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# EFFLUENT TREATMENT PLANT USING PLC

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**Abstract**— Water is basic necessity of life used for many purposes one of which is industrial use. Industries generally take water from rivers or lakes but they have to pay heavy taxes for that. So it's necessary for them to recycle that to reduce cost and also conserve it. Main function of Effluent Treatment Plant (ETP) is to clean industry effluent and recycle it for further use. Many manufacturing industries produce their products with using water. With their products industries produce wastewater, otherwise known as effluent, which can be removed with the help of an effluent treatment plant (ETP). Manufacturers face strict regulations on discharge and waste. Effluent from industries must meet the national effluent discharge quality standards (NEDQS) set by the Government. In this paper, we propose a few automated processes for a partial automation of the apartment which can be mostly used in residential areas and industries. It is developed using PLC. The main intent of the paper is to treat the waste water which can be in turn used for many other purposes and can be cost effective as well.

**Keywords**— PLC (Programmable Logic Controller), CV (Control Valve), ETP (Effluent Treatment Plant), Automation, pH, Sensor, Waste water Treatment

## INTRODUCTION

Automation is basically the delegation of human control function to technical equipment. It uses controlled systems such as computers, PLCs, Microcontrollers to control machinery and processes to reduce the necessity of human involvement and mental requirements. Different types of controllers can be used to operate and control the equipment such as machinery, processes in factories, heat treating ovens and boilers, and other applications with minimal or reduced human intervention. Food/ Beverage, Chemical industries, Power, Machine Manufacturing, etc. are the few examples where we see the mechanization today. Most of the automation has been existing in industries from decades. But the shift for automation in home and apartments has popped in very recently. One can employ this kind of a system which enables an individual to supervise devices such as Lighting, Heating and ventilation, water pumping, gardening system, Overhead water flow control remotely or from any centralized location. Automatic systems are being preferred over manual system because they reduce individual's effort. Similarly talking about apartment automation, by use of PLCs everything seems to be more accurate, reliable and more efficient than the existing controllers.

As our paper is based on automation thus we can use both microcontroller and PLC. Microcontroller being an application oriented and can be programmed using C or Basic need some highly trained programmers to program it. Also microcontroller cannot withstand extreme conditions and cannot be reprogrammed. On the contrary, PLC is robust and can be programmed using ladder programming, structured text programming and functional block diagram programming which can be done easily and also it can be reprogrammed i.e. connections can be same but programming can be changed as per requirement. Thus comparing both of them, we found that there are more advantages of PLC than microcontroller except one fact that PLCs are costly. But on a long run, it works efficiently and its reliability is high. This is one of the factor due to which the cost can be neglected.

## BLOCK DIAGRAM

The block diagram is shown in Fig.1 .The input action consists of a reservoir tank consisting of the waste water to be treated. The pump controlled by PLC pumps the water through a stainless steel mesh to filter macro particle macro particle like sand, stones etc. The next stage consists of the filter membrane which filter minute or dissolved particle present in the water. The system also allows the sedimentation to take place as the heavier particles settle at the bottom of the tank. The next stages consists of the flocculation, coagulation etc. as water treatment processes and the disinfection of water takes place by adding Alum, Sodium Bi sulphate and chlorine. The solenoid valves open and close according to the controlling action of PLC to allow the water treatment in different stages. Level sensors are applied in final tank to check the total amount or level of the waste water treated. The pH value of the treated water is checked if it lies in usable range the water is stored in the treated water tank and the untreated water i.e. the water which does not fulfil the pH criteria is pumped back to the waste water reservoir and the whole process for effluent treatment is repeated again. The components required are as follows:

Stainless steel mesh, Water Pump, Filter membrane, pH meter, Aluminum Sulphate (alum), Chlorine, Sodium Bisulphate, Level Sensors, Control Valves, PLC, LCD Display, PCB

