**Educational Objective:**

The objective of this lab is to start using automated measurements. A diode circuit is used as the unit under test. Important concepts introduced in this lab include: 1) scope skills and 2) diode characteristics.

**Pre-Laboratory:**

1. Review section 1.6 of ***Boylestad “Electronic Devices and Circuit Theory”***
2. Read and completely understand the entire procedure portion of this laboratory.
3. Given V1 = 5V and D1 has a forward drop of 0.7V, calculate the current in figure 1.

|  |
| --- |
|  |
| Diode Circuit |

Figure 1

1. *The Diode*:
   1. Obtain the manufacturer’s data sheet for the D1N4002 and D1N4004 diodes. *Determine the difference between the diodes and research the significance. Explain in Figure 2.*

|  |
| --- |
|  |
| Maximum Reverse Voltage |

Figure 2

* 1. Using the space provide in Figure 3 to sketch the characteristic curve of any Si (silicon) diode. Use the y-axis for diode current and the x-axis for diode voltage. Include both positive and negative diode voltages and be sure to label the axis on the diagram.

Using the *ideal diode with 0.7V drop model* add a second curve to the plot.

|  |
| --- |
|  |
| Diode Characteristic Curve |

Figure 3

**Procedure:**

1. Complete the quiz handed out in lab. The quiz will only be available for the first ten (10) minutes of your laboratory session. The content of this quiz is based on the knowledge you should have gained while completing the pre-lab section of this laboratory activity. You may use your pre-lab as a reference while taking the quiz.

Section 1: Diode Circuit

1. *Forward-Biased Diode – manual measurement*:
   1. Construct the diode circuit (Figure 1). Use the DC power supply for V1, not the function generator. Make sure ALL the grounds are connected at one point.
   2. Set both CH1 and CH2 so they are DC coupled. Follow the steps below:
      * Press 1 or 2. The button will light up.
      * Press the top soft key to change the coupling to DC.
      * Repeat for the other channel.
   3. Using the scope display V1 with CH1 and VD with CH2. Press the Math key and select minus to get CH1 – CH2. Math will be used to determine the current.
   4. Use the scope’s Measure (Meas) function to display the average value.
   5. Adjust V1 until 1 mA to flows through the diode. VD (measured by CH2) is relatively constant and should stay between 0.5V and 0.7V. The remaining voltage from V1 will be across VR and will be used to determine the current.
   6. Sketch Figure 1 in Figure 4 below and record V1 (supply voltage), VD (diode voltage) and ID (diode current) on a sketch.

|  |
| --- |
|  |
| Diode Circuit with measured values |

Figure 4

* 1. Obtain a sign-off for the above completed work. DO NOT DISCONNECT THE POWER SUPPPLY OR DIODE CIRCUIT. It will be used in the next section.

Section 2: Using the Microprocessor to make measurements

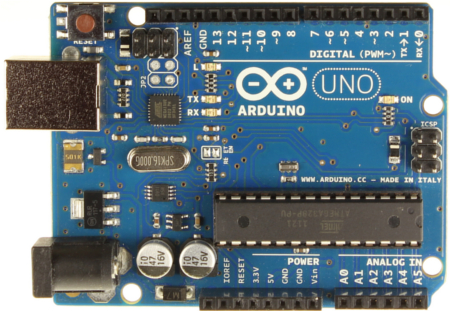
|  |
| --- |
| Silver  Gain ½  Gain 1    Diode Resistor Circuit used in the previous section |
| Voltage Divider with Buffer - “Automated Measurement Circuit” |

Figure 5

1. *Forward-Biased Diode – Microprocessor measurement*: **Print this page**.
   1. Do the following to setup the circuit in Figure 5.
      * Adjust a second power supply output voltage (V2) to 12V and apply power to the IC by: 1) connecting +12V to pin 4 and 2) connecting ground to both pin 11 and V1 ground. All grounds must be connected. Vin+ will not be within expected limits if this step is not followed exactly.
      * Connect the diode/resistor circuit you used before to the op-amp circuit by connecting the right of R1 to DCin1 as shown by the arrow. Use the same value for V1 used in section 1.
   2. Write the color of wire you used on each wire in Figure 5. For example the wire between pins 1 and 2 of U1A is usually silver (no insulation) so “silver” was added to Figure 5 for you.
   3. Use the scope to complete the data table below and get a sign-off. DO NOT DISCONNECT YOUR CIRCUIT.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | |  | VD1 | DCin1 | Vin+ | V1 | AnalogInA0 | Vcc | Gnd | | Located | Top of D1 | Left side of R6 | U1A pin 3 | Left side of R1 | U1A pin 1 | U1A pin 4 | U1A pin 11 | | Expected | 0.5 - 0.7V | 0.5 - 0.7V | 0.25 - 0.35V | 1.5 – 1.7V | 0.25 - 0.35V | 11.5 - 12.5V | 0 - 0.4V | | Actual |  |  |  |  |  |  |  | |  |  |  |  |  |  |

