

Industrial Conveyor Belt Monitoring and Safety System

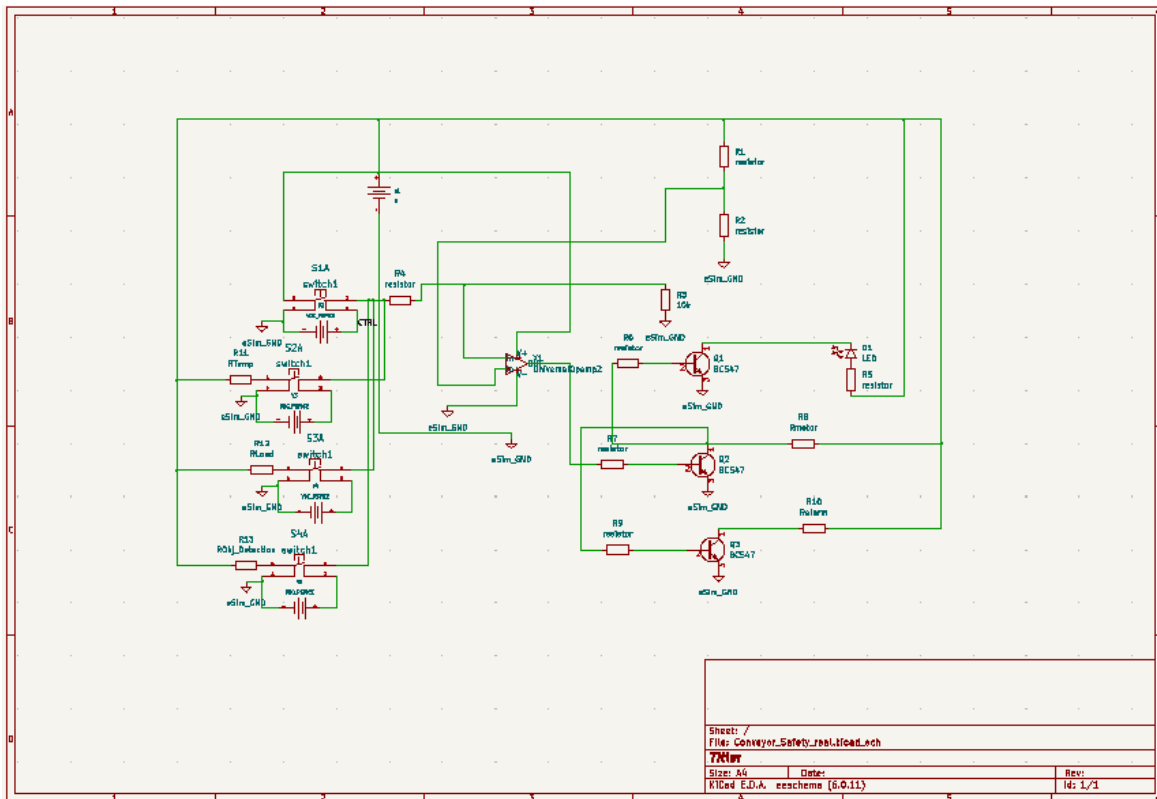
Introduction:

Industrial conveyor systems are widely used for continuous material handling in manufacturing, warehousing and other industrial environments. Because conveyor machinery operates continuously and contains moving parts, unsafe conditions such as emergency-stop activation, excessive temperature, overload/current abnormality and object obstruction must be detected and responded to promptly. This project presents a circuit-level safety monitoring and indication system designed and simulated using eSim software and NGSpice.

The proposed system represents four safety conditions as electrical input signals. These inputs are processed through an analog decision stage and transistor switching network. A 9 V supply is used for the circuit, and a diode model representing a red LED provides the simulated safety/fault indication. The project focuses on circuit-level verification and does not claim industrial safety certification or direct control of a mains-powered conveyor.

