Performance of an Automatic Switching Device at Temperature above 20°C.

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ABSTRACT

An automatic switching device with a remote control system has been designed and constructed to set a cooling system into operation when the ambient temperature is above 20^{0}C. The transmitter of the remote control system functions effectively within 15 meters from the cooling system, however the performance improves as the transmitter is brought closer. The device can switch ON the cooling system above 20^{0}C in factories and homes. This enhances maximum efficiency of machines and makes the environment conducive for the users. An automatic switching ON and OFF of cooling system with maximum efficiency has been achieved. This reduces the stress of operating the cooling system manually by the user.

(Keywords: thermistor, switching device, cooling system, ambient temperature)

INTRODUCTION

Ambient air temperatures are usually high in the tropical regions of the world, especially during the dry season [2]. In some parts of Nigeria**,** people complain about the harsh temperature experienced through much of the year. Due to this harsh environmental condition, cooling systems such as air conditioners and fans are always in use in various homes, offices, shops and cars. The machines in the factories and companies generate heat whenever they are in operation. As a result of this, the room temperature and the surrounding environment where they are installed are always subjected to excess waste heat. With time, the effectiveness of such machines is reduced and the life span is shortened and the machine may eventually get damaged. For proper effectiveness of the machines and to make the environment conducive for the users, cooling systems must be installed in such locations.

Since heating is a continuous process in our environment, an automatic switching device for cooling systems is necessary [5, 7, 9]. Instead of giving the assignment of switching the cooling system ON and OFF to a particular individual which could lead to ineffectiveness, this could be performed automatically with maximum efficiency.

A remote control system if incorporated would make it easier to achieve. The automatic switching device for cooling systems could be set to a desired temperature, the device will be OFF, and so the cooling system will not be in operation. But as soon as the temperature reaches the desired temperature or above it, the device will come ON and automatically the cooling system will start to function thereby cooling the environment. It is possible as well to switch ON / OFF the cooling system with the use of remote control.

METHOD OF STUDY

This design illustrates a switching device for cooling systems and the thermistor used is a semiconductor device (i.e., resistor whose resistance changes with the temperature of the surroundings). The automatic switching action of the system is carried out when there is an increase in temperature following the phenomenon employed by negative temperature coefficient thermistor (n.t.c.). The remote control incorporated comprises the transmitter and the receiver [11, 12, 14, 15]. This is to disengage the action of the automatic switching device by the user if desired.

THE PRINCIPLE OF OPERATION OF THE DEVICE

The power supply unit consists of a 15 volts step down transformer, a bridge rectifier, filter capacitors and a 12 volts regulator that supplies the exact voltage into the circuit [6, 8, 10]. The negative temperature coefficient (n.t.c.) thermistor at the temperature sensor unit responds to the ambient temperature. The resistance of the thermistor decreases as the temperature increases and this leads to an increase in current. At the control unit the operational amplifier IC 741 is used as a voltage comparator [1]. A reference voltage of 6 volts is set in between two resistors having the same resistance value. An output is produced when one voltage is larger than the other. A zener diode is fixed to one of the input voltages of the comparator so as to break down at a predictable voltage which is set at 6V in this research. The comparator assigns HIGH as the output.

The switching network is made up of a relay and a transistor. The relay coil is a coil of wire, which becomes magnetic whenever there is a current flowing inside it [13]. As soon as the current stops flowing it seizes to be magnetic. The combination of a relay and a transistor form the switching network. A diode is connected across the relay coil to block or clip–off the voltage surge that might be generated in the inductance coil when the transistor current flowing through the relay coil is switched off. The output of pin 6 of the IC 741, switches the transistor BC 556 'ON', and drives it into saturation. Since the transistor is in saturation, collector current, I_C flows through the relay coil. A magnetic flux is produced around the coil such that the relay makes contact. So it is normally closed (i.e. a complete circuit). Then the oscillator drives the system. But as soon as the collector current seizes to flow in the relay coil, it is open (i.e., an open circuit).

The photodiode at the receiver unit is reverse biased [3, 4]. This receives the infra-red ray from the transmitter unit. At the transmitter, IC 555 timer is used as an astable multi-vibrator. The light emitting diode (LED) is forward biased so as to emit radiation that is being transmitted few meters away from the receiver.

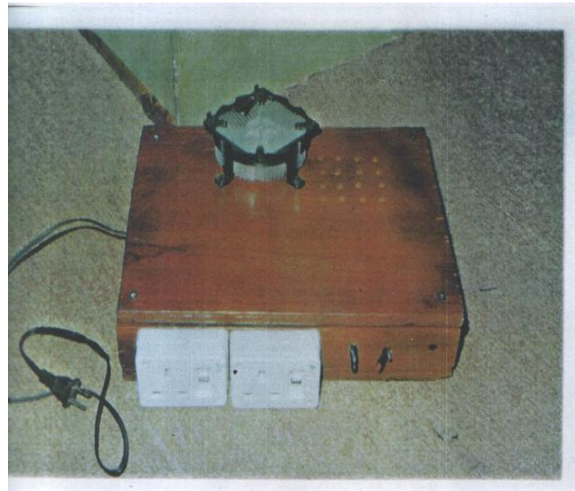

Plate 1: External View of an Automatic Switching Device for Cooling System.

