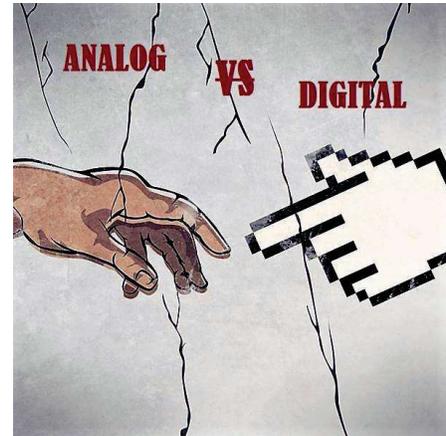


Mikropočítačové systémy MIPS

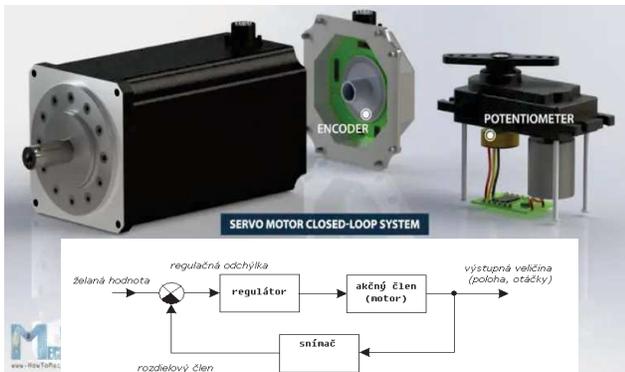


Prednáška 7: DAC



Servo

a) polohové

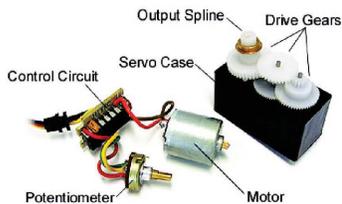


RC Servomotorčky



b) rýchlostné

Servomotorčky



Servomotorčky



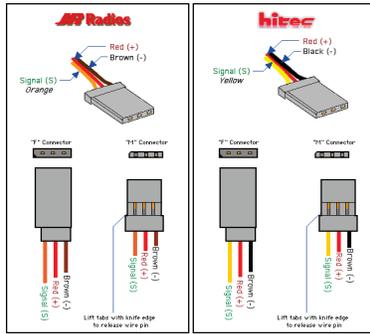
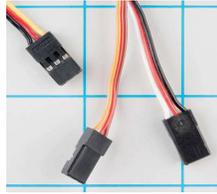
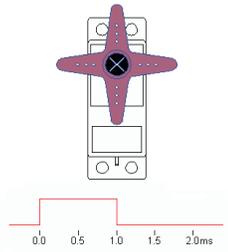
SG90 Micro Servo technical specifications:

Stall Torque	1.2kg·cm @4.8V, 1.6kg·cm @6V,
Operating Voltage	3.5 – 6V
No Load Current	100mA
Stall Current	650mA
Max Speed	60 degrees in 0.12s
Weight	9g

MG996R Servo technical specifications:

Stall Torque	11kg·cm @4.8V, 13kg·cm @6V
Operating Voltage	4.8 – 7.2V
No Load Current	220mA @4.8V, 250mA @6V
Stall Current	650mA
Max Speed	60 degrees in 0.20s
Weight	55g

