Al-Mustaqbal University
Department of Medical Instrumentation Techniques Engineering
Class: four
Subject: Advanced logic design
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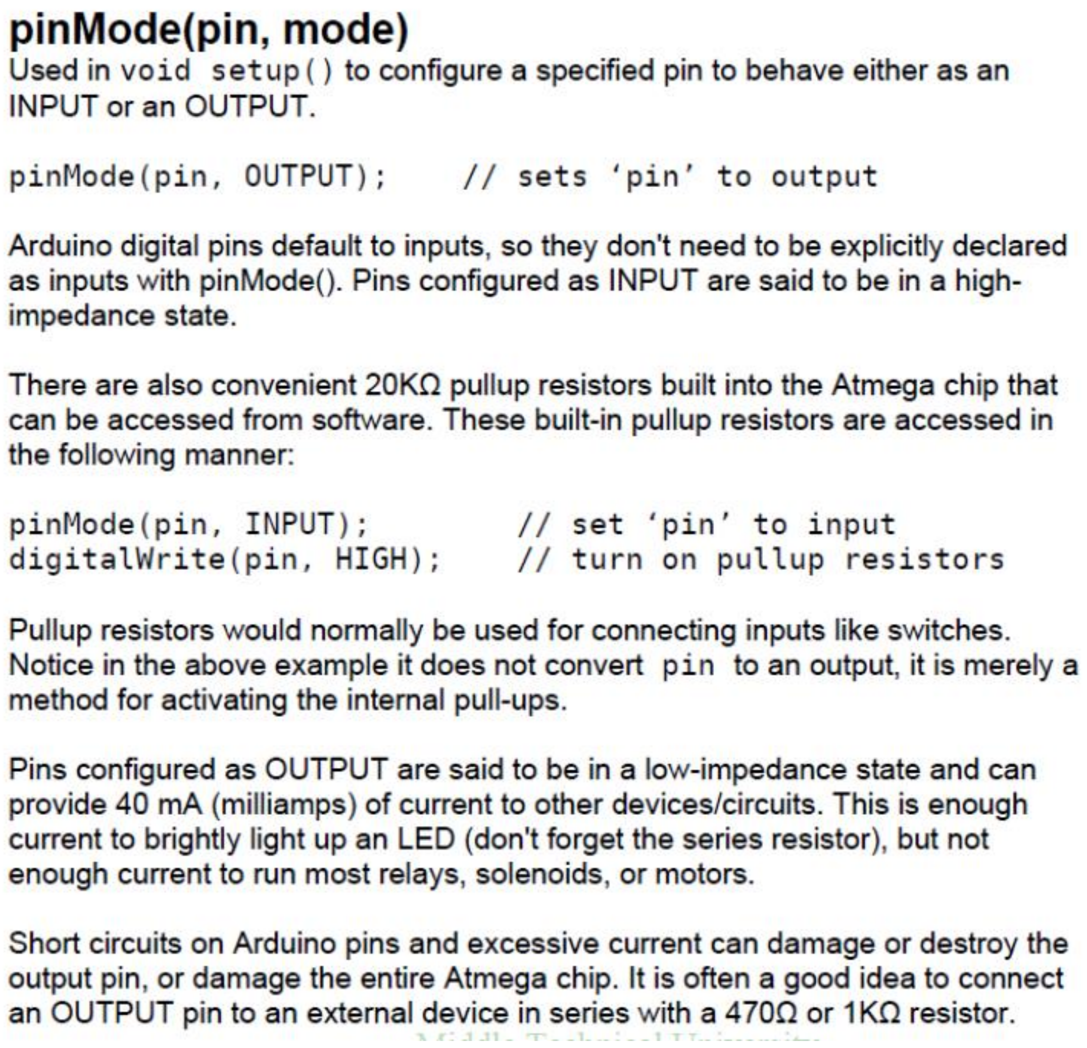
Lecture- 3: Digital and Analog Inputs of Arduino

Digital input/output



pinMode(pin, mode)

Used in `void setup()` to configure a specified pin to behave either as an INPUT or an OUTPUT.

```
pinMode(pin, OUTPUT);    // sets 'pin' to output
```

Arduino digital pins default to inputs, so they don't need to be explicitly declared as inputs with pinMode(). Pins configured as INPUT are said to be in a high-impedance state.

