Analog to Digital Conversion with Galileo: Photocell Circuit

Presented by

Phathom Donald and Alexis Wells

3.31.14

EECE494 Computer Bus and SoC Interfacing

Department of Electrical and Computer Eng

Howard University

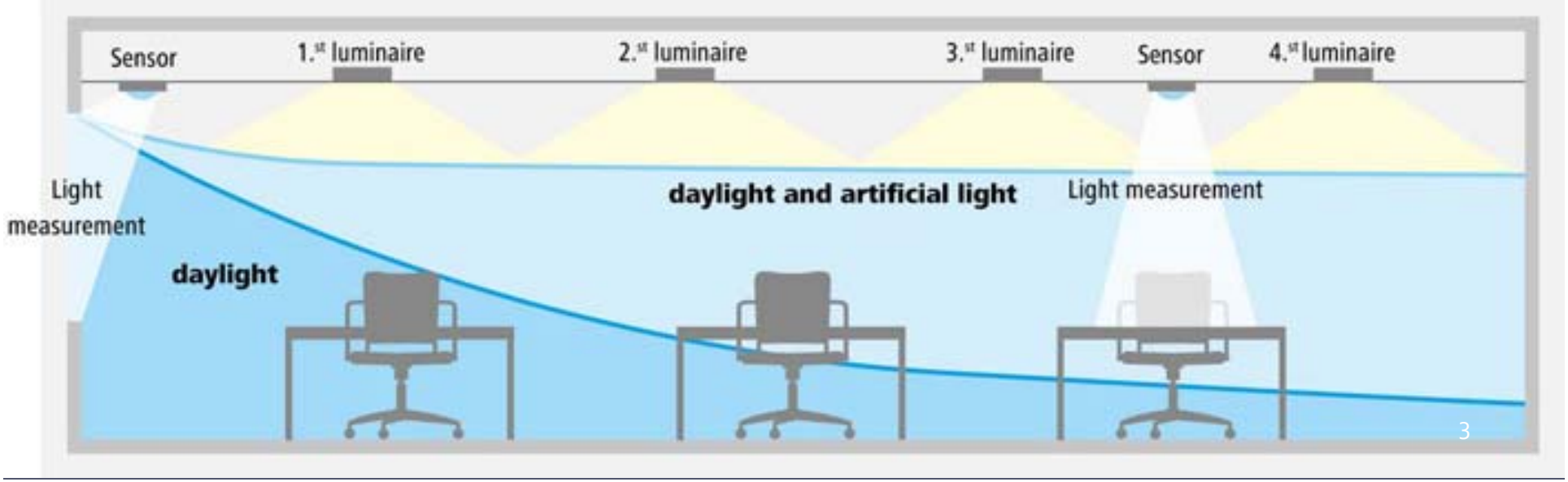
Instructor: Dr. Charles Kim

Introduction

- A photocell will detect light.
- As the amount of light detected increases, the amount of light emitted from the LED decreases, and vice versa.
- Input voltages (0 volts to 5 volts), along with level of brightness, will be displayed on Serial Monitor

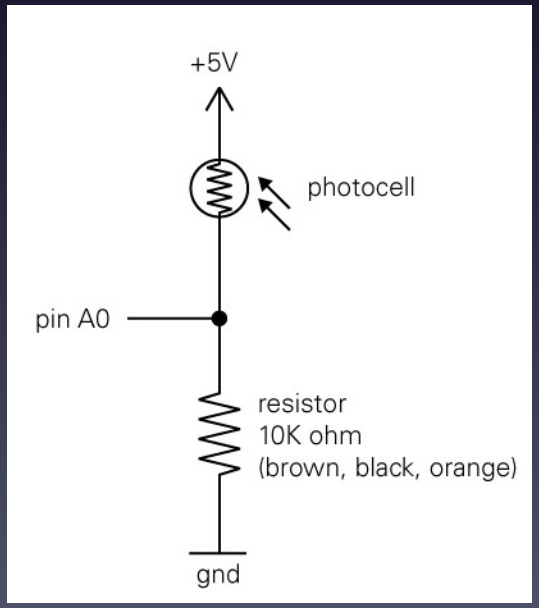
Idea Formation

Daylight harvesting systems reduce energy consumption by optimizing the use of daylight and reducing the amount of electric lighting needed to light a space.



