

# Generatoriai ir trigeriai

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Informatikos institutas



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# Papildomojo kodo gavimas

papildomasis kodas:  $2^N - b$

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$$\begin{array}{r} \phantom{-} \quad 1 \quad 0 \quad 0 \quad 0 \quad 0 \\ \phantom{-} \quad \quad b_3 \quad b_2 \quad b_1 \quad b_0 \\ \hline \phantom{-} \quad \quad c_3 \quad c_2 \quad c_1 \quad c_0 \end{array} \quad \leftarrow \text{papildomasis kòdas}$$

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$$2^N - b = (2^N - 1) - b + 1$$

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$$\begin{array}{r} + \quad \quad \overline{b_3} \quad \overline{b_2} \quad \overline{b_1} \quad \overline{b_0} \quad \leftarrow \text{atvirkštinis kodas} \\ \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad 1 \\ \hline \quad \quad c_3 \quad c_2 \quad c_1 \quad c_0 \quad \leftarrow \text{papildomasis kodas} \end{array}$$

# Papildinio iki 2 pavyzdys

$$10_2 - 11_2 = ???$$

Raskime dviejų papildinį skaičiui  $11_2$ :

$$\begin{array}{r} \text{—} \quad 0 \quad 1 \quad 1 \quad 1 \quad 1 \quad \leftarrow (2^N - 1) \\ \quad \quad 0 \quad 0 \quad 1 \quad 1 \\ \hline \\ \quad \quad \bar{0} \quad \bar{0} \quad \bar{1} \quad \bar{1} \\ \quad \quad 1 \quad 1 \quad 0 \quad 0 \quad \leftarrow \text{atvirkštinis kodas} \\ + \quad \quad \quad \quad \quad \quad 1 \\ \hline \quad \quad 1 \quad 1 \quad 0 \quad 1 \quad \leftarrow \text{papildomasis kodas} \end{array}$$

$$10_2 - 11_2 = 0010_2 + 1101_2 = 1111_2 = -1_2$$

# Dviejų papildinio pavertimas į dešimtinę sistemą

Dec.	2's Compl.	Dec.	2's Compl.
7	0111	-1	1111
6	0110	-2	1110
5	0101	-3	1101
4	0100	-4	1100
3	0011	-5	1011
2	0010	-6	1010
1	0001	-7	1001
0	0000	-8	1000



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Vyriausias neigiamo skaičiaus bitas (MSB) yra **1**

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Vyriausias neigiamo skaičiaus bitas (MSB) yra **1**  
Mažiausio atvaizduojamo neigiamo skaičiaus modulis yra *didesnis* už didžiausio atvaizduojamo teigiamo.

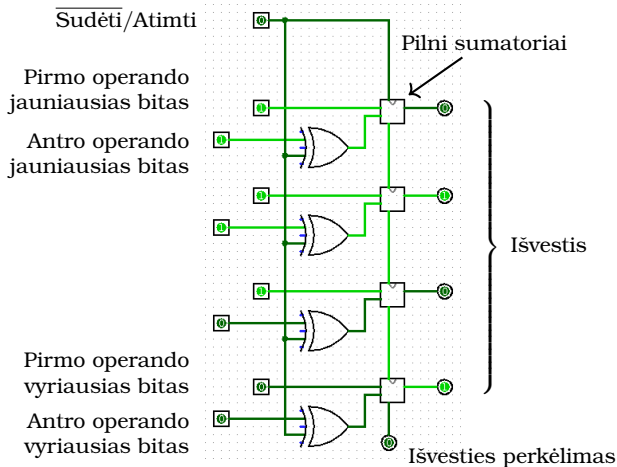
# Dviejų papildinio pavertimas į dešimtinę sistemą

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0	0000	<b>-8</b>	<b>1000</b>

$$\begin{aligned}1011_2 &= 1000_2 + 0011_2 = -2^3 + 11_2 \\ &= \overset{-2^3}{1} \overset{2^2}{0} \overset{2^1}{1} \overset{2^0}{1} \\ &= -2^3 + 2^1 + 2^0 = -8_{10} + 2_{10} + 1_{10} \\ &= -5_{10}\end{aligned}$$

