

Title of the project: Heartbeat Sensing and Detection System

Theory:

The proposed project is a circuit-level heartbeat sensing and detection system implemented and simulated entirely in eSim. The system processes a simulated heartbeat-like input signal, conditions and amplifies it, and generates a detectable electrical output corresponding to heartbeat activity. No external IoT platform or cloud service is used.

The system uses a simulated pulse waveform to represent the sensor signal. The input is then coupled and biased so that the heartbeat signal can be processed. An op-amp stage amplifies and conditions the input, after which an N-channel MOSFET detection stage uses the conditioned signal to control switching and produce a detectable output.

Proposed System:

Heartbeat input model: Provides a simulated pulse waveform representing the sensor signal.

Signal conditioning: Couples and biases the input so the heartbeat signal can be processed.

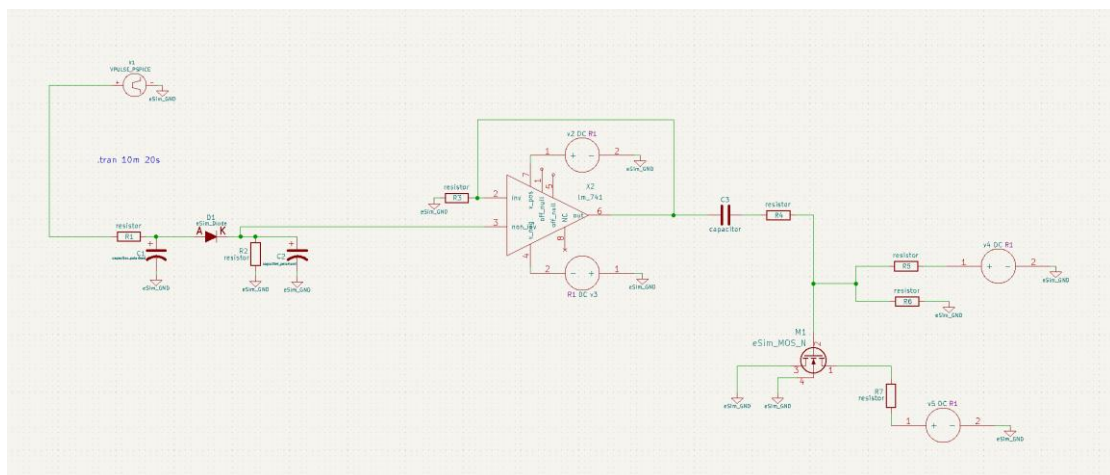
Op-amp stage: Amplifies and conditions the input signal.

MOSFET detection stage: Uses the conditioned signal to control switching and produce a detectable output.

Output: Drain waveform used to observe heartbeat-related switching activity.

Circuit Schematic:

The circuit has been constructed in the eSim/KiCad schematic environment. It uses an analog signal-conditioning section followed by an op-amp stage and an N-channel MOSFET switching/detection stage. The MOSFET drain is monitored as the principal detection output.



(fig.1: Circuit Schematic of the eSim-Based Heartbeat Sensing and Detection System)

Circuit Implementation:

The circuit is implemented at circuit level in eSim/KiCad. The signal-conditioning section prepares the simulated heartbeat input, the op-amp stage provides amplification and signal conditioning, and the N-channel MOSFET stage performs switching and detection.

