

Industrijski protokoli i mreže

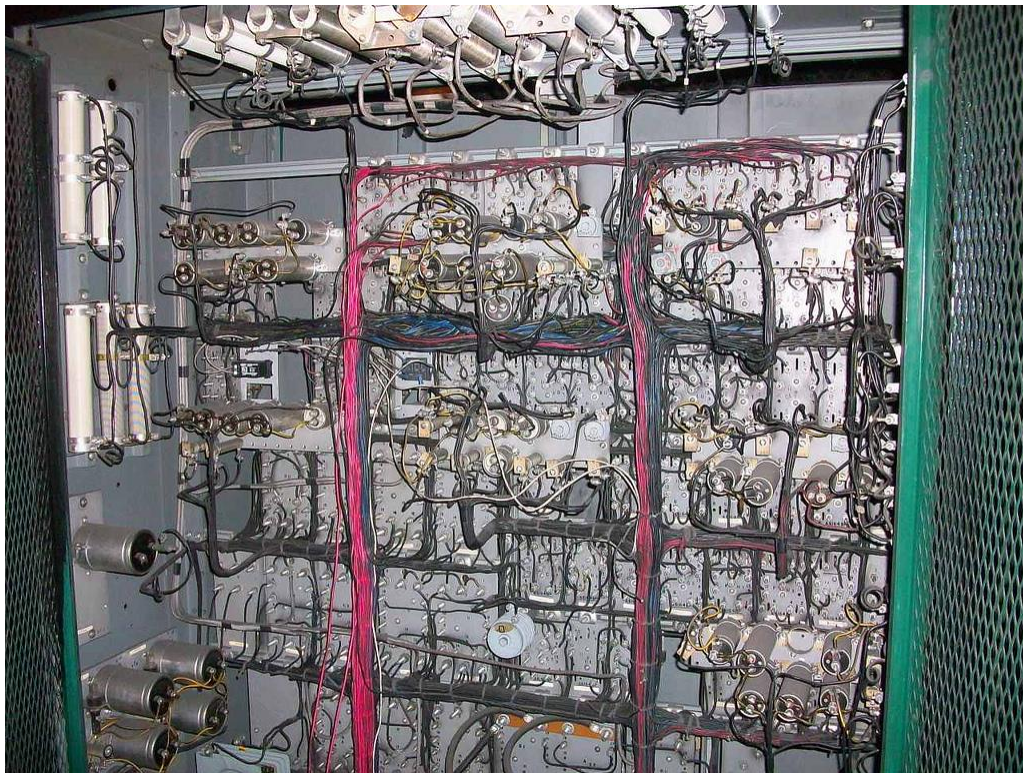
Vežbe – termin 2

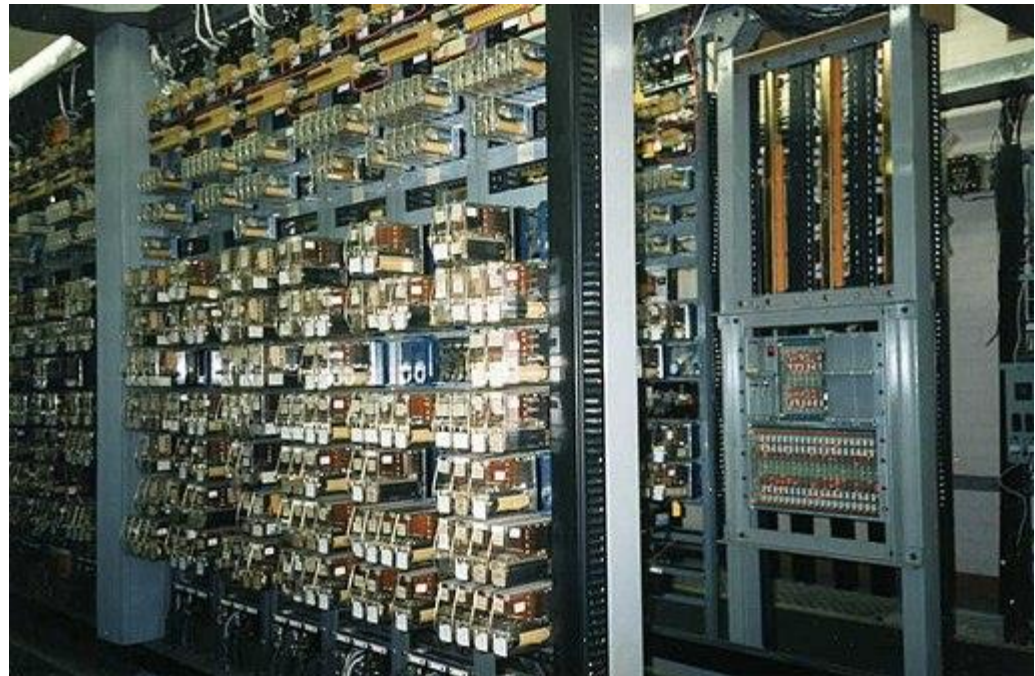


■ PLC

Šta je PLC?

- PLC (programabilni logički kontroler) je mikroprocesorski sistem u kome su hardver i softver specifično adaptirani industrijskom okruženju.
- Element automatizovanog sistema, koji na osnovu signala sa ulaznih uređaja, po određenom programu, izvršava različite logičke i sekvencionalne funkcije, na osnovu kojih formira izlazne signale kojima upravlja izlaznim uređajima; istovremeno može da obavlja komunikaciju sa udaljenim računarom, kontrolerom, operatorskim panelom ili drugim pokazivačkim uređajem.
- Prvobitno je osmišljen kao zamena za relejnu logiku, ali sada pored logičkih funkcija može da obavlja i aritmetička izračunavanja i složeno, potpuno digitalno upravljanje.





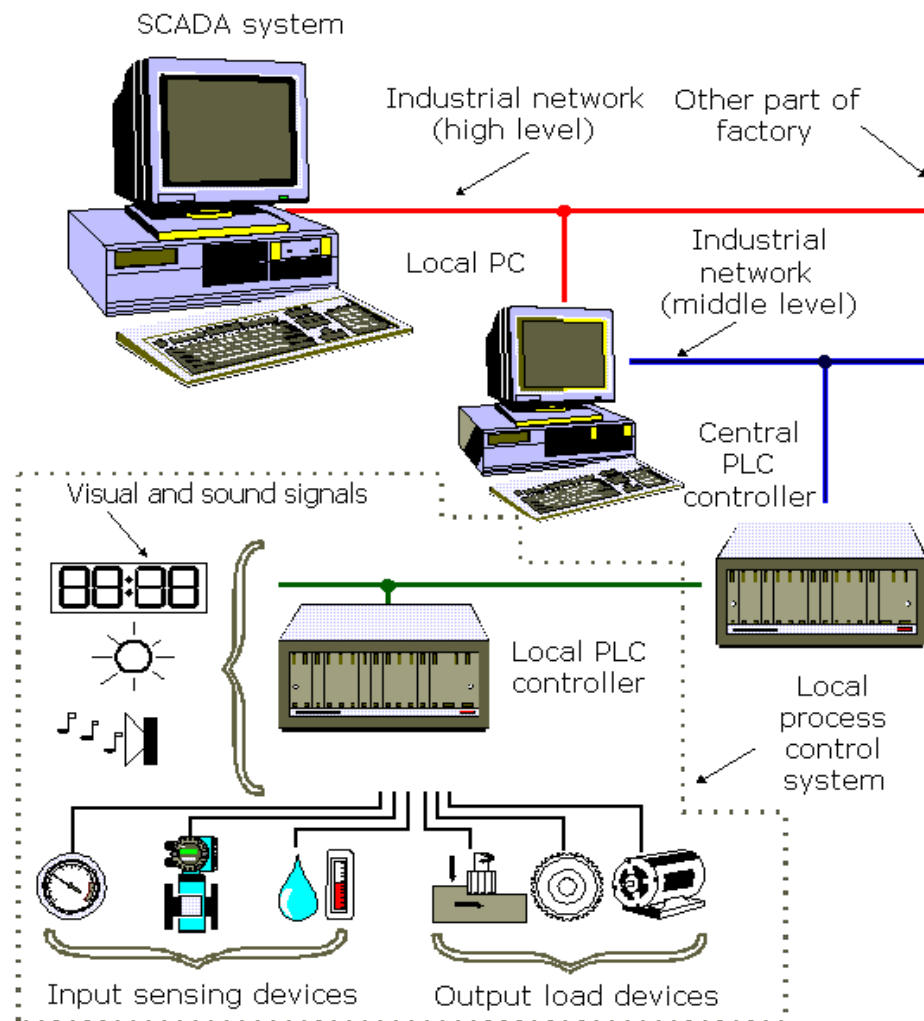


- Jednostavna ugradnja
- Modularna organizacija, lako proširenje i adaptacija
- Potrebno je mnogo manje (80%) provodnika za povezivanje
- Dijagnostikovanje - brzo i jednostavno otkrivanje grešaka

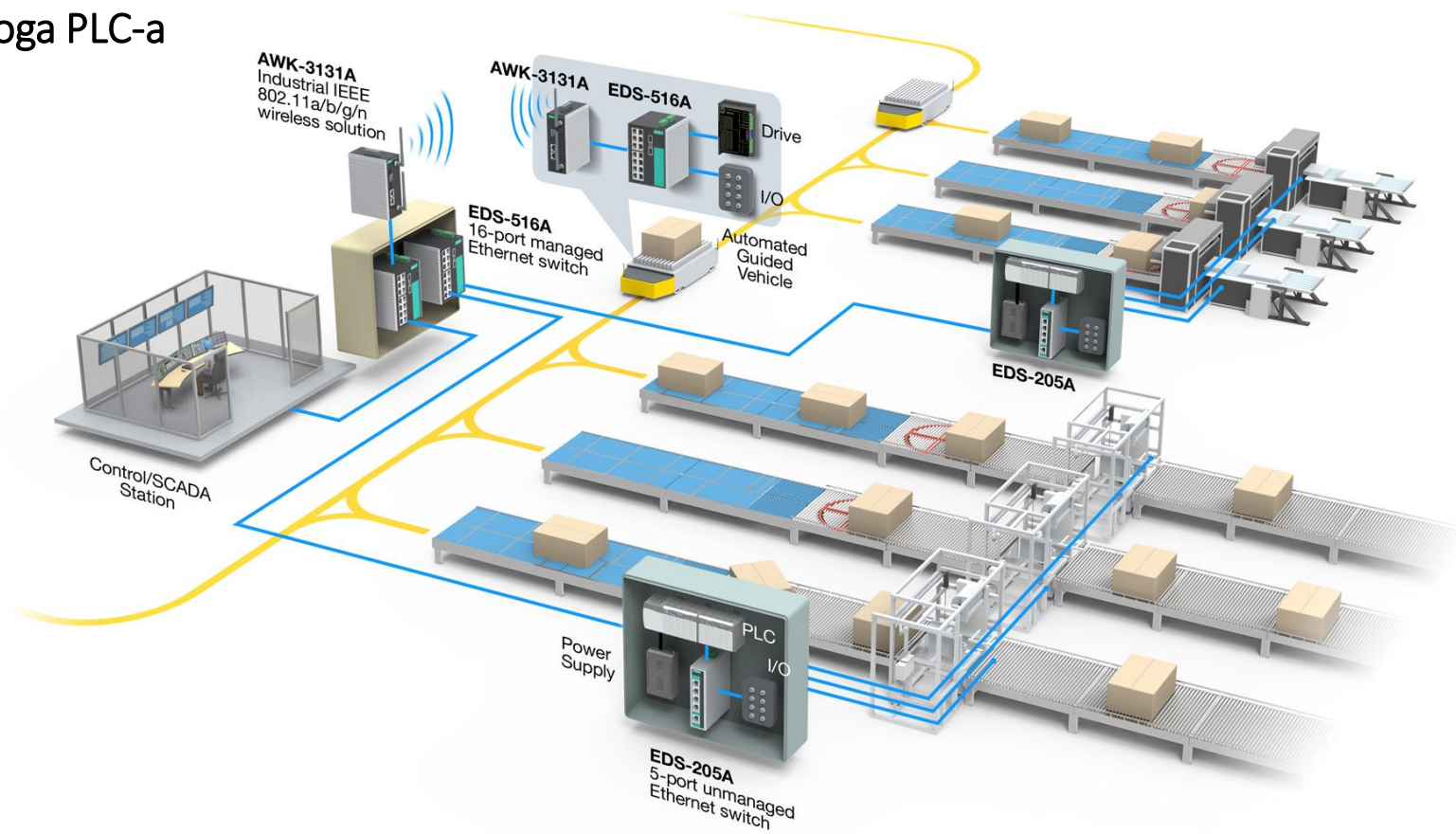
- Potrošnja je značajno smanjena
- Male dimenzije, mali broj rezervnih delova, lakše održavanje
- Jednostavno programiranje i održavanje programa
- Visok stepen dokumentovanosti programa
- Mogućnost povezivanja u hijerarhijski nadređeni sistem upravljanja
- Mogućnost instalacije i testiranja na samoj mašini
- Prihvatljiva cena, naročito kod složenih sistema sa velikim brojem U/I



