

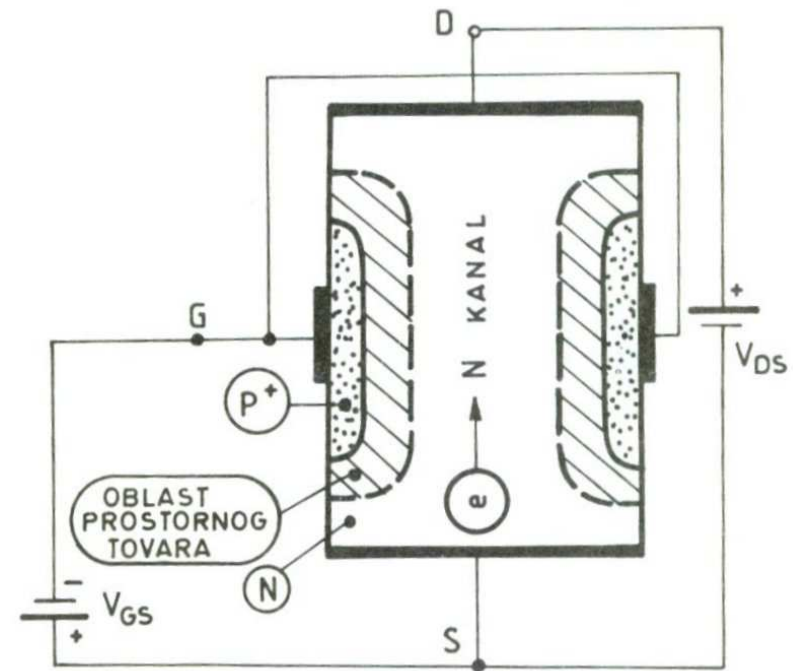
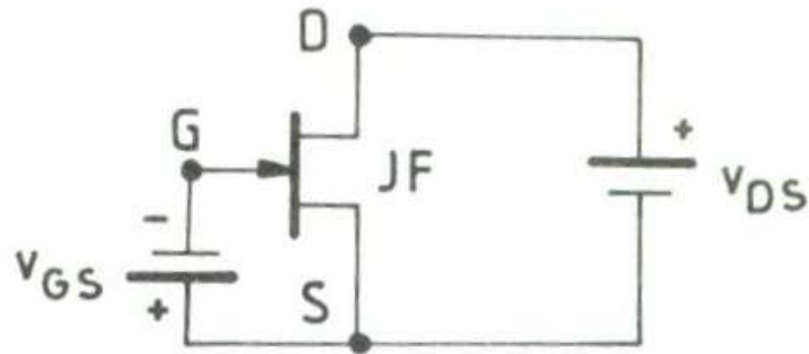


# OSMO PREDAVANJE

## **OSNOVNA KOLA SA TRANZISTORIMA SA EFEKTOM POLJA TIRISTORI**

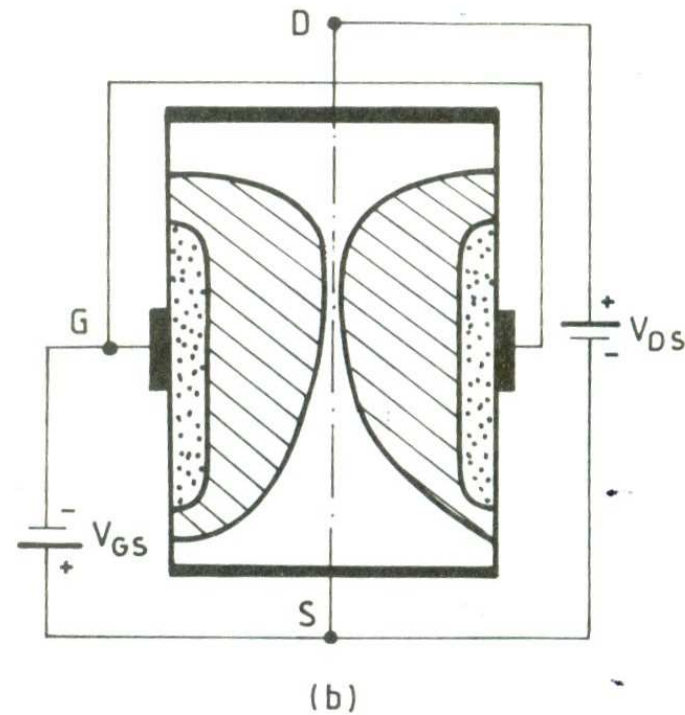
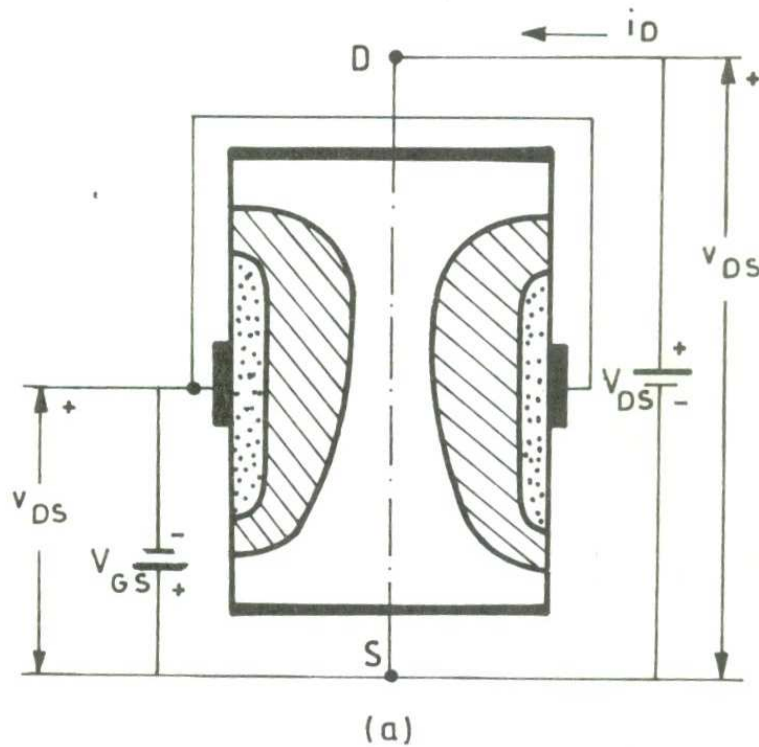
# TRANZISTORI SA EFEKTOM POLJA

- FET (FIELD EFFECT TRANSISTORS) – KORISTI SE ELEKTRIČNO POLJE ZA KONTROLU INTENZITETA STRUJE IZMEĐU IZLAZNIH PRIKLJUČAKA;
- ELEKTRIČNO POLJE SE JAVLJA KAO POSLEDICA NAPONA PRIKLJUČENOG NA **UPRAVLJAČKU ELEKTRODU – GEJT (GATE)**
- **IZLAZNI PRIKLJUČCI SE NAZIVAJU SORS (SOURCE) I DREJN (DRAIN)**
- FET TRANSISTORI SE DELE NA  
**JFET – SPOJNI TRANZISTORI SA EFEKTOM POLJA**  
**IGFET- FET SA IZOLOVANIM GEJTOM**



- $V_{DS} \sim 0$ ,  $V_{GS} = 0$ , KANAL IMA NAJVEĆU PROVODNOST
- $V_{GS} = V_P = V_{GS(OFF)}$ , FET ZAKOČEN
- $V_{DS} \sim 0$ ,  $V_{GS} \ll V_P = V_{GS(OFF)}$  LINEARNA OBLAST

$$i_D = G v_{DS} \quad G = 1 - \sqrt{v_{GS} / V_P}$$



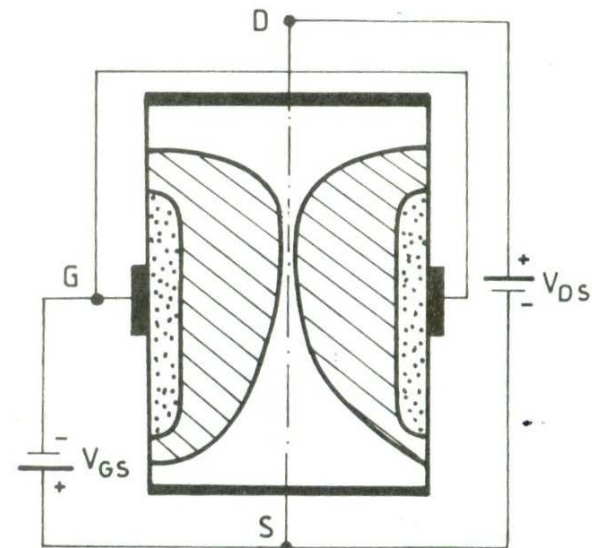
- KAKO  $V_{DS}$  RASTE ŠIRINA OBLASTI PROSTORNOG TOVARA DUŽ KANALA POSTAJE SVE NERAVNOMERNIJA (KANAL JE NAJUŽI KOD DREJNA)
- SVE DOK JE  $V_{GD} = V_{GS} - V_{DS} > V_P$  STRUJA DREJNA ZAVISI I OD  $V_{DS}$  I OD  $V_{GS}$  OVA OBLAST RADA SE NAZIVA OMSKA (TRIODNA) OBLAST RADA

# FET U ZASIĆENJU

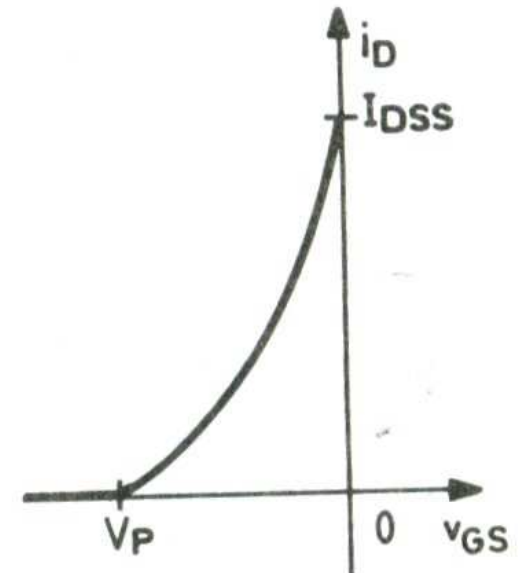
- KADA JE
- $V_{GD} = V_{GS} - V_{DS} < V_P$ ,  $V_{GS} > V_P$
- KANAL JE UŠTINUT KOD REJNA DOK KOD SORSA NIJE UŠTINUT I FET ULAZI U OBLAST ZASIĆENJA KADA STRUJA DREJNA VEOMA MALO ZAVISI OD NAPONA  $V_{DS}$

$$i_D = \left(1 + \frac{v_{DS}}{V_A}\right) I_{DSS} \left(1 - \frac{v_{GS}}{V_P}\right)^2$$

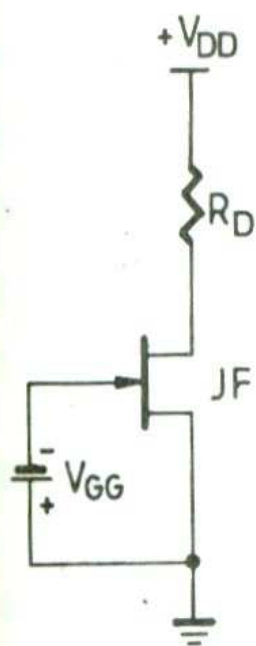
$$i_D = I_{DSS} \left(1 - \frac{v_{GS}}{V_P}\right)^2$$



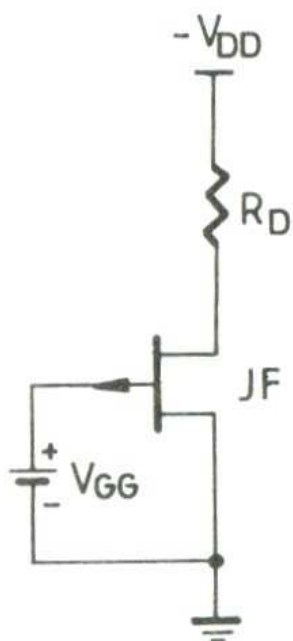
# STAT FET-A



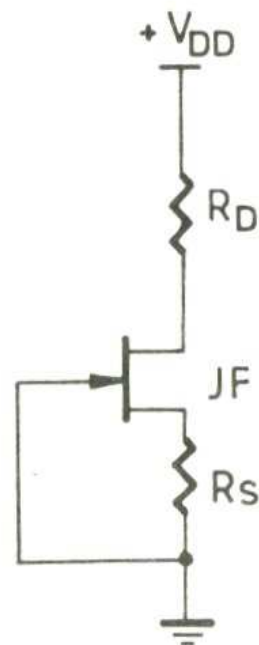
# POLARIZACIJA FETOVA



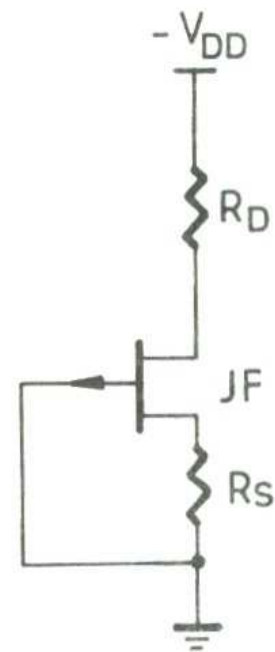
( a )



( b )



