NAMAL INSTITUTE

Department of Electrical Engineering

Power Electronics Lab

EE 312L

Open-Ended Lab

Design of Mobile Charger

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Signature	

Document History

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Introduction

In this lab session, we are going to design a Mobile Charger based on Full-Wave Uncontrolled Rectifier. This is the common circuit used for mobile charger and other applications. We will be using the transformer to step down the input source voltage and rectifier will be used to convert AC voltage into DC voltage. We will also use a voltage regulator to provide a proper regulated DC voltage.

Environment and Equipment:

- OrCad Capture CIS
- Transformer
- Voltage Regulator
- 4 Diodes (Rectifier)
- Capacitor
- Resistor

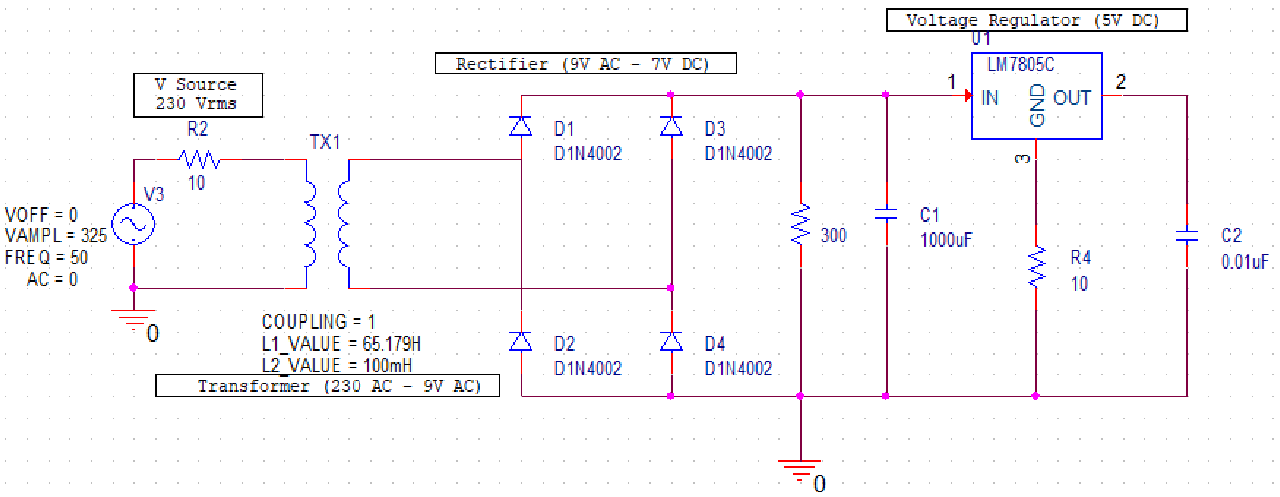
Purpose:

"To design a Mobile Charger of 5V from a Home Power Supply of 230 V_{rms} AC with ripple less than 5% of the output voltage."

Procedure:

As we know that mobile phones are charged with 5V regulated DC supply, so basically we are going to design a 5V regulated DC charger from 230 Vrms AC source voltage. This circuit can also be used for different applications but our main concern in this project is to design it for a Mobile Charger.

Circuit Diagram:



Mobile Charger Labelled Circuit Diagram Figure (1)

Description: In this circuit diagram, we have used an AC source of peak voltage 325V = 230 Vrms and connected this with primary side of the transformer through small resistance in series. Then we connected a rectifier circuit with secondary side of the circuit for rectification of step downed AC voltage. The output after the rectification is not a proper DC, it is oscillation output and has a very high ripple factor, so we have added filter for pure DC output. At the end, we used voltage regulator for a proper regulated DC voltage as shown in figure (1) above.
Now we will explain the working of the circuit with each block explained in detail.

1. Step Down AC Voltage Transformer

As the input source is home supply of 230 Vrms AC voltage which needs to step down from high voltage to low voltage. So we have used a 9-0-9 1A step-down transformer, which convert 230Vrms AC to 9V AC. We have calculated the Primary and Secondary inductances of transformer in using formula:

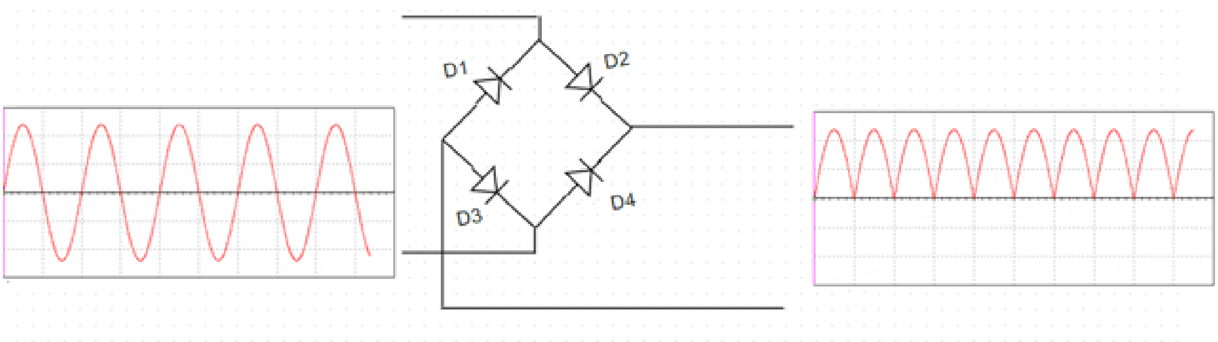
$$\frac{Vp}{Vs} = \frac{Np}{Ns} = \sqrt{\frac{Lp}{Ls}}$$

As given Vrms = 230V and Vs(rms) = 9V. So:
Vp = 230V*1.414 = **325V**
Vs = 9V*1.414 = **12.73V**
$\frac{Np}{Ns}$ = **25.53**
Now let's assume **Ls = 100mH** so putting values we get **Lp = 65.179 H**.

As we are using the voltage regulator at the end so the voltage rating should be more than the required voltage. Means if we need 5V DC, transformer should at least have a rating of 7V, because voltage regulator **IC 7805** at least need 2V more i.e. 7V to provide a 5V voltage.

2. Rectifier:

Rectification is the process of removing the negative part of the AC voltage and produce only DC part. This can be achieved through a rectifier circuit that we have built. A full wave rectifier circuit needs 4 diodes connected as shown in figure (2) below:



Full Wave Rectifier Circuit Figure (2) Reference [1]

The diode is an uncontrolled device that conducts in positive half cycle and blocks conduction in negative half cycle. So in first positive half cycle of AC voltage diode D2 & D3 are forward biased and D1 and D4 are reversed biased, and in the second half cycle (negative half) Diode D1 and D4 are forward biased and D2 and D3 are reversed biased. So in this way the negative cycle is also utilized and causes load current to flow in both half cycles. At the end we get waveform containing only oscillating DC part as shown in figure above.

3. DC Filter:

As the output of the rectification is not a proper DC voltage but it is oscillating DC with a very high ripple factor. To get rid of this pulsating DC output, we used a Capacitor and filtered out the output voltage. This capacitor increases the average DC output level even higher as the capacitor acts like a storage device in this case. The smoothing capacitor converts the full-wave rippled output of the rectifier into a smoother DC output voltage. The value of this capacitor depends on the load current. If the load current is high then a large value capacitor is used and vice versa.
In this case we used a **1000uF Capacitor** for which the calculations are given below:

Formula: The formula for capacitor value calculation is

$$\mathbf{C = I * t / V}$$

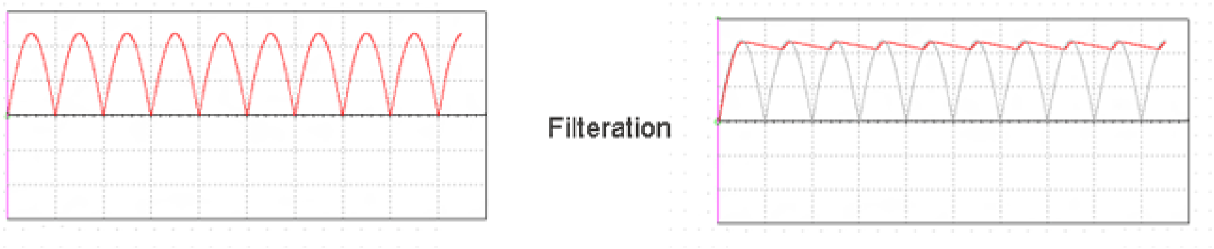
C= capacitance to be calculated
I= Max output current (Assuming 500mA)
t= time period.
As frequency id 50Hz but for two cycles it will is 1000Hz and so **t = 1/f = 1/100Hz = 10ms.**

V = Peak voltage – voltage given to voltage regulator IC (+2 more than rated means 5+2=7)
9-0-9 is the RMS value of transforms so peak voltage is Vrms * 1.414= 9* 1.414= **12.73V.**

Now 1.4v will be dropped on **2 diodes (0.7 per diode)** as 2 will be forward biased for half wave.
So **12.73 – 1.4 = 11.33V**
When capacitor discharges into load circuit, it must provide **7V to 7805 IC** to work so finally V is:
V = 11.33 – 7= 4.33

So now C = I * t / V
C = 500mA * 10ms / 4.33 = 1154uF ~ **1000uF**.

