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Wiedza Edukacja Rozwój

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Digital Circuits Design

Faculty of Automatic Control, Electronics and Computer Science, Informatics, Bachelor Degree

Lecture 4

Time dependencies circuits – part 2

Bartłomiej Zieliński, PhD, DSc

Time circuits – part 2

Program:

(last week)

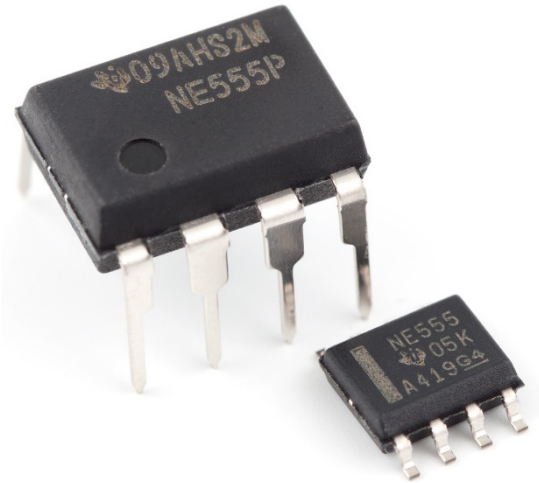
- 7412x circuit family
- Properties, applications

(today)

- 555 circuit
- CMOS 4000B-family timers
- Differential (trigger) circuits
- Square wave generators

Time circuits – part 2

- 555 circuit
  - NE555
    - Designed in 1971 by Signetics
    - „probably the most popular integrated circuit ever made”
    - DIP8 package
  - NE556
    - 2×NE555 in DIP14 package
  - NE558
    - 4×(not fully independent)NE555 in DIP16 package



Time circuits – part 2

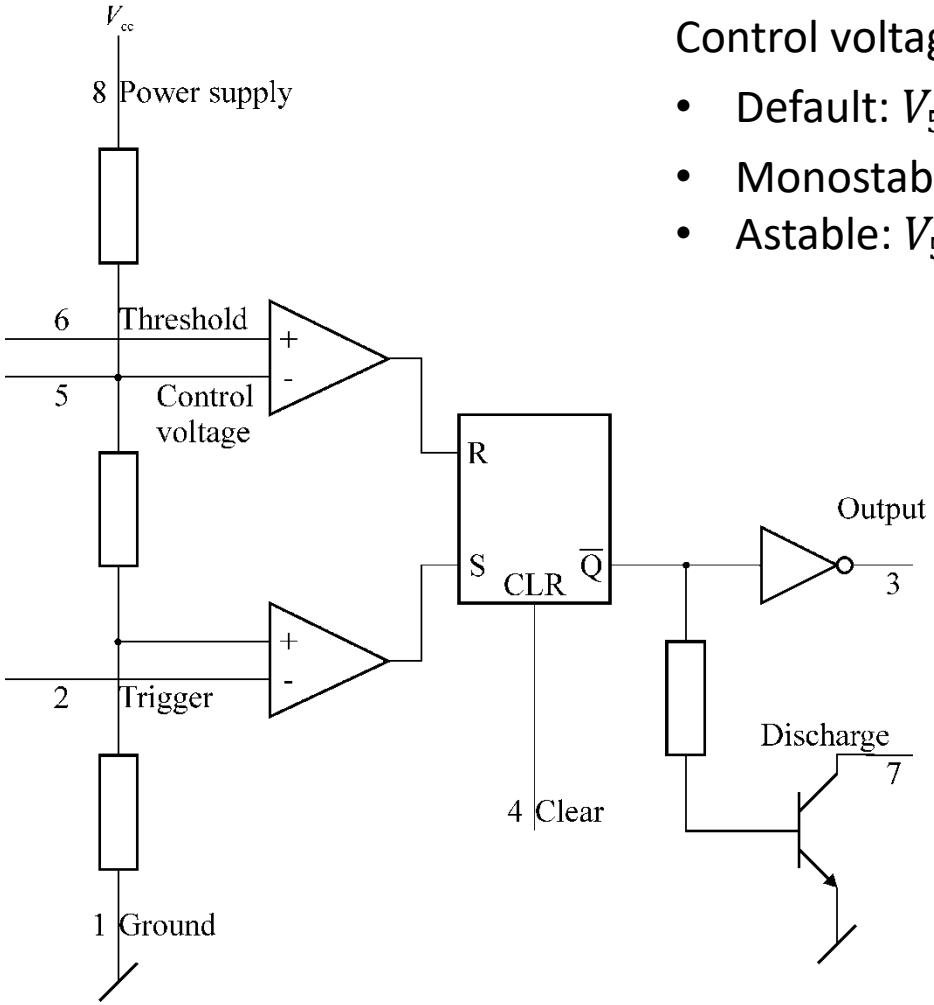
- 555 circuit
  - NE555, UL7855, MC1455, ICM755, TLC555

	Bipolar	CMOS	CMOS
f_{max}	100 kHz	500 kHz	1 MHz
V_{CC}	5-18 V	2-18 V	1.5-18 V

- Pulse length 5µs…few minutes
- t_r, t_f < 100 ns
- I_O ≤200 mA, I_I≤1µA
- I_{OL}<8mA → U_{OL}<0.1 V
- I_{OH}<16 mA → U_{OH}=about V_{CC}-1.4V

