THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

SCHOOL OF ENGINEERING AND APPLIED SCIENCE
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECE 2115: ENGINEERING ELECTRONICS LABORATORY

Experiment #3:
Solid State Diodes – Applications II

COMPONENTS

Type	*Value*	*Symbol Name*	*Multisim Part*	*Description*
Resistor	2.2kΩ	R_1	Basic/Resistor	---
Diode	1N4002	$D_1 – D_2$	Diodes/1N4002G	Series Silicon Diode
Thermistor	1746-97-D1	$R_{Thermistor}$	---	Thermal Resistor
Battery		V_1	Power_Sources/DC_Power	9V Battery

Table 1 – Component List

OBJECTIVES

· Use zener diodes and varistors as overvoltage protection (e.g., to protect high impedance bioamplifier inputs)
· To learn how to build and analyze a thermistor instrumentation device
· To learn how to use diodes for protection/limiting circuits

Introduction:

In this lab, you will once again have to use your AD2 as an oscilloscope. Check back to the last lab to get a refresher on how to do this. Alternatively, you may also check the lab from circuit theory. You will also have to use your AD2 as a waveform generator in this lab. This is, again, talked about in Circuit Theory Lab 2. An overview is also provided for your pleasure.

Introduction to the Function Generator* in *WaveForms

A function generator (Wavegen) is an electronic instrument that produces a voltage that varies with time. This function or waveform that is output from the function generator (Wavegen) can be used as the input signal to different circuits in a variety of applications.

The Basics:

• A function generator (Wavegen) produces time-varying voltage signals that can be used in AC circuits

• The function generators (Wavegen) used in this lab have two independent output channels.

• The time-varying signal can be configured using the following parameters:

- **Waveform**: basic types of waveforms are sine, square, and triangle
- **Frequency**: number of repetitions per unit time (Hz)
- **Amplitude**: voltage magnitude of the signal (may be defined by V_{pk} or V_{pp})
- **Offset**: DC offset of the signal (in voltage) with respect to ground
- **Phase Shift**: offset of the signal (in time) with respect to an unshifted signal

To generate the desired Waveform, ensure that the Sine waveform is selected. Then Configure the necessary Parameters: Frequency, Amplitude, and DC Offset as well as Phase. Then you turn it on.

PRELAB

Part I – Generate Equipment List

1. Read through the lab manual and generate an equipment list.

Part II – Specification Sheet Values

1. **Download** and **print** the specification sheet for the **thermistor** in your kit: 1746-97-D1 *(See the lab website for links to spec sheet downloads and ensure this part number matches your ECE 2115 parts kit list)*

a. From the spec sheet, find the thermistor with your model number and populate the following table.

Characteristic	***Value***
Resistance at 25°C	
Maximum Operating Temperature	
Resistance Ratio	

Table P.1 – Spec Sheet Values

LAB

Part I – Thermistor Calibration

A thermistor is a semiconducting device whose resistance depends strongly on temperature. Therefore, it is very sensitive to temperature changes. It is often used as part of a simple circuit as shown below.

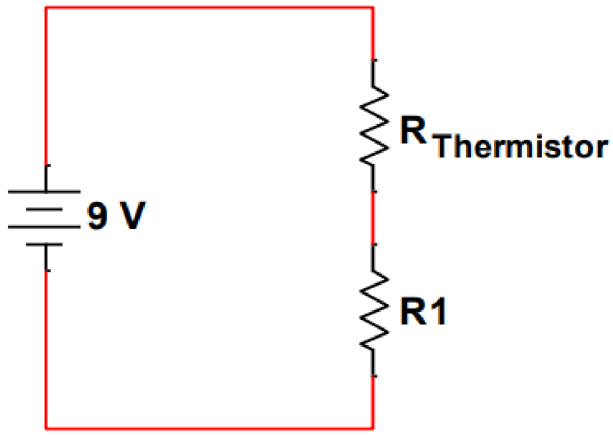

Figure 1.1 – Voltage Divider with Thermistor

In the example shown, let $V_{Thermistor}$ be the voltage drop across $R_{Thermistor}$ and V_1 be the voltage across R_1.

$$V_{Thermistor} + V_1 = 9V = iR_{Thermistor} + iR_1 \qquad (1)$$

From this, it follows that

$$\frac{V_{Thermistor}}{V_1} + 1 = \frac{R_{Thermistor}}{R_1} + 1 \qquad (2)$$

and thus

$$R_{Thermistor} = R_1 \frac{V_{Thermistor}}{V_1} \qquad (3)$$

The voltage ratio is independent of the battery voltage so that small drifts in a simple 9V battery will not affect the measurement of $\mathbf{R_{Thermistor}}$.

1. **Build** the thermistor circuit shown using a 9V battery as the power source and a 2.2kΩ resistor in addition to the thermistor.

2. **Calibrate** the output voltage with **temperature**:
a. **Measure** the **voltage output** with the thermistor in the room temperature air. b. **Measure** the temperature with a **thermometer**.
c. **Place** the thermistor in the supplied **warm**, **cold**, and **room temperature** water baths and **record** the output voltages.

3. **Plot** the voltage output of the circuit and the temperature to calibrate the device. a. Is this plot **linear**?

Part II – Diodes as Protection Circuits

As you discovered in Lab #1, diodes have low resistances to current flow in one direction and high resistances in the other direction. This property can make them very useful in constructing circuits that can prevent large voltages from damaging sensitive measurement equipment in the laboratory and hospital environments

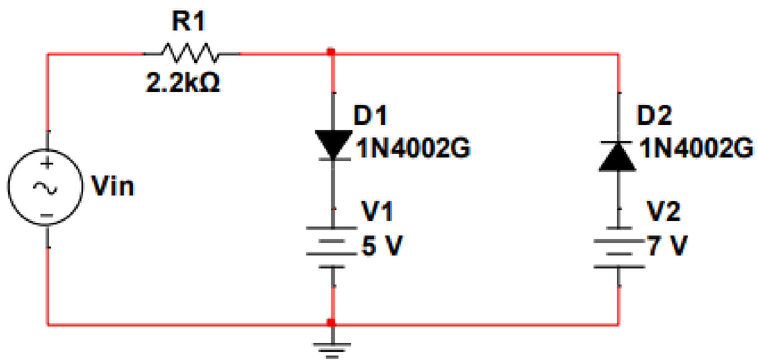

Figure 2.1 – Diode Protection Circuit

1. **Build** the circuit shown above. Use the DC power supplies from lab 1 for the two DC voltage sources.
2. **Apply** a sinusoidal voltage $\mathbf{V_{in}}$ at a frequency of **1kHz** using the AD2 for the following cases:
   a. $\mathbf{V_{in}} = 2V_P$
   b. $\mathbf{V_{in}} = 6V_P$
   c. $\mathbf{V_{in}} = 10V_P$

Note: *Be sure that your oscilloscope is DC coupled.*

3. **Use** the oscilloscope to **measure** the voltage across the 2.2kΩ resistor for each of the three input voltages. **Save** an image with both the input voltage waveform and the voltage across the resistor on the same graph.

Note: *Remember that you must use the MATH function on the oscilloscope to measure the voltage drop across R_1.*

<u>POST-LAB ANALYSIS</u>

1. **Explain** the shape of the waveform of the output voltage and the voltage across the 2.2kΩ

resistor for **each** of the **three** experimental cases.

2. From your observations of the three cases, **explain** why the diode protection circuit is also called a clipper or a limiter circuit.

3. **List two** practical applications of a thermistor. **Explain** how it would be used. 4. **Does** the resistance of a thermistor go up or down as the temperature increases?