MS101 Makerspace
2022-23/II Spring
Expt 2: DC Power Supply (Ver 1.1)

Objectives:

i) To measure and compare the ripple voltages of half and full wave (bridge) rectifiers.

ii) To compare the output voltage variations and output resistances of the bridge rectifier based DC power supply with that of an IC regulator based DC power supply.

List of components:

Step-down transformer (230 V/0-12 V), IN4007 diodes, electrolytic capacitors, resistors, and LM 7805 IC.

Important note:
This experiment is a very basic one, but a dangerous one too. You need to be extremely careful with your wiring. Incorrect connections of the diodes and/or the electrolytic capacitors can result in explosion and fire. You might severely damage your bread board too. Please note the following:

i) **Electrolytic capacitors used in circuits of Fig.1.3 and Fig. 2.3 have polarity, i.e. the capacitors have '+' and '-' terminals. If the electrolytic capacitor is connected with the wrong polarity, it may explode and may cause fire/injury.**

ii) **Similarly, the diodes have anode and cathode terminals, which need to be connected correctly. Wrong connections can result in the diode or the transformer burning. Once again careless wiring of the diodes may result in injury.**

iii) **In order to avoid the above dangerous scenarios, you must get your circuit tested by your TA before switching ON power to the transformer. Also, while making changes, such as changing the C value from 100 µF to 1000 µF, be sure to first switch OFF power to the transformer, and then connect the capacitor once again observing the correct polarity. Get your connection ok-ed by your TA and then only switch ON the power. Similarly, it is best to switch OFF power to the transformer while changing the R_L values.**

Part A – Unregulated DC Power Supply using Half-wave Rectifier Circuit and a Capacitor Filter

1.1 Half-wave Rectifier

The circuit diagram of a half-wave rectifier circuit is shown below. We will be using a 230 V/0-12 V step-down transformer and an IN4007 diode (peak forward current: 1A, peak-inverse voltage: 1000 V) to realize the circuit. As shown in the diode image, the cathode lead is identified by the band close to it.

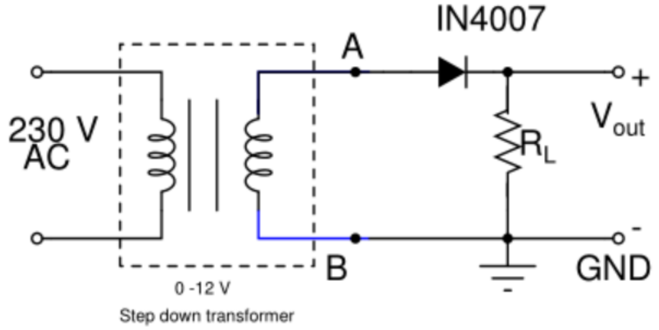

Fig 1.1 Half-wave rectifier circuit

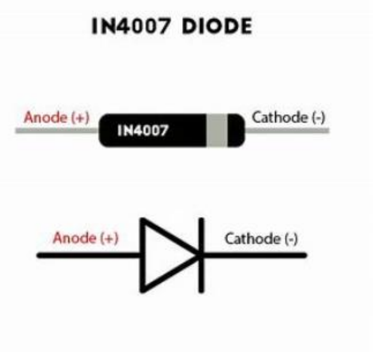

Fig. 1.2 IN4007 diode image

Experiment:

i) Wire the half-wave rectifier circuit neatly and carefully on the breadboard. R_L = 1 kΩ. **Take extra care in wiring the diode and the load resistance correctly.**

ii) Connect CH-1 of the DSO to the transformer output (the voltage V_{AB}) and CH-2 to the rectifier output (V_{out}).

Note:

a) Take extra care to avoid shock. The primary side of the transformer has already been insulated and connected to a plug. You should use only the two leads of the transformer secondary for circuit connections, i.e. points A and B shown in Fig.1.1.

b) For getting a stable display in CH-1 and CH-2, it is best to use 'AC Line' as the trigger source. (Use: Trigger Menu > Source > AC Line)

Observation and Measurement:

a) Sketch the V_{AB} and V_{out} waveforms and note down their peak-to-peak voltages.

b) After step (a), switch-OFF power to the transformer.

