MyKeypad

TUTORIAL

WHAT IS MyKeypad?

The MyKeypad Library allows you to use up to 16 switches, while using only one analog pin on the Arduino.

HOW DOES IT WORK?

First we wire the switches in a specific manner (which will be explained later). Then, we tell the MyKeypad Library which Arduino Analog pin we will use, and how many switches we have in our setup. (Here for Analog pin A0 and 6 switches):

```
MyKeypad keypad(A0,6);
```

The switches are numbered from 1 to the actual number of switches in our setup. Zero means that no switch is pressed. When we want to know which switch is pressed (if any), we call:

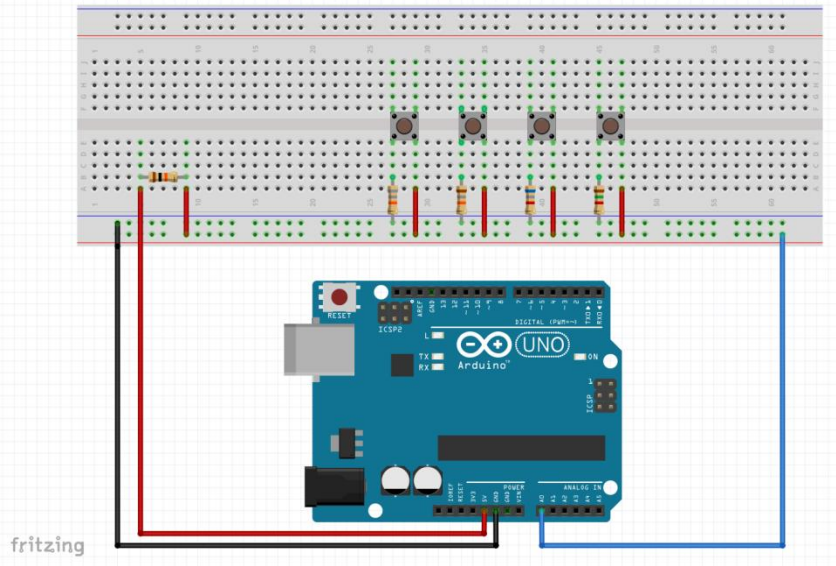
```
key = keypad.getKey();
```

HOW DO WE WIRE THE SWITCHES?

A first resistor (called Pullup) is tied to Arduino's +5V.
One of the pins of each switch is connected to the other end of the pullup. So is the Analog pin of the Arduino.
The other pin of each switch is connected to a resistor and then to Arduino's GND.

```
+5V-----Rpullup--------+-------+---    ...    ---+-------A0
                     SW0      SW1       ...      SWn
                      +        +        ...       +
                      R0       R1       ...      Rn
GND--------------------+-------+---    ...    ---+
```

Here is an example with four switches:



WHAT VALUES DO WE NEED FOR THE RESISTORS?

We can easily get those values by running the Example sketch: ResistorValuesEN.ino.

We don't have to actually plug anything for this sketch to work. We load the sketch, find GLOBAL VARIABLES, and change the following values:

```
//GLOBAL VARIABLES=============================================================
int switchCount = 10;      //The number of switches in our setup
double pullup = 10000.0;   //The value of the pullup resistor in ohms
int series = 24;           //Use 12 (E12) or 24 (E24) resistors series
//-----------------------------------------------------------------------------
```

A 10KΩ pullup is a good choice, but you can try other values. It's up to you. For a setup with more than 12 switches, pull out your multimeter and write the value that you obtained in the pullup line.

The ±5% resistors can be purchased from the E12 or E24 series. The E24 series has twice as much different values for the resistors as the E12 series. For setups up to 12 switches, it is ok to use the E12 series. For more switches, we will stick to the E24 series. They can be ordered individually and are not much more expensive than those in the E12 series. If we use ±1% resistors, it is even better… Way better.

Now, we open the serial monitor then upload the sketch to the Arduino. For a setup of 10 switches, a pullup of 10KΩ and the series E24, here is what the serial monitor will display:

```
Start...
Number of switches: 10
Pullup resistor: 10000.00
Resistors from: R12 series
R0  = 560 Ohms
R1  = 1.8 KOhms
R2  = 3.3 KOhms
R3  = 5.6 KOhms
R4  = 8.2 KOhms
R5  = 12 KOhms
R6  = 18 KOhms
R7  = 33 KOhms
R8  = 56 KOhms
R9  = 180 KOhms
```

Or, we could use this table. The values in **bold** are taken from the E24 Series