Principle

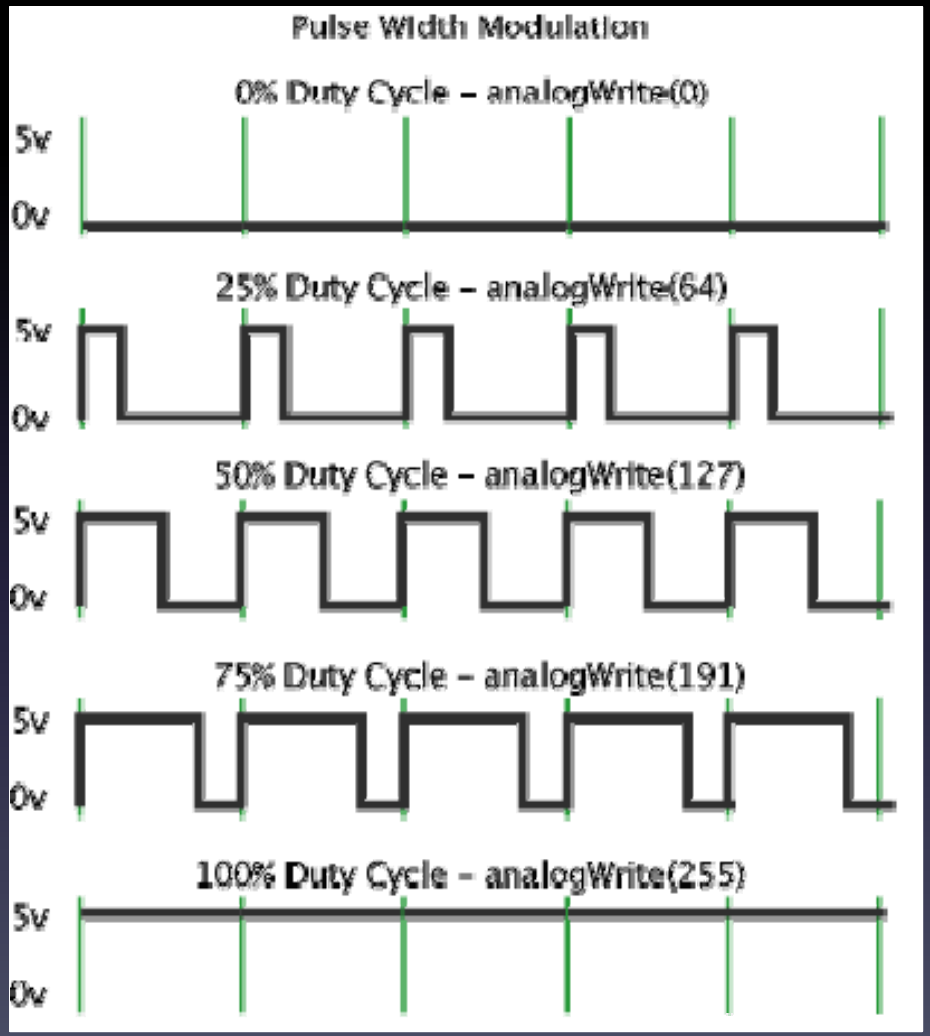
- **Photocell:** A light-controlled variable resistor. Its resistance decreases with increasing incident light intensity.