1.2 Half-wave Rectifier Circuit with a Capacitor Filter

The half-wave rectifier circuit of Fig. 1.1 is modified and re-drawn in Fig.1.3. In the modified circuit, a large value capacitor (1000 µF) is connected across R_L. Please note from Fig.1.2 the '-' terminal of the capacitor (the '-' terminal is generally the one with the shorter lead length).

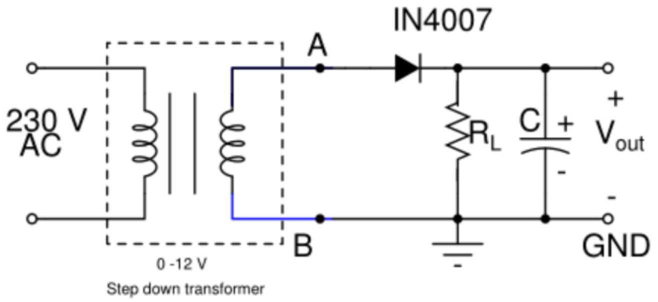

Fig 1.3 Half-wave rectifier circuit with a capacitor filter

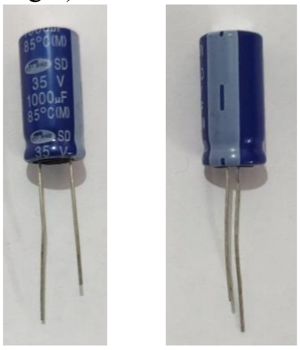

Fig. 1.4 Images of the 1000 µF capacitor

Experiment:

i) Switch-OFF power to the transformer. Modify the circuit of Fig.1.1 so as to connect the 1000 µF electrolytic capacitor *C* across R_L. **Take extreme care to see that '-' terminal of the electrolytic capacitor is connected to the GND and the '+' terminal to V_{out}.**

ii) Switch ON power to the transformer.

Observation and Measurement:

a) Sketch the V_{AB} and V_{out} waveforms for the following values

i) R_L = 1 kΩ, C = 1000 µF.

- For the above case, note down the peak-to-peak ripple voltage and the mean value of V_{out}. (Use the 'Measure' feature of the DSO to obtain the mean value of V_{out}). Please also use your DMM to measure V_{out}. For this measurement the DMM should be in the DC voltage setting.

Note: Peak-to-peak ripple voltage is relatively much smaller compared to the mean value of V_{out} (say 0.5 V of ripple riding over 16 or 17 V DC). In order to measure the small ripple voltage correctly, you should put the DSO channel to the ***AC mode*** *and choose an appropriate scale.*

Part B – Unregulated DC Power Supply using the Bridge Rectifier Circuit and a Capacitor Filter

2.1 Bridge Rectifier Circuit

Circuit diagram of the bridge rectifier circuit is shown below. We will be using the same 230 V/0-12 V step-down transformer of Part A. In addition, we will use four IN4007 diodes (peak forward current: 1A, peak-inverse voltage: 1000 V) to realize the circuit. As shown in the diode image (see Fig.2.2), the cathode lead is identified by the band close to it.

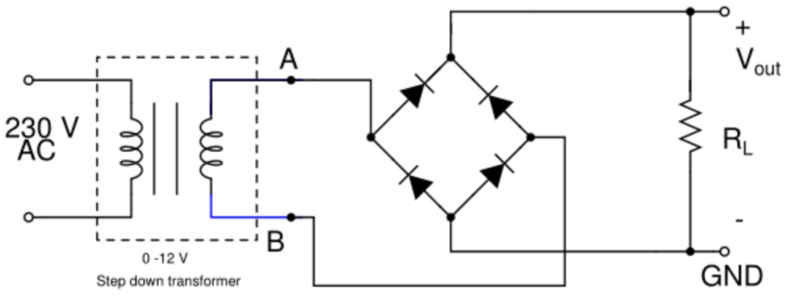

Fig 2.1 Bridge rectifier circuit

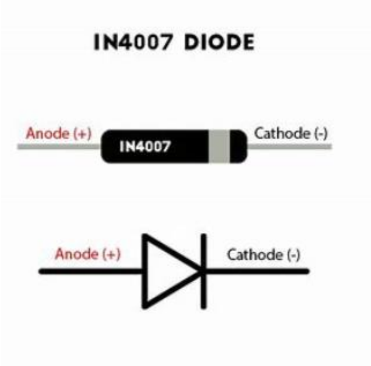

Fig. 2.2 IN4007 diode image

Experiment:

i) Wire the bridge rectifier circuit neatly and carefully on the breadboard. R_L = 10 kΩ. Take extra care in wiring the diodes correctly with the right polarity as shown. **Please note even though the wire from output B of the transformer is crossing the GND line, there is no connection there.**

ii) Connect DSO (CH-1 or CH-2) only to the rectifier output (V_{out}). <u>Do not connect any DSO probe to the transformer secondary outputs A or B. (i.e., do not try to display V_{AB} on the DSO). This will result the transformer secondary getting shorted through one of the diodes.</u>

Note:

a) For getting a stable display in **CH-1 or CH-2**, it is best to use ‘AC Line’ as the trigger source. (Use: Trigger Menu > Source > AC Line)

Observation and Measurement:

a) Sketch the V_{out} waveform (for R_L = 10 kΩ) and the peak-to-peak voltage.
b) After competing (a), switch-OFF power to the transformer.

1.3 Bridge Rectifier Circuit with a Capacitor Filter

The bridge rectifier circuit of Fig.2.1 is modified and re-drawn in Fig.2.3. In the modified circuit, a large value capacitor (100 µF or 1000 µF) is connected across R_L.

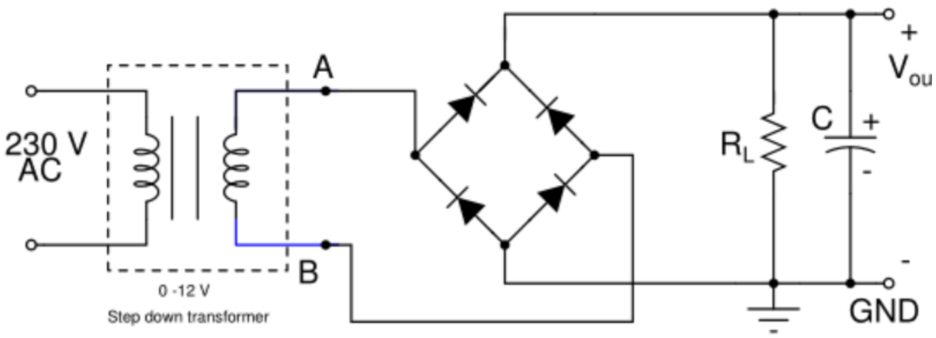

Fig 2.3 Bridge rectifier circuit with a capacitor filter

Experiment:

i) Switch-OFF power to the transformer. Modify the circuit of Fig. 2.1 so as to connect the 100 μF electrolytic capacitor C across R_L. **Take extreme care to see that '-' terminal of the electrolytic capacitor is connected to the GND and the '+' terminal to V_{out}.**

ii) Switch ON power to the transformer.

Observation and Measurement:

Sketch the V_{out} waveforms for the following values
i) R_L = 10 kΩ, C = 100 μF.
ii) R_L = 3.3 kΩ, C = 100 μF.
iii) R_L = 1 kΩ, C = 100 μF.

- For each of the above cases, note down the peak-to-peak ripple voltage and the mean value of V_{out} (= $V_{out-mean}$). Use the 'Measure' feature of the DSO to obtain $V_{out-mean}$. Use also your DMM to measure V_{out}. For this measurement the DMM should be in the DC voltage setting.

- Determine the output resistance of the bridge rectifier power supply (with capacitive filter).
  Output resistance = $| \Delta V_{out} / \Delta I_L |$.
  ΔV_{out} = ($V_{out-mean}$ for R_L = 10 kΩ) – ($V_{out-mean}$ for R_L = 1 kΩ). ΔI_L is the currents for these cases.
  For example, I_L (for R_L = 10 kΩ) = $V_{out-mean}$/10 kΩ. Similarly find I_L for R_L = 1 kΩ.

b) Switch-OFF power to the transformer. **Change C to 1000 μF, once again ensuring that '-'of the electrolytic capacitor is connected to the GND and the '+' terminal to V_{out}.**

Switch ON power to the transformer. Observe and sketch the V_{out} waveforms for the following values
i) R_L = 10 kΩ, C = 1000 μF.
ii) R_L = 3.3 kΩ, C = 1000 μF.
iii) R_L = 1 kΩ, C = 1000 μF.