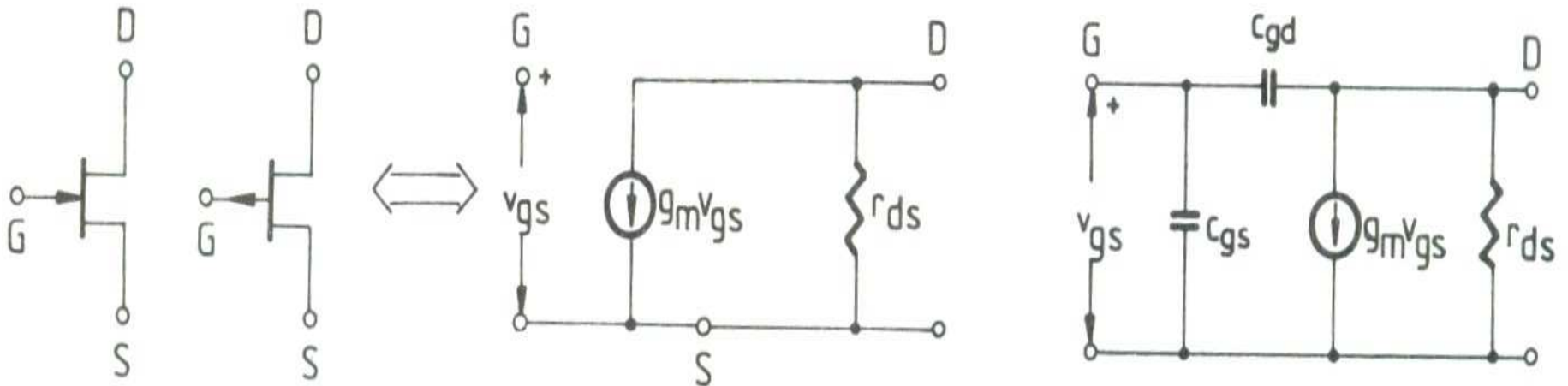
( c )



( d )

# EKVIVALENTNO KOLO FETA

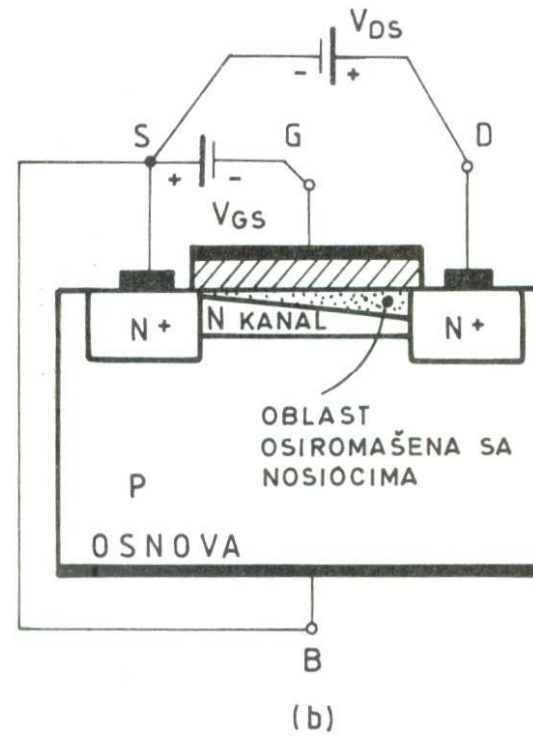
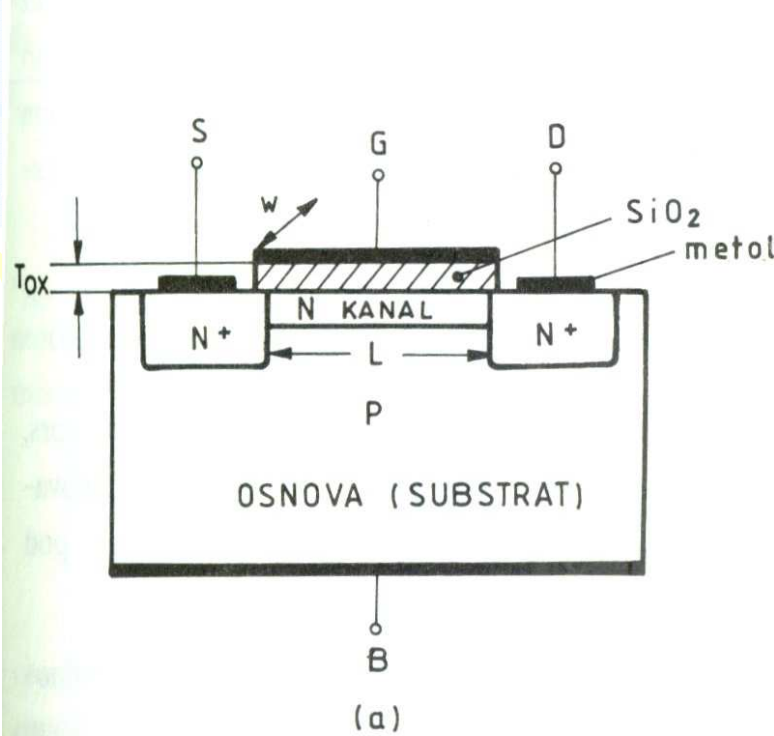
$$g_m = \left. \frac{di_D}{dv_{GS}} \right|_{i_D=I_{DQ}} = \frac{2\sqrt{I_{DSS}I_{DQ}}}{-V_P} \approx \frac{i_d}{v_{gs}} \quad r = \frac{1}{\left. \frac{di_D}{dv_{DS}} \right|_{i_D=I_{DQ}}} \approx \frac{V_A}{I_{DQ}} = \frac{v_{ds}}{v_{gs}}$$



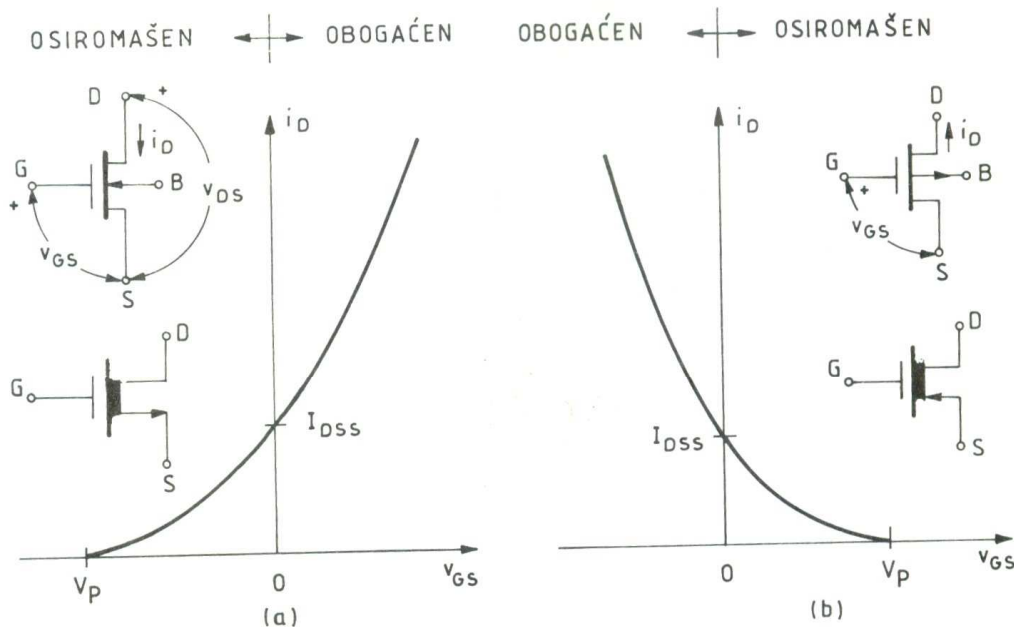


# MOSFET

- KOD MOSFETA IZMEĐU METALNE ELEKTRODE GEJTA I POLUPROVODNIKA SE NALAZI OKSID SILICIJUMA; OVA STRUKTURA FORMIRA KONDENZATOR
- MOSFETOVI MOGU BITI :SA UGRAĐENIM I INDUKOVANIM KANALOM



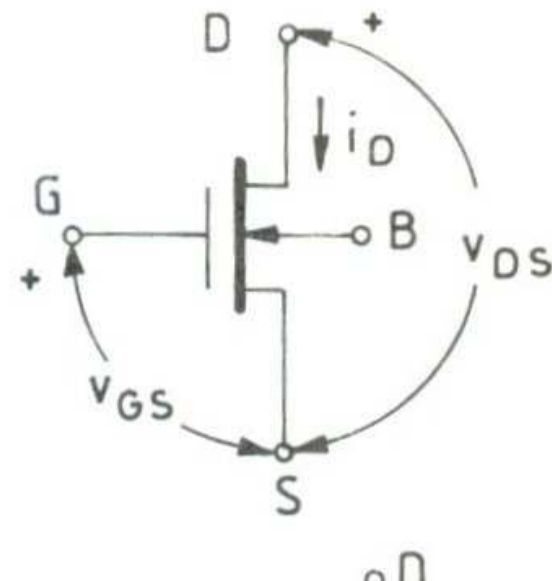
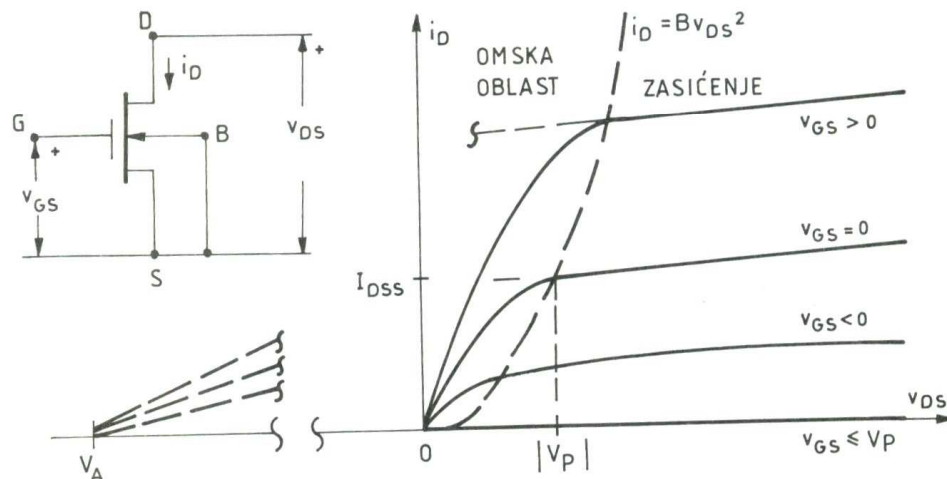
# STATIČKE KARAKTERISTIKE MOSFETA SA UGRAĐENIM KANALOM



U PBLASTI ZASIĆENJA

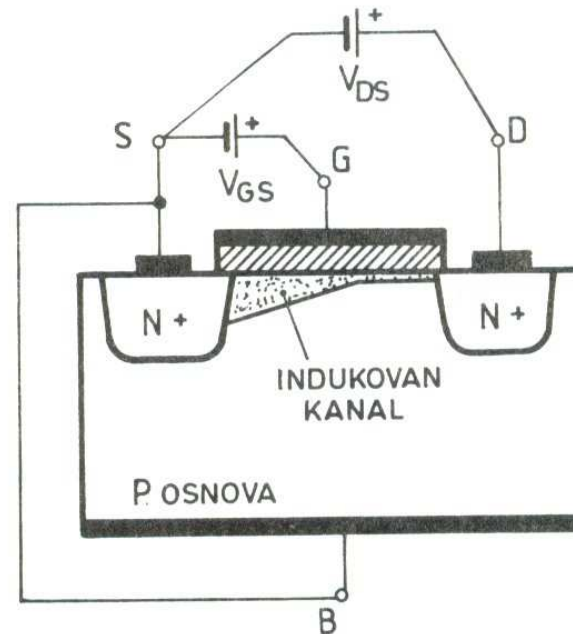
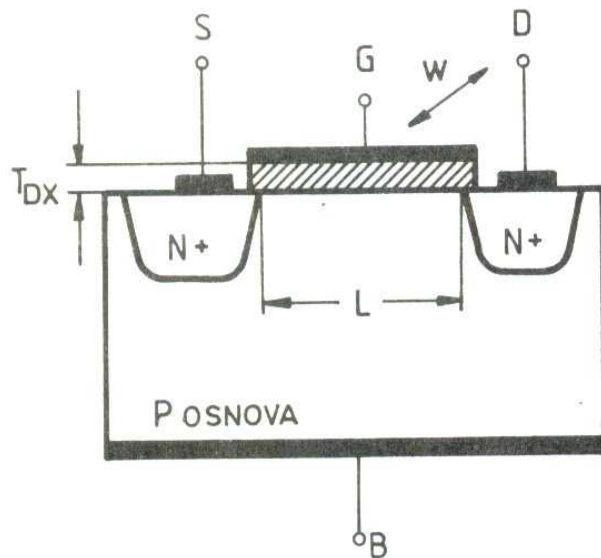
$$i_D = B \left( 1 + \frac{v_{DS}}{V_A} \right) (v_{GS} - V_P)^2$$

