International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08 | Aug 2019 www.irjet.net p-ISSN: 2395-0072

FURNACE TEMPERATURE INDICATOR CUM CONTROLLER

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Abstract - *The requirement to maintain temperature within narrow range is dealt with in this project. The temperature of the furnace is controlled within the specified temperature range by switching on and off the heater coils of the furnace. A temp indicator and over temp and under temp alarm is also provided. Older systems use thermostat or thermocouple to sense the temperature. In case of thermocouples, the voltage generated per ^{0}c is very low and needs amplification whereas in case of thermostat, the temperature Vs resistance characteristics is non linear. More advanced semi conductor temperature sensor (LM35) is used to detect the temperature inside the furnace.LM35 gives 10mv output per degree °c change of temperature. This property is used to detect the actual temperature and to indicate the same. This project deals with his aspect of the industry.*

Key Words: Transformers, Rectifier, LM35 (Sensor), Resistors, Capacitors, thermostat, temperature, thermo couple.

1. INTRODUCTION

The most reliable and widely used lab furnaces available today offer rapid heating and cooling rates uniform temperature control, compactness, and sturdy construction for long term use. Configurations are available for virtually any requirement with four basic configurations including front and bottom loading box furnaces, horizontal and vertical tube furnaces. Gas sealed systems, thermal cycling systems, as well as custom designs and specialized control systems are possible. The furnaces generate incorporate a graded insulation package using high purity alumina fiber. Due to the low thermal conductivity and light weight of this insulation extraordinary fast thermal cycling is possible. These furnaces will not hot spot at high temperatures and are resistant to degradation.

The double wall shell construction allows the fan cooling feature to maintain reduced skin temperatures while keeping the element terminals cool, extending element life. Kanthal Super 1800 molydisilicide heating elements are used, offering fast heat up rates and long life in oxidizing atmospheres. These elements are not subject to normal watt loading limitations and are not affected by thermal shock; therefore heat-up rates are only limited by the capability of the power supply. The electrical resistivity of these elements remains constant over long periods without aging so that individual elements can be replaced without having to match resistance values.

1.1 Basic type Temperature sensors

Temperature is defined as the energy level of matter which can be evidenced by some change in that matter. Temperature sensors come in a wide variety and have one thing in common i.e., they all measure temperature by sensing some change in physical characteristics.

The seven basic types of temperature sensors to are thermocouples, resistive temperature devices (RTDs, thermostats), infrared radiators, bimetallic devices, liquid expansion devices, and molecular change-of-state and silicon diodes. In this, we are using LM35 is used as a temperature sensor.

- **LM35:**

The IC LM35 is used as a temperature sensor. This temperature sensor senses the surrounding temperature and gives the output in terms of milivolt. For every 1^0 C of change in temperature it gives a change of 10 mill volt in its output. The change is directly proportional to temperature variation. Comparators are used to compare the temperature inside the furnace. Since LM 35 gives output directly in volts, reference temperature which is to be maintained can be set in terms of reference voltage. When temperature inside the furnace crosses the reference temperature, the comparator output changes switching off the heaters. Control of furnace temperature is the major prospect in most of the industries. To control this temperature we have to use a control circuit which obtains the value of temperature in terms of voltage. Thus conversion of temperature into voltage can be done by temperature sensors.

- **Thermostat:**

There are different types of temperature sensors one of which is thermostats. The thermostats convert the temperature into some resistance, whenever there is an increase in temperature the resistance value of a thermostat decreases and when there is a decrease in temperature the resistance value increases. Thus thermostat is called to be NTC (Negative Temperature Coefficient).

- **Resistance Thermal Detector:**

Another type of temperature sensor is RTD (Resistance Thermal Detector). This works on the principle of see back effect. The principle is that it has two different junctions one is hot junction and another is cold junction. Whenever there is any increase of temperature near the hot junction (also called as measuring junction) this creates change in emf of the device.

