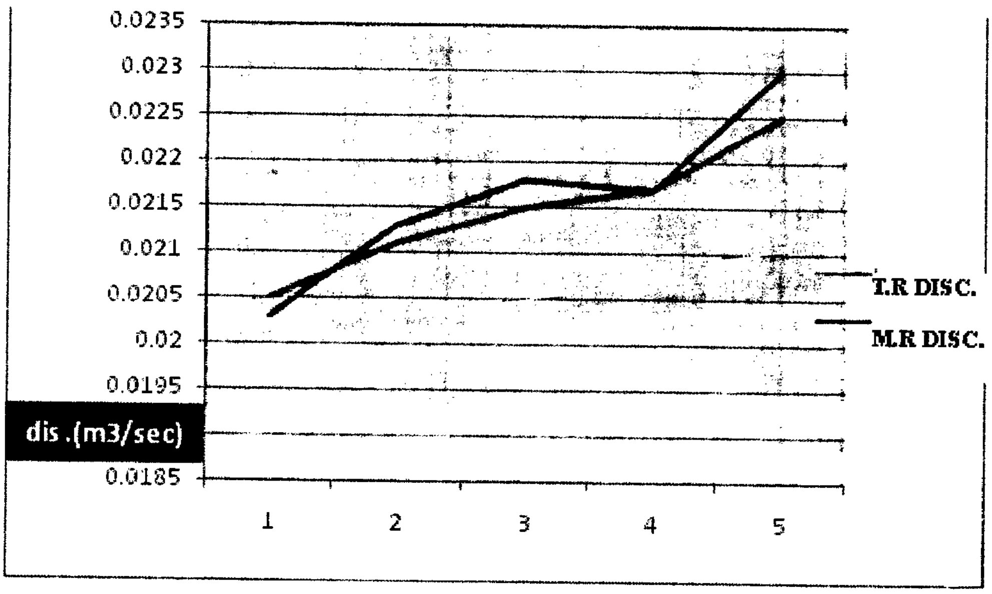


Figure 6.20 Deviation between readings of discharge

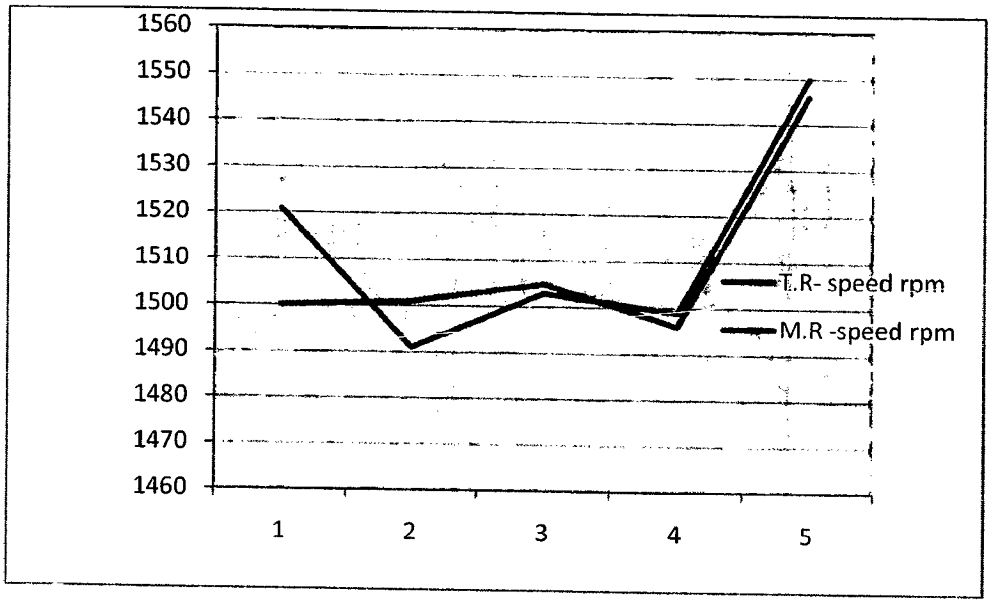


Fig6.21 deviation between turbine speed

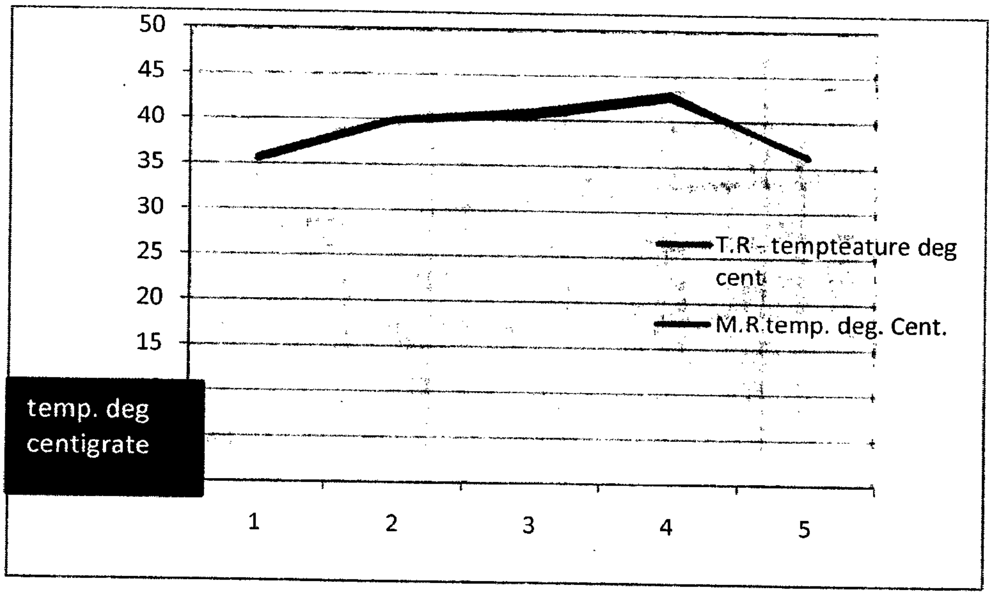


Figure 6.22 Deviation between readings Temperature

Fig 6.22 shows the Deviation between readings Temperature

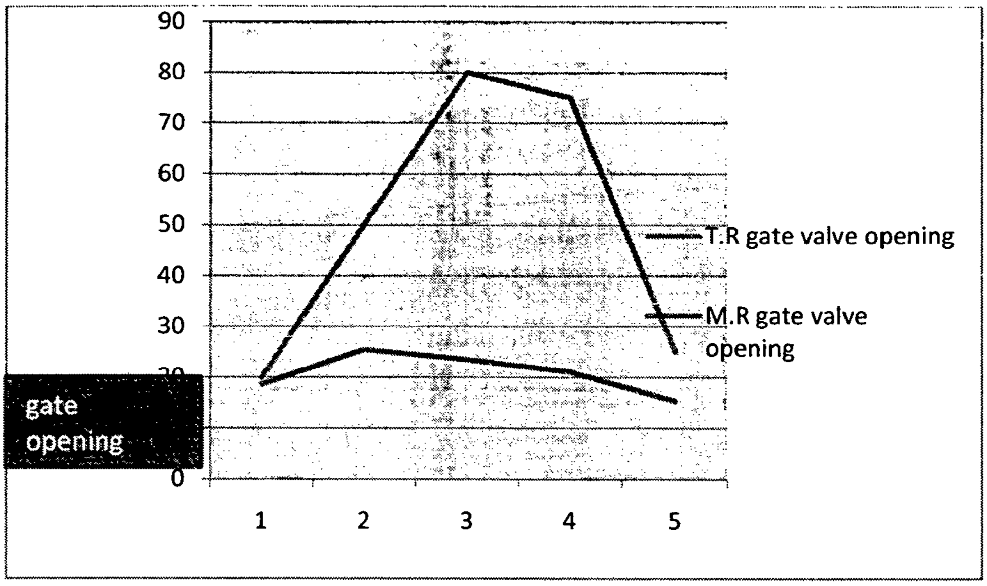


Fig. 6.23 deviation between % gate opening reading

Now With all these deviation manipulated in graphs we have calculated the % of error in the monitored reading with the equation 6.1

% of error = (T.R.- M.R)./T.R. x 100 (6.1)

For all sample readings we calculated the %of error and took its average as shown in table 6.4

Table 6.4 %of error between true value and monitored values.

S.No.	Parameter	%of error
1	V1	0.36
2	V2	0.33
3	V3	0.12
4	I1	1.11
5	I2	1.40
6	I3	0.56
7	kW	3.11
8	KVA	2.87
9	KVAR	2.09
10	pf	0.78
11	Freq	0.11
12	P	1.23
13	Q	0.31
14	Temp.	1.02
15	Speed	0.25

