Principles and Applications of Microcontrollers

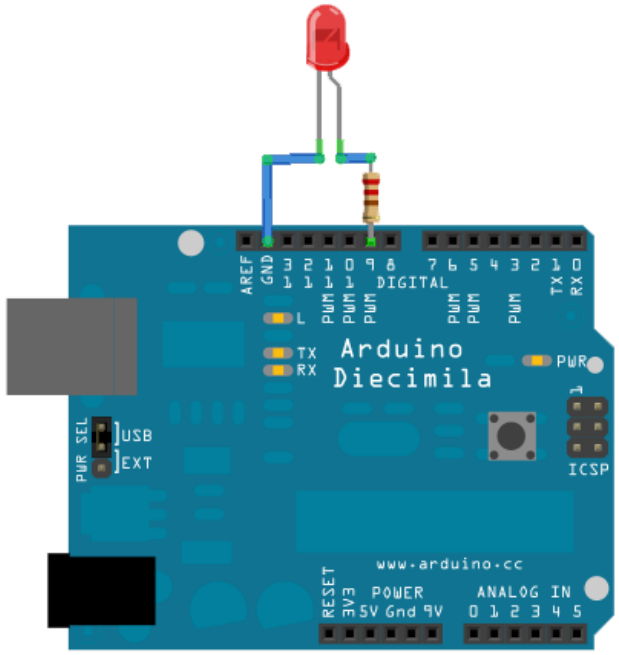
Yan-Fu Kuo
Dept. of Bio-industrial Mechatronics Engineering
National Taiwan University

Today:

