Design and Development of a Miniature Hydraulic Power Unit

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Course Title: Project & Thesis

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Chapter –1

Introduction

Overview

Energy is required now more than ever due to population growth, industrialization and modernization. Challenges such as carbon dioxide (CO_2) emissions and depletion of conventional source of energy necessitate for renewable sources, of which hydro energy seems to be the most predictable. Micro-hydro which is hydro energy in a “small” scale provides electricity to small communities by converting hydro energy into electrical energy. This paper is an overview of micro-hydro system by reviewing some of its basic components such as turbine and generator that make this conversion process possible. Estimating micro-hydro energy potential which is a function of Head and Flow rate, planning, advantages and its limitation will also be reviewed to provide the basic knowledge of micro-hydro system.

Worldwide, hydro is an important source of sustainable power supply and its role is expected to increase, especially in developing countries. As a result, IFC commissioned this guide to enhance understanding of the complete project development cycle, from inception to commissioning and operation. The guide explains each step of the project development process, including common challenges that must be addressed to ensure a successful project. The guide is intended for use by key stakeholders who are involved in hydropower project (HPP) planning, evaluation (appraisal) or monitoring. The guide aims to provide a comprehensive overview of all stages of hydropower development, and highlight hydropower’s unique characteristics compared with other power generation options. The guide describes a range of sizes and designs for hydropower facilities, and offers guidance on key issues during site selection, plant design, permitting/licensing, financing, contracting and commissioning. Some key issues are hydrology, social and environmental context, permits and licensing, political risk, off-taker creditworthiness, currency fluctuations, and power sector sustainability, among others. The guide covers all types and sizes of HPPs—run-of-river, storage, and pumped storage—and micro to large. Although the guide includes substantial technical information, it is intended as a reference for a non-technical audience. Sources for additional information are included. Throughout the guide, project case studies are used to illustrate specific situations encountered in hydropower project.

Energy is the most fundamental sector for the progress of a nation [1]. It is inevitable for survival and indispensable for developmental activities to promote education, health, transportation and infrastructure for attaining a reasonable standard of living and is also a critical factor for economic development and employment [2]. Urbanization, economic development, industrialization and rapid increase in population growth have raised the demand for power generation manifolds [3]. As the human population and activities are progressively developing, it is most certain that the demand for energy worldwide is increasing as well, and this trend is most likely to continue in the future [4]. For meeting the expected energy demand as the population will rise and to sustain economic growth, alternative form of energy such as renewable energy needs to be expanded [5]. Hydro power energy is one of the most clean renewable sources of energy [3]. Water power can be harnessed in many ways; tidal flows can be utilized to produce power by building a barrage across an estuary and releasing water in a controlled manner through a turbine; large dams hold water which can be used to provide large quantities of electricity; wave power is also harnessed in various ways [6]. Hydropower on a small scale, or micro-hydro, is one of the most cost-effective energy technologies to be considered for rural electrification in less developed countries [7]. Micro Hydropower (from hydro meaning water and micro meaning small scale) refers to electrical energy that comes from the force of moving water used to power a household or small village [6, 8]. Micro hydro systems can be regarded as a renewable energy source resulting from the natural hydrological cycle, it is by some considered sustainable due to the lack of impoundment of water and assumed negligible environmental impact [9]. The technology was initially used in Himalayan villages in the form of water wheels to provide motive power to run devices like grinders [10]. Hydropower has various degrees of _smallness‘. To date there is still no internationally agreed definition of _small ‘hydro [6, 10-12]. Table 1 shows the classification of hydropower system base on the generated power output.

Project Figure:

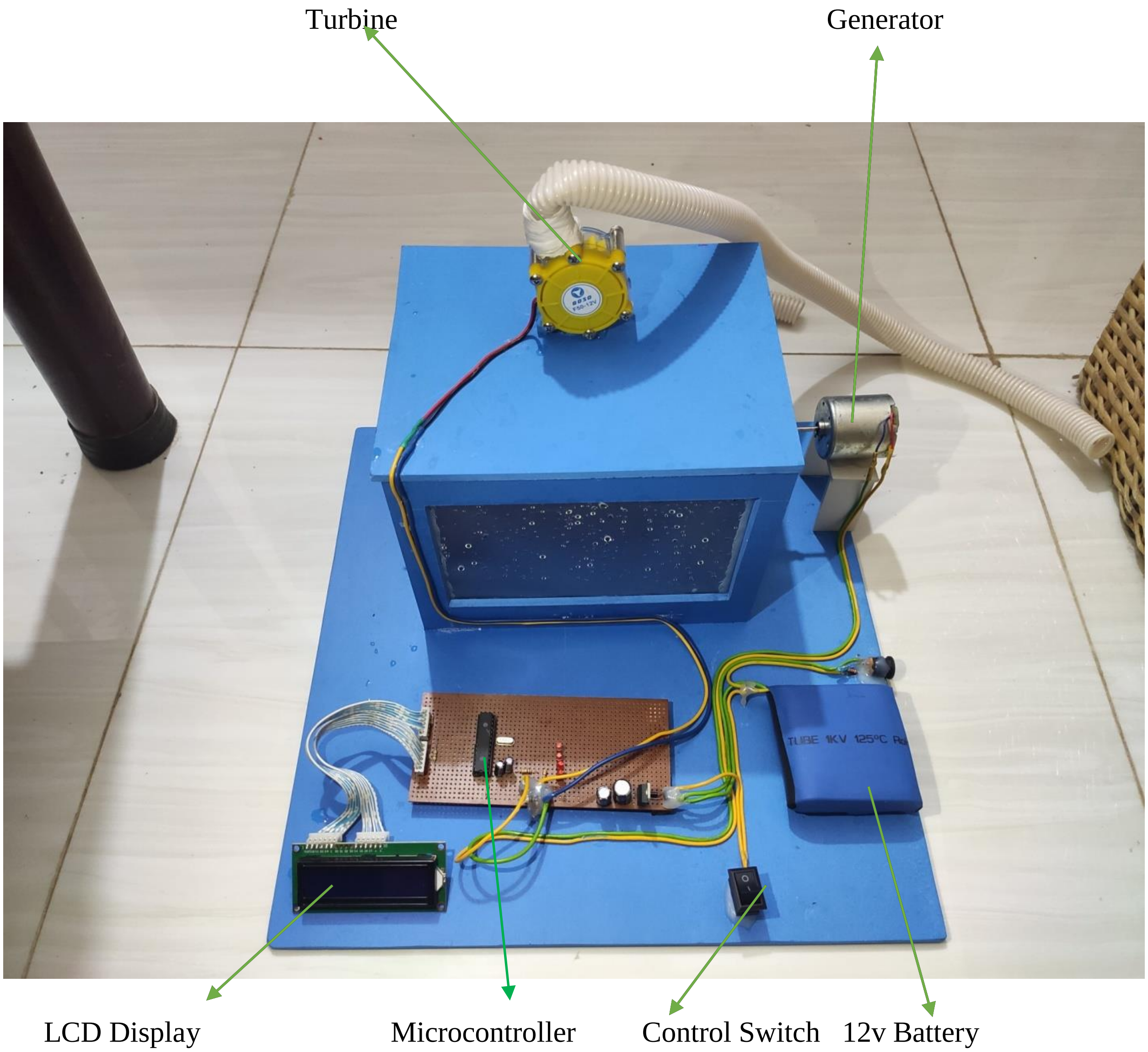

Fig: 1.1Miniature Hydraulic Power Unit

Objective

The main objective of our project given bellow,

- To Built a mini hydro power plant
- To Learn about how to generate electricity from water
- To Learn about microcontroller programming.
- To Generate low cost electricity.

