THE NATIONAL INSTITUTE OF ENGINEERING

MYSURU – 570008

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Analog CMOS IC Lab Project [EC3L01] – III Semester

Report on

TEMPERATURE SENSOR USING MOSFET

under the guidance of

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ABSTRACT

Temperature sensor is a circuit which is used to indicate any increase in temperature. MOSFET and a passive component called thermistor can be used to implement temperature sensor. The increase in temperature is sensed by the thermistor and the action is controlled by the MOSFET. Output device used here is an LED which glows when there is an increase in temperature.

CONTENTS

INTRODUCTION

Temperature sensors are the device or the part of the device which is made by the interconnection of electrical component and some temperature sensitive electrical components. A n-MOSFET, thermistor, LED, and resistors can be used to build simple temperature sensor.

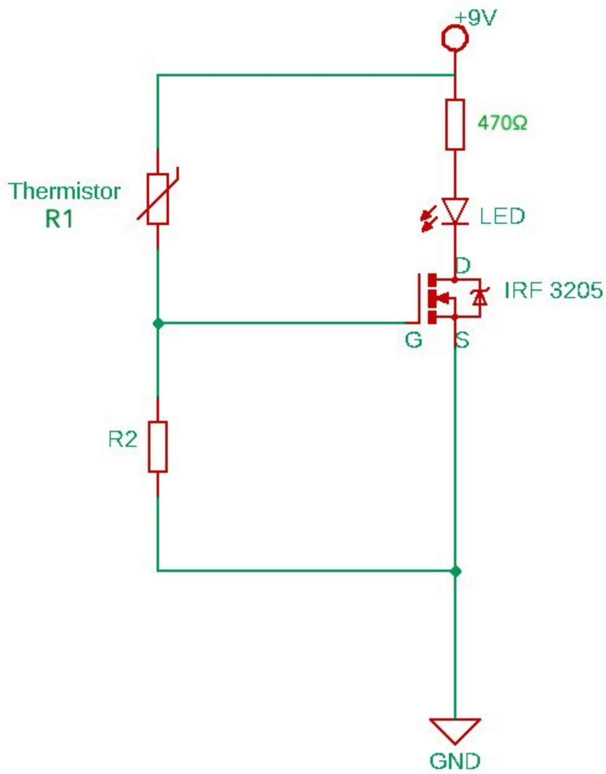
A n-MOSFET is a 3 terminal unipolar voltage controlled device. The 3 terminals are Gate, Drain, and Source. Voltage at the gate is used to control the drain current. The MOSFET IRF 3205 is used here to demonstrate the temperature sensor. The zener diode used in the internal construction is for the protection of the MOSFET.

A thermistor is a thermally sensitive resistor that exhibits a precise and predictable change in resistance proportional to small changes in it. An NTC(Negative Temperature Coefficient) thermistor of range 5kΩ is used in the circuit whose resistance decreases with the increase in temperature.

These components with proper biasing, can be used to implement a temperature sensor circuit.

DESIGN AND IMPLEMENTATION

The biasing technique used here is voltage divider bias. Here R_1 corresponds to the NTC thermistor of range 5kΩ and R_2 has the value of 1.2kΩ. The LED is connected in series with the voltage source and the drain terminal through a limiting resistor of 470Ω. The source is grounded whereas one of the terminals of thermistor and R_2 are shorted to gate terminal.



