

Analysis and Simulation of a Diode-Based Soft Clipper Circuit for Signal Limiting Applications

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Abstract

This paper presents the design, operation, and analysis of a diode-based soft clipper circuit, a fundamental technique for limiting signal amplitude and protecting electronic devices from excessive voltage. The soft clipper employs anti-parallel diodes with a series resistor to restrict the output waveform within the diode forward voltage, resulting in a rounded and flattened response rather than a sharp cutoff. This characteristic makes soft clippers valuable in signal conditioning, audio waveform shaping, and overvoltage protection. Through simulations performed in eSim software, the study demonstrates the clipping behavior of the circuit when subjected to a sinusoidal input, highlighting the influence of diode conduction thresholds on waveform shaping. The results confirm the role of diode soft clippers in providing controlled signal limitation while preserving waveform integrity, emphasizing their importance in both protection circuits and analog signal processing applications.

Keywords: Voltage Limiting, Soft Clipping, Diode Clipper, Signal Conditioning, Overvoltage Protection

I. INTRODUCTION

A diode soft clipper circuit is designed to limit the amplitude of an input signal, preventing it from exceeding a specified voltage threshold while preserving the general waveform shape. Unlike hard limiters, which abruptly cut off the waveform, a soft clipper gradually rounds the peaks as the signal approaches the diode conduction region. This controlled diode clipping action reduces distortion and ensures smoother signal conditioning, making soft clippers especially valuable in audio processing, analog communication systems, and overvoltage protection circuits.

The circuit typically consists of anti-parallel diodes connected across the output with a series resistor, allowing it to limit both positive and negative excursions of an alternating input waveform. When the input exceeds the forward voltage of the diodes, conduction occurs, restricting the output voltage to a safe range. This behavior not only protects sensitive electronic components from voltage surges but also enables practical applications such as waveform shaping and noise reduction. By providing a predictable and repeatable voltage-limiting action, diode soft clippers enhance circuit reliability while maintaining signal integrity in a variety of analog systems.

II. PURPOSE OF VOLTAGE LIMITING

Soft voltage clipping plays an important role in protecting and conditioning signals in electronic circuits:

- Protecting Circuits from Excess Voltage:** Voltage surges or high input signals can damage sensitive components. Voltage limiting ensures signals remain within safe bounds.
- Waveform Shaping:** In audio and analog systems, soft clipping is used to gently round off peaks instead of abruptly cutting them, preserving signal quality.
- Preventing Overdrive Distortion:** By limiting the maximum voltage, soft clippers avoid harsh distortions while still keeping signals within usable levels.
- Ensuring Reliability:** Voltage limiting protects downstream devices and enhances the overall robustness of the system.

III. WORKING PRINCIPLE

The working principle of a diode soft clipper revolves around limiting the maximum voltage of a signal to protect components and condition waveforms without entirely distorting their shape. Unlike hard clippers that abruptly cut signals, a soft clipper gradually rounds the waveform near the diode conduction threshold, resulting in controlled amplitude limitation.

- Input Signal Application:** A sinusoidal input is applied through a series resistor to the diode network. The resistor restricts current and ensures proper biasing of the diodes during conduction.
- Diode Conduction Threshold:** When the input signal is below the forward voltage of the diode (typically 0.6–0.7 V for 1N4148 or ~1.8–2 V for diodes), the diodes remain non-conductive, and the output closely follows the input.
- Onset of Clipping:** As the input exceeds the diode threshold, one of the diodes becomes forward-biased and conducts. This clamps the output, preventing the signal from rising significantly beyond the diode's forward voltage. The conduction occurs smoothly due to the exponential I–V characteristic, creating a rounded clipping effect.
- Symmetrical Limiting:** With anti-parallel diodes, both positive and negative halves of the waveform are clipped at approximately equal levels, producing a symmetrical output. This ensures that the output remains centered around zero while restricting excursions beyond the diode voltage.

5. **Soft Clipping Behavior:** Because diode conduction increases gradually with voltage, the output waveform transitions smoothly from linear to clipped. This is why the circuit is called a diode soft clipper—it avoids the harsh distortion associated with hard limiters.