1.3.Methodology:

1. First the requirements of the project were carefully analyzed to design the mini hydroelectric power plant system.

2. The methodology of this project design can be divided into two sections; hardware and software implementations.

3. Information's were collected from references books and websites to find out the possible improvement.

4. Required components have been purchased from local market.

5. Start built mechanical part of our system. Then

6. Write program for our project.

Chapter-2

Literature Review

ISO Standard 4409 [13] Defines the necessary measurements, symbols, measurement accuracy and suggested tests for pumps and motors.

2. ISO Standard 8426 [15] Presents a method of determining the actual displacement of a pump or motor during a test. For a certain displacement set point, several pressure measurements are used to extrapolate a line whose intercept is the actual displacement

3. Srinivas R et al., [16] -A hydraulic system is a group of hydraulic elements arranged in an order and using these hydraulic element powers is transmitted using a confined liquid i.e. Oil. Hydraulic power units are drive system for hydraulic machines

4. Sridharakeshava K. B. et. al., [14] has discussed about the General Requirements of a Fixture which includes constraints of Deterministic location, contained deflection, geometric constraint in order to maintain the work piece stability during a machining process. They also discussed three broad stages of fixture design, Stage one deals with information gathering and analysis, Stage two involves product analysis, and Stage three involves design of fixture elements

05. Johnson et al [17] Presents a model of the torque on the swash plate of variable displacement axial piston pumps. It does not include any information on efficiency. This is an example of a model which explains the behavior of the internal parts of a P/M, but does not directly address performance and efficiency

Chapter-3

Hardware Implementation

3.1 Impulse turbine

Impulse turbines, which have the least complex design, are most commonly used for high head microhydro systems [21]. They generally use the velocity of the water to move the runner and discharges to atmospheric pressure [22]. These turbines are more efficient for site with high head and low flow. High head hydro generally provides the most cost effective projects, since the higher the head, the lesser the water required for a given amount of power, so smaller and hence less costly equipment is needed [7]. Water is driven into the pipeline at forebay. This pipeline leads the water to a nozzle, where the kinetic energy of the water is used to push or impulse the blades coupled to the alternator. The most common types of impulse turbines include the Pelton turbine (figure 1) and the Turgo turbine [21].