Time circuits – part 2

- NE555

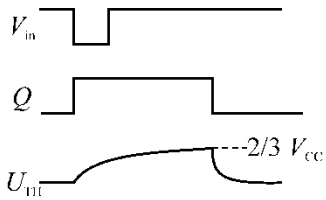


Control voltage

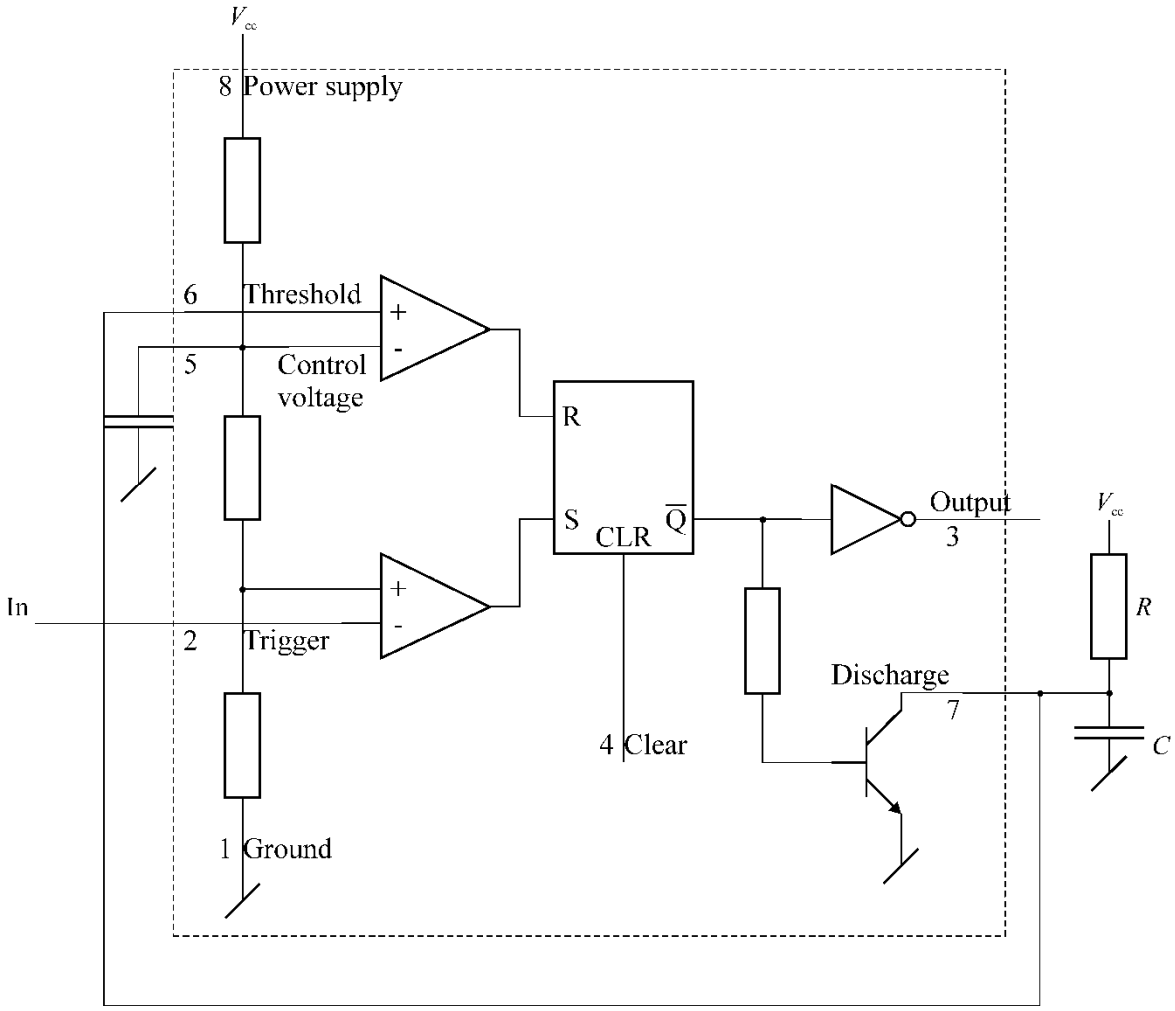
- Default: $V_5 = \frac{2}{3} V_{CC}$
- Monostable: $V_5 = 45 \div 90\%\ V_{CC}$
- Astable: $V_5 = 1.7\text{V} \div V_{CC}$

Time circuits – part 2

- NE555 as a monovibrator

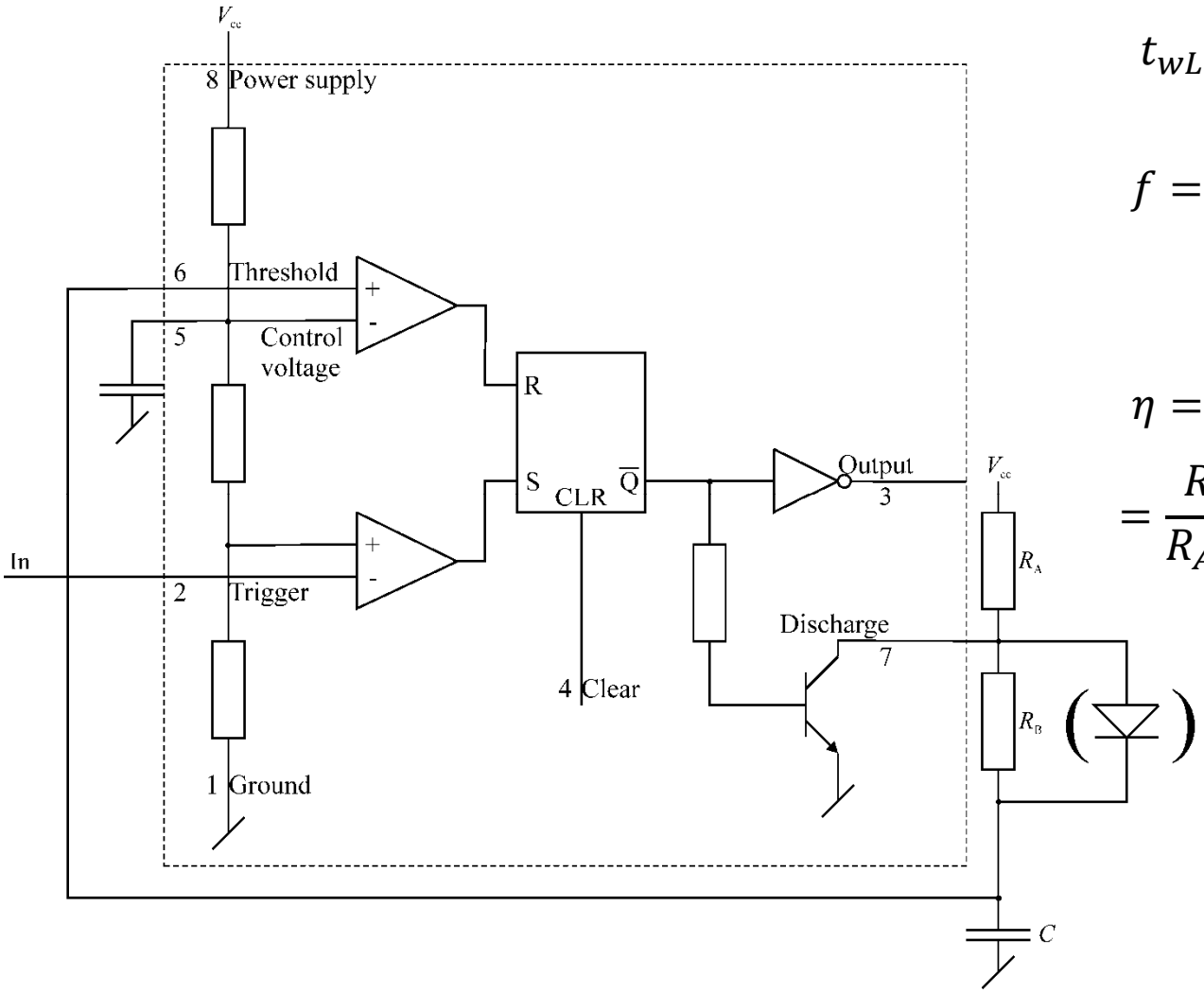


$$t_w = 1.1RC$$



Time circuits – part 2

- NE555 as a multivibrator (1)



