**Lab 1 – Breadboarding Circuits**

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| Check | PRE-LAB TASKS |
|  | Labeled Circuit Schematic. |
|  | Explanation of Circuits Operation. |
|  | Picture of Breadboard Layout. |
|  | Labeled Circuit Schematic with the diode replaced by diode model. Use the values of Vo and Ro suggested by the instructor. |
|  | Analysis determining current through the diode circuit as a function of the variable resistance, R (using the diode model). |
|  | Graph plotting expected current through diode circuit as a function of the variable resistance, R, for at least 10 values of R from 0 to 5000 ohms. . Use Excel or MATLAB for all graphs in this course. Include both the table of values used and the graph in the notebook. Tables and graphs must always be properly formatted. Always include sample Excel formulas at the bottom of each table. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. Also specifically discuss the procedure you used to measure current, voltage, and resistance. |
|  | For at least 10 values of resistance from 0 to 5kΩ, record the following values:   1. Measured diode current 2. Measured diode voltage 3. Measured resistance |
|  | Brightness observations as a function of current. Explain the scale used. |
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| Check | POST-LAB TASKS |
|  | Graph plotting expected and measured current through resistor as a function of variable resistance, R, on the same graph. Your expected values should be recalculated using the exact resistance values measured in lab. Show the table of values used to generate the graph as well. Include % error between expected and measured current. The expected current values should use the measured values of R. As always, show sample Excel formulas at the bottom of the table. |
|  | Graph current versus diode voltage. Discuss how well your diode model matches this graph. Show the table of values used to generate the graph. What values of Vo and Ro are implied by your graph? |
|  | Discuss the reason for putting the 100 ohm resistor in series with the potentiometer. |
|  | Assessment of the agreement between pre-lab predictions and in-lab measurements. |
|  | Name, Kit #, Lab Partner listed on each page of report. |
|  | All printouts neatly trimmed to fit onto lab notebook pages within the work area. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of lab  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 2 – MicroStamp11 Familiarization**

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| Check | PRE-LAB TASKS |
|  | Picture of Breadboard Layout (with the MicroStamp11 and USB module). |
|  | Explanation of how to program the MicroStamp11, including detailed step-by-step instructions (in your own words) for:   1. Compiling a program using the ICC11 2. Downloading a program using MicroLoad 3. Running the program using PuTTy |
|  | Program Listing: Write a C-language calculator program for the MicroStamp11. Your program should read two unsigned integers from the PuTTY, add these integers together, and then write the answer to the PuTTY. After doing this, the program should wait until a new addition problem is entered from the PuTTY. ***Note:*** ***Begin each program with a section of comments including your name, course number, lab number, filename of program (Lab1.c, for example), and a brief description of the program.*** ***All programs should include plenty of comments.*** |
|  | Note: Your program above must be typed. If you do not have access to the ICC11, then you can type it in NotePad (NotePad++ is even better). Avoid using MS Word, but if you do use it be sure to save files in text format, not as documents. |
|  | Explanation of how program works. |
|  | List the min and max values (in decimal form) for signed integers and unsigned integers. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | No additional connections are required for this lab, but ask ***the instructor to verify that your USB and power connections are correct before proceeding.*** |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Follow the instructions in the handout ***“Running Your First Program on the MicroStamp11”*** |
|  | Run your program and verify that it is working properly. Include at least 4 examples printed from the terminal program (PuTTy), including one with a result that is greater than 65535. Also test your program with negative numbers as inputs and discuss the result. |

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| Check | POST-LAB TASKS |
|  | Final program listing. Be sure to include plenty of comments. |
|  | Highlight any changes made to the original program listing and discuss the changes. |
|  | Explain in detail the answer for the example that was greater than 65535. |
|  | Discuss how well the program worked and any limitations to the program. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 3 - Lights and Switches**