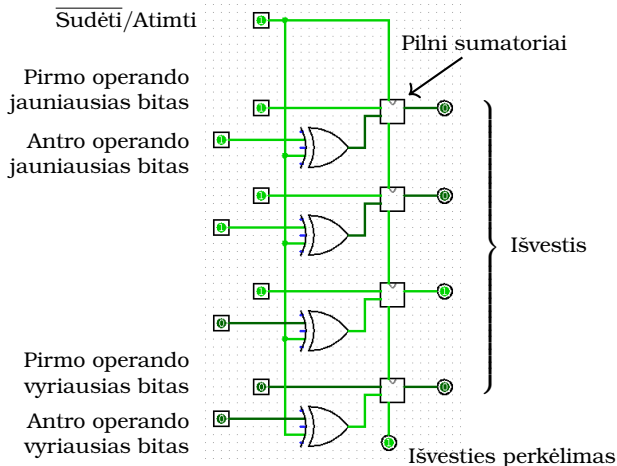
# Sudėties-atimties ALU

$$7_{10} + 3_{10} = 0111_2 + 0011_2 = 1010_2 = 10_{10}$$



# Sudėties-atimties ALU

$$7_{10} - 3_{10} = 0111_2 - 0011_2 = 0111_2 + 1101_2 = 1\ 0100_2 = 4_{10}$$



# Kiti neigiamų skaičių atvaizdavimai

Ženklas/modulis:

$$6_{10} = 0110_2; \quad -6_{10} = 1110_2$$

Papildinių aritmetika:

$$a + (-b) = a + \underbrace{((2^N - 1) - b)}_{\text{one's complement}} + 1 - 2^N$$

$\underbrace{\hspace{10em}}_{\text{2's complement}}$

Aritmetika su postūmiu  $K$ :

$$K = 2^{N-1} \quad (\text{kaip taisyklė, bet galimos ir kitos reikšmės})$$

$$b \leftrightarrow K + b = 2^{N-1} + b$$

$$-b \leftrightarrow K + (-b) = 2^{N-1} + (-b)$$

# Kiti neigiamų skaičių atvaizdavimai

Skaičius	Be ženklo	Pap. iki 2	Pap. iki 1	$\pm$ Modulis	Postūmis <sup>1</sup> K
7	111	-	-	-	-
6	110	-	-	-	-
5	101	-	-	-	-
4	100	-	-	-	-
3	011	011	011	011	111
2	010	010	010	010	110
1	001	001	001	001	101
0	000	000	000	000	100
-0	-	-	111	100	-
-1	-	111	110	101	011
-2	-	110	101	110	010
-3	-	101	100	111	001
-4	-	100	-	-	000

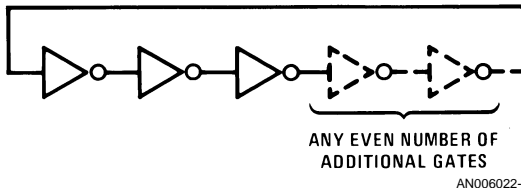
See also:  
Murdocca et al. 1999, chapt. 2;  
Walker 1996, "Minus Zero"

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$${}^1K = 4 = 2^{N-1}, N = 3$$

## CMOS Oscillators

Fairchild Semiconductor  
Application Note 118  
October 1974



**FIGURE 1. Odd Number of Inverters  
Will Always Oscillate**

(Fairchild Semiconductor 1974)

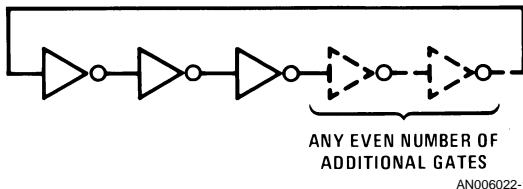


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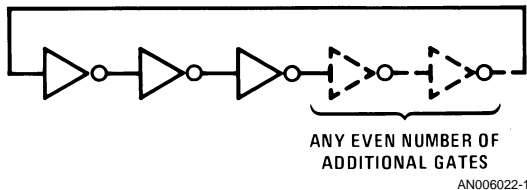


“It then becomes obvious that a “1” chases itself around the ring and the network oscillates.” :)

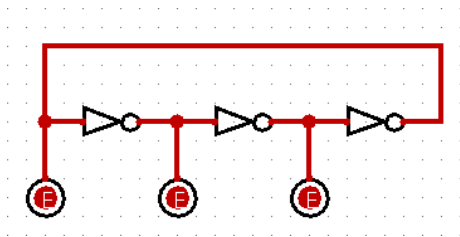


**FIGURE 1. Odd Number of Inverters  
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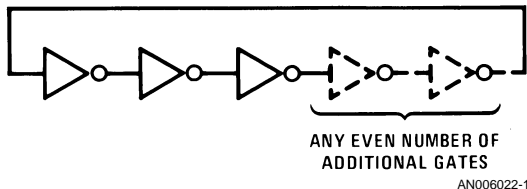
(Fairchild Semiconductor 1974)



