SEDMO PREDAVANJE

OSNOVNA KOLA SA BIPOLARNIM TRANZISTORIMA
TRANZISTORI SA EFEKTOM POLJA

POJAČAVAČKI STEPENI

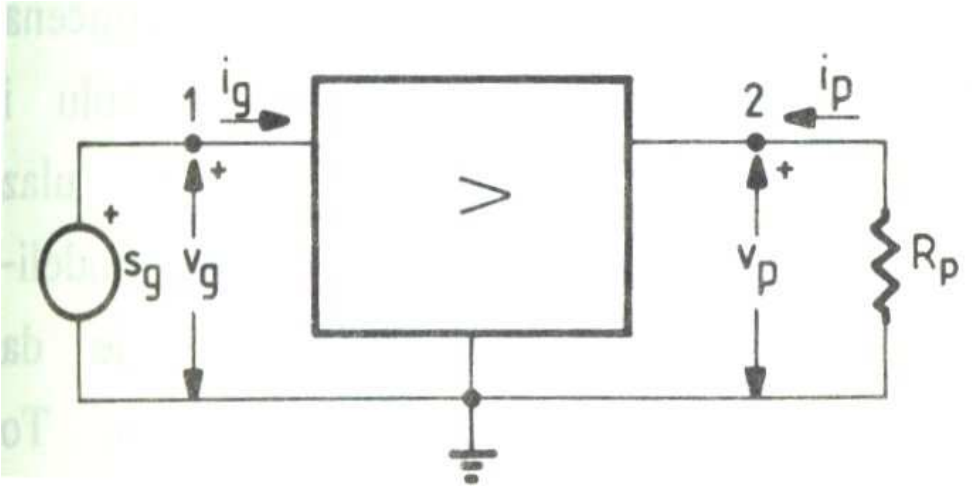
- POJAČANJE NAPONA

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

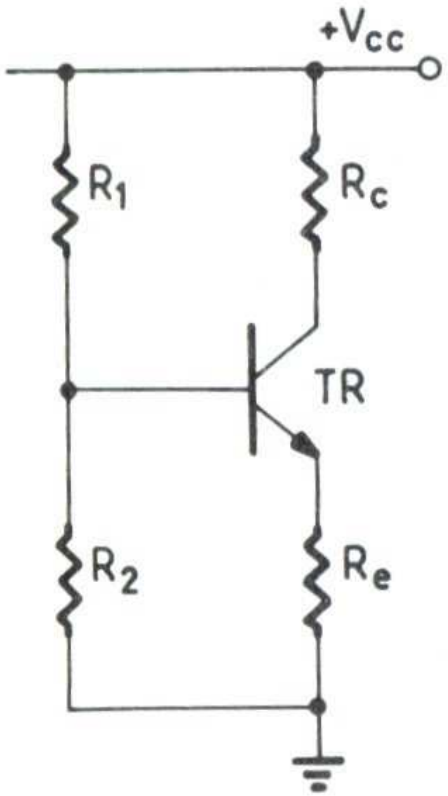
- POJAČANJE STRUJE

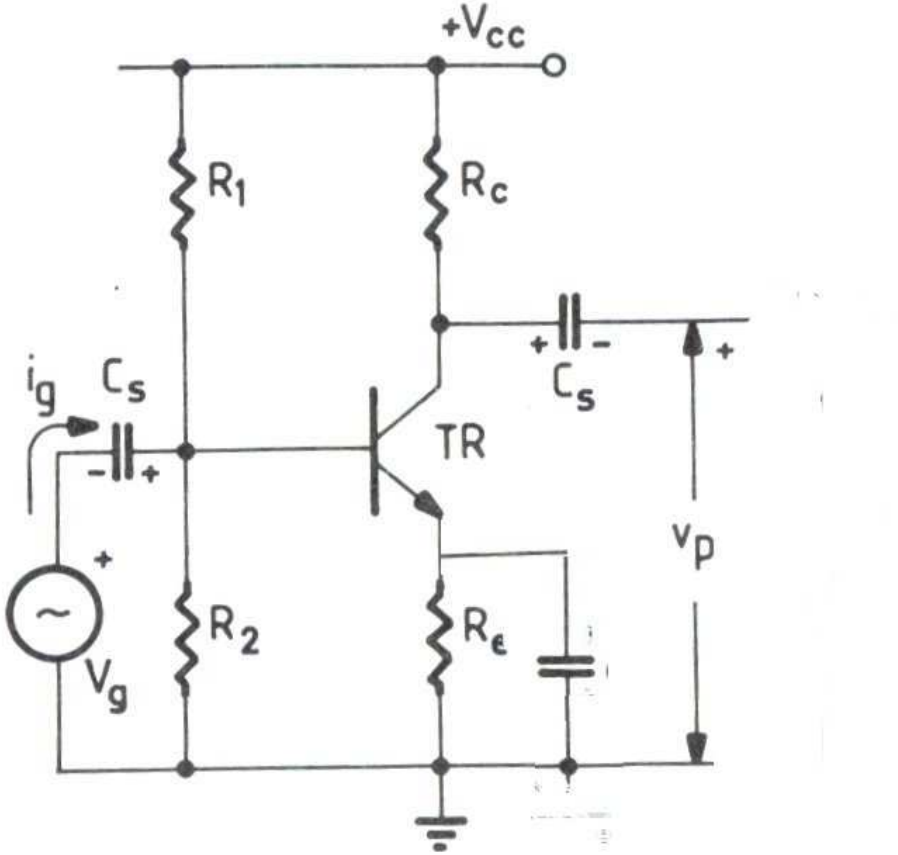
$$A_i = \frac{i_p}{i_g}$$

- ULAZNA OTPORNOST
- IZLAZNA OTPORNOST



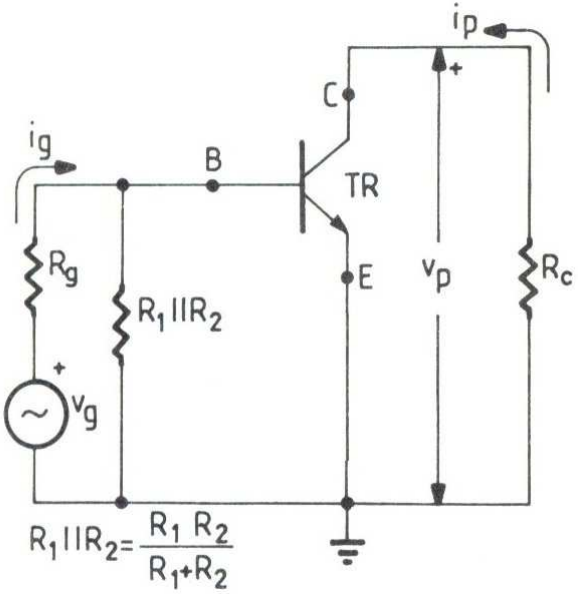
POJAČAVAČ SA ZAJEDNIČKIM EMITOROM

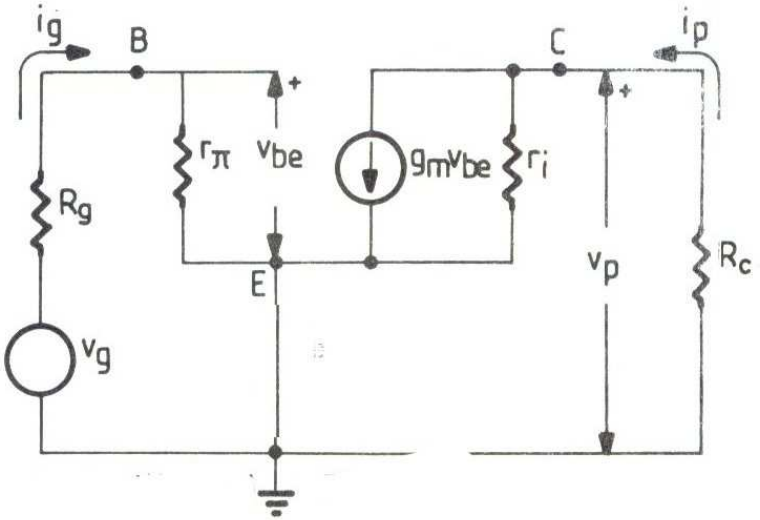




POJAČAVAČ SA ZAJEDNIČKIM EMITOROM

- KOLO ZA MALE SIGNALE





$$A_v = \frac{v_p}{v_g} = -(r_i \parallel R_C) g_m \frac{r_\pi}{r_\pi + R_g} \approx -\beta \frac{R_C}{r_\pi + R_g}$$

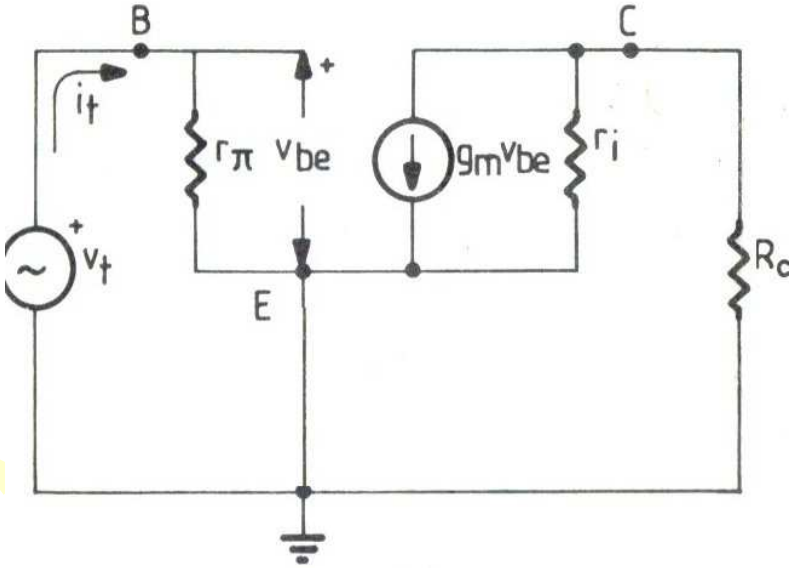
VELIKO NAPONSKO POJAČANJE

POJAČAVAČ SA ZAJEDNIČKIM EMITOROM

- POJAČANJE STRUJE:

