Simulation of Single Phase Full-Wave Bridge Rectification

Implementation and Analysis using MATLAB Simulink

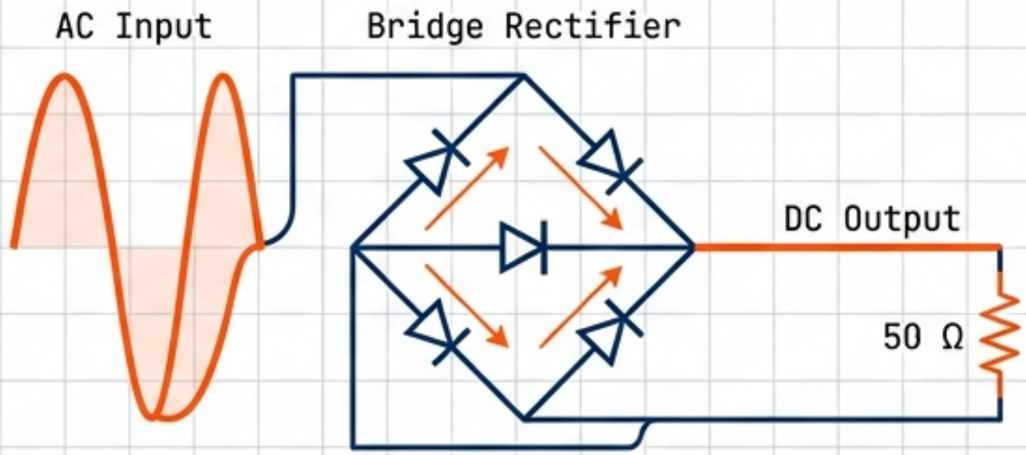
KEY SIMULATION PARAMETERS

Input Voltage: **100 V**

Frequency: **50 Hz**

Load: **50 Ω (Resistive)**

Topology: **4-Diode Bridge**



Course: Simulation and Control of Power Electronics Circuits (BEEL657B)
Department of Electrical and Electronics Engineering
Presenter: Dr. Sathish K R

Experiment Objectives and Fundamental Concepts

PRIMARY GOAL

To model a single-phase full-wave bridge rectifier within the Simulink environment to create a 'digital twin' of a physical circuit.

SPECIFIC OBJECTIVES

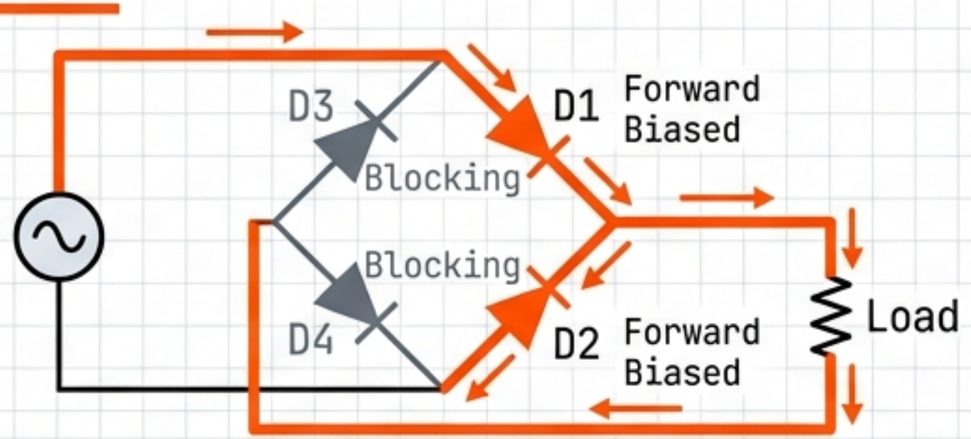
1. **Model:** Construct the circuit using standard Simulink Simscape components.
2. **Observe:** Capture input and output waveforms to verify rectification.
3. **Analyze:** Evaluate the rectified DC output characteristics across a 50 Ω load.