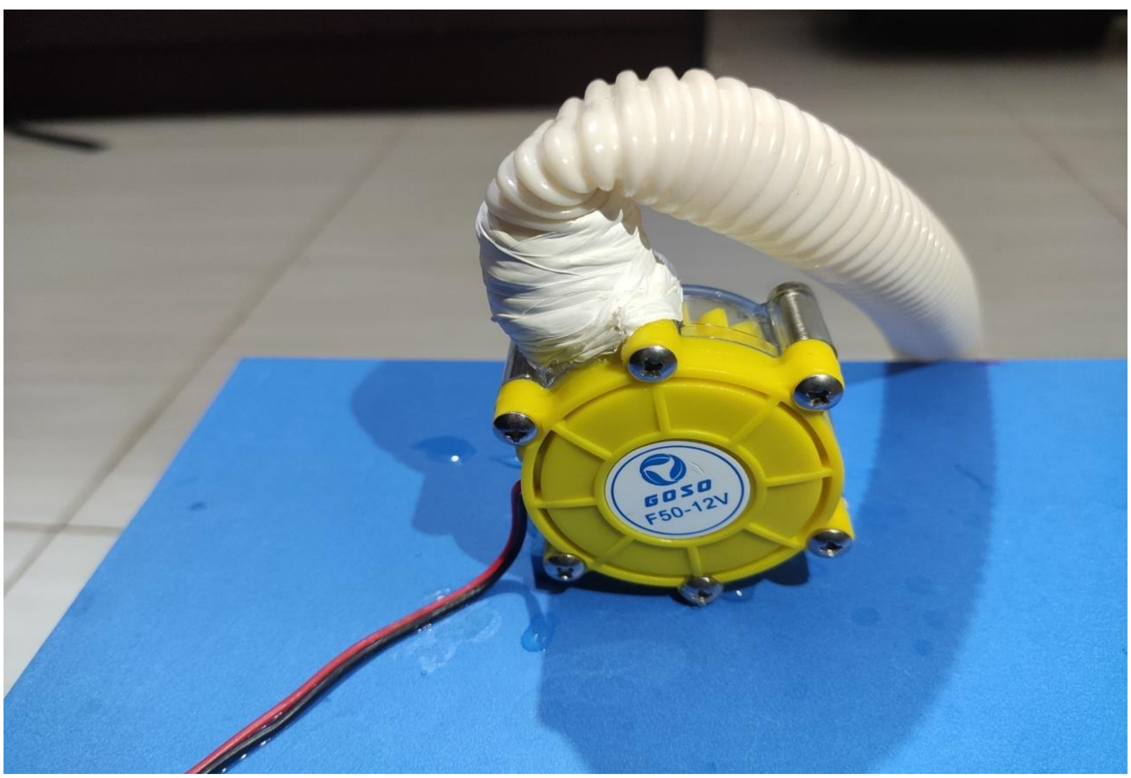

Fig: 3.1Turbine

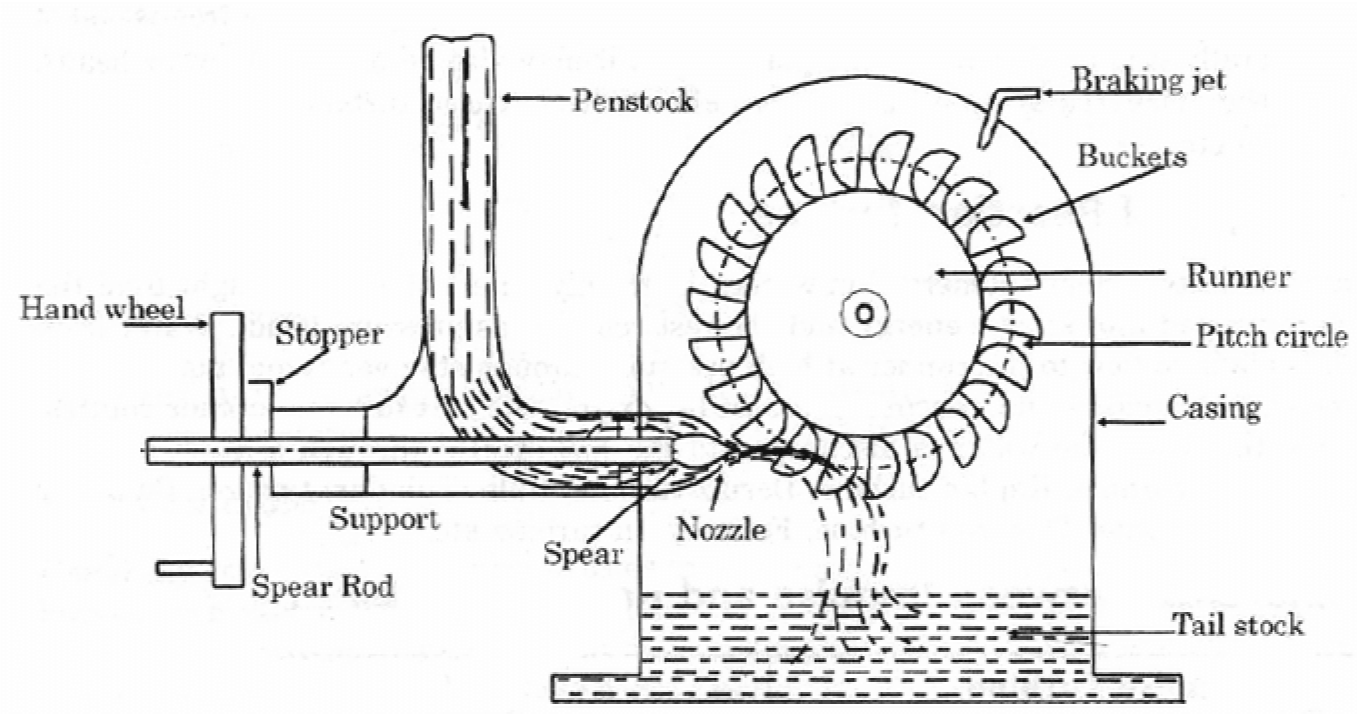

Fig 3.2 Impulse turbine

3.2 IC PIC16F73 (Microcontroller)

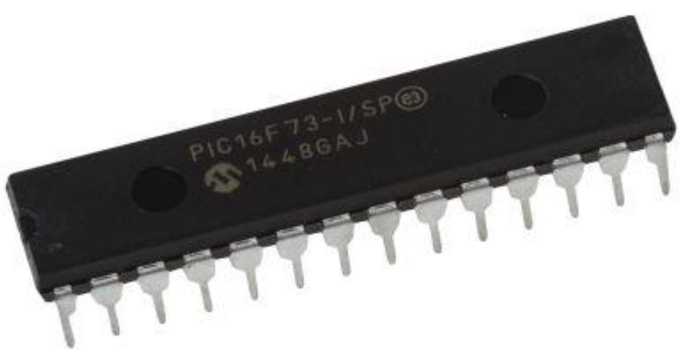

Fig 3.3Microcontroller

3.3 It contains following components:

- Central processing unit (CPU)
- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Input/output ports
- Timers and Counters
- Interrupt controls
- Analog to digital converters
- Digital analog converters
- Serial interfacing ports

3.4 PIC Microcontroller Architecture

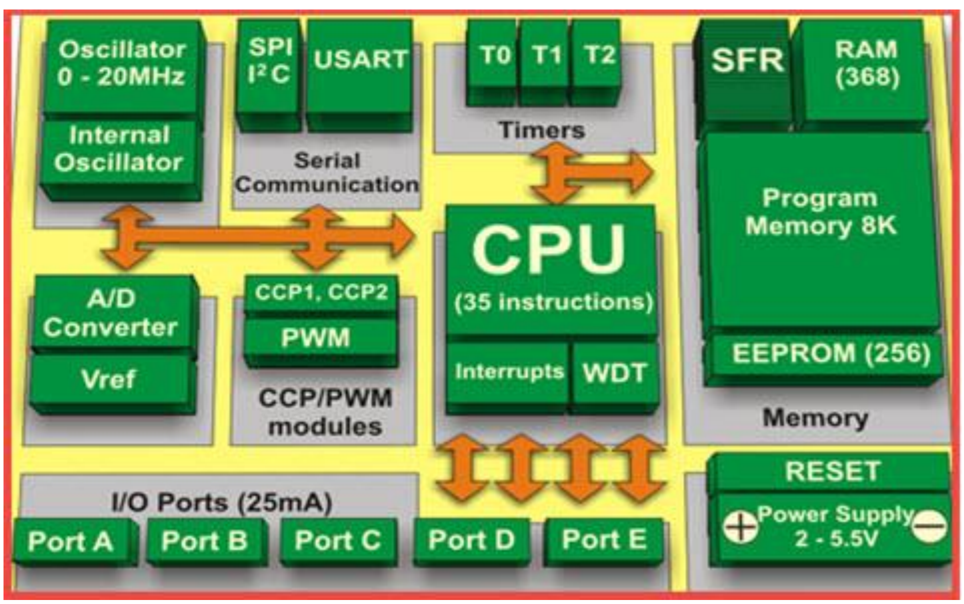

Fig 3.4 PLC

The term PIC stands for the peripheral interface controller was developed in the year 1993 by "Microchip Technology". Firstly, this controller was developed for supporting PDP computer to regulate its peripheral devices, and thus, termed as peripheral interface device.PIC microcontrollers are very fast and executing a program can be made easy compared with other controllers. The architecture of this microcontroller based on "Harvard architecture". The specifications of this microcontroller include wide availability, ease of programming, serial programming capacity, large user base, interfacing of microcontroller with other peripherals, etc.