$$B = \frac{1}{2} \mu_n C_0 \left( \frac{W}{L} \right)$$



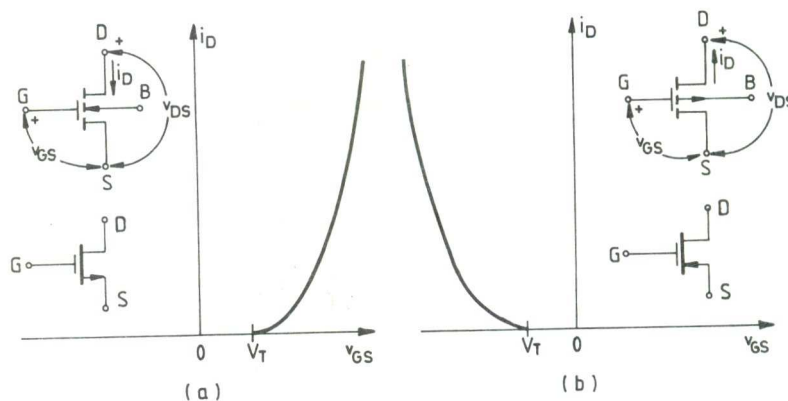
# MOSFET SA INDUKOVANIM KANALOM

- NEMA SLOJA POLUPROVODNIKA IZMEĐU DREJNA I SORSA
- $i_{DS}$  NE TEČE U ODSUSTVU  $V_{GS}$



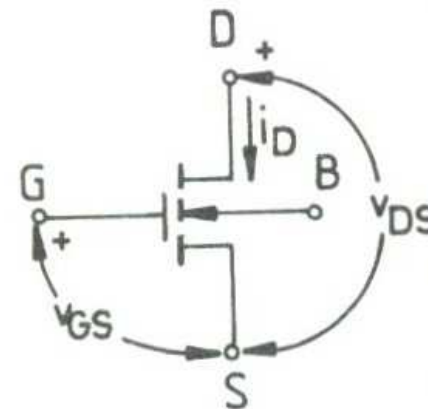
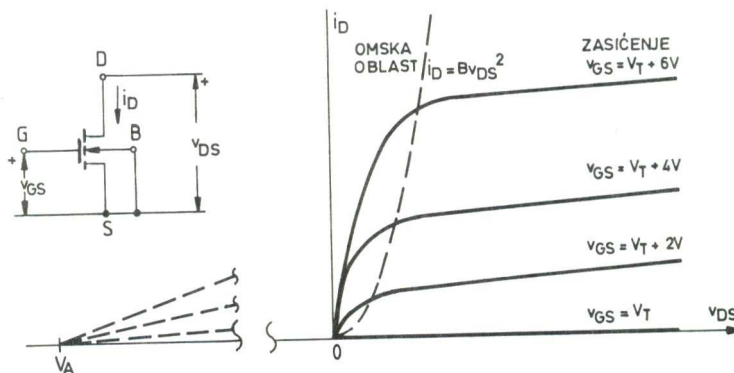
# STATIČKE KARAKTERISTIKE MOSFETA SA INDUKOVANIM KANALOM

## U OBLASTI ZASIĆENJA

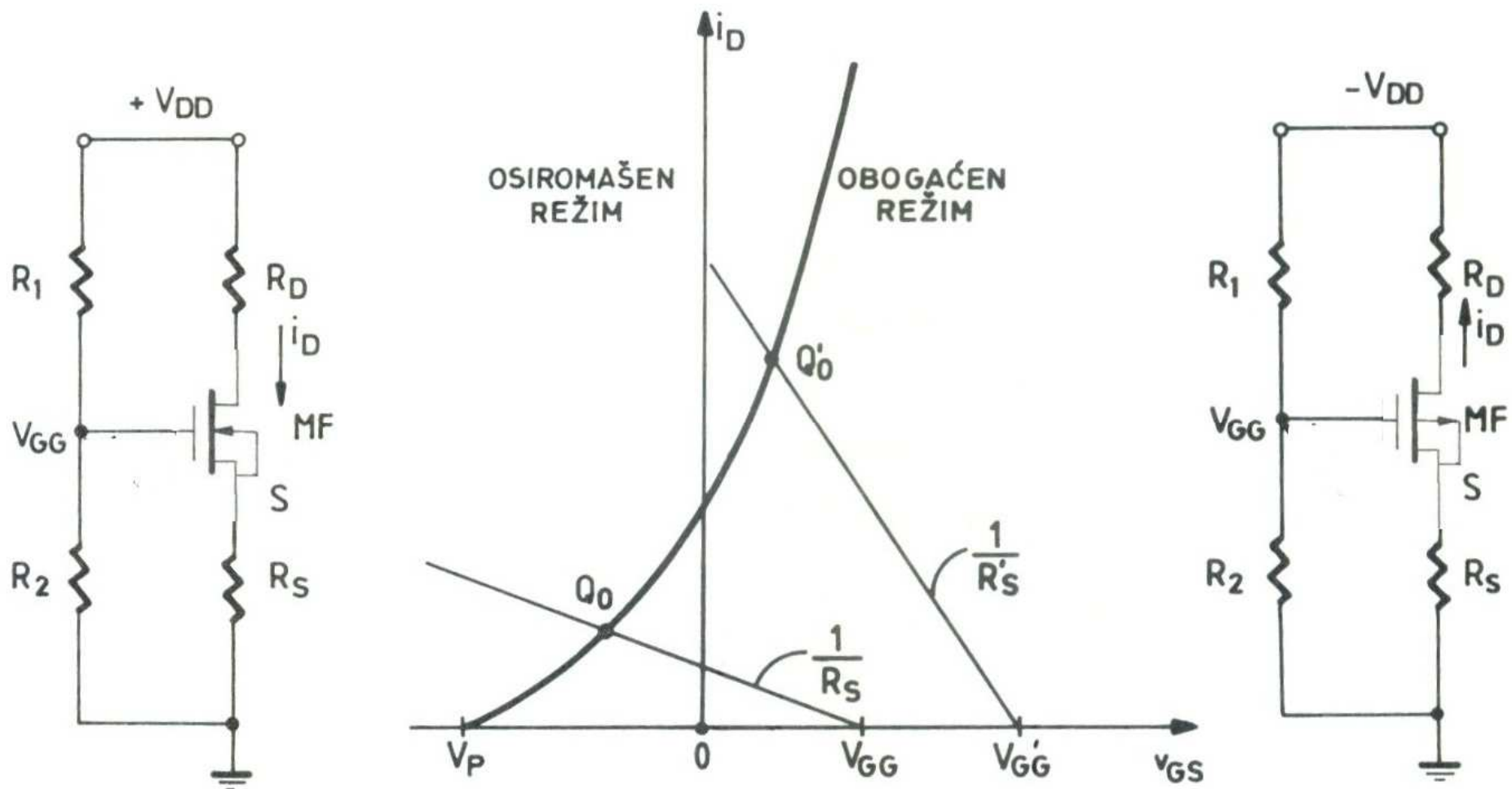


$$i_D = B \left( 1 + \frac{v_{DS}}{V_A} \right) (v_{GS} - V_T)^2$$

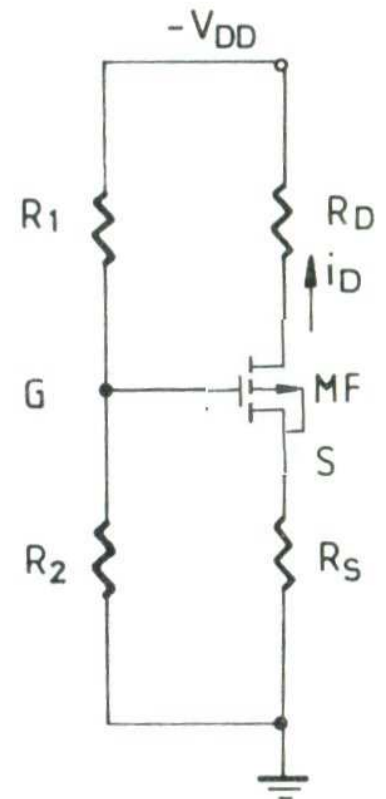
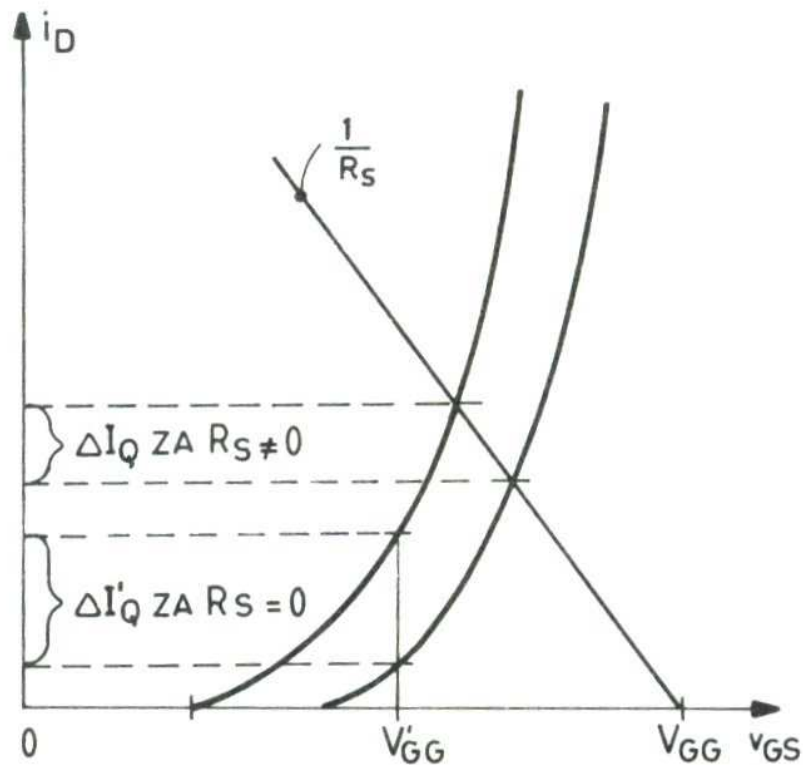
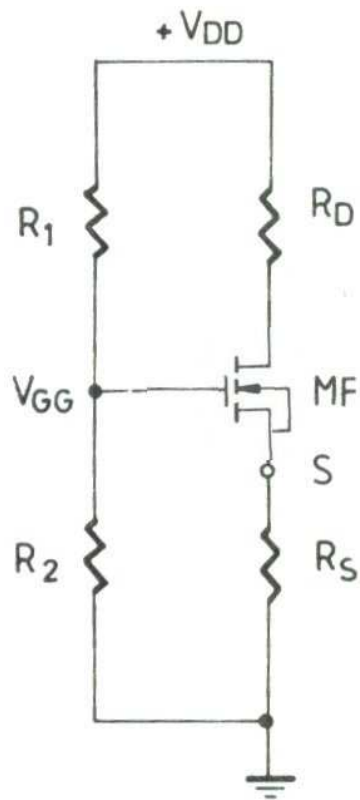
$$B = \frac{1}{2} \mu_n C_0 \left( \frac{W}{L} \right)$$



# POLARIZACIJA MOSFETOVA SA UGRAĐENIM KANALOM

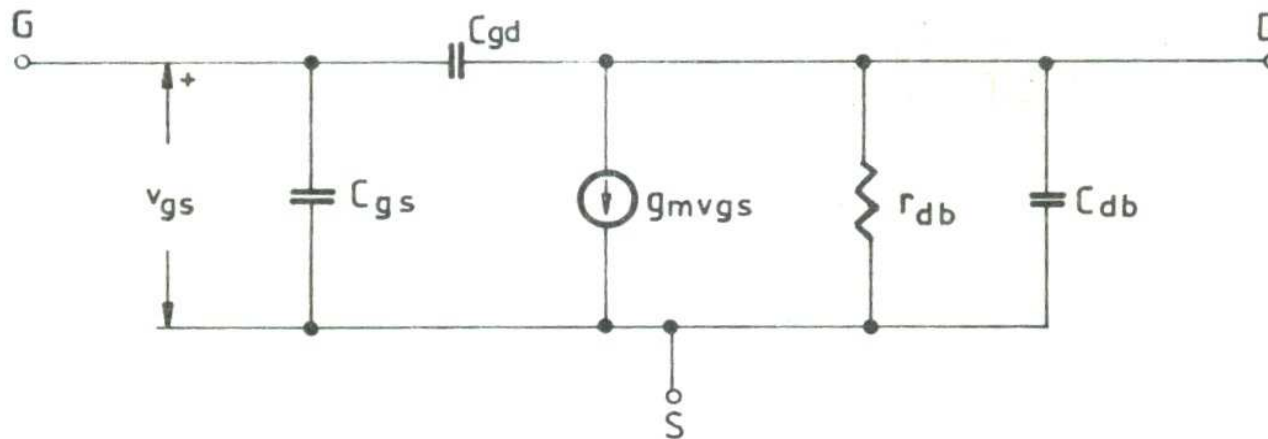
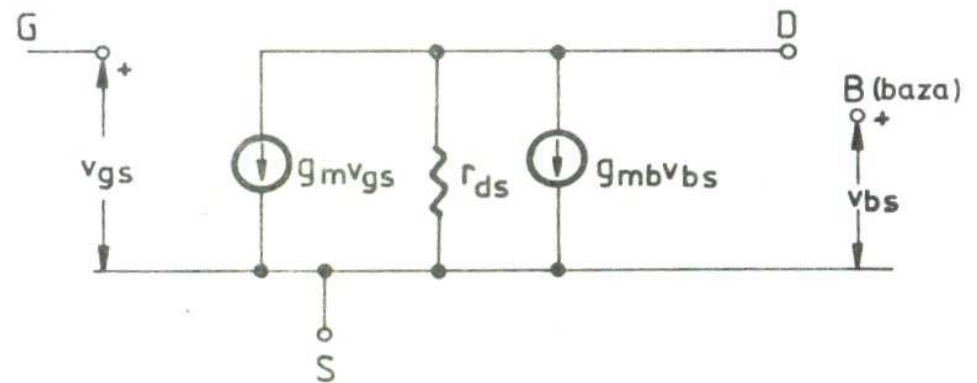
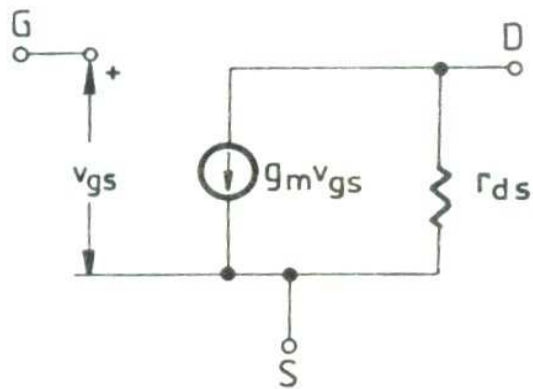


