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# Binary Inputs

**ECE 376 Embedded Systems**

**Jake Glower - Lecture #4**

Please visit [Bison Academy](#) for corresponding lecture notes, homework sets, and solutions

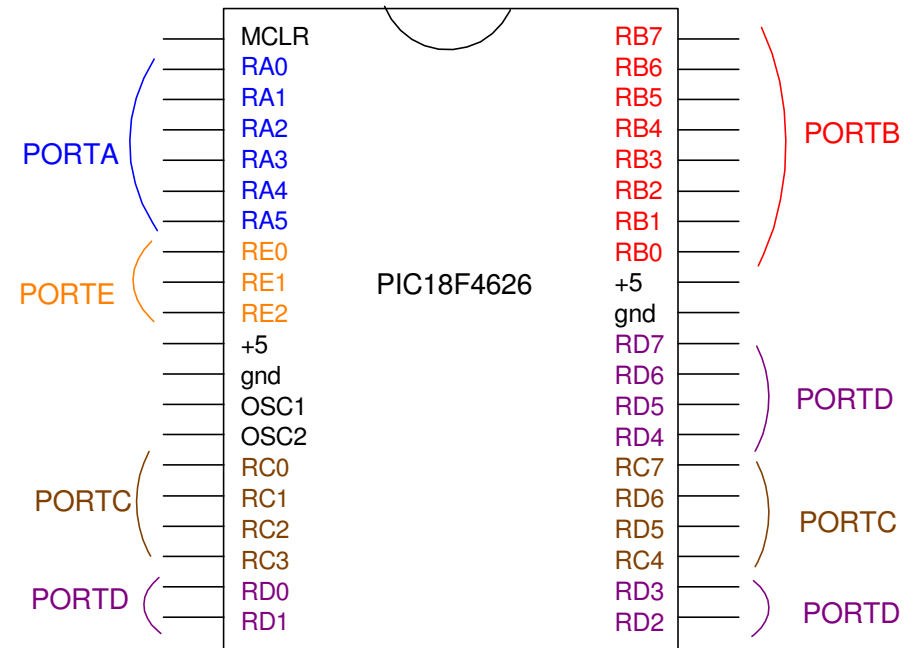
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# Binary Inputs: PORTA..E

The PIC18f4620 chip has

- 33 I/O lines
- Split into five ports:
- 0V = logic 0
- 5V = logic 1

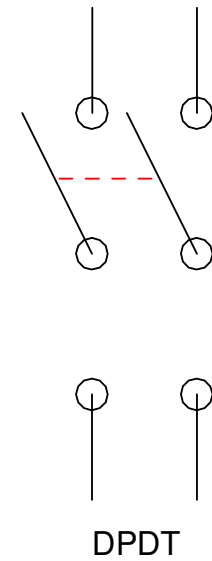
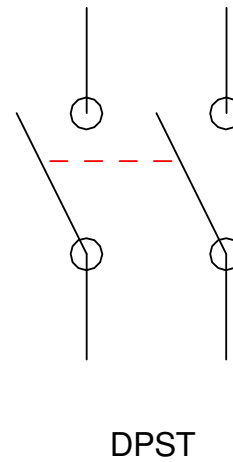
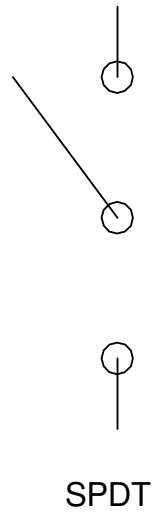
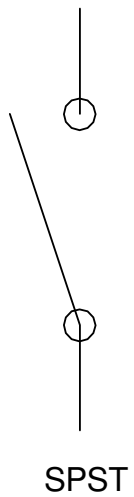
	PORTA	PORTB	PORTC	PORTD	PORTE
Pins	2..7	33..40	15..18, 24..26	19..22, 27..30	3
Binary Input	5	8	8	8	3
Binary Output	5	8	8	8	3
Analog Input	5	5	-	-	3



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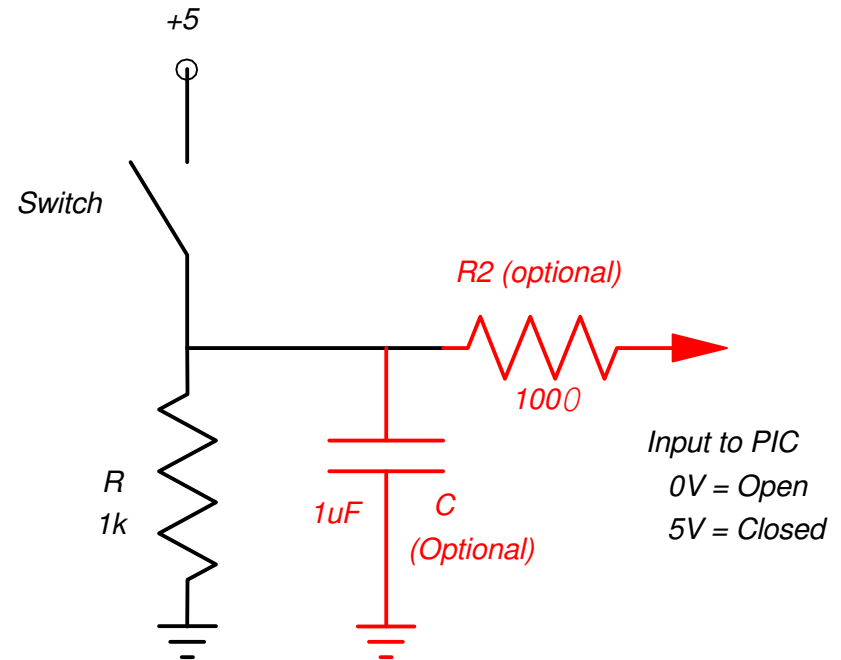
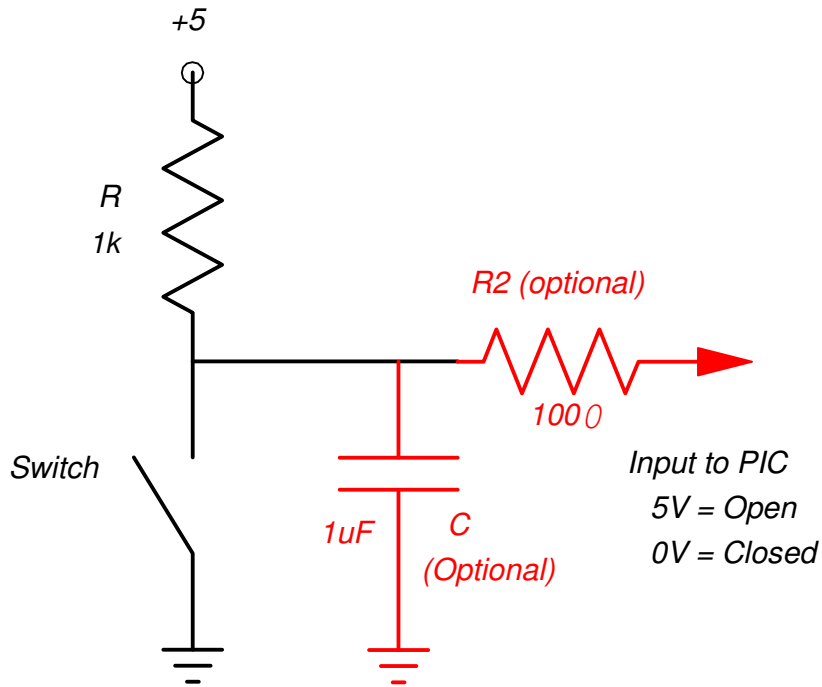
# Types of Switches

