Industrial Conveyor Belt Monitoring and Safety System — eSim

Title of the experiment:

Simulation of an Industrial Conveyor Belt Monitoring and Safety System using eSim.

Theory:

An Industrial Conveyor Belt Monitoring and Safety System is designed to detect unsafe operating conditions in a conveyor system and provide a corresponding safety indication. The proposed circuit monitors four safety-related conditions: emergency-stop activation, excessive temperature, overload/current abnormality, and object detection. In the eSim simulation, these conditions are represented by electrical input signals that change state at specified times.

The input signals are processed through an analog decision stage and transistor switching network. The circuit uses a 9 V DC supply, UniversalOpamp2 subcircuit, BC547B transistors, resistor networks, voltage-controlled switches, and an LED output indicator. The safety inputs are applied sequentially during the combined transient simulation to verify the input-to-output response of the system.

Schematic Diagram:

The complete circuit schematic of the Industrial Conveyor Belt Monitoring and Safety System implemented in eSim is shown below.

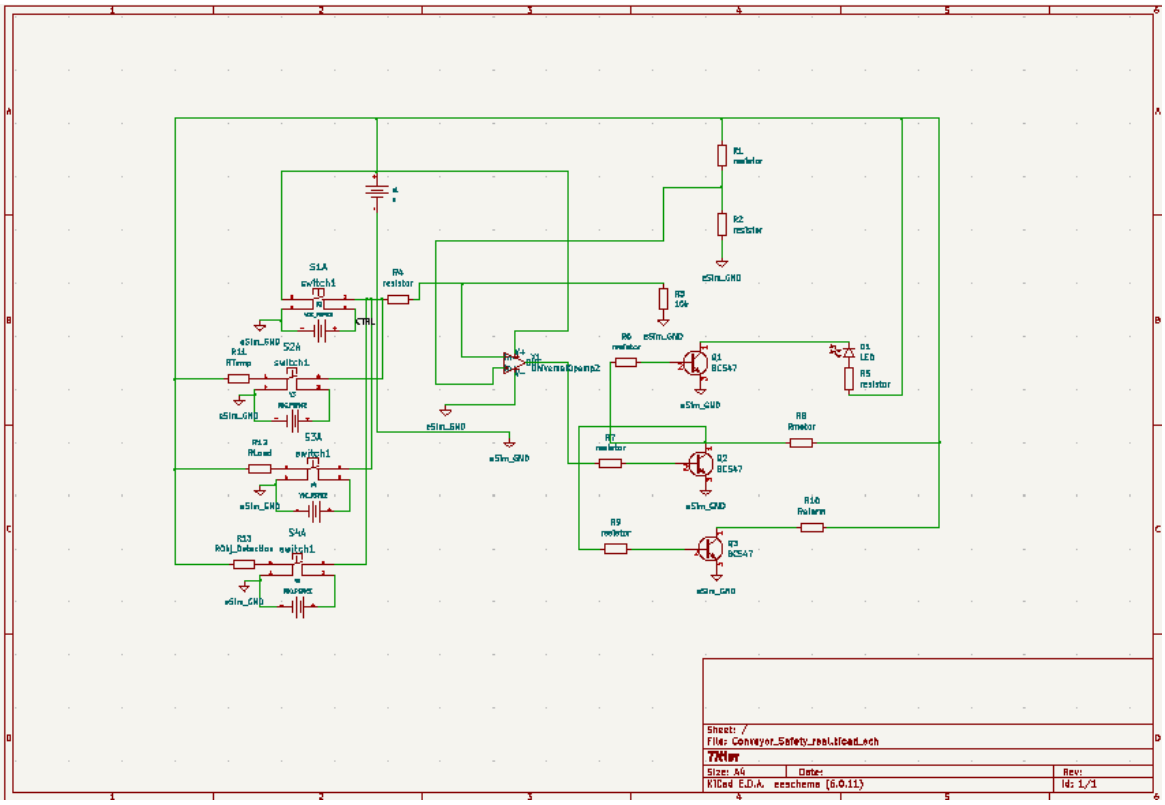

Figure 1: Industrial Conveyor Belt Monitoring and Safety System

Simulation Results:

1. NGSpice Plots

A transient NGSpice simulation is used to verify the response of the safety system. The final combined simulation is performed from 0 to 20 ms. The four safety inputs are activated sequentially as follows:

- E-Stop (V5): 2 ms
- Temperature (V2): 6 ms
- Overload (V4): 8 ms
- Object Detection (V3): 9 ms

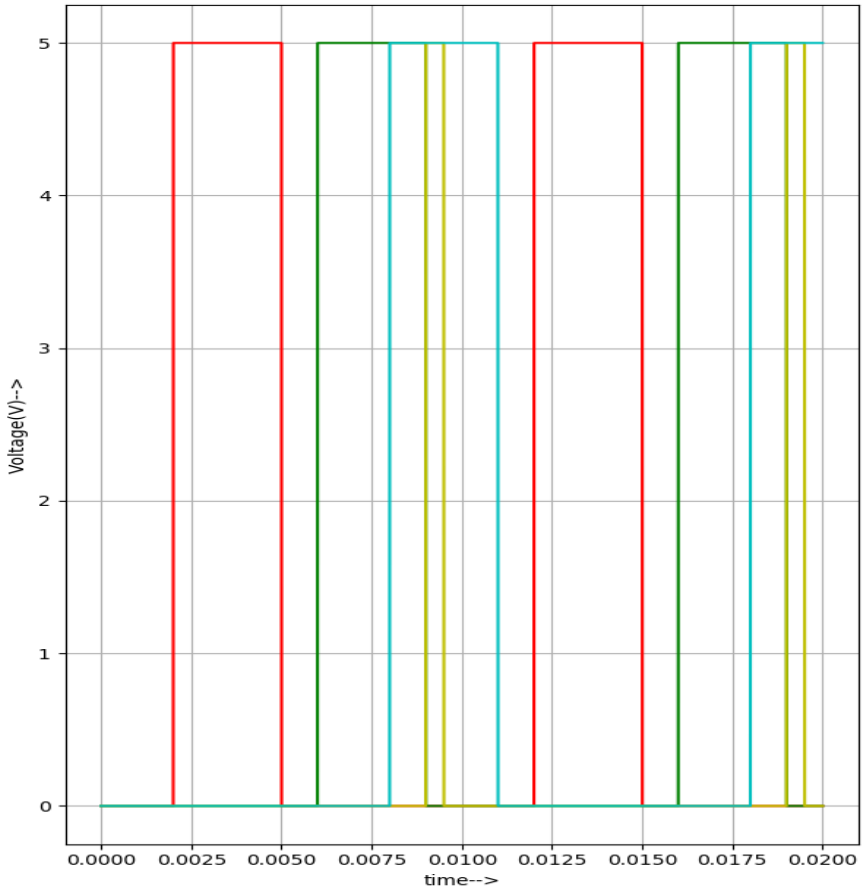

Figure 2: NGSpice Combined Safety-Input Plot

The corresponding system-response signals are observed at the op-amp output, Q1 collector, and LED anode.

