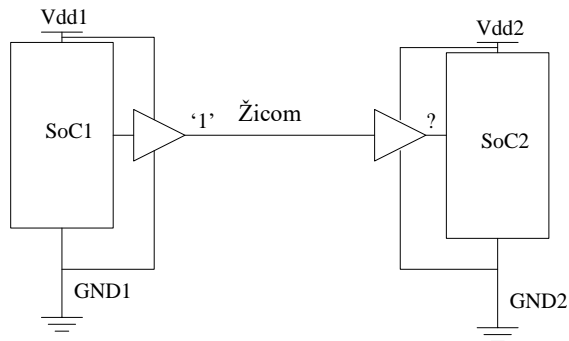


Žična veza



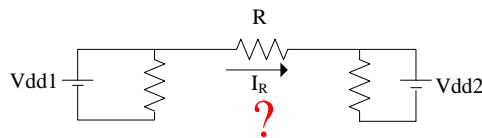
1

Prenos signala između dva dela sistema.



Šta je shvatio prijemnik drugog SoC-a?

Identična situacija

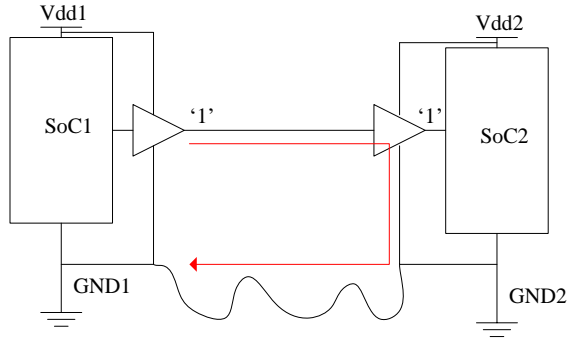
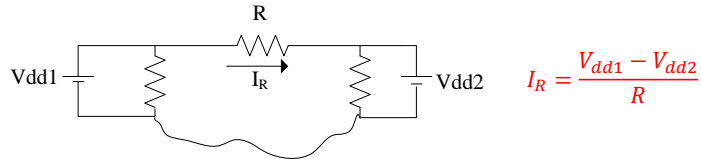


$$I_R = \frac{V_{dd1} - V_{dd2}}{R}$$



2

Struja teče samo ako povežemo dodatnom „žicom“ ova dva dela sistema

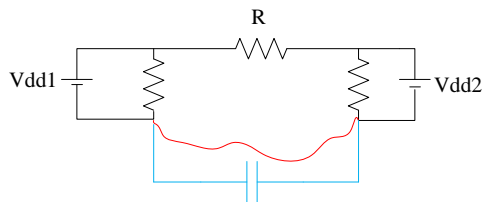


Masa je povratni put signala



3

Uočiti



Napon na kondenzatoru
pre spajanja Vdd2 – Vdd1

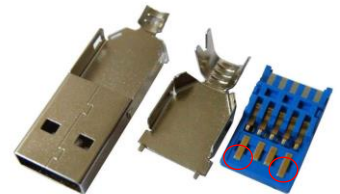
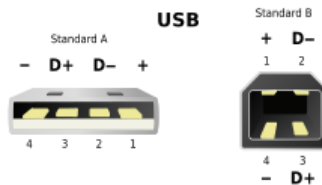
Prilikom spajanja „ogromna“
struja kroz liniju mase.

Spajanje uređaja:

1. Isključiti napajanje
2. Spojiti uređaje
3. Uključiti napajanje

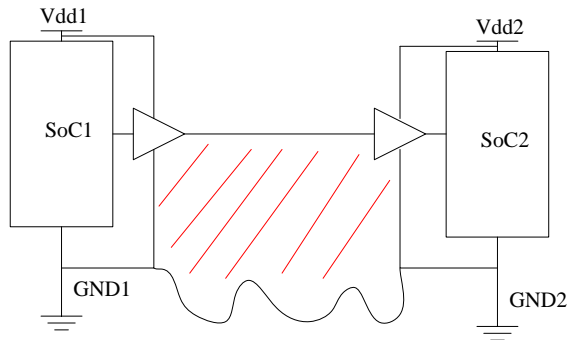
„mali trikovi“
vrhunsko inženjerstvo

Hot plugging
Hot swapping



4

Smetnje = površina konture

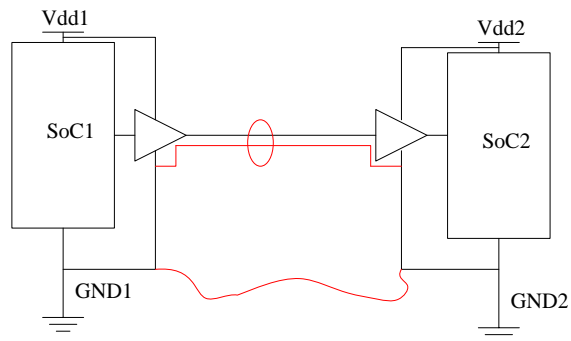


Cilj smanjiti površinu



5

Jednostruki prenos signala
Single ended



Žice, kablovi, koje se koriste

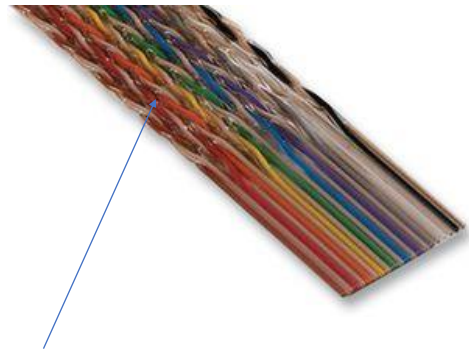
1. Untwisted pair cable
2. Coaxial cable
3. Twisted pair cable
4. Unshielded twisted pair cable
5. ...

Da li je baš pametno spojiti
dodatnu žicu na oba kraja?



6

Flat cable – uglavnom za paralelne prenose podataka



Uočiti – „upredeno“



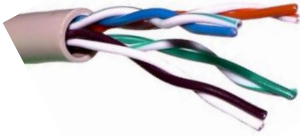
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

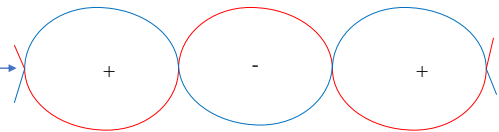
7

7

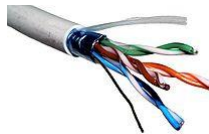
UTP



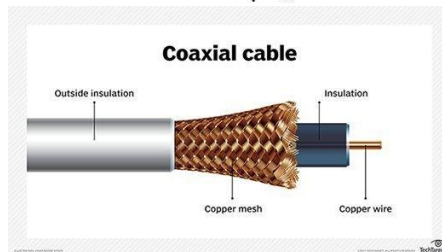
Zašto upredanje →



Sa izolacijom



Coaxial cable



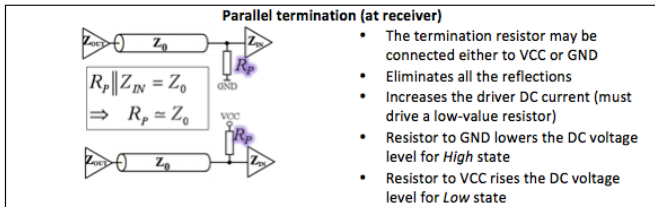
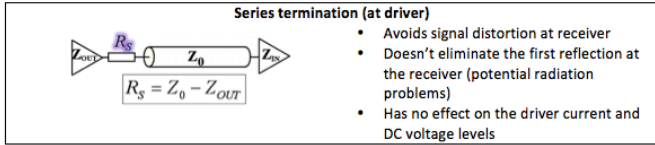
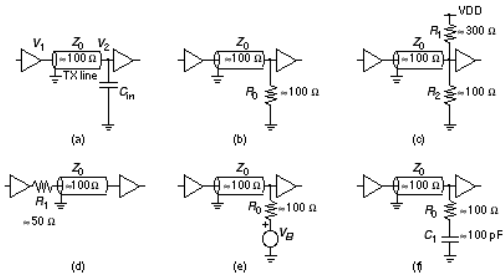
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