- SP: Single Pole. 2 connectors
- DP: Double Pole. Two sets of 2 connectors
- ST: Single Throw. Open or closed
- DT: Double Throw. Center lead can connect to two different leads



# Reading a SPST Switch

- Convert Open / Closed to 0V / 5V
- R: Limits current when switch is closed
- C: Eliminates bouncing (multiple-reads)
- R2: Dummy protection



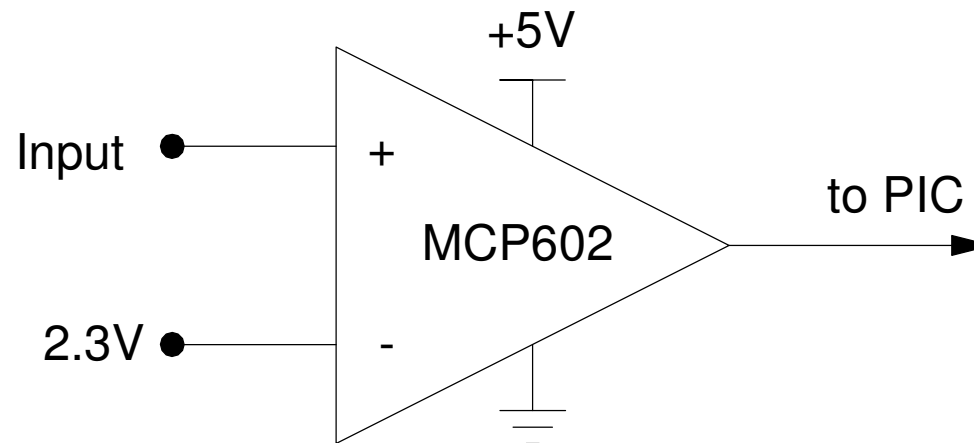
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$$Y = X > 2.3V$$

Design a circuit which outputs

- +5V when the input is more than 2.3V
- 0V when the input is less than 2.3V

Solution: Use a op-amp (such as the MCP602) in your lab kit

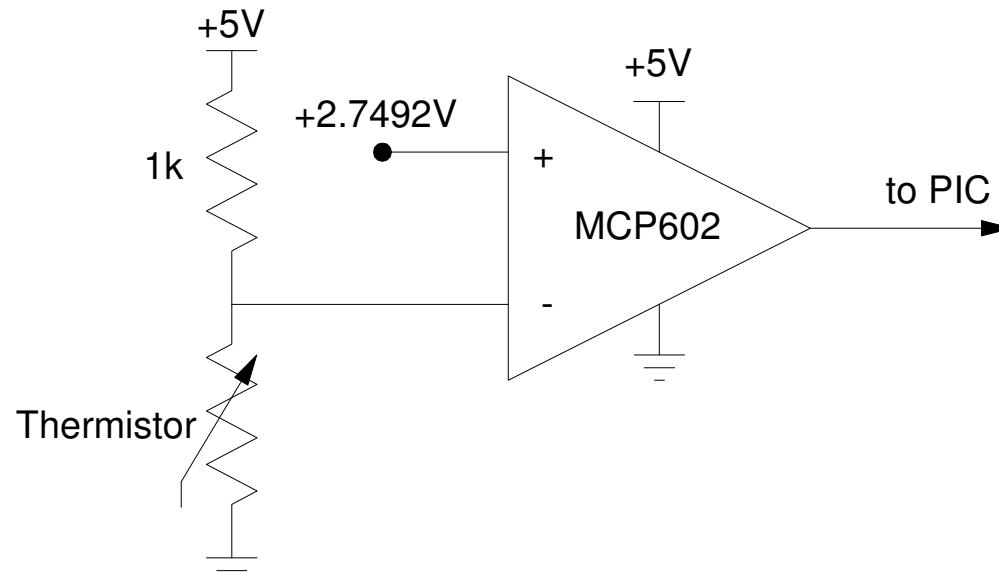


## Y = Temperature > 20C

- Y = +5V when the temperature is above +20C
- Y = 0V when the temperature is below +20C

