Topic:- FET Amplifier

UG-III

Fig (1) shows a basic common-source FET amplifier circuit with biasing batteries. The a.c. signal to be amplified is connected ~~to~~ in series with the gate bias battery V_{GG}. This causes a variation in the total gate-to-source voltage. The load resistance R_L is connected to the drain terminal, as shown. The output voltage is measured across this resistance or across the FET. Let the output ~~voltage~~ a.c. voltage be v_{ds} for an input signal voltage v_{gs}.

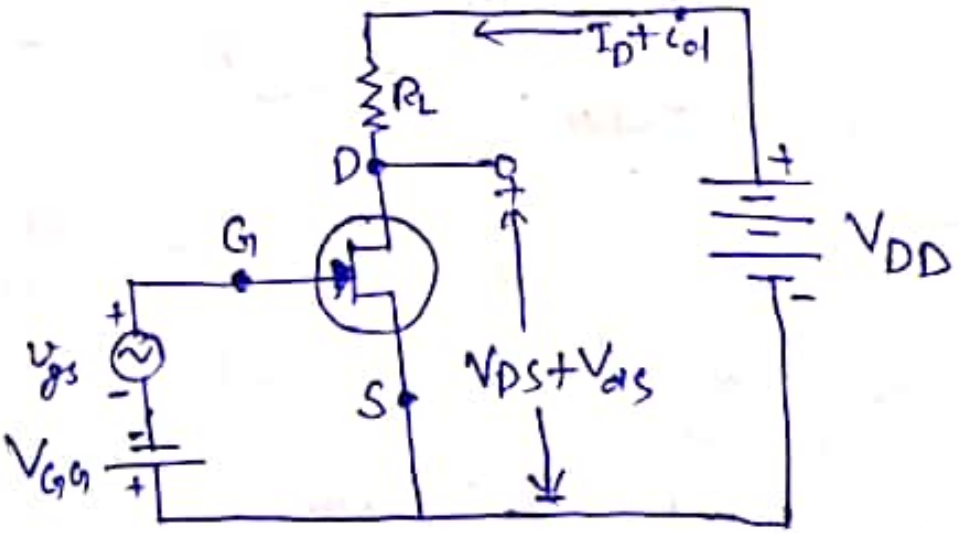

Fig (1)

When the signal voltage is positive the gate becomes less negative with respect to the source. As a result, the drain current is enhanced, causing a large voltage drop across R_L which makes the drain terminal less positive with respect to the source. A small voltage variation at the gate produces a sizable voltage variation across R_L resulting in amplification. Also, since an increase of the gate voltage causes a decrease in the drain voltage, there is a phase shift of 180° between the input and the output of the FET amplifier.

Expression For Gain

Applying Kirchhoff's voltage law to the output circuit in fig (1), we get for d.c. voltages

$$V_{DD} = V_{DS} + I_D R_L \quad \ldots\ldots (1)$$

and for a.c. voltages

$$v_{ds} + i_d R_L = 0 \quad \ldots\ldots (2)$$

Also we have for the small-signal case

$$i_d = g_m v_{gs} + \frac{1}{r_d} v_{ds} \longrightarrow (3)$$

Because about the quiescent point we can express the a.c. component of the drain current I_d as a linear sum of v_{gs} and v_{ds} that is

$$i_d = g_m v_{gs} + \frac{v_{ds}}{r_d} \longrightarrow (4)$$

Here v_{gs} and v_{ds} stand for the a.c. components of the gate-to-source and the drain-to-source voltages, respectively from equation (4) we can write

$$g_m = \left.\frac{i_d}{v_{gs}}\right|_{v_{ds}=0}$$

& is called the "mutual conductance or transconductance".

And $$r_d = \left.\frac{v_{ds}}{i_d}\right|_{v_{gs}=0}$$

& is called the a.c. drain or channel or output resistance of the FET.

($v_{ds}=0$ means. V_{DS} is constant and V_{GS} is constant for

Now from eqn (2) and (3), we have

$$v_{ds} + R_L\left(g_m v_{gs} + \frac{1}{r_d} v_{ds}\right) = 0 \longrightarrow (5)$$

or, $$v_{ds} + R_L g_m v_{gs} + \frac{R_L}{r_d} v_{ds} = 0$$

or, $$\left(1 + \frac{R_L}{r_d}\right) v_{ds} = -R_L g_m v_{gs}$$

or, $$\frac{v_{ds}}{v_{gs}} = -\frac{R_L g_m r_d}{(R_L + r_d)}$$

or, $$A_V = -\frac{\mu R_L}{r_d + R_L} \longrightarrow (6)$$

Here, $$\mu = -\left.\frac{v_{ds}}{v_{gs}}\right|_{i_d=0} = r_d g_m \longrightarrow (7)$$

and is known as "amplification factor" of the FET. from eqn (6) we have

$$v_{ds} = -\frac{\mu v_{gs} R_L}{r_d + R_L}$$

and the a.c. component of the drain current is (A)

$$i_d = -\frac{v_{dc}}{R_L} = \frac{\mu v_{gs}}{r_d + R_L} \cdot \longrightarrow (8)$$

Eq^{n} (8) gives the a.c. voltage source equivalent circuit of the common-source FET amplifier shown in fig (2). This is equivalent to the device of voltage source μv_g, in series with a resistor r_d.

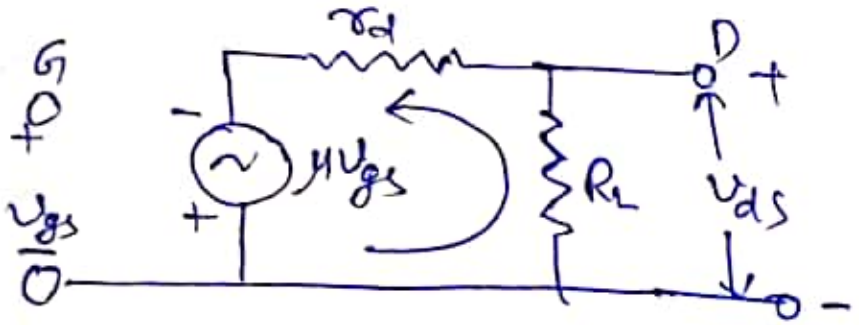

Fig (2)