

Digitalni multimetri

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Mjerenje



Mjerenje

- Uvijek želimo najbolje za sebe
- Što znači bolje?
 - Ukusnije, svježije, kaloričnije ili jeftinije povrće
 - Više, jače, brže, točnije...
- Tek kada znamo KOLIKO, možemo stvari rangirati po dobroti
- Tek tako ih možemo napraviti boljima

Mjerenje

- Mjerenje vremena...



- ...ili nečeg drugog

Mjerenje



WIMM One –
wearable computer



Benning CM8 –
multimeter

[1] en.wikipedia.org/wiki/Wearable_computer

[2] www.roselectronic.com/?str=1406

FLUKE 179 TRUE RMS MULTIMETER



AutoHOLD
HOLD MINMAX RANGE

Control panel featuring a rotary selector dial and several function buttons. The dial is positioned to the right of the 'OFF' position and is currently set to the AC voltage range. The dial has markings for: OFF, Hz V (AC), Hz V (DC), mV (DC), Ω (resistance), and a diode symbol. The function buttons include: a light icon, a temperature icon, a mV icon, an Ω icon, a diode icon, a Hz mA icon, and a Hz A icon.

Terminal block with four ports: 400 mA, 10A, COM, and V Ω. Safety ratings are indicated: 600V CAT IV and 1000V CAT III. A 'FUSED' label is positioned between the 10A and COM ports.

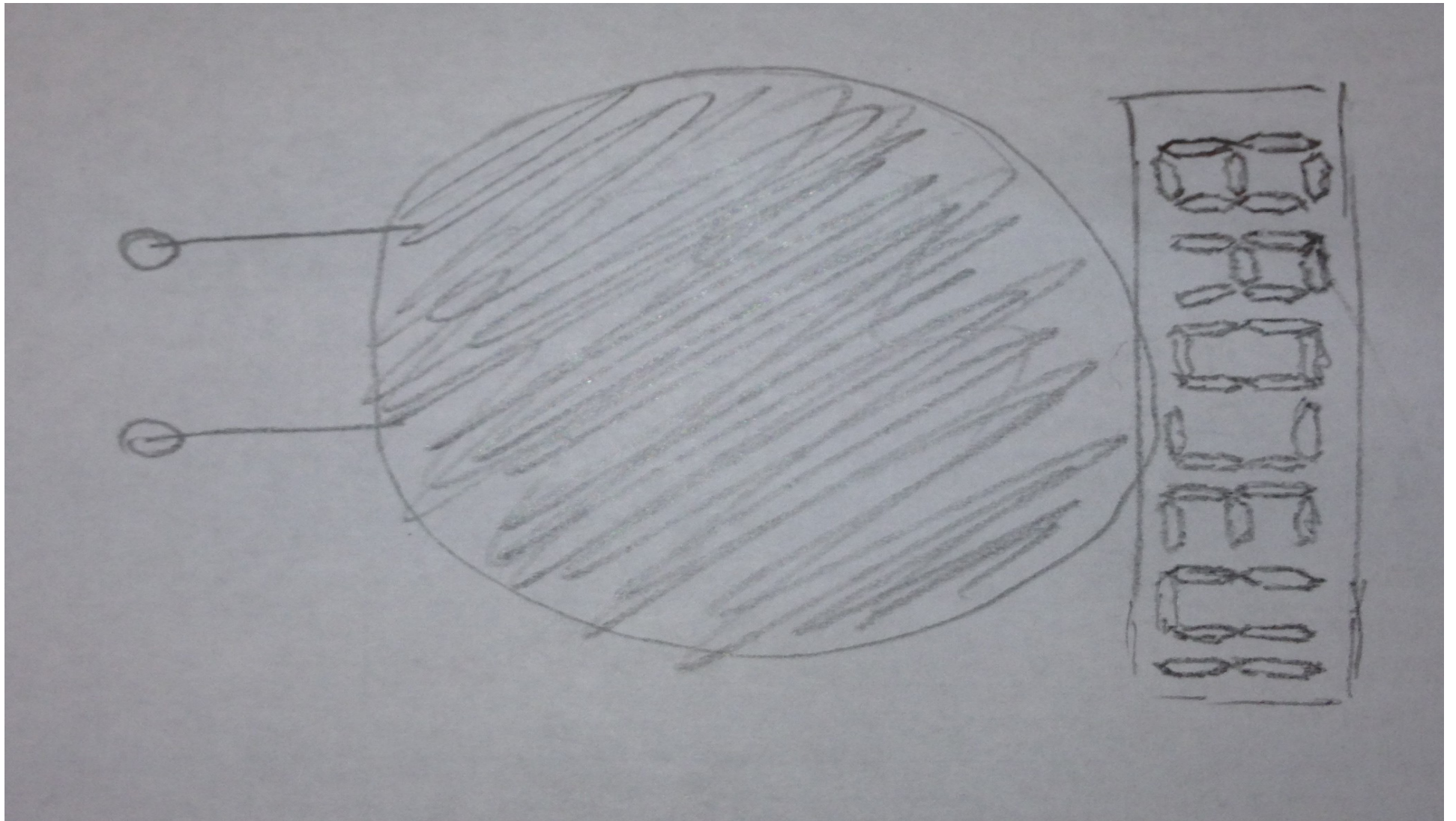
Multimeter

- Elektronički mjerni instrument kojim mjerimo različita elektronička svojstva, npr. napon, struju i otpor.
- Analogni i digitalni