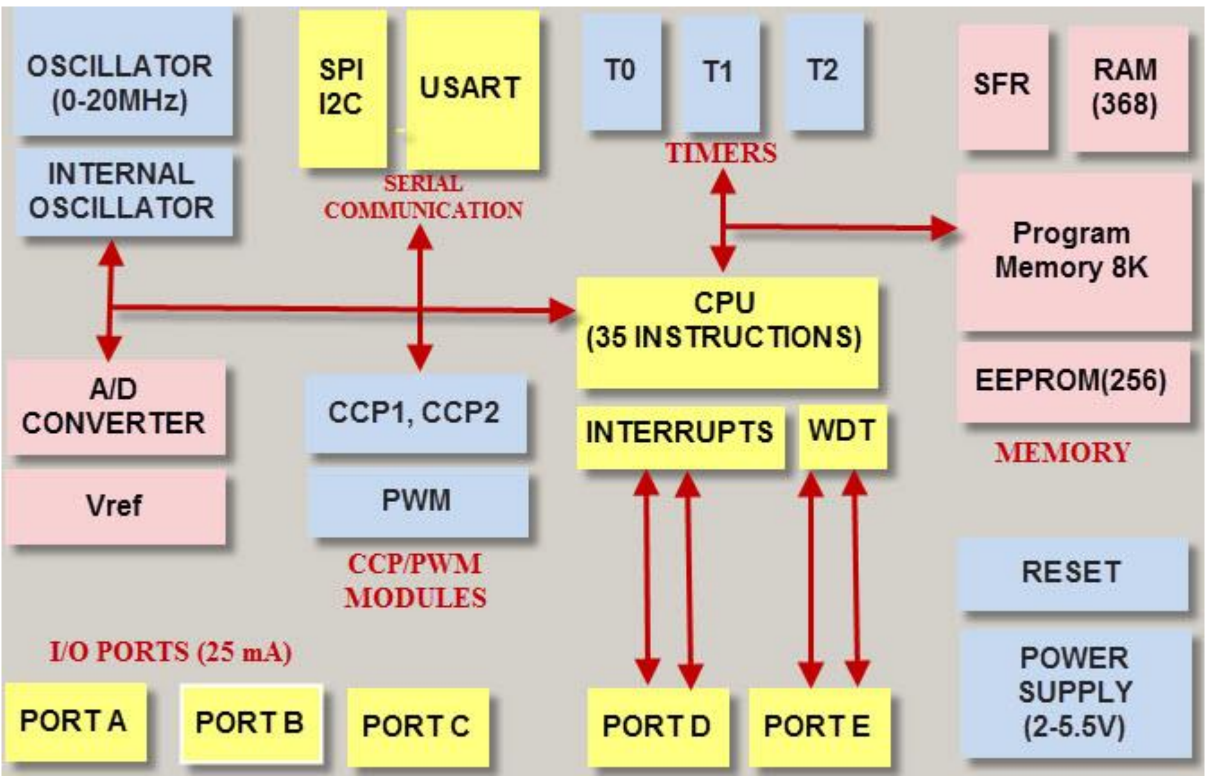

Fig 3.5 CPU

3.5 Central Processing Unit (CPU)

PIC microcontroller's CPU is not different like other microcontroller CPU, which includes the ALU, controller unit, the memory unit, and accumulator. ALU is mainly used for arithmetic and logical operations. The memory unit is used to store the commands after processing. The control unit is used to control the internal & external peripherals, and the accumulator is used to store the final results and further process.

3.6 Memory Organization

The memory module in the PIC microcontroller architecture consists of Random Access Memory, Read Only Memory and STACK.

Fig 3.6 Memory Organization

3.7 RAM (Random Access Memory)

RAM is used to store the information temporarily in its registers. It is categorized into two banks, each bank has so many registers. The RAM registers are categorized into two types, namely SFR (Special Function Registers) and GPR (General Purpose Registers).

3.8 GPR (General Purpose Registers)

As the name implies, these registers are used for general purpose only. For instance, if we want to multiply any two numbers by using this microcontroller. Usually, registers are used for multiplying and storing in other registers. So, GPR registers don’t have any superior function,-CPU can simply access the data in the registers.

3.9 Special Function Registers

As the name implies, SFRs are used only for special purposes. These registers will work based on the function assigned to them, and these registers cannot work as a normal register. For instance, if you cannot use the STATUS register for storing the information, SFRs are used for viewing the status of the program. So, a consumer cannot change the SFR’s function; the function is given by the retailer at the time of built-up.

3.10 Memory Organization

The memory organization of Peripheral Interface Controller includes the following

- Read Only Memory (ROM)
- Electrically Erasable Programmable Read Only Memory (EEPROM)
- Flash Memory
- Stack

3.11 I/O Ports

The PIC microcontroller consists of 5-ports, namely Port A, Port B, Port C, Port D and Port E.

3.12 BUS

BUS is used to transfer & receive the data from one peripheral to another. It is categorized into two types like data bus and address. Data Bus is used to transfer or receive the data.

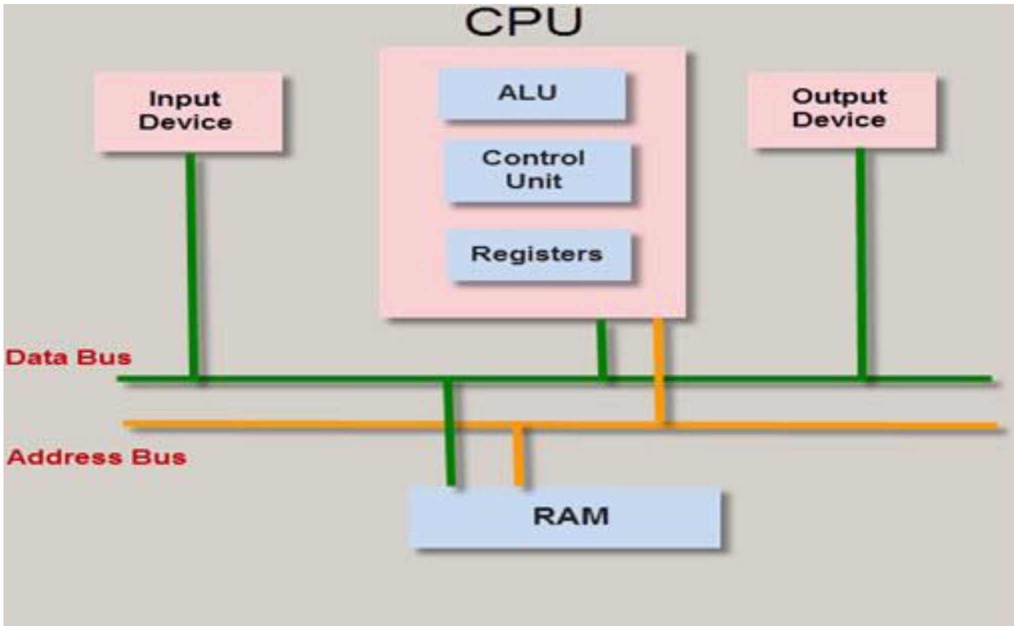

Fig 3.7 BUS

The address bus is used to transfer the memory address from the peripherals to the central processing unit. Input/output pins are used to interface the exterior peripherals; both the UART & USART are serial communication protocols, used to interface with serial devices such as GPS, GSM, IR, Bluetooth, etc.

3.13 USART

The term USART stands for "Universal synchronous and Asynchronous Receiver" and Tx which is a serial communication for two protocols. USART is used for transmitting & receiving the data bit by bit over a single wire with respect to CLK pulses. The Peripheral Interface Controller consists of two pins TXD & RXD. These pins are used for transmitting & receiving the data serially.

3.14 SPI Protocol

The term SPI (Serial Peripheral Interface) is used to send information between PIC microcontroller and other peripherals like sensors, SD cards, and shift registers. This microcontroller supports 3-wire SPI communications between two devices on a common CLK source. The data rate of this protocol is more than that of the USART.

3.15 I2C Protocol

The term I2C stands for "Inter-Integrated Circuit", and it is a serial protocol, used to connect low-speed devices like EEPROMS, A/D converters, microcontrollers, etc. PIC microcontroller supports this communication between two devices which can work as both Master & Slave device.

3.16 Oscillators

Oscillators are used for timing generation. This microcontroller comprises of external oscillators such as crystal oscillators or RC oscillators. Where the crystal oscillator is associated with the two pins of the oscillator. The capacitor value is connected to each pin that chooses the operation mode of the oscillator. These modes are the high-speed mode, crystal mode, and the low-power mode. In the case of RC oscillators, the resistor value and capacitor decide the CLK frequency and the clock frequency range from 30KHz to 4MHz.

