ELECTRONIC THERMOSTAT FOR FRIDGE

EM N. SHARMA TESTED

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Here is a simple and easy to build electronics circuit that would automatically turn ON and turn OFF your fridge at the two preset temperature extremes. Typically in a fridge, the temperature inside the deep freezer usually varies between -2^{0}C and -12^{0}C i.e. the fridge becomes ON when the temperature inside the freezer becomes -2^{0}C and it becomes OFF when the temperature reaches -12^{0}C. The extreme temperatures to usually provide in terms of numbers 1 to 9. In the thermostat circuit shown in Figure: 1, the two temperature extremes as well as difference between the two temperature extremes as well as the difference between the two temperatures, known as temperature hystersis, can be set independently with ease. This thermostat is certainly more precise and reliable.

Circuit Description

The AC mains voltage instead of going directly to input of automatic voltage stabilizer used with the fridge is routed through the normally open contact of the relay RL1. Obviously, the ON/OFF duty cycle of the fridge can now be controlled by controlling the closing or opening of the relay contact which in turn can be controlled from the relay coil. When the relay coil is energized which is the case when transistor (Q2) conducts or is turned ON, the relay contact is closed and the fridge gets AC power and starts cooling. The DC voltage required for operating the relay coil control circuitry (12V DC in this case) is generated from AC only by using a conventional AC/DC power supply arrangement of a step-down transformer (X1), a full wave rectifier (constituted by D1 and D2), a filter capacitor (C1) and a three terminal regulator (IC1). As there must always be a minimum of 3V differential between the input and the regulated output in a three terminal regulator to maintain regulation, we have used a 15-0-15 mains transformer to guarantee a regulated DC voltage for a mains voltage of 230V. The temperature control circuitry functions as follows:

IC2 is an op-amp comparator. It is basically a quad comparator and we are making use of one of the four-comparator circuits. It has been wired in the circuit as a voltage comparator with hystersis. The non-inverting input of the comparator is applied a reference voltage derived from a zener diode (ZD1). Resistor (R1) provides biasing current to the zener diode. The zener diode voltage is then divided by the potential divider arrangement

