Field effect transistor

* classification of FET
* Advantages of FET over BJT
* principle of operation of BJT
* FET parameters
    * DC drain resistance
    * AC drain "
    * Trans-conductance

* **Classification of FET :**

- FET
    - JFET (Junction field effect transistor)
        - N-channel
        - P-channel
    - MOSFET (metal oxide semiconductor field effect transistor)
        - Depletion type
            - N-channel
            - P-channel
        - Enhancement type
            - N-channel
            - P-channel

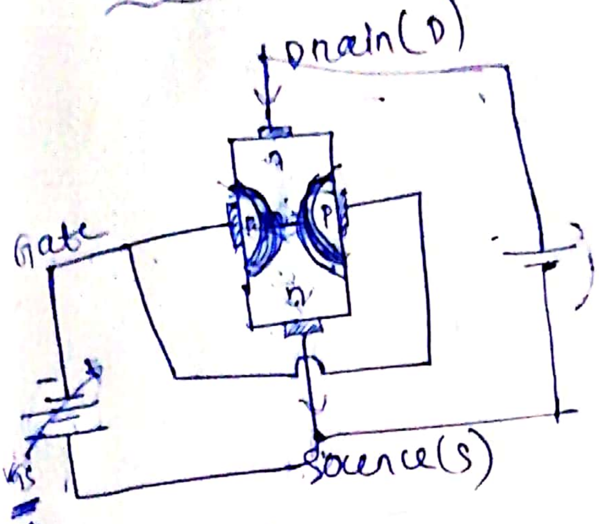
FET

- It stands for field effect transistor
- Three terminals are source, gate, Drain
- It is unipolar device as current flows due to electron or hole.
- It is a voltage control device, gate voltage control the device current
- High input resistance and low o/p resista
- less noisy
- High efficieny
- * Longer life
- * switching speed high
- * small gain bandwidth product

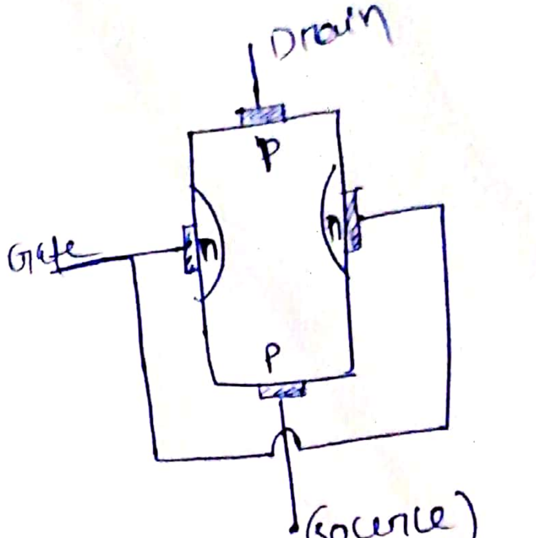
BJT

* stands for Bipolar Junction transistor
* It's terminals are Emitter, Base, collect
* It is a bipolar device, current flows due to both Electron and hole.
* It is a current control device; the base current control the collector current
* low input resistance high output resista
* High noisy
* low efficieny
* shorter life
* low
* Large gain bandwidth product

JFET



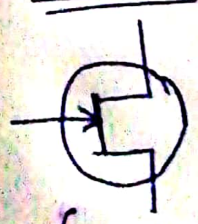
(n-channel JFET)



(P-channel JFET)

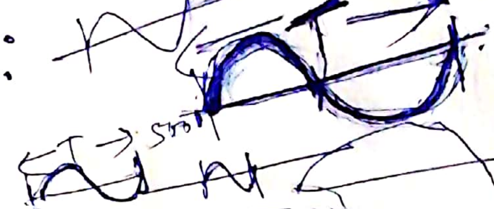
* The voltage between gate and socence is such that the gate is reversing biased.
* Drain and socence terminal are interchangeble
* Input resistance/impedance high
* $I_S = I_D$
  - I_S → socence current
  - I_D → drain current
* Two PN Junction form two depletion layer
* more is the reverse voltage, wider is the depletion layer, narrow the conducting channel and greater the resistance hence source to drain current decreases.