# POLARIZACIJA MOSFETA SA INDUKOVANIM KANALOM



# EKVIVALENTNO KOLO MOSFETA

$$g_m = 2\sqrt{BI_{DQ}} \quad r_{ds} = \frac{V_A}{I_{DQ}}$$



# POJAČAVAČKI STEPENI

- POJAČANJE NAPONA

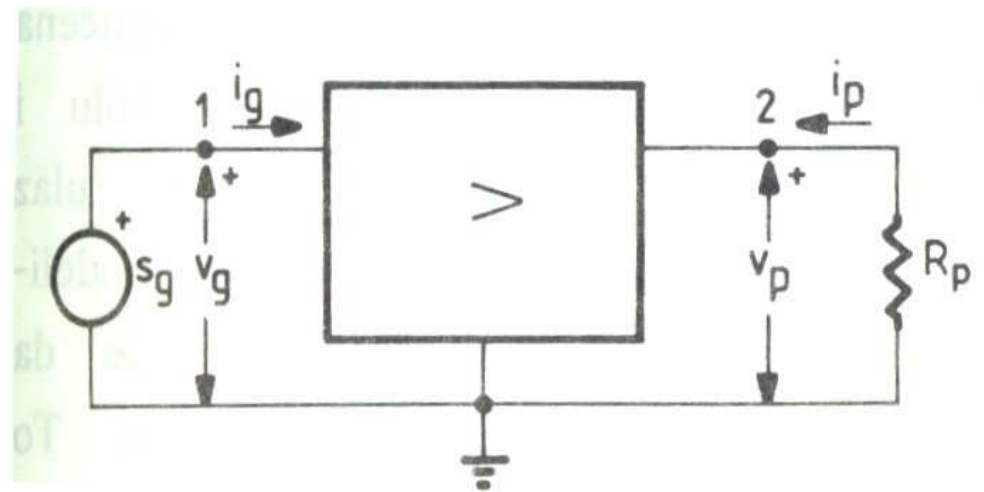
$$A_v = \frac{v_p}{v_g}$$

- POJAČANJE STRUJE

$$A_i = \frac{i_p}{i_g}$$

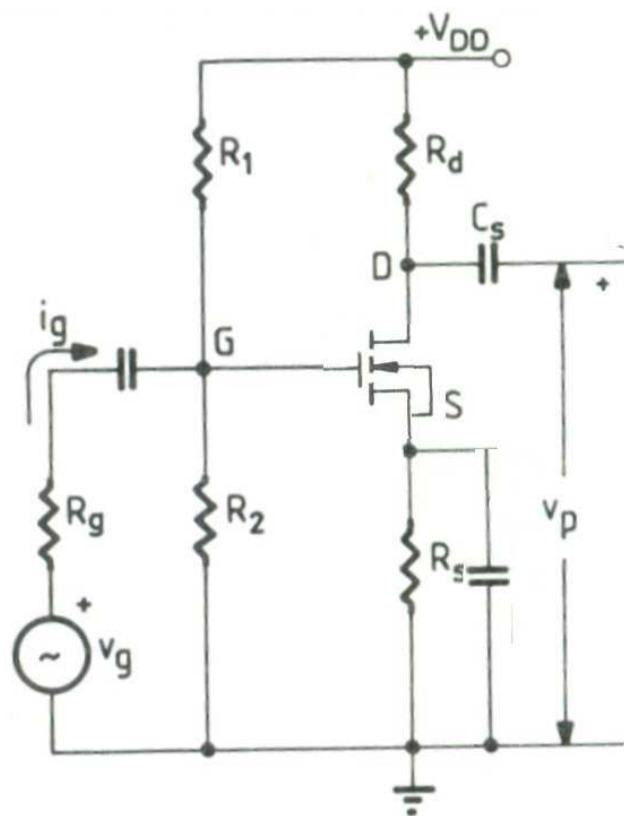
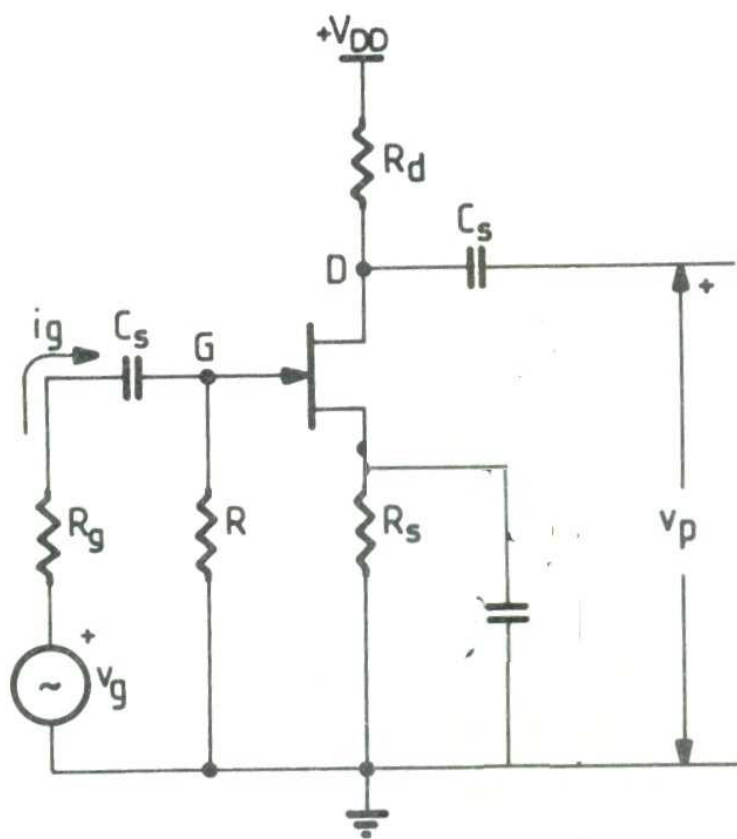
- ULAZNA OTPORNOST

- IZLAZNA OTPORNOST

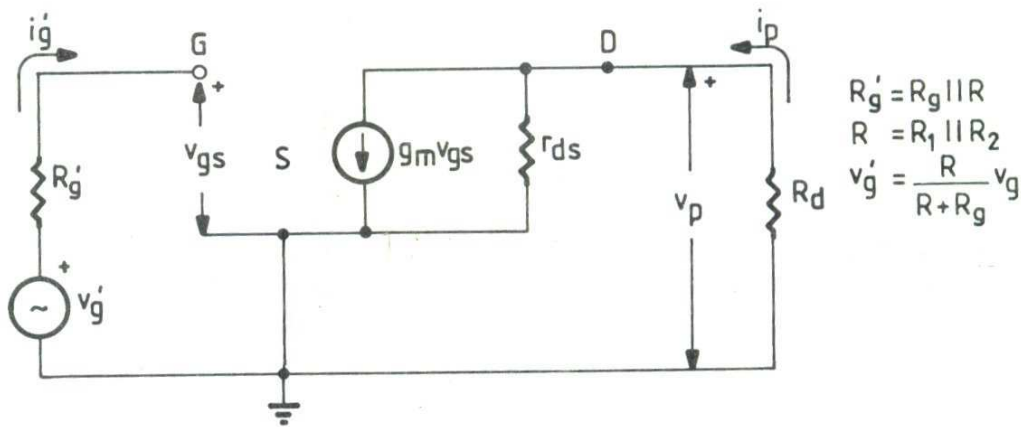




# POJAČAVAČ SA ZAJEDNIČKIM SORSOM



# POJAČAVAČ SA ZAJEDNIČKIM SORSOM



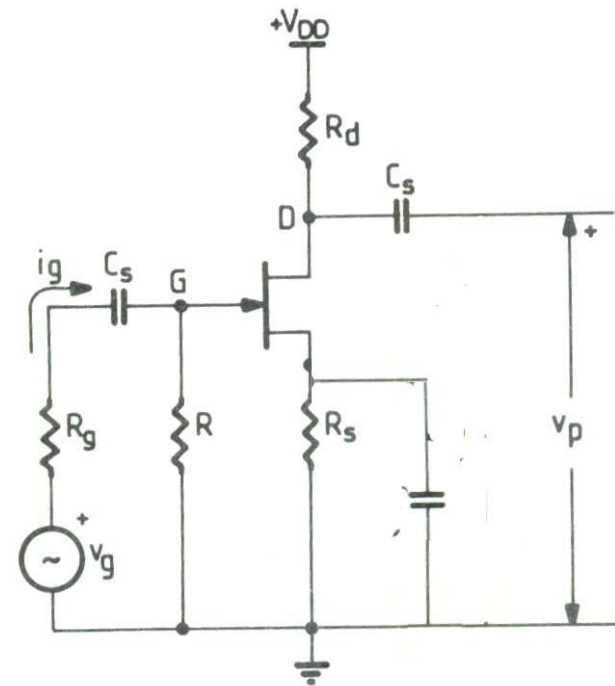
- POJAČANJE NAPONA

$$A_v = -g_m (r_{ds} \parallel R_d) = -g_m \frac{r_{ds} R_d}{r_{ds} + R_d}$$

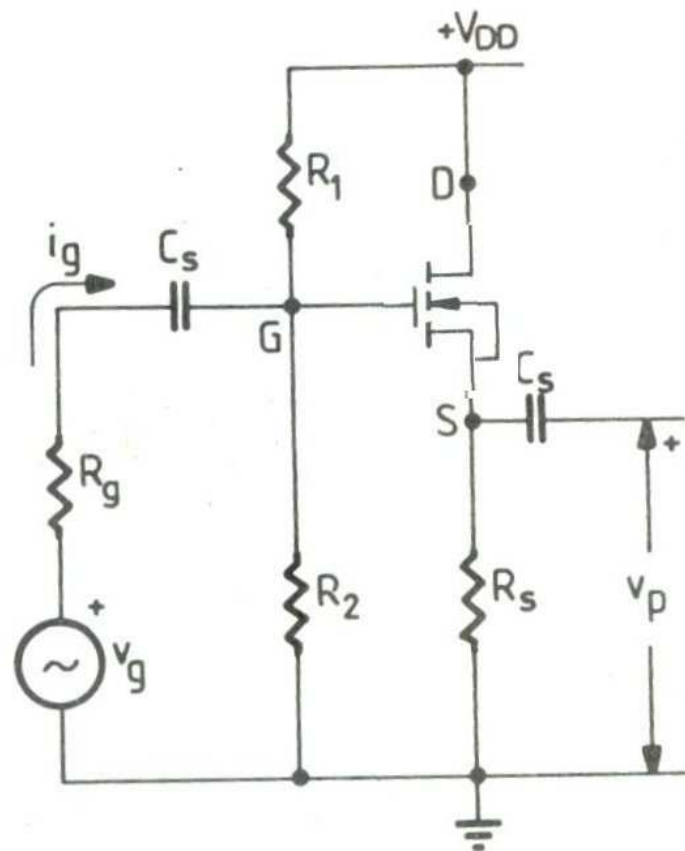
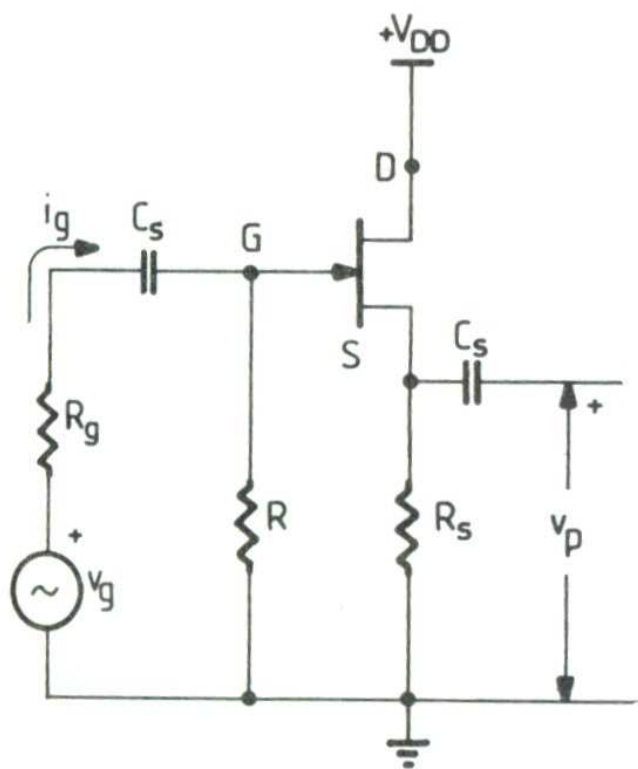
- STRUJNO POJAČANJE  $\approx \infty$

