Senzori

1

Biomedical: Motion, force, blood composition, blood pressure, temperature, flow rate, urine composition, excretion composition, ECG, breathing sound, pulse, x-ray image, ultrasonic image

Chemical: Organic compounds, inorganic compounds, concentration, heat transfer rate, temperature, pressure, flow rate, humidity

Electrical/electronic: Voltage, current, charge, passive circuit parameters, electric field, magnetic field, magnetic flux, electrical conductivity, permittivity, permeability, reluctance

Mechanical: Force (effort including torque), motion (including position and deflection), optical image, other images (x-ray, acoustic, etc.), stress, strain, material properties (density, Young's modulus, shear modulus, hardness, Poisson's ratio)

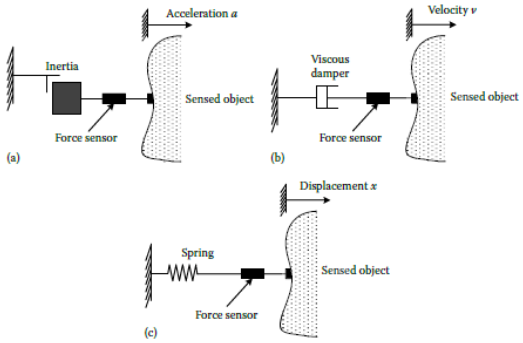
Thermofluid: Flow rate, heat transfer rate, infrared waves, pressure, temperature, humidity, liquid level, density, viscosity, Reynolds number, thermal conductivity, heat transfer coefficient, Biot number, image

Analogni senzor – prilagođenje – AD konverzija

2

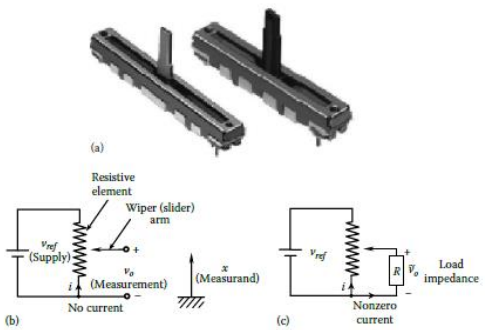
Motion Transducers

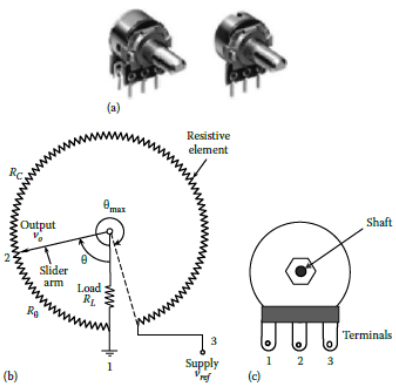
1. Displacement (including position, distance, proximity, size, and gauge)
2. Velocity (rate of change of displacement)
3. Acceleration (rate of change of velocity)
4. Jerk (rate of change of acceleration)