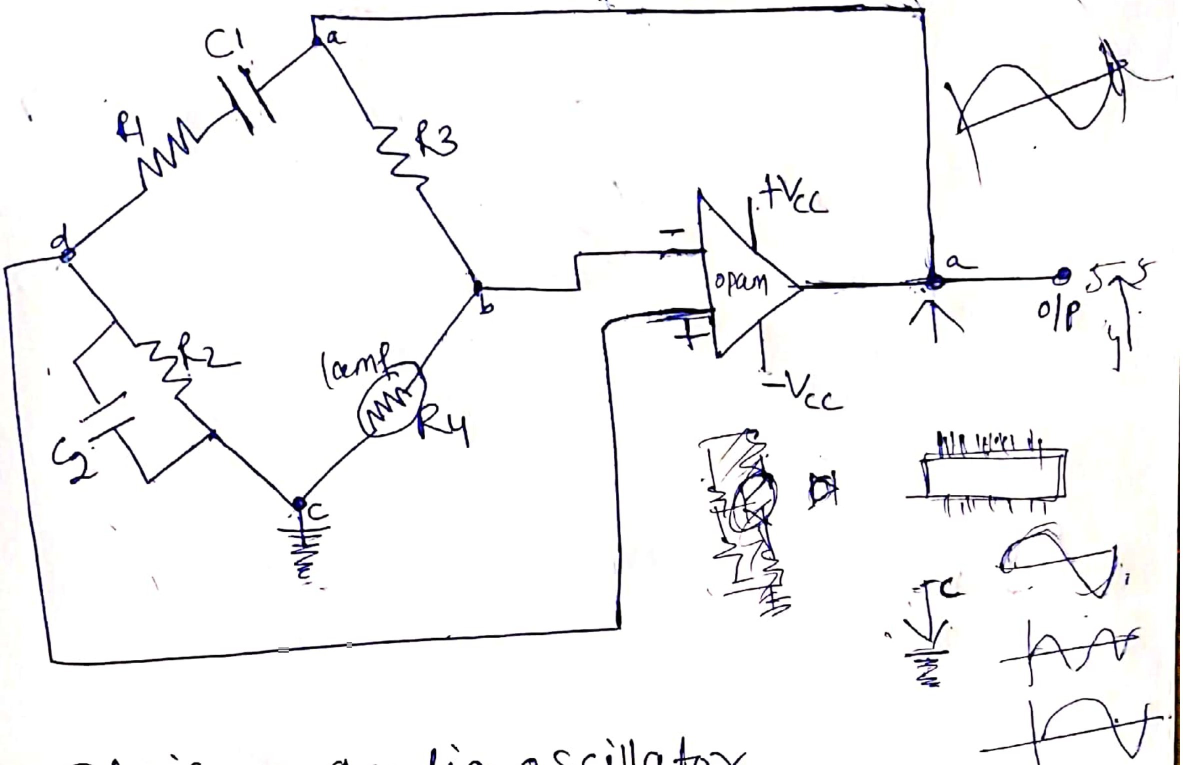
JFET



(symbol)

wein bridge oscillator :





* It is a audio oscillator.
* Frequency range of 10 HZ to 1 MHZ can be achieved.
* R_1 / R_2, C_1 / C_2 are the frequency adjustment element.
* op-amp output connected to the bridge point a and c.
* The bridge circuit output point b and d are input to the op-amp.
* vvimp The condition for oscillation is : $\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1}$
* vvimp The frequency of oscillation is

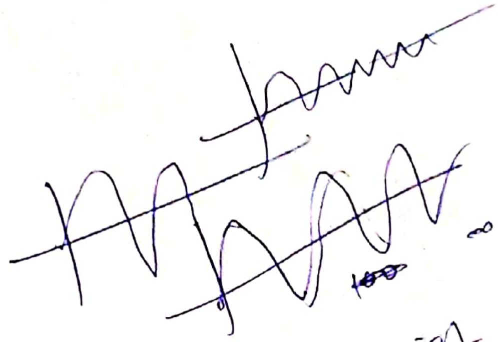
$$f_0 = \frac{1}{2\pi\sqrt{R_1 C_1 R_2 C_2}}$$

* This oscillator produces constant output. If $R_1 = R_2 = R$ and $C_1 = C_2 = C$

