SMART PNEUMATIC SYSTEM HEALTH AND LEAK DETECTION CONTROLLER USING ESIM

1. Theory / Description

Pneumatic systems require adequate pressure for reliable operation. A pressure loss caused by a leak or another unhealthy operating condition can be detected by monitoring the electrical signal corresponding to system pressure. This project implements the pressure-monitoring and threshold-alert stage of a Smart Pneumatic System Health and Leak Detection Controller using eSim.

In the eSim circuit, V1 is used as a pressure-sensor-equivalent input and produces the node PRESSURE_OUT. R1 and C1 provide input conditioning. An LM393 comparator compares the pressure signal with a fixed reference. The reference is generated from the 3 V supply V2 using R3 = 10 kΩ and R4 = 10 kΩ, giving:

VREF = 3 × (10 kΩ / (10 kΩ + 10 kΩ)) = 1.5 V

The comparator output is observed at ALERT_OUT. R2 = 10 kΩ provides the pull-up required for the LM393 open-collector output. Thus, when PRESSURE_OUT crosses the selected reference threshold, ALERT_OUT changes state and provides an indication of a pressure abnormality.

2. Circuit Elements and Functions

Element	Value	Function
V1	2.5 V nominal	Pressure-sensor-equivalent input / pressure signal source
R1	10 kΩ	Input conditioning network
C1	1 µF	Input filtering / smoothing
V2	3 V	Comparator supply and reference-divider supply
R3	10 kΩ	Upper resistor of reference divider
R4	10 kΩ	Lower resistor of reference divider
LM393	Comparator	Compares PRESSURE_OUT with VREF
R2	10 kΩ	Pull-up for ALERT_OUT

3. Circuit Diagram

The following figure shows the eSim comparator-based pressure monitoring circuit used for the simulation. The project ZIP contains the editable eSim project and its generated simulation files.

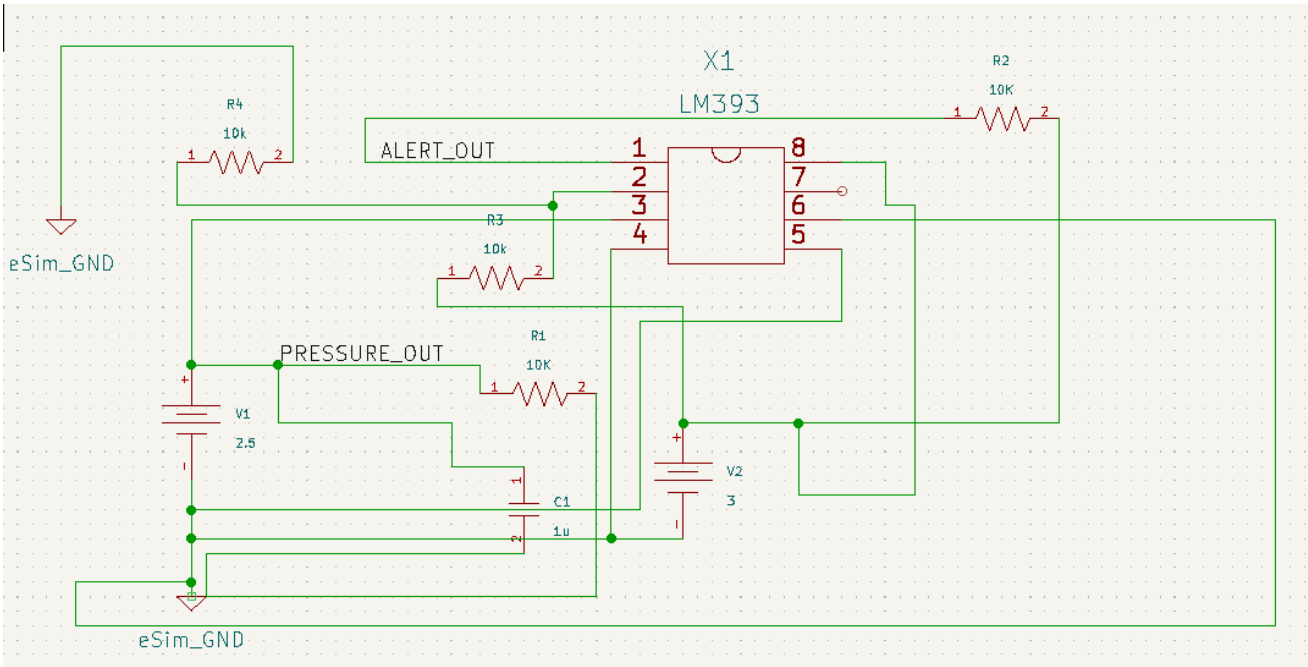

Figure 1. eSim schematic of the Smart Pneumatic System Health and Leak Detection Controller.