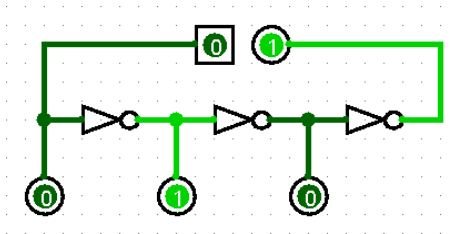
**FIGURE 1. Odd Number of Inverters  
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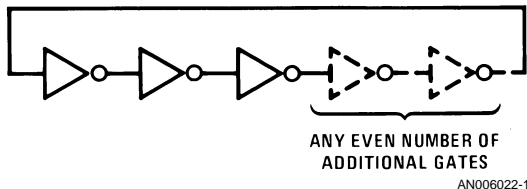
# Žiedinis generatorius



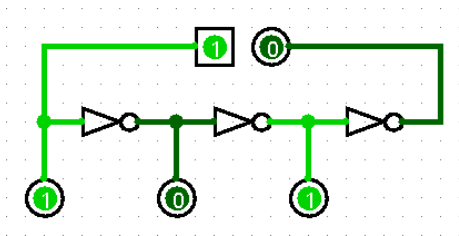
**FIGURE 1. Odd Number of Inverters  
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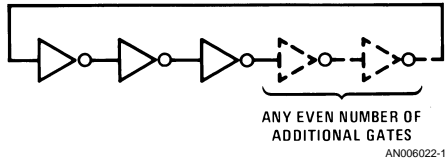
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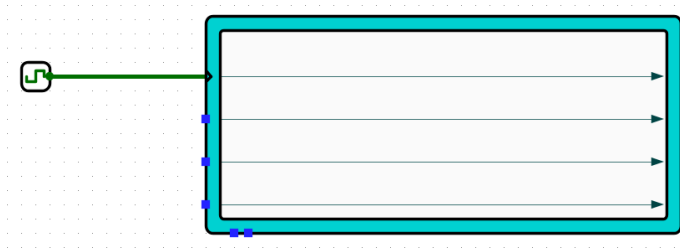
**FIGURE 1. Odd Number of Inverters  
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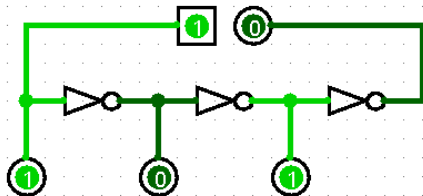
# Taktinis generatorius



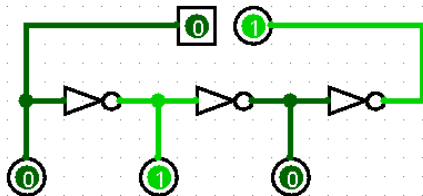
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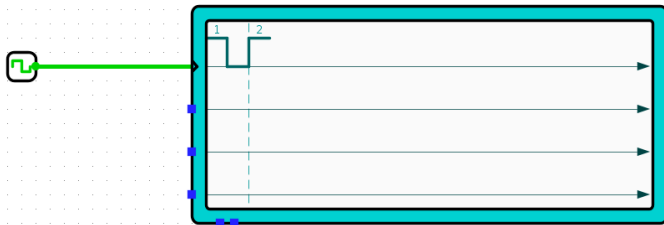
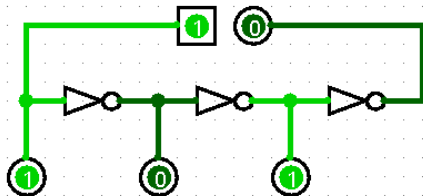
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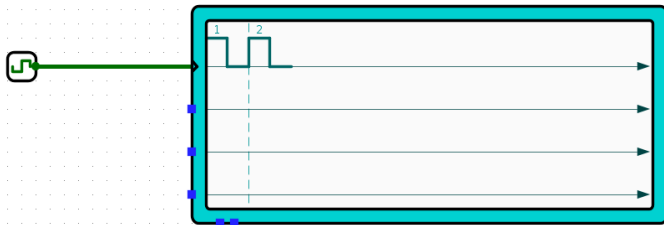
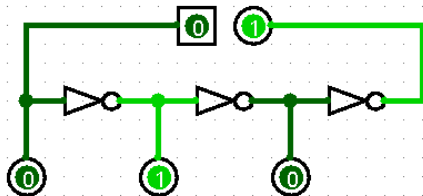


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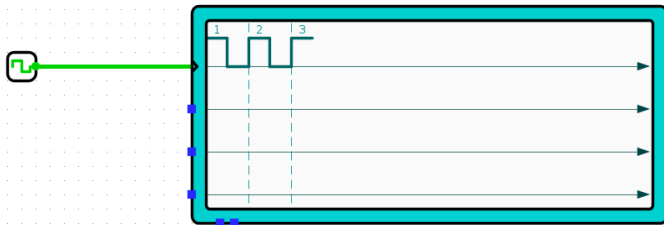
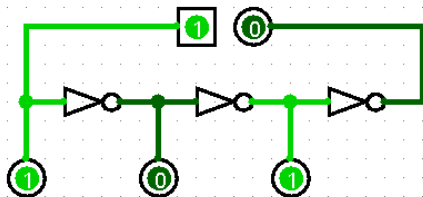




