Embedded Systems Week 2 Assignment – Danail Georgiev 3781496

Assignment 1A

1.What is the maximum current the Arduino can provide via VCC?

- 200 mA

2.What is the maximum current the Arduino can provide via digital output?

- 40 mA

3.What is the maximum current the Arduino can drain via GND?

- 200 mA

4.What is the voltage range that the Arduino sees as HIGH on digital input pins?

- from 3V to 5,5V

5.What is the voltage range the Arduino sees as LOW on digital input pins?

- from -0,5V to 1,5V

6.What is the voltage range the Arduino outputs as HIGH on digital output pins?

- From 4,1V and above

7.What is the voltage range the Arduino outputs as LOW on digital output pins?

- Below 0,8V

8.What is your conclusion when you see these specs?

- What I take out from these values is that the Arduino works with quite low voltages and it requires attention when working with hardware so as not to overload it and damage it. Therefore, resistors must be chosen and placed carefully and sometimes additional power supply might be necessary for some modules, which the Arduino could not possibly power alone.

(The following questions refer to a 5mm LED, which I will be using)

9. What is the maximum forward current (IF) of the LED? See datasheet.

- 20 mA

10. What is the forward voltage (UF) across the LED at the maximum forward current? See $IF - UF$ graph in the datasheet.

- 2 V

11. Use Ohm's law and Kirchhoff's laws to calculate the series resistor R for the maximum IF and UF. Show your calculations (formula's and results) and your reasoning with meshes and nodes.

- max If = 20mA

- Uf at max If = 2V

Ohm’s law => I=U/R

U = 5V – 2V = 3V

0,02 = 3/R => R = 150 Ohm

12. Recalculate the resistor for this safety limitation. You will use this “safe” resistor in the next step. Show how you calculated the values (formula’s and results).

- Since I will be using the 5V Vcc on the Arduino we will need a stronger resistor than 100 Ohm to keep the LED safe. My choice of a safe current value will be 10 mA at 5V, even though we could work with higher values. At 10mA the Vf is almost 2V according to the datasheet graph, so that is the value we are going to work with

Therefore, using Ohm’s law we can calculate the value of the resistor we are going to use.

I=U/R

U = 5V – 2V = 3V

R = 3/0,010

R = 3000/10 = 300 Ohm

13. If the resistor value is not a standard resistor in the E3 series, then can you create this resistor using standard resistors in the E3 series? Explain your answer and show the calculations.

- Since there is no 300 Ohm resistor available for me to work with, I could use one of the 330 Ohm resistors I have, which will reduce the current a bit more, but the LED will still be bright. Another way to solve this problem is to use for example 5 of the 1500 Ohm resistors in-parallel and we will receive Rv = 300 Ohm, which is exactly the value we need.

We can calculate it using the simple formula

1/Rv = 1/R1 + 1/R2 + 1/R3 + 1/R4 + 1/R5

R1, R2, R3, R4, R5 = 1500 Ohm =>

5x1/1500 = 5/1500 = 1/300 => Rv = 300 Ohm

However, I will be using a 330 Ohm resistor, because I do not have 5 1500 Ohm ones and it is much simpler as well. Therefore, the current through the circuit will be 3/330 = ~0,09 mA.

14. Measure VCC (U), the voltage drops over the resistor (UR) and the LED (UF), and measure the current (I) in the circuit. Explain the measurements.

- Voltage measured – 5,01 V

- Voltage over the resistor (Ur) – 2,80 V

- Voltage drop over the LED (Uf) – 2,06 V

- Current measured by the multimeter = 8,40 mA

15. Are the measured values equal to the calculated and datasheet values? Explain.

- The voltage drop over the LED measured is the same as in the graph in the datasheet, so the voltage over the resistor should be 5 – 2,06 = 3,94 V. The value measured is 2,80 which is close enough. The current(I) is a little bit below the calculated, but the difference is neglectable.

Now we are going to determine the resistor value needed for the night mode. We have to experiment with different resistor values until the LED brightness is suitable for the night mode.

16. Determine the resistor value for night mode. Explain the steps.

- After testing different resistors with higher resistance values, it appears that the one most appropriate for night mode is the 470 Ohm one, which isn't much more than the one we use for the day mode, but we chose a low brightness for it to begin with. Any resistor with higher values will dim the LED too much, even for the night mode.

17. What is the voltage (UF) across the LED at the forward current for night mode?

- 2,01 V

18. What is the forward current (IF) through the LED for night mode?

- 6,01 mA

19. Compare these measured values with the characteristics in the datasheet, and proof that this is correct using Ohm's law and Kirchhoff's law. Explain your answer and show the calculations.

0,06 mA ?= (5V – 2,01V) / 470 Ohm

0,06 ?= 3/470

3/470 = ~0,063

0,063 ~= 0,06

- ⇨ It is indeed correct

Assignment 1B

1. How can you determine the cathode or anode of the LED?

- A LED has a positive lead – anode and a negative – cathode. The cathode is one the side of the body of the LED with the flattened edge and is usually shorter than the anode.