$$A_i = \frac{i_p}{i_g} = \frac{\beta r_i}{R_C + r_i} \approx \beta$$

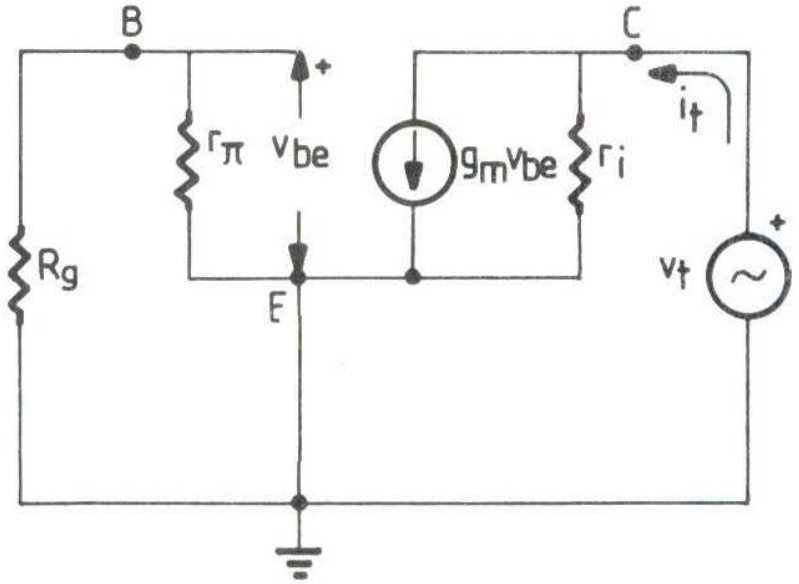
- ULAZNA OTPORNOST



$$R_u = \frac{v_t}{i_t} = r_\pi$$

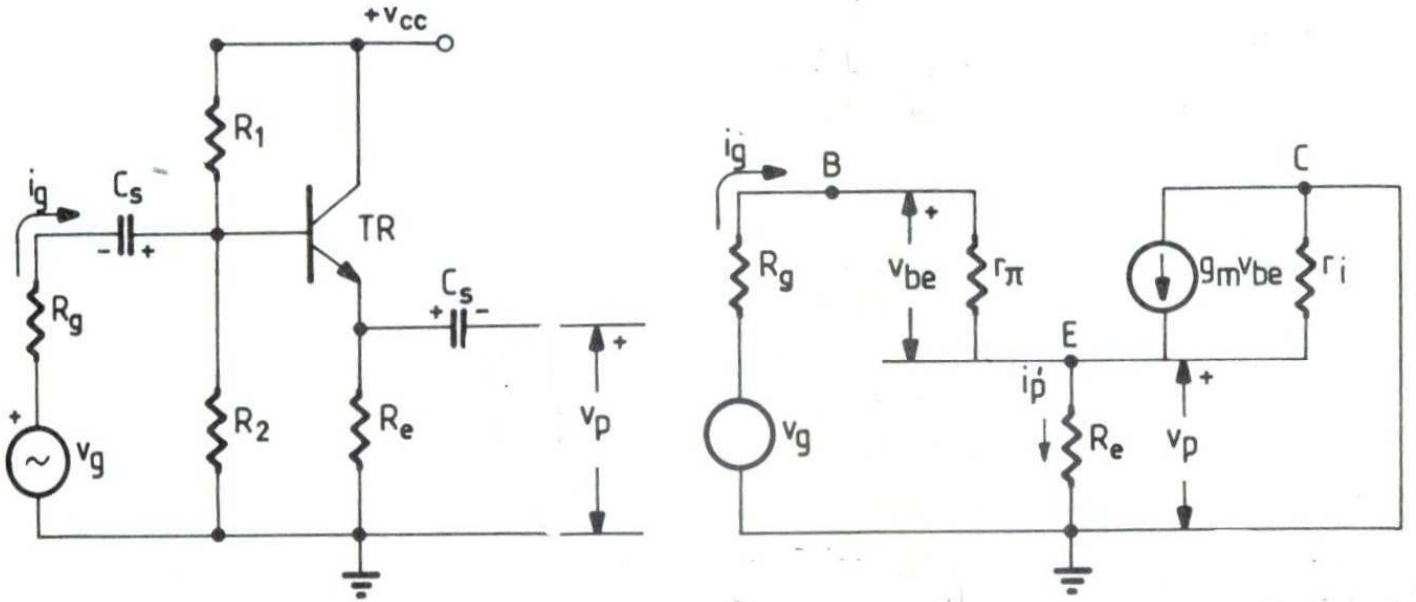
POJAČAVAČ SA ZAJEDNIČKIM EMITOROM

- IZLAZNA OTPORNOST



$$R_i = \frac{v_t}{i_t} = r_i$$

POJAČAVAČ SA ZAJEDNIČKIM KOLEKTOROM

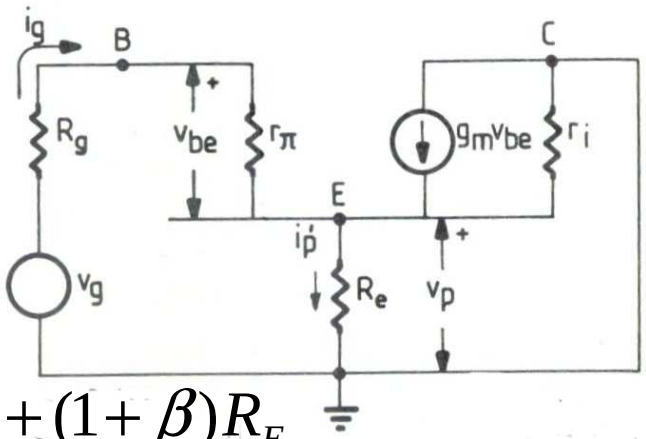


$$A_v = \frac{v_p}{v_g} = \frac{(1+\beta)(r_i \parallel R_E)}{R_g + r_\pi + (1+\beta)(r_i \parallel R_E)} <\approx 1$$

STEPEN SA ZAJEDNIČKIM KOLEKTOROM

- STRUJNO POJAČANJE

$$A_i = \frac{i_p}{i_g} = \frac{r_i}{r_i + R_E}(1+\beta) \approx (1+\beta)$$



- ULAZNA ORPORNOST

$$R_u = \frac{v_t}{i_t} = R_g + r_\pi + (1+\beta)(R_E \parallel r_i) \approx R_g + r_\pi + (1+\beta)R_E$$

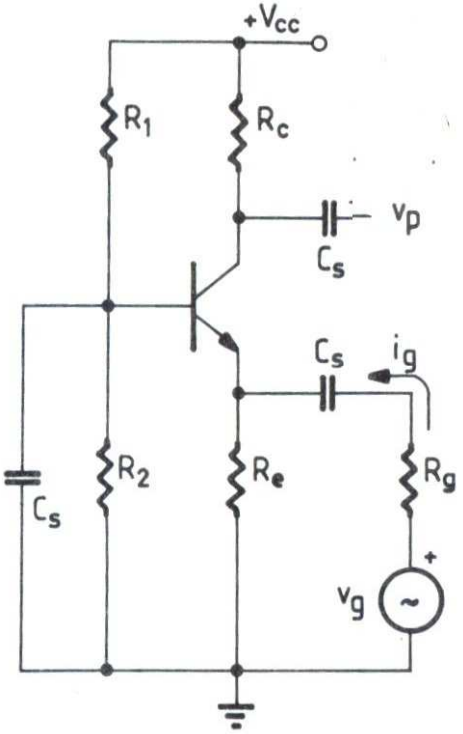
VELIKA ULAZNA OTPORNOST

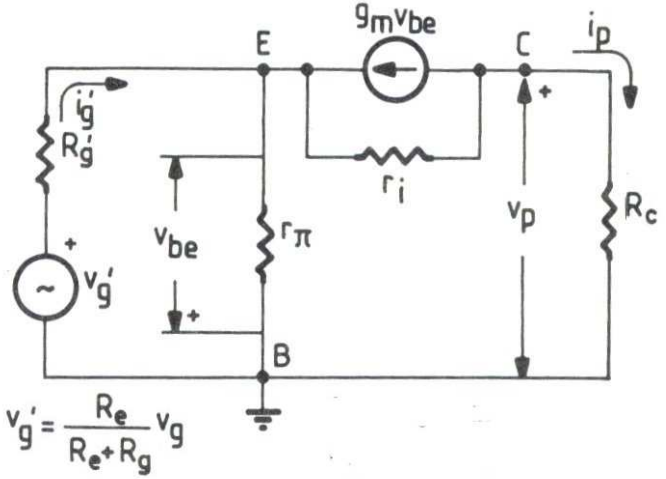
- IZLAZNA OTPORNOST

$$R_i = r_i \parallel \frac{r_\pi + R_g}{\beta + 1} \approx \frac{r_\pi + R_g}{\beta + 1}$$

MALA IZLAZNA OTPORNOST:

POJAČAVAČ SA ZAJEDNIČKOM BAZOM





$$A_v = \frac{\beta R_C}{r_\pi + R_g(1+\beta)}$$

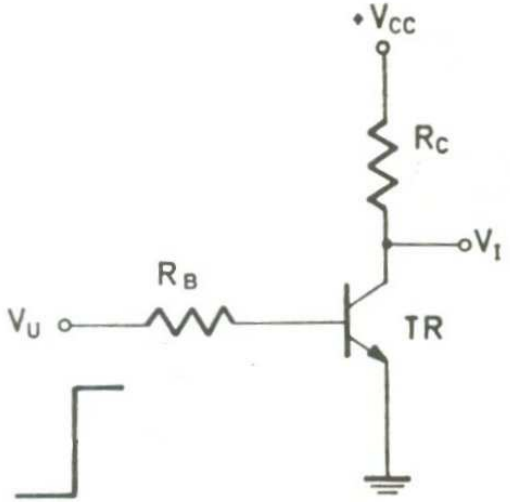
$$R_u \approx R_g + \frac{r_\pi}{1+\beta}$$