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| Check | PRE-LAB TASKS |
|  | Schematic diagram including the button circuit and the 7-segment display circuit (include pin numbers for the 7-segment display). |
|  | Explanation of how the button circuit works. |
|  | Diagram identifying segments on a 7-segment display and a truth table indicating which segments are lit for each decimal digit. |
|  | This lab will use common-anode 7-segment displays. Discuss the difference between common-anode displays and common-cathode displays. Include diagrams. |
|  | Pinout and part number for the 7-segment display. |
|  | Draw a diagram showing which segments are lit for each of the ten decimal values. |
|  | Explanation of how the LED circuit works. |
|  | Program Listing: Write a C-language program such that when the user presses a button an unsigned integer will be incremented (mod-10) and the value of the integer will be displayed both on the terminal program (HyperTerminal, Putty, etc.) and on a 7-segment display. See more details in the Lab Manual and class notes.  Remember to begin all programs with a section of comments including your name, course number, lab number, filename of program (Lab3.c, for example), and a brief description of the program. All programs should include plenty of comments. |
|  | Verification that the pre-lab TASKS were completed correctly (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. For example, if your program did not successfully compile or download, discuss what you did to correct the problem. |
|  | Breadboard of button and 7-segment display circuit checked by instructor. |
|  | Run the program which includes a delay used for debouncing. The display should operate perfectly. Print a sample of the results from the terminal program. |
|  | Remove the delay from the program above. The display should now have problems with switch debounce. Press the button (somewhat quickly) ten times and record the sequence of numbers seen on the 7-segment display. Calculate the average number of bounces that occurred. Print out a sample of the results the terminal program. Can you tell that there was a switch debounce problem looking at the results from the terminal program? Explain. |

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| Check | POST-LAB TASKS |
|  | Final program listing. Highlight any changes made to the original program listing and discuss the changes. |
|  | Discuss the problem of switch debounce and how it was handled in this lab. |
|  | Assessment of final program performance. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 4 - Lights and Switches – Real Time**

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| Check | PRE-LAB TASKS |
|  | Program Listing: Write a C-language program (Program 4A - One Second Timer) to increment and display a count (mod-10) in one-second increments on a 7-segment display after a button is pressed. Display the count on the terminal program (PuTTY or other) as well. |
|  | Write a description of how Program 4A works. |
|  | Program Listing: Write another C-language program (Program 4B - Ten Second Button Counter) to count the number of times that a button is pushed over a 10-second interval. See lab guide for additional specifications. |
|  | Write a description of how Program 4B works. |
|  | Include a schematic diagram breadboard layout. |
|  | Verification that the pre-lab TASKS were completed correctly (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Compile and download Program 4A and demonstrate it to the instructor. Record any changes made to the program. Include a printout from the terminal program. |
|  | Use an online stopwatch program to determine the amount of time required for your program/circuit to display 60 counts. Record this time. If the time is not within 1 second of being correct (60 seconds), adjust the length of pause used in your program. Make a table showing the values used with the pause statement and the corresponding times. |
|  | Compile and download Program 4B and demonstrate it to the instructor. Record any changes made to the program. |
|  | Experimentally verify that Program 4B works correctly. Record (in a table) the number of button presses versus the displayed value for several cases, including the following number of button presses: 0, 1, 2, 5, 10, 15, 20, 25, and the highest number that you can press. Include a printout from the terminal program. |

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| Check | POST-LAB TASKS |
|  | Include a final program listing for each program. Highlight any changes made to the original program listing and discuss the changes. |
|  | Discuss how well each program performed. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 5 – Digital to Analog Conversion**

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| Check | PRE-LAB TASKS |
|  | Schematic with MicroStamp11, two input switches, R2R ladder network, and 7-segment display with current-limiting resistors. |
|  | Breadboard layout for the schematic above. |
|  | Detailed R2R network analysis that predicts R2R ladder voltage V2 as a function of the 8 possible inputs (use superposition as shown in the class notes). |
|  | Summarize the results above in a table of binary inputs (000 – 111) versus analog output (V2). |
|  | Stair-step graph of analog output (V2) versus binary input. |
|  | Program Listing: Write a C-language program to increment and decrement the display using the two input buttons and to output the binary value of the display to the R2R ladder network in order to produce the desired analog voltage V2. See the lab guide and class notes for more details. |
|  | Print out a few lines from kernel5.c and highlight the change made to line 437. |
|  | Explanation of how the program works. |
|  | Explain why the function disable\_sci( ) was used. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Build the circuit consisting of the two button inputs and the R2R ladder network using only 2.2 kΩ resistors. Ask the instructor to check your circuit before proceeding. |
|  | Download and test your program to verify that the display properly increments and decrements (mod-8) and that the expected voltages are produces by the R2R ladder network (measure V2 using a DMM). |
|  | Record the output voltage V2 measured with a DMM for each of the 8 possible inputs. |