3

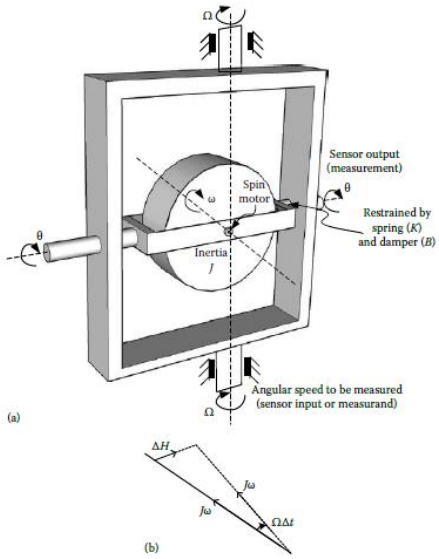
Potenciometri



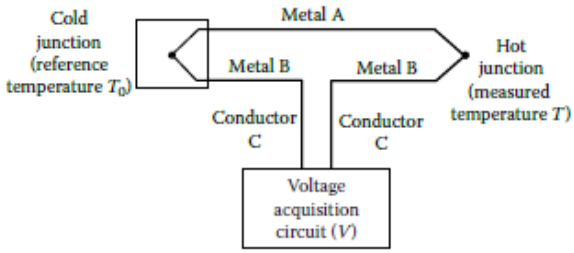


4

Žiroskop



Termopar

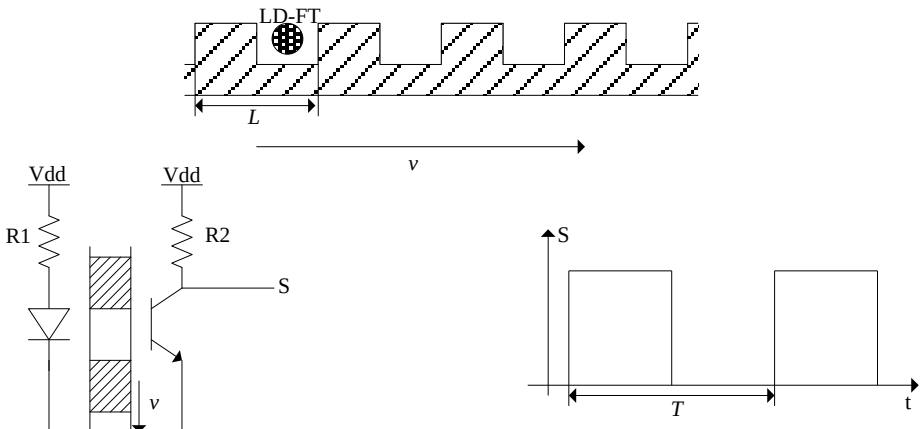


Sensor selection: Match *sensor* (*ratings*) *with the application* (*requirements/specifications*): (1) Study the application, its purpose, and what quantities (variables and parameters) need to be measured; (2) determine what sensors are available; what quantities cannot be measured (due to inaccessibility, lack of sensors, etc.); if cannot measure: estimate using other quantities that can be measured, or develop a new sensor for the purpose.

Sensor selection process:
(1) What parameters or variables have to be measured in your application;
(2) nature of the information (parameters and variables) needed for the particular application (analog, digital, modulated, demodulated, power level, bandwidth, accuracy, etc.);
(3) Specifications for the needed measurements (measurement signal type, measurement level, range, bandwidth, accuracy, SNR, etc.);
(4) available sensors for the application and their data sheets;
(5) signal provided by each sensor (type—analog, digital, modulated, etc.; power level; frequency range, etc.);
(6) type of signal conditioning or conversion needed for the sensors (filtering, amplification, modulation, demodulation, ADC, DAC, voltage–frequency conversion, frequency–voltage conversion, etc.).

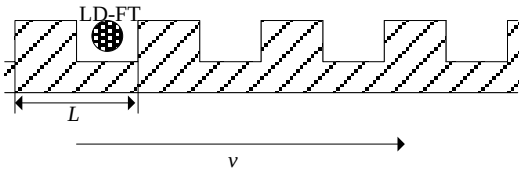
7

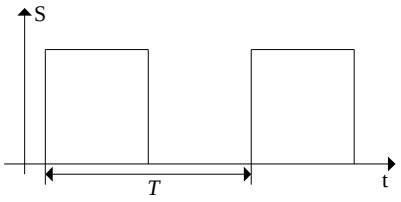
ENKODERI



Optički
Induktivni
Kapacitivni

8





Pozicija

Prebrojavanjem impulsa – Pozicija se promenila za B*L

Greška +- jedna impuls

Inkrementalna promena pozicije – po resetu se ne zna apsolutna pozicija.

Inkrementalni enkoder.

Inicijalizacija sistema.