% of error of all parameters is shown below in Fig. 6.22

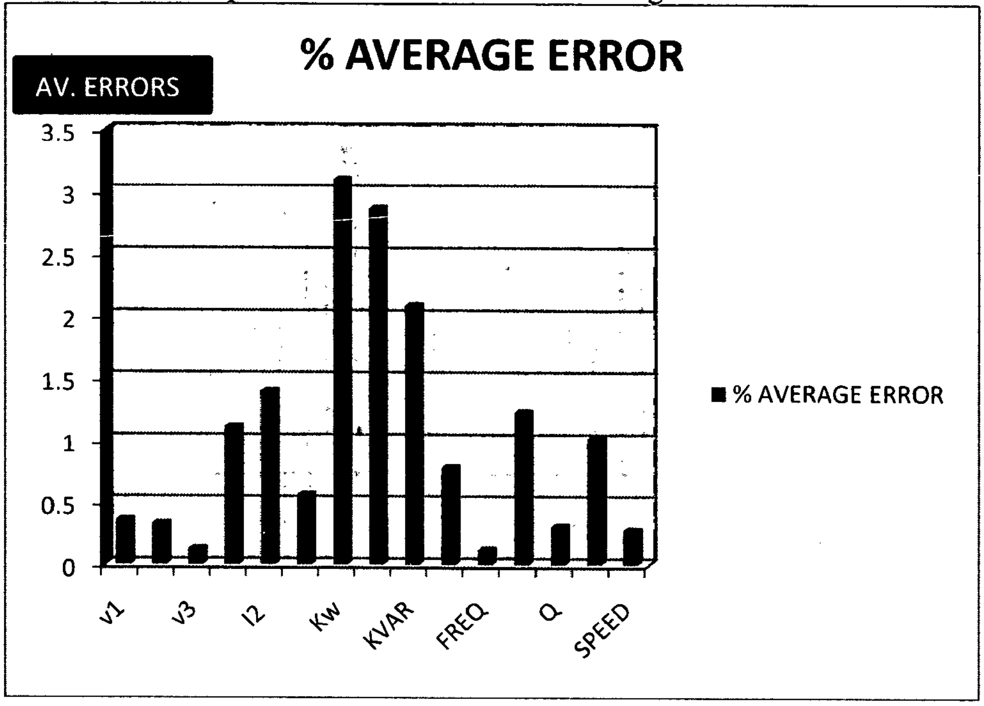


Fig. 6.24 %of error between true value and monitored values

6.2.3 Measurement & Monitoring of Noise level in Power House:

noise level is also measured in the Turbine –Generator set-up with the help of Sound Analyser & monitored value varies between 50 to 60 db

6.2.4 Analyzing parameters

6.2.4.1 Efficiency : The efficiency of the system has been calculated on the bases of measured parameters. All the parameters are measured by meters as well as monitored, by taking their analog outputs, we use equation 6.2 for power output and equation 6.3 for efficiency calculation.

$$P=9.81QH \qquad (6.2)$$

$$\text{Efficiency } (\eta) = \text{kilowatt}/\ (9.81QH) \qquad (6.3)$$

Where, Q= Discharge (m^3/sec)

H= (10000/density of water=approx 10) x pressure

Here table shows the calculated efficiency of the system.

Here we calculated the efficiency manually but with the same manipulation in LabVIEW programming Block Diagram we have measure the readings of Efficiency directly on Front Panel of LabVIEW on the PC.

Value on LabVIEW window is vary between 14.5 to 18.5.

Table 6.5 Calculation of Turbine efficiency

S.No.	Discharge(m^3/s)	Pressure(kg/cm^2)	Head(m)	9.81QH	Power output (kW)	Efficienc
1	0.0205	4.02	40.2	8.0861	0.7817	9.61
2	0.0211	4.01	39.5	8.379	0.7983	9.52
3	0.0215	3.87	39.1	8.1244	1.1822	14.55
4	0.0217	3.74	37.4	7.96	2.2912	27.78
5	0.0221	3.63	38.6	7.86	0.4177	5.31

As shown in table the efficiency is very low because the Turbine generator setup used in our experimentis Pump as Turbine which has generally very low efficiency & also due to high head losses efficiency of turbine calculated is very low . So, Table 6.5 shows the values of power output and efficiency of the system,the highest efficiency calculated foe the system is 19.78%

The efficiency is very less because in our experimental setup pump is used as turbine (PAT) , which has generally low efficiency.

6.2.3.2 Power Angle:

Power angle can also be manipulated with the help of power factor which is directly sensed by Power Analyser & power angle calculated by the formulae

Θ =cos-1(power Factor)

And also Monitered on the screen.

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

In this Dissertation work Development of a cost effective & Reliable system for Remote SHP stations the cost effectiveness is the main issue for this monitoring system because of remote SHP stations are less profitable business so spent of more money on monitoring system is not feasible A monitoring system is developed using remote data acquisition modules and LabVIEW software. This system is designed for simultaneous monitoring of all the parameters, in the form of virtual instrumentation, which is unique feature of LabView8.6 .

In this experiment work the following parameters of Remote Small hydropower station unit are monitored

(a) Electrical parameters such as Voltages, Current of all the three phases as well as all other parameters such as power generation (kW), KVA, KVAr, frequency and power factor, Power Angle .

(b) Non electrical parameters such as of speed of turbine, discharge, inlet head, outlet head ,temperature of bearings and gate valve position, Noise Level in Power House & Efficiency of Turbine.

All these parameters can be monitored directly on computer or remote monitoring through internet connection. Efficiency of the system is also calculated using these parameters.

This monitoring system can be useful for monitoring a hydropower plant from remote location.

7.2 FUTURE WORK

1. More parameters of Hydro power Stations like Level sensing in Forebay tank can also be monitored with the Data acquisition Modules with range more than 100m by using the same system developed
2. This can be made further effective by making a provision for monitoring electrical faults or abnormalities. This can be done using a digital input module with necessary hardware to take the status of different protective relays from their contacts.

3. Continuous monitoring of water Level in the Dam can also be done by making small changes in the same system & by using the wireless modules .

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