This voltage-limiting approach is crucial for applications in audio processing, communication circuits, and protection systems, as it prevents excessive voltage swings while preserving the essential shape of the waveform

CIRCUIT DIAGRAM

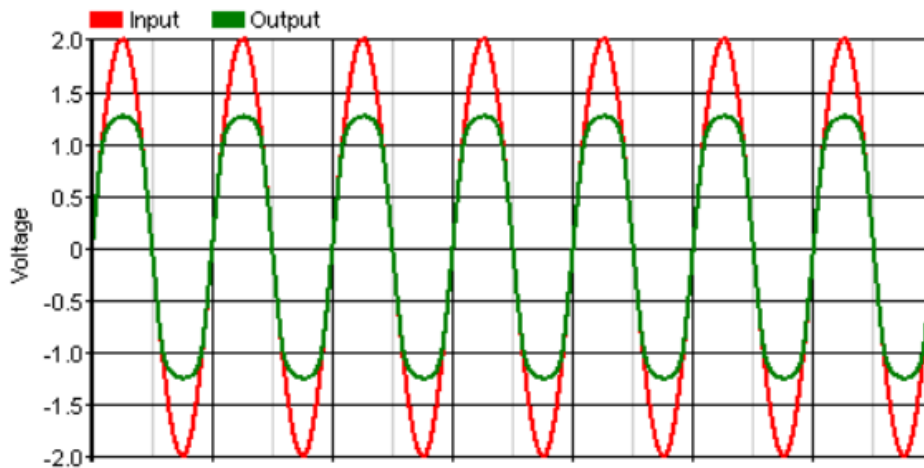
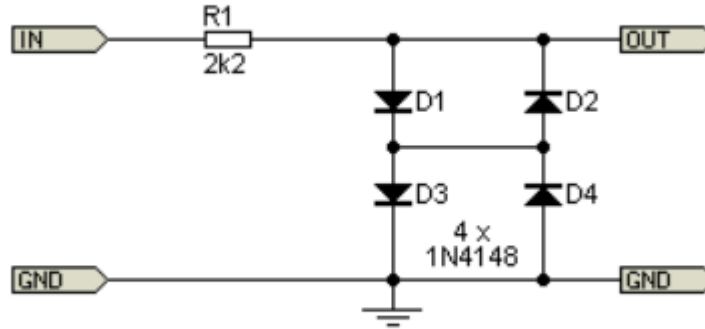


Fig. 1: Diode Soft Clipper Circuit for Symmetrical Signal Limiting

The diode soft clipper circuit is designed to limit the amplitude of an AC input signal in a smooth and controlled manner. In this design, two diodes are connected in opposite directions across the output path, with a series resistor controlling current flow. When the input signal is below the forward voltage of the diodes, the output remains unchanged. Once the input exceeds this threshold, the diodes gradually conduct and clip the waveform, preventing it from rising significantly above the diode forward voltage.

Unlike hard clipping circuits that cut signals sharply, the diode soft clipper introduces a rounded transition, which reduces distortion and preserves the waveform shape. This makes the circuit useful in audio processing, protection circuits, and waveform conditioning, where controlled signal limitation is required without harsh distortion.

IV. PROPOSED SYSTEM

The proposed system introduces a Diode Soft Clipper circuit implemented using eSim software. This circuit is designed to demonstrate the concept of waveform shaping and signal protection through control diode clipping. The diode soft clipper limits the amplitude of an AC input signal smoothly, avoiding the harsh distortion caused by hard clippers. By using diodes in opposite directions with a series resistor, the circuit provides symmetrical clipping of both positive and negative cycles. This ensures that the output remains within safe voltage limits while maintaining the overall shape of the waveform, making it useful for audio processing, communication circuits, and protection applications

