Interfacing with Sensor Devices

Lecture 3

Embedded Systems

Reference: Chapters 6, Arduino Cookbook, Michael Margolis, 1st Edition, 2011, O'Reilly books

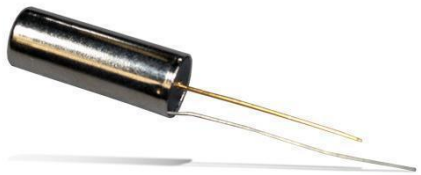
Agenda

- Tilt Sensors
- Light Sensors
- Motion Detection Sensors
- Vibration Detection Sensors
- Audio Sensors
- Temperature Sensors
- Identification Sensors
- Positioning Sensors
- Acceleration Sensors
- Rotation Rate Sensors
- Using PS/2 Mouse Device

Tilt Sensors

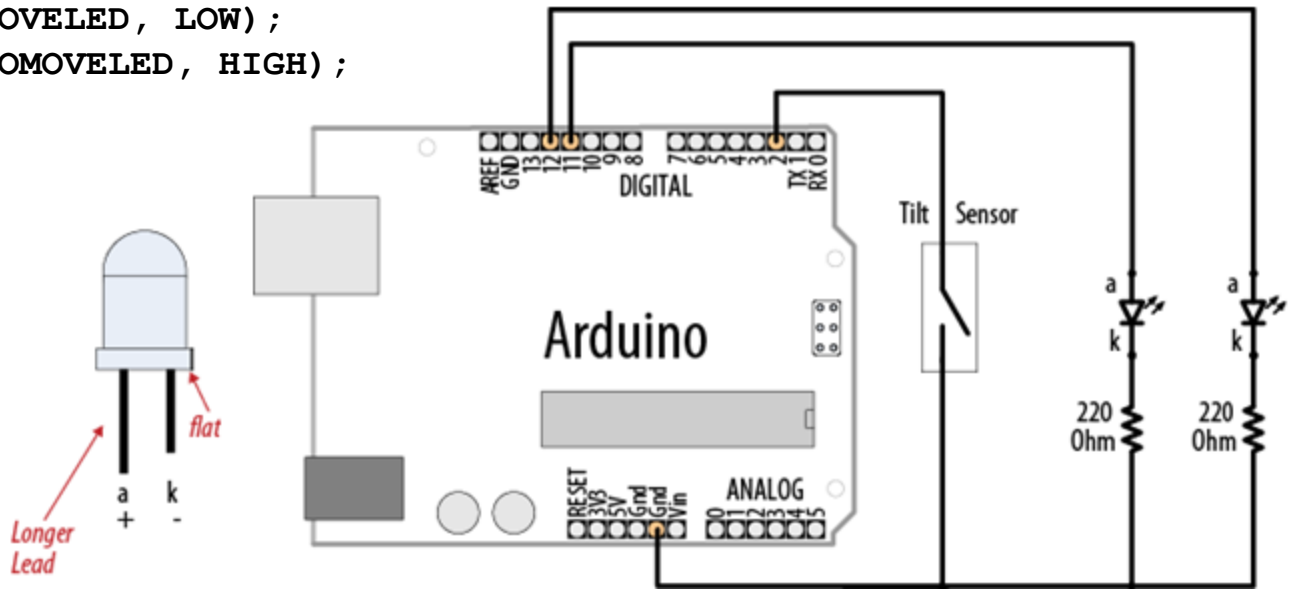
Tilt Sensors

- Sensors
  - Tilt sensor detect inclines using conducting liquid like mercury or rolling ball.
- Models:
  - Rolling Ball Mode: 107-2001-EV from www.mouser.com
  - Mercury Model: CM1320-0 from http://uk.rs-online.com



Tilt Sensors

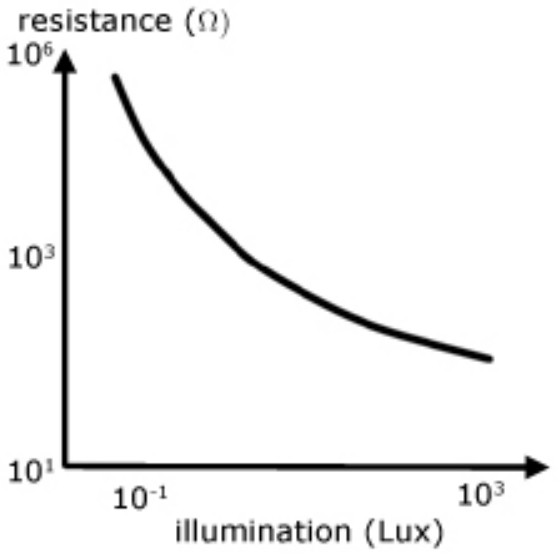
```
#define TILT 2
#define MOVELED 11
#define NOMOVELED 12
void setup()
{
     pinMode (TILT, INPUT);
     digitalWrite (TILT, HIGH);
     pinMode (MOVELED, OUTPUT);
     pinMode (NOMOVELED, OUTPUT);
}
void loop()
{
     if (digitalRead(TILT)){
          digitalWrite(MOVELED, HIGH);
          digitalWrite(NOMOVELED, LOW);
     }
     else{
          digitalWrite(MOVELED, LOW);
          digitalWrite(NOMOVELED, HIGH);
     }
}
```



Light Sensors

Light Sensors : LDR

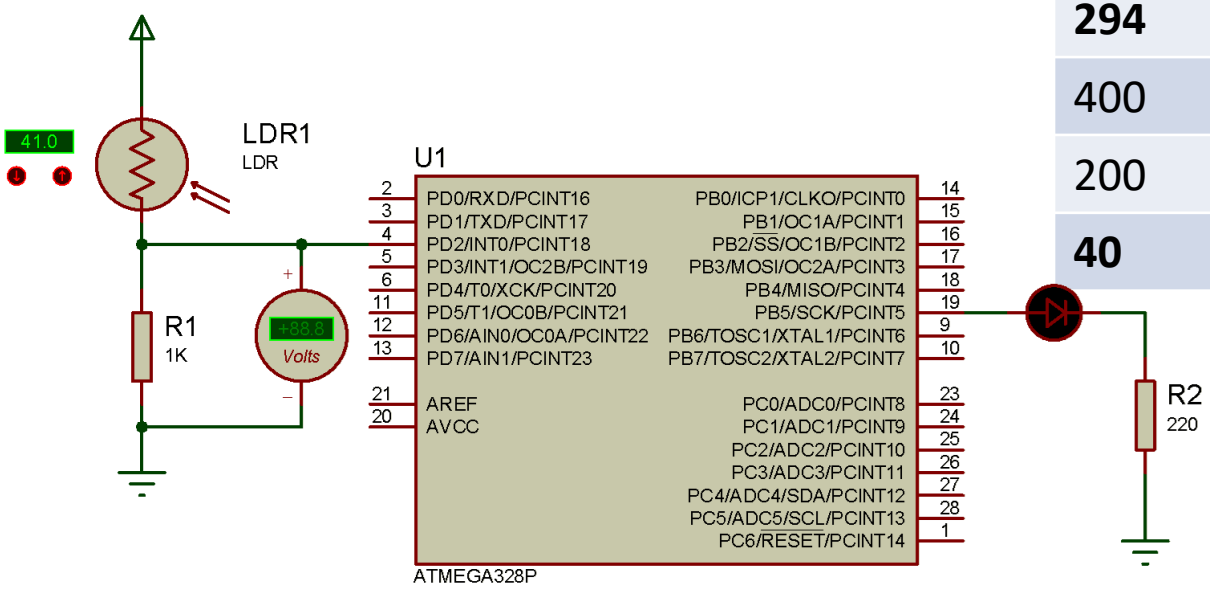
- LDR: Light Dependent Sensor
- Models
  - NSL-19M51 and NORPS-12 from http://uk.rs-online.com
  - SEN11302P from www.fut-electronics.com and http://www.seeedstudio.com
- Woke Idea
  - Variable Resistance Sensitive to Light Intensity
  - Light intensity is measured using Lux
    - Moonless clear night : 0.002 Lux
    - Full Moon clear night : 0.1 Lux
    - Home light : 50 Lux
    - Cloudy day : 100 Lux
    - Office light : 320 → 500 Lux
    - Light while sunrise or sunset : 400 Lux
    - TV studio light : 1,000 Lux
    - Sunny Day (Indirect) : 10,000 → 25,000 Lux
    - Sunny Day (Direct) : 32,000 → 130,000 Lux



