

Midterm 1: CST8227 Interfacing

Fall 2011

Time: 60 minutes; Test scored out of: 30 marks; Total Marks available: 35 marks
(Allocation of marks is shown beside each question)

Instructions:

1. **BEFORE** answering any questions, please check that your copy of the test has all pages (as indicated in the footer at the bottom of each page). Please read all questions carefully, then answer the question below first!
2. Be sure to **mark your name** on all pages of this midterm.
3. All work necessary for finding your answer should be shown on this test paper. If you do **not** show your work, **you will not get any marks!!**
4. No calculators are allowed. Numbers have been chosen to work out conveniently. Maybe you'd be better working in fractions instead of decimal values?
5. If you are uncertain what a question is asking, make reasonable assumptions, write those assumptions down on this test paper, and continue answering the question.
6. Use the last page (blank) to show extra work, if necessary.

What is your:

NAME? _____

Student Id? _____

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1. [9 marks+1 Bonus] Digikey sells a white LED, of the kind used for flashlights and other similar lighting. I want to use a Teensy to control one of these LEDs at full brightness. It **must** operate **safely** so neither the Teensy nor the LED burn out. I need to plan out the actual circuit and calculate all operating values, so that I can order any other required components at the same time. The opposite page shows a relevant section of the data sheet; make reasonable choices as necessary. (You may ask for help with this question, but it will cost you marks.)

Include correct units for all values and show all your work!

A. Operating Values

Total current from 5V supply = _____ **150 mA** [1 mark]

Voltage across the LED = _____ **3.5V** [1 mark]

Extra component(s) required = _____ **Resistor** [1 mark]
(component type(s) or "none")

Value of extra component(s) = _____ **10 ohms** [3 marks]
(if required)

Resistor voltage = $5.0 - 3.5 = 1.5$ [1 mark]

Resistor current = $1.5V / 150mA = 10$ ohms [2 marks; 1 for value, 1 for order of magnitude]

B. Draw a circuit diagram which **clearly** shows how to wire up the circuit.

[1 mark for basic circuit + 2 marks for multiple pins (1=awareness of high current, 1=solution)]
This is the simplest possible series circuit, with an LED in series with a current-limiting resistor
The pair can be wired between 5V and the Teensy pins, or between the Teensy pins and 0V
The critical part is to use **multiple** Teensy pins (between 4-8) to provide sufficient current!

C. Bonus What special wiring and/or programming consideration must be used to operate this circuit safely? Be **clear** in your answer.

All Teensy pins must belong to the same “port” and be switch simultaneously
eg. By assigning a value to a port register: PORTB = 0xFF or PORTB = 0x00

Description: “[This white] Power LED Light Source is a high performance energy efficient device which can handle high thermal and high driving current. The Cool White Power LED is available in various color temperature ranging from 4000K to 10000K and Warm White Power LED ranging from 2600K to 4000K.”

Absolute Maximum Ratings at T _A = 25°C					
Parameter	ASMT-Mx6x / ASMT-MxHx		Units		
DC Forward Current ^[1]	150		mA		
Peak Pulsing Current ^[2]	300		mA		
Power Dissipation	555		mW		
LED Junction Temperature	145		°C		
Operating Ambient Temperature Range	-40 to +120		°C		
Storage Temperature Range	-40 to +120		°C		

Notes:
 1. DC forward current – derate linearly based on Figure 7.
 2. Pulse condition duty factor = 10%, Frequency = 1kHz

Optical Characteristics (T _A = 25°C)					
Part Number	Color	Correlated Color Temperature, CCT (Kelvin)		Viewing Angle 2θ _½ ^[1]	Luminous Efficiency
		Min	Max	(Degrees)	(lm/W)
ASMT-MW62-NGJ00	Cool White	4000	10000	Typ	Typ
ASMT-MW62-NHK00		4000	10000	110	83
ASMT-MY62-NGJ00	Warm White	2600	4000	110	99
				110	77

Notes:
 1. θ_½ is the off-axis angle where the luminous intensity is ½ the peak intensity.

Electrical Characteristic (T _A = 25°C)				
Dice Type	Forward Voltage V _F (Volts) @ I _F = 150mA		Reverse Voltage V _R (Volts)	Thermal Resistance R _{θj-ms} (°C/W) ^[1]
	Typ.	Max.	Max.	Typ.
InGaN	3.3	3.7	5	27

Note:
 1. R_{θj-ms} is Thermal Resistance from LED junction to metal slug.

Digikey Part no: 516-2266-5-ND
 Manufacturer part no: ASMT-MWH2-NFH00
 Data sheet source: <http://www.avagotech.com/docs/AV02-1319EN>

2. [1 mark] What is the resistance, in ohms, of a resistor whose colour bands are:
gold, black, black, brown ?

10Ω

3. [2 marks] How much power is converted to heat when a 10Ω resistor has 100mA flowing through it? Show all your work.

[1 mark] $V = I \times R = 0.1 \times 10 = 1 \text{ Volt}$

[1 mark] $P = V \times I = 1 \times 0.1 = 0.1 \text{ Watt}$

4. [1 mark] What colour bands would appear on a 680KΩ resistor?

blue, grey, yellow, {tolerance band} (eg. gold)

5. [6 marks + 2 **Bonus**] Write a simple program for the Teensy which will take a reading of the voltage on pin 1, once per second, and “type” that into the host computer system running some sort of text editor or work processor. Note that measurements must be “typed” as the value in the range of 0 to 5 (volts). For any defaults, be sure to **include a comment** about it or them.

