

Iowa State University
Electrical and Computer Engineering
E E 452. Electric Machines and Power Electronic Drives

Laboratory #3
Figures of Merit

Summary

Simple experiments will be conducted. Experimental waveforms will be measured, and their figures of merit evaluated.

Learning objectives

- Implement simple diode-based rectifier circuits.
- Use a digital oscilloscope to measure voltages and currents, and extract waveforms.
- Calculate various figures of merit of dc and ac waveforms using MATLAB scripts.

Background material (should be read before coming to the lab)

- Trzynadlowski chapter 1 and lecture notes on figures of merit
- Agilent 33210A function generator User's Guide (especially the description of the PWM starting on page 84)
- Tektronix TDS2014C User's Guide
- MATLAB User's Guide (in particular, writing simple M-files and functions)

Exercises and Questions

Instructions: every student should deliver his/her own report at the end of the lab session, even though the experiments are conducted in groups. You may want to answer the questions as you go along the exercises. Time yourselves according to the recommendations below.

1. Pre-lab assignment

Study the single pulse diode rectifier described in *Trzynadlowski* chapter 1, using the parameters provided here. The voltage source is sinusoidal, and has rms value of 50 V and frequency of 60 Hz; the load is a series-connected RL load, and its parameters are $R = 300\ \Omega$ and $L = 0.8\text{ H}$.

DELIVERABLE 1: Sketch the expected output voltage and current waveforms. Be sure to label all points of interest (e.g. max, min, zero crossing, etc.).

2. Single-pulse Diode Rectifier Simulation [15 minutes]

Run the Lab-1 ASMG simulation of the single-pulse diode rectifier with a freewheeling diode shown in Figure 1, with the parameters given in the pre-lab.

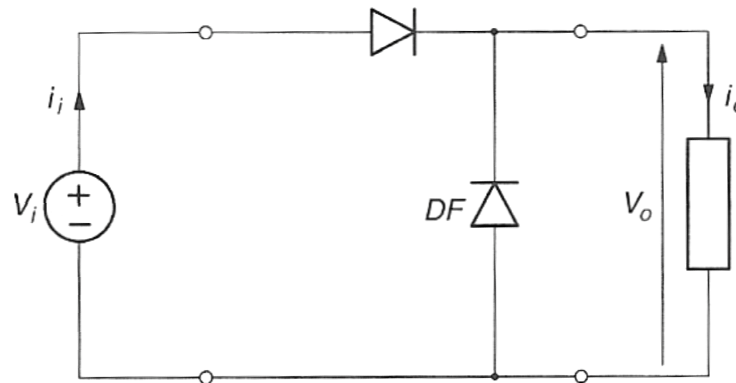


Figure 1. Circuit diagram of the single-pulse diode rectifier with a freewheeling diode (from *Trzynadlowski*).

3. Single-pulse Diode Rectifier Implementation & Analysis [90 minutes]

Create the circuit from section 2 using hardware components in the laboratory.

CAUTION!

Verify your circuit configuration with your group members and your T.A.

Observe the output voltage and current waveforms using the scope. Use the scope *Measurement* functions to measure the *average* and *rms* values of these waveforms. Plot output current vs. output voltage using the *XY Display* function of the scope.

DELIVERABLE 2: Report the measured values. Sketch the current vs. voltage waveform and try to explain its significance.

Copy the waveforms to a Comma-Separated Value (CSV) file using a USB stick, and transfer them to the desktop PC. (To do this, use the *Save/Recall* menu on the scope.)

CAUTION!

Do not leave an energized circuit unattended. Before continuing with the analysis, power down the circuit and turn off the power supply.

Open the CSV file using a text editor (like Notepad) to study its contents.

Write a MATLAB M-file that:

- a. Reads the waveforms from the hard drive.
See the code snippet below for an example on how to do this.

```
fid = fopen('CH1.CSV');  
Vs = textscan(fid, '%s %s %s %f %f', 'delimiter', ',');  
fclose(fid);  
  
t = Vs{4};  
vs = Vs{5};
```

- b. Plots the waveforms.
- c. Calculates the average value of the waveforms.
- d. Calculates the rms value of the waveforms.
- e. Calculates the ripple factor of the waveforms.
- f. Calculates the fundamental harmonic rms value and phase angle of the waveforms.
- g. Calculates the THD of the ac component of the waveforms.

DELIVERABLE 3: Email your MATLAB script and data file to the T.A. in a .zip folder. Each group should submit one set of files; write group member names in the email.

DELIVERABLE 4: Report all calculated values for the waveforms, and compare to the ones obtained by the scope. How close are the experimental waveforms to the simulated ones? Are there any major differences?

Hint: You will need to implement a numeric integration algorithm in MATLAB, using the discrete data collected from the scope. A very simple way to do this is using the following formula:

$$\int_a^b f(x)dx \approx \sum_{n=1}^N f(x_n)\Delta x$$

This means that the continuous interval $[a, b]$ is divided into N equally spaced subintervals of width $\Delta x = (b - a)/N$. The discrete points x_n could be the middle points of the intervals, or they could coincide with the intervals' start points (in which case you would have $N + 1$ points but you would not be using the last one).

In our applications (calculating average and rms values, etc.) the required integration interval is usually equal to one period, and the data has to be captured while the circuit is in the steady state. Your measured data will probably contain more than one period. You will have to truncate the data in MATLAB, and then integrate using the method described above. The approximation of the integral is a good one if the sampling rate is high.

4. Two-pulse Diode Rectifier Simulation [15 minutes] [Optional if time permits]

Rerun an ASMG simulation of the two-pulse diode rectifier shown in figure 2. Use the same circuit parameters as before.

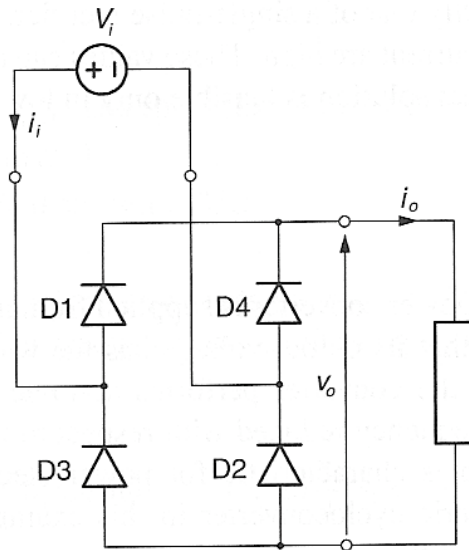


Figure 2. Circuit diagram of the two-pulse diode rectifier (from *Trzynadlowski*).

5. Two-pulse Diode Rectifier Implementation & Analysis [45 minutes] [Optional if time permits]

Create the circuit from section 4 using hardware components in the laboratory.

CAUTION!

Verify your circuit configuration with your group members and your T.A.

Repeat the calculations of the previous exercise. You just have to rerun the scripts that you wrote before.

6. Conclusion [15 minutes]

Write about one or two things you learned in this lab that you think are important or interesting, and why.