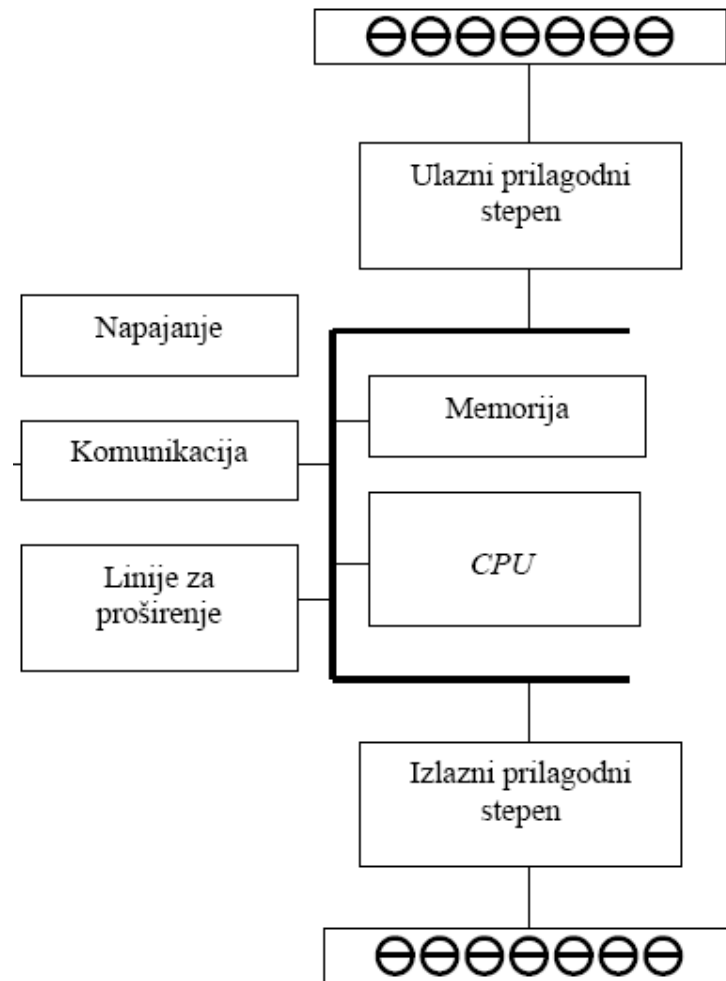
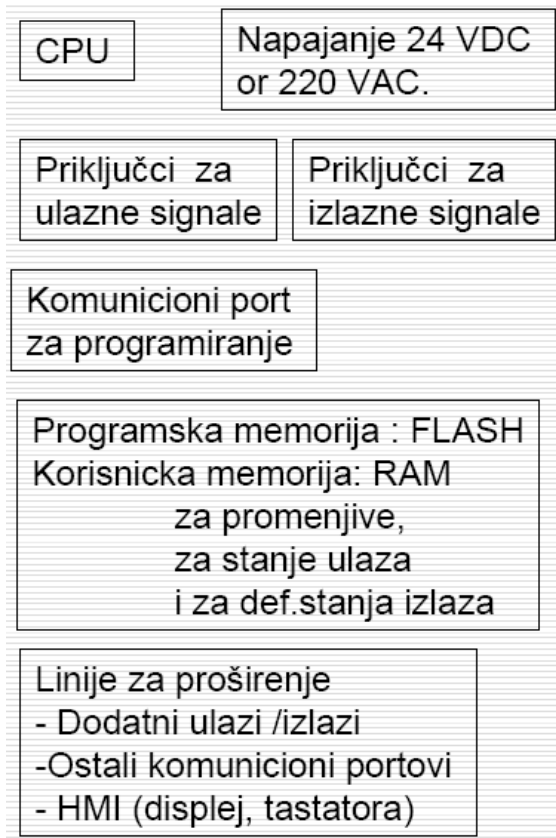
■ Uloga PLC-a



■ Uloga PLC-a



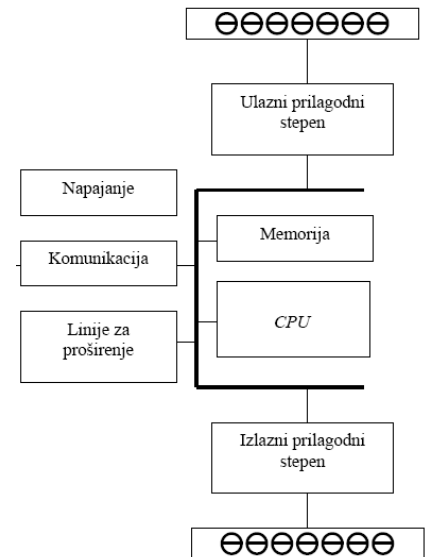
■ Hardverska organizacija (!)



■ CPU (Central Processing Unit)

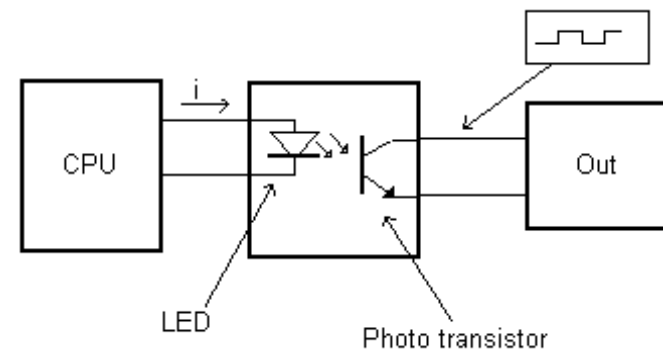
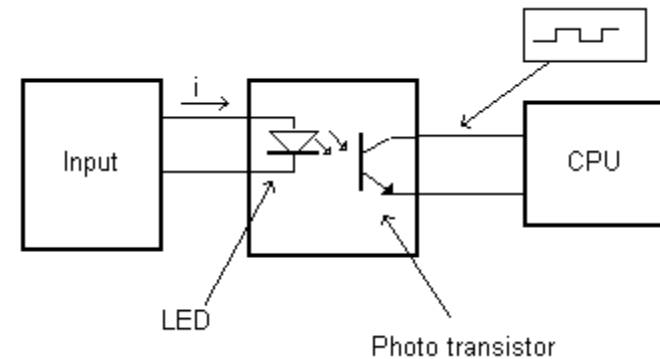
Ranije su to bili 8-bitni, danas 16-bitni i 32-bitni

Uloga CPU-a: Izvršava **program** (+upravljanje memorijom)
 Nadgleda ulaze (+upravljanje memorijom)
 Postavlja izlaze (+upravljanje memorijom)
 Brine o komunikaciji
 Vrši samodijagnostiku



■ Digitalni i analogni ulazi i izlazi

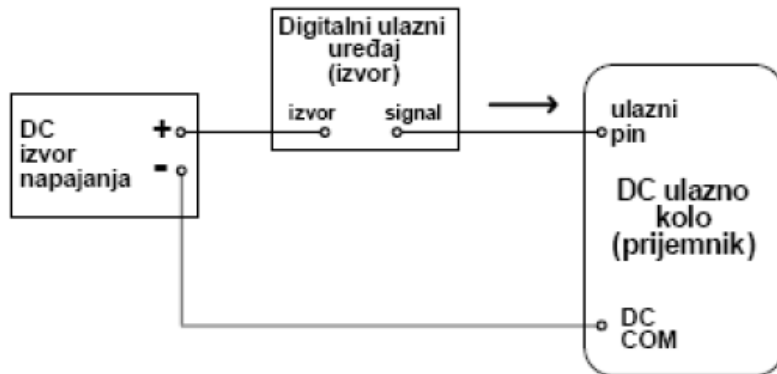
- Digitalni ulazi
(Primer: tasteri, prekidači...)
- Digitalni izlazi
(Primer: upravljaju kontaktorima, relejima, LED diodama...)
- Vrste: 1. tranzistorski (PNP, NPN)
2. relejni



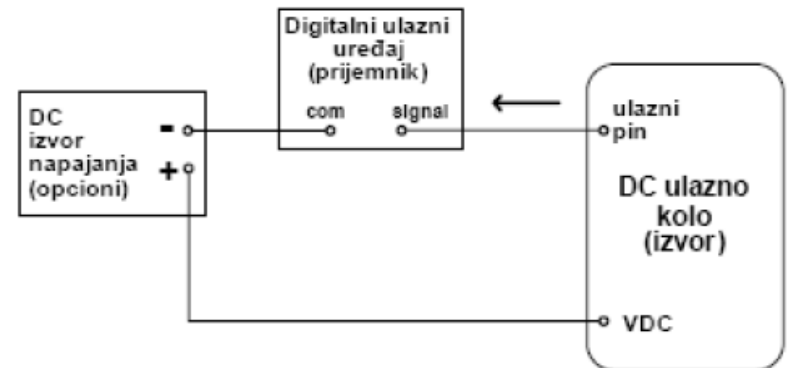
Galvanska izolacija

■ Digitalni i analogni ulazi i izlazi

Digitalni ulazi



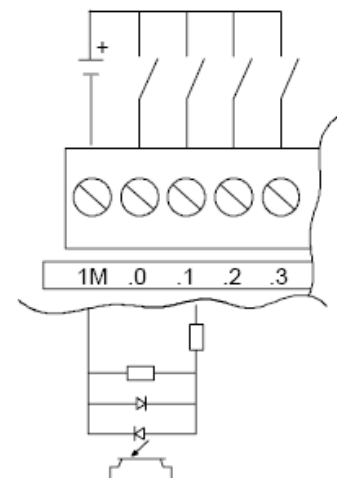
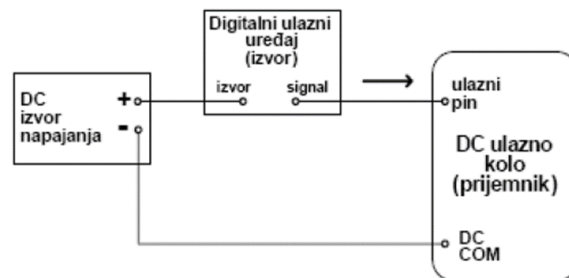
Sink koncept