8

8

Prilagođenje impedanse



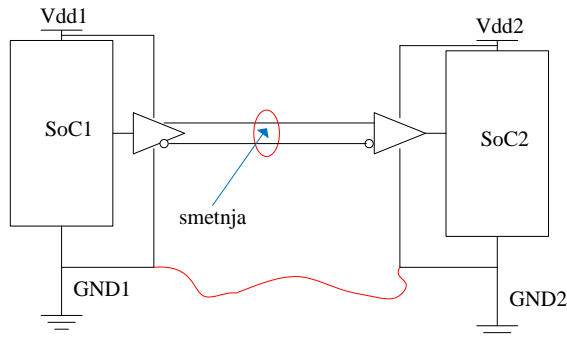
Uočiti: spajanje šilda na masu samo na jednoj strani



9

Diferencijalni prenos podataka Differential

Koriste se diferencijalni predajnici
i diferencijalni prijemnici



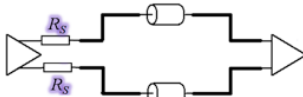
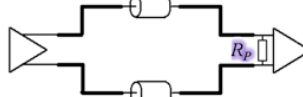
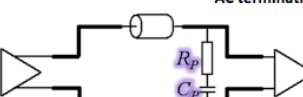
$$V_{+R} - V_{-R} = (V_{+T} + \Delta V) - (V_{-T} + \Delta V) = V_{+T} - V_{-T}$$

Untwisted pair cable
Twisted pair cable
Unshielded twisted pair cable



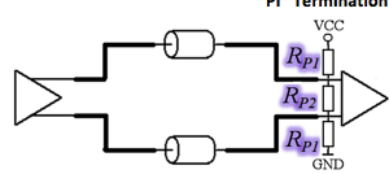
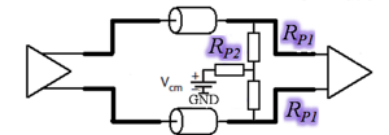
10

Prilagodnje impedanse

 <p style="text-align: center;">Series termination (at driver)</p> $R_S = \frac{Z_{OUT_diff} - Z_{diff}}{2}$	<ul style="list-style-type: none"> • Avoids signal distortion at receiver • Doesn't eliminate the first reflection at the receiver (potential radiation problems) • Has no effect on the driver current and DC voltage levels
 <p style="text-align: center;">Parallel termination (at receiver)</p> $R_P = Z_{diff}$	<ul style="list-style-type: none"> • Most common receiver termination • Eliminates all the reflections of the differential signal • Does not eliminate the reflections of the common mode signal (potential radiation problems) • Increases the driver DC current (must drive a low-value resistor)
 <p style="text-align: center;">AC termination (at receiver)</p> $R_P = Z_{diff}; \tau_{RC} = R_P \cdot C_P < 2 \cdot t_P$	<ul style="list-style-type: none"> • Similar to parallel termination but without the additional driver DC current • Increases the rise time at the receiver end (use with caution!)



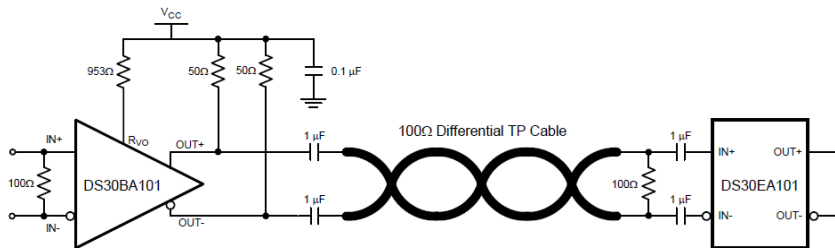
11

 <p style="text-align: center;">"P" Termination (at receiver)</p> $R_{P1} = Z_{even}; R_{P2} = \frac{2 \cdot Z_{even} \cdot Z_{odd}}{Z_{even} - Z_{odd}}$	<ul style="list-style-type: none"> • Terminates both common end and differential signals • Eliminates all the reflections • Assures a valid input state at the receiver when driver is in HighZ
 <p style="text-align: center;">"T" Termination (at receiver)</p> $R_{P1} = Z_{odd}; R_{P2} = \frac{Z_{even} - Z_{odd}}{2}$	<ul style="list-style-type: none"> • Terminates both common end and differential signals • Eliminates all the reflections • Requires an additional voltage source for differential signals with common mode offset (some differential receivers might have an internal regulator to provide common mode voltage outside the chip, if this is the case then use it!)



12

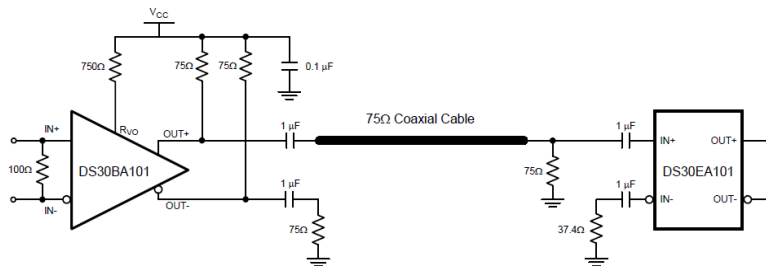
DS30BA101 3.125 Gbps Differential Buffer



Parameter	Test Conditions	Reference	Min	Typ	Max	Units
DR_{IN}	Input Data Rate	IN+, IN-			3125	Mbps
t_{TLH}	Transition Time Low to High	OUT+, OUT-		90	130	ps
t_{THL}	Transition Time High to Low			90	130	ps



DS30EA101 0.15 to 3.125 Gbps Adaptive Cable Equalizer

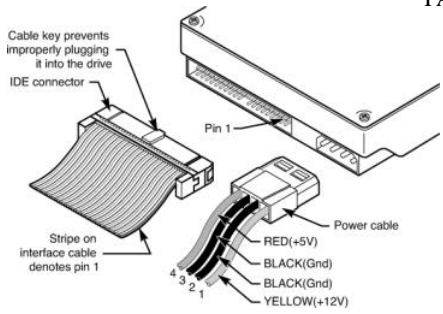


The DS30EA101 is an adaptive cable equalizer optimized for equalizing data transmitted over copper cables. The equalizer operates over a range of data rates from 150 Mbps to 3.125 Gbps and automatically adapts to equalize signals sent over any cable length from zero meters to lengths that attenuate the signal by 50 dB at 1.5 GHz.