Light Sensors : LDR

```
#define LED 13
#define LDR 2
void setup() {
      pinMode(LED, OUTPUT);
      pinMode(LDR, INPUT);
}
void loop(){
      int value = digitalRead(LDR);
      digitalWrite(LED, value);
}
```

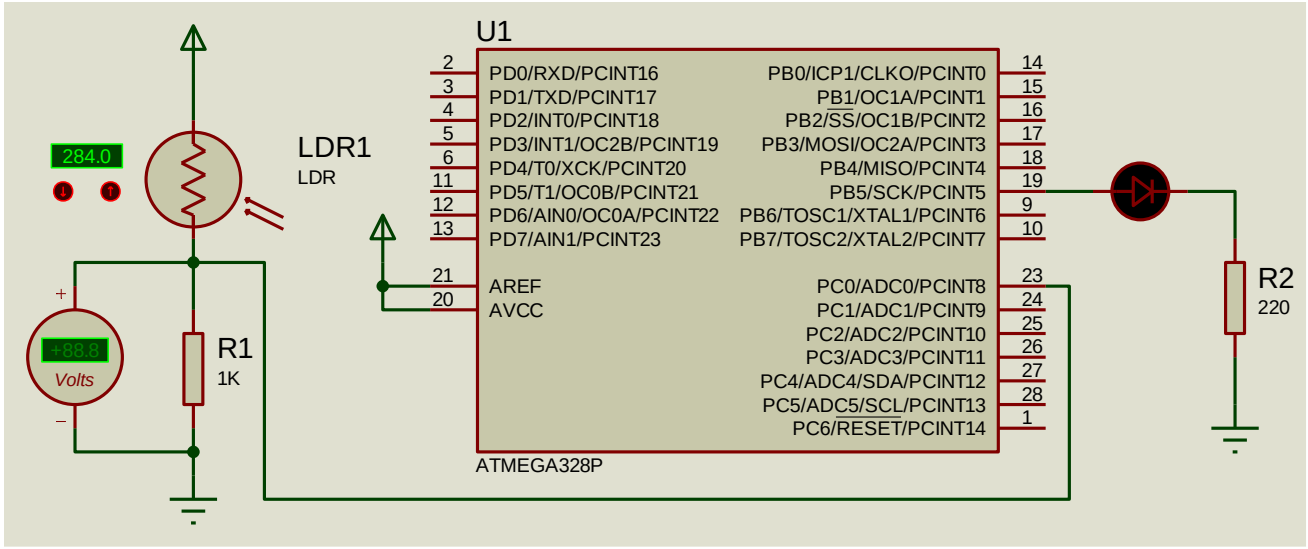
Intensity (Lux)	OP (Volt)
1	0.04 (OFF)
10	0.27 (OFF)
50	0.92 (OFF)
100	1.45 (OFF)
200	2.13 (OFF)
294	**2.50 (ON)**
400	2.78 (ON)
200	2.13 (ON)
40	**0.8 (OFF)**



Light Sensors : LDR

```
#define LED 13
void setup() {
     pinMode(LED, OUTPUT);
     analogReference(EXTERNAL);
}
int value;
void loop(){
     value = analogRead(0);
     digitalWrite(LED, (value>512)?HIGH:LOW);
}
```

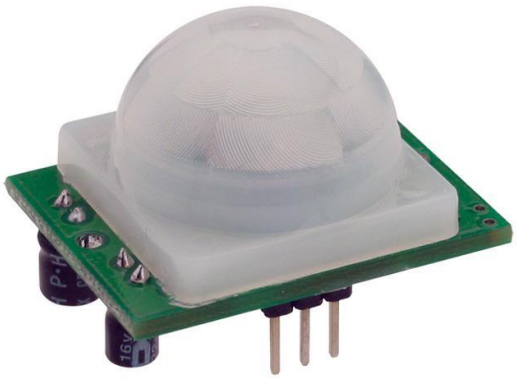
Intensity (Lux)	OP (Volt)
200	2.13 (OFF)
294	**2.50 (ON)**
400	2.78 (ON)
293	**2.49 (OFF)**
200	2.13 (OFF)

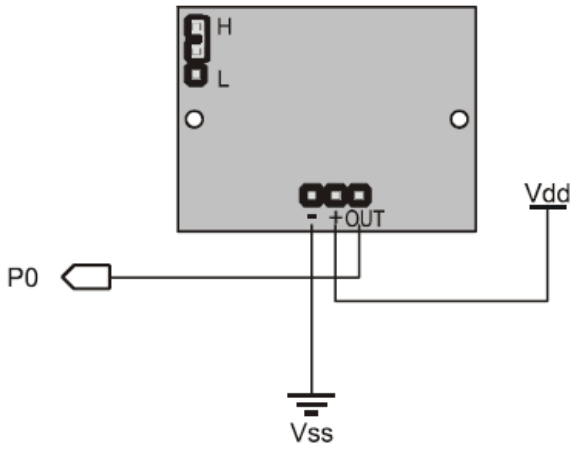


Motion Detection Sensors

Motion Detection Sensors : PIR

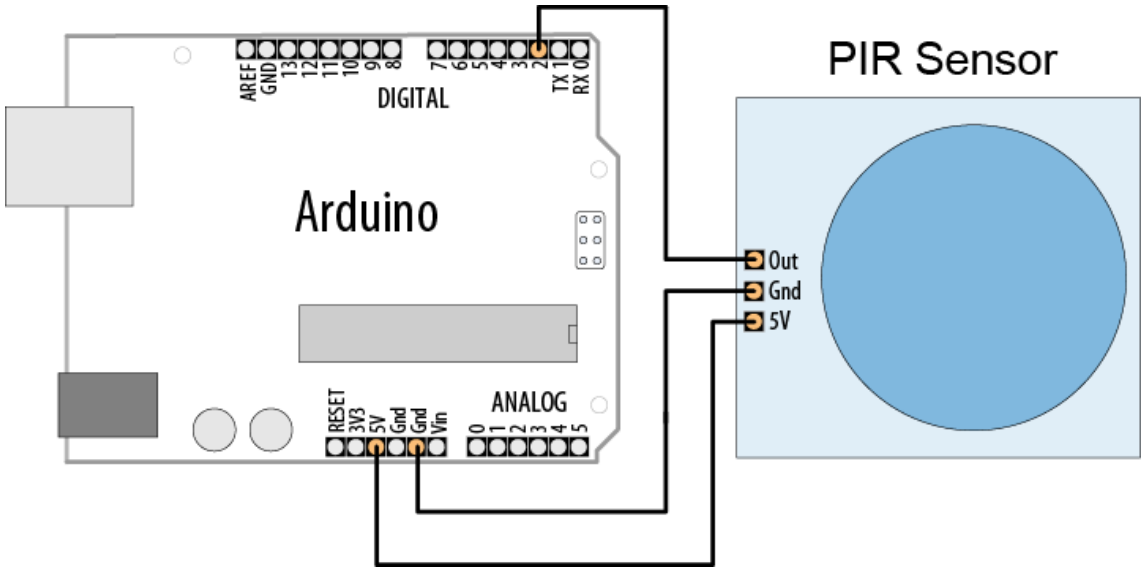
- PIR: Passive Infra-Red
- Model
  - PIR#: 555-28027 from www.mouser.com by Parallax
  - 1ELB106C5M by www.fut-electronics.com
- Work Idea
  - After powering it detect any motion 7m (20ft) around sensor
  - If any motion detected 5V is supplied to the OUT PIN