4	1,5K	5,6K	18,0K	68,0K												
5	1,2K	3,9K	10,0K	22,0K	82,0K											
6	820	3,3K	6,8K	15,0K	33,0K	120,0K										
7	820	2,7K	5,6K	10,0K	18,0K	39,0K	120,0K									
8	680	2,2K	4,7K	8,2K	12,0K	22,0K	47,0K	150,0K								
9	560	2,2K	3,9K	6,8K	10,0K	15,0K	27,0K	47,0K	180,0K							
10	560	1,8K	3,3K	5,6K	8,2K	12,0K	18,0K	33,0K	56,0K	180,0K						
11	470	1,5K	2,7K	4,7K	6,8K	10,0K	15,0K	22,0K	33,0K	68,0K	200,0K					
12	430	1,5K	2,7K	4,3K	6,2K	8,2K	12,0K	16,0K	24,0K	39,0K	68,0K	220,0K				
13	390	1,2K	2,2K	**3,6K**	**5,1K**	**7,5K**	10,0K	**13,0K**	18,0K	27,0K	39,0K	82,0K	270,0K			
14	330	1,2K	2,2K	3,3K	4,7K	**6,2K**	**9,1K**	**12,0K**	15,0K	22,0K	**30,0K**	47,0K	82,0K	270,0K		
15	330	1,2K	2,2K	**3,0K**	**4,3K**	5,6K	**7,5K**	10,0K	**13,0K**	18,0K	**24,0K**	33,0K	47,0K	82,0K	270,0K	
16	330	1,0K	1,8K	2,7K	3,9K	**5,1K**	6,8K	**9,1K**	**11,0K**	15,0K	**20,0K**	27,0K	33,0K	56,0K	100,0K	330,0K

WHAT ARE THE METHODS THAT THE MENU LIBRARY PROVIDES?

MANDATORY METHOD

MyKeypad::MyKeypad(int inputPin, int buttonCount) (MANDATORY)

```
MyKeypad keypad(A0, 4);
```

The first method is called a constructor, which creates the keypad. It has to be placed **before** setup().
inputPin is the Analog pin that you will connect the pullup resistor;
buttonCount is the number of switches you have in your setup.

You can have as many keypads as you wish. Just give them different names.

METHODS TO READ THE KEYPAD

int MyKeypad::getKey()

```
key = keypad.getkey();
```

You will use this method to get the ID number (1..N) of the key that is currently pressed. If no key is pressed, you will get zero (0). This method will debounce for 10 milliseconds.

int MyKeypad::getKey(int debounceLimit)

```
key = keypad.getkey(4);
```

You will use this method to get the ID number (1..N) of the key that is currently pressed. If no key is pressed, you will get zero (0).
debounceLimit is the time that the keypad will read the Analog pin in milliseconds.

int MyKeypad::repeatGetKey(`int startDelay, int sensitivity`**)**

```
key = keypad.repeatGetkey(500, 40);
```

You will use this method to get the ID number (1..N) of the key that is currently pressed. If no key is pressed, you will get zero (0).

If the key is pressed and released before "**startDelay**" in milliseconds, one instance of the key ID will be returned.

If the key is pressed and held for longer than "**startDelay**" in milliseconds, the key will be returned at a rate depending upon "**sensitivity**" in milliseconds plus the debounce time (10 milliseconds by default). A "**sensitivity**" of 40 will have a 40 + 10 = 50 milliseconds burst rate, stopping when the key is released.

int MyKeypad::getKeyAndWait()

```
key = keypad.getkeyAndWait();
```

You will use this method to get the ID number (1..N) of the key that is currently pressed. If no key is pressed, you will get zero (0). However, getKeyAndWait() will wait for the switch to be released before returning the ID number.

bool MyKeypad::keyPressed()

```
if (keypad.keyPressed()) { do something; }
```

or…

```
while (keypad.keyPressed()) {} //Wait for the release of all keys before going on
```

You will use this method to find out if there are any keys that are currently pressed.

int MyKeypad::lastKeyPressed()

```
key = keypad.lastKeyPressed();
```

You will use this method to get the ID of the last key that was pressed.

METHODS TO FIND THE PROPER RESISTOR VALUES

void MyKeypad:: calculateResistorsValues ()

```
keypad. calculateResistorsValues();
```

You will use this method to generate the resistors values based on the parameters you passed to the constructor (`MyKeypad keypad(A0,6);`) and a 10KΩ pullup resistor.

void MyKeypad:: calculateResistorsValues (double pullup)

```
keypad. calculateResistorsValues(15000);
```

You will use this method to generate the resistors values based on the parameters you passed to the constructor (`MyKeypad keypad(A0,6);`) and the value you wish to use as a pullup.

