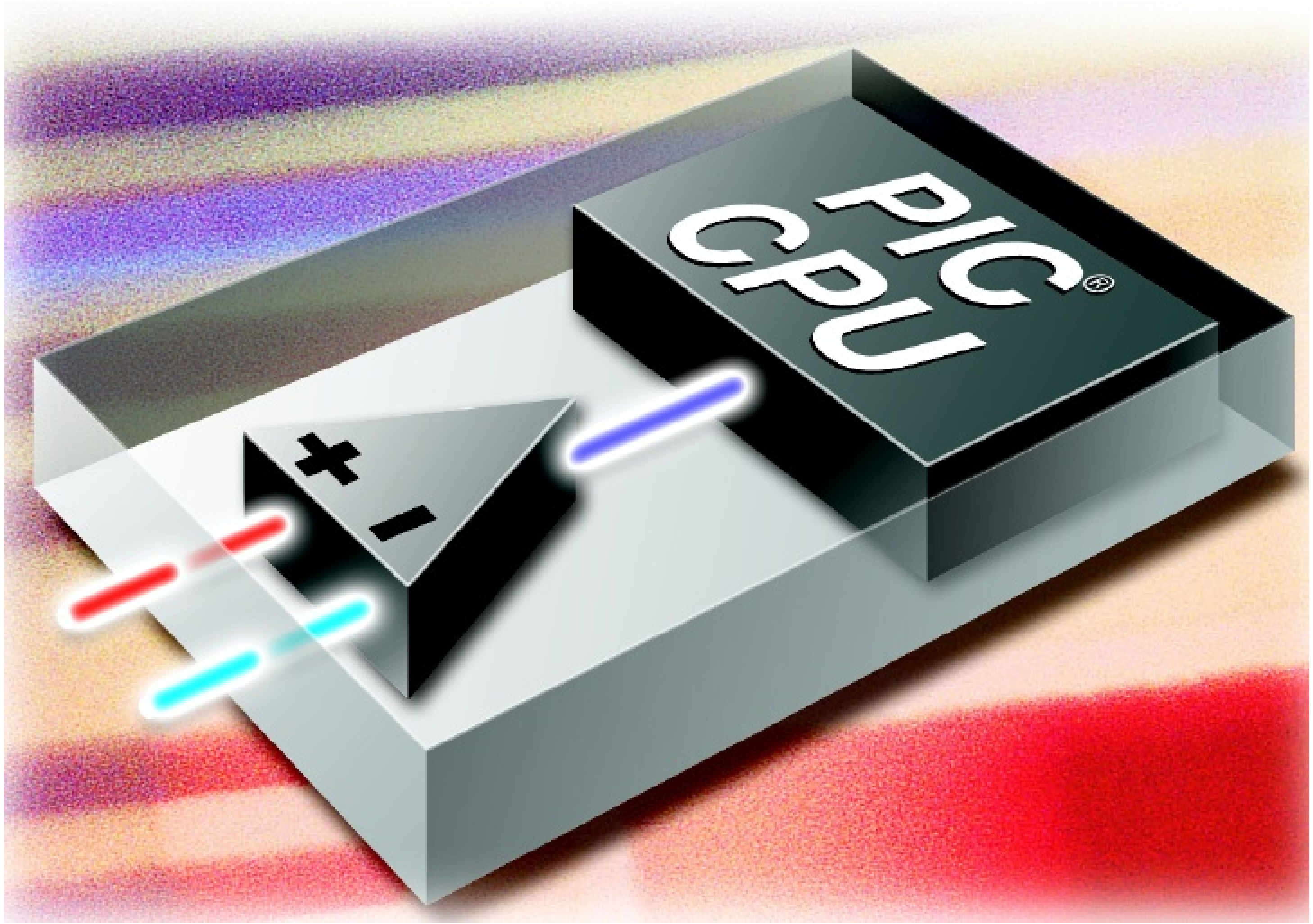
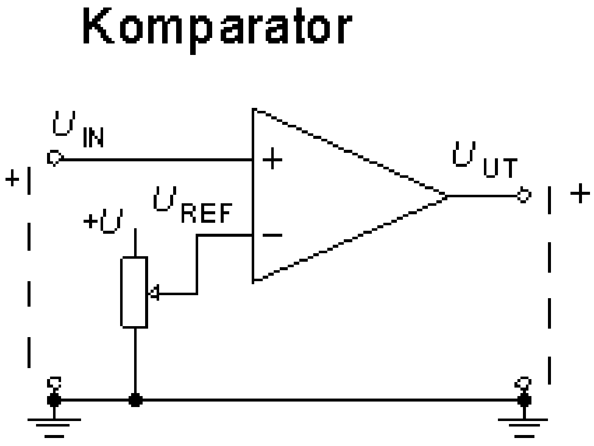
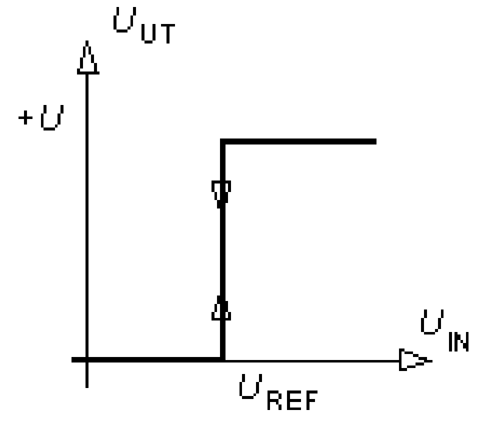


William Sandqvist william@kth.se

Comparator an 1 bit AD-converter

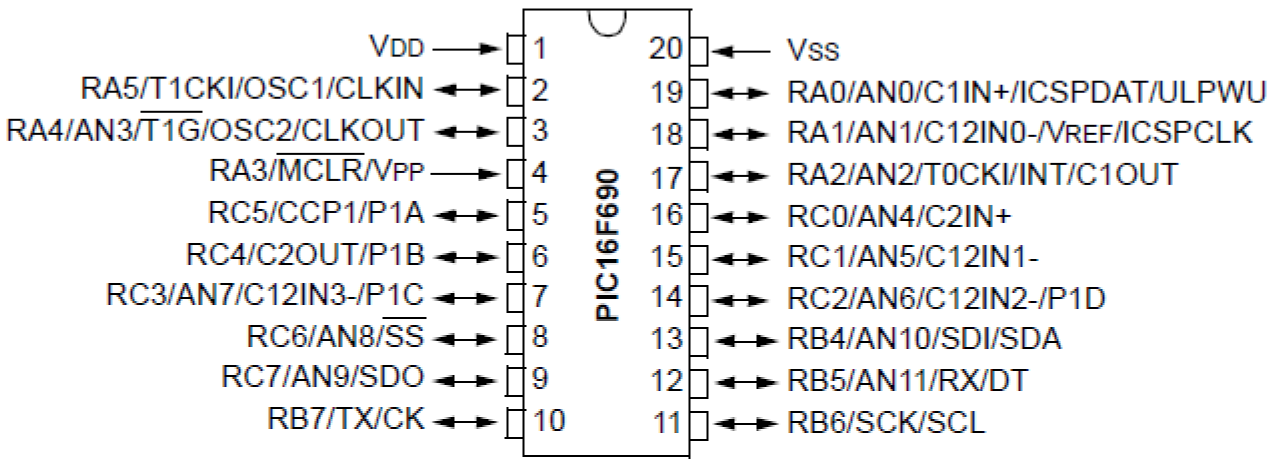




A comparator is a sensitive amplifier for the *difference* between input voltages. The slightest positive difference means that the output get (1) or negative difference get (0).

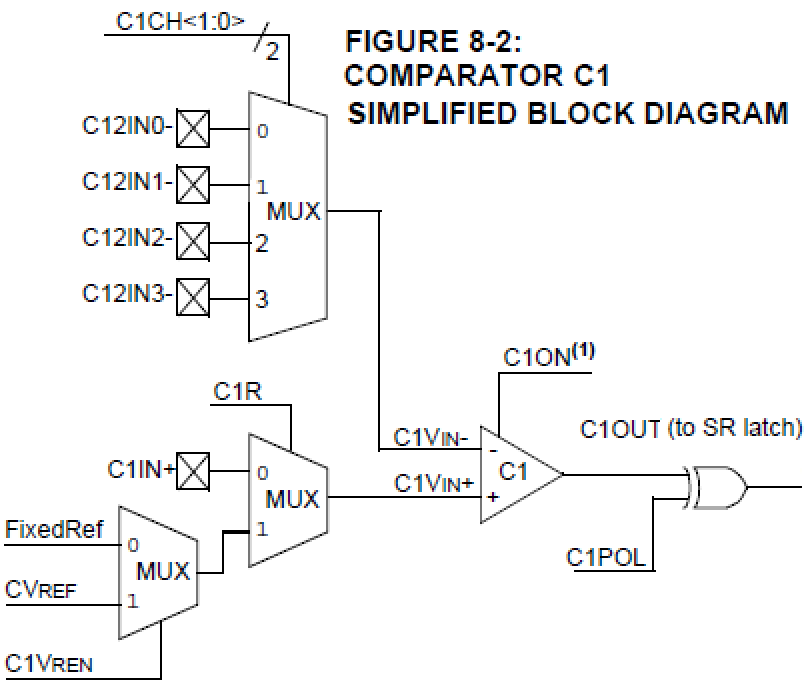
The comparator can be used to accurately determine when a voltage U_{IN} pass a certain reference voltage U_{REF}.