Schematic Diagram:

The schematic diagram of the Industrial Conveyor Belt Monitoring and Safety System is shown below:



Simulation and NGSPICE Output:

Transient NGSpice simulation was used to verify the circuit. The final combined test uses a 0–20 ms observation window with the four safety inputs occurring sequentially. The event timings are E-Stop at 2 ms, temperature fault at 6 ms, overload at 8 ms and object detection at 9 ms.

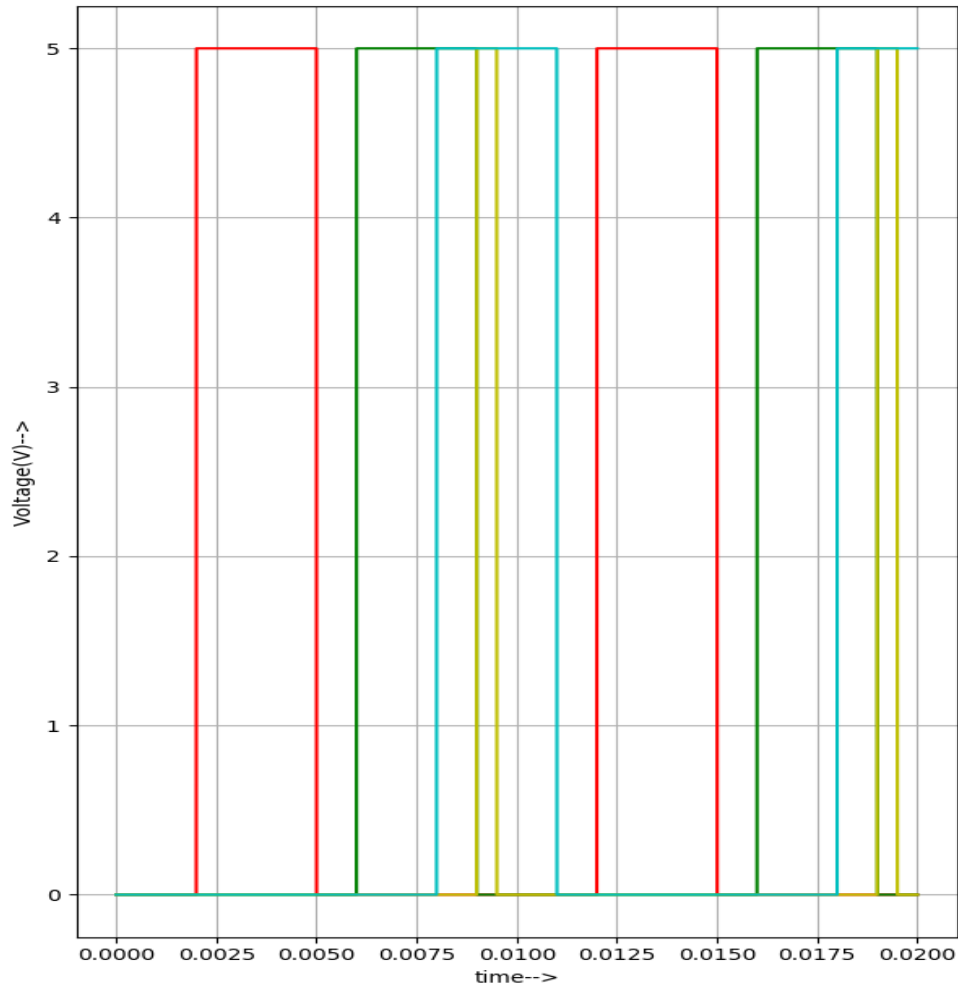


Fig.2. NGSPICE output waveform of combined safety inputs

NGSPICE Output waveform at system response:

The final response waveform uses the X1 output, Q1 collector and LED-anode nodes. Under the combined simulation, the system changes from its normal state when the first safety input is activated. The response remains in the safety/fault state while the triggered condition is active.