If your setup has more than 12 keys, Measure the exact value that your multimeter gives you for your pullup resistor.

double MyKeypad:: getResistorValue (int ID)

```
value = keypad.getResistorValue(4);
```

You will use this method to get the resistor value calculated for the switch **ID**. The result is given in Ohms.

double MyKeypad::resistorValueString (int ID)

```
value = keypad.resistorValueString(5);
```

You will use this method to get the resistor value calculated for the switch **ID** as a String:

```
R5 = 2.8 KOhms;
```

HOW DO WE FIGURE OUT THE VALUES FOR THE RESISTORS?

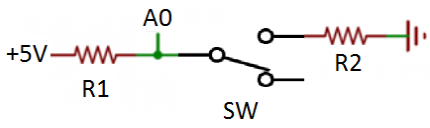
This last part is a little technical. You can stop reading here and everything will be OK.

If you are interested, read on…

The analogRead(A0) function returns a value between 0 and 1023. Those values correspond to the voltage read at the pin between 0V and 5V. What it effectively does, is to map 0V to 5V (an analog value) into an integer going from 0 to 1023 (a digital value).

We will use what is called a voltage divider to change the values of the voltage at the Analog pin. First, we place what is called a pullup resistor between +5V and the Analog pin. The pin will read 1023 from then on, until we split this current in two with a switch and another resistor connected to ground

The basic circuit with only one switch looks like this:



When the switch is off, the whole 5V is sent to A0. When the switch is on, part of the 5V goes to A0, and another part goes to ground. How much goes where depends of the values of R1 and R2. Before doing some math, simple logic says that if R1 equals R2, half the voltage will go to A0, and the other half will go to ground.

The formula for a voltage divider is:

$V_{out} = V_{in} \frac{R2}{R1+R2}$ Or, in our case: $V_{A0} = 5V \frac{R2}{R1+R2}$

Replacing R1 and R2 with 10KΩ gives:

$V_{A0} = 5V \frac{10000}{10000+10000} = 5V \frac{10000}{20000} = 2{,}5V$

This is half the voltage sent by Arduino's 5V pin. So, analogRead(A0) will return 1023/2 = 512

In our setup, R1 will be the pullup resistor. R1 will be the same, regardless of the number of switches we use. But R2 will be different for each switch.

So here is our strategy: We want to use "n" switches in our setup. Since analogRead(A0) returns a value between 0 and 1023, we will divide it in "n" bins of equal size. Let's try it for four switches.

Each bin will be 1024/4 = 256 wide:

Next, we will find the center of each bin: 256/2 = 128 for the center of the first bin. To obtain the center of the other bins, we will add 256: **128**+256 = **394**, 394+256 = **640** and 640+256 = **896**

To find the resistor value for each switch to match the center of each bin, we will re-write the voltage divider equation to make it easier for us. Now, we want to find R2, for the desired "binCenter", knowing that R1 is 10 000Ω. And to help us more, we will replace the voltage with what is actually returned by analogRead(A0) for 5V, which is 1023.

$$binCenter = 1023\ \frac{R2}{10000+R2}$$

Isolating R2 gives:

$$R2 = \frac{10000\ X\ binCenter}{(1023\ -\ binCenter)}$$

For the center of the first bin:

$R2 = \frac{10000\ X\ 128}{(1023\ -128)}$ = 1429Ω or 1.429KΩ

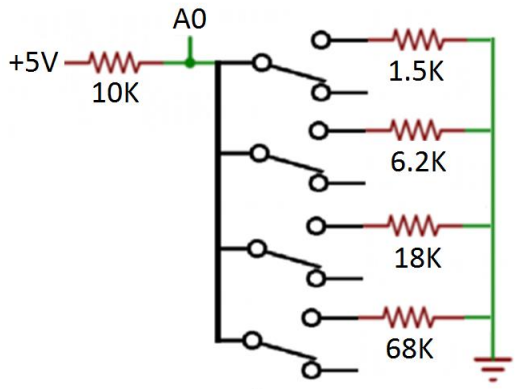
Of course, you won't find a resistor with this exact value, but you will find one with 1,5KΩ. This is the value that we will use for the first switch. Knowing that the resistor has ±5%, tolerance, its real value will be somewhere between 1425Ω and 1575Ω.

Using the original voltage divider equation, V_{out} will be between 0.625V and 0.679V, and, mapping 0..5V to 0..1023 the value returned by analogRead(A0) will be between 128 and 139.