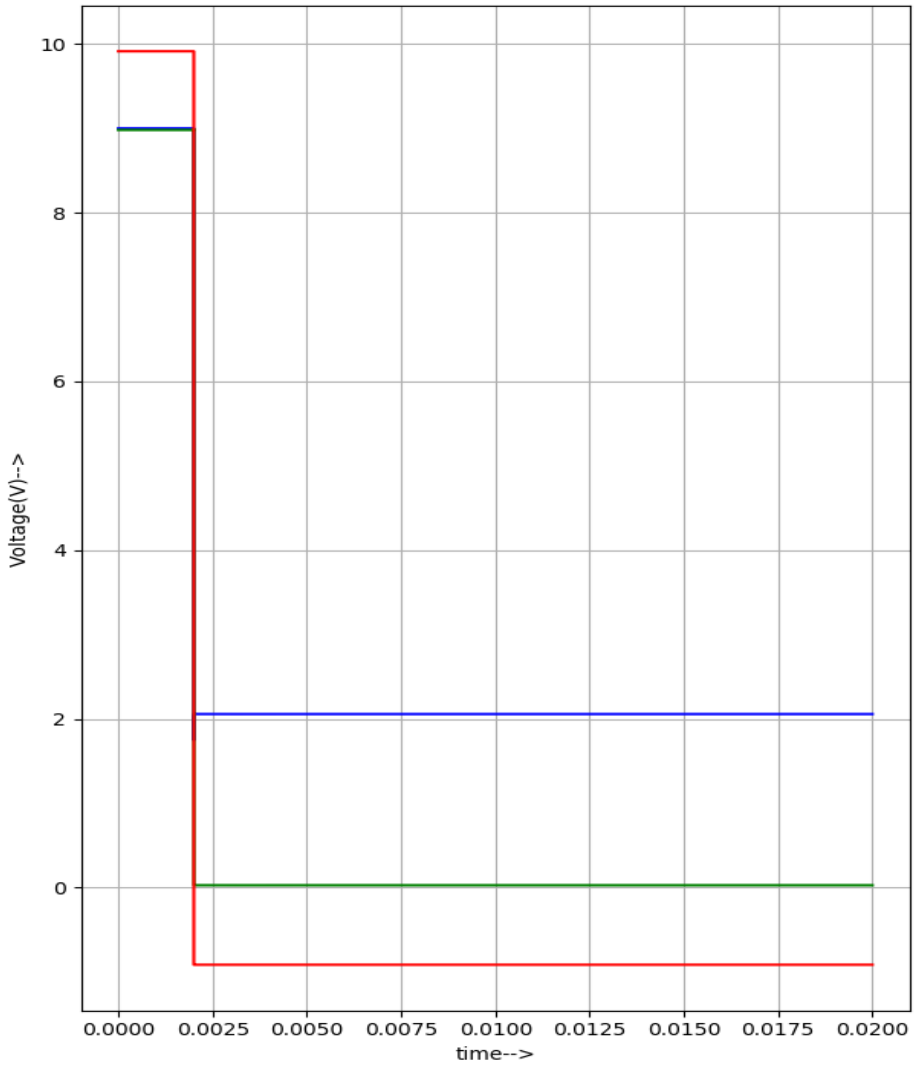

Figure 3: NGSpice System-Response Plot

Individual Fault Verification

Individual fault simulations are also performed to verify that each safety condition produces the expected system response.