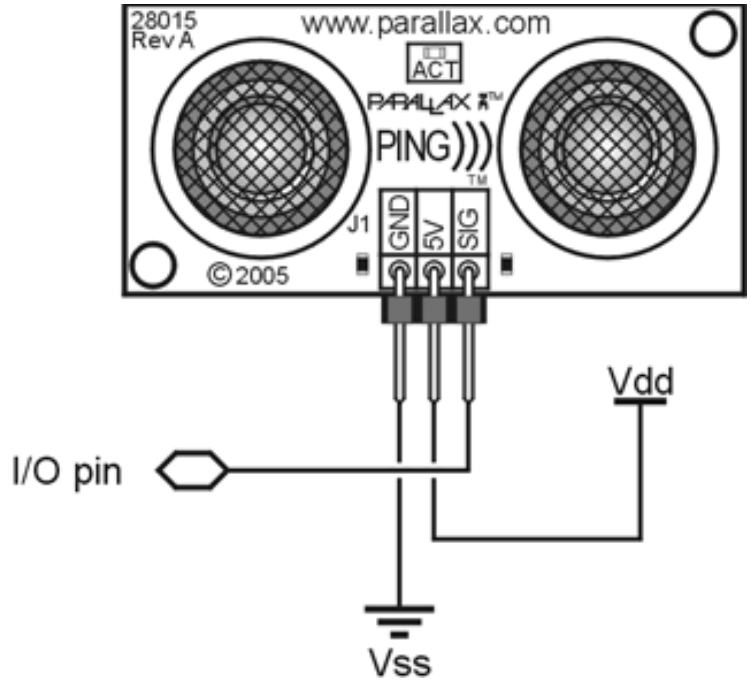
Motion Detection Sensor : PIR

```
#define LED 13
#define PIR 2
void setup() {
      pinMode(LED, OUTPUT);
      pinMode(PIR, INPUT);
}
void loop(){
      int value = digitalRead(PIR);
      if (value == HIGH)
      {
            digitalWrite(LED, HIGH);
            delay(50);
            digitalWrite(LED, LOW);
            delay(50);
      }
}
```



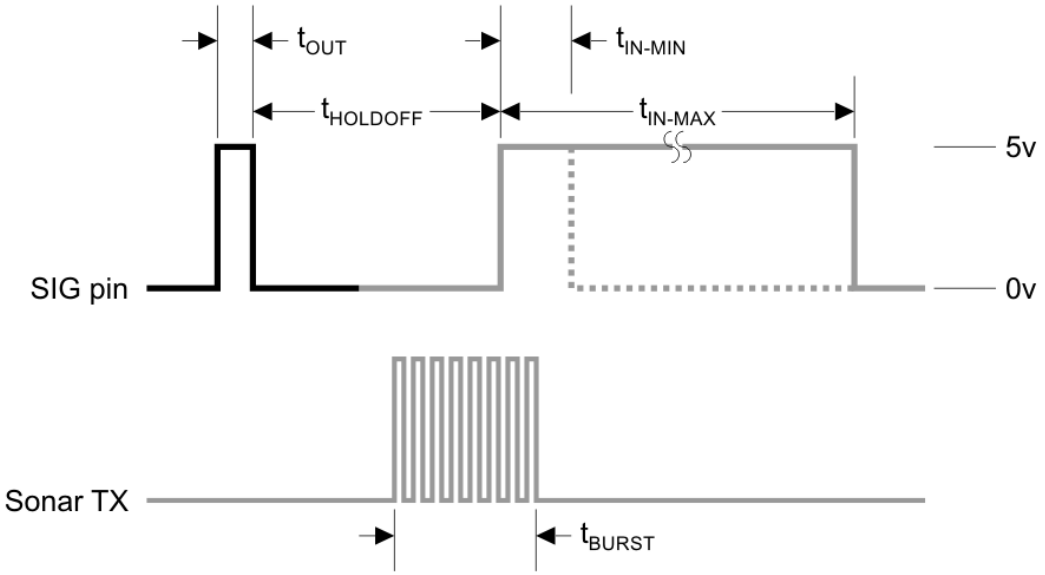
Motion Detection Sensors : PING

- Model
  - PING))) #28015 from www.mouser.com by Parallax
  - 1ELB106C5M by http://store.fut-electronics.com
- Work Idea
  - Measure distance of moving object up to 3m
  - It uses ultrasound



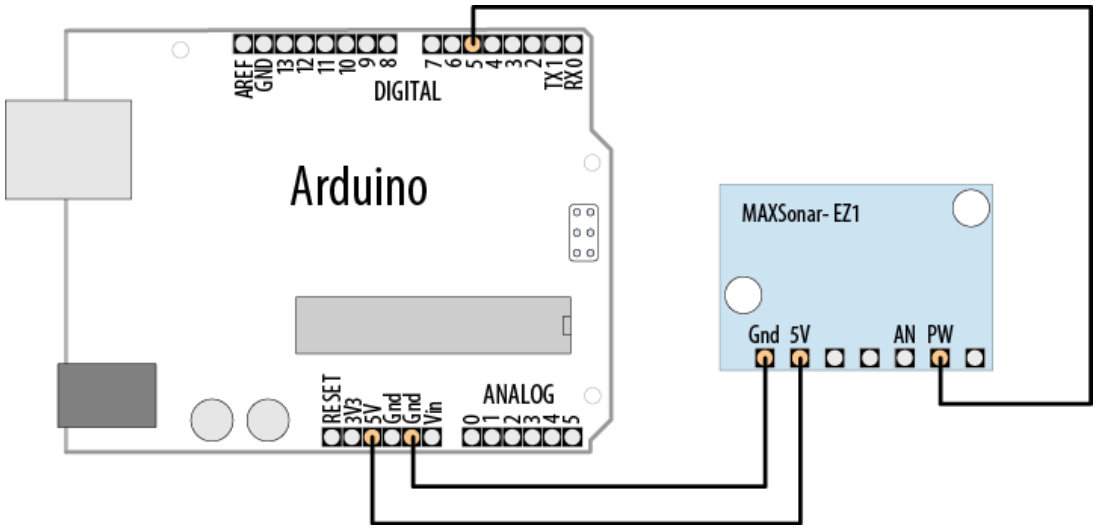
Motion Detection Sensors : PING

- Operation Idea
  - Send clear (2ms→5ms) pulse to the SIG port
  - Calculate the delay time until the device respond with another pulse at the same port
  - Use the formula (distance=delay/29/2) to calculate the distance in cm where delay in us
  - Note : The speed of sound in air is ~ 29 cm/us.
  - Why divided by two?



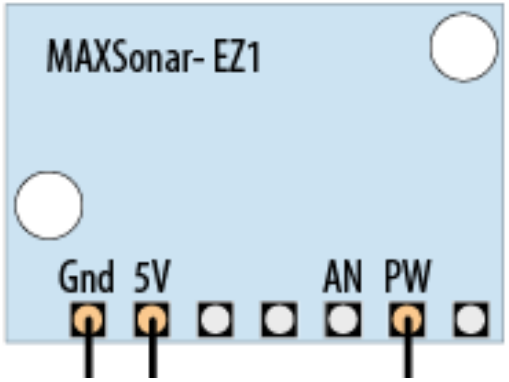
Motion Detection Sensor : PING

```
const int pingPin = 5;
const int ledPin = 13;
long microsecondsToCentimeters(long microseconds){
     return microseconds / 29 / 2;
}
int ping(int pingPin){
     long duration;
     //Generate Pulse to triggre the PING device
     pinMode(pingPin, OUTPUT);
     digitalWrite(pingPin, LOW);
     delayMicroseconds(2);
     digitalWrite(pingPin, HIGH);
     delayMicroseconds(5);
     digitalWrite(pingPin, LOW);

     //Wait for the back pulse from PING device
     pinMode(pingPin, INPUT);
     duration = pulseIn(pingPin, HIGH);

     return microsecondsToCentimeters(duration);
}
void setup(){
     Serial.begin(9600);
     pinMode(ledPin, OUTPUT);
}
void loop(){
     int cm = ping(pingPin) ;
     Serial.println(cm);
     digitalWrite(ledPin, HIGH);
     delay(cm * 10 );
     digitalWrite(ledPin, LOW);
     delay( cm * 10);
}
```