- ULAZNA OTPORNOST  $\approx \infty$

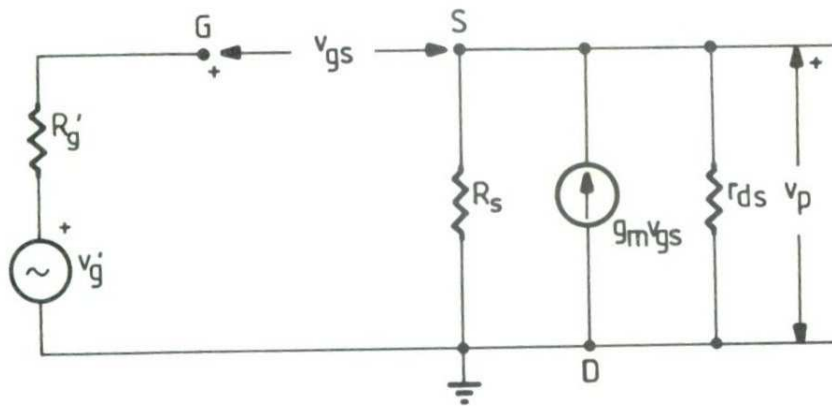
- IZLAZNA OTPORNOST  $R_i = r_{ds}$



# STEPEN SA ZAJDNIČKIM DREJNOM



# STEPEEN SA ZAJEDNIČKIM DREJNOM



$$R_g' = R_g \parallel R$$

$$R = R_1 \parallel R_2$$

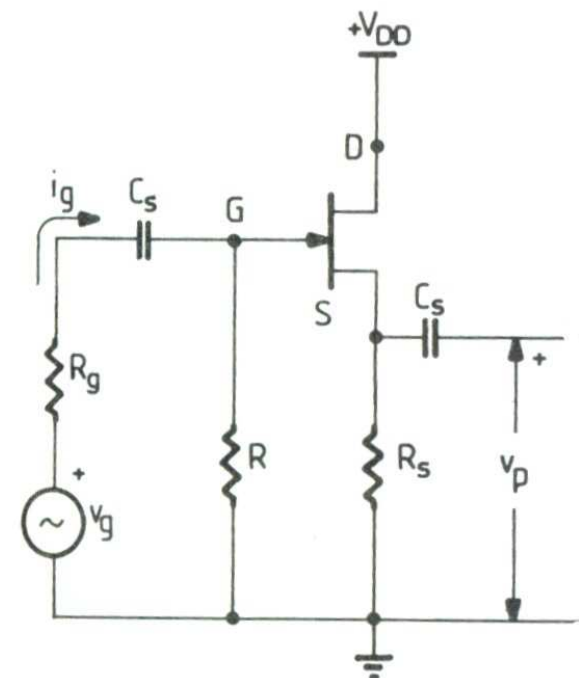
$$v_g' = \frac{R}{R + R_g} v_g$$

- NAPONSKO POJAČANJE

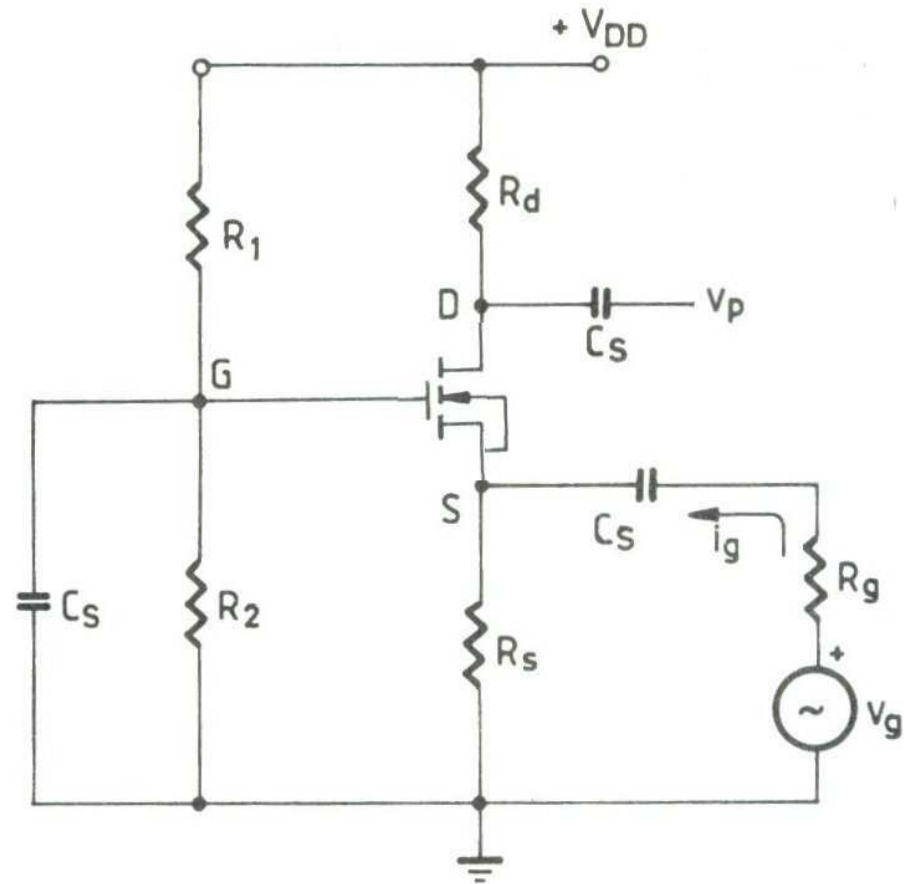
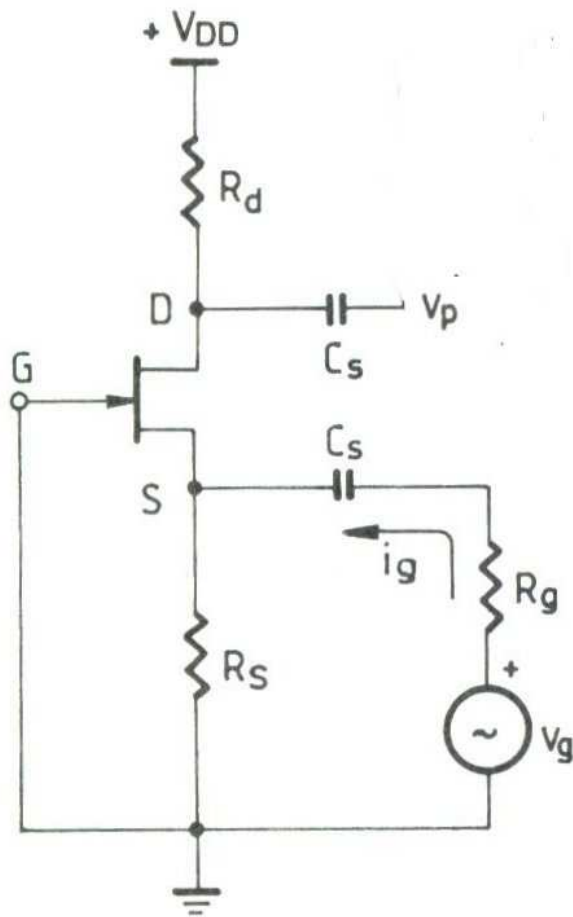
$$A_v = \frac{g_m (r_{ds} \parallel R_s)}{1 + g_m (r_{ds} \parallel R_s)}$$

- IZLAZNA OTPORNOST

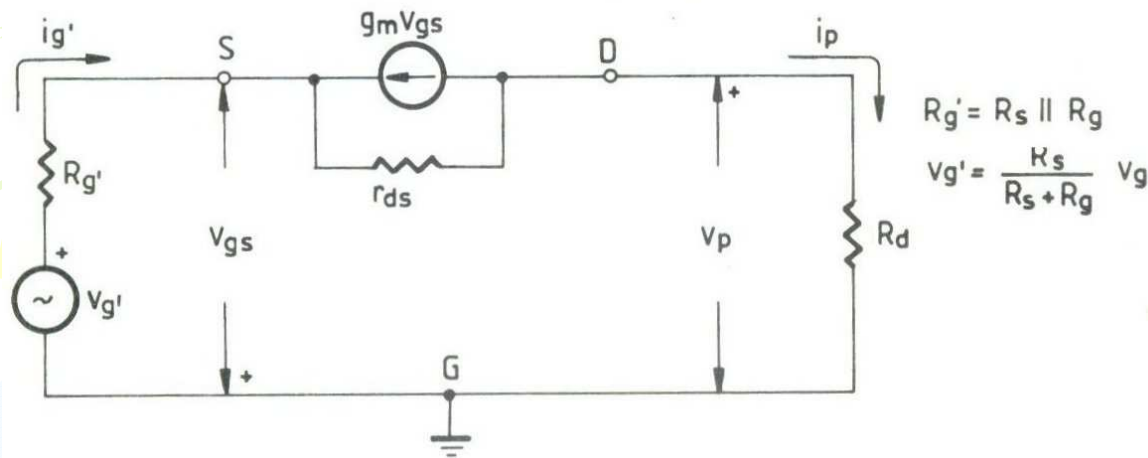
$$R_i = \frac{r_{ds} \parallel R_s}{1 + g_m (r_{ds} \parallel R_s)}$$



# POJAČAVAČ SA ZAJEDNIČKIM GEJTOM



# STEPEN SA ZAJEDNIČKIM GEJTOM



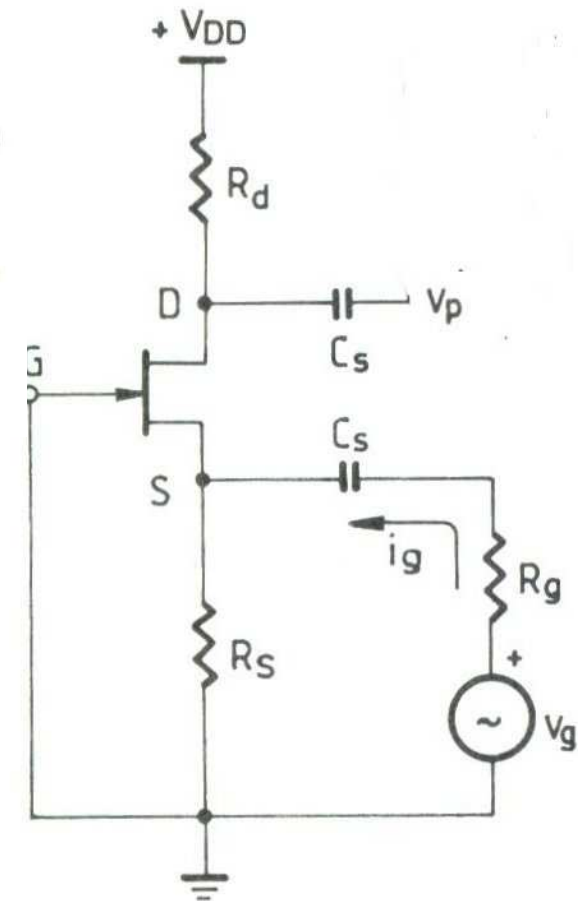
POJAČANJE NAPONA

$$A_v = \frac{R_d (1 + g_m r_{ds})}{r_{ds} + R_d + R_g (1 + g_m r_{ds})}$$

POJAČANJE STRUJE = 1

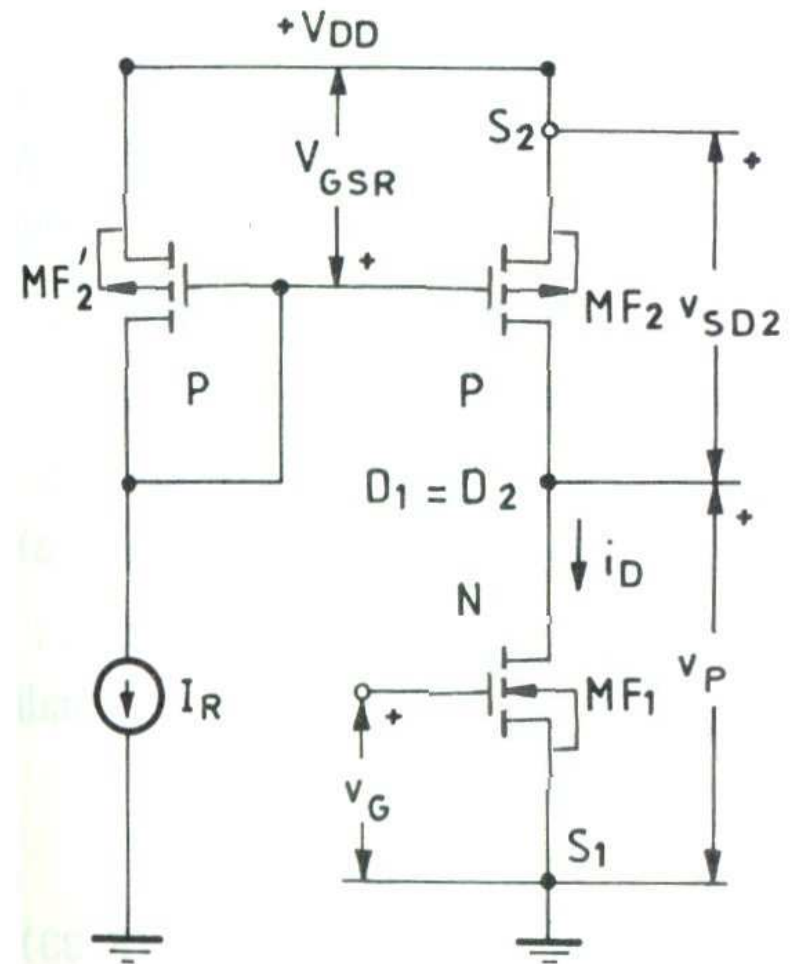
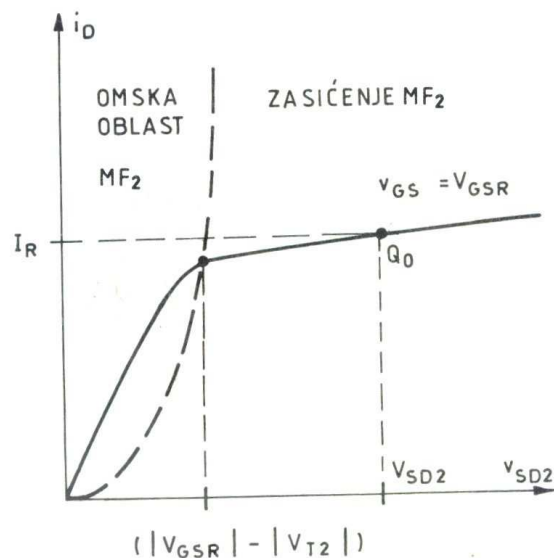
ULAZNA OTPORNOST: MALA