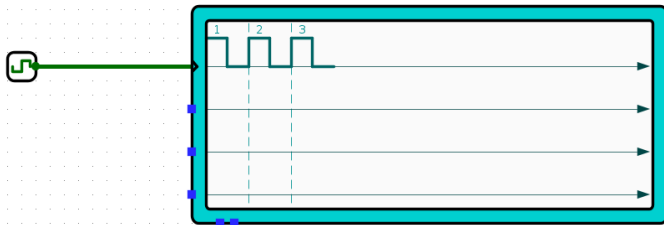
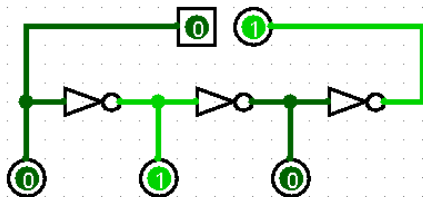
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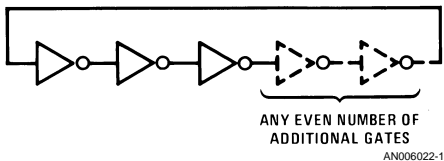
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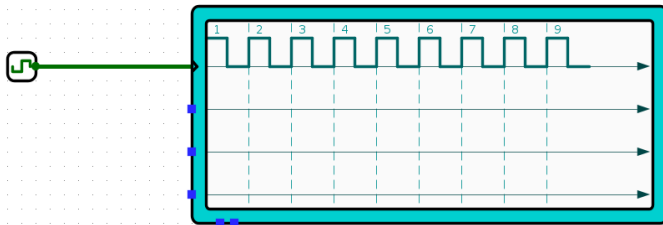
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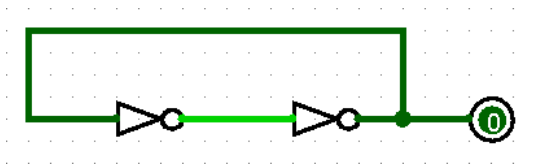
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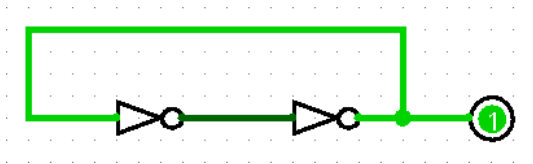
**FIGURE 1. Odd Number of Inverters  
Will Always Oscillate**



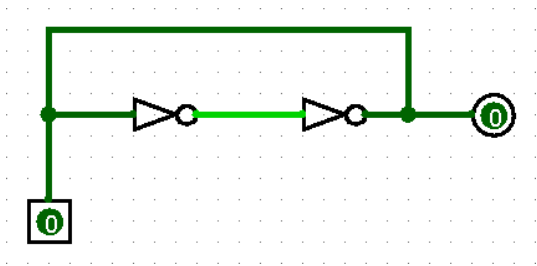
# Lyginis inverterių skaičius



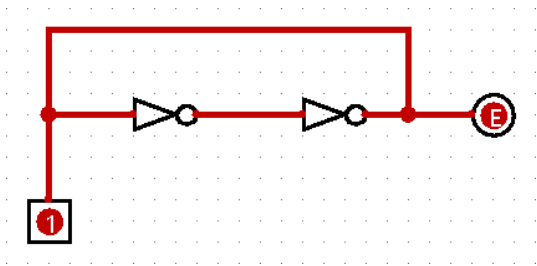
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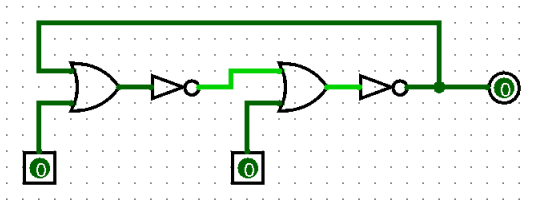
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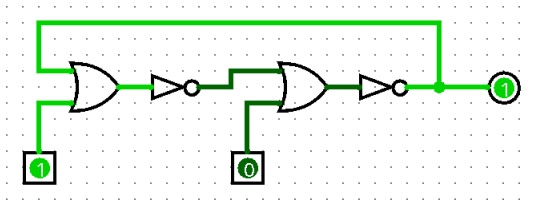
# Lyginis inverterių skaičius