So we have used 1000uF Capacitor for the filter design.



After Filter Waveform Figure (3) Reference [1]

4. Voltage Regulator:

At the end we have used a voltage regulator IC 7805 which provides a 5V regulated DC voltage. This IC needs 2V more than the rated output voltage which means it needs at least 7V to operate [2]. The range is from 7-20V although. And at the output part of IC 7805, we have connected a Capacitor of 0.01uF to eliminate the noise.

After Voltage Regulation Figure (4) Reference [1]

Data (Performance Parameters):

Now we will take a look at the data we have measured and calculated after running the circuit. Basically we need the efficiency and the ripple factor that must be less than 5% of output voltage as in our design specifications. So we will take Peak Voltage after rectification and calculate the ripple factor with the help of this peak voltage and supporting calculations.

Peak output voltage, $V_m = 11.33$ V

Average value of output voltage, $V_{dc} = 2V_m / \pi = 7.212$ V

Average value of output current, $I_{dc} = V_{dc} / R = 0.024$ A

RMS value of output voltage, $V_{rms} = V_m / \sqrt{2} = 8.011$ V

RMS value of output current, $I_{rms} = V_{rms} / R = 0.0267$ A

Output DC power, $P_{dc} = V_{dc} I_{dc} = 0.173$ W

Output AC power, $P_{ac} = V_{rms} I_{rms} = 0.2139$ W

Rectifier efficiency, $\eta = P_{dc} / P_{ac} = 0.808 = 80.8\%$

Form factor, FF = Vrms / Vdc = 1.110

Ripple factor, RF = $\sqrt{FF2 - 1}$ = 0.483

As the ripple factor is 0.4817 and the output voltage is 11.33 Vm of which the **5% is 0.5665**. Hence:

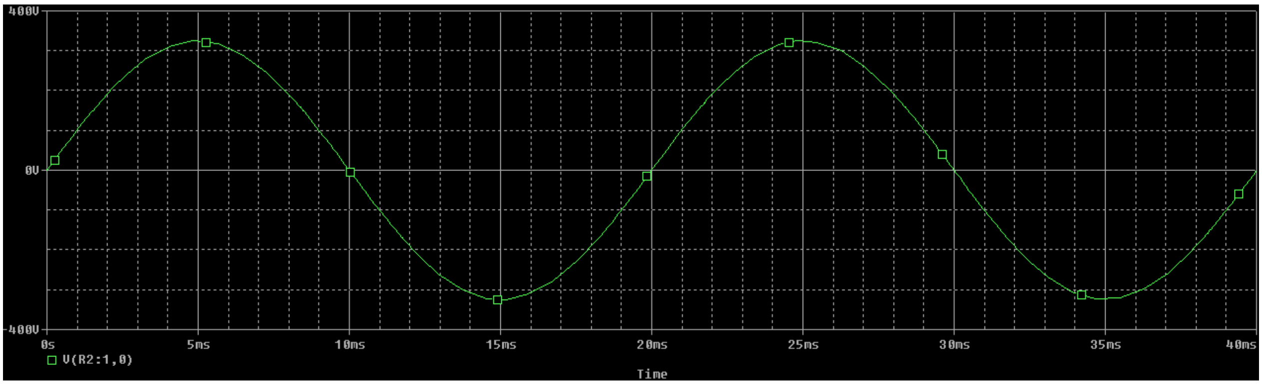
Ripple Factor RF = 0.483 < 0.5665

So, we have achieved our design specification of having ripple factor less than 5% of the output voltage.

Data Analysis:

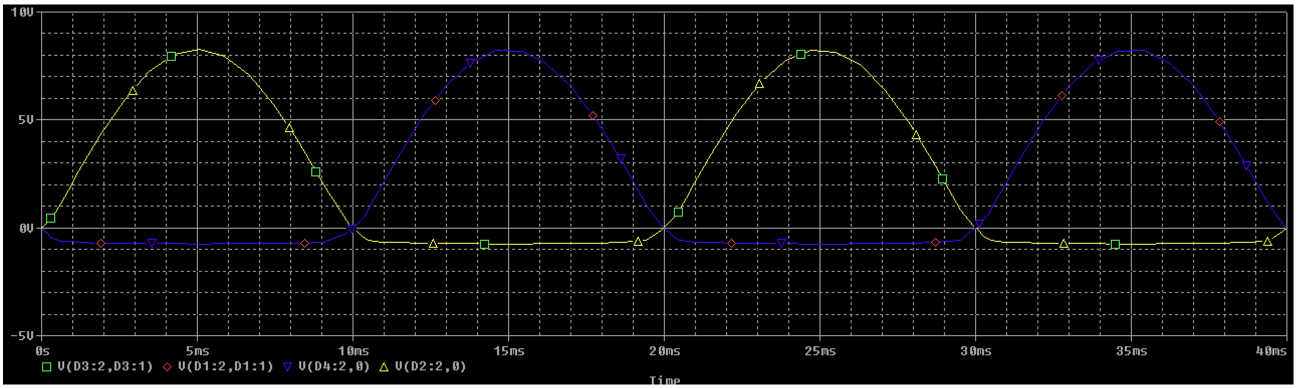
Here are the graphs of our results with output written at bottom of each graph.