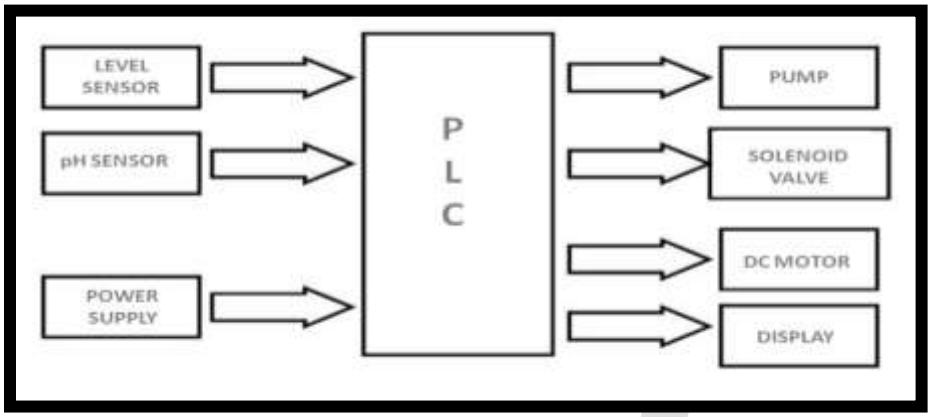
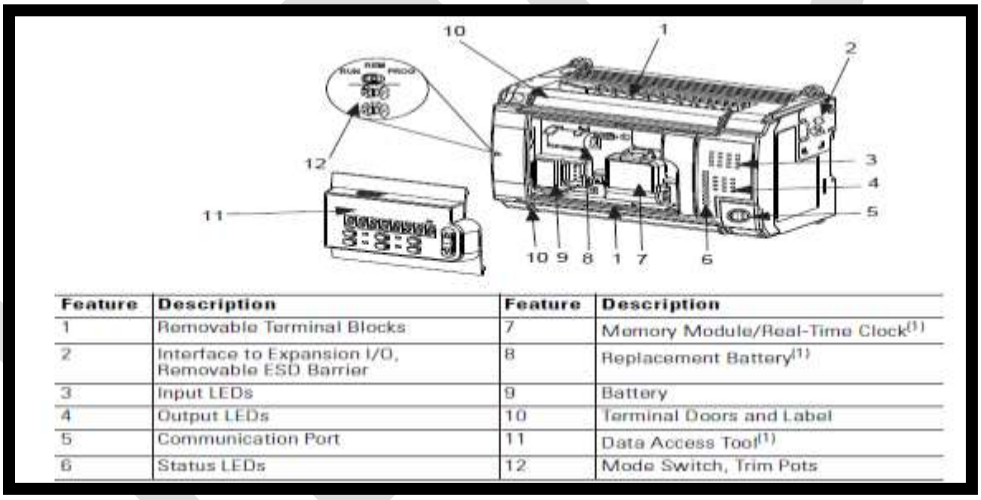



Fig.1 Block Diagram of PLC based ETP

Some of the components of the system are explained in brief below.

**PLC:** The programmable logic controller is defined as a digital electronic device that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic words to control machines and processes as shown in Fig.2. Here it is controlling the input parameters like pH sensor and Level sensor and output parameters like pump, solenoid valves, dc motor and display. The MicroLogix 1500 (Allen Bradley) Programmable Controller contains a power supply, input circuits, output circuits, and a processor. The controller is available in 24 I/O and 28 I/O configurations.
The hardware features of the controller are:




| Feature | Description | Feature | Description |
|---|---|---|---|
| 1 | Removable Terminal Blocks | 7 | Memory Module/Real-Time Clock[1] |
| 2 | Interface to Expansion I/O, Removable ESD Barrier | 8 | Replacement Battery[1] |
| 3 | Input LEDs | 9 | Battery |
| 4 | Output LEDs | 10 | Terminal Doors and Label |
| 5 | Communication Port | 11 | Data Access Tool[1] |
| 6 | Status LEDs | 12 | Mode Switch, Trim Pots |