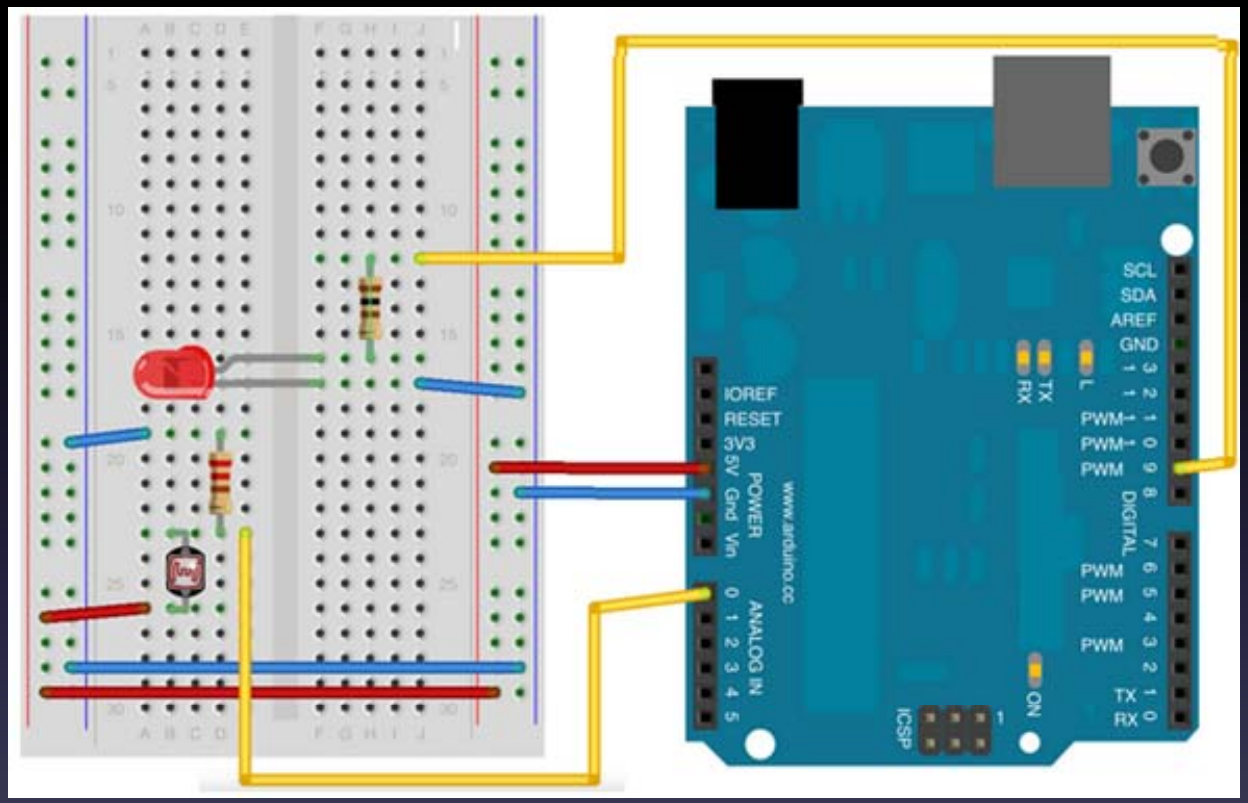
Principle

Pulse Width Modulation (PWM):

- Used for getting analog results with digital means.
- Digital control is used to create a square wave, a signal switched between on and off.
- This pattern simulates voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off.



Setup & Materials



Materials:

