EL-313 Linear Control System

FALL-2021

Lab Design Project

Temperature Control of Light Bulb

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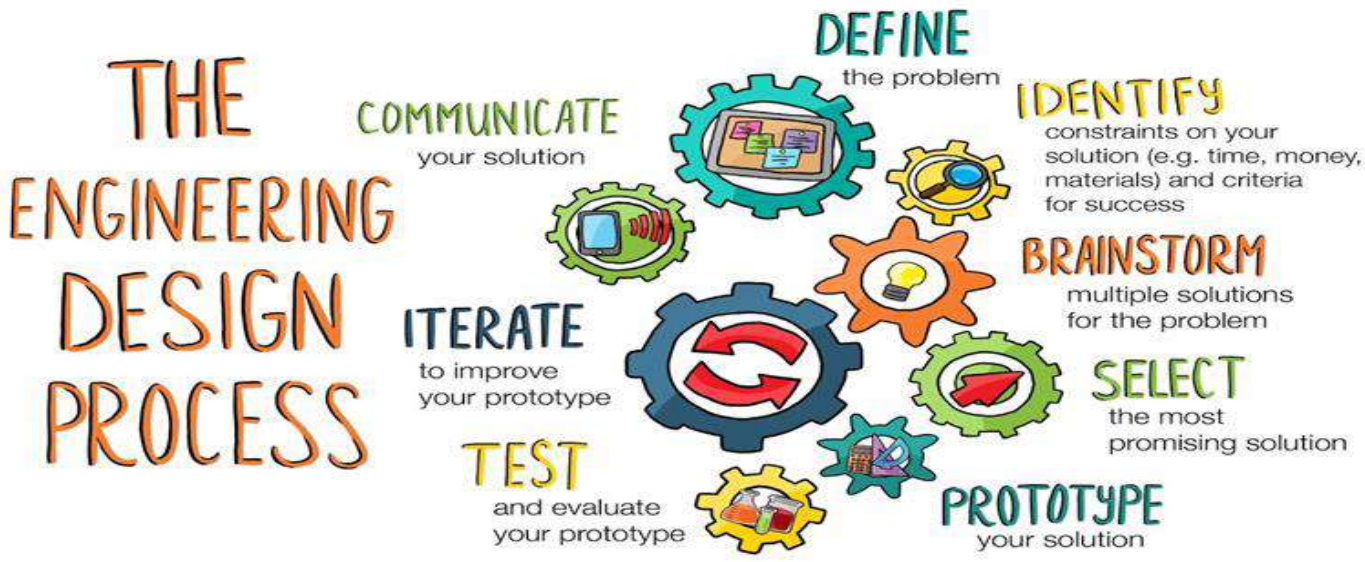


What is the Engineering Design Process?

The engineering design process, also known as iterative design, is a cycle that provides a framework for addressing your problems with inventive and effective solutions**.**

How do you make it?

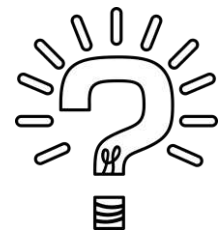
We'll start with the Six essential ingredients, that are needed for doing your Lab design project in interactive way.

- Curiosity
- Critical Thinking
- Technical Knowledge
- Creativity
- Research
- Passion

Breaking Down the Engineering Design Process

Step	Defining the Step
Ask	What is the Problem?
Imagine	What are some of the potential solutions to this problem?
Plan	What is the most promising solution that I will focus on?
Create	What can I sketch, create, and build to solve the problem?
Experiment	Does my proposed solution to the problem actually work?
Improve	How can I improve my design now that I tested it?