CONTEXTUAL NOTE

Rectifiers are foundational to DC power supplies, utilizing AC line voltage to produce unidirectional current. While half-wave rectifiers only utilize one half-cycle, the full-wave bridge maximizes efficiency by utilizing both.

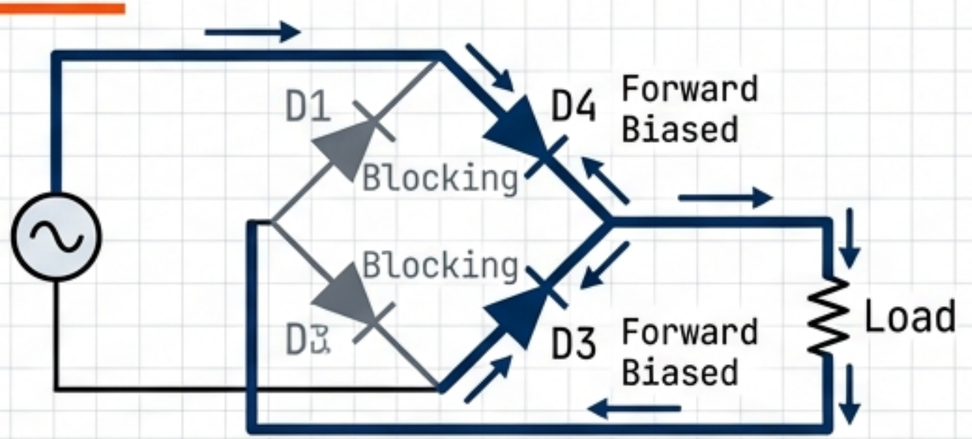
Operational Theory: The Physics of Rectification

Positive Half Cycle



Diodes D1 & D2: Conducting
Diodes D3 & D4: Blocking
Path: Source → D1 → Load → D2 → Return

