Physics 2P30 Lab Test

Name . . . .

There are six test circuits hidden in a "black box". Each circuit has three connecting points for V_{in}, V_{out} and ground $V = 0$V. The test circuits are voltage dividers consisting of a combination of resistor and resistor, capacitor, inductor, Si diode, LED or Zener diode. These circuits have all been analysed during your lab sessions.

For each circuit, outline the methods used in the analysis. Include the circuit diagram, pertinent formulas and calculations, measurements results and sketches of scope displays to support your conclusions.

Hint: Begin by verifying that your workstation equipment is behaving as expected.

Unknown circuit 1 is a . . . .

Unknown circuit 2 is a . . . .

Unknown circuit 3 is a . . . .

Unknown circuit 4 is a . . . .

Unknown circuit 5 is a . . . .

Unknown circuit 6 is a . . . .

How to analyse a circuit: a short summary

Most circuits can be viewed as a voltage divider consisting of two resistances in series. A voltage V_{in} is applied to one end of the circuit relative to a reference ground $V = 0$V at the other end.

The challenge is to analyse the output voltage V_{out} at the point between the two resistances as V_{in} is varied in frequency, amplitude, etc.

The resistance of Ohmic resistors is independent of voltage amplitude and frequency. Capacitors and inductors have a frequency-dependent resistance (reactance) that changes significantly as the frequency of the input voltage V_{in} is varied.

Diodes and other semiconductors have a voltage-dependent resistance. When a turn-on voltage of the correct polarity is applied, diodes change from a very high to a very low resistance, hence a current limiting resistor is always placed in series with the diode.

An Ohmmeter measures resistance by applying a DC voltage across the component under test. A capacitor behaves like an open circuit to a DC voltage and will then display an infinite resistance or overload condition. An inductor, being a coiled length of wire, will display a very small resistance. An Ohmic resistor will have a measurable resistance between these two limits, it's function being to regulate the current flowing through the circuit.

A diode is a polarised component. A band identifies the negative electrode. A diode will have a very large resistance when the DC voltage is applied in the reverse direction to the diode polarity (reverse bias). A smaller resistance is noted when the DC voltage is applied in the same direction as the diode polarity (forward bias).

A step-by-step analysis might proceed as follows:

1. Connect your instruments to the breadboard and verify that the connections are correct and that the test signal from the voltage source appears at the oscilloscope;

2. with an Ohmmeter, measure the resistance of R_1 and R_2 of the voltage divider circuit. This will allow you to guess the component types and their location in the circuit, as described above;

3. connect the breadboard to the black box circuit: the voltage source to V_{in}, the oscilloscope to V_{out} and the protoboard ground reference point to the ground of the circuit;

4. monitor how V_{out} changes as you change the V_{in} frequency. The amplitude of a circuit incorporating Ohmic resistors or diodes will not change so proceed to the next step.

   An RC or RLC circuit will change amplitude with frequency. Proceed to determine the centre frequency f_0 of the circuit: for a high-pass or low-pass RC filter circuit, the amplitude will be $V_{out} = 0.7V_{in}$ and the two signals will be 45 degrees out of phase.

   A band-pass or notch RLC circuit will have a maximum/minimum at f_0 and 0 degree phase shift. To determine the RLC circuit components, you need to make it oscillate using a square wave.

   Use the appropriate equations and your obtained values for R and f_0 to calculate the values of the unknown components.

5. Monitor how V_{out} changes as you change the V_{in} amplitude. The output of circuits using some combination of R,C,L components will vary in proportion to changes in the input voltage amplitude.

   The output of a circuit involving a diode will suddenly stop changing when there is sufficient positive voltage to make the diode conduct. A diode will not conduct with an applied negative voltage. A silicon diode turns on ($R \approx 0$) with an applied voltage of $V \approx 0.7$V. Light emitting diodes turn on between 1.5-3 V. A Zener diode behaves like a silicon diode with an applied positive voltage but will also begin to conduct sharply when a specific negative voltage, the Zener voltage, is exceeded.