Fig.2 PLC MicroLogix 1500

**pH sensor**: It will sense the PH level of the waste water and is being controlled by PLC. A glass electrode is a type of ion-selective electrode made of a doped glass membrane that is sensitive to a specific ion. It is an important part of the instrumentation for chemical analysis and physio-chemical studies. In modern practice, widely used membranous ion-selective electrodes (ISE, including glasses) are part of a galvanic cell. The electric potential of the electrode system in solution is sensitive to changes in the content of certain type of ions, which is reflected in the dependence of the electromotive force (EMF) of galvanic element concentrations of these ions.It is shown in Fig.3.
A typical modern pH probe is a combination electrode, which combines both the glass and reference electrodes into one body. The combination electrode consists of the following parts (see the drawing):

1. A sensing part of electrode, a bulb made from a specific glass
2. Internal electrode, usually silver chloride electrode or calomel electrode
3. Internal solution, usually a pH=7 buffered solution of 0.1 mol/L KCl for pH electrodes or 0.1 mol/L MeCl for pMe electrodes
4. When using the silver chloride electrode, a small amount of AgCl can precipitate inside the glass electrode
5. Reference electrode, usually the same type as 2
6. Reference internal solution, usually 0.1 mol/L KCl
7. Junction with studied solution, usually made from ceramics or capillary with asbestos or quartz fiber.

8. Body of electrode, made from non-conductive glass or plastics.

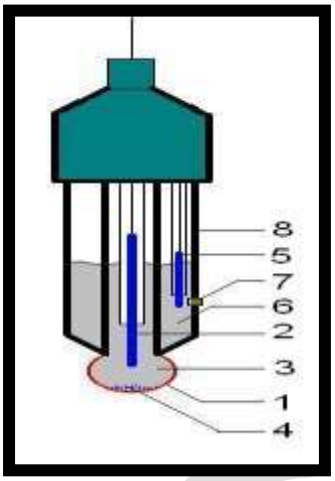



Fig.3 pH Electrode

The bottom of a pH electrode balloons out into a round thin glass bulb. The pH electrode is best thought of as a tube within a tube. The innermost tube (the inner tube) contains an unchanging $1\times10^{-7}$mol/L HCl solution. Also inside the inner tube is the cathode terminus of the reference probe. The anodic terminus wraps itself around the outside of the inner tube and ends with the same sort of reference probe as was on the inside of the inner tube. It is filled with a reference solution of 0.1 mol/L KCl and has contact with the solution on the outside of the pH probe by way of a porous plug that serves as a salt bridge.

**Pump:** It is acting as booster which will boost the flow of liquid through it. It is acting as an output parameter for PLC. It is shown in Fig.4.


Fig.4 Submersible Pump

**Solenoid Valve:** A solenoid valve or solenoid actuated valve is basically an electrical valve that controls the flow of media either open/closed or diverting my means of an electro magnet or solenoid. The principles are based around a thin copper wire wound around a bobbin or core (The solenoid) in such a way that when electrical energy is applied a sufficient magnetic field is generated to provide a lifting force to a ferromagnetic stainless steel armature within the solenoid valve armature assembly which in turn will directly or indirectly change the position of the valve. It is acting as an output parameter for PLC.A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. Besides the plunger-type actuator which is used most frequently, pivoted-armature actuators and rocker actuators are also used.It is shown in Fig.5.

Fig.5 Solenoid Valve

**DC Motor:** A dc motor is being controlled by PLC. It will operate the stirrer. A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications. It is shown in Fig.6.

Fig.6 DC Motor

**LCD Display:** It will display the parameters like pH value, level of liquid and project name. LCD stands for **L**iquid **C**rystal **D**isplay. It is shown in Fig.7.LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

- The declining prices of LCDs.
- The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
- Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
- Ease of programming for characters and graphics.