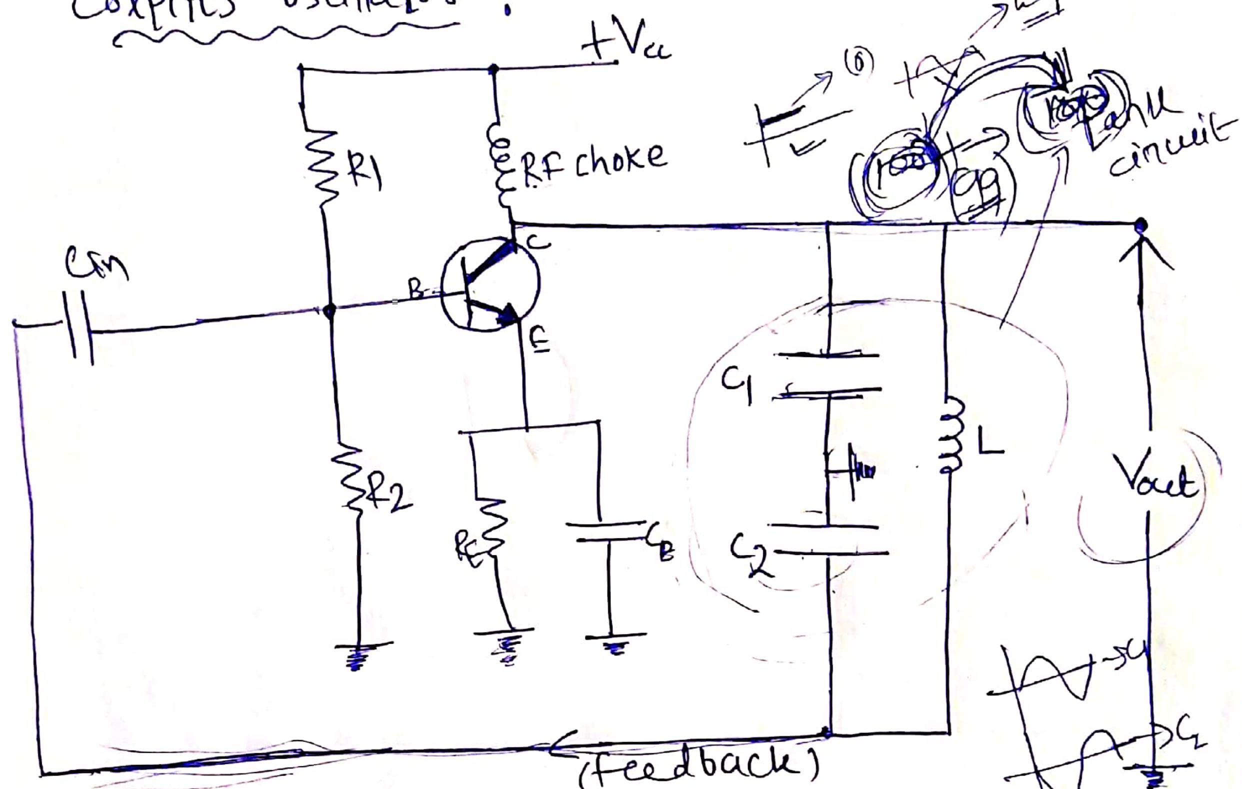
$$f_0 = \frac{1}{2\pi RC}$$

* If output increase or decrease the lamp changes and its resistance to bring the output constant. $R_3/R_4 = 2$ [$\because \frac{R_1}{R_2} = \frac{R_1}{R_1}$

Colpitts oscillator :