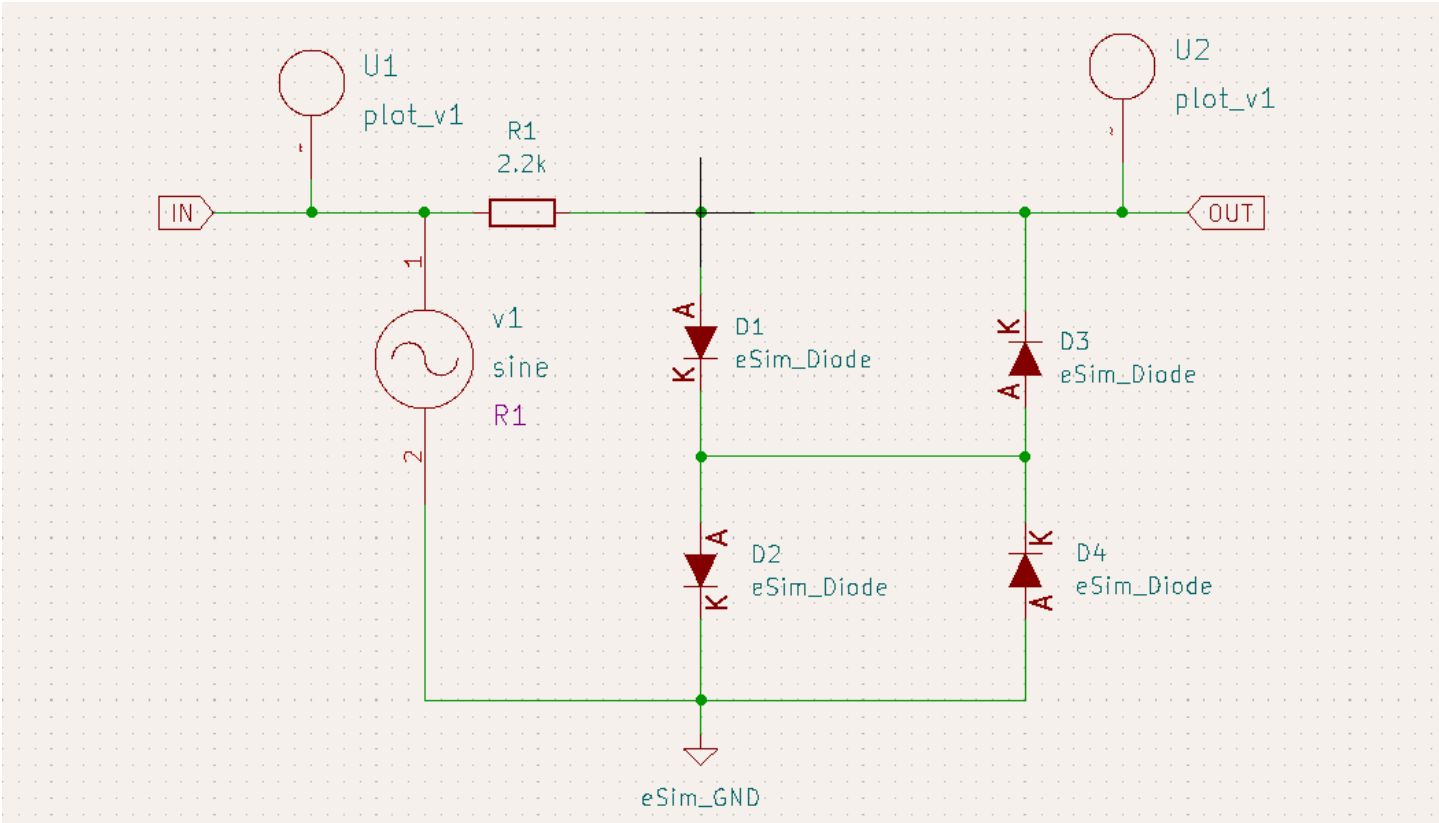


Fig. 3: Diode Soft Clipper Circuit in eSIM

Figure 3 presents the circuit diagram of a Diode Soft Clipper designed within the eSim software environment. Key components include two diodes connected in opposite directions across the signal path and a series resistor to control current flow. The diodes act as the clipping elements: when the input signal is below their forward voltage, the output follows the input without alteration. As the input voltage exceeds the forward threshold, the diodes begin conducting, thereby limiting the signal amplitude. This arrangement provides symmetrical clipping of both the positive and negative halves of the waveform, ensuring smooth limitation without harsh distortion. The circuit effectively demonstrates how diode-based soft clipping can be used for waveform shaping, signal protection, and audio processing applications.

