The Five Basic Methods for Eliminating Switch Bounce

By Michael H. Pelkey, Founder & CEO, LogiSwitch LLC

Overview

This tutorial is to demonstrate all five methods for debouncing switches using single pole-single throw, or single pole-double throw switches. The guide includes the two methods for single pole-double throw (SPDT) switches which require no output delay and the two best methods for interfacing with the simpler single pole-single throw (SPST) switches.

What is Switch Bounce

The electric "snap switch" consists of one or two stationary electrodes called "Throws", and a movable electrode, called a "Pole". When the switch is activated, the movable pole is forcefully snapped onto the fixed surface of the stationary throw. Like snapping a rubber ball onto the floor, it naturally bounces. The greater the force of the snap, the greater the bounce. Unfortunately, the spring in the switch that provides the "snap" action through mechanical hysteresis also adds to the force of the contacts coming together. If the switch is used to turn on and off electric lights or to start a motor at 50 or 60 Hertz, the bounce is not noticeable and causes no problems.

Unfortunately, such is not the case with high-speed, low current DC applications such as microprocessor and microcontroller-based digital applications. Switch bounce is an inherent characteristic of the electric switch, and almost always causes problems that must be dealt with by the digital circuit designer. To make life easier for electronics design engineers and hobbyists, LogiSwitch manufactures switches and NoBounce+ ICs incorporating integral debounce circuitry. It is the stated position of LogiSwitch that it is time for the field of digital electronics to have their own switches that work for them rather than to continue borrowing from the field for which they were originally designed that requires way too much extra effort just to make them usable. LogiSwitch switches are made for high-speed digital applications.

History of the Legacy Switch

Since the advent of the microprocessor and microcontrollers the propensity of the mechanical switch to "bounce" has proved to be a design problem for hardware and/or software designers that nearly always must be dealt with.

The Electric Snap Switch was designed and patented in 1884 by J. H. Holmes to ease the arcing and burning of contacts for Thomas Edison's new invention of five years earlier, the incandescent light bulb. It has been with us for the past 134 years, and still does a great job when used for the purpose for which it was originally intended: high-voltage, high-current 50 and 60 Hertz AC applications.

Debounce Tutorial

This tutorial demonstrates all five methods for debouncing switches, using single pole-single throw, or single pole-double throw switches. The guide includes the two methods for single pole-double throw (SPDT) switches which require no output delay:

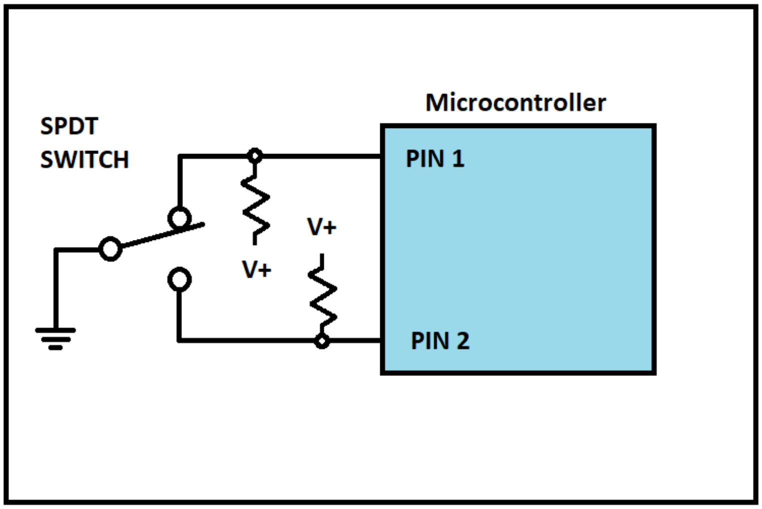
1. The 2-Pin Debounce. This is the simplest method, but it requires two processor pins.
2. The Cross-coupled Nand or S/R Debounce. This method is functionally equivalent to the 2-Pin method, but it uses only one processor pin.

and the two best methods for interfacing with the simpler single pole-single throw (SPST) switches. Note that a delayed output is needed for the SPST switch:

1. Hardware SPST Debounce.
2. Software SPST Debounce.

Note that both the hardware and the software methods for debouncing the SPST switch simply delay the switch output until after the bounce time has ended.