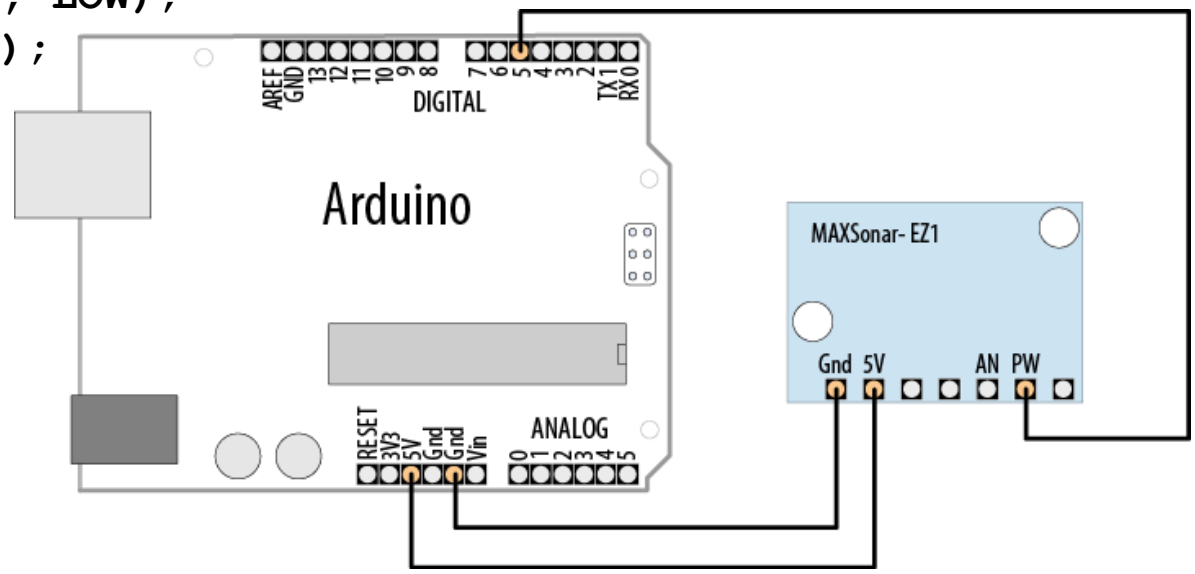
Other Motion Detection Sensors

- Model
  - XL MaxSonar EZ1 http://www.maxbotix.com by MaxBotix
- Work Idea
  - Measure distance of moving object up to (25 ft) 7.5m using the ultrasound
- Operation Idea
  - The device is more simple since it can send continuous pulses without a trigger.
  - The pulses is sent from PW PIN.
  - Divide the pulse duration(us) by 58 to get the distance in cm

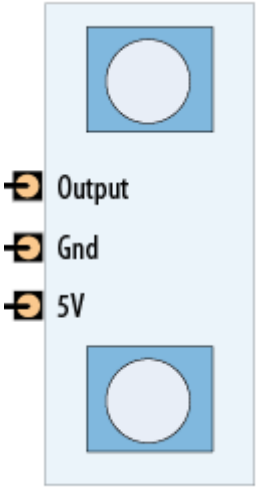


Other Motion Detection Sensor

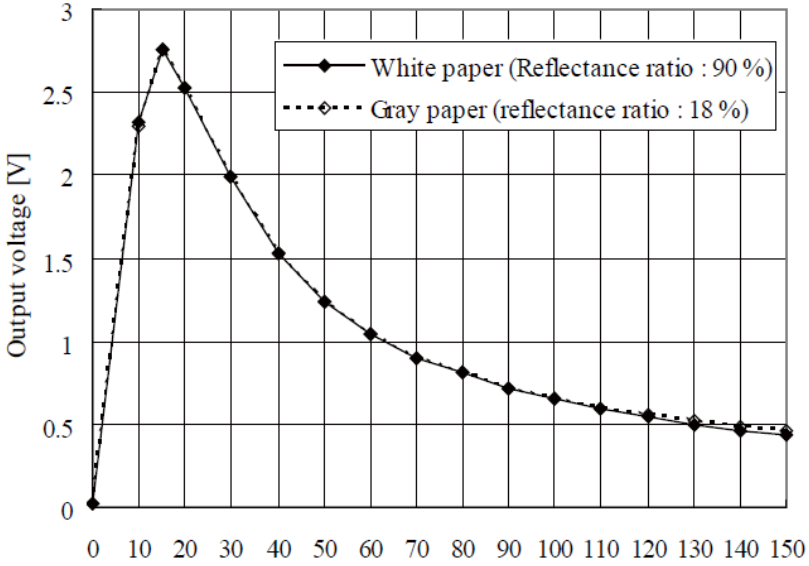
```
const int sensorPin = 5;
const int ledPin = 13;
void setup()
{
      Serial.begin(9600);
      pinMode(ledPin, OUTPUT);
}
void loop()
{
      int duration = pulseIn(sensorPin, HIGH) ;
      int distance = duration / 58;
      Serial.println(distance);
      digitalWrite(ledPin, HIGH);
      delay(distance * 10);
      digitalWrite(ledPin, LOW);
      delay(distance * 10);
      delay(20);
}
```



Motion Detection Sensors : IR

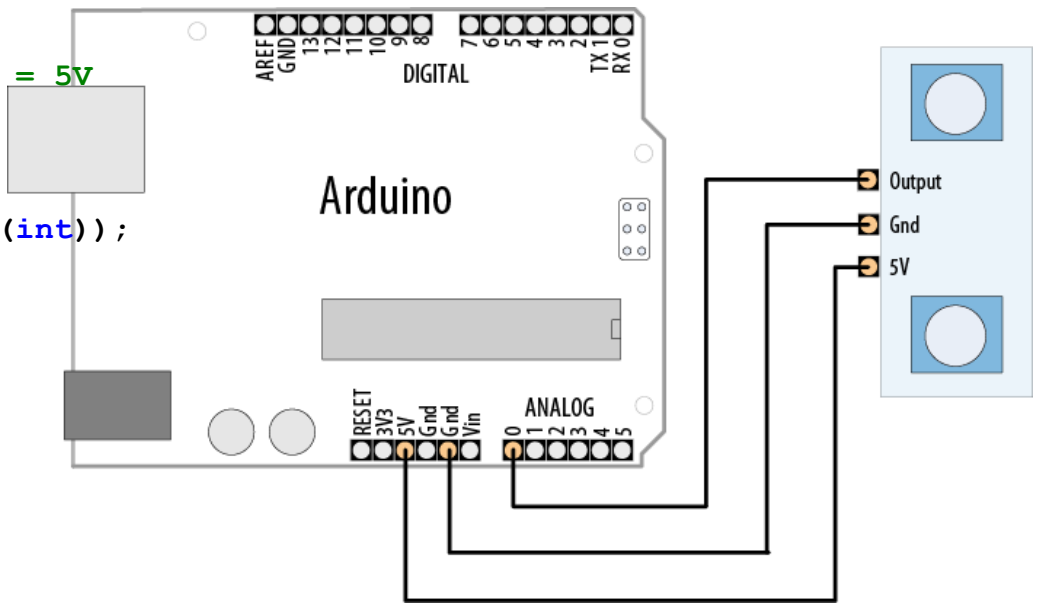


- IR: **I**nfra**R**ed
- Model
  - GP2Y0A02YK0F from www.mouser.com by Sharp
- Work Idea
  - Measure distance of moving object between 15 to 150cm.
  - This device uses Infrared signal.
- Operation Idea
  - The device provide analog signal in the Output PIN.
  - The relation between the output voltage and the distance is nonlinear.
  - Lookup table or graph can be used for conversion.