Note: To truly automate the measurements we need a microcontroller. The Arduino UNO microcontroller is a very powerful, inexpensive micro. Connected to the PC we can automatically make measurements. In industry, engineers often setup systems like this to test production parts (*both* Electrical and Computer ETs)



|  |
| --- |
| Gain ½  Gain 1    Diode Resistor Circuit used in the previous section |
| Voltage Divider with Buffer - “Automated Measurement Circuit” |

Figure 6

* 1. Connect the USB cable to the Arduino. There is a cable on the equipment side of the lab that is connected to one of the computers (LOOK FOR IT).
  2. Connect ground on the Arduino board as shown by the arrow in Figure 6.
  3. Connect “AnalogInA0” to pin A0 in the Analog In section of the Arduino as shown by the arrow in Figure 6.

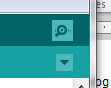
Note: Programming the Arduino is simple. There are two blocks of code: setup and loop. The setup code turns on the serial port so the computer can talk to the Arduino and waits 100 ms. The loop code tells the micro to read the voltage on pin A0 of the ANALOG IN section.

* 1. Start the Arduino software.
  2. Select the “Arduino Uno” board in the “Tools” menu > “Board”.
  3. Select one of the COM ports in the “Tools” menu > “Serial Port”. Do not use COM1, it will not work.
  4. Open a new sketch (what the programs are called) in the “File” menu > “New”.
  5. Add the code in Figure 7 to the sketch. Each line is commented. Read the comments. The code is easy to understand, I promise!

|  |
| --- |
| void setup()// routine used to setup the system, only runs once  { Serial.begin( 9600); // initialize serial communication:  delay(100); // wait for 100 ms, so output can stabilize  }  void loop() {  unsigned int vin=analogRead(0); // digital value from 0 to 1023 where 5V = 1023  delay(100);  Serial.println(vin);  } |
| PWM Code |

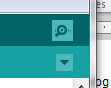
Figure 7



* 1. Click the verify button to compile. Fix any errors. Click to upload.
  2. Click the serial monitor button on the top right of the window to run the program and display the voltage reading.

1. A digital value will be provided after you run the program. Convert the digital value to a voltage by multiplying by 2\*5/1023. Complete the table below. (Note: the times 2 is needed to cancel the voltage divider and the 5/1023 is because 5V equals 1023.)

|  |  |  |
| --- | --- | --- |
|  | Digital Value | VD1 |
| Expected | 45 - 75 | 0.5 - 0.7V |
| Actual |  |  |

1. Close the serial window and move DCin to the other side of R1 to measure V1.
2. Click the serial monitor button on the top right of the window to run the program and display the digital value. Fill in the table below. ID is found by using Ohm’s Law and the voltages VD1 (last table) and V1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Digital Value | V1 | ID |
| Expected | 140 - 175 | 1.4 - 1.7V | 0.8 - 1.2mA |
| Actual |  |  |  |

* 1. Obtain a sign-off for the above completed work.
  2. In later labs we will have the Arduino make dozens of measurements and have Excel make all the calculations. Engineers set up computers to reduce tedious, redundant measurement.

1. *Sign-offs Name*

Section 1: Diode Measurements

|  |  |  |
| --- | --- | --- |
|  |  | / / |
| Signature |  | Date |

Section 2: Voltage Divider with Buffer

|  |  |  |
| --- | --- | --- |
|  |  | / / |
| Signature |  | Date |

Section 2: Arduino Current Measurements

|  |  |  |
| --- | --- | --- |
|  |  | / / |
| Signature |  | Date |

1. *Post Lab Work*:

Submit signed of laboratory work with sign-offs and a summary.