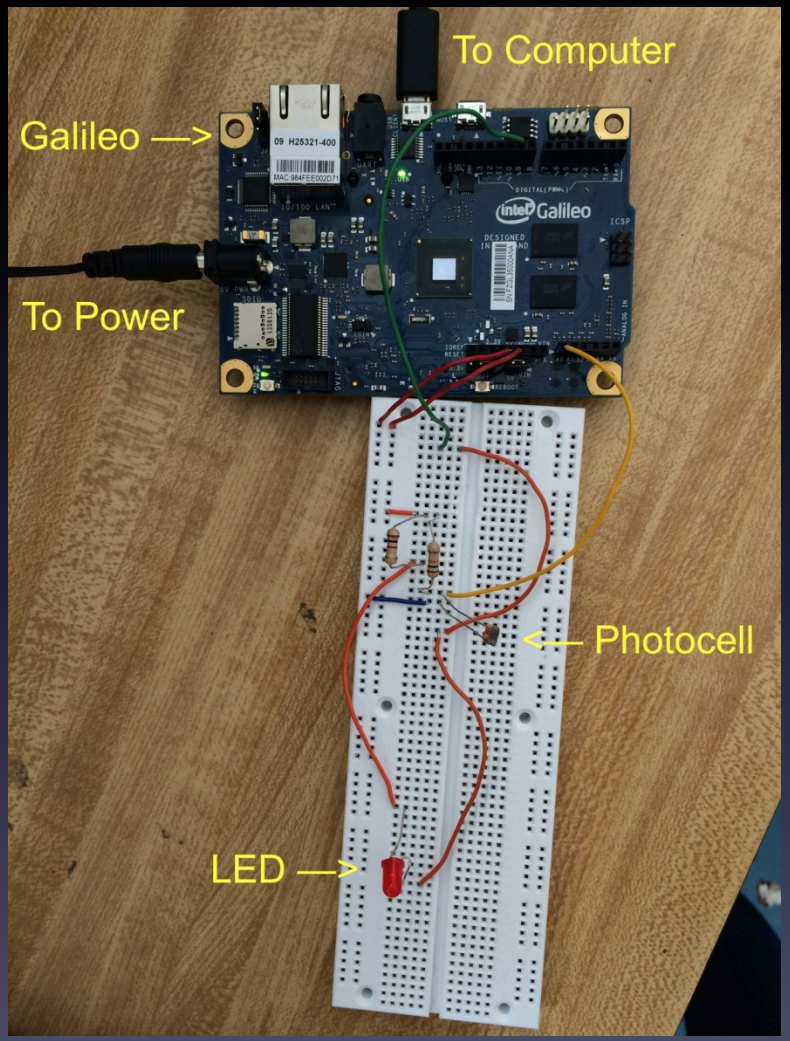
- 1 Galileo board
- 1 Photocell
- 1 LED
- 2 Resistors
  - 1 kΩ (LED)
  - 10 kΩ (Photocell)
- Wires

Setup:

- Connect anode (+) of LED to pin 9 (PWM) of Galileo board
- Connect of photocell to pin AO (analog input) of Galileo board

