ADSR ENVELOPE GENERATOR CIRCUIT USING eSim

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ABSTRACT

An Attack-Decay-Sustain-Release (ADSR) envelope generator is a crucial component in electronic music synthesis, defining the amplitude contour of a sound over time. The ADSR envelope controls how a sound evolves from the moment a note is pressed until it is released, impacting the expressiveness and character of synthesized audio. This project aims to design and simulate an ADSR envelope generator circuit using eSim, an open-source EDA tool that facilitates the creation and simulation of electronic circuits.

The primary objective of this project is to design an ADSR envelope generator circuit that can produce a variable envelope controlling the amplitude of a signal. This envelope generator will be used to modulate other parameters in synthesizers, such as filter cutoff or pitch, to create dynamic and expressive sounds.

COMPONENTS AND TOOLS

- **eSim Software:**

  eSim will be used for schematic design and circuit simulation.

- **Op-Amps (Operational Amplifiers):**

  Essential for building the integrator and comparator circuits required for generating the envelope.

- **Resistors and Capacitors:**

  These passive components set the timing characteristics of each stage (Attack, Decay, Sustain, Release) in the ADSR envelope.

- **Potentiometer:**

  Allow fine-tuning of the Attack, Decay, Sustain, and Release times.

- **Diodes and Transistors:**

Facilitate switching and signal shaping within the circuit.

METHODOLOGY

1. **Attack Phase:**
- The Attack phase is the time taken for the initial run-up of the envelope from zero to its peak. Design this phase using an op-amp integrator where the rate of voltage increase is controlled by a resistor-capacitor (RC) network.

2. **Decay Phase:**
- The Decay phase follows the Attack, where the envelope falls to the Sustain level. This is implemented using another op-amp integrator circuit, where the decay rate is controlled by adjusting the RC time constant.

3. **Sustain Phase:**
- The Sustain phase is the level during the main sequence of the sound's duration while the note is held. A simple voltage divider circuit can be used to set this level, which remains constant until the note is released.

4. **Release Phase:**
- The Release phase is the time taken for the envelope to fall from the Sustain level to zero after the note is released. Similar to the Attack and Decay phases, this is controlled by an RC network in an op-amp integrator configuration.

DESIGN AND IMPLEMENTATION

- **Schematic Design:**

- Using eSim, create the schematic diagram of the ADSR envelope generator circuit. This includes:

- Designing the Attack stage using an op-amp integrator to gradually increase the output voltage.

- Configuring the Decay stage to decrease the voltage after the Attack phase using another integrator circuit.

- Setting up the Sustain level, which holds the voltage steady as the note is pressed.

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- Implementing the Release stage to smoothly drop the voltage to zero
when the note is released.

- **Simulation:**

- Simulate the circuit in eSim to verify the correct operation of each ADSR stage. Adjust component values and observe the output waveform to ensure it meets the desired characteristics. This involves:

- Running transient analysis to visualize the envelope shape.

- Adjusting potentiometers to test different envelope settings and their impacts on the waveform.

OUTPUT

Response of an ADSR (Attack, Decay, Sustain, Release) envelope applied to a sine wave input with an amplitude of 6V and a frequency of 2kHz. Here's a detailed description of the output waveform:

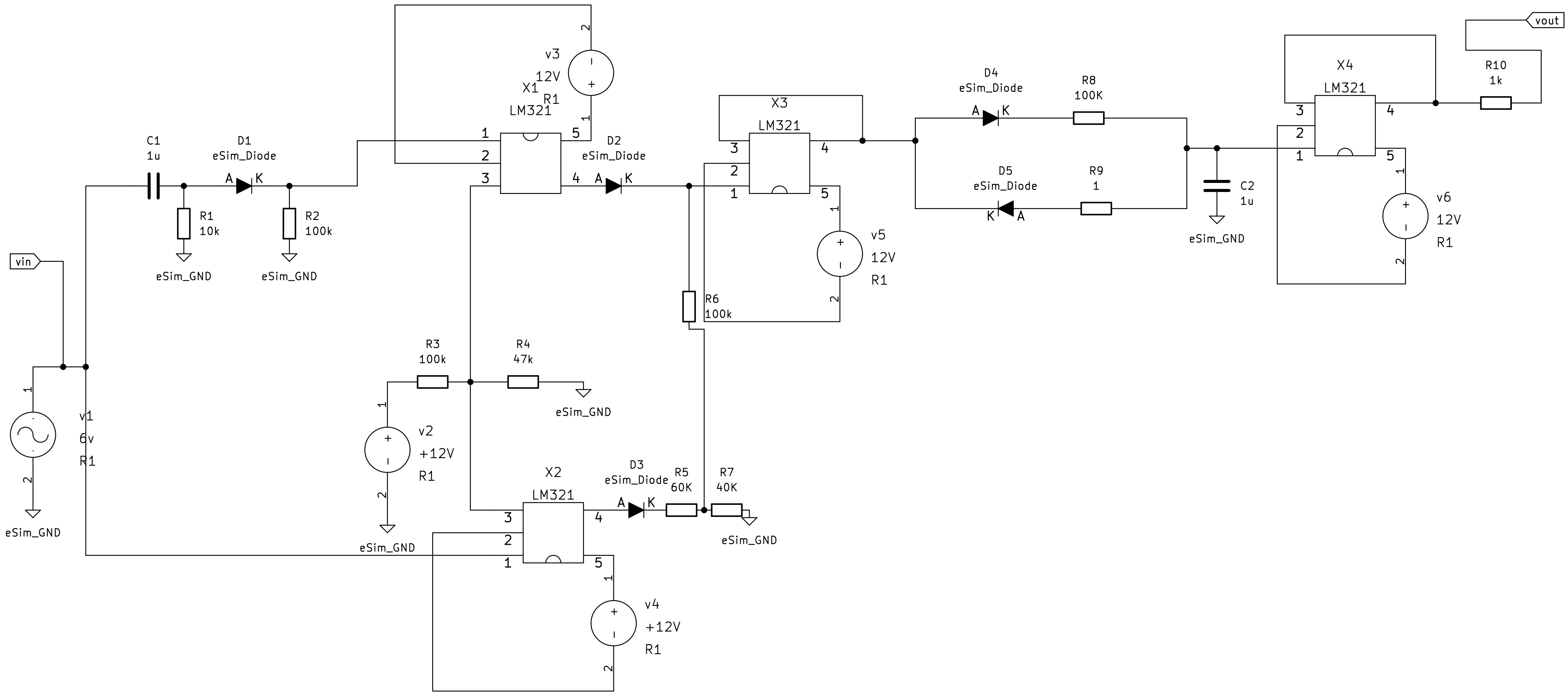
Attack Phase: The waveform quickly rises from 0V to its peak value. This phase represents the time taken for the amplitude to rise to its maximum value.