- Advanced Arduino programming
- Arduino PWM

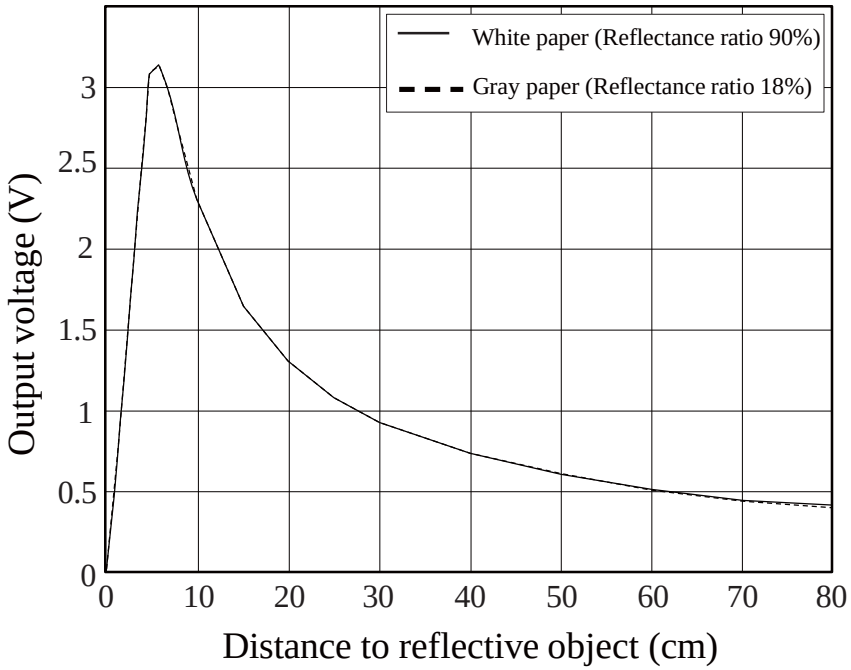
Quiz

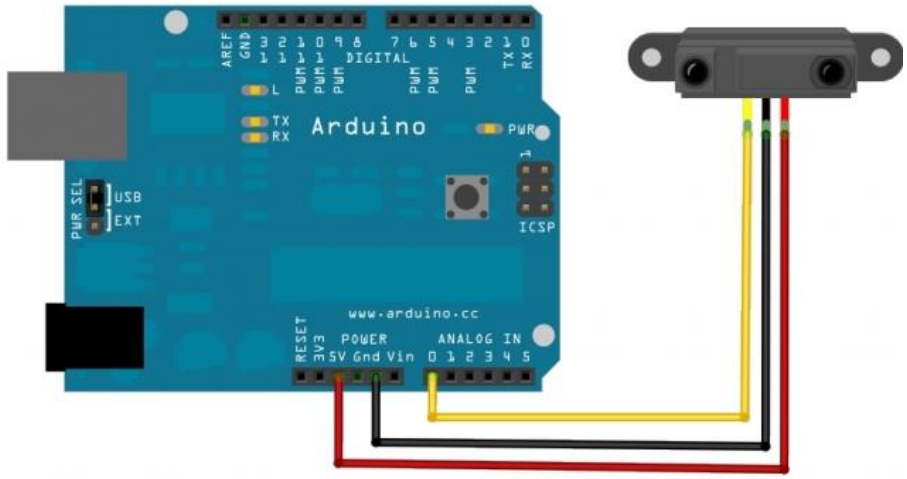
- Build a circuit that composes of an LED
- The LED is connected to a PWM pin
- Increase the brightness of the LED when the key ‘+’ of the computer keyboard is pressed
- Decrease the brightness of the LED when the key ‘-’ of the computer keyboard is pressed



Example – DMS Sensor

- Read distance from proximity sensor
- It is an analog device
- Insusceptible to object color