DEBAUNSIRANJE

9

Merenje brzine $v = \frac{L}{T}$ Merenjem T

1. Brojačem između dve usponske ivice

$$T = NT_{CLK} \qquad v = \frac{L}{NT_{clk}}$$

Dve susedne brzine koje mogu da se mere

$$v_i = \frac{L}{iT_{clk}} \qquad v_{i+1} = \frac{L}{(i+1)T_{clk}}$$

Kvantizacija nelinerna

$$v_i - v_{i+1} = \frac{1}{i(i+1)}\frac{L}{T_{clk}}$$

Što je manja brzina tačnije merenje – veće i

Velike brzine mala tačnost merenja

10

2. Brojanjem impulsa u fiksnom intervalu T_f

$$T = \frac{T_f}{B} \qquad v = \frac{BL}{T_f}$$

Dve susedne brzine koje mogu da se mere

$$v_i = \frac{iL}{T_f} \qquad v_{i+1} = \frac{(i+1)L}{T_f}$$

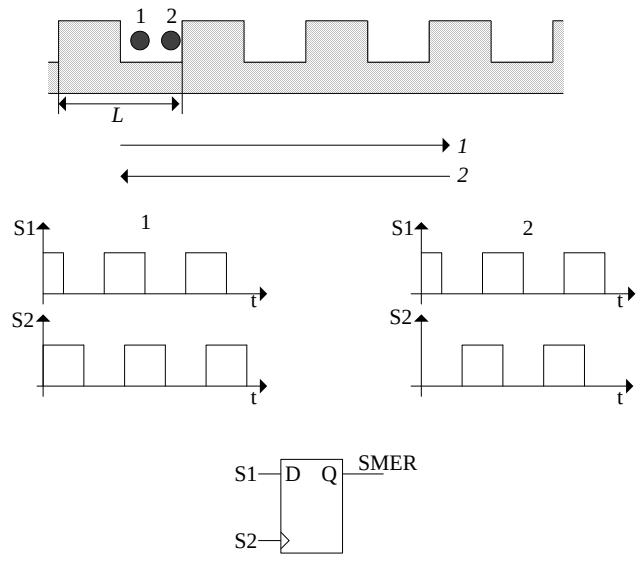
Kvantizacija linerana

$$v_{i+1} - v_i = \frac{L}{T_f}$$

Što je veća brzina tačnije merenje – veće B
Male brzine mala tačnost merenja

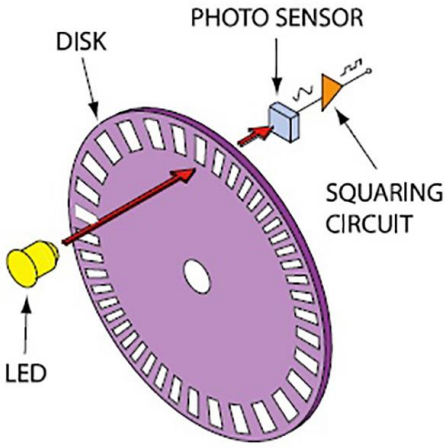
11

Promena smera kretanja



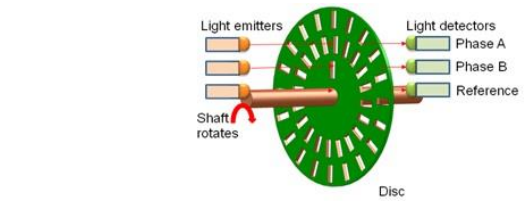
12

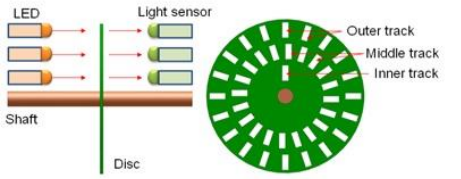
Obrtni enkoder

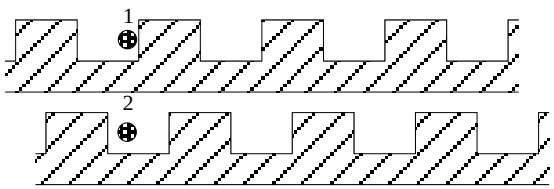


13

Obrtni enkoder







14

Obrtni enkoder

NM – nulti marker
Početna pozicija – pun krug

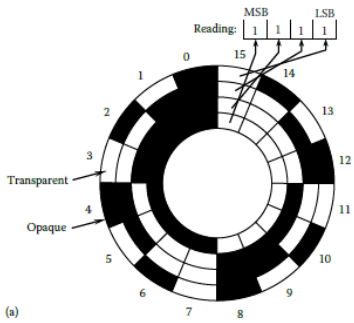
Promena pozicije - ugao
Brzina – ugaona brzina

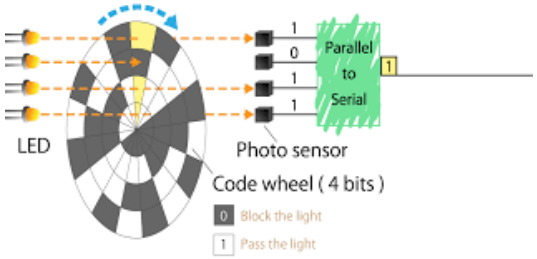
Prava pozicija - preračunavanjem
Prva brzina – preračunavanjem

Da li je moguća inicijalizacijacija da bi se znala prava absolutna pozicija?

15

Absolutni enkoder





Binarni kod - NE

0111

1111

1000

16

Absolutni enkoder

Grejov kod - DA

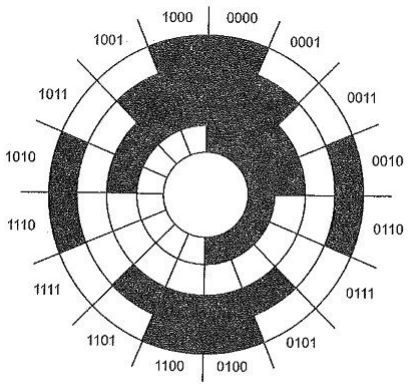


Fig. 15.21 Gray coded optical encoder

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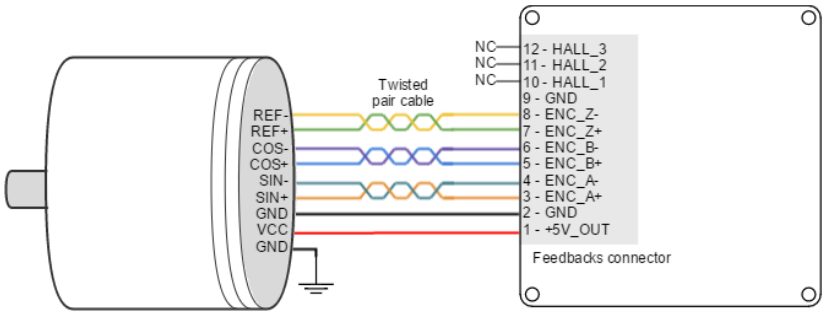
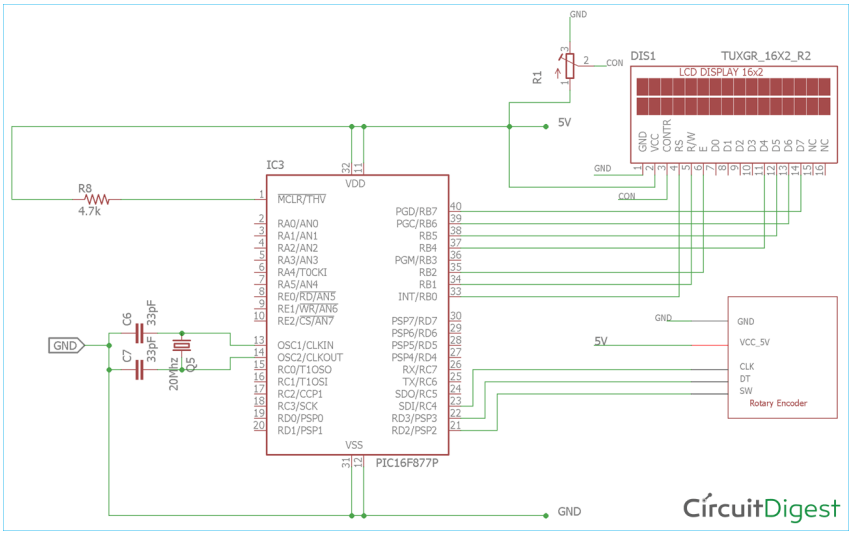
Povezivanje