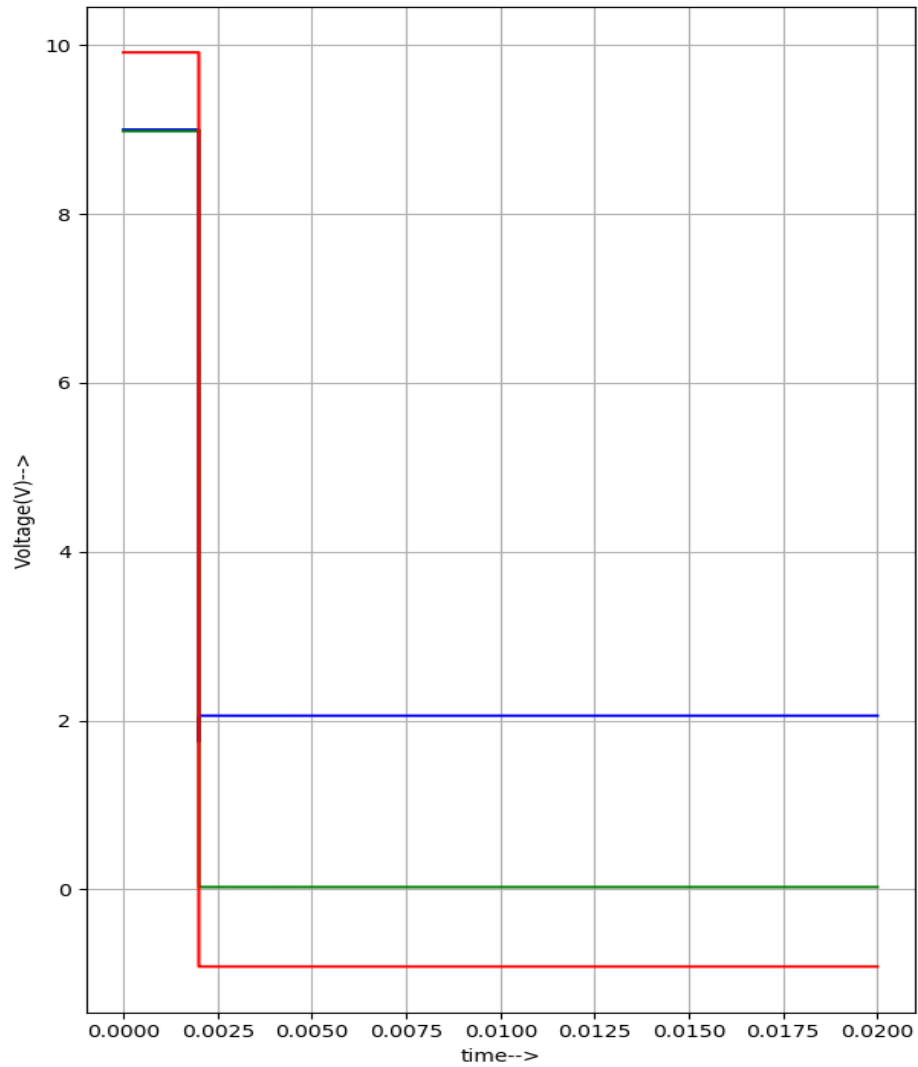


Fig.3. NGSPICE output waveform at the system response nodes

Fault timing:

Input	Safety condition	Trigger
V2	E-Stop	2 ms
V3	Temperature	6 ms
V4	Overload	8 ms
V5	Object detection	9 ms

Individual Fault Verification:

Temperature Fault at 6 ms:

For the isolated temperature test, V3 was activated at 6 ms while V2, V4 and V5 were delayed outside the observation window. The circuit remained in its normal state before the temperature input and changed to the safety/fault state when V3 was applied.