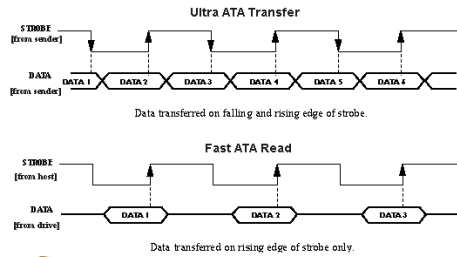
The DS30EA101 allows either single-ended or differential input. This enables equalization of signals over coaxial cables as well as twisted pair cables.



PATA – Parallel AT Attachment



Signal Name	Pin	Pin	Signal Name
-RESET	1	2	GROUND
Data Bit 7	3	4	Data Bit 8
Data Bit 6	5	6	Data Bit 9
Data Bit 5	7	8	Data Bit 10
Data Bit 4	9	10	Data Bit 11
Data Bit 3	11	12	Data Bit 12
Data Bit 2	13	14	Data Bit 13
Data Bit 1	15	16	Data Bit 14
Data Bit 0	17	18	Data Bit 15
GROUND	19	20	KEY (pin missing)
DRQ 3	21	22	GROUND
-IOW	23	24	GROUND
-IOR	25	26	GROUND
I/O CH RDY	27	28	CSEL:SPSYNC ¹
-DACK 3	29	30	GROUND
IRQ 14	31	32	Reserved ²
Address Bit 1	33	34	-PDIAG
Address Bit 0	35	36	Address Bit 2
-CS1FX	37	38	-CS3FX
-DA/SP	39	40	GROUND



¹ Pin 28 is usually cable select, but some older drives could use it for spindle synchronization between multiple drives.
² Pin 32 was defined as -IOCS16 in ATA-2 but is no longer used.
 Note that - preceding a signal name (such as -RESET) indicates the signal is "active low."

40 → 80 žica. Svaka druga GND. Brži prenos.



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

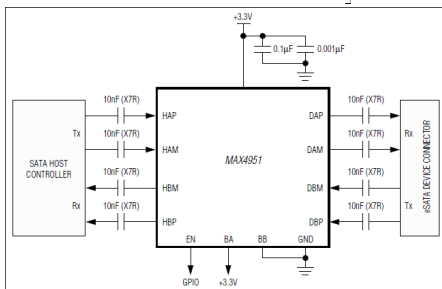
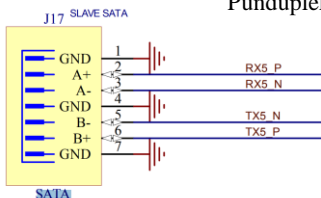
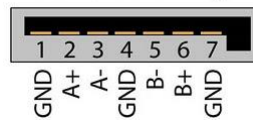
15