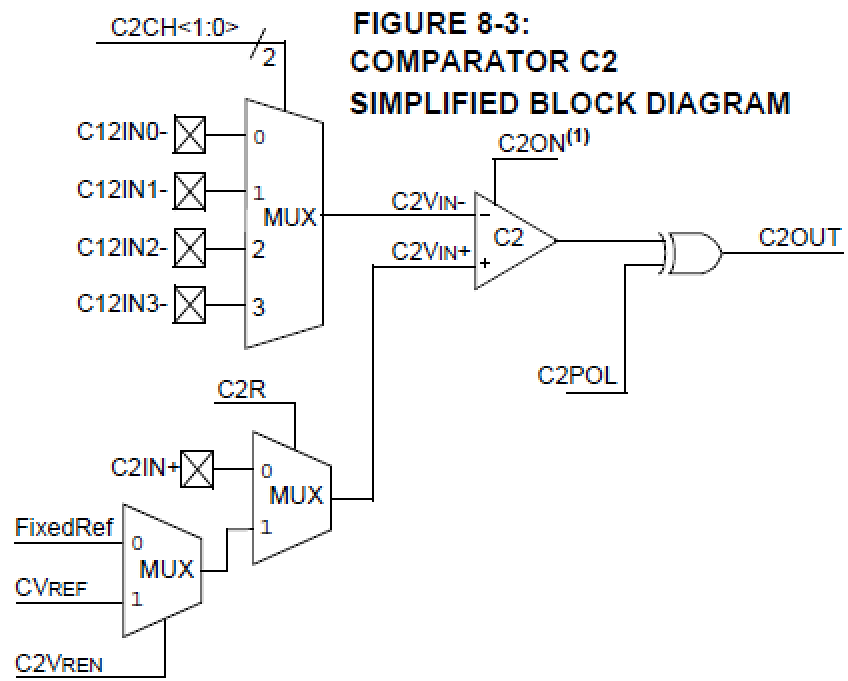
PIC-processor comparators



PIC16F690 has *two* internal analog comparators. They can be connected to different pins or to internal units. The comparator is a very versatile component..

Many configuration options!





C1:s and C2:s outputs are are accessible internally, but can also be connected to external pins (eg. C2OUT → **RC4**).

Analog function?

One choose to use the "analog" function on pins with the ANSEL registers. **PIC16F690**:

REGISTER 4-3: ANSEL: ANALOG SELECT REGISTER

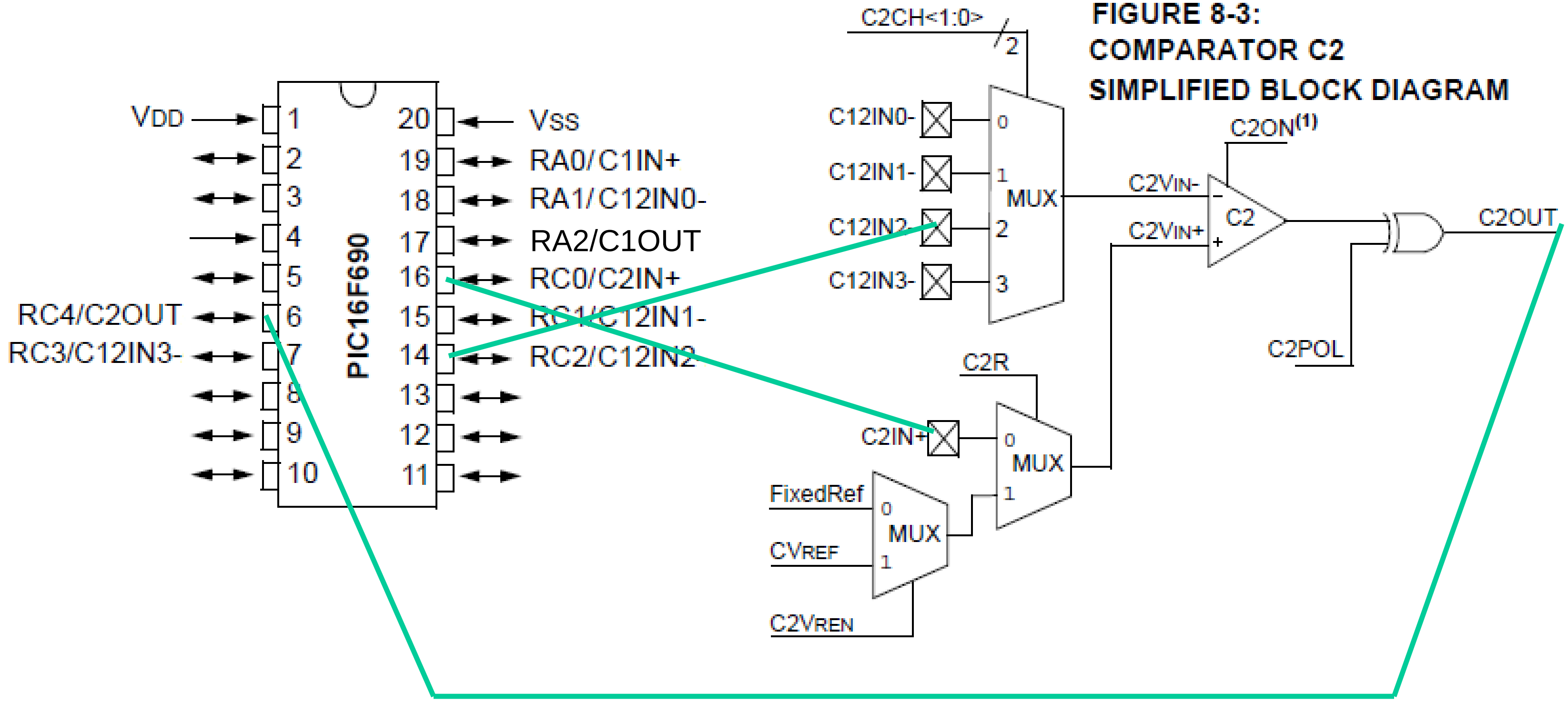
R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
ANS7	ANS6	ANS5	ANS4	ANS3	ANS2	ANS1	ANS0
bit 7							bit 0
RC3	**RC2**	**RC1**	**RC0**	**RA4**	**RA2**	**RA1**	**RA0**

REGISTER 4-4: ANSELH: ANALOG SELECT HIGH REGISTER

U-0	U-0	U-0	U-0	R/W-1	R/W-1	R/W-1	R/W-1
—	—	—	—	ANS11	ANS10	ANS9	ANS8
bit 7							bit 0
				RB5	**RB4**	**RC7**	**RC6**

Default-setting is the analog function – so in practice choose to remove analogous function when you need digital.

CMP2 at lab



ANSEL.4=1; ANSEL.6=1; TRISC.0=1; TRISC.2=1; TRISC.4=0;

Control registers

REGISTER 8-1: CM1CON0: COMPARATOR C1 CONTROL REGISTER 0

R/W-0	R-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
C1ON	C1OUT	C1OE	C1POL	—	C1R	C1CH1	C1CH0
bit 7							bit 0

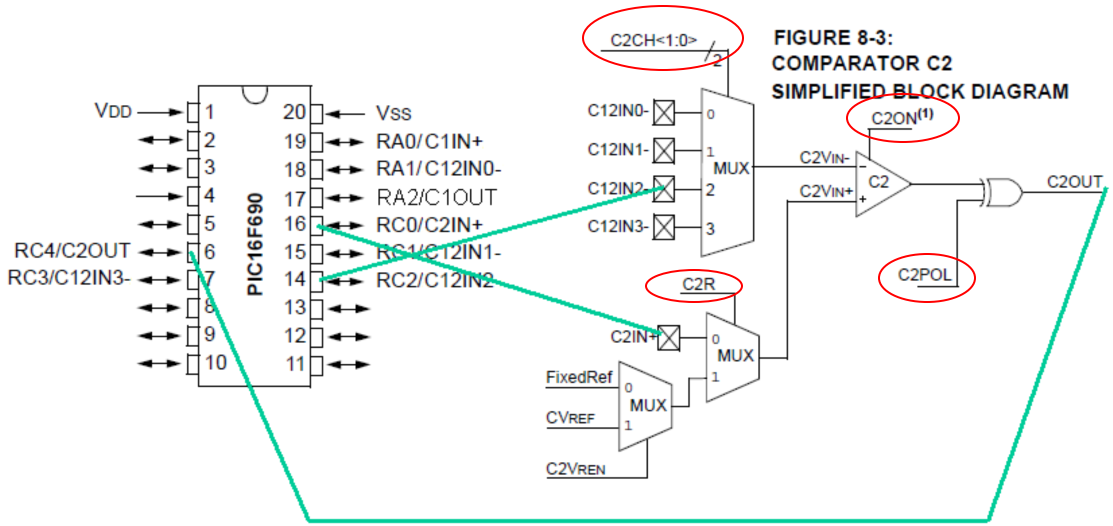
REGISTER 8-2: CM2CON0: COMPARATOR C2 CONTROL REGISTER 0

R/W-0	R-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
C2ON	C2OUT	C2OE	C2POL	—	C2R	C2CH1	C2CH0
bit 7							bit 0

REGISTER 8-3: CM2CON1: COMPARATOR C2 CONTROL REGISTER 1

R-0	R-0	U-0	U-0	U-0	U-0	R/W-1	R/W-0
MC1OUT	MC2OUT	—	—	—	—	T1GSS	C2SYNC
bit 7							bit 0

CMP2 at lab

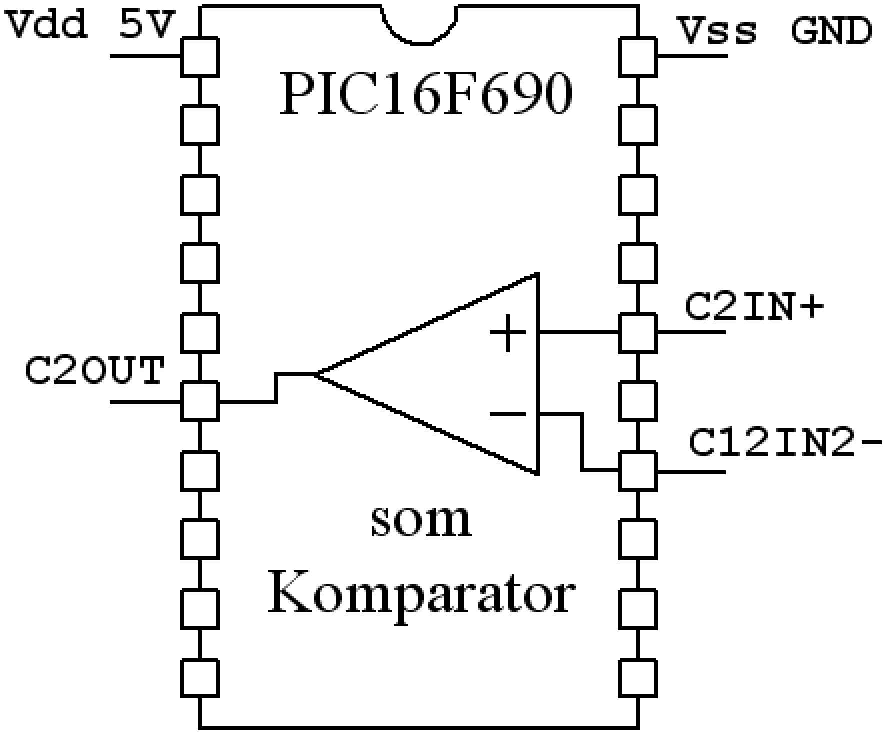


REGISTER 8-2: CM2CON0: COMPARATOR C2 CONTROL REGISTER 0

R/W-0	R-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
C2ON	C2OUT	C2OE	C2POL	—	C2R	C2CH1	C2CH0
bit 7							bit 0
1	**-**	**1**	**0**	**-**	**1**	**1**	**0**