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| Check | POST-LAB TASKS |
|  | Final program listing. Highlight any changes made to the original program listing and discuss the changes. |
|  | Stair-step graph of measured analog voltages (V2) versus possible binary inputs. |
|  | Table comparing predicted output voltages (V2) to measured output voltages (V2). Include % error. |
|  | Assessment of how well the DAC works. Discuss reasons for the error in the measured values of the output analog voltage (V2). |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 6 – Analog to Digital Conversion - Hardware**

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| Check | PRE-LAB TASKS |
|  | Schematic of a unity-gain buffer. Explain how the circuit works. Write an expression for the output voltage. |
|  | Schematic of a comparator circuit. Your circuit should generate a voltage that is either 0 or 9 volts. Explain how the circuit works. Write an expression for the output voltage. |
|  | Schematic of a clamp circuit. Explain how the circuit works. Write an expression for the output voltage. |
|  | Show the calculation for the resistance so that the maximum current drawn from the source is around 1 mA. |
|  | Complete schematic including the MicroStamp11, R2R ladder network, buffer, comparator, and clamp circuit. |
|  | Breadboard layout of the schematic above. |
|  | Verification of pre-lab TASKS (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Note: It is best to build and test one circuit at a time rather than building the entire circuit. Build the buffer circuit and connect it to the DAC you built earlier. Test your circuit by measuring the buffer output voltage versus the buffer input voltage from the DAC for all 8 possible cases. See sample table in lab notes. |
|  | Build the comparator circuit and connect it to the buﬀer. Test your circuit by measuring the comparator’s output voltage as a function of at least 10 diﬀerent reference voltage levels between 0 and 9 volts. Repeat this test for each of the 8 possible voltages that can be generated by your DAC (80 total measured values). See sample table in lab notes. |
|  | Build the clamp circuit and connect it to the comparator. (The thumbwheel potentiometer seems to work best here.)Adjust potentiometer on the output of the clamp circuit to exactly 5V when the output of the comparator circuit is 9V and then put a piece of tape on the potentiometer so that it will not be accidentally changed. Test your circuit by measuring the clamp’s output as a function of at least 10 diﬀerent reference voltage levels. Repeat this test for each of the 8 possible voltages that can be generated by your DAC (80 total measured values). See sample table in notes. |
|  | Measure the *threshold* voltage where the comparator/clamp circuit transitions from zero to 5 volts as a function of the reference voltage for each of the 8 possible DAC voltages. See sample table in lab notes. |

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| Check | POST-LAB TASKS |
|  | Plot the buffer output voltage and input buffer voltage for each of the 8 cases. Assess how well the buffer works. |
|  | Graph of experimental data for the comparator circuit. Note: Use either 8 graphs of Vcomp vs. Vref (1 for each DAC input) or else use one 3D graph (80 points total). Assess how well the comparator circuit works. |
|  | Graph of experimental data for the clamp circuit. Note: Use either 8 graphs of Vclamp vs. Vref (1 for each DAC input) or else use one 3D graph (80 points total). Assess how well the clamp circuit works. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 7 – Analog to Digital Conversion - Software**

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|  | PRE-LAB TASKS |
|  | Program Listing: Write a C-language program to implement a binary search as described in the lab manual. |
|  | Explanation of how the program works. |
|  | Include a circuit schematic. |
|  | Stair-step graph of predicted digital outputs (to be displayed on the 7-segment display) as a function of applied reference voltage. Use the data table of threshold voltages from last lab. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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|  | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Verify that circuit/program from Lab 6 is still operating correctly and that final potentiometer on clamp circuit is taped for 0V/5V output. |
|  | Add wire to close the loop between clamp circuit and MicroStamp11. |
|  | Compile and download your program to the MicroStamp11. |
|  | Test your program to see if it is working correctly. As you vary the reference voltage (potentiometer) from 0 to 5V, the 7-segment display should change from 0 to 7. |
|  | Record the output value on your 7-segment display as the reference voltage varies from 0 to 5V in 0.2V increments. |
|  | Demonstrate the functionality of your system to the instructor. |

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|  | POST-LAB TASKS |
|  | Final program listing. Highlight any changes made to the original program listing and discuss the changes. |
|  | Graph of digital output (shown on 7-segment display) versus applied reference voltage (stair step graph using the 26 measured data points). |
|  | Comparison of graphs from pre-lab and post-lab. |
|  | Assessment of how well the ADC works. |

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|  | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 8 – Pulse Width Modulation**