ASK

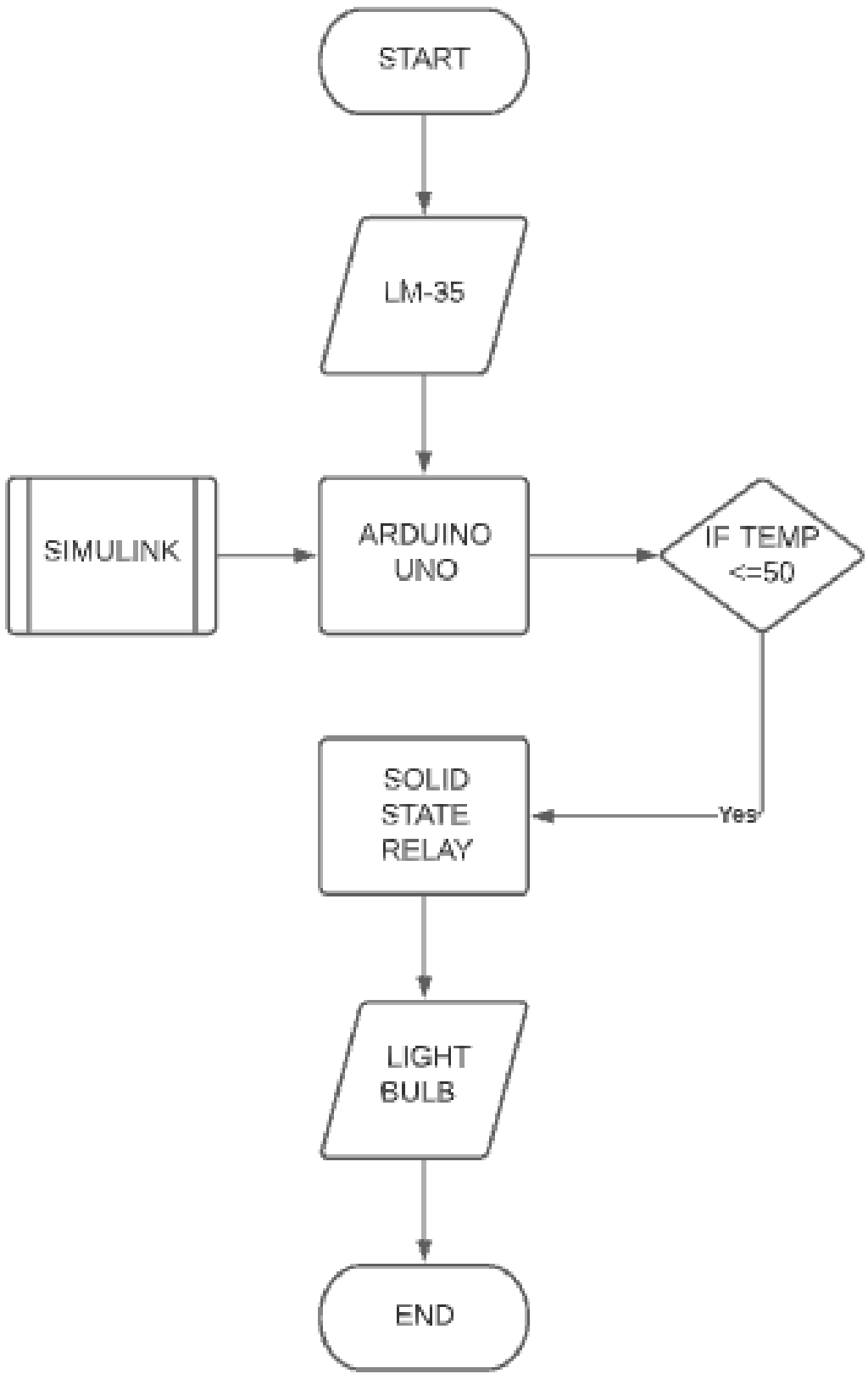


What is the problem you are trying to solve?

The goal of this lightbulb project is to demonstrate how to control switched systems. Turning on the lightbulb raises the temperature of the lightbulb, while turning it off lowers the temperature of the lightbulb (up to environmental limits). The lightbulb is a binary system that has only two states: on and off. The lightbulb is either connected to an alternating current source or not; its intensity cannot be modulated. In this experiment, we observe the lightbulb's resulting "chattering" behaviour and investigate alternative methodologies for reducing the frequency of this chatter, or smoothing the chatter, using deadband.

IMAGINE

Imagine the best way to solve the problem on your own. Sketch out your block diagram/ flow chart and brainstorm a list of ideas