Negative Half Cycle

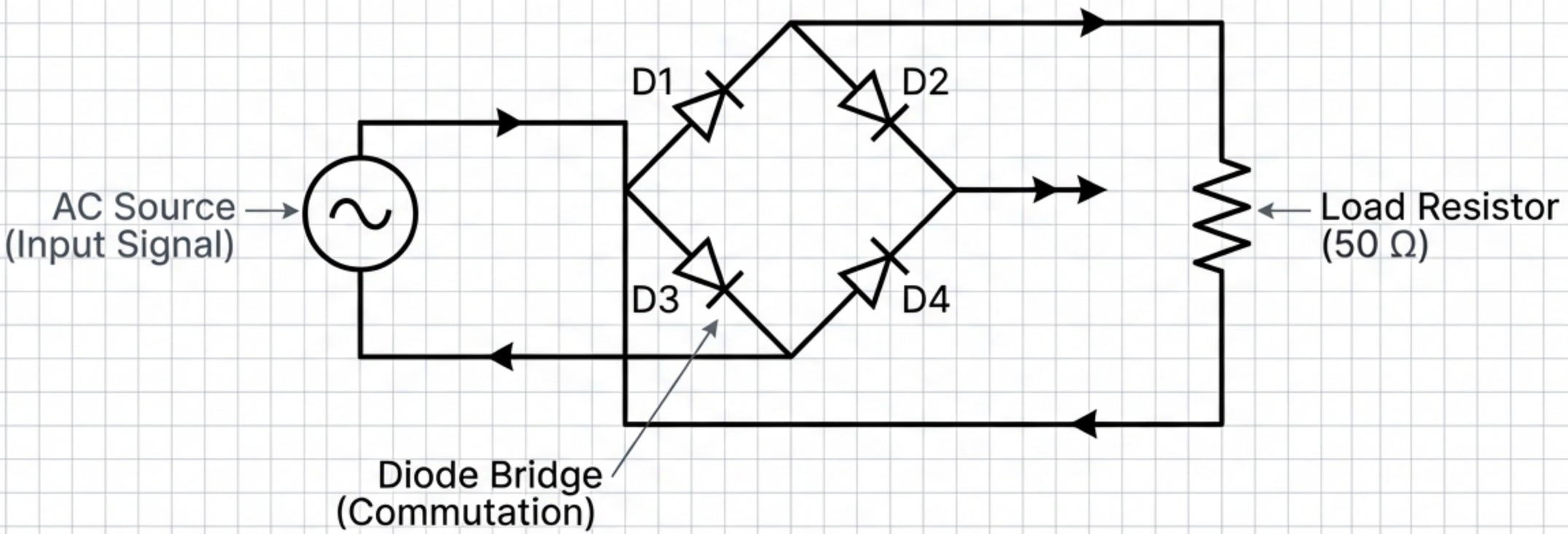


Diodes D3 & D4: Conducting
Diodes D1 & D2: Blocking
Path: Source → D3 → Load → D4 → Return

KEY TAKEAWAY

Despite the alternating input, the load current flows in the same direction during both cycles.

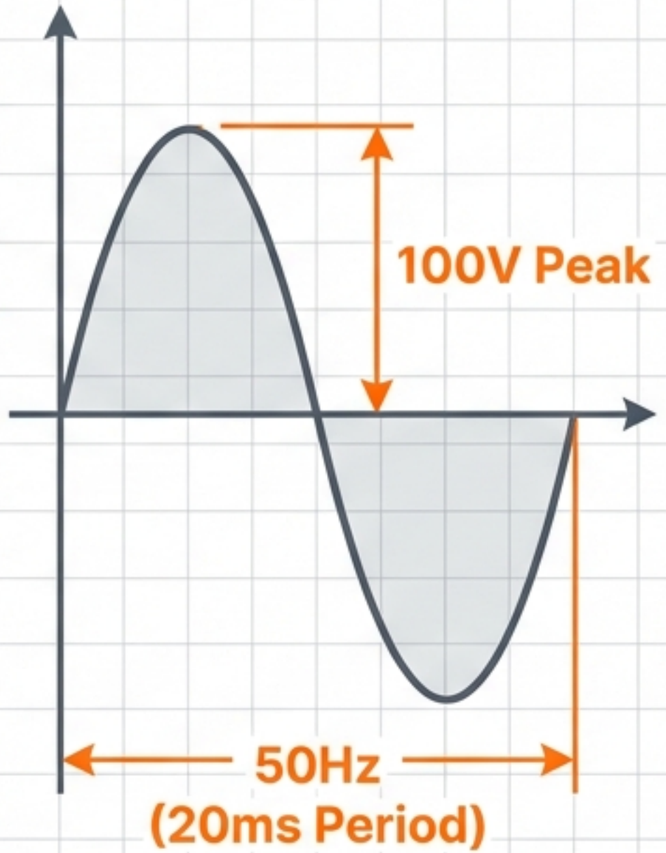
Schematic Diagram: The Bridge Topology



Simulation Parameters and Specifications

Accurate simulation requires precise parameter definitions to match theoretical calculations.

Parameter	Value / Setting
AC Supply Voltage	100 V (Peak Amplitude) (JetBrains Mono)
Frequency	50 Hz (JetBrains Mono)
Load Resistance	50 Ω (JetBrains Mono)
Diode Model	Ideal / Practical (0.7V drop) (JetBrains Mono)



Required Simulink Library Components

AC Voltage Source

Diode (×4)

Series RLC Branch (Set to R)