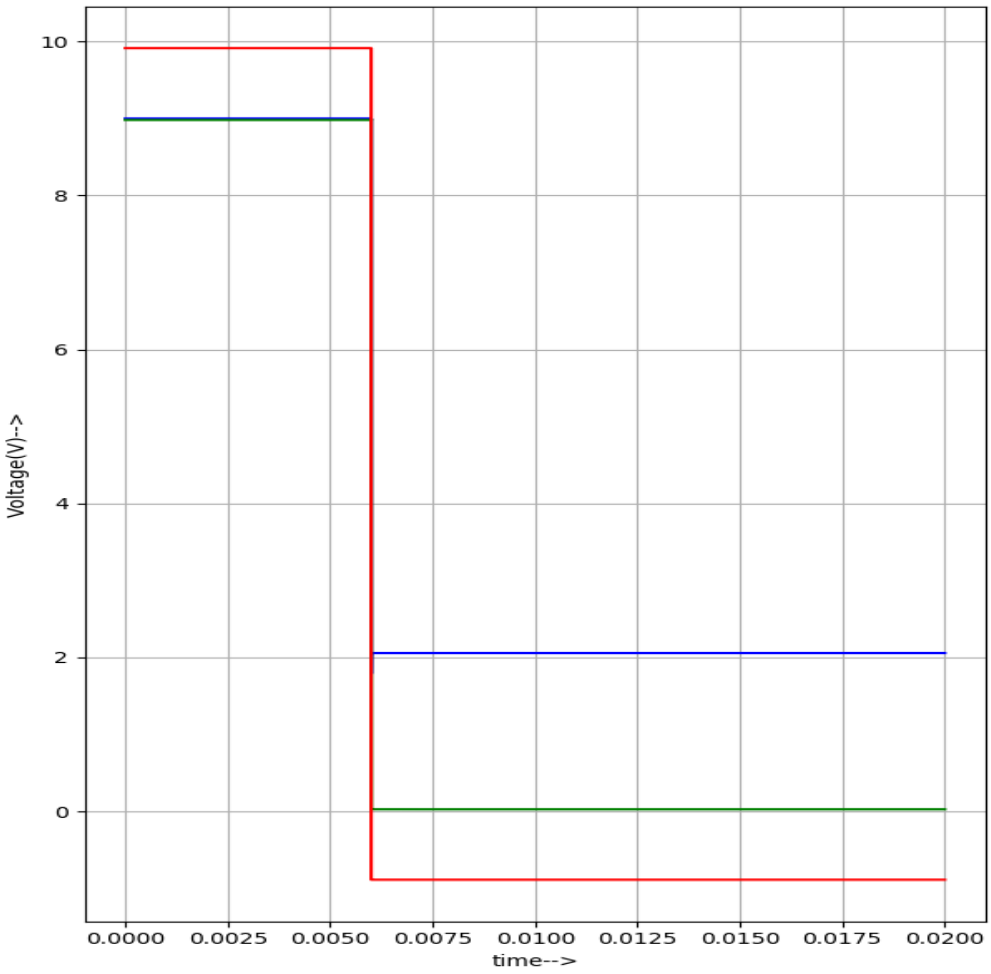

Figure 4: Temperature Fault Response

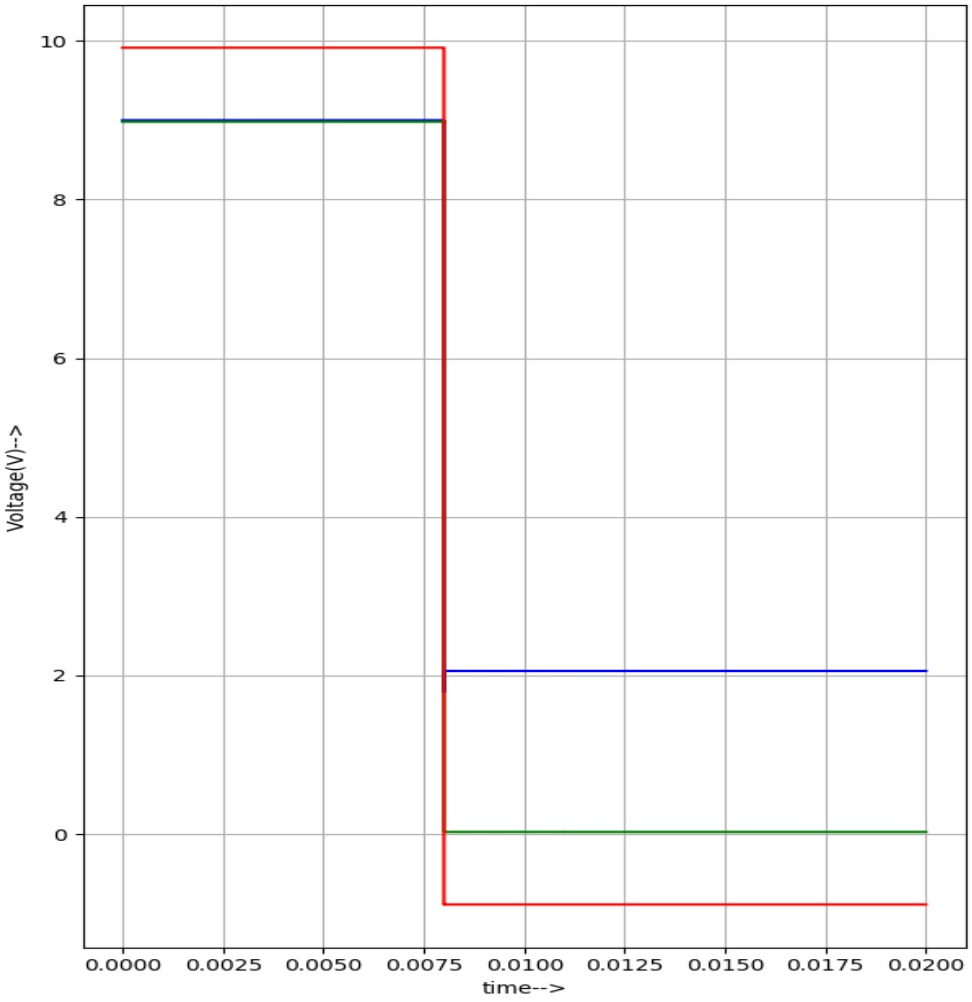

Figure 5: Overload Fault Response

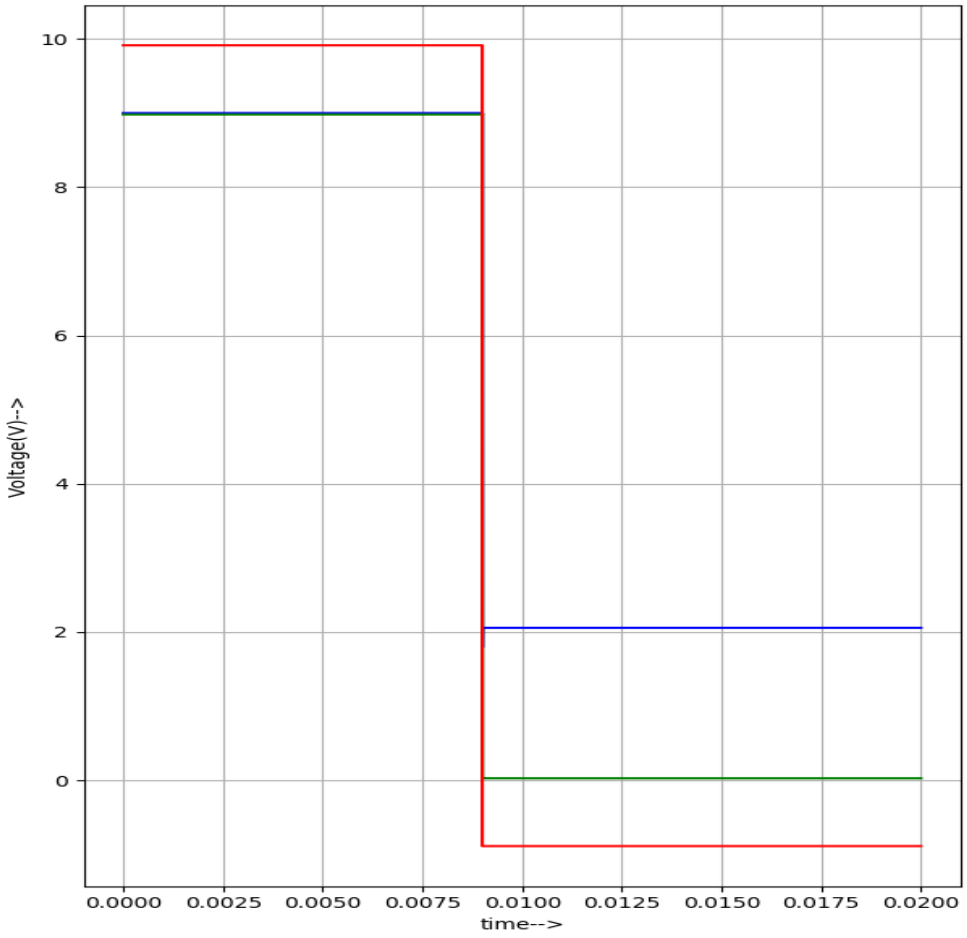

Figure 6: Object Detection Fault Response

2. Python Plots

The voltage data generated from the eSim/NGSpice simulation is also processed using Python to provide a clear representation of the voltage-versus-time behaviour of the safety inputs and system response.