Būsenos nustatymas



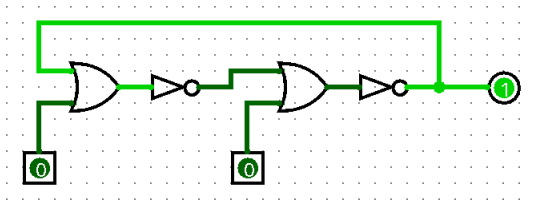
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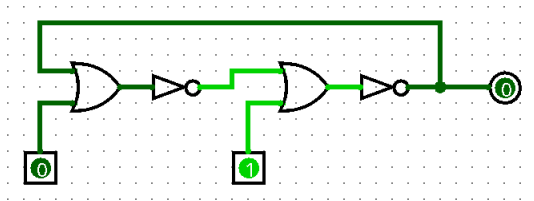
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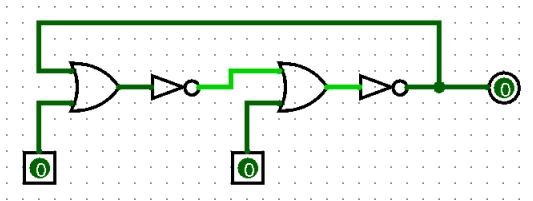
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Būsenos nustatymas

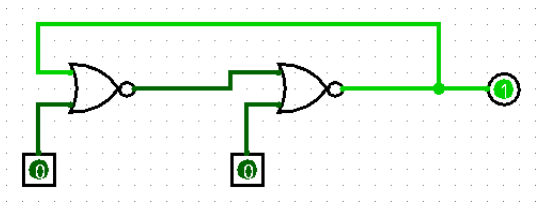


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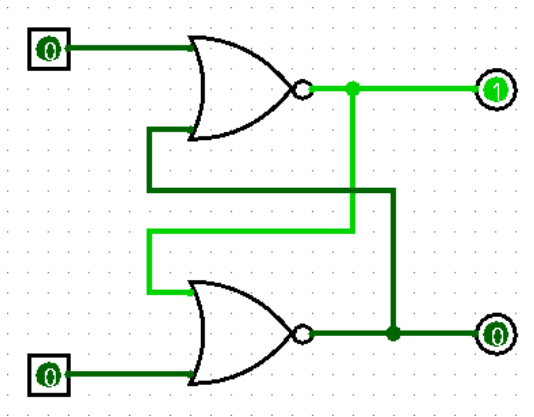
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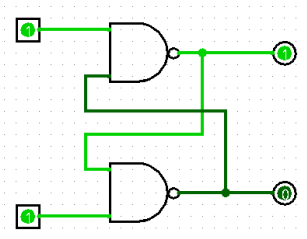
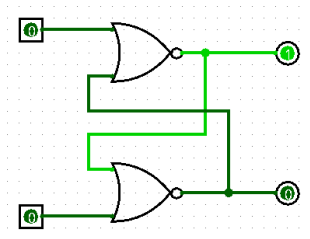
# RS trigeris iš ARBA-NE ventilių



# RS triggeris iš ARBA-NE ventilių



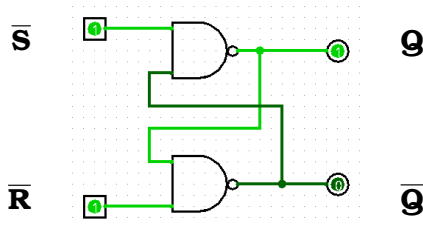
# RS triggeris iš ARBA-NE arba IR-NE ventilių





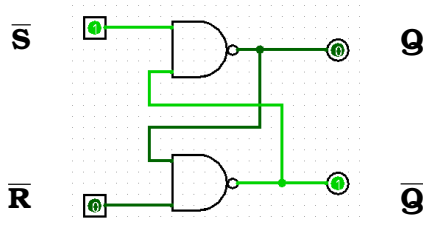
# RS triggeris

<b>S</b>	<b>R</b>	$\bar{\mathbf{S}}$	$\bar{\mathbf{R}}$	<b>Q</b>	
0	0	1	1	Q	←
0	1	1	0	0	
1	0	0	1	1	
1	1	0	0	X	



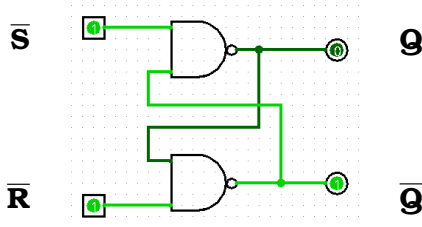
# RS triggeris

<b>S</b>	<b>R</b>	<b><math>\bar{S}</math></b>	<b><math>\bar{R}</math></b>	<b>Q</b>	
0	0	1	1	Q	
0	1	1	0	0	←
1	0	0	1	1	
1	1	0	0	X	