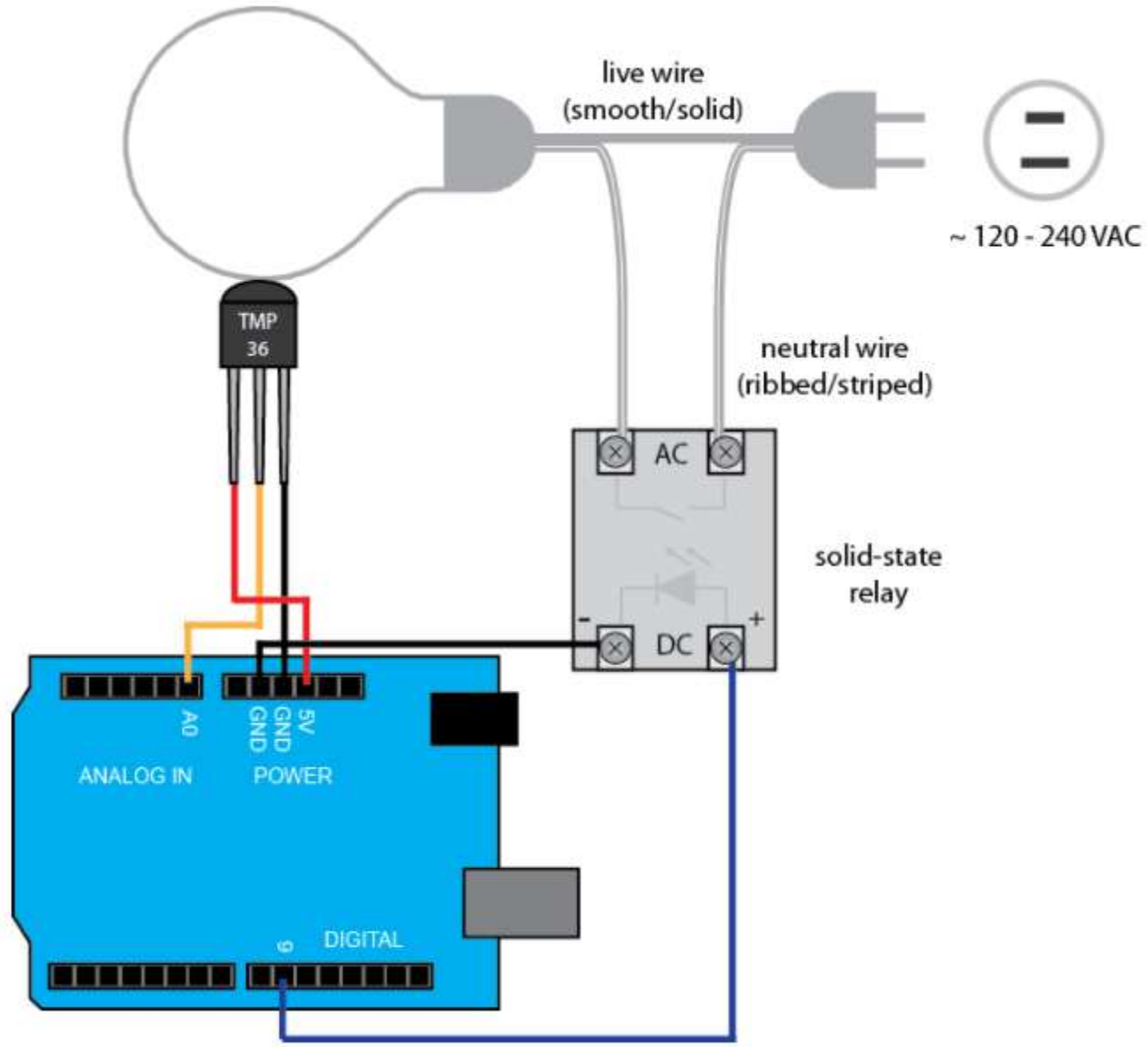
In above flow chart ;

- the temperature of the lightbulb is measured with a LM-35 sensor.
- The Arduino Uno reads output of temperature sensor via an Analog Input.
- The Arduino board will also generate the Digital Output that turns on and off the solid-state relay.
- To put it another way, the digital output alternately connects and disconnects the light bulb from the AC power source (from the wall) via the relay to turn the light bulb on and off.
- Simulink, which is also used to visualise the lightbulb's temperature and the control signal, is used to implement the control logic for determining when to switch the relay on and off.

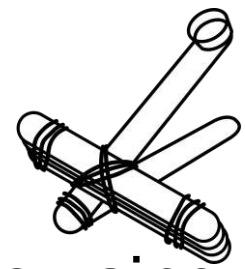
PLAN

With your group, sketch out your plan to design your project.

In this experiment, our plant is a standard incandescent lightbulb, and we will (eventually) try to control the temperature of the lightbulb. In order to keep the maximum temperature within the limits of the temperature sensor, we chose a 15 W LED bulb. The temperature sensor can be attached to the surface of the lightbulb employing thermally conductive epoxy, or with adhesive metal tape. The LM-35 is connected to the Arduino Board as shown below. Specifically, if the sensor is oriented such that the pins are pointed downward and the flat side of the sensor is facing you, then the leftmost pin is the power (must be between 2.7 V and 5.5 V), the middle pin is the signal, and the rightmost pin is ground. Power and ground for the LM-35 are supplied from the Arduino board and the signal, which is a voltage that is linearly proportional to temperature, is read on one of the board's Analog Inputs.The lightbulb is turned on and off using a solidstate relay and a digital output fro m the Arduino board. A solidstate relay is essentially an electrical switch that uses a lowpower DC signal to connect or disconnect a (possibly highpower) device from an A C source. In our case, the AC power is supplied by a standard wall outlet, and the DC s ignal is provided by a Digital Output on our Arduino board. AAs a result, our solid-state relay must be capable of handling 240 V(6AMPS) on the AC side and a 5 V signa l on the DC side. Because our load (the lightbulb) is resistive (rather than inductive) & doesn't require a lot of current.


live wire
(smooth/solid)
~ 120 - 240 VAC
TMP
36
neutral wire
(ribbed/striped)
AC
DC
-
+
solid-state
relay
A0
5V
GND
GND
ANALOG IN
POWER
9
DIGITAL

CREATE



Build your prototype. What components/tools you are using

EQUIPMENT USED:

1. ARDUINO BOARD (UNO)
2. LIGHTBULB (15W LED)
3. SOLID STATE RELAY (MP240D6)
4. TEMPERATURE SENSOR (LM35)
5. CONNECTING WIRES

SOFTWARES:

