FET DIFFERENTIAL AMPLIFIER

The JFET differential amplifier with resistive load is considered for the analysis. MOSFETs are widely used in the input stages due to their better stability.

i. FETs are used instead of BJT when we require

a. High Impedance

b. Better Stability

ii. Fig.3.23 shows the dual input balanced output differential amplifier using JFET.

Apply KVL to the input loop,

$$V_{I1} - V_{I2} = V_{GS1} - V_{GS2}$$
$$V_{I1} = V_{GS1} - V_{GS2} + V_{I2}$$

We know that

$$V_{GS} = V_P\left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right)$$

Where $I_D \rightarrow$ Saturation drain current

$I_{DSS} \rightarrow I_{DS}$ when $V_{GS} = 0$

$V_P \rightarrow$ Pinch-off voltage

The differential voltage in the input

$V_{ID} = V_{I1} - V_{I2}$

Assuming Q_1 and Q_2 as ideal transistors, then

$V_{P1} = V_{P2}$

$I_{SS} = I_{D1} + I_{D2}$

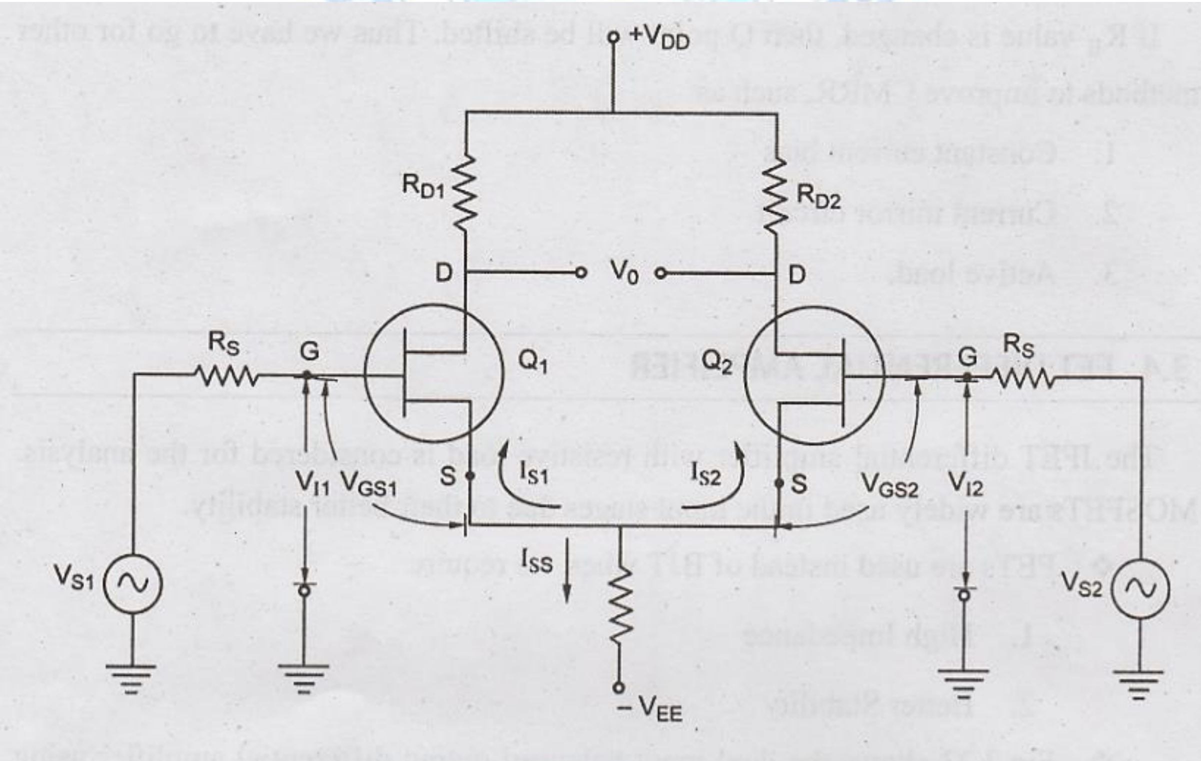

Fig. 3.23. JFET differential amplifier

JFET differential amplifier can handle larger input signals than BJT differential amplifier. The drain output voltage is obtained from the Fig.3.23 is

$$V_{o1} = V_{DD} - I_{D1} R_{D1}$$

$$V_{o2} = V_{DD} - I_{D2} R_{D2}$$

If $R_{D1} = R_{D2} = R_D$, then

$$V_{o1} = V_{DD} - I_{D1} R_D$$

$$V_{o2} = V_{DD} - I_{D2} R_D$$

Then the output differential voltage

$$V_{OD} = V_{o1} - V_{o2}$$

$$= (V_{DD} - I_{D1} R_D) - (V_{DD} - I_{D2} R_D)$$

$$= - I_{D1} R_D + I_{D2} R_D$$

$$= R_D (I_{D2} - I_{D1})$$

For smaller differential input voltage, the transfer function is approximately linear. The transfer characteristics of FET differential amplifier is shown in Fig. 3.24.

