Heaven's Light is Our Guide

Rajshahi University of Engineering and Technology

Course Code

ECE 3206

Course Title

Industrial Electronics Sessional

Lab Reports

Submitted to	Submitted by
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Exp. No.	Experiment Name	Exp. Date
01	Basics of Oscilloscope and Signal Generator	Nov 24, 2024
02	Study of Diode Characteristics R, L, and Series Combination	Dec 09, 2024
03	Study of Thyristor Characteristics R, RL Load	Jan 13, 2025
04	Study of 3-Φ Star Rectifier using Diode & Thyristor with R, RL Load	Feb 10, 2025
04.1	Rectifier (Half-Wave, Full-Wave Using Centre Tapped, Full-Wave Bridge) Implementation in Experiment Kit Using Diodes Load	
05	Single Phase AC-AC Bidirectional (Full Wave) Voltage Controller with R, RL Load	Feb 24, 2025
06	Study of Single Phase Bridge Inverter Using Simulink	Apr 21, 2025
07	Study of Buck Converter Using Simulink	Apr 21, 2025

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Course Title
Industrial Electronics Sessional

Experiment Date: November 24, 2024,
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Lab Report 1:
Basics of Oscilloscope and Signal Generator

Submitted to	Submitted by
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Contents

Basics of Oscilloscope and Signal Generator

Theory

Oscilloscope

An oscilloscope is an electronic test instrument that allows observation of constantly varying signal voltages, typically as a two-dimensional plot of one or more signals as a function of time. It is widely used in electronics, telecommunications, and engineering to measure and visualize waveforms.

Features of Oscilloscope:

Waveform Visualization: Shows the shape of electrical signals such as voltage & currents.

Measurement: Provides tools to measure signal properties, such as amplitude, frequency, rise time, peak voltage, periodicity, and many other properties.

Trigger: Allows stable visualization of repetitive signals by syncing the display to a specific point in the waveform.

Types:

Analog Oscilloscope: Displays signals in real time using cathode ray tubes.

Digital Oscilloscope: Uses digital storage to record and display signals.

Mixed Signal Oscilloscope (MSO): Combines analog and digital signal analysis.

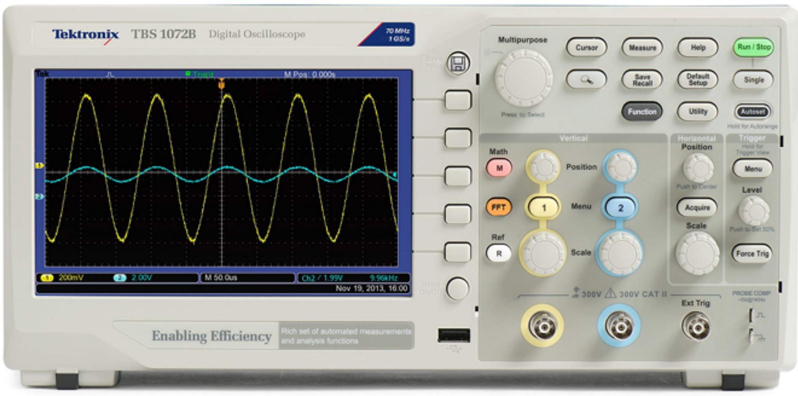

Figure 1: Oscilloscope

Signal Generator

A signal generator is an electronic device that produces repeating or non-repeating waveforms. These waveforms can be of different shapes, such as sine waves, square waves, or triangular waves, and are used to test and troubleshoot electronic circuits. The properties of the waves generated by it can be tweaked to match the purpose.

Key Features of a Signal Generator:

- **Wave Generation:** Creates various types of waveforms or signals.
- **Frequency Adjustment:** Frequency can be adjusted as required.
- **Modulation:** Modulate amplitude, frequency, or phase of signals.

Types:

- **Function Generators:** Generate standard waveforms like sine, square, and triangle.
- **Arbitrary Waveform Generators:** Create user-defined waveforms.
- **RF Signal Generators:** Used for radio frequencies.

Figure 2: Signal Generator

Required Tools & Apparatus

- Oscilloscope - Tektronix TBS1072B
- Signal Generator - SG 1639A
- Probes
- Power Cables
- Latex

Procedure

1. The oscilloscope & the signal generator was turned on.
2. The probes were connected to the oscilloscope and signal generator.
3. The signal generator's probes were connected to the oscilloscope's.
4. The oscilloscope was adjusted to display the signal from the signal generator.
5. Using the modulation feature of the signal generator different types of signals was generated and the waves were observed using the oscilloscope.

Inputs and Outputs

Oscilloscope

Display

Trigger Position Icon: Indicates the trigger position on the screen, adjustable with the knobs.

Horizontal Position: Indicates the position of the X-axis of the waveform(s).

Menu: Shows various options to adjust the display for better understanding of the waveform(s).

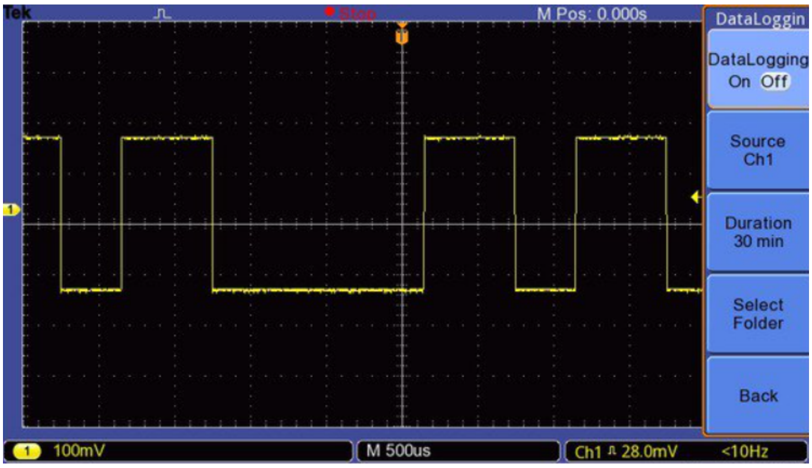

Figure 3: Display Interface of Oscilloscope

Menu

Multipurpose Knob: Can be turned to adjust cursor position

Help: Highlights entries in the Index. Highlights links in a topic. Push to select the highlighted item.

Math: Scroll to position and scale the Math waveform. Scroll and push to select the operation.

Measure: Scroll to highlight and push to select the type of automatic measurement for each source and various properties of that source.

Save/Recall: Scroll to highlight and push to select the action and file format. Scroll through the list of files. Pressing also saves current display screenshot to a externally connected device.

Utility: Scroll to highlight and push to select miscellaneous menu items. Turn to set the backlight value.

Autoset: Adjusts the current display and makes it so that its shows best.

Run/Stop: Pressing freezes the current output.

Figure 4: Menu of Oscilloscope

Horizontal Control[1]

Position: Positions a waveform horizontally.

Scale: Selects horizontal scale factors like time.

Acquire: Displays the acquisition mode: Sample, Peak Detect, or Average.

Figure 5: Horizontal Control of Oscilloscope

Vertical Control[1]

Position (1 & 2): Positions a waveform vertically.

Menu (1 & 2): Displays the Vertical menu selections and toggles the display of the channel waveform on and off.

Scale (1 & 2): Selects vertical scale factors such as amplitude.

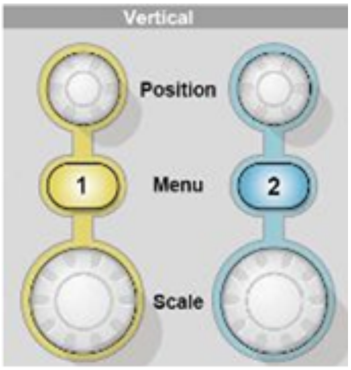

Figure 6: Vertical Control of Oscilloscope

Trigger Control[1]

Trigger Menu:

- Pressing the button once will open the Trigger Menu.
- Holding the button for more than 1.5 seconds will switch to the trigger view, where the trigger waveform replaces the channel waveform. This view allows to observe how the trigger settings (e.g., coupling) impact the trigger signal.
- Releasing the button will return to the standard view and stop displaying the trigger waveform.

Level:

- When using Edge or Pulse triggers, the Level knob adjusts the amplitude level at which the signal must cross to capture a waveform.
- Pressing the knob sets the trigger level to the vertical midpoint between the peaks of the trigger signal (50%).

Force Trig:

- Use the Force Trig button to manually acquire a waveform, regardless of whether the oscilloscope detects a trigger.
- This function is helpful for single sequence acquisitions and Normal trigger mode.
- In Auto trigger mode, the oscilloscope automatically forces triggers periodically if no trigger is detected.

Figure 7: Trigger Control of Oscilloscope

Connectors

Blue Port: Used to input one of the waveform signals for display.

Yellow Port: Used to input the second waveform signal for display.

Ext Trig (External Trigger): Provides a connection for an external trigger signal to synchronize waveform acquisition.

Figure 8: Input Connectors of Oscilloscope

Signal Generators

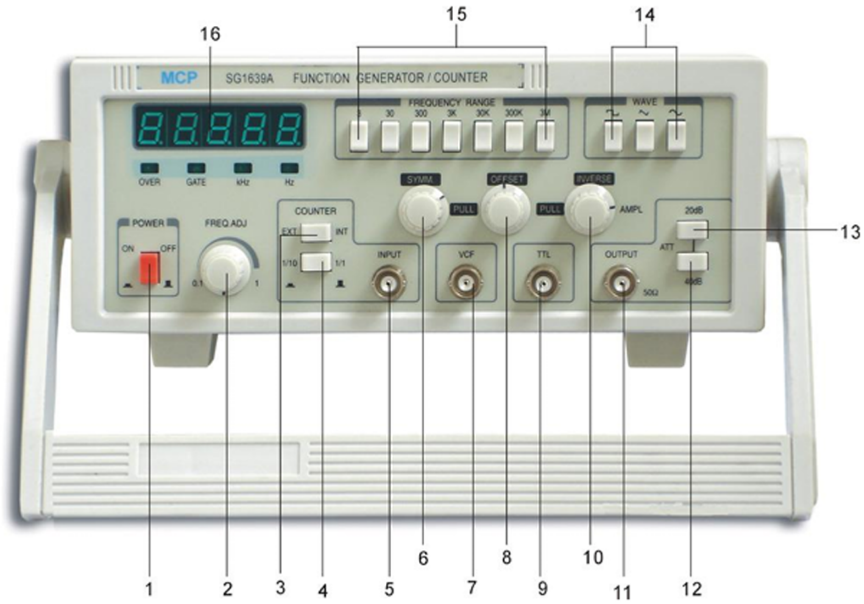

Figure 9: Signal Generator

1. **Power:** Turns the device "ON" when the button is pressed
2. **Frequency Adjust:** Adjusts the output frequency.
3. **Select Switch (INT/EXT):** [2]Measures external (EXT) frequency when the button is pressed.
4. **Attenuation (Input):** Reduces input signal by 10dB when pressed.
5. **Input Socket:** [2]Socket for external (EXT) signal input.
6. **SYMM. Switch:** Adjusts the waveform to be symmetrical when the switch is pulled out.
7. **VCF Input Socket:** [2]Allows external signals to control the main output frequency.
8. **DC Offset Switch:** [2]Adjusts the DC offset when the switch is pulled out.
9. **TTL Output:** [2]Socket for TTL signal output.
10. **Amplitude:**Adjusts the output signal's amplitude (inverts when the switch is pulled out).
11. **Output Socket:** Socket for the main signal output.
12. **Attenuation (Output):** Reduces output signal by 40dB when pressed.

13. **Attenuation (Output):** Reduces output signal by 20dB when pressed.
14. **Waveform Selector:** Selects the output waveform type.
15. **Frequency Range:** Adjusts and selects the output frequency range.
16. **Frequency Counter:** Displays the frequency of the output signal.

Discussion

In this experiment, we worked with two essential tools in electronics laboratories: the oscilloscope and the signal generator. The oscilloscope allows us to visualize electronic signals, while the signal generator produces a variety of signals at adjustable frequencies. Together, these devices play a critical role in testing and analyzing electronic circuits.

We gained hands-on experience by using these tools to observe and evaluate signals. Adjustments were made to both devices to see how changes in settings affected the signals. Additionally, we connected the signal generator to the oscilloscope to monitor the generated waveforms directly on the screen.

This practical session was highly beneficial, providing us with valuable experience in using these tools effectively. It demonstrated their importance in the field of electronics for testing, troubleshooting, and analyzing circuits.

In summary, the oscilloscope and signal generator are indispensable instruments in any electronics laboratory. The oscilloscope offers a detailed representation of signal characteristics, while the signal generator provides controlled test signals. By combining their functionalities, they allow engineers to create, measure, and analyze signals, ensuring that electronic devices and circuits perform as expected.

Precaution & Conclusion

To ensure safe and effective use of the equipment, the following precautions were observed during the experiment:

- Both the oscilloscope and signal generator were powered off when not in use to prevent potential damage.
- Probes and cables were connected or disconnected only when the devices were switched off to maintain safety and avoid electrical faults.
- Settings on the instruments were adjusted carefully to prevent any misconfigurations or damage to the devices.

- Only the provided, calibrated probes and cables were used to ensure accurate measurements.
- After completing the experiment, all equipment was returned to its designated safe storage location.

This experiment reinforced the critical role of the oscilloscope and signal generator in electronics. It highlighted their complementary functionalities, with the oscilloscope visualizing signal behavior and the signal generator providing precise, controllable inputs for testing. Through this exercise, we developed a deeper understanding of how these tools are used in real-world applications to diagnose, validate, and optimize electronic circuits. Moreover, adhering to proper precautions ensured the longevity of the equipment and the safety of the users, emphasizing the importance of best practices in a laboratory setting.