Servomotorčky



Servomotorčky

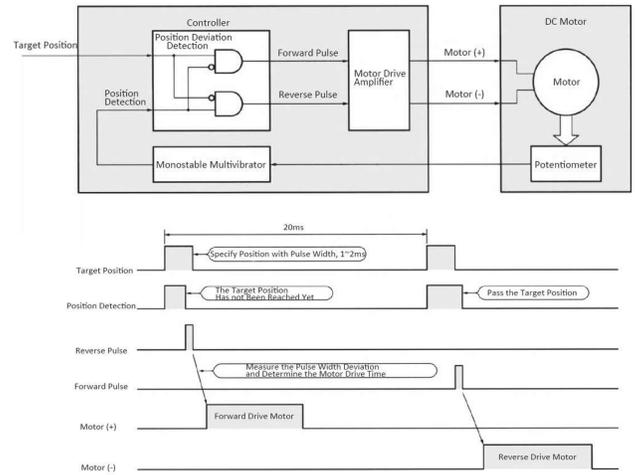
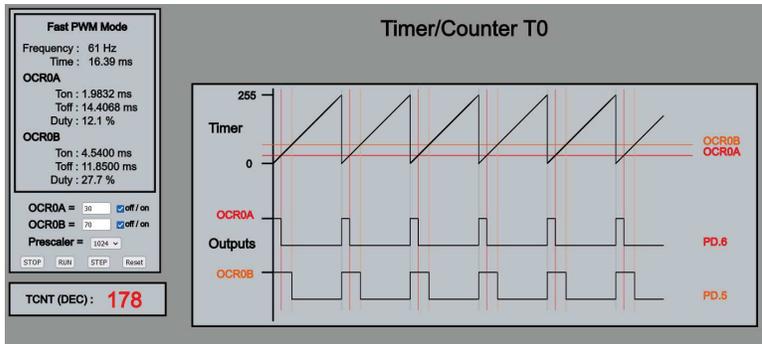


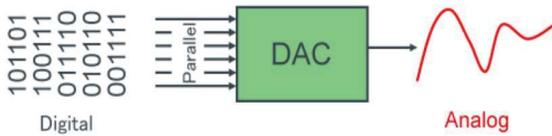
Figure 2



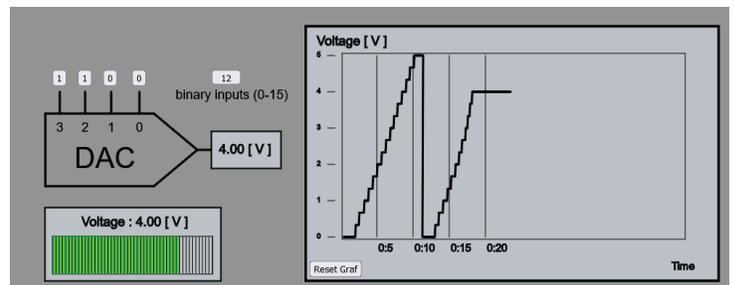
https://senzor.robotika.sk/mmp/anim/TimerCounter_T0/TimerCounter.html



D/A prevodník

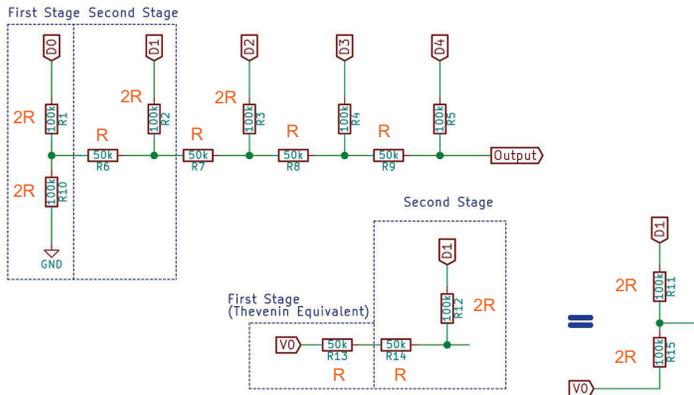


D/A prevodník

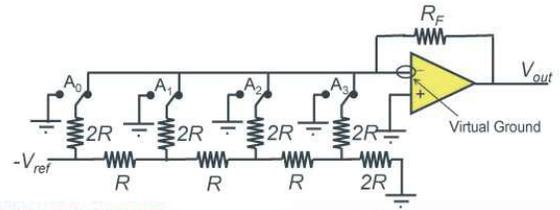


<https://senzor.robotika.sk/mmp/anim/dac.html>

D/A prevodník typu R-2R



D/A prevodník



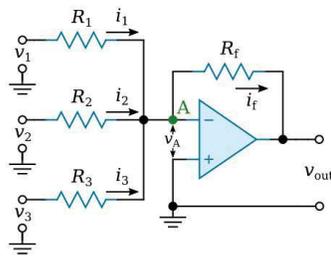
Switch → Partial Resistance
 Switch dimensions are made to be proportional to the amount of current