C2CH.0=0; C2CH.1=1; C2R=0; C2POL=0; C2OE=1; C2ON=1;

CMP2 at lab

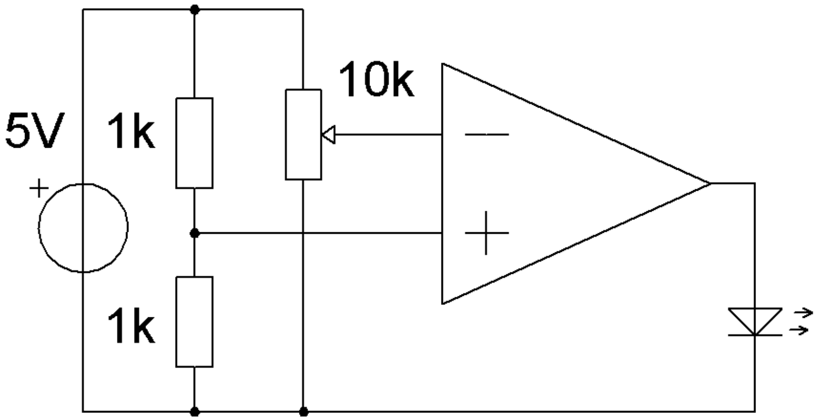


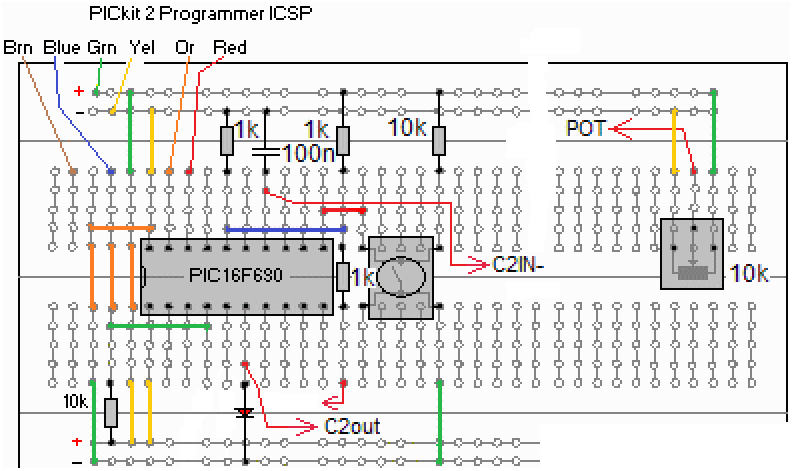

```
C2CH.0=0;   // C12IN2-
C2CH.1=1;   // C12IN2-
C2R=0;      // C2IN+
C2POL=0;    // not invert
SR1=0;      // no SR-latch
C2OE=1;     // out to pin
C2ON=1;     // C2 on
ANSEL.4=1;  // analog
ANSEL.6=1;  // analog
TRISC.0=1;  // RC0 input
TRISC.2=1;  // RC2 input
TRISC.4=0;  // RC4 output
```

With these settings we use Comparator 2 as independent stand alone component!

In gray
– default setting

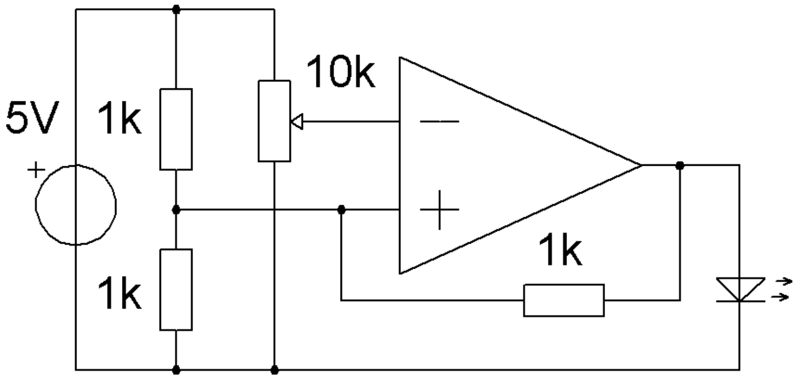
Lab: try a Comparator

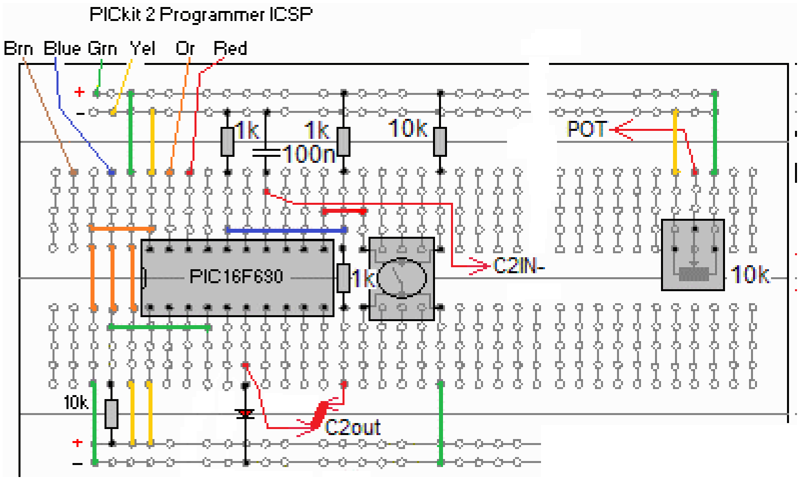




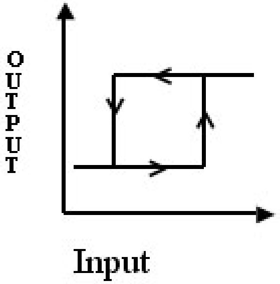
When the voltage at the twerminal on the 10k potentiometer is passing reference voltage 2.5V (5V divided by two) the comparator output turns on. The trip point is very distinct.

Lab: try a Schmitt-trigger





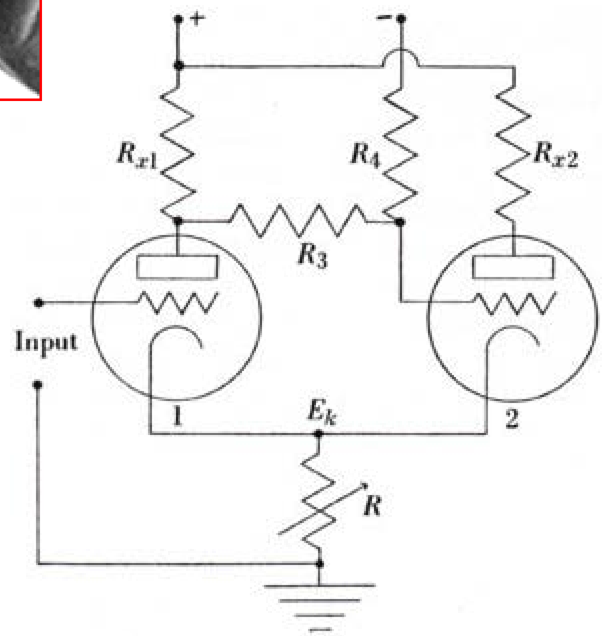
A third 1k resistor from the output to the "+" input shifts the reference level so that we must now turn more to change the output. There are dual threshold for on and off. The function will be more secure. The connection is called the Schmitt trigger and the phenomen of dual tresholds is called hysteresis.

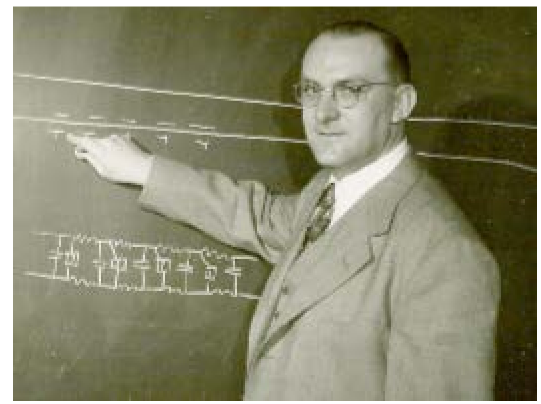


Hysteres.