- For each of the above cases, note down the peak-to-peak ripple voltage and the mean value of V_{out} (=$V_{out-mean}$).
- Determine the output resistance of the above power supply.
  Output resistance = $| \Delta V_{out} / \Delta I_L |$. Use the method as was described earlier to determine ΔV_{out} and ΔI_L.
- Compare the output resistance of the bridge rectifier with C = 100 μF with the case when C = 1000 μF. Which case is better? Justify your answer.

Part C – IC Regulator (LM 7805)

We shall use a very commonly used three-terminal 5V regulator IC to realize a regulated DC power supply. This regulator IC is capable of giving a constant V_{out} (= 5 V) for a large range of V_{in} (for V_{in} varying from 7 V to 25 V). Also, V_{out} will be a constant for a large range of I_L (for I_L varying from 0 to 1 A).

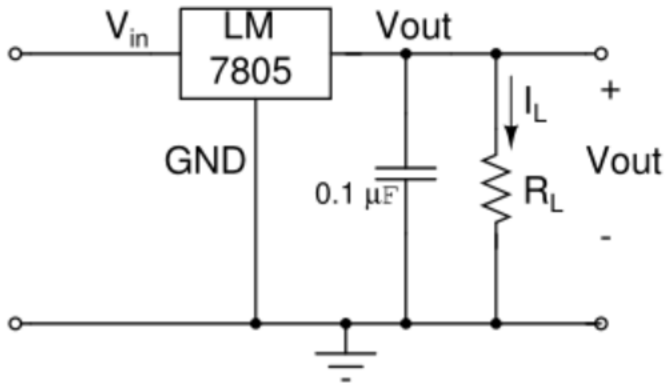

Fig. 3.1 7805 regulator circuit

Fig. 3.2 LM7805 IC image

Part C.1 – Measurement of Output Voltage Fluctuations with Load Currents (Output Resistance)

Circuit values: LM7805, 0.1 µF ; R_L = 680 Ω, 1 kΩ, and 3.3 kΩ

V_{in} (of LM7805)= V_{out} of the Bridge rectifier circuit of Fig. 2.3 with R_L removed and C = 1000 µF;

For measuring output resistance of the LM7805 IC, we need to vary the load currents while keeping V_{in} to the circuit at a constant value. The output resistance is indicative of the load regulation of LM7805.

<u>Experiment:</u>

1. Wire the circuit of Fig.3.1. Identify the V_{in}, *GND* and V_{out} pins of the LM7805 and take special care to connect the three terminals correctly. The IC terminals may be thicker compared to other components; hence you need to insert the pins carefully. Also, connect the 0.1 µF ceramic capacitor as shown.
2. We shall use the output of the Bridge rectifier (circuit shown in Fig.2.3, but with RL removed and C = 1000 µF) as V_{in} to the LM 7805 regulator IC.
3. Vary R_L values: 680 Ω, 820 Ω, 1 kΩ, 2.2 kΩ and 3.9 kΩ. For each R_L value, measure V_{out} using your DMM. Tabulate your results as: V_{in} R_L, V_{out}, I_L (in mA). ($I_L = V_{out} / R_L$)
4. Calculate output resistance of LM7805 as: $|\Delta V_{out} / \Delta I_L|$, where ΔV_{out} is the variation in V_{out} corresponding to the minimum and maximum values of I_L.
5. Compare the output resistance value you obtained above with that of the bridge rectifier with C = 1000 µF. Which is a better DC supply? Justify your answer.
6. Refer to the Datasheet of LM 7805 IC (see the 'Electrical Characteristics' on page 2) and note the various parameters of the IC. In particular, note down the specified line regulation, load regulation and the output resistance.

Note: Since variations in V_{out} will be very small (in the mV range), your DMM may not be able to indicate these minute variations; you will most likely find V_{out} to be a constant for all values of R_L.