3.17 LCD (2 Line 16 Carriers):

LCD (Liquid Crystal Display) screen is an electronic display module. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

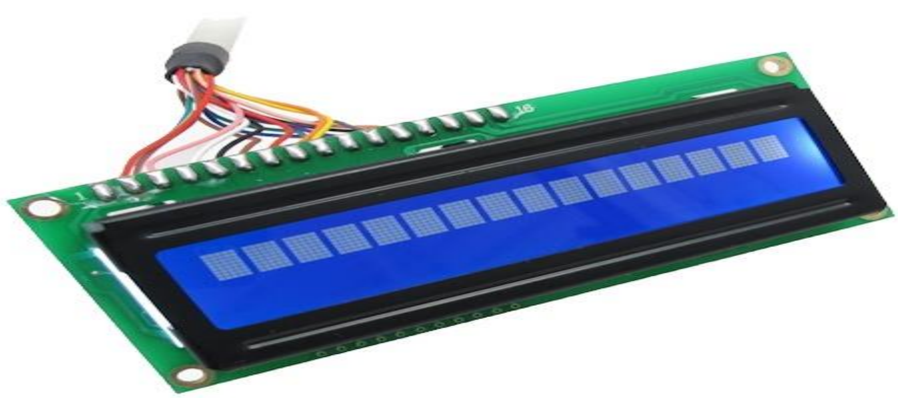

Fig 3.8 LCD

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. A register which commanded storage the command instructions to the given LCD like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

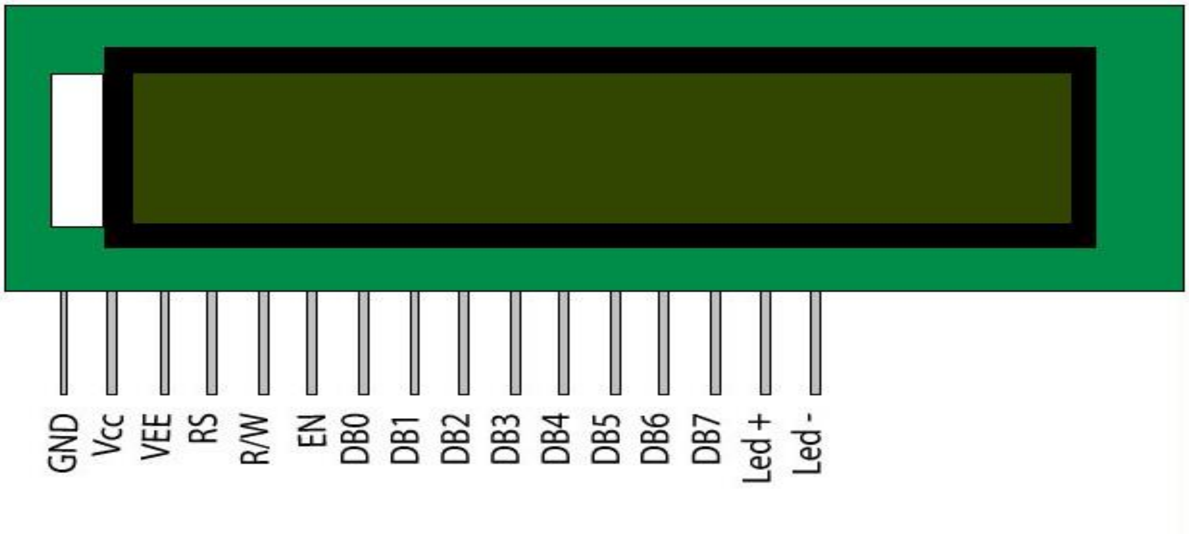

Fig 3.9 LCD (2*16) Pin

3.18 Pin Features:

- 5*8 Dots with cursor
- 16 Characters *2 line display
- 4-bit or 8-bit MPU interfaces
- Display mode & Backlight Variations
- ROHS Compliant

3.19 Pin Description:

16 pin LCD description given bellow:

Pin No	Function	Name
01	Ground (0V)	Ground
02	Supply Voltage ;5V (4V-5.3V)	Vcc
03	Contrast Adjustment; through a variable resistor	VEE
04	Selects command register when low; and data register when high	Register Select
05	Low to write to the register; High to read from the register	Read/Write
06	Sands data to data pins when a high to low pulse is given	Enable
07	8 Bit Data Pins	DB0
08		DB1
09		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight Vcc(5V)	Led+
16	Backlight Ground (0V)	Led-

3.20 Voltage regulator:

A voltage regulator generates a fixed output voltage of changes to its input voltage or load conditions. The voltage regulator must be stable with its condition. Here we use IC 7805 voltage Regulator. IC 7805 is a 5V Voltage Regulator that restricts the voltage output to 5V and draws 5V regulated power supply. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value

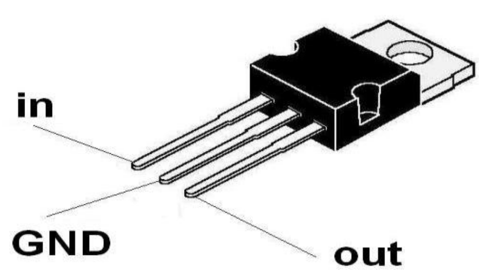

Fig 3.10 Voltage Regulator

IC 7805 is a 5V Voltage Regulator that restricts the voltage output to 5V and draws 5V regulated power supply. It comes with provision to add heat sink. The maximum value for input to the voltage regulator is 35V. It can provide a fixed steady voltage flow of 5V for higher voltage input till the threshold limit of 35V. If the voltage is near to 7.5V then it does not produce any heat and hence no need for heat sink. If the voltage input is more, then excess electricity is liberated as heat from 7805.It regulates a steady output of 5V if the input voltage is in rage of 7.2V to 35V. Hence to avoid power loss try to maintain the input to 7.2V. In some circuitry voltage fluctuation is fatal (for e.g. Microcontroller), for such situation to ensure constant voltage IC 7805 Voltage Regulator is used. IC 7805 is a series of 78XX voltage regulators. The name the last two digits 05 denotes the amount of voltage that it regulates. Hence a 7805 would regulate 5v and 7806 would regulate 6V and so on. The schematic given below shows how to use a 7805 IC, there are 3 pins in IC 7805, pin 1 takes the input voltage, GND of both input and out are given to pin 2, pin 3 produces the output voltage.

3.21 Pin Description:

Pin no.	Function	Name
1	Input voltage (5V-18V)	Input
2	Ground (0V)	Ground
3	Regulated output; 5V (4.8V-5.2V)	Output

3.22 Capacitor:

Capacitor is an essential component of our project. We can use the capacitor in different many applications. Using capacitor in a microcontroller its must because of the microcontroller is a digital device with fast switching edges which uses a large amount of current for a very short period of time at each transition. The capacitors supply the large amount of current needed so that the power supply doesn't sag during that time creating noise. The main function of a capacitor is storing electric charge. A charged capacitor could be used as a voltage source. It is always best to use a variety of capacitors on the power supply pins of the microcontroller to provide a low impedance wideband supply. In our work we used variable value of capacitors and they are 10 μF (6 Pcs) & 100μF (1Pc). Capacitors are used for several purposes like timing, smoothing power supply, coupling, filtering, tuning for radio system, storing energy etc.