MOSFET $\left(\frac{W}{L}\right)$ is made proportional to the current

$$V_{out} = R_F \left(I_r \cdot A_0 + \frac{I_r}{2} \cdot A_1 + \frac{I_r}{2^2} \cdot A_2 + \frac{I_r}{2^3} \cdot A_3 \right)$$

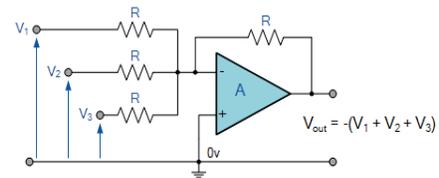
$$I_r = \frac{V_{ref}}{2R}$$

Sumátor (invertujúci)



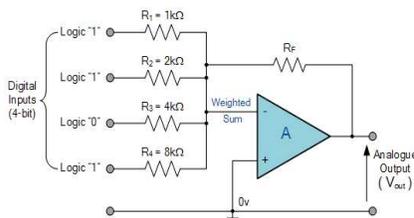
$$v_{out} = -R_f \left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

Sumátor (invertujúci)



$$v_{out} = -R_f \left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

Sumátor (invertujúci)



$$v_{out} = -R_f \left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} \right)$$

$$V_{out} = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3 + \frac{R_f}{R_4} V_4 \right)$$

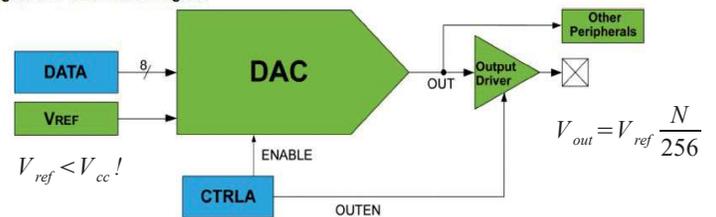
$$V_{out} = -\left(\frac{1}{2} V_1 + \frac{1}{4} V_2 + \frac{1}{8} V_3 + \frac{1}{16} V_4 \right)$$

- $R_f = 0,5 k \Omega$
- $R_1 = 2 R_f$
- $R_2 = 4 R_f$
- $R_3 = 8 R_f$
- $R_4 = 16 R_f$

D/A prevodník

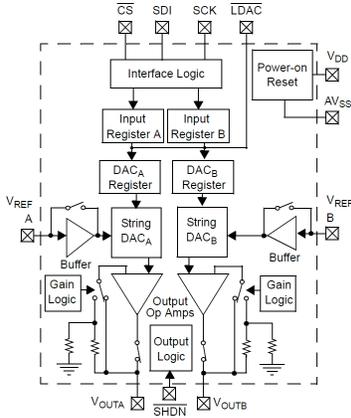
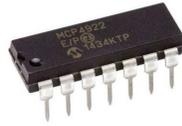


Figure 2-1. DAC Block Diagram



Bloková schéma D/A prevodníka v procesore ATTiny214.

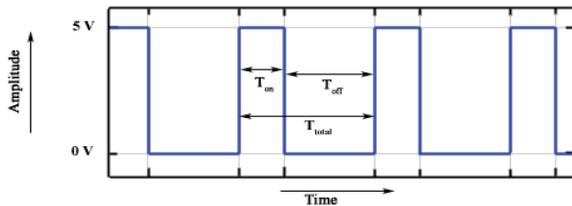
D/A prevodník



MCP4921 - dvojité 12-bitový A/D prevodník na zbernicu SPI.