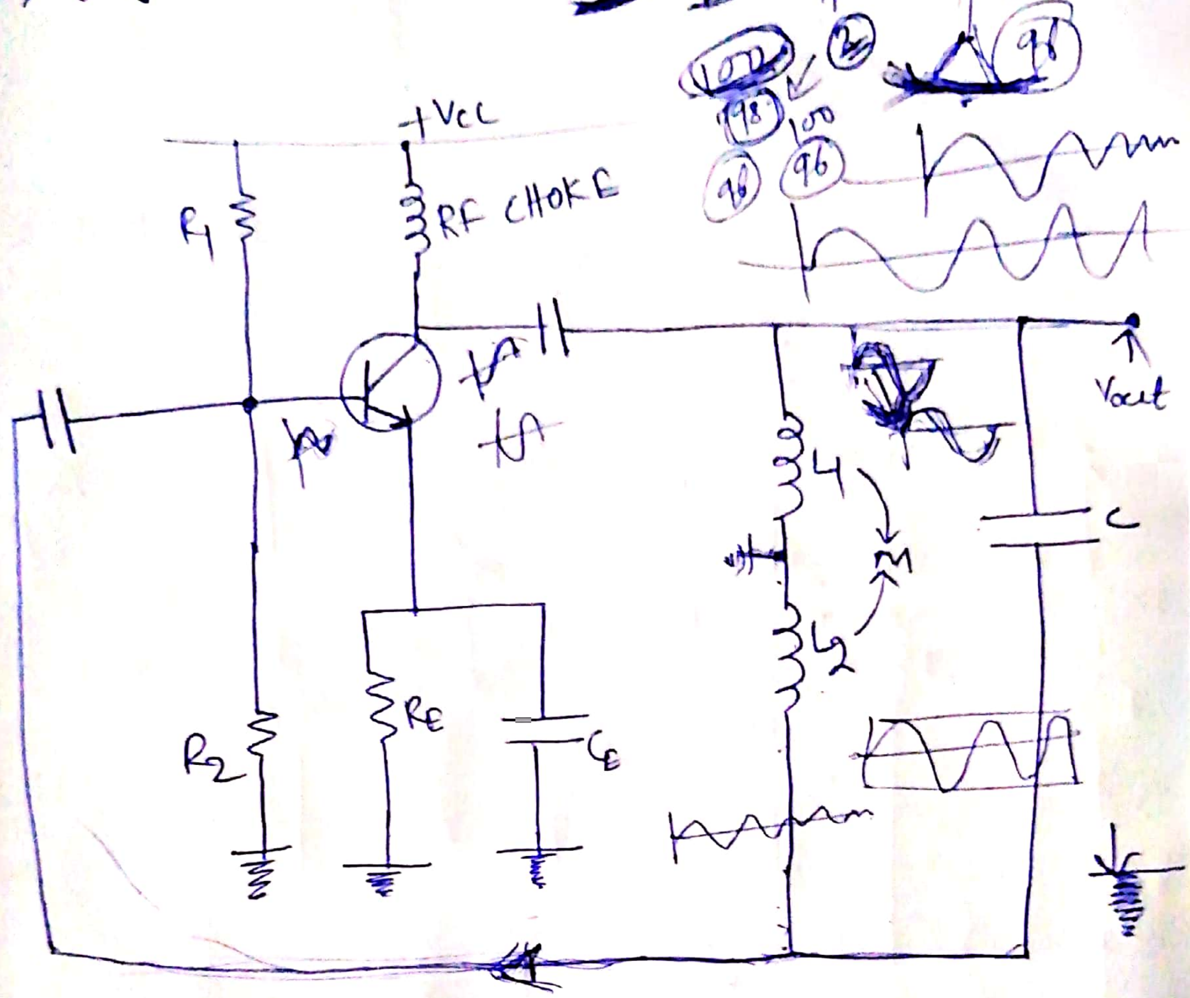


Colpitts oscillator :



* Tank circuit is made up of C_1, C_2 and L.
* Total capacitance $C_{Total} = \frac{C_1 C_2}{C_1 + C_2}$
* C_1 and C_2 charged and discharged through L setting up oscillation $f_0 = \frac{1}{2\pi\sqrt{L C_{eq}}}$ $C_{eq} = C_{Total}$
* output voltage of the amplifier appears across C_1 and feedback voltage developed across C_2.
* voltage across C_2 is 180° out of phase with C_1
* 180° phase shift by the transistor and further 180° phase shift by C_1-C_2 voltage devided which will cause proper undamped oscillation.
* The choke coil (RF → Radio frequency) allows d.c to flow and block a.c.