William Sandqvist william@kth.se

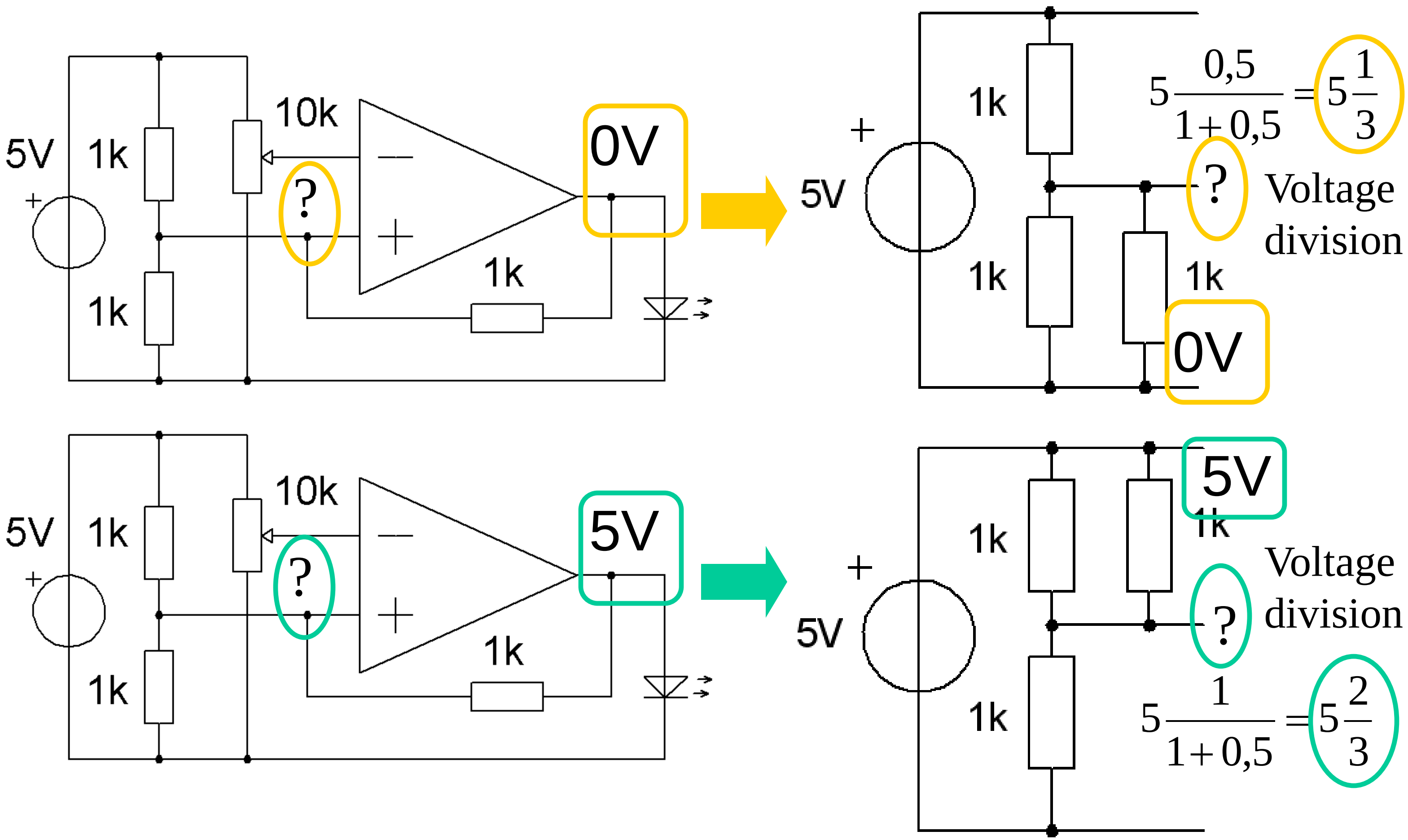
Otto Schmitt



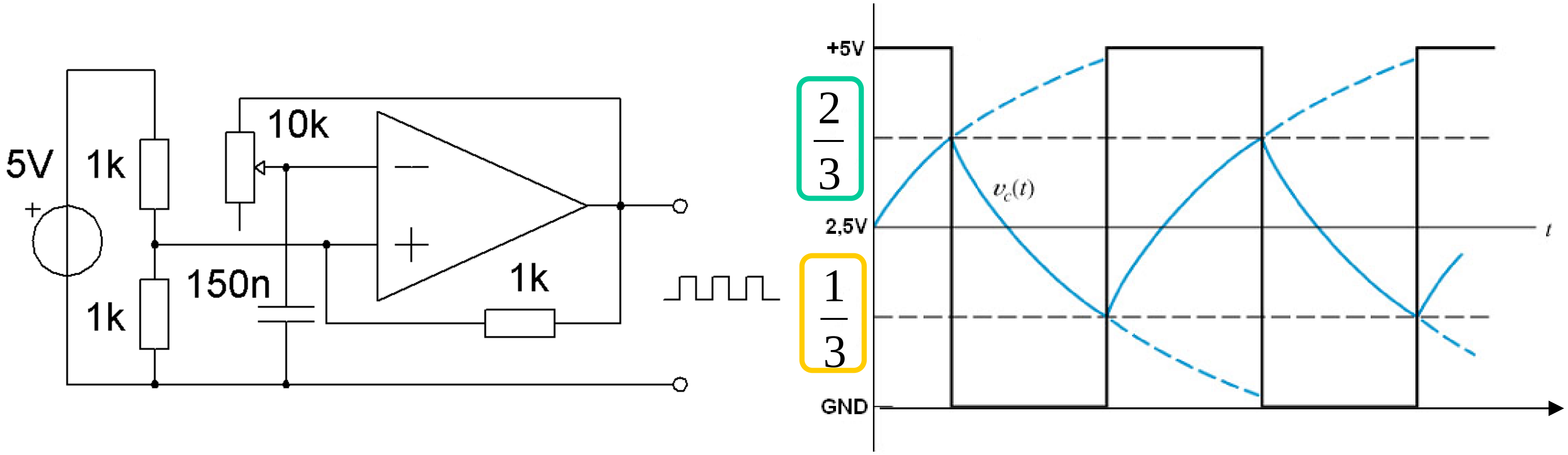


A schmitt-trigger has ”snap action”. When you have passed the trip-point the process is no longer possible to prevent …

Threshold voltages? (10.10)

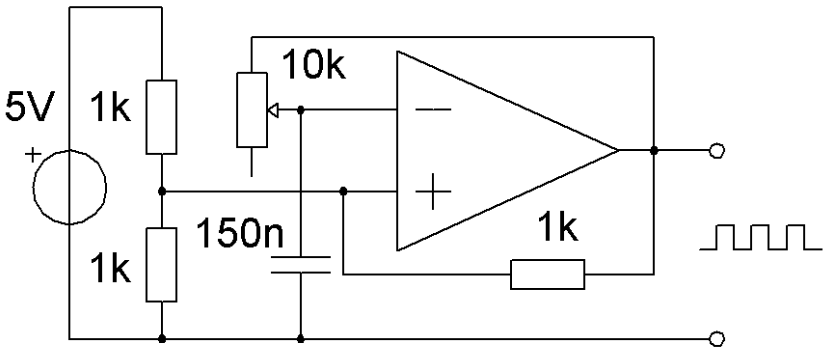


RC-oscillator



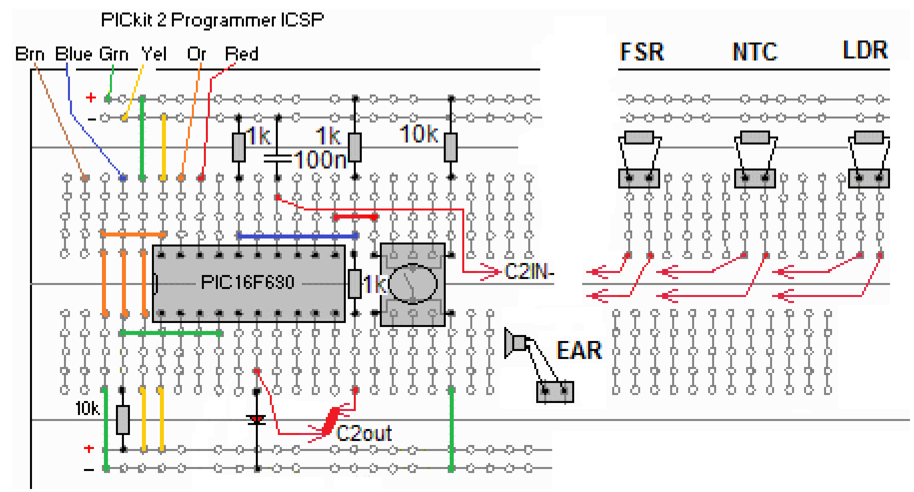
The comparator charges the capacitor to the upper trig level, then turn the output on and discharges the capacitor to the lower trigger level. The frequency of the output of the comparator depends on the product *R*·*C*. As *C* is constant ***R*** **will determine the frequency**.

Lab: try RC-oscillator



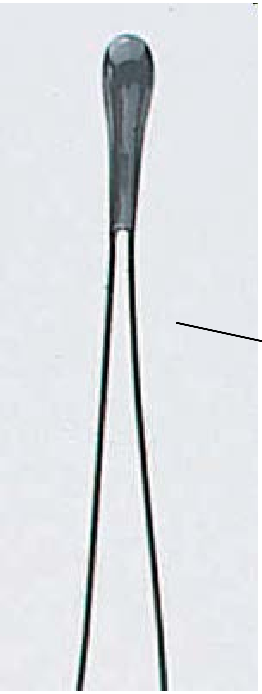
Schmitt trigger is continuously charging and discharging the capacitor voltage between the two threshold levels.

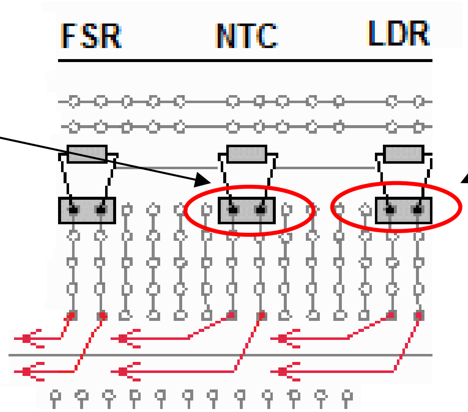
Along with the earphone, we now have a buzzer!

