Vhodno-izhodne naprave (VIN)

Predavanja

1. Osnove elektrotehnike in signalov

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1. Osnove elektrotehnike in signalov

Poudarki poglavja :

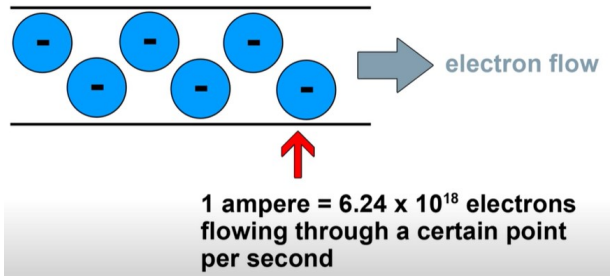
- 1.1 Osnove elektrotehnike (OE)
  - Električna napetost (U), električni tok (I), električna upornost (R)
  - Električna moč (P), Električna energija (E)
  - Ohmov zakon
  - 1. Kirchoffov zakon
  - 2. Kirchoffov zakon
- 1.2 Signali
  - Osnove
  - Signali: Električni, Zvezni, Diskretni, Digitalni
    - Periodični (sinusni, pravokotni) signal
    - Urin signal

1.1 Osnove elektrotehnike – el. napetost, tok

- Električni tok in napetost sta osnovni količini v elektrotehniki.
- **Električna napetost – U** [Volt: V]
  - Razlika dveh električnih potencialov v dveh točkah (+ je višji potencial, – je nižji potencial).
  - Če sta točki sklenjeni v zaključeni zanki, dobimo vezje v katerem steče električni tok.

Basic Electricity - What is voltage? https://www.youtube.com/watch?v=TBt-kxYfync

- **Električni tok - I** [Amper: A]
  - Količina električnega naboja, ki preteče v nekem času.
  - 1 Amper := 1A = $6.241*10^{18}$ elektronov/sek = 1 Coulomb/sek

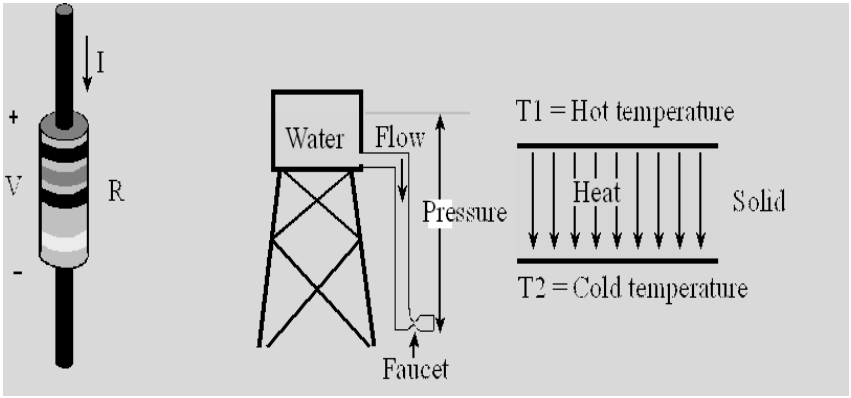


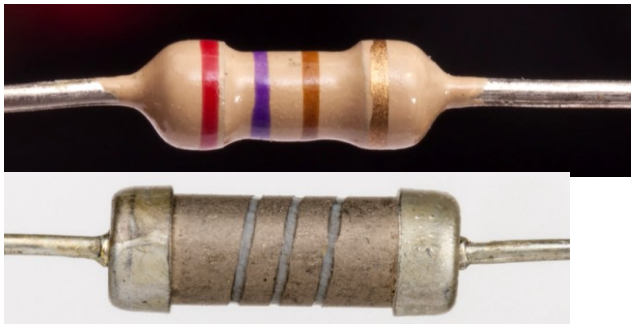
Basic Electricity - What is an amp? https://www.youtube.com/watch?v=8gvJzrjwjds

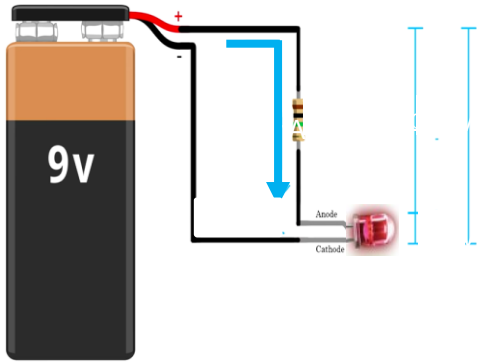
1.1 Osnove elektrotehnike

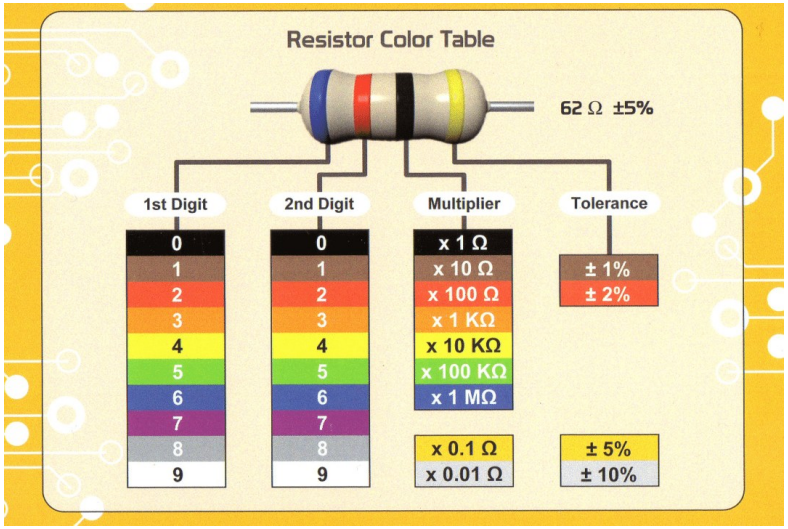
Basic Electricity - Resistance and Ohm's law, https://www.youtube.com/watch?v=NfcgA1axPLo&ab_channel=Afrotechmods

- **Električna upornost - R** [Ohm: Ω = V/A]
  - Količina določena z Ohmovim zakonom, ki ovira pretok nabojev.
    - žica ima zanemarljivo upornost (≈0Ω), upor ima precej višjo upornost.







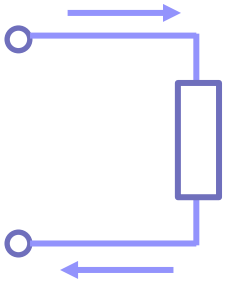


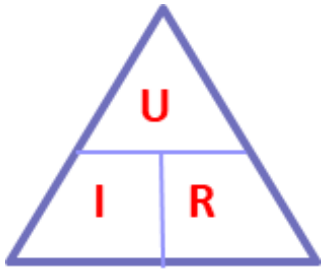
1.1 Osnove elektrotehnike – Ohmov zakon

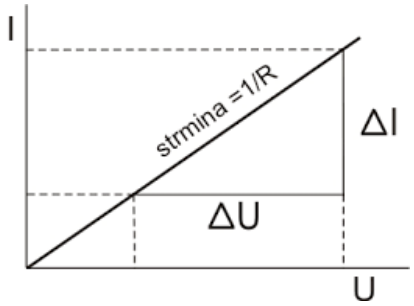
Georg Simon **Ohm** (1789-1854), nemški matematik
http://theor.jinr.ru/~kuzemsky/gohmbio.html

- **Ohmov zakon** – zveza med tokom, napetostjo in upornostjo

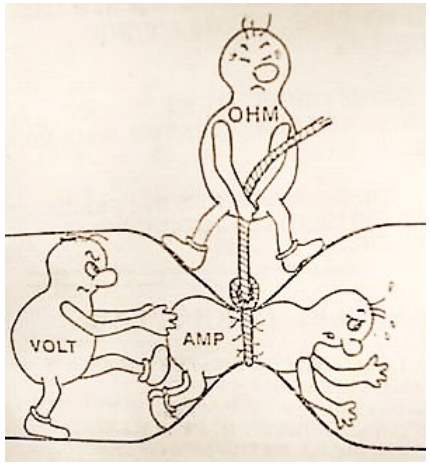
$$U = I * R,\quad R = U / I,\quad I = U / R$$







  - Sprememba napetosti na bremenu je premo sorazmerna spremembi toka. Faktor sorazmernosti je upor R.



- **Električna moč – P** = U*I [Watt: W = J/s in W = VA]
- **Električna energija – E** = P*t = U*I*t [Joul: J = Ws, KWh]

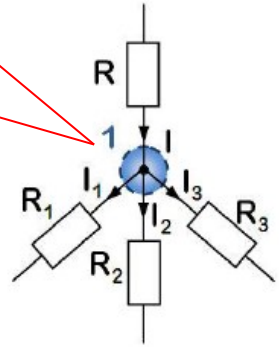
1.1 Osnove elektrotehnike – 1. Kirchoffov zakon

- **1. Kirchoffov zakon** (tokovni) sledi zakonu o ohranitvi naboja.