Motion Detection Sensor : IR

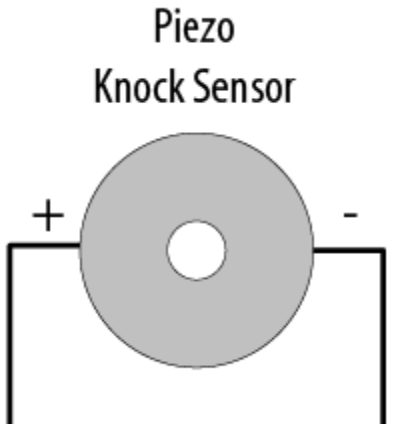
```
const int ledPin = 13;
const int sensorPin = 0;
int lookup(int XValue, int XStart, int XStep, int YValues[], int nYValues){
     if(XValue > (XStart + XStep*(nYValues-1)))
          return YValues[nYValues-1];
     if(XValue < XStart)
          return YValues[0];

     int index = (XValue - XStart) / XStep;
     float fraction = (XValue - index * XStep - XStart)/float(XStep);
     return (int)(YValues[index] - fraction * (YValues[index] - YValues[index+1]));
}
void setup(){
     Serial.begin(9600);
     pinMode(ledPin, OUTPUT);
}
static int dValues[] = {150,140,130,100,60,50,40,35,30,25,20,15};
const int start = 250, step = 250;
long value; int volt, distance;
void loop(){
     value = analogRead(sensorPin);
     volt = (value * 5000) / 1023; //5000 = 5V
     Serial.print(volt);
     Serial.print(",");
     distance = lookup(volt, start, step,
          dValues, sizeof(dValues)/sizeof(int));
     Serial.println(distance);
     digitalWrite(ledPin, HIGH);
     delay(distance * 1);
     digitalWrite(ledPin, LOW);
     delay(distance * 1);
     delay(100);
}
```



Vibration Detection Sensors

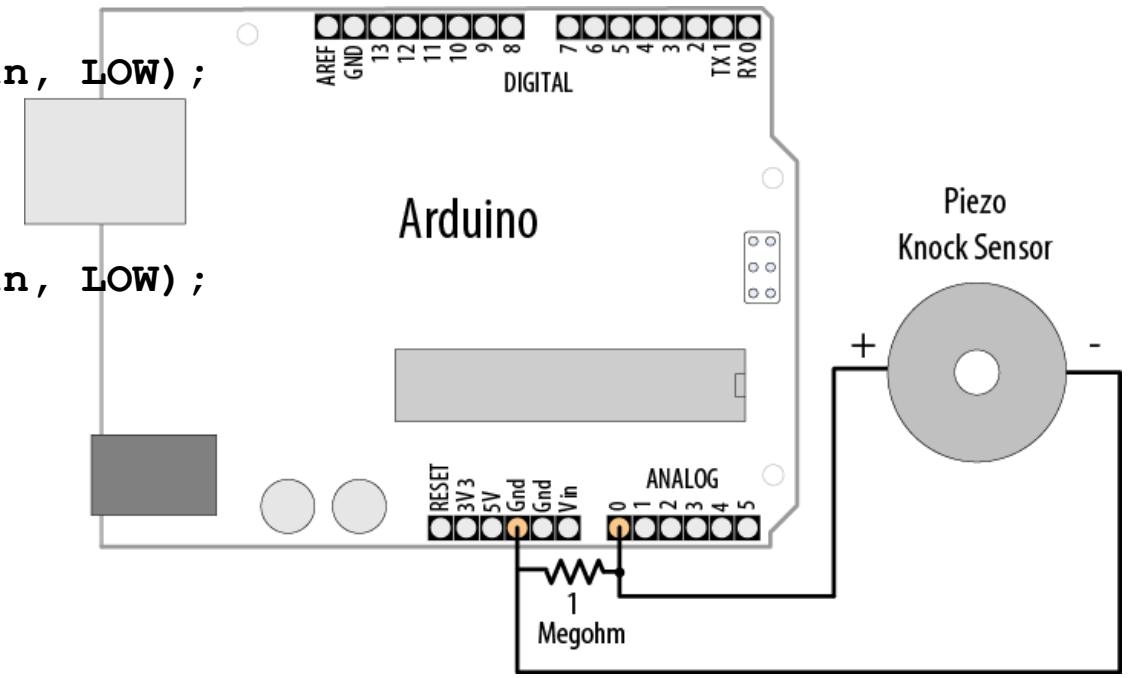
Vibration Detection Sensors

- Model
  - MiniSense 100 from www.fut-electronics.com
- Work Idea
  - Uses Piezoelectric material. It produces voltage output while vibration.
- Operation Idea
  - The otput voltage level is proportional to the vibration strength.



Vibration Detection Sensors

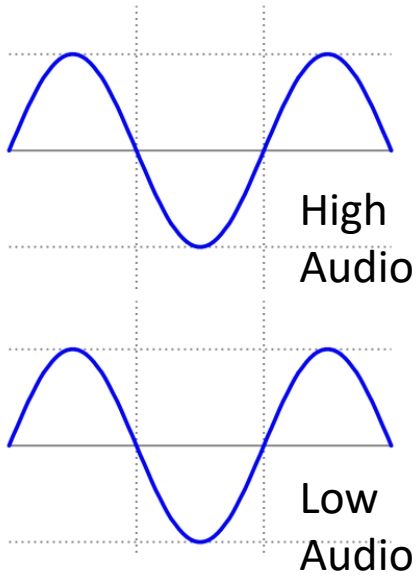
```
const int sensorPin = 0;
const int ledPin = 13;
const int THRESHOLD = 100;
void setup()
{
     pinMode(ledPin, OUTPUT);
}
void loop()
{
     int val = analogRead(sensorPin);
     if (val >= THRESHOLD)
     {
          digitalWrite(ledPin, HIGH);
          delay(100);
          digitalWrite(ledPin, LOW);
          delay(100);
     }
     else
          digitalWrite(ledPin, LOW);
}
```



Audio Sensors

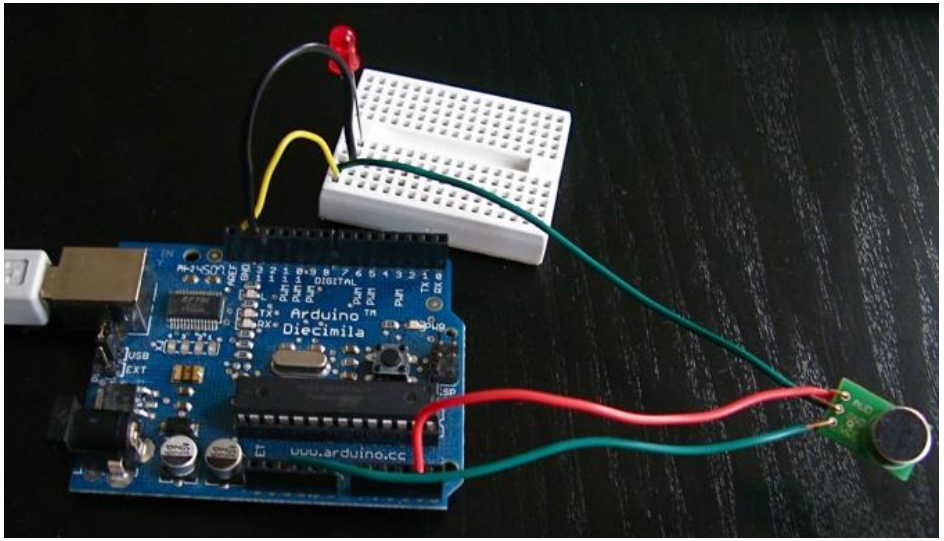
Audio Sensors : MIC

- MIC: Microphone
- Model
  - SEN12945P from www.fut-electronics.com or http://www.seeedstudio.com
  - BOB-08669 from http://www.sparkfun.com
- Work Idea
  - Covert audio signal into a vibration which affect the internal resistance of the device.
- Operation Idea
  - Connect the device as shown in next page.
  - The output PIN generate an oscillatory signal (audio wave). As the audio signal go high as the average output increases.