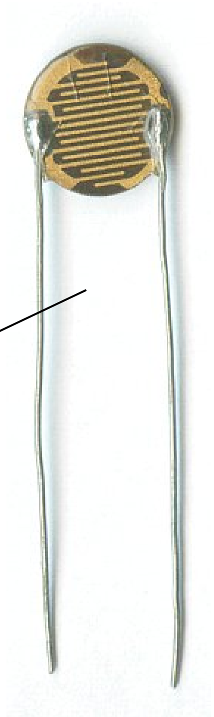


Sensors

Try some resistive sensors …







NTC-Thermistor

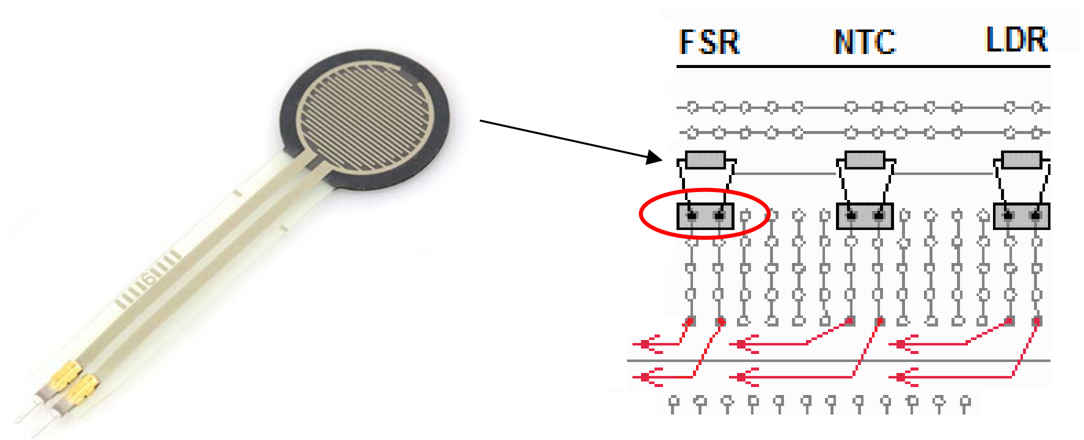
LDR-Photo resistor

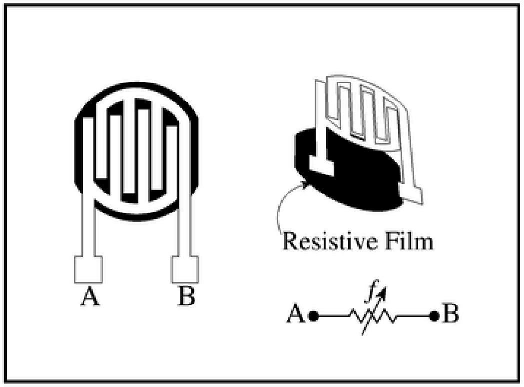
We will measure frequency with the PIC-processorn CCP-unit later in the course …

William Sandqvist william@kth.se

Sensors

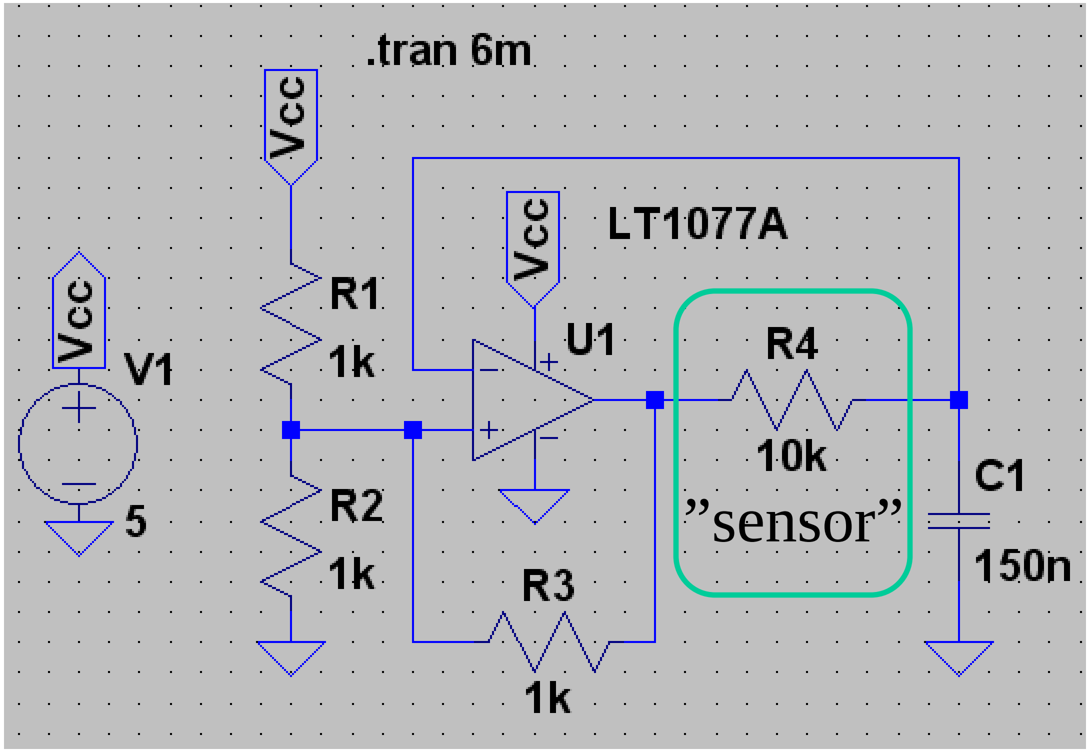
Try some resistive sensors …



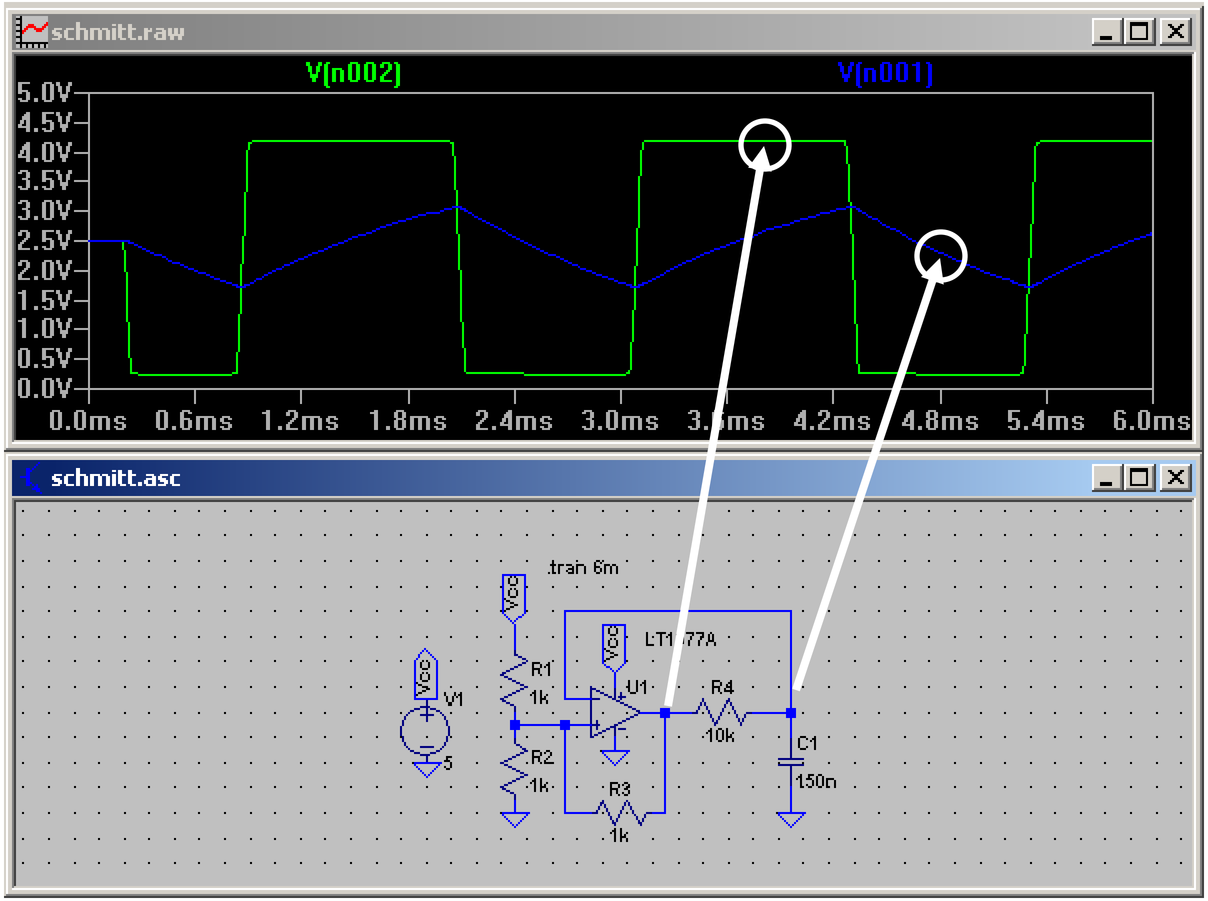


FSR-Force Sensitive Resistor, press between your fingers.

Simulate the RC-oscillator

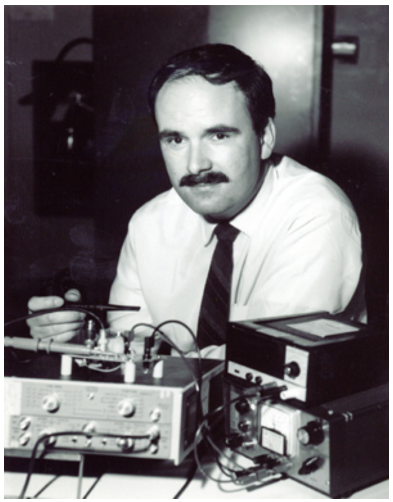


Simulate RC-oscillator



William Sandqvist william@kth.se

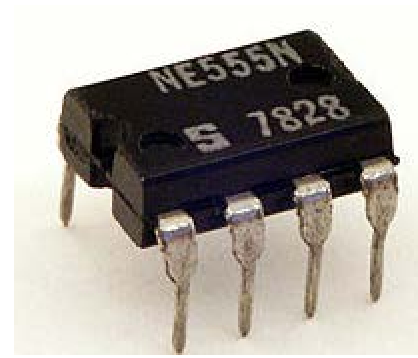
A more stable RC-oscillator

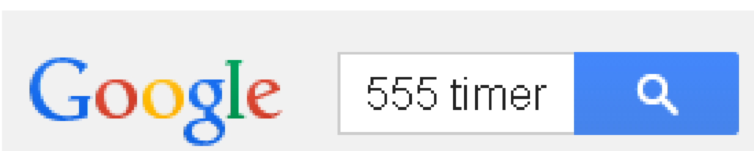


Hans Camenzind
designer of the
555 timer

(1934-2002)