PWM ako D/A prevodník

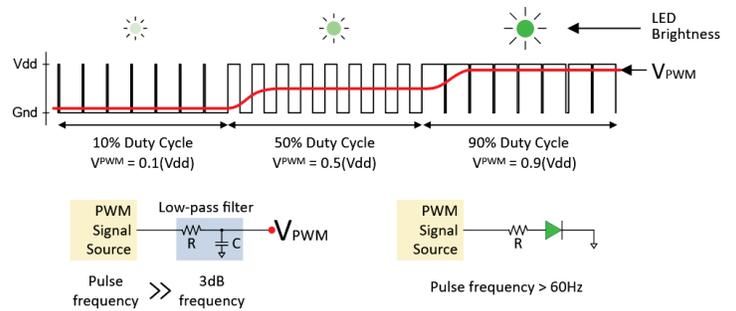
Charakteristiky PWM signálu



$$T_{total} = T_{on} + T_{off}$$

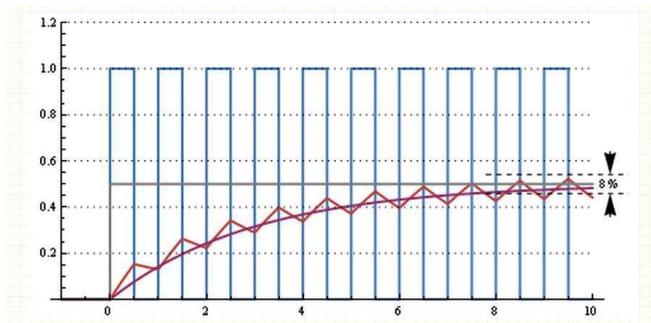
$$D = \frac{T_{on}}{T_{total}} = \frac{T_{on}}{T_{on} + T_{off}}$$

PWM signál ako D/A prevodník



$$V_{out} = DV_{in} = \frac{T_{on}}{T_{total}} V_{in}$$

Charakteristiky PWM signálu



SW PWM

```
#include <avr/io.h>
#include <util/delay.h>

/* Pripajenie periferii k vyvojovej doske Arduino: */

#define LED2 PD7 // externa LED dioda
#define LED2_ON (PORTD |= (1<<LED2))
#define LED2_OFF (PORTD &= ~(1<<LED2))

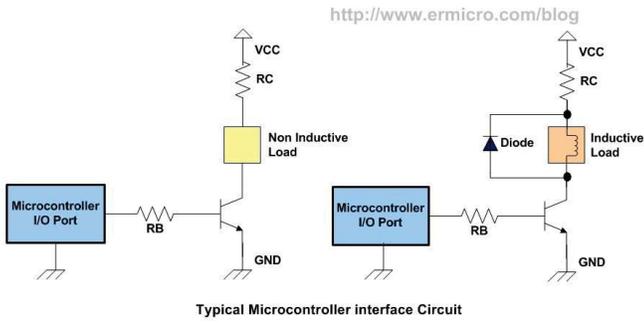
int main(void)
{
    /* SETUP */
    DDRD = (1<<LED2); // PORTD: LED2 na PD7 je output

    /* LOOP */
    unsigned char duty = 250;

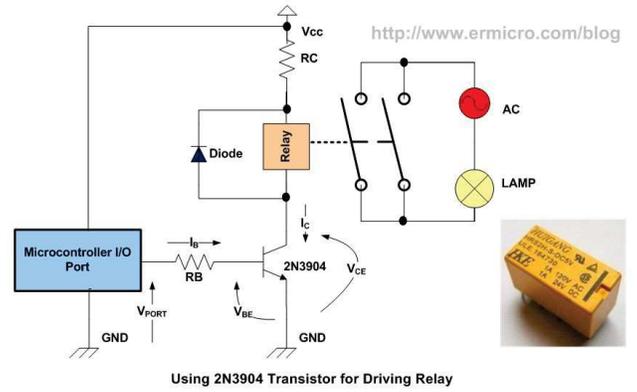
    while(1)
    {
        // nase vlastne pocitadlo pocita stale dokola, rychlost dana delay
        for (int time=0;time<255;time++)
        {
            if (time > duty)
                LED2_ON;
            else
                LED2_OFF;
            _delay_us(200);
        }
    } /* end of while */

    return(0);
}
```