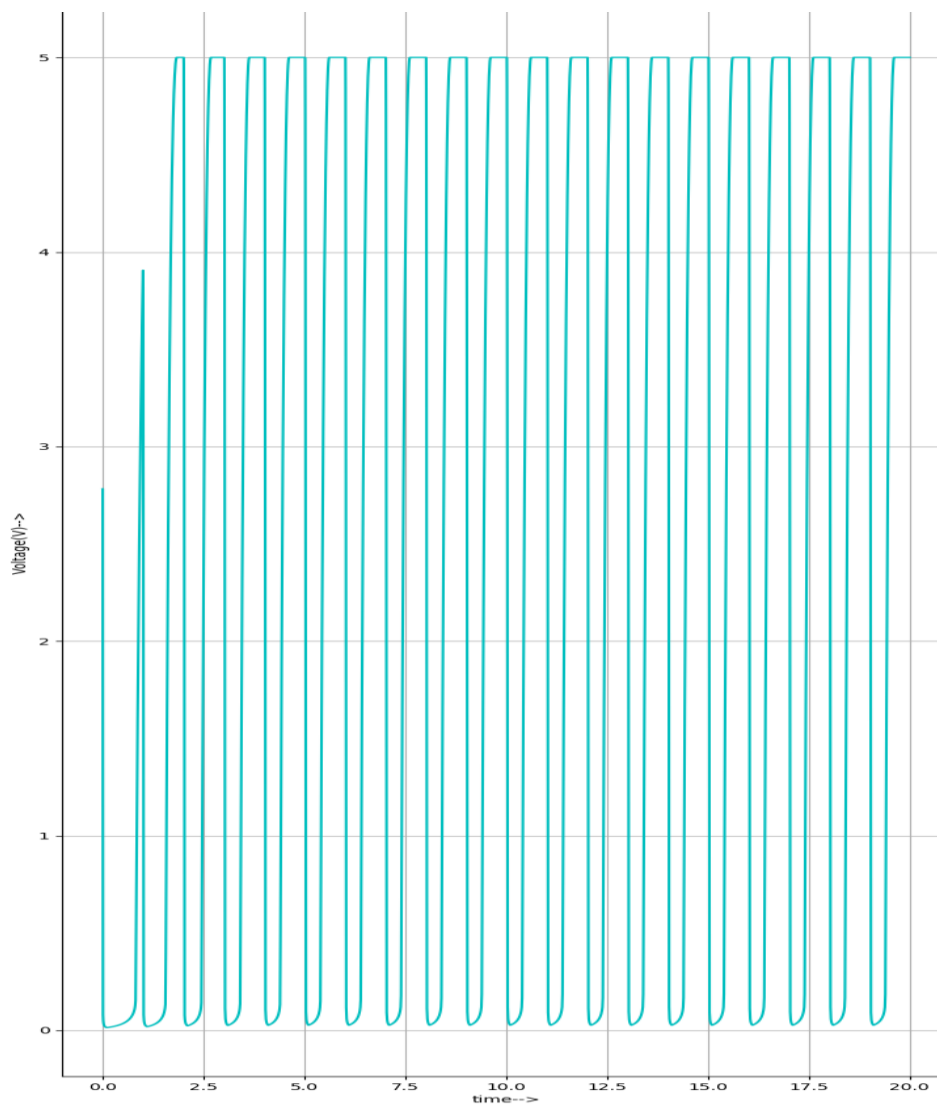
The circuit is simulated using transient analysis. The MOSFET drain waveform is used as the principal detection output to observe heartbeat-related switching activity.

Simulation Results:

The circuit has been tested under multiple input conditions. The verification includes heartbeat rate cases corresponding to approximately 60 BPM and 90 BPM, together with a no-heartbeat condition.