Fig 3.11 100μF & 10μF Capacitors

3.23 Hydro Generator

Generators convert the mechanical (rotational) energy produced by the turbine to electrical energy [11]. The principle of generator operation is quite simple: when a coil of wire is moved past a magnetic field, a voltage is induced in the wire [14]. As the turbine blades turn, the rotor inside the generator also turns and electric current is produced as magnets rotate inside the fixed-coil generator to produce current [20]. The basic parameters to be considered in the selection of a suitable type of electrical generator are; Type of desired output, Hydraulic turbine operation modes and Type of electrical load i.e Interconnection with the national grid, storage in batteries or an isolated system supplying variety of household or industrial loads [25]. There are basically two types of generator which are induction and synchronous generator [18].

3.24 Asynchronous Generator

Asynchronous generators are simple squirrel-cage induction motors with no possibility of voltage regulation and running at a speed directly related to system frequency. They draw their excitation current from the grid, absorbing reactive energy by their own magnetism. Adding a bank of capacitors can compensate for the absorbed reactive energy [11]. The asynchronous generators are generally suitable for the micro hydropower generation [26], due to advantages such as availability, low cost and robustness [27]. Induction generator (IG) offers many advantages over a conventional synchronous generator as a source of isolated power supply.

Reduced unit cost, ruggedness, brushless (in squirrel cage construction), reduced size, absence of separate DC source and ease of maintenance, self-protection against severe overloads and short circuits, are the main advantages of IG [13]

3.25 Synchronous generator

Synchronous generator are equipped with a DC excitation system (rotating or static) associated with a voltage regulator, to provide voltage, frequency and phase angle control before the generator is connected to the grid and supply the reactive energy required by the power system when the generator is tied into the grid [11]. A synchronous generator usually has a built-in excitation system and automatic voltage regulation [28]. It can be used in stand-alone or grid-tied system; it has higher efficiency but higher cost [18]

3.26 Classification of hydropower by size:

S/L	Classification	Rated Power	Consumer
01	Large Hydro	>100MW	Usually feeding into a large electricity gird.
02	Medium-Hydro	15-100MW	Usually feeding a gird.
03	Small-Hydro	1-15 MW	Usually feeding into a gird.
04	Mini-Hydro	100KW- 1MW	Either standalone schemes or more often feeding into the grid.
05	Micro-Hydro	5KW- 100KW	Usually provided power for a small community or rural industry in remote areas away from the grid.
06	Pico-Hydro	<5KW	

