Arduino Programming Part 3

EAS 199A
Fall 2011

Overview

Part I

- Circuits and code to control the speed of a small DC motor.
- Use potentiometer for dynamic user input.
- Use PWM output from Arduino to control a transistor.
- Transistor acts as variable voltage switch for the DC motor.

Part II

- Consolidate code into reusable functions.
- One function maps 10-bit analog input to 8-bit PWM output.
- Another function controls the motor speed.
- Using functions provides modular features that are useful for more complex control tasks, e.g. the desktop fan project.

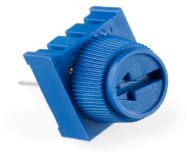
Part 1: Control motor speed with a pot

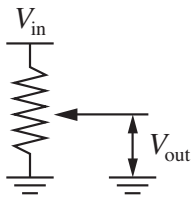
Increase complexity gradually

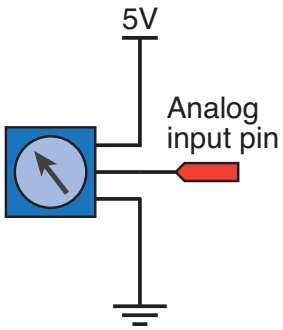
1. Use a pot to generate a voltage signal
   (a) Read voltage with analog input
   (b) Print voltage to serial monitor to verify
2. Convert 10-bit voltage scale to 8-bit PWM scale
   (a) Voltage input is in range 0 to 1023
   (b) PWM output needs to be in the range 0 to 255
   (c) Print voltage to serial monitor to verify
3. Write PWM data to DC motor
4. Write a function to linearly scale the data
5. Write a function to update the motor

Potentiometer Circuit

Use the potentiometer from the Arduino Inventor's Kit



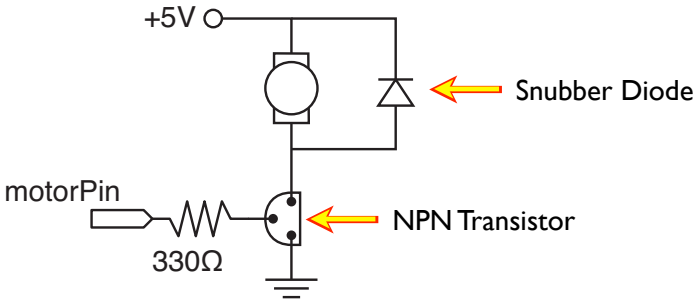




Code to print potentiometer reading

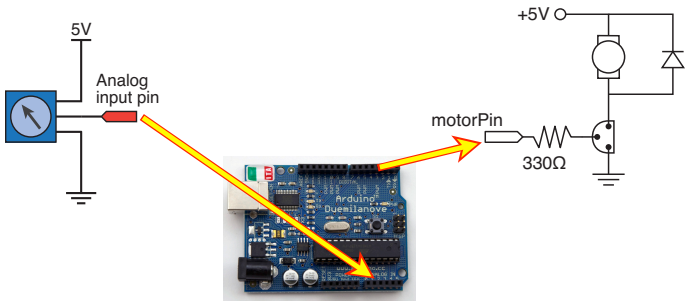
```
//  Function:  read_potentiometer
//
//  Read a potentiometer and print the reading

int  sensor_pin = 3;    //  Wire sweeper of pot to
                        //  analog input pin 3
void setup()
{
  Serial.begin(9600);
}

void loop()
{
  int  val;

  val = analogRead( sensor_pin );
  Serial.print("reading = ");
  Serial.println( val );
}
```


DC Motor Control Circuit



Add this to the breadboard with the potentiometer circuit

DC Motor Control Circuit



Control the DC motor with PWM Output

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = pot_val*255.0/1023.0;    // Include decimal
  analogWrite( motor_pin, motor_speed);
}
```

Subtle: Don't use integer values of 255 and 1023 here. Aggressive compilers pre-compute the integer division of 255/1023 as zero.

Take Stock

You now have a working solution

- Potentiometer creates a variable voltage input that is read by the Arduino (analogRead)
- Motor speed is controlled via PWM

Next step: Use functions to encapsulate code

- Reuse code
- Organize code: Isolated activities happen inside a function.

Part II: Create functions for reusable code

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = pot_val*255.0/1023.0;    // Include decimal
  analogWrite( motor_pin, motor_speed);
}
```

Adjust motor speed

Map input values to output scale

Final version of the loop() function

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  adjust_motor_speed( sensor_pin, motor_pin);

  ... // do other useful stuff
}
```

adjust_motor_speed takes care of the two main tasks: reading the potentiometer output sand setting the PWM signal to the transistor

Using and Writing Functions

Arduino web site

- http://www.arduino.cc/en/Reference/FunctionDeclaration

Functions are reusable code modules:

- Functions encapsulate details of tasks into larger building blocks
- Well-written functions can be reused
- Functions can accept input (or not) and return output (or not)
- All Arduino sketches have at least two functions
  - setup: runs once to configure the system
  - loop: runs repeatedly after start-up is complete
- Users can add functions in the main sketch file, or in separate files

The setup() Function

Consider the simple blink sketch

"void" means Returns nothing

No inputs

"setup" is the name of the function

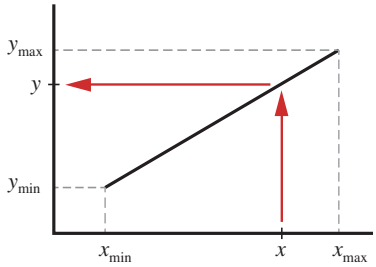
```
//  Blink.pde:  turn on an LED for one second, then
//              off for one second.  Repeat continuously.