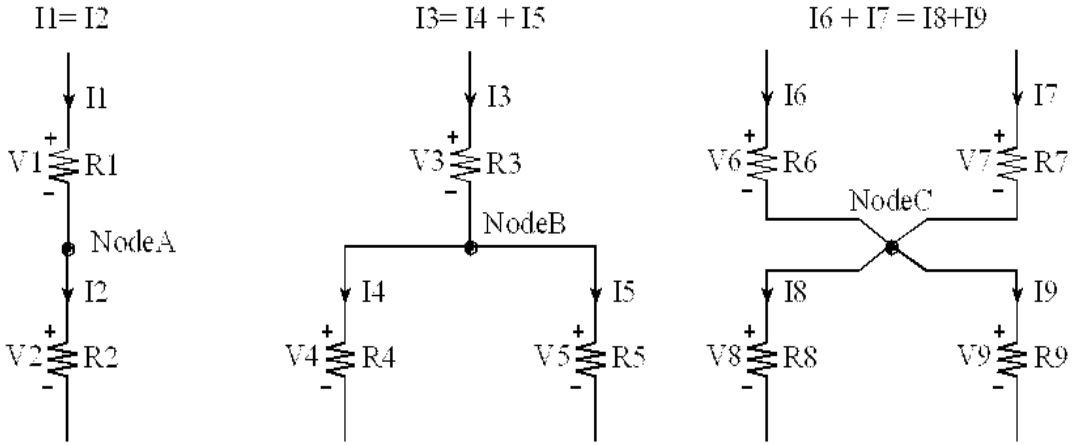
Vsota vseh tokov v spojišče je enaka vsoti tokov iz spojišča. $I = I_1 + I_2 + I_3$

ali

Vsota vseh tokov v spojišču je enaka 0. $I - I_1 - I_2 - I_3 = 0$



Primeri:



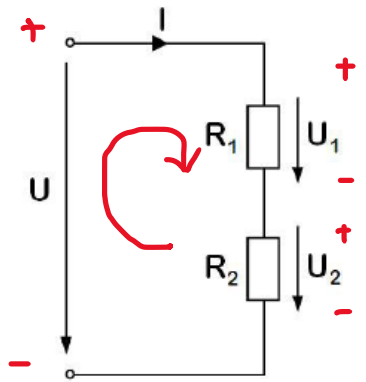
Gustav Robert **Kirchhoff** (1824-1887) – nemški fizik

1.1 Osnove elektrotehnike – 2. Kirchoffov zakon

- **2. Kirchoffov zakon** (napetostni)

  Vsota padcev napetosti v zaključeni zanki je enaka nič.

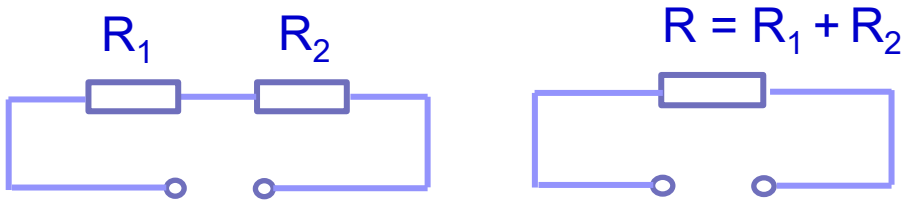
$$U = U_1 + U_2$$
$$U - U_1 + U_2 = 0$$

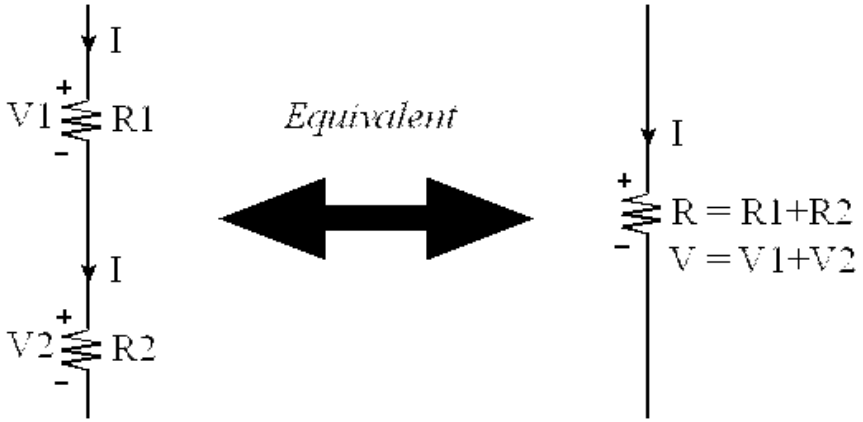


Gustav Robert **Kirchhoff** (1824-1887) – nemški fizik

1.1 Osnove elektrotehnike

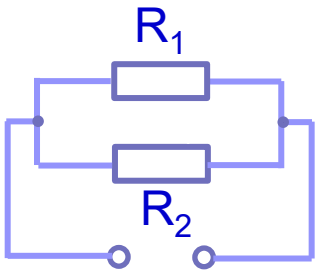
- Zaporedna vezava uporov
  - Seštevajo se
    - Padci napetosti
    - Upornosti
  - Enak tok skozi R_1 in R_2



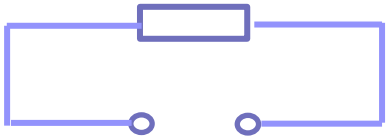


1.1 Osnove elektrotehnike – vzporedna

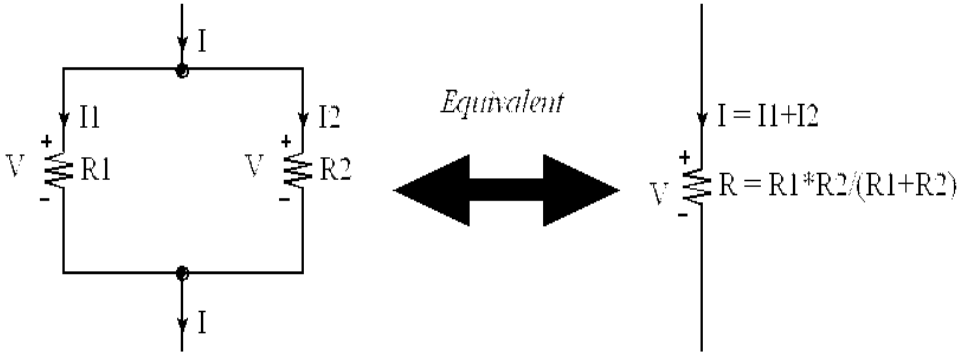
- Vzporedna vezava uporov
  - Seštevajo se
    - Različni tokovi (glede na upornost)
    - Prevodnosti:
      - $1/R = 1/R_1 + 1/R_2 + \ldots$
      - $G = G_1 + G_2 + \ldots$
  - Enak padec napetosti



$R = R_1 * R_2 / (R_1 + R_2)$



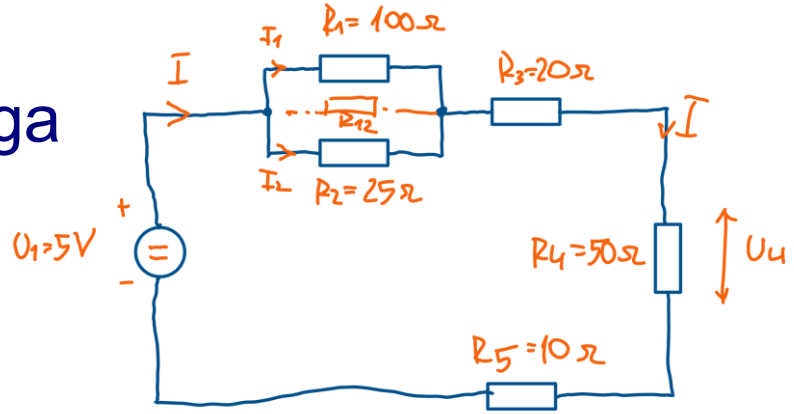
- Za 2 upora uredimo izraz: $R = R_1 * R_2 / (R_1 + R_2)$



1.1 Osnove elektrotehnike - naloga

Naloga z vezavo uporov :

- Izračunaj padec napetosti na uporu R_4



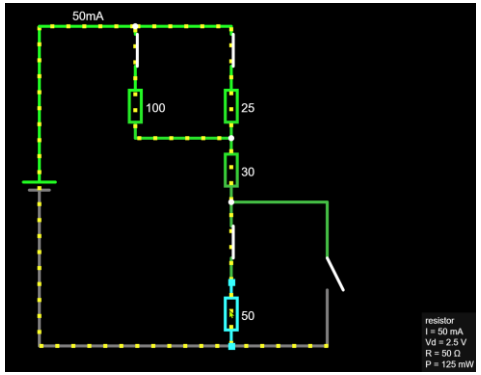
$$U_4 = I_4 \cdot R_4 = 0{,}05A \cdot 50\Omega = 2{,}5V$$

$I_4 = I$

$$I = \frac{U_1}{R_S} = \frac{5V}{100\Omega} = 0{,}05A = 50mA$$

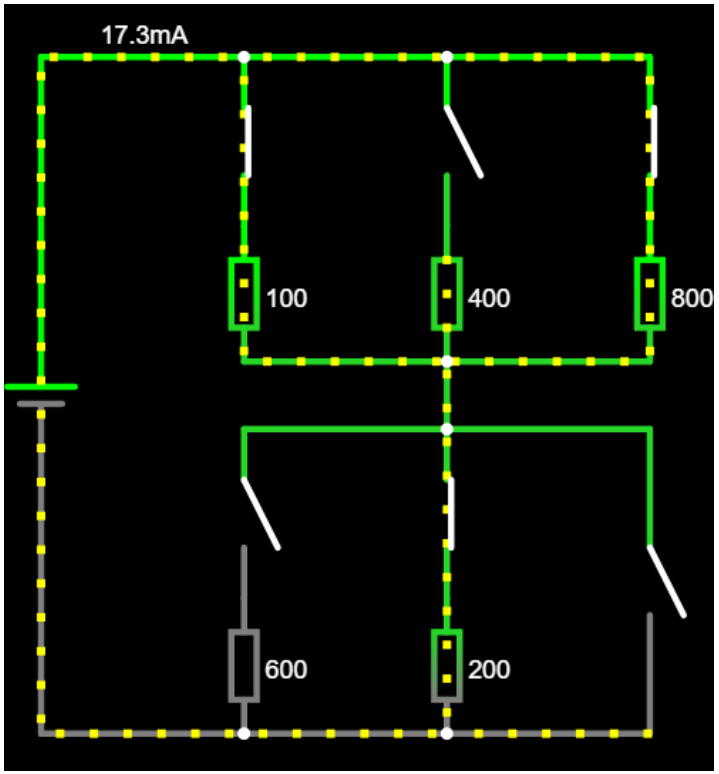
$$R_S = R_{12} + R_3 + R_4 + R_5 = 20 + 20 + 50 + 10 = 100\Omega$$