Chapter-4

Model Setup And Procedure

4.1 Block Diagram

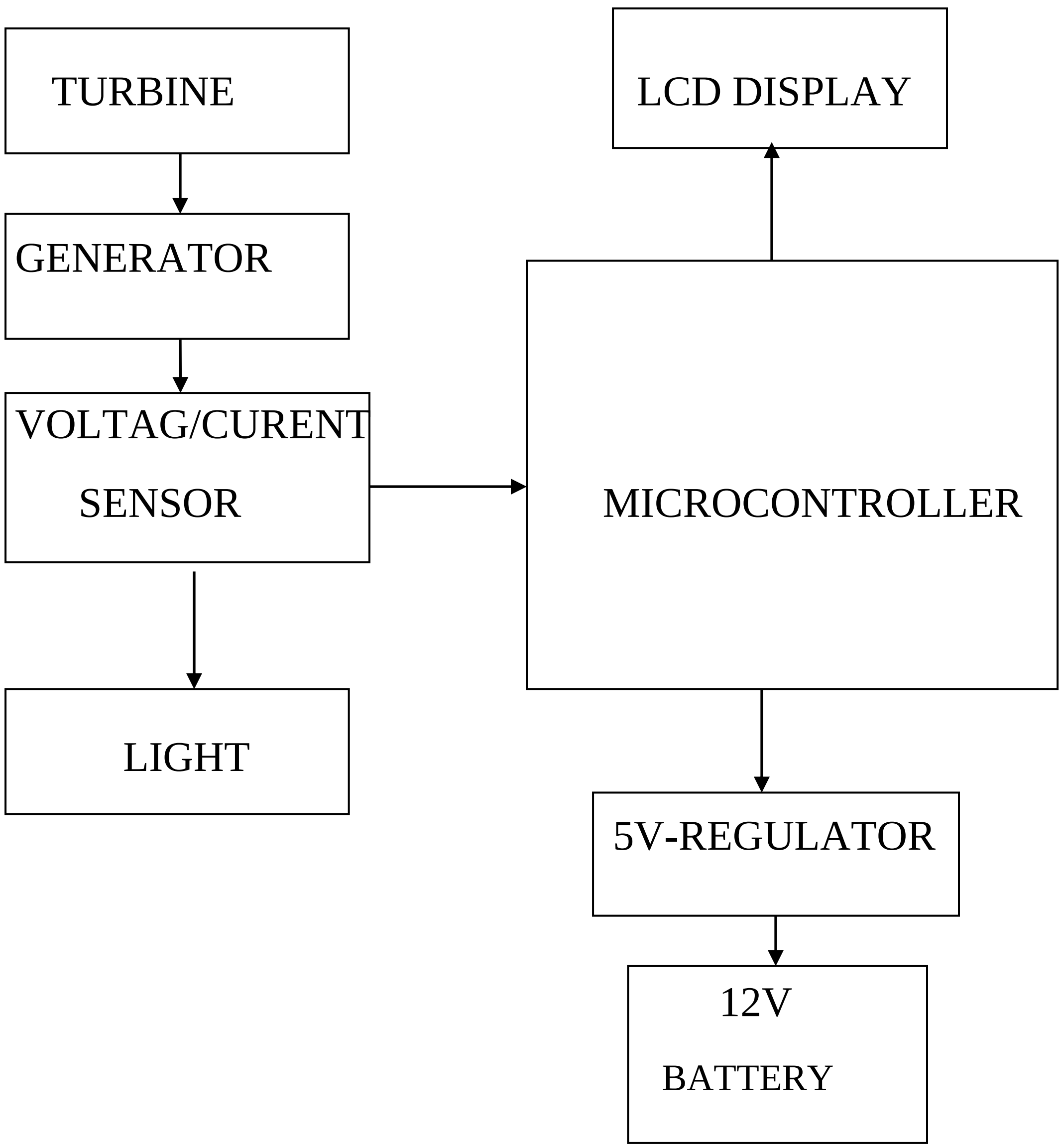

Fig 4.1 Block Diagram

4.2 Circuit Diagram

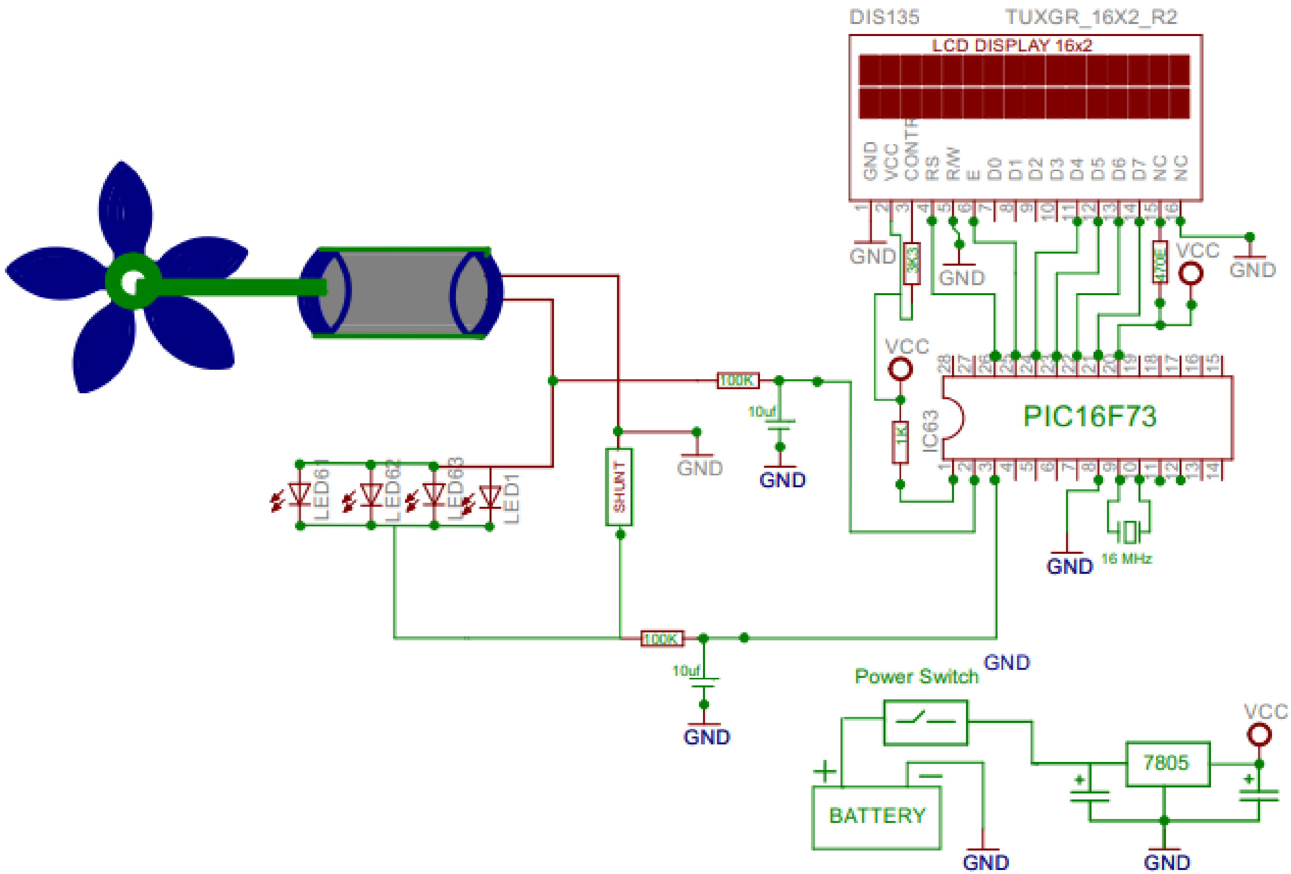

Fig 4.2 Circuit Diagram

Chapter-5

working principle

Generators convert the mechanical (rotational) energy produced by the turbine to electrical energy [11]. The principle of generator operation is quite simple: when a coil of wire is moved past a magnetic field, a voltage is induced in the wire [14]. As the turbine blades turn, the rotor inside the generator also turns and electric current is produced as magnets rotate inside the fixed-coil generator to produce current [20]. The basic parameters to be considered in the selection of a suitable type of electrical generator are; Type of desired output, Hydraulic turbine operation modes and Type of electrical load i.e. Interconnection with the national grid, storage in batteries or an isolated system supplying variety of household or industrial loads [25]. There are basically two types of generator which are induction and synchronous generator [18

In our project we used a dc motor, microcontroller, LCD display, LED, PVC board,

For our project we made a dame for reserve water and turbine and turbine chamber. We use a dc motor as a generator. In this project we used 12V battery for supply power for in microcontroller unit. This supply connect to input of 7805 linier voltage regulator.7805 voltage regulator convert 12v dc to 5v dc that called VCC. For our project we used pic16f72microcontroller.That have 28 pin. 19 no pin of microcontroller is VSS / GND and 20 no pin VCC/VDD that connect to 5v VCC and GND. 9 and 10 no pin connect with 16 MHz crystal. ADC channel 0/ 2 no pin connect to output of generator. We use a shunt resistor and lm358 op-amp for measuring current. When Generator output voltage more than 2 voltage microcontroller turn on 11 no pin that connect to base of an npn transistor . LED positive terminal connect to positive of generator and led negative of led connect to collector of transistor and emitter of transistor connect to negative of generator.

Chapter-6

Result

6.1 Result Description table:

SL NO	Flow Rate Lit/Min	Current (A)	Voltage(V)	Power =VI (W)
01	1	2.1	2.1	4.41
02	2	3.2	4.3	13.76
03	3	5	7.89	39.45
04	3.2	7.6	8.2	62.32
05	4	8	8.5	68
06	4.43	9	9.9	89.1