18



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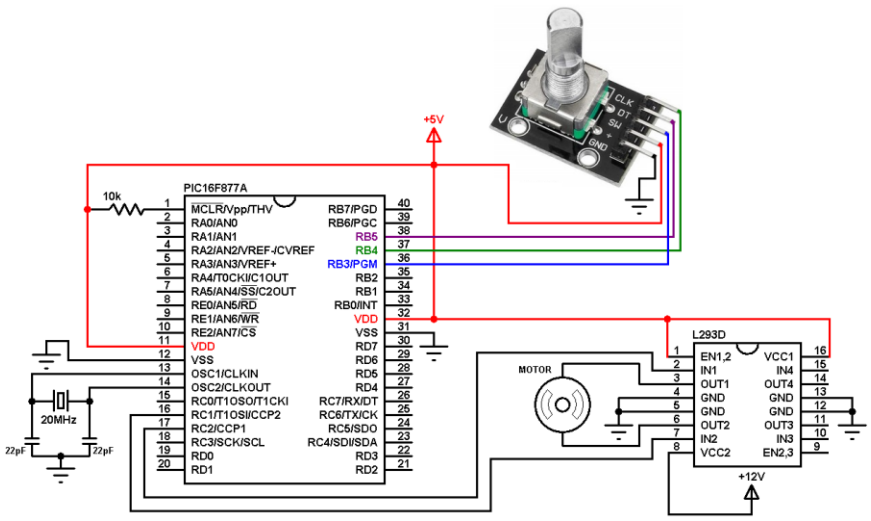
Debaunsiranje

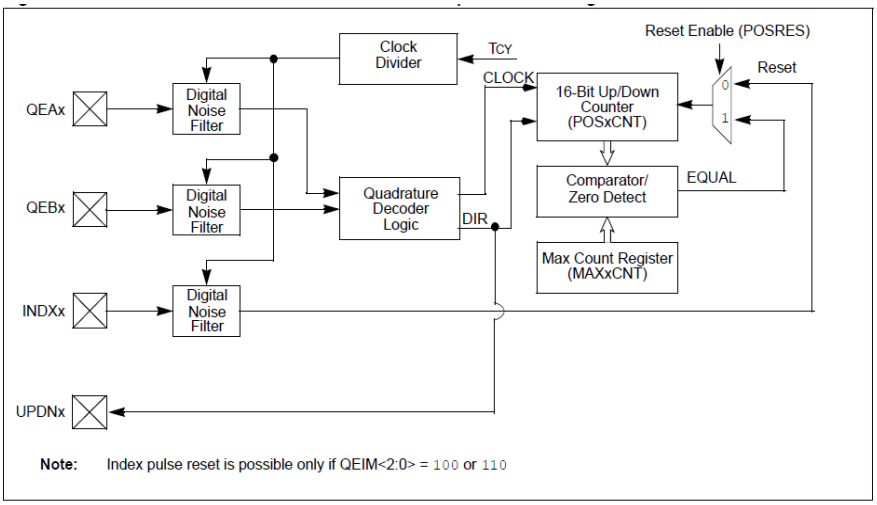
```
if (Encoder_SW == 0){
        sw_delayms(20); //debounce delay
        if (Encoder_SW == 0){
                //lcd_com(1);
                //lcd_com(0xC0);
                lcd_puts ("switch pressed");
//              itoa(counter, value, 10);
//              lcd_puts(value);
```