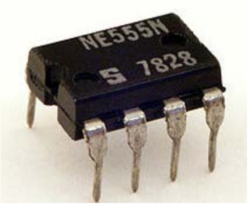
Signetics 1970

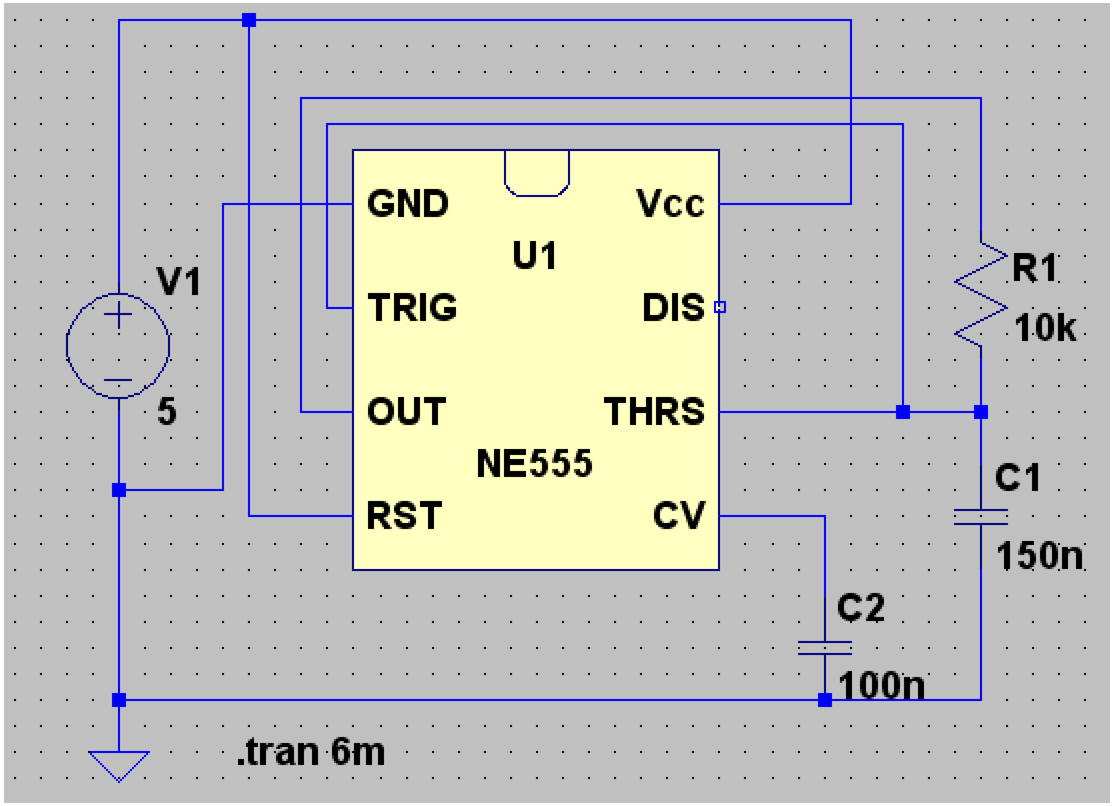




About **2 130 000** results
(0,30 sekonds)