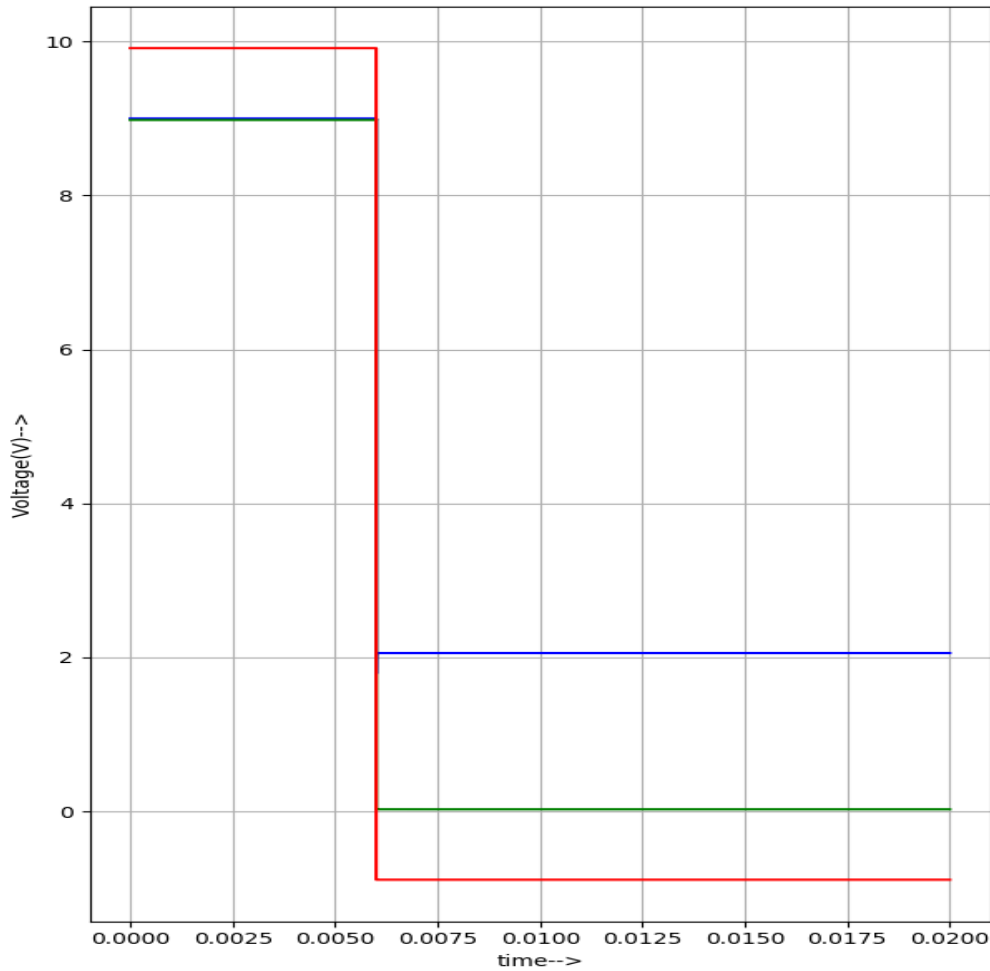


Fig.4. NGSPICE output waveform for temperature fault

Overload Fault at 8 ms:

For the isolated overload test, V4 was activated at 8 ms while the other fault inputs were delayed outside the observation window. The response was observed at the selected system-response nodes.

