ELG3331: Digital Tachometer

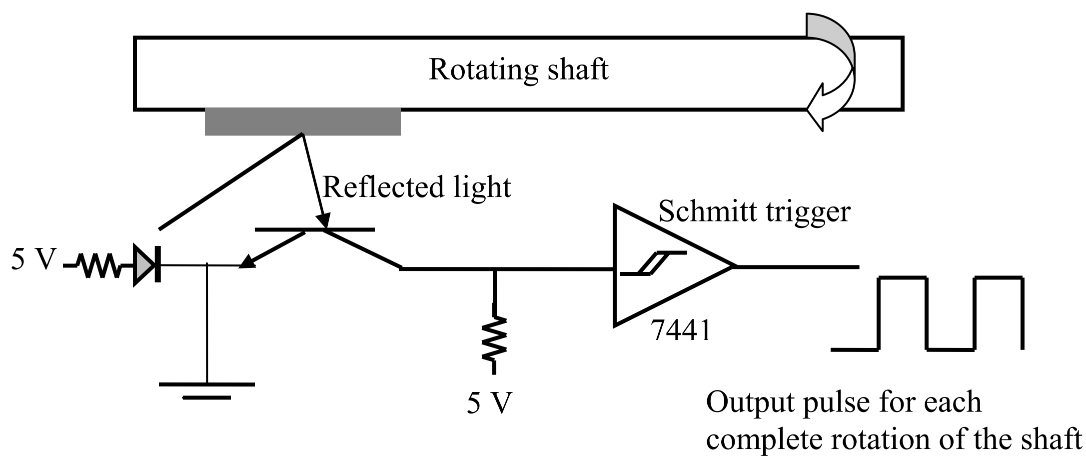
Introduction to Mechatronics by DG Alciatore and M B Histand

Our objective is to design a system to measure and display the rotational speed of a shaft. A simple method to measure rotational speed is to count the number of shaft rotations during a given period of time. The resulting count will be directly proportional to the shaft speed.

Sensor

A number of different sensors can detect shaft rotation. A proximity sensor that uses magnetic, optical, or mechanical principles to detect some feature on the shaft is an example.

We may use LED-phototransistor pair as an optical sensor and replace a small piece of reflective tape on the shaft.

