BOILER AUTOMATION USING PROGRAMMABLE LOGIC CONTROLLER

INTRODUCTION

PLC applications are extensively used in industries to control and facilitate repetitive processes such as manufacturing cell management, fly-by-wire control, or nuclear plant systems. One of these applications is industrial automation which includes numerous automated processes. This again includes boiler automation which demands determination of certain physical parameters (viz. pressure, temperature, etc.) & utilizing these parameters to make the boiler start-stop or function in any manner we want, but automatically, without involvement of any human. Nowadays, every new industry before stepping into the production line, never gives up thinking about ways of automating it’s production process, so as to reduce it’s overall expenditure in terms of wages, wastage of material due to inaccurate manual work and to reduce the overall time taken for production. This is where the job of PLCs come into picture. There are many companies manufacturing PLC trainer kits. Companies like Siemens, Allen Bradley, ABB, LG, Mitsubishi, Omron, GE Fanuc are the leading global manufacturers of PLCs, each varying from the other in terms of CPU memory, number of digital and analog inputs and so on. The main theme behind using a PLC is reduction of cost as well as complexity of incorporating huge number of electrical devices, easier error detection, optimization of overall production time and above all automation.

This project which includes applications of PLC, reflects the true and exact nature of operation of a boiler used in an industry where steam energy is greatly required for other useful operations to take effect. The current project is controlled and automated fully by LG made PLC which uses KGL Master K-series (120S) software. The overall logic i.e the ladder diagram for the boiler operation is designed with the help of this software which is then downloaded into the PLC CPU memory. The physical parameters that are taken care of are water level, temperature & pressure. This PLC accepts the outputs from four sensors (2-water level sensors, 1-temperature sensor & 1-pressure sensor) incorporated within the boiler, evaluate them and generate appropriate signals which will ultimately be used to turn on or terminate the heater or
the water pump. The whole project is divided into four main sections which involves two stages of completion. Individual section and the stages of completion are briefly described in the successive parts.

**PROJECT IN BRIEF**

**OBJECTIVE:** Designing of a PLC controlled boiler for production of steam with temperature, pressure & level as control parameters.

**OVERVIEW OF THE PROJECT:**

**DIFFERENT SECTIONS OF THE PROJECT:**

The project incorporates the requirement of a physical PLC trainer kit which is responsible for collection of data from field sensors (within the boiler), evaluate them & generate appropriate output for the boiler to operate in a specific desired procedure. Initially, we divided our project into four sections viz., power supply section, water supply section, boiler(including sensors) section, process controlling section.

**Boiler Section:** Boiling container, sensors (pressure, temperature & level sensors) & a heater assemble altogether to give rise to the boiler section.
**Controlling Section:** This section includes the PLC trainer kit which is responsible for data collection from field sensors, evaluation of collected data & generation of appropriate output signals for automatic actuation and termination of different peripherals incorporated in the overall system.

**Water Supply Section:** Water supply to the boiler is ensured by a water pump whose actuation & termination is controlled by the PLC trainer.

**Power Supply Section:** This takes care of the power requirements for the whole project. This mostly comprises of the circuits providing DC power for the field sensors and valves (solenoids).

**APPLICATIONS:** The main advantage of using PLCs is the drastic reduction in the requirement of electrical components in terms of number of switches, relays, wiring, etc. The applications of this project are solely the applications of a boiler i.e., production of steam and using it for numerous processes like rotating the generator fins and hence producing power for commercial or industrial purposes.

**STAGES OF PROJECT DESIGN:**
We divided the overall construction of the project in two stages. These are described as follows:

**STAGE 1:**
- Software design & simulation.

**STAGE 2:**
- Hardware design
  - (a) Power supply
  - (b) Sensing unit
    - Level Sensing Unit.
    - Temperature sensing unit.
    - Pressure sensing unit.