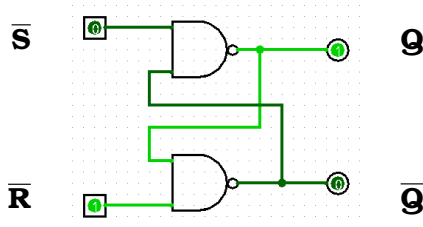
# RS triggeris

<b>S</b>	<b>R</b>	$\bar{\mathbf{S}}$	$\bar{\mathbf{R}}$	<b>Q</b>	
0	0	1	1	Q	←
0	1	1	0	0	
1	0	0	1	1	
1	1	0	0	X	



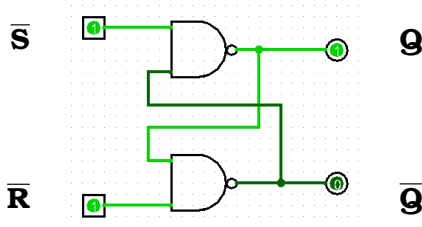
# RS triggeris

<b>S</b>	<b>R</b>	$\bar{\mathbf{S}}$	$\bar{\mathbf{R}}$	<b>Q</b>	
0	0	1	1	Q	
0	1	1	0	0	
1	0	0	1	1	←
1	1	0	0	X	

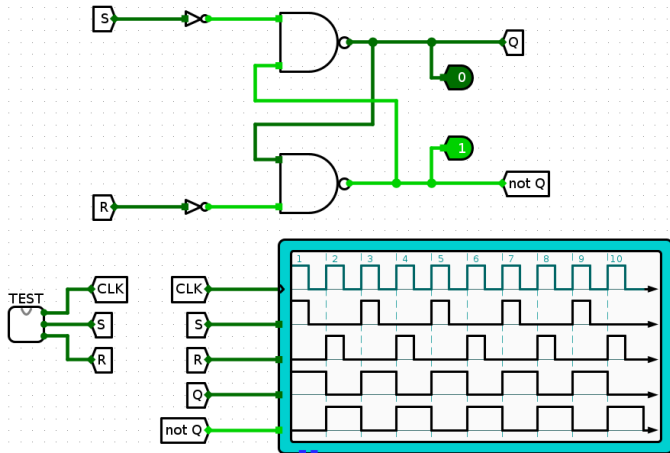


# RS triggeris

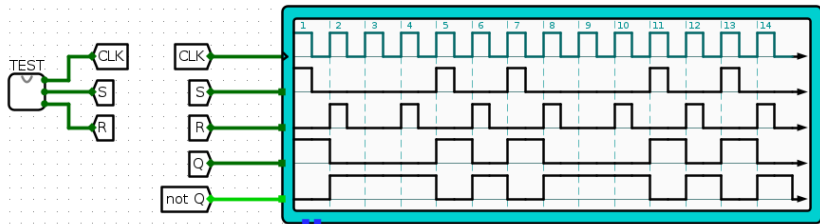
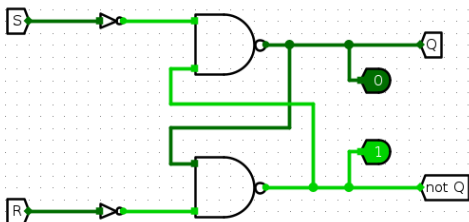
<b>S</b>	<b>R</b>	$\bar{\mathbf{S}}$	$\bar{\mathbf{R}}$	<b>Q</b>	
0	0	1	1	Q	←
0	1	1	0	0	
1	0	0	1	1	
1	1	0	0	X	