2. BLOCK DIAGRAM

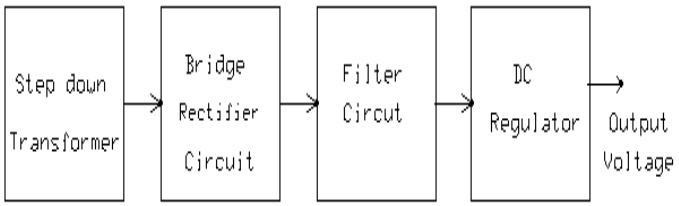

Fig- 2.1: Block diagram for power supply

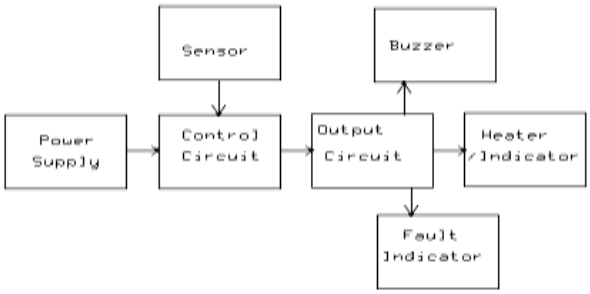

Fig-2.2: Block diagram for Main panel

3. CIRCUIT DIAGRAM

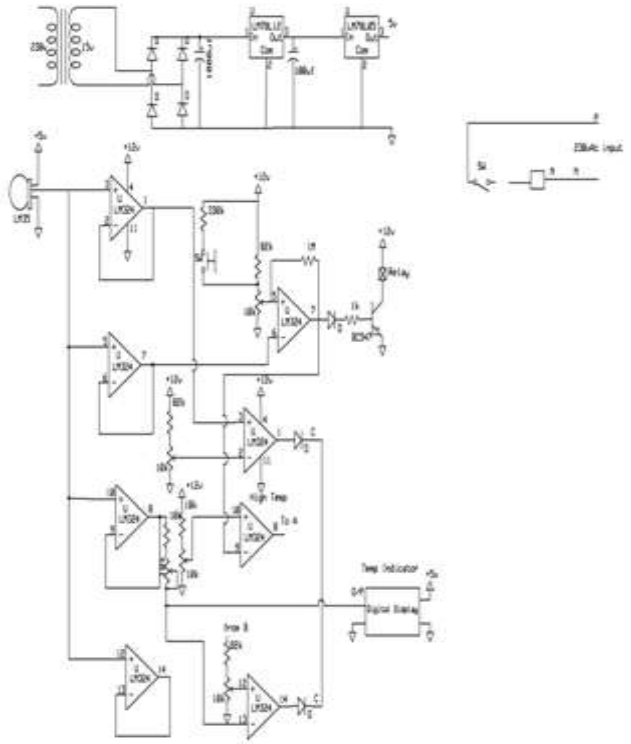

Fig- 3.1: Circuit diagram for power supply

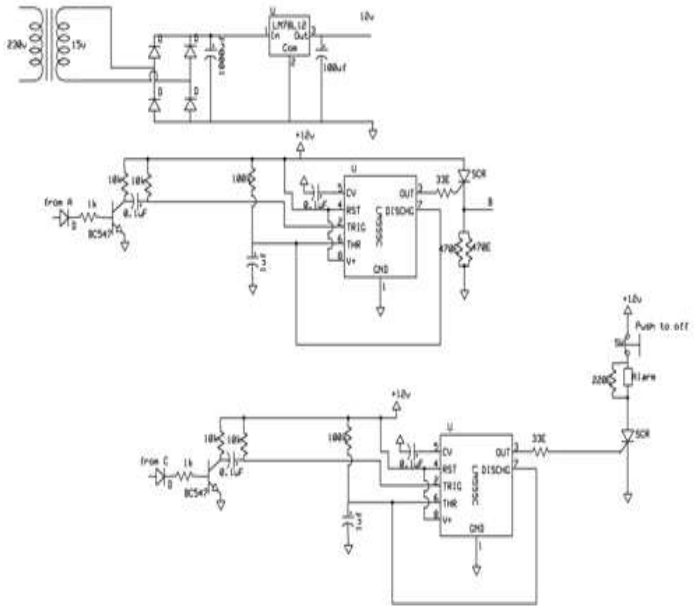

Fig- 3.2: Circuit diagram for Regulators

4. CIRCUIT EXPLANATION

The circuit can be divided into following sections

1. Power supply
2. Sensor circuit
3. Control circuit
4. Alarm circuit
5. Temperature indicator circuit

1. Power Supply: There are two separate but almost identical power supply circuits except that while one of the power supplies contains one additional 5 volt regulator and other one has additional filter capacitor of 1000 microfarads.

