Class: 4th Stage
Subject: Control Lab
Lecturer:Dr.Essam Zuhair,Eng.Aceel Talib Hussain
E-mail: aceel.talib@mustaqbal-college.edu.iq

(Control laboratory)

Experiment No. 00(4)

(Comprehensive Training on the electronic temperature control system)

Prepared by
(Eng. Aceel Talib Hussain)

Exp.No.(4):- Comprehensive Training on The Electronic Temperature control system of Refrigerator

Training Objective:

1. To understand the circuitry of electric control system of electronic temperature controller in refrigerator.
2. The control principle of electronic temperature control circuit and functions of components in refrigerator.
3. To analyze the control flow of electronic temperature control circuit in refrigerator.
4. To understand the connection of peripheral circuit of electronic temperature control circuit in refrigerator.

Training Equipment:-

NO.	Name	Quantity	Remark
1	Training Evaluation Equipment for Air conditioner and Refrigerator Assembly and Commissioning	1	
2	Power and instrument modules	1	M280
3	Electric control module of air conditioner	1	M282
4	Multimeter	1	
5	Leads	10 or more	

Training contents:-

The electric control module of electronic temperature control in refrigerator uses the temperature control circuitry of TOSHIBA GR-204E refrigerator. Hereunder is further explanation on its basic circuit and working principle. The whole electrical

system is composed of power circuit, startup circuit of compressor, indicator working circuit and so on.

1. **Meaning of electronic temperature controller**: the control circuit of electronic temperature control refrigerator is composed of electronic components, but it doesn't adopt microcomputer control chip. The same as microcomputer controlled refrigerator, the temperature sensing elements of temperature controller also use thermistor.it is directly placed in appropriate position inside the chamber. When thermistor encounters with slight temperature variation inside the chamber, its resistance will vary accordingly. Hence, the voltage at the two ends of the resistor will vary to cause control circuit working, so as respectively control the start and stop of compressor. In this way, the temperature inside the refrigerator can be controlled. As this type of temperature controller uses a great many of electronic components, it is also known as electronic temperature controller.
2. **The chip used in the whole circuit includes 339 and 4011.**
3. **Startup circuit**: - the circuit principle as indicated in fig 6-1. As relay and LED require great current to start they cannot be directly driven by control signal. Therefore, control signal is used to control the saturation and close (equivalently the make and break of switch) and operate to start the action of relay and LED. Control signal is the no. 11 pin of NAND gate 4014 in the schematic diagram.

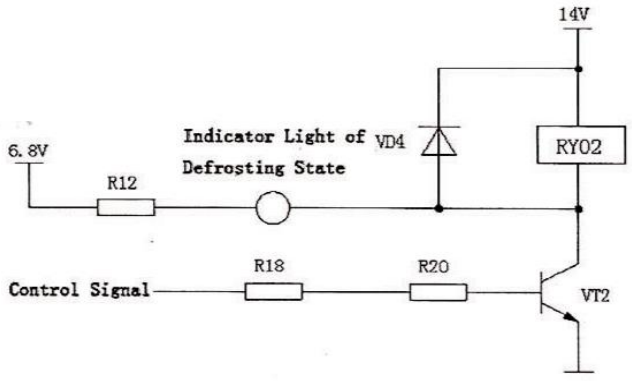

Fig. 6-1: Start-up Circuit

Class: 4th Stage
Subject: Control Lab
Lecturer:Dr.Essam Zuhair,Eng.Aceel Talib Hussain
E-mail: aceel.talib@mustaqbal-college.edu.iq

4. **Temperature control circuit of refrigerating chamber**: - the electronic temperature controller of TOSHIBA GR-204E refrigerator has adopted two different types of thermistor sensors, namely temp. Sensors of refrigerating chamber and temperature sensors of evaporator. The temperature in refrigerating chamber can be learnt by the temperature sensor in refrigerating chamber, thus to control the start and stop of compressor.