20



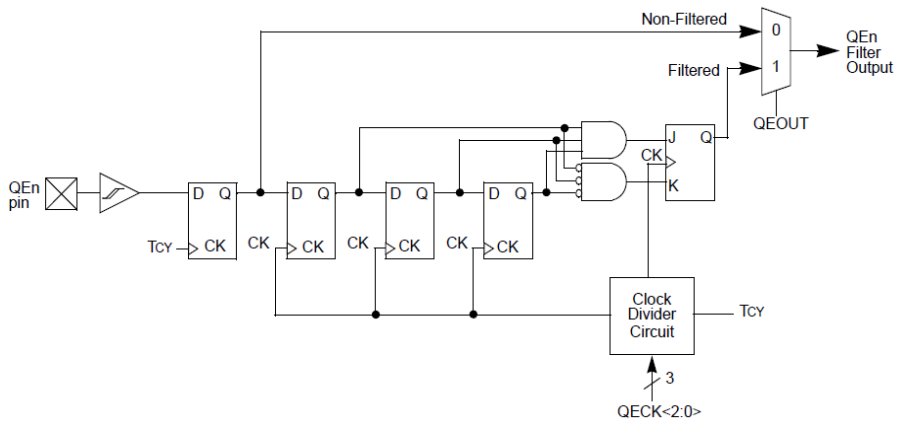
21

Integrisano kolo za enkoder



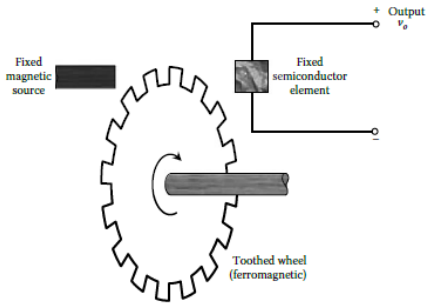
22

Hardversko debaunsiranje



23

Hall - effect

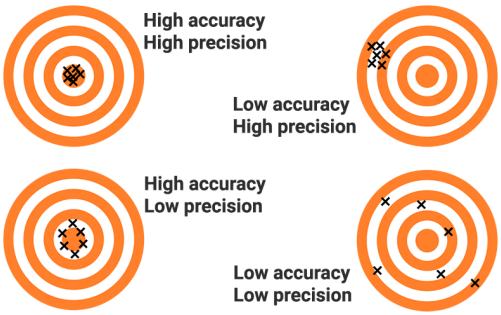


24

Da se podsetimo – tačnost i preciznost

tačnost

preciznost



AD
Tačnost – referentni napon
Preciznost – broj bita

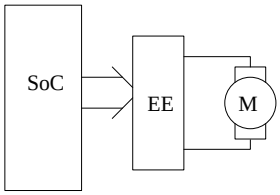
Primer: 10 bitni konvertor 1024 kvantizaciona nivoa. Prva pomisao tačnost je 0.1%
Neka je vrednost jednog kvantizacionog nivoa 1mV
Ako se meri napon od 1000mv može da se pogreši 1mv i greška jeste 0.1%
Ali ako se meri napon od 1.5mV može da se pogeši 1mV i greška je 66%

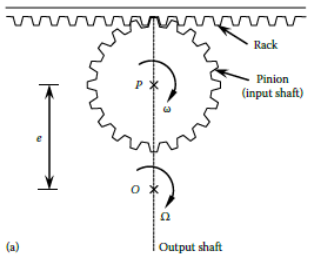
25

Aktuatori

26

Motori



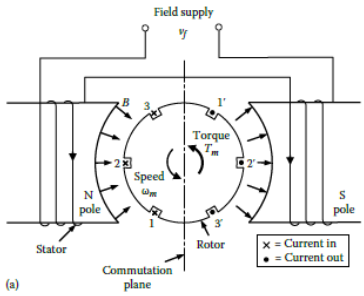


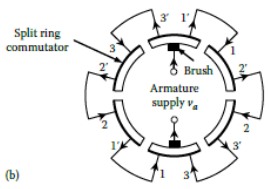
Jednosmerni
Naizmenični
- Sinhroni
- Asinhroni

Koračni
Brushless

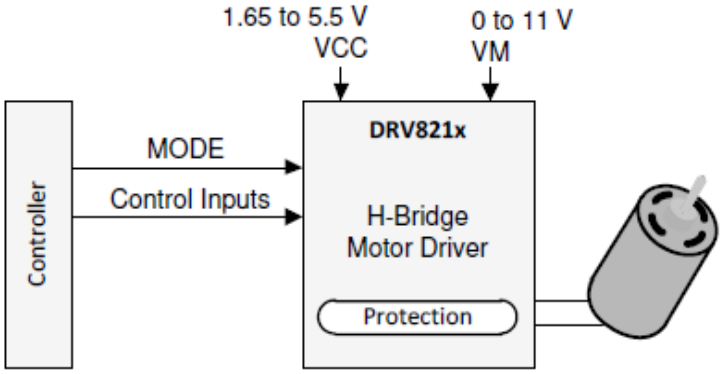
27

Jednosmerni motor





28



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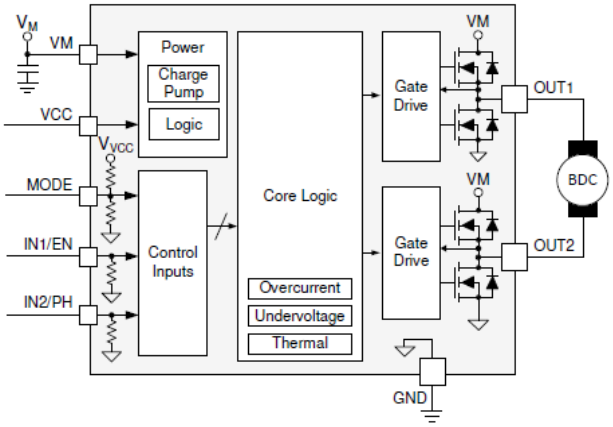
Standard PWM Interface (IN1/IN2)