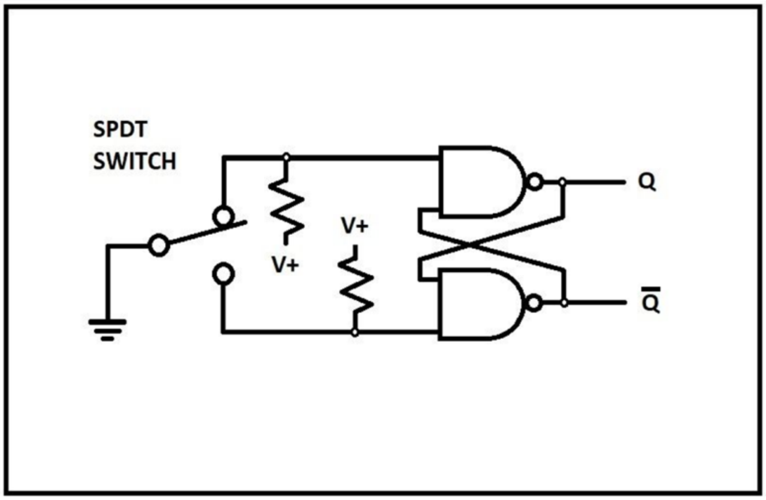
Method 1. Simple Two-Pin Debounce



If you can spare two pins, this is the way to go. Using a SPDT switch, Pin 1 Low indicates the switch is deactivated, and Pin 2 Low indicates it is activated. In other words, Switch Closure is determined by finding Pin 2 low, and Switch Release is determined by finding Pin 1 low.

This rarely used, but highly effective debounce method performs every bit as well as the best cross-coupled NAND circuit when two pins are available for use with a single switch. Note that most microcontrollers provide programmable internal pull-up resistors for pins parameterized as inputs, in which case the circuit may be even further simplified by omitting the two resistors shown in the circuit drawing

Method 2: Cross-Coupled NAND Debounce



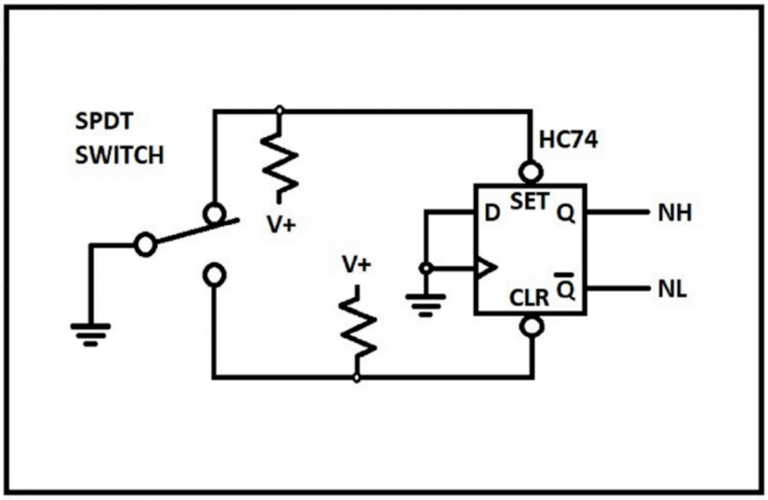
The cross-coupled NAND gate method is ideal for projects where two processor pins are not available for use with one switch.

Output Q is high when the switch is idle, and low when it is activated. The /Q output is the opposite: low when idle and high when activated. Note that only Methods 1, Two-Pin Debounce, Method 2, Cross-coupled Nand Debounce or Method 3, D-Type Flip Flop Debounce provide immediate outputs with no delay on activation and release (see Waveform 1).