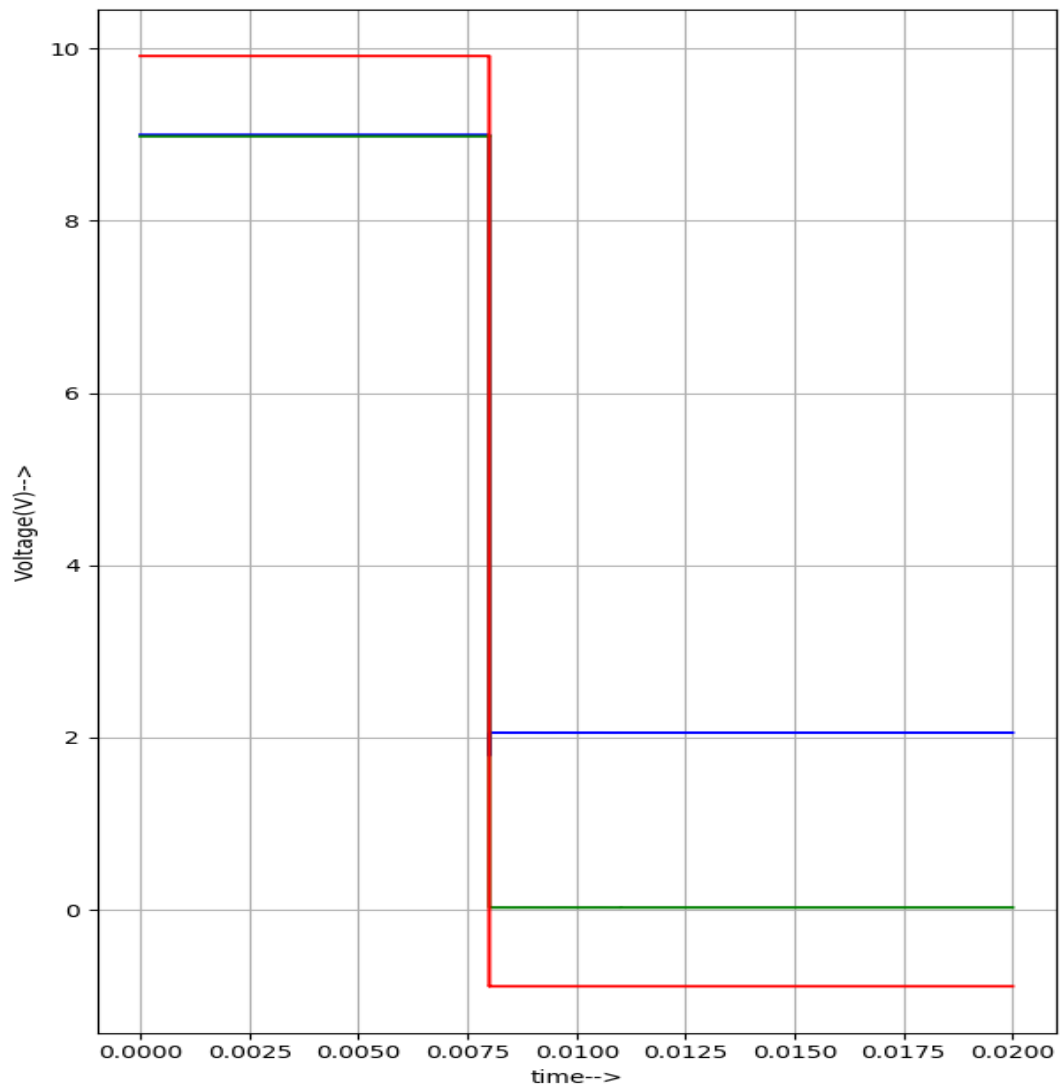


Fig.5. NGSPICE output waveform for overload fault

Object Detection Fault at 9 ms:

For the isolated object-detection test, V5 was activated at 9 ms using the specified short pulse duration, while the other fault inputs were delayed outside the observation window. The output response was observed through the Q1 collector and LED-anode response.