This stage basically involves the interfacing of all the hardware components with each other as well as with the PLC. After the completion of the interfacing, a trial run is done so as to be ensured that all the components including both software and hardware, are working satisfactorily.
STAGE 1:

Software design & simulation:

COMPONENTS USED FOR PROJECT WORK

1 – SWITCH

Switches are the basic components of PLC. Two types of switches are available in plc.

i) Digital switch (ON/OFF).

ii) Analog switch (continuous varying).

I) DIGITAL SWITCH

Two type of states are available under digital type i.e NO(normally open) or NC(normally closed).

NORMALLY OPEN:

A switch is said to be NORMALLY OPEN when it doesn’t allow current to pass till it is off. When the switch is made on by applying appropriate voltage, in case of PLC, it allows current to pass and actuate the coil or component attached to it. NO switches are used when we required no current till we made the switch ON and again it can be made OFF by removing voltage source from the respective switch. A NO switch is represented as following symbol.

```
\[ \text{NORMALLY OPEN} \]
\[ \text{SWITCH} \]
```

NORMALLY CLOSED:

A switch is said to be NORMALLY CLOSED when at off condition (i.e when voltage is not applied to the switch in PLC) is act as closed that is it allows the current to flow through it. When the voltage is applied to the switch it becomes open circuited. These type of switches are normally used when we need current at the coil in absence of input voltage. Example is emergency off switches which need to be on initially and should be off when switch is pressed i.e when voltage is applied. The circuit symbol is as bellow.

```
\[ \text{NORMALLY CLOSED} \]
\[ \text{SWITCH} \]
```
In PLC point of view the transition from ON to OFF or OFF to ON is done by applying 24V DC to the respective switch. The following diagram shows the switches ON and OFF conditions and OFF refers to withdraw of supply.

* In PLC BLUE at center of switch of both NO and NC represent close circuit of switch and absent of colour indicates open circuit.

* In LG PLC the number of digital switch is 24.

II) ANALOG SWITCH

As the name indicates the analog switches are continuously varying switches. These switches are the combination of sensor output and comparator circuit. Analog switches are used when a device (heater, valve) has to be turned on or off with respect to the set value of continuously varying parameters (temperature, pressure etc.).

WORKING PRINCIPLE:

It is the series combination of sensor output and comparator circuit. The continuously varying parameter is measured and the conditioned output is provided to the comparator whose one set point is provided previously by programmer. As per the sensor output comparator gives output + Vcc or –Vee (ON/OFF). The diagram bellow represents the normal notation of temperature regulated analog switch and analog switch define by KGL software.

There are two analog switches in the LG PLC. One varies with current (0 to 20 ma), switch number ‘D4980’ and other varies with voltage (0 to 10 V), switch number ‘D4981’.

- NORMALLY OPEN TEMPERATURE SWITCH

- MEASURED VALUE

- ANALOG SWITCH DEFINED BY LG - KGL SOFTWARE
To insert a analog switch in KGL software go to the applied instruction (F10) option.

A window will appear and a comparison sign is inserted.

Two analog switches ‘D4981’ current switch and ‘D4980’ voltage switch is available and we can choose any one foe the operation.

The set point is inserted after it and ok button is pressed.

**Adjusting the setpoint:**

The range of analog input variable linearly varies from 0-4000 units, in which for voltage change it varies from 0-10 volts and in case of current circuit it varies from 0-20mA. 4000 is analogous to 10 volts in voltage circuit and 20mA in case of a current circuit.

2 – **TIMER**

Timer is the electronics device which introduced delay in the circuit. In analog timers, when the supply is given it start its countdown from a preset value set by the user. When the countdown reaches zero the output of timer becomes high. An analog timer uses the IC 555 for its operation. Analog timer only provides delay after the supply is given to it but timers in PLC provide more flexibility to the programmer. Following types of timers are available in PLC:

1. **ON DELAY** – countdown starts when supply is ON and timer is ON when countdown becomes zero. If timer is made OFF output is OFF.

2. **OFF DELAY** – Timer is ON when the supply is ON and countdown start when the supply is made OFF and timer is OFF when countdown reaches zero.