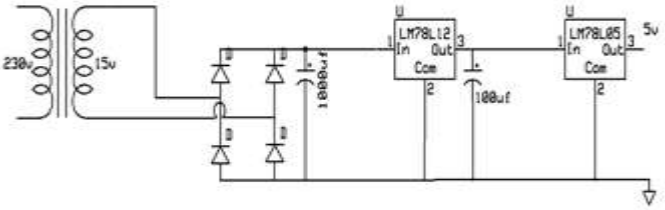

Fig- 4.1: Circuit diagram for Power Supply

Input voltage from transformer is fed to bridge and the rectified voltage is then filtered by 1000 microfarad capacitor. This is fed to three pin voltage regulator IC 7812 which gives 12 volt regulated output voltage which is required for operation of the circuit. An additional three pin regulator IC 7805 provides 5 volt regulated output for operation of Digital display which is used to indicate temperature inside the furnace.

2. Sensor Circuit: Sensor circuit consists of IC LM 35 which is a three terminal IC which gives 10 milivolt output per degree centigrade change of temperature. IC is supplied with 5 volt input supply and output of the IC is connected to all non inverting inputs of IC LM 324 which is quad op – amp in one single package. Output pins of the amplifiers are connected to inverting input to get buffered outputs to avoid loading the IC LM 35. These outputs are used in the control circuit.

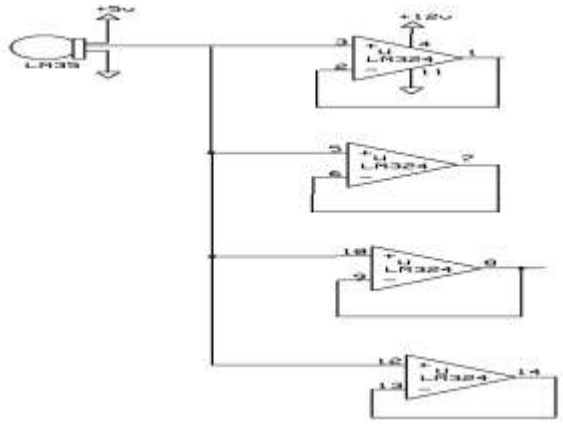

Fig- 4.2: Circuit diagram for Sensor Circuit

3. Control Circuit: Control circuit consists of one LM 324 IC which is a quad op- amp used as comparator. Buffered outputs from LM 35 are connected to pin no's 6, 13, and 3 of LM 324.

Reference voltages generated from potential dividers consisting of 82 K ohms and 10 K potentiometers are connected to pin no's 5, 2 and 13 of the IC. Output pin 7 is connected to the base of transistor BC 547 via a diode and resistor series combination. A resistor is connected between pin 7 and 5 to generate small amount of hysteresis. When transistor is on, it switches on the relay which in turn connects the heater to mains supply.

Output pin 7 is also connected to pin 9 of the IC. Output pin 1 is connected to a diode which is connected to the base of transistor BC547 (point A) in the alarm circuit.

Control circuit also includes an IC 555 timer circuit output pin 3 of which is connected to SCR TYN 612. Cathode of the scr is connected to series combination of 82 kilo ohms and 10 K potentiometer which act as reference for low temperature condition.

4. Alarm Circuit: Alarm circuit consists of IC 555 timer circuit wired as short duration pulse generator whenever pin 2 momentarily goes below 1/3 rd VCC. Whenever furnace temperature goes higher or lower than preset higher or lower limits, transistor base of BC547 (point C) gets high signal from pin 1 or pin 14 of LM 324 in control circuit. This turns on transistor which momentarily grounds pin 2 of IC 555. Output pin 3 goes high triggering scr. Voltage is developed across parallel combination of 470 ohms resistors (point B) which are connected to series combination of 82 k ohms resistor and 10k Potentiometer.

5. Temperature indicator circuit: Temperature indicator circuit is nothing but a digital volte meter used to indicate temperature. It operates on five volt supply and input signal is given from a series combination 10k potentiometer and 1k resistor.

5. OPERATION OF THE CIRCUIT

When the supply is switched on output of pin 7 goes high as the preset temperature limit at pin no 5 is higher than ambient temperature. Relay is now on and heaters of the furnace get the supply. Temperature inside the furnace starts rising. The output of LM 35 also proportionally increases.