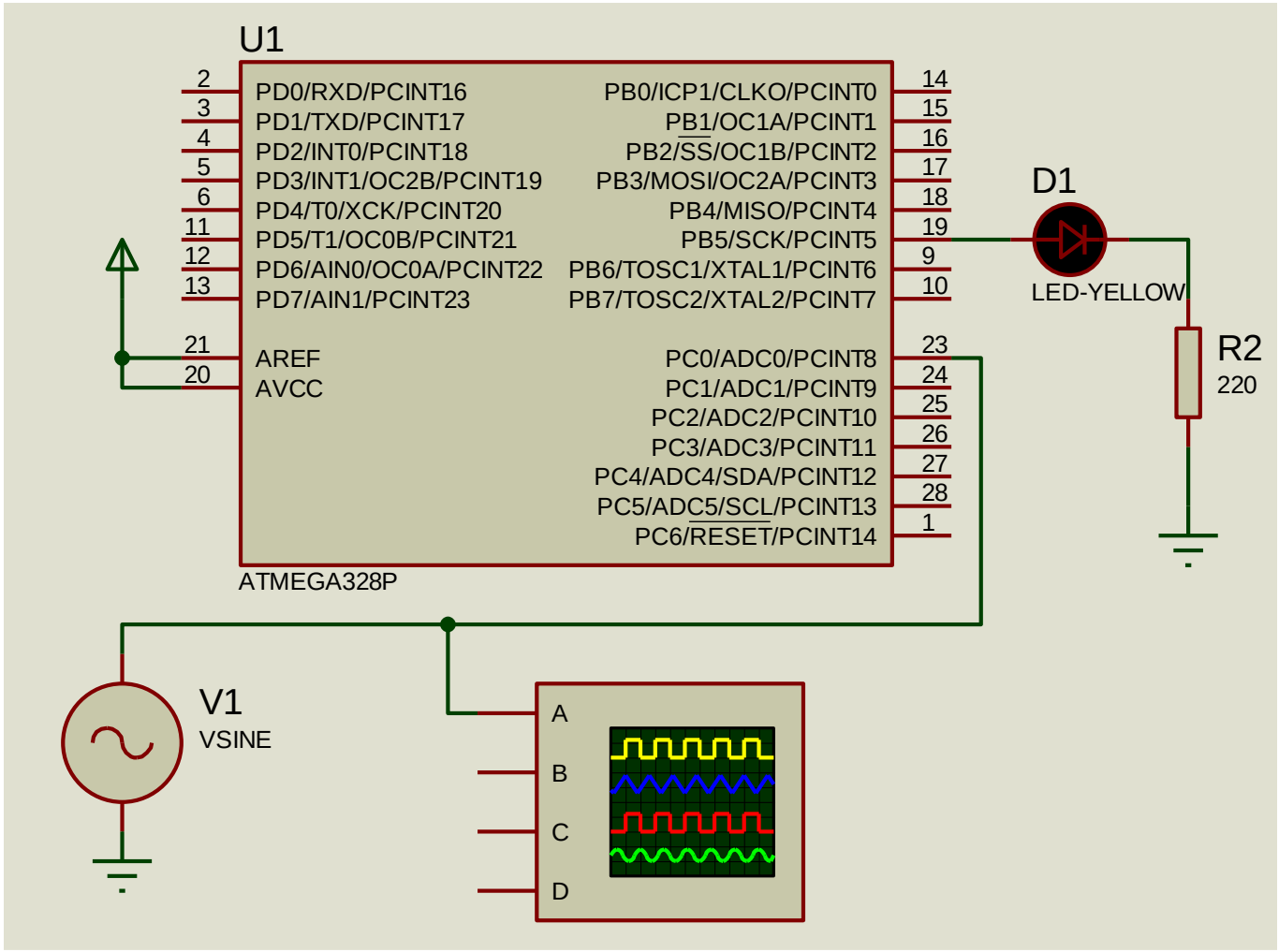


Audio Sensors : MIC

```
const int ledPin = 13;
const int middleValue = 512;
int samples[128];
int nSamples = sizeof(samples)/sizeof(int);
int index = 0;
const int threshold = 400;
long average;

void setup() {
     pinMode(ledPin, OUTPUT);
     Serial.begin(9600);
     for(int i=0;i<nSamples;i++)samples[i] = 0;
}
void loop() {
     samples[index] = analogRead(0);
     index = (index+1)%nSamples;

     average = 0;
     for(int i=0;i<nSamples;i++)average += samples[i];
     average /= nSamples;

     if(average>512)
          digitalWrite(ledPin, HIGH);
     else
          digitalWrite(ledPin, LOW);

     Serial.println(average);
}
```