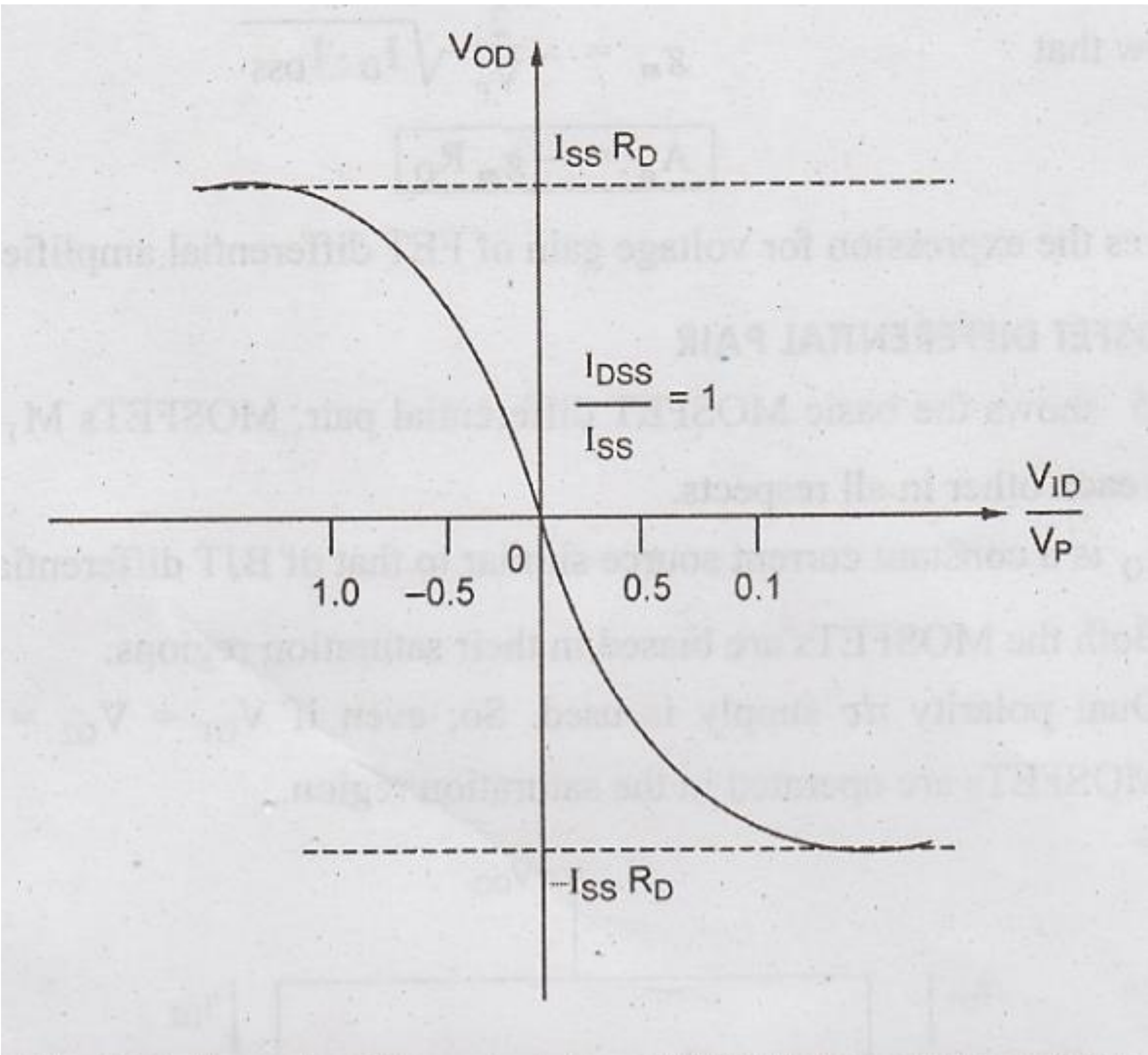

Fig. 3.24. Transfer Characteristics of FET differential amplifier

The differential voltage gain is the ratio of differential output voltage to differential input voltage

$$A_d = \left.\frac{d\,V_{OD}}{d\,V_{ID}}\right|_{V_{ID}=0}$$

$$= \frac{I_{SS}\,R_D}{V_P}\sqrt{\frac{2\,I_{DSS}}{I_{SS}}}$$

$$= \frac{R_D}{V_P}\,\frac{\sqrt{2\,I_{DSS}\,I_{SS}^2}}{\sqrt{I_{SS}}}$$

$$\boxed{A_d = \frac{R_D}{V_P}\sqrt{2\,I_{DSS}\,I_{SS}}}$$

At $V_{ID} = 0,\ I_{SS} = 2\,I_D$

$$A_d = \frac{R_D}{V_P}\sqrt{2\,I_{DSS}\cdot 2\,I_D}$$

$$= \frac{2\,R_D}{V_P}\sqrt{I_D\cdot I_{DSS}}$$

We know that $g_m = -\frac{2}{V_P}\sqrt{I_D\cdot I_{DSS}}$

$$\boxed{A_d = -g_m\,R_D}$$

This gives the expression for voltage gain of FET differential amplifier.