Sketch Code – DMS Sensor

```
void setup() {
  Serial.begin(9600);   // initialize serial communication at 9600 bits per second
}

void loop() {
  int sensorValue = analogRead(A0);  // read the input on analog pin 0
  Serial.println(sensorValue);       // print out the value you read
  delay(100);                        // wait for 1000 milliseconds
}
```

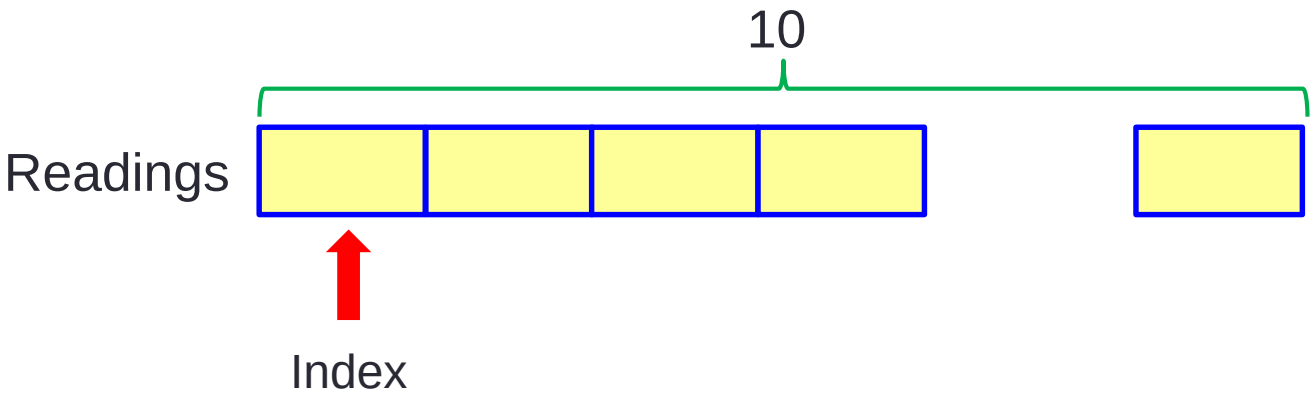
What is the minimum and maximum analogRead values?

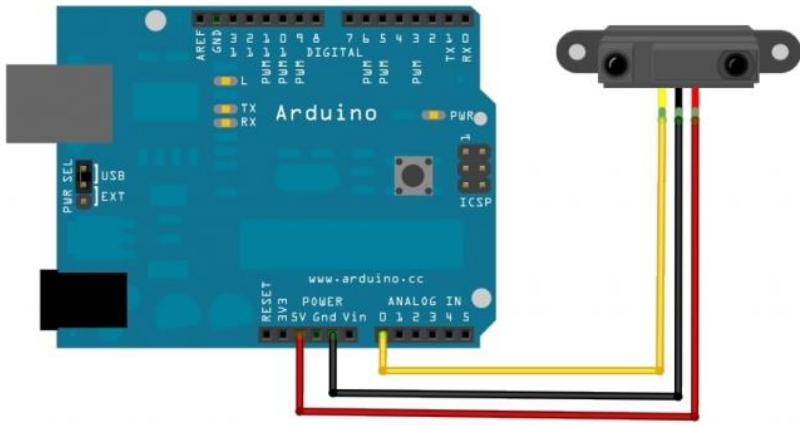
Practice – Fading LED according to Distance