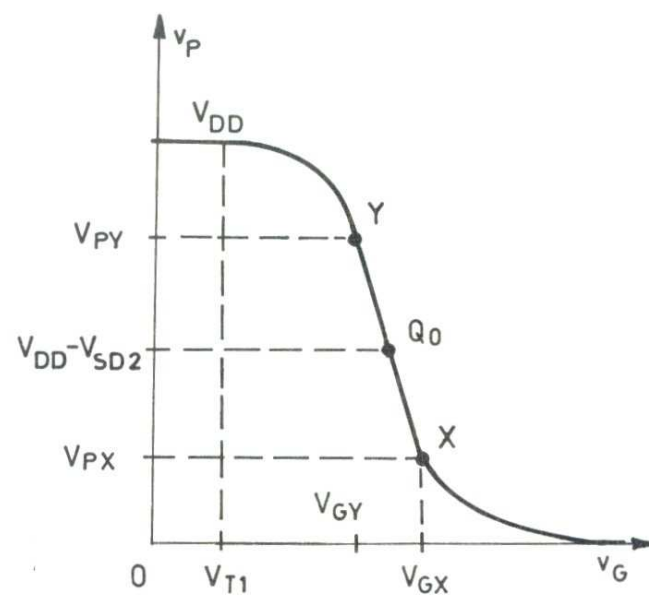
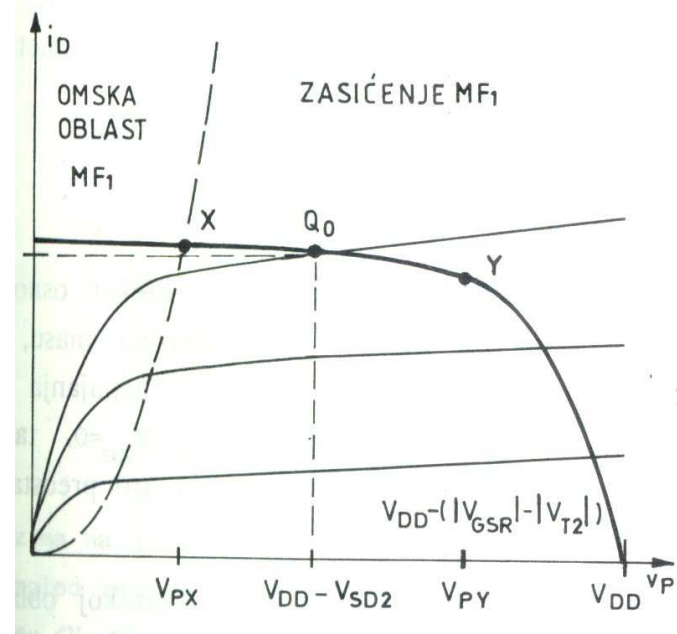
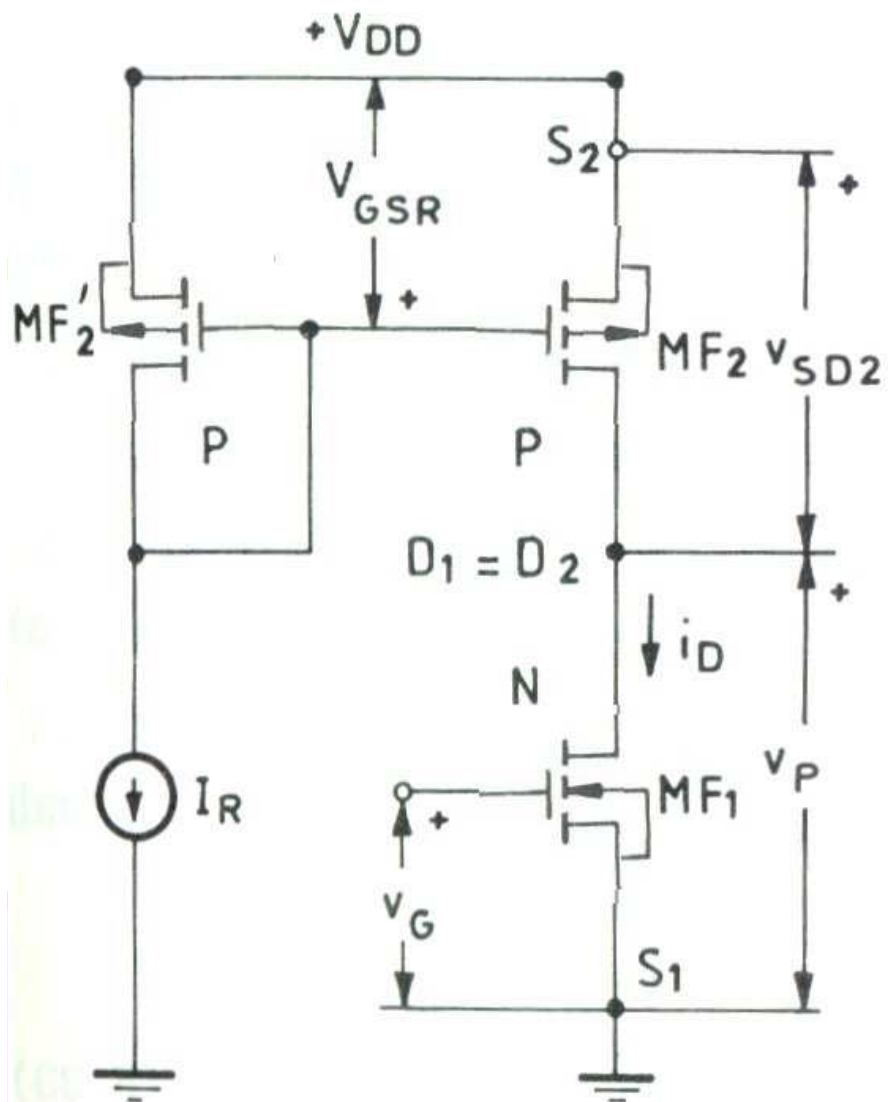
$$R_u = R_g' + \frac{r_{ds} + R_d}{1 + g_m r_{ds}}$$



# KOMPLEMENTARNI MOS POJAČAVAČ (CMOS)

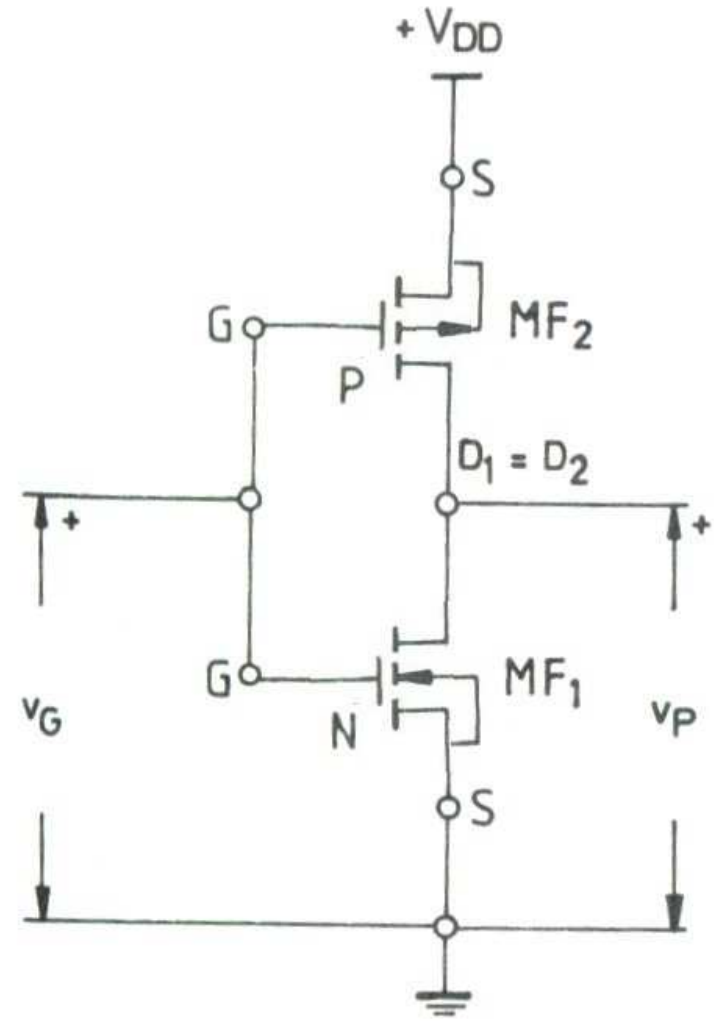
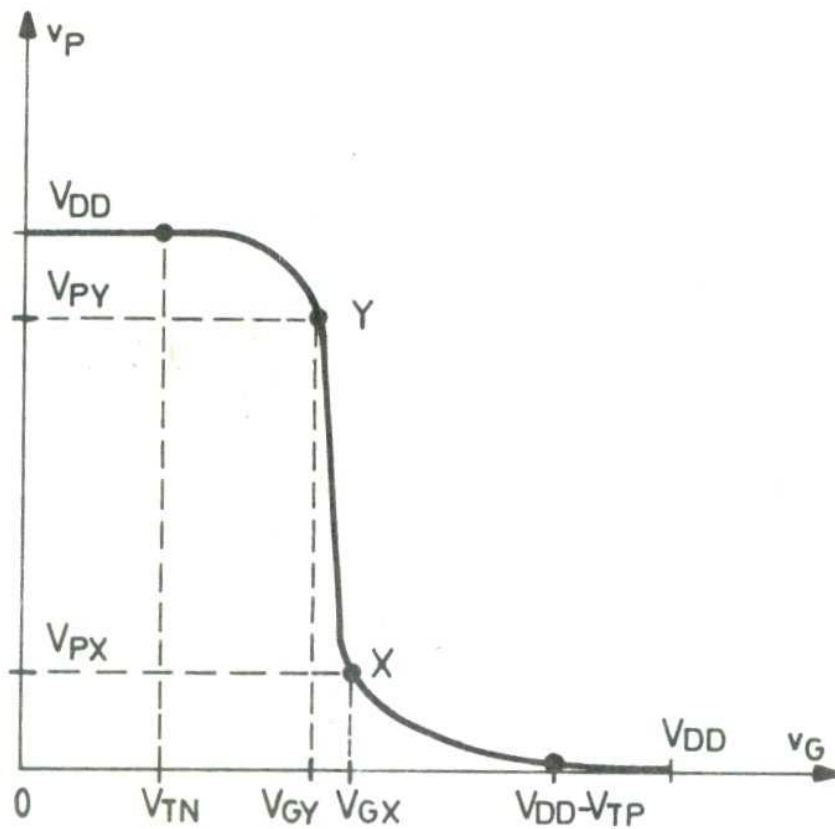
- POJAČAVAČIKI TRANZISTOR I OPTEREĆENJE SU KOMPLEMENTARNI MOSFETOVI (JEDAN JE N A DRUGI P TIP)
- CMOS IMAJU VEĆE POJAČANJE I MANJE IZRAŽEN PARAZITNI EFEKAT OSNOVE