Step 1 – Set Up Circuit

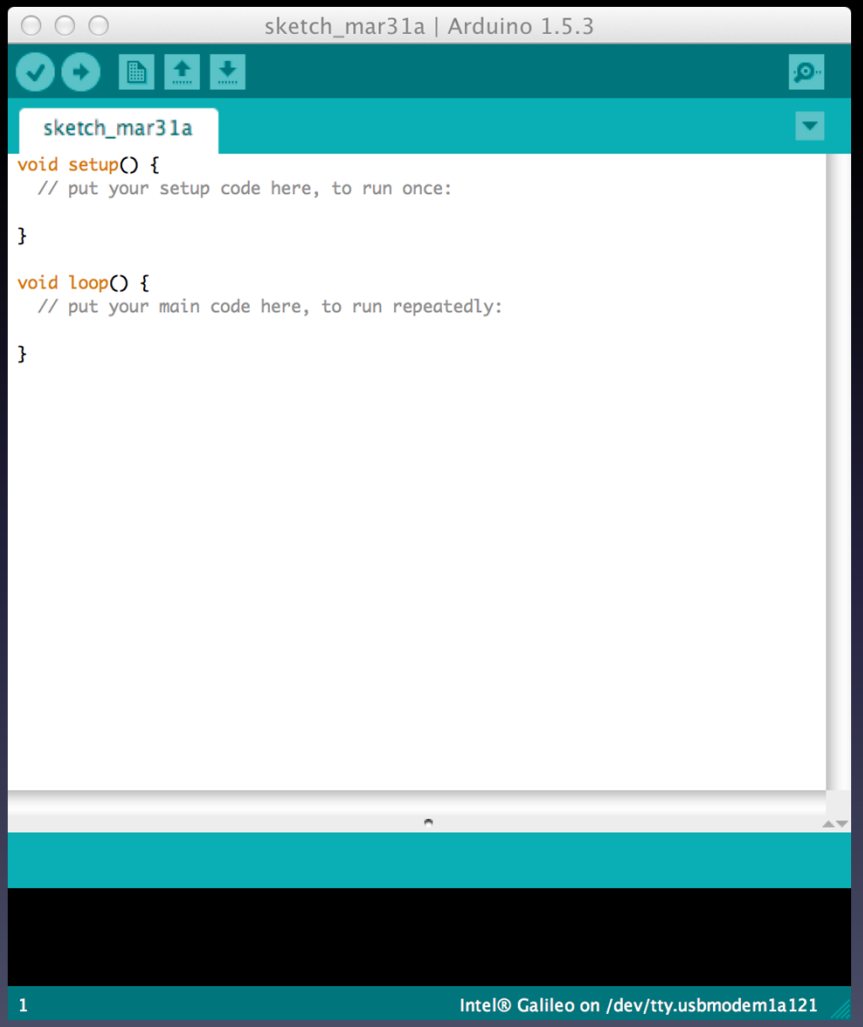
- One pin of the photocell is connected to both GND, through a resistor, and the analog input pin, AO.



Step 2 – Open New Galileo Sketch

- Verify: To check for errors in the code

- Upload: To send code to Galileo board



Step 3 – Pin Assignments

```
int photoPin = A0; // The photocell is connected to pin AO
int ledPin = 9;    // The LED is connected to PWM pin 9
int photoValue;    // The analog reading from the photocell
int LEDbrightness; // The LED brightness
```

- The photocell acts as an analog input to the Galileo board, and is therefore connected to the analog pin, AO.
- The LED acts as an digital (PWM) output, and is therefore connected to the digital pin, 9.

Step 4 – Setup Routine

```
void setup() {

  // Initialize serial communications at 9600 bps:
  Serial.begin(9600);

}
```

- begin(): Sets the data rate in bits per second for serial data transmission.
- Communication between the Galileo board and the computer is initialized at a data rate of 9600 bps.

Step 5 – Loop Routine

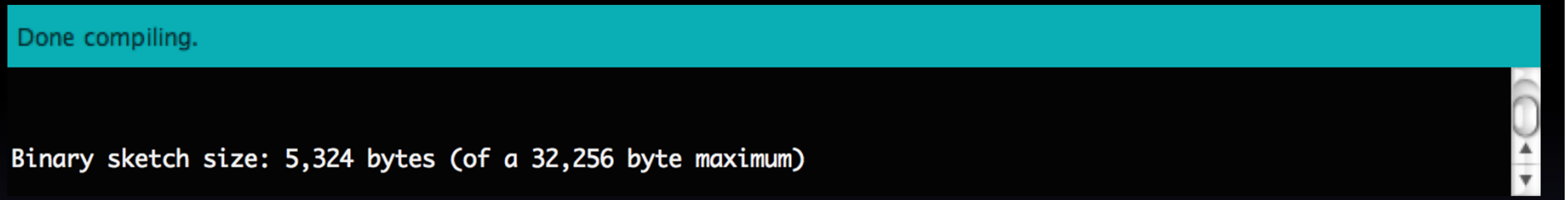
```
void loop() {
  // Read the analog in value:
  photoValue = analogRead(photoPin);
  // Display photocell analog readings in Serial Monitor
  Serial.print("Photocell reading = ");
  Serial.print(0.0049*photoValue); // There are 5 volts per 1024 units (0.0049 volts per unit)
  Serial.print(" V");

  if (photoValue < 10) {
    Serial.println(" - Dark");
  }
  else if (photoValue < 200) {
    Serial.println(" - Dim");
  }
  else if (photoValue < 500) {
    Serial.println(" - Light");
  }
  else if (photoValue < 800) {
    Serial.println(" - Bright");
  }
  else {
    Serial.println(" - Very bright");
  }
  // LED gets brighter the darker it is at the sensor
  photoValue = 1023 - photoValue; // Reading from 0-1023 is inverted to 1023-0
  //Map 0-1023 to 0-255 (the range of analogWrite)
  LEDbrightness = map(photoValue, 0, 1023, 0, 255);
  analogWrite(ledPin, LEDbrightness);
  delay(10);
}
```