1. Heartbeat Condition – Approximately 60 BPM

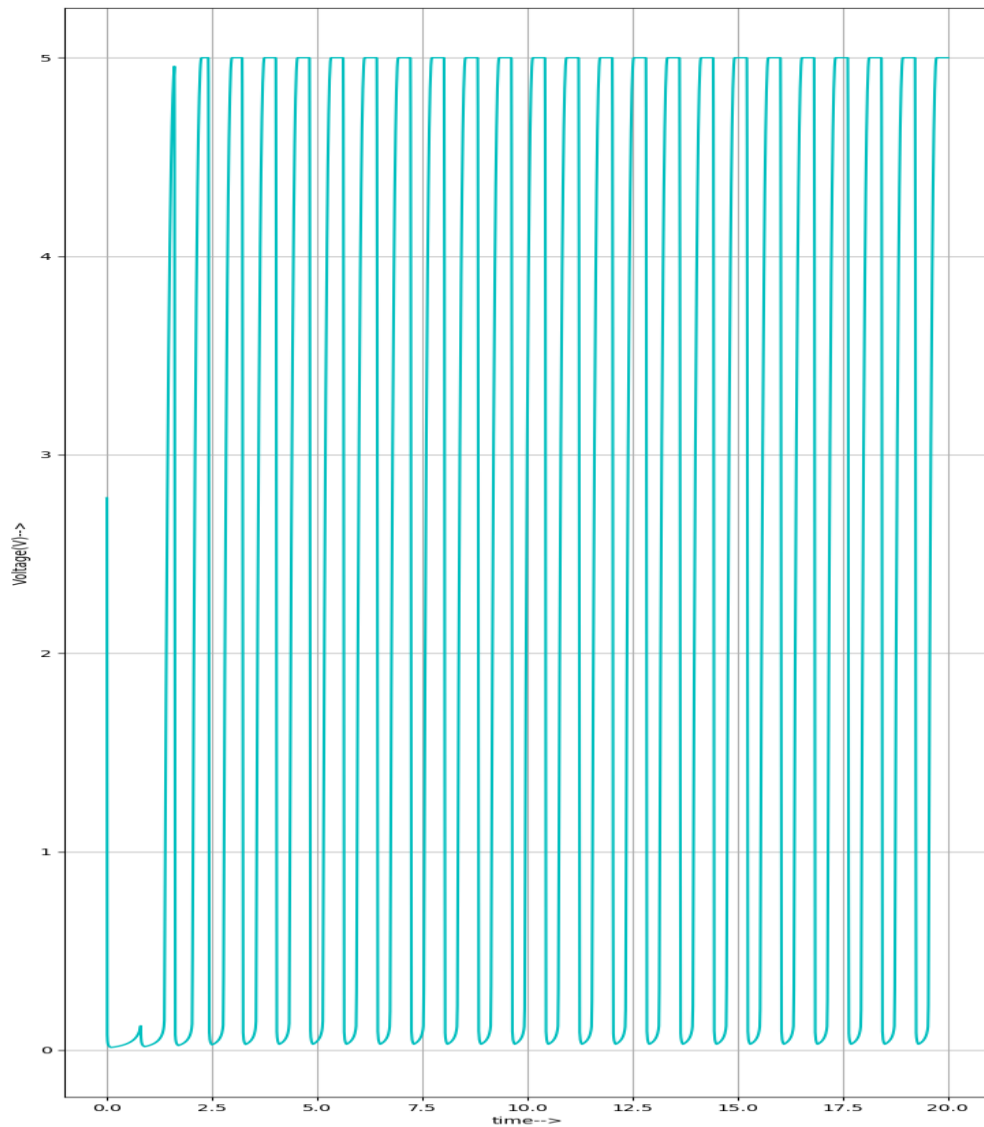
The simulation is used to observe the detection-stage output for a simulated heartbeat input corresponding to approximately 60 BPM.



(fig.2: Ngspice Output Drain Waveform for Approximately 60 BPM)