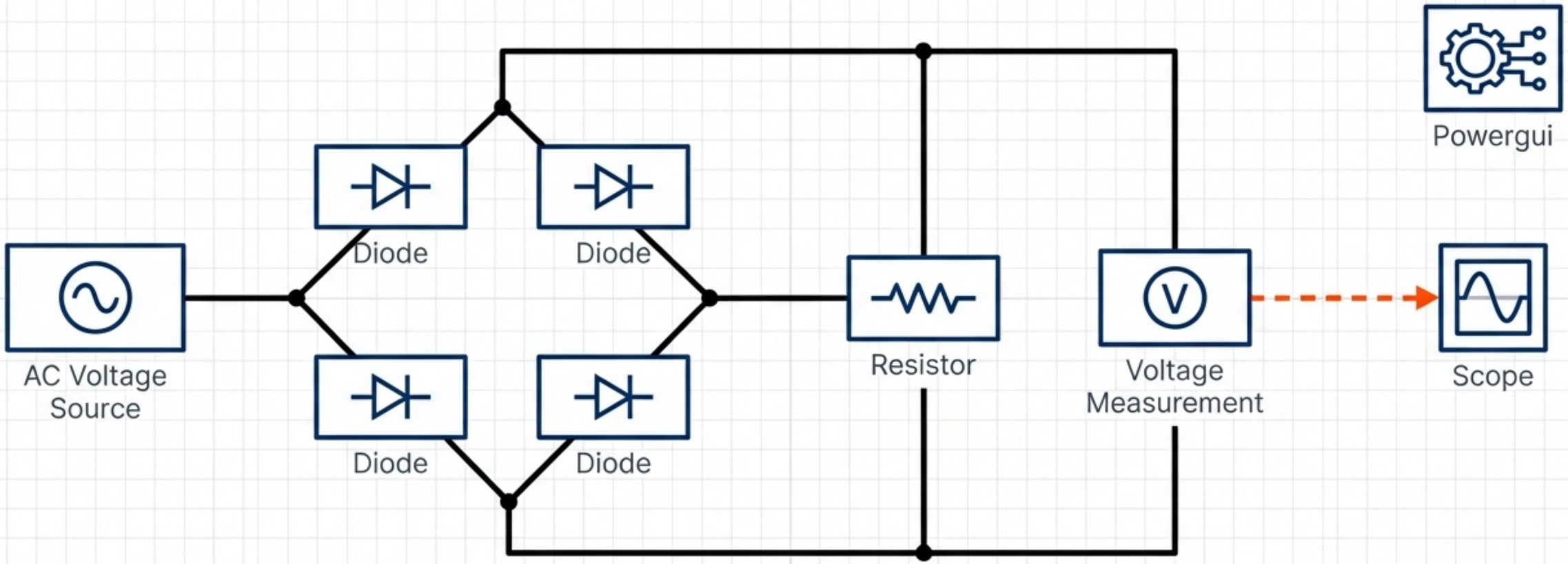
Voltage Measurement

Current Measurement

Scope

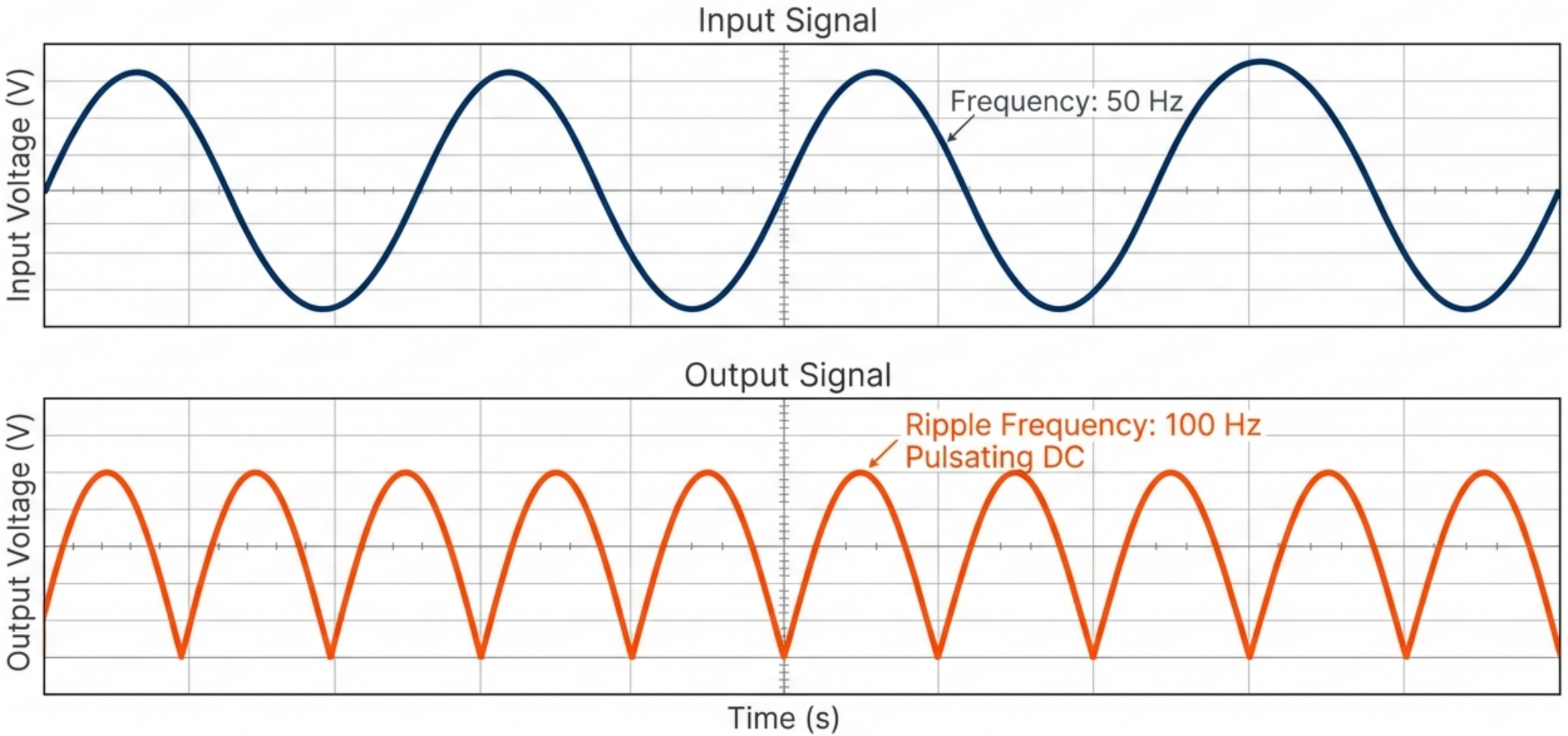
Powergui (Critical for Solver)

The Digital Workbench: Simulink Model Layout



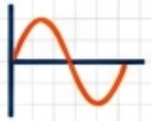
The Voltage Measurement block captures the differential voltage across the load, sending real-time data to the Scope for analysis.

Verification: Waveform Analysis



Observations and Results

Continuity



Unlike half-wave rectifiers, output voltage is present during both half-cycles of the AC input.

Magnitude

