Introduction to Spring Term Analogue Electronics Project

In the spring term you will be carrying out an analogue electronics project: building a simple DC power supply unit. Figure 1 shows the simplified functional block diagram of the Power Supply Unit (PSU) and which block(s) you will be working on in each laboratory exercise.

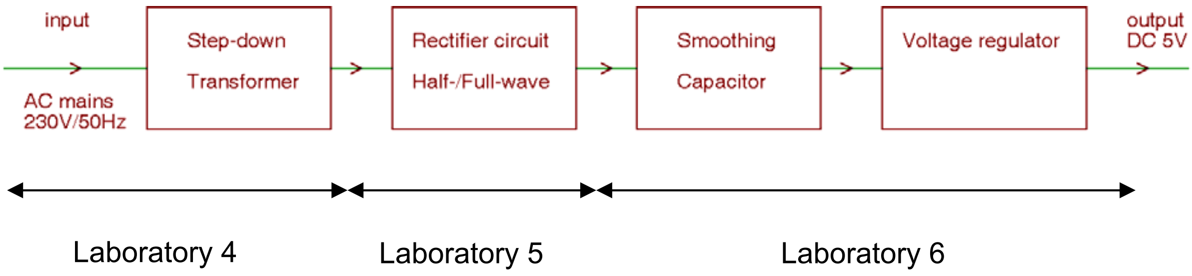

Figure 1 DC Power supply.

You will be building the PSU step-by-step, one functional block at a time, while familiarising yourself with standard laboratory equipment and measurement procedures. Due to safety reasons, you will be provided with a pre-assembled step-down transformer module that is shown in Figure 2.

Figure 2. Transformer module.

Figure 3 depicts a photograph of the PSU Design Exercise Printed Circuit Board (PCB) that will also be provided to you at the start of the first laboratory session. The PCB has copper tracks on both sides of the boards, but as the layout is fairly simple you can easily trace a track on the board. The PCB is populated with the following components (one from each type is marked in Figure 3):

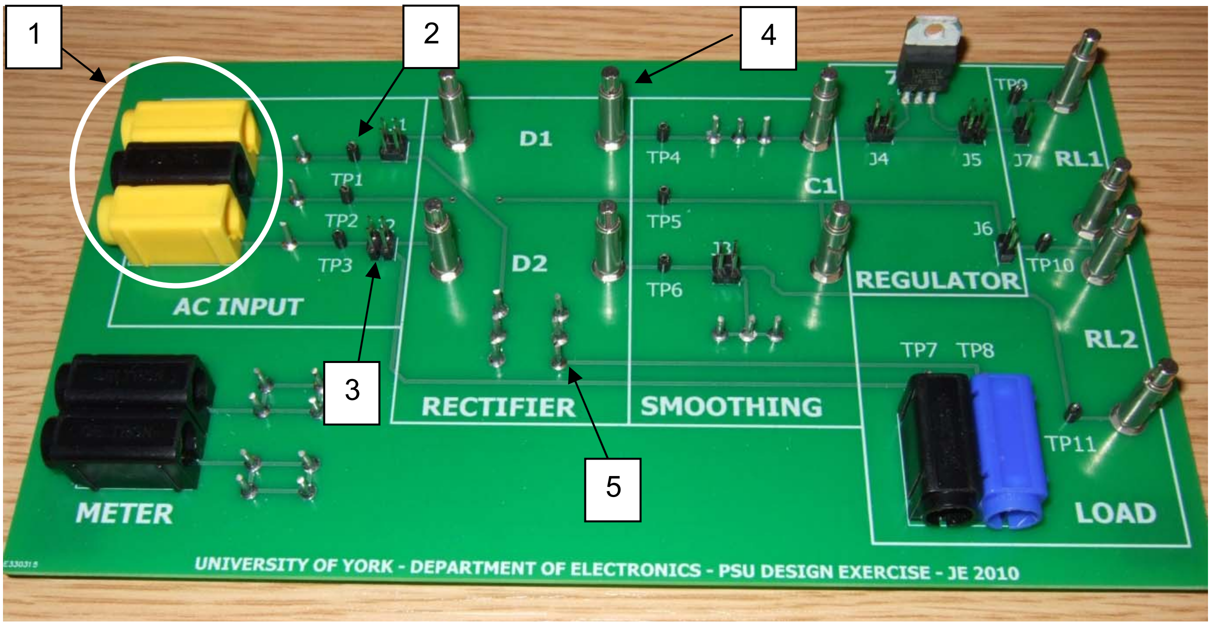

Figure 3. PSU Design Exercise PCB.