3. **RETENTIVE TIMER** – It is same as ON DELAY timer except that once the output is ON by the timer switching OFF the timer does not affect the output. To OFF the output the timer should be reset by setting high the reset switch.

4. **PULSE TIMER** – Output is ON as soon as the timer is ON and countdown starts. As soon as the timer reaches zero output becomes OFF. Anytime timer is OFF output becomes OFF.

5. **EXTENDED PULSE TIMER** – It is same as pulse timer but if once the timer is ON countdown starts OFF of the supply doesn’t affect the output.

KGL-WIN provides only ON & OFF delay type of timer from above list. To insert a timer to the ladder diagram following procedure must be followed:

- Select the portion where the timer us to be inserted
- Go to the application instruction option on the tool bar or press F10.
- A new window will open with device, variable and comment option.
- Enter the device name as follows- TIMER TYPE’’’ TIMER NAME’’’ SET VALUE’’’
- If necessary fill the other two options but it is not mandatory.
- Then the timer will appear and you can use the timer NO/NC switch anywhere in the ladder diagram in its timer name.

*It is the type of timer available in that software i.e TON or OFF
** It is the timer name must start with ‘T’ followed by a number starting from 0.
*** Set value is given in milliseconds and multiplied by 1000 during input

**DIAGRAM OF ANALOG AND PLC TIMERS**

3- COILS

Coil represents the output of the PLC. When current reaches the coil by any means the coil become ON. In the PLC the coils are numbered as ‘P0040’ to ‘P0060’. When a particular coil is made ON (e.g P0040 named motor) then 24V DC appear at that output port (at P0040).

The same name of the coil is used for the switch purpose i.e when the coil is actuated transition in the switch is occurred.
4- MEMORY BIT

In PLC a bit of memory is use for intermediate switching. It acts both as coil and switch. When it act as coil it store the status about the output that is high or low simultaneously the same memory which is used as switch change its status (NO/NC) according to the memory coil.

<table>
<thead>
<tr>
<th>MEMORY COIL</th>
<th>MEMORY NO SWITCH</th>
<th>MEMORY NC SWITCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>CLOSE</td>
<td>OPEN</td>
</tr>
<tr>
<td>LOW</td>
<td>OPEN</td>
<td>CLOSE</td>
</tr>
</tbody>
</table>

KGL provide 8bit memory i.e 256 numbers of memory switches are possible. Its switch selection and coil selection in the program is same as the selection of digital switch and coil respectively. The only difference is both the coil and switch has same name. The name is given as ‘M’ then number of memory start from zero. e.g M0002

![A MEMORY COIL](image1)

![ITS NC SWITCH](image2)

**STEP TO OPEN A PROJECT**

Different brand of PLC use different software. As we are using LG-K120S PLC and KGL software so we discuss about KGL software only.

**OPENING A PROJECT**

- Double-click KGL_WE.exe file to run KGLWIN.
The Start-up Screen will be shown as below. To create a new project, select Project- New Project... in the Start-up Screen.

Select Blank Project in the dialog box and click OK button.

In the following dialog box will appear, type in PLC Type, Programming Language, Title, Company, Author and Description.
• Select MK_S and 120S in the above dialog box.
• Click OK button. Then, Project, Message and Program Windows are displayed automatically.

**CREATING A LADDER PROGRAM**
In this heading we discuss how to create a program so we only concentrate on program window.

- A tool bar and a view bar are present at the top of the program window to easy access to the parameters.
- After selecting the Normally Open Contact icon in the Ladder Tool Bar, Move the cursor to the place to insert the contact.

- Click the left button of the mouse or press Enter key, then the contact input dialog box appears.
- Type in the contact name(M0000) you want to insert and click OK button or press Enter key.

- Select the Output Coil icon in the Ladder Tool Bar and move the cursor to the next column of M000.
• Click the mouse button or press Enter key.

![Ladder Editor Box (Output Coil)](image)

• Type in the Output Coil (P040) and click OK button or press Enter key.