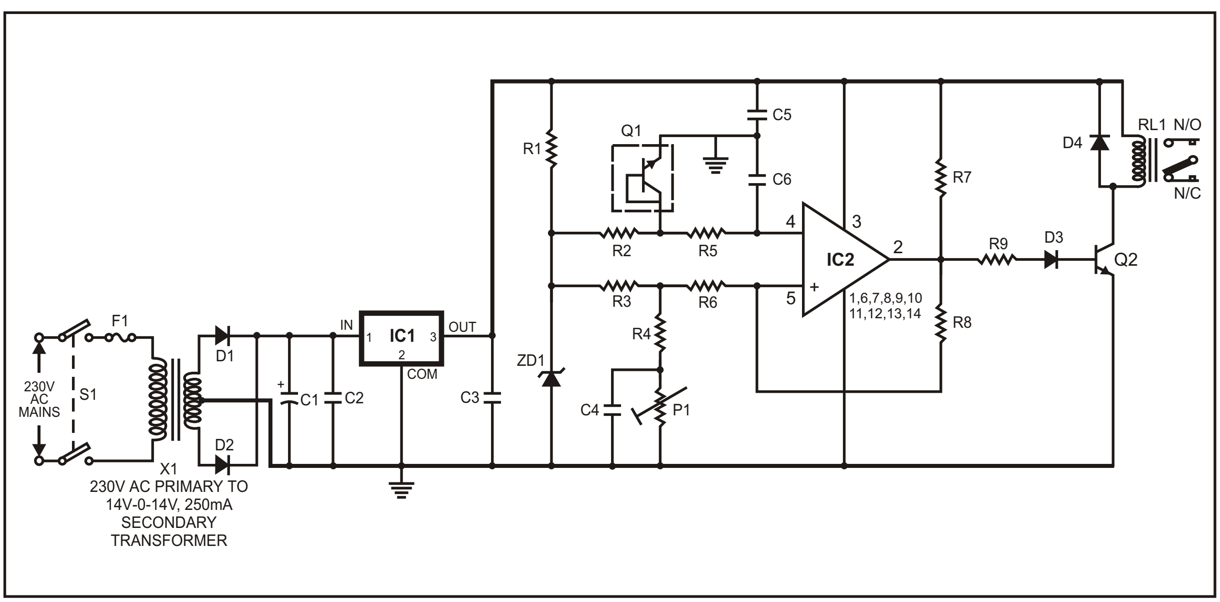

Fig.1: Circuit diagram of Electronic Thermostat For Fridge

provided by (R3), (R4) and (P1). Capacitor (C4) is decoupling capacitor to bypass AC noise if any. Between the inverting input and ground is connected the temperature sensor. The temperature sensor is nothing but a silicon NPN transistor with its collector shorted to its base. We are making use of the temperature dependent characteristic of the base emitter junction. You would remember that this junction voltage decreases by 2mV for every degree rise in the temperature of its body. Sensor fabrication and calibrations are discussed separately. Potentiometer (P1) is adjusted to set the reference voltage at a value equal to the sensor's junction voltage corresponding to less negative temperature of the two temperature extremes (-2^{0}C in our case). Now let us assume that the temperature inside the freezer is -2^{0}C or more negative than -2^{0}C but less negative than -12^{0}C. The voltage at the non-inverting input of the comparator, which is equal to the reference voltage (corresponding to a voltage equivalent of -2^{0}C) plus the fraction of the voltage fed back through potential divider (R8) and (R6). The feedback voltage in our case is 20mV whenever the comparator output is HIGH and zero whenever it is LOW. Now 20mV corresponds to a temperature change of 10^{0}C. Therefore, as long as temperature is less negative than -12^{0}C, the voltage at the non-inverting input is greater than that at the inverting input, the comparator output is HIGH, transistor Q2 saturates and the relay coil is energized. The fridge is ON. When the temperature tends to go low below -12^{0}C, comparator output goes LOW and the relay coil is de-energizes. The fridge is OFF. When the comparator goes LOW, the feedback voltage of 20mV vanishes and the voltage at the non-inverting input corresponds to a temperature of 2^{0}C. So, the temperature cycles between -2^{0}C and -12^{0}C. To summarize, the reference voltage setting (potentiometer P1) decides the less negative of the two temperature extremes whereas the temperature hystersis and subsequently the more negative of the two temperature depends upon the voltage divider arrangement formed by (R8) and (R6). If (T) is the temperature hystersis desired, then

T (in degrees) = 3000 R6/(R8+R6)

Sensor Fabrication and calibration

The sensor is fabricated by shorting the collector and base leads of transistor 2N2222 and bringing out two leads from the base collector common points and emitter. The sensor is mounted on the sidewall of the freezer with some epoxy (like araldite). The connections from the sensor to the circuit should be made with a shield cable or a twisted pair of wire if shielded cable is not available. The sensor leads should be fully insulated from each other and from the transistor body using some epoxy so that the water deposition on the sensor does not short the leads. Also, preferably, the sensor's metallic body should be housed in a ceramic block and the ceramic block should be affixed to the Freezer body. The sensor should be fitted in the ceramic block quiet tightly so there is complete thermal contact. Remember that ceramic is a very good thermal conductor and an electrical insulator.

The sensor can be calibrated by bringing it in full contact with ice water and at the same times biasing its base emitter junction at about 100uA using a series resistance and a suitable voltage. The junction voltage thus observed corresponds to a temperature of 0^{0}C. The junction voltage corresponding to any other temperature can then be determined from the figure of temperature co-efficient (-2mV/^{0}C).

SEMICONDUCTORS	
IC1	7812
IC2	LM339
Q1-Q2	2N2222
D1-D4	1N4001
ZD1	5.6V, 400mW
RESISTORS	
R1	470
R2	47K
R3	15K
R4	1K
R5	10K
R6	33K
R7,R9	3.9K
R8	10M
P1	1K, multy-turn trimmer
CAPACITORS	
C1	1000μf, 25V
C2-C5	0.1μf
C6	1μf (solid tantalum)
MISCELLANEOUS	
X1= 230V AC Primary to 14-0-14V, 250mA Secondary Transformer	
S1 mains power ON/OFF switch	
F1 fuse with holder, fuse rating 0.5A	

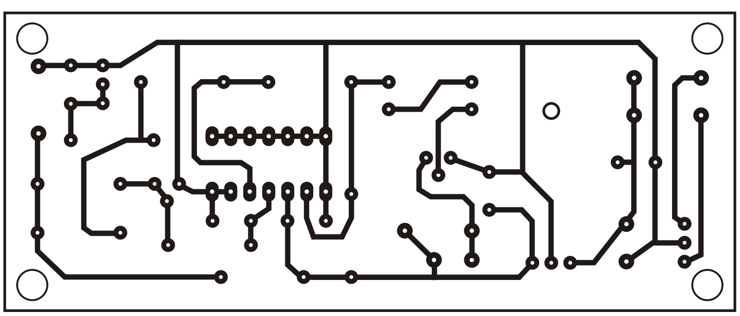

Fig.2: Actual size, solder-side PCB layout.

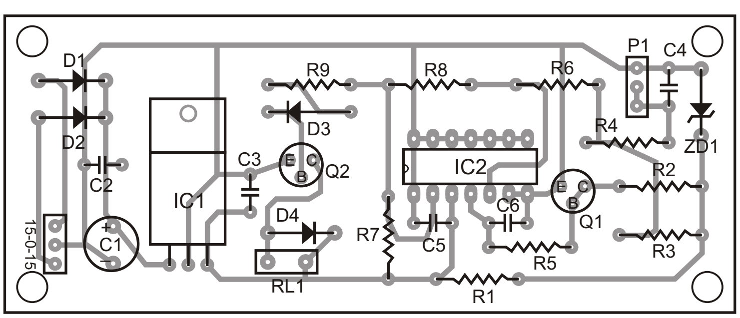

Fig.3: Component layout for the PCB.