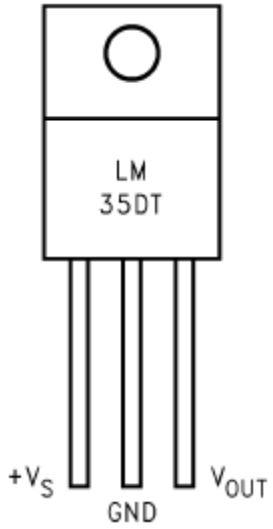


Audio Sensors : MIC



Temperature Sensors

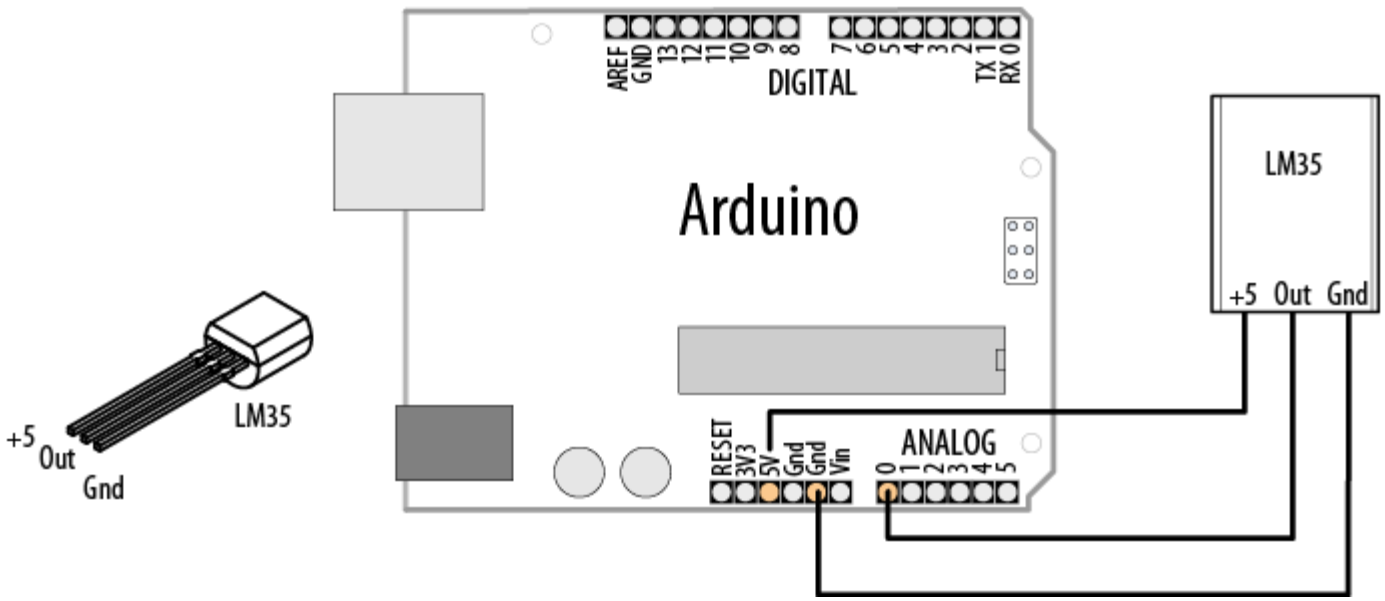
Temperature Sensors



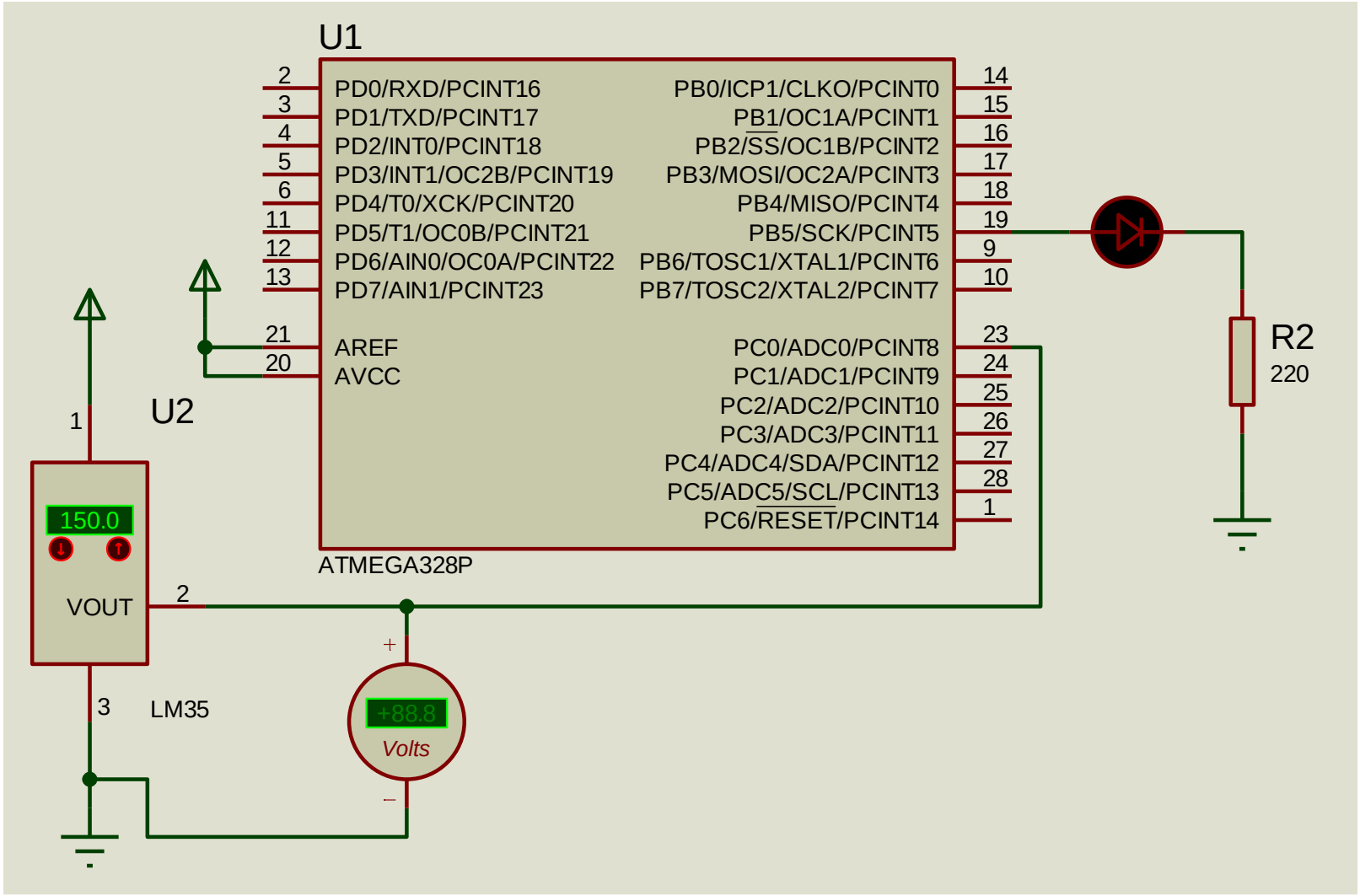
- Model
  - LM35
- Work Idea
  - Depend on semiconductor material. The resistance of the material changes with temperature.
  - Produces linear output proportional to the temperature (Celsius).
  - Temperature range (-55 to 150 Celsius).

Temperature Sensors

```
const int inPin = 0;
void setup()
{
      Serial.begin(9600);
}
void loop()
{
      int value = analogRead(inPin);
      Serial.print(value); Serial.print(" > ");
      float millivolts = (value / 1024.0) * 5000;
      float celsius = millivolts / 10;
      Serial.print(celsius);
      Serial.print(" degrees Celsius, ");
      Serial.print( (celsius * 9)/ 5 + 32 );
      Serial.println(" degrees Fahrenheit");
      delay(1000);
}
```

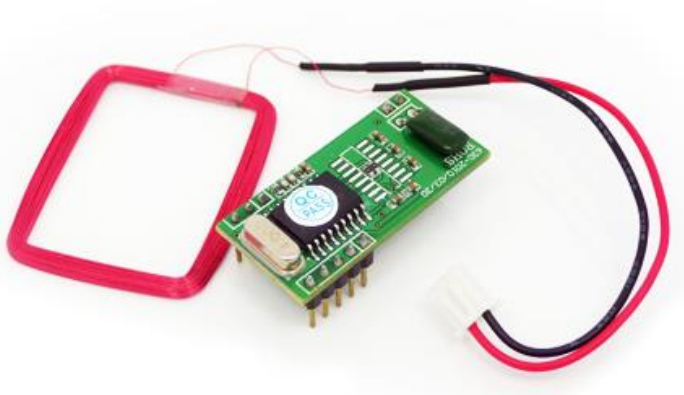


Temperature Sensors



Identification Sensors

Identification Sensors : RFID

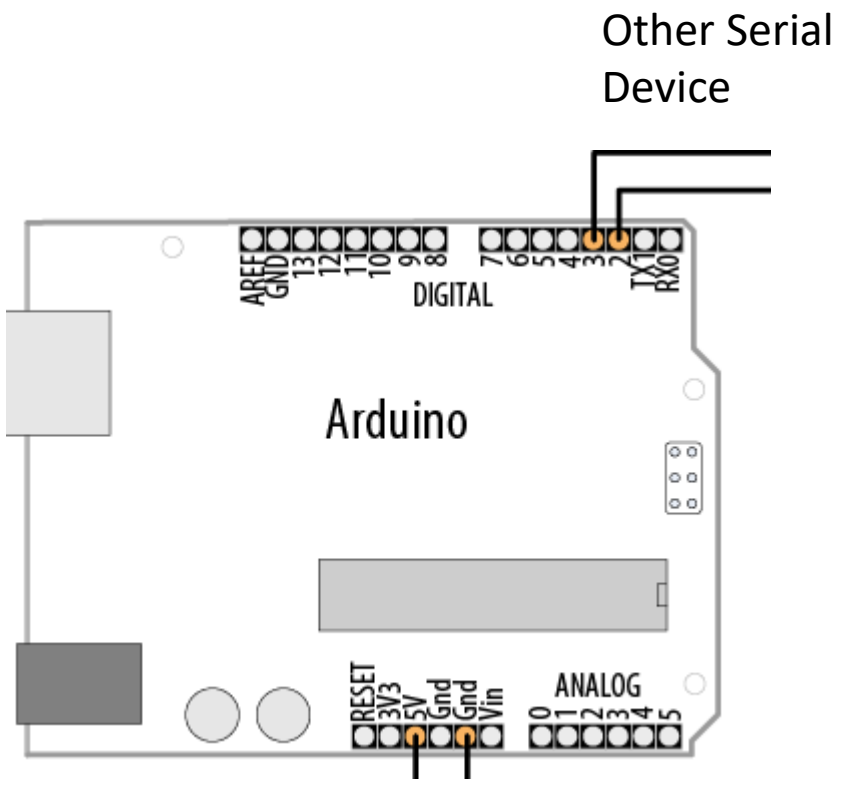


- RFID: Radio Frequency Identification
- Model
  - RFR101A1M Reader and RFID Tags/Cards from www.fut-electronics.com or http://www.seeedstudio.com
- Work Idea
  - Read RFID tags and produce serial signal containing the tag information.