There are also convenient 20KΩ pullup resistors built into the Atmega chip that can be accessed from software. These built-in pullup resistors are accessed in the following manner:

```
pinMode(pin, INPUT);        // set 'pin' to input
digitalWrite(pin, HIGH);    // turn on pullup resistors
```

Pullup resistors would normally be used for connecting inputs like switches. Notice in the above example it does not convert `pin` to an output, it is merely a method for activating the internal pull-ups.

Pins configured as OUTPUT are said to be in a low-impedance state and can provide 40 mA (milliamps) of current to other devices/circuits. This is enough current to brightly light up an LED (don't forget the series resistor), but not enough current to run most relays, solenoids, or motors.

Short circuits on Arduino pins and excessive current can damage or destroy the output pin, or damage the entire Atmega chip. It is often a good idea to connect an OUTPUT pin to an external device in series with a 470Ω or 1KΩ resistor.

digitalRead(pin)

Reads the value from a specified digital pin with the result either HIGH or LOW. The pin can be specified as either a variable or constant (0-13).

```
value = digitalRead(Pin);    // sets 'value' equal to
                             // the input pin
```

digitalWrite(pin, value)

Ouputs either logic level HIGH or LOW at (turns on or off) a specified digital pin. The pin can be specified as either a variable or constant (0-13).

```
digitalWrite(pin, HIGH);   // sets 'pin' to high
```

The following example reads a pushbutton connected to a digital input and turns on an LED connected to a digital output when the button has been pressed:

```
int led   = 13;   // connect LED to pin 13
int pin   =  7;   // connect pushbutton to pin 7
int value =  0;   // variable to store the read value

void setup()
{
  pinMode(led, OUTPUT);     // sets pin 13 as output
  pinMode(pin, INPUT);      // sets pin 7 as input
}

void loop()
{
  value = digitalRead(pin);  // sets 'value' equal to
                             // the input pin
  digitalWrite(led, value);  // sets 'led' to the
}                            // button's value
```

Analog input/output

analogRead(pin)

Reads the value from a specified analog pin with a 10-bit resolution. This function only works on the analog in pins (0-5). The resulting integer values range from 0 to 1023.

```
value = analogRead(pin);  // sets 'value' equal to 'pin'
```

Note: Analog pins unlike digital ones, do not need to be first declared as INPUT nor OUTPUT.

analogWrite(pin, value)

Writes a pseudo-analog value using hardware enabled pulse width modulation (PWM) to an output pin marked PWM. On newer Arduinos with the ATmega168 chip, this function works on pins 3, 5, 6, 9, 10, and 11. Older Arduinos with an ATmega8 only support pins 9, 10, and 11. The value can be specified as a variable or constant with a value from 0-255.

```
analogWrite(pin, value);  // writes 'value' to analog 'pin'
```

A value of 0 generates a steady 0 volts output at the specified pin; a value of 255 generates a steady 5 volts output at the specified pin. For values in between 0 and 255, the pin rapidly alternates between 0 and 5 volts - the higher the value, the more often the pin is HIGH (5 volts). For example, a value of 64 will be 0 volts three-quarters of the time, and 5 volts one quarter of the time; a value of 128 will be at 0 half the time and 255 half the time; and a value of 192 will be 0 volts one quarter of the time and 5 volts three-quarters of the time.

Time and match

delay(ms)

Pauses your program for the amount of time as specified in milliseconds, where 1000 equals 1 second.

```
delay(1000);   // waits for one second
```

millis()

Returns the number of milliseconds since the Arduino board began running the current program as an unsigned long value.

```
value = millis();  // sets ‘value’ equal to millis()
```

Note: This number will overflow (reset back to zero), after approximately 9 hours.

min(x, y)

Calculates the minimum of two numbers of any data type and returns the smaller number.

```
value = min(value, 100); // sets 'value' to the smaller of
                         // 'value' or 100, ensuring that
                         // it never gets above 100.
```

max(x, y)

Calculates the maximum of two numbers of any data type and returns the larger number.

```
value = max(value, 100); // sets 'value' to the larger of
                         // 'value' or 100, ensuring that
                         // it is at least 100.
```

random(max)
random(min, max)

The random function allows you to return pseudo-random numbers within a range specified by min and max values.

```
value = random(100, 200);  // sets 'value' to a random
                           // number between 100-200
```

Note: Use this after using the randomSeed() function.