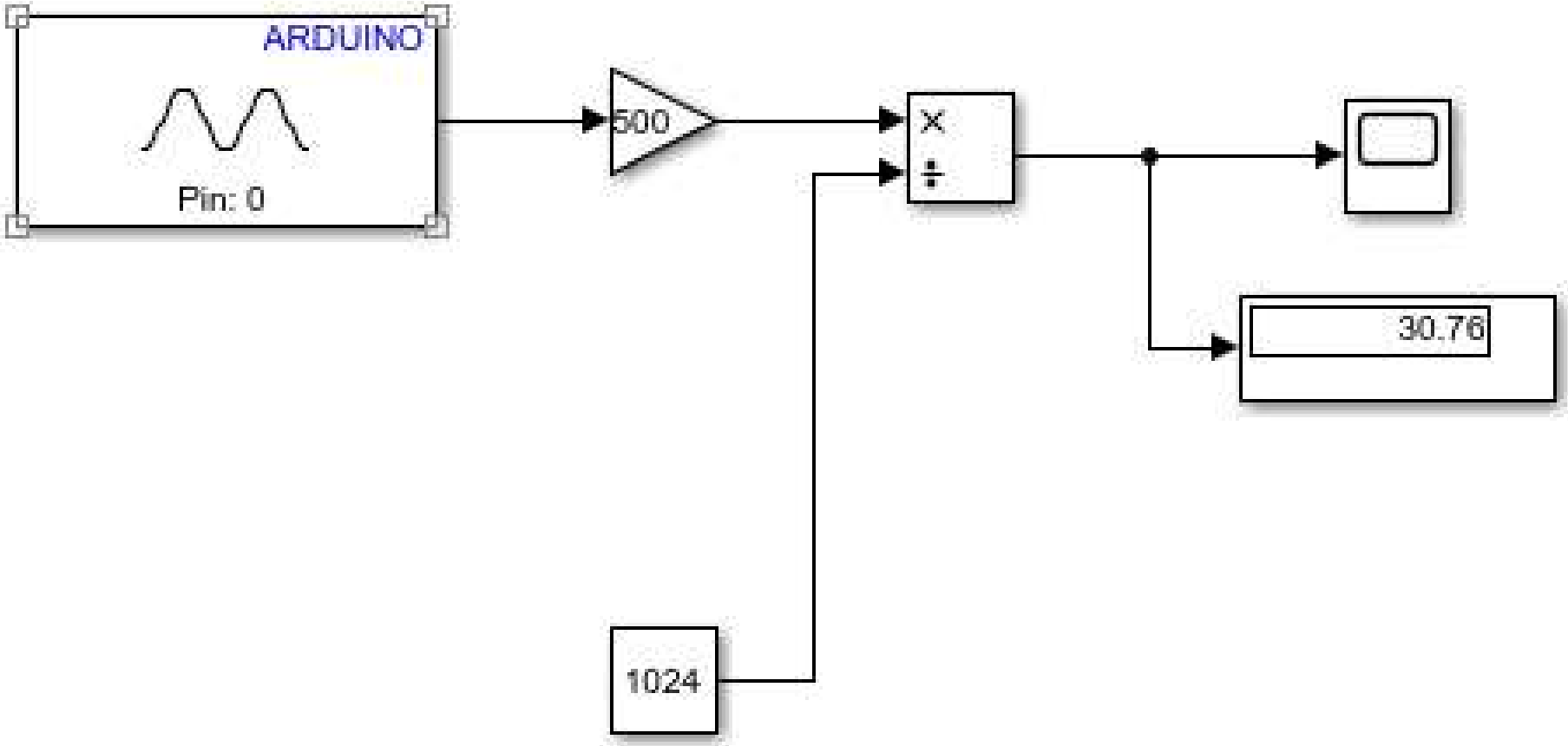
1. MATLAB 2018A (TO GET HARDWARE SUPPORT PACKAGE)
2. SIMULINK MODEL (FOR PROGRAMMING ARDUINO & SIMULATIONS)
3. MICROSOFT VISIO (SCHMETIC DIAGRAM)
4. MICROSOFT OFFICE (PRESENTATION AND DOCUMENTATION)
5. LUCID (FOR FLOWCHART)