References

[1] "The working of oscilloscope - tektronix tbs1072b signal generator - sg 1639a," https://www.google.com/search?q=The+workiing+of+Oscilloscope+-+Tektronix+TBS1072B+Signal+Generator+-+SG+1639A, (Accessed on: 12/08/2024).

[2] "The working of signal generator - sg 1639a," https://www.google.com/search?q=The+workiing+of+Signal+Generator+-+SG+1639A, (Accessed on: 12/08/2024).

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Industrial Electronics Sessional

Experiment Date: December 9, 2024,

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Lab Report 2:

Study of Diode Characteristics R, L, and Series Combination.

Submitted to	**Submitted by**
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Contents

Basics of Oscilloscope and Signal Generator

Theory

In this experiment, we investigate the characteristics of a diode under different load conditions using both DC and AC supplies. The experiment is conducted using simulation software to observe the behavior of the diode in various scenarios.

Diode Characteristics with DC Supply

When a diode is connected to a DC supply, it exhibits distinct forward and reverse bias characteristics. In forward bias, the diode allows current to flow through it once the applied voltage exceeds the threshold voltage (typically around 0.7V for silicon diodes). The current increases exponentially with the increase in voltage. In reverse bias, the diode blocks current flow, allowing only a very small leakage current until the breakdown voltage is reached [1].

Forward Bias

In forward bias, the diode's anode is connected to the positive terminal of the DC supply, and the cathode to the negative terminal. The I-V characteristic curve shows a rapid increase in current after the threshold voltage.

Reverse Bias

In reverse bias, the diode's anode is connected to the negative terminal of the DC supply, and the cathode to the positive terminal. The I-V characteristic curve shows a very small current until the breakdown voltage is reached, beyond which the current increases sharply.

Diode Characteristics with AC Supply

When a diode is connected to an AC supply, it exhibits rectification properties, converting the AC signal into a pulsating DC [2].

Required Equipments/Software

- Proteus Design Suite
- Oscilloscope
- Signal Generator
- Diodes (e.g., 1N4148, 1N4007)
- Resistors (various values)
- Capacitors (various values)
- Power Supply (DC and AC)
- Breadboard
- Connecting Wires

Circuit Diagrams

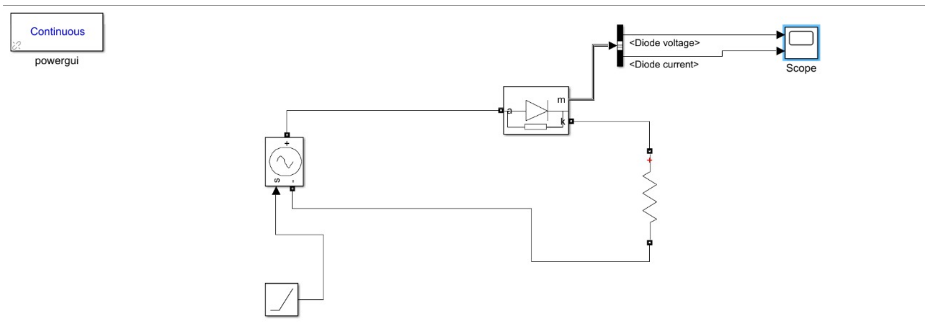

Figure 1: Diode with Resistive Load

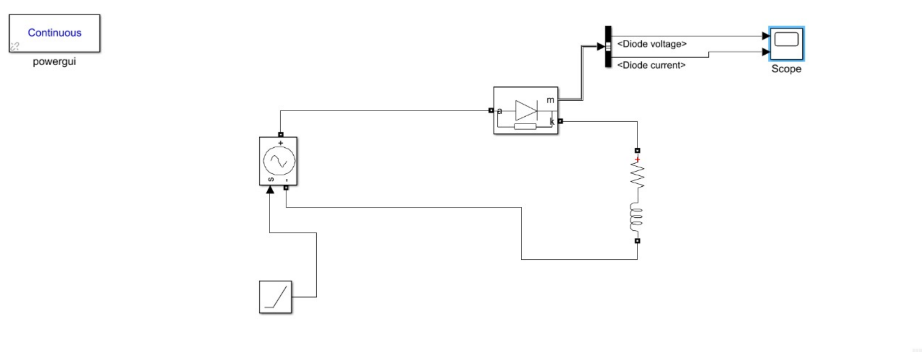

Figure 2: Diode with Resistive-Inductive Load

Observations

- The diode conducts current in the forward bias and blocks current in the reverse bias.
- The diode exhibits rectification properties when connected to an AC supply.
- The load conditions (resistive, inductive) affect the diode's behavior and the output waveform.
- The output waveform changes based on the load conditions and the applied voltage.
- The diode's characteristics can be analyzed using an oscilloscope and signal generator.
- The diode's threshold voltage, forward current, and reverse current can be measured using the oscilloscope.
- The diode's response to different input signals can be observed using the oscilloscope.

Outputs

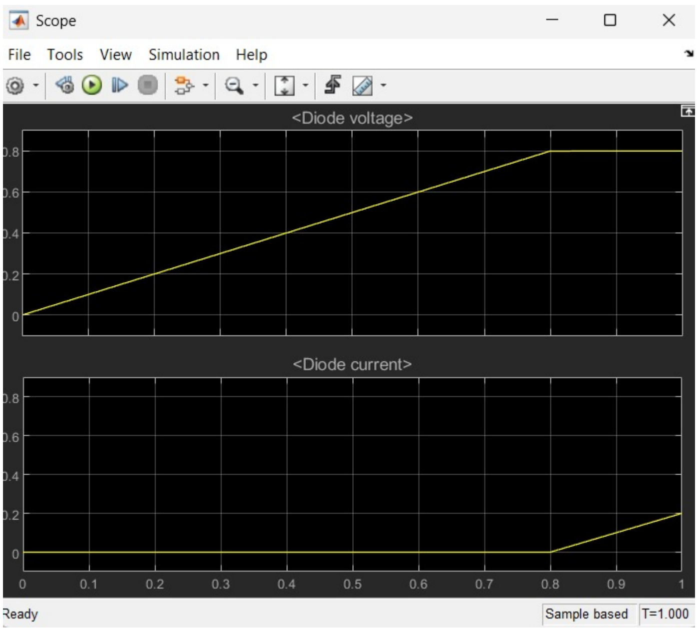

Figure 3: Simulation Diagram of Diode Circuit With R Load

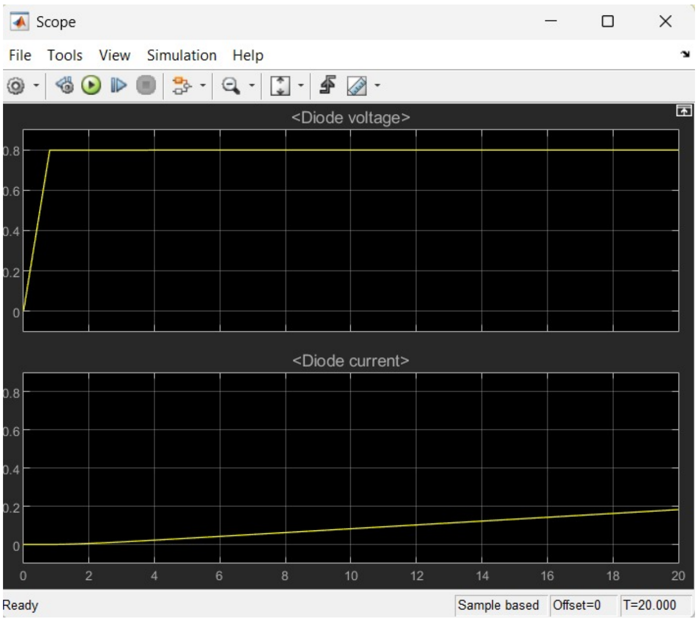

Figure 4: Oscilloscope Output for Forward Bias With RL Load

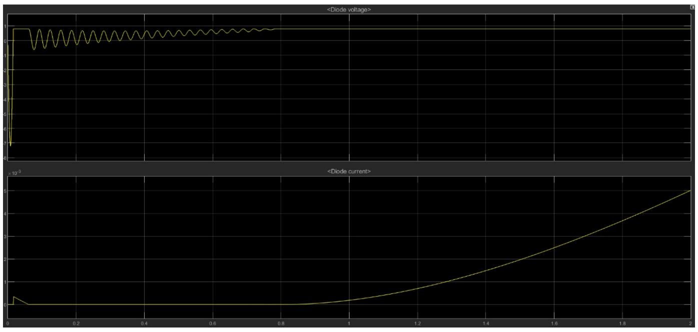

Figure 5: Oscilloscope Output for RL Load

Discussion

The experiment demonstrates the diode's behavior under different load conditions and supply voltages. The diode's characteristics, such as forward bias, reverse bias, and rectification properties, are observed using simulation software. The oscilloscope and signal generator help visualize the diode's response to various input signals and load conditions. The experiment provides insights into the diode's operation and its applications in electronic circuits.

Conclusion

The experiment explores the characteristics of a diode under different load conditions using DC and AC supplies. The diode's behavior in forward bias, reverse bias, and rectification is observed using simulation software. The oscilloscope and signal generator help analyze the diode's response to various input signals and load conditions. The experiment enhances understanding of the diode's operation and its applications in electronic circuits.

References

[1] A. Author, "Diode characteristics," *Journal of Electronics*, vol. 10, no. 2, pp. 123–130, 2020.

[2] B. Author, *AC Supply and Rectification*. Tech Books Publishing, 2018.

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Industrial Electronics Sessional

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Lab Report 3:

Study of Thyristor Characteristics R, RL Load

Submitted to	**Submitted by**
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Contents

Study of Thyristor Characteristics R, RL Load

Theory

In this experiment, the characteristics of a thyristor (SCR) under different load conditions using both DC and AC supplies were investigated using simulation software.

Thyristor Characteristics with DC Supply

With a DC supply, the thyristor exhibited forward and reverse blocking characteristics. In forward blocking mode, it blocked current until a gate pulse was applied, then conducted until the current fell below the holding current. In reverse blocking mode, it blocked current flow, allowing only a small leakage current until the breakdown voltage was reached [1].

R Load

With a resistive (R) load, the thyristor's behavior is straightforward. When a gate pulse is applied, the thyristor switches to the forward conduction mode, allowing current to pass through the resistive load. The current waveform follows the input voltage waveform, and the thyristor remains on until the current drops below the holding current.

RL Load

With a resistive-inductive (RL) load, the thyristor's behavior is more complex due to the inductance. When a gate pulse is applied, the thyristor switches to the forward conduction mode, and the current through the load increases gradually due to the inductance. The thyristor remains on until the current drops below the holding current, but the inductive load causes the current to continue flowing even after the input voltage drops to zero, resulting in a phase shift between the voltage and current waveforms.

Gate Trigger Timing

The timing of the gate pulse is crucial in controlling the thyristor's conduction. By adjusting the gate trigger timing, the conduction angle of the thyristor can be controlled, which in turn controls the average power delivered to the load. For an R load, the gate pulse timing directly affects the point at which the thyristor starts conducting. For an RL load, the gate pulse timing affects both the conduction angle and the phase shift between the voltage and current waveforms.

Required Equipments/Software

- MATLAB/Simulink
- Oscilloscope
- AC Voltage Source
- Thyristor
- Series RLC Branch
- Pulse Generator
- Measurement Tools

Circuit Diagrams

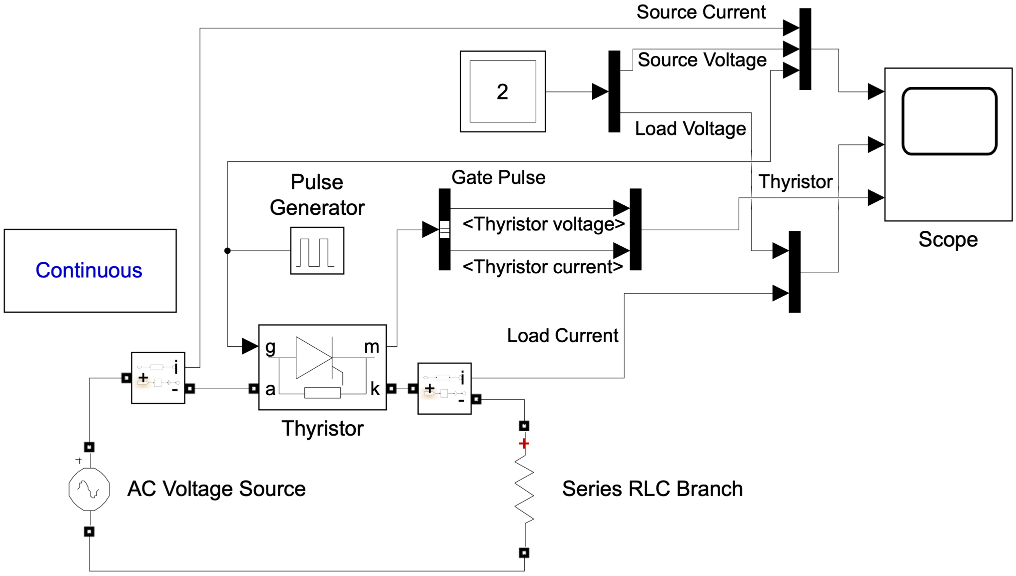

Figure 1: Diode with Resistive Load

Observations

- Observed the input, output, and pulse voltage/current graphs in the oscilloscope.
- Four cases were analyzed:
  - R Load: With gate voltage delay.
  - R Load: Without gate voltage delay.
  - RL Load: With gate voltage delay.
  - RL Load: Without gate voltage delay.