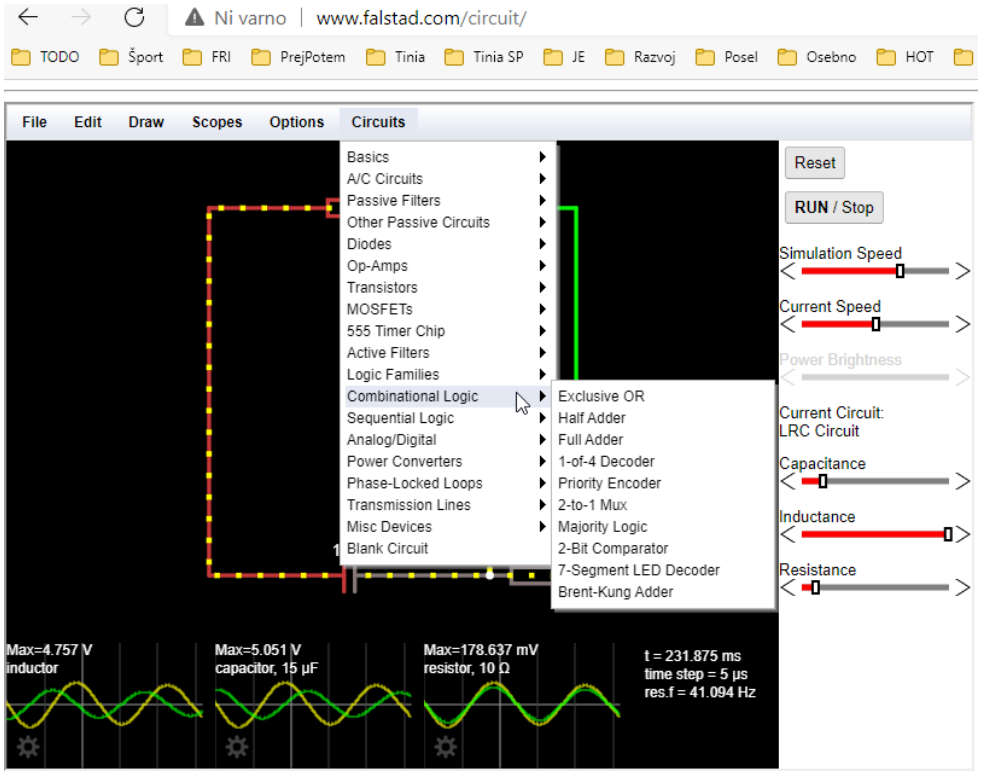
$$R_{12} = \frac{R_1 \cdot R_2}{R_1 + R_2} = \frac{100 \cdot 25}{100 + 25} = 20\Omega$$



Falstad Circuit

Orodje za simulacijo preprostih vezij – Falstad.com





http://www.falstad.com/circuit/e-resistors.html (Javascript)

http://www.lushprojects.com/circuitjs/circuitjs.html

http://www.indiabix.com/electronics-circuits/resistors/ (Java Applet)

1.2 Signali

Signal

- je **fizikalni pojav**, s katerim je mogoče prenašati podatke. **[i-slovar]**
  - Poznamo različne signale: zvočni, optični ali svetlobni, slikovni, električni, analogni, digitalni, časovni, …
- je **električni impulz**, ki se prenaša z elektromagnetnim valovanjem in vsebuje kako sporočilo, ukaz: radar, radarska postaja oddaja, sprejema signale. **[SSKJ]**
- je **funkcija**, ki "posreduje informacije o stanju, obnašanju ali atributih nekega pojava, fizikalnega sistema".
  - V svoji najpogostejši uporabi v elektroniki in telekomunikacijah je to časovno spremenljiva napetost, tok ali elektromagnetni val, ki se uporablja za prenos informacij. [https://en.wikipedia.org/wiki/Signal]
- je **fizikalna veličina**, ki se spreminja v odvisnosti od časa (najbolj ustreza za VIN)

1.2 Signali

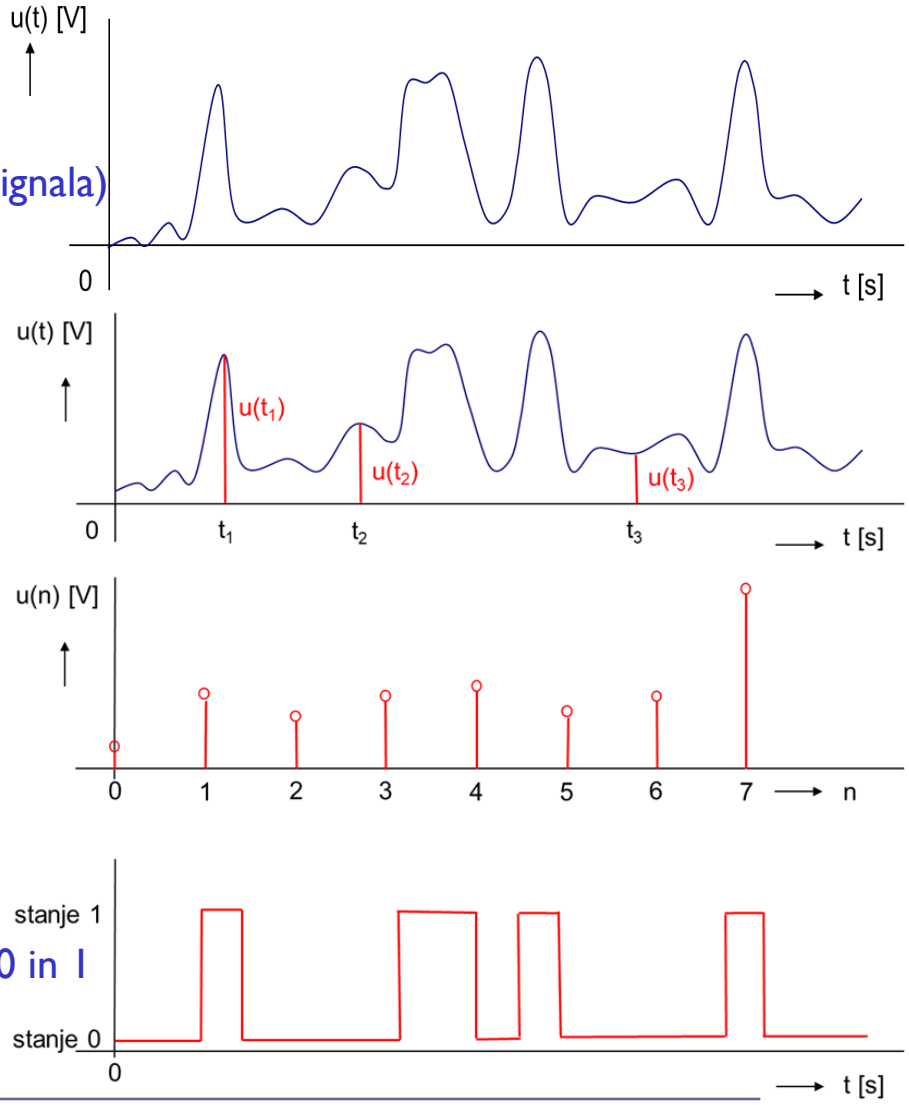
Primeri signalov:

- **Električni** signal – u(t)
  (napetost je funkcija časa, ustreza definiciji zveznega signala)

- **Zvezni** signal – u(t)
  (t je zvezni čas, zvezna amplituda)

- **Diskretni** signal – u(n)
  (diskretni čas, n je celo število)

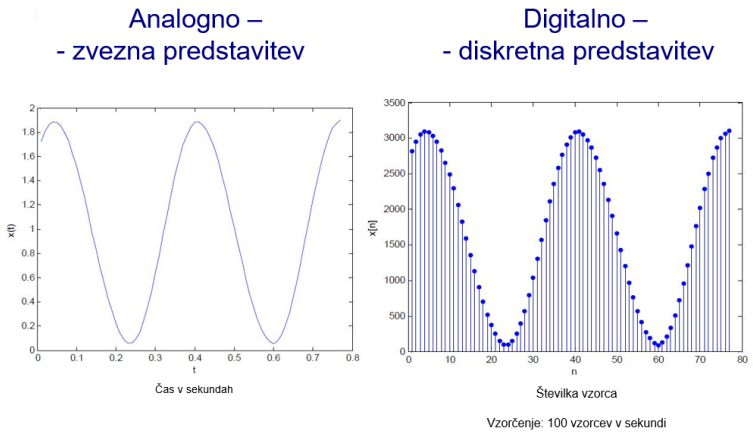
- **Digitalni** signal (diskretna amplituda)
  - dps: amplituda več diskretnih vrednosti (več bitov)
  - dig. vezja : amplituda ima dve diskr. vrednosti, stanji 0 in 1 (1 bit)