SIMULATE

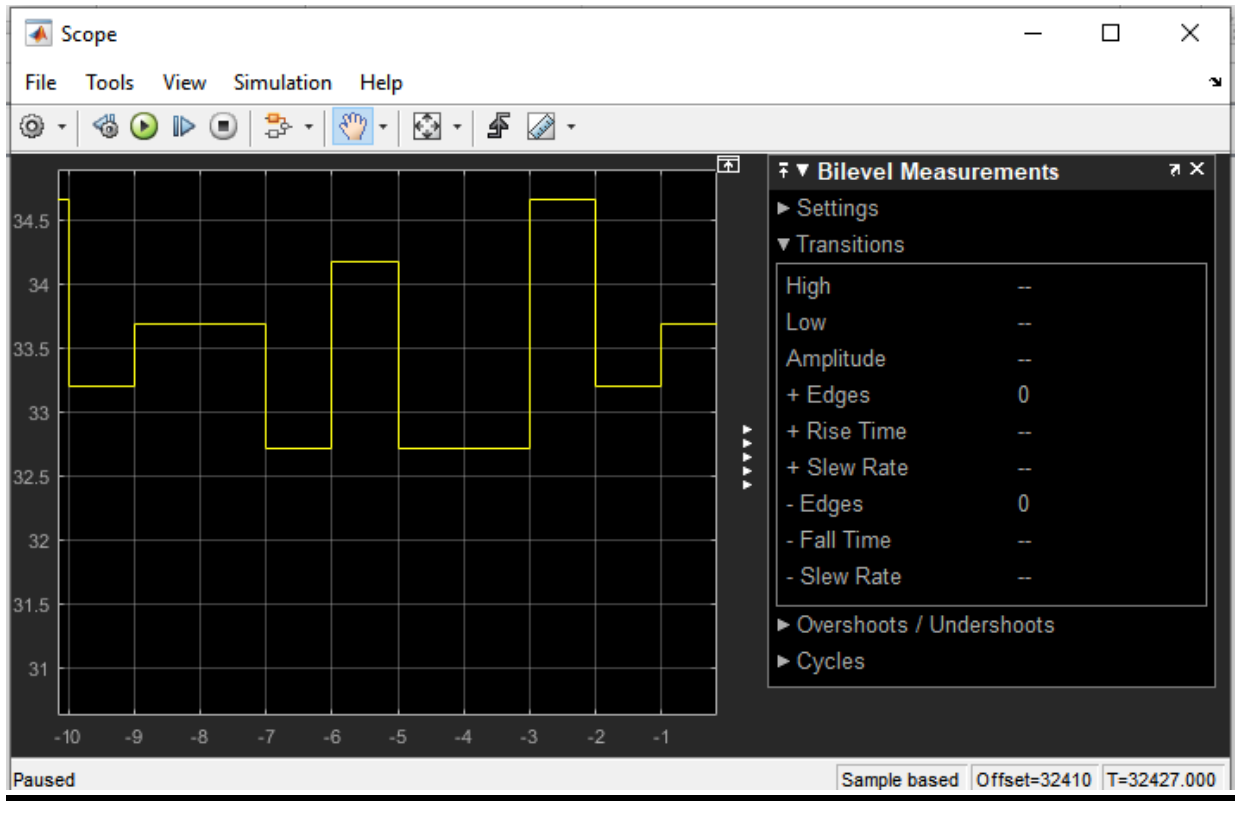
With the suitable design software tool test your prototype and share your key observations.

ANALOGUE OUTPUT OF TEMPRATURE SENSOR LM-35:

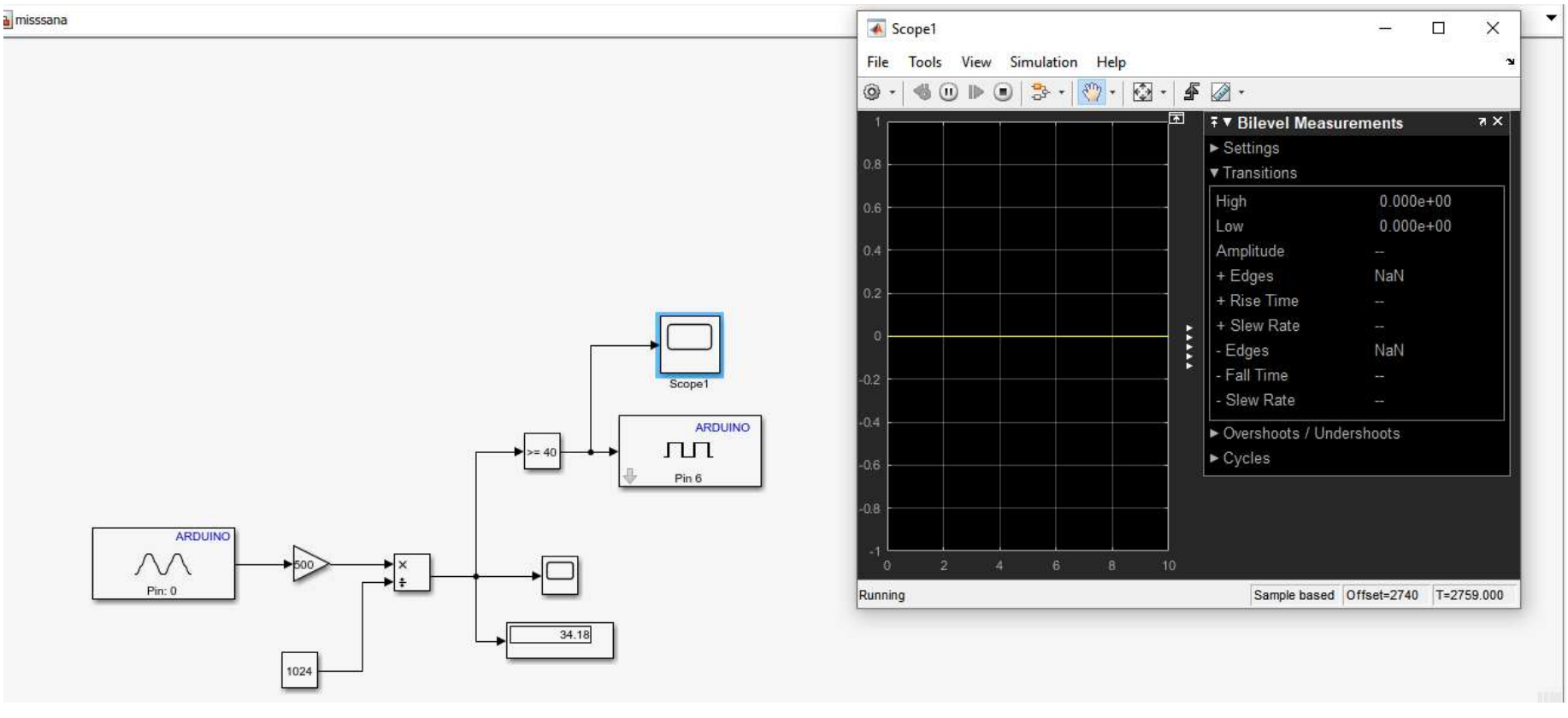
GIVEN BLOCK IS CONVERTING TEMPRATURE SENSOR OUTPUT INTO CELCIUS



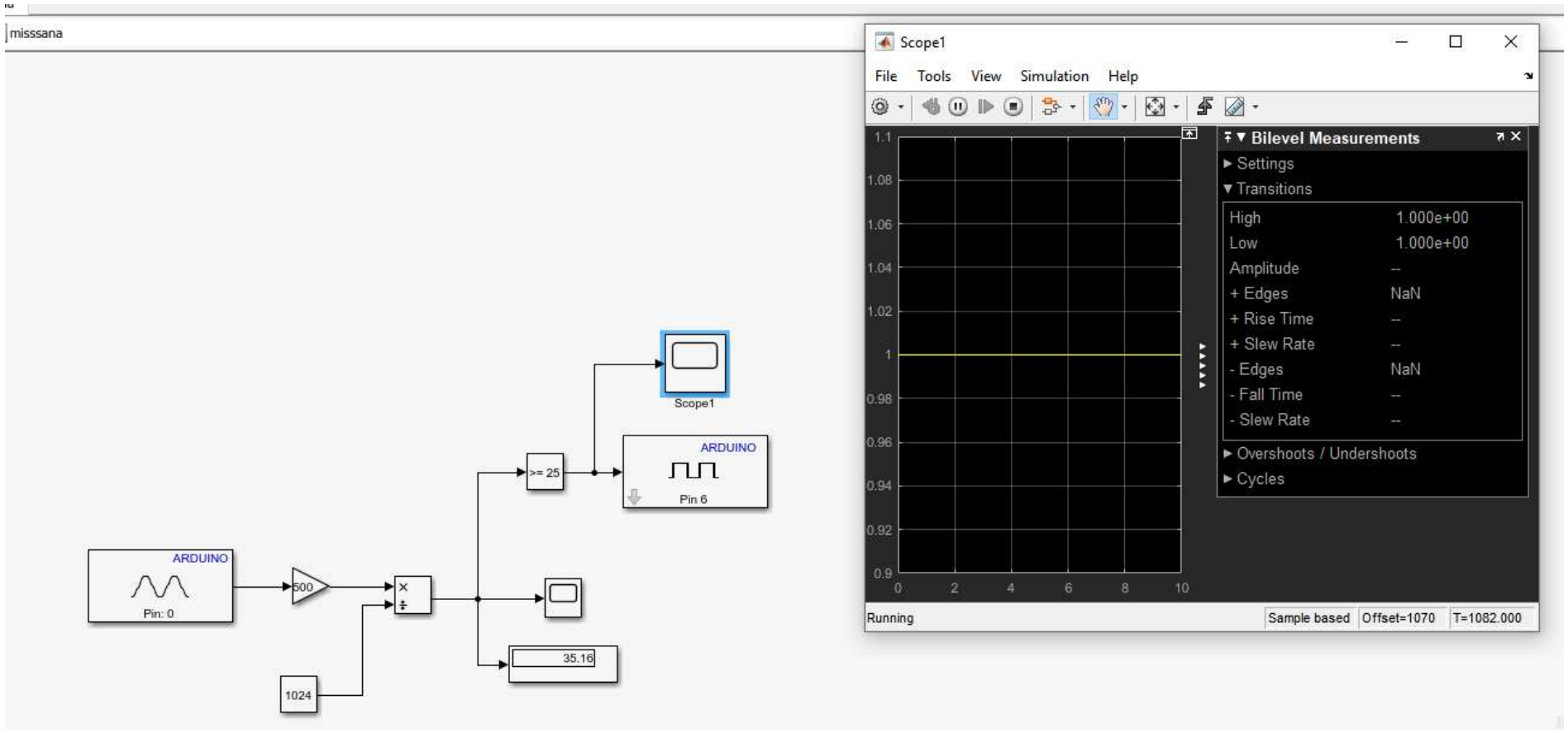
IN GIVEN SIMULATION TEMPRATURE IS GETTING OBSERVED BY LM-35 THAT IS ROTATING BETWEEN 32.5-34.5 DEGREE CELCIUS