$$t_{wH} = 0.693(R_A + R_B)C$$

$$t_{wL} = 0.693R_BC$$

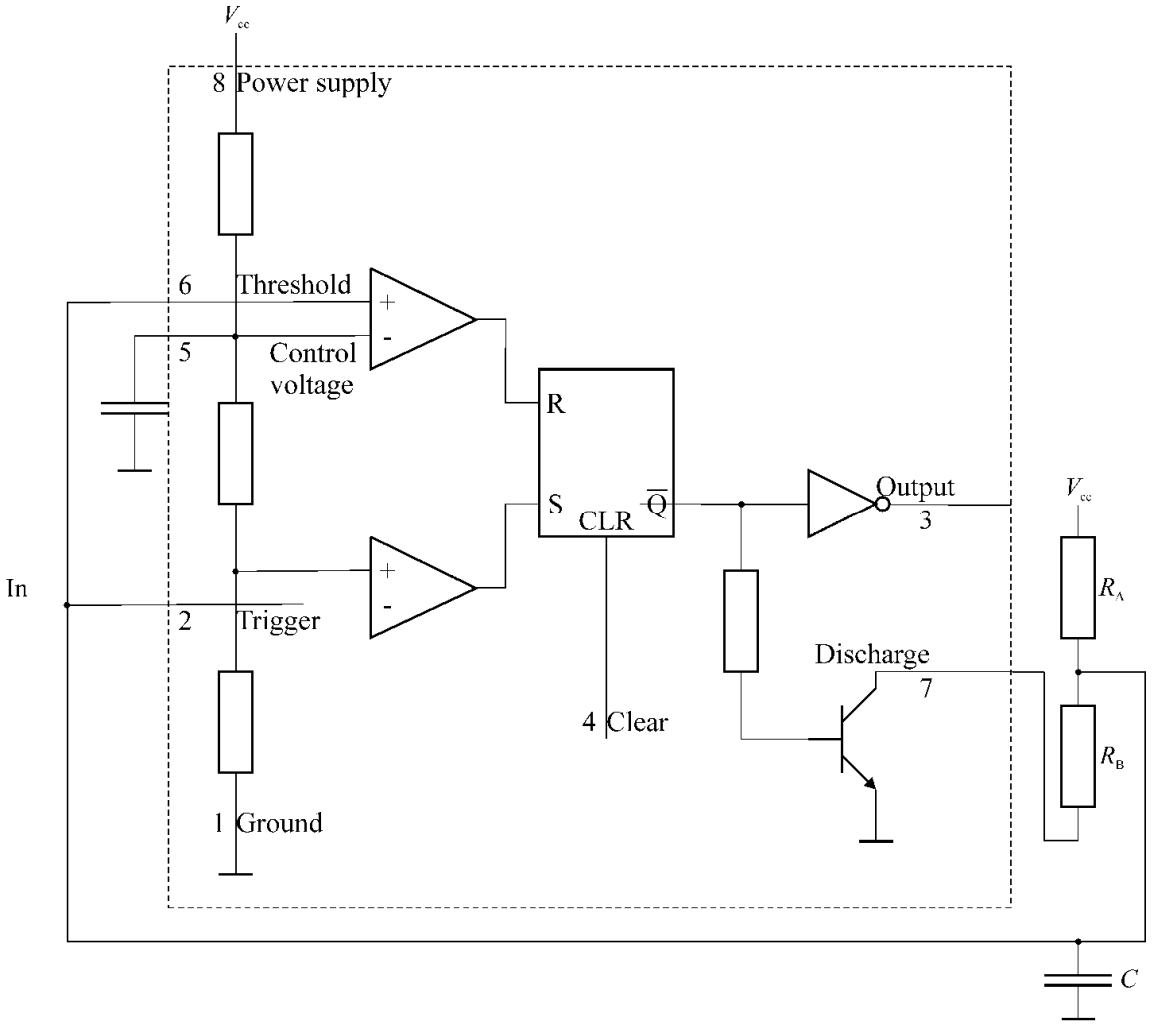
$$f = \frac{1.44}{(R_A + 2R_B)C}$$

$$\eta = \frac{t_{wH}}{t_{wH} + t_{wL}} = \frac{R_A + R_B}{R_A + 2R_B} > 0.5$$

$$\eta = \frac{R_B}{R_A + R_B + R_D}$$

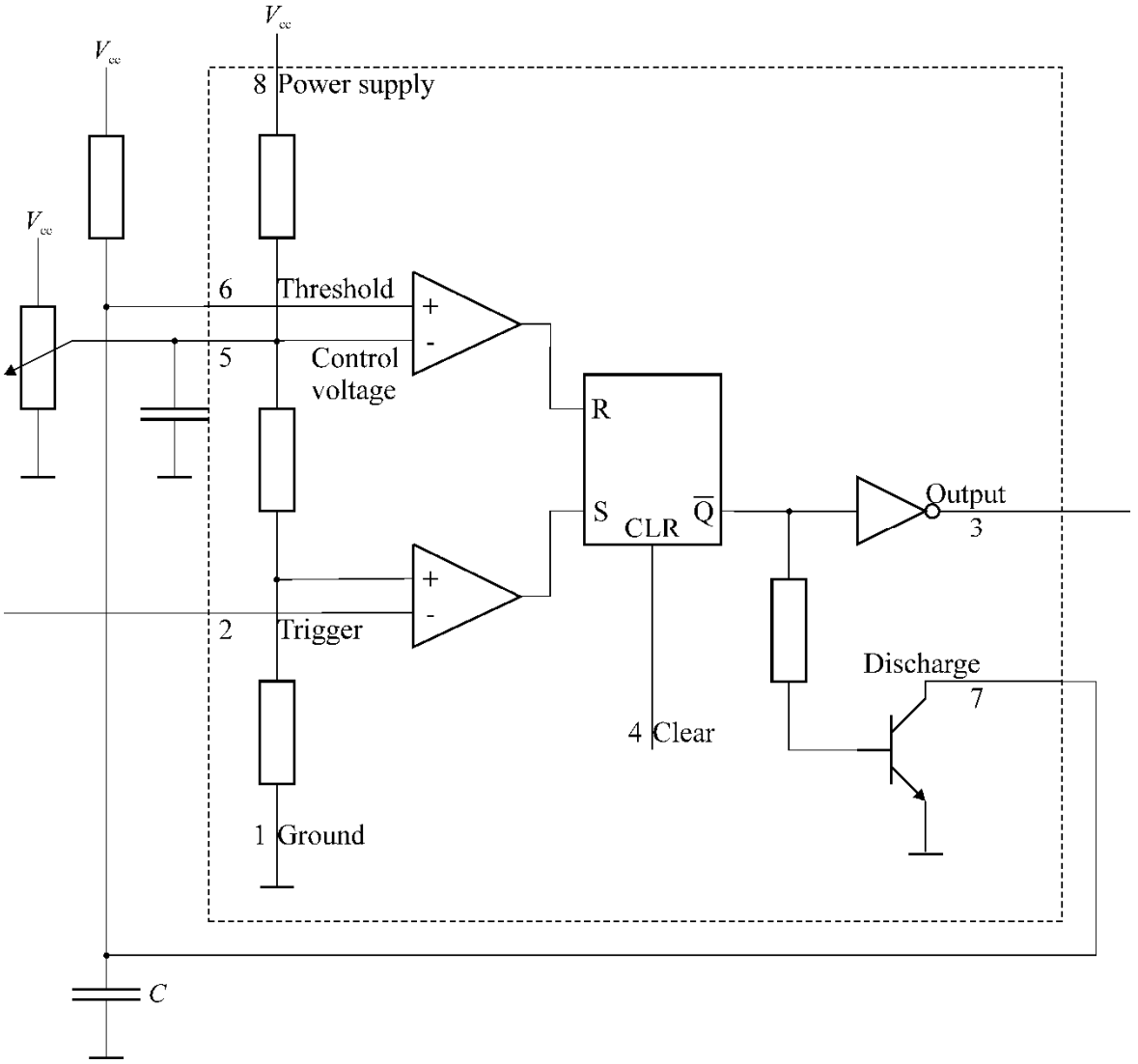