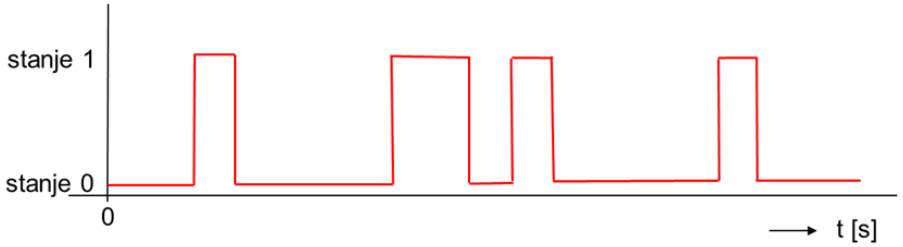
1.2 Signali

Primeri signalov: digitalni signali

- **Digitalni** signal – dve interpretaciji:
  - dps: amplituda ima več diskretnih vrednosti (št. bitov), tudi diskretna časovna os



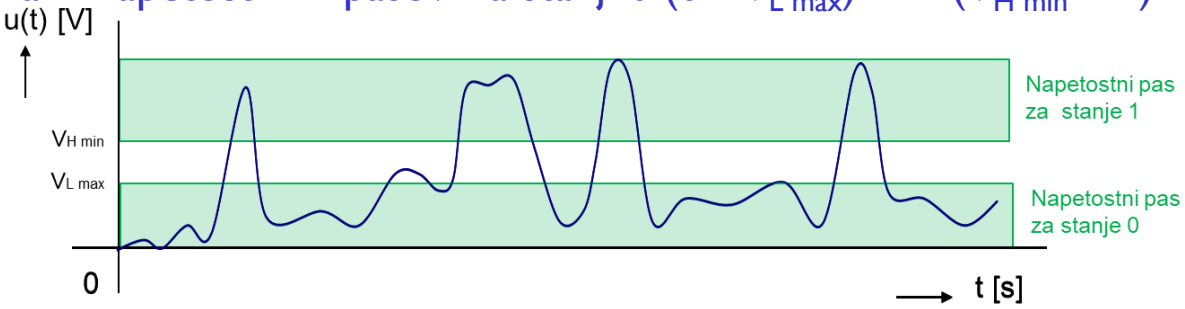
  - dig. vezja : amplituda ima dve diskr. vrednosti, stanji 0 in 1 (idealni signal)
    čas pogosto zvezen



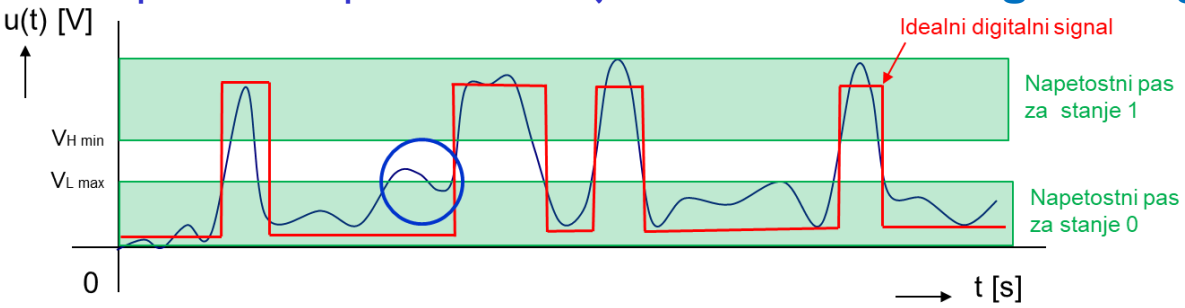
Preslikava med stanji in nap. nivoji

Digitalna vezja: *preslikava: realna amplituda signala -> stanji 0, 1*

- Električni signal z napetostnimi pasovi za stanji 0 (0 - $V_{L\ max}$) in 1 ($V_{H\ min}$ – x)



- Električni signal z napetostnimi pasovi za stanji 0 in 1 ter **idealni digitalni signal**.

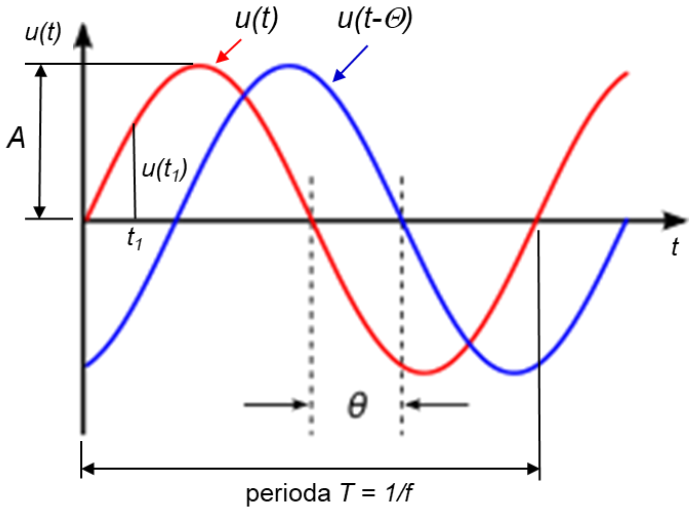


- Prednosti digitalnega signala - ?
  - Prenos in shranjevanje podatkov
  - Obdelava in predstavitev podatkov

Periodični signal

- Časovni potek se po določnem času ponavlja (perioda T)

- Primer: Sinusni električni signal – u(t) = A sin(2 π f t + Θ)



$$u(t_1) = A \cdot \sin(2\pi f \cdot t_1)$$

t .. čas

u(t) .. trenutna velikost signala v času t

A .. amplituda signala

T .. perioda signala (f je frekvenca signala – to je število period (T) v sekundi)

Θ .. faza ali fazni kot je premik signala glede na začetno stanje ali glede na drug signal

Periodični pravokotni signal

- Časovni potek se po določnem času ponavlja (perioda T)

Primer: Pravokotni električni signal – u(t) f = 1/T

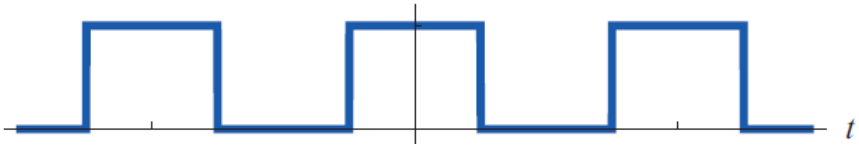
t .. čas

u(t) .. trenutna velikost signala v času t

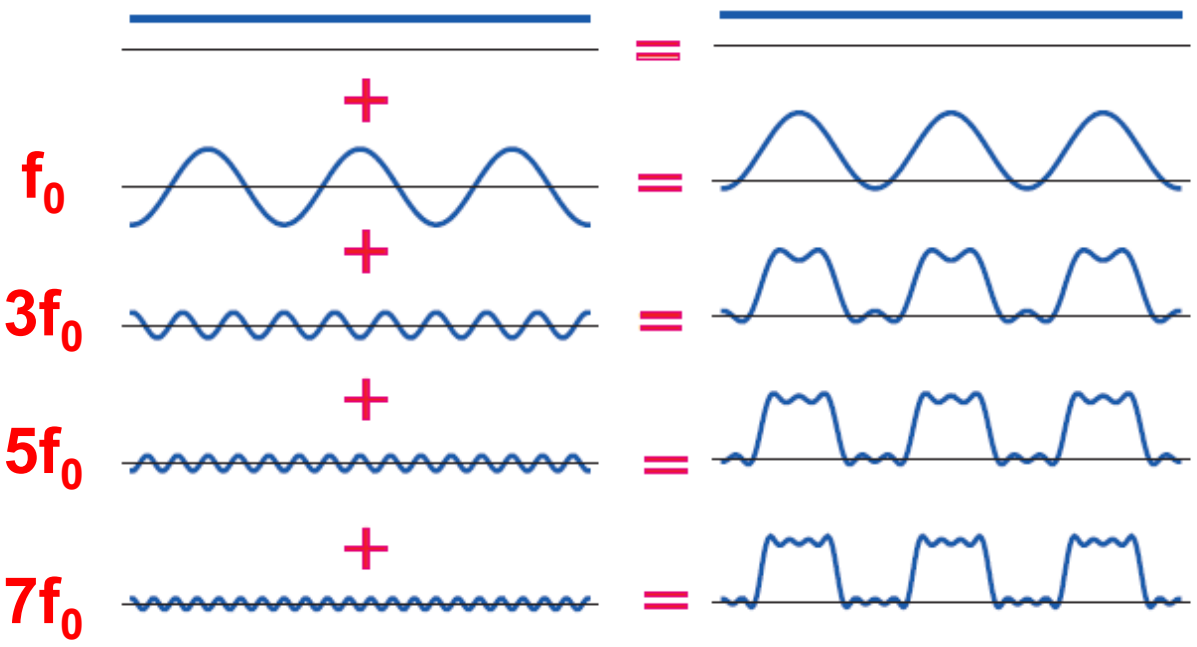
T .. perioda signala (f je frekvenca signala – to je število period (T) v sekundi)