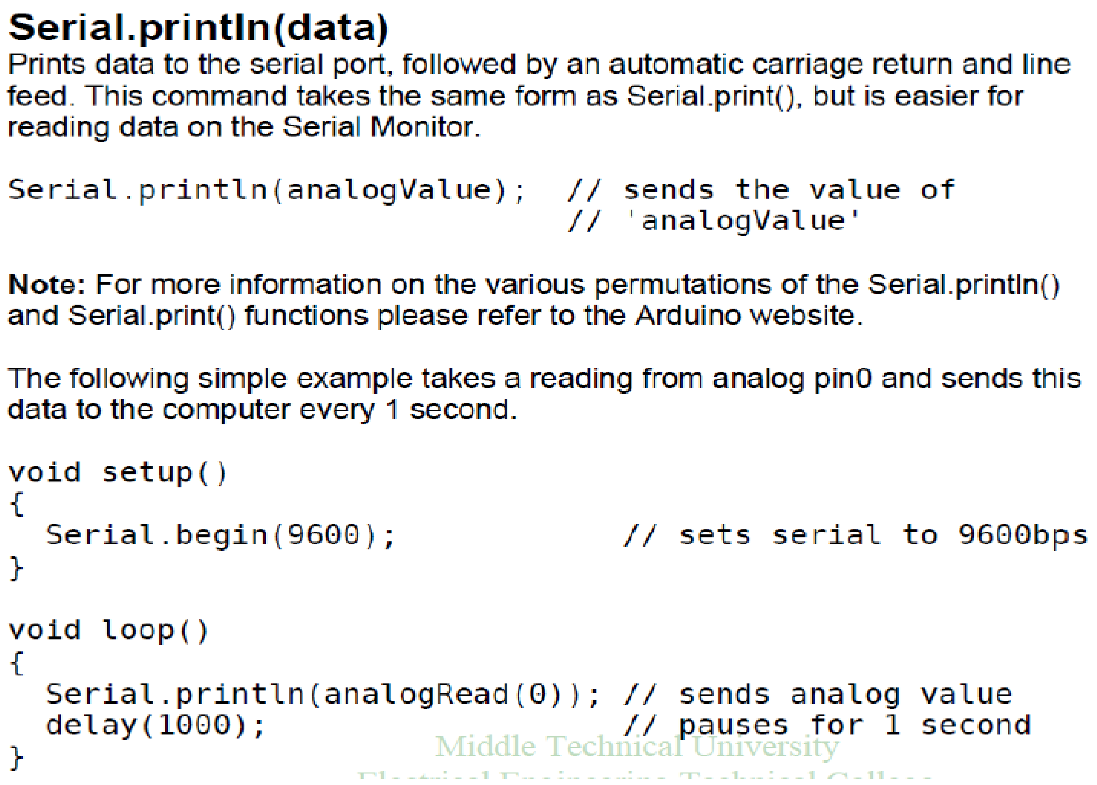
The following example creates a random value between 0-255 and outputs a PWM signal on a PWM pin equal to the random value:

```
int randNumber;  // variable to store the random value
int led = 10;    // LED with 220 resistor on pin 10

void setup() {}  // no setup needed

void loop()
{
  randomSeed(millis());          // sets millis() as seed
  randNumber = random(255);      // random number from 0-255
  analogWrite(led, randNumber); // outputs PWM signal
  delay(500);                    // pauses for half a second
}
```

Serial



Serial.println(data)

Prints data to the serial port, followed by an automatic carriage return and line feed. This command takes the same form as Serial.print(), but is easier for reading data on the Serial Monitor.

```
Serial.println(analogValue);  // sends the value of
                              // 'analogValue'
```

Note: For more information on the various permutations of the Serial.println() and Serial.print() functions please refer to the Arduino website.