Time circuits – part 2

- NE555 as a multivibrator (2)



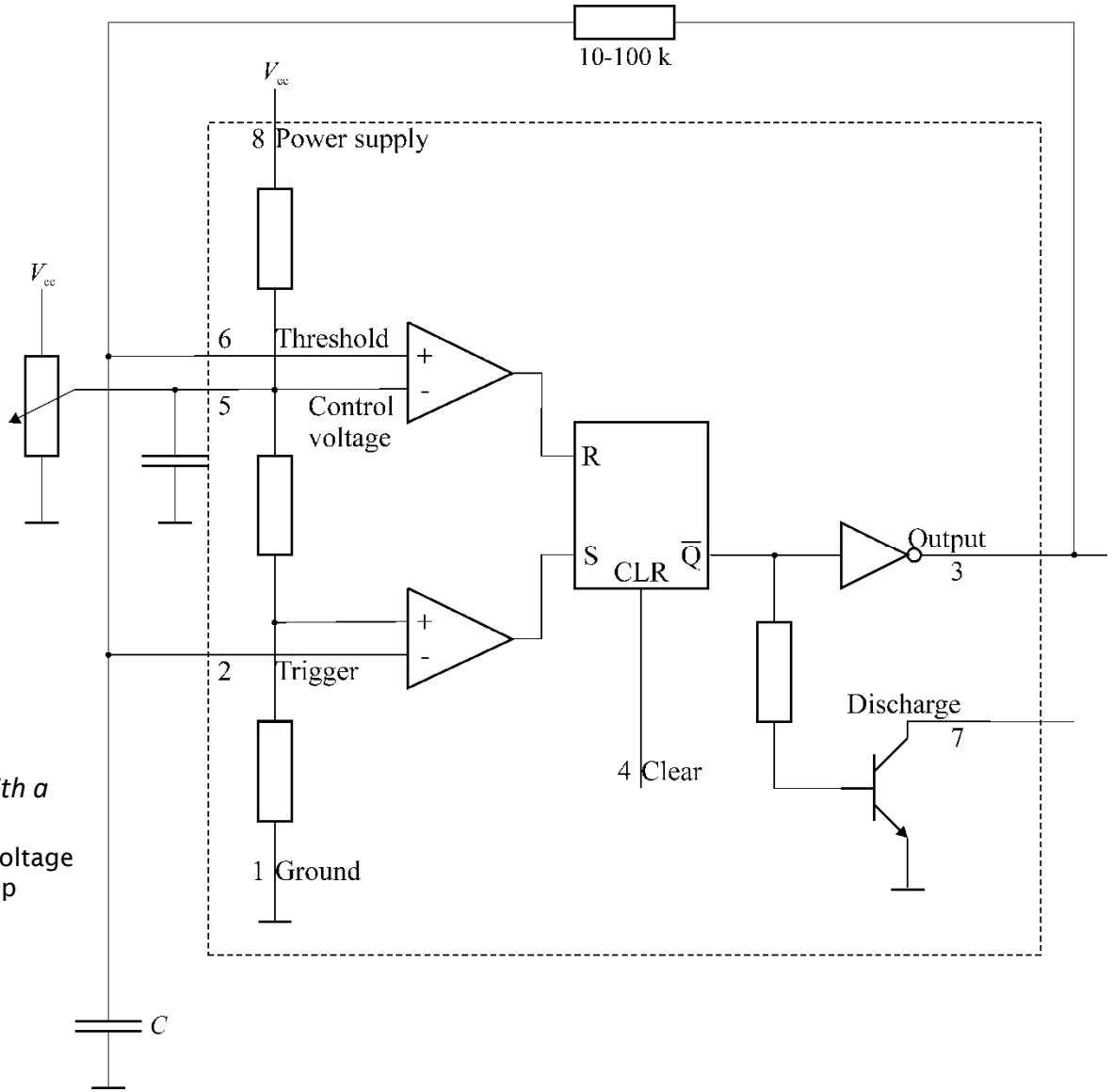
Time circuits – part 2

- NE555 as a PWM



Time circuits – part 2

- NE555 as a VCO
  - $V_5 \nearrow \rightarrow f \searrow$
  - $R \searrow \rightarrow f \nearrow$