Outputs

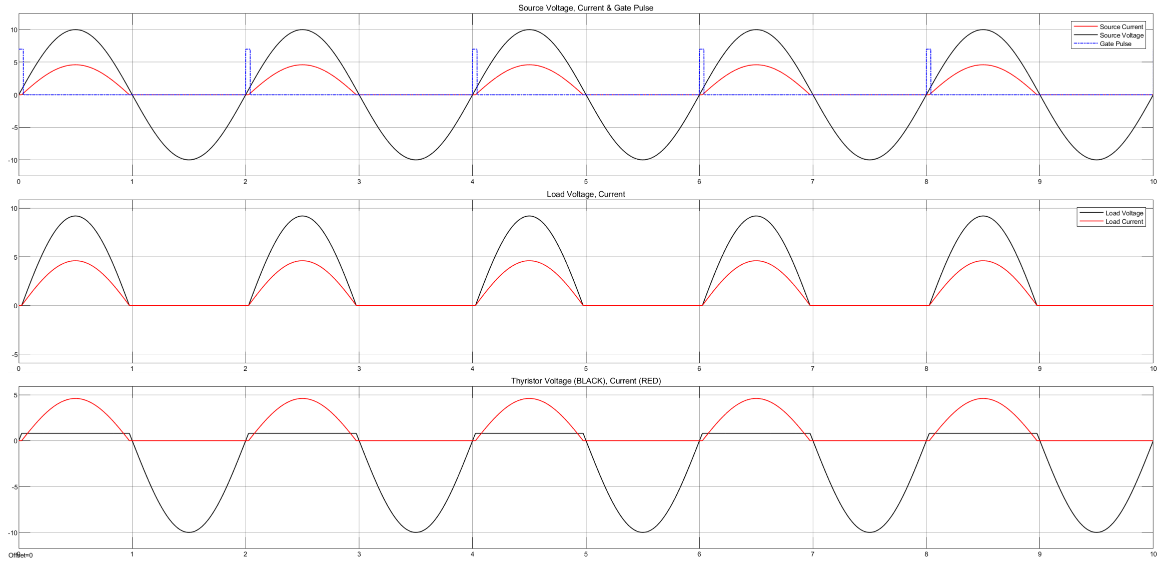

Figure 2
Oscilloscope Output for Thyristor with R Load, No Gate Voltage Delay.

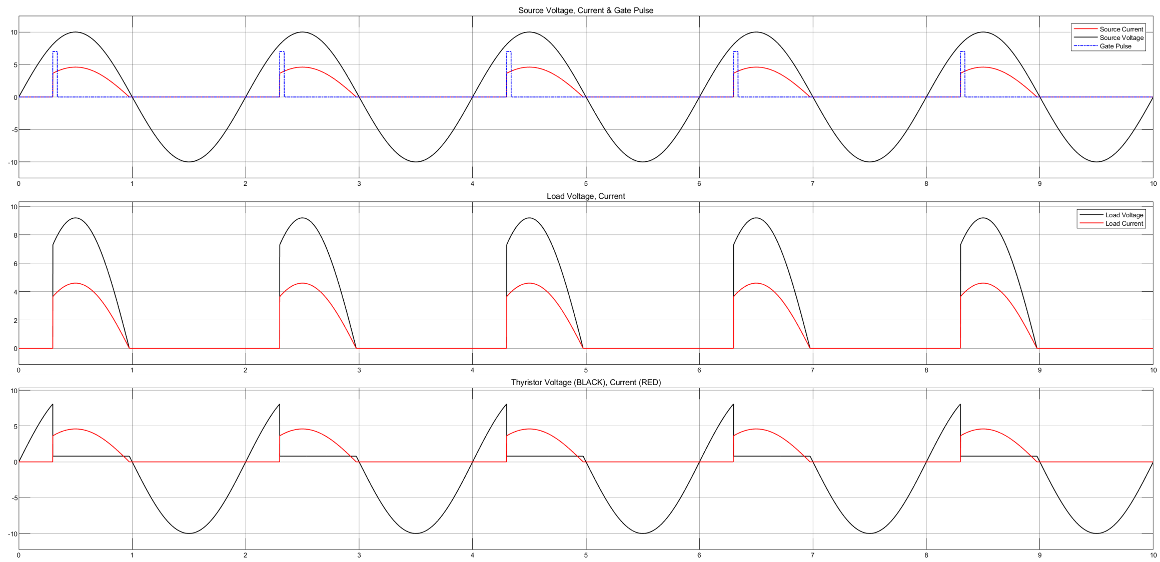

Figure 3: Oscilloscope Output for R Load, With Gate Voltage Delay

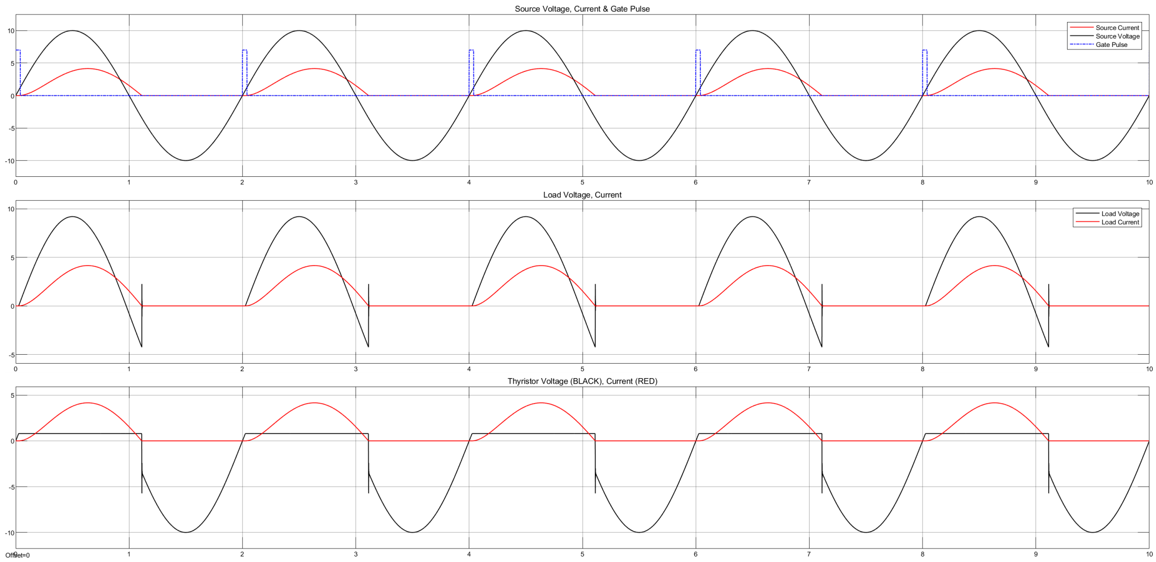

Figure 4: Oscilloscope Output for RL Load, No Gate Voltage Delay

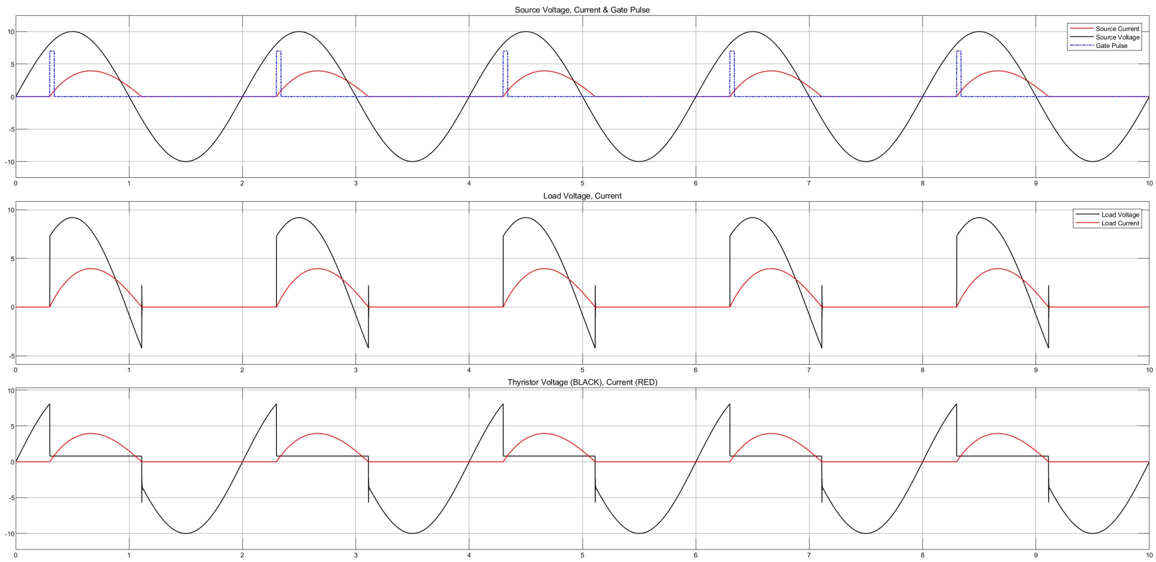

Figure 5: Oscilloscope Output for RL Load, With Gate Voltage Delay

Discussion

The experiment explores the characteristics of a thyristor under different load conditions using DC and AC supplies. The thyristor's behavior in forward bias, reverse bias, and rectification is observed using simulation software. The oscilloscope and signal generator help analyze the thyristor's response to various input signals and load conditions. The experiment enhances understanding of the thyristor's operation and its applications in electronic circuits.

Conclusion

The experiment investigates the characteristics of a thyristor under different load conditions using DC and AC supplies. The thyristor's behavior in forward bias, reverse bias, and rectification is observed using simulation software. The oscilloscope and signal generator help visualize the thyristor's response to various input signals and load conditions. The experiment enhances understanding of the thyristor's operation and its applications in electronic circuits.

References

[1] J. Doe, "Thyristor characteristics," *Journal of Power Electronics*, vol. 15, no. 3, pp. 123–130, 2020.

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Lab Report 4: Study of 3-Φ Star Rectifier using Diode & Thyristor with R, RL Load

Submitted to	**Submitted by**
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Contents

Study of 3-Φ Star Rectifier using Diode, & Thyristor with R, RL Load

Theory

A three-phase star rectifier is a type of rectifier circuit that converts three-phase AC (Alternating Current) input into DC (Direct Current) output. This type of rectifier is commonly used in industrial applications due to its efficiency and ability to handle high power levels [1].

In a three-phase star rectifier, diodes are arranged in a star configuration. Each phase of the AC supply is connected to a diode, and the other ends of the diodes are connected together to form the DC output. The rectifier can be used with different types of loads, such as resistive (R) and inductive-resistive (RL) loads [2].

When a resistive load is used, the current through the load is in phase with the voltage, resulting in a purely resistive circuit. However, when an inductive-resistive load is used, the current lags behind the voltage due to the inductance, creating a more complex circuit behavior [3].

Thyristors, also known as silicon-controlled rectifiers (SCRs), can be used in place of diodes in a three-phase star rectifier to provide controlled rectification. By adjusting the gate signal of the thyristors, the conduction angle can be controlled, allowing for regulation of the output voltage. This makes thyristors suitable for applications where variable DC output is required [**?**].

When using thyristors with a resistive load, the output voltage can be controlled by varying the gate signal, which delays the conduction angle and reduces the average output voltage. For an inductive-resistive load, the current lags behind the voltage, and the gate signal delay further affects the conduction angle and the current waveform [1].

MATLAB/Simulink is a powerful tool for simulating and analyzing the performance of such rectifier circuits. By using MATLAB/Simulink, we can model the three-phase star rectifier with both diodes and thyristors and observe the output waveforms for different load conditions. This helps in understanding the behavior of the rectifier and optimizing its performance for various industrial applications [4].