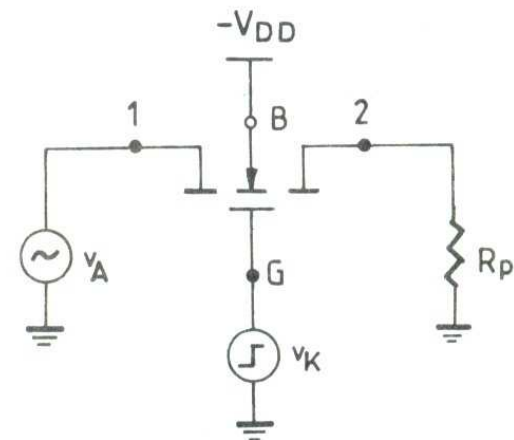
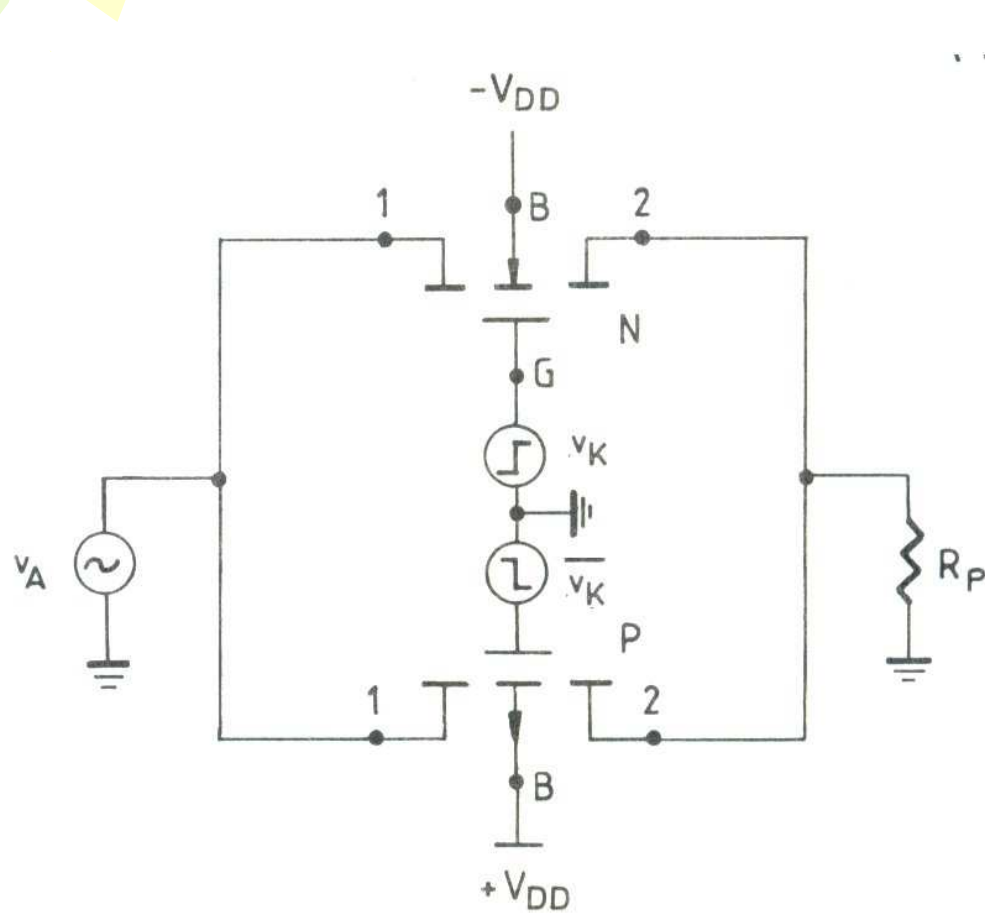




# DIGITALNI CMOS INVERTOR



# ANALOGNI PREKIDAČ

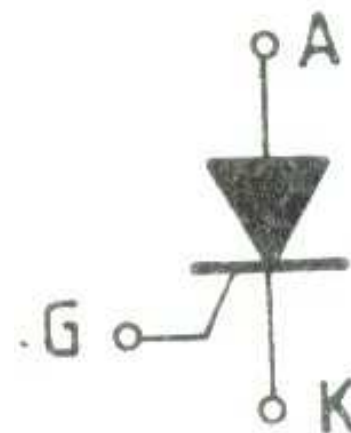
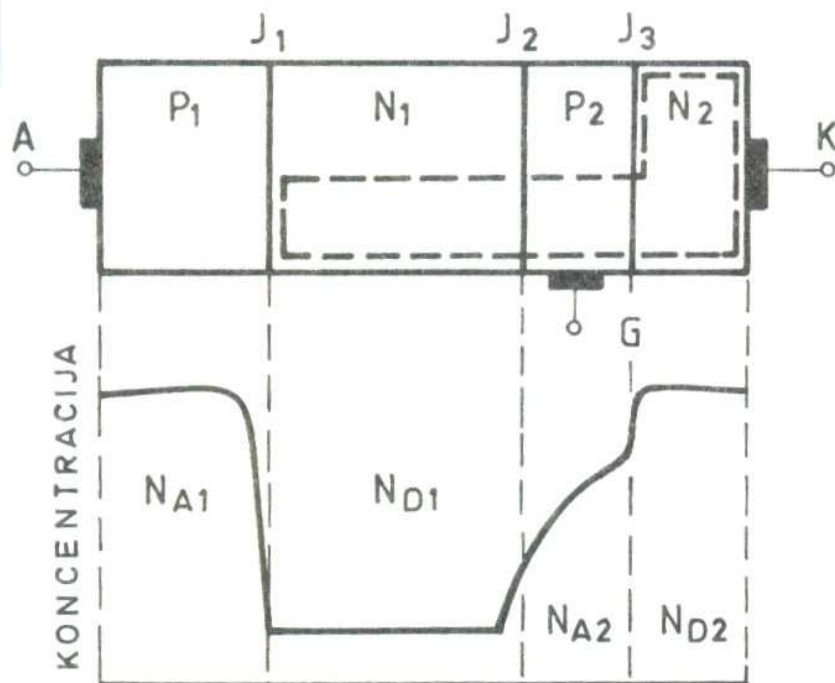


# TIRISTORI

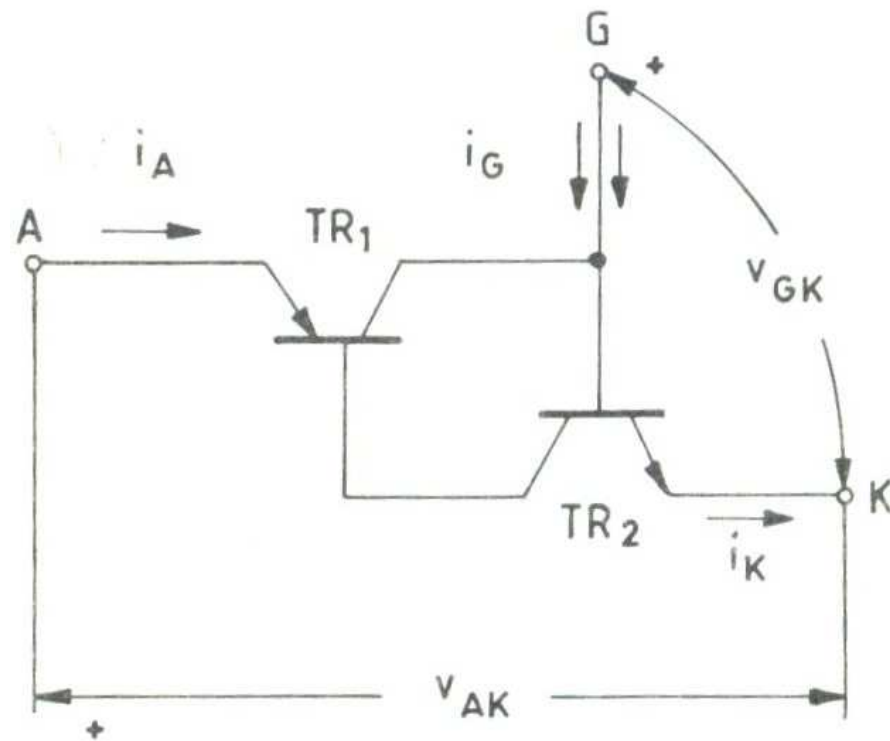
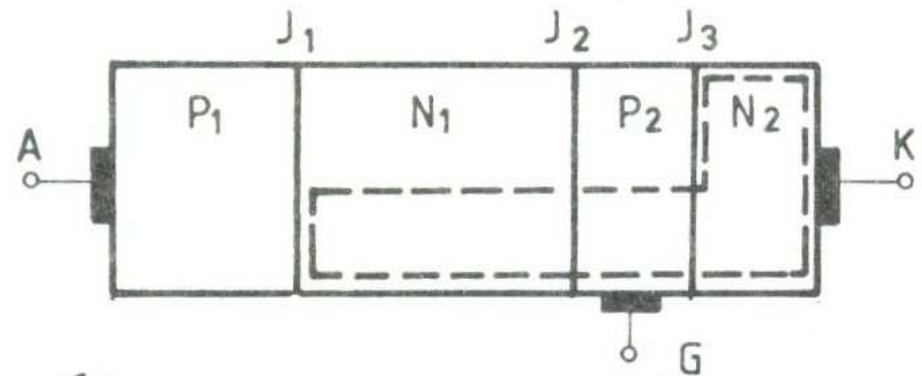
- TIRISTOR JE VIŠESLOJNI POLUPROVODNIČKI ELEMENT (IZRAĐUJE SE OD Si) SA DVA STANJA (PROVODNO – UKLJUČENO) I NEPROVODNO (ISKLJUČENO)
- U PROVODNOM STANJU UNUTRAŠNJA OTPORNOST TIRISTORA JE MALA A STRUJA PO PRAVILU VELIKA DOK JE U NEPROVODNOM STANJU OTPORNOST TIRISTORA VELIKA A STRUJA MALA
- U ODNOSU NA TRANZISTORSKE PREKIDAČE TIRISTORI PREKIDAJU ZNATNO VEĆU SNAGU
- POSTOJI MNOGO RAZLIČITIH TIPOVA TIRISTORA ZAVISNO OD VELIČINE STRUJE U PROVODNOM SMERU (OD NEKOLIKO MILIAMPERA DO NEKOLIKO HILJADA AMPERA) I VELIČINE NAPONA KOJI SE PREKIDA (OD NEKOLIKO DESETINA VOLTU DO NEKOLIKO KILOVOLTU)
- TIRISTORI MOGU DA IMAJU DVE TRI ILI ČETIRI ELEKTRODE

# TRIODNI TIRISTOR

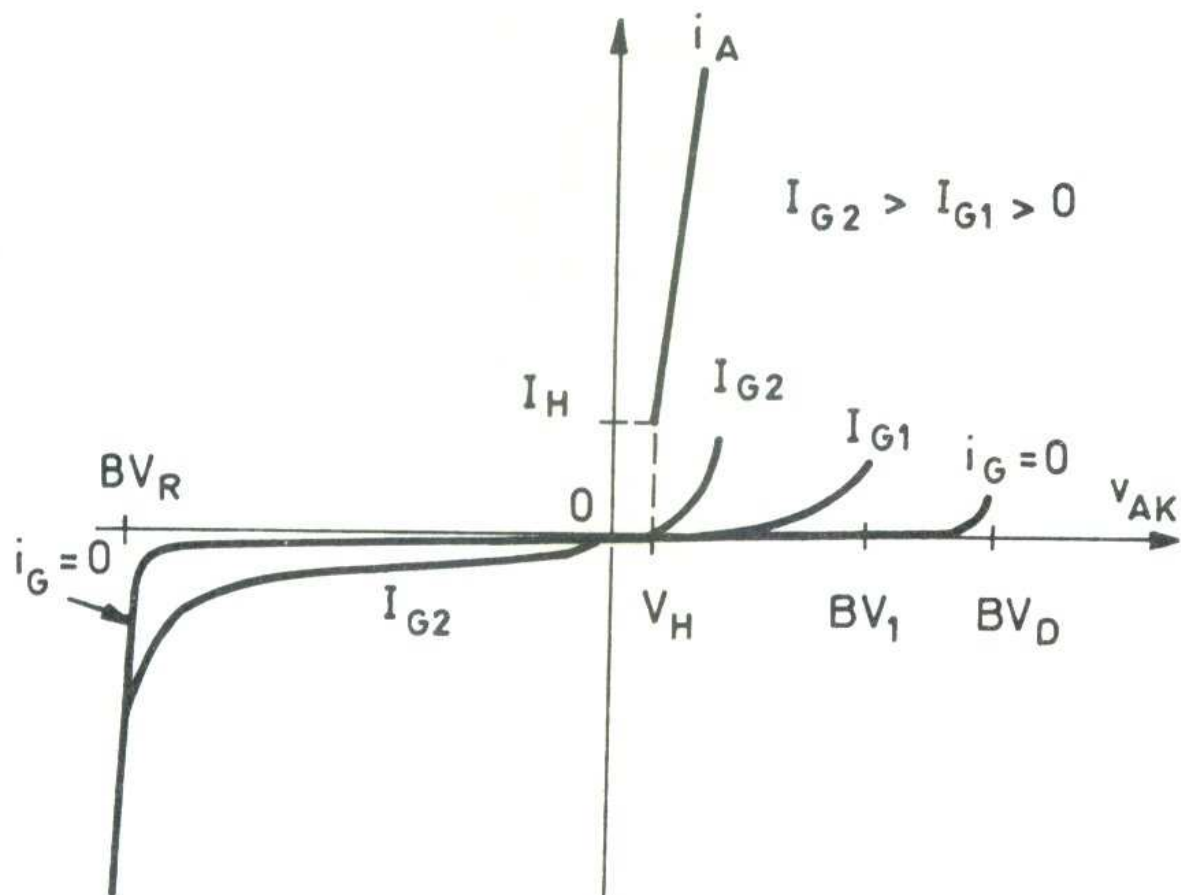
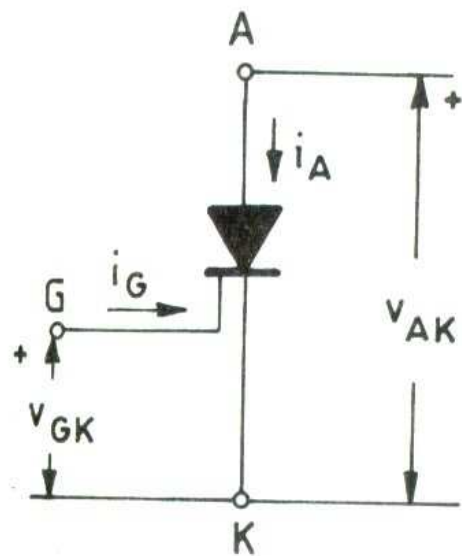
- ČETVOROSLOJNI ELEMENT SA TRI KRAJA KOJI PROVODI STRUJU SAMO U JEDNOM SMERU; POMOĆU TREĆEG PRIKLJUČKA OMOGUĆUJE SE PREBACIVANJE IZ PROVODNOG U NEPROVODNO STANJE PRE DOSTIZANJA NAPONA PROBOJA PNPN STRUKTURE