Bonus: Ensure the file is saved to disk after each value; include enough lines of code, reasonably close to being correct, to **convincingly** show that you know what to do.

```
void setup() {  
    pinMode( 1, input ); // [1 mark for pinMode()]  
}  
void loop() { // [1 mark for program structure setup(), loop()]  
    int reading;  
    float voltage;  
  
    reading = analogRead( 1 ); // [1 mark for analogRead()]  
    voltage = ((float) reading / 1023.0 ) * 5.0; // [1 mark for conversion]  
    Keyboard.println( voltage ); // [1 mark for typing to host]  
  
    Keyboard.set_modifier( MODIFIERKEY_CTRL );  
    Keyboard.set_key1( KEY_S );  
    Keyboard.send_now(); // [1 mark for setting up CTRL+S]  
    Keyboard.set_modifier( 0 );  
    Keyboard.set_key1( 0 );  
    Keyboard.send_now(); // [1 mark for restoring keyboard to default state]  
  
    delay( 1000 ); // [1 mark for correct delay in ms]  
}
```

6. [2 marks] Think about an ordinary kitchen fridge and its basic operation to keep food at a (*reasonably*) constant temperature. how would you characterize: (**A**) the temperature sensing method; and (**B**) the control of the cooling mechanism. Refer to “analog” and “digital” and any specific implementations of these two.

**temperature sensing = analog (converted to digital)
cooling = PWM (digital emulation of analog)**

7. [1 mark] Give a **clear** definition of the term "analog" when referring to electronic signals.

**A current or voltage that varies continuously with time
and has no abrupt transitions between levels.**

8. [1 mark] Which is a faster data transfer method on the Teensy, the keyboard emulation or serial mode?

serial

9. [1 mark] Your lab kit includes only the resistor values 220Ω , 330Ω , $1K\Omega$, and $10K\Omega$. A project requires a resistance as close as possible to 80Ω . How can you obtain that value?

4 x 330 ohm in parallel = 82.5

10. [1 mark] You used a photocell light sensor in the theramin project for Lab 7. Did the resistance go up or down when light was shone on it?

resistance goes down with increasing light

(Continued on next page)

11. [7 marks] You have a project where you need to acquire (ie. receive) a stream of serial data. Unfortunately, the Arduino is too slow to capture each data bit, so you decide to use a shift register. The data **bits** are available as an electrical signal (normal 0-5V) but the data **clock** is available only as a flash of light. The resistance of your photocell light sensor varies between 1K Ω – 1M Ω with the light pulse (choose whichever value you like for light / no light).

The control and data signals for the 74HC575 shift register are:

- SER = SERIAL input data
- SRCLK = Shift Register CLock, rising edge triggered
- RCLK = output Register CLock, rising edge triggered
- \overline{OE} = Output Enable (active low)
- $Q_A - Q_H$ = parallel data output

You must create a basic circuit diagram showing how things will be connected, including the following items:

A. [1 mark] **Clearly** show how you will arrange the photocell and another resistor to create a signal that varies from (close to) 0V to (close to) 5V when a light pulse occurs. **Clearly** indicate your assumption about how the photocell resistance changes with increased light.

B. [1 mark] **Clearly** show the connection from the photocell circuit to a suitable shift register pin. Label the pin by its signal name. Connect this same signal to some pin on the Arduino (just pick some number so you can reference it in your code below). 'HC575 = SRCLK

C. [2 marks] **Clearly** show all necessary shift register connections: data signals, control signals, and connections to the Arduino. Identify shift register pins by name, and choose numbers for Arduino pins (so they can be referenced in your code below).

D. [3 marks] Write a snippet of Teensy code to poll the photocell input. (1)When it goes High for the 8th time, activate the shift register so the serial data is available on the output pins and then (2) read this data. [You may use approximate / pseudo code for (2), but it must be very **clear** !]

A. The photocell resistance *decreases* with increased light, so there should be a **series circuit** with the photocell connected between 5V and the fixed resistor, and the other end of the fixed resistor connects to ground.
If you assumed the photocell resistance *increases* with increased light, then the fixed resistor goes between 5V and the photocell, and the other end of the photocell goes to ground. In either case, the output signal is taken from the junction point between the two components. Although not required by the question, the fixed resistor could be any value from 10K – 100K.

B. Connect the output of the above circuit to the **SRCLK pin** on the shift register. For the purposes of illustration, it will also connect to pin 10 on the Teensy.

C. Data pins ($Q_A - Q_H$) go from the Teensy to the Arduino (eg. to pins 1-8).
The \overline{OE} signal goes to ground; we always want the shift register outputs enabled.
The **RCLK** signal comes from the Teensy (eg. from pin 9)
(The SRCLK connection is already described above.)
The “data bits” signal goes to the SER input on the shift register.

(Continue your work from the previous question on this page)

- D. 1 mark = counting 8 pulses; 1 mark = xfer data from input to output stage of shift register;
1 mark = reading data byte from shift register

```
// Count 8 pulses: each pulse starts with a HIGH and finishes with a LOW
Loop 8 times
  While ( digitalRead(10) == LOW )
    ; // just keep polling, waiting for the pulse to start
  While ( digitalRead(10) == HIGH )
    ; // just keep polling, waiting for the pulse to finish
  {increment loop counter}
end loop

// Transfer data from input to output stage of shift register: Pulse the RCLK signal
#define RCLK 9
digitalWrite( RCLK, HIGH );
digitalWrite( RCLK, LOW );

// Read data byte from shift register
// Assume input pins are all part of Port B, or are numbered 1 to 8
byteVal = PINB
OR
byteVal = 0
for ( i = 1; i <=8; i++ ) {
  byteVal = (byteVal << 1) & digitalRead( i );
}
```