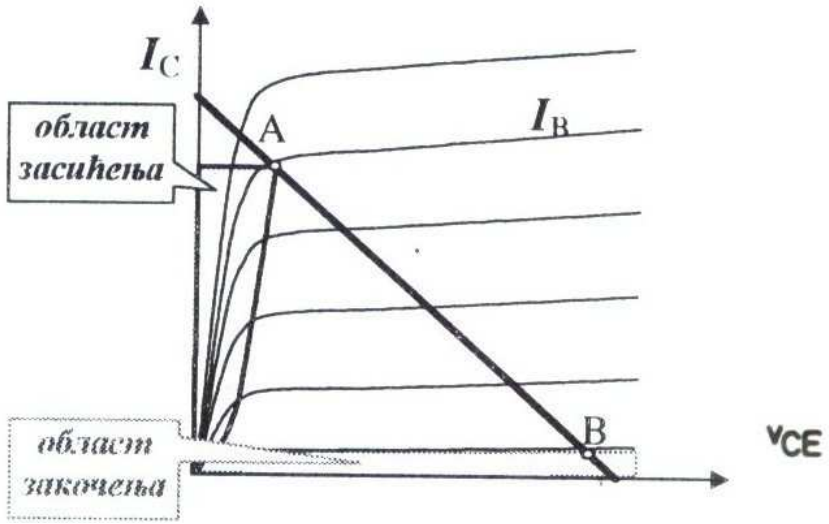
$$A_i \approx \frac{\beta}{\beta+1}$$

$$R_i = r_i + (1+g_m r_i)(r_\pi \parallel R_g)$$

STEPEN SA ZAJEDNICKIM EMITOROM U PREKIDAČKOM REŽIMU

- TRANZISTOR U ZASIĆENJU – UKLJUČEN PREKIDAČ
- TRANZISTOR ZAKOČEN - ISKLJUČEN PREKIDAČ

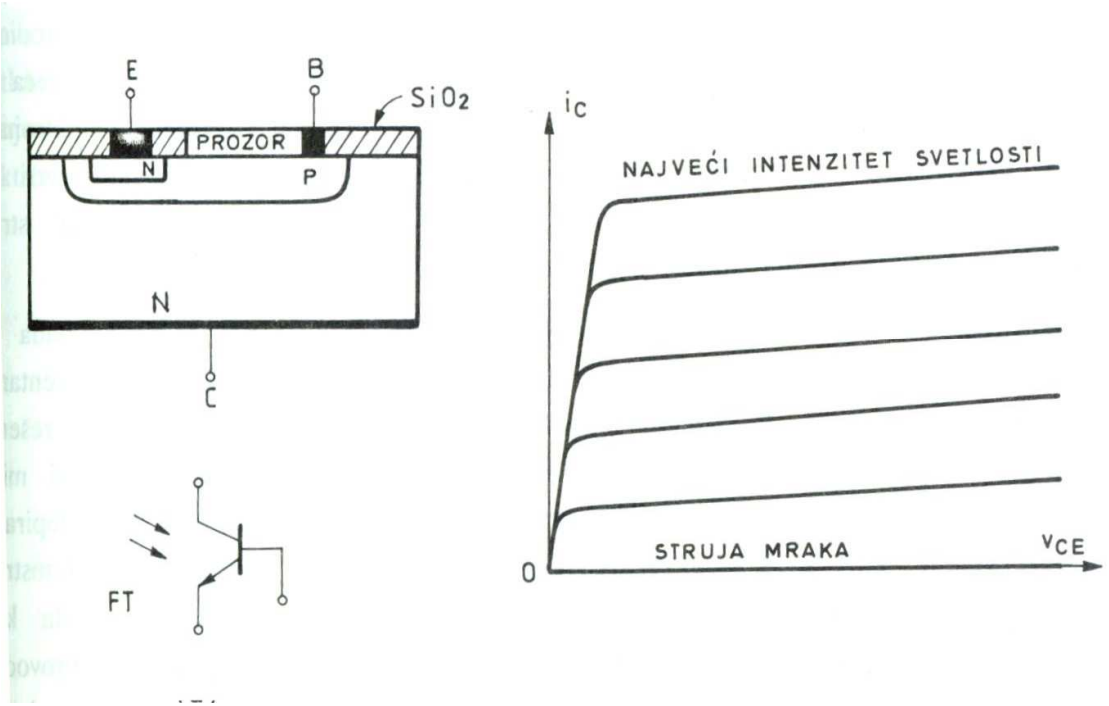




- VREME IZLASKA TRANZISTORA IZ ZASIĆENJA (PRELAZAK U ZAKOČENI REŽIM) SE SMANJUJE SA SMANJIVANJEM R_C

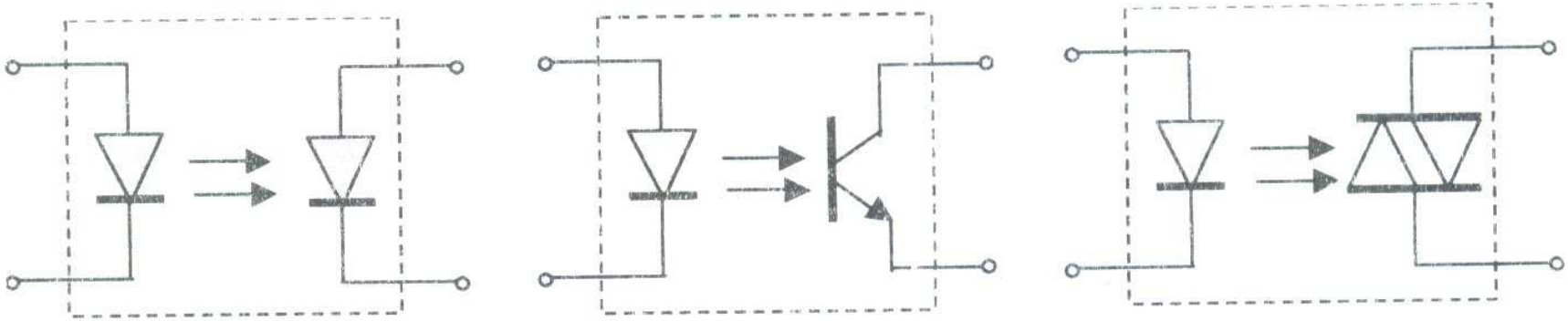
FOTOTRANZISTORI

- KORISTE APSORPCIJU SVETLOSTI YA GENERISANJE SLOBODNIH NOSILACA KAO I FOTODIODE, S TIM DA POMOĆU MEHANIZMA STRUJNOG POJAČANJA PRI ISOJ JAČINI SVETLOSTI SE DOBIJA VEĆA KOLEKTORSKA STRUJA
- POSTOJE I FOTOFET TRANZISTORI, I FOTOTIRISTORI

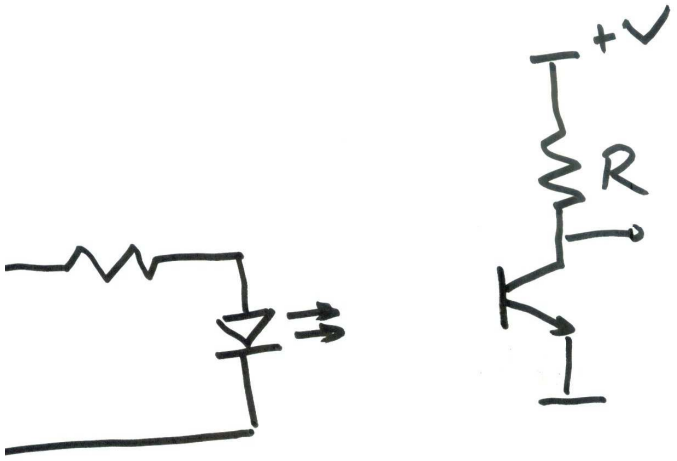


OPTOKAPLER

- ELEMENTI SA SVETLOSNOM SPRGOM SE NAZIVAJU OPTOKAPLERI
- OVI ELEMENTI PREDSTAVLJAJU KOMBINACIJU FOTOEMITUJUĆE DIODE I FOTOOSETLJIVOG ELEMENTA KAO ŠTO SU DIODA, TRANZISTOR ILI TIRISTOR



PRIMER OPTOKAPLERA



- OPTOKAPLERI SE PRETEŽNO KORISTE U DIGITALNIM SISTEMIMA ZA PRENOS INFORMACIJE: IMA SIGNALA NEMA SIGNALA
- VREDDNOST OTPRNIKA UTIČE NA

VREME IZLASKA IZ ZASIĆENJA FOTO TRANZISTORA

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

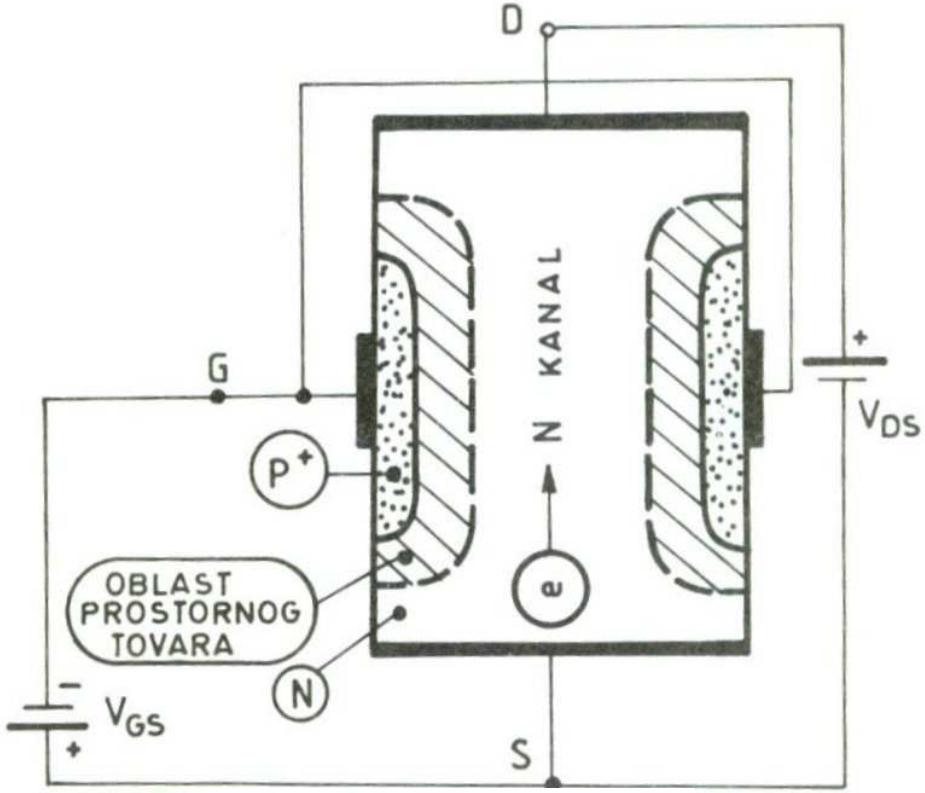
  JFET – SPOJNI TRANZISTORI SA EFEKTOM POLJA