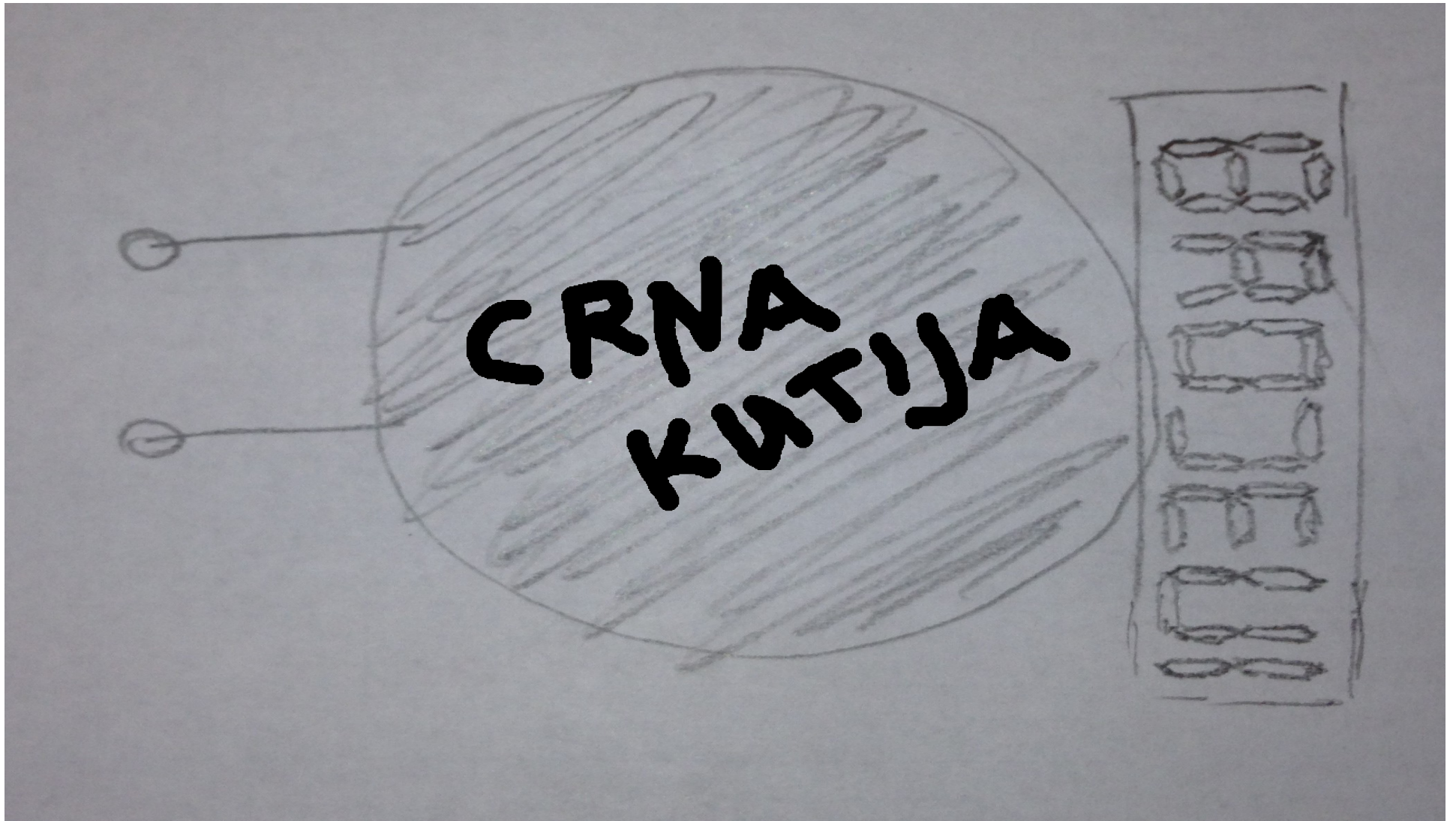


Shema DMM

Shema DMM



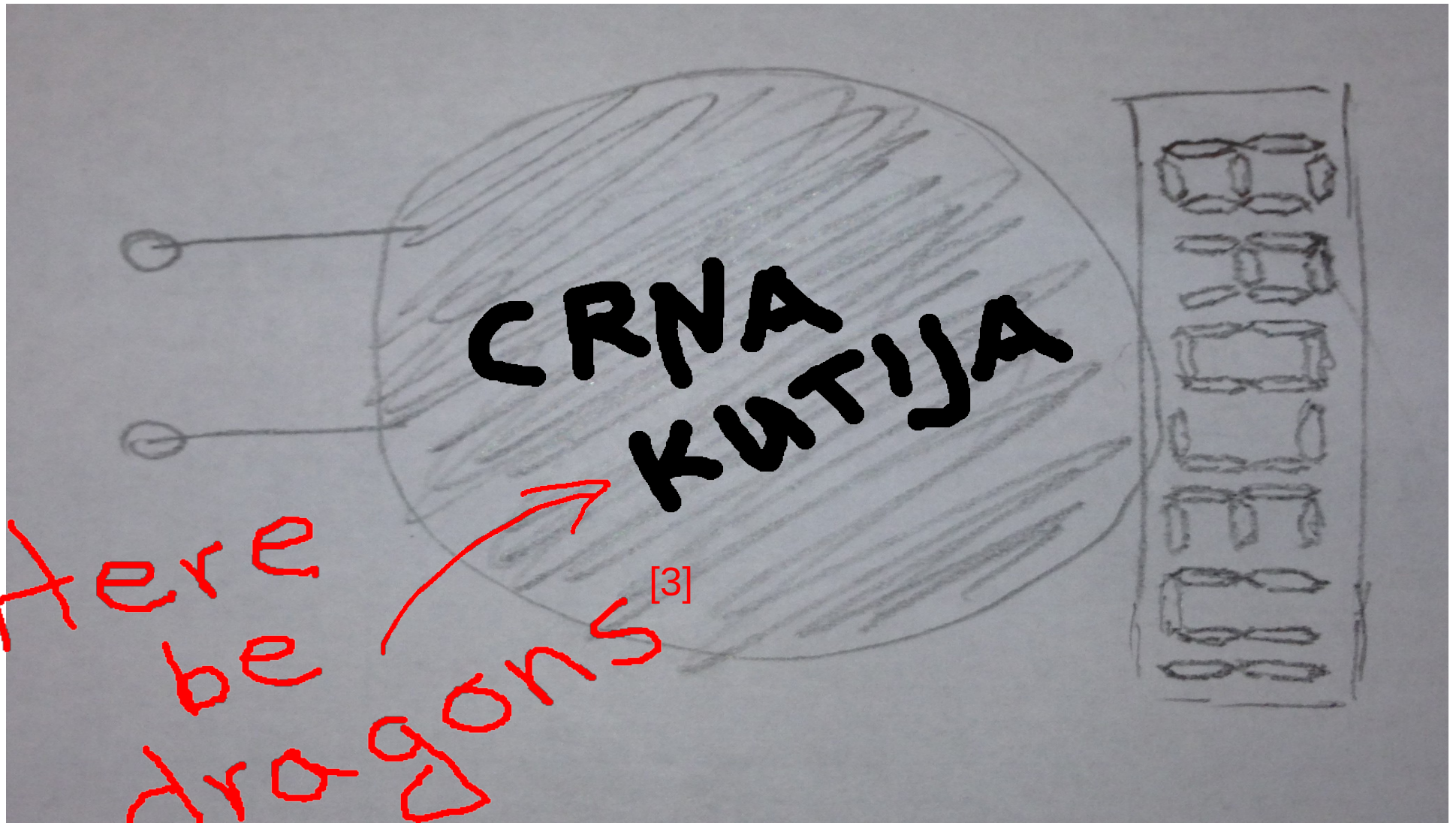
Shema DMM



Shema DMM

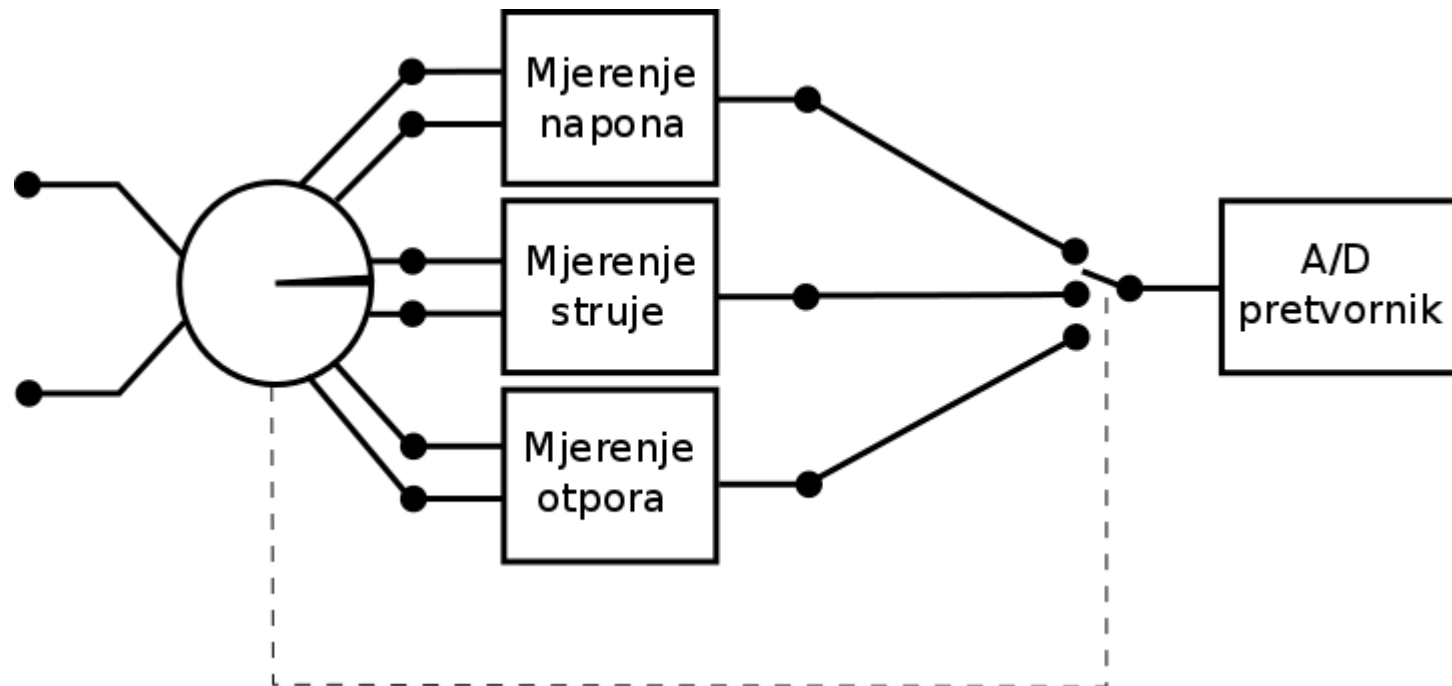


Shema DMM

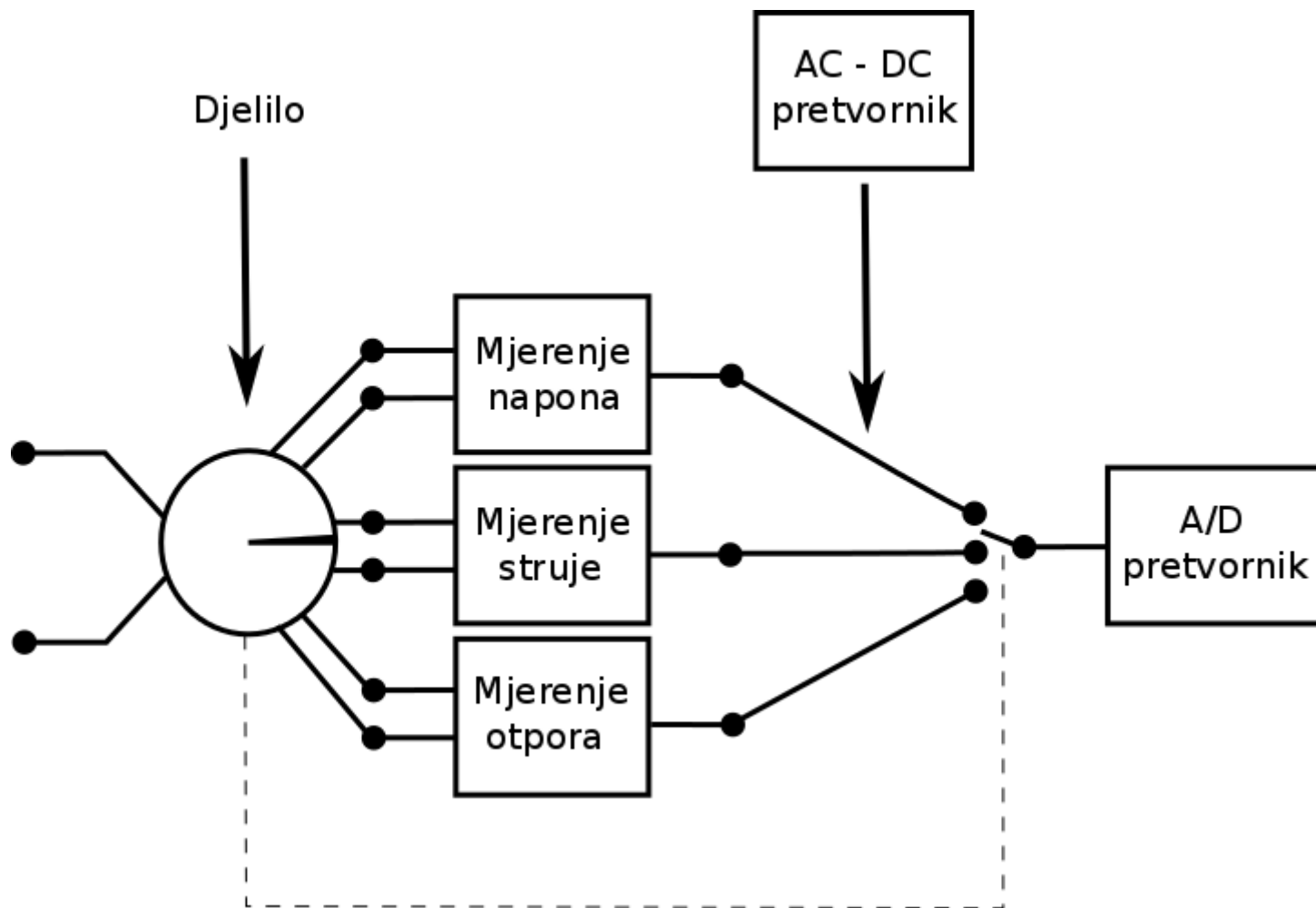


[3] <http://imgtfy.com/?q=here+be+dragons>

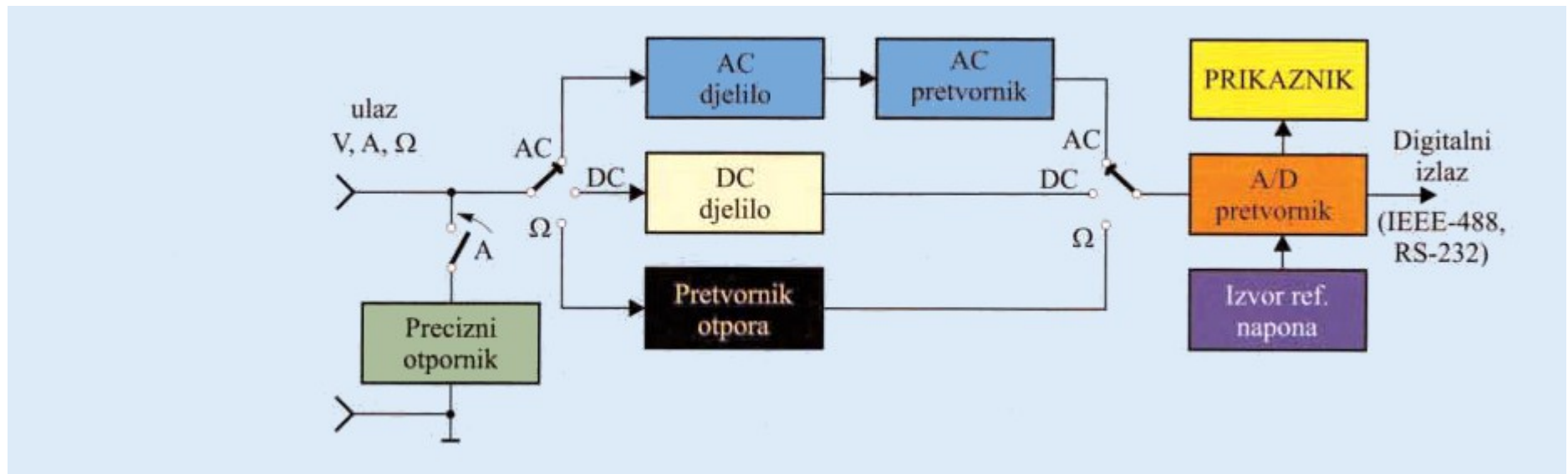
Shema DMM



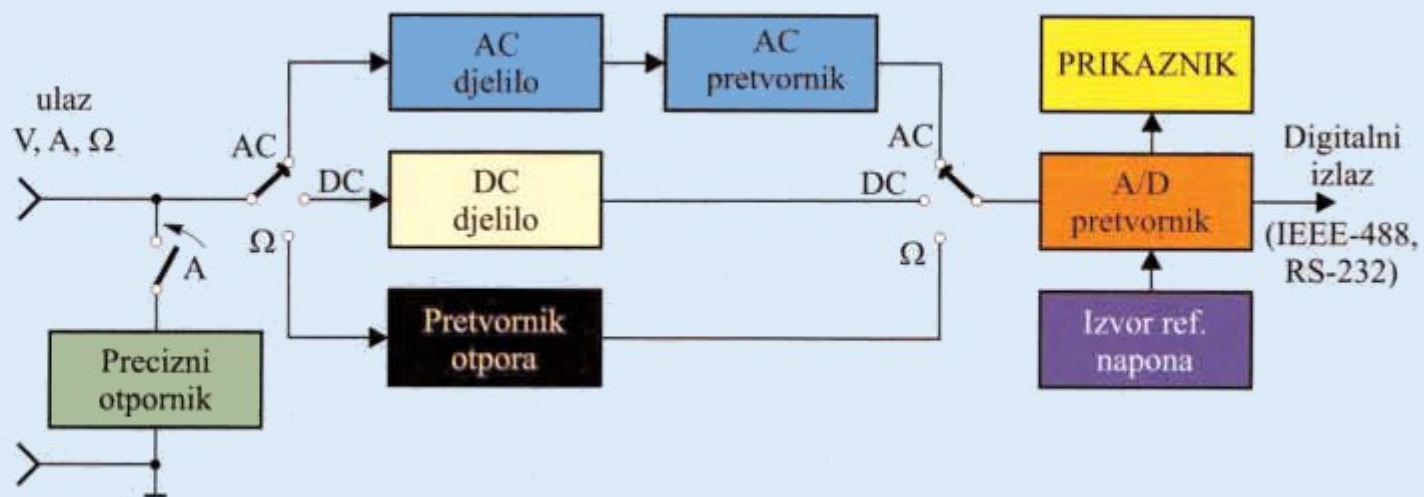
Shema DMM



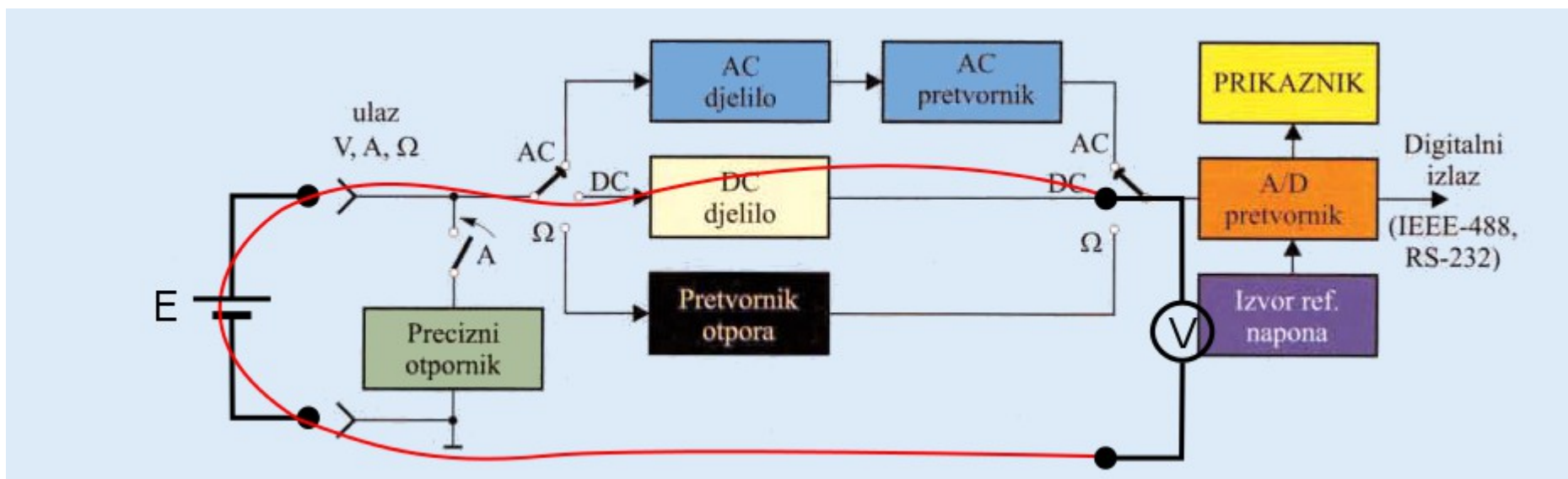
Shema DMM



Mjerenje istosmjernog napona

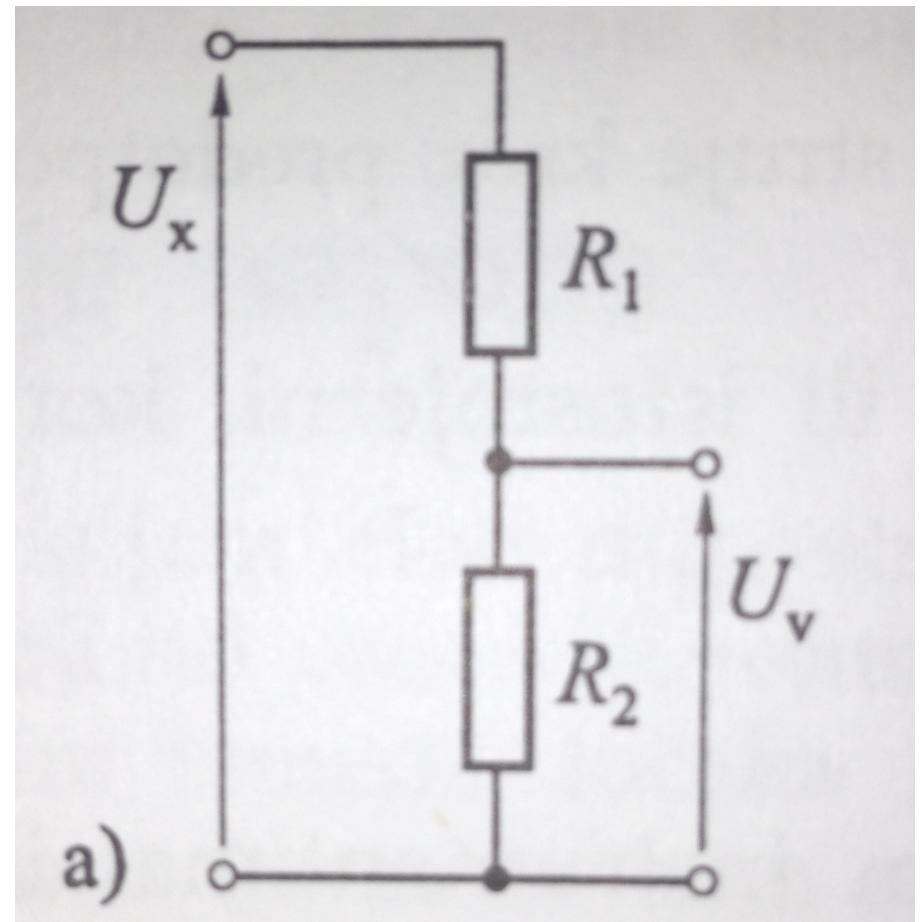


Mjerenje istosmjernog napona

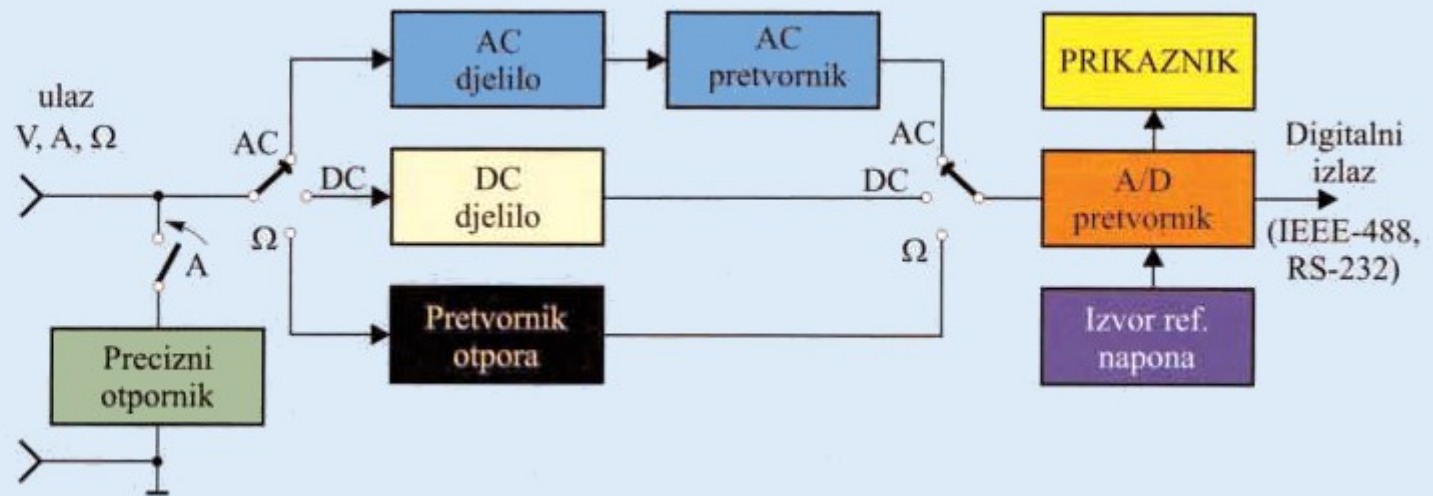


Mjerenje istosmjernog napona

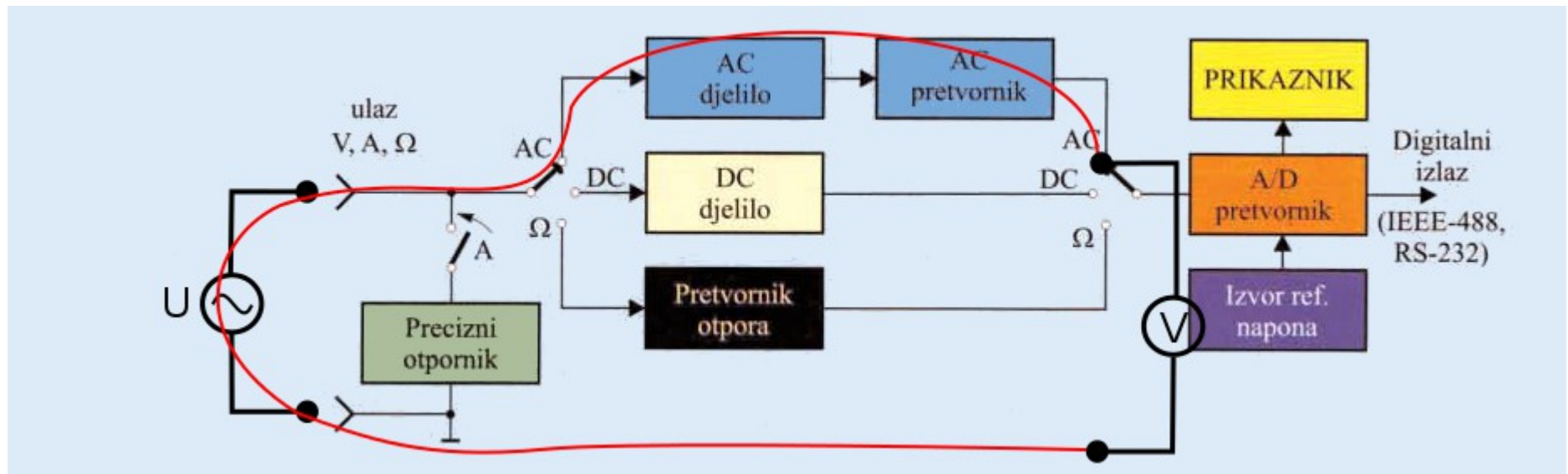
- DC djelilo



Mjerenje izmjeničnog napona



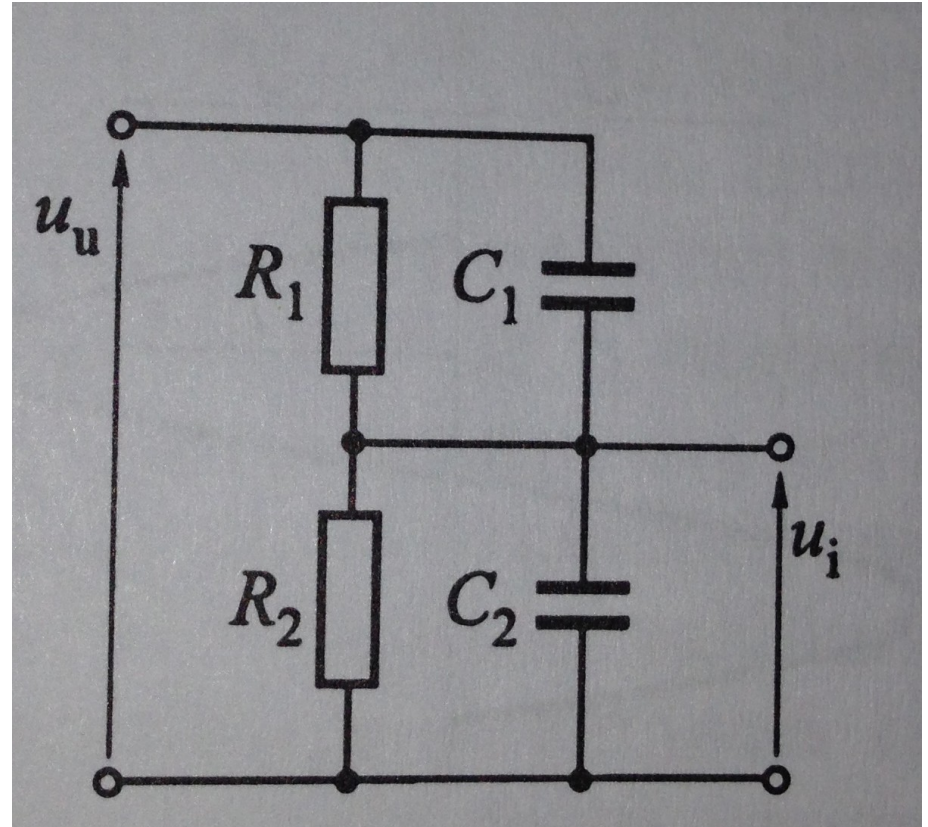
Mjerenje izmjeničnog napona



Mjerenje izmjeničnog napona

- AC djelilo
 - Frekvencijski kompenzirano

$$R_1 C_1 = R_2 C_2$$



True RMS ili ne?

FLUKE®

Why true-rms matters for HVAC technicians

Non-linear loads need a true-rms test tool for accurate readings

Application Note

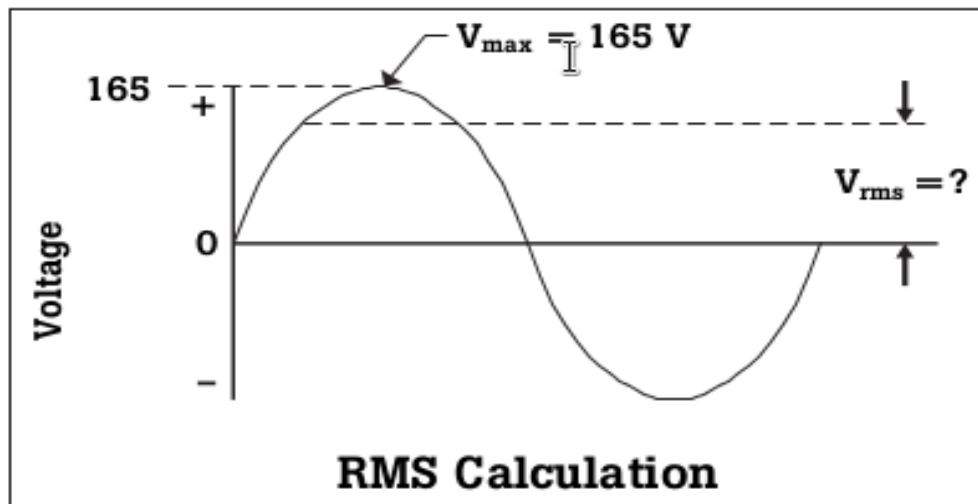