- analogRead(): Reads the value from the specified analog pin.
- analogWrite(): Writes an analog value (PWM wave) to a pin.
- print(): Prints data to the serial port as text.
- map(): Re-maps a number from one range to another.
- delay(): Pauses the program for specified amount of time (miliseconds)

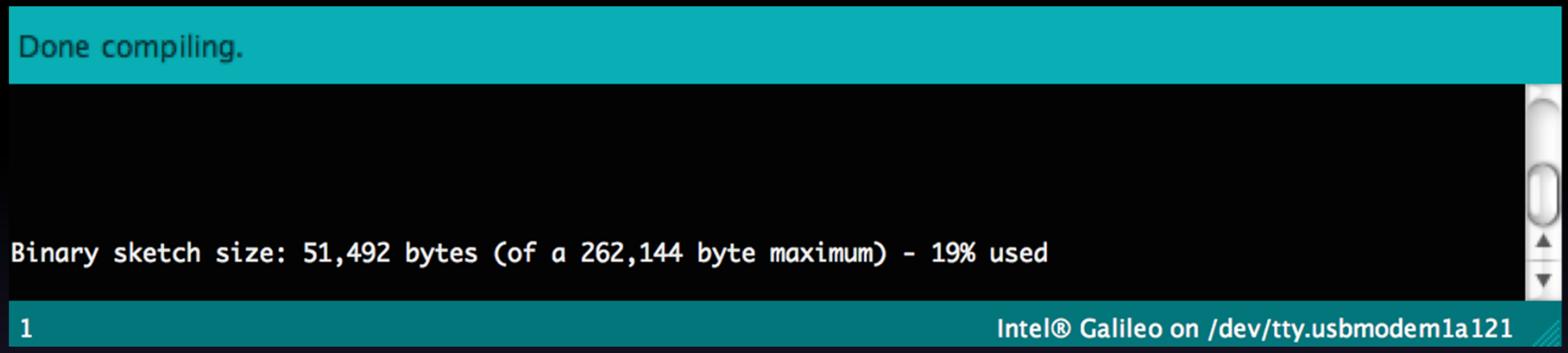
The analog value that is read is converted from integer values (0-1023) to voltage values (0-5V) by multiplying it by 0.0049 [0.0049 (4.9 mV) per unit].

Step 6 – Verify Code



- Verify the code to check for errors
- Errors would be displayed at the bottom of the window