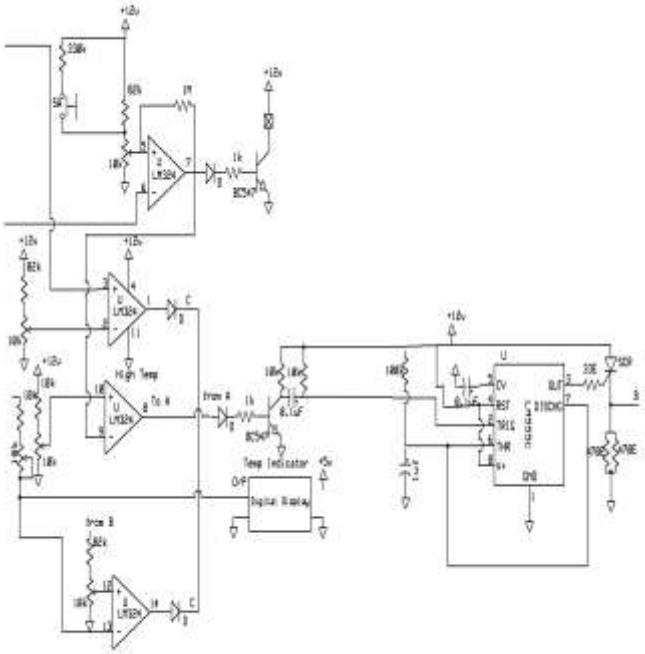

Fig- 5.1: Circuit diagram for Operation of Pins in Circuit

Since pin 7 is High output pin 8 is low hence pin 12 is at ground potential since there is no voltage available at point B. When temperature inside the furnace rises above preset value output pin 7 goes low turning off transistor, relay and heater off. Temperature inside the furnace starts falling. When it falls below the limit as decided by hysteresis resistor connected across pin 7 and pin 5, output pin 7 goes high turning heater on. This process repeats in normal condition of the furnace. When voltage at pin 7 goes low, output pin 8 goes high. Base of transistor connected to it (point A) is on which momentarily grounds pin 2 of IC 555 in that circuit to generate a gate pulse to fire SCR in the circuit. SCR conducts and voltage at point is high now. This gives

reference to pin 10 of the IC 324 to lower temperature alarm circuit.

Testing of alarm circuit: Alarm circuits can be tested in following manner- To test Higher temperature alarm, switched connected to pin 5 of IC is turned on. This raises the reference at pin 5. Hence the heater does not get cut off at previous limit and temperature inside furnace goes beyond previous limit. When voltage at pin 3 goes beyond pin 3 voltage (higher temperature limit) the output pin goes high which turns on transistor connected at point C triggering the alarm.

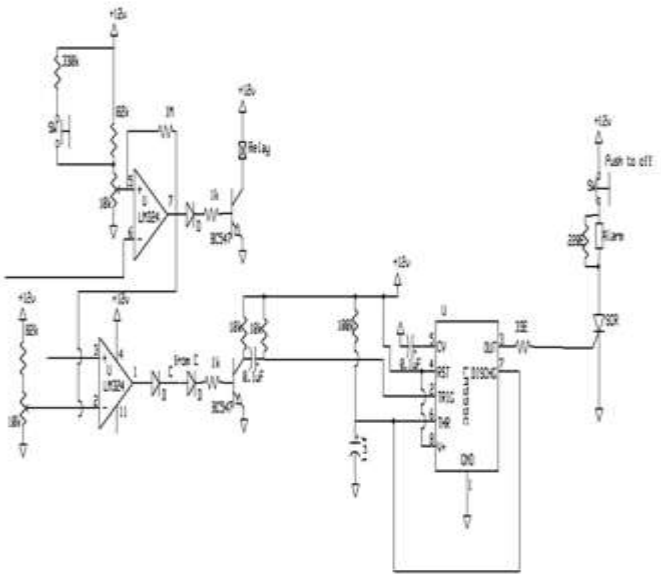

Fig- 5.2: Circuit diagram for Operation Alarm Circuit

Testing Lower temperature alarm point: Switch connected to pin 5 is turned off and normal operation of controller is restored. To test lower temperature alarm following procedure is adopted. When heaters are turned off when normal temperature is reached, the supply to heater is cut off so that heaters do not turn on again. The temperature inside the furnace starts falling. When voltage at pin 13 falls below that of pin 12 (lower temperature limit point), output pin 14 goes high turning on transistor connected to point C which momentarily grounds the pin 2 of IC 555. Pin 3 goes high to trigger SCR and activate alarm.