2. Heartbeat Condition – Approximately 72 BPM

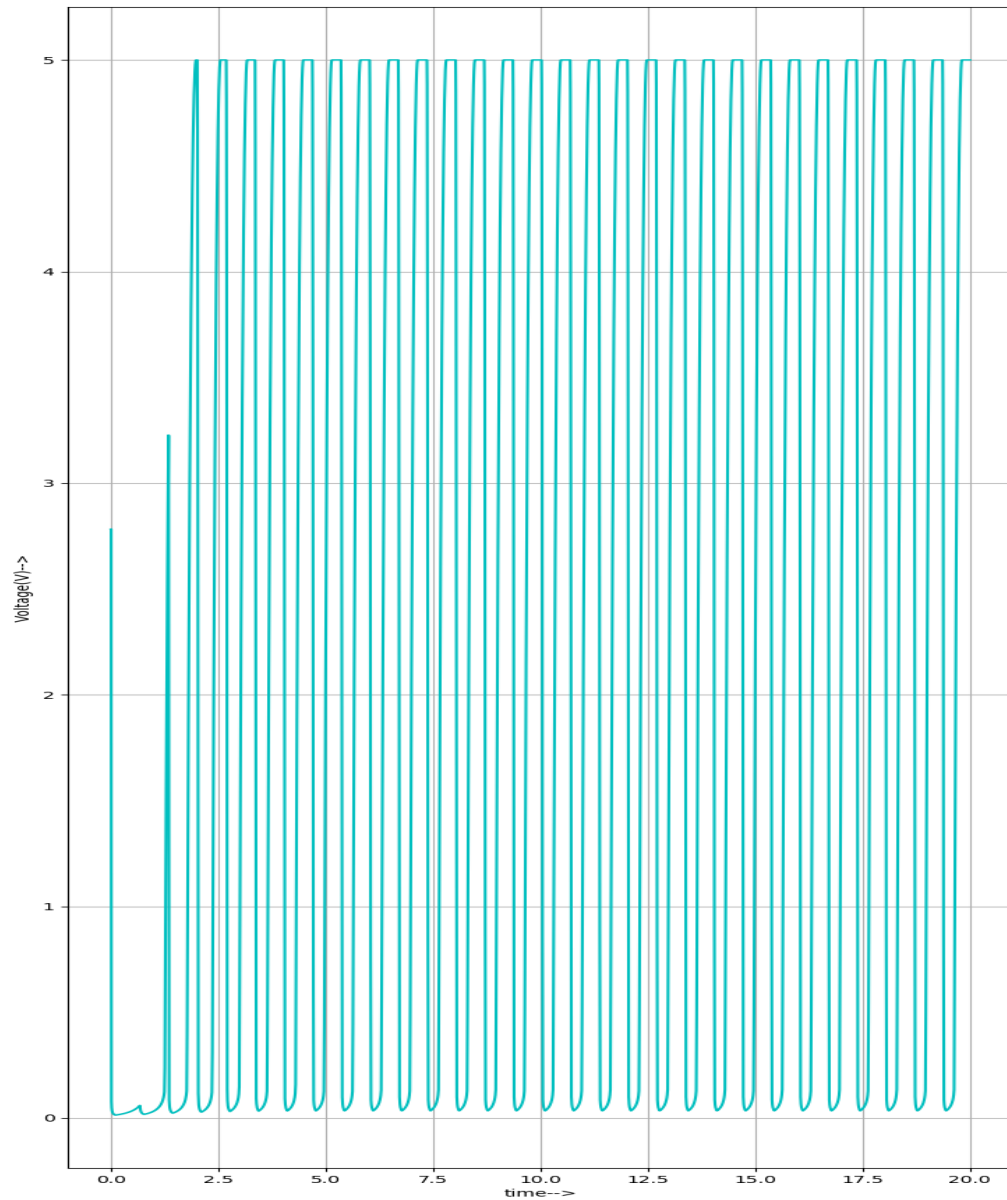
The simulation is also tested with a simulated heartbeat input corresponding to approximately 72 BPM to verify the intended input-to-output signal flow under a different heartbeat rate.



(fig.3: Ngspice Output Drain Waveform for Approximately 72 BPM)