4. Working Principle

- Pressure input: V1 represents the electrical output of the pressure sensing stage and is swept during DC analysis.
- Signal conditioning: R1 and C1 form the input conditioning network associated with PRESSURE_OUT.
- Reference generation: R3 and R4 divide the 3 V supply to obtain a 1.5 V reference for the comparator.
- Comparison: The LM393 compares PRESSURE_OUT with the reference level.
- Alert generation: The open-collector comparator output is pulled up through R2 and observed at ALERT_OUT.

5. Simulation and Results

A DC sweep of V1 from 0 V to 5 V was performed with a 0.1 V increment. The simulated PRESSURE_OUT response follows the applied voltage sweep, while ALERT_OUT exhibits threshold switching around the 1.5 V reference level. The combined plot below was obtained from the eSim simulation output.

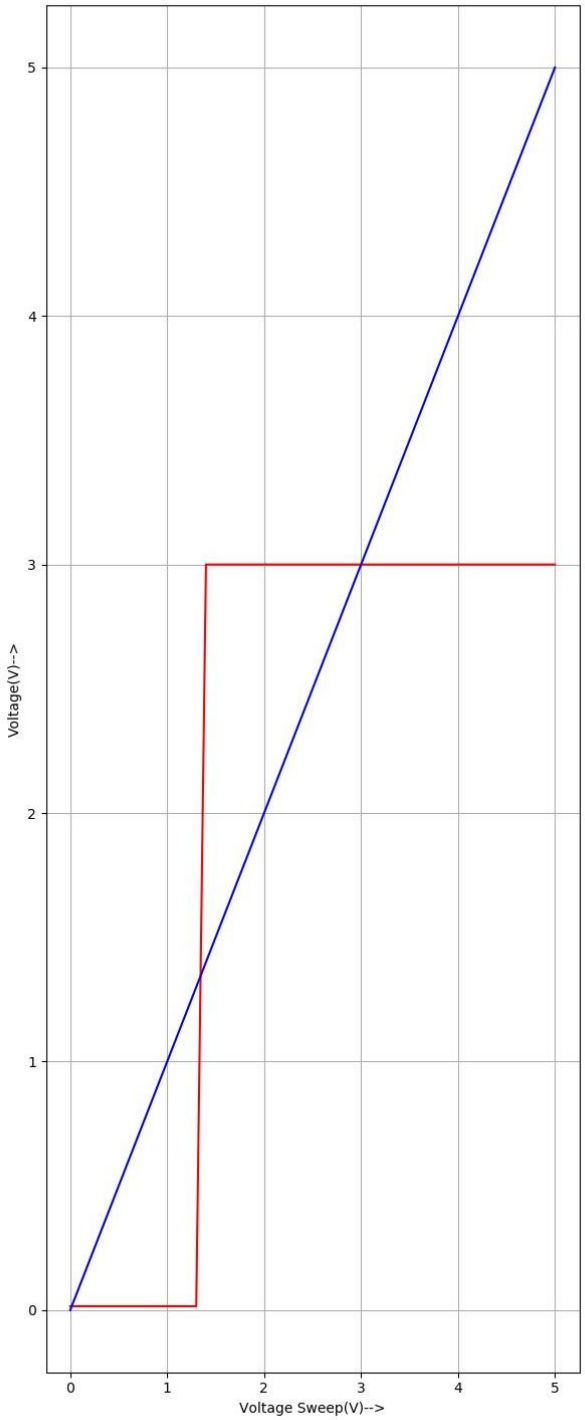

Figure 2. Combined PRESSURE_OUT and ALERT_OUT response for the DC voltage sweep.

6. Result Interpretation

The simulation demonstrates the intended threshold-monitoring behaviour. PRESSURE_OUT varies with the applied pressure-equivalent input, while ALERT_OUT changes state when the monitored voltage crosses the reference level generated by the R3-R4 divider. With a 3 V supply and equal 10 kΩ divider resistors, the reference is approximately 1.5 V.

The present eSim model represents the electronic pressure-monitoring/controller stage. A physical pneumatic implementation would use the actual pressure sensor output in place of the simulated pressure-source input. This makes the simulation suitable for demonstrating the sensing-interface, threshold-comparison and alert generation stages of the proposed pneumatic health/leak-monitoring system.

7. Conclusion

The Smart Pneumatic System Health And Leak Detection Controller was designed and simulated using eSim. The circuit combines pressure-signal conditioning, reference-voltage generation and LM393-based threshold comparison to produce an ALERT_OUT indication. The simulation results verify the expected threshold response and provide a functional electronic controller stage for pressure-health and leak-related anomaly monitoring in a pneumatic system.

8. References

- FOSSEE, eSim – Circuit Simulation Project, Submission Guidelines and Procedure.
- Texas Instruments / LM393 family comparator documentation and datasheet.
- eSim/Ngspice documentation for DC analysis and circuit simulation.

Submission note: The completed eSim project is submitted separately as a ZIP file through the FOSSEE Circuit Simulation Project upload portal. The ZIP should retain the original eSim project structure/name.