- Fad an LED according to the distance from an proximity sensor
- Fad off the LED when the proximity sensor reading is small; fad on the LED when the reading is large

Example – Smoothing

- Calculate a running average of an analog signal and print it on the computer screen





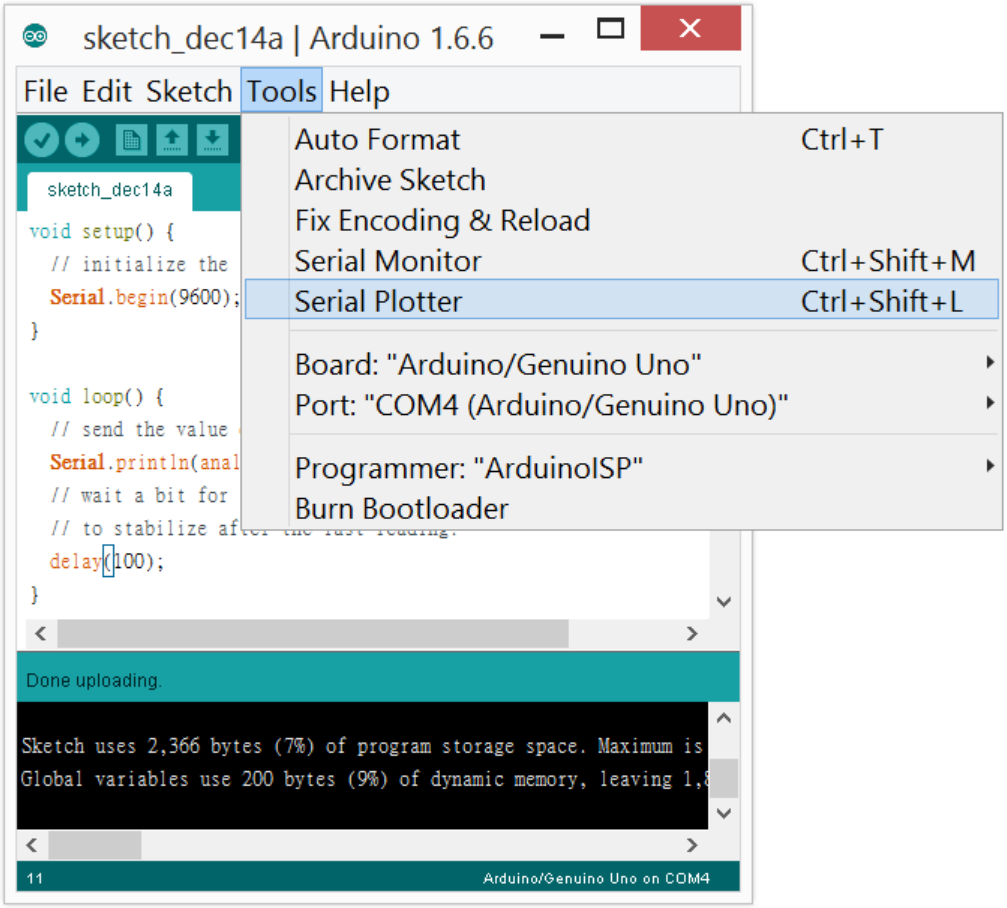
Sketch Code – Smoothing

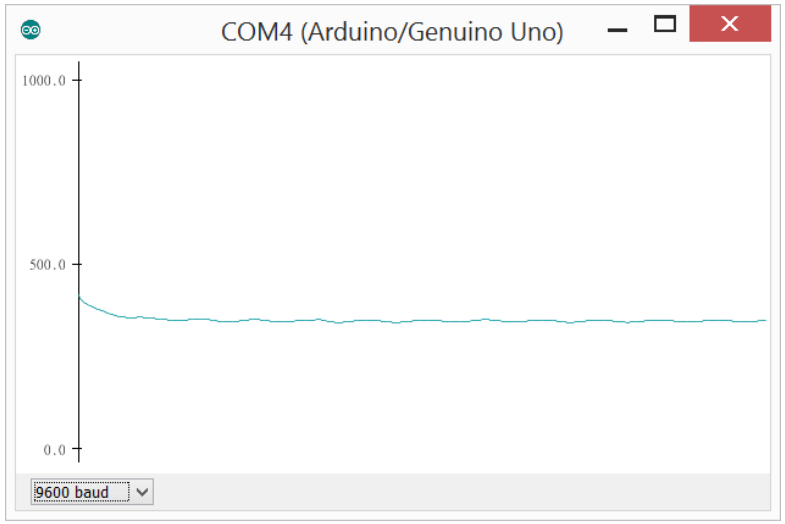
Link

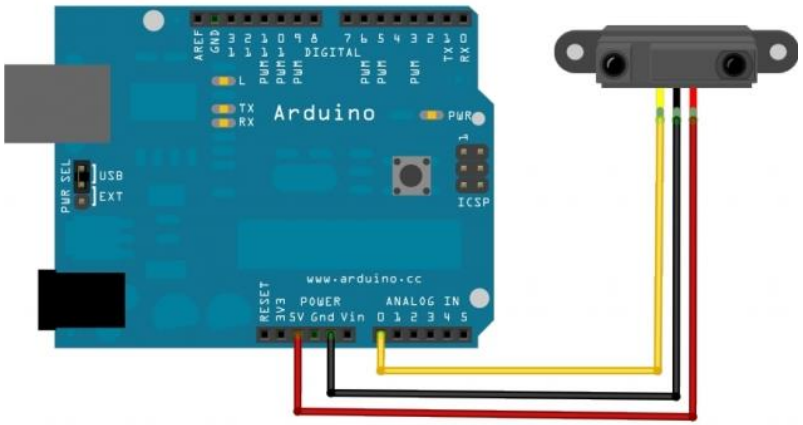
```
const int numReadings = 10;
int readings[numReadings];                    // the readings from the analog input
int readIndex = 0;                            // the index of the current reading
int total = 0;                                // the running total
int average = 0;                              // the average
int inputPin = A0;
void setup() {
  Serial.begin(9600);
  for (int thisReading = 0; thisReading < numReadings; thisReading++) {  // initialize
    readings[thisReading] = 0;
  }
}
void loop() {
  total = total - readings[readIndex];        // subtract the last reading
  readings[readIndex] = analogRead(inputPin); // read from the sensor
  total = total + readings[readIndex];        // add the reading to the total
  readIndex = readIndex + 1;                  // advance to the next position in the array
  if (readIndex >= numReadings) {             // wrap around to the beginning if at the end
    readIndex = 0;
  }
  average = total / numReadings;              // calculate the average
  Serial.println(average);
  delay(10);
}
```

