UPH013:
PHYSICS WORKING MODEL REPORT

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Assembling a Full Wave Rectifier to demonstrate DC supply using a Transformer

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Introduction

- A **transformer** is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. It operates on the principle of mutual induction, where a changing current in one coil induces a voltage in another coil without physical contact. It consists of a primary winding, secondary winding and a magnetic core.
- A DC power supply with a transformer converts high-voltage AC (Alternating Current) into a stable low-voltage DC (Direct Current).
- For converting the power supplied by electrical grids in the form of AC (Alternating Current) to DC (Direct Current), we use a **rectifier**.
- A rectifier is an electrical circuit that converts AC to DC, making it an essential component in power supplies.
- Among different types of rectifiers, a **full-wave rectifier** is highly efficient because it utilizes both halves of the AC waveform.
- There are two common types of full-wave rectifiers namely, center-tapped and bridge rectifiers.
- We have used a **bridge rectifier** for this model instead of a center-tapped rectifier as it does not require a center-tapped transformer, making it more cost-effective and efficient.
- This report presents a working model of a full-wave rectifier, explaining its principle, circuit design, construction, and practical applications.

Theory

A bridge rectifier is a type of full-wave rectifier that converts Alternating Current (AC) into Direct Current (DC) using four diodes arranged in a bridge configuration.

The components of a bridge rectifier include:

1. Power Supply Components:

- AC Mains Supply (220V) – Provides alternating current (AC) for rectification.
- Step-Down Transformer(0-12V) – Converts high-voltage AC to a lower voltage suitable for rectification.

2. Rectifier Circuit Components:

- Four Diodes (1N4007) – Arranged in a bridge configuration to rectify the AC input.
- Breadboard – Used for assembling the circuit without soldering.
- Transistor (IC7805) - Used for voltage regulation.

3. Load & Output Components:

- Load Resistor (1kΩ) – Simulates the connected load and consumes the rectified DC output.
- Capacitor (1000µF Electrolytic) – Used as a filter to smooth out the DC voltage.
- LED – Used to indicate the presence of rectified DC output.

4. Connecting & Supporting Materials:

- Jumper Wires – Connect components on the breadboard.
- Output Wires(Orange and Red) - The orange wire is connected to the positive output and the red wire is connected to the ground pin of the 7805.

5**. Measuring & Testing Components:**

- **Multimeter** – Measures AC and DC voltage at different points in the circuit.

Working Principle

1. **AC Step-Down Transformation:**
- A 0-12V, 500mA step-down transformer reduces 220V AC mains supply to 12V AC(V_{RMS}), making it suitable for rectification.

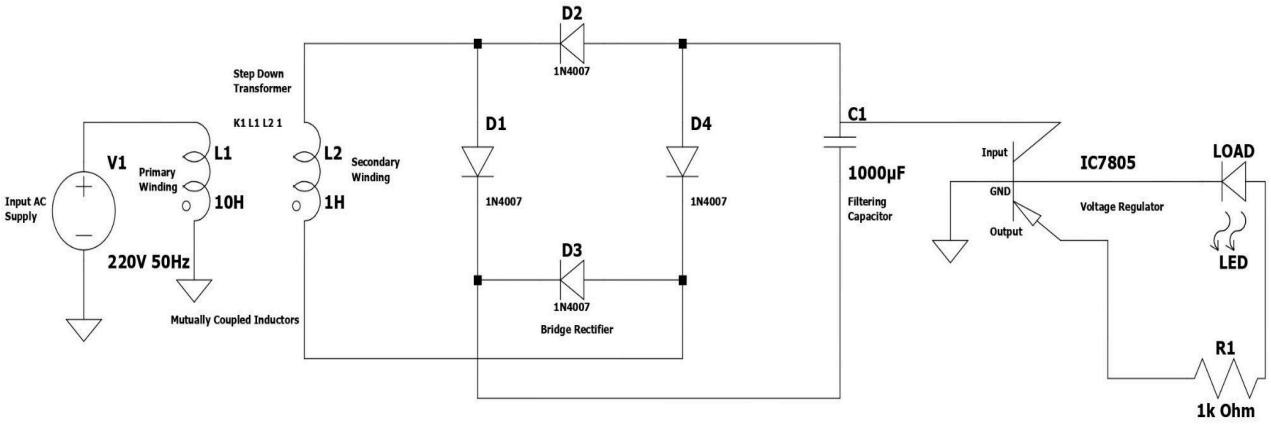
2. **Bridge Rectification:**
- A bridge rectifier (four 1N4007 diodes) converts AC to pulsating DC by conducting in alternate pairs:
- Positive half-cycle: D1 & D3 conduct.
- Negative half-cycle: D2 & D4 conduct.
- Voltage drop across each diode (V_{Diode})=**1.4V**.
- This ensures unidirectional current flow to the load.