Decay Phase: After reaching the peak value, the amplitude decreases to a lower level (the sustain level). This reduction happens over a short period.

Sustain Phase: The amplitude remains relatively constant during this phase. The small fluctuations might be due to the high-frequency nature of the sine wave being modulated by the envelope.

Release Phase: Towards the end of the graph, the amplitude decreases back to 0V. This represents the release phase, where the amplitude gradually returns to zero after the sustain phase ends.

The vertical axis represents the amplitude of the output voltage, and the horizontal axis represents time. The fine details in the graph suggest high-frequency content consistent with a 2kHz sine wave modulated by the ADSR envelope.



vin
vout
C1
1u
D1
eSim_Diode
A
K
R1
10k
R2
100k
eSim_GND
v1
6v
R1
v3
12V
R1
X1
LM321
D2
eSim_Diode
X3
LM321
v5
12V
R1
R6
100k
R3
100k
R4
47k
v2
+12V
R1
X2
LM321
D3
eSim_Diode
R5
60K
R7
40K
v4
+12V
R1
D4
eSim_Diode
R8
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D5
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R9
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C2
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X4
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R10
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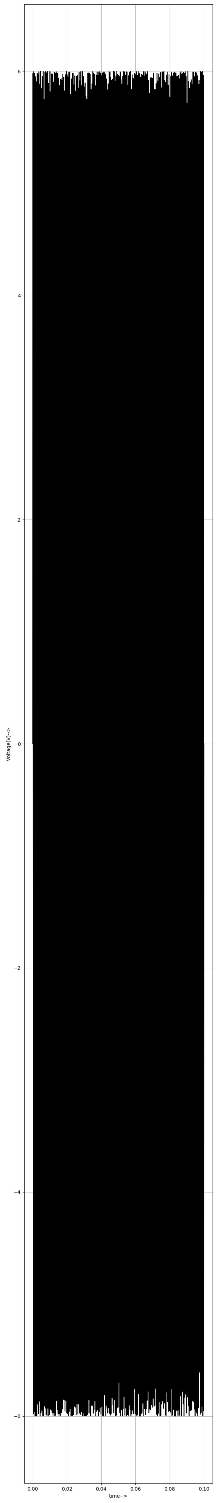

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−6
Voltage(V)-->
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0.02
0.04
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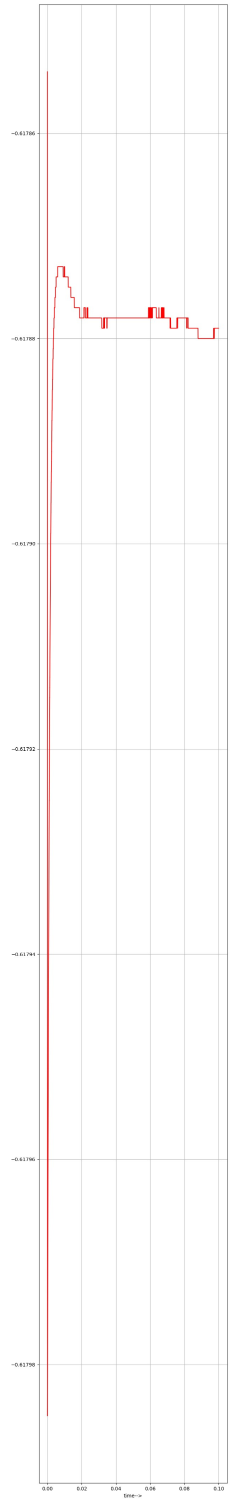
0.10
time-->



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−0.61794
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0.00
0.02
0.04
0.06
0.08
0.10
time-->

CONCLUSION

The ADSR envelope generator circuit project not only deepens understanding of electronic sound synthesis but also enhances proficiency in using eSim software for electronic design and simulation. By completing this project, one gains practical experience in analog circuit design and simulation, equipping them with valuable skills for further explorations in electronic music synthesis and broader electronics engineering fields.