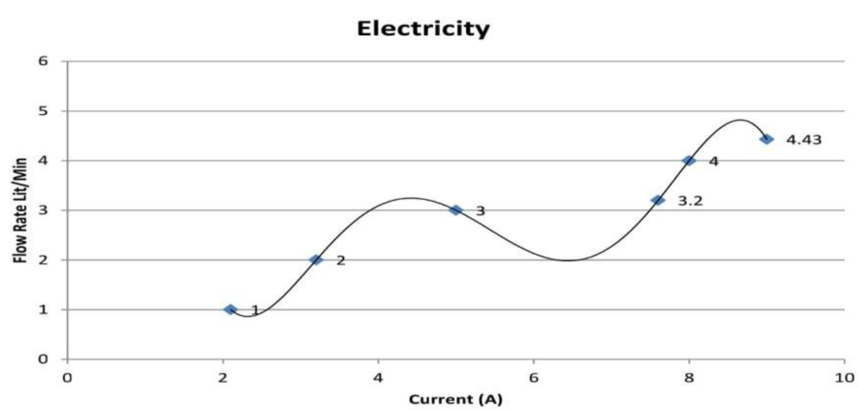

Fig6.1 Current vs flow rate

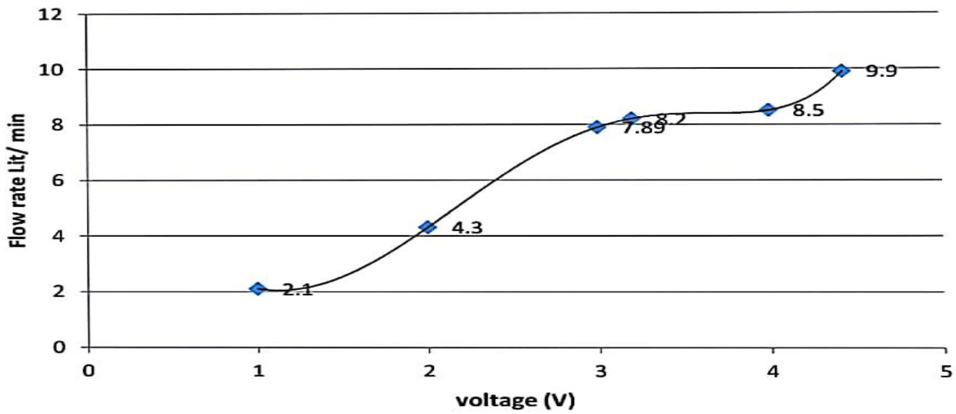

Fig6.2 Voltage vs flow rate

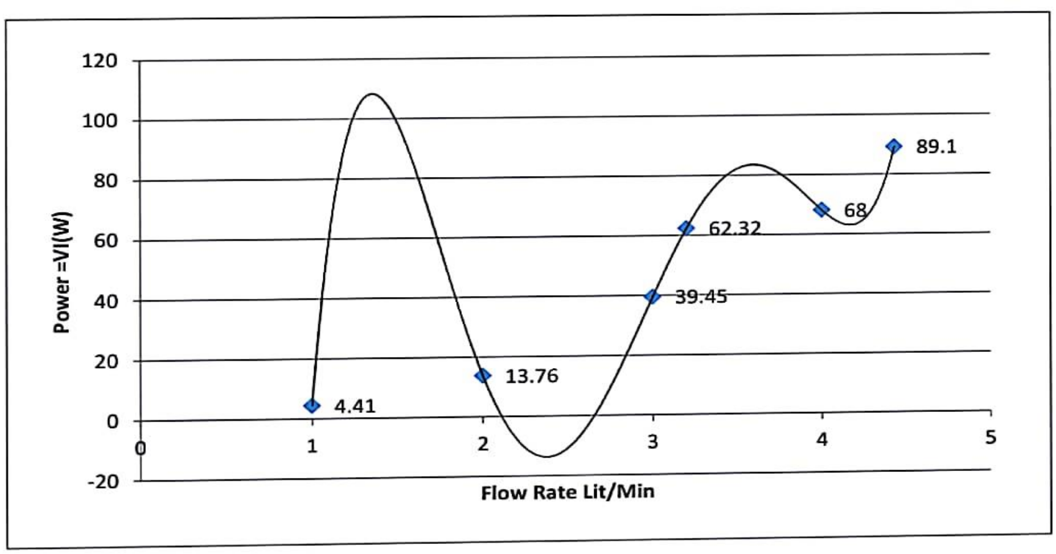

Fig6.3 Electrical power vs flow rate

Experimental Result:

Fig6.3 shows that the power output is proportional to the flow rate, and also power of the product. equation shows a positive increment, and shall be used as datum for the future experimentation.

Unfortunately, the potential of the DC generator cannot been fully explored. According to specification, the DC generator is capable in achieving 62.32 Watt. Where in this experiment, we could only achieve only half of the result, which is around 89 Watt. In near future, by concentrating on the optimization factor of the DC generator and the design, a better and positive result could be achieved. The flow rate result can be used to understand the basic behaviour of fluid in normal pipeline, in order to generate electricity. The fact is, fluid flow in a normal pipeline always behaves in a turbulent manner and difficult to control. The main reason in determining pipeline size is actually more towards suiting consumer usage. This is done by increase the flow rate, at the same time reduce any side effect such as vibration and noise. Fundamental theory and engineering knowledge is sometime irrelevant in real cases. The final judgement and decisions needs to be made by us human, based on trial and experience.

Our initial objective is to operate the product below the quiet flow rate specification, which is 4.43 liter/mi

Applications

01. Home
02. Industry
03. Others Sources Of Water.

Chapter-7

Advantages Disadvantages & Conclusion

7.1 Advantages of Miniature Hydraulic Power:

Compared with other technologies, the most important advantages of hydropower are the following:

• Hydropower generation is based on a reliable proven technology that has been around for more than a century and hydropower plants can be easily rehabilitated or upgraded utilizing recent advances in hydro technologies.

• Hydropower generation is renewable because it does not reduce the water resources it uses and does not require fuel.

• In most cases, hydropower is an economically competitive renewable source of energy. The level zed cost of electricity (LCOE) is usually in the range of US$0.05 to US$0.10 per kWh [EIA 2010]. Rehabilitating or upgrading existing hydropower schemes provides opportunities for cost-effective capacity increases.

• Hydropower exploits domestic water resources, thereby achieving price stability by avoiding market fluctuations.

• Storage hydropower schemes (dams, pumped storage) offer operational flexibility because they can be easily ramped up or shut down, creating potential for immediate response to fluctuations in electricity demand. Thus storage hydro are valuable to meet peak demand or to compensate for other plants in the grid (especially solar and wind), which can experience sudden fluctuations in power output.

• The creation of reservoirs also allows water to be stored for drinking or irrigation, reducing human vulnerability to droughts. Reservoirs can provide flood protection, and can improve waterway transport capacity. Further, HPPs with reservoirs can generate energy during dry periods and regulate fluctuations in the energy supply network by using the stored water.

• Environmental impacts triggered by implementing hydropower schemes are well known and manageable.

7.2 Disadvantages of Miniature Hydraulic Power:

• High up-front investment costs compared to other technologies, such as thermal power (but low operational costs since no fuel is required).

• Reservoirs may have a negative impact on the inundated area, damage river flora and fauna, or disrupt river uses such as navigation. However, most negative impacts can be mitigated through project design. The IFC and other multilateral financial institutions have strict mandatory requirements for assessment and mitigation of social and environmental impacts.

For more information, refer to the IFC Performance Standards on Environmental and Social Sustainability or the IFC Environmental, Health and Safety Guidelines for construction works and transmission lines

7.3 Conclusion

In this paper the basic component of micro-hydro system such as turbine, generator, and the diversion. system has been discussed with emphasis on the technology involve, application and the necessary condition under which such components will be applied. The methods involved in estimating the flow rate and the head in order to have an idea of the available power were also discussed. Micro hydro benefits the rural folks in many as well as other advantages. The limitation, these advantages as well as planning involve in micro-hydro project were discussed. Though micro hydro itself will not solve all the energy problems around the globe, through proper and careful planning and implementation involving the recipient communities, it can serve as an excellent decentralized electricity generation grid or as a secondary power generating unit, making the grid more

robust• Risks influence investor choices; high-risk projects are likely to be developed and financed by the public sector; low-risk projects attract private sector investors. Projects with risk mitigation measures can be developed and financed as a PPP. Risks and project development type influence debt and equity sources.

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