3. **Smoothing (Filtering):**
- A 1000µF capacitor smooths out fluctuations by charging during voltage peaks and discharging during drops, providing a more stable ~12V DC output.
- After rectification and filtering of the input signal, using a multimeter the voltage is measured to be **15.6V**.

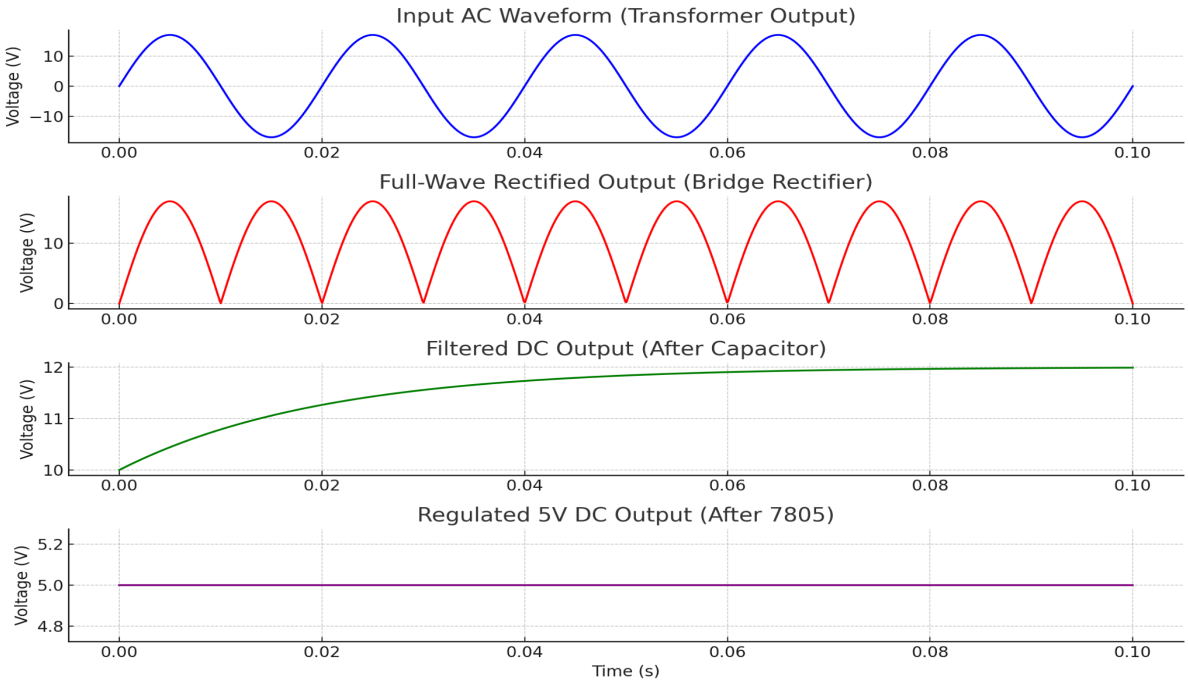
4. **Voltage Regulation:**
- The 7805 voltage regulator maintains a steady DC output regardless of minor input fluctuations.
- Pin 1: Accepts ~12V DC input.
- Pin 2: Connected to ground.
- Pin 3: Provides a regulated DC output for low-power devices.