These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

Fig.7 LCD Display

A model described here is for its low price and great possibilities most frequently used in practice. It is based on the HD44780 microcontroller (*Hitachi*) and can display messages in two lines with 16 characters each.
It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols that user makes up on its own.
General process diagram of PLC based ETP plant is:

## PROCESS EXPLAINATION

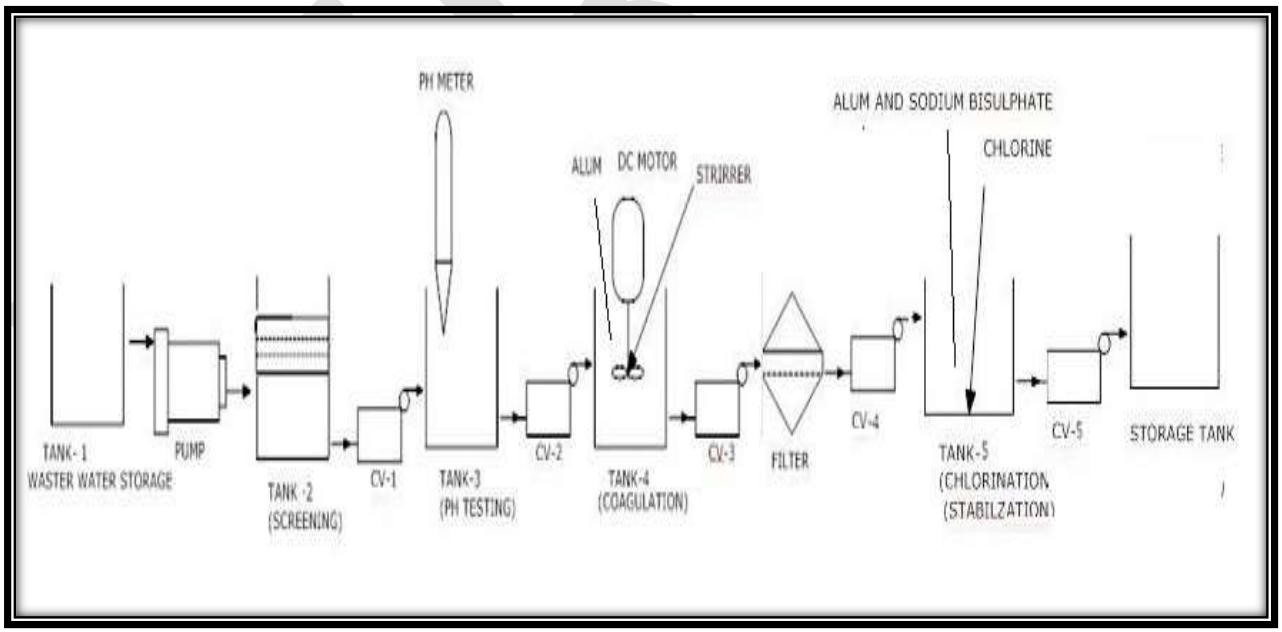



Fig.8 Process Diagram

The process of ETP mainly consists of four stages:

- preliminary
- primary
- secondary
- tertiary(advanced)

And treatment of three types

- physical
- chemical
- biological

In this diagram there are total six tanks including storage tank. Tank 1 contains waste water or untreated water or water containing effluents that has to be treated, is pumped to the tank 2 by the pump or dc motor.
In tank 2, the first stage takes place i.e. preliminary.
There are three processes in this stage i.e., screening, sedimentation and clarification.

- In screening process a screen with openings of uniform size is used to remove large solids such as plastics, cloth etc.. Maximum 10mm shall be used.
- Sedimentation process is a physical water treatment process using gravity to remove suspended solids from water.
- Filtration is a physical operation which is used for separation of solids from fluids.