Hartly oscillator



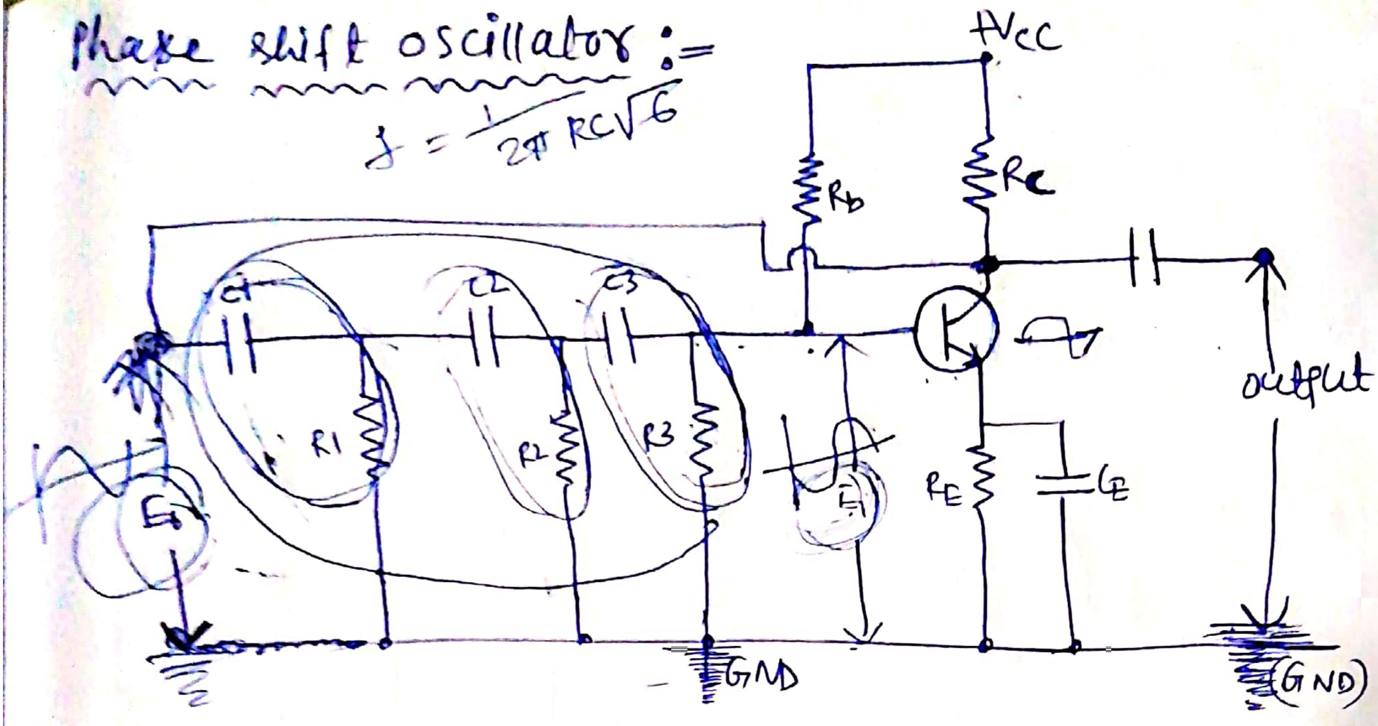
* It is similar to colpitt's oscillator with a minor modification, here two inductor are placed in series and a capacitor connected across it. The centre of the inductors tapped
* The tank circuit is made up of L_1, L_2 and C.
* The total inductance $L_{Total} = L_1 + L_2 + 2M$

  M = mutual inductance bet^n L_1 and L_2
* The frequency of oscillation

  $$f = \frac{1}{2\pi\sqrt{L_T C}}$$
* when the circuit is turned on the capacitor start charging, when it fully charge it starts discharging through coil L_1 and L_2.
* The voltage across L_1 and L_2 are 180° out of phase
* Transistor provide 180° phase shift and (L_1-L_2 circuit) provide further 180° phase shift.