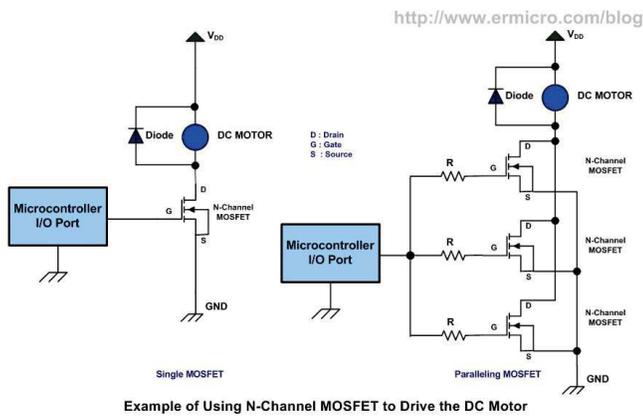
PWM interface



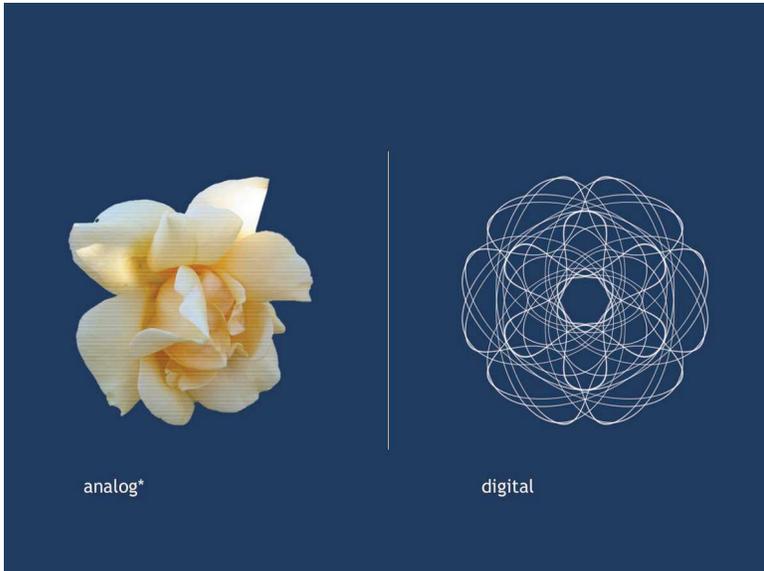
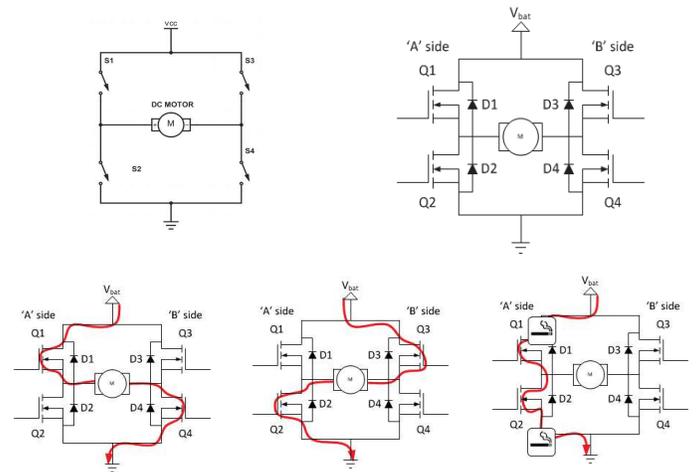
PWM interface



PWM interface



PWM interface: H-most

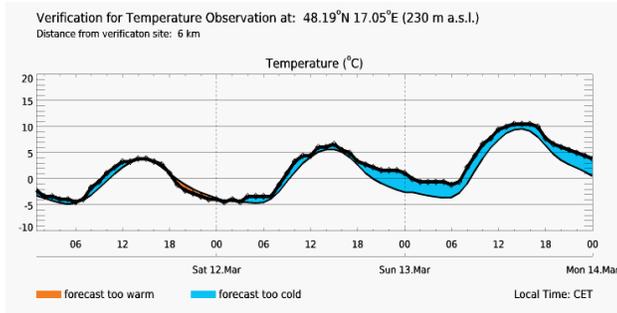


Počítač – analógový / digitálny

analógový (spojitý) – číslicový, digitálny (diskrétny)