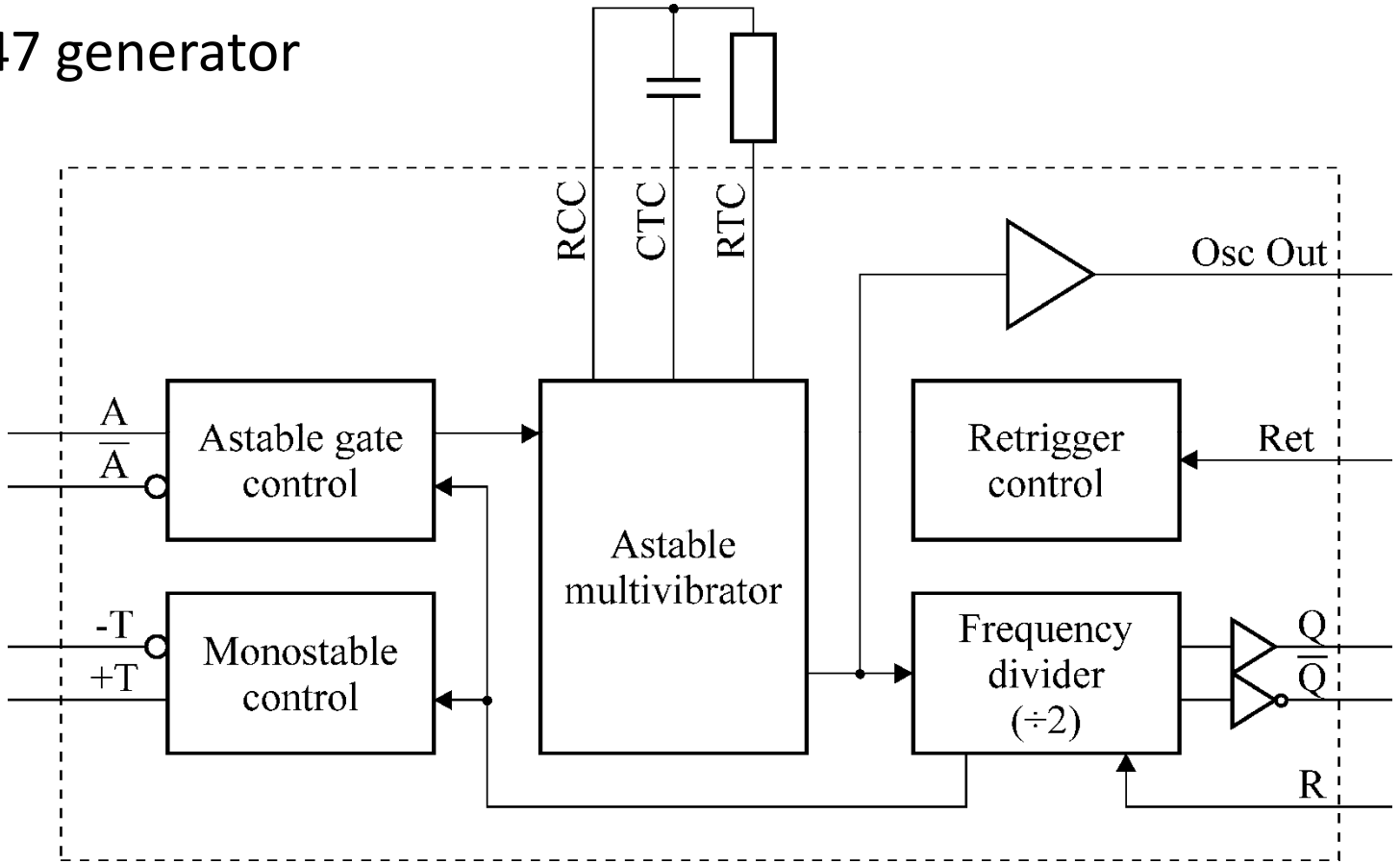
How to Build a Voltage Controlled Oscillator (VCO) with a 555 Timer Chip
http://www.learningaboutelectronics.com/Articles/Voltage-controlled-oscillator-VCO-circuit-with-a-555-timer.php

Time circuits – part 2

- CMOS 4000B pulse generators
  - 4528 – double monostable multivibrator
  - 4538 – precise double monostable multivibrator
    - Both similar to 74123
    - Retriggerable
    - trigger function a little different than in 74123
  - 4047 – monostable/astable multivibrator

Time circuits – part 2

- CMOS 4047 generator

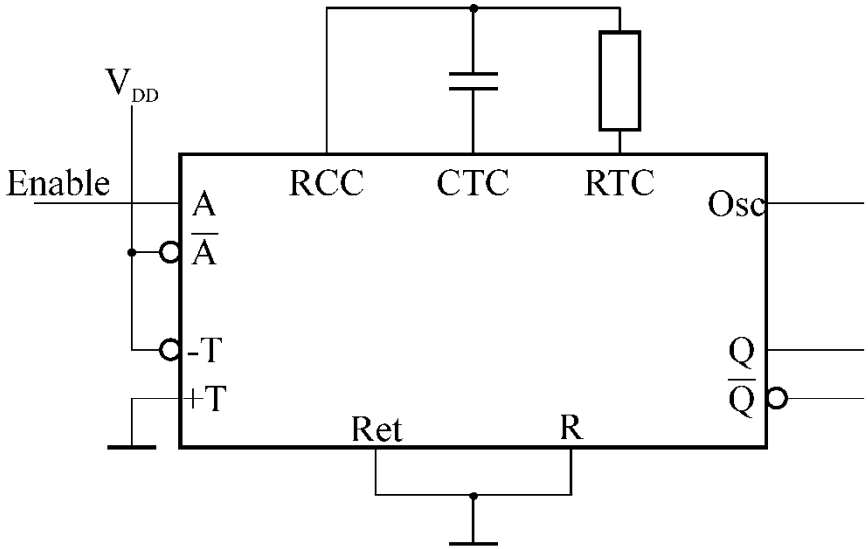


- A(*stable*) – force astable mode
- T(*rigger*) – force monostable mode
- Ret(*rigger*), R(*eset*)