Phase shift oscillator :-

$f = \frac{1}{2\pi RC\sqrt{6}}$



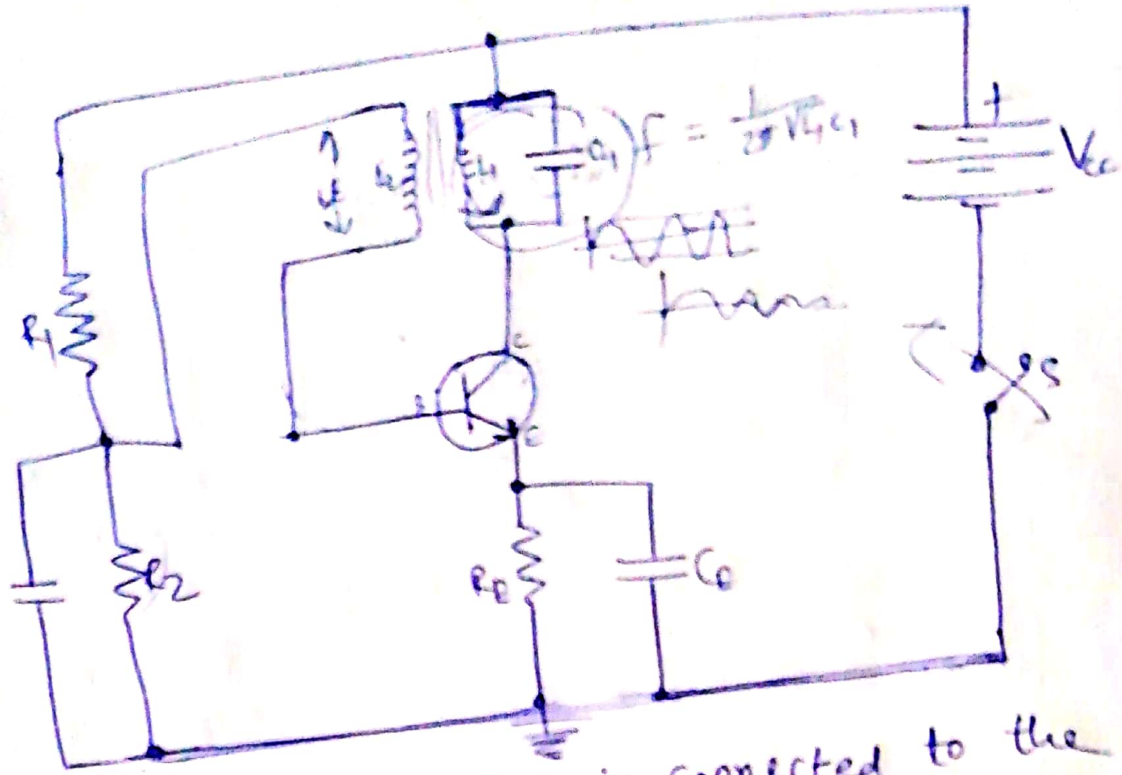
- The phase shift network consist of R_1C_1, R_2C_2, R_3C_3.
- The phase shift in each RC section is 60° the total phase shift produced by the RC network is 180°.
- The frequency of oscillation is given by $f_o = \frac{1}{2\pi RC\sqrt{6}}$ for $R_1 = R_2 = R_3 = R$, $C_1 = C_2 = C_3 = C$

circuit operation: when the circuit is switch on, it produces oscillation of frequency determined by eqn ①. 180° phase shift by the (RC) Network and a further 180° phase shift by the transistor amplifier.

Advantages: ① Not required a transformer or inductor
② used to produce very low frequency

Disadvantage: (i) It is difficult for the circuit to start oscillation as the feedback is small.
(ii) The circuit gives small output.

Tuned collector oscillator :



* The tuned circuit L_1C_1 is connected to the collector.
* The frequency of oscillation depends on the value of L_1 and C_1, given by

$$f = \frac{1}{2\pi\sqrt{L_1C_1}}$$

* The feedback coil L_2 in the base circuit is magnetically coupled to the tank circuit coil L_1.
* L_1 and L_2 are basically the primary and secondary coil inductance of a transformer.
* The biasing is provided by the potential divider arrange

Circuit operation

> when switch S is closed, collector current starts increasing and charges the capacitor C_1, when the capacitor is fully charged, it discharge through L_1. setting up oscillation of frequency $f = \frac{1}{2\pi\sqrt{L_1C_1}}$

Due to mutual inductance voltage induced in coil L_2.