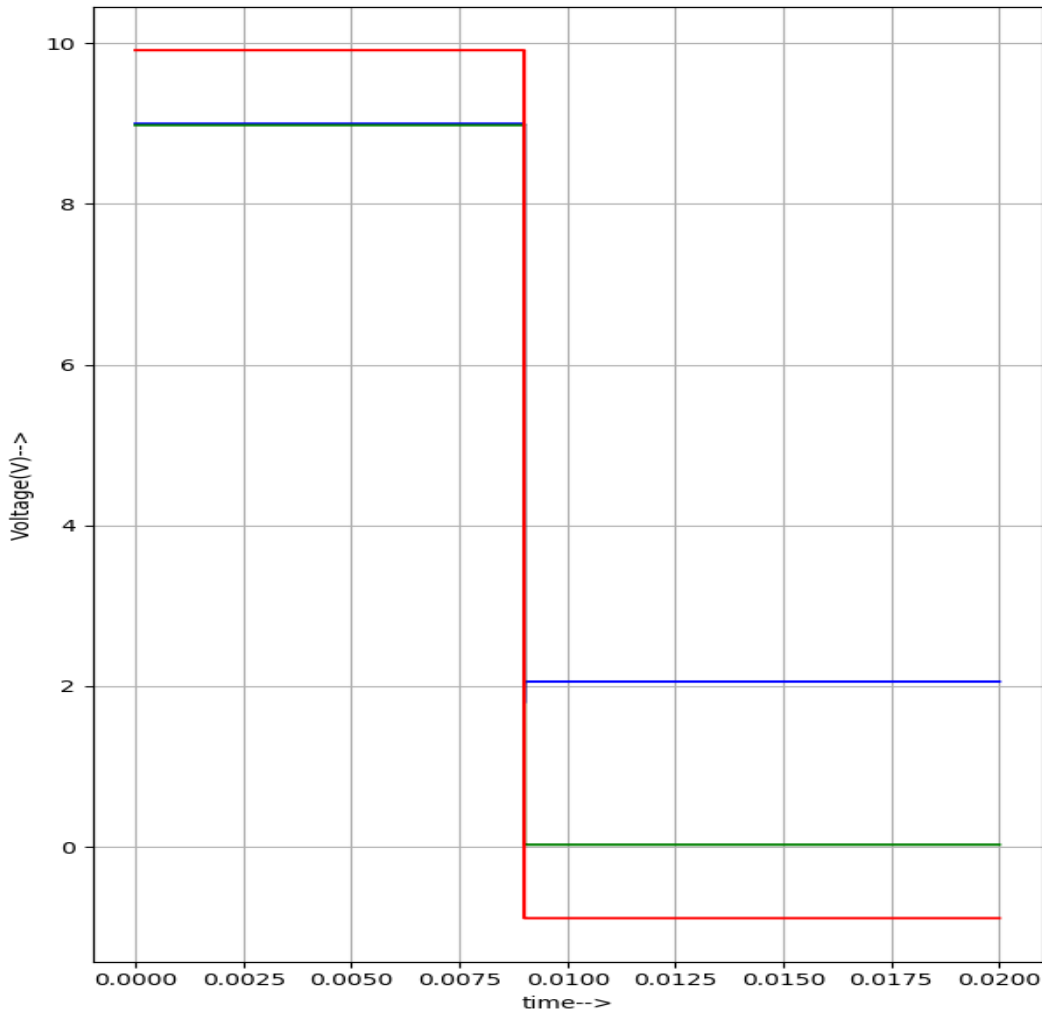


Fig.6. NGSPICE output waveform for object-detection fault

Python Plot / Processed Simulation Results:

The simulation data can also be represented using Python plots for clearer presentation of voltage-versus-time behavior. The Python plots below are generated from the final combined simulation data of the working project.

Python Plot at combined input terminals:

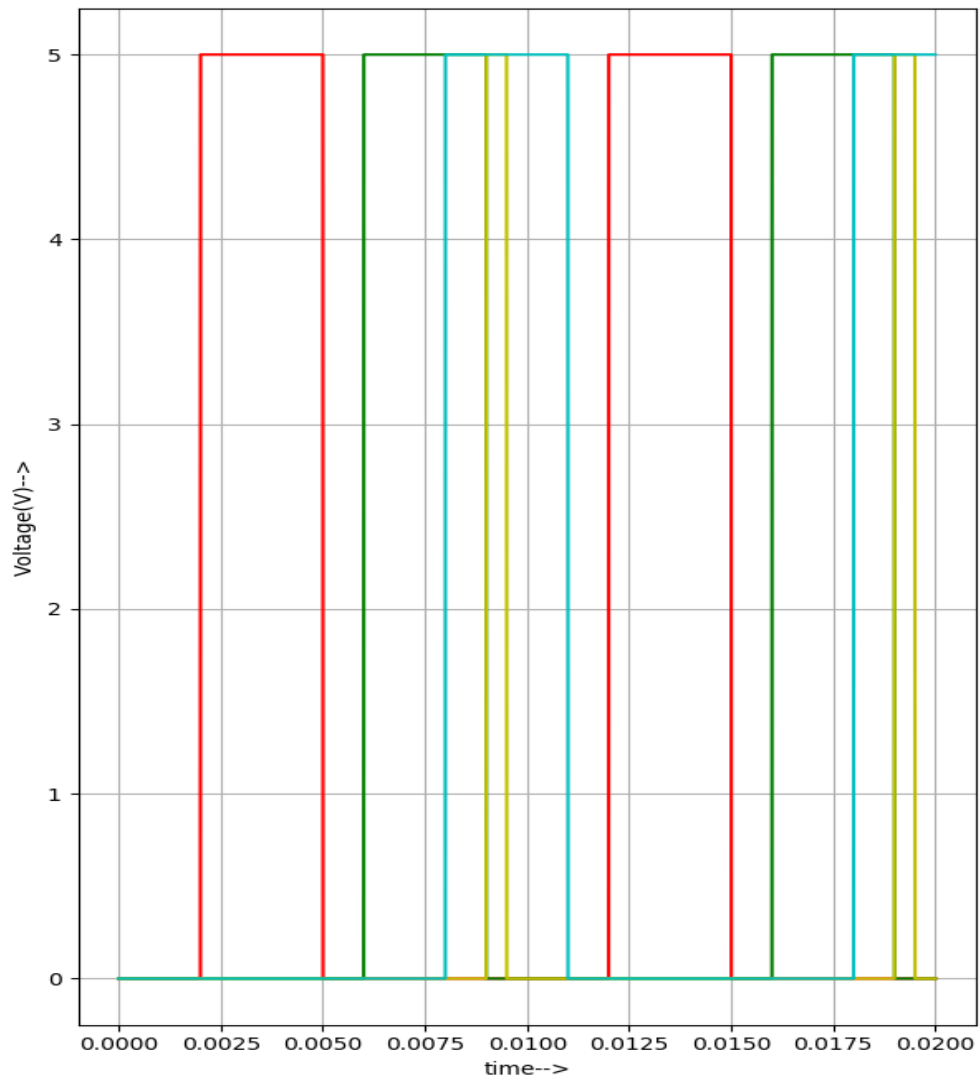
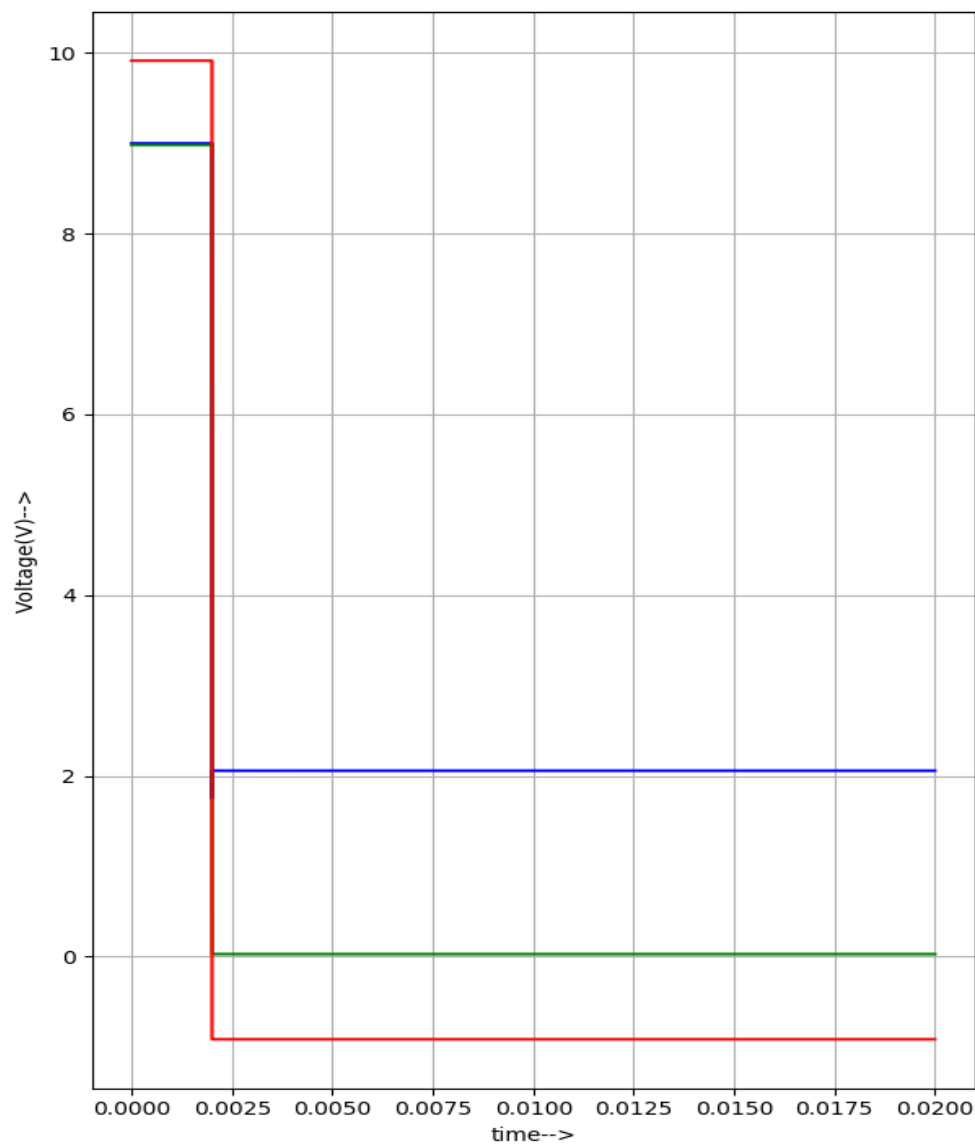