   (1) **Temperature detection circuit**. As indicated in Fig. 6-2, temperature detection circuit is composed of the temperature sensor in refrigerating chamber and resistor (R7) in series. By use of the temperature characteristic of thermistor, i.e. the lower temperature is ,the higher the resistance will be, the voltage (U_R) acquired on resistor (R7) will be lower, refer to table 8-1 for its temperature characteristic, when the temperature on sensor shows 30°,its resistance learnt from table 8-1 will be 2.16kΩ, here:

$$U_{R7} = \frac{10k}{10k + 2.16k} \times 6.8v \approx 5.59v$$

When the temperature of sensor shows 3.5°C, its resistance will be 6.7kΩ, here:

$$U_{R7} = \frac{10k}{10k + 6.7k} \times 6.8v \approx 4.07v$$

In this way by the use of the negative characteristic of sensor, the variation of temperature can be turned into the variation of voltage.

   (2) **Temperature regulation circuit** . as indicated in Fig.6-3, temperature regulation circuit is composed of R1,R2 and R3 resistors and R_w slider resistor. The slide resistor can be used to alter reference voltage (U_{R1}). This is the output signal of temperature regulation circuit used as the actuating voltage to stop the compressor.

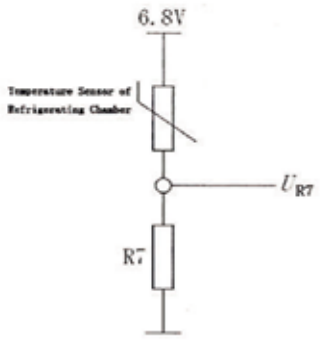

Fig. 6-2: Temperature Detection Circuit

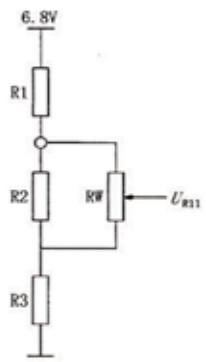

Fig. 6-3: Temperature Regulation Circuit

Table 1: Enquiry of Temperature Characteristics of Sensor

Temperature (℃)	Resistance (KΩ)	Temperature (℃)	Resistance (KΩ)
-30	39.39	1	7.58
-29	37.17	2	7.22
-28	35.07	3	6.89
-27	32.80	4	6.57
-26	31.26	5	6.28
-25	29.53	6	5.99
-24	27.90	7	5.72
-23	26.37	8	5.47
-22	24.94	9	5.23
-21	23.59	10	5.00
-20	22.10	11	4.78
-19	21.12	12	4.57
-18	20.00	13	4.37
-17	18.94	14	4.19
-16	17.95	15	4.01
-15	17.01	16	3.84
-14	16.13	17	3.68
-13	15.30	18	3.53
-12	14.52	19	3.38
-11	13.78	20	3.24
-10	13.08	21	3.11
-9	12.43	22	2.98
-8	11.81	23	2.86
-7	11.23	24	2.75
-6	10.67	25	2.64
-5	10.15	26	2.53
-4	9.66	27	2.43
-3	9.20	28	2.34
-2	8.76	29	2.25
-1	8.43	30	2.16
0	7.95		

5. Start up and close down control circuit of compressor

(1) **Close down detection circuit of compressor**. As indicated in Fig.6-4, in the control circuit of GR-204E refrigerator, the power comparator composed by chip LM339N operational amplifier, by comparing the output voltage U_{R7} and U_{R11} of the above two circuits (output of temperature detection cct U_{R7} and output of temperature regulation cct U_{R11})the working state of relay RY01 in refrigerating compressor can be controlled, in case of $U_{R7} > U_{R11}$ comparator will output U_1 high level, and the relay RY01 in '1' will remain the original state; in case of $U_{R7} < U_{R11}$, comparator will output u_1 low level, RS flip-flop in '0' will turn over, and relay RY01 will back out. R16 is a pull up resistor, which is the functional to raise the potential at the point of U_1 when U_1 outputs high level. U_1 output will reach the reset of RS flip-flop composed by 4011B (NAND gate), and control the start and stop relay RY01 of compressor.