15

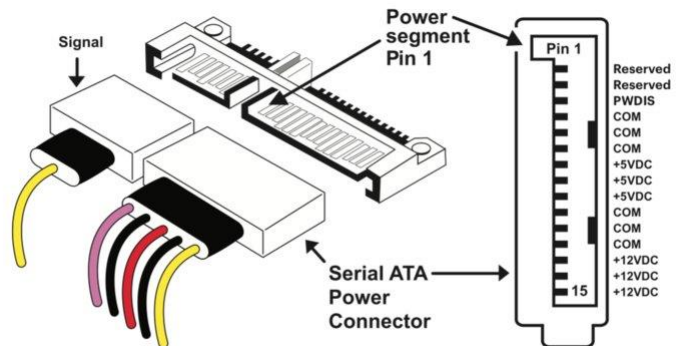
SATA – Serial ATA

Pundupleks diferencijalni prenos

SATA Pinout - Plug



Bafer zbog dužine kablova



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

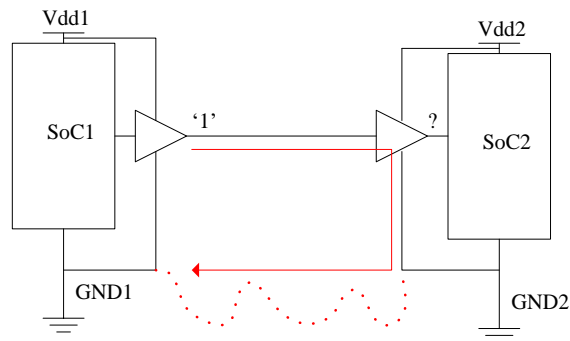
16

16

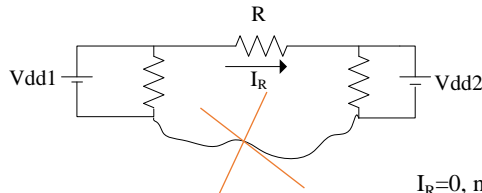
Galvanska izolacija



ŠTA AKO MASE NE SMEJU ili NE MOGU DA SE SPOJE



Masa je povratni put signala – ne postoji

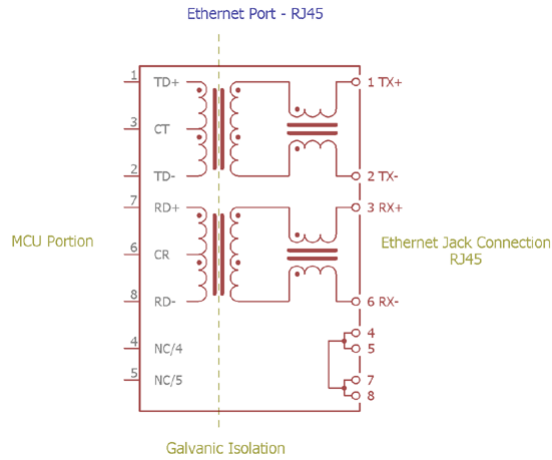


$I_R=0$, nema prenosa signala

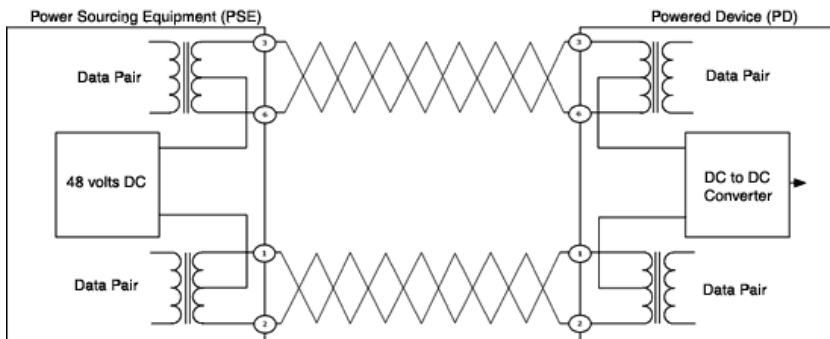


Galvanska izolacija signala

Transformator

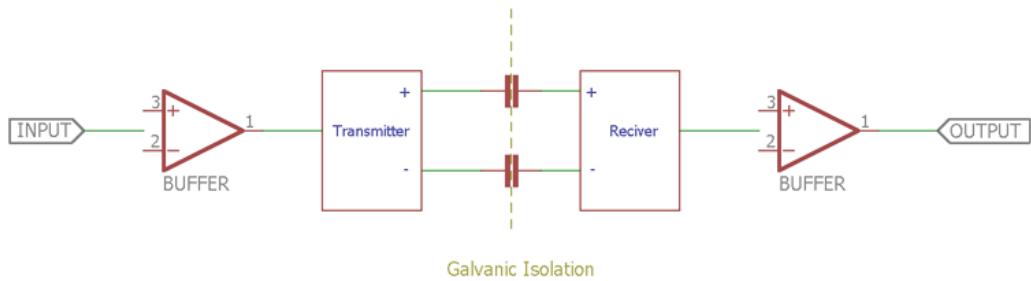


Galvanska izolacija signala + prenos napajanja PoE



Galvanska izolacija signala

Kapacitivnosti



Katedra za elektroniku
prof dr Lazar Saranovac

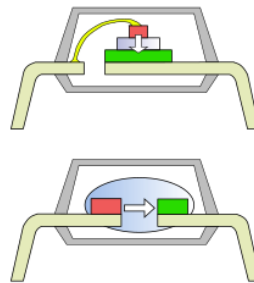
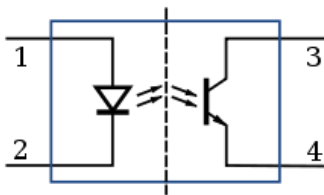
Namenski računarski sistemi - 2021/22

21

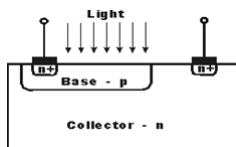
21

U oba prethodna slučaja – naizmjenični signali. Šta je sa jednosmernim?

Optokapler



Led dioda + Fototranzistor



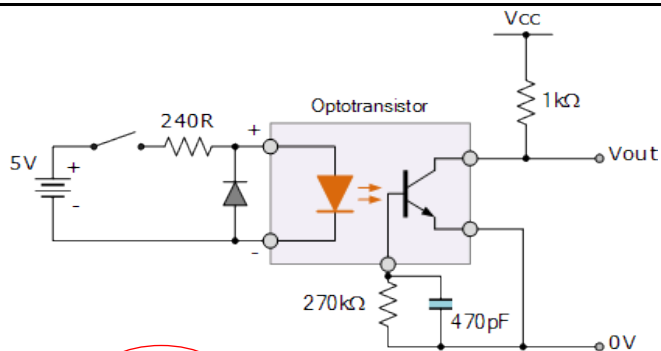
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

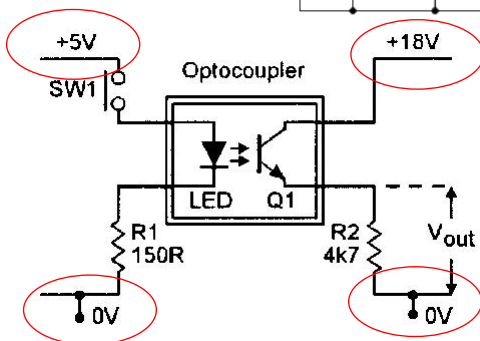
22

22

Povezivanje



„zajednički emitor“

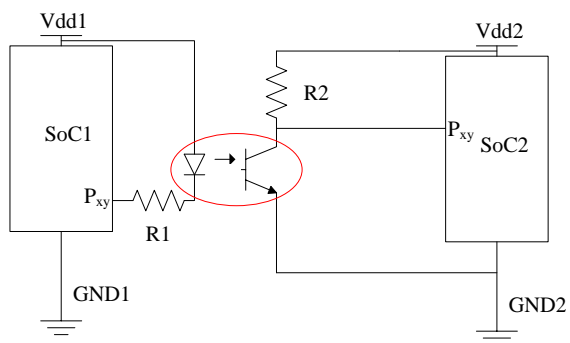


„zajednički kolektor“



23

Komunikacija između dva dela sistema – galvanski razdvojeni



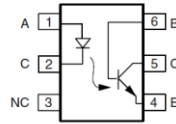
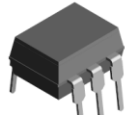
Različita napajanja.
Različite mase.

Izbor R1 i R2



24

Realna komponenta



ABSOLUTE MAXIMUM RATINGS ⁽¹⁾				
PARAMETER	TEST CONDITION	SYMBOL	VALUE	UNIT
INPUT				
Reverse voltage		V_R	6	V
Forward current		I_F	50	mA
Surge current	$t \leq 10 \mu s$	I_{FSM}	1	A
Power dissipation		P_{diss}	70	mW
OUTPUT				
Collector emitter breakdown voltage		V_{CEO}	70	V
Emitter base breakdown voltage		V_{EBO}	7	V
Collector current		I_C	50	mA
	$t \leq 1 ms$	I_C	100	mA
Power dissipation		P_{diss}	70	mW
COUPLER				
Isolation test voltage		V_{ISO}	5000	V_{RMS}
Creepage			≥ 7	mm
Clearance			≥ 7	mm
Isolation thickness between emitter and detector			≥ 0.4	mm



ELECTRICAL CHARACTERISTICS ⁽¹⁾							
PARAMETER	TEST CONDITION	PART	SYMBOL	MIN.	TYP.	MAX.	UNIT
INPUT							
Junction capacitance	$V_R = 0 V, f = 1 MHz$		C_j		50		pF
Forward voltage ⁽²⁾	$I_F = 10 mA$		V_F		1.3	1.5	V
	$I_F = 10 mA, T_{amb} = -55 ^\circ C$		V_F	0.9	1.3	1.7	V
Reverse current ⁽²⁾	$V_R = 6 V$		I_R		0.1	10	μA
Capacitance	$V_R = 0 V, f = 1 MHz$		C_O		25		pF
OUTPUT							
Collector emitter breakdown voltage ⁽²⁾	$I_C = 1 mA$	4N35	BV_{CEO}	30			V
		4N36	BV_{CEO}	30			V
		4N37	BV_{CEO}	30			V
Emitter collector breakdown voltage ⁽²⁾	$I_E = 100 \mu A$		BV_{ECO}	7			V
OUTPUT							
Collector base breakdown voltage ⁽²⁾	$I_C = 100 \mu A, I_B = 1 \mu A$	4N35	BV_{CBO}	70			V
		4N36	BV_{CBO}	70			V
		4N37	BV_{CBO}	70			V
Collector emitter leakage current ⁽²⁾	$V_{CE} = 10 V, I_F = 0$	4N35	I_{CEO}		5	50	nA
		4N36	I_{CEO}		5	50	nA
	$V_{CE} = 10 V, I_F = 0$	4N37	I_{CEO}		5	50	nA
		4N35	I_{CEO}			500	μA
	$V_{CE} = 30 V, I_F = 0, T_{amb} = 100 ^\circ C$	4N36	I_{CEO}			500	μA
		4N37	I_{CEO}			500	μA
Collector emitter capacitance	$V_{CE} = 0$		C_{CE}		6		pF
COUPLER							
Resistance, input output ⁽²⁾	$V_{IO} = 500 V$		R_{IO}	10^{11}			Ω
Capacitance, input output	$f = 1 MHz$		C_{IO}		0.6		pF



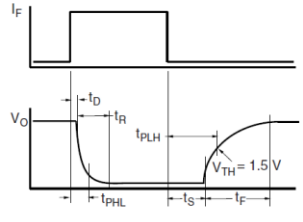
CURRENT TRANSFER RATIO							
PARAMETER	TEST CONDITION	PART	SYMBOL	MIN	TYP.	MAX	UNIT
DC current transfer ratio ⁽¹⁾	$V_{CE} = 10\text{ V}, I_F = 10\text{ mA}$	4N35	CTR_{DC}	100			%
		4N36	CTR_{DC}	100			%
		4N37	CTR_{DC}	100			%
	$V_{CE} = 10\text{ V}, I_F = 10\text{ mA}, T_A = -55\text{ }^\circ\text{C to } +100\text{ }^\circ\text{C}$	4N35	CTR_{DC}	40	50		%
		4N36	CTR_{DC}	40	50		%
		4N37	CTR_{DC}	40	50		%

Note
⁽¹⁾ Indicates JEDEC registered values.