![Program (New Project!)](image)

• After inserting required switches and coil an ‘END’ command has to be inserted this shows the end of the program.
• ‘END’ is inserted from the applied instruction.
• Select Run ( ) Mode in Online - Change Mode menu.
• To examine the program and parameters stored in PLC are the same one of KGLWIN, select Online-Verify menu. Then, the following message box will appear. Click OK button to verify.
• Click OK button to start verifying. If you want to stop verifying, click Cancel button.

• Connect, Download, Run and Monitor Start above Functions at one time by clicking the Connect+Download+Run+Monitor Start button in the Pull-down menu. Then following box will appear.

**FLOW CHART:**
PROGRAMING

All industries use push button for switch ON and OFF purpose. As push button provides momentary contact thus a concept of latching comes under play. In the concept of latching the NO switch of the memory or coil is connected parallel to the NO switch of the push button. So that when momentary contact is made the current flows to the coil and the coil switch become NC providing a parallel path to current, though the push button is released the output doesn’t OFF. An emergency push button has to be provided before the earlier bush button which is a NC provides supply till it is not pressed. Once emergency push button is pressed it discontinue the supply to the coil and the coil switch change its status to NO so the whole system shutdown. At the beginning an emergency stop push button and a start push button with latching is used for turn on and turn off the whole system.

As per the flow diagram the pump should be made on when water level sensor does not sense water and the pump should made on for 50 seconds more after level sensor sense water. If during turn on of the system, the sensor sense water the pump does not start. The motor starts only if the water is below level sensor. For above logic a NC of the level switch is connected to
the motor coil. Again same NC switch of level sensor is connected to an OFF TIMER of delay 50 seconds. The NO of timer switch is connected parallel to pump coil. So when level sensor doesn’t sense water due to NC contact of level switch the pump coil is actuated. So output of 24 V DC is generated from output port which is used to run a pump through relay. Due to increase in water level at a time water will reach the level sensor and 24 V appear at the input port which make NO of the level switch but a off timer is connected so that it delay the off of the timer switch connected parallel to pump coil. So the pump will run for more 50 milliseconds. As the timer expired, the timer switch turned off causing the pump to turn off through relay.

The flow diagram shows that the heater should turn on 5 seconds after the pump is off for safety purpose. An also the temperature should in between 90 to 110 degree (sufficient to form steam) and water level should above level sensor. As temperature is continuous varying parameter the output of temperature sensor is connected to PLC analog input port. We select the current port as LM35, the temperature sensor varies linearly with current. One analog switch with lower limit and other switch of same name but with upper set point is connected differently to two memory coils. NO of lower set point switch and NC of upper set point switch is connected to heater coil. So that when sensor sense temp. less then lower value NO of memory switch change its state while NC of upper set point provide the current continuity. While the upper set point is reached the memory coil is actuated and the NC of memory switch becomes NO and it discontinues the connection. Mean while the NC of an off timer connected to pump output is connected series to the heater coil. A NO of the level switch conform water is available. A protection switch NC is connected to sudden turn off of the heater. A memory coil is connected to the protection switch and a recovery switch NO is connected parallel to memory coil and the memory switch is connected series to the heater coil. So a lot of protection should be taken before connection.

The pressure valve is actuated as per the set value of pressure sensor. Pressure is also continuous varying parameter so the pressure sensor output is connected to analog switch operated on voltage output. The set point is calculated as per the capacity of container, force required to rotate the turbine. The voltage switch is connected to a memory coil which is turned on when the pressure reached the set value. The memory switch directly turns on the valve. A protection switch is designed as stated above for heater for emergency exit of steam.

Combining all above logic the whole ladder diagram for boiler automation can be done.

*At the end ‘END’ instruction must be inserted.
** The run procedure must be followed strictly.