5. **Power Indicator (LED):**
- Using a multimeter across the red and orange wire, the output voltage is measured to be **5V**.
- A red LED with a 1kΩ resistor is connected to the 5V output as a power indicator. When power is supplied, the LED lights up, confirming the circuit is operational.

Circuit Diagram and Waveforms



Circuit Designed Using LTSpice software



Input and Output Waveforms generated using LTSpice software

Calculations

- **DC Voltage after rectification:**

  $V_{DC} = (V_{RMS} \times 1.414) - V_{Diode}$

  $= (12 \times 1.414) - 1.4$

  $V_{DC} = 15.6$ V

  Therefore, voltage across the 1000µF capacitor approximately lies between **15.5-16V**.

- **Voltage and Current across the output:**

  $V_{Output} = 5V$

  $I_{Output} = 500mA$

- **Power dissipation in IC7805 regulator :**

  $P_{loss} = (V_{DC} - V_{Output}) \times I_{Output}$

  $= (15.6 - 5) \times 0.5$

  $P_{loss} = 5.3$ W

- **Current through LED and Resistor:**

  $R_{load} = 1k\Omega$

  Voltage drop across LED, $V_{LED} = 2V$ (for red LED)

  $$I = \frac{V_{Output} - V_{LED}}{R_{load}} = \frac{5 - 2}{1000}$$

  I = 3mA

- **Total Current Drawn from Transformer:**

  $I_{Transformer} \approx I_{Output}$

  $I_{Transformer} = 500mA$

Practical Applications

- **Power Supply Units (PSUs):** Converts AC mains voltage to a stable 5V DC for microcontrollers, sensors, and small electronic circuits.
- **Embedded Systems:** Provides regulated 5V power to microcontrollers like Arduino, Raspberry Pi, and other digital circuits.
- **Battery Charging Circuits:** Used in chargers for low-power batteries, ensuring a stable DC output.
- **LED Drivers:** Powers low-voltage LEDs and indicator circuits with a steady 5V output.
- **Mobile and USB Chargers:** Can be used in basic mobile phone adapters and USB power sources.
- **Automation and IoT Devices:** Provides stable power to IoT sensors and automation modules.
- **Laboratory Power Supplies:** Acts as a simple, low-cost DC power source for electronic experiments and testing.
- **Home Appliances:** Used in power adapters for household electronic devices like routers, modems, and set-top boxes.
- **Industrial Control Circuits:** Provides regulated 5V DC for PLCs(Programmable Logic Controllers), motor controllers, and other industrial automation systems.
- **Security Systems:** Powers surveillance cameras, alarm circuits, and motion sensors that require a stable DC supply.
- **Medical Devices:** Used in low-power medical electronics like digital thermometers and portable diagnostic tools.

Conclusion

This project successfully demonstrates the complete process of AC-to-DC conversion and voltage regulation using a step-down transformer, bridge rectifier, capacitor filter, and voltage regulator.

The process begins with the step-down transformer, which reduces the high-voltage **2**20V AC from the mains to a safer 12V AC level. This lower AC voltage is then fed into the bridge rectifier, where four 1N4007 diodes work together to convert the AC into pulsating DC. However, this rectified output still contains ripples, which are significantly reduced by the 1000µF capacitor, providing a smoother DC voltage (~12V).

To ensure a stable and regulated output, a 7805 voltage regulator is used. This regulator takes the unregulated 12V DC and outputs a consistent 5V DC, making it suitable for low-voltage electronic devices. Additionally, an LED power indicator, along with a current-limiting resistor, confirms the proper functioning of the circuit by lighting up when the circuit is operational.

This model is highly practical and finds applications in powering microcontrollers, battery charging circuits, household electronics, and industrial control systems. The successful completion of this project highlights the efficiency of transformer-based power supplies in providing a steady and reliable DC output for various electronic applications.

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