For some industrial automation and robotics applications, the immediate attention of signaling from these debounce methods is needed.

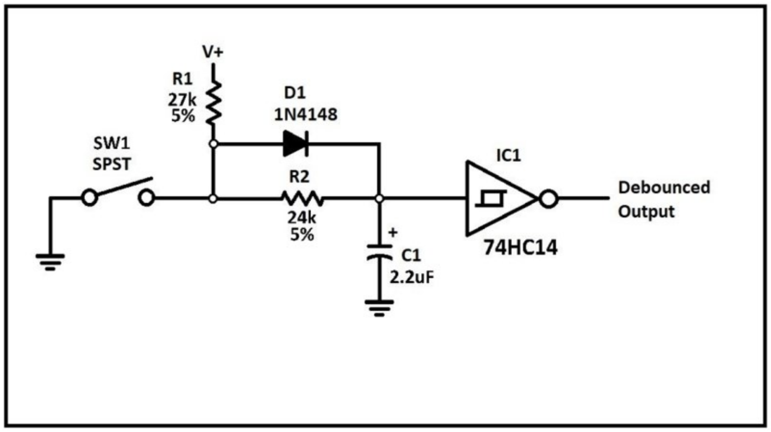
Note that the LogiSwitch integral debounce switches or LS100 series debouncer ICs incorporate a circuit like the circuitry of Method 2.

Method 3: D-Type Flip-Flop Debounce



Using the internal cross-coupled NAND gating of a D-Type Flip flop provides an excellent Method 3 Debounce. Note the Q output is normally high and goes low when the switch is activated.

Method 4: Hardware Debounce for SPST Switches



Whenever a single pole-single throw (SPST) switch is used for input into high-speed digital devices, the only thing you can do is to wait out the bounce interval with either hardware or software delays (see Waveform 2). The individual application dictates the usefulness of this debounce method. Most applications can handle delays of up to 100 ms with a barely noticeable delay. Method 4 is the hardware implementation for single poll-single throw switches.

This circuit charges the capacitor C1 through Resistor R1 and Diode D1 when the switch is released and discharges it through Resistor R2 when it is activated. The 74HC14 Schmitt trigger provides the needed hysteresis for a snap-action output when the slow ramp of the RC circuit rises and falls. Hysteresis assures a single transition with no oscillation when the switch is activated or released.

NOTE: The values shown in the drawing provide delays of approximately 36 ms on activation and release with a 5 Volt supply. The resistance of R1 and R2 may be raised or lowered for longer or shorter delay times.

Using a 2.2 µF Capacitor for C1, a very simple way to calculate the delay time for the circuit shown is R1 = T * 750, and R2 = R1 * 0.9

where T is the desired delay time in milliseconds, and R1 & R2 are resistance in ohms:

For 100 ms delay:	R1 = 100 * 750	R1 = 75,000 ohms	
	R2 = R1 * 0.9	R2 = 75,000 * 0.9	R2 = 67,500 ohms
For 20ms delay:	R1 = 20 * 750	R1 = 15,000 ohms	
	R2 = R1 * 0.9	R2 = 15,000 * 0.9	R2 = 13,500 ohms

Method 5: Software Delay Debounce

There are numerous examples online for software debounce routines for every computer language known to mankind. They all amount to simply waiting out the estimated bounce period.