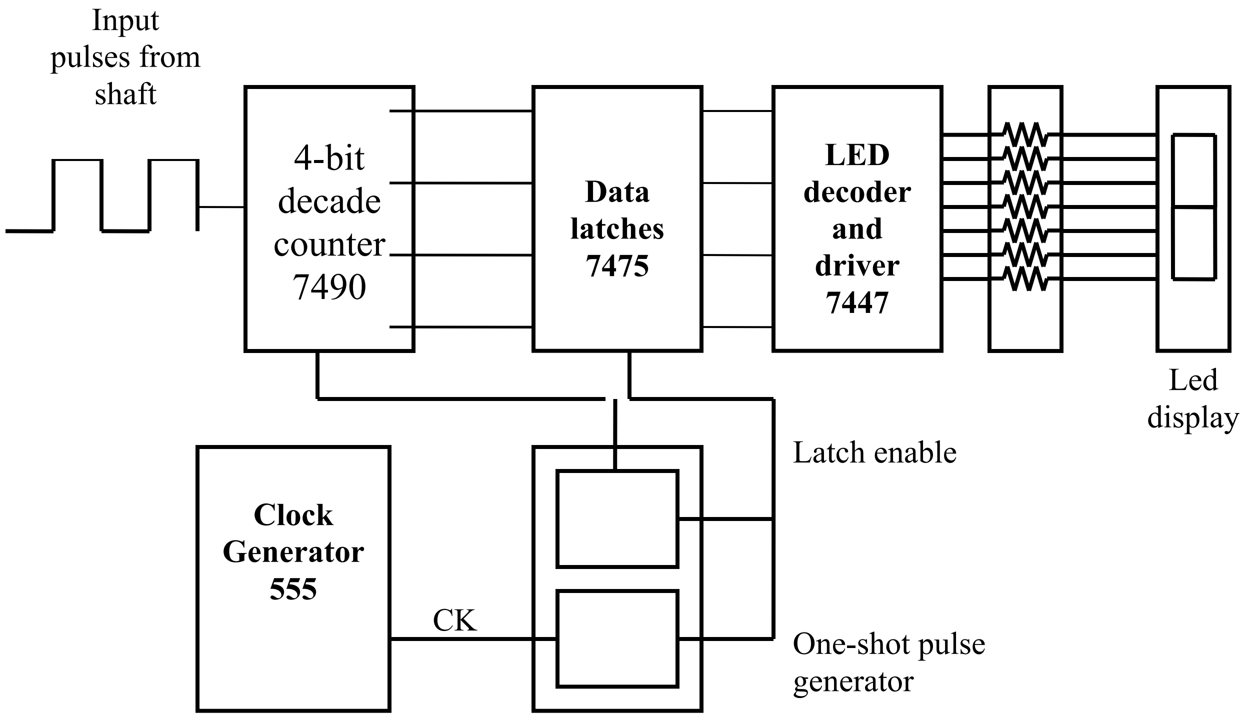


Counter

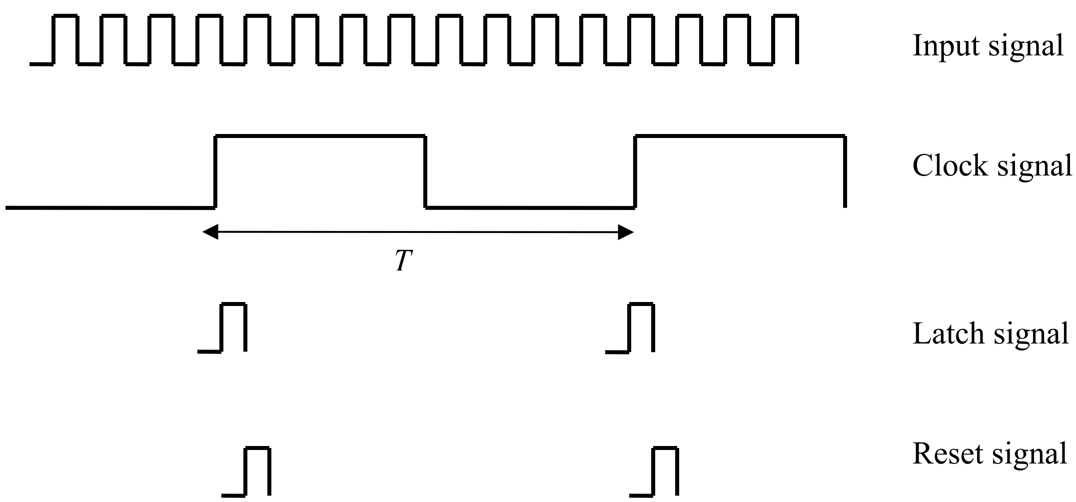
Now we need a circuit to count and display the pulses over a given interval of time *T*. The decade counter counts the pulses and is reset by a negative edge on signal *R* after the time period *T*. The period T is set by a resistor-capacitor combination using a 555 oscillator circuit. If the count exceeds nine during the period T, additional 7490s must be cascaded to provide the full count. Prior to counter reset, the output is stored by 7475 data latches that are enabled by a brief pulse. The shaft speed in revolutions per minute is related to the displayed pulse count

$$\text{rpm} = \frac{\text{pulse count/ppr}}{T} \times 60$$

Where ppr is the number of pulses per revolution generated by the sensor.



Input
pulses from
shaft
4-bit
decade
counter
7490
Data
latches
7475
LED
decoder
and
driver
7447
Led
display
Latch enable
Clock
Generator
555
CK
One-shot pulse
generator



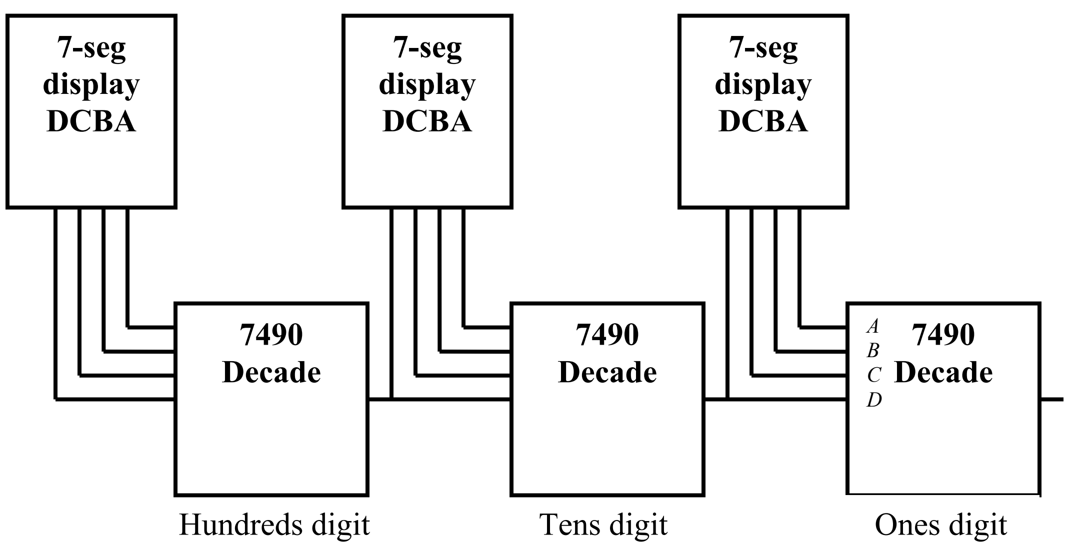
Input signal
Clock signal
T
Latch signal
Reset signal