1. Block connectors – to connect the step-down transformer and load resistor using suitable leads.

2. Test points – numbered with prefix ‘TP’, e.g. TP1-TP11, to connect probes to the measurement equipment.

3. Link Headers – numbered with prefix ‘J’, e.g. J1-J7, to route the signal to different areas in the PCB. Please note that 4-pin headers require only one link at a time and it can be either between the top or bottom two pins.

4. Component posts- allow you to securely fix the components to the PCB.

5. Pins – to make connections with in the PCB using limrose connectors or to connect an Ammeter.

Schedule for Term 2

Week 2	Lecture: ac signals in resistive circuits, internal resistance of voltage sources
Week 3	Laboratory 4: AC signals
Week 4	Lecture: half- and full-wave rectifiers
Week 5	Laboratory 5: Half- and Full-wave rectifier circuits
Week 6	Laboratory 5 (continues)
Week 7	Lecture: RC circuits
Week 8	Laboratory 6: Smoothing capacitor and Voltage regulator IC

Some general information

As you will be working on the PCB throughout the term it is important that you store your PCB securely in the storage area allocated to you in the cupboard underneath the laboratory bench after each session.

Please read the section ‘introduction to Foundation Course Laboratory Work’ on page 1 of autumn term laboratory scripts booklet, specifically the guidance on how to maintain a lab book and a description of the assessment of it.

Please note that the lectures are tailored to help you with the laboratory sessions and missing them will place you at significant disadvantage.

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Laboratory 4: AC Signals and Internal Resistance

Aims and Objectives

The aims of this laboratory are to familiarise yourself with measurements related to a.c. voltages and the internal resistance of a voltage source.

By the end this laboratory you should be able to do the following:

-measure peak-to-peak, rms and mean values of ac voltage waveforms;

-measure the period and frequency of an ac voltage waveform;

-devise a simple experiment to measure the internal resistance of a voltage source.

Guide to progress

You have one half-day session to complete this laboratory. Theory related to this laboratory will be covered in the week 2 lecture. If you are stuck on a problem for more than a few minutes or if you feel you are falling behind, then seek guidance from a demonstrator or a member of academic staff.

1 AC signals

In this section you will set up a simple experiment to determine the dc equivalent voltage of a sinusoidal signal that delivers the same power to a resistive load. This quantity is called the effective or rms (Root Mean Squared) value of the sinusoid. This experiment will be performed using two identical lamps. One lamp will be connected to the sinusoidal output from the transformer. You will be using the secondary side of the transformer for this purpose. Note that the secondary side has three outputs terminals: yellow terminals are outer taps of the secondary winding and the black terminal is the centre tap. The other lamp will be connected to a DC power supply. Steps to set up the experiment and to make necessary measurements are given below.

(a) Connect a lamp with the holder across a yellow and the black terminals of the transformer and switch on the power to the circuit.
(b) Use the oscilloscope to observe the waveform across the lamp. As you may need to measure higher voltages in this experiment, use the x10 probes and set the probe's multiplication factor in the Oscilloscope to x10 (press the 'CH1 MENU' button and then selecting the factor. If you require more details refer to the user manual of the Oscilloscope).
(c) Manually (by inspection) measure the peak-to-peak voltage and then determine the peak voltage of the waveform across the lamp.

(TIP: It is a good practice to draw the waveforms that you observe and note down any measurements you make on them.)

(d) Connect the other lamp with the holder across a DC power supply initially set to 0V. Adjust the voltage of the DC power supply until the lamp appears to be the same brightness of the lamp connected to the output of the transformer. Measure the DC voltage across the lamp using a Digital Multi-meter (DMM) or the Oscilloscope. Since the comparative brightness of the lamps is difficult to judge accurately, you may wish to repeat the experiment several times, resetting the DC power supply to zero each time to test the repeatability of the experiment.

(e) Using your knowledge of power in resistive loads, comment on the voltages measured in (c) and (d) and how they are related.

(f) Use the Digital Multi-meter, set to ac voltage to measure the voltage across the lamp connected to the transformer. How does this measurement compare with your previous measurements?

(g) In order to compare measurements in this way using the relationship for power in resistive circuits, we must be able to apply Ohm’s Law to the device in question. Comment on whether you think this will apply well in this case, possibly referring to measurements you might make.