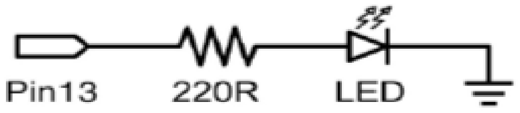
The following simple example takes a reading from analog pin0 and sends this data to the computer every 1 second.

```
void setup()
{
  Serial.begin(9600);              // sets serial to 9600bps
}

void loop()
{
  Serial.println(analogRead(0)); // sends analog value
  delay(1000);                   // pauses for 1 second
}
```

Examples

1- Digital output



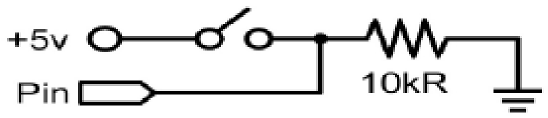
This is the basic 'hello world' program used to simply turn something on or off. In this example, an LED is connected to pin13, and is blinked every second. The resistor may be omitted on this pin since the Arduino has one built in.

```
int ledPin = 13;                 // LED on digital pin 13

void setup()                     // run once
{
  pinMode(ledPin, OUTPUT);       // sets pin 13 as output
}

void loop()                      // run over and over again
{
  digitalWrite(ledPin, HIGH);    // turns the LED on
  delay(1000);                   // pauses for 1 second
  digitalWrite(ledPin, LOW);     // turns the LED off
  delay(1000);                   // pauses for 1 second
}
```

2- Digital input



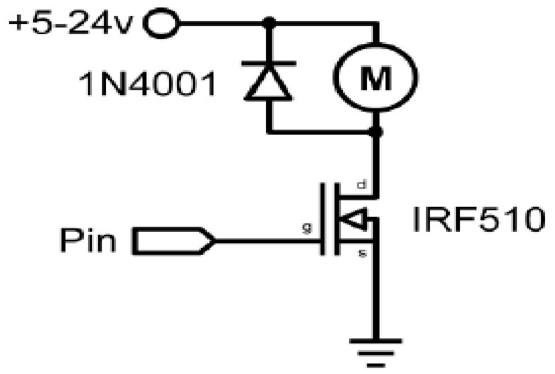
This is the simplest form of input with only two possible states: on or off. This example reads a simple switch or pushbutton connected to pin2. When the switch is closed the input pin will read HIGH and turn on an LED.

```
int ledPin = 13;             // output pin for the LED
int inPin = 2;               // input pin (for a switch)

void setup()
{
  pinMode(ledPin, OUTPUT);   // declare LED as output
  pinMode(inPin, INPUT);     // declare switch as input
}

void loop()
{
  if (digitalRead(inPin) == HIGH) // check if input is HIGH
  {
    digitalWrite(ledPin, HIGH);   // turns the LED on
    delay(1000);                  // pause for 1 second
    digitalWrite(ledPin, LOW);    // turns the LED off
    delay(1000);                  // pause for 1 second
  }
}
```

3- <u>High current output</u>



Sometimes it is necessary to control more than 40ma from the Arduino. In this case a MOSFET or transistor could be used to switch higher current loads. The following example quickly turns on and off the MOSFET 5 times every second.

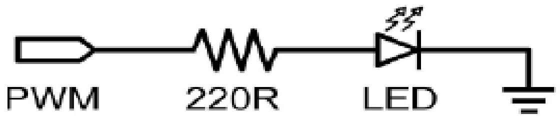
Note: The schematic shows a motor and protection diode but other non-inductive loads could be used without the diode.

```
int outPin  =  5;         // output pin for the MOSFET

void setup()
{
  pinMode(outPin, OUTPUT);      // sets pin5 as output
}

void loop()
{
  for (int i=0; i<=5; i++)      // loops 5 times
  {
    digitalWrite(outPin, HIGH); // turns MOSFET on
    delay(250);                 // pauses 1/4 second
    digitalWrite(outPin, LOW);  // turns MOSFET off
    delay(250);                 // pauses 1/4 second
  }
  delay(1000);                  // pauses 1 second
}
```

4- PWM output



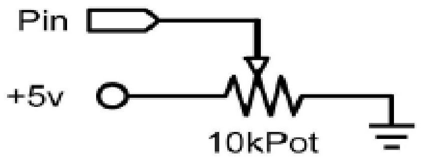
Pulsewidth Modulation (PWM) is a way to fake an analog output by pulsing the output. This could be used to dim and brighten an LED or later to control a servo motor. The following example slowly brightens and dims an LED using for loops.

```
int ledPin  =  9;     // PWM pin for the LED

void setup(){}        // no setup needed

void loop()
{
  for (int i=0; i<=255; i++)  // ascending value for i
  {
    analogWrite(ledPin, i);   // sets brightess level to i
    delay(100);               // pauses for 100ms
  }
  for (int i=255; i>=0; i--)  // descending value for i
  {
    analogWrite(ledPin, i);   // sets brightess level to i
    delay(100);               // pauses for 100ms
  }
}
```