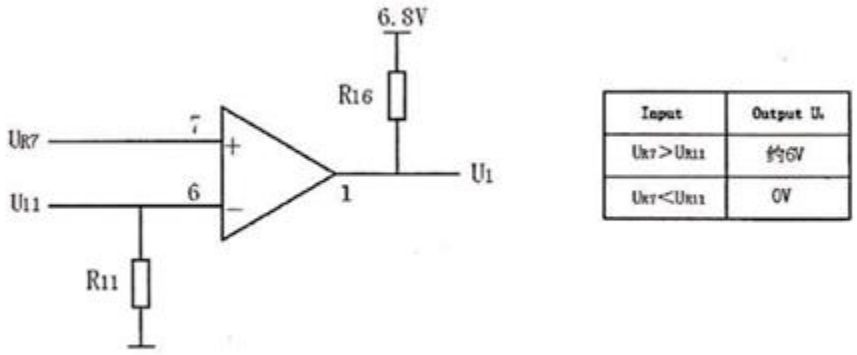

Fig. 6-4: Close-down Detection Circuit of Compressor

(2) **Startup temperature detection circuit**. As indicated in Fig.6-5, in the control circuit of GR-204E refrigerator, the power comparator composed by chip LM339N operational amplifier, by comparing the fixed voltage acquired by the above output of temperature detection cct U_{R7} and R8 andR9, the working state of relay RY01 in refrigerating compressor can be

controlled, in case of $U_{R7} < U_{R9}$ comparator will output U_2 high level, V1 terminal placed into '1', and relay RY01 powered on to work; in case of $U_{R7} > U_{R9}$, comparator will output U_2 low level, V1 terminal placed into '0' , RS flip-flop in '0' will remain the working state of relay RY01 unchanged. R15 is a pull up resistor, which is the functional to raise the potential at the point of U2 when U2 outputs high level. U_2 output will reach the reset of RS flip-flop composed by 4011B (NAND gate), and control the start and stop relay RY01 of compressor.

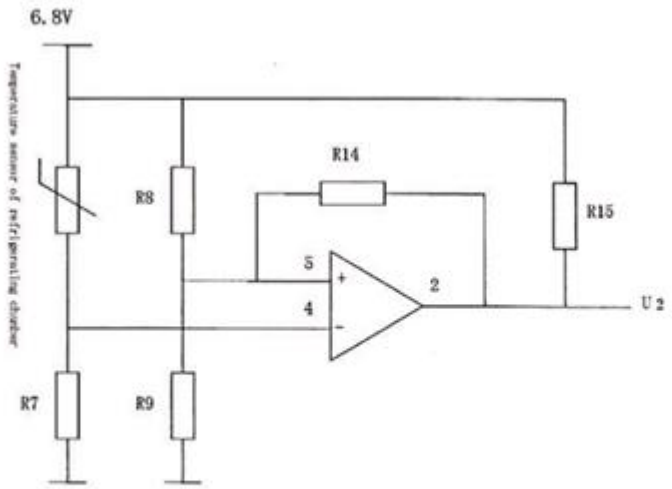

Fig. 6-5: Start-up Temperature Detection Circuit of Compressor

6. as indicated in Fig.6-7, connect the temperature sensor of refrigerating chamber , temperature sensor of evaporator, RY01,RY02-1 and RY02-2 at the output terminal of the hanging tank respectively to the numbers on the terminal block at the wiring area of training table, and then carry out commissioning and operating practice on the whole machine.

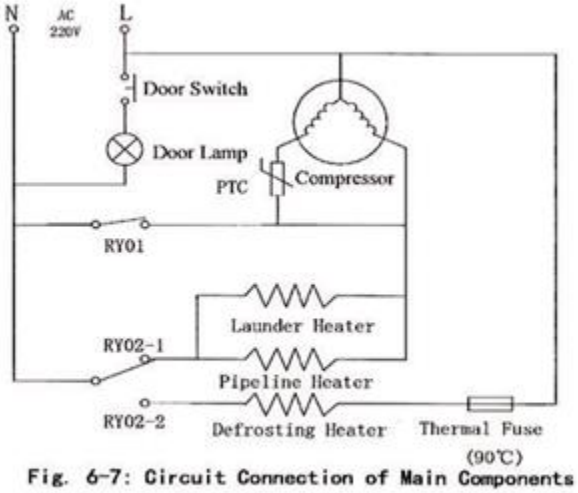

Fig. 6-7: Circuit Connection of Main Components

Discussion:-

- How many circuit does the trainer has? And what are they?
- What is the chip used in whole circuit?
- Temperature control circuit of refrigerating chamber divided into two circuits what are they, explain briefly with drawings?
- How does chip LM339N in Close down detection circuit of compressor work?
- In Temperature detection circuit when the sensor shows (-11oC), what is the output of (U_{R7})?