Power supply circuits

Practical exercise in Analog Electronics

Abstract

In this lab some different power supply circuits should be characterized.

1 Introduction

The four basic constituents of a power supply circuit are the *transformer*, the *rectifier bridge* and the *electrolyte capacitor*. In this laboration, we examine how these different parts influence the output voltage as well as the load's influence. Voltage stabilization with a Zener diode, as well as a Boost converter are also constructed. In all cases set the oscilloscope to dc-mode to observe the general appearance of the output voltage. In case of a reasonably good rectification, the voltage is roughly constant with small variations, the 'ripple'. Set the oscilloscope to ac-mode in order to observe the ripple voltage. Note that it is not possible to measure the RMS-value using a conventional voltmeter, if the voltage is not sinusoidal.

2 Half wave rectifier

Connect the diode 1N4002 between the output of the transformer and a 1kΩ/4W resistor load (see figure 4.2).

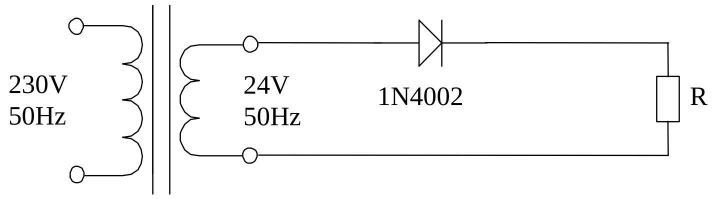

Figure 1. Half wave rectifier without capacitance

Observe and measure the load voltage using the oscilloscope. Draw the observed waveform. Calculate the average and RMS (root-mean-square) values. Calculate the output power in this case. Turn the diode in the opposite direction. Observe and measure the load voltage using the oscilloscope. Draw the observed waveform. Calculate the average and RMS (root-mean-square) values. Calculate the output power in this case.

⇒ ***Summary: Draw U(t)*** *as seen on the oscilloscope.* ***Calculate*** U_m ***and*** U_{RMS}. *Do this with the* <u>*diode in both directions*</u> *.* ***Calculate*** P_{out}.

3 Half wave rectifier with filtering capacitance

Connect the capacitance C = 220uF/50V (*Observe the polarity and use a* ***shielding box*** *supplied by the laboratory teacher*) in parallel to the load R=1kΩ/4W (as shown in figure 4.3).

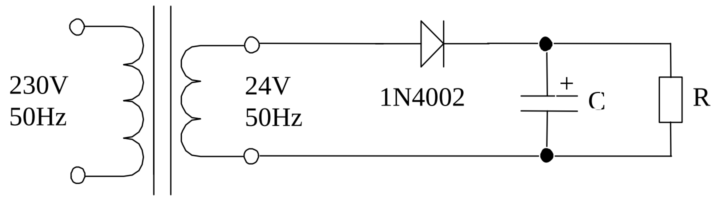

Figure 2. Half wave rectifier with capacitance

⇒ ***Summary: Draw U(t)*** *as seen on the oscilloscope.* ***Calculate*** U_m ***and*** U_{RMS}. *The signal can be approximated to ramp function in the calculations. Do this* <u>*with*</u> *and* <u>*without*</u> *the load.* ***Calculate*** P_{out}.

4 Full wave rectifier

Connect the full wave rectifier (built using four diodes 1N4002) between the output of the transformer and the load R=1kΩ/4W (as in figure 4.4).

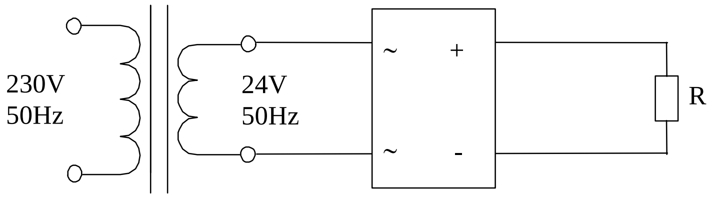

Figure 3. Full wave rectifier without capacitance

Observe and measure the load voltage using the oscilloscope. Draw the observed waveform. Calculate the average and RMS values as well as the load power.