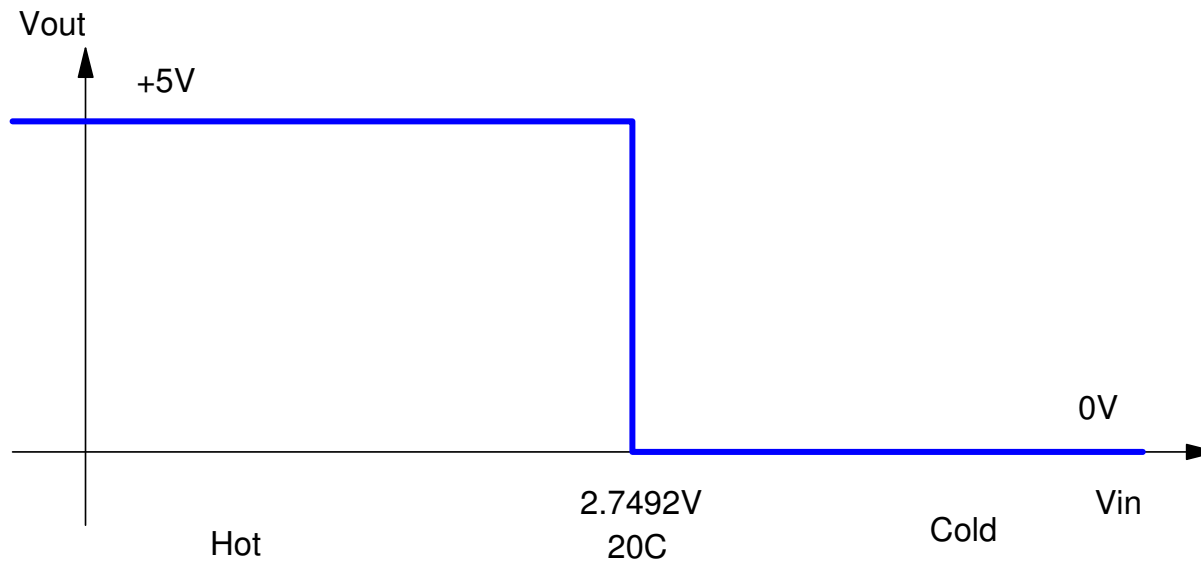
Solution: Use a Thermistor and a voltage divider

- $R(20C) = 1250 \text{ Ohms}$
- $V_x(20C) = 2.778V$



## I/O Characteristics:

- At 20C (2.778V), the output switches.
- For voltages below 2.778V ( $T > 20C$ ), the output goes to 5V
- For voltages above 2.778V ( $T < 20C$ ), the output goes to 0V

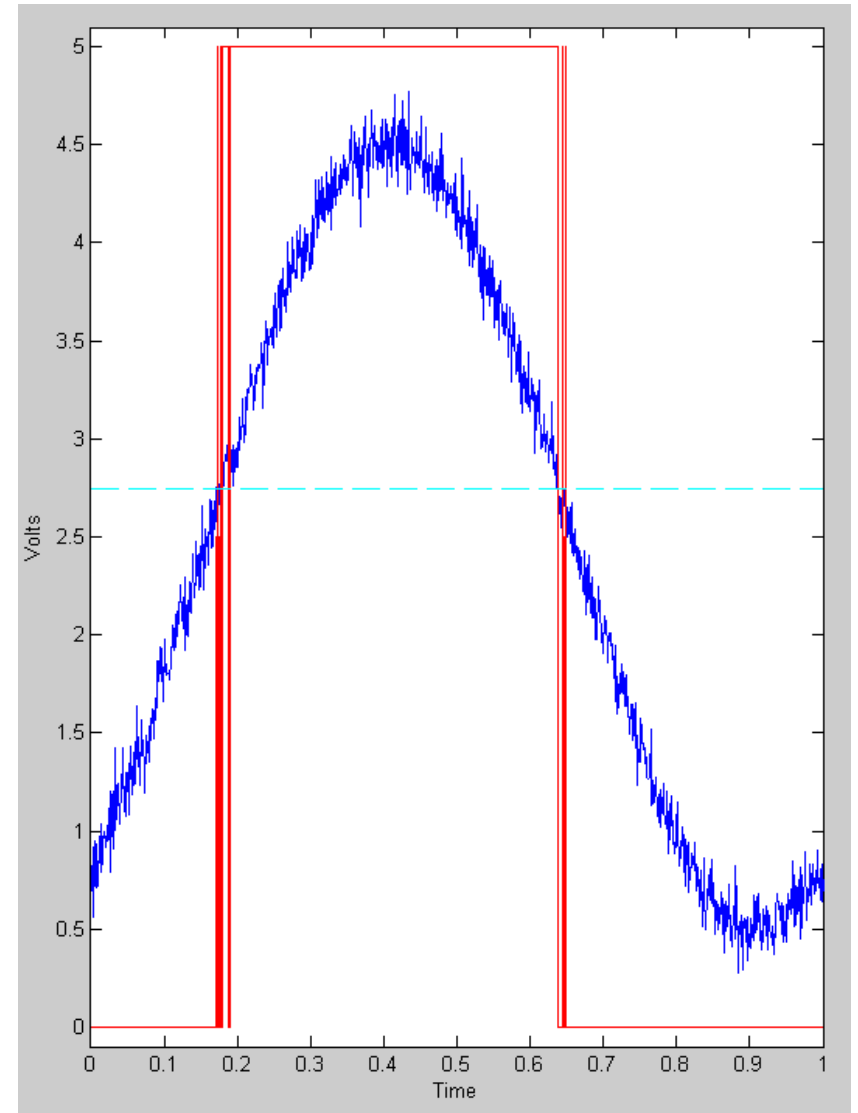


Input / Output Characteristic of the Comparitor

# Comparitors and Noise

Problem with comparitors:

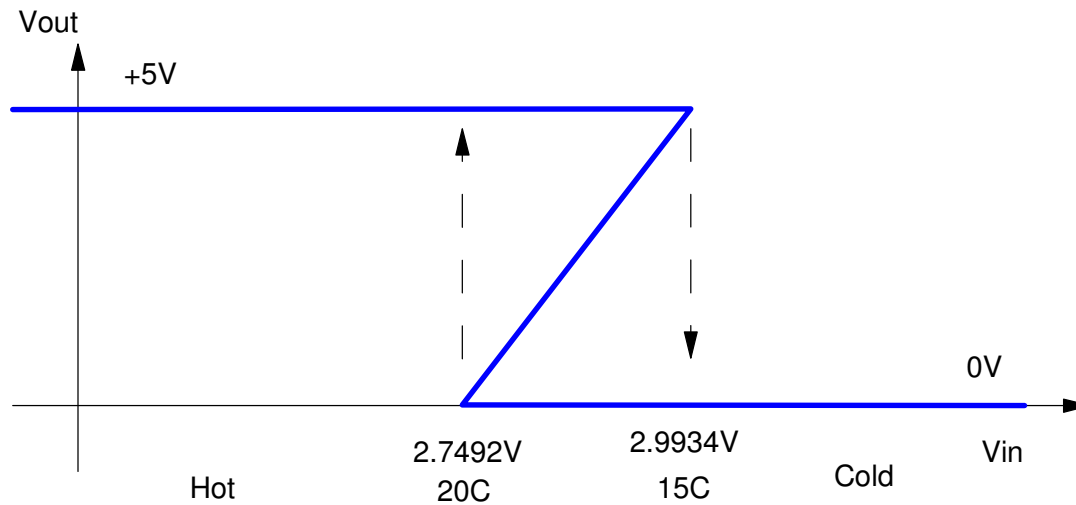
- If the input signal has noise on it, you can get chatter at the 0-1 and 1-0 transistions.
- This chatter can mess up counters, which interprit this as multiple 0-1 transistions.





# Removing Chatter:

- Software: Add a delay
- Hardware: Add hysteresis
  - The output switches to +5V when the temperature goes above +20C
  - The output switches to 0V when the temperature drops below +15C



# Schmitt Trigger:

As  $V_a$  increases, Output Decreases

- Connect to the - input

Turn on at +20C

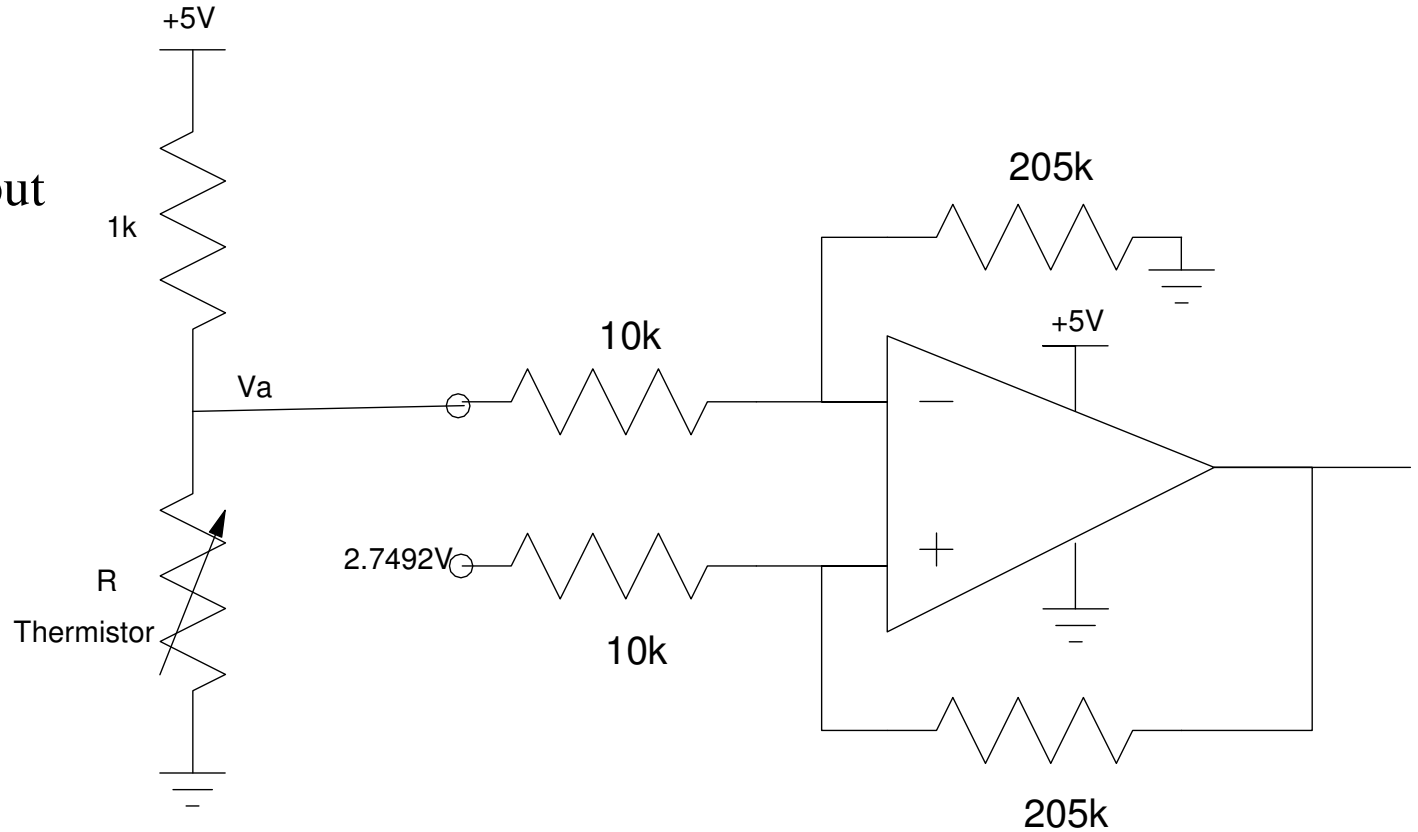
- $R = 1250.6$  Ohms
- $V_a = 2.7492V$
- Apply  $2.7492V$  to + input