Required Equipments/Software

- MATLAB/Simulink
- Oscilloscope
- AC Voltage Source
- Diode
- Thyristor
- Series RLC Branch
- Pulse Generator
- Measurement Tools

Circuit Diagrams

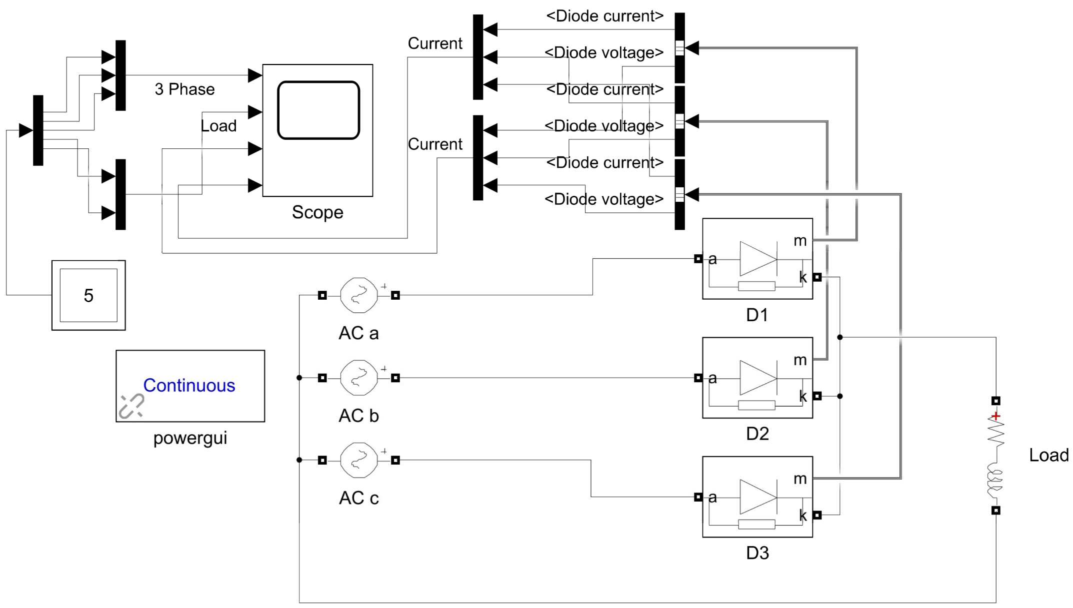


Figure 1: 3-Phase Star Rectifier with Diode

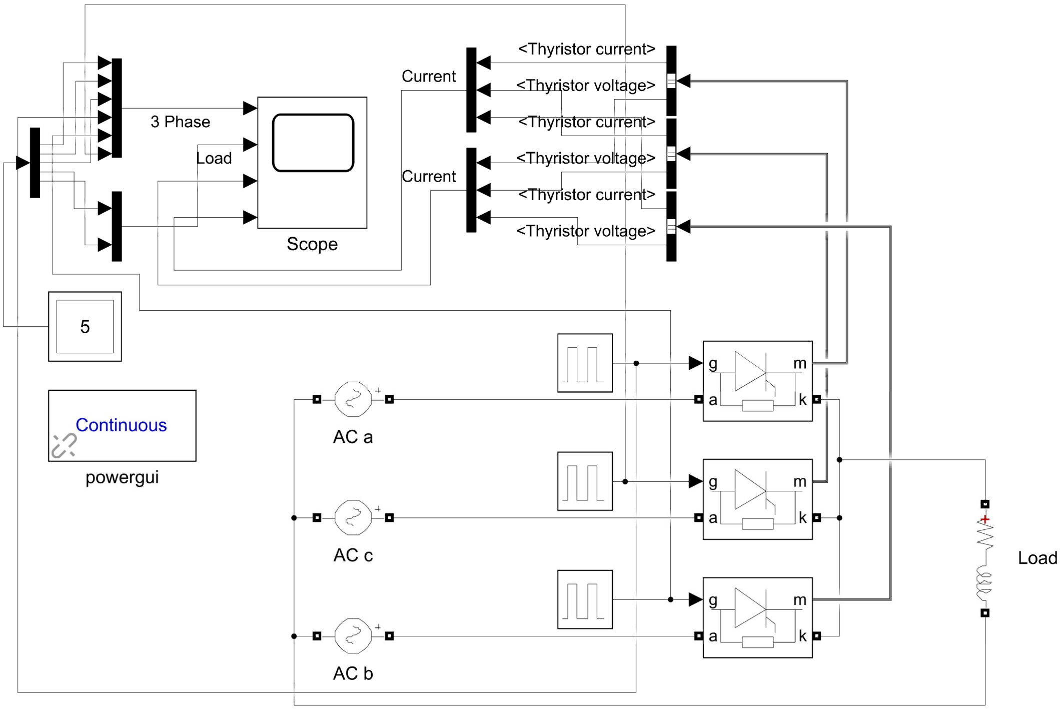


Figure 2: 3-Phase Star Rectifier with Thyristor

Observations

- The output voltage for the R load is a pulsating DC with a frequency 6 times the input AC.
- With gate voltage delay for the thyristor and R load, the output voltage shows a delayed conduction angle, reducing the average output.
- For the RL load, the output voltage is pulsating DC, with the current lagging due to inductance.
- Gate voltage delay for the thyristor with RL load results in a delayed conduction angle and a more pronounced current lag.
- Thyristor with 15-degree gate delay and R load: reduced average output due to delayed conduction.
- Thyristor with no gate delay and R load: output similar to diode rectifier with controlled conduction.
- Thyristor with 15-degree gate delay and RL load: delayed conduction and increased current lag.

- Thyristor with no gate delay and RL load: output similar to diode rectifier with controlled conduction.
- MATLAB/Simulink helps analyze and visualize rectifier performance.