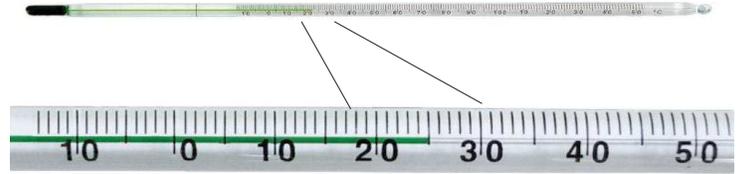
Analógový vs. Digitálny



VZORKOVANIE = SAMPLING

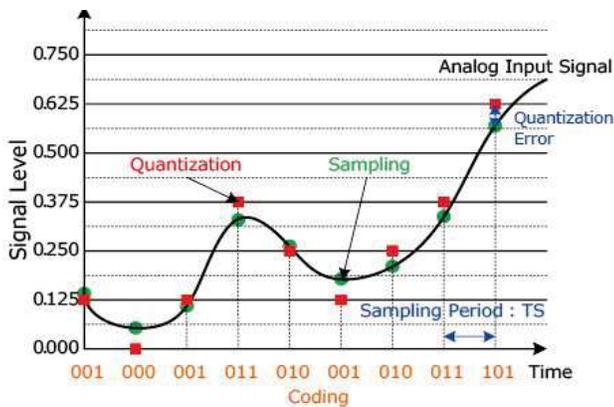
https://www.meteoblue.com/sk/po%C4%8Dasie/historyclimate/verificationshort/bratislava_slovensk%C3%A11-republika_3060972

Analógový vs. Digitálny



KVANTOVANIE = QUANTIZATION

Analógový vs. Digitálny



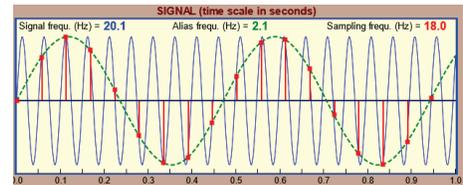
Vzorkovanie

Nyquist -- Shannon -- Kotel'nikov

$$x(t) \rightarrow x_0, x_1, x_2, \dots, x_n : x_k = x(kT)$$

kde T je perióda vzorkovania $f_s = \frac{1}{T}$

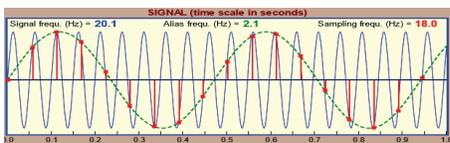
$$f_s > 2 f_{max}$$



http://195.134.76.37/applets/AppletNyquist/App1_Nyquist2.html

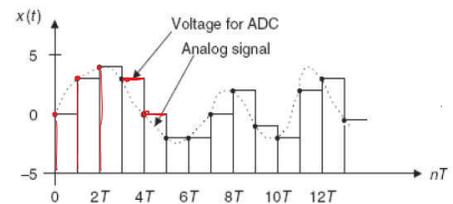
Vyskúšajte:

Aká bude zdanlivá frekvencia, ak signál s $f = 10\text{Hz}$ budeme merať 8x za sekundu?