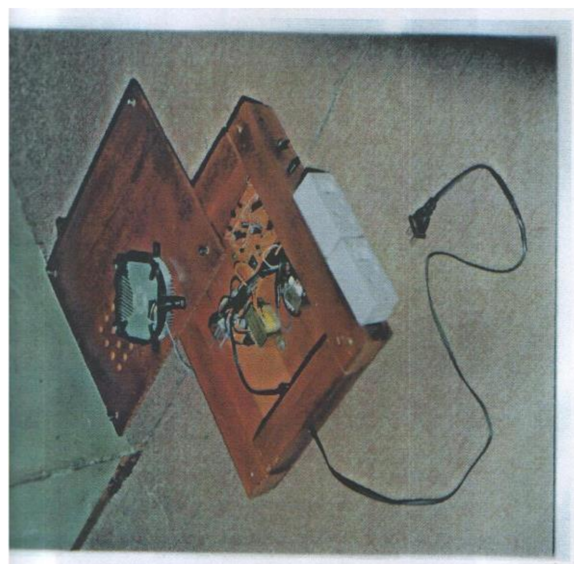

Plate 2: Internal View of an Automatic Switching Device for Cooling System.

RESULTS

The reference voltage of 6 volts is set in between two resistors R_3 and R_4 having the same resistance value of 10 KΩ at the control unit.

$$VR_1 = [\, R_1 / (R_1 + R_2)]\, V_{cc} \qquad \textbf{(1)}$$
$$VR_1 = [\, 10\text{ k}\Omega / (10\text{ K}\Omega + 10\text{ k}\Omega)\,]\, 12$$
$$VR_1 = 6 \text{ volts}$$

With the transistor in saturation, collector current, I_C, flows through the relay coil, thus producing a magnetic flux around the coil. The relay makes contact by closing thus energizing and activating the oscillator.

The relay coil used has an internal resistance of about 400Ω and it serves as the collector resistance.

$R_C = 400\Omega$ (resistance of relay coil)

$V_{CC} = 12V$ (dc supply voltage)

$V_{BE} = 0.7V$ (voltage required to forward bias the transistor)

$V_{CE} = 0.1V$ (transistor in saturation)

$R_B = 10k\Omega$ (base resistor)

For transistor BC556
$h_{fe} = 420$ (transistor current gain as in data sheet)

At the output of the switching circuit:

$$V_{CC} = I_C R_C + V_{CE} \quad \textbf{(2)}$$

At the input of the switching circuit:

$$V_{in} = I_B R_B + V_{BE} \quad \textbf{(3)}$$

$$\text{So, } h_{fe} = \beta = I_C / I_B \quad \textbf{(4)}$$

At saturation, V_{CE} is approximately zero.
Therefore at output of switching circuit:

$V_{CC} = I_C R_C + V_{CE}$

$V_{CC} = I_C R_C + 0.1$

$12V = I_C (400\Omega) + 0.1$

$(12 – 0.1) V = I_C (400\Omega)$

$I_C = 11.9 / 400$

$I_C = 0.03A = 30mA$ (collector current)

From Equation (4):

$h_{fe} = \beta = I_C / I_B$

$\beta = I_C / I_B$

$\beta I_B = I_C$

$I_B = I_C / \beta = 0.03 / 420$

$I_B = 0.0000714A = 71.4\mu A$ (base current)

To determine the R_B, with the input voltage (V_{in}) assumed 2V from the comparator IC output.

At the input of the switching circuit:

$V_{in} = I_B R_B + V_{BE}$

$2 = (71.4) R_B + 0.7$

$2 – 0.7 = 71.4 R_B$

$1.3 = 71.4 R_B$

$R_B = 0.0182073\Omega = 18k\Omega$

Base resistor is 18kΩ but preferred value of 22kΩ is used.

DISCUSSION

The device consists of the output from the negative coefficient thermistor and a 6 volts zener diode. A reference voltage of 6 volts at the input of the voltage comparator compares the voltages at its input. An output is produced when one voltage is larger than the other. The value of the base resistor for transistor BC556 at the switching unit is 18kΩ but a preferred value of 22kΩ is used so as to regulate the amount of current that gets into the transistor. As a result of this, the transistor is in saturation, collector current, I_C flows through the relay coil, a magnetic flux is produced around the coil such that the relay coil makes contact.

CONCLUSION

Market demands continue to grow for using thermistors not only as in equipment functionality but also for the reason of equipment safety and stability. Meanwhile, applications are expanding to include overheat detector, over current protection, temperature compensation and more.
If the ambient temperature is below 20^0C, the switching device will be OFF. Also the transmitter of the remote control system functions effectively within 15 meters away from the cooling system, however the performance improves as the transmitter is brought closer. The device can switch ON the cooling system above 20^0C in factories and homes. This enhances maximum efficiency of machines and makes the

environment conducive for the users. An automatic switching ON and OFF of cooling system with maximum efficiency has been achieved. This reduces the stress of operating the cooling system manually by the users.

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SUGGESTED CITATION

Iyiade, O.J. and O.A. Aremu. 2013. "Performance of an Automated Switching Device at Temperature above 20°C". *Pacific Journal of Science and Technology*. 14(1):75-78.

Pacific Journal of Science and Technology