For today's HVAC technician, troubleshooting electrical problems is becoming more difficult without the use of true rms test tools. This is due in part to the proliferation of new solid state adjustable speed motor drives and heating controls containing power semiconductors or rectifiers. These loads are referred to as "non linear." Non linear loads draw current in short pulses rather than the smooth sine wave drawn



True RMS ili ne?

A comparison of average responding and true-rms units

Multimeter type	Response to sine wave	Response to square wave	Response to single phase diode rectifier	Response to 3 Δ phase diode rectifier
Average responding	Correct	10 % high	40 % low	5 % to 30 % low
True-rms	Correct	Correct	Correct	Correct



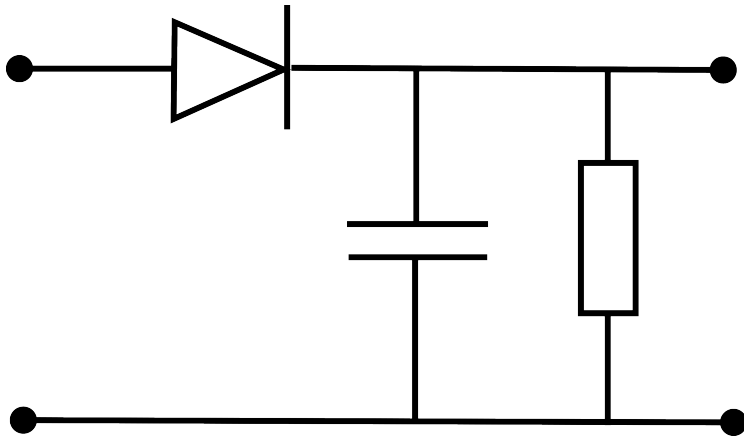
RMS voltage conversions for sine waves

To convert	To	Multiply by
Rms	Average	.9
Rms	Peak	1.414
Average	Rms	1.111
Average	Peak	1.567
Peak	Rms	.707
Peak	Average	.637
Peak	Peak-to-Peak	2

*Example and supporting data courtesy of American Technical Publishers Inc.

True RMS ili ne?