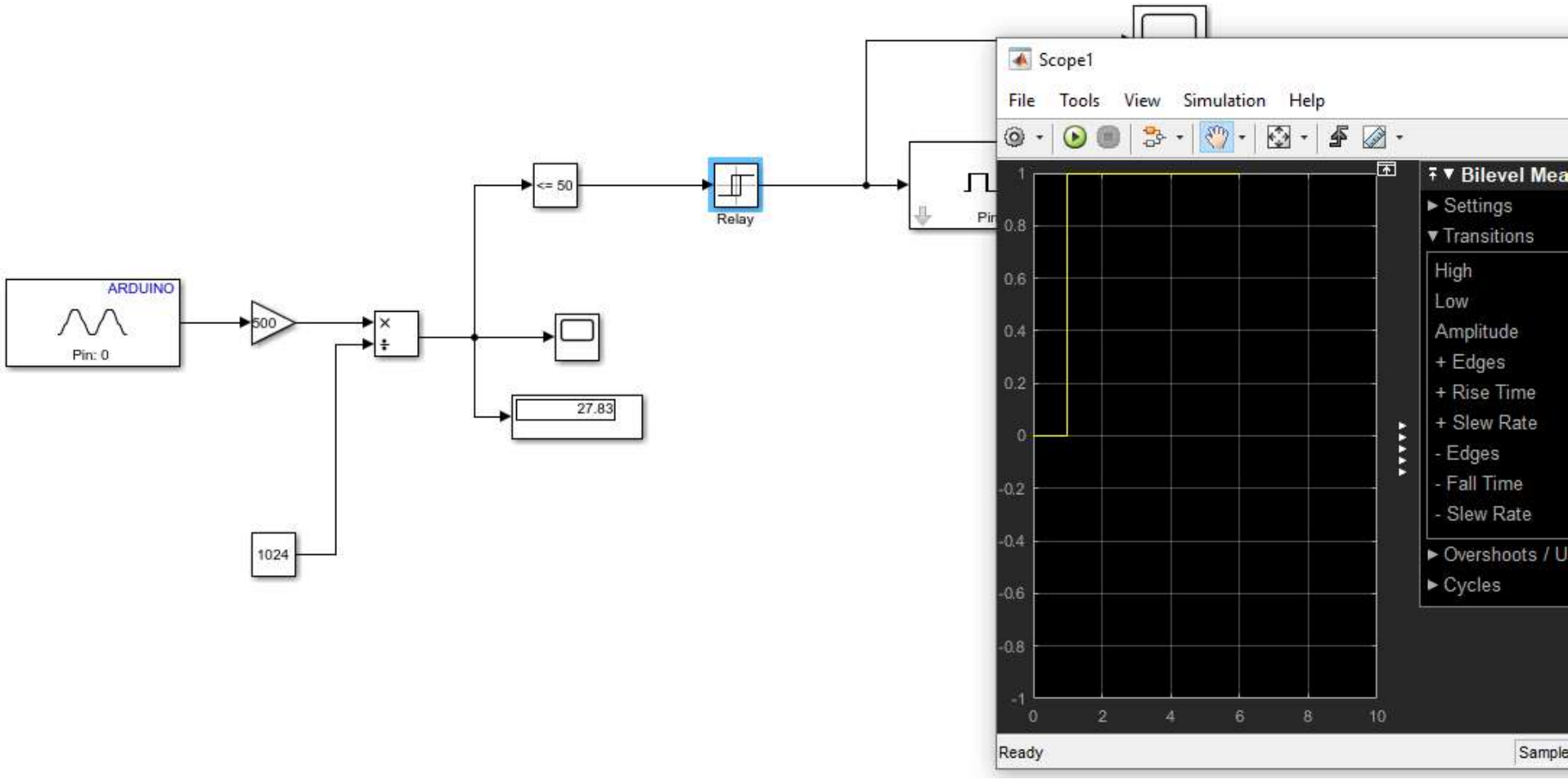
WHEN CONDITION IS NOT TRUE SSR IS OFF:



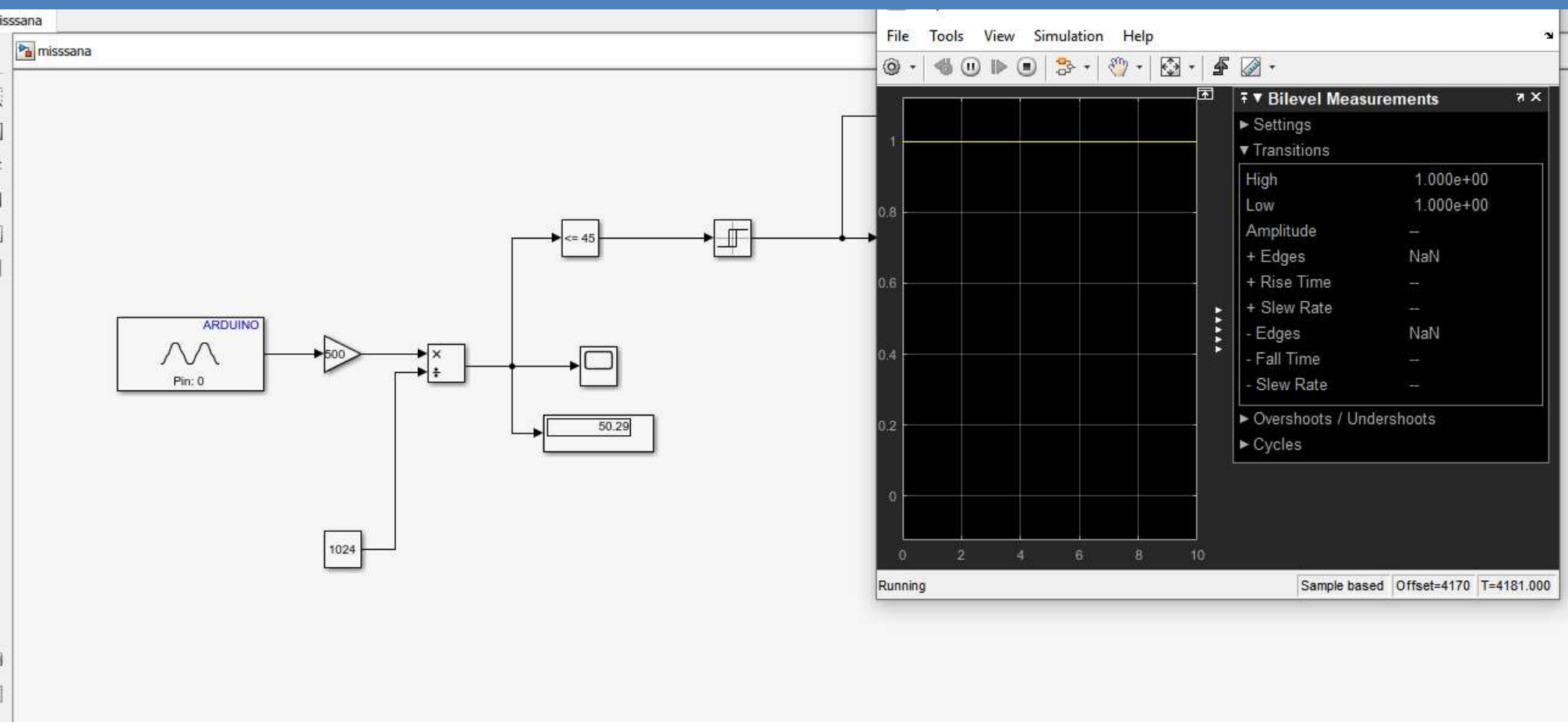
WHEN CONDITION IS TRUE SSR IS ON:



WHEN CONDITION IS GETTING TRUE AND SSR IS CHANGING ITS STATE:

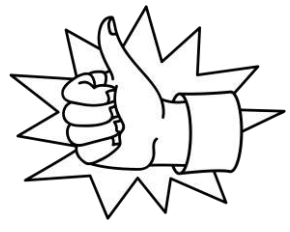


BOTH OF ABOVE SITUATIONS ARE WITHOUT IMPLEMENTATION OF DEADBAND WHICH MEAN THE SWITCHING AT MEAN POINT WILL PERFORM QUICKLY AND THAT CAN ALSO CAUSE DAMAGE TO LIGHTBULB SO IN ORDER TO TROUBLESHOOT THIS PROBLEM WE HAVE IMPLEMENTED DEADBAND USING RELAY BLOCK



BY IMPLEMENTING DEADBAND IT CAN BE OBSERVED THAT TEMPRATURE IS AROUND 50 DEGREE CELCIUS AND CONDITION IS FALSE BUT WE ARE GETTING TOLERANCE OF +-6 DEGREE CELCIUS SO THE LIGHT BULB IS STILL ON.

IMPROVE



How can you improve your design? (Future Recommendations)

THIS PTOJECT CAN BE FURTHERMORE MODIFIED TO CONTROLL TEMPERATURE AT VARIOUS PLACES BULB CAN WORK AS INDICATOR AS WELL AS A COOLANT TO CONTROL TEMPERATURE IN ADDITION TO IT BULB CAN BE REPLACED BY THE CONTROL VALVE OF COOLANT IN INDUSTRY TO FLOW COOLANT ACCORDING TO THE TEMPERATURE OF EQUIPMENT WANTED TO BE MAINTAINED