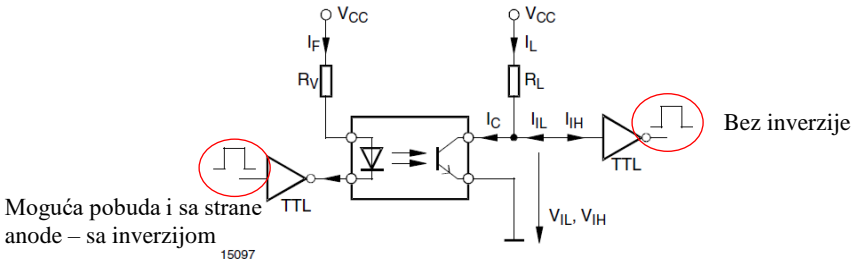
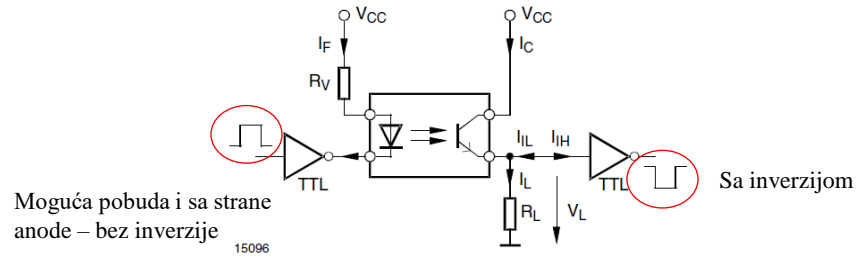
SWITCHING CHARACTERISTICS							
PARAMETER	TEST CONDITION	SYMBOL	MIN.	TYP.	MAX.	UNIT	
Switching time ⁽¹⁾	$V_{CC} = 10\text{ V}, I_C = 2\text{ mA}, R_L = 100\text{ }\Omega$	t_{on}, t_{off}		10			μs

Note
⁽¹⁾ Indicates JEDEC registered values.

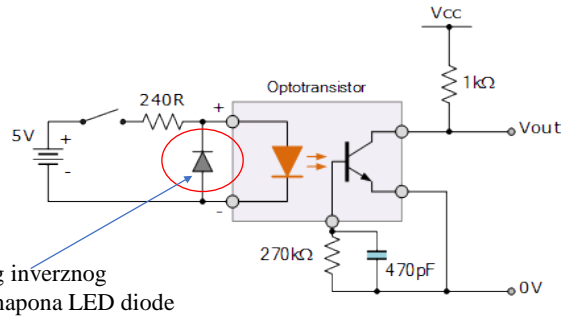
TYPICAL CHARACTERISTICS
 $T_{amb} = 25\text{ }^\circ\text{C}$, unless otherwise specified



i4n25_13
 Fig. 13 - Switching Timing

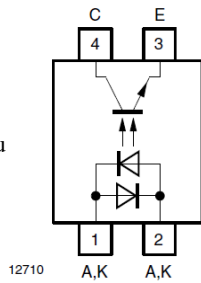


Optokapler sa dve LED diode

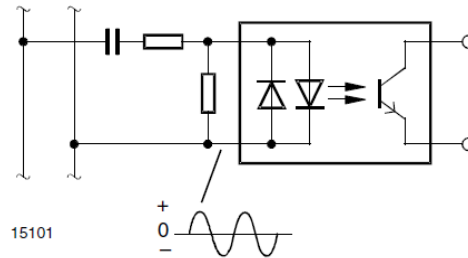


Zbog malog inverznog probojnog napona LED diode

Praktično ima ga u svakom žičnom telefonu



Ring Line



Katedra za elektroniku
prof dr Lazar Saranovac

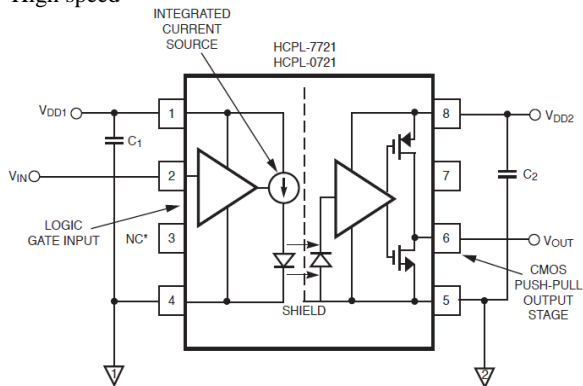
Namenski računarski sistemi - 2021/22

29

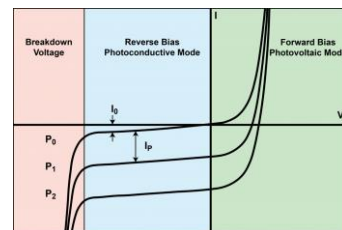
29

„brzi“ optokapleri –manja kašnjenja - za prenos signala viših učestanosti

High speed



Fotodioda



P – različiti nivoi svetlosti
P₀ – u mraku

...