Outputs

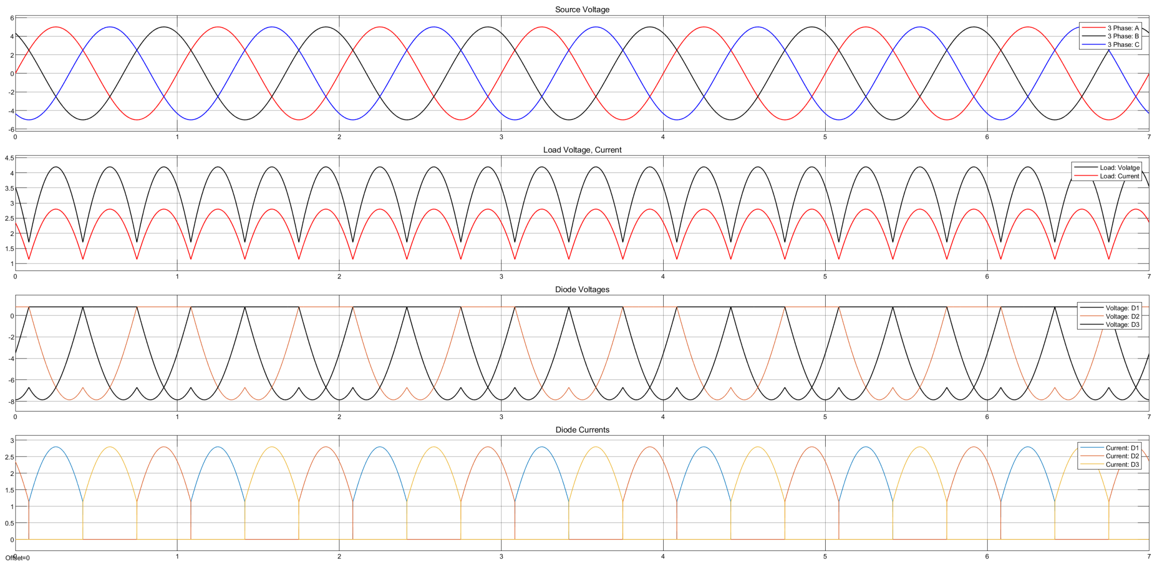


Figure 3: Simulation Output for R Load, 3-Phase Star Rectifier

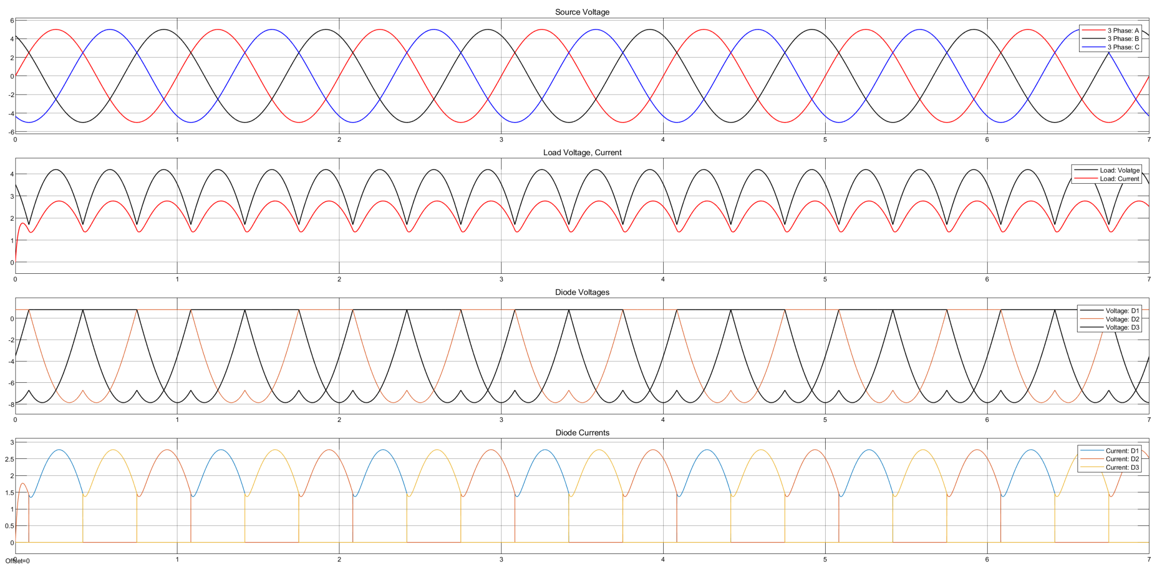


Figure 4: Simulation Output for RL Load, 3-Phase Star Rectifier

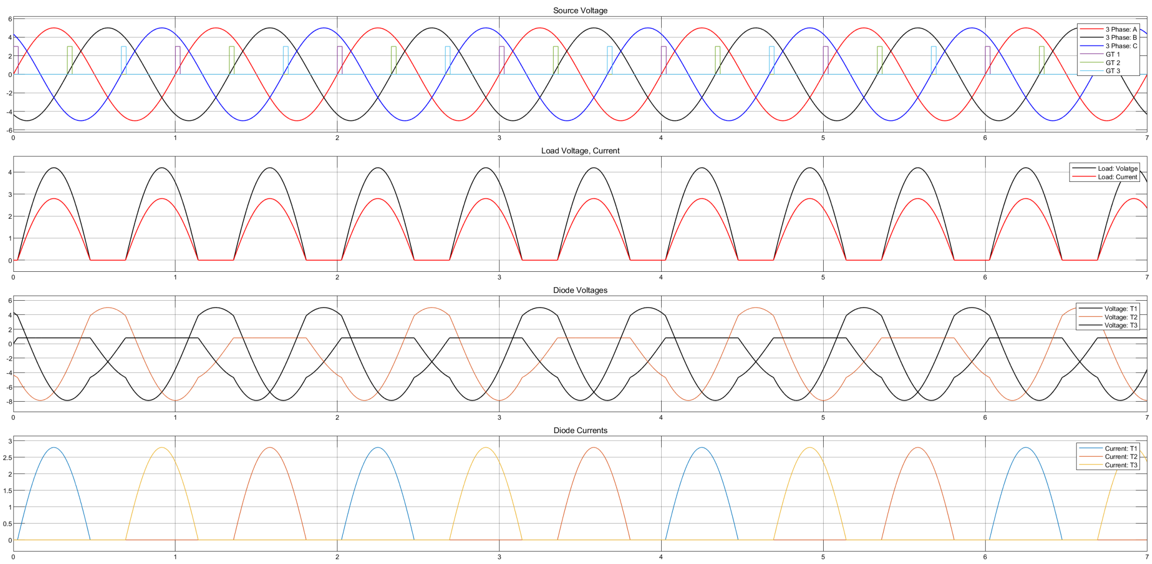


Figure 5: Simulation Output for R Load, Controlled Rectifier, No Delay

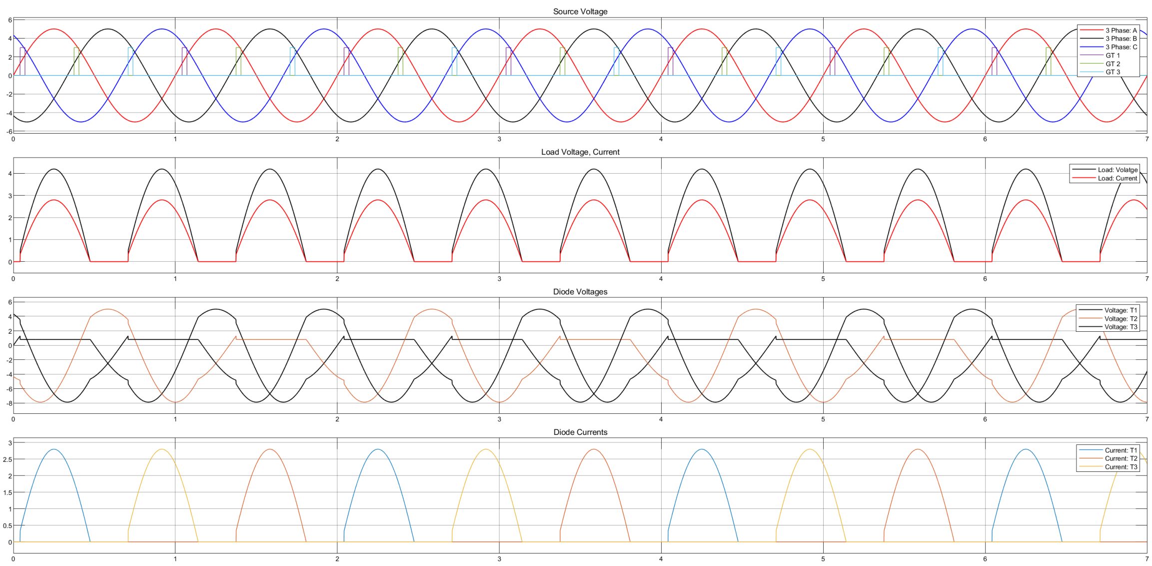


Figure 6: Simulation Output for R Load, Controlled Rectifier, With Delay

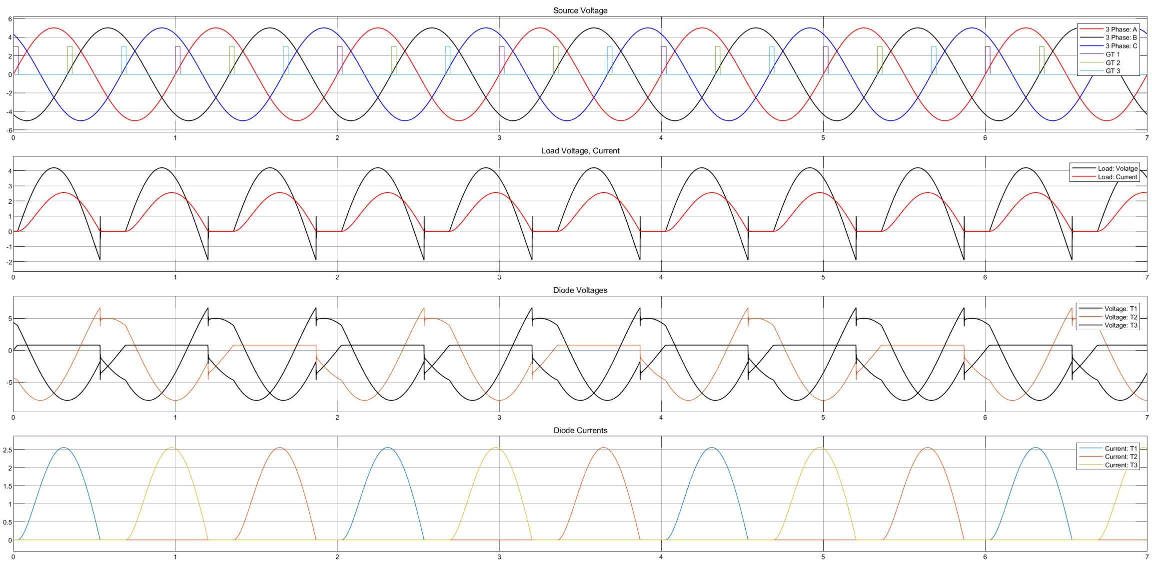


Figure 7: Simulation Output for RL Load, Controlled Rectifier, No Delay

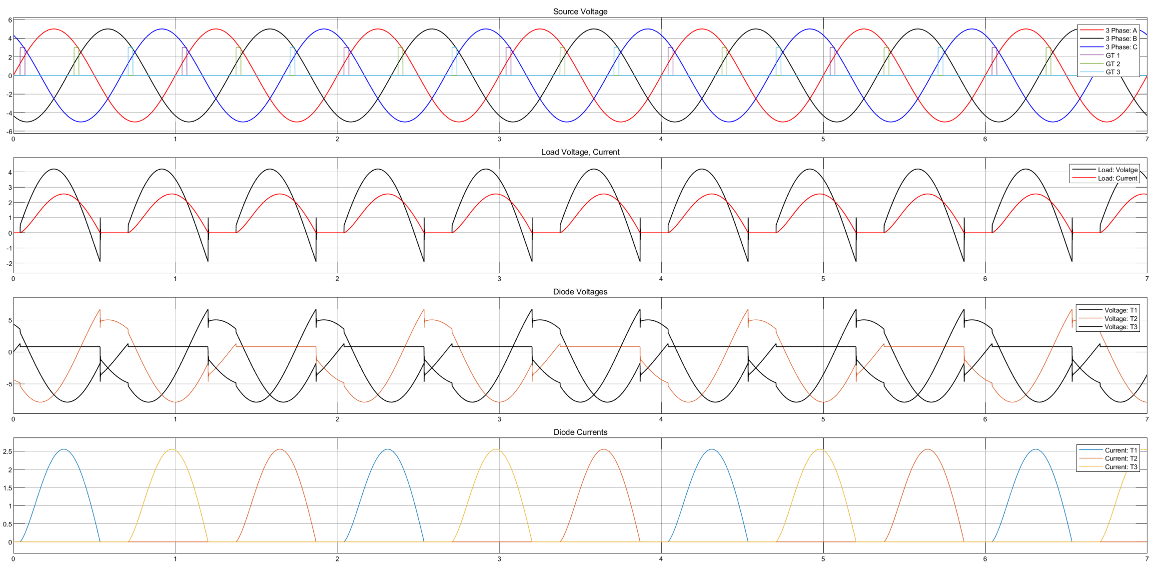


Figure 8: Simulation Output for RL Load, Controlled Rectifier, With Delay

Discussion

The three-phase star rectifier is a versatile circuit that can be used with different types of loads to convert AC input into DC output. By using MATLAB/Simulink, we can model the rectifier and analyze its performance under various conditions. The output voltage and current waveforms can be observed to understand the rectifier's behavior and optimize its performance for different industrial applications.

Conclusion

The study of the three-phase star rectifier using diodes and thyristors with R and RL loads provides valuable insights into the rectifier's behavior under different load conditions. By analyzing the output waveforms using MATLAB/Simulink, we can optimize the rectifier's performance and ensure efficient power conversion in industrial applications.

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

[2] B. K. Bose, "Three-phase rectifier circuits: Analysis and design," *IEEE Transactions on Industrial Electronics*, vol. IE-32, no. 3, pp. 269–278, 1985.

[3] P. S. Bimbhra, *Electrical Machinery*, 7th ed. Khanna Publishers, 2011.

[4] S. T. Karris, *Introduction to Simulink with Engineering Applications*, 2nd ed. Orchard Publications, 2006.

Single Phase Half Wave Rectifier Using Diode with R, RL Load

Objective

- To use diodes to construct a half-wave rectifier.
- To perform the experiment using a diode testing kit.
- To learn and understand the operation of the diode testing kit.

Circuit Diagrams

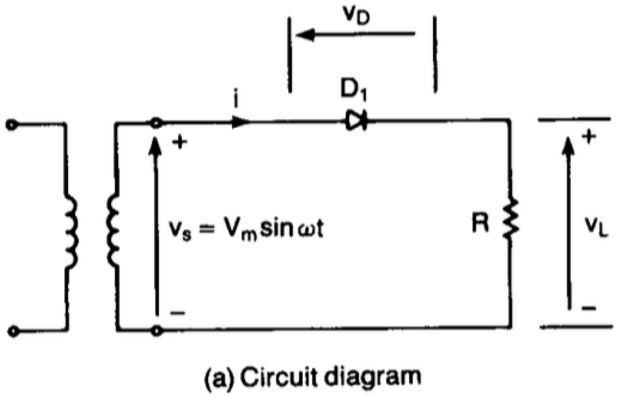


Figure 1: Diode Rectifier Circuit [1]

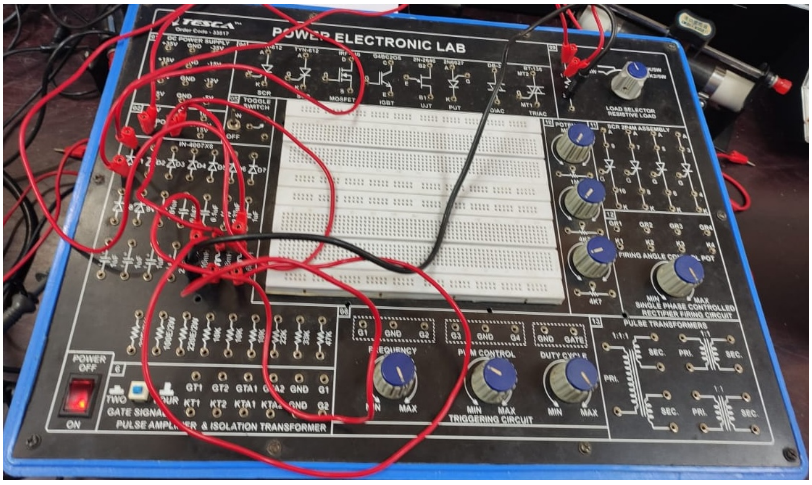


Figure 2: Diode Rectifier Circuit [1]

Observations

- Constructed a half-wave rectifier using a diode and testing kit.
- Analyzed waveforms for R and RL loads on an oscilloscope.
- Observed smoother transitions and delays in RL load due to inductance.
- Confirmed diode's unidirectional conduction, blocking negative half-cycles.

Outputs

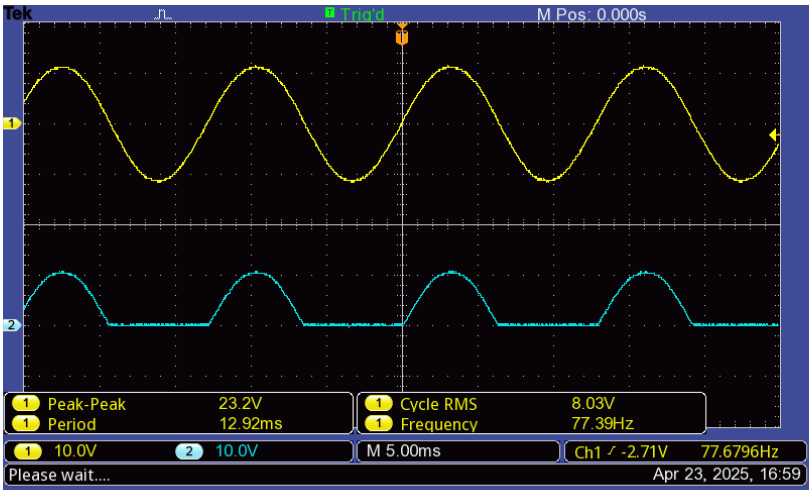


Figure 3: Half wave rectifier output for R load

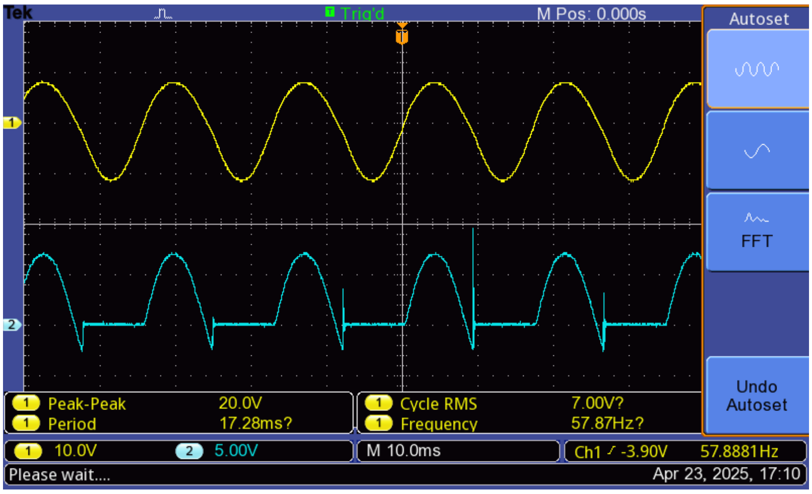


Figure 4: Half wave rectifier output for RL load

References

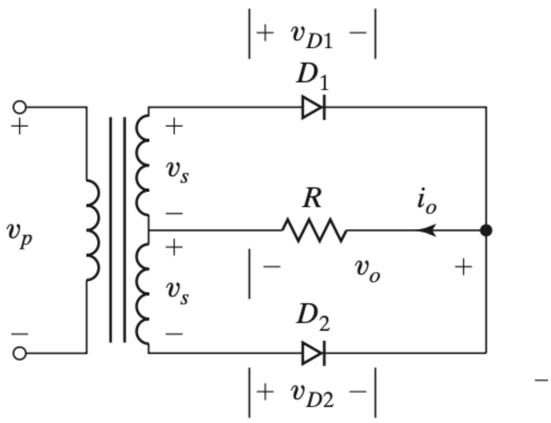
[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

Single Phase Full Wave Rectifier Using Centre Tap Transformer & Diode

Objective

- To construct a single-phase full-wave rectifier using a center-tap transformer and diodes.
- To analyze the output waveforms for resistive and inductive loads.
- To understand the working principle of a full-wave rectifier.

Circuit Diagrams



(a) Circuit diagram

Figure 1: Diode with Resistive Load [1]

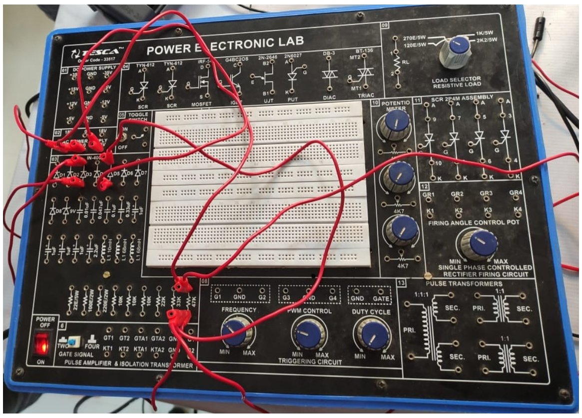


Figure 2: Diode with Resistive Load [1]

Observations

- Built a full-wave rectifier with a center-tap transformer and diodes.
- Observed waveforms for R and RL loads on an oscilloscope.
- Verified continuous conduction for both half-cycles.
- Confirmed smoother DC output than a half-wave rectifier.