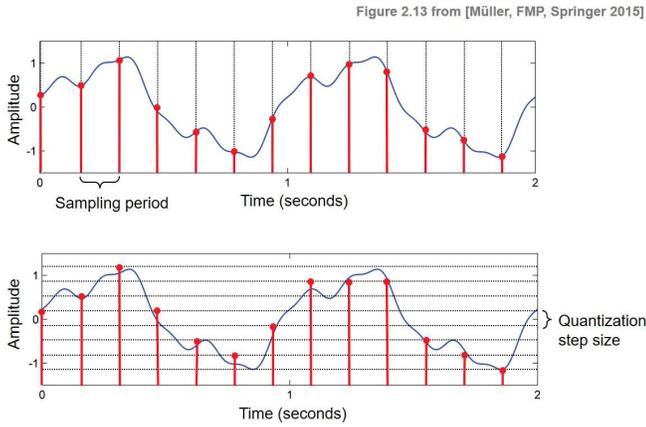


http://195.134.76.37/applets/AppletNyquist/App1_Nyquist2.html

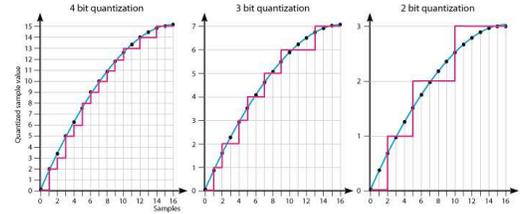
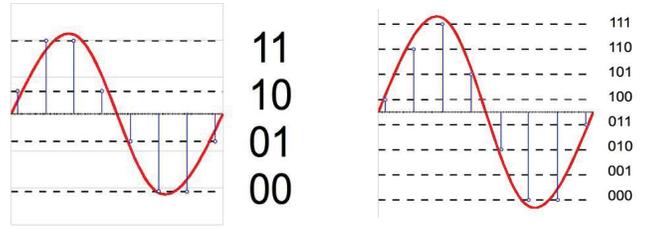
Rekonštrukcia



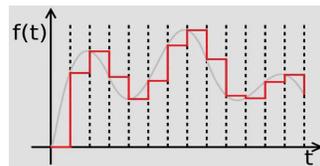
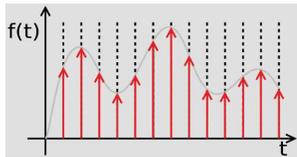
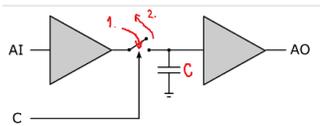
Kvantovanie



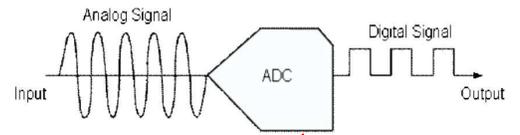
Kvantovanie



Sample & Hold



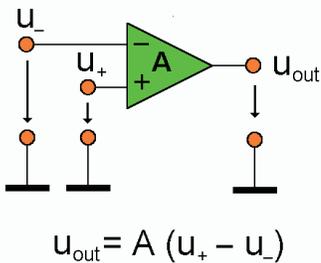
A/D prevodník I.



Electrical symbol [edit]



Operačný zosilňovač operational amplifier, Op-Amp



Ideálny zosilňovač:

- 1) $A = \infty$
- 2) $R_{vst} = \infty$
- 3) $R_{vyst} = 0$
- 4) $f_{max} = \infty$
- 5) $u_{out} = 0$ ak $u_{diff} = 0$
- 6) $u_{max} = \infty$

11. História Technology

GAP/R's model PP65: a solid-state op-amp in a potted module (1962)

Early FET input AD op-amp (1970)

ADI's HOS-050: a high speed hybrid IC op-amp (1979)

TI's OPA2188: first zero-drift, 36-V operational amplifier (2012)

Operačné zosilňovače

Základné vlastnosti

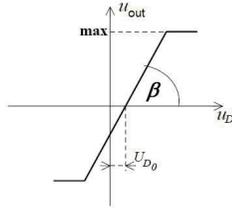
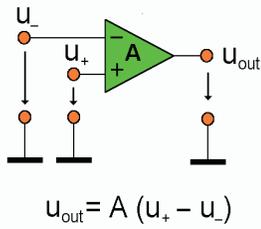
Jednosmerné zosilnenie

- súhlasné (súfázne)
- rozdielové

A je jednosmerné rozdielové zosilnenie naprázdno (ideál $A = \infty$)

$$A = \frac{\Delta u_{out}}{\Delta u_D} = \text{tg } \beta$$

U_{D0} je vstupná napät'ová nesymetria (tiež napät'ový ofset - U_{D0} je potrebné do vstupu na $U_{out} = 0$)



Operačné zosilňovače

Základné vlastnosti

Jednosmerné zosilnenie súhlasné

Reálny OZ zosilňuje i súhlasné u_{CM}

$$u_{CM} = \frac{u_- + u_+}{2}$$

jednosmerné súhlasné zosilnenie B_0

$$u_{out} = A \cdot u_D + B_0 \cdot u_{CM}$$

- kvalitný zosilňovač $\rightarrow B_0 \ll A$

činiteľ potlačenia súhlasného napätia
CMRR (Common Mode Rejection Ratio)

$$CMRR = \frac{A_0}{B_0}$$

Poznámka:

V katalógoch tiež ako diskriminačný súčiniteľ k_d . Reálne býva $10^4 + 10^7$, resp. 80 + 100 dB.