Decade Counter

It is a negative edge-triggered counter and the output is a binary coded decimal (BCD) consisting of 4 bits, making it useful for decimal counting applications. The following table shows the output sequence for the 4 bits as the counter increments from 0 to 9.

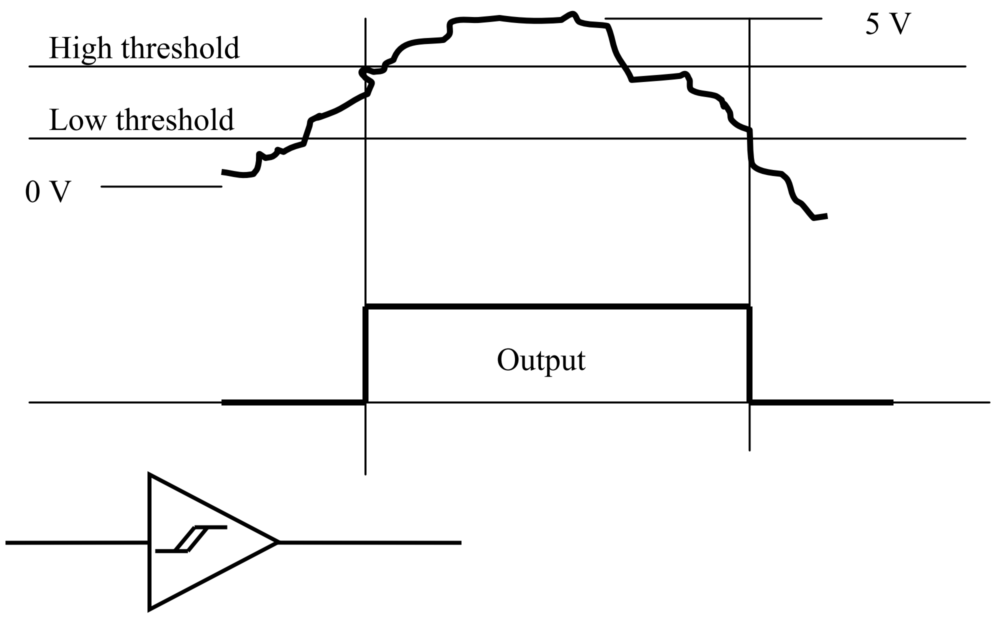
Decimal	*D*	*C*	*B*	*A*
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

BCD counters can be cascaded in order to count in powers of 10. Output *D* can be used as the clock input for a second 7490, thus cascading the two together to raise the range for counting from 0 to 99 and higher.



Schmitt Trigger

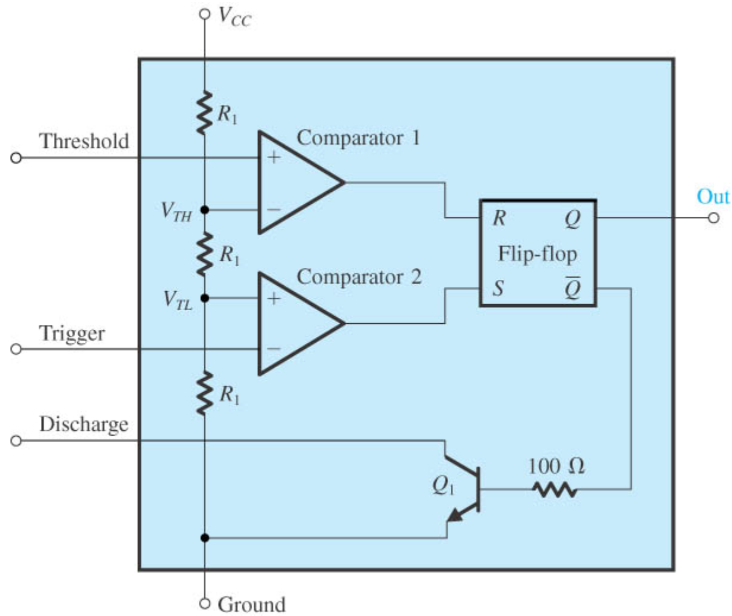
Digital pulses may not exhibit sharp edges; instead, the signal may ramp from 0 to 5 V over a finite time period, and it may do so in a "noisy" (jumpy) fashion. The Schmitt trigger is a device that can convert such a signal into a sharp pulse using the threshold hysteresis.