Outputs

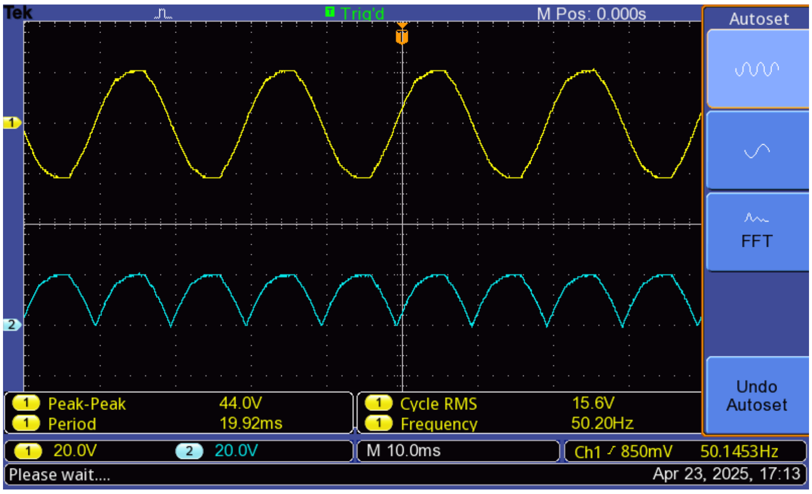


Figure 3: Full wave rectifier output for R load 1

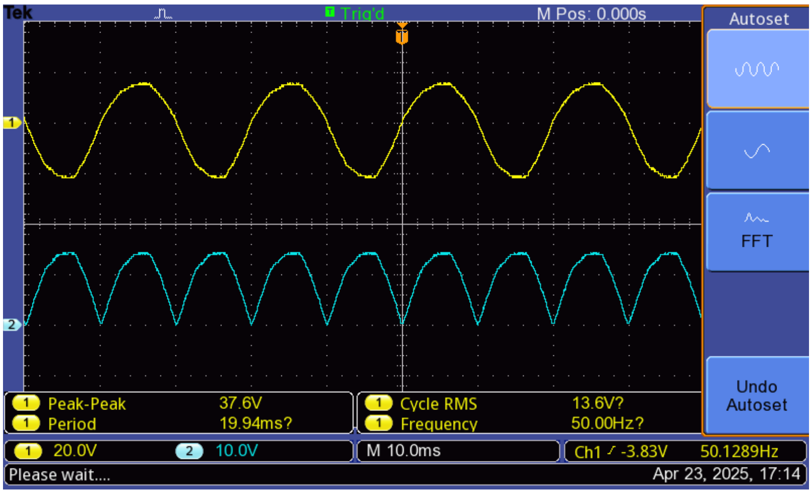


Figure 4: Full wave rectifier output for R load 2

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

Full Wave Bridge Rectifier Using Diodes

Objective

- To construct a single-phase full-wave bridge rectifier using diodes.
- To analyze the output waveforms for resistive and inductive loads.
- To understand the working principle of a full-wave bridge rectifier.

Circuit Diagrams

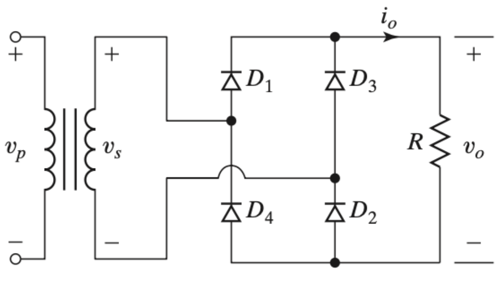


Figure 1: Full Wave Bridge Rectifier Circuit [1]

Observations

- Constructed a full-wave bridge rectifier using four diodes.
- Observed output waveforms for resistive and inductive loads.
- Verified continuous conduction through the bridge for both half-cycles.
- Confirmed that the output DC voltage is smoother compared to a half-wave rectifier.

Outputs

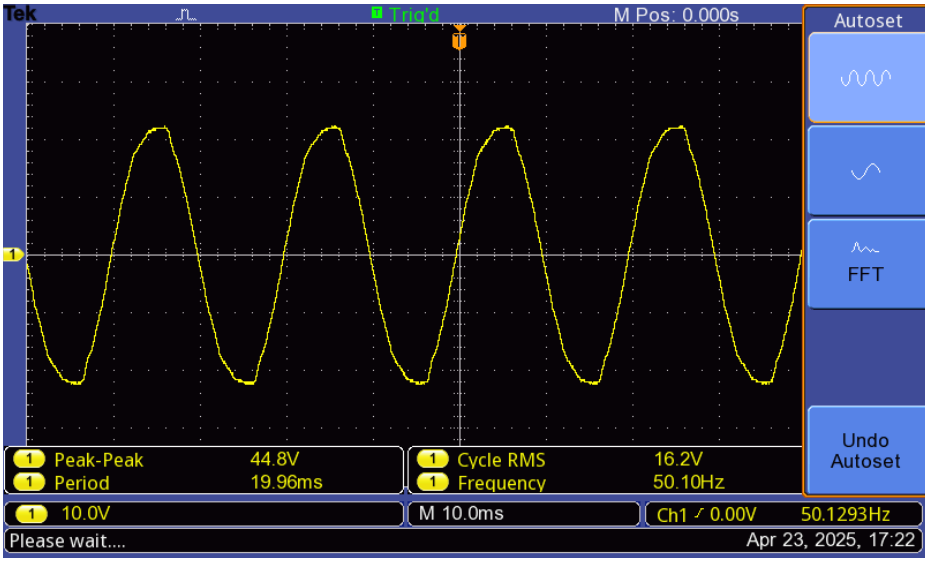


Figure 2: Full wave rectifier input voltage signal

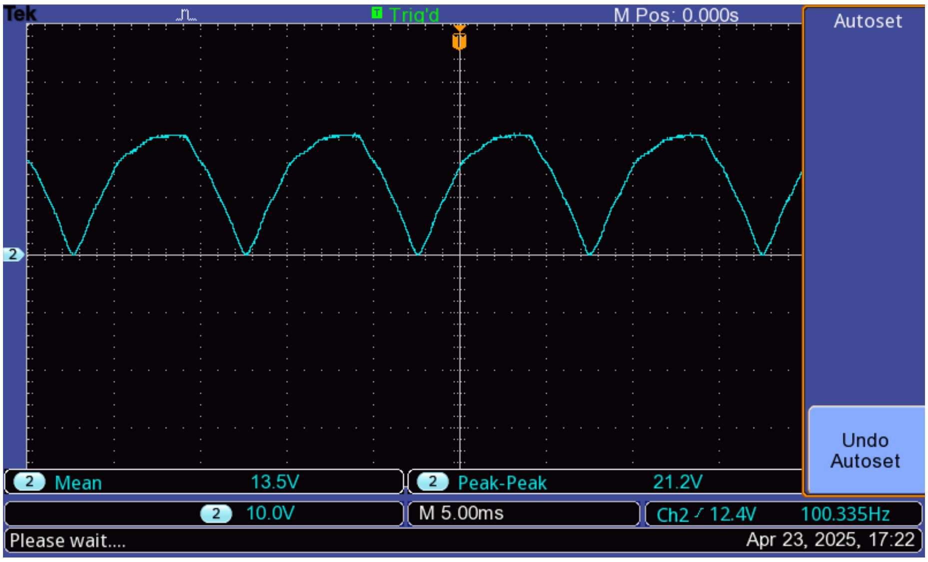


Figure 3: Full wave rectifier output voltage signal

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

Heaven's Light is Our Guide

Rajshahi University of Engineering and Technology

Course Code

ECE 3206

Course Title

Industrial Electronics Sessional

Experiment Date: February 24, 2025,

Submission Date: April 21, 2025

Lab Report 5:
Single Phase AC-AC Bidirectional(Full Wave) Voltage Controller with R, RL Load

Submitted to

Md. Faysal Ahamed

Lecturer

Dept of ECE, Ruet

Submitted by

Md. Tajim An Noor

Roll: 2010025

Contents

Single Phase AC-AC Bidirectional(Full Wave) Voltage Controller with R, RL Load

Theory

The Single Phase AC-AC Bidirectional (Full Wave) Voltage Controller is a power electronic circuit that allows control of the output voltage applied to a load by varying the firing angle of thyristors. It is widely used in industrial applications for controlling power delivered to resistive (R) and inductive (RL) loads [1].

Working Principle

The circuit consists of two thyristors connected in anti-parallel configuration. During the positive half-cycle of the AC input, one thyristor conducts when triggered, while during the negative half-cycle, the other thyristor conducts when triggered. By adjusting the firing angle of the thyristors, the effective RMS voltage applied to the load can be controlled [2].

Behavior with R Load

For a purely resistive load, the current waveform follows the voltage waveform. The output voltage is a controlled AC waveform, and the power delivered to the load is proportional to the RMS value of the output voltage. The firing angle directly determines the portion of the input voltage waveform applied to the load [3].

Behavior with RL Load

For an inductive load, the current lags the voltage due to the inductance. This lag affects the conduction period of the thyristors, as the current may continue to flow even after the voltage crosses zero. The output voltage waveform is still controlled by the firing angle, but the current waveform exhibits a phase lag [4].

Applications

- Speed control of AC motors
- Light dimming
- Heating control
- Industrial power regulation

The use of MATLAB/Simulink for simulation allows for detailed analysis of the circuit's behavior under different load conditions, enabling optimization for specific applications [5].

Required Equipments/Software

- MATLAB/Simulink
- AC Voltage Source
- Thyristors (2 in anti-parallel configuration)
- Resistive Load (R)
- Inductive Load (RL)
- Pulse Generator for firing angle control
- Measurement Blocks (Voltage and Current)
- Scope for waveform visualization

Circuit Diagrams

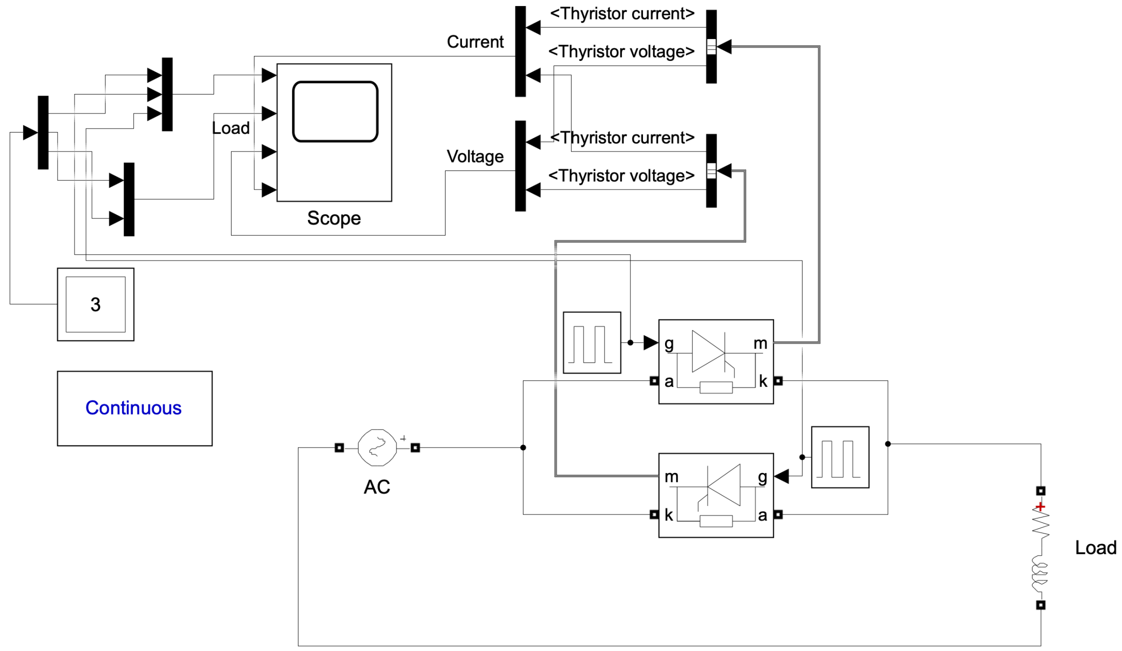


Figure 1: AC-AC Bidirectional Voltage Controller with R, Rl Load

Observations

- For the R load, the output voltage waveform is a controlled AC waveform, with the RMS value depending on the firing angle of the thyristors.
- Increasing the firing angle for the R load reduces the effective RMS voltage and power delivered to the load.
- For the RL load, the output voltage waveform is controlled by the firing angle, but the current waveform lags due to the inductance.
- The lagging current in the RL load causes the thyristors to conduct beyond the zero-crossing of the voltage waveform.
- MATLAB/Simulink simulations show the impact of firing angle on the output voltage and current waveforms for both R and RL loads.
- The circuit demonstrates effective control of power delivered to the load by varying the firing angle of the thyristors.
- The behavior of the circuit under different load conditions highlights the importance of considering load characteristics in power control applications.