**LADDER LOGIC:**

The ladder program for the entire project is designed using the above mentioned procedure. This ladder program needs to be downloaded into the PLC CPU memory. Once it is done, each and every process henceforth is controlled automatically, apart from pressing the START push button or the EMERGENCY STOP button. The following step by step explanations will help in understanding the behavior of all the process undertaken.
B. HARDWARE:

DESCRIPTION OF SENSORS AND CIRCUITS USED:

1 – POWER SUPPLY UNIT

Every circuit and sensor required power to drive itself. So it is important to generate various value of power supply unit as per the requirement. Almost every sensor is designed to operate using DC power ranging between 5v-30v so it’s required to have a step down transformer to down convert the 230v AC to a lower value after which rectification is done using a rectifier. A stable DC can be obtained by by-passing AC through capacitor and stabilized it using 78XX or 79XX IC available in market.

OUR REQUIREMENT:

- LEVEL SENSOR 12 V DC
- TEMPERATURE SENSOR 0-30 V DC
- PRESSUER SENSOR 0-16 V DC
- IC -12 v and 12v DC
- STEAM VALVE 12 V DC
- PLC OPERATION 0-24 V DC
- LED 5V DC
- TRANSFORMER 230 V AC
- MOTOR 230 V AC
- HEATER 230 VAC

As 230V AC can be directly used from household supply in order to design the power supply unit for DC power supply of 5V, 12V, 24V & (-)12V which are sufficient to satisfy all our requirement.

A transformer of 12V-0-12V is sufficient to derive all above power supply. A rectifier circuit contains a bridge network of diodes for rectification. Here we implement bridge rectifier for rectification purpose. The output of rectifier is not purely DC so a capacitor is used to bypass any remaining AC component, to ground. A voltage regulator IC is available to generate constant and stabilized output. Following are the stabilizing ICs and their respective stabilized output voltages:-

- IC 7805 for 5V
- IC 7812 for 12V
- IC 7824 for 24V
2 - LIQUID LEVEL SENSOR

Most of the sensors placed inside the water cause electrolytic reaction between liquid and sensor causing loss of effectiveness. One solution to this problem is to ensure an AC potential rather than DC potential between the electrodes. The constant reversal of electrode polarity drastically inhibits the electrolytic process so that corrosion is considerably reduced and effectiveness doesn’t hampered.

In this liquid level sensor AC is generated by an oscillator by connecting a capacitor (C1) to the input of IC4093 (a NAND) gate and proving a feedback through the resistor (R1). This AC current is given to the capacitor (C4) to charge up through the AC coupled capacitors C2 and C3. Between C2 and C3 two sensor electrodes are placed so that when the liquid touches the electrode, a conducting path is being created by the liquid so that C4 can be charged. Two diodes D1 and D2 provide blockage to discharge capacitor C4. This high input of the charged capacitor C4 is given to the IC4093 whose output is used to drive the base of transistor BC557. A relay is connected to ground through BC157. As the transistor is driven by IC4093 which drive relay in and the 230 volt ac output of relay is used to drive the motor.
3- PRESSURE SENSOR

The MPX10DP series devices are differential pressure silicon piezoresistive pressure sensors providing a highly accurate and linear voltage output, directly proportional to the applied differential pressure. The sensor is a single, monolithic silicon diaphragm with the strain gauge and a thin-film resistor network integrated on-chip. The chip is laser trimmed for precise span and offset calibration and temperature compensation.
The figure beside illustrates the differential or gauge configuration in the basic chip carrier, a silicone gel isolates the die surface and wire bonds from the environment, while allowing the pressure signal to be transmitted to the silicon diaphragm. Freescale designates the two sides of the pressure sensor as the Pressure (P1) side and the Vacuum (P2) side. The pressure (P1) side is the side containing the silicone gel which isolates the die. The pressure sensor is designed to operate with positive differential pressure applied, P1 > P2. The maximum pressure MPX10DP can measure linearly is 10 kPa (1.45 psi) and operating temperature of -40°C to +125°C and gives an output of 35mv of full scale span.

The pin configuration is mentioned in the following table:

Note: Pin 1 is the notched pin.

