TECHNOCRATS ROBOTICS

VACATION TASKS

SET-4

Pull up and down resistors

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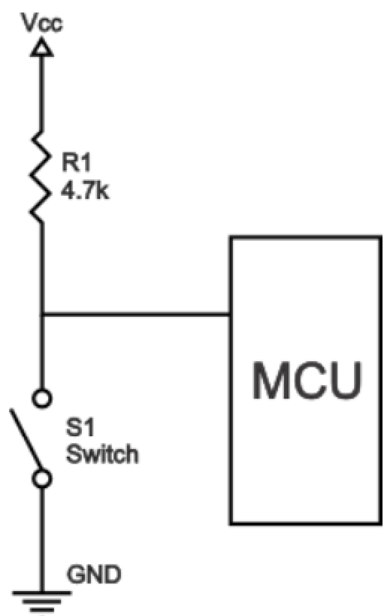
Pull up Resistors

Pull-up resistors are resistors used in logic circuits to ensure a well-defined logical level at a pin under all conditions. As a reminder, digital logic circuits have three logic states: high, low and floating (or high impedance). The high-impedance state occurs when the pin is not pulled to a high or low logic level, but is left “floating” instead.

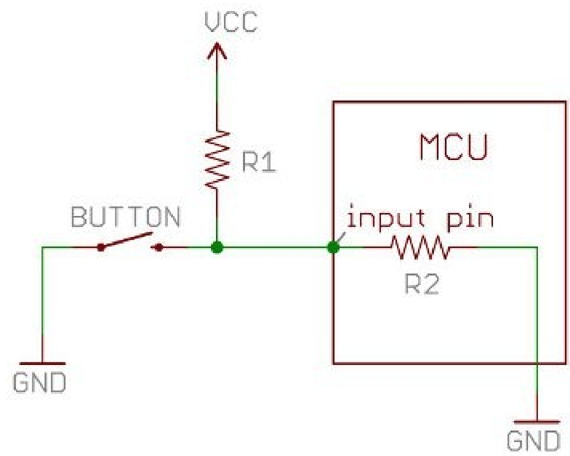
A good illustration of this is an unconnected input pin of a microcontroller. It is neither in a high or low logic state, and a microcontroller might unpredictably interpret the input value as either a logical high or logical low. Pull-up resistors are used to solve the dilemma for the microcontroller by pulling the value to a logical high state, as seen in the figure. If there weren’t for the pull-up resistor, the MCU’s input would be floating when the switch is open and brought down only when the switch is closed.

Pull-up resistors are not a special kind of resistors; they are simple fixed-value resistors connected between the voltage supply (usually +5V) and the appropriate pin, which results in defining the input or output voltage in the absence of a driving signal. A typical pull-up resistor value is 4.7kΩ, but can vary depending on the application.



Pull-up resistor circuit

A low resistor value is called a strong pull-up (more current flows), a high resistor value is called a weak pull-up (less current flows).



The value of the pull-up resistor needs to be chosen to satisfy two conditions:
When the button is pressed, the input pin is pulled low. The value of resistor R1 controls how much current you want to flow from VCC, through the button, and then to ground.
When the button is not pressed, the input pin is pulled high. The value of the pull-up resistor controls the voltage on the input pin.

For condition 1, you don't want the resistor's value too low. The lower the resistance, the more power will be used when the button is hit. You generally want a large resistor value (10kΩ), but you don't want it too large as to conflict with condition 2. A 4MΩ resistor might work as a pull-up, but its resistance is so large (or weak) that it may not do its job 100% of the time.

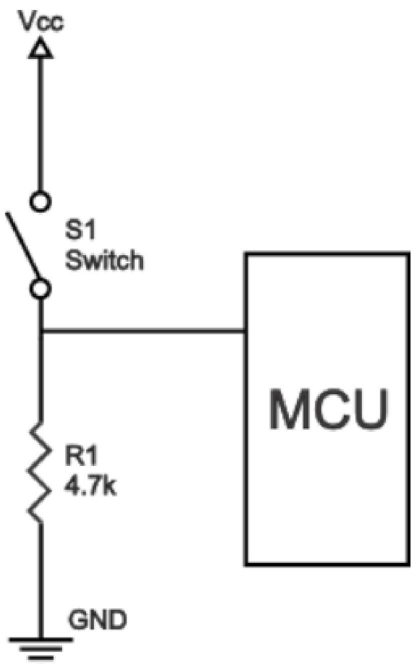
The general rule for condition 2 is to use a pull-up resistor (R1) that is an order of magnitude (1/10th) less than the input impedance (R2) of the input pin. An input pin on a microcontroller has an impedance that can vary from 100k-1MΩ. For this discussion, impedance is just a fancy way of saying resistance and is represented by R2 in the picture above. So, when the button is not pressed, a very small amount of current flows from VCC through R1 and into the input pin. The pull-up resistor R1 and input pin impedance R2 divides the voltage, and this voltage needs to be high enough for the input pin to read a high state.