- Kako se mjeri vršna vrijednost
- Kako se mjeri srednja vrijednost



Izvod

$$U(t) = U_M \sin(t)$$

$$U_{sr} = \bar{U} = \frac{1}{T} \int_0^T |U(t)| dt$$

$$U_{ef} = U_{RMS} = \sqrt{\frac{1}{T} \int_0^T |U(t)|^2 dt}$$

$$\begin{aligned} U_{sr} &= \frac{1}{T} \int_0^T |U(t)| dt = \frac{1}{\pi} \int_0^\pi |U_M \sin(t)| dt = \\ &= \frac{1}{\pi} - U_M \cos(t) \Big|_0^\pi = \frac{1}{\pi} (-U_M \cos(\pi) + U_M \cos(0)) = \frac{2}{\pi} U_M \end{aligned}$$

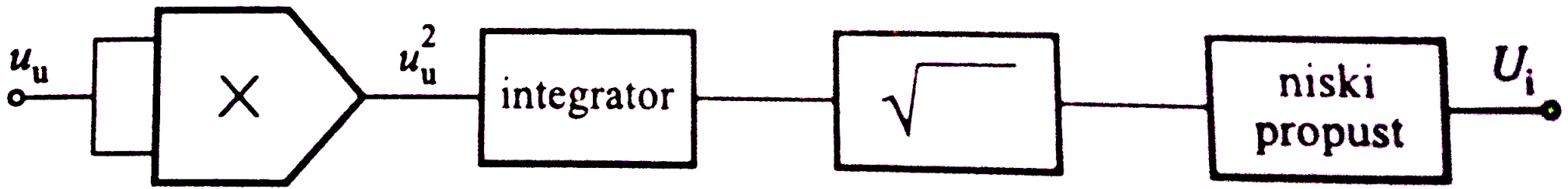
Izvod

$$\begin{aligned}U_{ef} &= \sqrt{\frac{1}{T} \int_0^T |U(t)|^2 dt} = \sqrt{\frac{1}{\pi} \int_0^\pi |U_M \sin(t)|^2 dt} = \\&= \sqrt{\frac{1}{\pi} U_M^2 \int_0^\pi \sin^2(t) dt} = \sqrt{\frac{1}{\pi} U_M^2 \int_0^\pi \frac{1 - \cos(2t)}{2} dt} = \\&= \sqrt{\frac{1}{\pi} U_M^2 \int_0^\pi \sin^2(t) dt} = U_M \sqrt{\frac{1}{2\pi} \int_0^\pi 1 - \cos(2t) dt} = \\&= U_M \sqrt{\frac{1}{2\pi} (\pi - 0 - (\sin(2\pi) - \sin(0)))} = \frac{1}{\sqrt{2}} U_M\end{aligned}$$

$$\frac{U_{ef}}{U_{sr}} = \frac{\frac{1}{\sqrt{2}} U_M}{\frac{2}{\pi} U_M} = \frac{\pi}{2\sqrt{2}} \approx 1.111$$

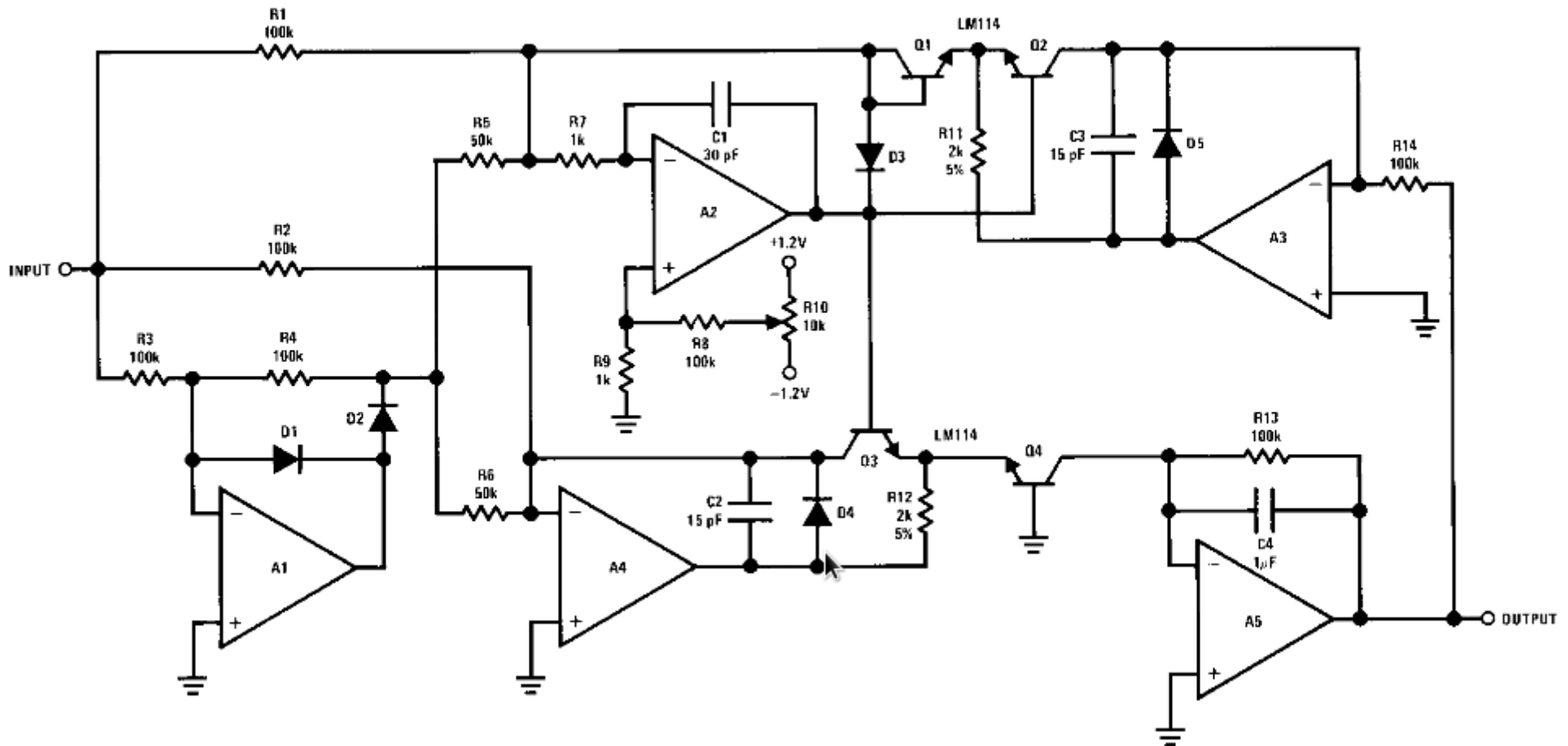
True RMS ili ne?

- Kako se mjeri efektivna vrijednost

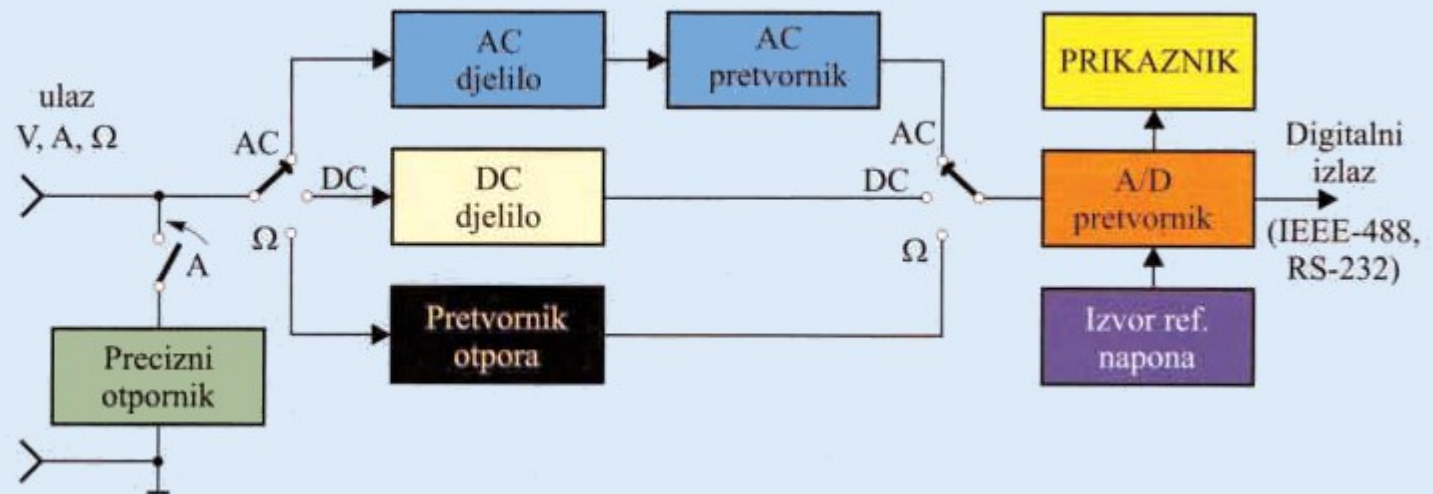


True RMS ili ne?