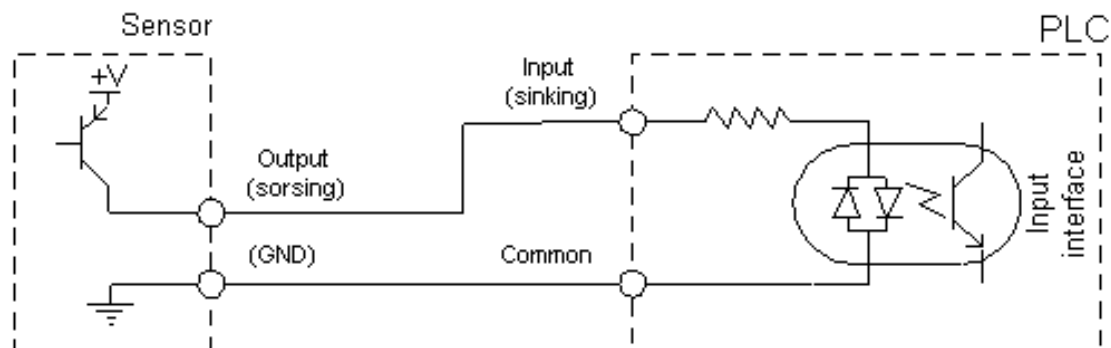
Source koncept

■ Digitalni i analogni ulazi i izlazi

Digitalni ulazi

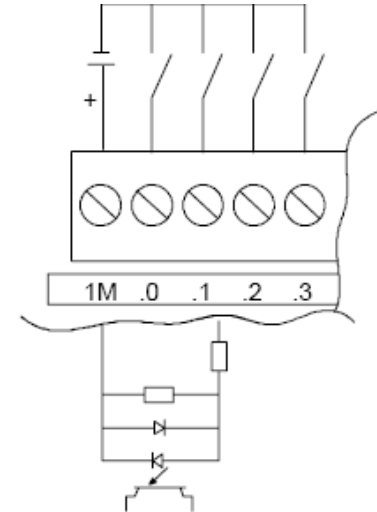
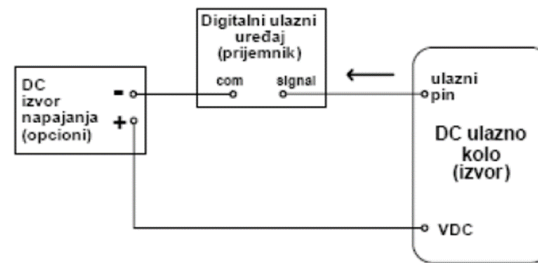


Sink koncept

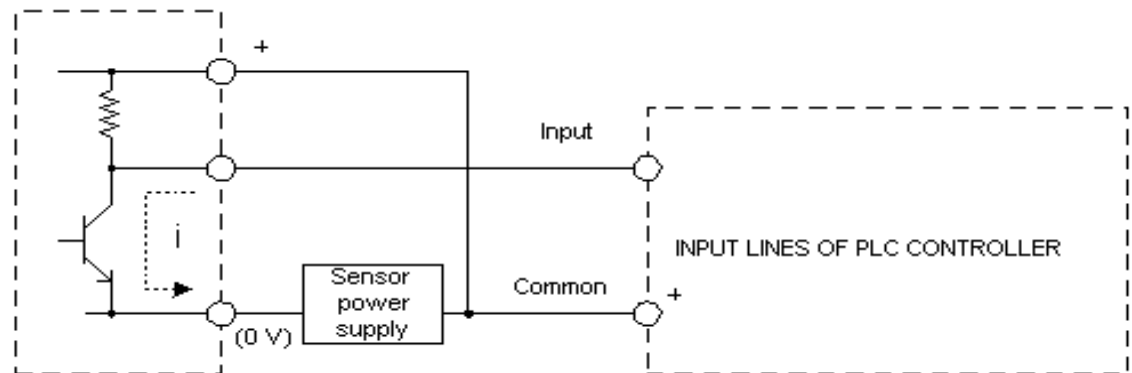


■ Digitalni i analogni ulazi i izlazi

Digitalni ulazi



Source koncept

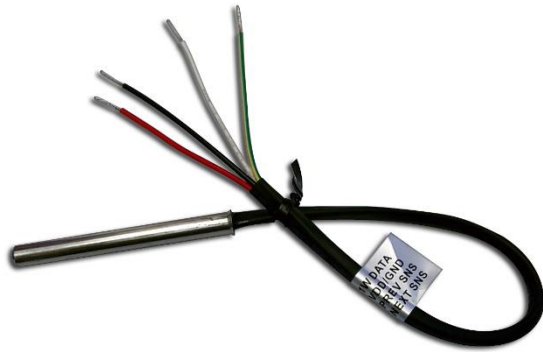


■ Digitalni i analogni ulazi i izlazi

Digitalni ulazi - simboli

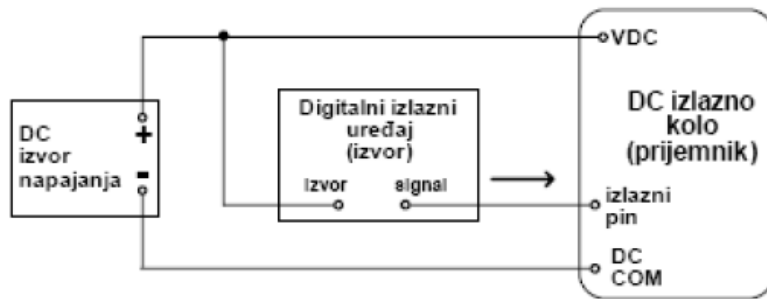
Opis	Simbol	
	Normalno otvoren	Normalno zatvoren
Običan prekidač		
Granični prekidač		
Prekidač sa oprugom		
Taster		
Temperaturni prekidač		
Prekidač aktiviran protokom		
Prekidač aktiviran nivoom		
Prekidač aktiviran pritiskom		
Prekidač aktiviran rastojanjem		
Relejni kontakt		
Osigurač		

■ PLC

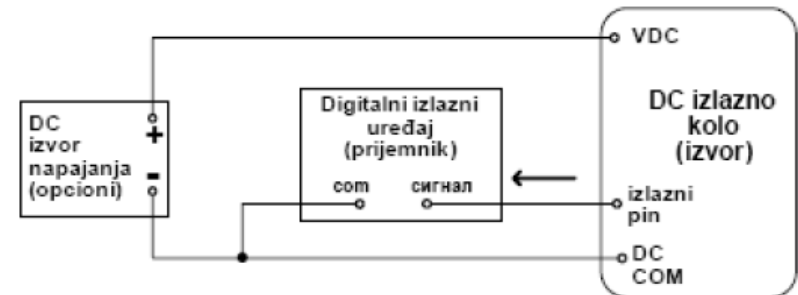


■ Digitalni i analogni ulazi i izlazi

Digitalni izlazi



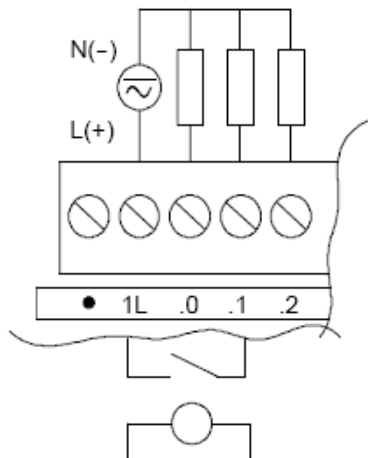
Sink koncept



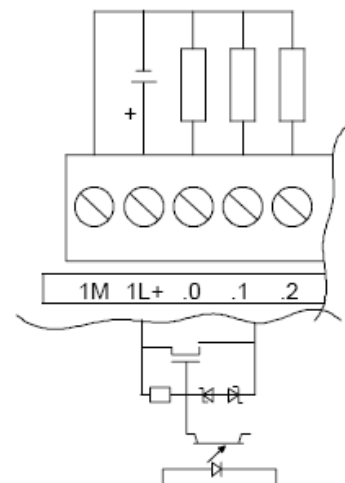
Source koncept

■ Digitalni i analogni ulazi i izlazi

Digitalni izlazi (source)



Relejni



Tranzistorski

■ Digitalni i analogni ulazi i izlazi

Analogni ulazi i izlazi

Ulazi

- Ulazi sa raznih senzora: temperatura, napon, protok, pritisak...

Izlazi

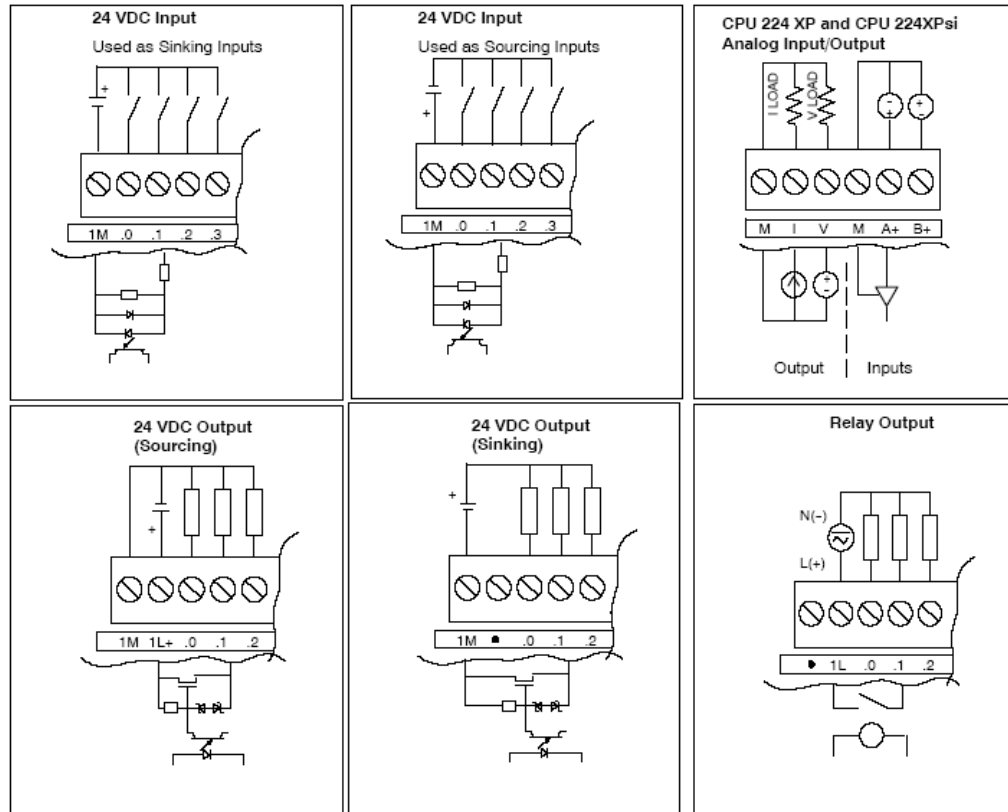
- Promenjivi analogni signal za regulaciju, npr. servo ventil, frekventni regulator...