Software Serial Library

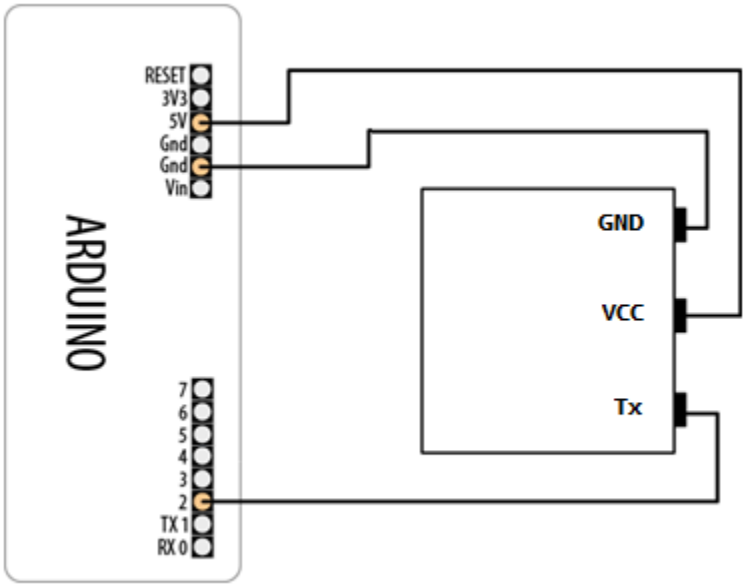
Library allows developer to communicate with serial devices not connected to the PINs(0,1)

```
#include <NewSoftSerial.h>
const int rxpin = 2;
const int txpin = 3;
NewSoftSerial newserial(txpin, rxpin);
void setup()
{
      newserial.begin(9600);
}
void loop()
{
      if(newserial.available())
      {
            byte data = newserial.read();
            newserial.print(data);
            newserial.println("arrived");
      }
}
```



Identification Sensors : RFID

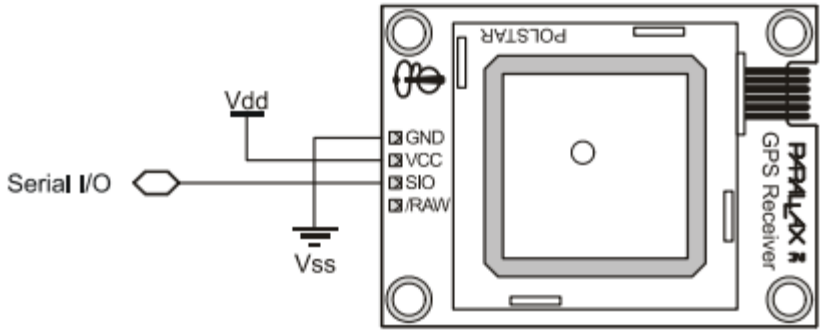
```
#include <NewSoftSerial.h>

NewSoftSerial RFID(2, 3);
void setup()
{
      Serial.begin(9600);
      RFID.begin(9600);
}
void loop(){
      String msg;
      if(RFID.available())
      {
            while(RFID.available()>0)
                  msg += (char)RFID.read();
            Serial.println(msg);
      }
}
```



Positioning Sensors

Positioning Sensors : GPS

- GPS: Global Positioning System
- Model
  - PMB-648 GPS from http://www.parallax.com
- Work Idea
  - Read GPS position and provide it using serial comm
  - Example
    - $GPGLL,4916.45,N,12311.12,W,225444,A,*1D
    - → 49 16.45‘ North latitude
    - →123 11.12' West longitude



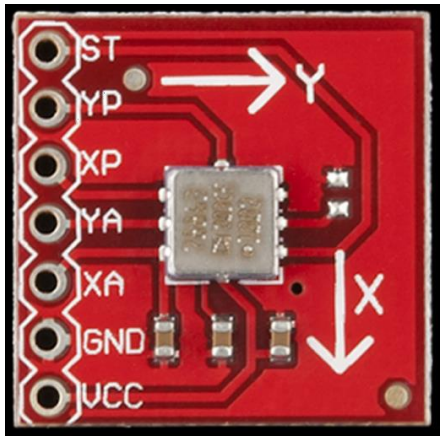
Positioning Sensors : GPS

```
#include <NewSoftSerial.h>
#include <TinyGPS.h>
TinyGPS gps;
#define RXPIN 3
#define TXPIN 2
NewSoftSerial nss(RXPIN, TXPIN);
void setup(){
     nss.begin(9600);
}
void loop(){
     while (nss.available())
     {
          int c = nss.read();
          if (gps.encode(c))
          {
               long lat, lon;
               unsigned long fix_age, time, date, speed, course;
               unsigned long chars;
               unsigned short sentences, failed_checksum;
               int year;
               byte month, day, hour, minute, second, hundredths;

               gps.get_position(&lat, &lon, &fix_age);
               gps.get_datetime(&date, &time, &fix_age);
               gps.crack_datetime(&year, &month, &day,
                    &hour, &minute, &second, &hundredths, &fix_age);
               speed = gps.speed();
               course = gps.course();
          }
     }
}
```

Acceleration Sensors

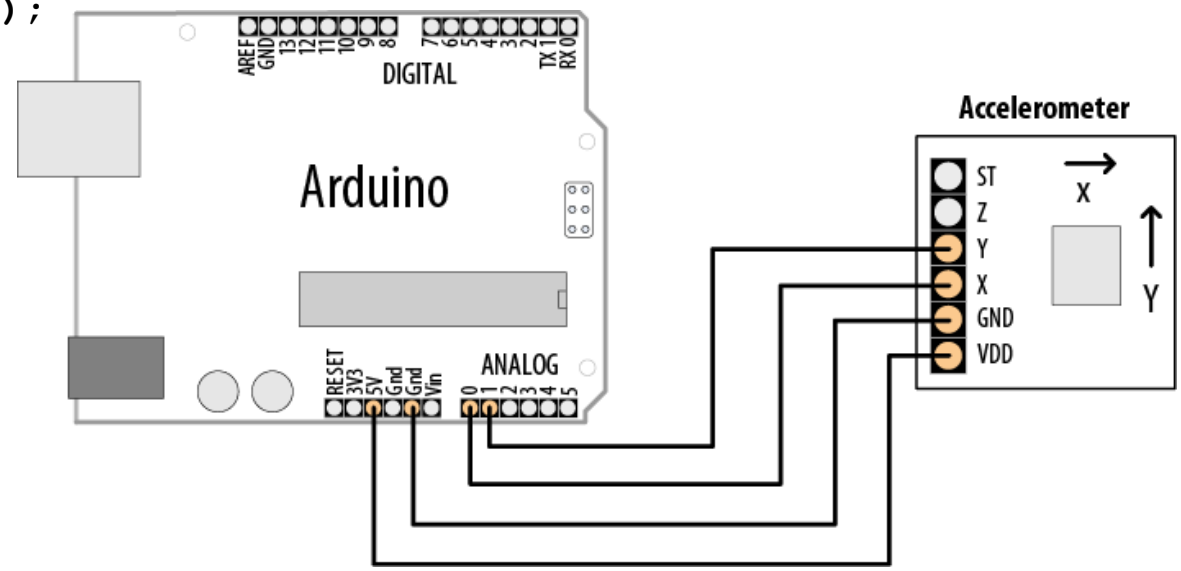
Acceleration Sensors: Accelerometer

- Model
  - ADXL203CE from http://www.sparkfun.com
- Work Idea
  - Read XY acceleration using MEMS.



Acceleration Sensors: Accelerometer

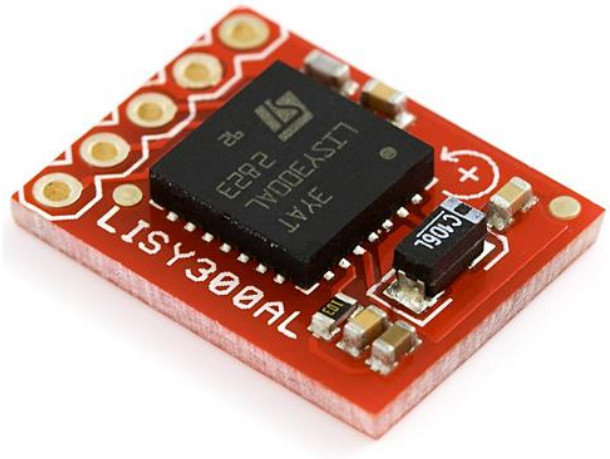
```
const int xPin = 0;
const int yPin = 1;
void setup()
{
      Serial.begin(9600);
}
void loop()
{
      int xValue;
      int yValue;
      xValue = analogRead(xPin);
      yValue = analogRead(yPin);
      Serial.print("X value = ");
      Serial.println(xValue);
      Serial.print("Y value = ");
      Serial.println(yValue);
      delay(100);
}
```



Rotation Sensors

Rotation Sensors : Gyroscope

- Model
  - LISY300ALfrom http://www.sparkfun.com
- Work Idea
  - Read rotation around Z using MEMS.



Rotation Sensors : Gyroscope

```
const int inputPin = 0;
int rotationRate = 0;
void setup()
{
     Serial.begin(9600);
}
void loop()
{
     rotationRate = analogRead(inputPin);
     Serial.print("rotation rate is ");
     Serial.println(rotationRate);
     delay(100);
}
```