„koliko para toliko muzike“



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

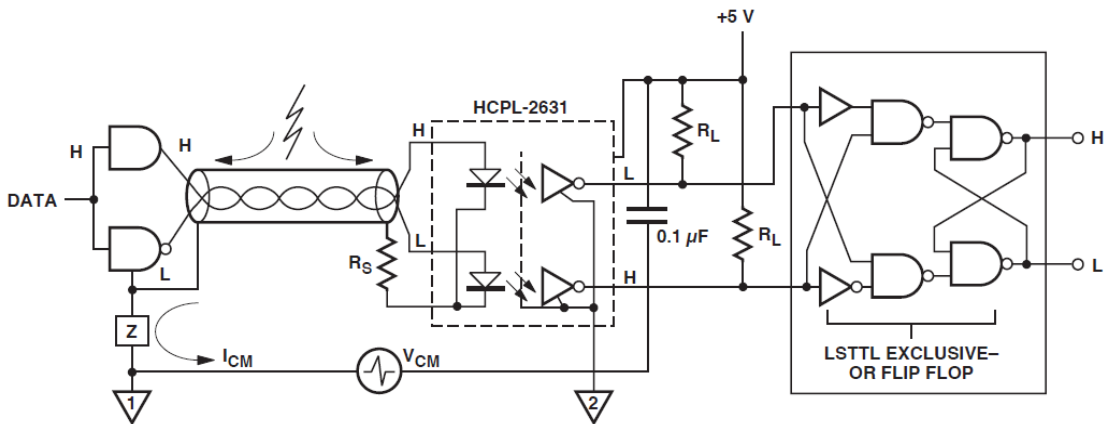
30

30

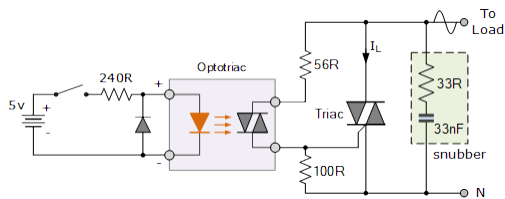
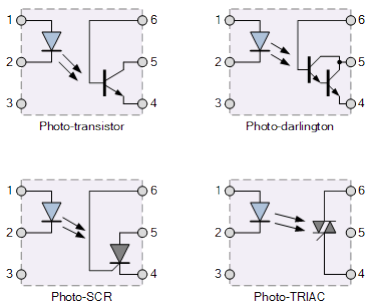
Photodiode	Phototransistor
The photodiode is a PN-junction diode, used to generate electric current once a photon of light strikes on their surface.	The phototransistor is used to change the energy of the light into an electrical energy
It is less sensitive	It is more sensitive
The output response of photodiode is fast	The output response of the phototransistor is low
It produces current	It produces voltage and current
It is used in solar power generation, detecting UV otherwise IR rays & also for light measuring, etc.	It is used in compact disc players, smoke detectors, lasers, invisible light receivers, etc.
It is more reactive to incident lights	It is less reactive
The photodiode has a less dark current	Phototransistor has high dark current
In this, both the biasing is used like forward and reverse	In this, forward biasing is used
The linear response range of photodiode is much wider	The linear response range of phototransistor is much lower
Photodiode allows low current as compared to a phototransistor	Phototransistor allows high current as compared to the photodiode
The photodiode is used for battery-powered devices that use less power.	The phototransistor is used as a solid-state switch, not like a photodiode.



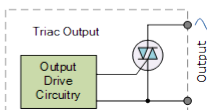
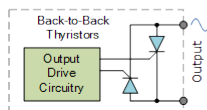
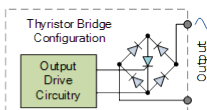
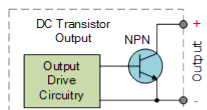
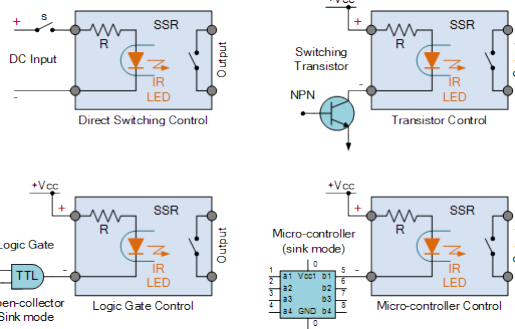
High speed optokapleri + diferencijalni prenos



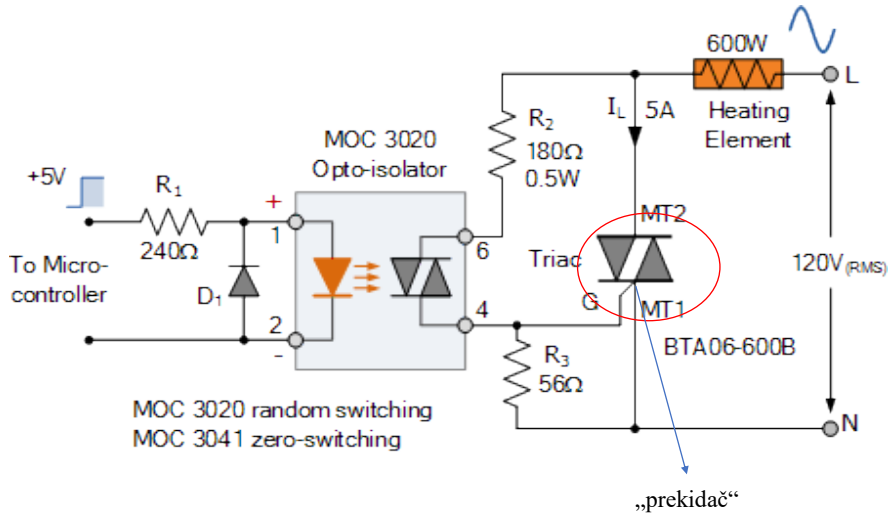
„Upravljanje snagom“



Solid state relay

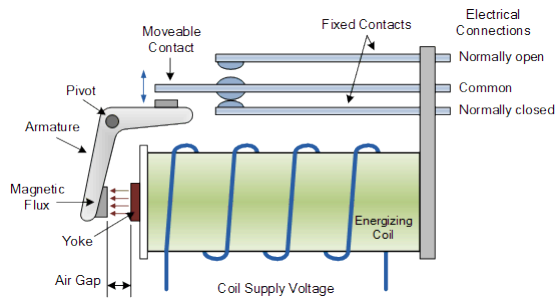
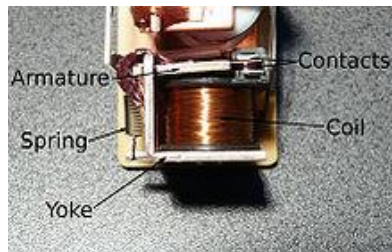


Solid state relay – primer upotrebe



35

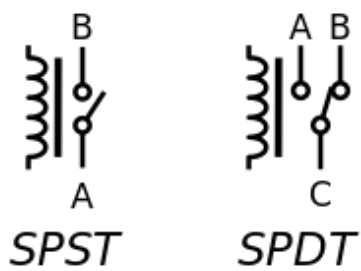
Elektromehaničke komponente – Rele(j) - Relay



36

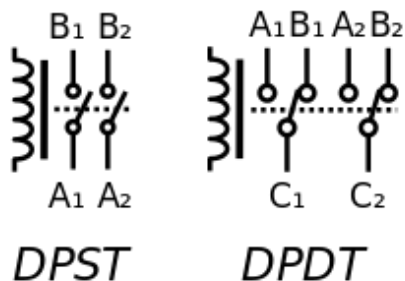
Simboli

SPST – Single Pole Single Throw
 SPDT – Single Pole Double Throw
 DPST – Double Pole Single Throw
 DPDT – Doble Pole Double Throw
 ...