Opsezi

- strujni 0mA – 20mA
- strujni 4mA – 20mA
- naponski 0-10V
- naponski -10-+10V

Najčešće 12 bitni

■ Digitalni i analogni ulazi i izlazi



■ Siemens SIMATIC S7-200 PLC serija



- **Različite CPU i broj ulaza/izlaza u S7-200 seriji**
- CPU 221 DC/DC/DC 6 Inputs/4 Outputs CPU 221 AC/DC/Relay 6 Inputs/4 Relays
- CPU 222 DC/DC/DC 8 Inputs/6 Outputs CPU 222 AC/DC/Relay 8 Inputs/6 Relays
- CPU 224 DC/DC/DC 14 Inputs/10 Outputs CPU 224 AC/DC/Relay 14 Inputs/10 Relays
- CPU 224XP DC/DC/DC 14 Inputs/10 Outputs CPU 224XP AC/DC/Relay 14 Inputs/10 Relays
- CPU 226 DC/DC/DC 24 Inputs/16 Outputs CPU 226 AC/DC/Relay 24 Inputs/16 Relays

■ Siemens SIMATIC S7-1200 PLC serija



CPU models		Order Number
CPU 1211C	CPU 1211C DC/DC/DC	6ES7 211-1AE31-0XB0
	CPU 1211C AC/DC/Relay	6ES7 211-1BE31-0XB0
	CPU 1211C DC/DC/Relay	6ES7 211-1HE31-0XB0
CPU 1212C	CPU 1212C DC/DC/DC	6ES7 212-1AE31-0XB0
	CPU 1212C AC/DC/Relay	6ES7 212-1BE31-0XB0
	CPU 1212C DC/DC/Relay	6ES7 212-1HE31-0XB0
CPU 1214C	CPU 1214C DC/DC/DC	6ES7 214-1AG31-0XB0
	CPU 1214C AC/DC/Relay	6ES7 214-1BG31-0XB0
	CPU 1214C DC/DC/Relay	6ES7 214-1HG31-0XB0
CPU 1215C	CPU 1215C DC/DC/DC	6ES7 215-1AG31-0XB0
	CPU 1215C AC/DC/Relay	6ES7 215 -1BG31-0XB0
	CPU 1215C DC/DC/Relay	6ES7 215-1HG31-0XB0

Feature	CPU 221	CPU 222	CPU 224	CPU 224XP	CPU 226
Physical size (mm)	90 x 80 x 62	90 x 80 x 62	120.5 x 80 x 62	140 x 80 x 62	190 x 80 x 62
Program memory: with run mode edit without run mode edit	4096 bytes 4096 bytes	4096 bytes 4096 bytes	8192 bytes 12288 bytes	12288 bytes 16384 bytes	16384 bytes 24576 bytes
Data memory	2048 bytes	2048 bytes	8192 bytes	10240 bytes	10240 bytes
Memory backup	50 hours typical	50 hours typical	100 hours typical	100 hours typical	100 hours typical
Local on-board I/O Digital Analog	6 In/4 Out -	8 In/6 Out -	14 In/10 Out -	14 In/10 Out 2 In/1 Out	24 In/16 Out -
Expansion modules	0 modules	2 modules ¹	7 modules ¹	7 modules ¹	7 modules ¹
High-speed counters Single phase Two phase	4 at 30 kHz 2 at 20 kHz	4 at 30 kHz 2 at 20 kHz	6 at 30 kHz 4 at 20 kHz	4 at 30 kHz 2 at 200 kHz 3 at 20 kHz 1 at 100 kHz	6 at 30 kHz 4 at 20 kHz
Pulse outputs (DC)	2 at 20 kHz	2 at 20 kHz	2 at 20 kHz	2 at 100 kHz	2 at 20 kHz
Analog adjustments	1	1	2	2	2
Real-time clock	Cartridge	Cartridge	Built-in	Built-in	Built-in
Communications ports	1 RS-485	1 RS-485	1 RS-485	2 RS-485	2 RS-485
Floating-point math	Yes				
Digital I/O image size	256 (128 in, 128 out)				
Boolean execution speed	0.22 microseconds/instruction				

Feature		CPU 1211C	CPU 1212C	CPU 1214C	CPU 1215C
Physical size (mm)		90 x 100 x 75	90 x 100 x 75	110 x 100 x 75	130 x 100 x 75
User memory	Work	30 Kbytes	50 Kbytes	75 Kbytes	100 Kbytes
	Load	1 Mbyte	1 Mbyte	4 Mbytes	4 Mbytes
	Retentive	10 Kbytes	10 Kbytes	10 Kbytes	10 Kbytes
Local on-board I/O	Digital	6 inputs/4 outputs	8 inputs/6 outputs	14 inputs/10 outputs	14 inputs/10 outputs
	Analog	2 inputs	2 inputs	2 inputs	2 inputs / 2 outputs
Process image size	Inputs (I)	1024 bytes	1024 bytes	1024 bytes	1024 bytes
	Outputs (Q)	1024 bytes	1024 bytes	1024 bytes	1024 bytes
Bit memory (M)		4096 bytes	4096 bytes	8192 bytes	8192 bytes
Signal module (SM) expansion		None	2	8	8
Signal board (SB), Battery board (BB), or communication board (CB)		1	1	1	1
Communication module (CM) (left-side expansion)		3	3	3	3
High-speed counters	Total	3 built-in I/O, 5 with SB	4 built-in I/O, 6 with SB	6	6
	Single phase	3 at 100 kHz	3 at 100 kHz	3 at 100 kHz	3 at 100 kHz
		SB: 2 at 30 kHz	1 at 30 kHz SB: 2 at 30 kHz	3 at 30 kHz	3 at 30 kHz
	Quadrature phase	3 at 80 kHz SB: 2 at 20 kHz	3 at 80 kHz 1 at 20 kHz SB: 2 at 20 kHz	3 at 80 kHz 3 at 20 kHz	3 at 80 kHz 3 at 20 kHz
Pulse outputs ¹		4	4	4	4
Memory card		SIMATIC Memory card (optional)			
Real time clock retention time		20 days, typ. / 12 day min. at 40 degrees C (maintenance-free Super Capacitor)			
PROFINET		1 Ethernet communication port			2 Ethernet communication ports
Real math execution speed		2.3 µs/instruction			
Boolean execution speed		0.08 µs/instruction			

¹ For CPU models with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

■ Napajanje

Technical data		CPU 1211C AC/DC/Relay	CPU 1211C DC/DC/Relay	CPU 1211C DC/DC/DC
Voltage range		85 to 264 VAC	20.4 VDC to 28.8 VDC 22.0 VDC to 28.8 VDC for ambient temperature -20° C to 0° C	
Line frequency		47 to 63 Hz	--	--
Input current	CPU only at max. load	60 mA at 120 VAC 30 mA at 240 VAC	300 mA at 24 VDC	300 mA at 24 VDC
	CPU with all expansion accessories at max. load	180 mA at 120 VAC 90 mA at 240 VAC	900 mA at 24 VDC	900 mA at 24 VDC
Inrush current (max.)		20 A at 264 VAC	12 A at 28.8 VDC	12 A at 28.8 VDC
Isolation (input power to logic)		1500 VAC	Not isolated	Not isolated
Ground leakage, AC line to functional earth		0.5 mA max.	--	--
Hold up time (loss of power)		20 ms at 120 VAC 80 ms at 240 VAC	10 ms at 24 VDC	10 ms at 24 VDC
Internal fuse, not user replaceable		3 A, 250 V, slow blow	3 A, 250 V, slow blow	3 A, 250 V, slow blow

■ Digitalni ulazi

Technical data	CPU 1211C AC/DC/Relay, CPU 1211C DC/DC/Relay, and CPU 1211C DC/DC/DC
Number of inputs	6
Type	Sink/Source (IEC Type 1 sink)
Rated voltage	24 VDC at 4 mA, nominal
Continuous permissible voltage	30 VDC, max.
Surge voltage	35 VDC for 0.5 sec.
Logic 1 signal (min.)	15 VDC at 2.5 mA
Logic 0 signal (max.)	5 VDC at 1 mA
Isolation (field side to logic)	500 VAC for 1 minute
Isolation groups	1
Filter times	0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 ms (selectable in groups of 4)
HSC clock input rates (max.) (Logic 1 Level = 15 to 26 VDC)	Single phase: 100 KHz Quadrature phase: 80 KHz
Number of inputs on simultaneously	6 at 60° C horizontal, 50° C vertical
Cable length (meters)	500 m shielded, 300 m unshielded, 50 m shielded for HSC inputs

Technical data	CPU 1211C AC/DC/Relay and CPU 1211C DC/DC/Relay	CPU 1211C DC/DC/DC
Number of outputs	4	4
Type	Relay, dry contact	Solid state - MOSFET (sourcing)
Voltage range	5 to 30 VDC or 5 to 250 VAC	20.4 to 28.8 VDC
Logic 1 signal at max. current	--	20 VDC min.
Logic 0 signal with 10 K Ω load	--	0.1 VDC max.
Current (max.)	2.0 A	0.5 A
Lamp load	30 W DC / 200 W AC	5 W
ON state resistance	0.2 Ω max. when new	0.6 Ω max.
Leakage current per point	Technical data	CPU 1211C AC/DC/Relay and CPU 1211C DC/DC/Relay
Surge current		CPU 1211C DC/DC/DC
Overload protection	Maximum relay switching frequency	1 Hz
Isolation (field side to logic)	Switching delay (Qa.0 to Qa.3)	10 ms max.
	Pulse Train Output rate (Qa.0 and Qa.2)	Not recommended ¹
	Lifetime mechanical (no load)	10,000,000 open/close cycles
	Lifetime contacts at rated load	100,000 open/close cycles
	Behavior on RUN to STOP	Last value or substitute value (default value 0)
	Number of outputs on simultaneously	4 at 60° C horizontal, 50° C vertical
	Cable length (meters)	500 m shielded, 150 m unshielded

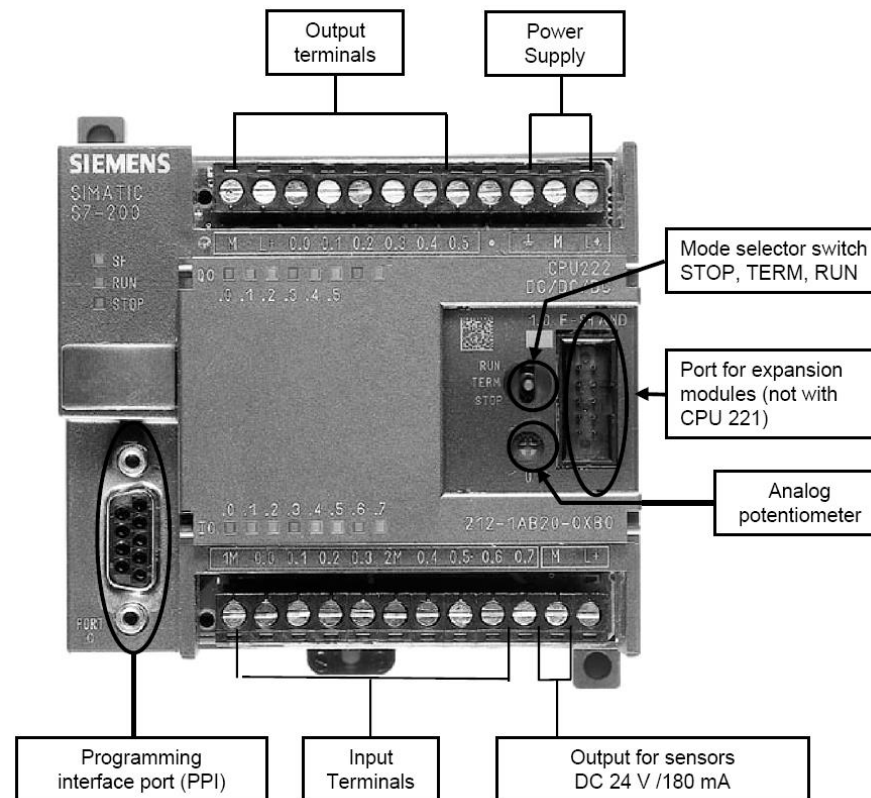
■ Analogni ulazi

Technical data	Description
Number of inputs	2
Type	Voltage (single-ended)
Full-scale range	0 to 10 V
Full-scale range (data word)	0 to 27648
Overshoot range	10.001 to 11.759 V
Overshoot range (data word)	27,649 to 32,511
Overflow range	11.760 to 11.852 V
Overflow range (data word)	32,512 to 32,767
Resolution	10 bits
Maximum withstand voltage	35 VDC
Smoothing	None, Weak, Medium, or Strong See the table for step response (ms) for the analog inputs of the CPU (Page 711).
Noise rejection	10, 50, or 60 Hz
Impedance	$\geq 100 \text{ K}\Omega$
Isolation (field side to logic)	None
Accuracy (25°C / -20 to 60°C)	3.0% / 3.5% of full-scale
Cable length (meters)	100 m, shielded twisted pair