Temperature Sensor Schematic

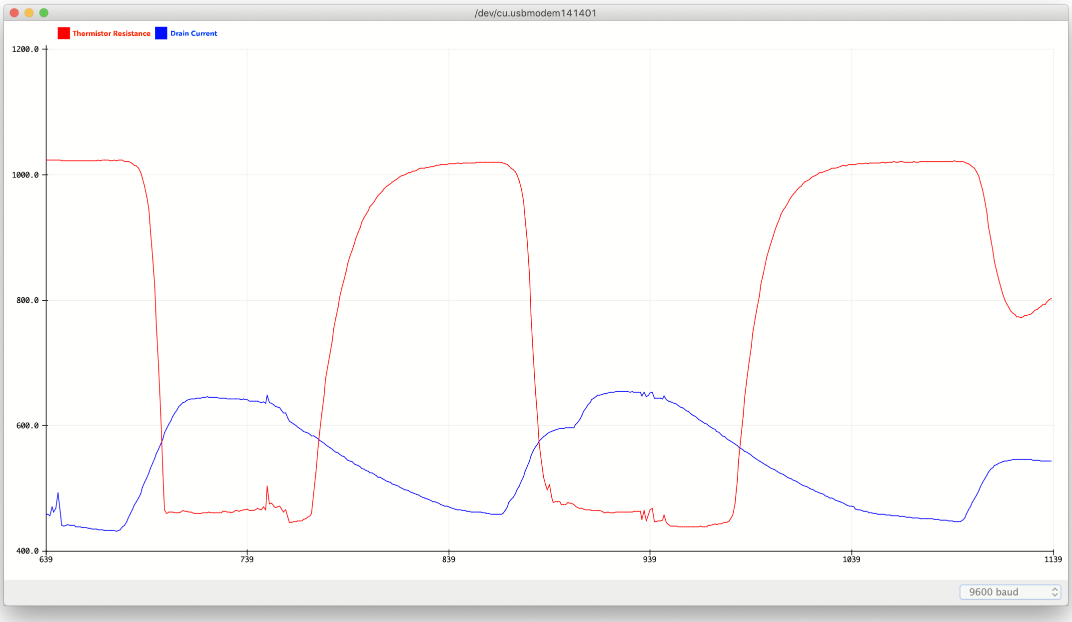
Heat is used to increase the gate voltage(V_G) as per the voltage divider rule,

$$VG = VDD * R2/(R1 + R2)$$

Where V_{DD} is the supply voltage = 9V, R_1 is the thermistor resistance which decreases with the increase in temperature, and R_2 is a biasing resistor whose value is 1.2kΩ. When the thermistor is heated, its resistance decreases and hence V_G increases. Since gate voltage is responsible for the drain current, an increase in gate voltage causes a drain current to flow through the LED, making it glow.

RESULT AND ANALYSIS

In n-MOS, the drain current flows from source to drain only when the gate to source voltage(V_{GS}) is greater than Threshold voltage(V_T). The calculated V_T of MOSFET IRF 3205 is 2.6V. This means gate voltage must be greater than 2.6V for the drain current to flow through the LED. The condition where $V_{GS} > V_T$ is known as saturation region. If $V_{GS} < V_T$ then it is known as cut-off region. The LED glows only when MOSFET is in Saturation region.



Plot of Thermistor Resistance and Drain current vs **Time**

The above plot is of thermistor resistance(R_1) and drain current(I_D) vs time. We see that in room temperature, the resistance of the thermistor is approximately equal to 5kΩ and we see the drain current is very less insufficient to glow the LED. In between the time interval 721 to 782 the thermistor offers low resistance to the circuit whereas the drain current increases in this interval. When the thermistor is cooled, resistance is increased thereby lowering the drain current. This is seen in the time interval 783 to 893.

When the resistance of the thermistor changes due to changes in temperature, the fraction of the supply voltage across the thermistor will also change producing an output voltage which is proportional to the temperature provided to the thermistor, where the resistance of the thermistor is controlled by temperature with the output voltage produced being proportional to the temperature. So the hotter the thermistor gets, the higher the output voltage.

$$VG \propto 1/T$$

When the thermistor is heated extremely, its resistance value becomes 1.3kΩ and the gate to source voltage raises to 4.2V. Since V_{GS} is greater than V_T, the MOSFET goes into saturation region. Therefore the drain current flows through the LED, making it glow. At higher temperature, drain current of 4.15mA flows through the LED. The LED becomes dimmer as the thermistor cools down. In normal room temperature the thermistor will be having high resistance of 4.8kΩ and V_G will be equal to 1.06V.

At VDD = 9V

Temperature	26 °C	65 °C
V_{GS}	1.06 V	4.2 V
R_1	4.8 kΩ	1.3 kΩ
I_D	0.01 mA	4.15 mA

CONCLUSION

A simple temperature sensor circuit can be built using a passive component thermistor and a MOSFET with voltage divider biasing method. A thermistor of higher or lower range can of resistance values can be used as per the desired application. A three terminal temperature sensor LM35 can be used to sense the change in temperature which gives accurate results compared to thermistor. This circuit with some modifications can be used in home appliances, cooling systems in computers, to control the heat on electric radiators, and many more.