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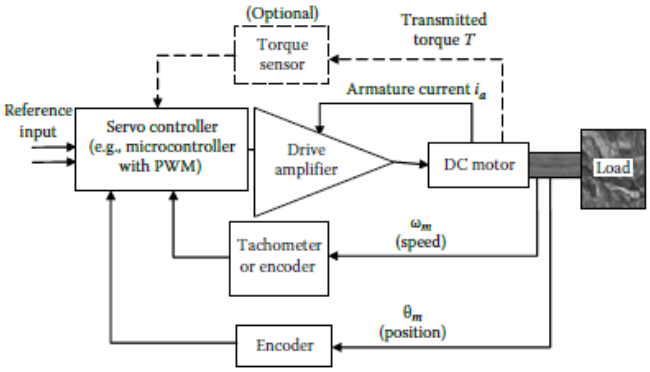
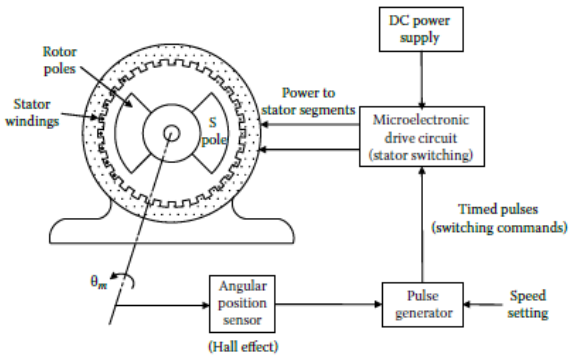
Upravljanje



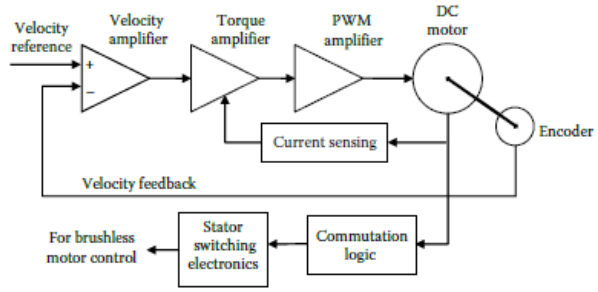
31

Brushless



32

Upravljanje



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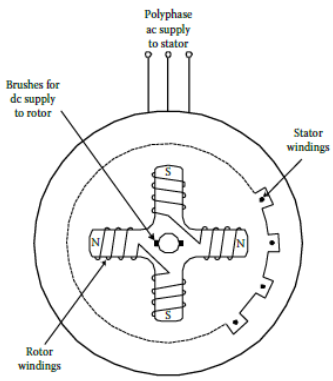
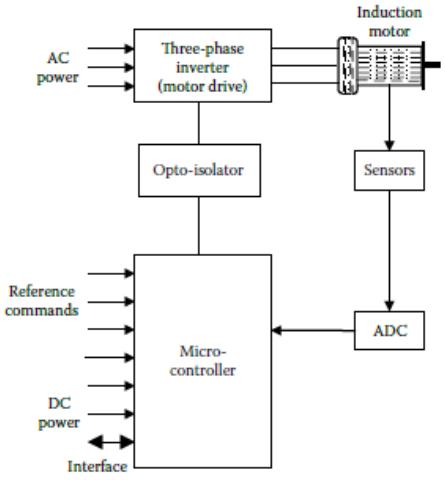
Naizmenični motori upravljanje



Sinhroni motor



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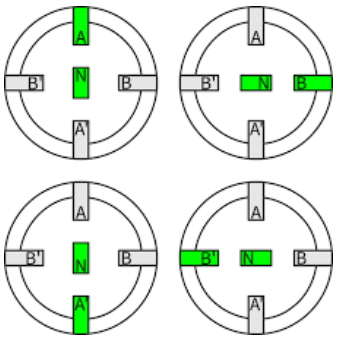
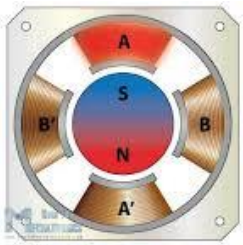
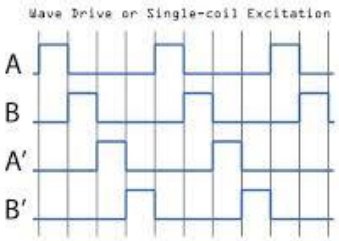
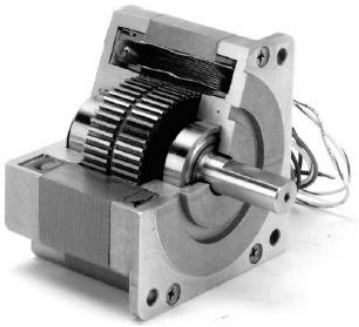
Koračni motor