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|  | PRE-LAB TASKS |
|  | Explanation of how the initial OC4han interrupt handler works (50 percent duty cycle PWM). |
|  | Program Listing of modified version on init( ). Highlight all changes and explain how it works. Add comments to all new or changed code. See class notes for more details. |
|  | Program Listing of the portion of kernel8.c where highticks, lowticks, and setpwm are defined. Highlight all changes and explain how it works. Add comments to all new or changed code. See class notes for more details. |
|  | Program Listing of the modified OC4han. Highlight all changes and explain how it works. See lab guide and class notes for more details. |
|  | Program Listing of your main program that prompts the user to enter a duty cycle D (from 0 to 100) and then calls the function setpwm. Explain how it works. Add many comments. See class notes for more details. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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|  | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Remove the R2R ladder network, buffer circuit, comparator circuit, and clamp circuit from your breadboard. Leave the 7-segment display connected. |
|  | Compile and download your main program written in the pre-lab task. Be sure that kernel8.c has been saved in the include folder for the ICC11 compiler. |
|  | View the output on PA4 on the oscilloscope. Verify that your program is working correctly. As you enter different values for D, you should see the period of the waveform change on the oscilloscope. |
|  | Capture oscilloscope images on the computer in lab to capture each of the 11 oscilloscope screens (for D = 1%, 10%, 20%, …, 80%, 90%, 99%). Add cursors to each screen to measure TH. Verify that the period is 4 ms (or f = 250 Hz). Print each of them and tape them into your lab notebook. Show the input value of D next to each screen capture. Also show the calculated value of D using the measured value of TH. See a sample screen capture in the class notes. |

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|  | POST-LAB TASKS |
|  | Form a table comparing the duty cycle input to your program to the duty cycle measured on the oscilloscope. |
|  | Assess the performance of your program. |
|  | Final program listings for any programs that were modified during lab. Highlight any changes made to the original program listings and discuss the changes. |

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|  | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 9 – Digital to Analog Conversion Revisited**

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| Check | PRE-LAB TASKS |
|  | Derivation of Vm and Vr as a function of R, C, T1, and T (Eq. 5-6). |
|  | Derivation of Vm and Vr as a function of T (Eq. 7-8). |
|  | Table of values of Vm, Vr, % ripple, and T. Highlight T for max of 5% ripple. Add an explanation as to the significance of this highlighted line in the table. |
|  | Derivation of Vm as a function of D (Eq. 9). |
|  | Calculate the frequency,f, for T = 2 ms. |
|  | Table and graph of values of Vm and D. Discuss the relationship between Vm and D. |
|  | Table of 5 or more R and C values such that RC = 10 ms. List the additional constraints in lab guide. Indicate which set of RC values you plan to use in lab. |
|  | Schematic showing MicroStamp11 and selected values of R and C. |
|  | Program Listing: Modify the main program you wrote in the preceding lab as follows:  A) Prompt the user to enter a digital value (0-63) representing a 6-bit digital input.  B) Convert the digital value to a duty cycle (perhaps D = x\*100/63) before calling setpwm.  Add comments to any new/changed code. |
|  | Program Listing: Modify kernel8.c (and save as kernel9.c) changing T from 4 ms to 2 ms (i.e., change number of clock ticks from 9828 to 4914). Explain how the number of clock ticks was determined. Add comments to all new/changed code. |
|  | Explanation of how the program and circuit work. |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Measure R with an ohmmeter and C with an impedance bridge and record their values. Calculate RC and verify that it is within 20% of the designed 10 ms value. |
|  | Build the RC circuit and attach it to pin PA4. |
|  | Verify that the circuit is working properly. As the input varies from 0 to 63, the output voltage should vary from 0V to 5V. Note that the output may not be correct for 0 and 63, but should work correctly for 1-62. |
|  | Include a printout from the terminal program showing how the user interacts with the program. |
|  | Create a table for measuring the analog output, Vm, for 64 digital input values (shown in both decimal and binary form) to be entered using the keyboard. Use a DMM (set to measure DC voltages) to measure the analog voltage output by your DAC circuit for digital inputs of 0 to 63. See sample table in class notes. |
|  | Use the oscilloscope to capture an image of the analog output voltage, Vm, for at least 10 different digital inputs between 1 and 62. Add cursors to the max and min points on the waveform to measure the ripple voltage. See notes on triggering in the lab manual. See a sample screen capture in the class notes. |
|  | Label each screen capture with the digital input and the calculated ripple voltage. |