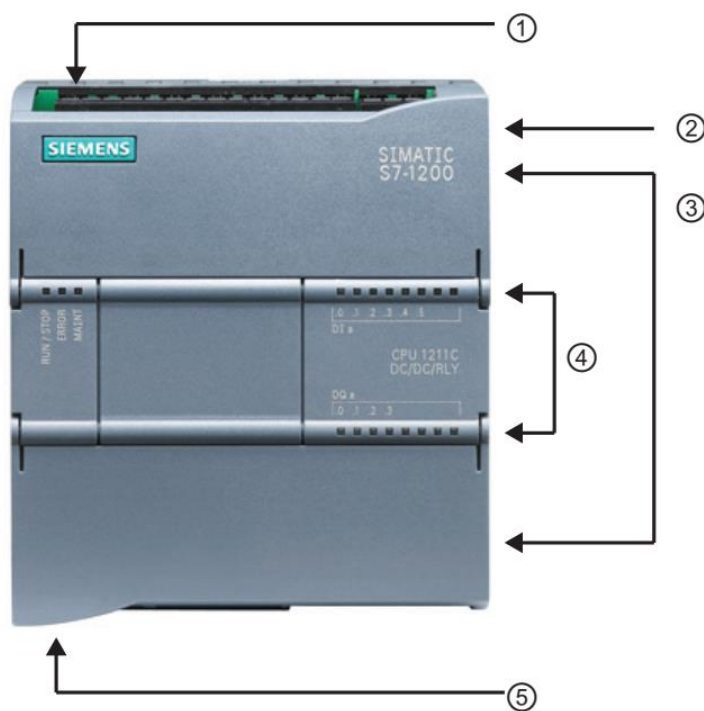
■ Moduli za proširenja

Expansion Modules		Types		
Discrete modules	Input	8 x DC In	8 x AC In	16 x DC In
	Output	4 x DC	4 x Relays	
		8 x DC Out	8 x AC Out	8 x Relay
	Combination	4 x DC In / 4 x DC Out 4 x DC In / 4 x Relay	8 x DC In / 8 x DC Out 8 x DC In / 8 x Relay	16 x DC In/16 x DC Out 16 x DC In/16 x Relay
Analog modules	Input	4 x Analog In	4 x Thermocouple In	2 x RTD In
	Output	2 x Analog Out		
	Combination	4 x Analog In / 1 Analog Out		
Intelligent modules		Position Ethernet	Modem Internet	PROFIBUS-DP
Other modules		AS-Interface		

■ PLC S7-200 - osnovni model (prednja ploča)

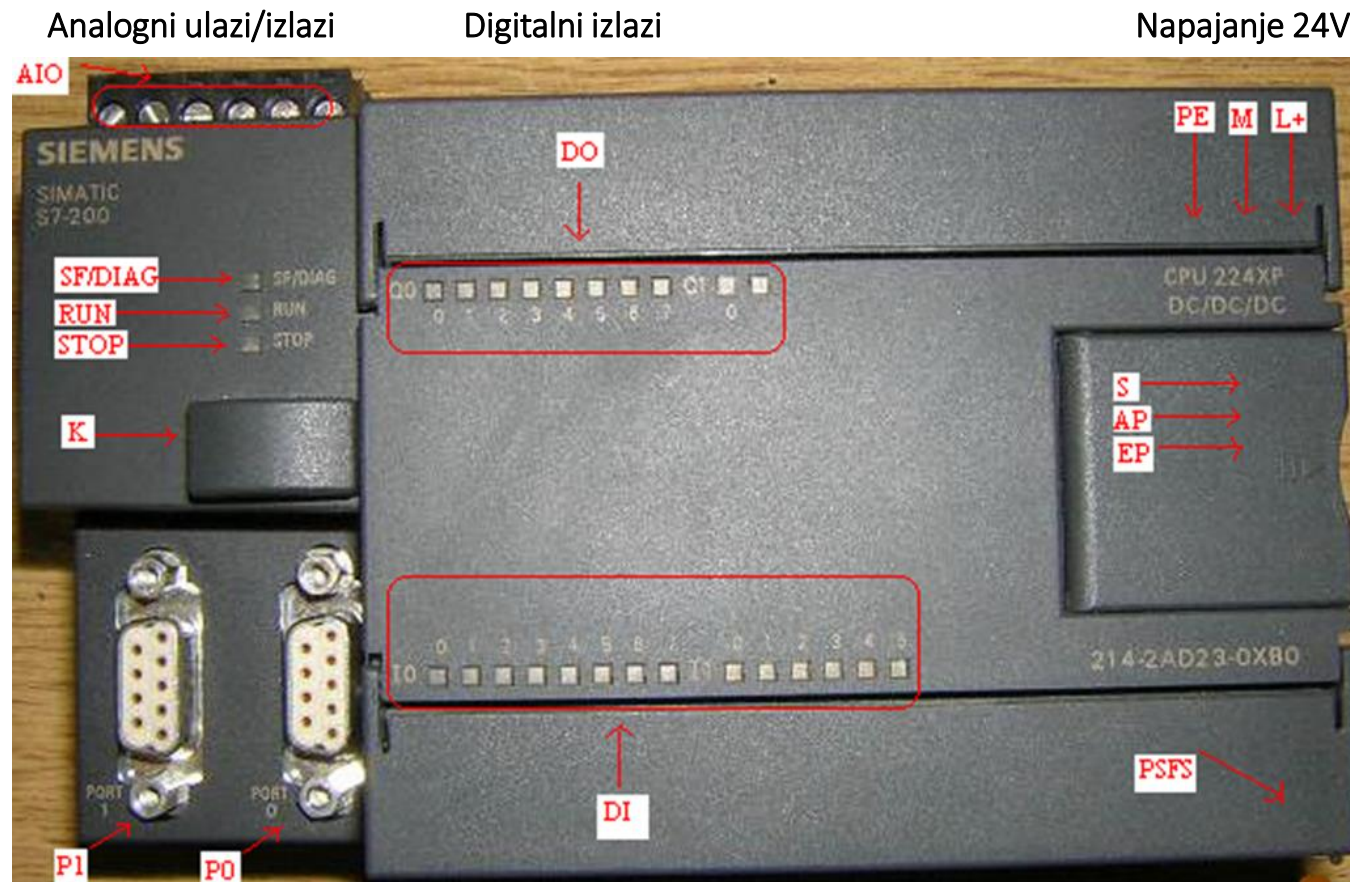


■ PLC S7-1200 - osnovni model (prednja ploča)



- ① Power connector
- ② Memory card slot under top door
- ③ Removable user wiring connectors (behind the doors)
- ④ Status LEDs for the on-board I/O
- ⑤ PROFINET connector (on the bottom of the CPU)

■ PLC



Prekidač run/stop

Kabel za proširenje

Dva potenc.

Dva komunikaciona serijska porta

Digitalni ulazi

Izlaznih +24V

■ PLC S7-200 CPU 224XP - Prednja ploča

■ PLC S7-200 - osnovni model (prednja ploča)

Oznake imaju značenje:

AIO – analogni ulazi i izlazi

DO – digitalni izlazi

DI – digitalni ulazi

PE, M, L+ – napajanje PLC-a: zaštitni (uzemljenje), “-” i “+” kraj jednosmernog naponskog izvora, respektivno

SF/DIAG – LED dioda za signalizaciju u slučaju sistemske greške

RUN – LED dioda za signalizaciju radnog režima PLC-a

STOP – LED dioda za signalizaciju stop režima PLC-a

K – konektor za nadogradnju uređaja (memorijskim kertridžom, tajmerom, spoljnom baterijom)

S – prekidač za biranje željenog radnog režima uređaja

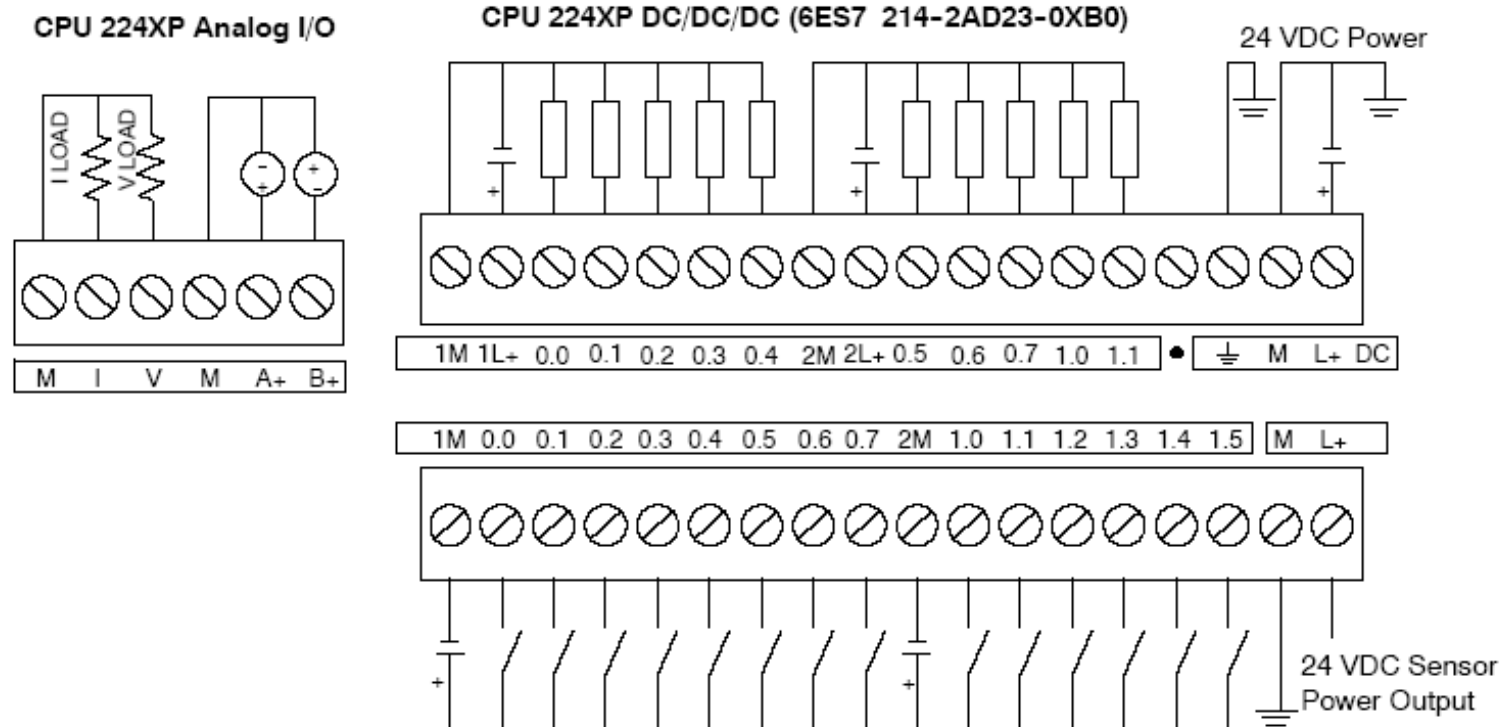
AP – potenciometri za regulaciju raspoloživog internog analognog signala

EP – port za povezivanje sa modulima za proširenje

P0,P1 – portovi za povezivanje sa računarom, tekst displej jedinicom, touch panelom

PSFS – jednosmerni naponski izvor od 24V, napajanje senzora

■ Siemens S7-200 (CPU 224XP)



■ Siemens S7-200 (CPU 224XP)