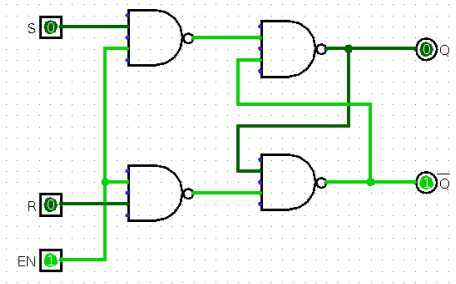
# RS triggerio įtampos epiūros



# RS triggerio įtampos epiūros

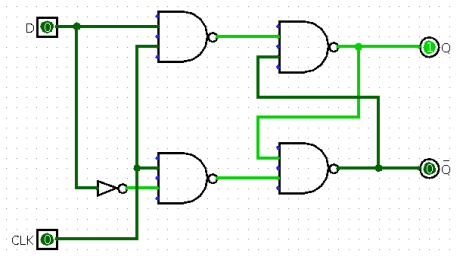


# Valdomas RS trigeris

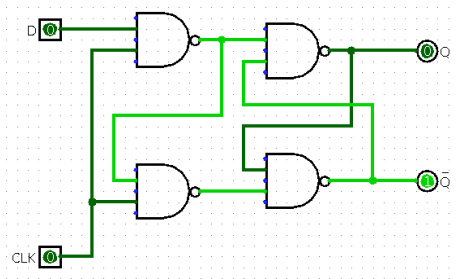




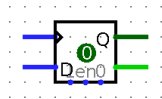
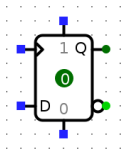
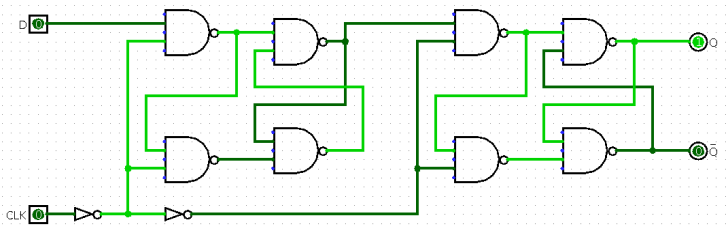
# D trigeris (užsklanda)



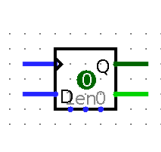
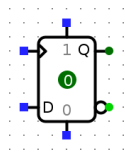
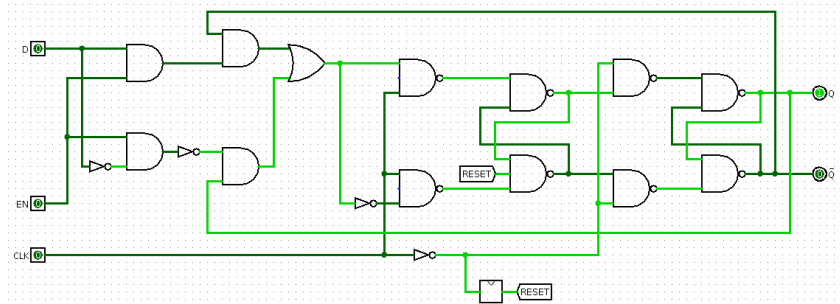
# D triggeris (užsklanda)



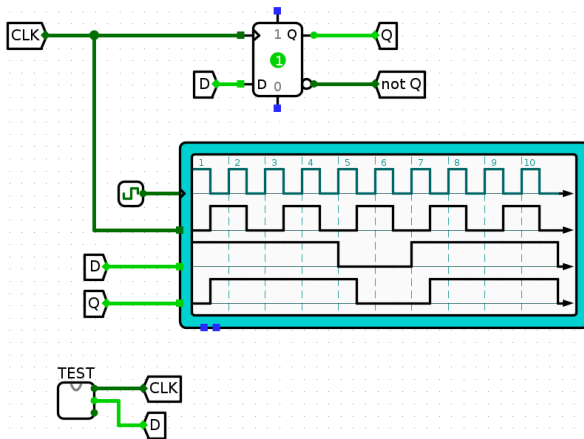
# MS D trigeris (valdomas frontu)



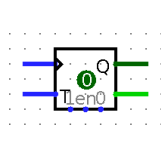
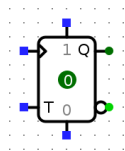
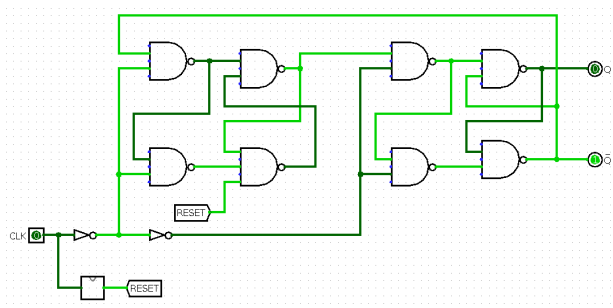
# MS D triggeris (valdomas frontu)