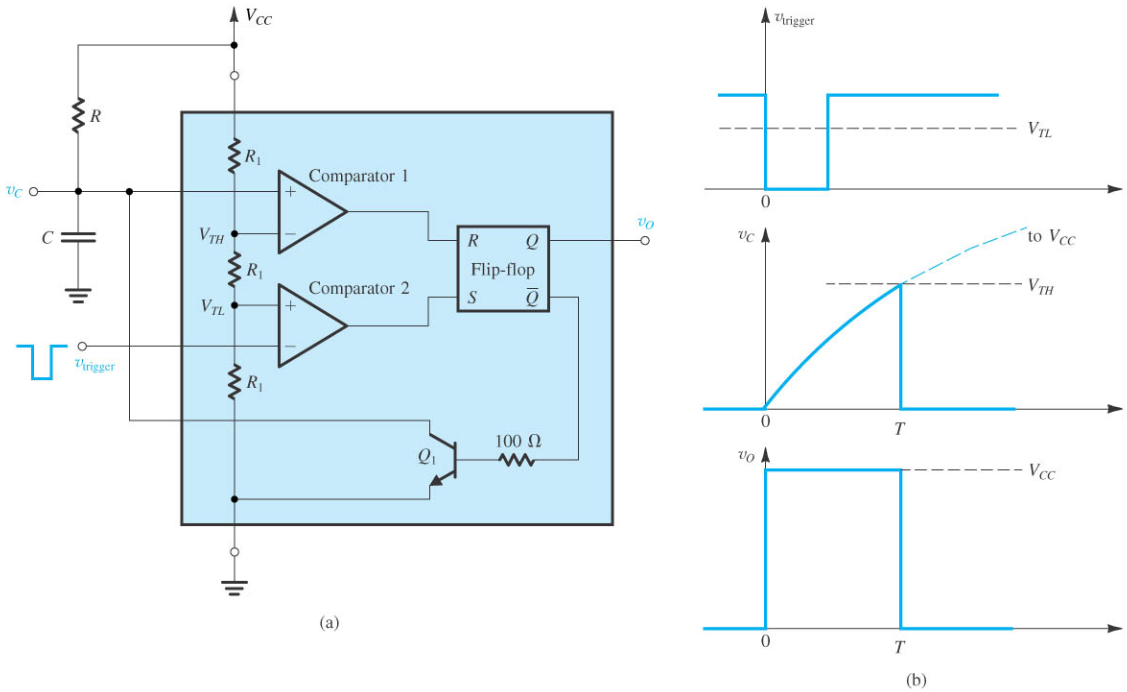


555 Timer

The 555 integrated circuit is known as the "time machine" since it performs a wide variety of timing tasks. It is a combination of digital and analog circuits. Applications for the 555 include bounce-free switches, cascaded timers, frequency dividers, voltage-controlled oscillators, pulse generators, LED flashers, etc. The circuit easily built with a 555 IC is the monostable multivibrator. It is constructed by adding an external capacitor and resistor to a 555 circuit. The circuit generates a single pulse of desired duration when it receives a trigger signal, hence it is called a one-shot. The time constant of the resistor-capacitor combination determines the length of the pulse.

The circuit consists of two comparators, which drive an RS flip-flop, an output buffer, and a transistor that discharges an external timing capacitor. Comparator 1 is called the threshold comparator which converts its input with an internal voltage reference set at 2/3 *Vcc*. Comparator 2, called the trigger comparator, compares the input trigger voltage to an internal voltage reference set at 1/3 *Vcc*.





Operation

- It is called also one shot, operates by charging a timing capacitor with a current set by external resistance.
- When the one shot is triggered, the charging network cycles only once during the timing interval. The total timing interval includes the recovery time needed for the capacitor to charge up to the threshold level.
- When *Vcc* high is applied to the trigger input, the trigger comparator output is low, the flip flop output is high, the transistor is on, the timing capacitor is discharged to ground potential. The output of the 555 circuit is low.
- When negative voltage is applied to the trigger input, output of trigger comparator goes high. When trigger pulse drops below 1/3 Vcc output of flip flop goes low, output of 555 circuit goes high and the transistor turns off