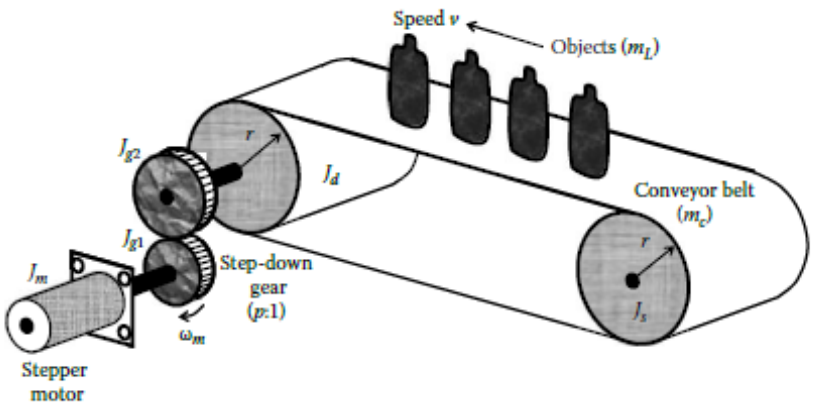








35



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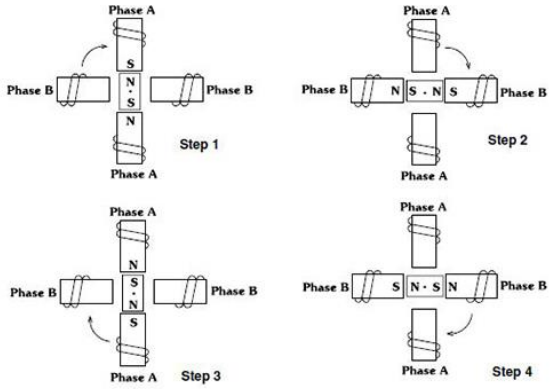
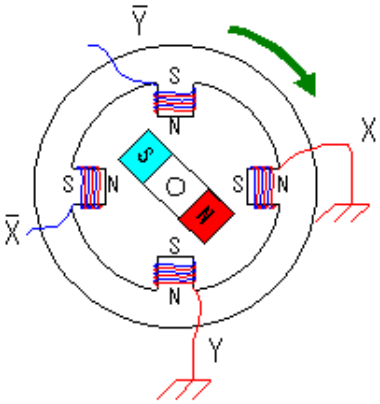
Koračni motor



37

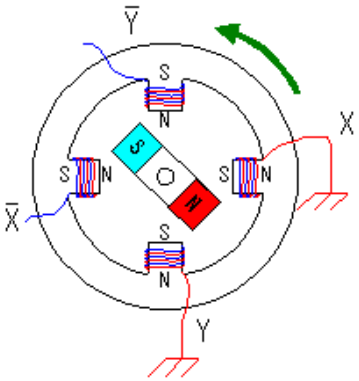
Koračni motor



X	$\overline{X}$	Y	$\overline{Y}$
0	1	0	1
1	0	0	1
1	0	1	0
0	1	1	0

38

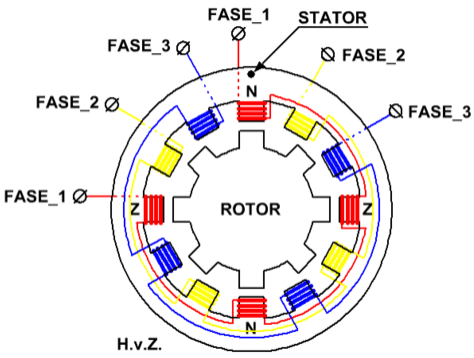
Koračni motor

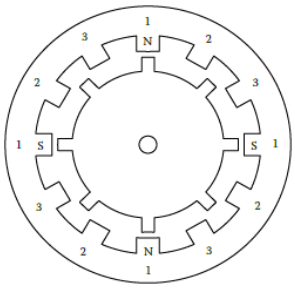


X	$\bar{X}$	Y	$\bar{Y}$
0	1	0	1
0	1	1	0
1	0	1	0
1	0	0	1

39

Trofazni koračni motor





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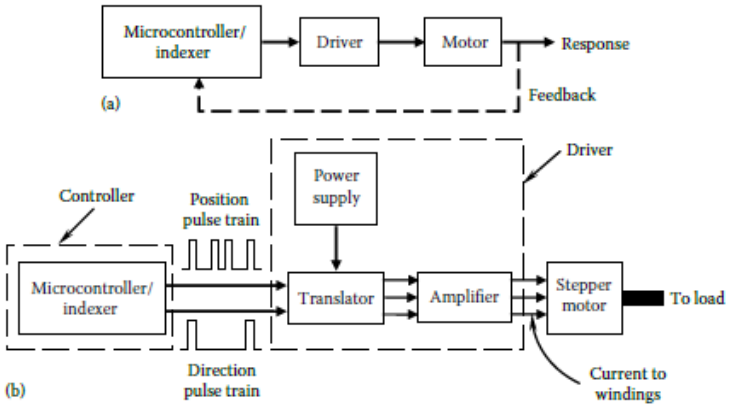
Upravljanje



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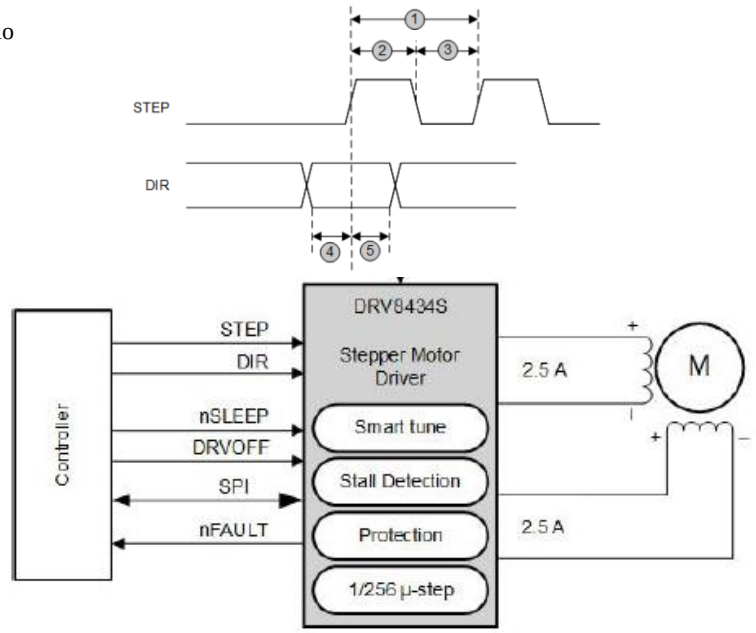
Integrisano kolo