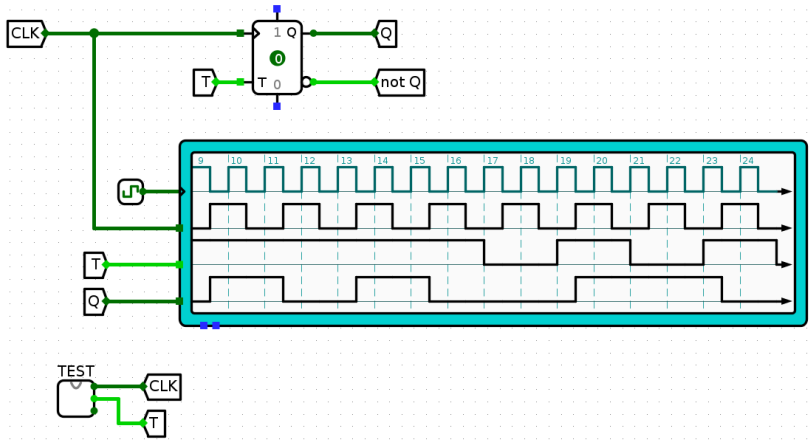
# MS D trigerio veikimas

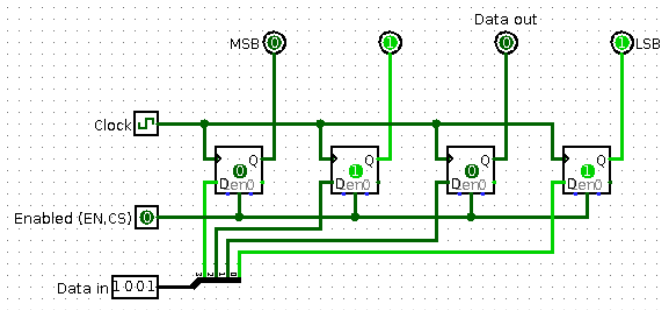


# T triggeris

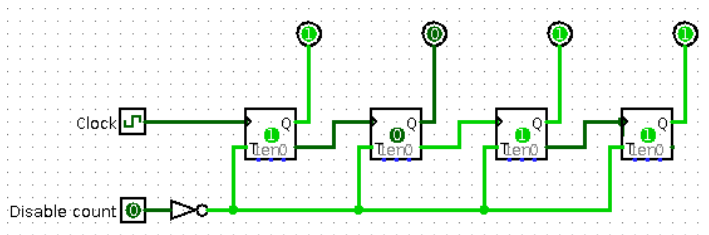


# T trigerio veikimas

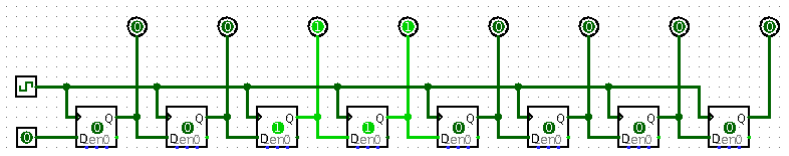




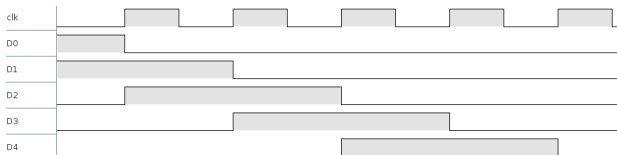
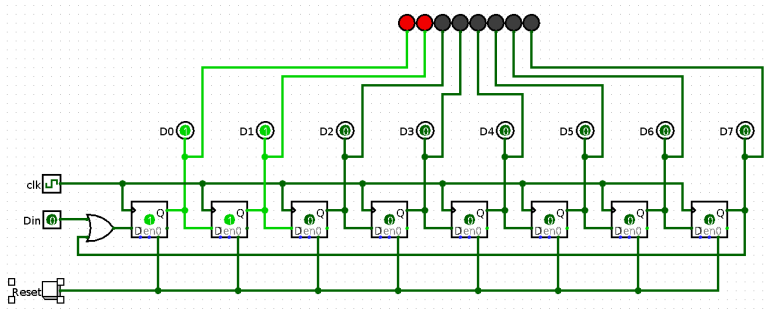




# Postūmio registrai



# Žiediniai postūmio registrai



- Neigiami sveiki skaičiai šiuolaikiniuose kompiuteriuose atvaizduojami papildomuoju kodu, bet įmanomi ir kiti atvaizdavimo metodai.
- Šiuolaikiniai kompiuteriai yra sinchroniniai – jie naudoja taktų generatorių visos grandinės valdyti.
- Generatoriams ir atminties ląstelėms būtinas grįžtamasis ryšys.
- Iš pagrindinės RS trigerio schemos padaromos D- ir T-trigerių schemos, valdomos signalo lygiu arba frontu.
- Iš D- ir T-trigerių toliau konstruojami registrai ir skaitikliai – esminiai kompiuterių mazgai.

- Fairchild Semiconductor (1974). *CMOS oscillators*. Tech. rep. ON Semiconductor. URL: <https://www.onsemi.com/pub/Collateral/AN-118.pdf>.
- Murdocca, Miles J. et al. (1999). *Principles of Computer Architecture*. Prentice Hall.
- Walker, John (Aug. 19, 1996). *Minus zero*. eng. URL: <http://www.fourmilab.ch/documents/univac/minuszero.html>.