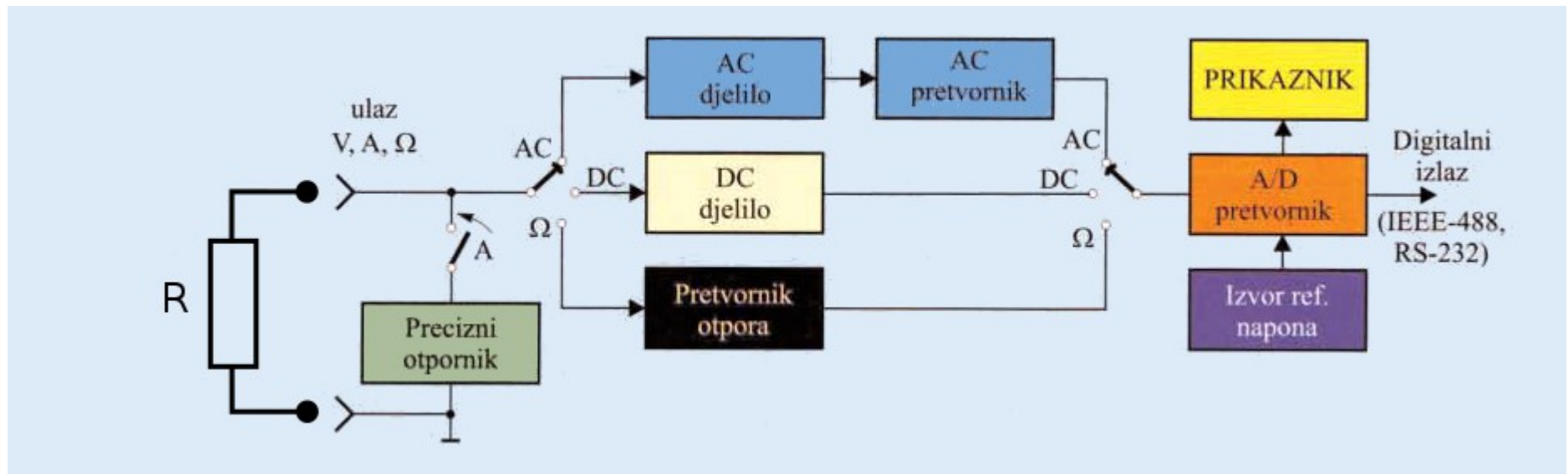
- Kako se mjeri efektivna vrijednost



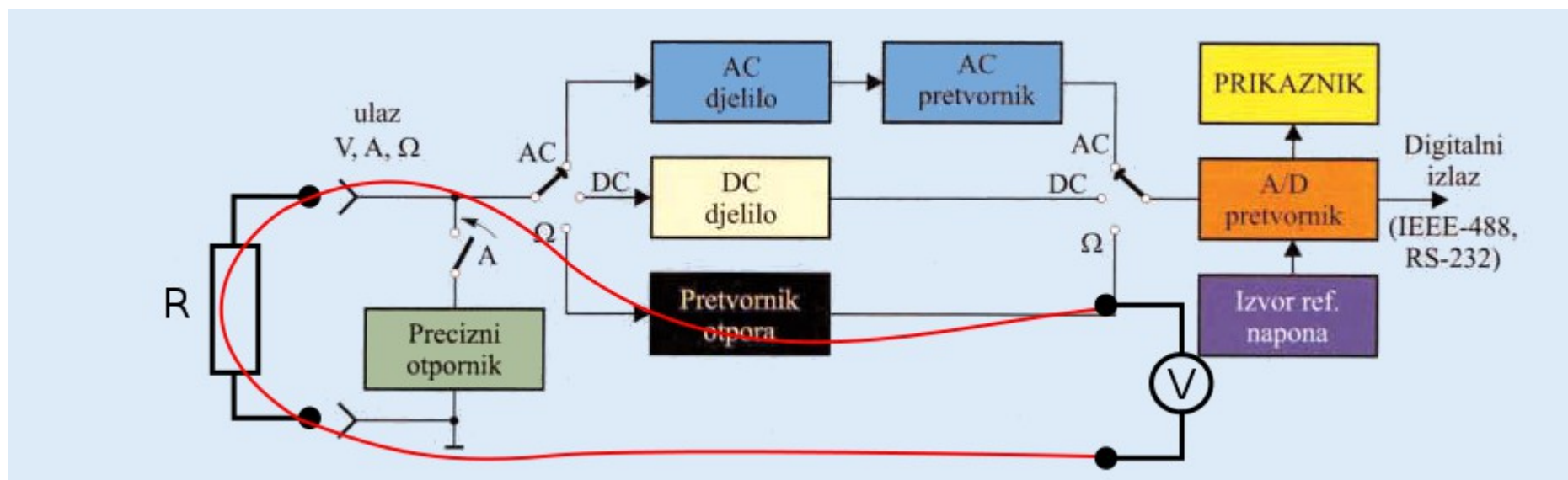
Mjerenje otpora



Mjerenje otpora



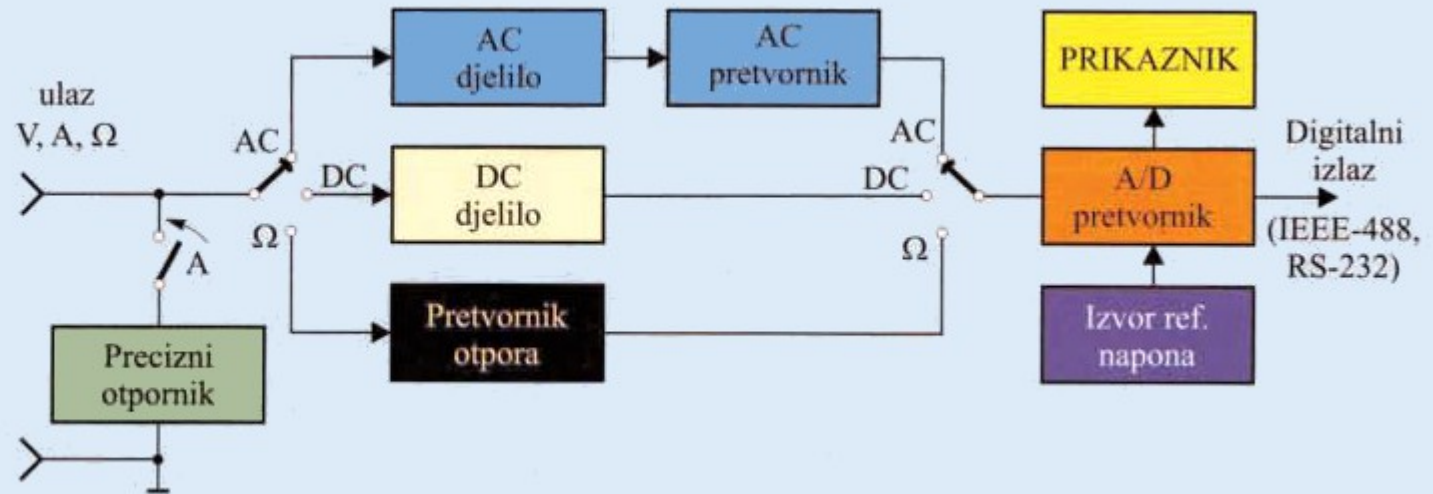
Mjerenje otpora



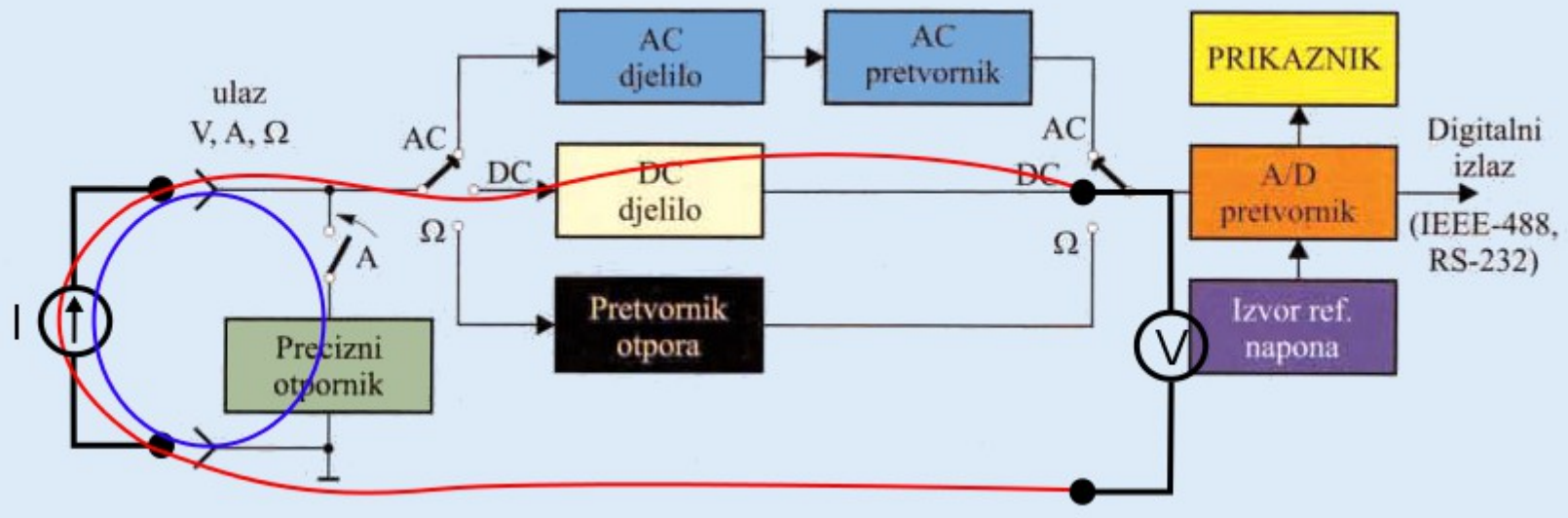
Mjerenje otpora

- Shema strujnog kruga
- Mjerenje malih otpora
- Naglasiti potrebu za vlastitim izvorom napajanja
- --- Plivajući? Znači da je beskonačan otpor prema zemlji