Turn off at +15C

- $R = 1576.2$  Ohms
- $V_a = 2.9934V$

Slope = 20.5

- $\left( \frac{5V-0V}{2.9934V-2.7492V} \right) = 20.5$
- $R1 / R2 = 20.5$



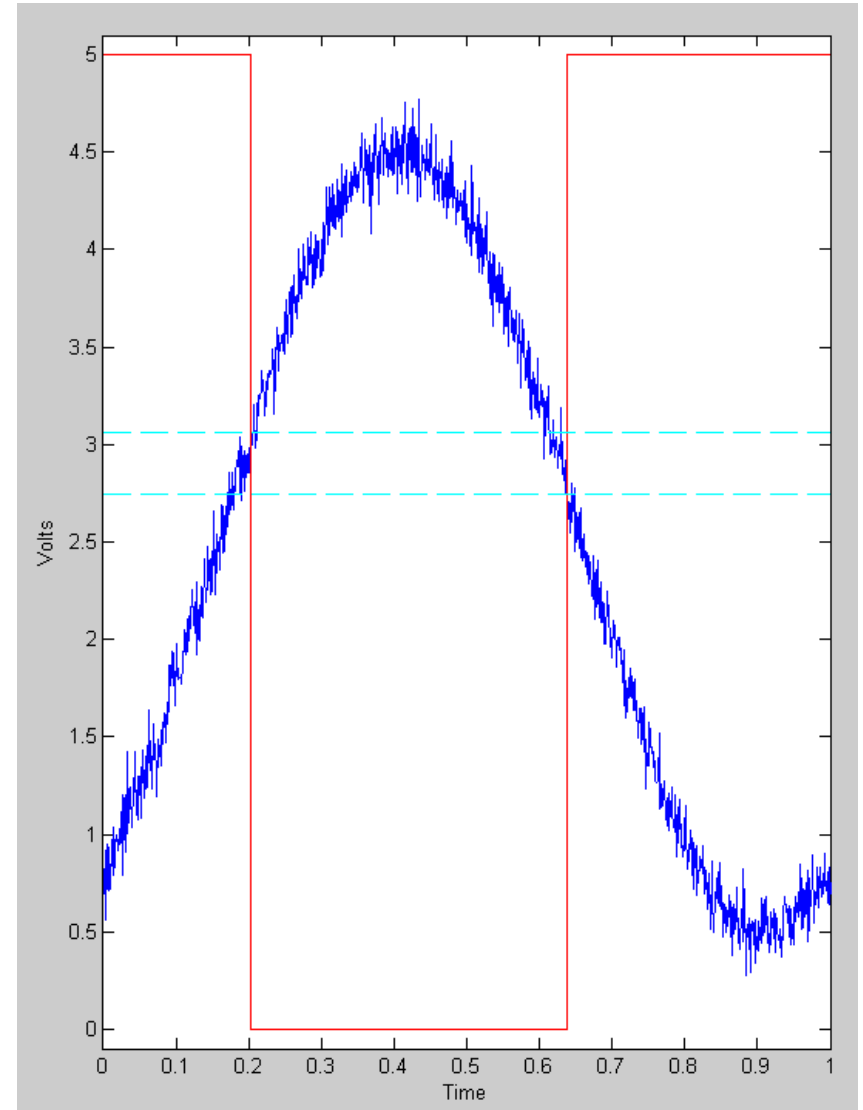
# Schmitt Triggers and Noise

Hysteresis adds two thresholds:

- $Y = 5V$  when  $X < 2.7492V$
- $Y = 0V$  when  $X > 2.9934V$
- No change when  $2.74V < X < 2.99V$

By adding a hysteresis, chatter is avoided

- This prevents multiple counts

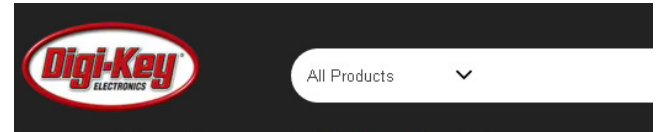


# Changing Sensors

Change R and you can measure...

- CdS sensors convert light to resistance
- Photovoltaic sensors convert light to voltage (current actually...)
- Gas sensors convert O<sub>2</sub>, CO<sub>2</sub>, methane, etc to a resistance or voltage
- Strain gages convert strain (or weight or pressure) to resistance
- Tachometers convert motor speed to a voltage.

10,000+ sensors are available from Digikey



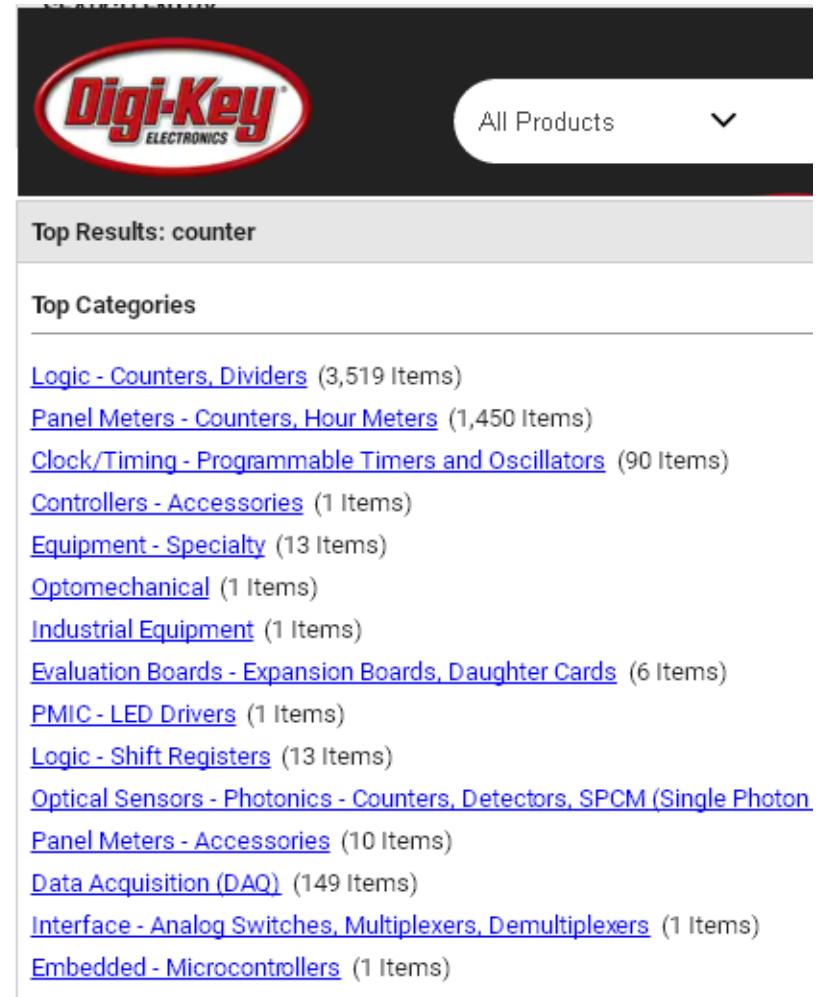
Sensors, Transducers - [1,613 New Products](#)