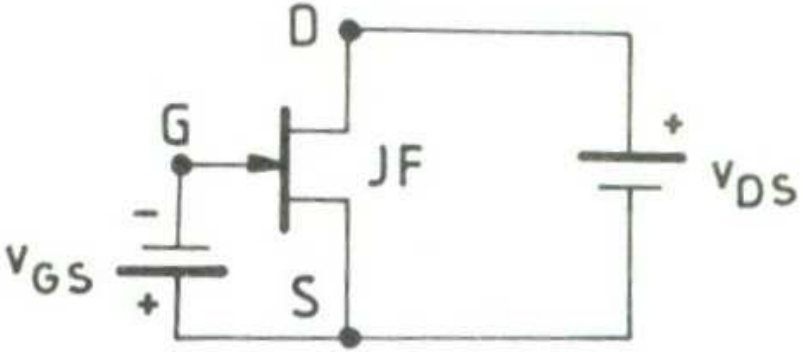
  IGFET- FET SA IZOLOVANIM GEJTOM

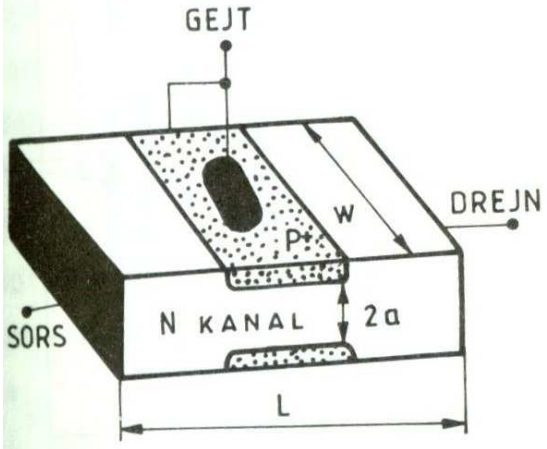
FET (JFET) TRANZISTORI

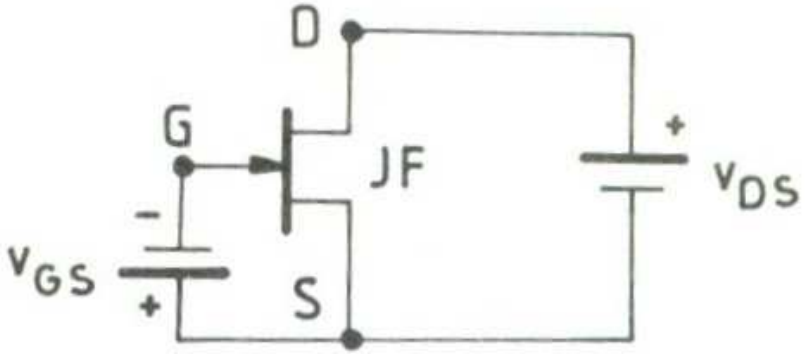
- SPOLJNI NAPON V_{GS} INVERZNO POLARIŠE PN SPOJ

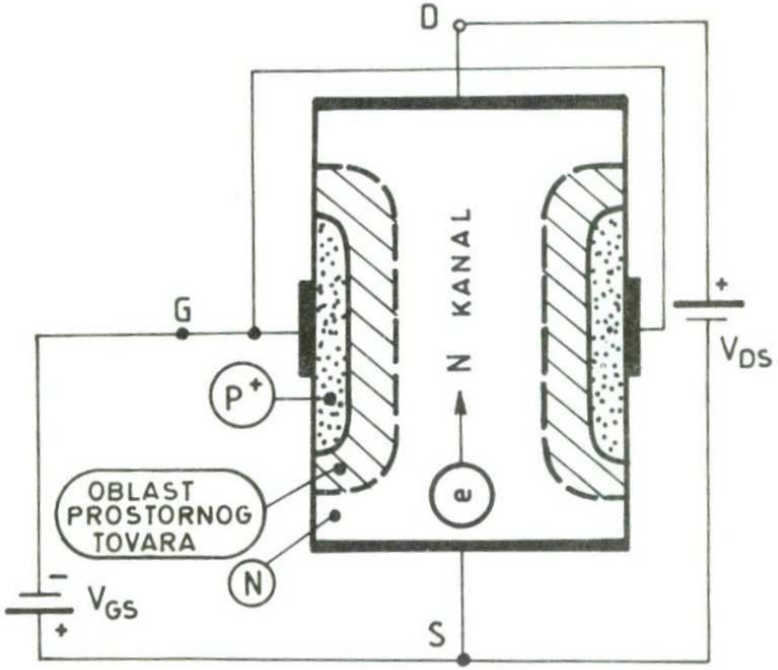
V_{DS} UTIČE DA NOSIOCI U KANALU IZVIRU IZ SORSA I PONIRU U DREJNU





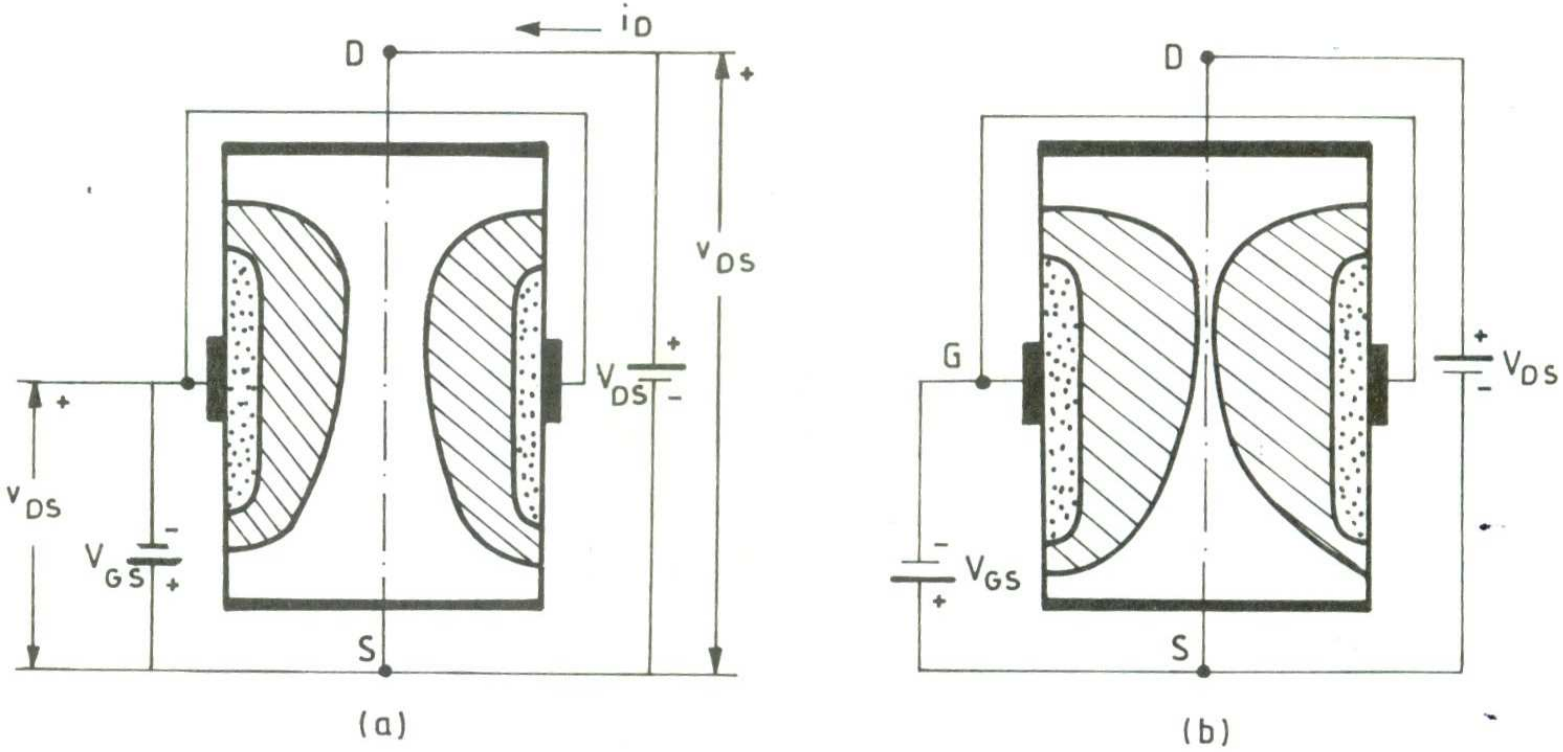






- V_{DS}~0, V_{GS}=0, KANAL IMA NAJVEĆU PROVODNOST
- V_{GS}= V_P=$V_{GS(OFF)}$, FET ZAKOČEN
- V_{DS}~0, V_{GS}<<V_P=$V_{GS(OFF)}$ LINEARNA OBLAST

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



- KAKO V_{DS} RASTE ŠIRINA OBLASTI PROSTORNOG TOVARA DUŽ KANALA POSTAJE SVE NERAVNOMERNIJA(KANAL JE NAJUŽI KOD DREJNA)
- SVE DOK JE $V_{GD}=V_{GS}-V_{DS}>V_P$

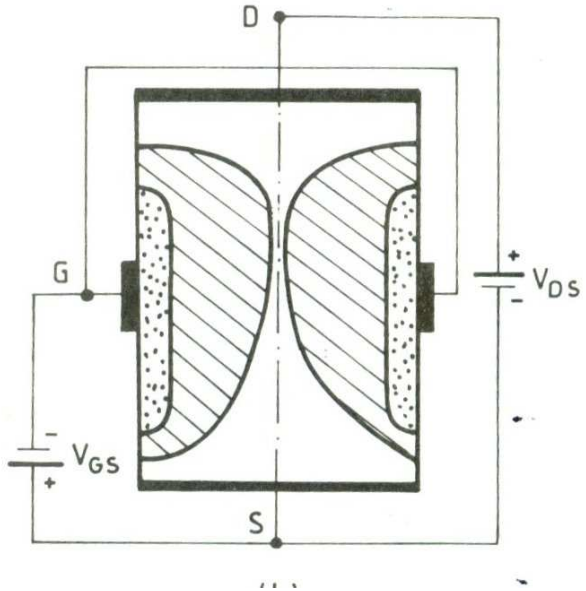
  STRUJA DREJNA ZAVISI I OD V_{DS} I OD V_{GS} OVA OBLAST RADA SE NAZIVA TRIODNA OBLAST RADA