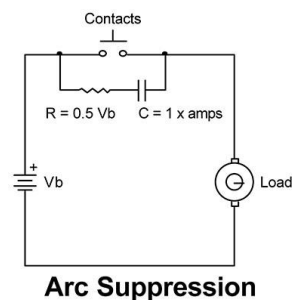
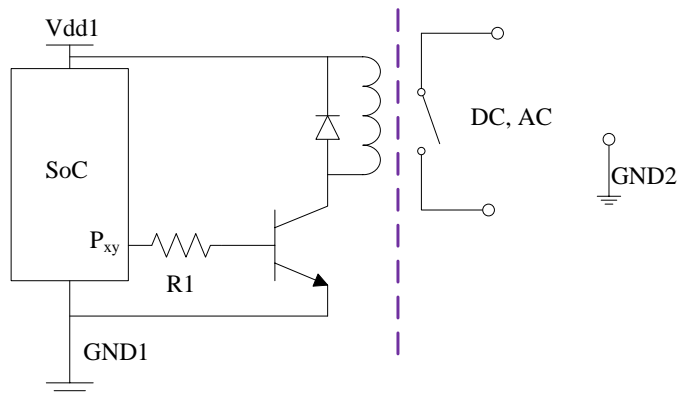


U kom stanju je prekidač kada nema pobude

NO – Normally open
 NC – Normally closed



Upravljanje



Pomoćna kola – dovoljno struje

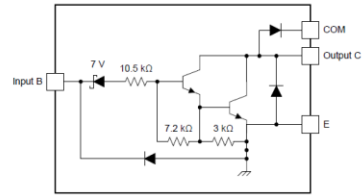
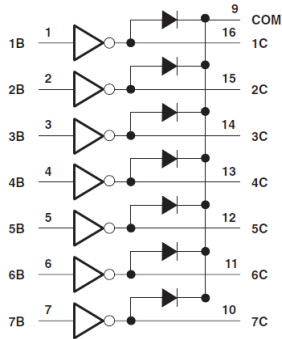


Figure 19. ULN2002A Block Diagram

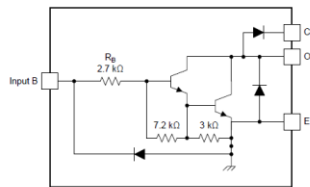


Figure 20. ULN2003A, ULQ2003A and ULN2003AI Block Diagram

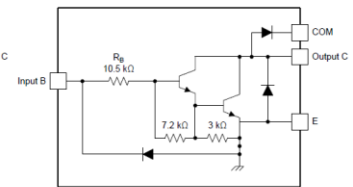


Figure 21. ULN2004A and LQ2004A Block Diagram



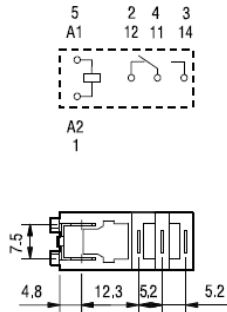
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

39

39

Realna komponenta



Contact specification		
Contact configuration		2 CO (DPDT) 1 CO (SPDT)
Rated current/Maximum peak current	A	8/15 16/25*
Rated voltage/ Maximum switching voltage	V AC	250/440 250/440
Rated load AC1	VA	2000 4000
Rated load AC15 (230 V AC)	VA	350 750
Single phase motor rating (230 V AC)	kW	0.37 0.55
Breaking capacity DC1: 30/110/220 V	A	6/0.5/0.15 12/0.5/0.15
Minimum switching load	mW (V/mA)	300 (5/5) 300 (5/5)
Standard contact material		AgNi AgNi



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

40

40

Coil specification			
Nominal voltage (U_N)	V AC (50/60 Hz)	12 - 24 - 48 - 110 - 120 - 230 - 240	
	V DC	12 - 24 - 48 - 110 - 125	
Rated power	VA/W	1.2/0.5	1.2/0.5
Operating range	AC	$(0.8...1.1)U_N$	$(0.8...1.1)U_N$
	DC	$(0.73...1.1)U_N$	$(0.73...1.1)U_N$
Holding voltage	AC/DC	$0.8 U_N / 0.4 U_N$	$0.8 U_N / 0.4 U_N$
Must drop-out voltage	AC/DC	$0.2 U_N / 0.1 U_N$	$0.2 U_N / 0.1 U_N$
Technical data			
Mechanical life AC/DC	cycles	$10 \cdot 10^6$	$10 \cdot 10^6$
Electrical life at rated load AC1	cycles	$100 \cdot 10^3$	$100 \cdot 10^3$
Operate/release time	ms	10/3	15/5
Insulation between coil and contacts (1.2/50 μ s)	kV	6 (8 mm)	6 (8 mm)
Dielectric strength between open contacts	V AC	1000	1000
Ambient temperature range	$^{\circ}$ C	-40...+70	-40...+70
Environmental protection		RT II	RT II

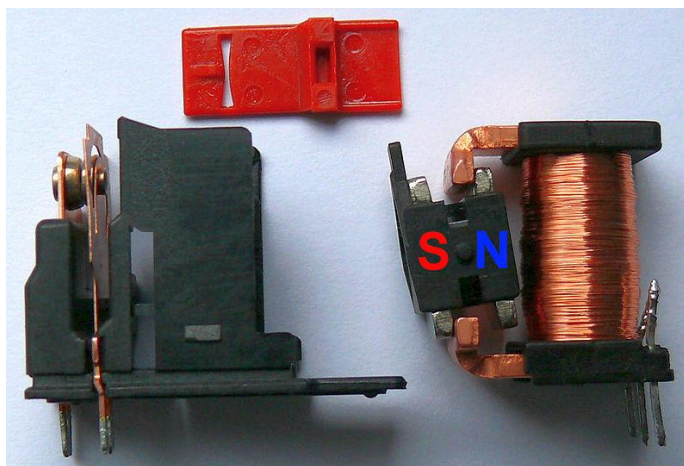


Do sada videli - Monostabilna relea – Potrebna pobudna struja „stalno“ – Troše energiju

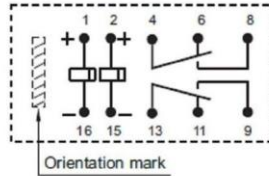
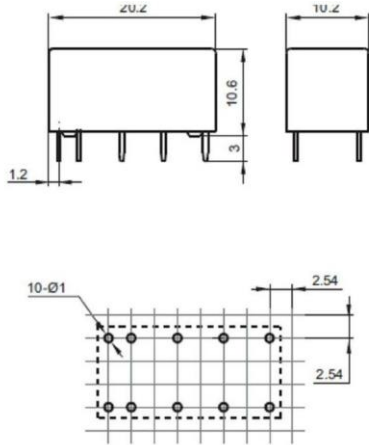
Ideja kao kod klasičnih električnih prekidača.

Delujemo silom, prebacujemo u odgovarajuće stanje i nije više potreban pritisak, mehanička sila.