For Switch Activated:

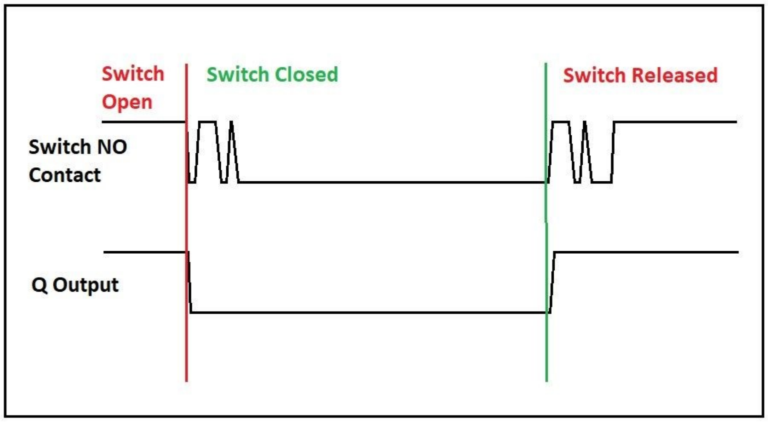
1. Loop until switch activated.
2. Delay 20 ms to 100 ms.
3. Retest to be sure it is still activated. (If not, go to 1)
4. Continue with the program. Switch is activated.

For Switch Released:

1. Loop until switch released.
2. Delay 20 ms to 100 ms.
3. Retest to be sure it is still released. (If not, go to 1)
4. Continue with the program. Switch is released.

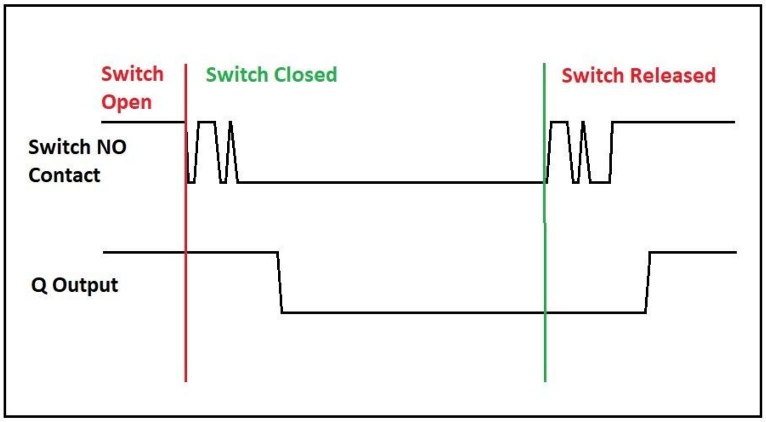
You must provide a longer delay period than any switch you use will ever bounce. Contact bounce time varies among switch types and even among switches of the same type and models. Delay time also is said to change over time with the same switch. Typical delay times used are 20 ms to 100 ms, even when the actual bounce time may be as little as a few milliseconds.

For compute-bound applications where time is literally of the essence, such as in high-speed automated industrial machinery or robotics applications, your choice of debounce method should be Method 1: Two-Pin Debounce, or Method 2: Cross-Coupled Nand Debounce.



Waveform 1. Cross-Coupled Nand and 2-Pin Debounce Methods

Note the immediate Q output. Methods 1 and 2 change the output state with no delay both on actuation and release.



Waveform 2. SPST and Software Delay Methods

Note the delayed Q output for these methods. The Hardware Debounce circuit of Method 3 and Software Debounce of Method 4 require delaying action until the bounce time is through.

About the Author

Michael H. Pelkey, Founder and CEO, LogiSwitch LLC

Mike is a serial inventor and serial entrepreneur who has a broad background in designing, using, and manufacturing electronic systems and equipment. In his younger years, Mike pioneered the sport of BASE Jumping.

Prior to founding LogiSwitch, Mike was an Automation Engineer at Jaxx Manufacturing where he designed and built assembly and metalworking machines to increase production rates, such as automatic screwdrivers, optical cut to length machines, and a variety of machines, jigs and fixtures to automate printed circuit assembly operations.

Mike's 40+ year career goes back to the early days of the microprocessor where he was the lead engineer for the first microprocessor-based product in the numerical control industry a Z-axis controller called the Micro-Z. Mike also developed the world's first networked cash register in the mid-1970s, and he founded Macrotech International Corporation, which was a major manufacturer of board-level computer products in the late-1970s and early-1980s.