FET U ZASIĆENJU

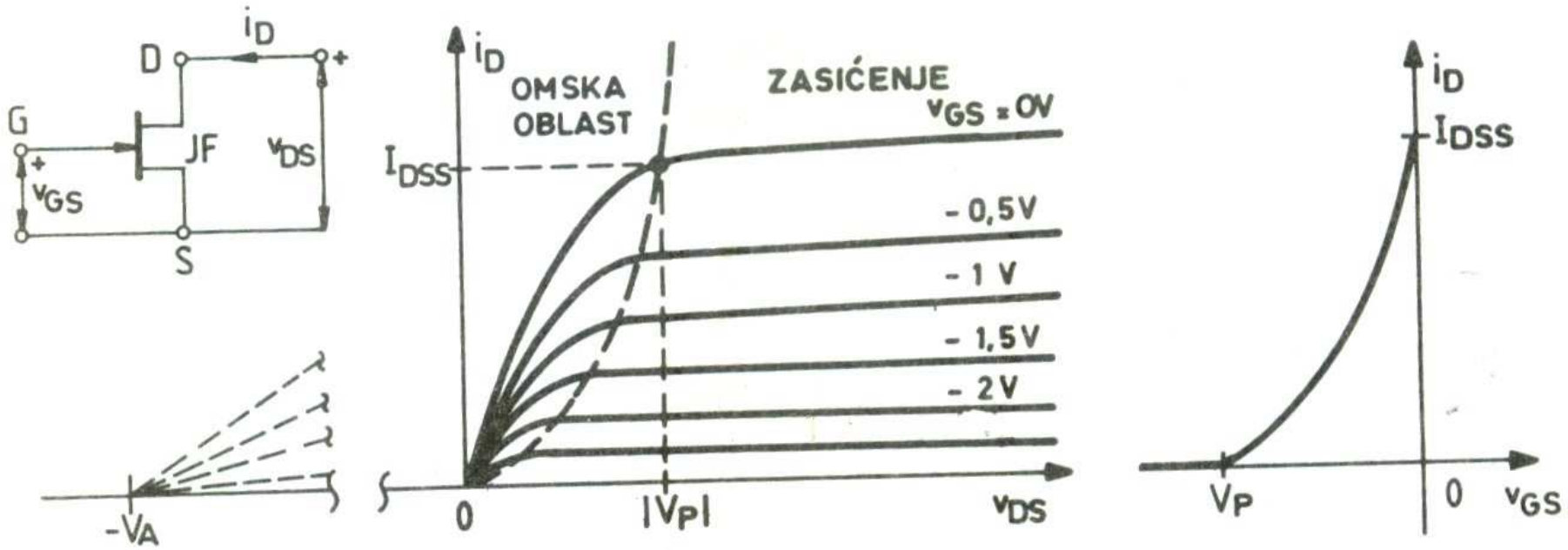
- KADA JE
- $V_{GD}=V_{GS}-V_{DS}<V_P$, $V_{GS}>V_P$
- KANAL JE UŠTINUT KOD REJNA DOK KOD SORSA NIJE UŠTINUT I FET ULAZI U OBLAST ZASIĆENJA KADA STRUJA DREJNA VEOMA MALO ZAVISI OD NAPONA V_{DS}

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

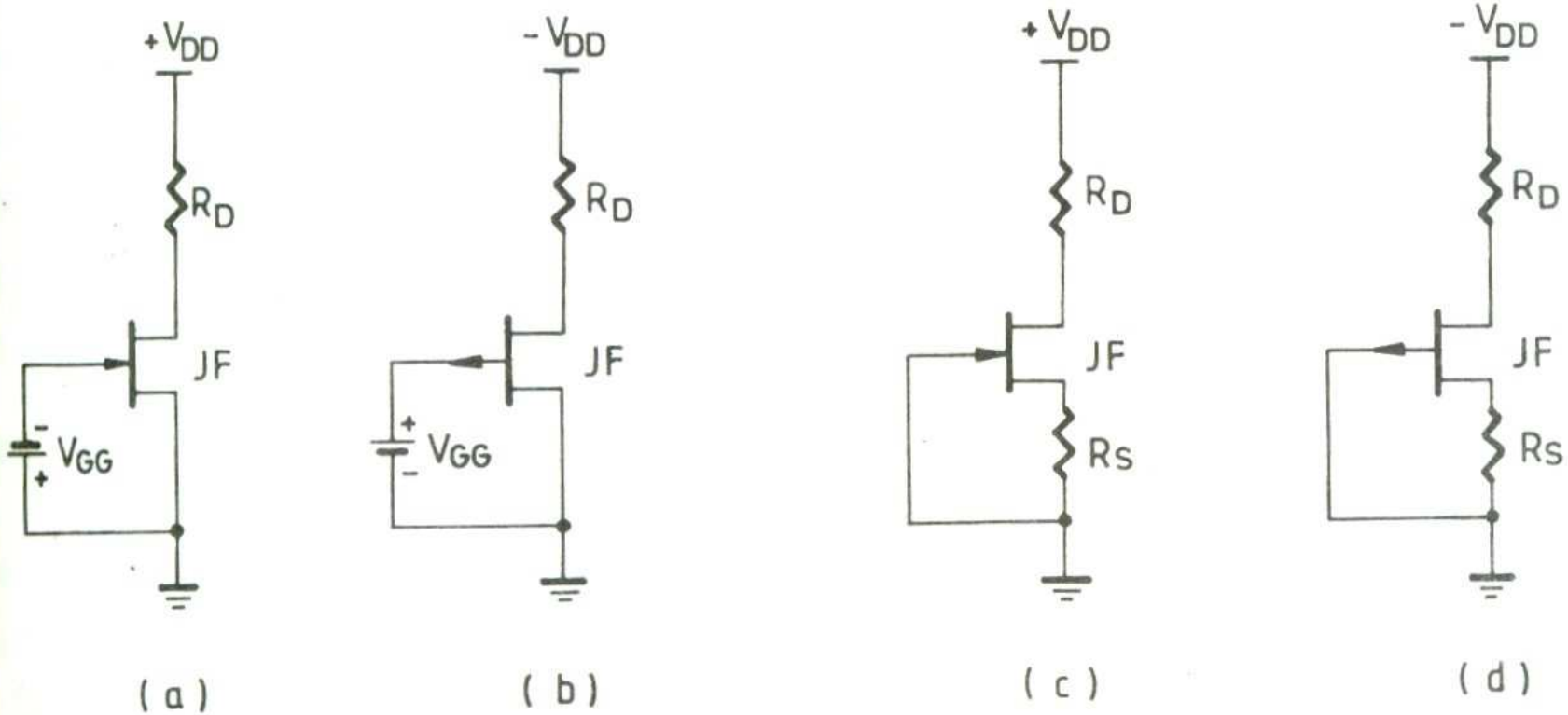
$$i_D = I_{DSS}\left(1-\frac{v_{GS}}{V_P}\right)^2$$



STATIČKA KARAKTERISTIKA FET-A



POLARIZACIJA FETOVA

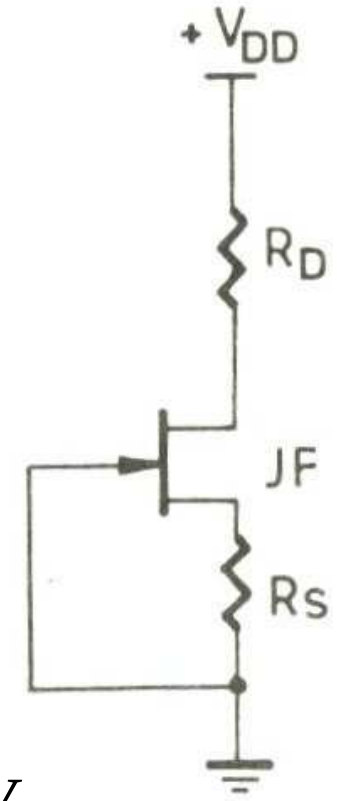


POLARIZACIJA FETOVA PRIMER

- V_{DD}=15 V , V_P=-2V, R_S=1kΩ, R_D=3kΩ I_{DSS}=4mA

$$I_D = I_{DSS}\left(1+\frac{R_S I_D}{V_P}\right)^2 \quad V_{GS} = -R_S I_D$$

$$I_D = I_{DSS}(1-\frac{V_{GS}}{V_P})^2 \quad I_{D1} = 4mA,\ I_{D2} = 1mA$$

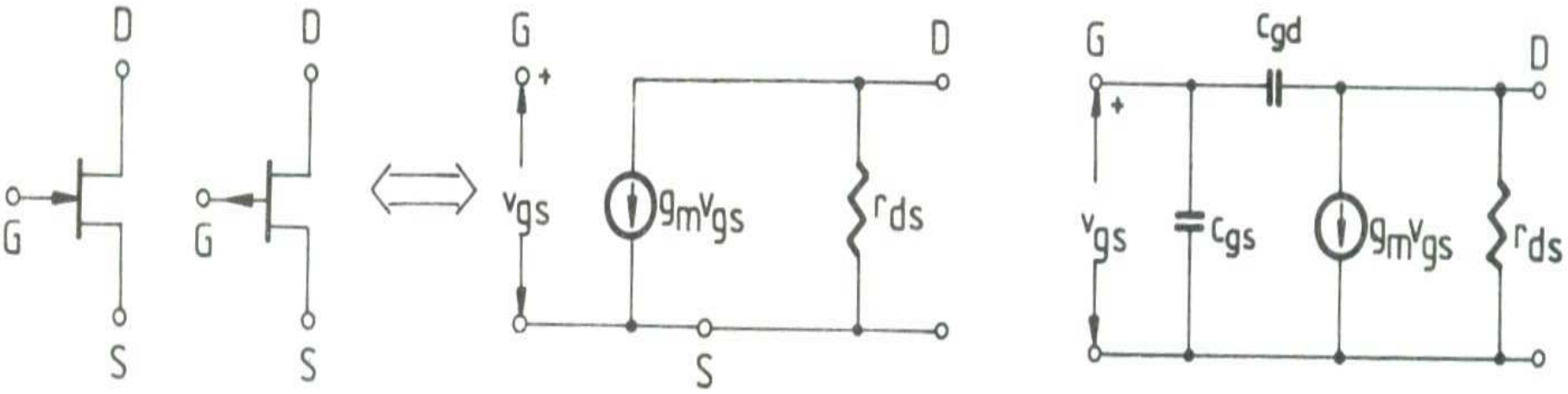


- ZA I_{D1}=4 mA sledi V_{GS}=0, ŠTO JE U
- SUPROTNOSTI SA V_{GS}=-$R_S I_D$
- ZNAČI I_{D1}=1 mA
- PROVERA PREDPOSTAVKE ZASIĆENJA