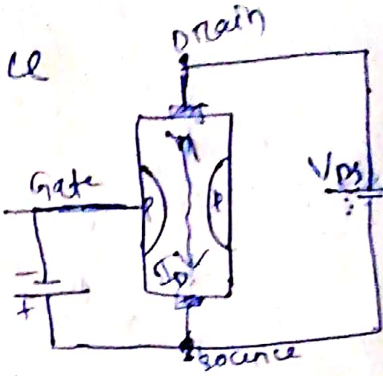
* This voltage get amplified to supply losses to the tank circuit.
* 180° phase shift achieved by the transformer action and a further 180° by the transistor action

Parameters of FET

D.C. drain resistance (R_{DS})

static / ohmic resistance

$$R_{DS} = \frac{V_{DS}}{I_D}$$



A.C. drain resistance (r_d)

Dynamic drain resistance

$$r_d = \frac{\Delta V_{DS}}{\Delta I_D}\Bigg|_{const\ V_{GS}}$$

* It's value ranges from 10kΩ to 1MΩ

* It is the ratio of change in drain to source voltage to change in drain current while V_{GS} constant.

Transconductance / forward transmitance

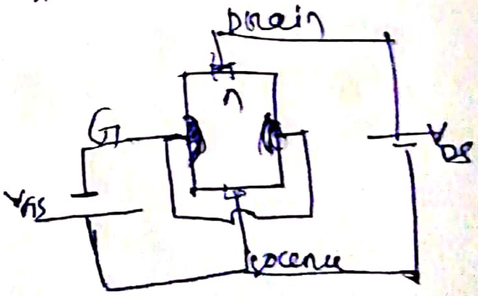
$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}\Bigg|_{cost.(V_{DS})}$$

(Unit → siemens / mho)

Amplification factor (μ)

$$\mu = \frac{\Delta V_{DS}}{\Delta V_{GS}}\Bigg|_{I_D = const}$$

$$\mu = r_d \times g_m$$



~~* Input resistance (R_i)~~

~~$R_i = \frac{V_{GS}}{I_{GS}}$ → reverse current~~

It is the ratio of (drain to source) voltage V_{DS} to the change in gate to source voltage (V_{GS}) at constant drain current I_D.