- Astable mode: C>100 pF
- Monostable mode: C>1000 pF
- 10 kΩ<R<1 MΩ

Time circuits – part 2

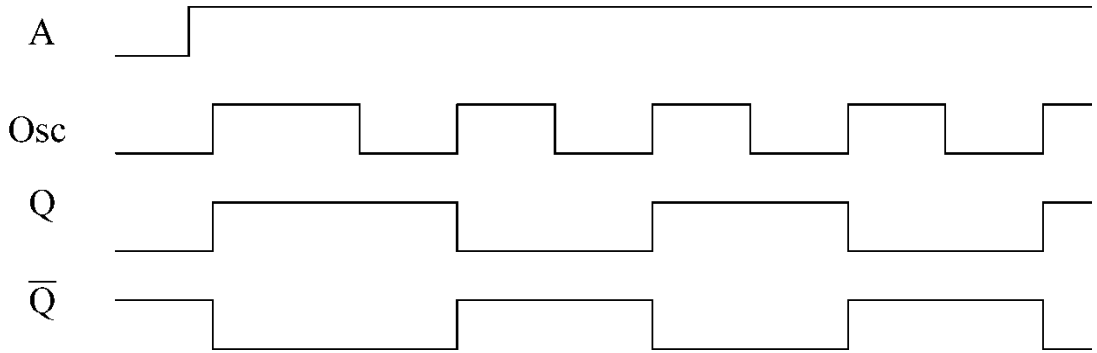
- 4047 as a frequency generator



$T_{Osc} = 2.2RC$

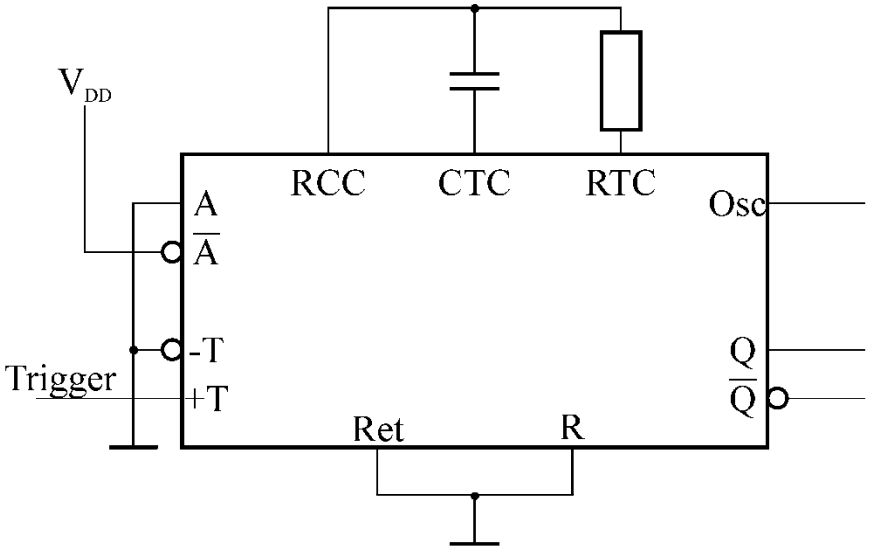
$T_Q = 4.4RC$

$\eta_Q = 0.5$

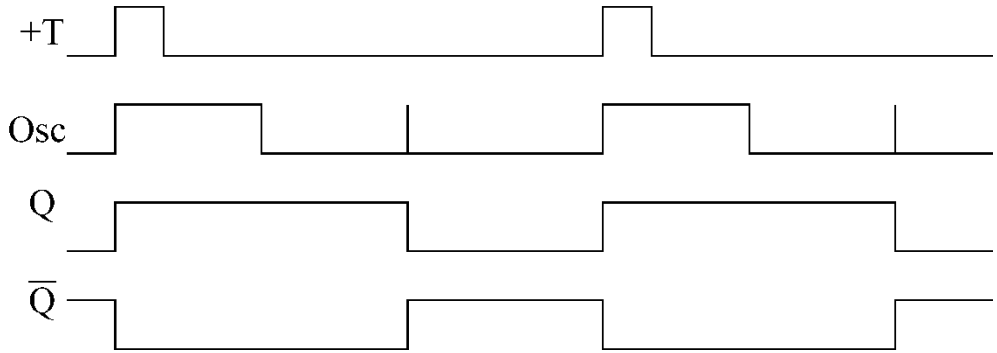


Time circuits – part 2

- 4047 as a pulse generator