The other characteristics are mentioned in the following table:

<table>
<thead>
<tr>
<th>PIN NUMBER</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin Name</td>
<td>Gnd</td>
<td>+Vout</td>
<td>VS</td>
<td>-Vout</td>
</tr>
</tbody>
</table>

### MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure(P1&gt;P2)</td>
<td>P&lt;sub&gt;max&lt;/sub&gt;</td>
<td>75</td>
<td>kPa</td>
</tr>
<tr>
<td>Burst Pressure(P1&gt;P2)</td>
<td>P&lt;sub&gt;burst&lt;/sub&gt;</td>
<td>100</td>
<td>kPa</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>T&lt;sub&gt;stag&lt;/sub&gt;</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>T&lt;sub&gt;A&lt;/sub&gt;</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
</tbody>
</table>

### OPERATING CHARACTERISTICS (V<sub>GS</sub> = 3.0 Vdc, T<sub>A</sub> = 25°C unless otherwise noted, P1 > P2)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential Pressure Range</td>
<td>P&lt;sub&gt;OP&lt;/sub&gt;</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>kPa</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt;</td>
<td>5.0</td>
<td>3.0</td>
<td>6.0</td>
<td>Vdc</td>
</tr>
<tr>
<td>Supply Current</td>
<td>I&lt;sub&gt;0&lt;/sub&gt;</td>
<td>0.0</td>
<td>6.0</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Full Scale Span</td>
<td>V&lt;sub&gt;FSS&lt;/sub&gt;</td>
<td>20</td>
<td>35</td>
<td>50</td>
<td>mV</td>
</tr>
<tr>
<td>Offset(4)</td>
<td>V&lt;sub&gt;off&lt;/sub&gt;</td>
<td>0</td>
<td>20</td>
<td>35</td>
<td>mV</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>∆V&lt;sub&gt;Idi&lt;/sub&gt;</td>
<td>3.5</td>
<td></td>
<td></td>
<td>mV/kPa</td>
</tr>
<tr>
<td>Linearity(5)</td>
<td></td>
<td>-1.0</td>
<td>1.0</td>
<td></td>
<td>%V&lt;sub&gt;FSS&lt;/sub&gt;</td>
</tr>
<tr>
<td>Pressure Hysteresis(5) (0 to 10 kPa)</td>
<td></td>
<td>±0.1</td>
<td></td>
<td></td>
<td>%V&lt;sub&gt;FSS&lt;/sub&gt;</td>
</tr>
<tr>
<td>Temperature Hysteresis(6) (−40°C to +125°C)</td>
<td></td>
<td>±0.5</td>
<td></td>
<td></td>
<td>%V&lt;sub&gt;FSS&lt;/sub&gt;</td>
</tr>
<tr>
<td>Temperature Coefficient of Full Scale Span(5)</td>
<td>TC&lt;sub&gt;FSS&lt;/sub&gt;</td>
<td>-0.22</td>
<td></td>
<td>-0.16</td>
<td>%V&lt;sub&gt;FSS&lt;/sub&gt;/°C</td>
</tr>
<tr>
<td>Temperature Coefficient of Offset(5)</td>
<td>TC&lt;sub&gt;off&lt;/sub&gt;</td>
<td></td>
<td>±15</td>
<td></td>
<td>µV/°F</td>
</tr>
<tr>
<td>Temperature Coefficient of Resistance(5)</td>
<td>TC&lt;sub&gt;R&lt;/sub&gt;</td>
<td>0.21</td>
<td>0.27</td>
<td></td>
<td>%R&lt;sub&gt;rel&lt;/sub&gt;/°C</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>Z&lt;sub&gt;In&lt;/sub&gt;</td>
<td>500</td>
<td>550</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>Z&lt;sub&gt;Out&lt;/sub&gt;</td>
<td>750</td>
<td>1250</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Response Time(10% to 90%)</td>
<td>TR</td>
<td>1.0</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>Warm-Up</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>Offset Stability</td>
<td></td>
<td>±0.6</td>
<td></td>
<td></td>
<td>%V&lt;sub&gt;FSS&lt;/sub&gt;</td>
</tr>
</tbody>
</table>
The above circuit was used to obtain the differential output from the pressure sensor and amplify it using an opamp to a level suitable for further processing and hence can be applied to the PLC. In the project the pressure sensor is connected to the voltage terminal (AI-0) on the PLC input panel.