All the above processes are physical in nature.
There is a valve CV-1 which allows the passage of treated water of first stage to tank3 for further treatment.
In tank 3, second stage takes place i.e. primary stage.
In this stage various floating and settable materials like suspended particles and organic materials are removed and pH value is maintained. In order to check the pH value, pH meter is used.
**pH Control*:*** It is necessary to adjust the pH in the treatment process to make the wastewater pH neutral. Various chemicals are used for pH control. For acidic wastes (low pH) sodium hydroxide, sodium carbonate, calcium carbonate or calcium hydroxide, may be added among other things. For alkali wastes (high pH)sulphuric acid or hydrochloric acid may be added. pH maintained water pass to the tank 4 through valve i.e. CV-2 in which process of coagulation takes place which is another process of primary stage.
**Coagulation:** Coagulation is a complex process but generally refers to collecting into a larger mass the minute solid particles dispersed in a liquid. Chemical coagulants such as aluminum sulphate (alum) or ferric sulphate may be added to wastewater to improve the attraction of fine particles so that they come together and form larger particles called flocs. Coagulation requires gentle mixing of particles which is done with the help of stirrer operated by dc motor.
The processes of primary stage are physical and chemical in nature.
Depending upon the possibility of the presence of biological wastes like bacteria or nature of the waste water, secondary stage treatment can be done in this stage also. If water consist waste like harmful bacteria and other biological effluents then water is treated under secondary treatment or biological treatment. The objective of biological treatment of industrial wastewater is to remove, or reduce the concentration of, organic and inorganic compounds. Biological treatment process can take many forms but all are based around microorganisms, mainly bacteria**.** Biological treatment plants must be carefully managed as they use live microorganisms to digest the pollutants. It consist two main processes i.e. Aerobic and Anaerobic. These processes are biological in nature. The treated water from tank 4 pass to the filter from third valve CV-3.Filter allows the water to pass to the tank 5 through valve CV-4 and in tank 5 final stage of treatment i.e. tertiary or advanced stage takes place.

- Tertiary treatment is the final cleaning process that improves wastewater quality before it is reused, recycled or discharged to the environment.
- The treatment re Tertiary moves remaining inorganic compounds, and substances, such as the nitrogen and phosphorus.
- Bacteria, viruses and parasites, which are harmful to public health, are also removed at this stage. Alum is used to help remove additional phosphorus particles and group the remaining solids together for easy removal in the filters.
- The chlorine contact tank disinfects the tertiary treated wastewater.
- Chlorine removes microorganisms in treated wastewater including bacteria, viruses and parasites.
- Any remaining chlorine is removed by adding sodium bisulphate just before it's discharged.

The process of this stage are physical, chemical and biological in nature. The water from tank 5 is completely treated water ready for discharge or further use can be collected in storage tank after passing through valve CV-5.
The figure 9 shows the flow diagram of the process.

First of all the waste water from the waste water tank is pumped to the screening section where all the solid waste are removed. Then after clearance control valve CV-1is activated .This stage is the pH testing stage. There exists a condition if pH sensor detects that the pH value is greater than 7, then it is basic waste so for that CV-2 is activated and to neutralise the effect of basicity, some acid is added like HCl. In a similar context, if pH value is less than 7, being an acidic waste CV-3 is activated and base NaOH is added. In next stage, Stirrer is being driven by dc motor and coagulant alum is being added. After that control valve CV-4 is activated, in this stage filtration of water is done where flocs are removed after that control valve CV-5 is activated. Now stabilization and disinfection of water is done by adding alum, sodium bisulphate and chlorine. After this stage is over control valve CV-6 is activated and water is stored in the reservoir tank which is fitted with level sensor that will show the level water being treated.