$$T_Q = 2.48RC$$

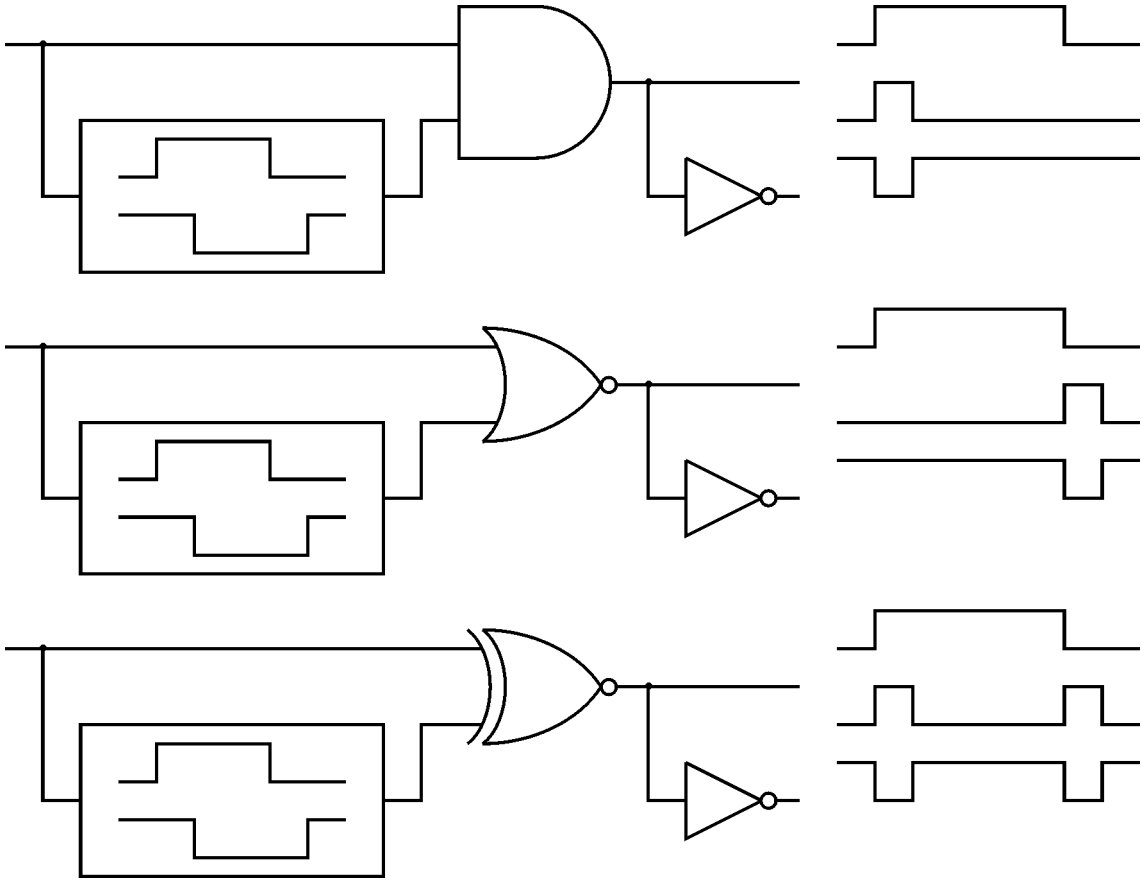


Time circuits – part 2

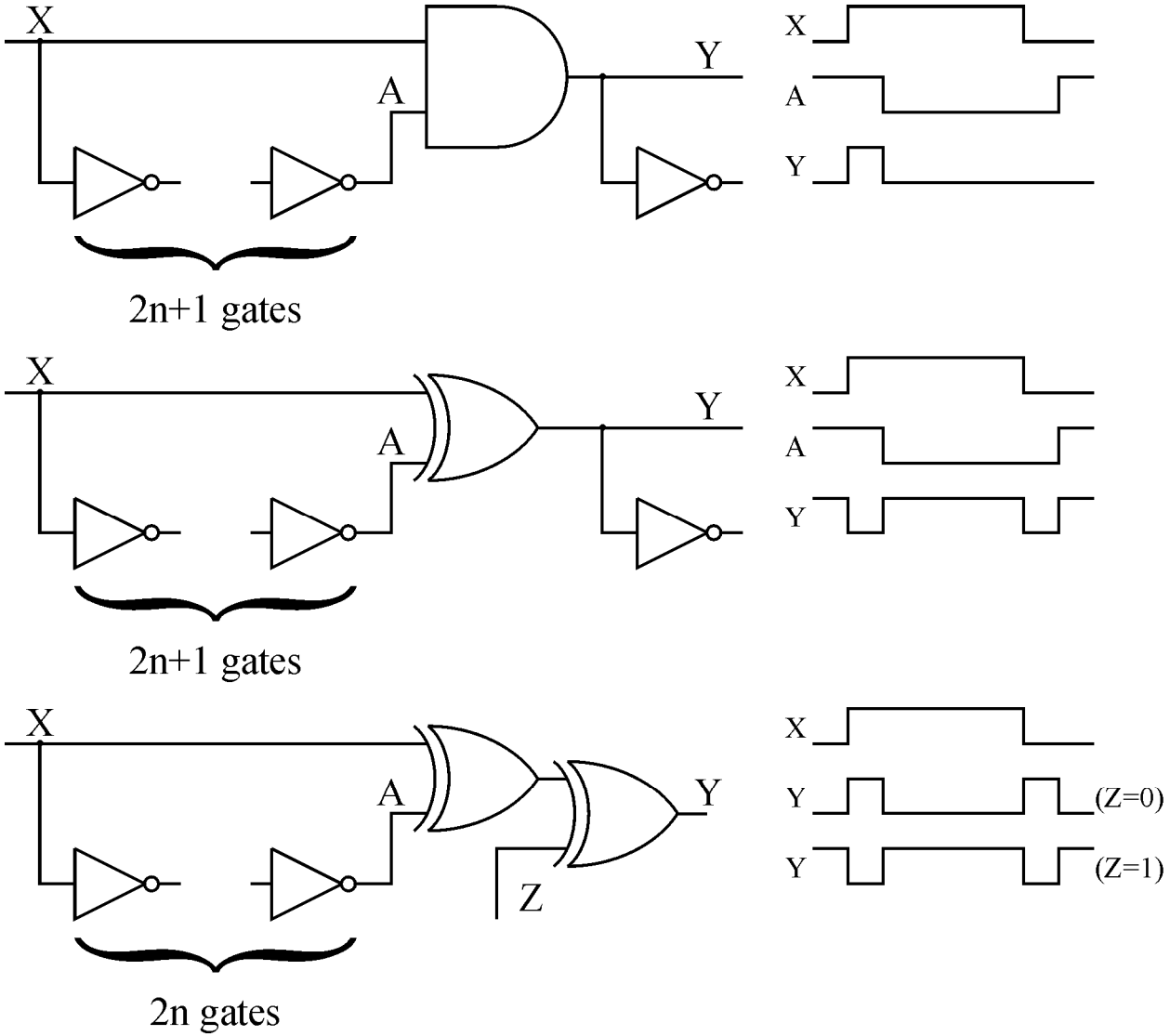
- Trigger circuits
  - (Edge detectors, differential circuits)
    - Generate short pulses upon switch of an input signal
  - *How to do it*?
    - Integrated monostable flip-flops
    - natural gate delays
    - RC circuits