Sestava pravokotnega signala

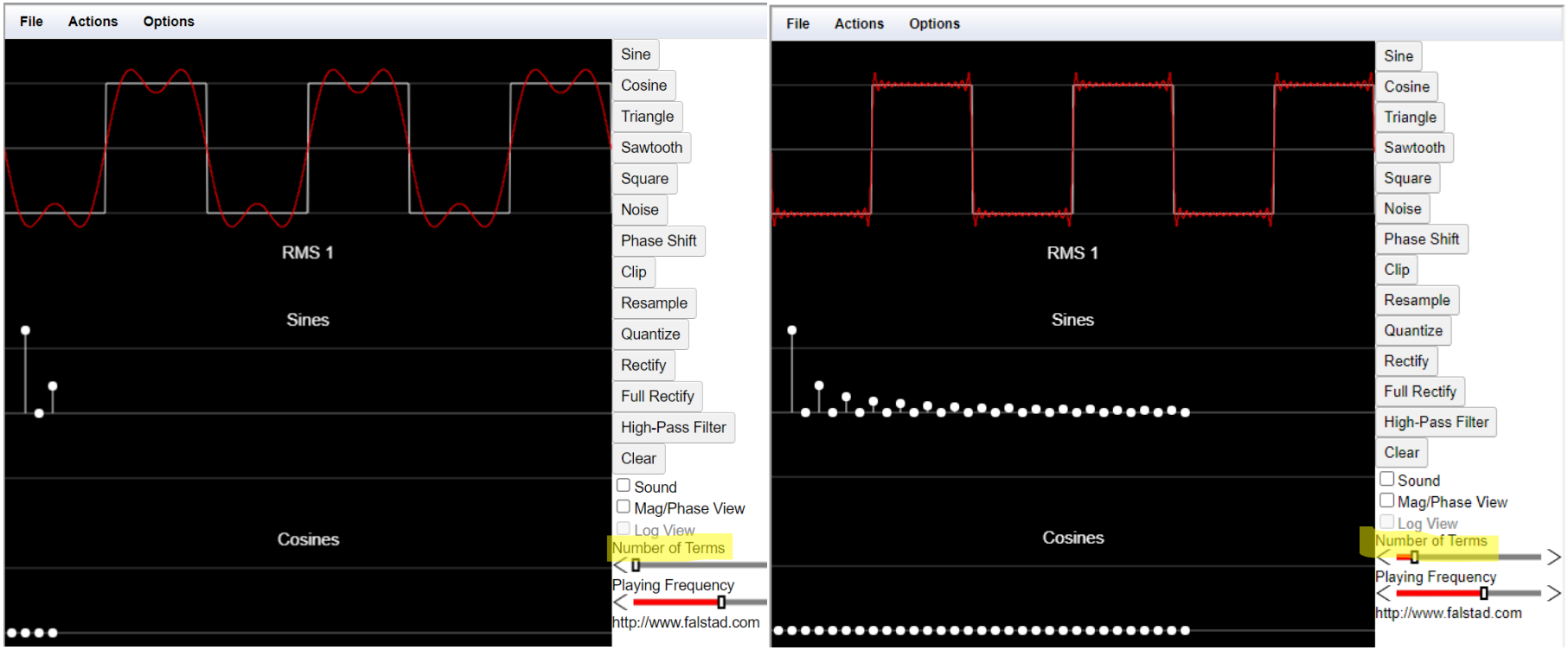
- Kako sestavimo pravokoten periodični signal?



- Seštevanje harmonskih komponent pravokotnega signala



Sestava periodičnega pravokotnega signala - Falstad



Vir: http://www.falstad.com/fourier/

Primer sinusnega signala

- Primer: Sinusni signal: $u(t) = A.\sin(2.\pi.f.t + \theta)$

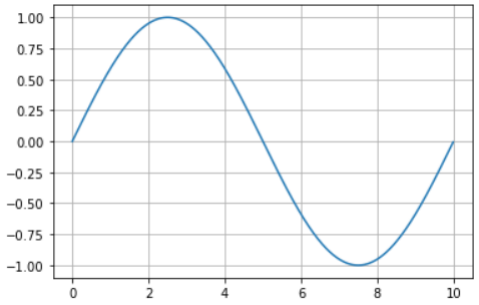
  A=1

  T=10

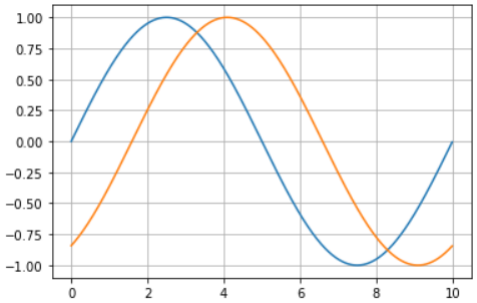
  θ=0

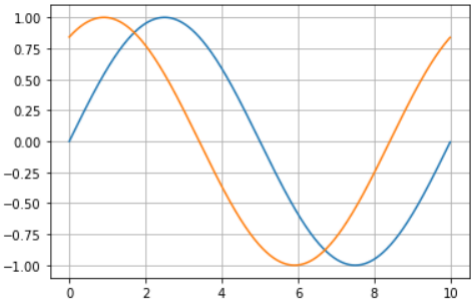
  f=1/T

  t=0 -10, dt=0.01

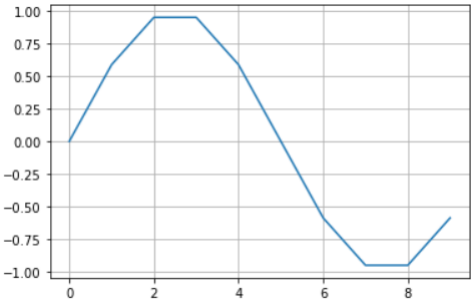


Vpliv faznega koda θ = ?





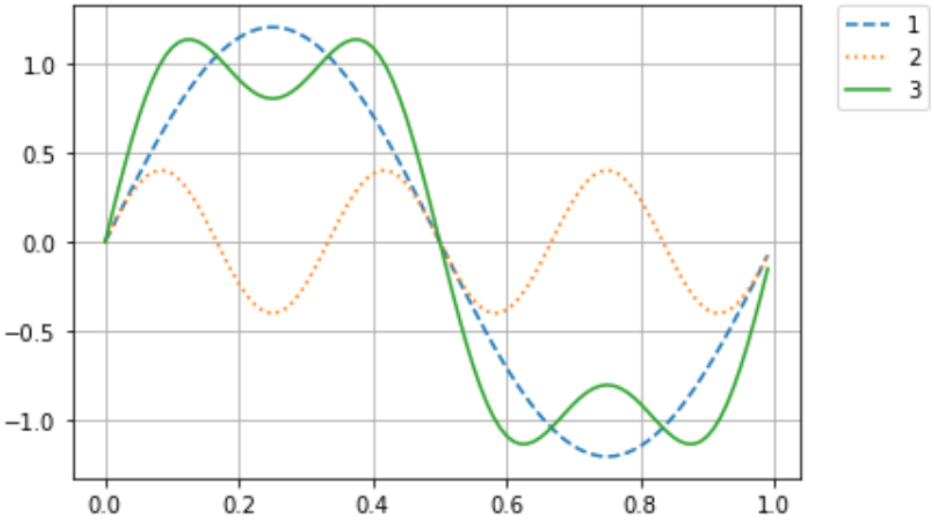
Kaj smo spremenili?



Primer seštevanja sinusnih funkcij v pravokotni signal - Python

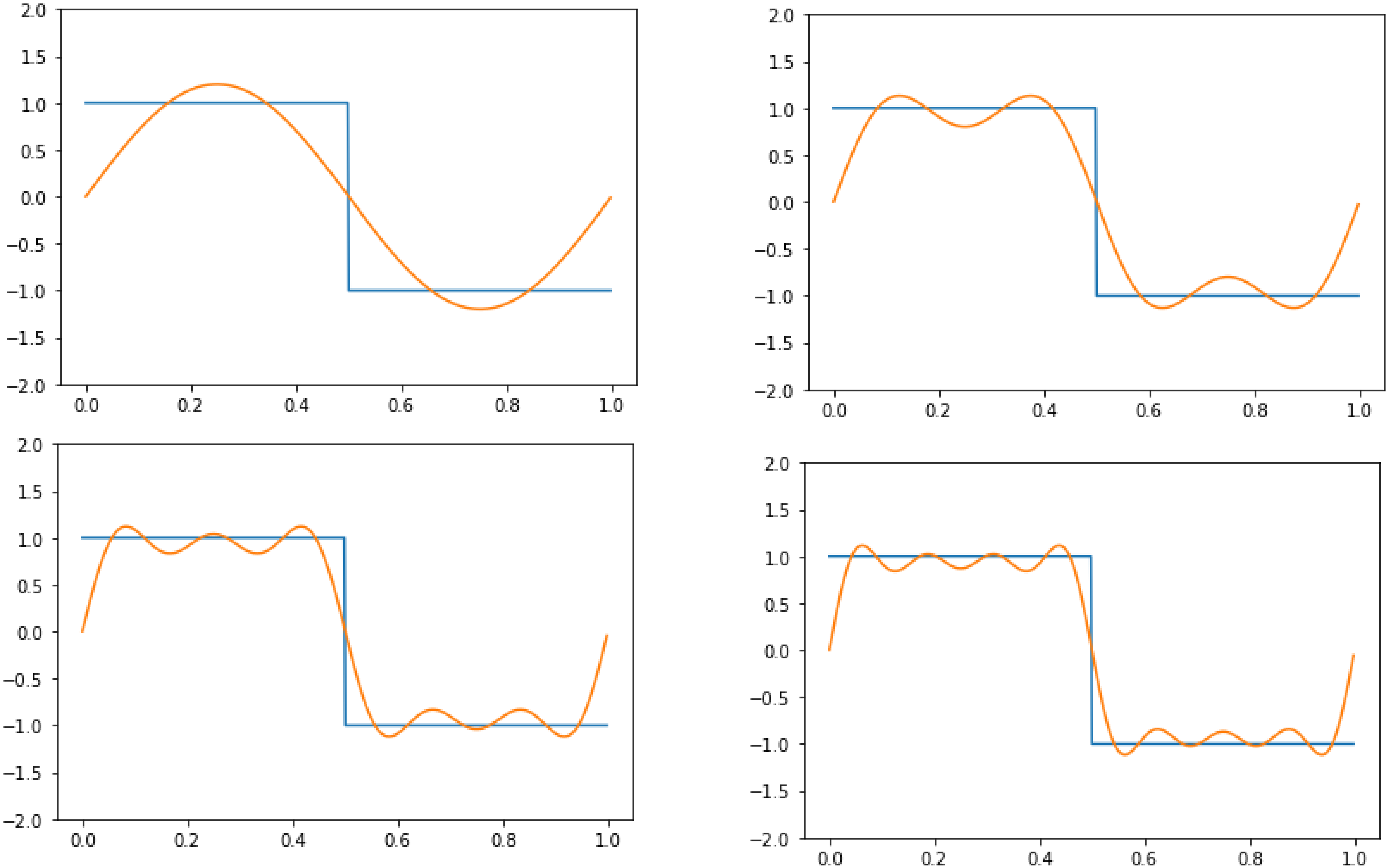
- Program v Pythonu – seštevanje harmonskih komponent sinus funkcije

```
from pylab import *
A=1.2
T=1
f=1/T
t=np.arange(0,1,0.01)
sin1 = A*np.sin(2*np.pi * f * t)
sin2 = A*np.sin(6*np.pi * f * t)/3
sin3 = sin1 + sin2
plt.plot(t, sin1,label="1", linestyle='dashed')
plt.plot(t, sin2,label="2", linestyle='dotted')
plt.plot(t, sin3,label="3")
plt.legend(bbox_to_anchor=(1.05, 1), loc='upper left', borderaxespad=0.)
grid()
plt.show()
```