Input Voltage Waveform:



Vp = 323 V ➔ Vrms =228.39 V

Output across Diodes D1, D2, D3 and D4:



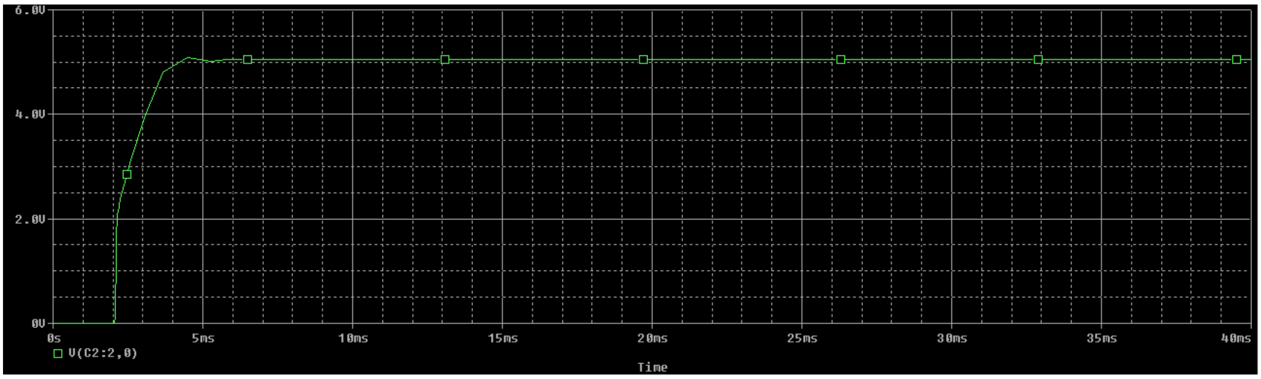
Output across D1

Output across D4

Output across D2

Output across D3

Output Voltage Waveform:



Regulated DC Output Voltage = 5.046 V.

Observations and Discussion:

As we can see in the graphs that for sinusoidal input of **228.39 AC voltage**, we get the regulated DC output of **5.046 voltage**. This voltage can directly use to charge a mobile phone. We can also see the rectifier diodes D1 and D4 output which is giving only positive peaks of DC voltages in positive half cycle of input and diodes D2 and D3 output which is also giving positive peaks of DC voltage but in negative half cycle of the input. Hence, both half cycles are utilized which gives the **efficiency of 80.8%.**

Conclusion:

At the end of this lab session, we conclude that using full-wave rectifier circuit we can design a Mobile Charger with the help of Voltage Regulator. This mobile charger has the efficiency of more than 80% which can be improved with more accurate measurements and component values. Furthermore, we can also decrease the number of diodes used in rectifier by replacing linear transformer with Center Tapped Transformer. This will reduce cost but it is hard to implement as more calculations will be required. There are also some specifications of discrete components and ICs used in the circuit which affect the output voltage. However, overall results were satisfactory.

References:

[1] *Cell Phone Charger Circuit [Online]. Available:* *Cell Phone Charger Circuit Diagram (circuitdigest.com)*

[2] *7805 Voltage Regulator IC [Online]. Available:* 7805 Voltage Regulator IC Pinout, Features, Circuit, Equivalent & Datasheet (components101.com)

CLO’s	Assessment Type	Excellent 5	Good 4	Average 3	Unsatisfactory 2	Poor 1	Marks
CLO1/2/3	**Circuit Implementation**	Successfully completed in time with complete understanding	Successfully performed but not with clear understanding	Had difficulty in completing the tasks	Not completed about half of the tasks	Task not completed	
CLO1/2/3	**Report**	Clean and clear without any match with fellow students	Clean and clear but slight overlap with other students	Not very clear and clean and partial overlap with fellow students	Not very clear and clean and most of content overlapping with fellow students	Report not submitted	
CLO1/2/3	**Timeline**	Report received with in due time	Report was 1 day late	Report was 3 days late	Report was late for 1 week	Report not submitted	