Outputs

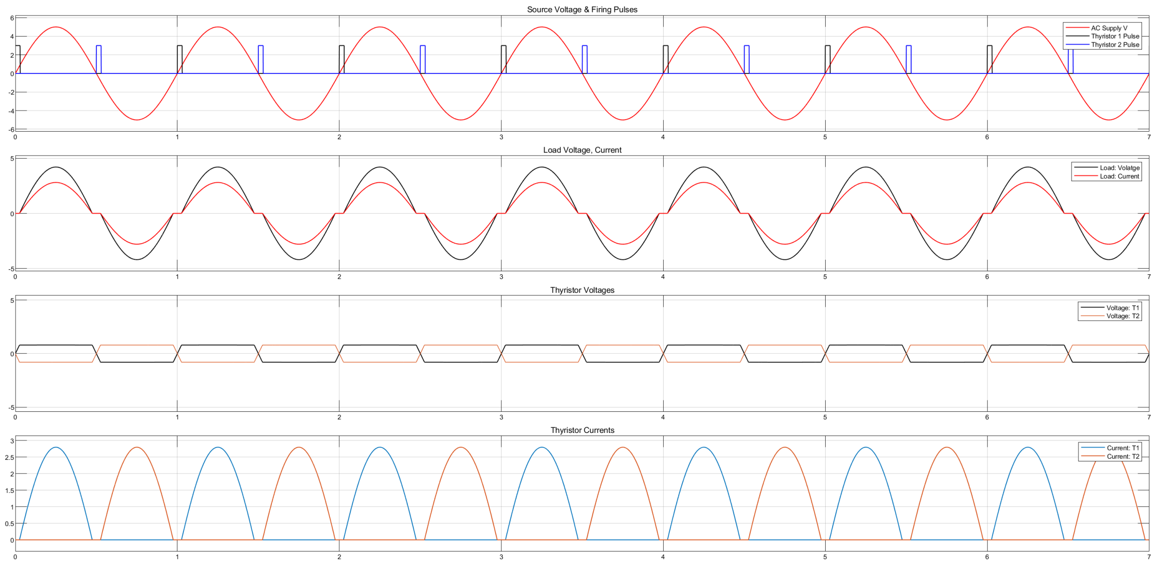


Figure 2: Simulation Output for R Load, Controlled Rectifier, No Delay

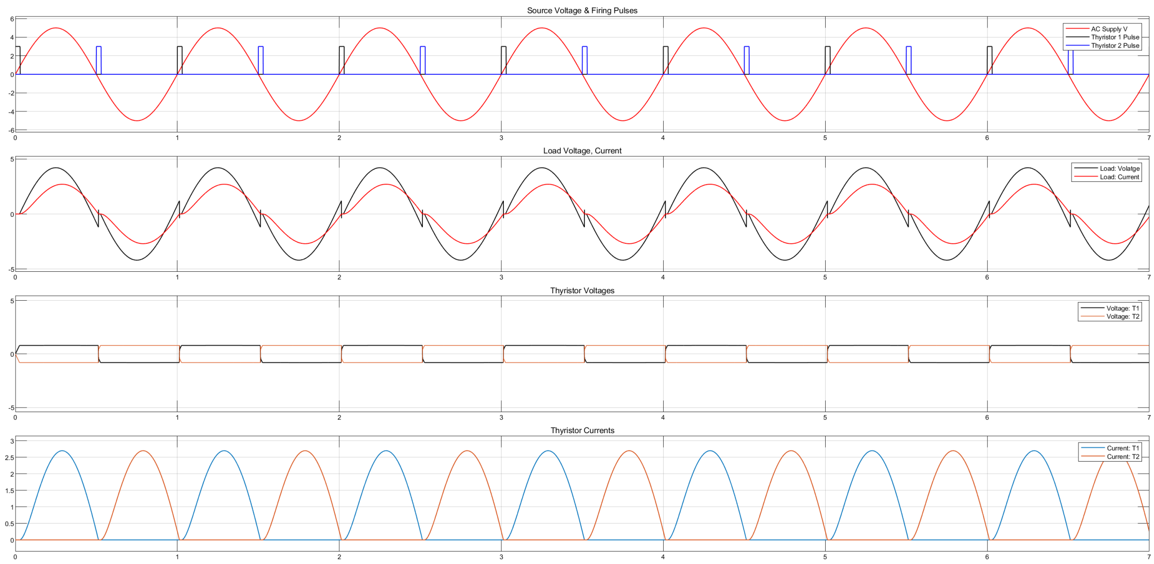


Figure 3: Simulation Output for RL Load, Controlled Rectifier, No Delay

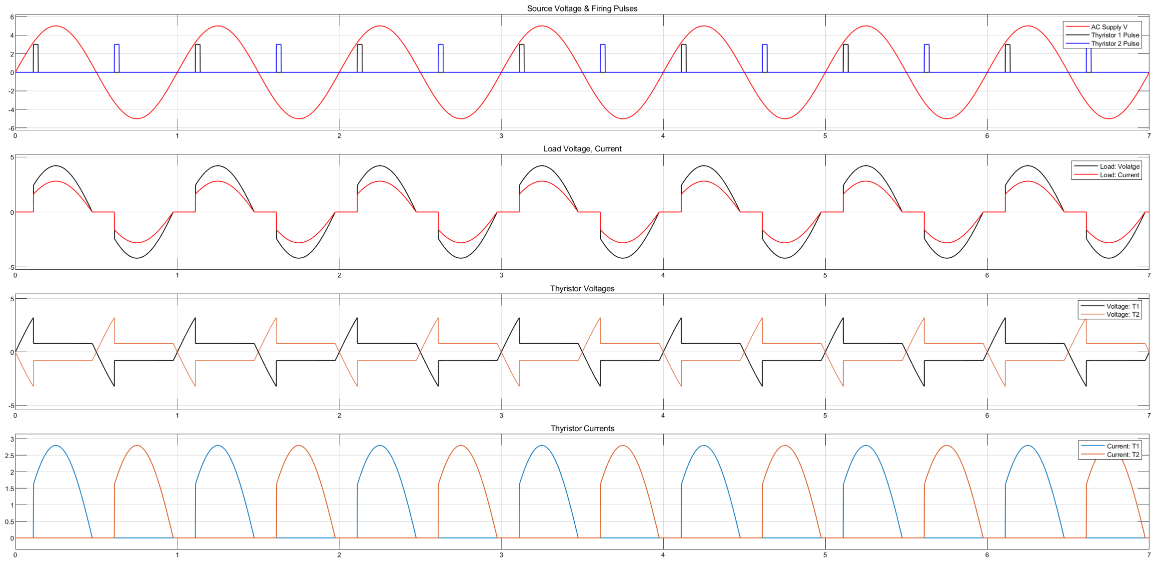


Figure 4: Simulation Output for R Load, AC-AC Bidirectional Voltage Controller

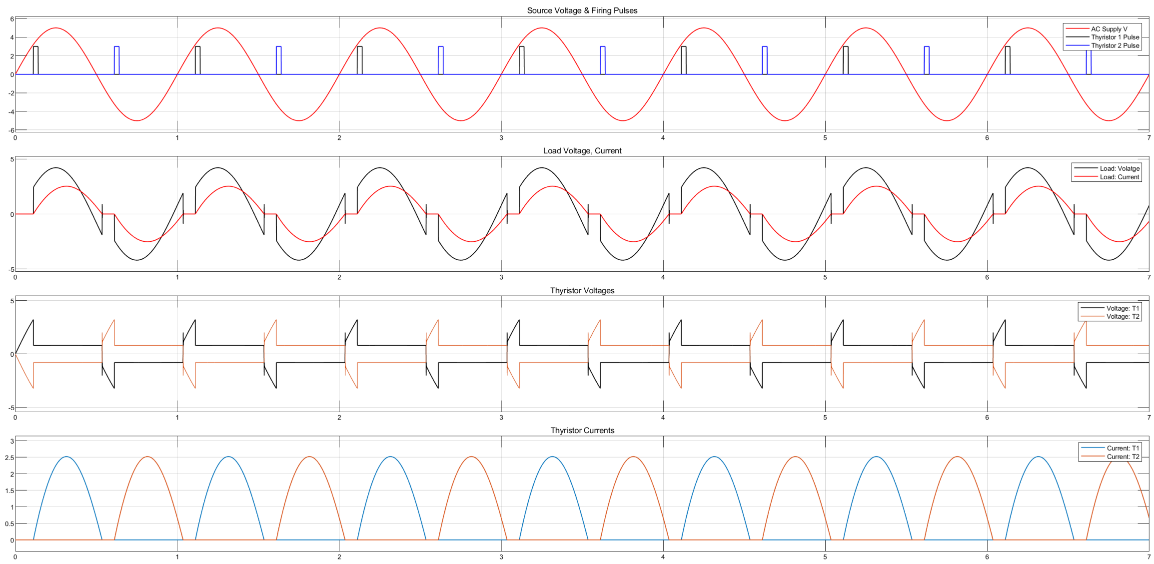


Figure 5: Simulation Output for RL Load, AC-AC Bidirectional Voltage Controller

Discussion

The Single Phase AC-AC Bidirectional (Full Wave) Voltage Controller is an essential circuit for controlling power delivered to various types of loads. Through MATLAB/Simulink simulations, we observed the impact of firing angle on the output voltage and current waveforms for both resistive (R) and inductive (RL) loads. The results highlight the importance of precise firing angle control in achieving desired power regulation. For R loads, the output voltage waveform closely follows the input waveform, while for RL loads, the current lags the voltage due to inductance, affecting the conduction period of the thyristors.

Conclusion

The study of the Single Phase AC-AC Bidirectional Voltage Controller with R and RL loads demonstrates its effectiveness in controlling power delivery by varying the firing angle of thyristors. The circuit's behavior under different load conditions emphasizes the need to consider load characteristics in power control applications. MATLAB/Simulink simulations provide valuable insights into the circuit's performance, enabling optimization for industrial applications such as motor speed control, heating, and lighting.

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

[2] P. C. Sen, *Principles of Electric Machines and Power Electronics.* Wiley, 1987.

[3] N. Mohan, T. M. Undeland, and W. P. Robbins, *Power Electronics: Converters, Applications, and Design*, 3rd ed. Wiley, 2003.

[4] B. K. Bose, *Modern Power Electronics and AC Drives.* Prentice Hall, 2002.

[5] MathWorks, *Simulink User's Guide*, 2023, available at https://www.mathworks.com/products/simulink.html.

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Rajshahi University of Engineering and Technology

Course Code

ECE 3206

Course Title

Industrial Electronics Sessional

Experiment Date: April 21, 2025,

Submission Date: April 26, 2025

Lab Report 6:

Study of Single Phase Bridge Inverter Using Simulink

Submitted to	**Submitted by**
Md. Faysal Ahamed	Md. Tajim An Noor
Lecturer	Roll: 2010025
Dept of ECE, Ruet	

Contents

Study of Single Phase Bridge Inverter Using Simulink

Theory

The Single Phase Bridge Inverter is a power electronic circuit that converts DC input into AC output, enabling the operation of AC loads from a DC source. It is widely used in industrial applications for driving AC motors, renewable energy systems, and uninterruptible power supplies (UPS) [1].

Working Principle

The circuit consists of four switches (typically IGBTs or MOSFETs) arranged in an H-bridge configuration. By controlling the switching sequence, the polarity of the DC voltage applied to the load is alternated, generating an AC output. The output waveform can be controlled to approximate a sinusoidal waveform using techniques such as Pulse Width Modulation (PWM) [2].

Behavior with R Load

For a purely resistive load, the current waveform follows the voltage waveform. The output voltage is a controlled AC waveform, and the power delivered to the load is proportional to the RMS value of the output voltage. The switching pattern directly determines the quality of the output waveform [3].

Behavior with RL Load

For an inductive load, the current lags the voltage due to the inductance. This lag affects the switching transitions, as the current may continue to flow through the free-wheeling diodes even after the switches are turned off. The output voltage waveform is still controlled by the switching pattern, but the current waveform exhibits a phase lag [4].

Applications

- Speed control of AC motors
- Renewable energy systems (e.g., solar inverters)
- Uninterruptible Power Supplies (UPS)
- Industrial power regulation

The use of MATLAB/Simulink for simulation allows for detailed analysis of the inverter's behavior under different load conditions, enabling optimization for specific applications [5].

Required Equipments/Software

- MATLAB/Simulink
- DC Voltage Source
- IGBTs
- Capacitors
- Diodes
- Resistive Load (R)
- Inductive Load (RL)
- Pulse Generator for firing angle control
- Measurement Blocks (Voltage and Current)
- Scope for waveform visualization

Circuit Diagrams

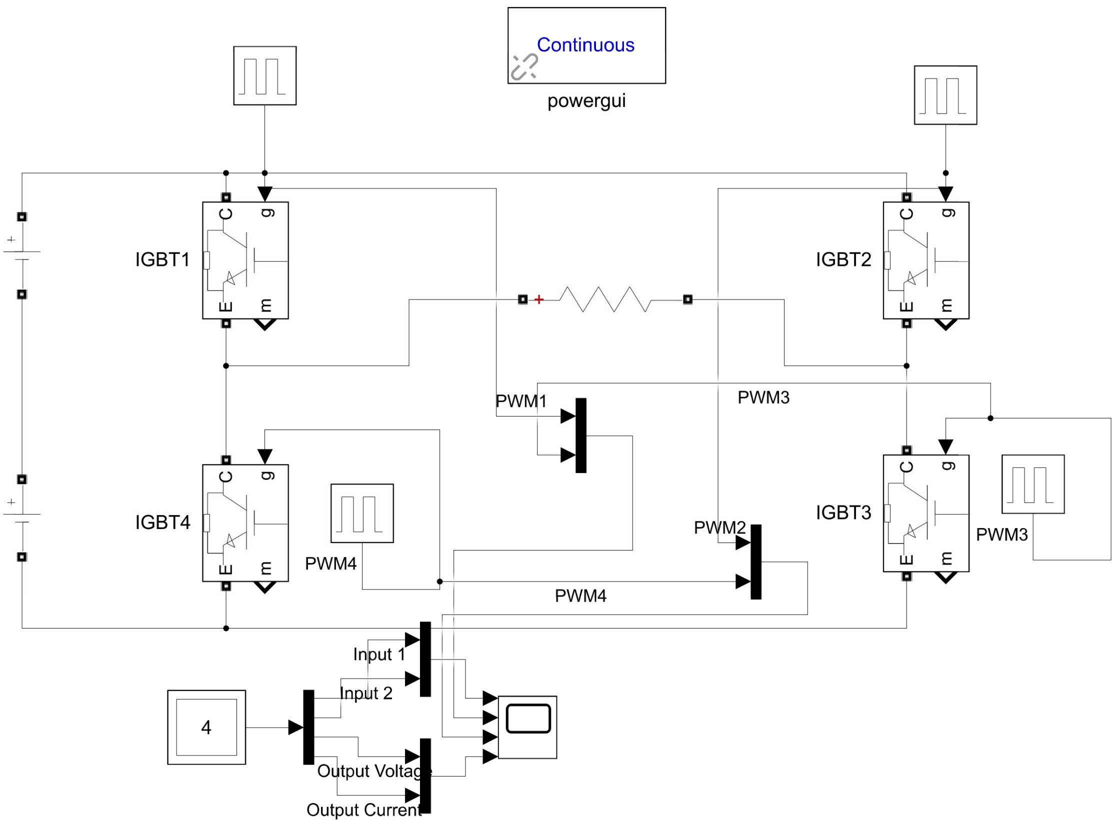

Figure 1: Single Phase Full Bridge Inverter Circuit

Observations

- For the R load, the output voltage waveform is a controlled AC waveform, with the RMS value depending on the switching pattern of the inverter.
- Increasing the modulation index for the R load increases the effective RMS voltage and power delivered to the load.
- For the RL load, the output voltage waveform is controlled by the switching pattern, but the current waveform lags due to the inductance.
- The lagging current in the RL load causes the freewheeling diodes to conduct during the switching transitions.
- MATLAB/Simulink simulations show the impact of switching patterns on the output voltage and current waveforms for both R and RL loads.
- The circuit demonstrates effective conversion of DC to AC power, enabling operation of AC loads from a DC source.