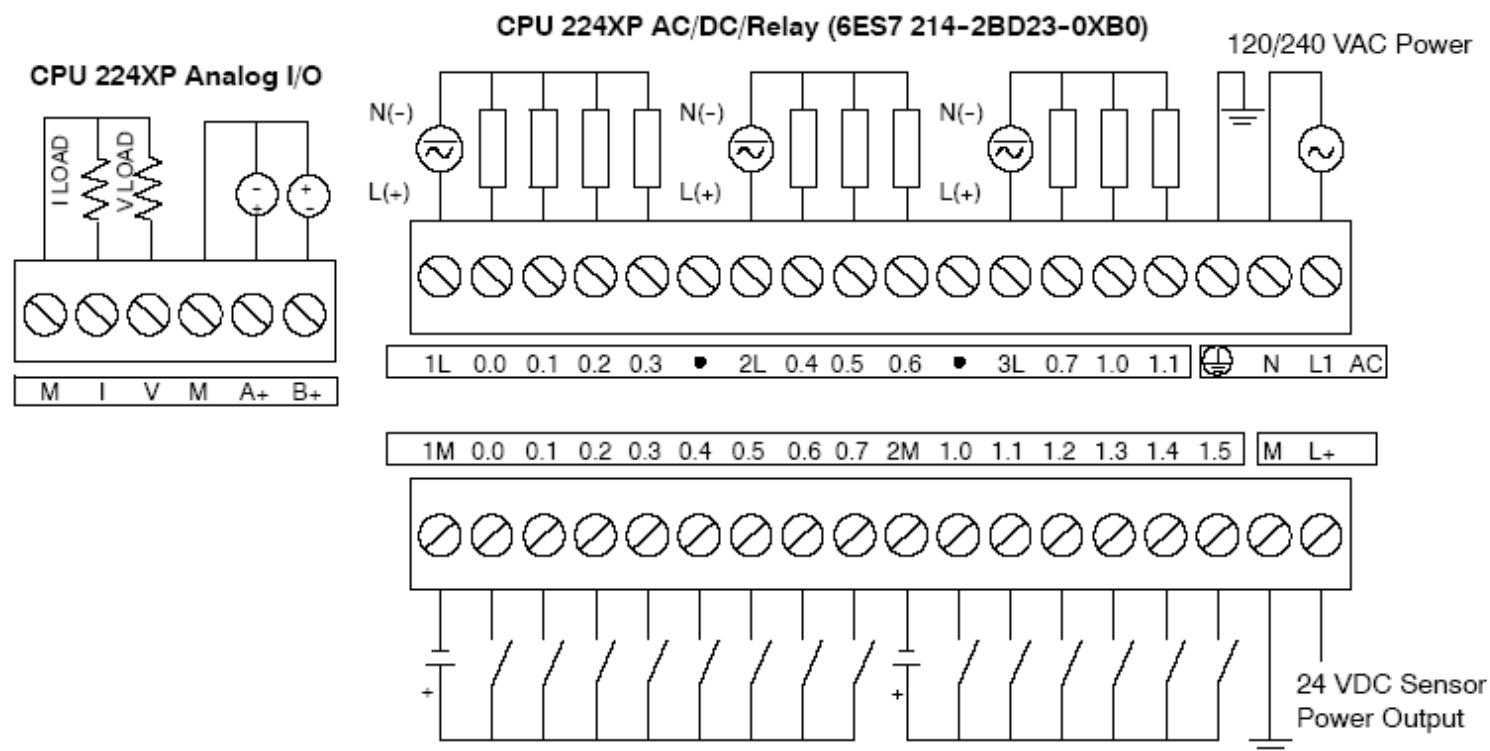
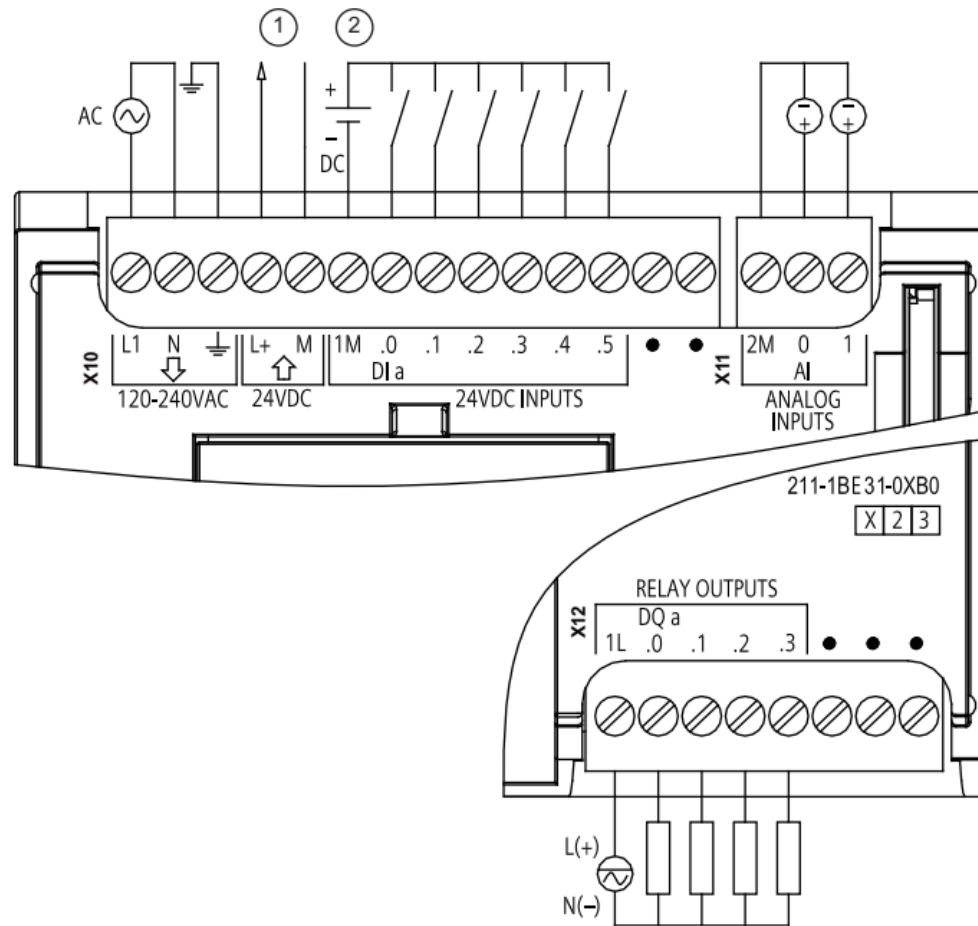


Table A- 20 CPU 1211C AC/DC/Relay (6ES7 211-1BE31-0XB0)



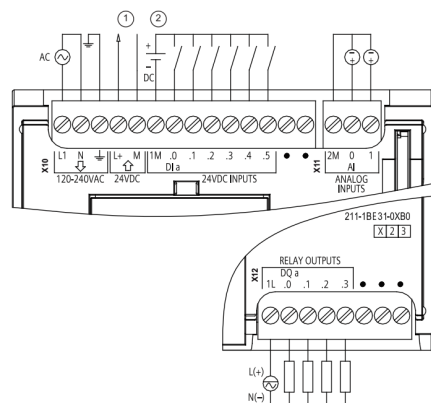
① 24 VDC Sensor Power Out
For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

② For sinking inputs, connect "-" to "M" (shown).

For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 20 CPU 1211C AC/DC/Relay (6ES7 211-1BE31-0XB0)



① 24 VDC Sensor Power Out

For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

② For sinking inputs, connect "-" to "M" (shown).

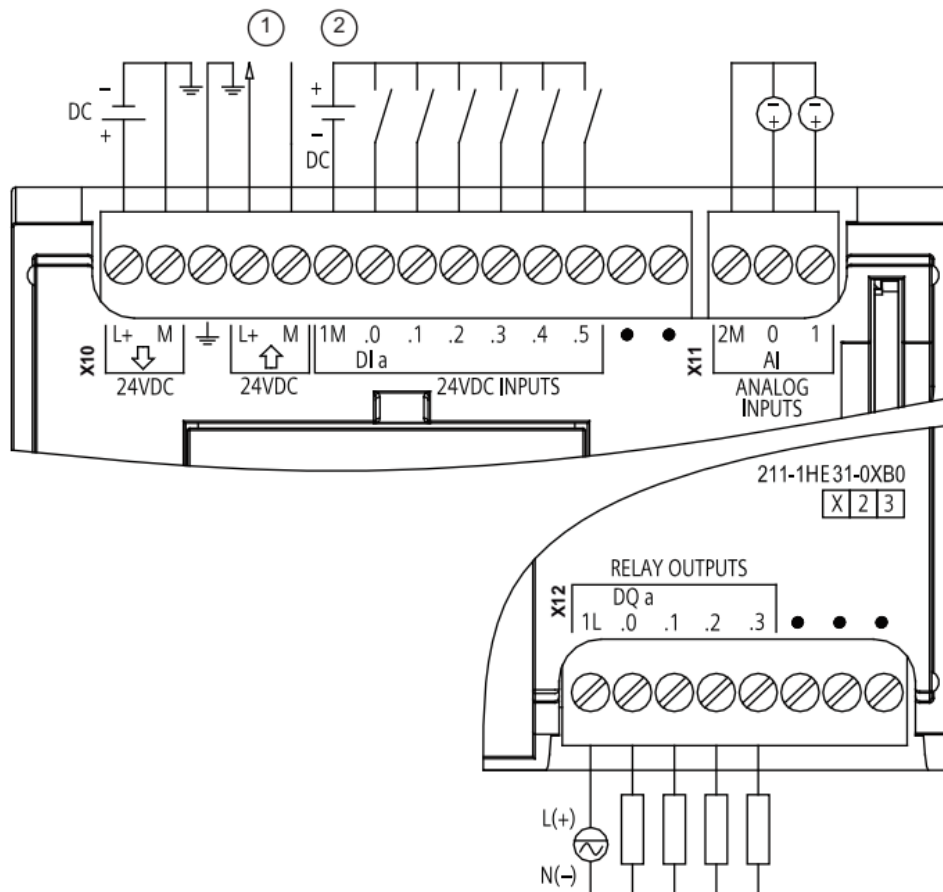
For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 21 Connector pin locations for CPU 1211C AC/DC/Relay (6ES7 211-1BE31-0XB0)

Pin	X10	X11 (gold)	X12
1	L1 / 120-240 VAC	2 M	1L
2	N / 120-240 VAC	AI 0	DQ a.0
3	Functional Earth	AI 1	DQ a.1
4	L+ / 24VDC Sensor Out	--	DQ a.2
5	M / 24VDC Sensor Out	--	DQ a.3
6	1M	--	No connection
7	DI a.0	--	No connection
8	DI a.1	--	No connection
9	DI a.2	--	--
10	DI a.3	--	--
11	DI a.4	--	--
12	DI a.5	--	--
13	No connection	--	--
14	No connection	--	--

Table A- 22 CPU 1211C DC/DC/Relay (6ES7 211-1HE31-0XB0)



① 24 VDC Sensor Power Out

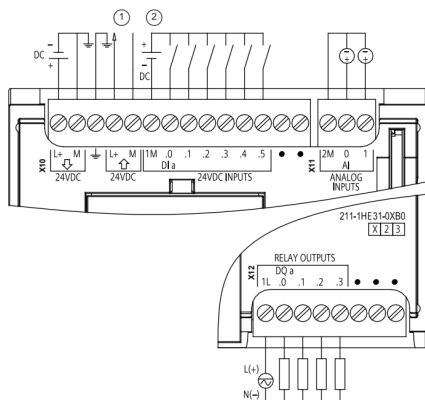
For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

② For sinking inputs, connect "-" to "M" (shown).

For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 22 CPU 1211C DC/DC/Relay (6ES7 211-1HE31-0XB0)



① 24 VDC Sensor Power Out

For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

② For sinking inputs, connect "-" to "M" (shown).