⇒ ***Summary: Draw U(t)*** *as seen on the oscilloscope.* ***Calculate*** U_m ***and*** U_{RMS}. ***Calculate*** P_{out}.

5 Full wave rectifier with filtering capacitance

Connect the capacitance C=220µF/50V (***with*** **SHIELD** ***supplied by the laboratory instructor***) in parallel to the load R = 1kΩ/4W (shown in figure 4.5).

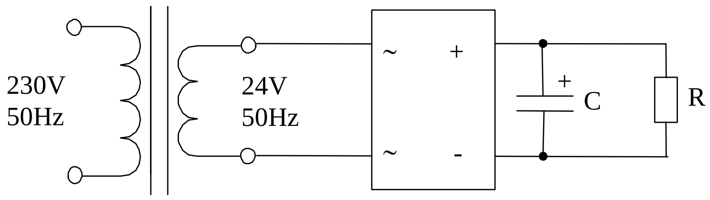

Figure 4. Full wave rectifier with capacitance

Observe and measure the load voltage using the oscilloscope. Draw the observed waveform. Calculate the average and RMS values as well as the load power.

⇒ ***Summary: Draw U(t)*** *as seen on the oscilloscope.* ***Calculate*** U_m ***and*** U_{RMS}. ***Calculate*** P_{out}.

6 The Zener diode as a voltage stabilizer

A Zener diode can be used as a voltage stabiliser to further improve the performance of the rectifying circuits. The serial resistance R_S in figure 4.6 needs to be chosen in such a way that the maximum power dissipation (1.3 W) of the Zener diode BZX85/C30, is not exceeded. Calculate R_S in such a way that the maximum power dissipation (which occurs when $R \to \infty$) is 1 W. Calculate the maximal power dissipation in R_S when for the voltage where the stabilization stops working and select a resistor that fulfills the requirements. (Observe that the R_s in this way will not tolerate a short circuited load as the all of the input voltage will be dissipated in R_s)

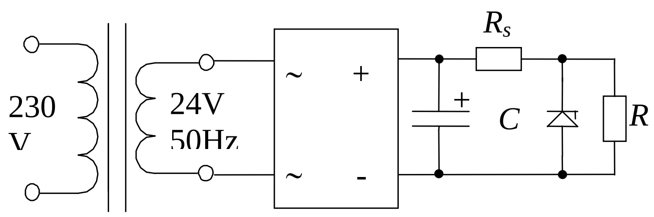

Figure 5. Zener diode voltage stabilizer

Measure the Zener diode voltage and current for R = ∞. Use the oscilloscope for the measurement and measure the maximum ripple voltage. Connect the load R=1kΩ/4W. Measure the voltage and current as well as the maximum ripple voltage.
Use the results to calculate the dynamic resistance of the diode.

⇒ ***Summary: Determine R_s*** *to limit power dissipation.* ***Calculate P_{max}*** *for R_s.* ***Draw U(t)*** *as seen on the oscilloscope.* ***Calculate U_m and U_{RMS}****. Do this* *<u>with</u>* *and* *<u>without</u>* *the load.* ***Calculate R_d.***

7 Formulas

$$U_{mean} = \overline{U} = \frac{1}{T}\int_0^T u(t)dt$$

$$U_{RMS} = U = \sqrt{\frac{1}{T}\int_0^T u^2(t)dt}$$

Hint: To simplify the integrals, the period of the functions can be chosen to:

Sinusoidal functions: Use a period of 2·π
Ramp functions: Use a period of 1

This makes the calculations as simple as possible but will not affect the result.

$$P = U \cdot I = (U_{RMS} \cdot I_{RMS})$$

$$R_d = \frac{\Delta U}{\Delta I} = \frac{U_{R=\infty} - U_{R=0}}{I_{R=\infty} - I_{R=0}}$$

$$V_{Out}^{Boost} = \frac{V_{in}}{1 - Duty}$$

8 Documentation

The lab should be documented in word or some other word-processor. All steps in the filter design should be included as well as the circuits and bode diagrams. The report should be submitted by e-mail and the simulation files should also be attached.

Good Luck
/Kent