- The behavior of the circuit under different load conditions highlights the importance of considering load characteristics in inverter design and operation.

Outputs

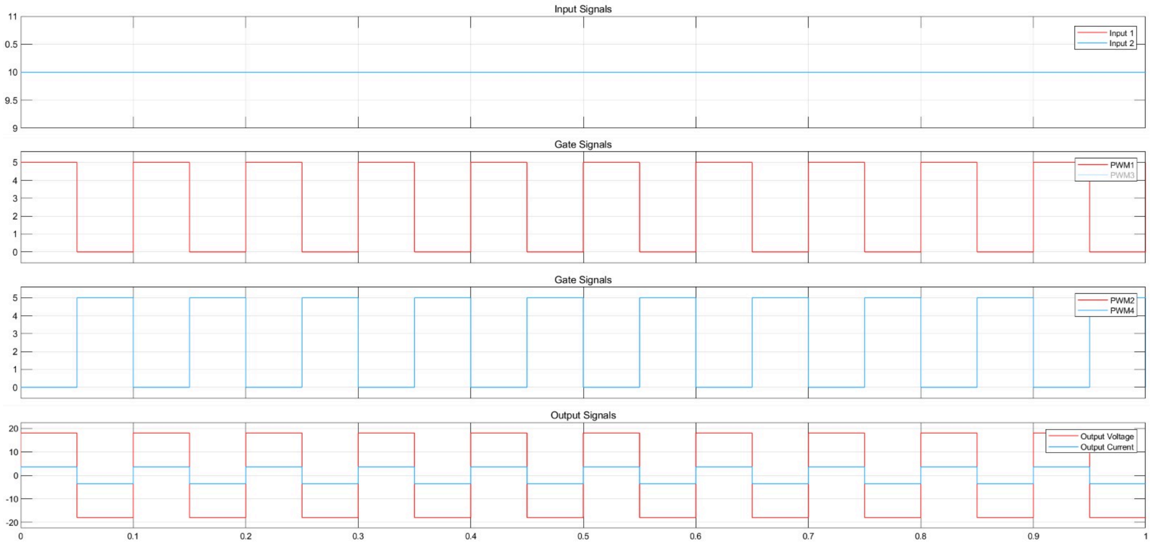

Figure 2: Simulation Output for Single Phase Bridge Inverter

Discussion

The Single Phase Bridge Inverter is a crucial circuit for converting DC power to AC power, enabling the operation of AC loads from a DC source. Through MATLAB/Simulink simulations, we analyzed the behavior of the inverter under resistive (R) and inductive (RL) loads. The results demonstrate the impact of switching patterns on the output voltage and current waveforms. For R loads, the current waveform closely follows the voltage waveform, while for RL loads, the current lags the voltage due to inductance, affecting the conduction period of the freewheeling diodes.

Conclusion

The study of the Single Phase Bridge Inverter with R and RL loads highlights its effectiveness in converting DC to AC power and controlling the output waveform through switching patterns. The circuit's behavior under different load conditions underscores the importance of considering load characteristics in inverter design and operation. MATLAB/Simulink simulations provide valuable insights into the inverter's performance, enabling optimization for industrial applications such as motor drives, renewable energy systems, and uninterruptible power supplies.

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

[2] P. C. Sen, *Principles of Electric Machines and Power Electronics*. Wiley, 1987.

[3] N. Mohan, T. M. Undeland, and W. P. Robbins, *Power Electronics: Converters, Applications, and Design*, 3rd ed. Wiley, 2003.

[4] B. K. Bose, *Modern Power Electronics and AC Drives*. Prentice Hall, 2002.

[5] MathWorks, *Simulink User's Guide*, 2023, available at https://www.mathworks.com/products/simulink.html.

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Rajshahi University of Engineering and Technology

Course Code

ECE 3206

Course Title

Industrial Electronics Sessional

Experiment Date: April 21, 2025,
Submission Date: April 26, 2025

Lab Report 7: Study of Buck Converter Using Simulink

Submitted to	Submitted by
Md. Faysal Ahamed	Md. Tajim An Noor
Lecturer	Roll: 2010025
Dept of ECE, Ruet	

Contents

Study of Buck Converter Using Simulink

Theory

The Buck Converter is a DC-DC power electronic circuit that steps down the input voltage to a lower output voltage while maintaining high efficiency. It is widely used in applications such as power supplies, battery chargers, and voltage regulation in electronic devices [1].

Working Principle

The Buck Converter operates by switching a transistor on and off at high frequency. When the transistor is on, the input voltage is applied to the inductor, causing the current to increase. When the transistor is off, the inductor maintains the current flow through a diode and the load. The output voltage is determined by the duty cycle of the switching signal [2].

Key Components

- Switching Transistor: Controls the on/off state of the circuit.
- Diode: Provides a path for the inductor current when the transistor is off.
- Inductor: Stores energy and smooths the current.
- Capacitor: Reduces voltage ripple at the output.
- Pulse Width Modulation (PWM) Controller: Regulates the duty cycle to achieve the desired output voltage.

Operation Modes

- Continuous Conduction Mode (CCM): The inductor current never falls to zero during operation.
- Discontinuous Conduction Mode (DCM): The inductor current falls to zero during part of the switching cycle.

Applications

- Voltage regulation in electronic devices
- Battery-powered systems
- Renewable energy systems
- Automotive electronics

MATLAB/Simulink simulations provide a powerful tool for analyzing the performance of the Buck Converter under various operating conditions, enabling optimization for specific applications [3].

Required Equipments/Software

- MATLAB/Simulink
- AC Voltage Source
- Thyristors (2 in anti-parallel configuration)
- Resistive Load (R)
- Inductive Load (RL)
- Pulse Generator for firing angle control
- Measurement Blocks (Voltage and Current)
- Scope for waveform visualization

Circuit Diagrams

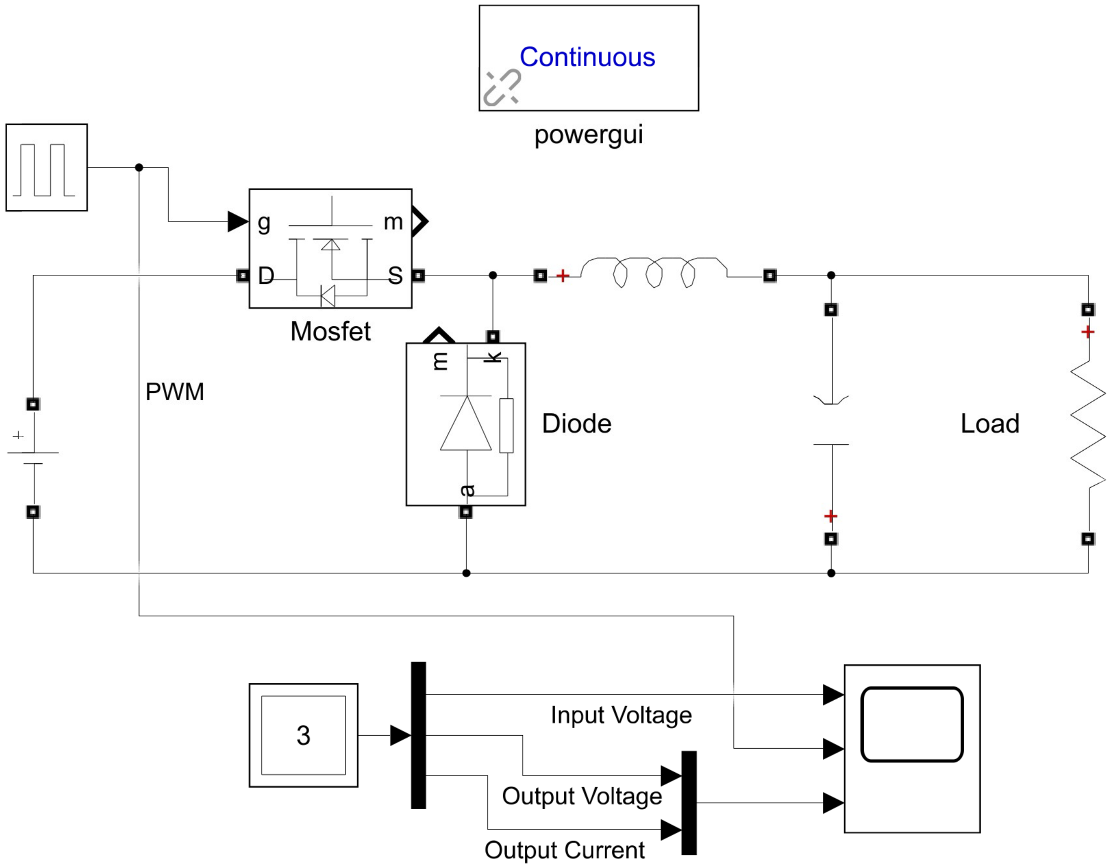

Figure 1: DC-DC Buck Converter Circuit Diagram

Observations

- For the Buck Converter, the output voltage is directly proportional to the duty cycle of the PWM signal.
- Increasing the duty cycle results in a higher output voltage, while decreasing it reduces the output voltage.
- In Continuous Conduction Mode (CCM), the inductor current never falls to zero, ensuring smooth operation and reduced ripple.
- In Discontinuous Conduction Mode (DCM), the inductor current falls to zero during part of the switching cycle, leading to increased ripple.
- MATLAB/Simulink simulations demonstrate the relationship between duty cycle, output voltage, and inductor current under various load conditions.

- The circuit effectively steps down the input voltage to the desired level with high efficiency.
- The results highlight the importance of proper component selection and PWM control for optimal performance in Buck Converter applications.

Outputs

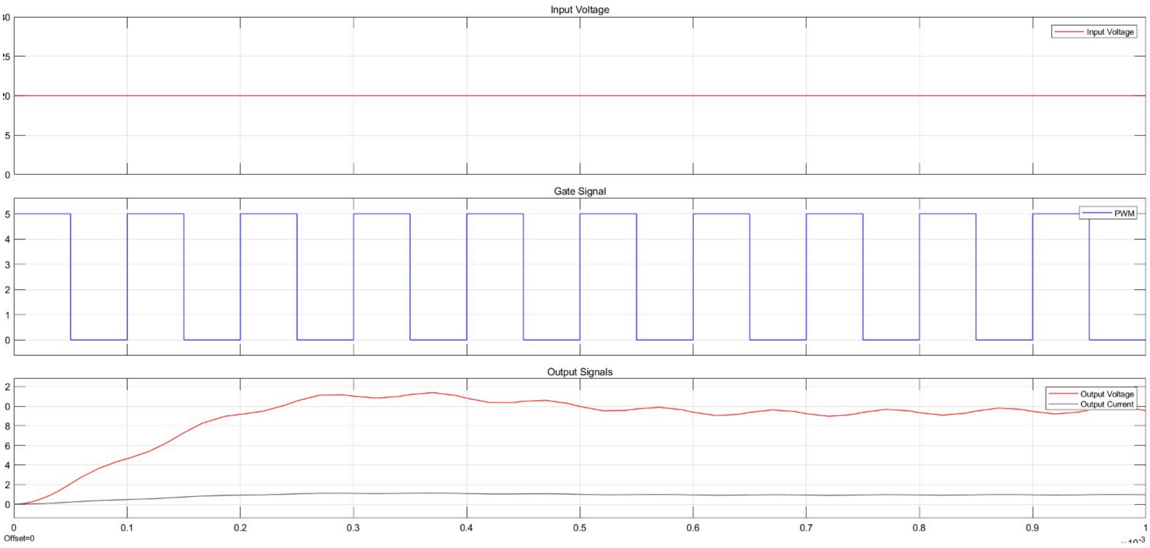

Figure 2: Simulation Output for DC-DC Buck Converter

Discussion

The Buck Converter is a versatile DC-DC power electronic circuit widely used in various applications. Through MATLAB/Simulink simulations, we analyzed the relationship between the duty cycle of the PWM signal and the output voltage. The results demonstrate that the output voltage is directly proportional to the duty cycle, with higher duty cycles resulting in higher output voltages. For Continuous Conduction Mode (CCM), the inductor current remains smooth and does not fall to zero, ensuring efficient operation. In Discontinuous Conduction Mode (DCM), the inductor current falls to zero during part of the switching cycle, leading to increased ripple and reduced efficiency. These observations highlight the importance of proper component selection and PWM control for achieving optimal performance in Buck Converter applications.

Conclusion

The study of the Buck Converter using MATLAB/Simulink simulations provides valuable insights into its operation and performance. The simulations confirm the theoretical principles of the Buck Converter, including the relationship between duty cycle, output voltage, and inductor current. The circuit effectively steps down the input voltage to the desired level with high efficiency, making it suitable for applications such as power supplies, battery chargers, and voltage regulation in electronic devices. The results emphasize the importance of understanding the operating modes and selecting appropriate components to optimize the converter's performance for specific applications.

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*, 4th ed. Pearson, 2013.

[2] P. C. Sen, *Principles of Electric Machines and Power Electronics.* Wiley, 1987.

[3] MathWorks, *Simulink User's Guide*, 2023, available at https://www.mathworks.com/products/simulink.html.