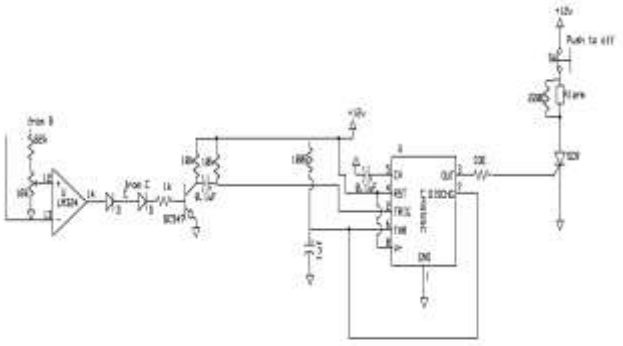

Fig- 5.3: Circuit diagram for Testing lower Temperature Alarm Point

6. RESULTS

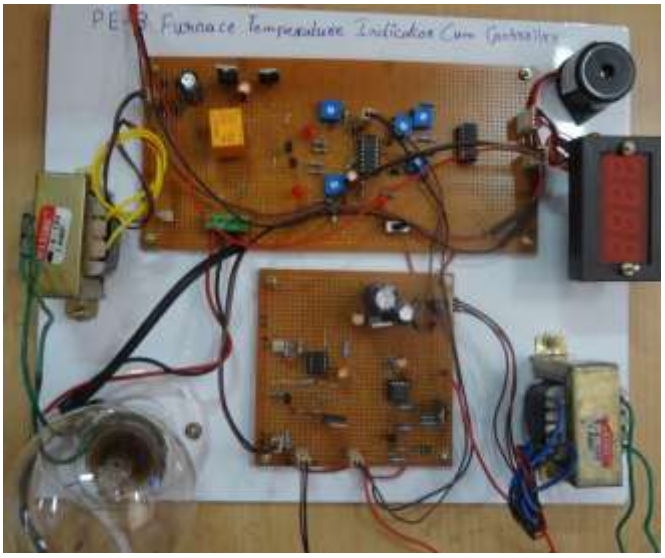

Fig- 6.1: Basic Indicator cum controller kit

Fig- 6.2: Indicator cum controller kit at switch on condition with sensor

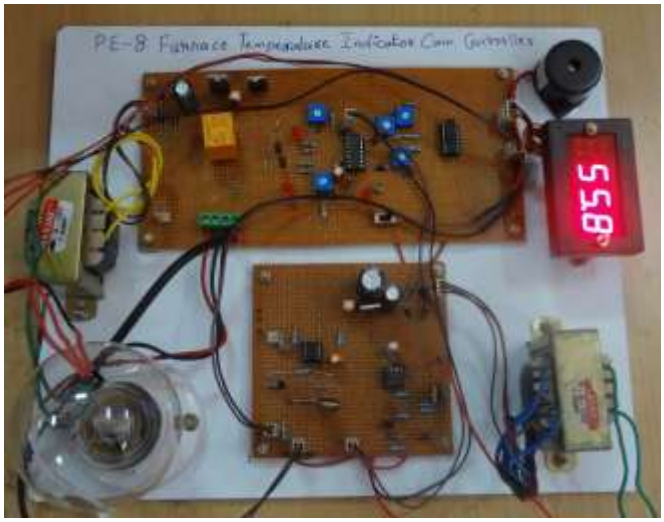

Fig- 6.3: Indicator cum controller kit at switch off condition automatically

7. CONCLUSION

The regulation of the furnace temperature in a certain range is successfully demonstrated in this project. Under and over temperature alarms are provided to stop the process immediately in order to prevent the losses that may occur due to rejection of material because of improper temperature conditions. This circuit scheme finds application in the charging of high performance silver zinc batteries which are extensively used in defense and aircraft installations. Hence, there is ample scope to carry out further development in this area.

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