Fig.7. Python plot of combined safety inputs

Python Plot at system response nodes:



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Fig.8. Python plot of system response

Summary of observed values:

The values below are approximate values read from the new combined Python response plot. They replace the old report values and should be retained only if they agree with the final saved NGSPICE/Python plots.

Simulation phase	Q1 collector	LED anode	LED indication
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Normal (0–2 ms)	$\approx 9.0 \text{ V}$	$\approx 9.0 \text{ V}$	OFF
E-Stop (2 ms)	$\approx 2.05 \text{ V}$	$\approx 0 \text{ V}$	ON
Temperature (6 ms)	Safety/fault response	Safety/fault response	ON
Overload (8 ms)	Safety/fault response	Safety/fault response	ON
Object detection (9 ms)	Safety/fault response	Safety/fault response	ON

Note: the exact steady-state values for the later individual fault events should be taken from the corresponding final plots if a numerical value is required in the final submission.

Conclusion:

The Industrial Conveyor Belt Monitoring and Safety System was designed and verified at circuit level using eSim and NGSpice. The combined 0–20 ms simulation demonstrated sequential responses to the four represented safety conditions: emergency stop, temperature fault, overload and object detection. Separate temperature, overload and object-detection simulations were also used to verify the response to individual fault conditions.

The final working implementation uses an eSim diode symbol with the eSim_RedLED SPICE model for the LED indication stage. The system provides a circuit-level proof of concept for monitoring multiple conveyor safety conditions. It is intended for simulation and academic demonstration; a practical industrial implementation would require certified safety hardware, sensor interfaces, electrical isolation, protection circuitry and standards-based validation.

Simulation Recording:

A screen recording showing the project execution, KiCad-to-NGSPICE conversion, simulation and generated waveform should be provided as a Google Drive link here:

https://drive.google.com/file/d/1LXZN0YrKs3uF_ANI10eD5ViMlrB70A98/view?usp=sharing

References:

FOSSEE eSim — Circuit Simulation Project and eSim documentation.

KiCad Documentation — Schematic Editor and circuit/netlist workflow.

Texas Instruments — Operational amplifier documentation.

Jacksha, R. & Raj, K. V. — Assessing the Feasibility of a Commercially Available Wireless Internet of Things System to Improve Conveyor Safety.

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