Example – Serial Plotter

- Plot the analog signals

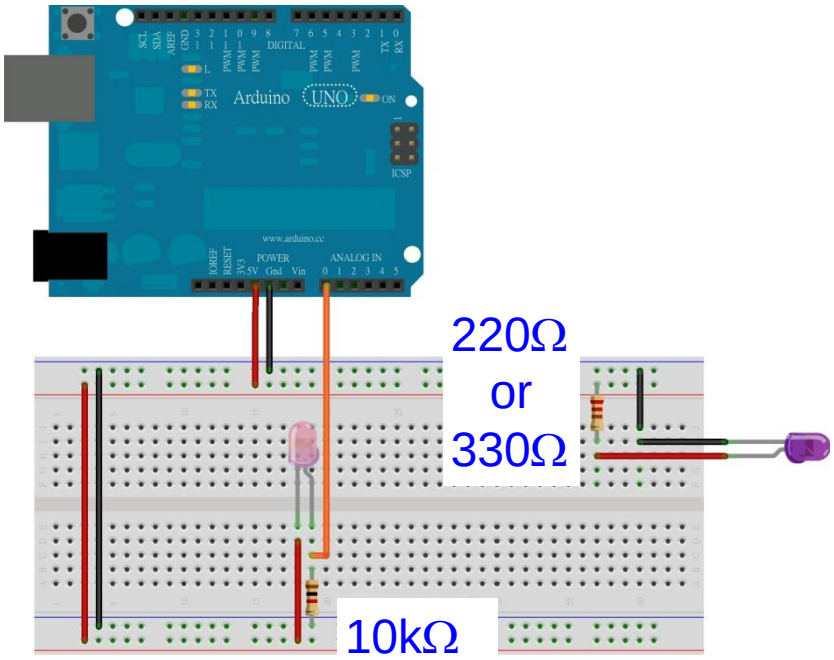


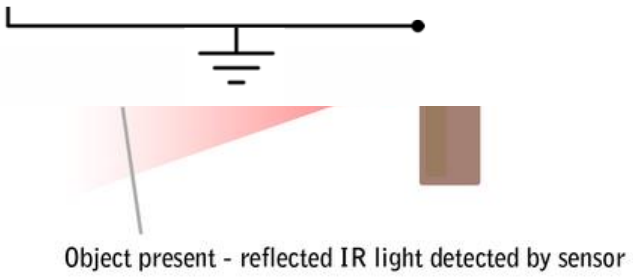




Example – IR Sensor

- An infrared (IR) sensor is an electronic device that emits and detects infrared radiation to sense surroundings
- It is an analog device





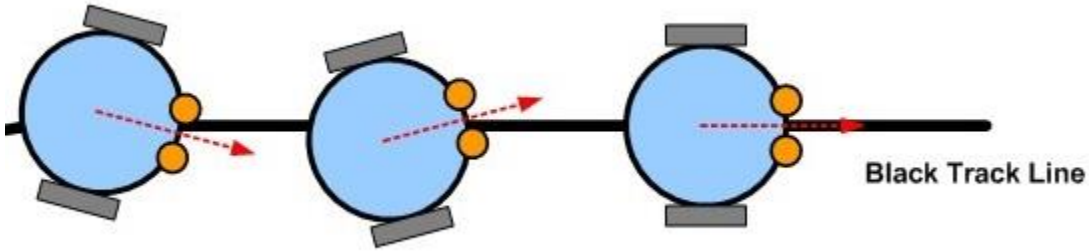
Sketch Code – IR Sensor

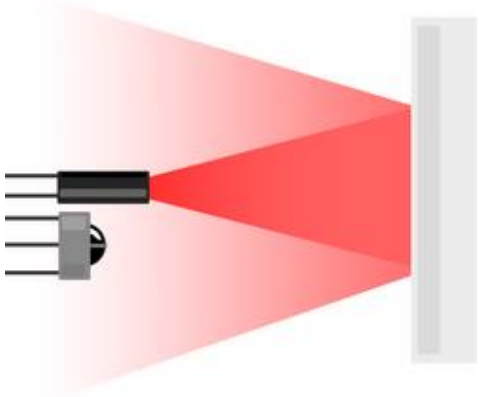
```
void setup() {
  Serial.begin(9600);   // initialize serial communication at 9600 bits per second
}

void loop() {
  int sensorValue = analogRead(A0); // read the input on analog pin 0
  Serial.println(sensorValue);          // print out the value you read
  delay(1000);                          // wait for 1000 milliseconds
}
```

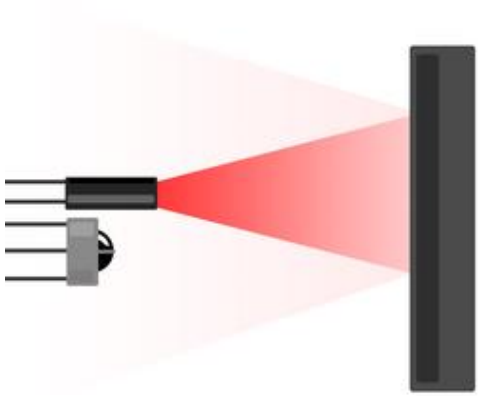
IR Sensor to Detect Brightness

- IR sensors can be used to detect brightness of objects
- An approach to detect black line using two IR sensors:





Lightly colored objects reflect more IR light

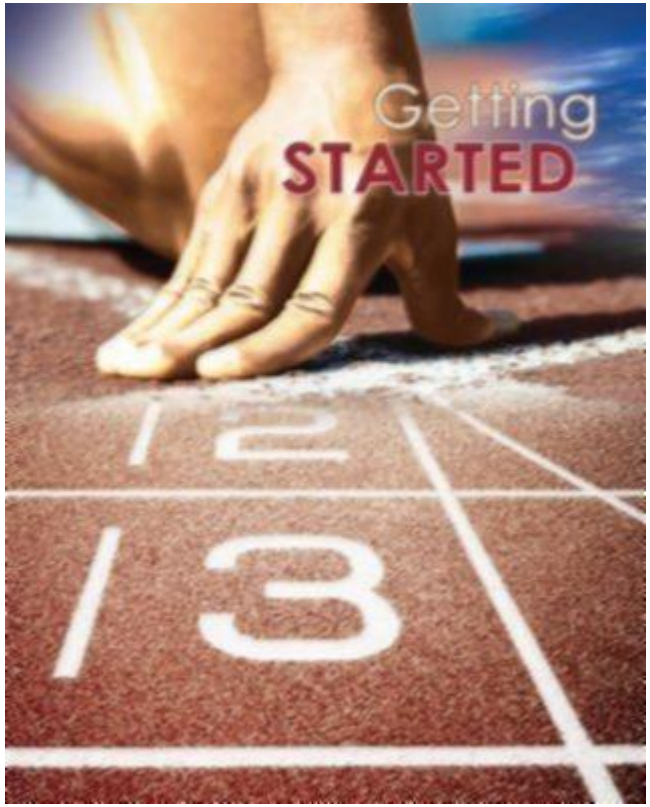


Darker colored object reflect less IR light

What Have We Learned So Far?

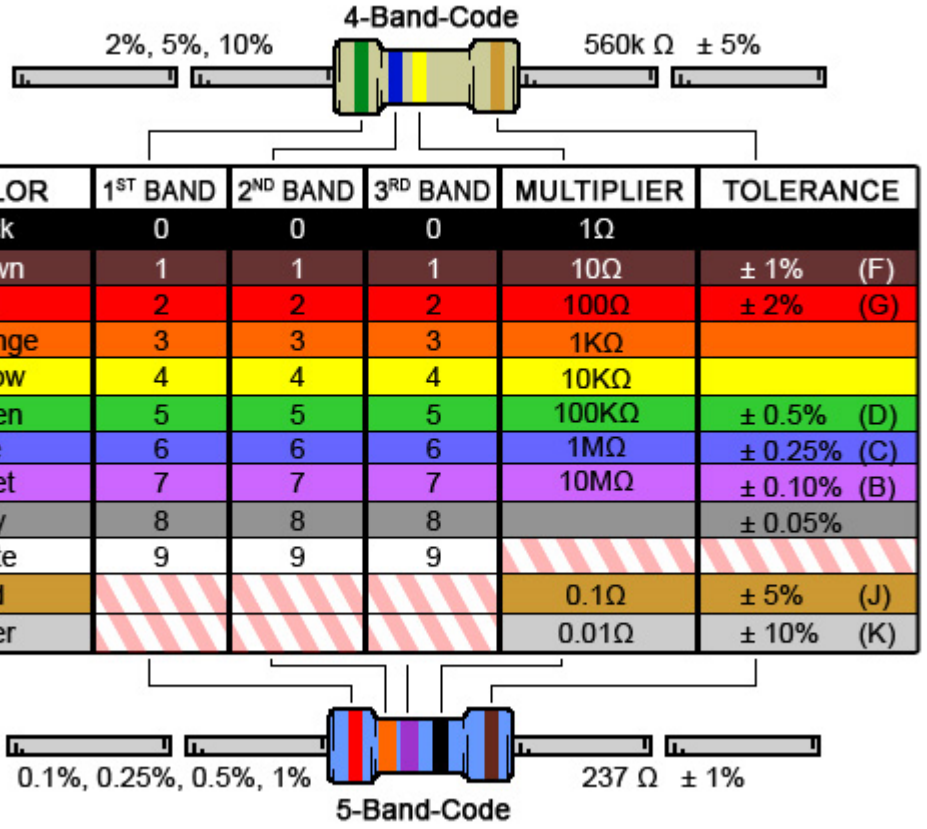
- There is a math library from Arduino
- There is a component in the microcontroller that can approximate digital output to analog one – PWM

Getting Started



Reference

- http://www.arduino.cc/
- ATmega328P data sheet



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)