- [Accessories](#) (6,216 Items)
- [Amplifiers](#) (1,786 Items)
- [Camera Modules](#) (514 Items)
- [Color Sensors - Industrial](#) (36 Items)
- [Color Sensors](#) (80 Items)
- [Current Sensors](#) (2,488 Items)
- [Encoders - Industrial](#) (4,535 Items)
- [Encoders](#) (4,470 Items)
- [Float, Level Sensors - Industrial](#) (195 Items)
- [Float, Level Sensors](#) (1,061 Items)
- [Flow Sensors - Industrial](#) (49 Items)
- [Flow Sensors](#) (445 Items)
- [Force Sensors - Industrial](#) (339 Items)
- [Force Sensors](#) (71 Items)
- [Gas Sensors](#) (650 Items)
- [Humidity, Moisture Sensors](#) (512 Items)
- [Image Sensors, Camera](#) (2,064 Items)
- [IRDA Transceiver Modules](#) (150 Items)
- [LVDT Transducers \(Linear Variable Differential Transformer\)](#) (147 Items)
- [Magnetic Sensors - Compass, Magnetic Field \(Modules\)](#) (54 Items)
- [Magnetic Sensors - Linear Compass \(ICs\)](#) (1,115 Items)
- [Magnetic Sensors - Position, Proximity, Speed \(Modules\) - Industrial](#) (480 Items)
- [Magnetic Sensors - Position, Proximity, Speed \(Modules\)](#) (4,889 Items)
- [Magnetic Sensors - Switches \(Solid State\)](#) (3,345 Items)
- [Magnets - Multi Purpose](#) (994 Items)
- [Magnets - Sensor Matched](#) (88 Items)
- [Motion Sensors - Accelerometers](#) (1,559 Items)
- [Motion Sensors - Gyroscopes](#) (178 Items)
- [Motion Sensors - IMUs \(Inertial Measurement Units\)](#) (334 Items)
- [Motion Sensors - Inclinometers](#) (138 Items)
- [Motion Sensors - Optical](#) (592 Items)
- [Motion Sensors - Tilt Switches](#) (65 Items)
- [Motion Sensors - Vibration](#) (263 Items)
- [Multifunction](#) (380 Items)
- [Optical Sensors - Ambient Light, IR, UV Sensors](#) (1,108 Items)
- [Optical Sensors - Distance Measuring](#) (225 Items)
- [Optical Sensors - Photo Detectors - CdS Cells](#) (63 Items)
- [Optical Sensors - Photo Detectors - Logic Output](#) (136 Items)
- [Optical Sensors - Photo Detectors - Remote Receiver](#) (1,865 Items)
- [Optical Sensors - Photodiodes](#) (1,289 Items)
- [Optical Sensors - Photoelectric, Industrial](#) (12,089 Items)
- [Optical Sensors - Photointerrupters - Slot Type - Logic Output](#) (1,191 Items)
- [Optical Sensors - Photointerrupters - Slot Type - Transistor Output](#) (1,329 Items)
- [Optical Sensors - Photonics - Counters, Detectors, SPCM \(Single Photon Counting\)](#)
- [Optical Sensors - Phototransistors](#) (884 Items)

# Counters

Once you have whatever you're measuring converted to TTL levels (0V / 5V), you can write a program to do things, like count.

- Count each riding edge (counter)
- Up / Down Counter
- Multiple Counters
  - Hungry Hungry Hippo



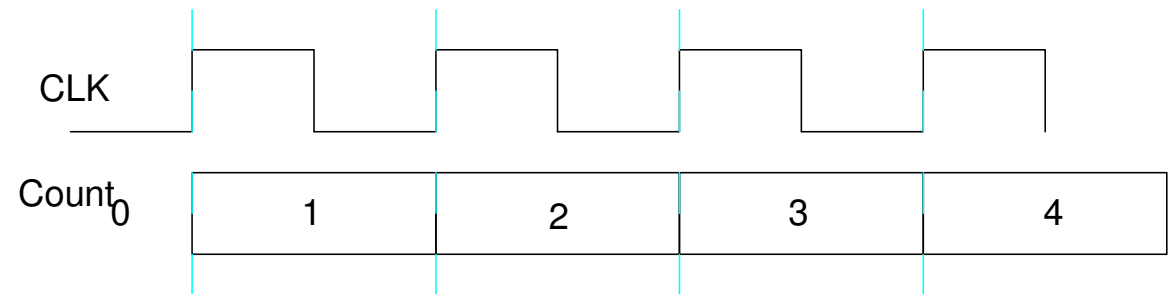
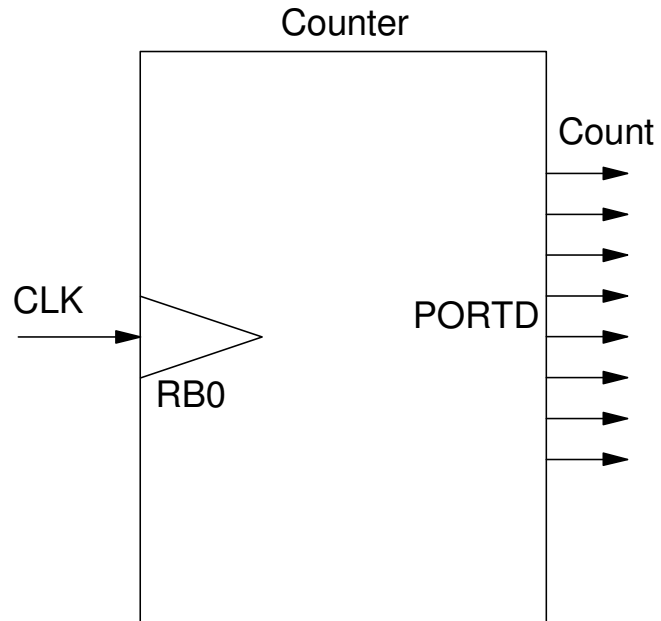
The screenshot shows the Digi-Key Electronics website search results for the term "counter". The page features the Digi-Key logo at the top left and a search bar with "All Products" and a dropdown arrow. Below the search bar, the text "Top Results: counter" is displayed. A section titled "Top Categories" lists various product categories with their respective item counts:

- [Logic - Counters, Dividers](#) (3,519 Items)
- [Panel Meters - Counters, Hour Meters](#) (1,450 Items)
- [Clock/Timing - Programmable Timers and Oscillators](#) (90 Items)
- [Controllers - Accessories](#) (1 Items)
- [Equipment - Specialty](#) (13 Items)
- [Optomechanical](#) (1 Items)
- [Industrial Equipment](#) (1 Items)
- [Evaluation Boards - Expansion Boards, Daughter Cards](#) (6 Items)
- [PMIC - LED Drivers](#) (1 Items)
- [Logic - Shift Registers](#) (13 Items)
- [Optical Sensors - Photonics - Counters, Detectors, SPCM \(Single Photon](#)
- [Panel Meters - Accessories](#) (10 Items)
- [Data Acquisition \(DAQ\)](#) (149 Items)
- [Interface - Analog Switches, Multiplexers, Demultiplexers](#) (1 Items)
- [Embedded - Microcontrollers](#) (1 Items)

## Electronic Components

# Example 1: Up Counter

- Start with PORTD = 0
- Each rising edge on RB0, increment the count by one



# Counter: Flow Chart & Code

```
#include <p18f4620.inc>

COUNT equ 0

    org 0x800

    movlw 0xFF
    movwf TRISB
    clrf TRISD
    movlw 0x0F
    movwf ADCON1

    clrf COUNT
    clrf PORTD

; while(RB0 == 1);

L1:
    btfsc PORTB,0
    goto L1

; while(RB0 == 0);

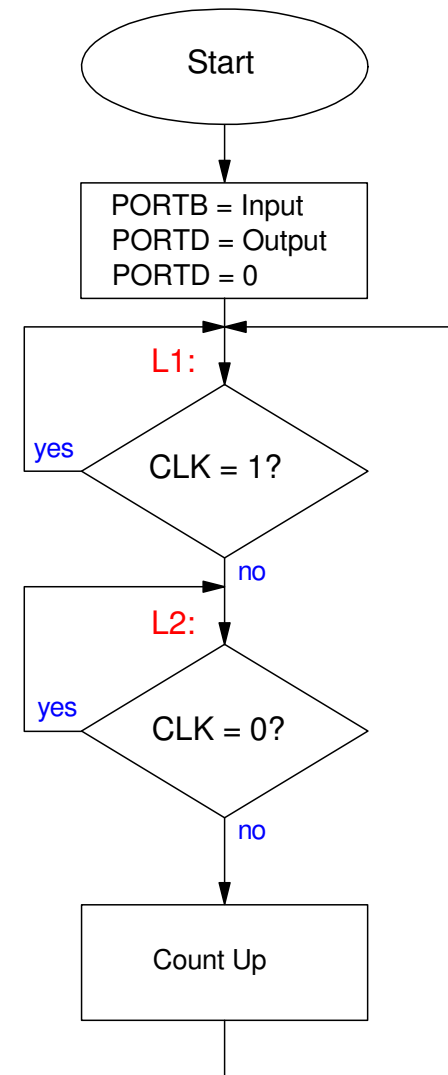
L2:
    btfss PORTB,0
    goto L2

; Rising edge detected
; PORTD = PORTD + 1;

    incf COUNT,F
    movff COUNT, PORTD

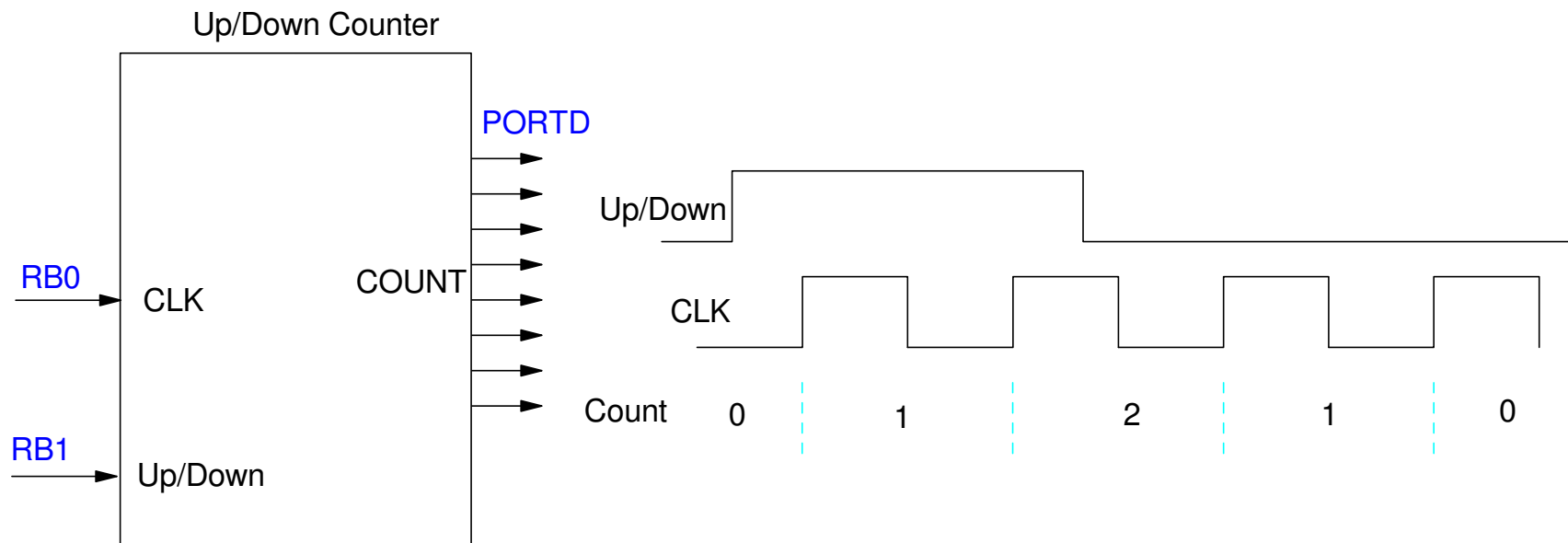
    goto L1

end
```