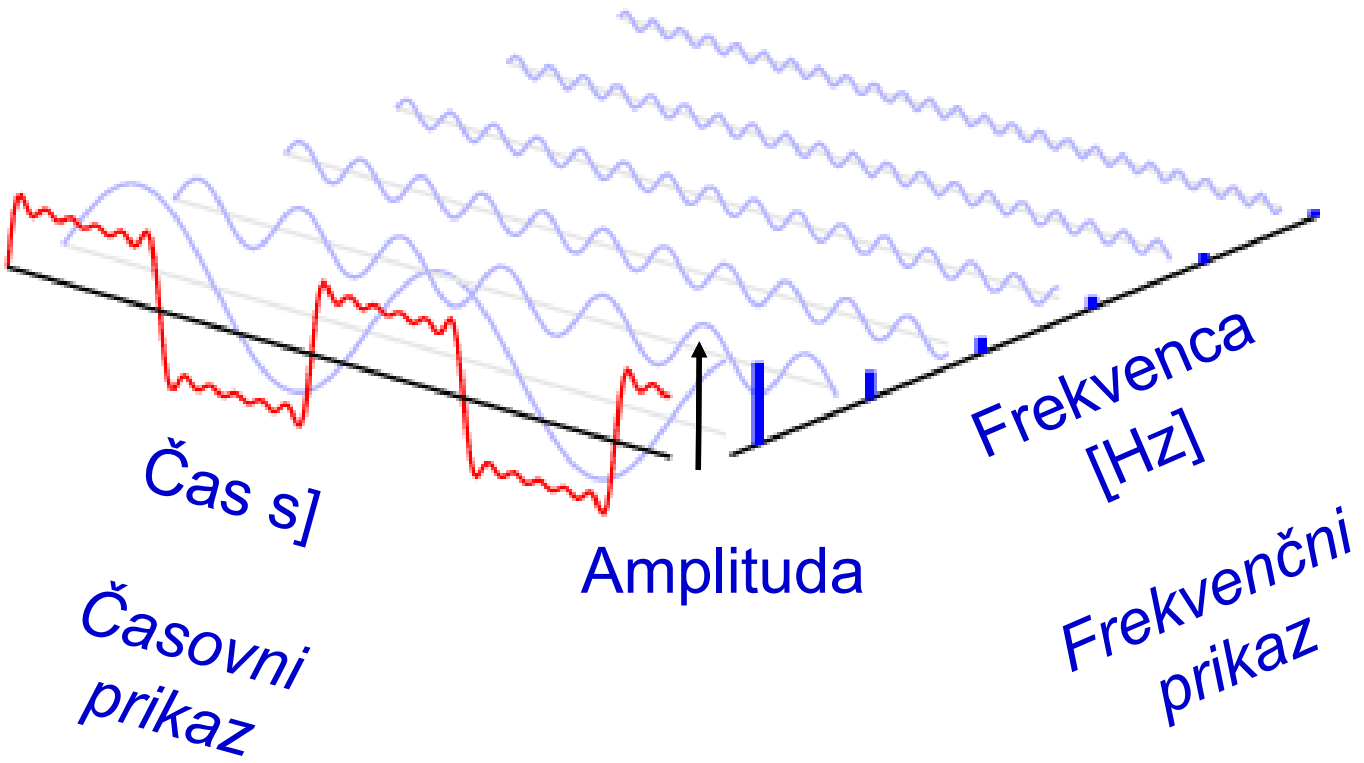


Vir : https://www.tutorialspoint.com/execute_matplotlib_online.php

- Primer: Sestavljanje periodičnega pravokotnega signala



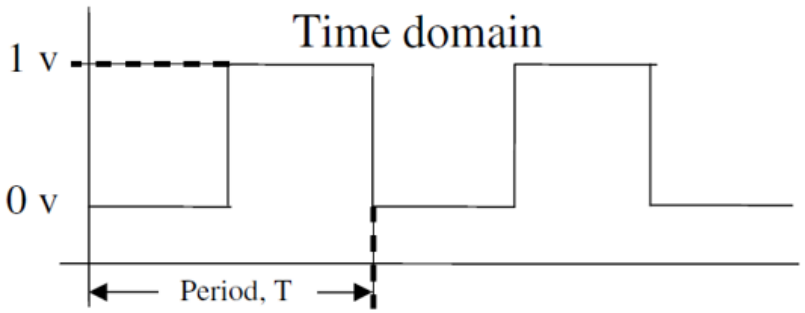
Sestava periodičnega pravokotnega signala



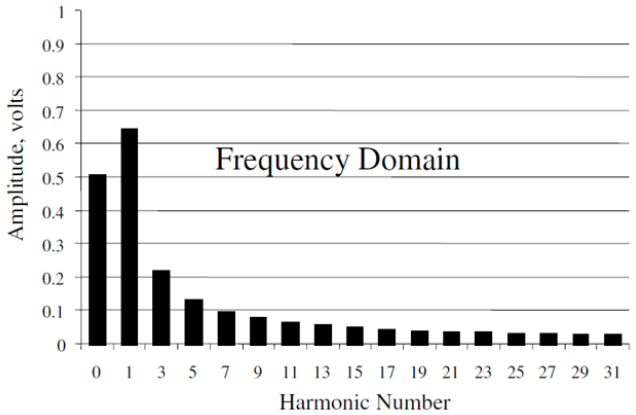
VIRI: https://en.wikipedia.org/wiki/Frequency_domain

Sestava periodičnega pravokotnega signala

Amplituda



Amplituda



Čas s]

Časovni prikaz

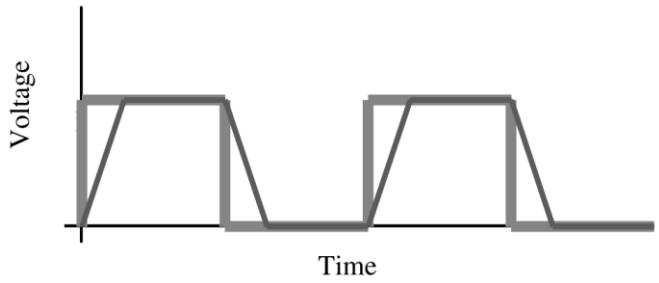
Frekvenca [Harmoniki]

Frekvenčni prikaz

VIRI: Test Happens - Teledyne LeCroy Blog: Transmission Lines (Part I): Introduction

Sestava periodičnega pravokotnega signala

Amplituda



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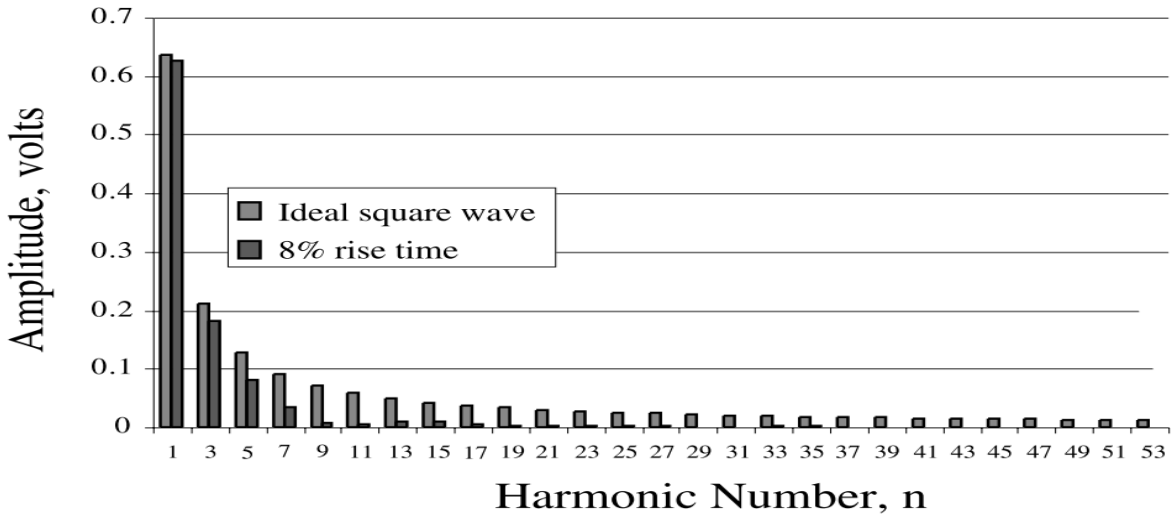
Časovni prikaz