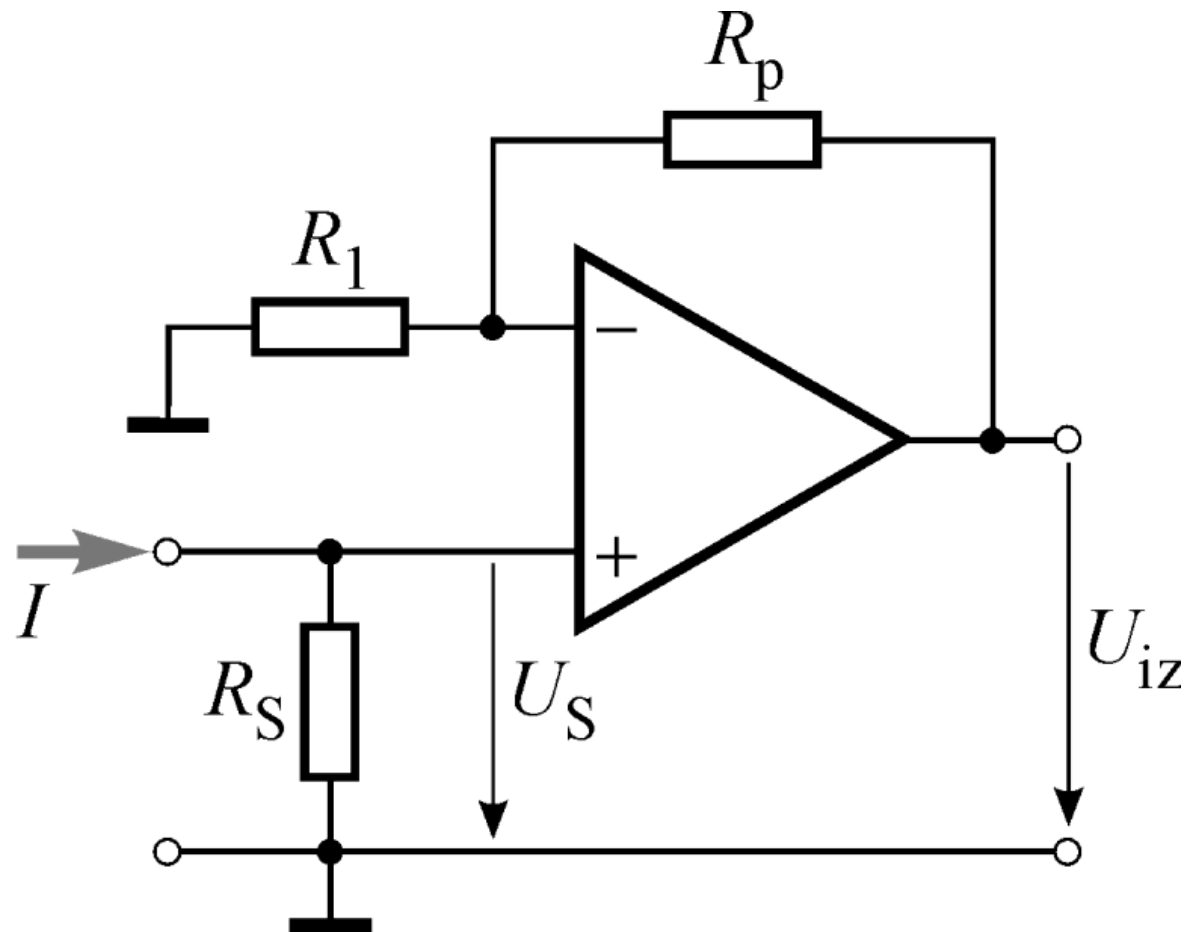
Mjerenje istosmjerne struje



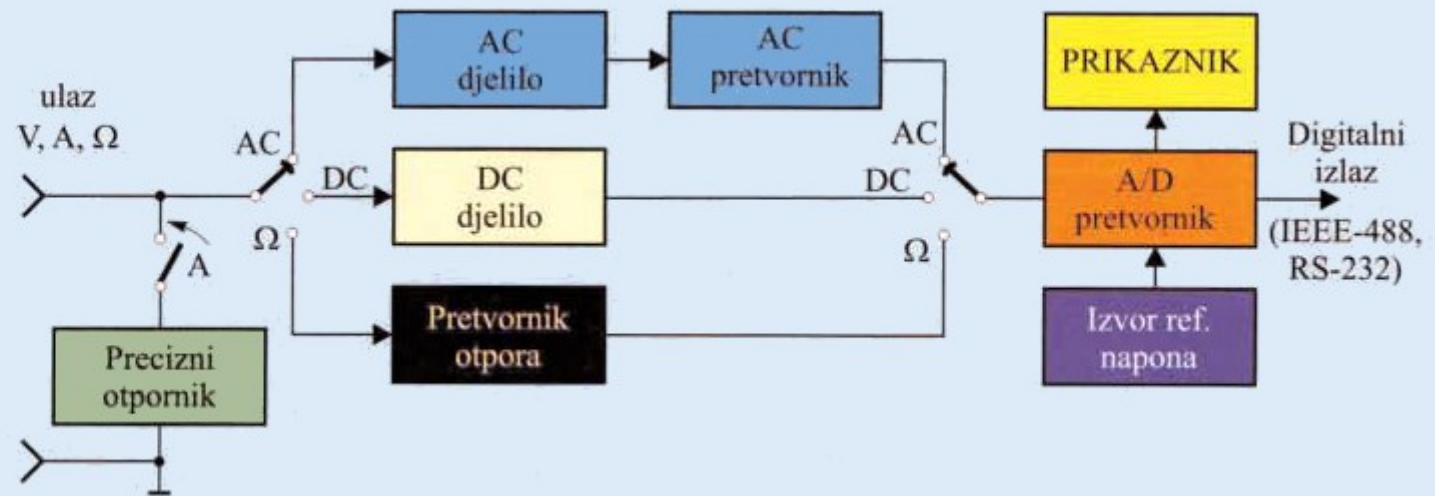
Mjerenje istosmjerne struje



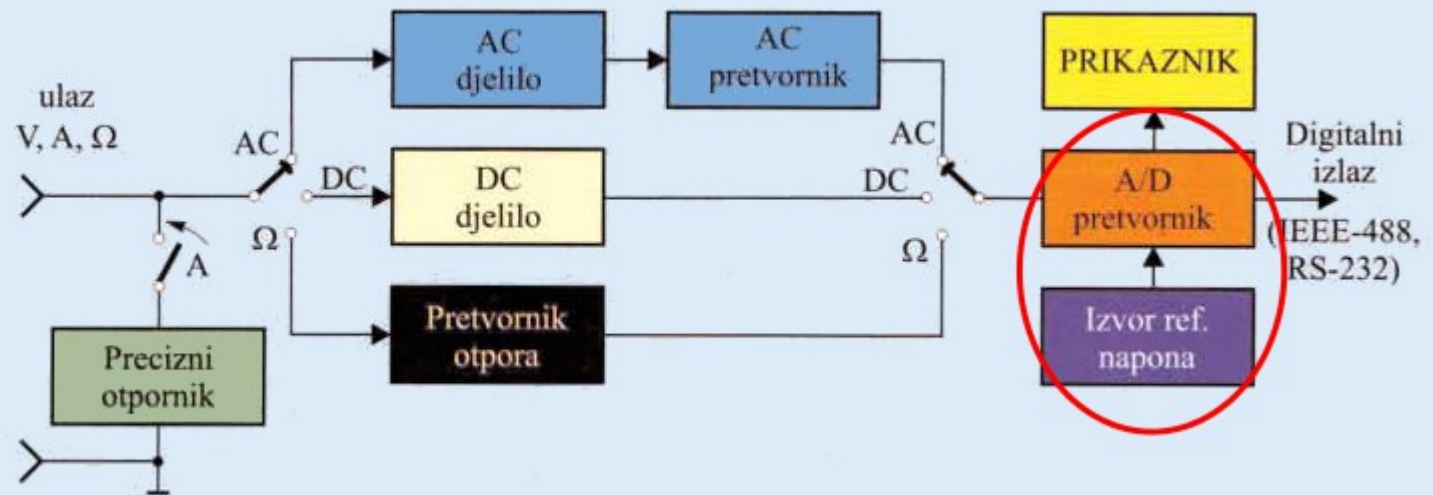
Mjerenje istosmjjerne struje



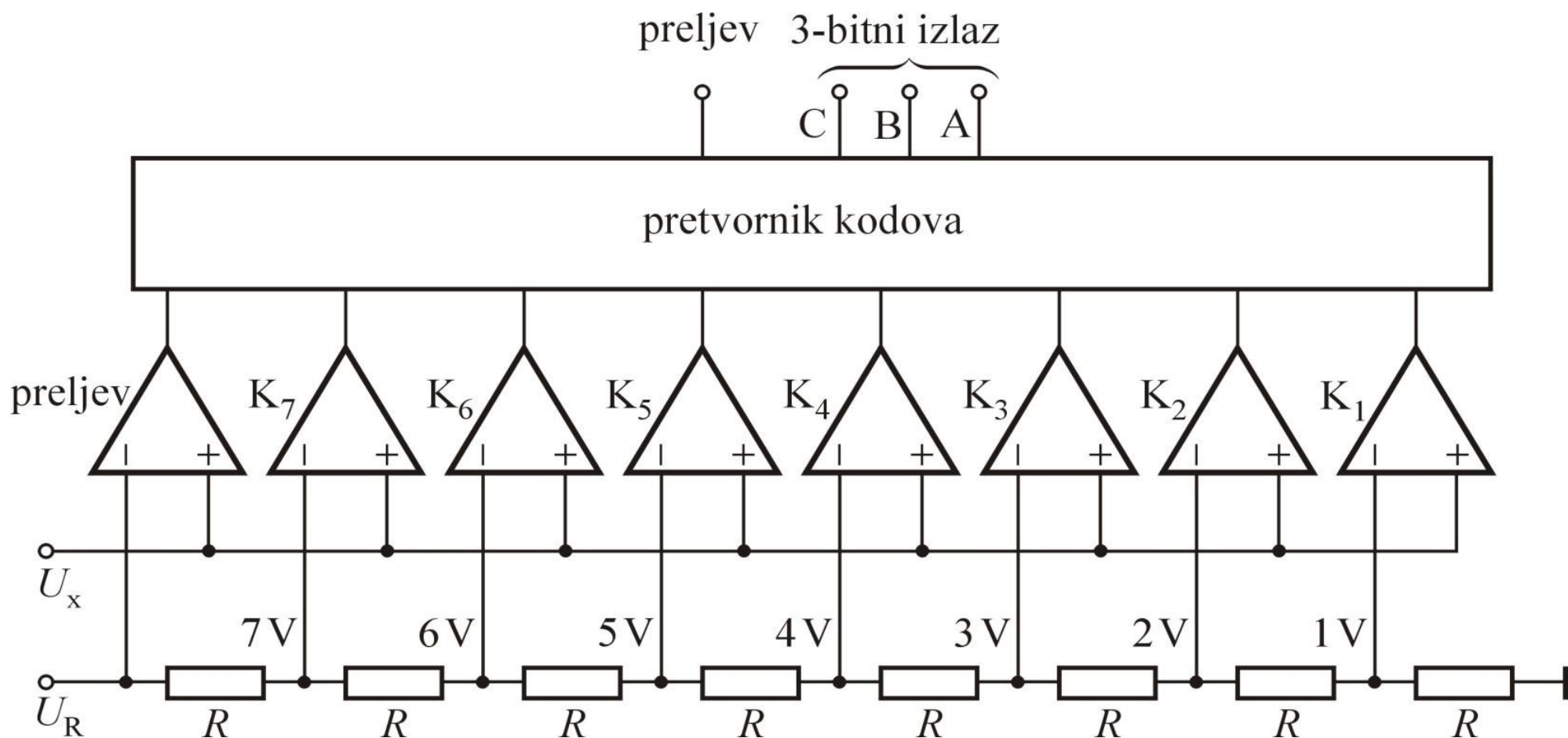
AD pretvornik



AD pretvornik



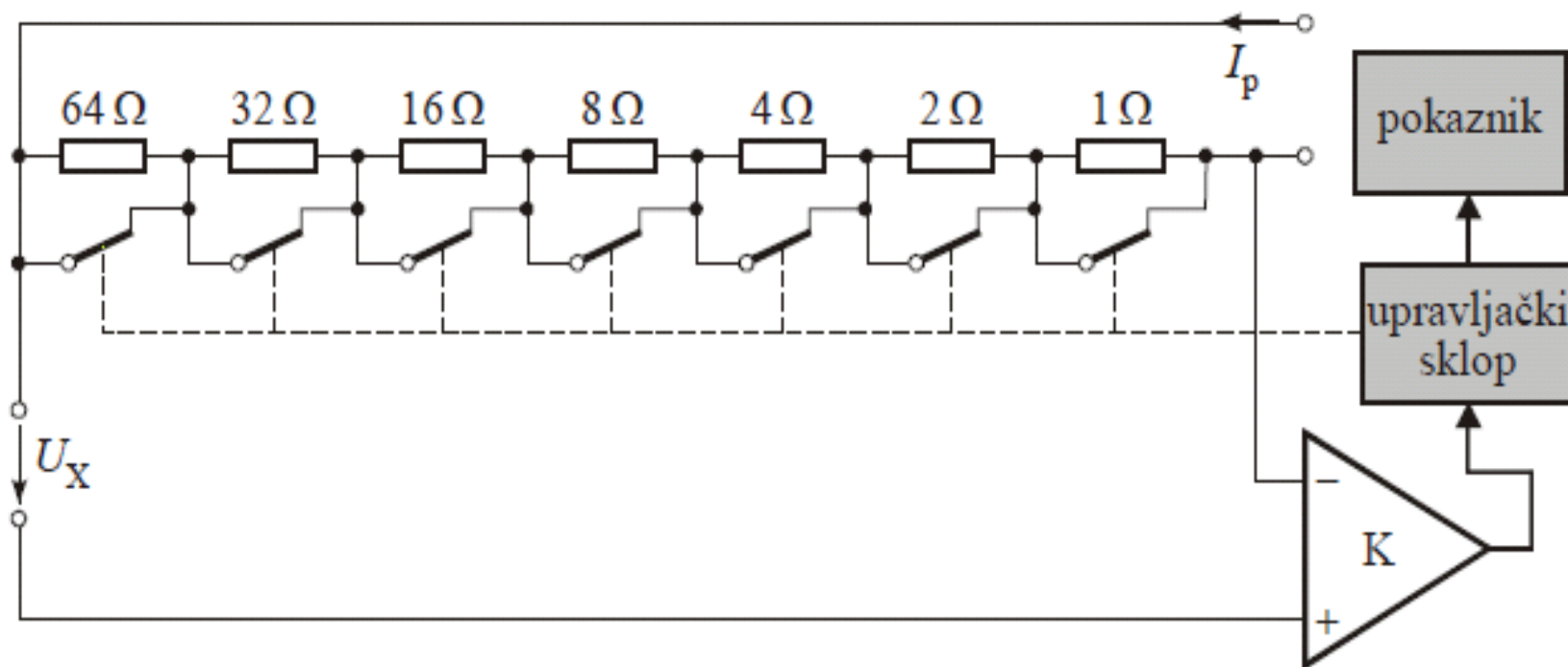
Shema paralelnog AD pretvornika



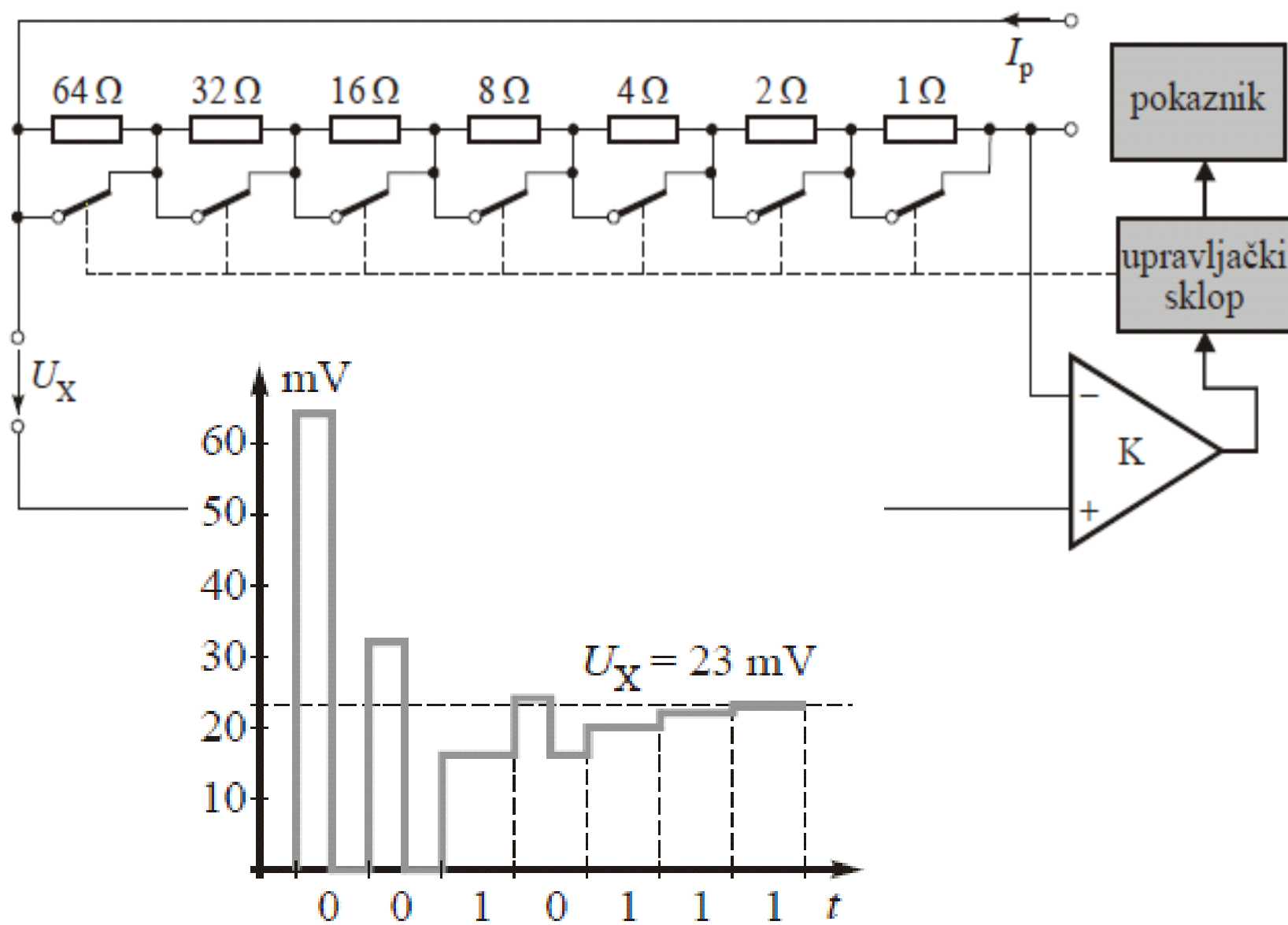
Svojstva paralelnog AD pretvornika

- Mnogo sklopova
- Brza pretvorba

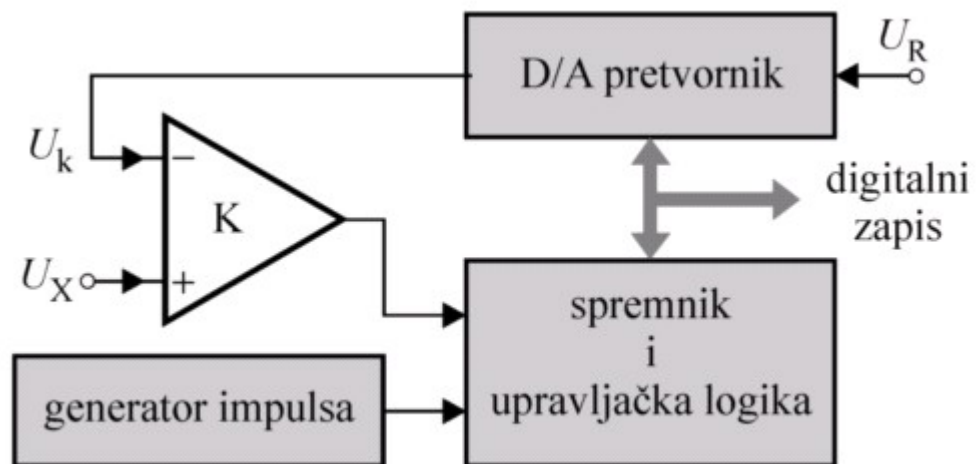
Načelna shema stupnjevitog AD pretvornika



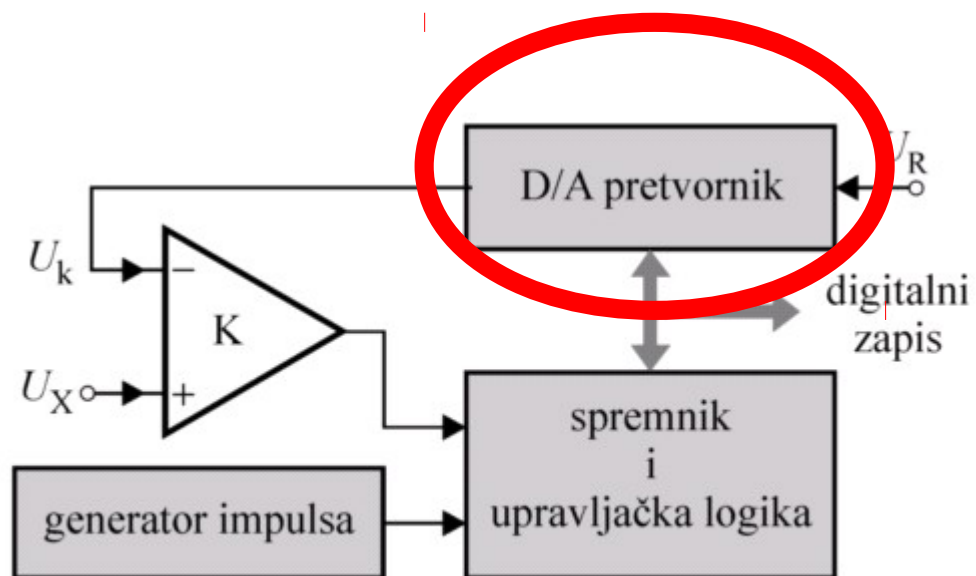
Načelna shema stupnjevitog AD pretvornika