$$V_{GD} = V_{GS} - V_{DS} = V_{GS} - (V_{DD} - (R_S + R_D)I_D) \le V_P$$

EKVIVALENTNO KOLO FETA

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



FET POJAČAVAČ PRIMER

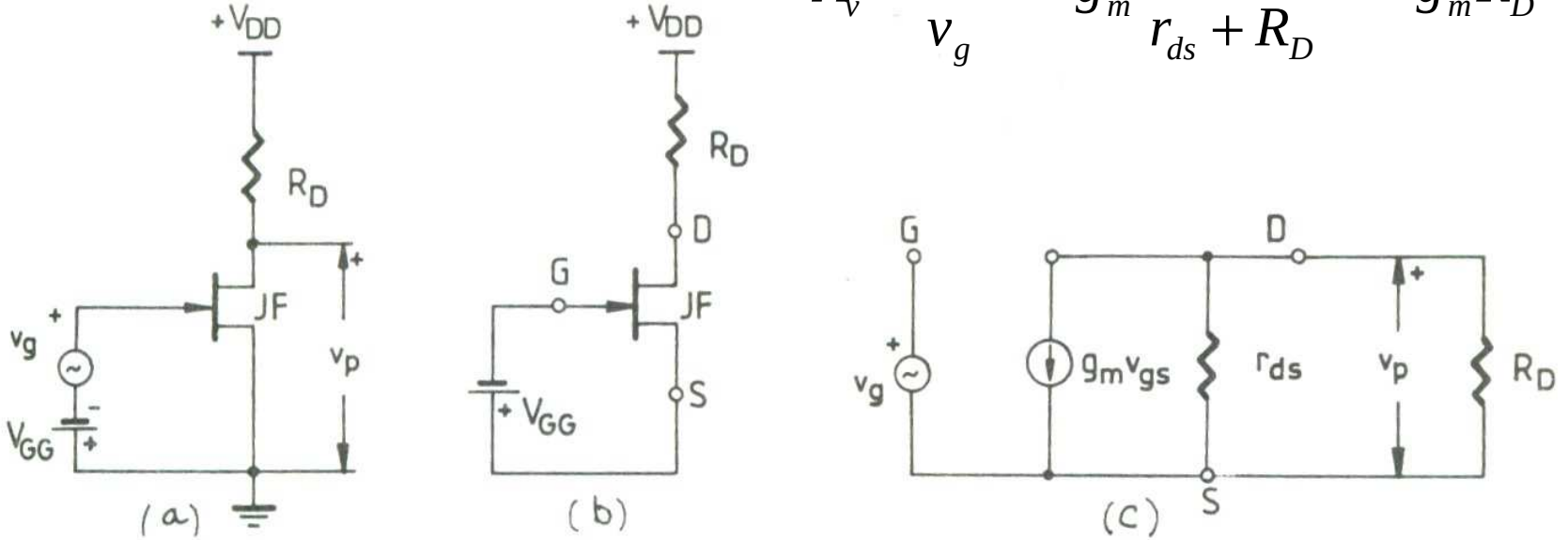
- I_{DSS}=4mA, V_P=-3V, V_A=100V, R_D=5kΩ, V_{GG}=-1.5V, V_{DD}=12V

$$I_{DQ} = I_{DSS}\left(1-\frac{V_{GG}}{V_P}\right)^2 = 1mA \qquad g_m = \frac{2\sqrt{I_{DSS}I_{DQ}}}{-V_P} = 4/3S$$

- PROVERA REŽIMA ZASIĆENJA

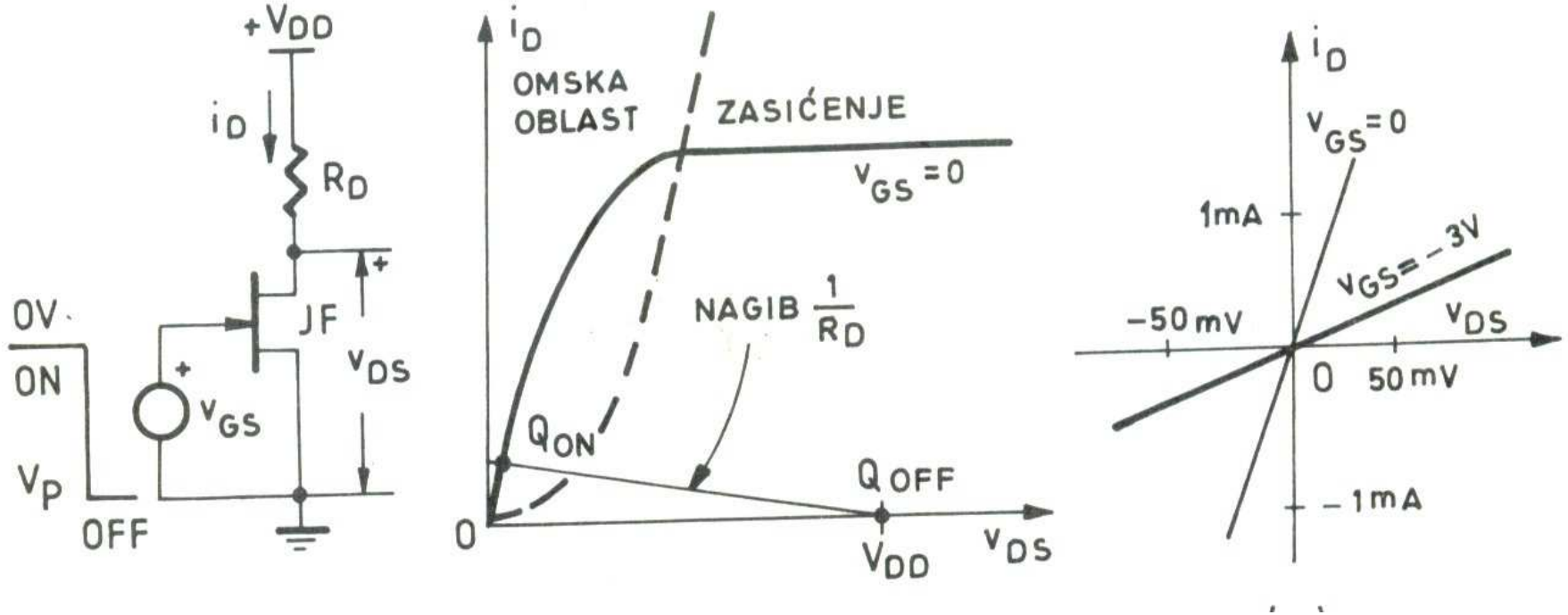
$$V_{GDQ} = V_{GG} - V_{DSQ} = -8.5V < V_P \qquad r_{ds} = \frac{V_A}{I_{DQ}} = 100k\Omega$$

$$A_v = \frac{v_p}{v_g} = -g_m \frac{r_{ds}R_D}{r_{ds}+R_D} \approx -g_m R_D = -6.6$$



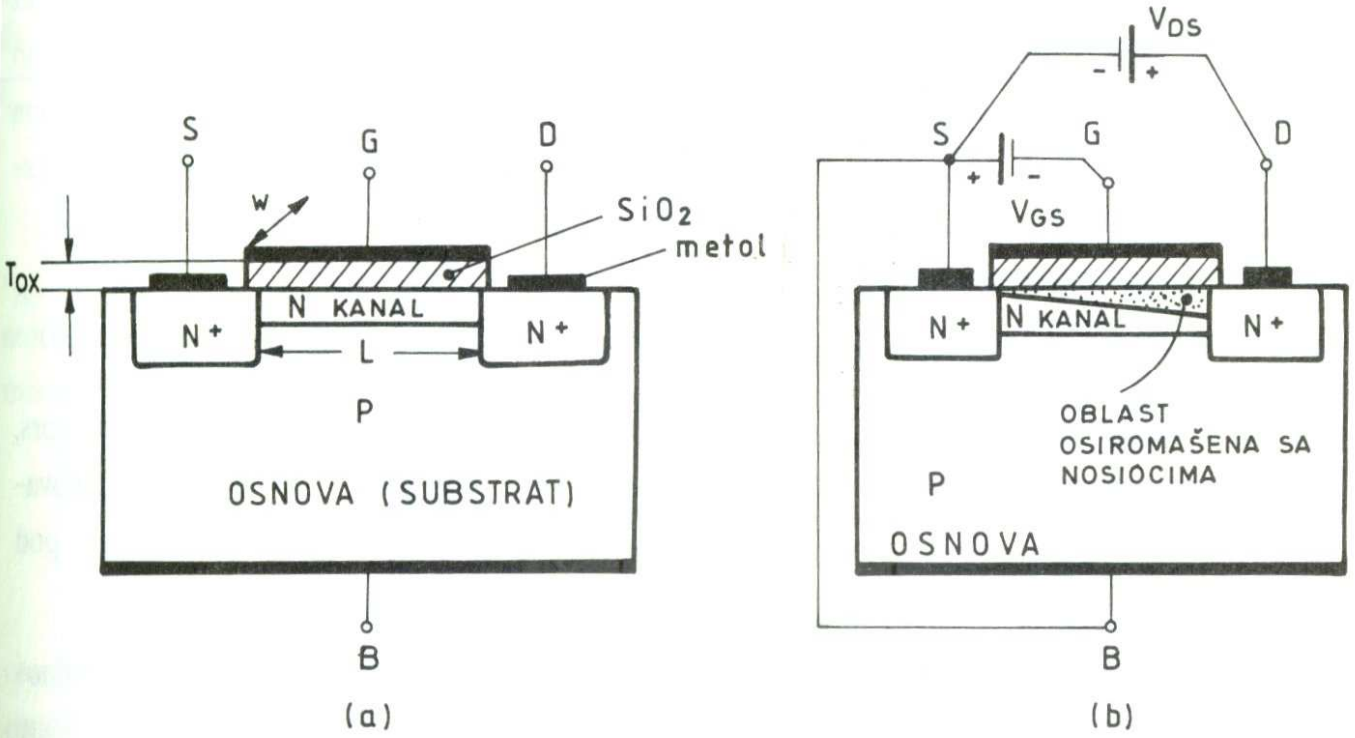
FET KAO PREKIDAČ

- STANJE PREKIDAČA SE KONTROLIŠE SA V_{GS}
- KADA JE FET ZAKOČEN $V_{GS}<V_P$ PREKIDAČ OTVOREN
- PREKIDAČ ZATVOREN: FET PROVODI I IMA MALU OTPORNOST