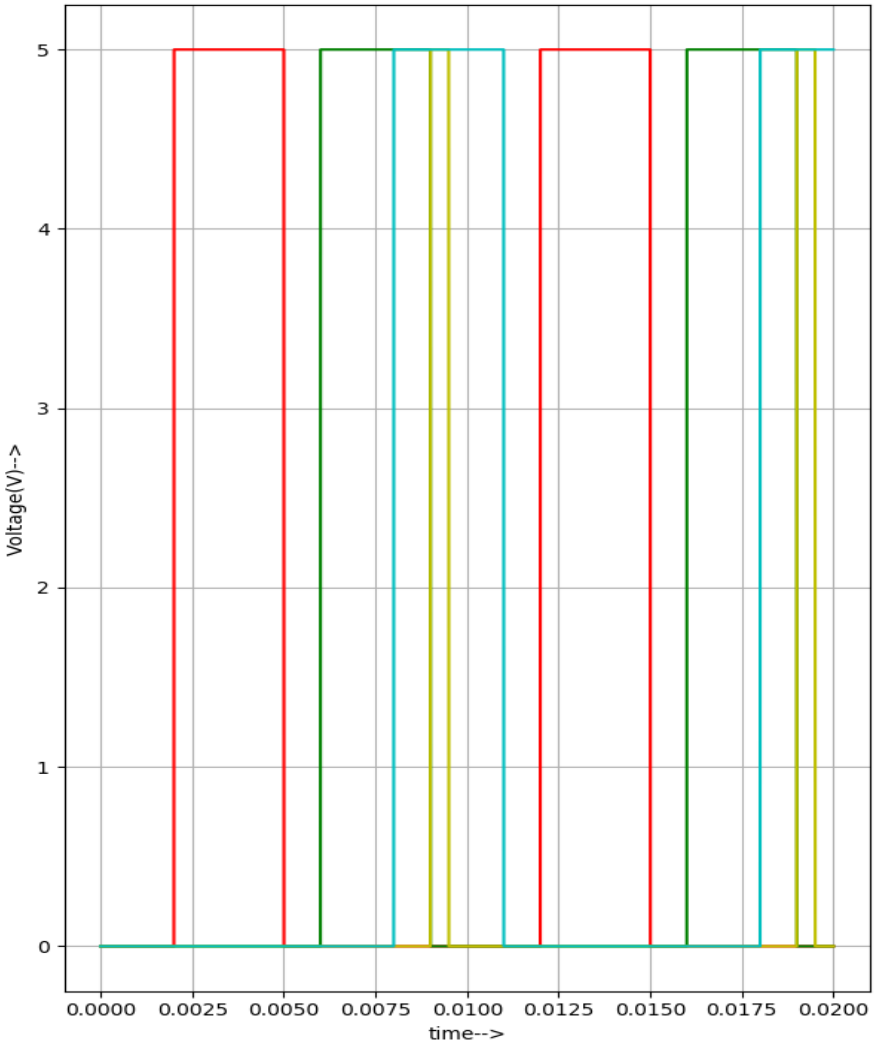

Figure 7: Python Combined Safety-Input Plot

The corresponding system-response signals are plotted separately using Python.