Time circuits – part 2

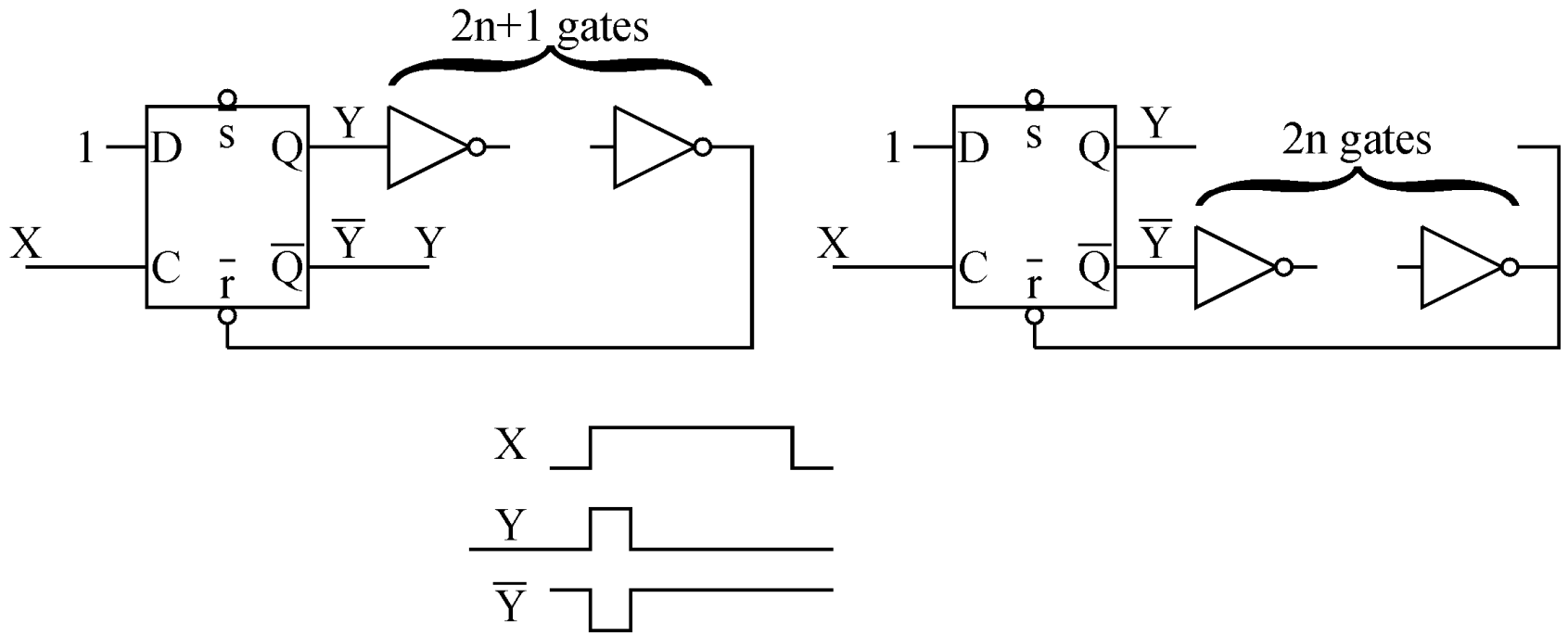
- Trigger circuits



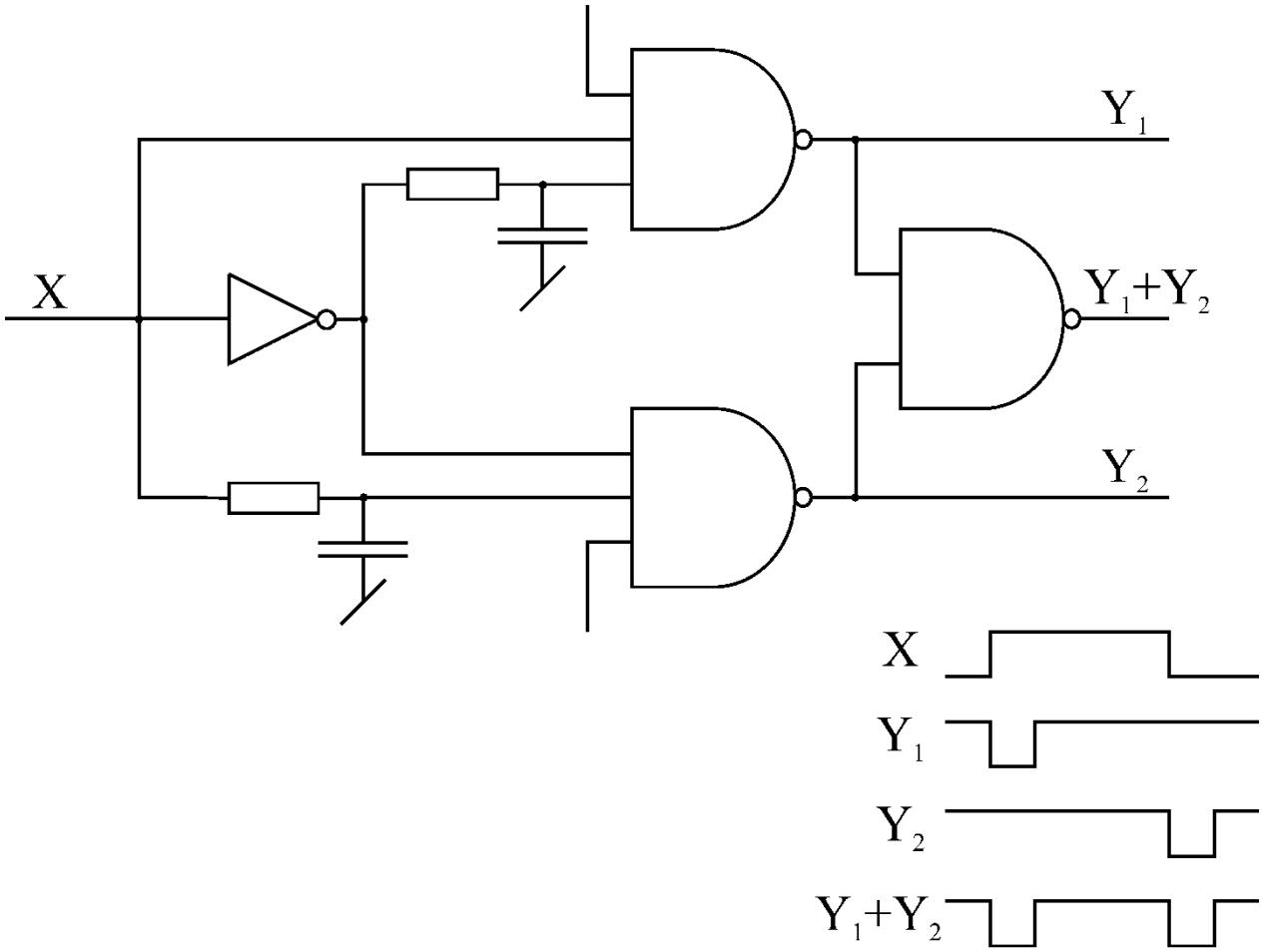
Time circuits – part 2



Time circuits – part 2



Time circuits – part 2



Time circuits – part 2

- Frequency generators
  - parameters:
    - generated frequency stability
    - frequency range
    - duty cycle range
    - start with a non-zero phase
  - implementation:
    - 74121x, 555, etc.
    - linearised logic gates (linearised gate = linear amp.)

Time circuits – part 2

- Frequency generators