2. What is the wavelength of the emitted light?

- It depends on the colour of the LED; it varies from 360 to 950 nm. For example, the red LED used in these exercises has a wavelength of 630 nm

3. Why do we need a resistor in series with the LED?

- We need a resistor to limit the current going through the LED so that it doesn't burn. If the voltage in the circuit is equal to the forward voltage, no resistor is necessary.

4. What is the forward voltage and what is the reverse voltage?

- The forward voltage varies between 1.8 and 3.3 volts. It depends on the forward current and the colour of the LED. It is the value required for the LED to light up using certain current. The reverse voltage is needed for the LED to be able to be connected backwards (polarity-wise) to the circuit and work.

5. What is the maximum reverse voltage of the LED?

- 6 V for this red LED

6. What will happen to the LED when the reverse voltage exceeds the maximum reverse voltage?

- The current will be able to flow through the diode even if connected to the wrong side of it.

7. Can you make any statements on the amount of light emitted by the LED during daytime mode?

- I am not certain I understand this question. If it is about the brightness of the light, I would say that the LED is quite efficient, having in mind how much energy it uses and it reaches pretty high brightness.

Assignment 1C

1. Why can't we use the circuits for daylight and nightlight from assignment 1A with 12V? Explain your answer. Give proof by calculation.

- If we use the same resistors as the ones before, the voltage will be too strong and therefore the current as well. The LED will burn out. If we increase U, I will increase as well, because we use the same resistor (R) as before.

I = U/R

I = (12-2)/300 = 33mA

That is well over the safe value for the LED.

2. Recalculate the daytime resistor using the 12V power supply. Build the circuit with the new resistor, the LED and the 12V desktop power supply. Use the voltage range 0-12V. Start at 0V and slowly turn it up until 12V.

0,01 = (12-2)/R

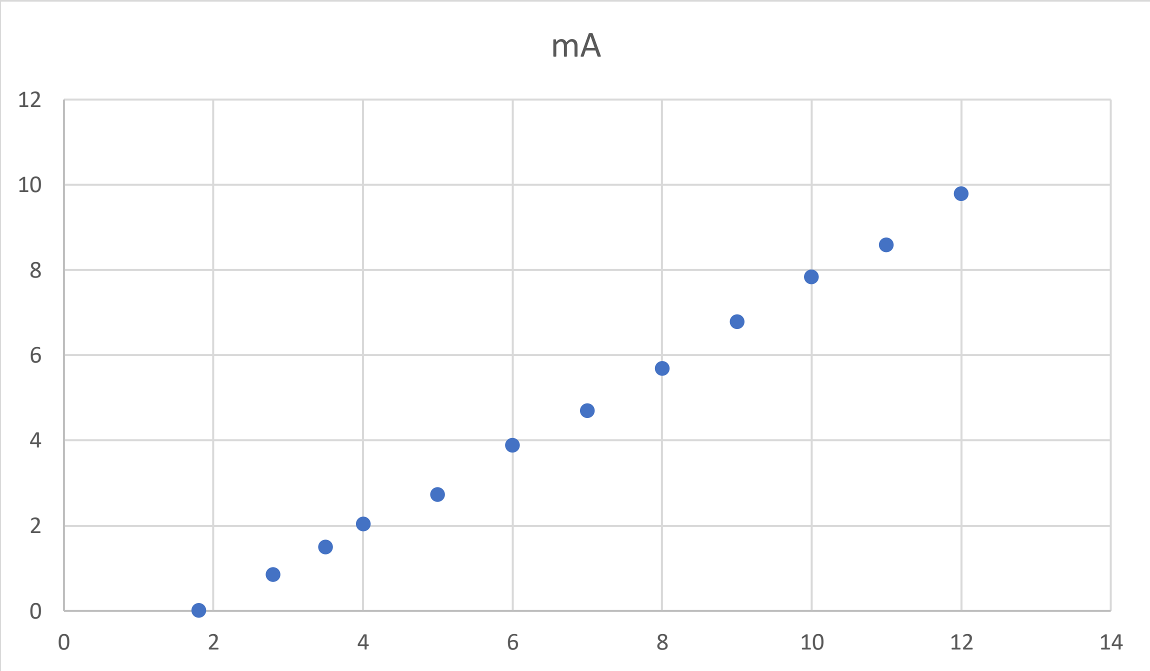
R = (12-2)/0,01 = 1000 Ohm

3. Determine when the LED starts to conduce current. Explain the process.

- The LED starts working at voltage values around 1.80V, which is expected, considering this is around the minimal value of the forward voltage for current to be able to flow through the LED (according to the datasheet).

4. Write down the voltages (UF) and currents (IF) for each step and draw a plot that shows the IF – UF characteristics of the LED. Explain the plot. Tip: Use sufficient steps so that the plot is accurate

enough. Reverse the power supply to generate -1V and -4V.



5. Measure the current for -1V and -4V thought the circuit and explain the values found using the datasheets.

- There was no current measured in the circuit with either of the voltages. I believe the reason is that the reverse voltage of the LED is 6V and therefore 1 and 4 volts were insufficient to counter that.

6. What does the datasheet say about the reverse characteristics?

- The reverse voltage of the LED is 6V