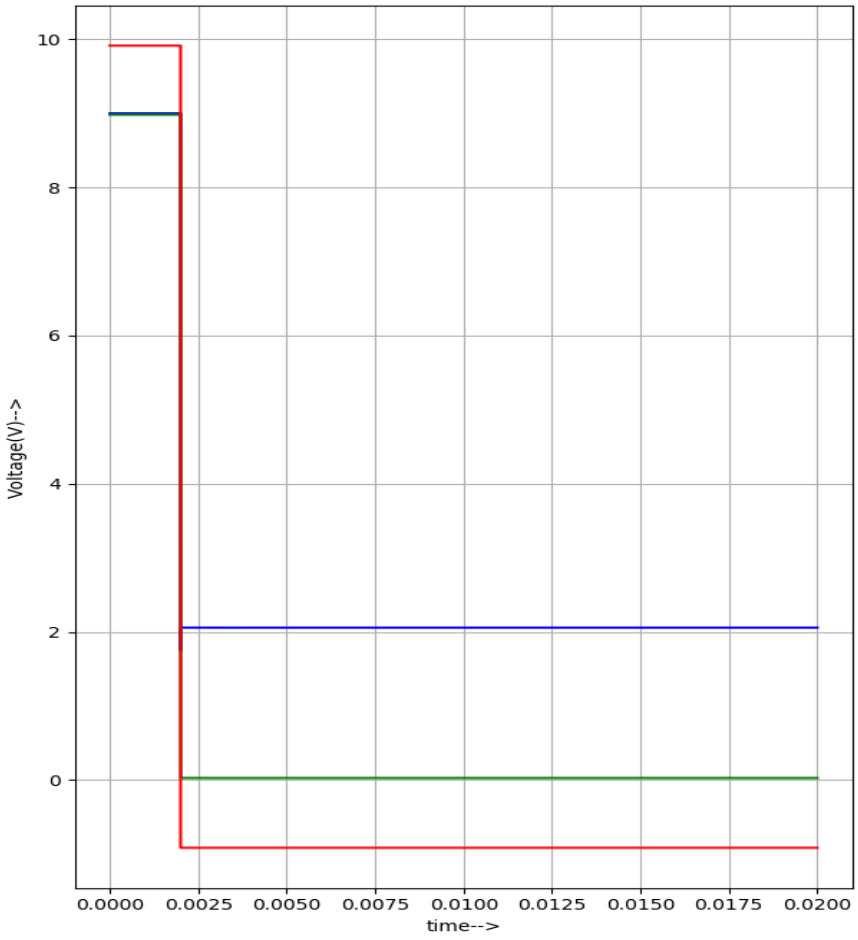

Figure 8: Python System-Response Plot

Observed Results:

The individual fault simulations and the final combined simulation verify the operation of the circuit. During normal operation, the system remains in its normal state. When any safety input is activated, the analog decision and transistor switching stages respond accordingly, producing a corresponding change in the output signals and LED indication.

The combined simulation demonstrates the intended input-to-output signal flow, with the four safety conditions being activated at 2 ms, 6 ms, 8 ms, and 9 ms, respectively. The resulting waveforms confirm that the circuit responds to the simulated emergency-stop, temperature, overload, and object-detection conditions.

Conclusion:

Thus, the Industrial Conveyor Belt Monitoring and Safety System has been designed and simulated using eSim and NGSpice. The circuit models four conveyor safety conditions—emergency-stop, temperature, overload/current abnormality, and object detection—and produces a corresponding safety response.

The individual fault tests and the combined 0–20 ms transient simulation provide waveform-based verification of the circuit operation. The simulation demonstrates a circuit-level proof of concept for monitoring multiple conveyor safety conditions using analog and transistor-based signal processing.

The implementation is intended for academic circuit-level simulation and does not represent a certified industrial safety controller or a direct mains-powered conveyor control system.

Screen Recording:

[INSERT GOOGLE DRIVE SCREEN-RECORDING LINK HERE]

The screen recording should show the eSim project execution, simulation, and generated waveform output.

References:

1. FOSSEE, IIT Bombay — eSim Circuit Simulation Project and eSim documentation.
2. KiCad Documentation — Schematic capture and circuit/netlist workflow.
3. NGSpice Documentation — Transient simulation and device modelling.
4. Texas Instruments — Operational amplifier documentation.
5. Jacksha, J. and Raj, K. V., “Assessing the Feasibility of a Commercially Available Wireless Internet of Things System to Improve Conveyor Safety,” Mining, Metallurgy & Exploration, Vol. 38, pp. 567–574.

Note: Insert the final circuit schematic and output plots at the indicated figure positions before submission.