BIBLIOGRAPHY

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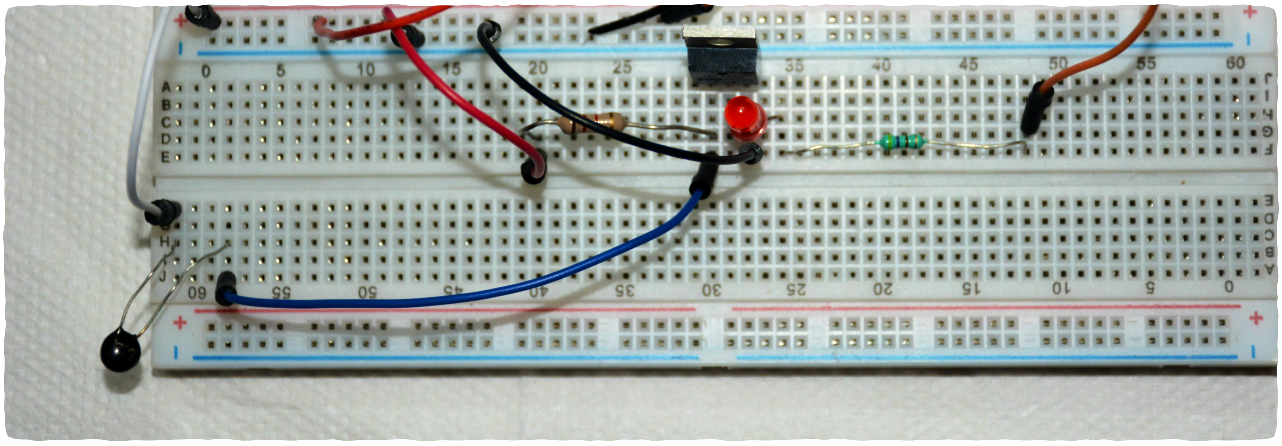
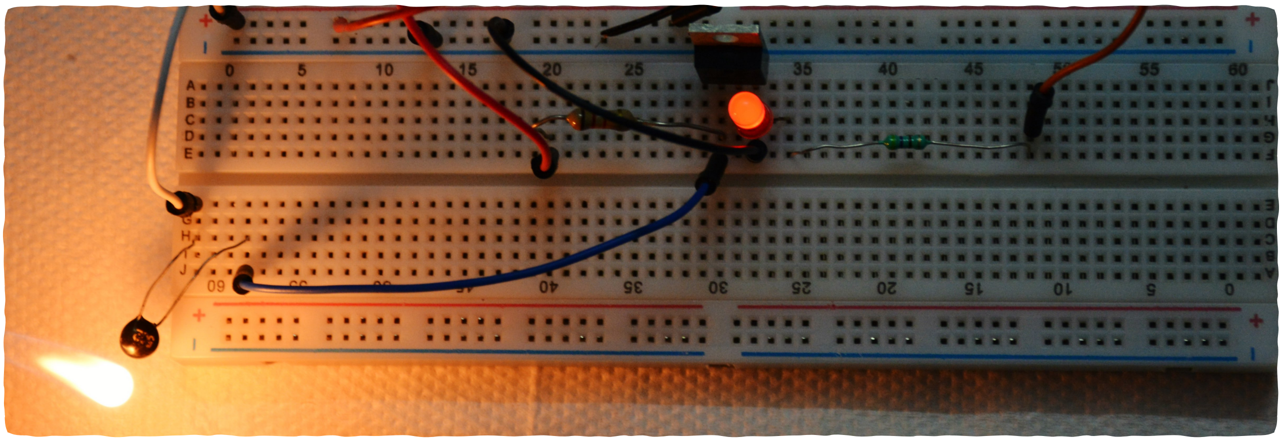
APPENDICES



Response of Sensor at Room Temperature



Response of Sensor at Higher Temperature