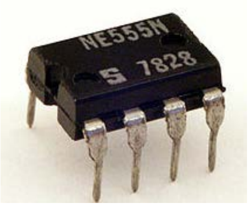
555 as RC-oscillator

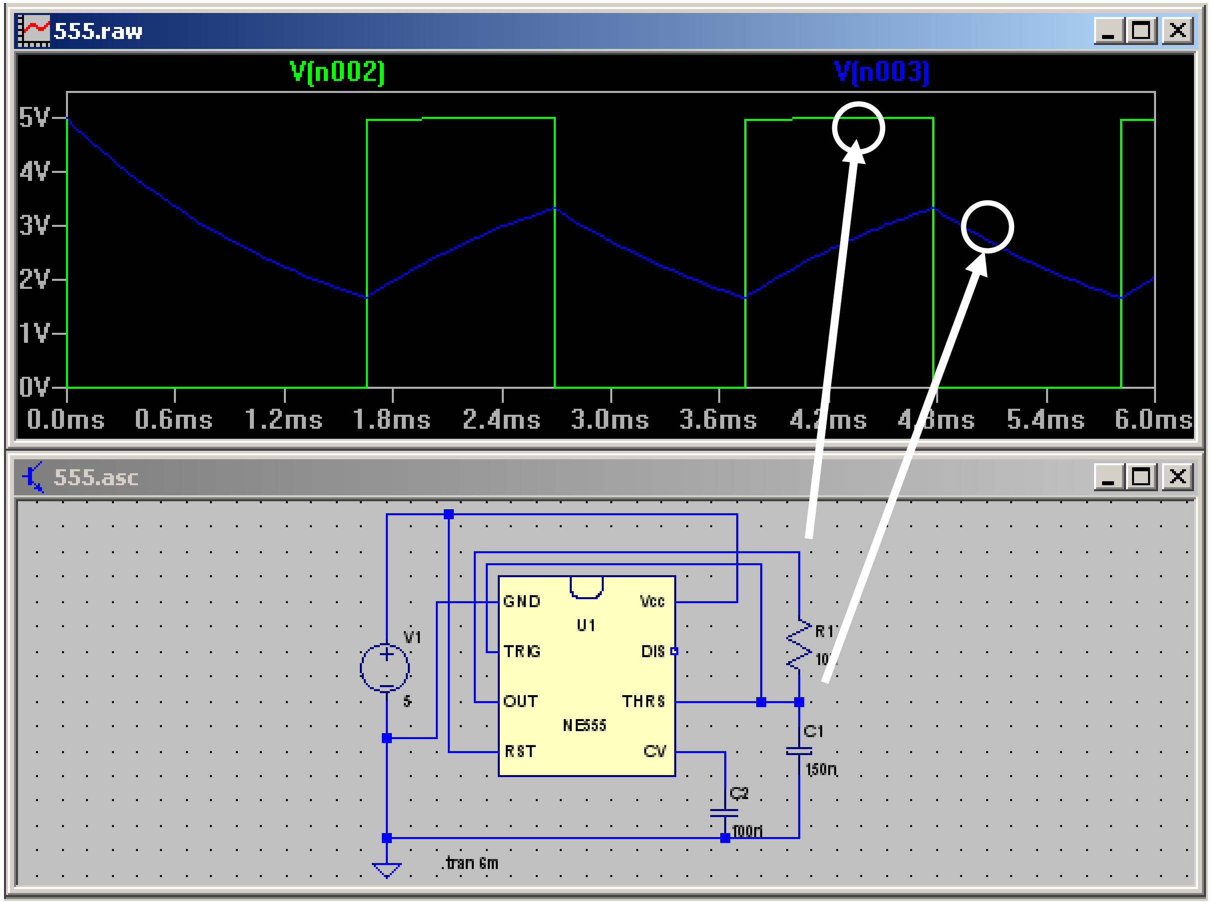




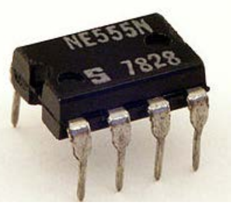
William Sandqvist william@kth.se

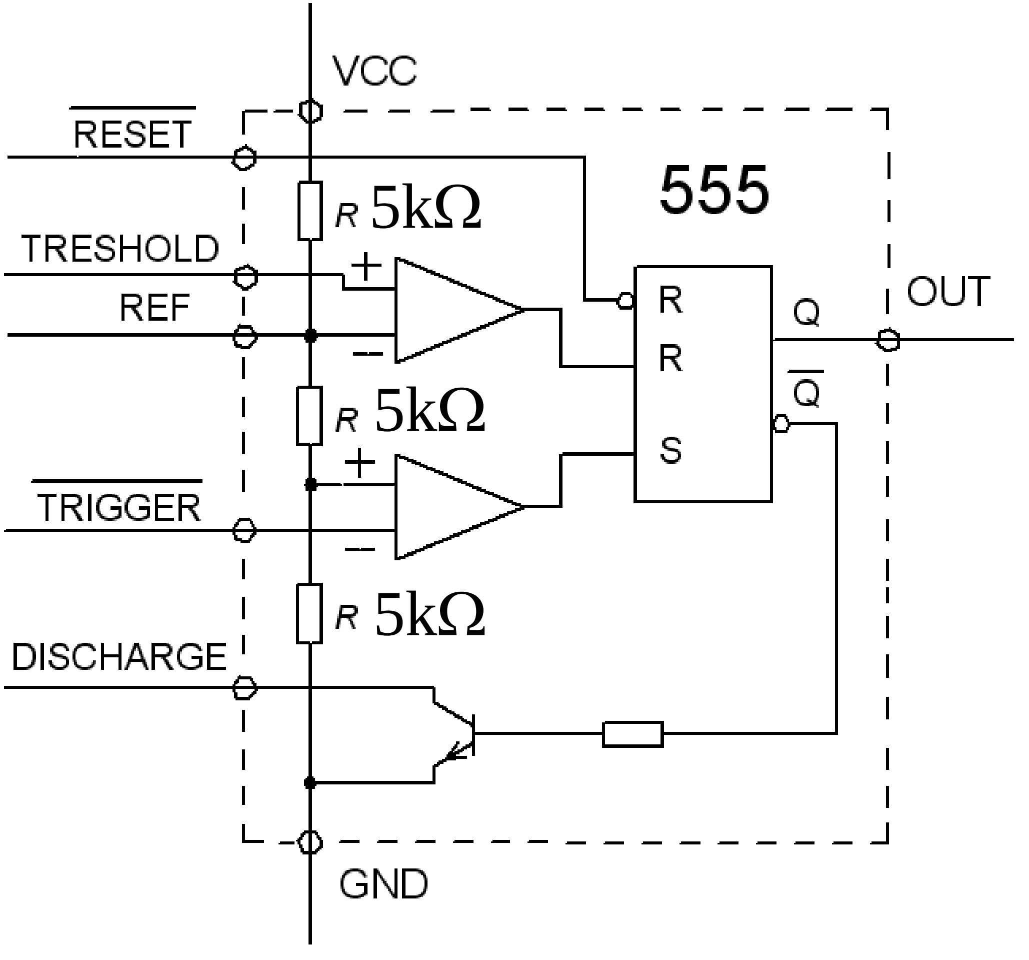
555 RC-oscillator





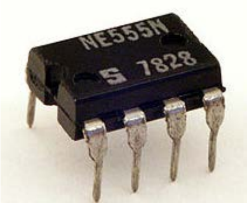
The 555 inside story



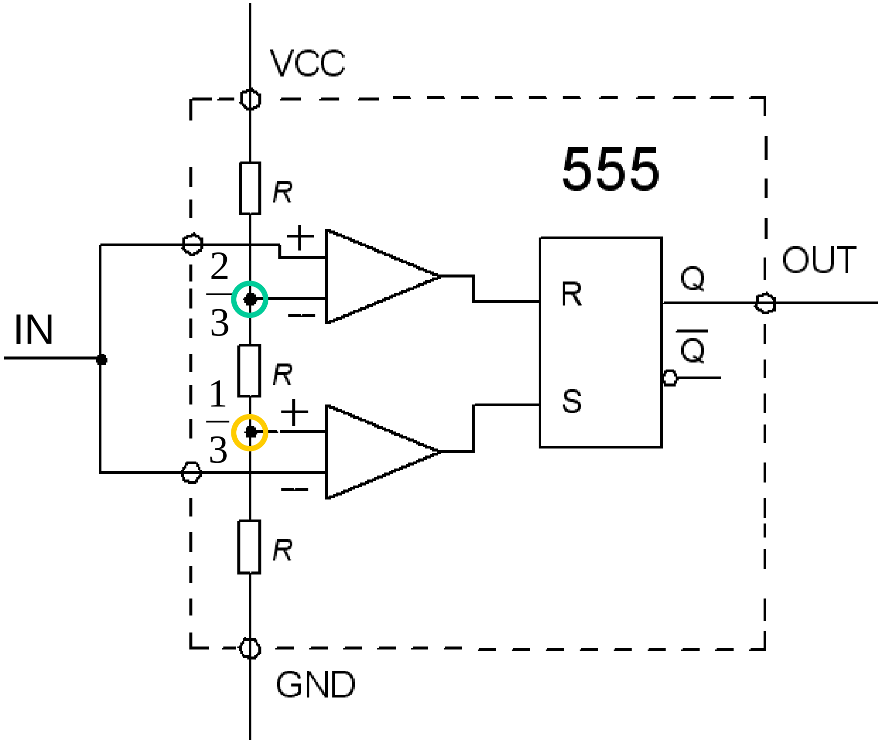


Two comparators and one SR-latch.

555 as Schmitt-trigger



With these connections the 555 becomes a Schmitt-trigger with the threshold levels 1/3 and 2/3 of the supply voltage.

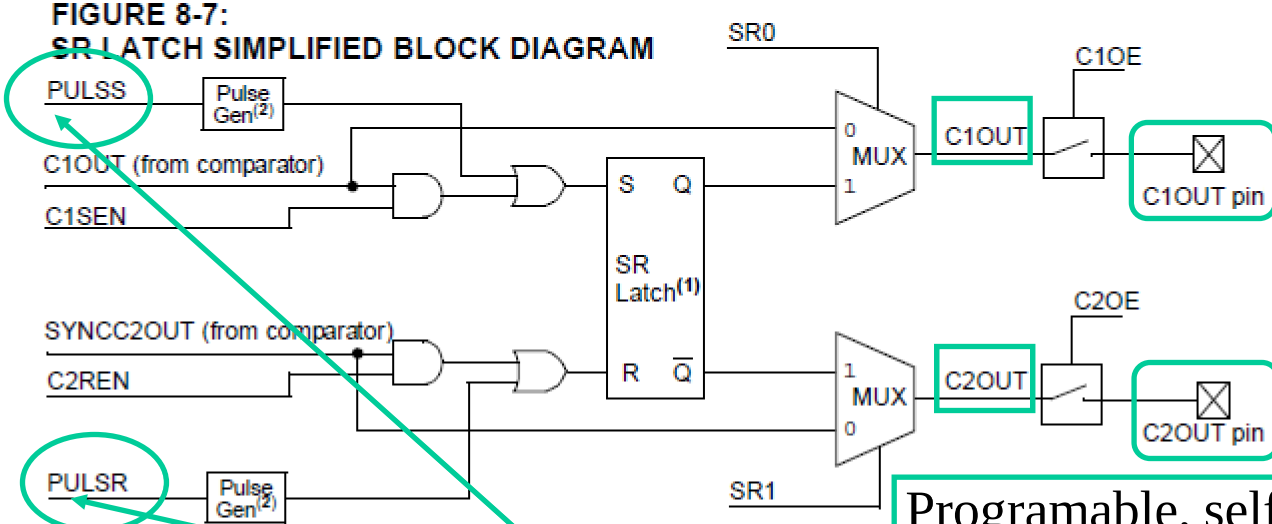


This circuit has better "performance" than the single comparator connected as Schmitt trigger we have shown previously.

PIC-processor SR-latch

SR-latch **output** can be read by the program (C1OUT, C2OUT),
or connected directly to the chip pins (C1OUT/RA2, C2OUT/RC4).

FIGURE 8-7: SR LATCH SIMPLIFIED BLOCK DIAGRAM



Programable, self resetting, bits to generate pulses on S and R.

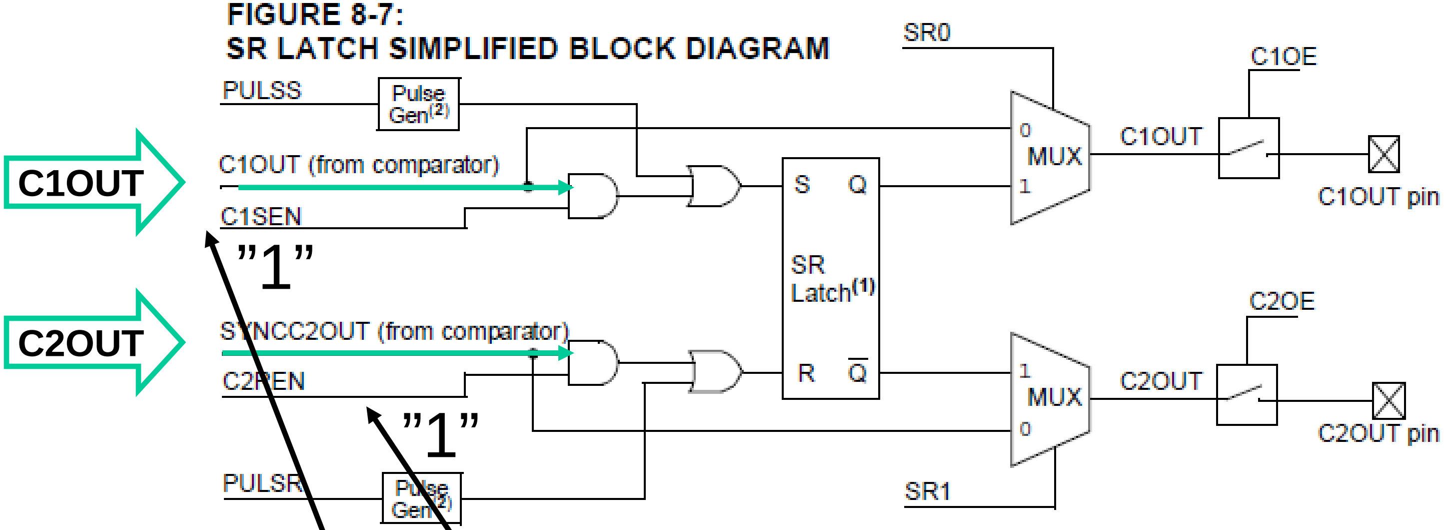
REGISTER 8-4: SRCON: SR LATCH CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/S-0	R/S-0	U-0	U-0
SR1(2)	SR0(2)	C1SEN	C2REN	PULSS	PULSR	—	—
bit 7							bit 0

PIC-processorns SR-latch

SR-latchs **inputs** can be configured to connect to the comparators.

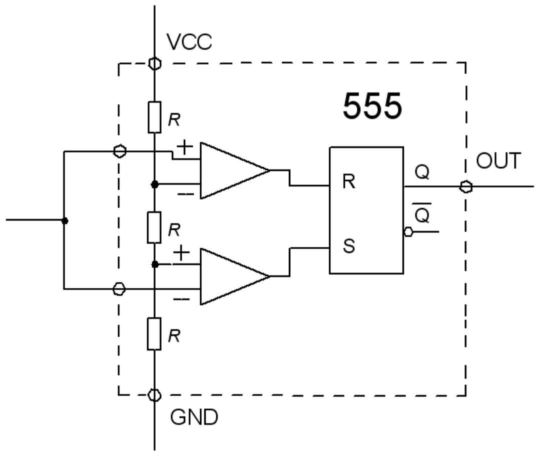
FIGURE 8-7: SR LATCH SIMPLIFIED BLOCK DIAGRAM



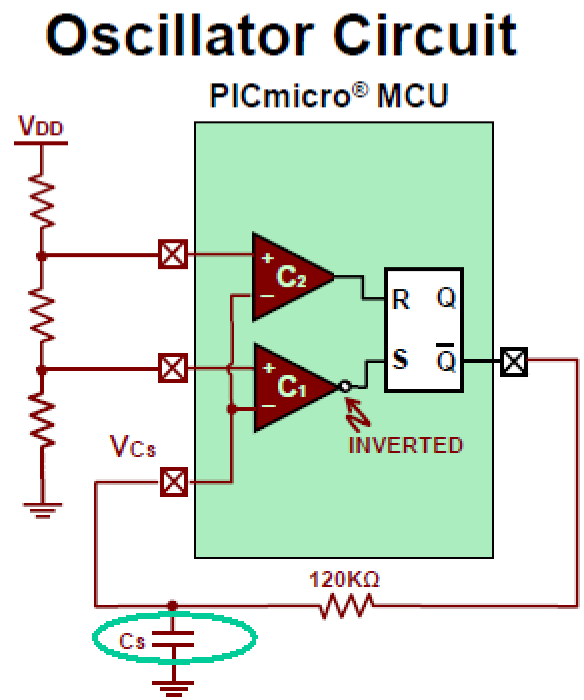
REGISTER 8-4: SRCON: SR LATCH CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/S-0	R/S-0	U-0	U-0
SR1(2)	SR0(2)	C1SEN	C2REN	PULSS	PULSR	—	—
bit 7							bit 0