## Example 2: Up / Down Counter

- Start with Count = 0
- Look for a rising edge on RB0
- When found
  - Count up if RB1 = 1
  - Count down if RB1 = 0





# Up/Down Counter: Flow Chart and Code

```
#include <p18f4620.inc>

COUNT equ 0

    org 0x800

    movlw 0xFF
    movwf TRISB
    clrf TRISD
    movlw 0x0F
    movwf ADCON1

    clrf COUNT
    clrf PORTD

L1:
    btfsc PORTB,0
    goto L1

L2:
    btfss PORTB,0
    goto L2

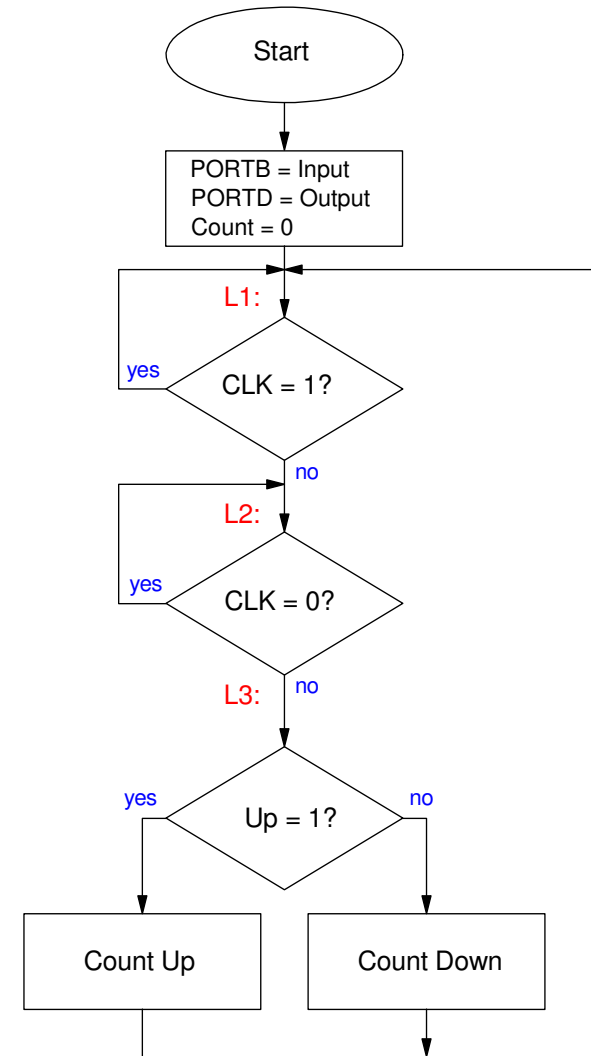
L3:
    btfsc PORTB, 1
    goto Up

Down:
    decf COUNT,F
    goto L4

Up:
    incf COUNT,F

L4:
    movff COUNT, PORTD
    goto L1

end
```



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## Example 3: Multiple Counters

- Hungry-Hungry Hippo Game

Input:

- Push buttons RB0 and RB7

Output:

- PORTC and PORTD

Relationship:

- Start with  $PORTC = PORTD = 0$
  - Each time you detect a rising edge on RB0, increment PORTC by one
  - Each time you detect a rising edge on RB7, increment PORTD by one
-



# Flow Chart & Assembler Code

```
#include <p18f4620.inc>
```

```
OldB equ 0
```

```
org 0x800
```

```
clrf TRISA  
movlw 0xFF  
movwf TRISB  
clrf TRISC  
clrf TRISD  
clrf TRISE  
movlw 0x0F  
movwf ADCON1  
movff PORTB, B
```

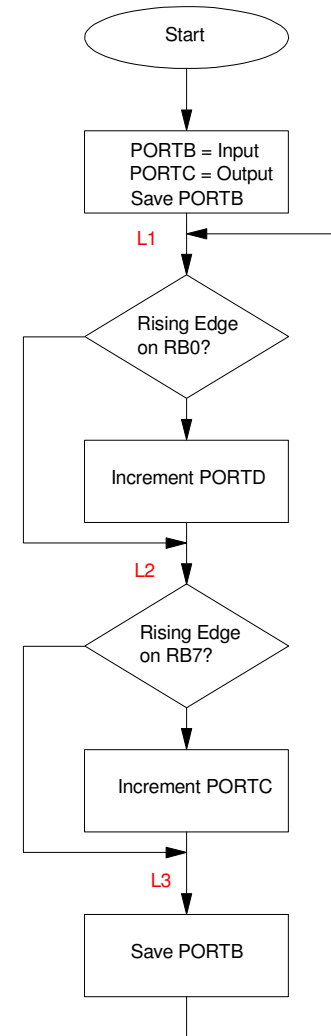
```
L1:  
movff B, OldB  
movff PORTB, B
```

```
btfs B, 0  
goto L2  
btfs OldB, 0  
goto L2  
incf PORTD, F
```

```
L2:  
btfs B, 7  
goto L3  
btfs OldB, 7  
goto L3  
incf PORTC, F
```

```
L3:  
goto L1
```

```
end
```



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# Summary

PIC uses TTL logic levels

- 0V = logic 0
- 5V = logic 1

With an op-amp, you can convert signals to TTL logic levels

- Comparitor (no hysteresis, can result in chatter)
- Schmitt Trigger

With software, you can then count the number of rising edges

- Up Counter
  - Up / Down Counter
  - Multiple Counters
-