Amplituda



Frekvenca [Harmoniki]

Frekvenčni prikaz

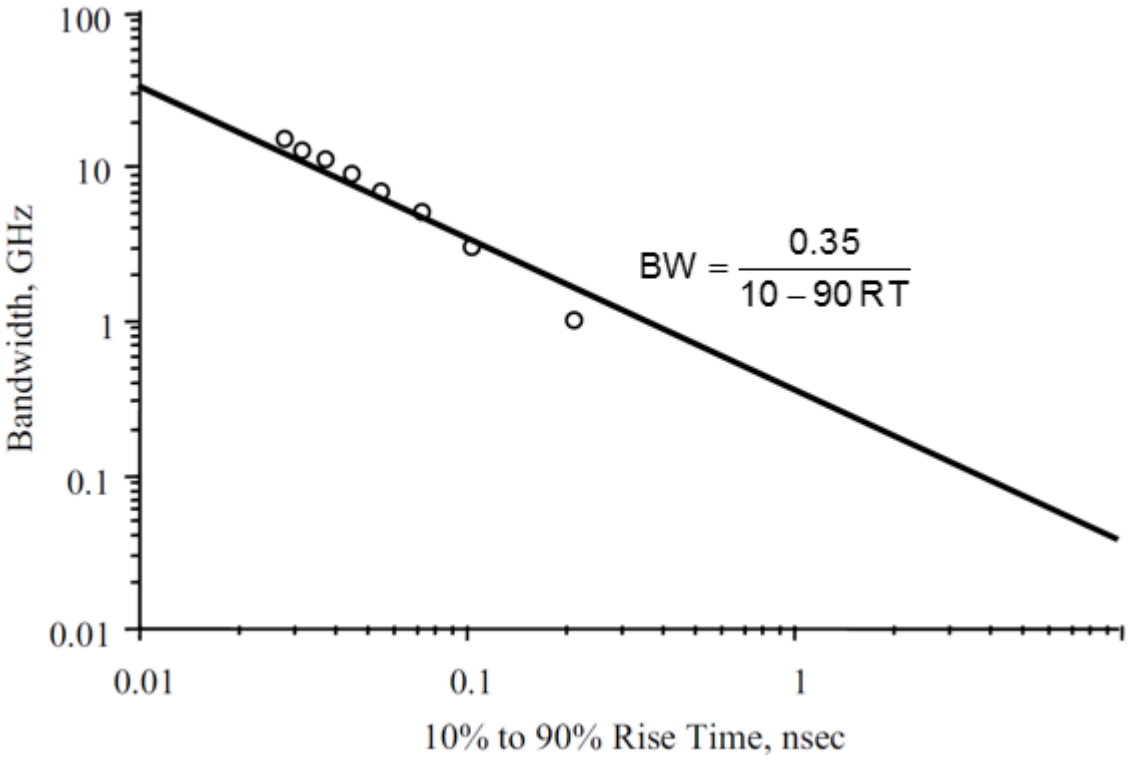
Višje frekvenčne komponente signalov se bolj slabijo pri prenosu skozi povezave (linije)!

VIRI: Test Happens - Teledyne LeCroy Blog: Transmission Lines (Part I): Introduction

Sestava periodičnega pravokotnega signala

Povezava: čas vzpona – pasovna širina signala

Pasovna širina –
BW [GHz



Čas vzpona [ns]

EDN

BLOGS BOGATIN'S RULES OF THUMB

Bandwidth of a signal from its rise time: Rule of Thumb #1

NOVEMBER 19, 2013
BY ERIC BOGATIN

$$BW[GHz] = \frac{0.35}{RT[nsec]} \quad \text{or} \quad RT[nsec] = \frac{0.35}{BW[GHz]}$$

https://www.edn.com/rule-of-thumb-1-bandwidth-of-a-signal-from-its-rise-time/

VIRI: Test Happens - Teledyne LeCroy Blog: Transmission Lines (Part I): Introduction

Sestava periodičnega pravokotnega signala

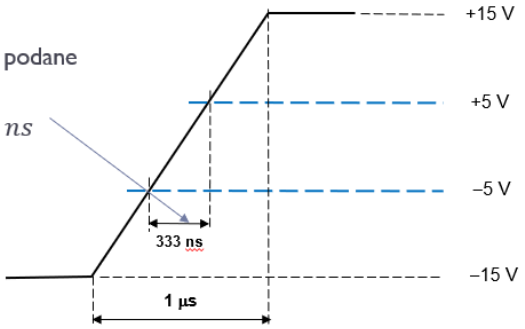
Praksa: čas vzpona – pasovna širina signala

RS232

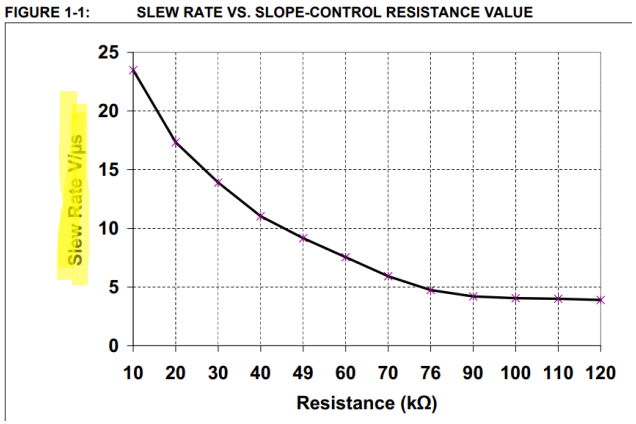
- Hitrost spreminjanja kateregakoli signala je omejena na 30 V/µs (ang. slew rate).

Čas vzpona t_r signala je za podane napetostne omejitve

$t_r \geq 333\ ns$



CANBUS Low speed Automotive – Fault tolerant



MICROCHIP

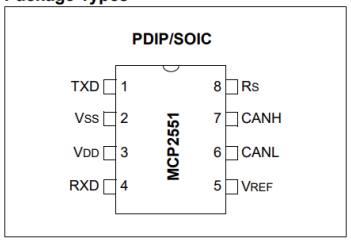
MCP2551

High-Speed CAN Transceiver

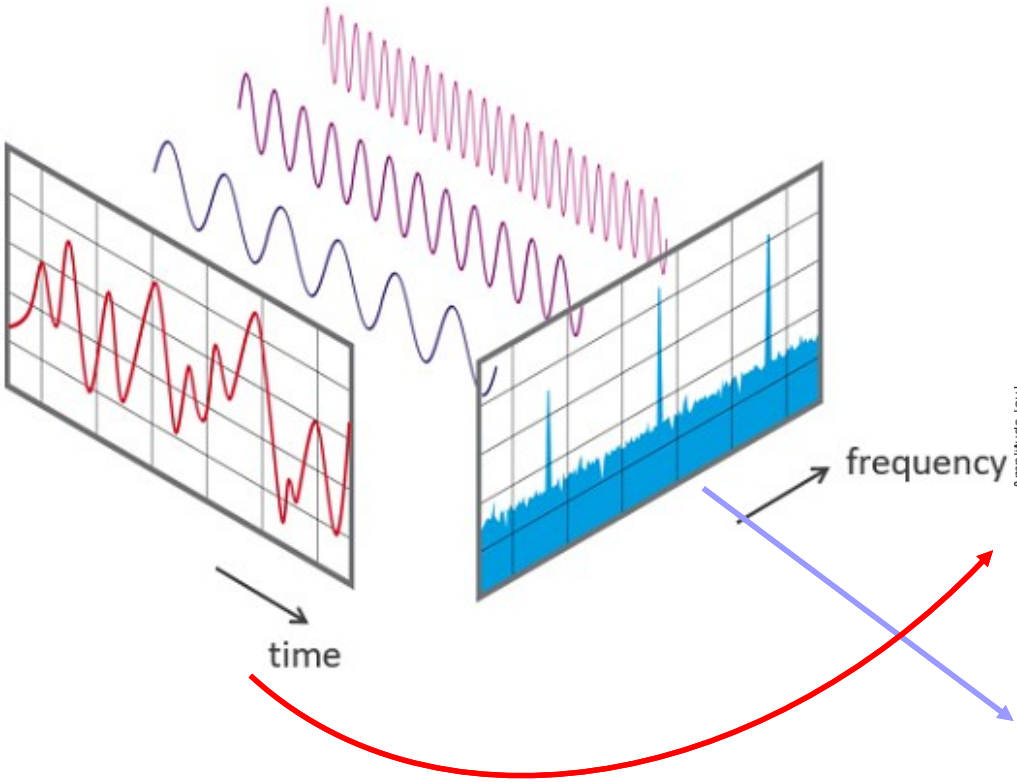
Features

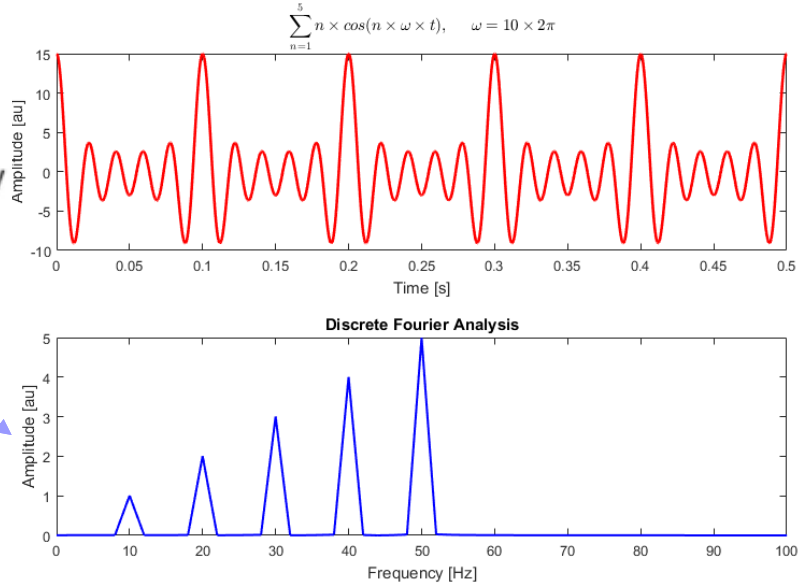
- Supports 1 Mb/s operation
- Implements ISO-11898 standard physical layer requirements
- Suitable for 12V and 24V systems
- Externally-controlled slope for reduced RFI emissions
- Detection of ground fault (permanent Dominant) on TXD input
- Power-on Reset and voltage brown-out protection
- An unpowered node or brown-out event will not disturb the CAN bus
- Low current standby operation