# EKVIVALENTNI MODEL TIRISTORA

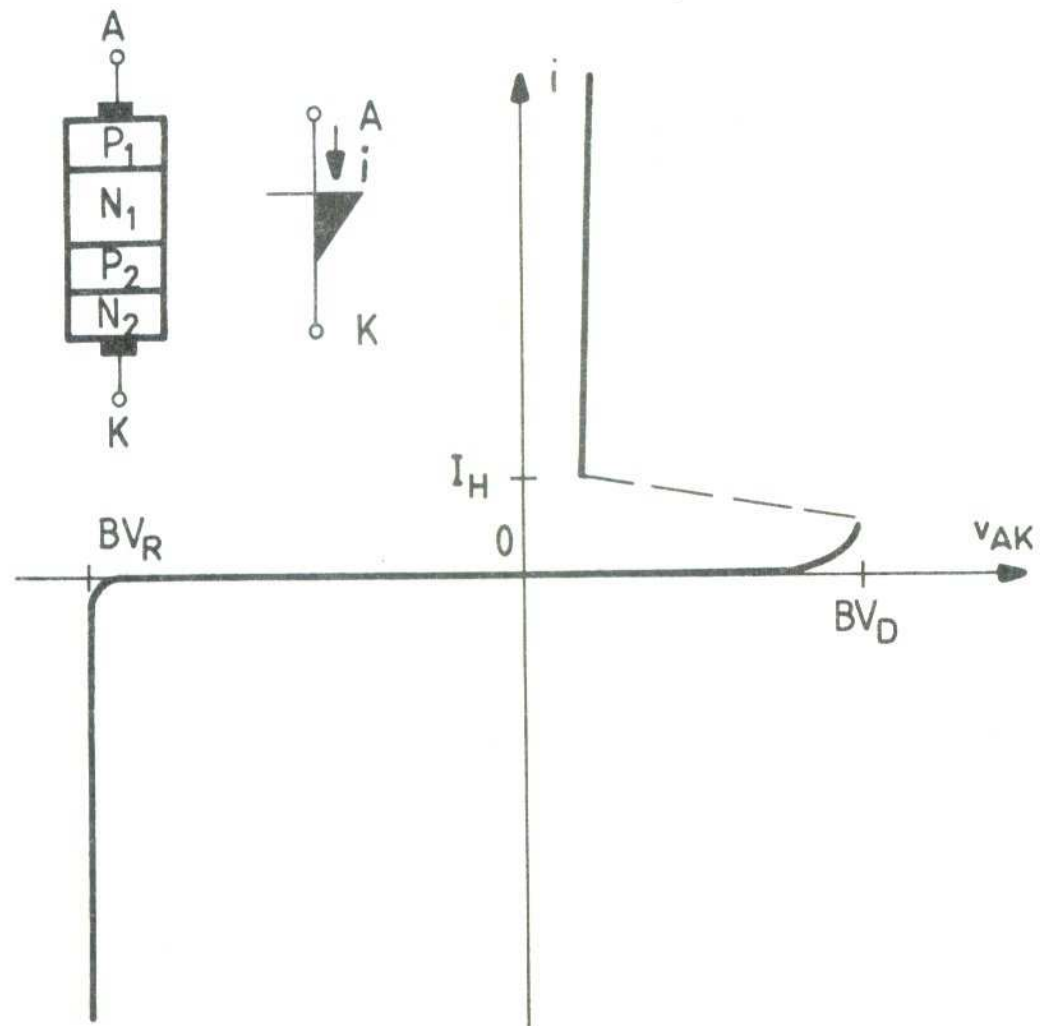


# STATIČKE KARAKTERISTIKE TIRISTORA

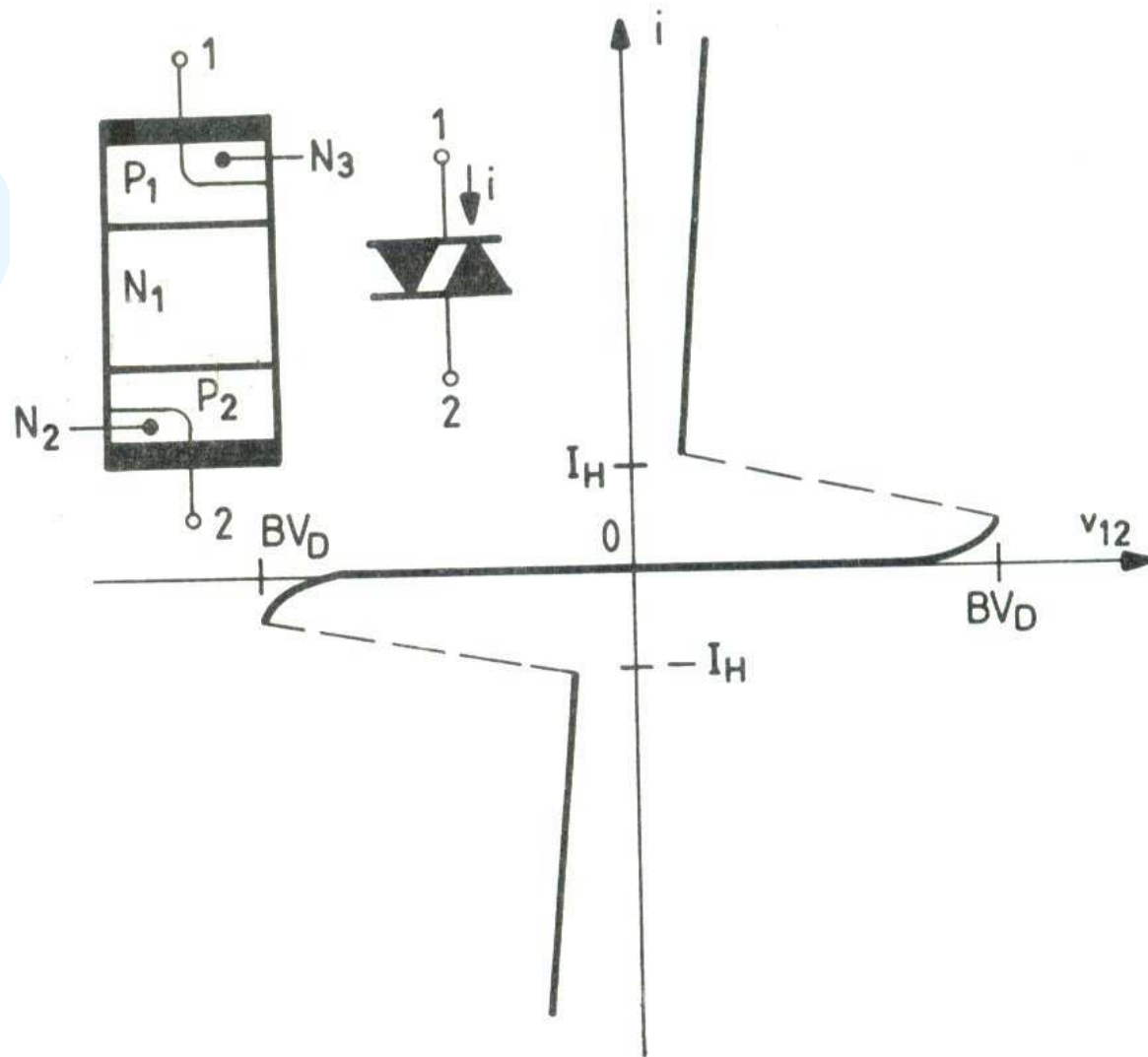


# ČETVOROSLOJNA DIODA

- DIODNI TIRISTOR

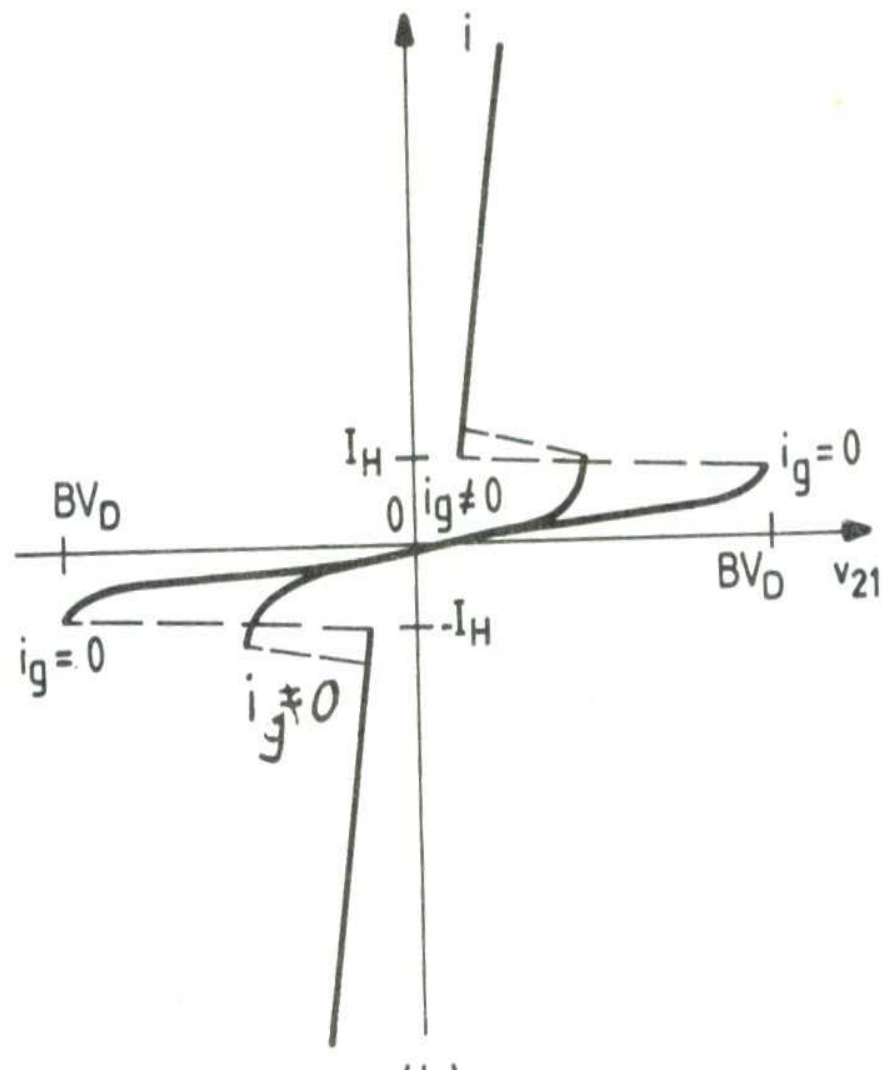
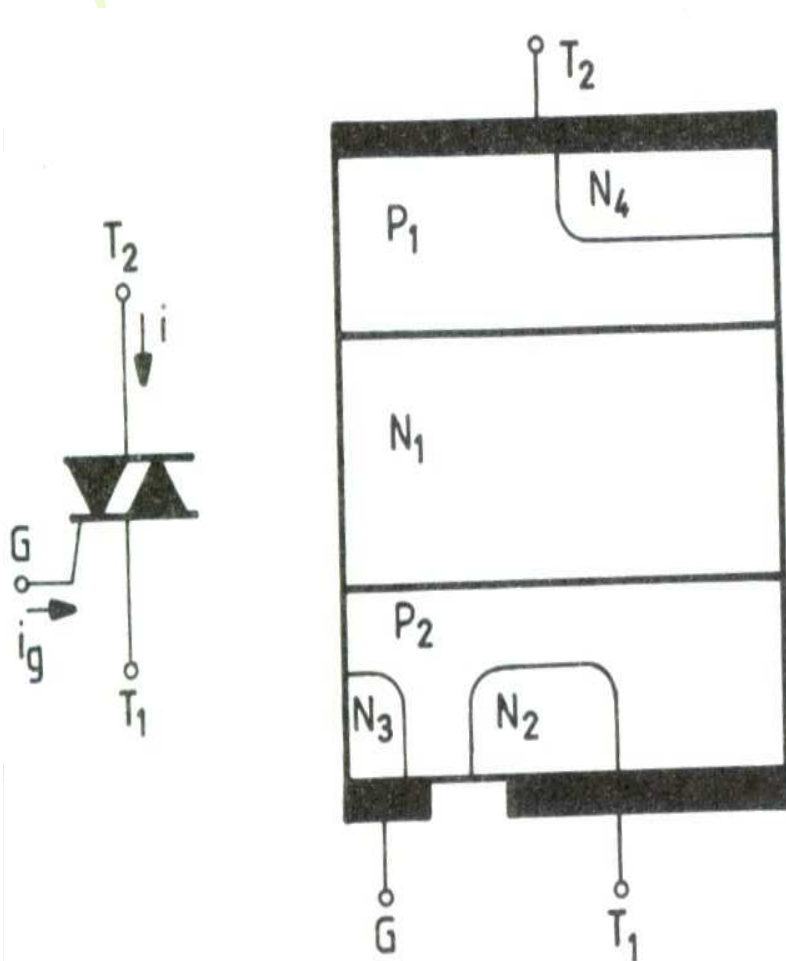


# SIMETRIČNI DIODNI TIRISTOR DIJAK





# SIMETRIČNI TRIODNI TIRISTOR- TRIJAK



# KOLO ZA KONTROLU SNAGE POTROŠAČA