PIC-processor as oscillator



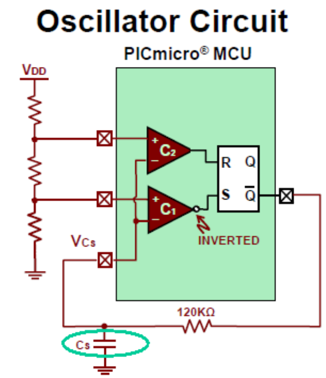
PIC-processor two comparators and SR-latch can be configured as a RC-oscillator, ”555 style”

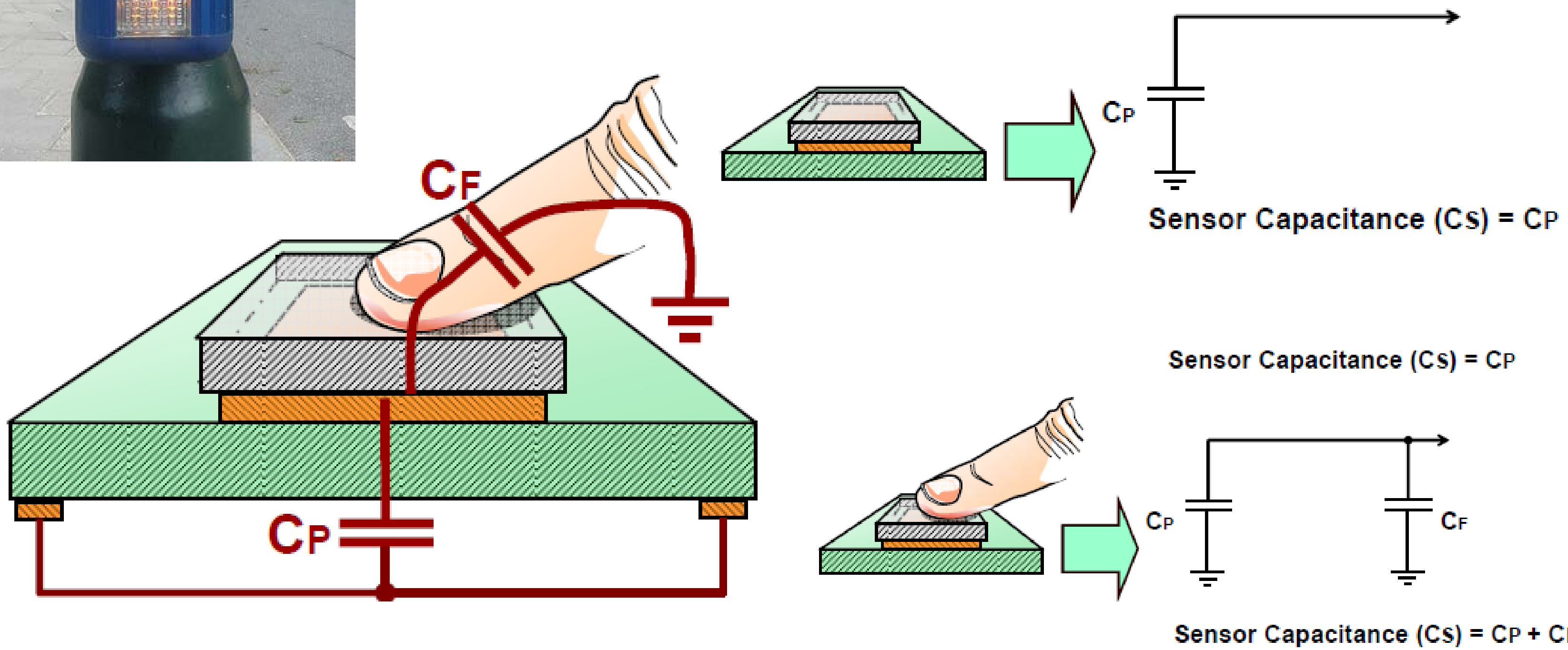


A stable oscillator is needed when it is *C* that the sensor is – as the capacitive sensing.

Touch-control

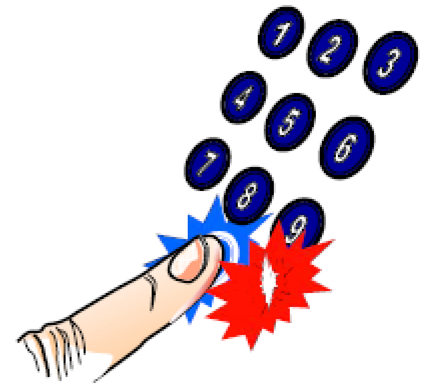
Vandal proof button at
the pedestrian crossing!



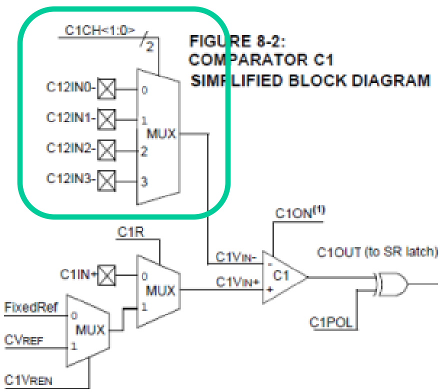


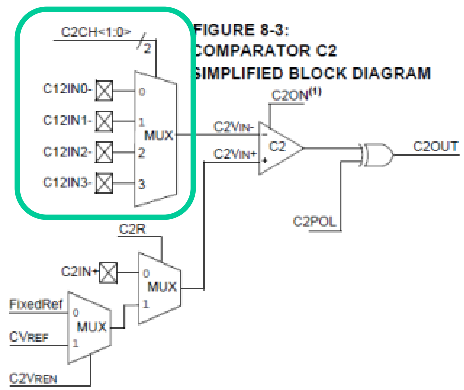
William Sandqvist william@kth.se

Touch-control

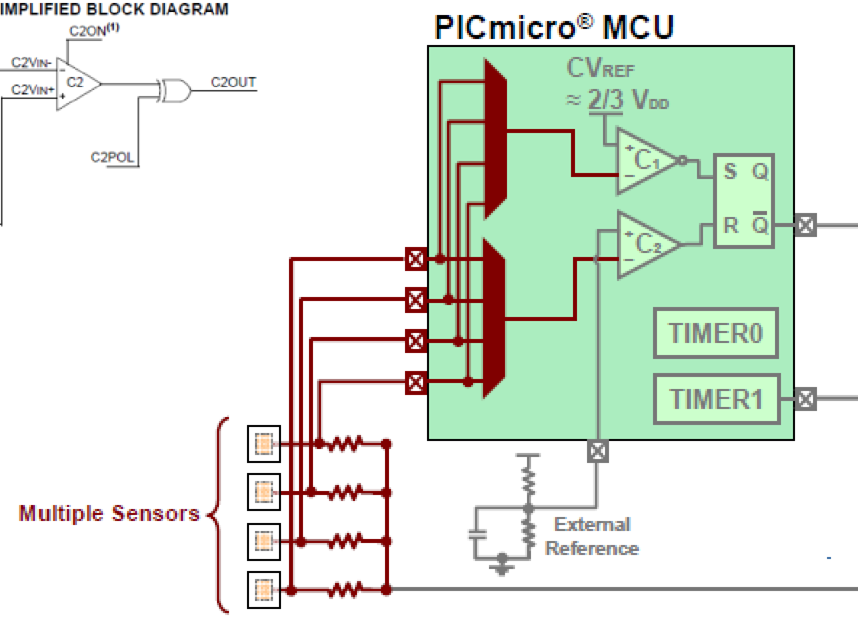


Moore contacts – Keyboard.



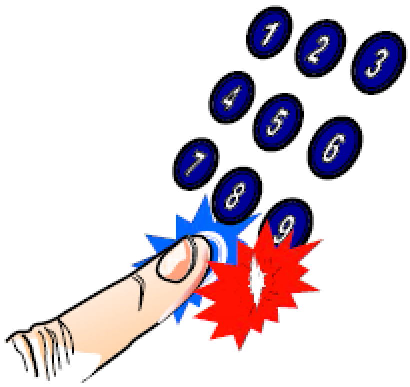


Comparators inputs are multiplexed to the same pins – useful when you want to sense several keys …

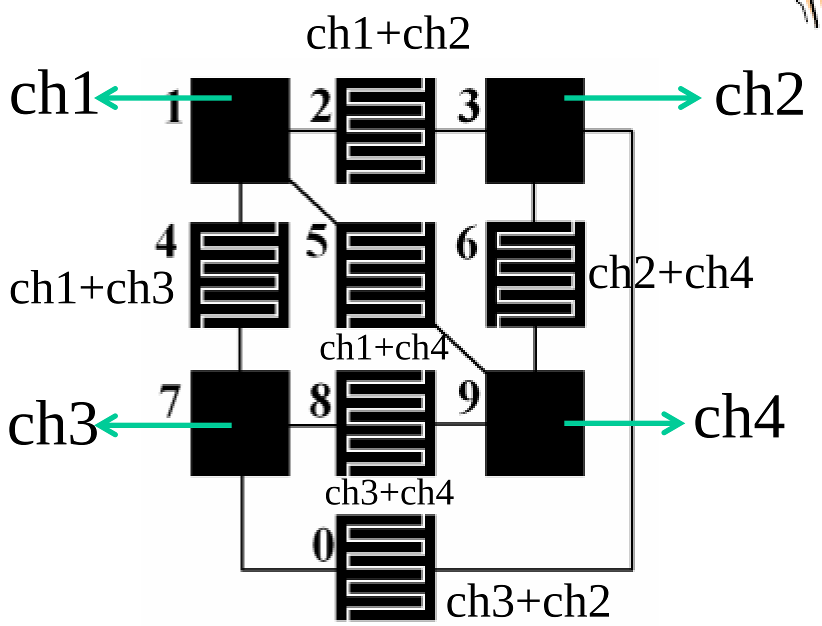


William Sandqvist william@kth.se

Touch-control



Moore contacts – Keyboard.



William Sandqvist william@kth.se

For More Information

- AN1101: Introduction to Capacitive Sensing
- AN1102: Layout and Physical Design Guidelines for Capacitive Sensing
- AN1103: Software Handling for Capacitive Sensing
- AN1104: Capacitive Multi-Button Configurations
- mTouch™ Design Center at www.microchip.com/mTouch