Another thing to point out is that the larger the resistance for the pull-up, the slower the pin is to respond to voltage changes. This is because the system that feeds the input pin is essentially a capacitor coupled with the pull-up resistor, thus forming a RC filter, and RC filters take some time to charge and discharge. If you have a really fast changing signal (like USB), a high value pull-up resistor can limit the speed at which the pin can reliably change state. This is why you will often see 1k to 4.7KΩ resistors on USB signal lines.

Pull down Resistors

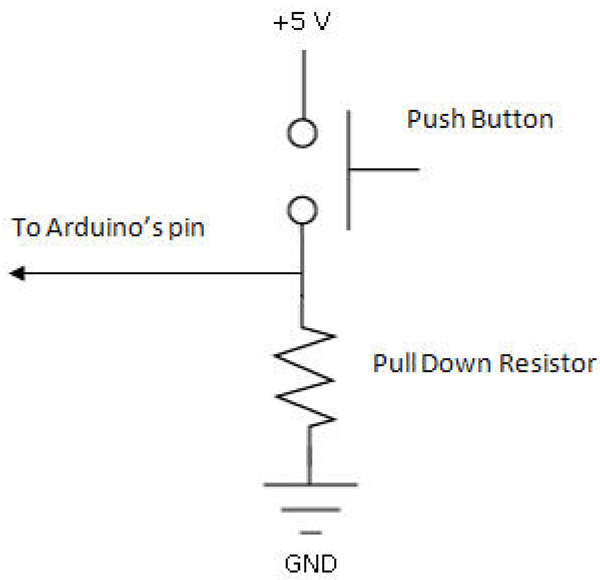
Pull-down resistors work in the same manner as pull-up resistors, except that they pull the pin to a logical low value. They are connected between ground and the appropriate pin on a device.

An example of a pull-down resistor in a digital circuit can be seen in the figure. A pushbutton switch is connected between the supply voltage and a microcontroller pin. In such a circuit, when the switch is closed, the micro-controller input is at a logical high value, but when the switch is open, the pull-down resistor pulls the input voltage down to ground (logical zero value), preventing an undefined state at the input. The pull-down resistor must have a larger resistance than the impedance of the logic circuit, or else it might be able to pull the voltage down by too much and the input voltage at the pin would remain at a constant logical low value – regardless of the switch position.



Pull-down resistor

Pull-down resistor configuration is particularly useful for digital circuits like latches, counters and flip-flops that require a positive one-shot trigger when a switch is momentarily closed to cause a state change.
While they may seem to operate in the same way as the pull-up resistor, the resistive value of a passive pull-down resistor is more critical with TTL 74LSxxx series of logic gates than with similar CMOS gates. This is because a TTL 74LSxxx input sources much more current out of its input in its LOW state.



Pull-up resistor value

The appropriate value for the pull-up resistor is limited by two factors. The first factor is power dissipation. If the resistance value is too low, a high current will flow through the pull-up resistor, heating the device and using up an unnecessary amount of power when the switch is closed. This condition is called a strong pull-up and is avoided when low power consumption is a requirement.

The second factor is the pin voltage when the switch is open. If the pull-up resistance value is too high, combined with a large leakage current of the input pin, the input voltage can become insufficient when the switch is open. This condition is called having a weak pull-up. The actual value of the pull-up's resistance depends on the impedance of the input pin, which is closely related to the pin's leakage current.

A rule of thumb is to use a resistor that is at least 10 times smaller than the value of the input pin impedance. In bipolar logic families which operate at operating at 5V, the typical pull-up resistor value is 1-5 kΩ. For switch and resistive sensor applications, the typical pull-up resistor value is 1-10 kΩ. If in doubt, a good starting point when using a switch is 4.7 kΩ. Some digital circuits, such as CMOS families, have a small input leakage current, allowing much higher resistance values, from around 10kΩ up to 1MΩ.

The disadvantage when using a larger resistance value is that the input pin responses to voltage changes slower. This is the result of the coupling between the pull-up resistor and the line capacitance of the wire which forms an RC circuit. The larger the product of R and C, the more time is needed for the capacitance to charge and discharge, and consequently the slower the circuit. In high-speed circuits, a large pull-up resistor can sometimes limit the speed at which the pin can reliably change state.

Typical applications for pull-up and pull-down resistors

Pull-up and pull-down resistors are often used when interfacing a switch or some other input with a microcontroller or other digital gates. Most microcontrollers have in-built programmable pull up/down resistors so fewer external components are needed. It is possible to interface a switch with such microcontrollers directly. Pull-up resistors are in general used more often than pull-down resistors, although some microcontroller families have both pull-up and pull-downs available.
They are often used in analog to digital converters to provide a controlled current flow into a resistive sensor.
Another application is the I2C protocol bus, where pull-up resistors are used to enable a single pin to act as an input or an output. When not connected to a bus, the pin floats in a high-impedance state.
Pull-down resistors are also used on outputs to provide a known output impedance.