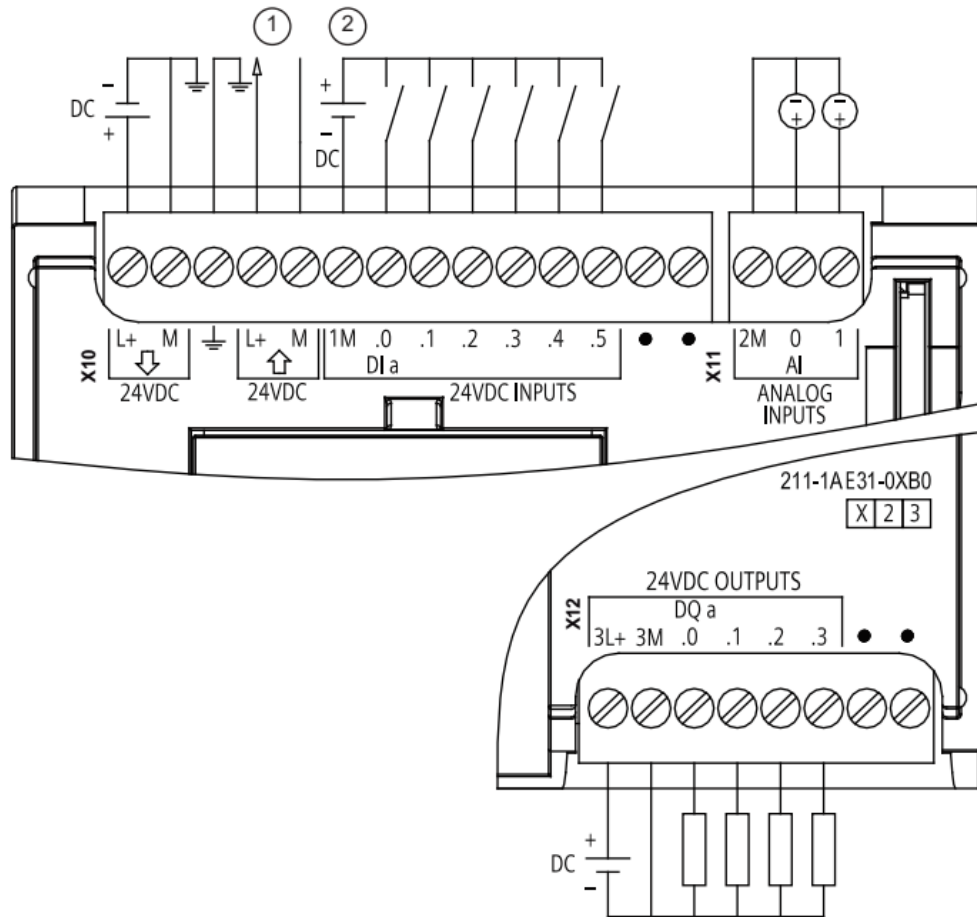
For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 23 Connector pin locations for CPU 1211C DC/DC/Relay (6ES7 211-1HE31-0XB0)

Pin	X10	X11 (gold)	X12
1	L+ / 24VDC	2 M	1L
2	M / 24VDC	AI 0	DQ a.0
3	Functional Earth	AI 1	DQ a.1
4	L+ / 24VDC Sensor Out	--	DQ a.2
5	M / 24VDC Sensor Out	--	DQ a.3
6	1M	--	No connection
7	DI a.0	--	No connection
8	DI a.1	--	No connection
9	DI a.2	--	--
10	DI a.3	--	--
11	DI a.4	--	--
12	DI a.5	--	--
13	No connection	--	--
14	No connection	--	--

Table A- 24 CPU 1211C DC/DC/DC (6ES7 211-1AE31-0XB0)



① 24 VDC Sensor Power Out

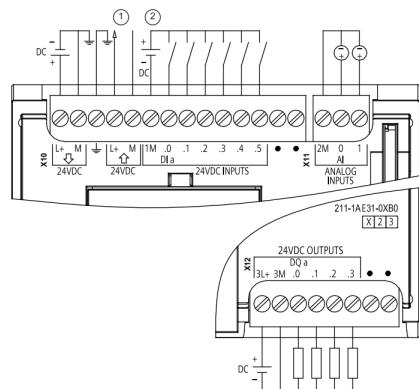
For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

② For sinking inputs, connect "-" to "M" (shown).

For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 24 CPU 1211C DC/DC/DC (6ES7 211-1AE31-0XB0)



- ① 24 VDC Sensor Power Out

For additional noise immunity, connect "M" to chassis ground even if not using sensor supply.

- ② For sinking inputs, connect "-" to "M" (shown).

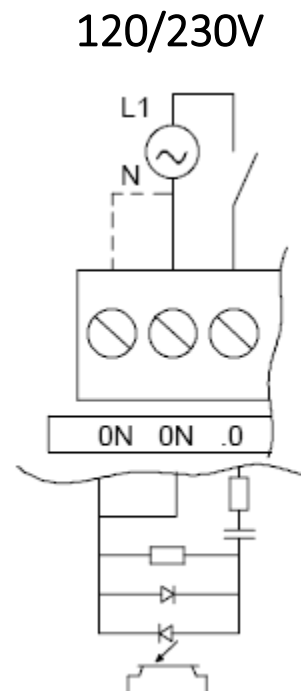
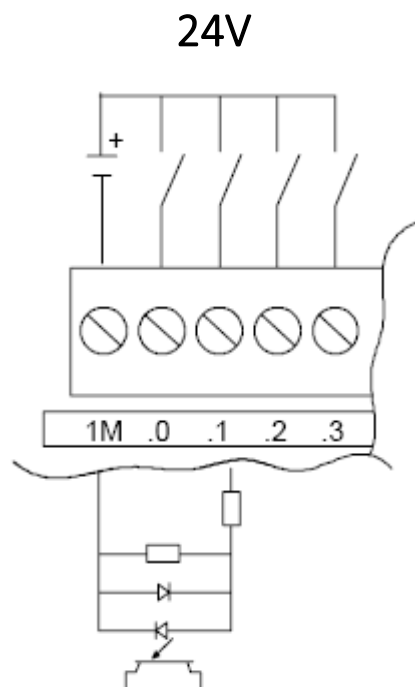
For sourcing inputs, connect "+" to "M".

Note: X11 connectors must be gold. See Appendix C, Spare Parts for order number.

Table A- 25 Connector pin locations for CPU 1211C DC/DC/DC (6ES7 211-1AE31-0XB0)

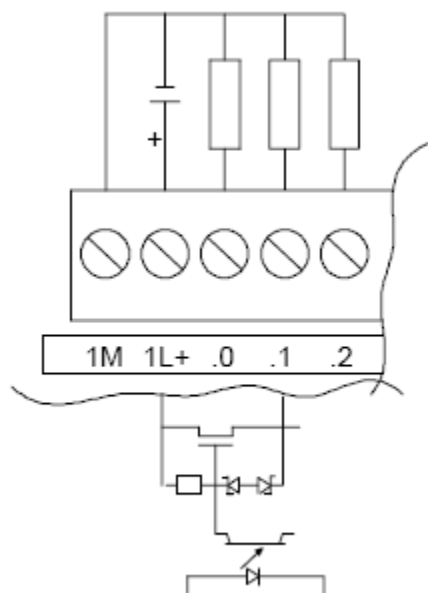
Pin	X10	X11 (gold)	X12
1	L+ / 24VDC	2 M	3L+
2	M / 24VDC	AI 0	3M
3	Functional Earth	AI 1	DQ a.0
4	L+ / 24VDC Sensor Out	--	DQ a.1
5	M / 24VDC Sensor Out	--	DQ a.2
6	1M	--	DQ a.3
7	DI a.0	--	No connection
8	DI a.1	--	No connection
9	DI a.2	--	--
10	DI a.3	--	--
11	DI a.4	--	--
12	DI a.5	--	--
13	No connection	--	--
14	No connection	--	--

■ Dodatni moduli (ulazi)

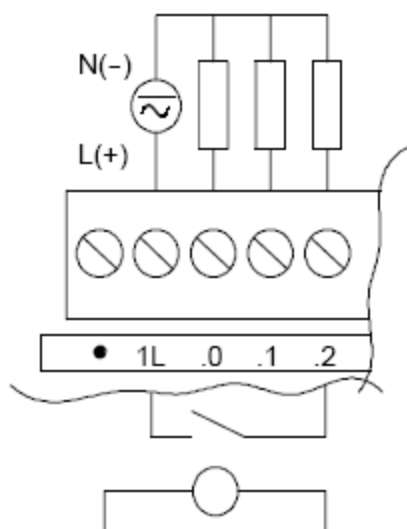


■ Dodatni moduli (izlazi)