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| Check | POST-LAB TASKS |
|  | Final program listing. Highlight and discuss any changes made to the original program listing. |
|  | Plot the measured analog voltages for digital inputs 1-62. Is the graph linear? Should it be? |
|  | Plot % ripple versus digital input. Use % ripple = (ripple voltage measured with screen capture)/2.5\*100%. What is the max % ripple? Does this match the design specifications? |
|  | Discuss the performance of the DAC. |
|  | Compare the DAC constructed in Lab 9 to the one using an R2R ladder network in Lab 5. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 10 – Getting Power off the Wall**

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| Check | PRE-LAB TASKS |
|  | Sketch of power supply waveforms at node a, node b, node c (without the capacitor) and node c (with the capacitor) in Figure 6. |
|  | Explain in your own words how your power supply works. |
|  | Schematic of the Zener diode regulator power supply, including the AC input, transformer, full-wave rectifier, filter capacitor, Zener-diode regulator (with 1kΩ resistor between filter capacitor and a 1N4733A (5.1V) Zener diode) and a load resistance. The load resistance should consist of a 100 Ω resistor and a 10 kΩ potentiometer in series |
|  | Calculate the predicted output voltage, Vout, of the Zener diode regulator if the unregulated voltage is 17V (not 12V as shown in the lab guide) and Rload = 100 Ω , 200 Ω , 300 Ω , 400 Ω , 500 Ω , 1kΩ, 2kΩ, … , 10kΩ. Show a sample calculation for Vout. Also calculate the power dissipated by Rload for each case and tabulate the results. What is the max power dissipation seen in this table? Graph Vout versus Rload. If the thumbwheel potentiometer used in lab has a max power rating of ¾ W, will the max rating be exceeded? |
|  | Schematic of 7805 (5V) regulator power supply, including the AC input, transformer, full-wave rectifier, filter capacitor, 7805, and a load resistance. The load resistance should consist of a 100 Ω resistor and a 10 kΩ potentiometer in series |
|  | Show the predicted output voltage, Vout, of the 7805 regulator if the unregulated voltage is 17V (not 12V as shown in the lab guide) and Rload = 100 Ω , 200 Ω , 300 Ω , 400 Ω , 500 Ω , 1kΩ, 2kΩ, … , 10kΩ. Explain how the predicted voltages were determined. Also calculate the power dissipated by Rload for each case. What is the max power dissipation seen in this table? Graph Vout versus Rload. If the thumbwheel potentiometer used in lab has a max power rating of ¾ W, will the max rating be exceeded? |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Build the power supply circuit ﬁrst without the voltage regulator and 100 μF capacitor. Use the oscilloscope to view the output of the transformer at node b. Use the ***Measurement*** feature on the oscilloscope to find the ***maximum voltage.*** Capture the image. (Use a 10X probe and 10X oscilloscope setting if the waveform is too large to fit on the oscilloscope screen.) |
|  | Use the oscilloscope to view the output of the full-wave rectifier at node c (without the capacitor – but you may need to temporarily add a load resistor to get a stable output). Use the ***Measurement*** feature on the oscilloscope to find the ***maximum voltage***. Capture the image. |
|  | Measure the value of the capacitor (before adding it to your circuit) on an impedance bridge and record the value. |
|  | Now add the capacitor to your circuit and use the oscilloscope to view the voltage waveform at node c. Use the ***Measurement*** feature on the oscilloscope to find the ***average voltage*** and the ***ripple voltage***. Capture the image. |
|  | Add the Zener-diode regulator circuit and 10 kΩ load resistor (potentiometer). Also add a 100 Ω resistor in series with the 10 kΩ potentiometer to insure that the total load resistance will not go below 100 Ω. Measure the output voltage as a function of total load resistance for Rload = 100 Ω , 200 Ω , 300 Ω , 400 Ω , 500 Ω , 1kΩ, 2kΩ, … , 10kΩ. (Note that Rload = 100 Ω + value of potentiometer.) |
|  | Remove the Zener-diode circuit and add the 7805 voltage regulator circuit and 10 kΩ load resistor (potentiometer). Again add a 100 Ω resistor in series with the 10 kΩ potentiometer. Measure the output voltage as a function of total load resistance for Rload = 100 Ω , 200 Ω , 300 Ω , 400 Ω , 500 Ω , 1kΩ, 2kΩ, … , 10kΩ. (Note that Rload = 100 Ω + value of potentiometer.) |