4- TEMPERATURE SENSOR

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

Features:

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1/4°C typical
- Low impedance output, 0.1Ω for 1 mA load

Absolute Maximum Ratings:

- Supply Voltage +35V to −0.2V
- Output Voltage +6V to −1.0V
- Output Current 10 mA
- Storage Temp. TO-220 Package −65°C to +150°C
- Lead Temp. TO-92 and TO-220 Package,
The output (current of mA range) of the LM35 temperature sensor is directly fed to the current input terminal (AI-1) of the PLC. No additional amplifier circuit is required as the PLC accepts current inputs of 4mA – 20mA range.

5- LM78XX SERIES VOLTAGE REGULATORS

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. The main objective of using these regulators is to provide a stabilized voltage power supply to the sensors despite the voltage fluctuations within the specified range. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Voltage Range:

- LM7805 5V
- LM7812 12V
- LM7815 15V
- LM7824 24V

Absolute Maximum Ratings:

- Input Voltage (for VO = 5V to 18V) 35V.
- (For VO = 24V) 40V.
- Thermal Resistance Junction-Cases (TO-220) 5 –C/W.
- Thermal Resistance Junction-Air (TO-220) 65 –C/W.
- Operating Temperature Range 0 ~ +125 –C.
- Storage Temperature Range -65 ~ +150 –C.

The above power supply circuit utilises an IC7812 so as to provide a stabilized 12V supply to the load connected across its output terminals.

6- BOILER CONTAINER DESCRIPTION:

The boiler container used in the project has the following dimension:
Height: 12 inches (30.48 cm)
Diameter: 10 inches (25.4 cm)
Thickness: 3 mm
Container Material: Mild steel

The following diagram shows the signal inputs/outputs as well as the outlet/inlet for water and steam.

### 7- HEATER DESCRIPTION:

The heater used in the boiler heating process are immersion type heaters.

Power: 1000 watts
Input supply: 230 v ac.
Quantity: 2 units.

Immersion type of heater are used to avoid any current to flow through the container & water.

It takes about 45 mins to raise the temperature to boiling point.

### 8- MOTOR DESCRIPTION:

A immersion motor was used in the project.

Power: 45 watts.
Input supply: 230 v ac.
The motor takes about 50 sec to fill the boiler container.

**9- PRESSURE VALVE:**
Pressure valve is used to exit the extra pressure when the pressure exceeds the maximum pressure. It measures a pressure from 0 to 15 psi. It takes 12volts input for actuating & has high current requirement.

**PROCEDURE:**

1. The software was opened and the ladder diagram was drawn.
2. Power supply to PLC and the Circuit board was given.
3. The ladder logic was downloaded into the plc memory.
4. Then the start button was pressed.
5. Then the specified operation i.e. level, pressure & temperature control were carried out based on the ladder logic diagram.
6. The operations were monitored whether the it is according to the flowchart.
7. In case of emergency due to any fault the emergency stop button was pressed to stop the whole process.

**OPERATION:**

Initial assumptions:

1. Water level is below lower level sensor.
2. Temperature is normal room temperature.
3. Pressure is normal.
4. Start button is open.
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1. As water level is below lower level so both the sensors are on.

2. The heater is off as water level is below lower level sensor.
1. After start button is pressed on the motor starts & continues till water reaches upper level sensor.

2. There is a latching between motor & lower level sensor so even after lower level sensor is off the motor continues to run.

1. Then after the water level reaches upper level, the motor stops & motor timer starts.

2. The timer is provided to keep a time gap between the motor stop & heater on if temperature is low to avoid loading effect.

3. After a specified time delay the heater starts & continues till temperature reaches upper level.

4. If the water level goes below lower level then the heater goes off & the heater timer starts to maintain a delay.
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