The average (DC) voltage is significantly higher than that of a half-wave configuration.

Smoothing

The ripple factor is reduced compared to half-wave rectification, though the output is still pulsating and not pure DC.

Frequency Shift

The output ripple frequency is confirmed to be double the input frequency (100 Hz vs 50 Hz).

Advantages of Bridge Rectification

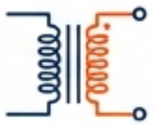
Efficiency

Higher rectification efficiency; power is delivered to the load during the entire AC cycle.

Quality

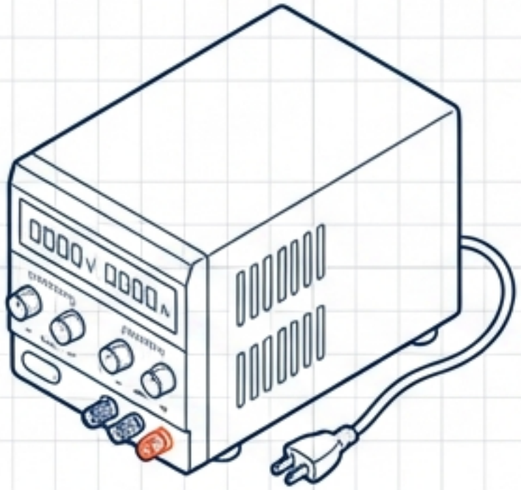
Lower ripple content makes the output easier to filter into smooth DC.