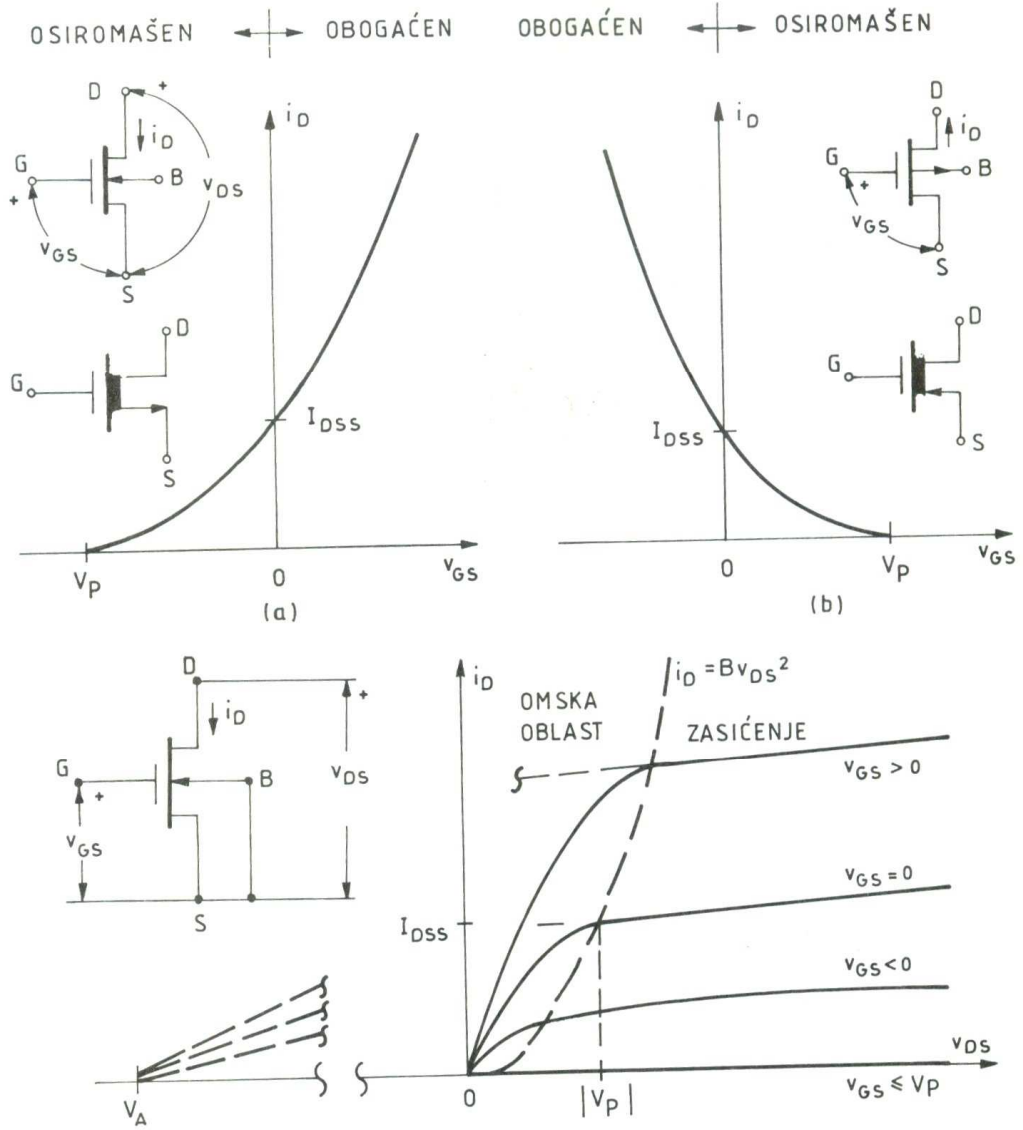


MOSFET

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



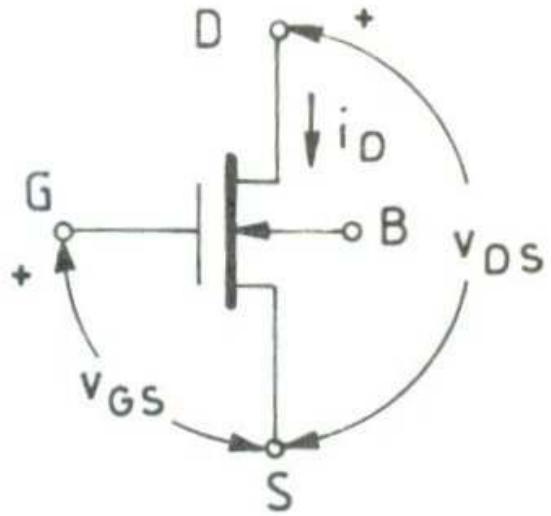
STATIČKE KARAKTERISTIKE MOSFETA SA UGRAĐENIM KANALOM



U PBLASTI ZASIĆENJA

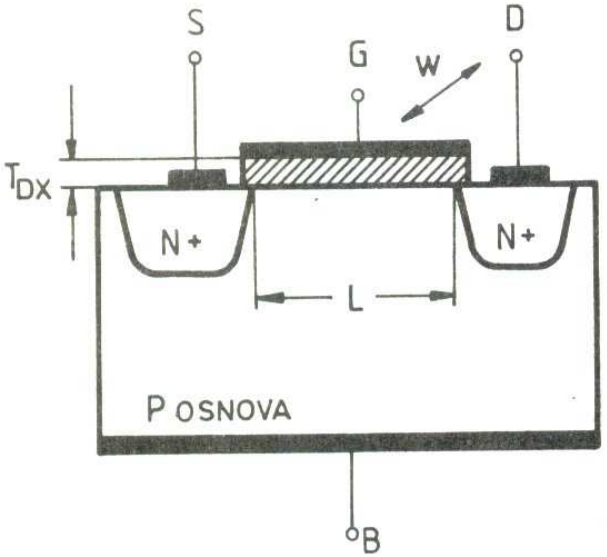
$$i_D = B\left(1+\frac{v_{DS}}{V_A}\right)\left(v_{GS}-V_P\right)^2$$

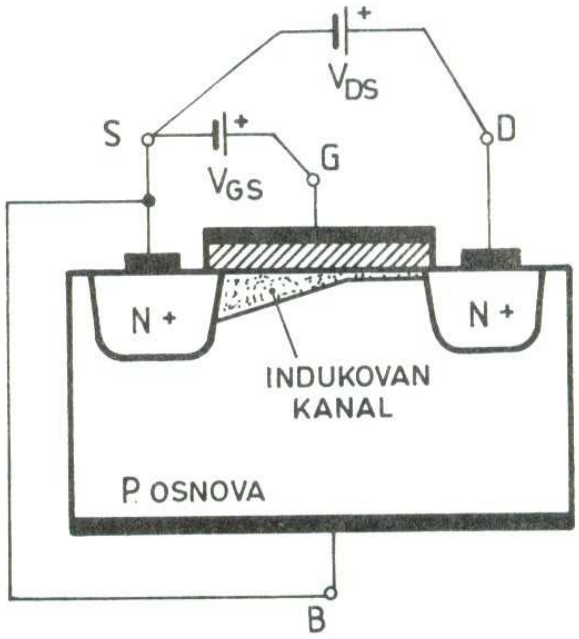
$$B = \frac{1}{2}\mu_n C_0\left(\frac{W}{L}\right)$$



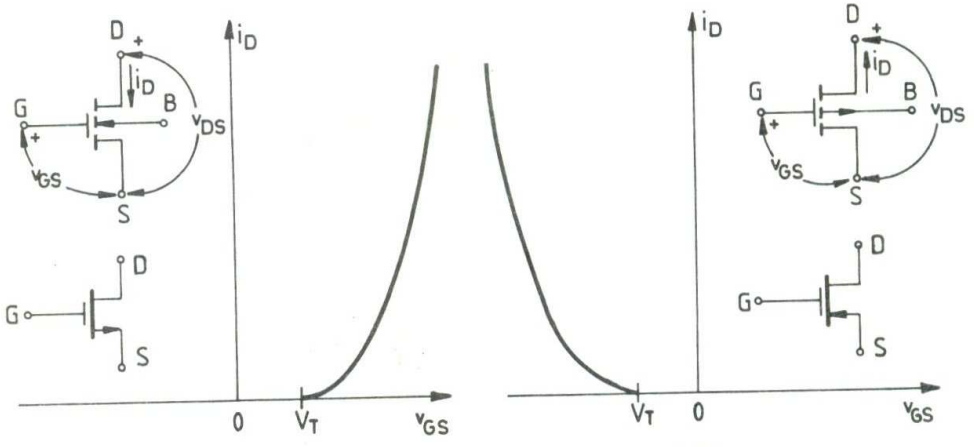
MOSFET SA INDUKOVANIM KANALOM

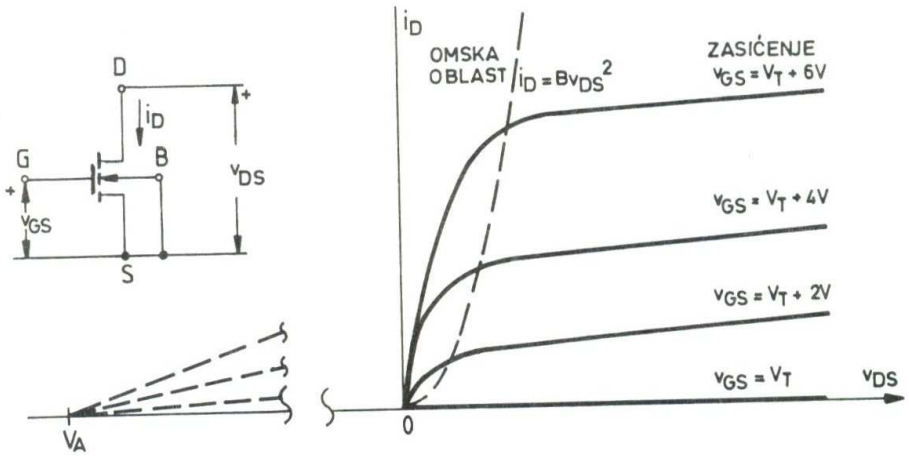
- NEMA SLOJA POLUPROVODNIKA IZMEĐU DREJNA I SORSA
- i_{DS} NE TEČE U ODSUSTVU V_{GS}