5- Potentiometer input



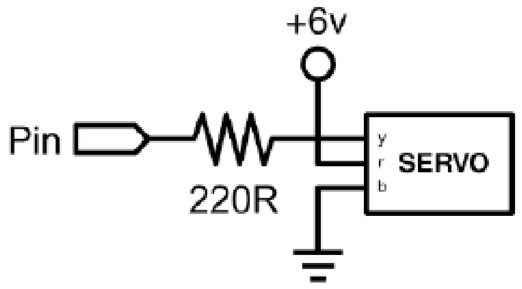
Using a potentiometer and one of the Arduino's analog-to-digital conversion (ADC) pins it is possible to read analog values from 0-1024. The following example uses a potentiometer to control an LED's rate of blinking.

```
int potPin = 0;    // input pin for the potentiometer
int ledPin = 13;   // output pin for the LED

void setup()
{
  pinMode(ledPin, OUTPUT);  // declare ledPin as OUTPUT
}

void loop()
{
  digitalWrite(ledPin, HIGH);    // turns ledPin on
  delay(analogRead(potPin));     // pause program
  digitalWrite(ledPin, LOW);     // turns ledPin off
  delay(analogRead(potPin));     // pause program
}
```

7- Servo output



Hobby servos are a type of self-contained motor that can move in a 180° arc. All that is needed is a pulse sent every 20ms. This example uses a servoPulse function to move the servo from 10° -170° and back again.

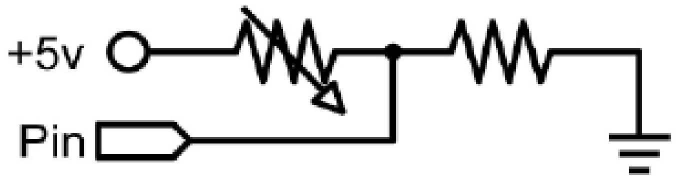
```
int servoPin = 2;    // servo connected to digital pin 2
int myAngle;         // angle of the servo roughly 0-180
int pulseWidth;      // servoPulse function variable

void setup()
{
  pinMode(servoPin, OUTPUT);   // sets pin 2 as output
}

void servoPulse(int servoPin, int myAngle)
{
  pulseWidth = (myAngle * 10) + 600;  // determines delay
  digitalWrite(servoPin, HIGH);       // set servo high
  delayMicroseconds(pulseWidth);      // microsecond pause
  digitalWrite(servoPin, LOW);        // set servo low
}

void loop()
{
  // servo starts at 10 deg and rotates to 170 deg
  for (myAngle=10; myAngle<=170; myAngle++)
  {
    servoPulse(servoPin, myAngle);    // send pin and angle
    delay(20);                        // refresh cycle
  }
  // servo starts at 170 deg and rotates to 10 deg
  for (myAngle=170; myAngle>=10; myAngle--)
  {
    servoPulse(servoPin, myAngle);    // send pin and angle
    delay(20);                        // refresh cycle
  }
}
```

6- Variable resistance input



Variable resistors include CdS light sensors, thermistors, flex sensors, and so on. This example makes use of a function to read the analog value and set a delay time. This controls the speed at which an LED brightens and dims.

```
int ledPin    =  9;    // PWM pin for the LED
int analogPin =  0;    // variable resistor on analog pin 0

void setup(){}        // no setup needed

void loop()
{
  for (int i=0; i<=255; i++)  // ascending value for i
  {
    analogWrite(ledPin, i);   // sets brightess level to i
    delay(delayVal());        // gets time value and pauses
  }
  for (int i=255; i>=0; i--)  // descending value for i
  {
    analogWrite(ledPin, i);   // sets brightess level to i
    delay(delayVal());        // gets time value and pauses
  }
}

int delayVal()
{
  int v;                      // create temporary variable
  v  = analogRead(analogPin); // read analog value
  v /= 8;                     // convert 0-1024 to 0-128
  return v;                   // returns final value
}
```