(h) You may have learned that the DMM can be used to measure the rms value of an ac signal. The Oscilloscope can be configured to make a variety of measurement of a waveform including the rms value. This feature can be enabled by pressing the ‘MEASURE’ button and selecting the appropriate measurement(s) for a selected channel. If you require further details please refer to the user manual of the oscilloscope (pg 24-25).

(i) Now using the ‘MEASURE’ function of the oscilloscope obtain the following measurements for the voltage waveform <u>across the lamp connected to the transformer</u>.

    Peak-to-peak, rms, and mean values;

    Period and frequency of the waveform.

(j) What is the theoretical mean value of a pure sinusoidal signal? Briefly explain why the measured mean value of the signal deviates from the theoretical value.

(k) Determine the approximate turns ratio of the transformer assuming the primary side is connected to ac mains (230V/50Hz).

2. Measuring the internal resistance of a voltage source

It is important to determine the input and output resistance of most electronic circuits to characterise them, e.g. amplifiers. The secondary side of the transformer can be modelled as a voltage source with an internal resistance. In this section you will be devising an experimental setup to measure the internal (output) resistance of the transformer's secondary side. You will follow a similar procedure to find the input and output resistance of many electronic circuits as you progress through your degree programme.

Figure 1 shows an arrangement to measure the internal resistance of a voltage source.

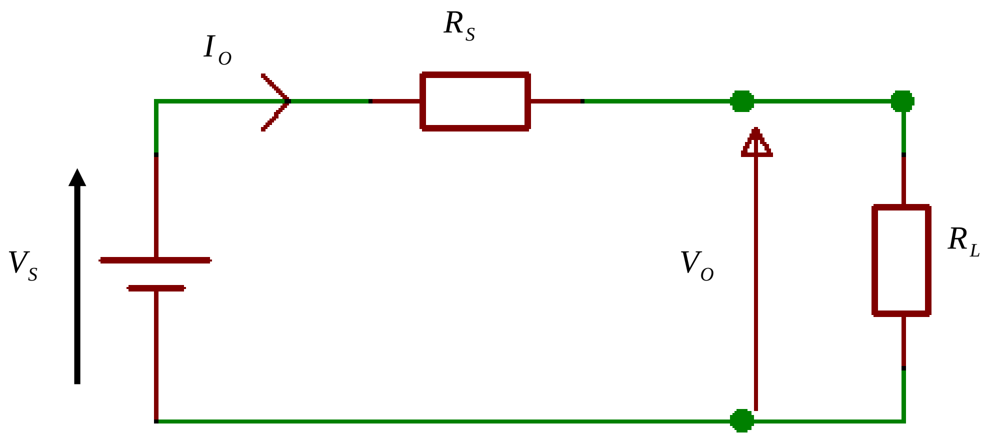

Figure 1. Voltage source connected to a load resistor.

The relationship to determine the voltage across the load, V_O, driven by the voltage source, V_O, is given by

$$V_O = V_S - I_O R_S \qquad (1)$$

or with a simple manipulation the above equation can be written as

$$V_O = -I_O R_S + V_S\,. \qquad (2)$$

Equation (2) can be used to determine the value of the internal resistance of the source using a graphical method as explained in the lecture.

For this part of the experiment you are required to use the transformer and the PSU Design Exercise Printed Circuit Board (PCB).

(a) First remove any links placed on the link headers in the PCB.
(b) Connect the secondary side of the transformer to connectors (Yellow) in the 'AC INPUT' area of the PCB using suitable leads.
(c) Use a wooden cover resistor box as the variable load resistor and initially set it to a sufficiently high value (3-4kΩ). Connect the resistor box across the two connectors in the 'LOAD' area of the PCB.
(d) Place the Links on headers J1 and J2 to route the ac signal to the load resistor. By observation you should be able to determine it is the bottom two pins on each header that you need to link.

(e) Set up the DMM as an Ammeter and connect it appropriately to measure the load current. If you cannot determine how to connect the ammeter please ask.
(f) Determine which test points (TP1&3 OR TP7&8) that you would use to measure the load voltage, V_O , and explain the reason(s) for your selection.
(g) Now your setup is ready for taking some measurements. Draw a diagram in your logbook to represent the experimental setup that you have just finished.
(h) Obtain a set of readings for V_O and I_O by varying the load resistance, R_L . Make sure that you take extra care not to short circuit the output of the transformer (always $R_L > 0$)
(i) Plot a graph of V_O vs I_O and determine the internal resistance of the secondary side of the transformer.
(j) By how much does the actual voltage differ from the 'ideal voltage source' value at low load resistances?

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