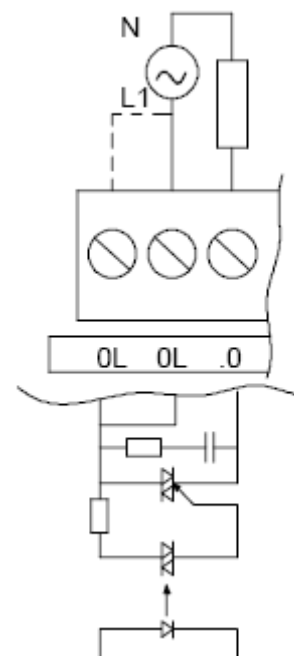
24V



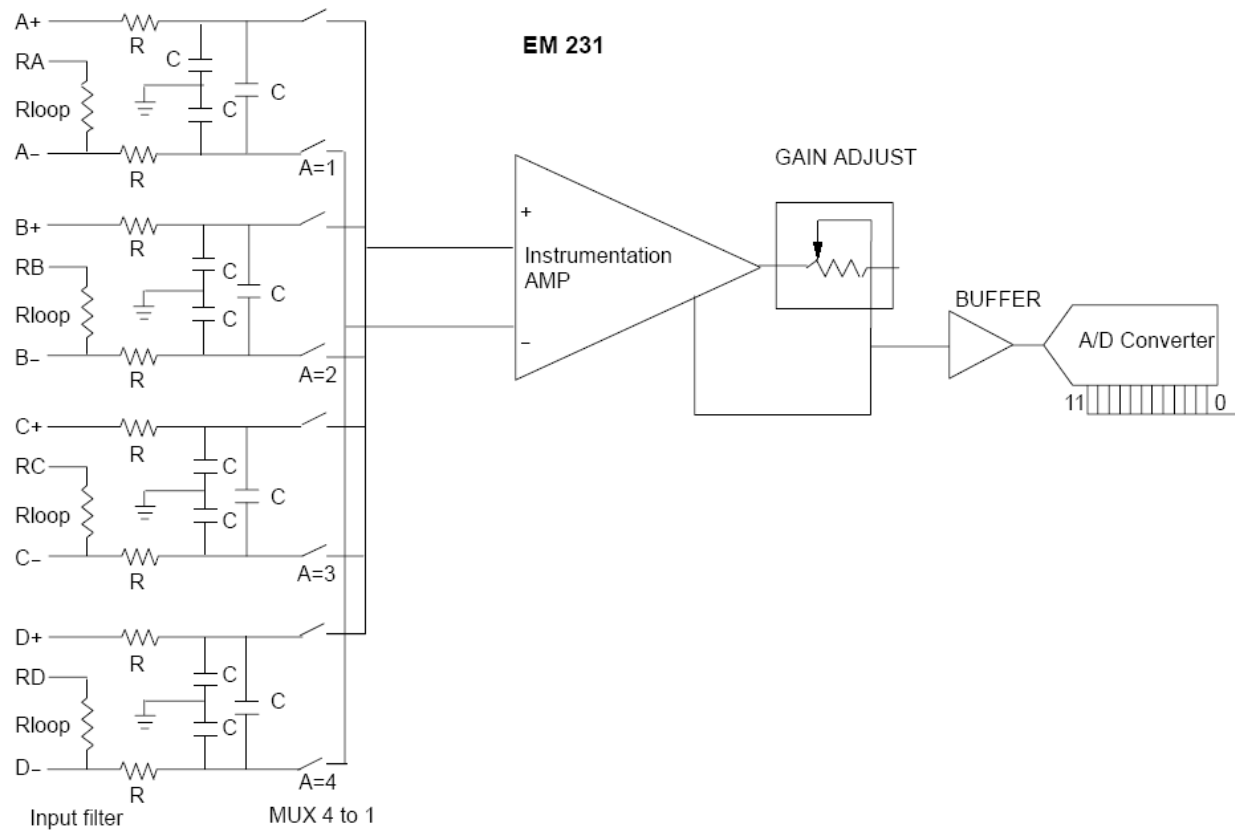
Relejni



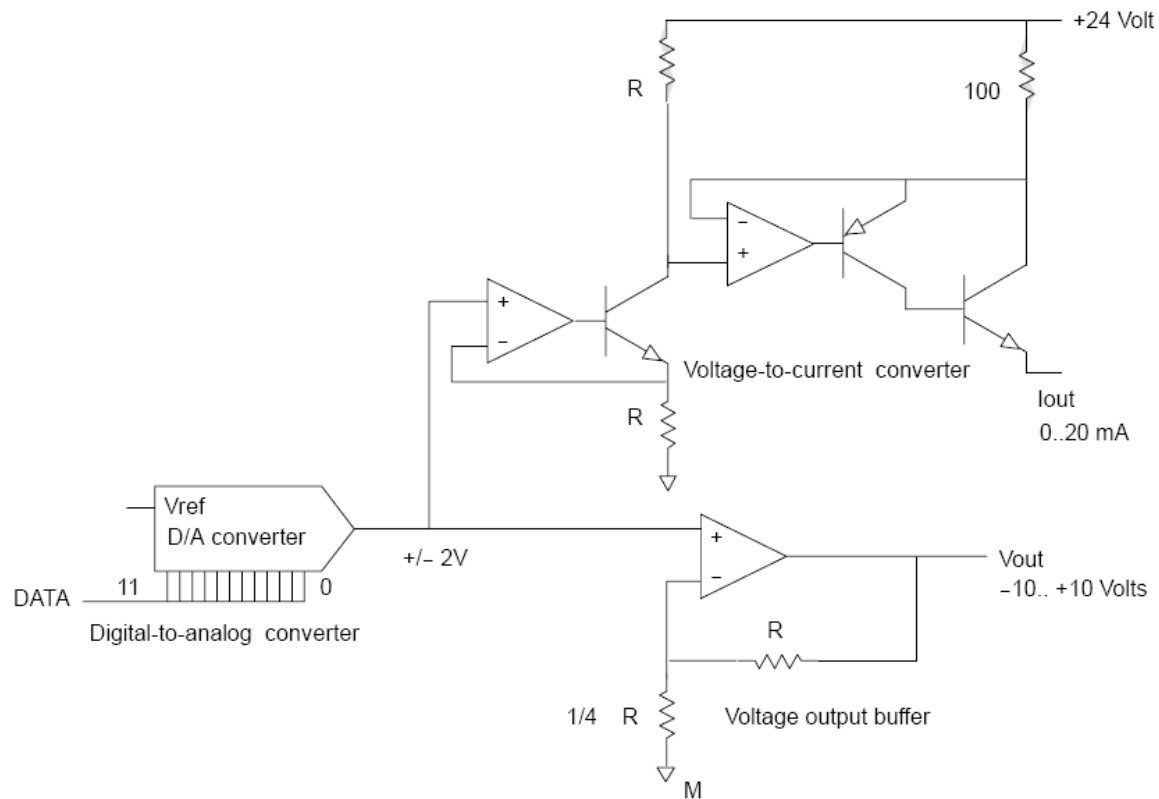
Trijak



■ Dodatni moduli (analogni ulaz)

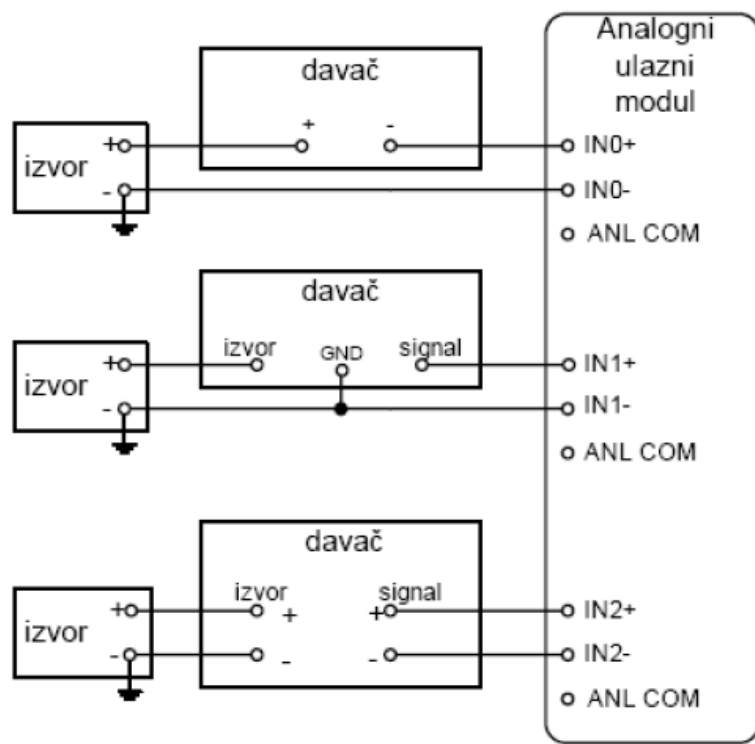


■ Dodatni moduli (analogni izlaz)

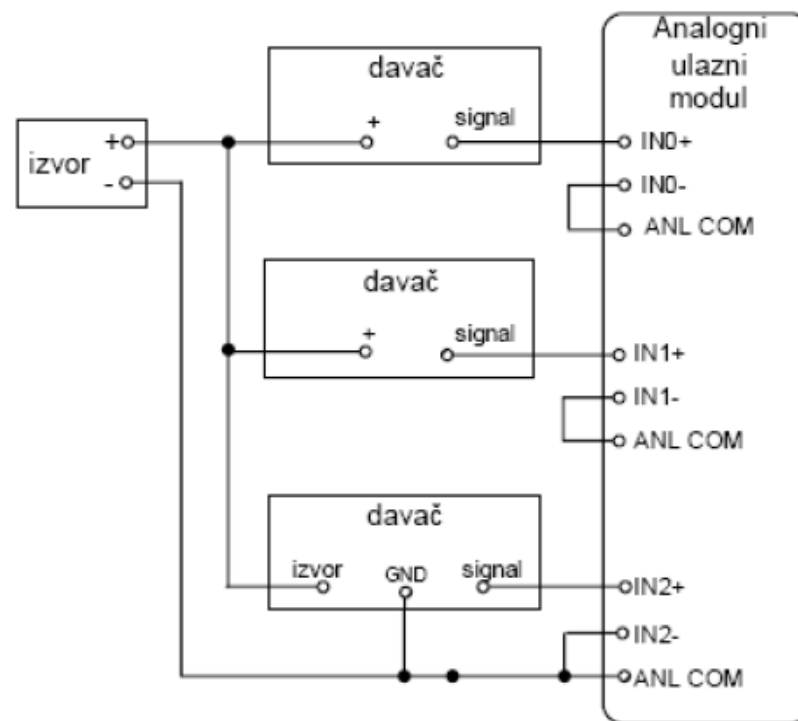


■ Načini vezivanja analognih ulaza

Diferencijalno



Sa zajedničkim krajem



■ S7-200 – primer povezivanja ulaza/izlaza

Ulazni portovi

I0.0 – kontroliše motor

I0.1 – kontroliše smer

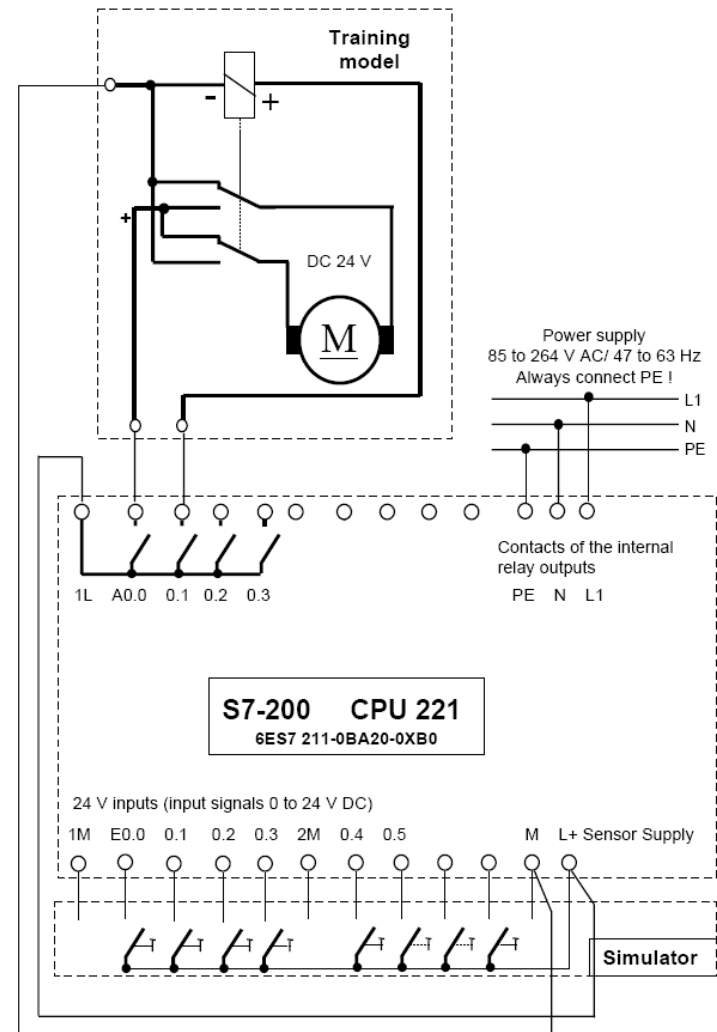
- ulazi primaju +24V i to opet iz PLC
- pritisnut taster dovodi 24V na ulaz
- nepritisnut ostavlja ulaz bez napona

Izlazni portovi

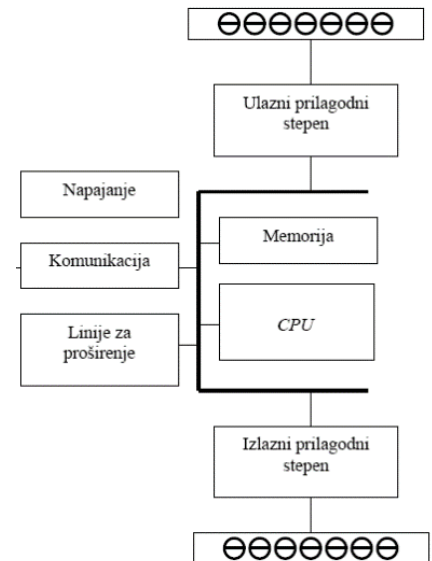
Q0.0 – kontroliše motor (ON/OFF)

Q0.1 – kontroliše smer

- Koriste +24V iz PLC
- Relejni izlazi spoje +24V
- na motor ili na rele za smer



■ Softverska organizacija



■ Način rada PLC-a

1. Prihvat stanja ulaza (senzor, prekidač...) u memoriju, u posebno područje koje predstavlja sliku ulaza
2. Izvršenje programa - Ulazni operandi: memorija (slika ulaza). Rezultati: u memoriju (slika izlaza). Dakle, podaci ne direktno sa ulaznih modula, niti se direktno iznose na izlazne module, već program razmenjuje podatke isključivo sa memorijom!
3. Ispis stanja izlaza - prenos podataka iz slike izlaza na izlazne linije (registre izlaznih modula)
4. Komunikacija
5. Održavanje – ažuriranje internih časovnika i registara, upravljanje memorijom, kontrola ispravnosti PLC-a, kao i niz drugih poslova vezanih za održavanje sistema

■ Način rada PLC-a

Posle izvršenja petog koraka PLC se vraća na početak ciklusa i neprekidno ponavlja sve korake.

Osnovni sken ciklus može biti modifikovan pomoću zahteva za prekid ili nekih drugih specijalnih programskih naredbi.

Prihvat ulaza, obrada, ispis izlaza, komunikacija i održavanje se ciklički ponavljaju i u skladu sa unesenim programom, njihovo pojedinačno trajanje zavisi od broja ulaza i izlaza i složenosti algoritma i vrste primenjenog procesora. Ciklusi obrade obično traju od 0,1 ms do nekoliko desetina ms.

■ Kraj