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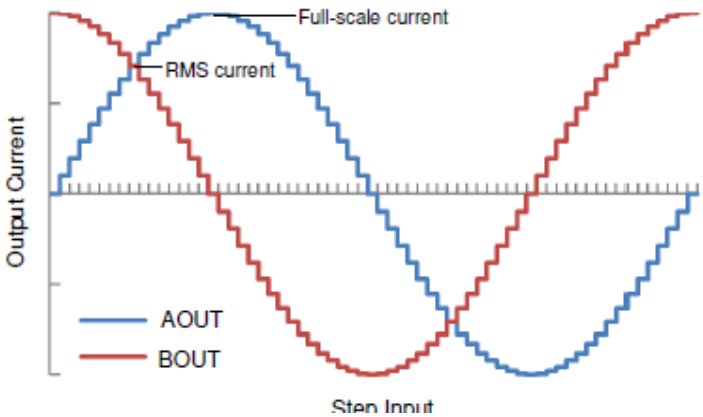
Koračni motor - mikrostep



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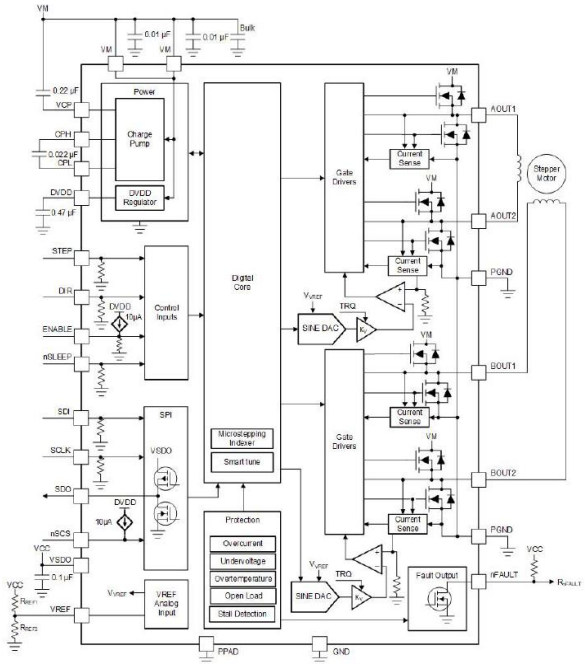

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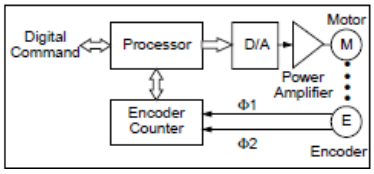
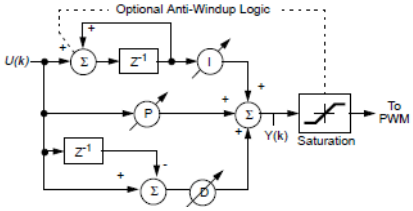
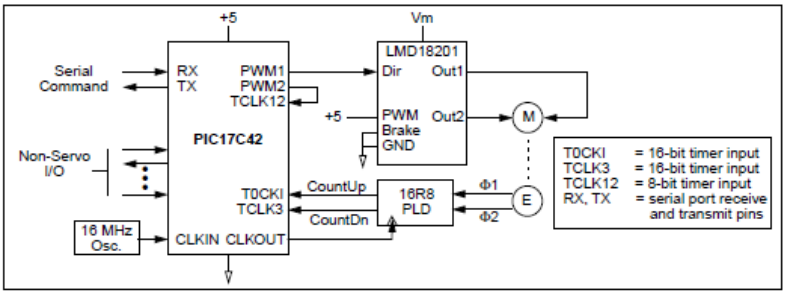

Digital Command
Processor
D/A
Motor
M
Power Amplifier
Encoder Counter
Φ1
Φ2
E
Encoder


Optional Anti-Windup Logic
U(k)
Σ
Z-1
I
P
D
Y(k)
Saturation
To PWM


+5
Vm
Serial Command
RX
TX
PWM1
PWM2
TCLK12
PIC17C42
LMD18201
Dir
Out1
PWM
Brake
GND
Out2
M
Non-Servo I/O
T0CKI
TCLK3
CountUp
CountDn
16R8 PLD
Φ1
Φ2
E
16 MHz Osc.
CLKIN
CLKOUT
T0CKI = 16-bit timer input
TCLK3 = 16-bit timer input
TCLK12 = 8-bit timer input
RX, TX = serial port receive and transmit pins