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);   // set the LED on
  delay(1000);              // wait for a second
  digitalWrite(13, LOW);    // set the LED off
  delay(1000);              // wait for a second
}
```


A Function to Translate Linear Scales

Linear scaling from x values to y values:

$$y = f(x)$$

where f is a linear mapping



$$\frac{y - y_{\min}}{y_{\max} - y_{\min}} = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

$$\Longrightarrow \quad y = y_{\min} + (y_{\max} - y_{\min})\frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

In words: Given x, $x_{\min}$, $x_{\max}$, $y_{\min}$, and $y_{\max}$, compute y

A Function to Translate Linear Scales

Enter the code at the bottom into your sketch

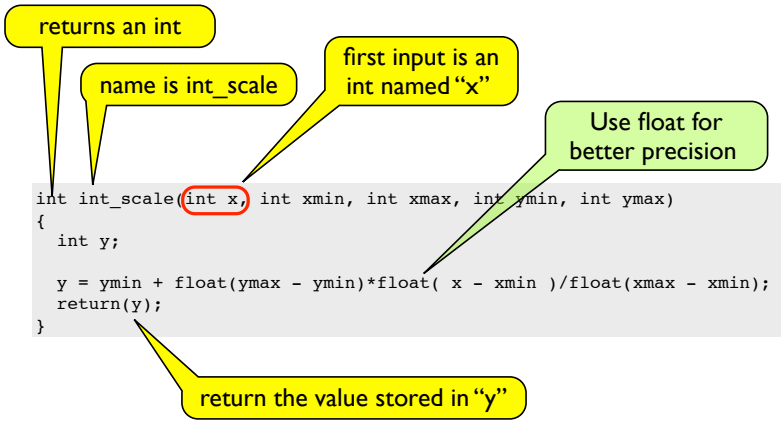
- The code is *not* inside any other program block (like setup or void)

How would you test that this function is working?

```
int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```

N.B. This code is essentially a reimplementation of the built-in map function.
See http://arduino.cc/en/Reference/Map

A Function to Translate Linear Scales




```
int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```


Functions are not nested

```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
}
```


Functions call other functions

```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
  motor_speed = int_scale( pot_val, 0, 1023, 0, 255);
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
  return( y );
}
```

Functions call other functions

```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
  motor_speed = int_scale( pot_val, 0, 1024, 0, 255);
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
  return( y );
}
```


Use the int_scale function

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = int_scale( pot_val, 0, 1023, 0, 255;
  analogWrite( motor_pin, motor_speed);
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```

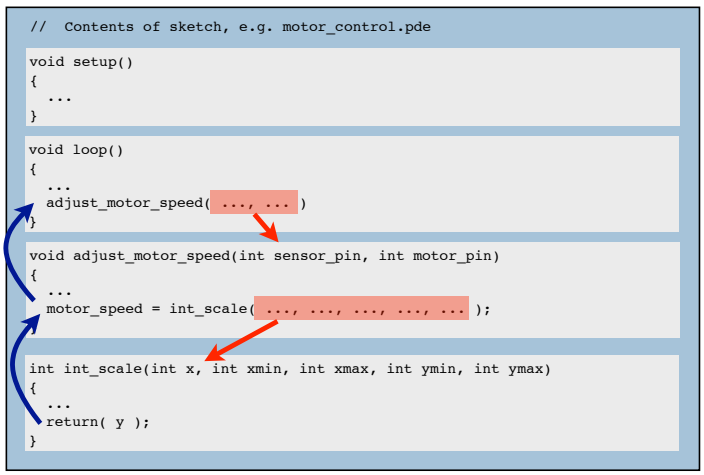

A Function to update motor speed

Inputs

- sensor pin
- motor output pin

Tasks:

- Read potentiometer voltage
- Convert voltage from 10 bit to 8 bit scales
- Change motor speed

```
void adjust_motor_speed(int sensor_pin, int motor_pin)
{
  int  motor_speed, sensor_value;

  sensor_value = analogRead(sensor_pin);
  motor_speed = int_scale(sensor_value, 0, 1023, 0, 255);
  analogWrite( motor_pin, motor_speed);

  Serial.print("Pot input, motor output = ");
  Serial.print(sensor_value);
  Serial.print(" ");  Serial.println(motor_speed);
}
```

Functions call functions, call functions, ...