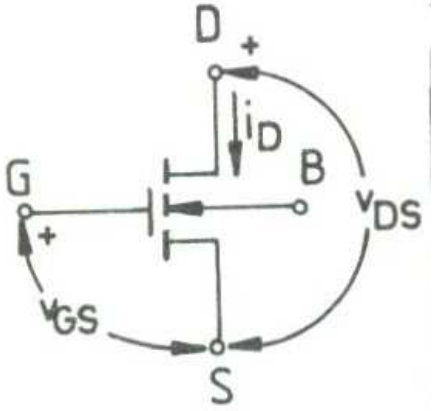
STATIČKE KARAKTERISTIKE MOSFETA SA INDUKOVANIM KANALOM



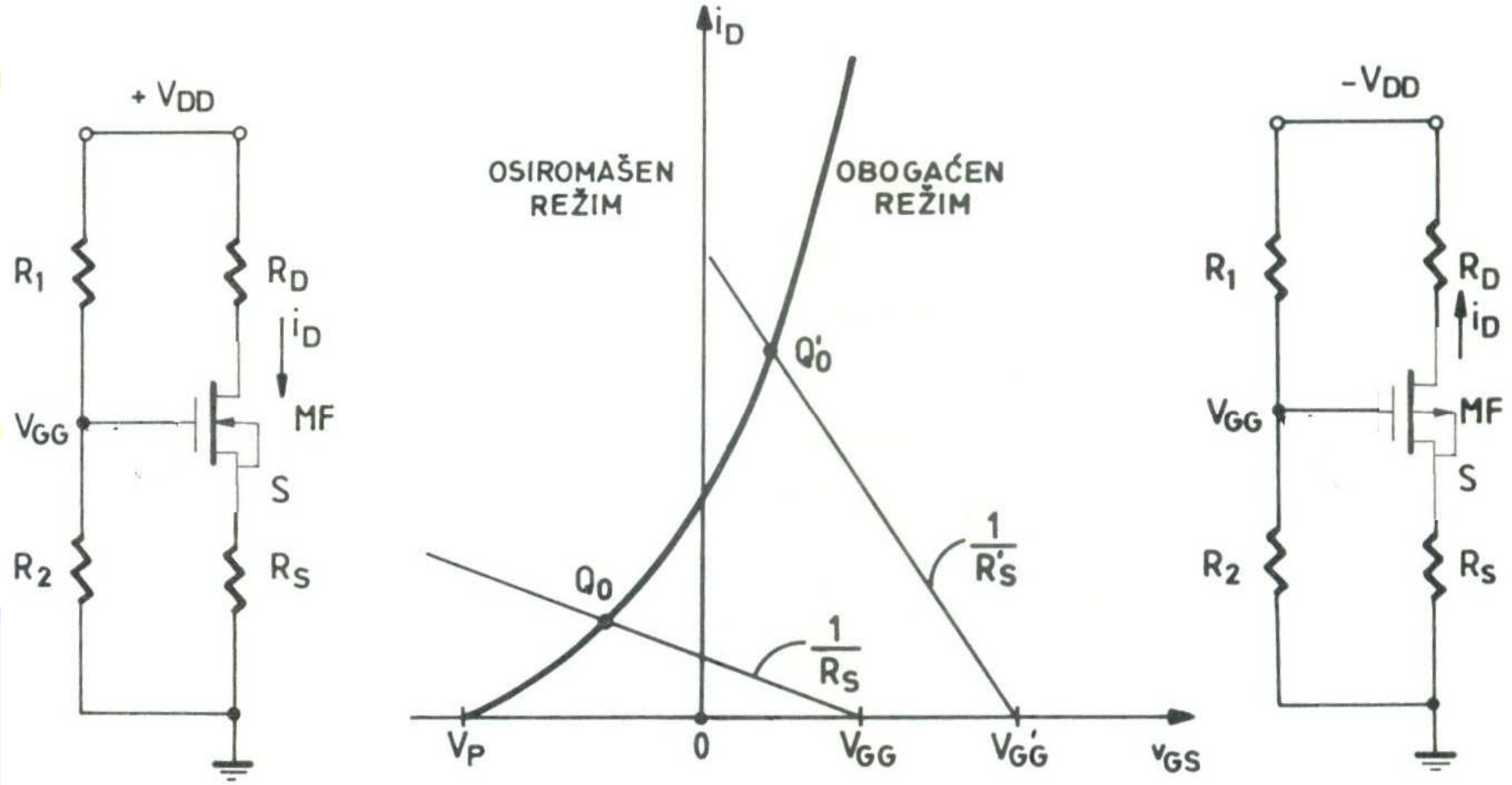


J OBLASTI ZASIĆENJA

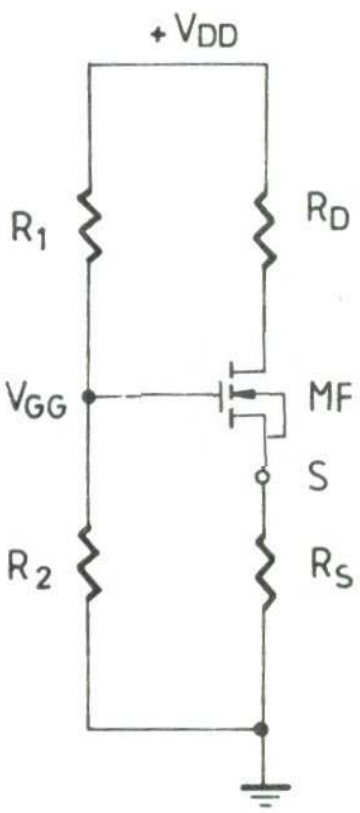
$$i_D = B\left(1+\frac{v_{DS}}{V_A}\right)\left(v_{GS}-V_T\right)^2$$

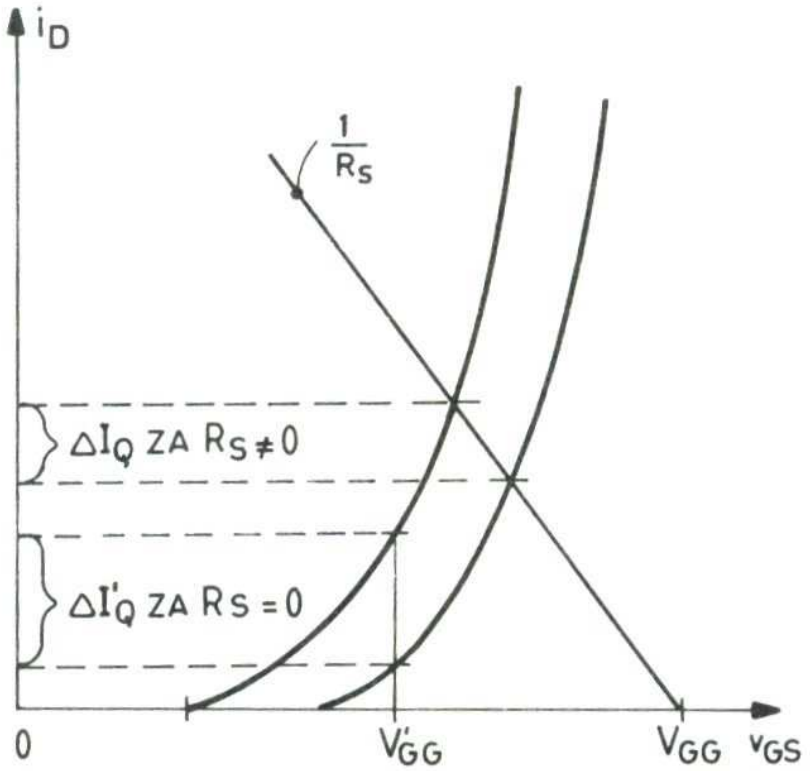


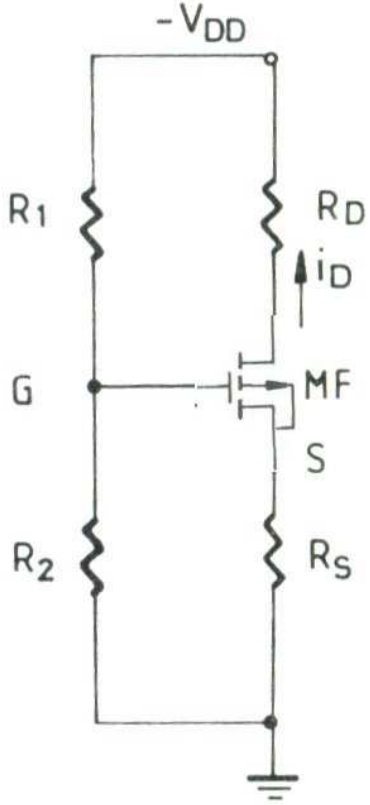
POLARIZACIJA MOSFETOVA SA UGRAĐENIM KANALOM



POLARIZACIJA MOSFETA SA INDUKOVANIM KANALOM







EKVIVALENTNO KOLO MOSFETA

$$g_m = 2\sqrt{BI_{DQ}}$$

$$r_{ds} = \frac{V_A}{I_{DQ}}$$