Package Types



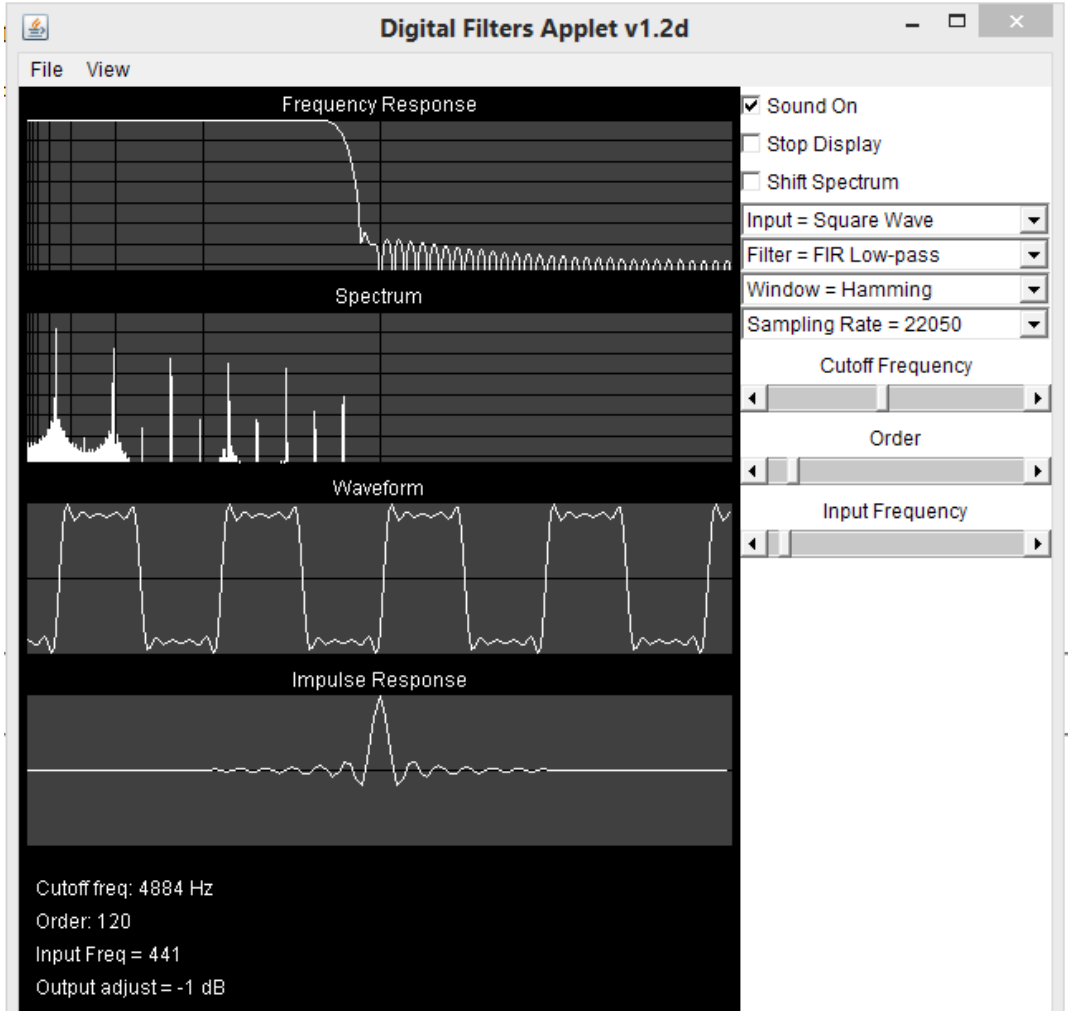
Sestava poljubnega signala (frekvenčna sestava/analiza)





VIRI: https://en.wikipedia.org/wiki/Fast_Fourier_transform

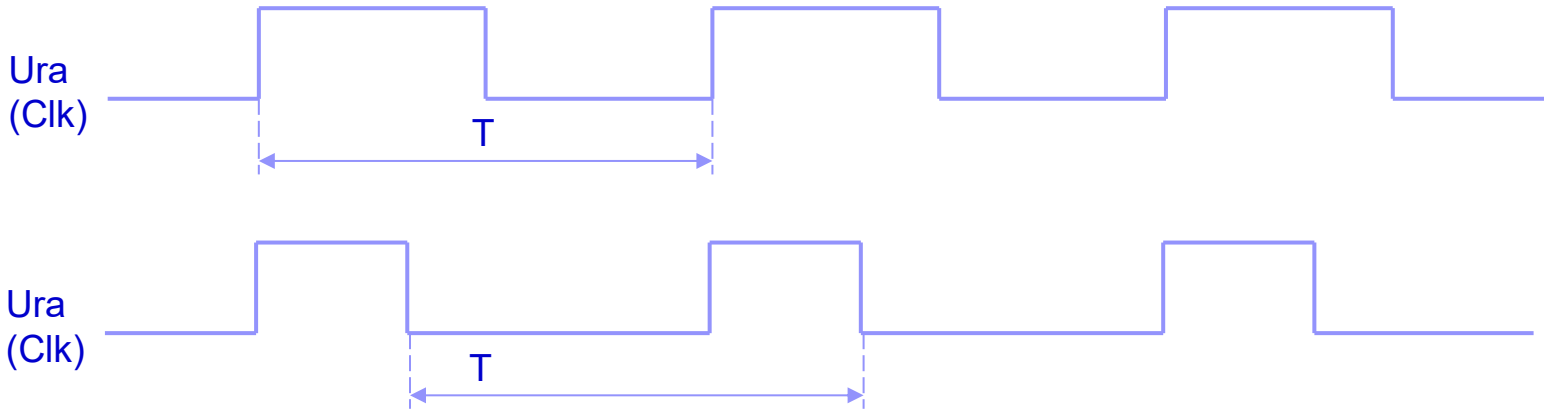
Zvočna sestava periodičnega pravokotnega signala



VIR: http://www.falstad.com/dfilter/

Urin signal

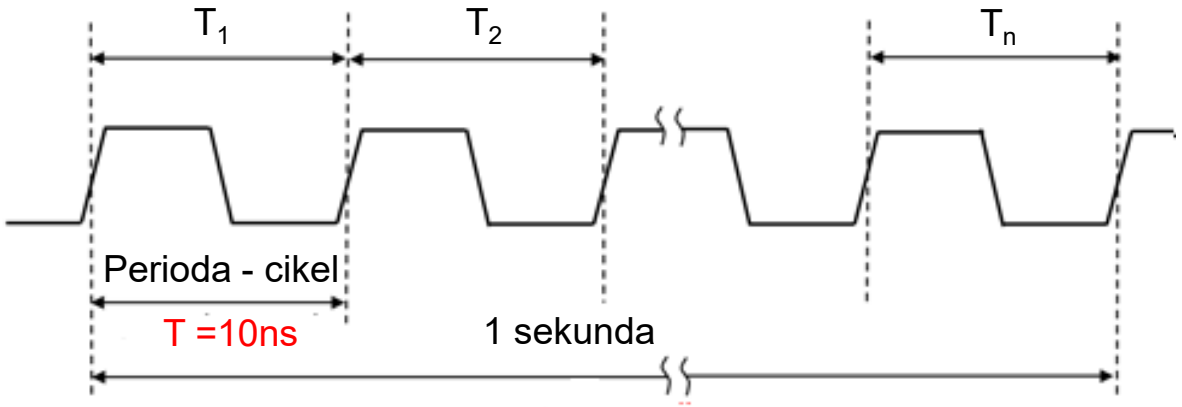
- Periodičen pravokoten signal – idealni graf



- Urin signal:
  - T = 1/frekvenca = 1/f
  - enota za frekvenco [Hz = 1 s-1 = 1 perioda/s],

Urin signal

- Primer: f = 100 MHz
  1. Koliko period je v 1 s?
  2. Izračunaj periodo T= ?



Pri f = 100 MHz je v 1 sekundi 100.000.000 period

Frekvenca periodičnega signala: f = število period (ciklov) v 1 sekundi

Enota za frekvenco je Hertz (Hz) : 1 Hz = 1 perioda/s = 1 s^{-1}

Čas trajanja ene periode T = 1 / f

$$T = \frac{1}{f} = \frac{1}{100MHz} = \frac{1}{100 \cdot 10^6 \frac{1}{s}} = 0{,}01 \cdot 10^{-6} s = 0{,}01 \mu s = 10 ns$$