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| Check | POST-LAB TASKS |
|  | Discuss the waveform captured showing the output of the transformer. Was it as expected? |
|  | Discuss the waveform captured showing the output of the full-wave rectifier without the filter capacitor. Was it as expected? |
|  | Discuss the waveform captured showing the output of the full-wave rectifier with the filter capacitor. Was it as expected? |
|  | Discuss the reason for adding the 100 Ω resistor in series with the 10 kΩ potentiometer as the load for each regulator. |
|  | Create a table comparing Vout (predicted) and Vout(measured) for each value of Rload for the Zener diode regulator circuit. Include % error. Also graph Vout (predicted) versus Rload and Vout(measured) versus Rload (on the same graph and include a legend). Discuss the results and explain any differences. |
|  | Create a table comparing Vout (predicted) and Vout(measured) for each value of Rload for the 7805 regulator circuit. Include % error. Also graph Vout (predicted) versus Rload and Vout(measured) versus Rload (on the same graph and include a legend). Discuss the results and explain any differences. |
|  | Compare the two power supplies built and tested in lab. Which is better? |
|  | The power supply you built provides 5 volts for your MicroStamp11. However, the op-amps used in Labs 6-7 require 9 volts. Explain how you could modify your power supply to power your op-amps. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 11 – Serial Interfaces**

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| Check | PRE-LAB TASKS |
|  | Schematic diagram of LED display circuitry, breadboard layout, and explanation of how the circuit works. |
|  | Program listing of lab 7s program (modified to use the serial interface) and explanation of how the modified program works. |
|  | Labeled drawing showing the expected oscilloscope waveform you expect to observe for each of the possible inputs to the serial LED display. (62.5kHz) |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Current measured on one of the LED segments BEFORE changing display circuitry. |
|  | Current measured on one of the LED segments AFTER changing display circuitry. |
|  | Sketch of oscilloscope traces for serial lines waveform for each of the possible display values (62.5kHz). |
|  | Sketch of oscilloscope traces for faster serial rates. |

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| Check | POST-LAB TASKS |
|  | Table comparing LED circuits before and after circuit change. Explanation of table’s significance. |
|  | Comparison of predicted and measured oscilloscope traces (62.5kHz). |
|  | Assessment of oscilloscope traces for faster serial rates. |
|  | Constructive Comments about whole lab course. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Lab 12 – Analog to Digital Conversion Revisited – Time Multiplexing**

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| Check | PRE-LAB TASKS |
|  | Schematic diagram of dual digit display circuitry, breadboard layout, and explanation of how the circuit works. |
|  | Schematic diagram of completed ADC hardware and breadboard layout. |
|  | Program listing for revised ADC program and explanation of how it works. |
|  | Analysis predicting the quantized voltage levels as a function of the reference voltage level. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Instructor’s check of breadboard prior to testing. |
|  | Observed LED display values for at least 32 different constant reference voltages. |
|  | ADC/square wave results General observations for at least 10 frequencies. |
|  | ADC/square wave results table of maximum value versus frequency. |

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| Check | POST-LAB TASKS |
|  | Final Program listing and explanation of how it works, focusing on differences from pre-lab listing. |
|  | Graph of quantized display value versus reference voltage (constant case). |
|  | Assessment of ADC performance for constant reference voltages. |
|  | Graph of maximum quantized value versus frequency (square wave case). |
|  | Assessment of ADC performance for time-varying reference voltages. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration on completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_

**Sample Lab – Traffic Light Control Circuit**

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| Check | PRE-LAB TASKS |
|  | Schematic diagram. |
|  | Breadboard Layout. |
|  | Program Listing. |
|  | Explanation of how the program works. |
|  | Verification that the pre-lab TASKS were completed correctly  (Initialed by instructor). |

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| Check | IN-LAB TASKS |
|  | Detailed handwritten comments (like a diary) of all activities during lab. |
|  | Circuit checked by instructor before power-up. |

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| Check | POST-LAB TASKS |
|  | Final Program Listing. |
|  | Explanation of differences between pre-lab program and final program. |
|  | Assessment of final program performance. |

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| Check | DEMONSTRATION ….. STOP if not checked off |
|  | Successful demonstration of completed system  (Initialed by instructor). |

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ MicroStamp11 Kit Number: \_\_\_\_\_\_\_

Lab Partner: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Grade: \_\_\_\_\_\_\_\_\_\_\_\_