Bistabilna relea - latching



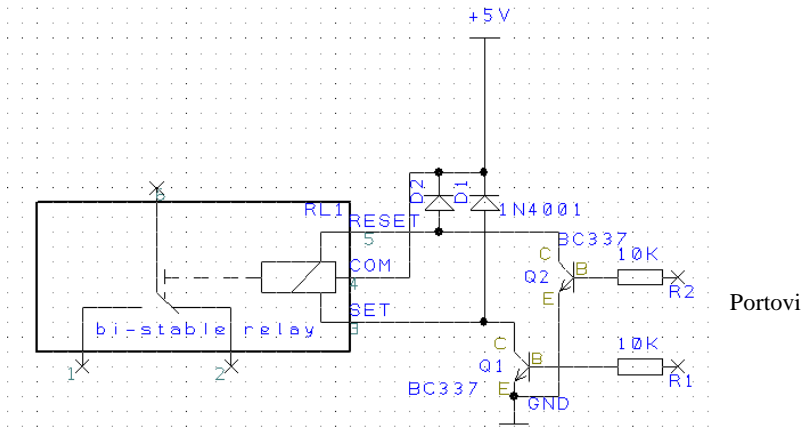
Bistabilna relea sa dva pobudna namotaja



Orientation mark
 Diagram shows the "reset" position
 Energize terminals 1 and 16 to "set"
 Energize terminals 2 and 15 to "reset"

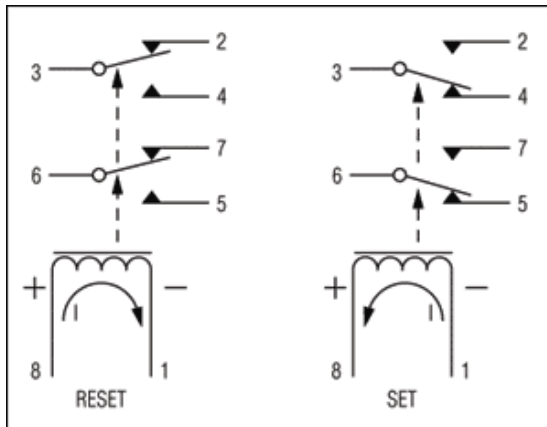
Matching 16 pin IC socket

Upravljanje bistabilnim releom

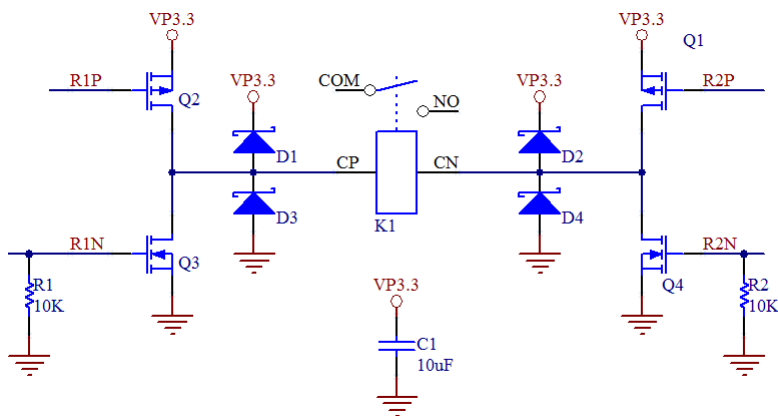


Portovi

Bistabilna relea sa jednim namotajem



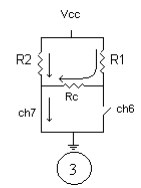
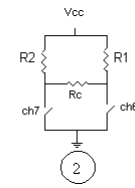
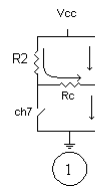
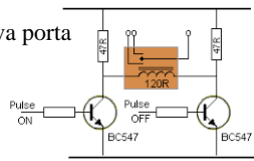
Upravljanje bistabilnim releima sa jednim namotajem



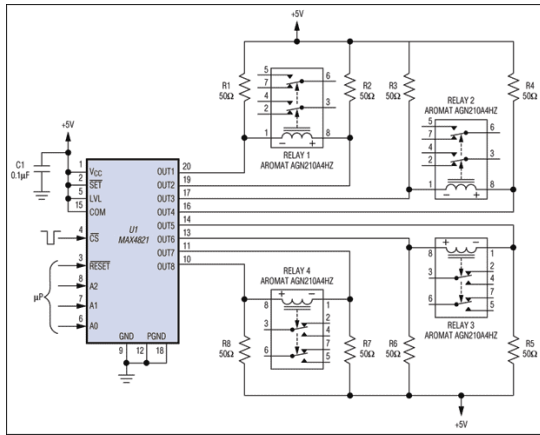
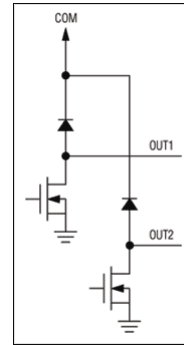
Treba četiri porta



Ideja kako se najčešće koriste – samo dva porta



Izlazi MAX4821



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

47

47

Kontaktor – upravljanje trofaznom snagom



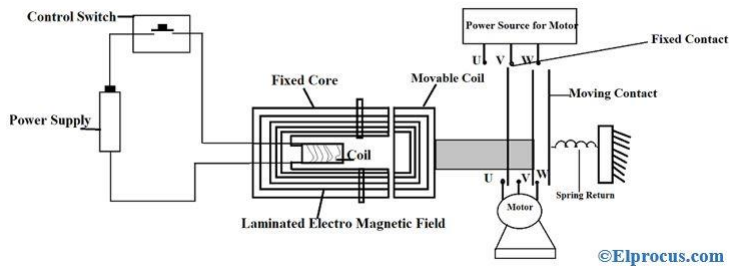
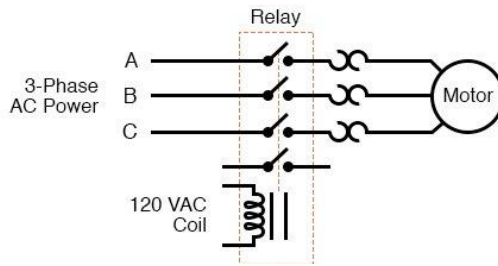
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

48

48

kontaktor



©Elprocus.com



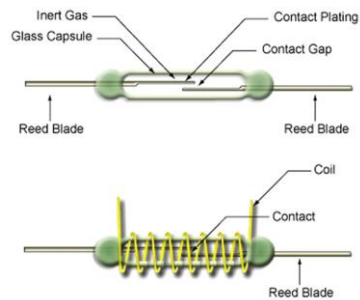
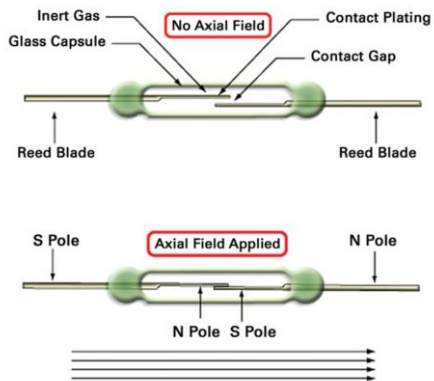
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

49

49

Reed relay – brza – često za prenos signala



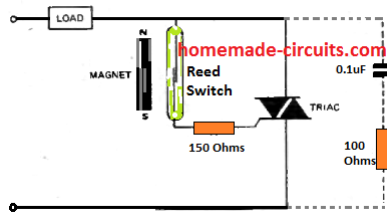
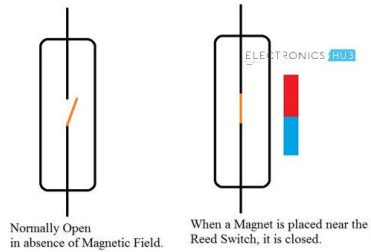
Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

50

50

Reed switch – dosta često u alarmnim sistemima



Katedra za elektroniku
prof dr Lazar Saranovac

Namenski računarski sistemi - 2021/22

51