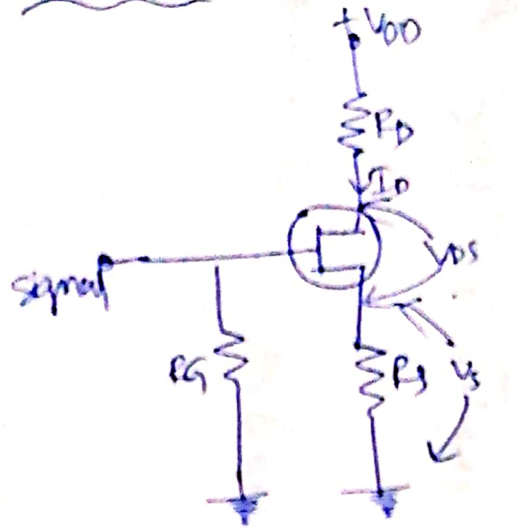
Biasing of JFET

most commonly used

(a) self bias

(b) potential divider bias

(a) self bias



$V_s = I_D R_S = I_S R_S$

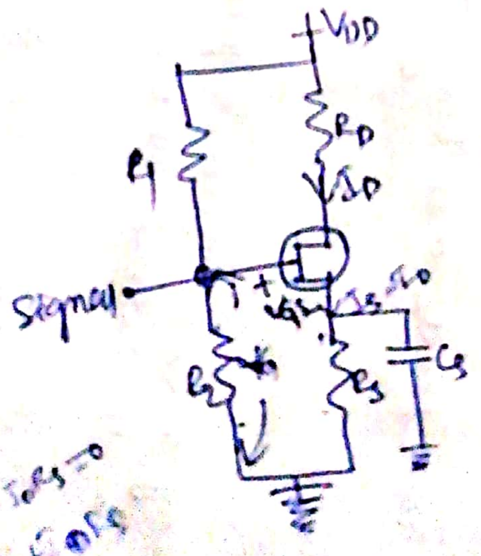
$V_{GS} = V_G - V_S$

$= 0 - V_S$

$V_{GS} = -I_D R_S$

$V_{GS} = -I_D R_S$

voltage divider bias



$V_2 = V_G = \frac{V_{DD}}{R_1 + R_2} \times R_2$

$V_2 = V_{GS} + I_D R_S$

$I_D = \frac{V_2 - V_{GS}}{R_S}$

$V_{DS} = V_{DD} - I_D (R_D + R_S)$

$+V_G - V_{GS} - I_D R_S = 0$

$V_G = V_{GS} + I_D R_S$

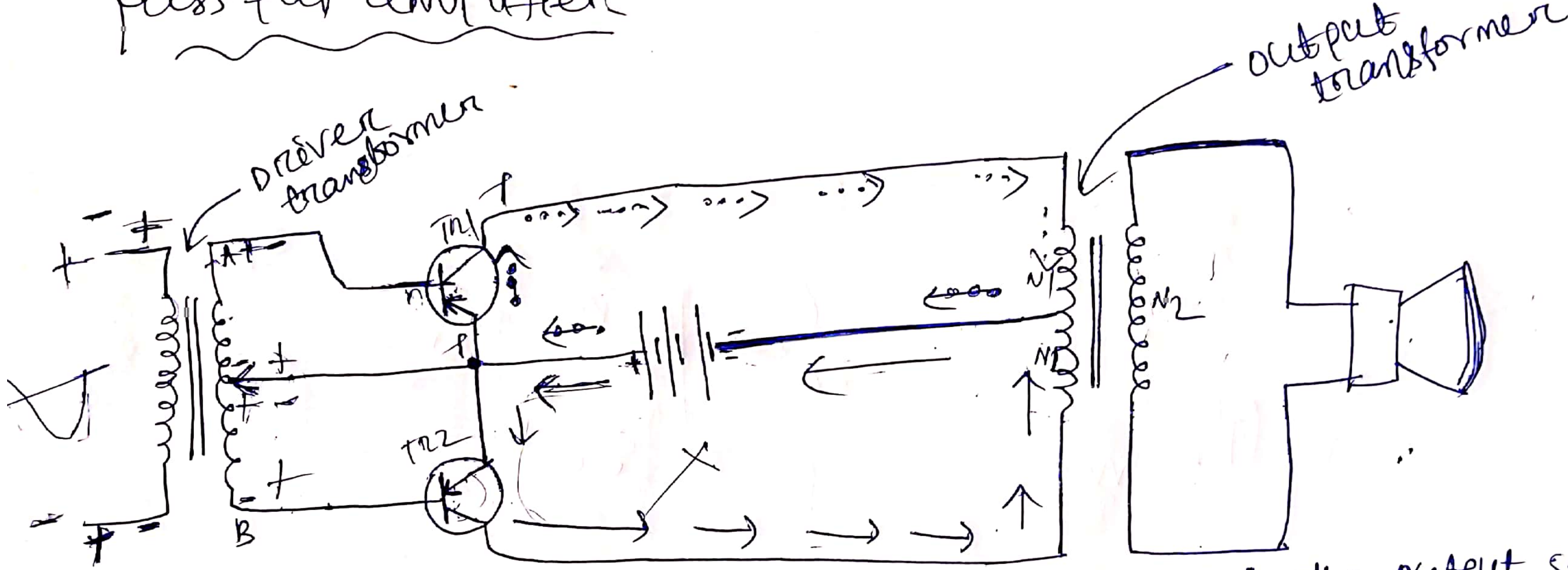
* This methode provide good stability to operating point

Application of JFET as : (a) As RF amplifier

(b) As a phase-shift oscillator

PUSH-PULL amplifier

Push-pull amplifier



* Push-pull amplifier is a power amplifier, and is used in the output stages of electronic circuit. It is required wherever high efficiency output power is required.
* Two transistor are used and operated in class B operation i.e. collector current is nearly zero in the absence of signal.

The centre tapped secondary of driver transformer T_1 supplies equal and opposite voltage to the base circuit of two transistor.

Circuit operation :

* During the +ve half cycle end A becomes positive and end B becomes negative.
* This will make the base-emitter junction of Tr1 reverse biased and that of Tr2 forward biased. The circuit will conduct current due to Tr2 only and the path shown by solid line.
* In the next half cycle Tr2 reverse biased and Tr1 forward bias, hence current flows due to Tr1 and the path is shown by dot line.
* Through impedance matching, maximum power transfer from source to load happen.

Advantage
* Efficiency of the circuit is quite high (=75%) due to class B operation
* A high ac output power ~~obtained~~

Disadvantage
* Two transistor have to be used
transformer used are bulky and expensive