3. Heartbeat Condition – Approximately 90 BPM

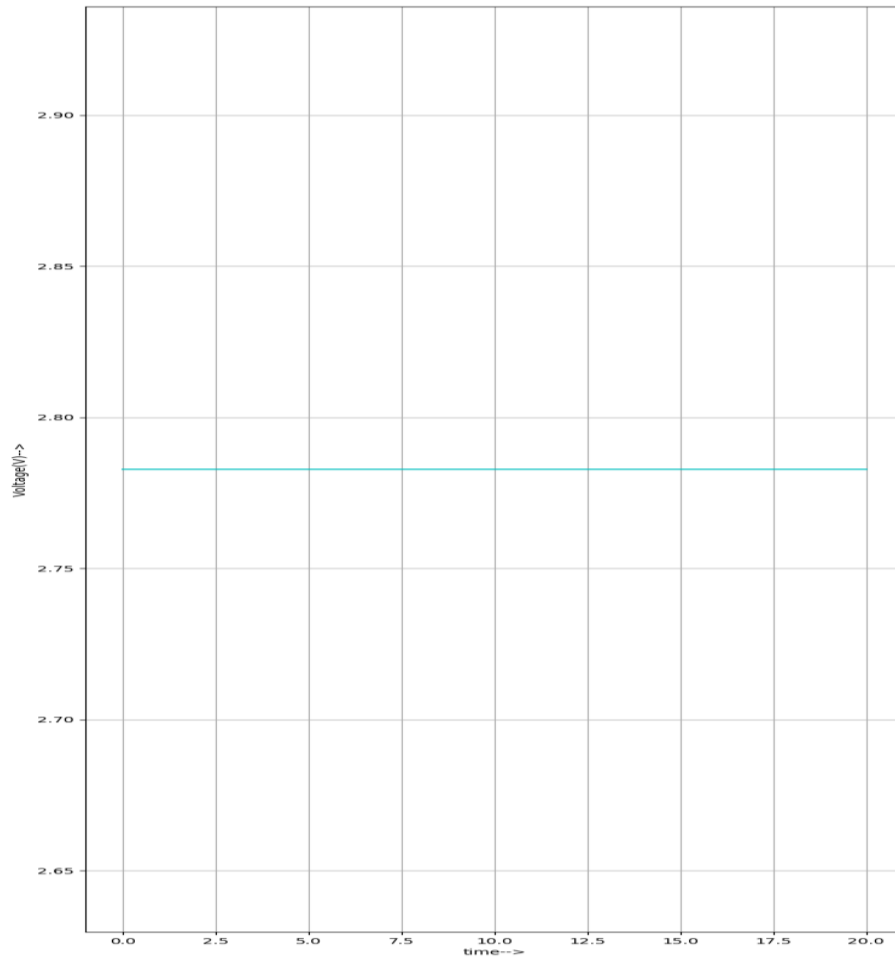
The simulation is also tested with a simulated heartbeat input corresponding to approximately 90 BPM to verify the intended input-to-output signal flow under a different heartbeat rate.



(fig.4: Ngspice Output Drain Waveform for Approximately 90 BPM)

4. No-Heartbeat Condition

A no-heartbeat condition is included as part of the preliminary verification. The detection-stage output is observed to compare the system response with the heartbeat cases.



(fig.5: Ngspice Output Drain Waveform for No-Heartbeat Condition)

Comparison of Tested Conditions:

The preliminary verification covers approximately 60 BPM, approximately 90 BPM, and a no-heartbeat condition. These tests are intended to verify the input-to-output signal flow and the observable output waveform at the detection stage.

Parameter	Heartbeat Present	No Heartbeat
Heartbeat signal	Pulses continuously	No pulses
Input/clock	Periodic signal	Constant LOW
Circuit operation	Circuit operates normally	Circuit detects absence of heartbeat
Output	Normal output sequence	No/changed output indicating failure
Waveform	Periodic pulses	Flat/constant waveform
System status	Healthy/active	Heartbeat absent/fault condition

Working Principle:

A simulated heartbeat pulse is supplied as the input model. The signal-conditioning section couples and biases the input, allowing it to be processed by the op-amp stage. The op-amp amplifies and conditions the signal. The conditioned signal then controls the N-channel MOSFET switching/detection stage. The MOSFET drain waveform is

monitored as the principal output, providing an electrical indication of heartbeat-related switching activity.

Expected Outcome:

The completed system should provide a clear electrical indication of heartbeat activity from the simulated sensor input. The project demonstrates a complete circuit-level sensing chain in eSim, including signal conditioning, amplification, detection, transient simulation and verification.

Conclusion:

Thus, the eSim-based heartbeat sensing and detection system demonstrates a complete circuit-level sensing chain using a simulated heartbeat input. The system includes signal conditioning, op-amp amplification, N-channel MOSFET-based detection, transient simulation and verification under approximately 60 BPM, approximately 90 BPM and no-heartbeat conditions. The MOSFET drain waveform serves as the principal detection output for observing heartbeat-related switching activity.

References:

[2N7002L 6V N-channel MOSFET datasheet \(Rev. A\)](#)