Design Utility Inter

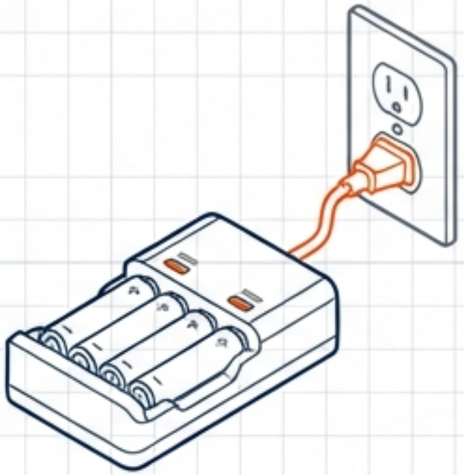


- **Better Transformer Utilization**: Secondary winding carries current in both half-cycles.
- **No Center-Tap Needed**: Works with standard two-wire transformer secondary.

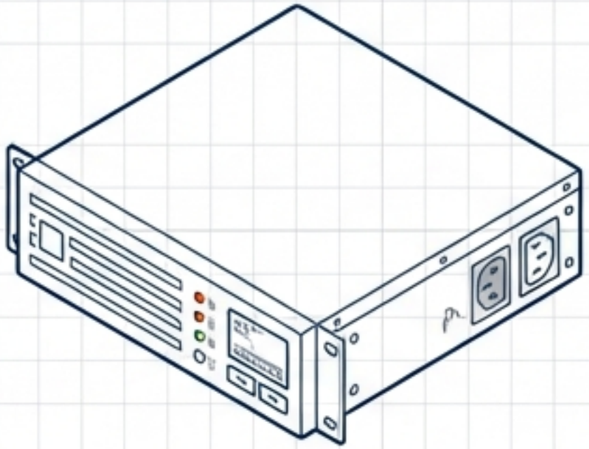
Real-World Applications



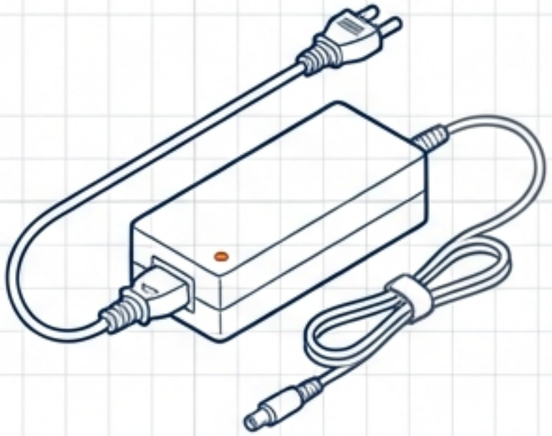
DC Power Supplies



Battery Chargers



Uninterruptible Power Supplies (UPS)



Consumer Electronics

Conclusion

SUMMARY OF FINDINGS

- The Single Phase Full-Wave Bridge Rectifier was successfully modeled and simulated.
- MATLAB Simulink provided an accurate 'Digital Twin" visualization of the circuit behavior.
- Waveform analysis confirms the output is smoother and more efficient compared to half-wave rectification.
- The simulation verified the frequency doubling effect (Input 50Hz → Output 100Hz ripple).

References and Documentation

MathWorks Documentation

Full-Wave Rectifier (Simulink): mathworks.com/help/sps/ug/full-wave-rectifier.html

Diode Block: mathworks.com/help/sps/ref/diode.html

AC Voltage Source: mathworks.com/help/sps/ref/acvoltagesource.html

Powergui Block: mathworks.com/help/sps/ref/powergui.html

Academic Resource

NPTEL – Power Electronics (Single-Phase Rectifiers): nptel.ac.in/courses/108/105/108105066/