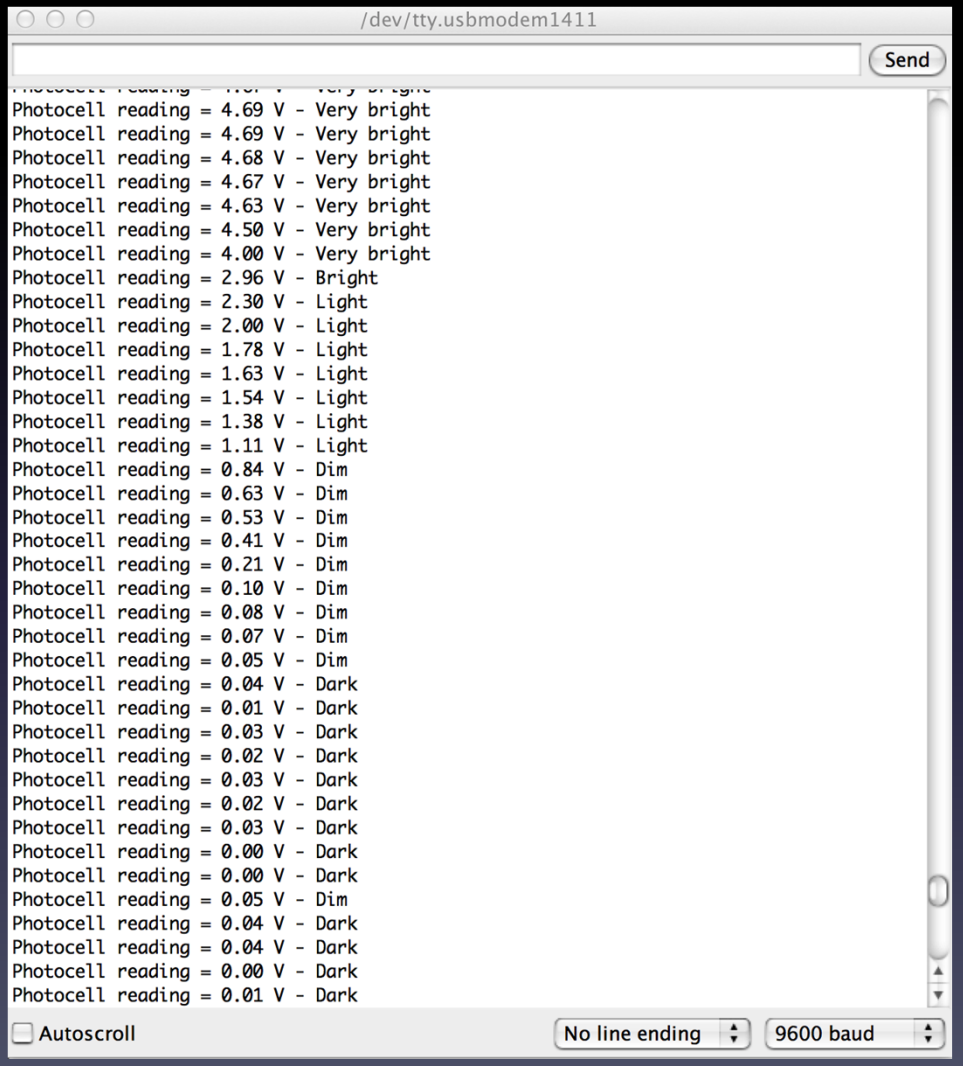
Step 7 – Upload to Galileo



- Send code to Galileo board via USB
- If unknown, serial port can be found by:
  - Tools -> Serial Ports -> /dev/tty.usbmodel1a121

Step 8 – Serial Monitor

- Tools -> Serial Monitor
- Change in input voltage and light intensity is displayed every 10 milliseconds



Conclusion

- Using a photocell and LED with Galileo is a great hands-on introduction to analog to digital conversion.
- Tip: Test different photocells to find the one that is most operable.

References

- http://en.wikipedia.org/wiki/Daylight_harvesting
- http://www.omslighting.com/rightlight/1597/
- http://arduino.cc/en/Tutorial/PWM
- http://arduino.cc/en/Reference/analogRead
- http://arduino.cc/en/Reference/analogWrite
- http://arduino.cc/en/Serial/begin
- http://arduino.cc/en/Reference/delay
- http://arduino.cc/en/reference/map
- http://arduinoarts.com/2011/08/tutorial-led-controlled-by-photo-sensor/
- http://learn.adafruit.com/photocells/using-a-photocell