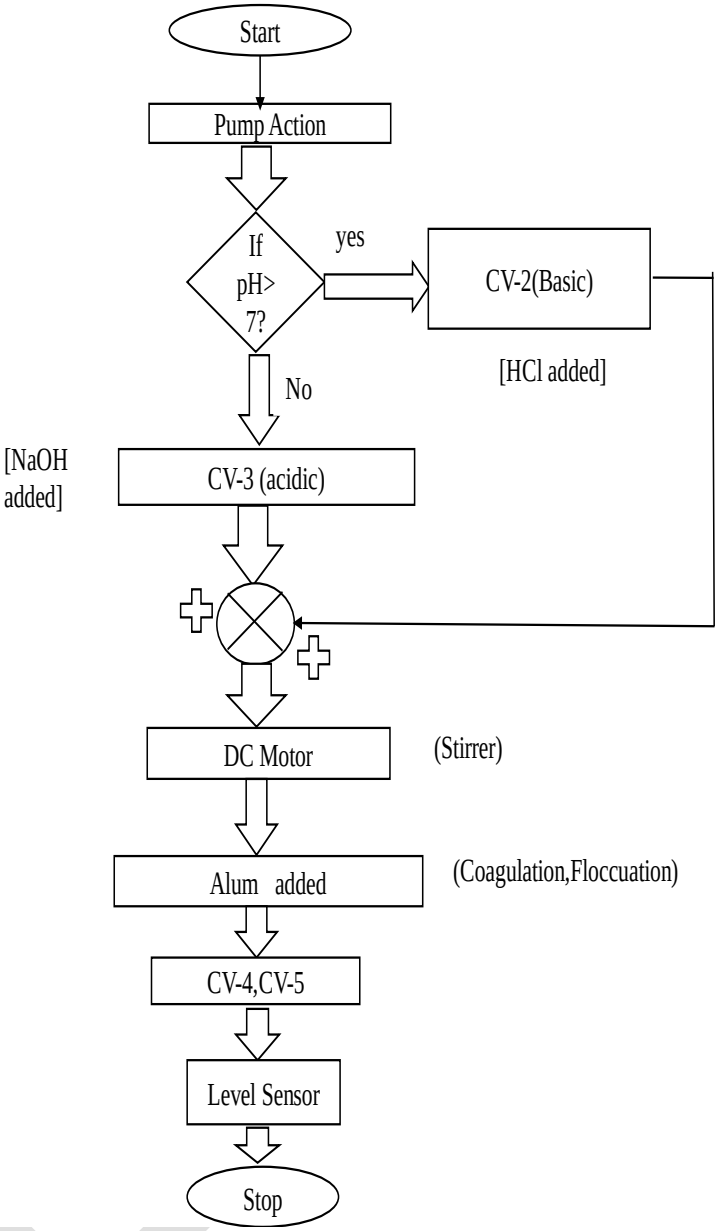



Fig.9 Flow Diagram of Process

**CONCLUSION**

The treatment of contaminated water can be done with the ETP, which is a effluent treatment plant clean up the industry effluents, polluted water from rivers, lakes, etc. So, they can be recycled for further use. Thus, water is recycled and stored. Water is one of the most important natural resource that is one of the basic necessities in human life. Water is used for a number of purposes, but it is used mainly for drinking. Apart from household uses, it is also use for several industrial purposes.Though water is found in abundant in nature, yet most of it is contaminated, and therefore it needs to be treated so that it can be recycled. The treatment of contaminated water can be done with the ETP, it is an effluent treatment plant that cleans the effluents form the industry, polluted water from rivers, lakes etc so that it can be recycled for further use. In this way, water is recycled and conserved. It is technically proven that any kind of pollutant can be removed from such effluent by the use of the water treatment plant. Again the treatment of these effluents is treated depending on the type of industries.

The ETP has a great role to play in discharging the contaminated and polluted water before releasing it back to the environment. Without these water treatment plants, we would not be able to get clean water for domestic uses.

By using PLC the cost effective automation system for residences can be developed and it is very user friendly for the operator or control engineer to trouble shoot the process if any errors occurs and can also be kept track of what is happening in the process.

This kind of implementation has many advantages. Some of them are:

- Increased level of comfort and time saving.
- Time and money saving during maintenance.
- Effective monitoring of the processes.
- Improved plant Reliability and life.
- Flexibility on change of building use.
- Remote monitoring of plants like water treatment plant or electrical supply, etc.
- Ease of storing reports of the systems.

By using PLC based automation in and around residences or apartments, we can lead to a better,comfortable life by reducing costs and improve the quality of life.

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