Doing the same math for the tree other switches yields:

Ideal (KΩ)	Real (KΩ)	Min(KΩ)	Max (KΩ)	Min Read()	Max Read()
1.429K	**1.5**	1.425	1.575	128	139
6.0	**6.2**	5.890	6.510	379	403
16.7	**16**	15.2	16.8	617	641
70	**68**	64.6	71.4	886	897

Now, our schematics look like this:



The last step to do is to use the results of analogRead(A0) to be able to return a switch number between 1 and 4 (in this case).The figure bellow shows, to scale, in red, the expected return values of analogRead(A0) for this setup. Also shown at the right end, the range that what we will use for “no key”. Notice that when R1 is close to R2, the range of possible reads gets wider. With ±5% resistors, when R1 = R2, the voltage read is ±0.062V or an analogRead(A0) difference of ±13.

If we divide the values returned by the size of our bins the results will be:

Min Read()	Max Read()	Min	Max
128	139	0.500	0.543
379	403	1.480	1.574
617	641	2.410	2.504
886	897	3.461	3.504

If we only use the integer part of those values, we will get 0, 1, 2 and 3 for the four switches. Adding one will give us the number of the switch that was pressed. So, in Arduino’s language:

```
key = int(analogRead(A0)/binSize) + 1;
```

Now, we have to take care of when there is no key pressed. We said that we would return zero. As we saw earlier, when no key is pressed, the whole 5V goes into pin A0, causing analogRead(A0) to return 1023.

Yes, but… there is some electrical noise (perturbations) which will fluctuate the voltage read by Analog pins. So, to make ourselves safe, we will consider that a value higher than 1010 will be considered as a “no key” situation.

```
if (analogRead(A0) > 1010) return 0;
```

ARE THE SWITCH DEBOUNCED?

Certainly so. Switches are switches and they will bounce.

The way to go is to read the Analog pin repeatedly during a certain period of time (10 milliseconds is the default value), then average all the reads, and use this to return the key number.

Furthermore, if the key was released within the debounce time, the average means nothing. That has to be taken care of by returning 0 if no key is pressed at the end of debouncing.

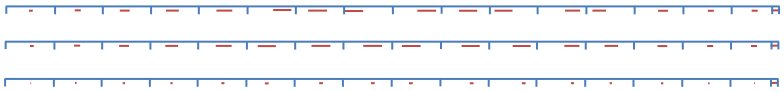
When we put it all together, the code looks like this:

```
int MyKeypad::getKey() {
  unsigned long start = millis();          //start the timer
  int average = analogRead(A0);            //read the pin
  if (average > 1010) return 0;            //If “no-key”, return 0
  while (millis() - start < 10) {          //For 10 milliseconds (≈ 80 times @ 16MHz)
    int key = analogRead(A0);                //read the pin
    average = int((average + key) / 2);      //average it
  }
  if (analogRead(A0) > 1010) return 0;     //If “no key”, return 0
  return int(average / binSize) + 1;       //calculate key number
```

WHY STOP AT 16 SWITCHES?

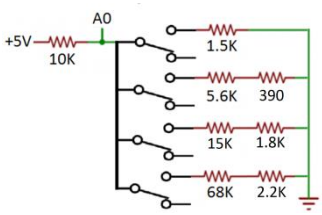
As the bins gets smaller, the margin of error caused by the ±5% tolerance on our resistors also gets smaller. To make matters worse, we have a limited set of values for our resistors. At 16 switches, the bin size is only 64 (0.3V). As you can see, even at 16 switches we are pushing our luck.

Below, you will find three graphics. The two top ones use ±5% resistors. The first one uses resistors from the E12 series. Notice how the voltages can get real close to the bins boundaries. The second one uses resistors from the E24 series. Still not perfect, but the voltages are more centered in their bins. The third one shows that using ±1% resistors helps a lot.



If we can find them and if we can afford them, the E48 series will give us two advantages: just ±1% tolerance, and a choice amongst 48 values per decade instead of 24.

To get closer to the center we could also put another small resistor in series with the real value. Looking at our 4 key keypad example, the values for the fourth switch are: Ideal: 70kΩ, Real: 68KΩ . We could use 68KΩ plus 2.2KΩ in series and having a center at 70.2kΩ, much closer to the ideal resistor.



With this setup, we get Ideal, vs Real for the analogRead(A0):

Switch 1	128 > 133 vs 133
Switch 2	384 > 381 vs 392
Switch 3	639 > 641 vs 630
Switch 4	895 > 895 vs 892

With 4 keys, it is useless… with 16, well, it could help.

I sincerely hope that this MyKeypad Library will help you in your projects.
Jacques Bellavance