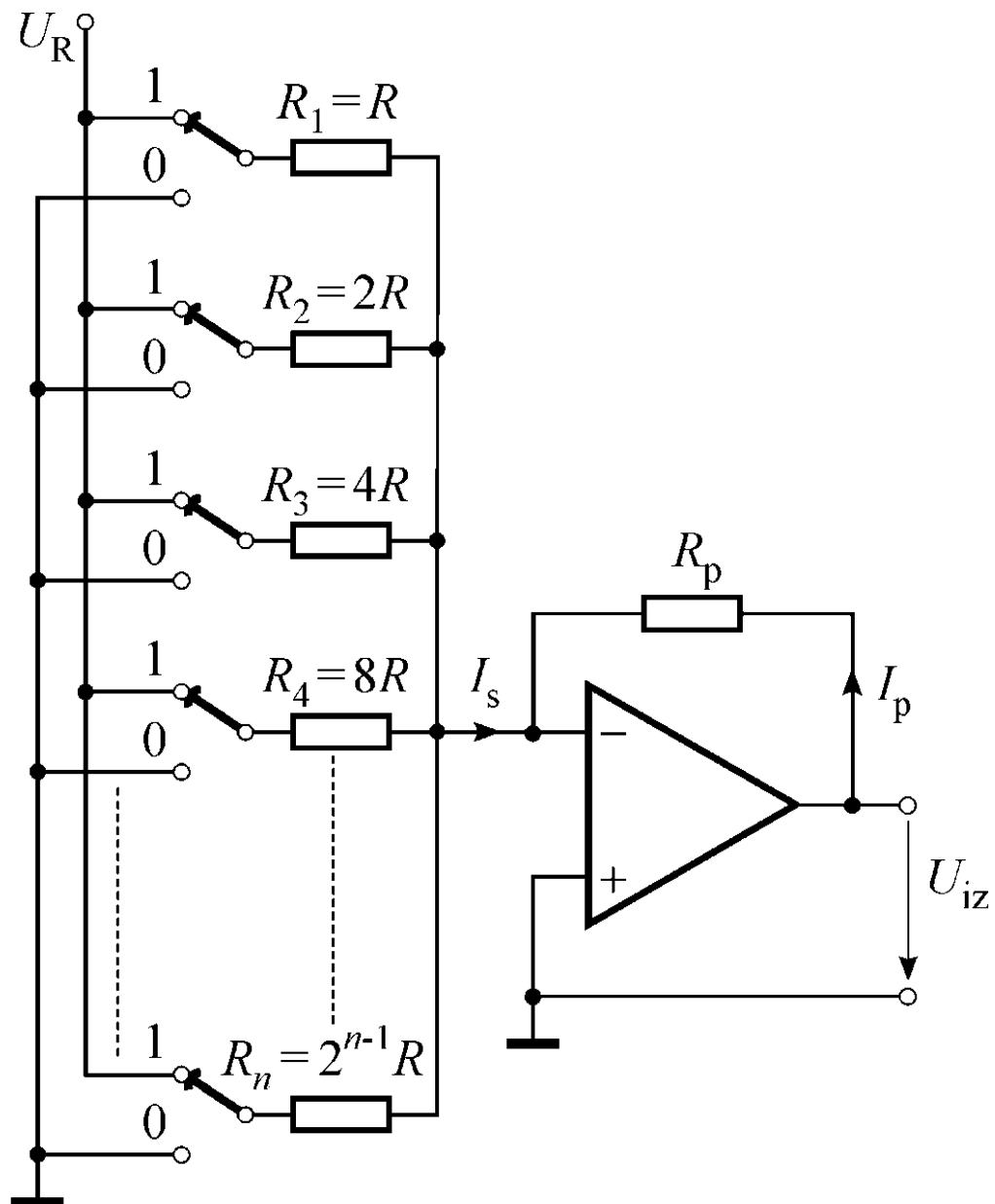
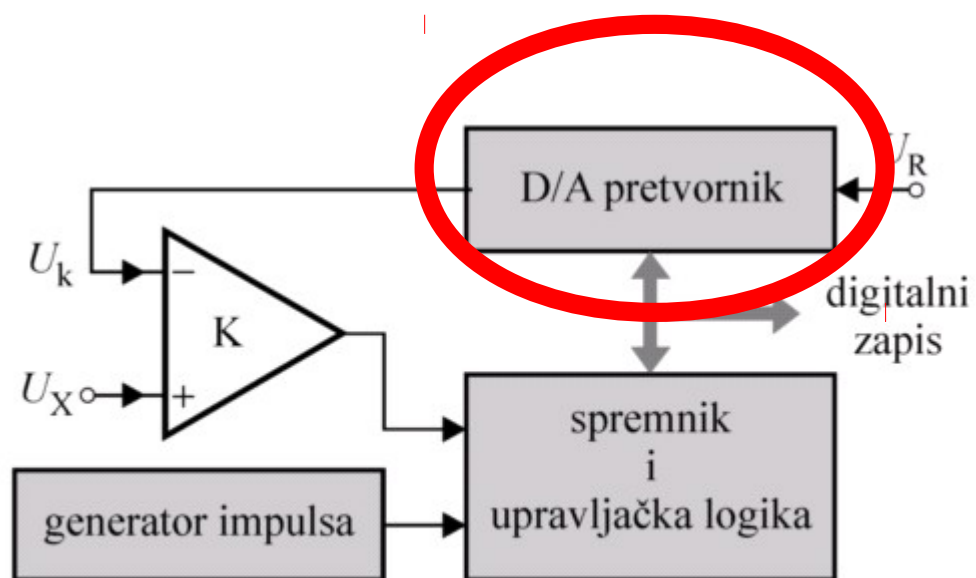
Shema stupnjevitog AD pretvornika



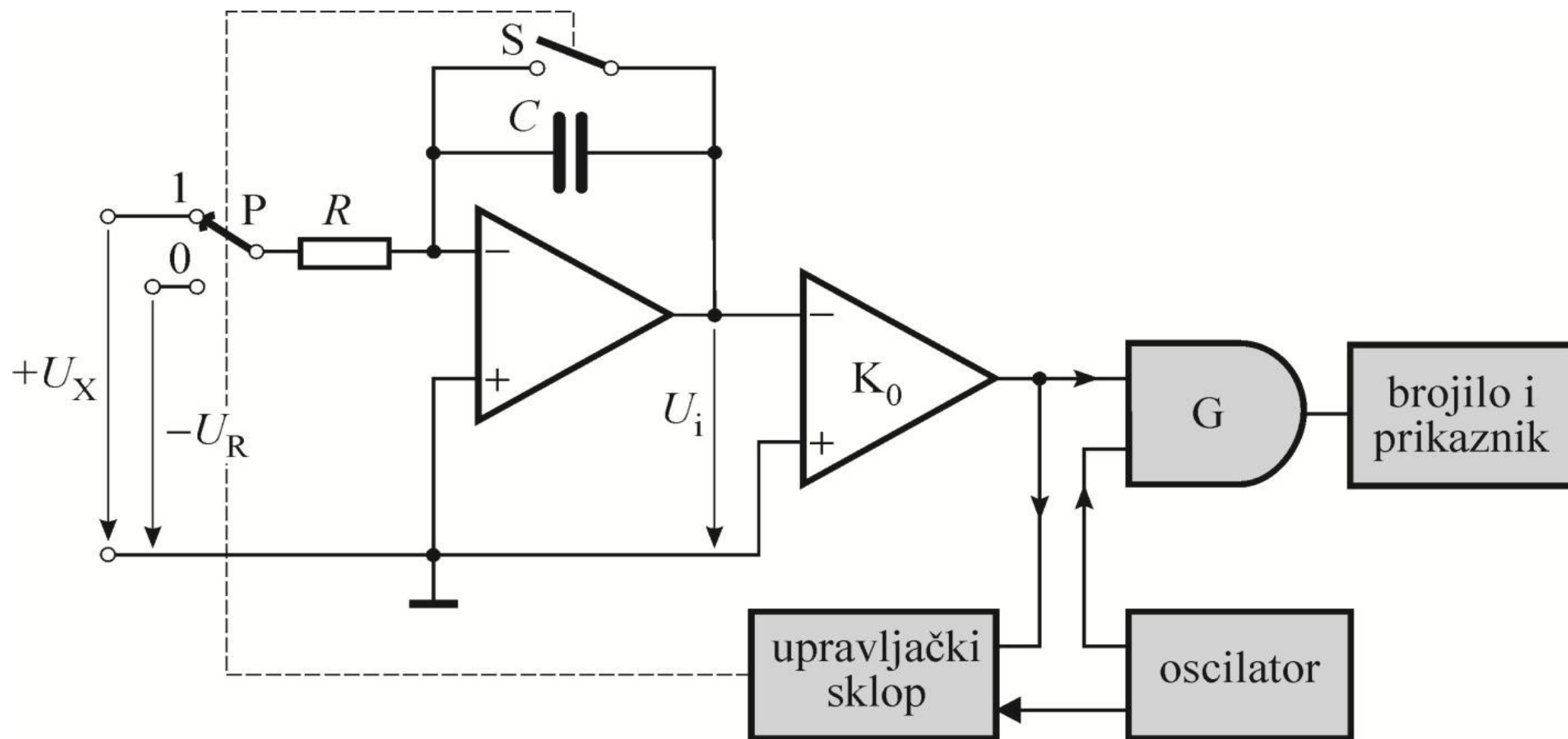
Shema stupnjevitog AD pretvornika

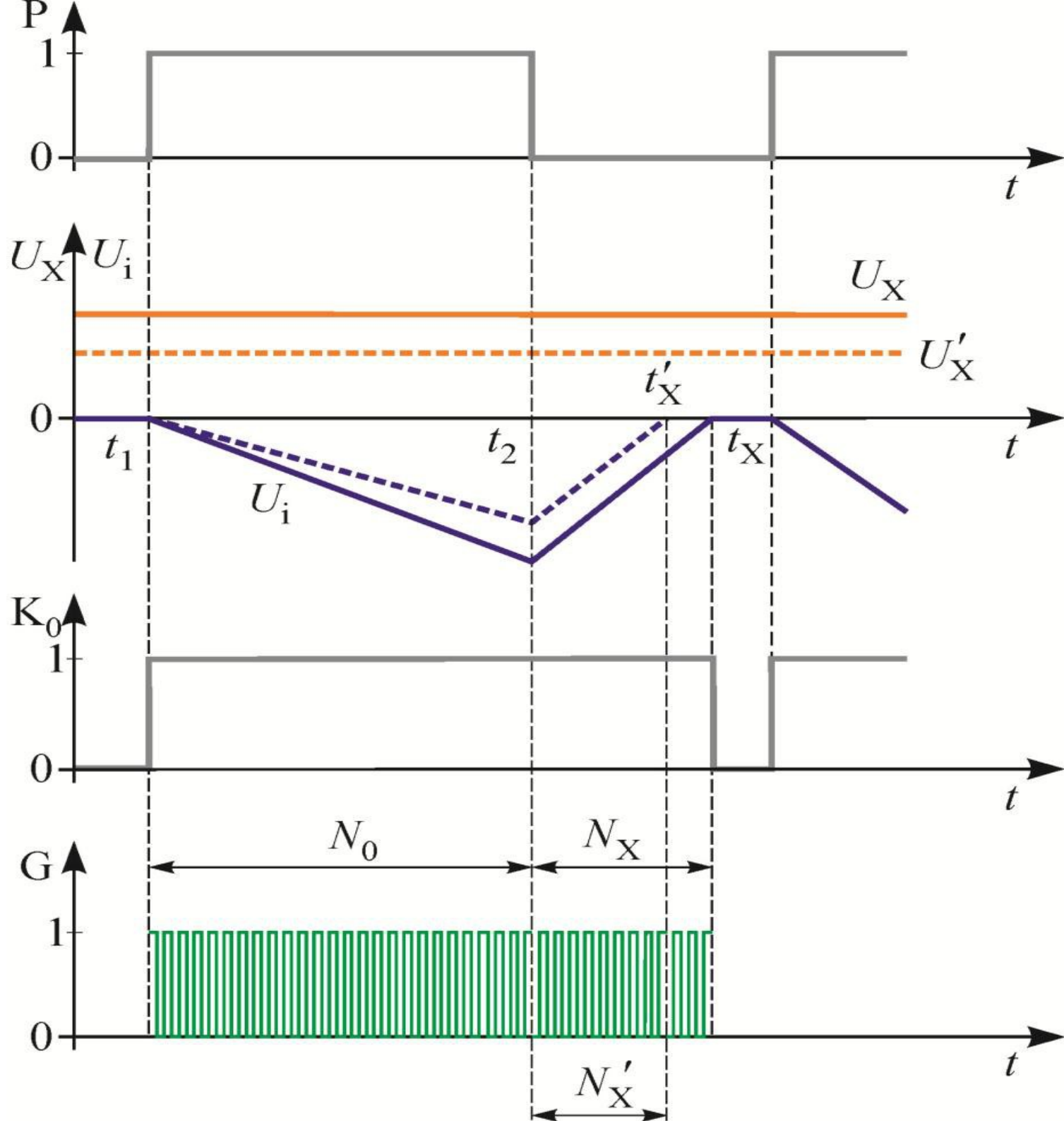


Shema stupnjevitog AD pretvornika

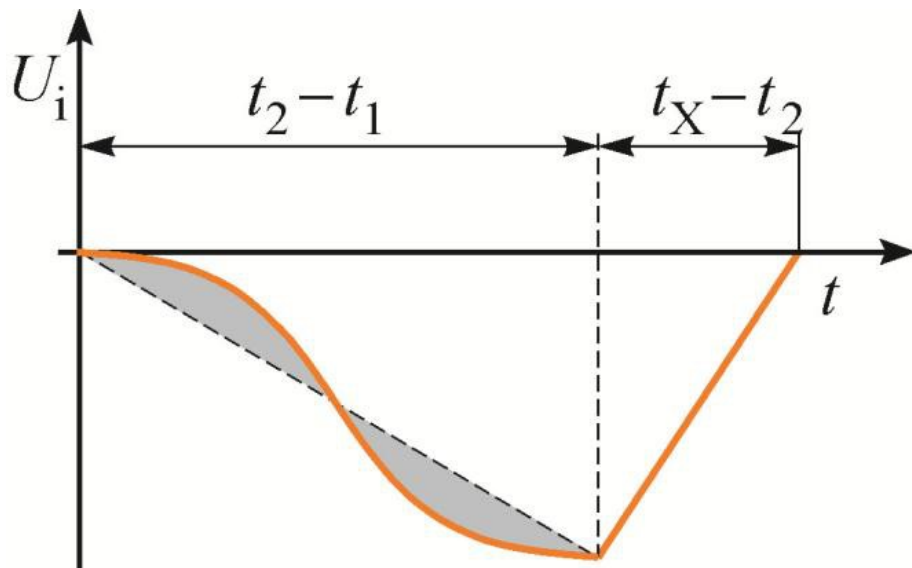


Shema AD prevornika s dvostrukim pilastim naponom





AD prevornik s dvostrukim pilastim naponom



- Dobro potiskivanje smetnji mrežne frekvencije postiže se izborom vremena integracije Δt višekratnikom periode mrežnog napona (50 Hz).