OUTPUT WAVEFORM

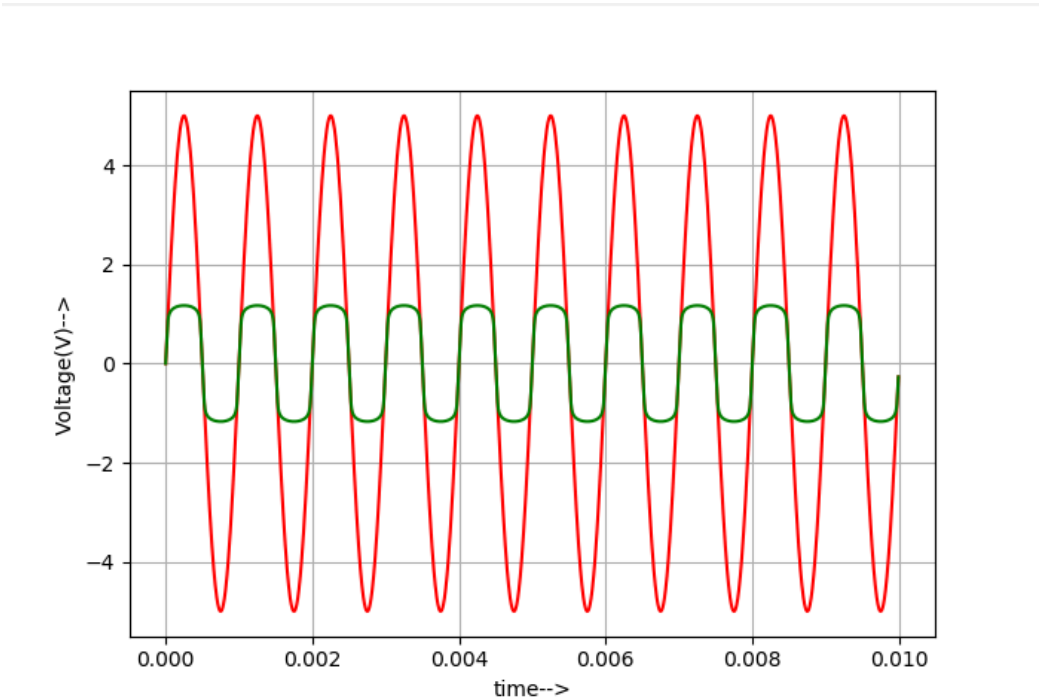


Fig. 4: Output Waveform of Diode Soft Clipper Circuit in eSim

Figure 4 showcases the output waveform of the Diode Soft Clipper circuit simulated using eSim software. The graph illustrates the effect of clipping on a sinusoidal input signal. The input waveform is initially sinusoidal, while the output waveform demonstrates smooth amplitude limitation once the signal exceeds the forward voltage of the diodes. The peaks of the positive and negative cycles are gradually rounded instead of sharply cut, indicating the soft clipping behavior. This ensures that the output remains within safe voltage limits while preserving the overall sinusoidal shape, highlighting the circuit's ability to provide controlled waveform shaping with reduced distortion.

KEY OBSERVATIONS FROM THE GRAPH:

- **Threshold Action:** The output follows the input sinusoid until the signal amplitude reaches the forward voltage of the diodes.
- **Soft Clipping:** Beyond this threshold, the waveform peaks are smoothly rounded, showing the gradual conduction of the diodes instead of abrupt cut-off.
- **Symmetry:** Both positive and negative halves of the waveform are clipped at nearly equal levels, confirming symmetrical clipping action.
- **Waveform Preservation:** Despite amplitude limitation, the overall sinusoidal shape is preserved, indicating reduced distortion compared to hard clipping..

In summary, this graph shows that the diode soft clipper limits the amplitude of the sinusoidal input once the signal exceeds the forward voltage of the diodes. The output waveform remains unchanged at lower amplitudes but transitions smoothly into clipped peaks as the diodes conduct. This gradual conduction produces soft clipping rather than abrupt cut-off, preserving the overall sinusoidal shape while restricting excessive voltage swings. The behavior demonstrates the effectiveness of the diode soft clipper in providing controlled waveform shaping and signal protection with reduced distortion.

APPLICATIONS OF DIODE SOFT CLIPPER:

1. **Audio Processing:** Used in amplifiers and mixers to limit signal peaks, reducing distortion and protecting speakers.
2. **Communication Systems:** Prevents over-voltage in RF/IF stages, ensuring clean and reliable signal transmission.
3. **Waveform Shaping:** Generates nonlinear effects in analog circuits, useful for testing and educational purposes.
4. **Protection Circuits:** Limits voltage excursions to safeguard sensitive electronic components from transient spikes.
5. **Musical Instruments:** Creates soft distortion effects in guitar pedals and synthesizers, enhancing sound quality.
6. **Measurement Systems:** Ensures accurate readings by preventing over-range inputs in oscilloscopes and measuring instruments.

VI. CONCLUSION

In conclusion, the design and simulation of a Diode Soft Clipper circuit using eSim provided valuable insights into the principle of soft clipping and waveform shaping. By limiting the amplitude of the input signal in a smooth and controlled manner, the diode soft clipper prevents excessive voltage swings while preserving the overall waveform shape. The simulation results confirmed its effectiveness in achieving symmetrical clipping with reduced distortion compared to hard clippers. This study highlights the importance of diode-based clipping circuits in applications such as audio processing, protection systems, and communication electronics, where controlled signal limitation and reliability are essential..

REFERENCES

1. Sedra, A. S., & Smith, K. C. (2015). *Microelectronic Circuits* (7th ed.). Oxford University Press.
2. Horowitz, P., & Hill, W. (2015). *The Art of Electronics* (3rd ed.). Cambridge University Press.
3. <https://www.electronics-tutorials.ws/diode/diode-clipping-circuits.html>
4. <https://sound-au.com/articles/soft-clipping.htm>
5. Douglas Self. (2010). *Small Signal Audio Design*. Focal Press.
6. Franco, S. (2014). *Design with Operational Amplifiers and Analog Integrated Circuits* (4th ed.). McGraw-Hill