AD prevornik s dvostrukim pilastim naponom

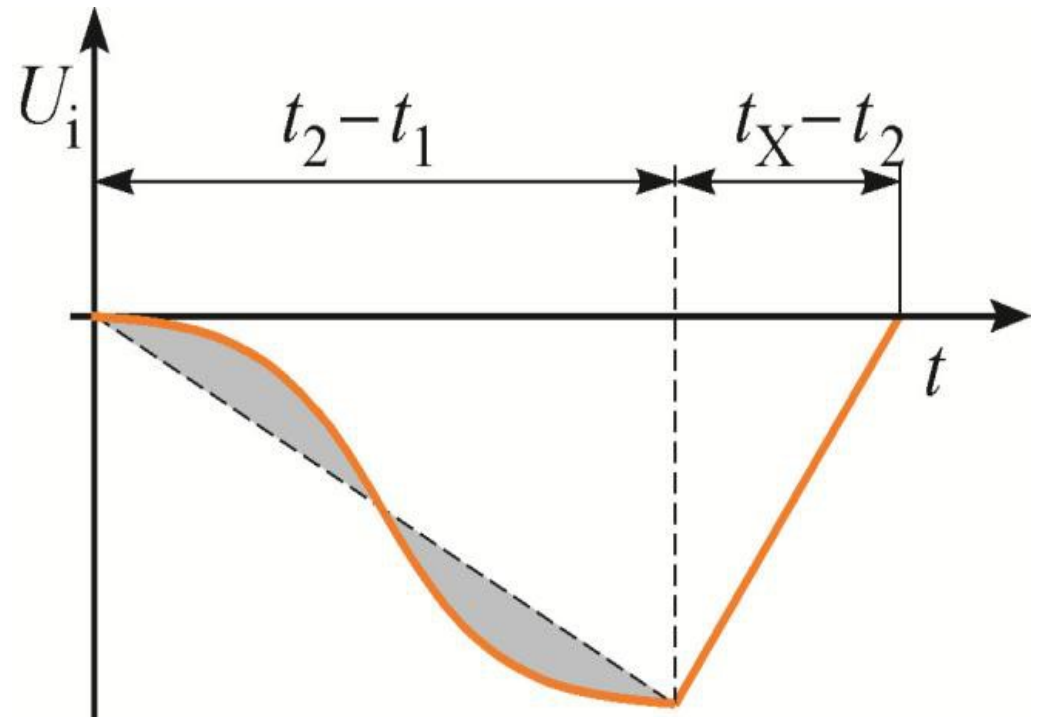
$$U_i(t_x) = 0$$

$$-\frac{1}{RC} \bar{U}_X \Delta t_0 = -\frac{1}{RC} U_R \Delta t_X$$

$$\Delta t_0 = \frac{N_0}{f}$$

$$\Delta t_X = \frac{N_X}{f}$$

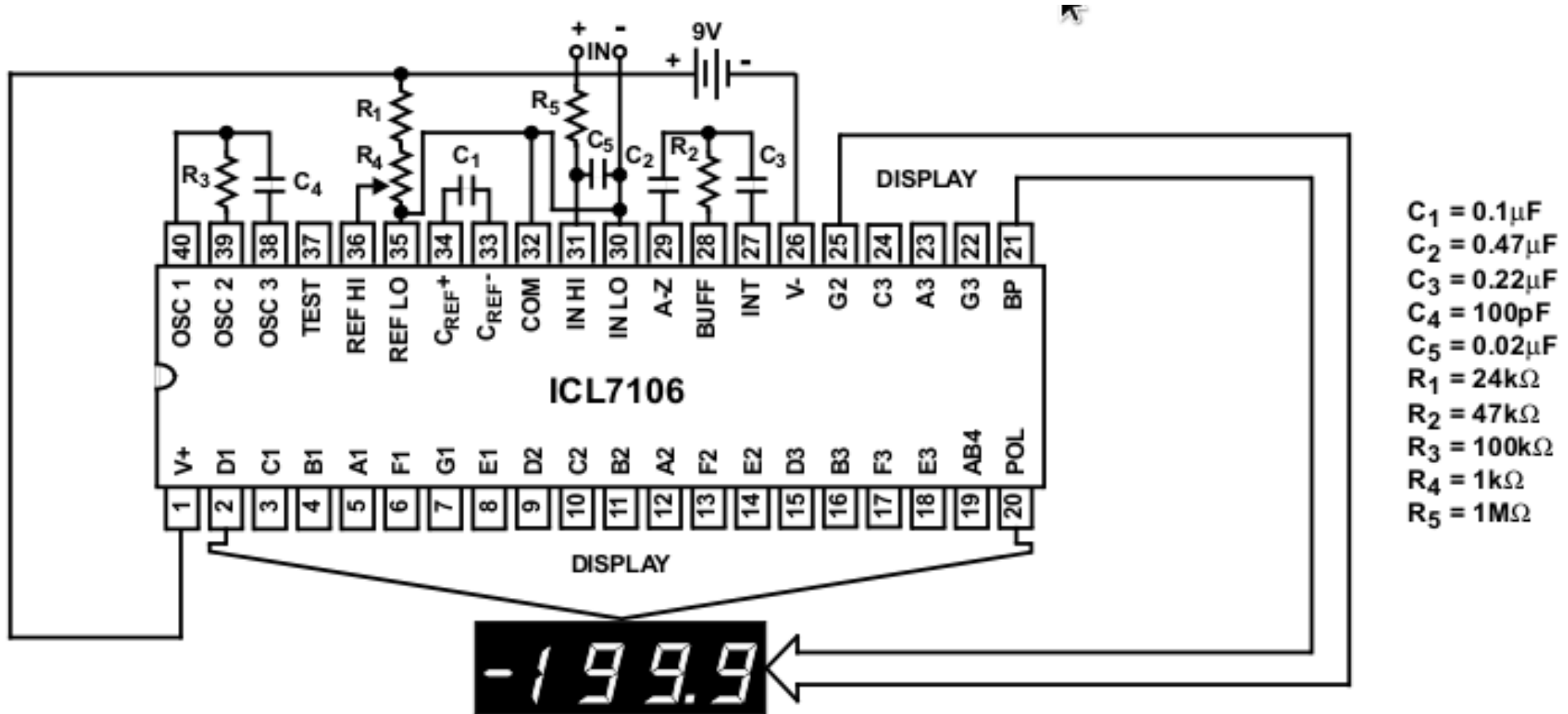
$$\bar{U}_X = U_R \frac{N_X}{N_0}$$



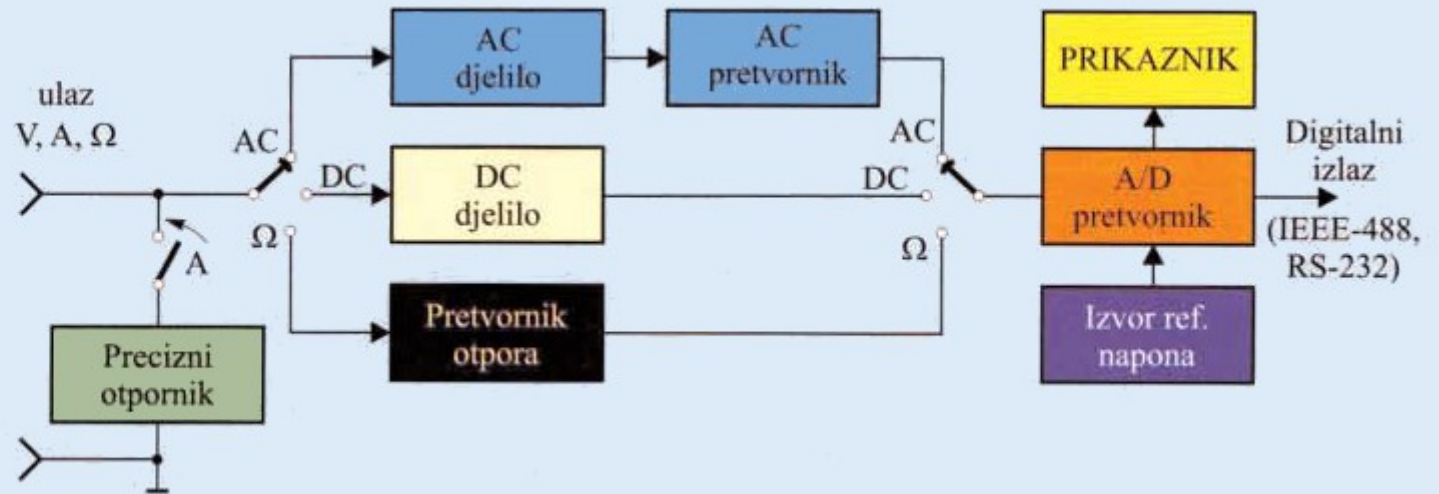
AD prevornik s dvostrukim pilastim naponom

- Potreba za referentnim naponom
- Karakteristike: odziv na srednju vrijednost napona, visoka točnost i razlučivanje te relativno skromna brzina (100ms)

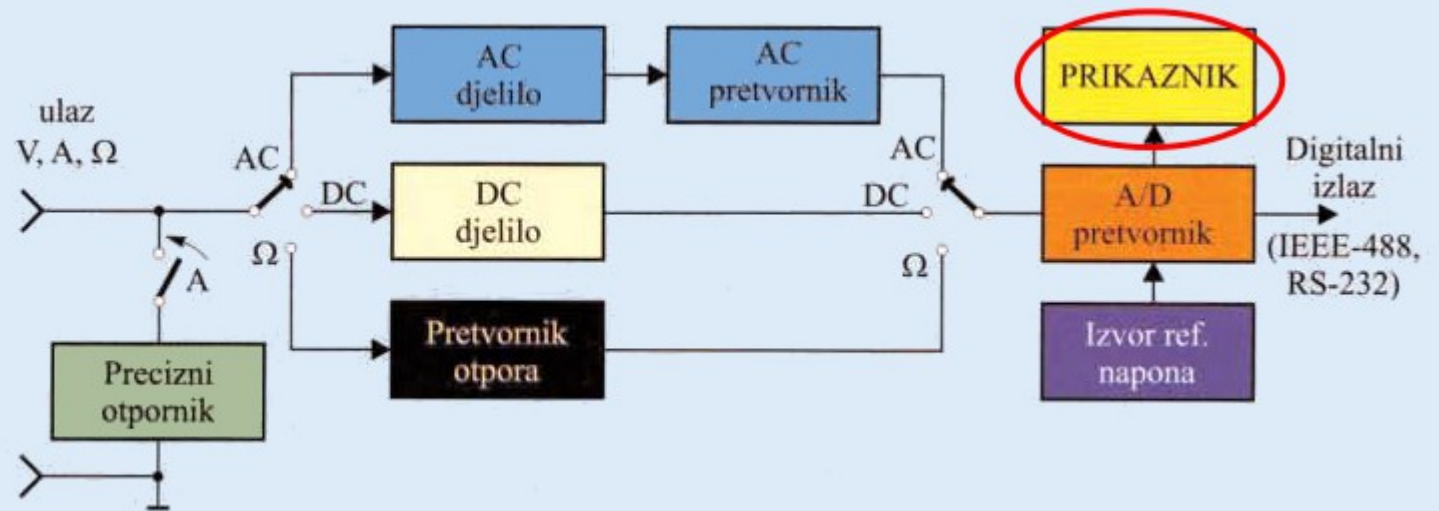
AD prevornik s dvostrukim pilastim naponom



Prikaznik



Prikaznik



Prikaznik

- Broj znamenaka: npr. $3\frac{1}{2}$
- Razlučivost: npr. 0.1% ili 0.1mV na skali 1V
- Granice pogreške: razmjerna + stalna pogreška, dana je najčešće izražena kao:
a % vijednosti očitavanja + b digita
- Laiku glavna razlika između analognog i digitalnog

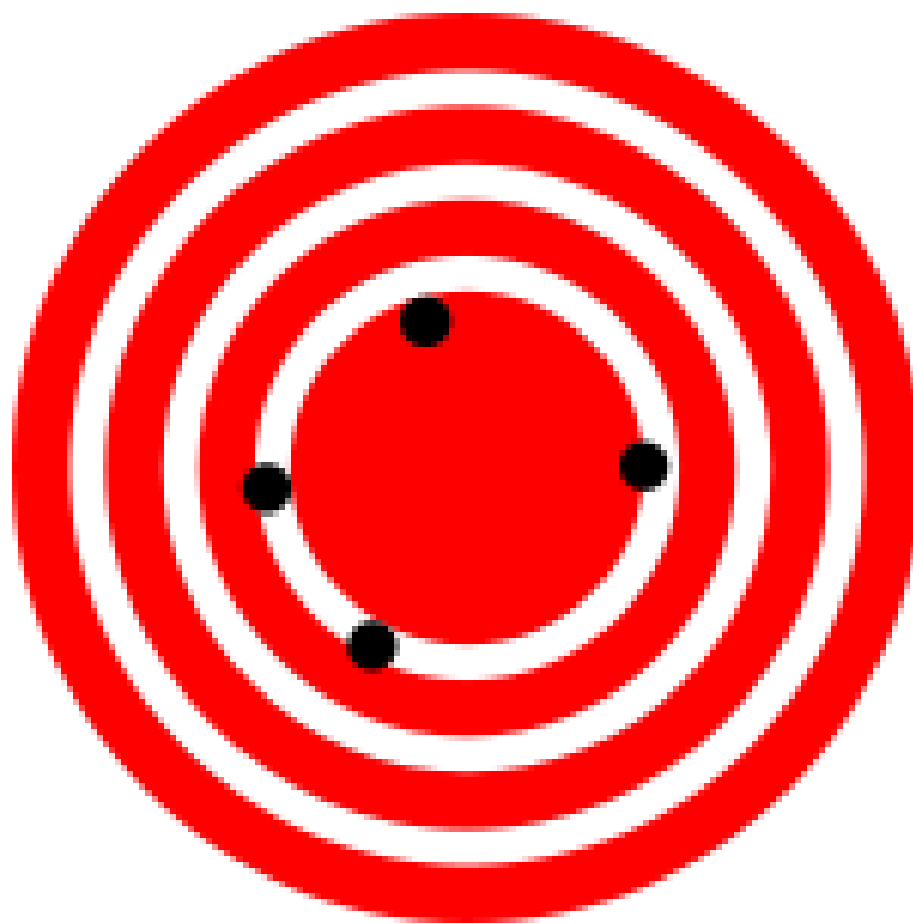
Digitalni vs. Analogni multimetri

- Digitalni:
 - Lakši
 - Brži odziv
 - Robusni na pomicanje
 - Jednostavniji za korištenje korištenja
 - Precizniji...
- Analogni:
 - Lakše praćenje više mjerenja
 - Ne trebaju napajanje
 - Robusni na smetnje
 - Dulje zadržava deklariranu preciznost

Preciznost vs. točnost



Precizno, ali netočno



Točno, ali neprecizno

DMM - ukratko

- Definicija: Digitalni mjerni uređaji za mjernje različitih veličina
 - Mjeri li to neelektrične veličine?
- Stara tehnologija?

DMM - ukratko

- Definicija: Digitalni mjerni uređaji za mjernje različitih veličina
 - Mjeri li to neelektrične veličine?
- Stara tehnologija?
- Pogledajmo kako izgleda budućnost...

Skopemetar



????



????



????



Trikoder



The
Economist

Open-source
medical devices

Dealing with
nuclear waste

Burt Rutan, a
maverick in flight

Technology Quarterly

December 1st 2012



**The dream of the
medical tricorder**
the hand held devices inspiring medical
add-ons for smartphones

Video



Ponovimo

- Mjerenje
- Koje su pogreške
 - Non RMS vs. True RMS DMM
 - Granica pogreške ($a\%$ očitavanja + b digita)
- AD konverteri omogućili digitalno doba
- Stara tehnologija nije "stara", već temelj nove