UNIT 1

Introduction to Analog Electronics

Session-2

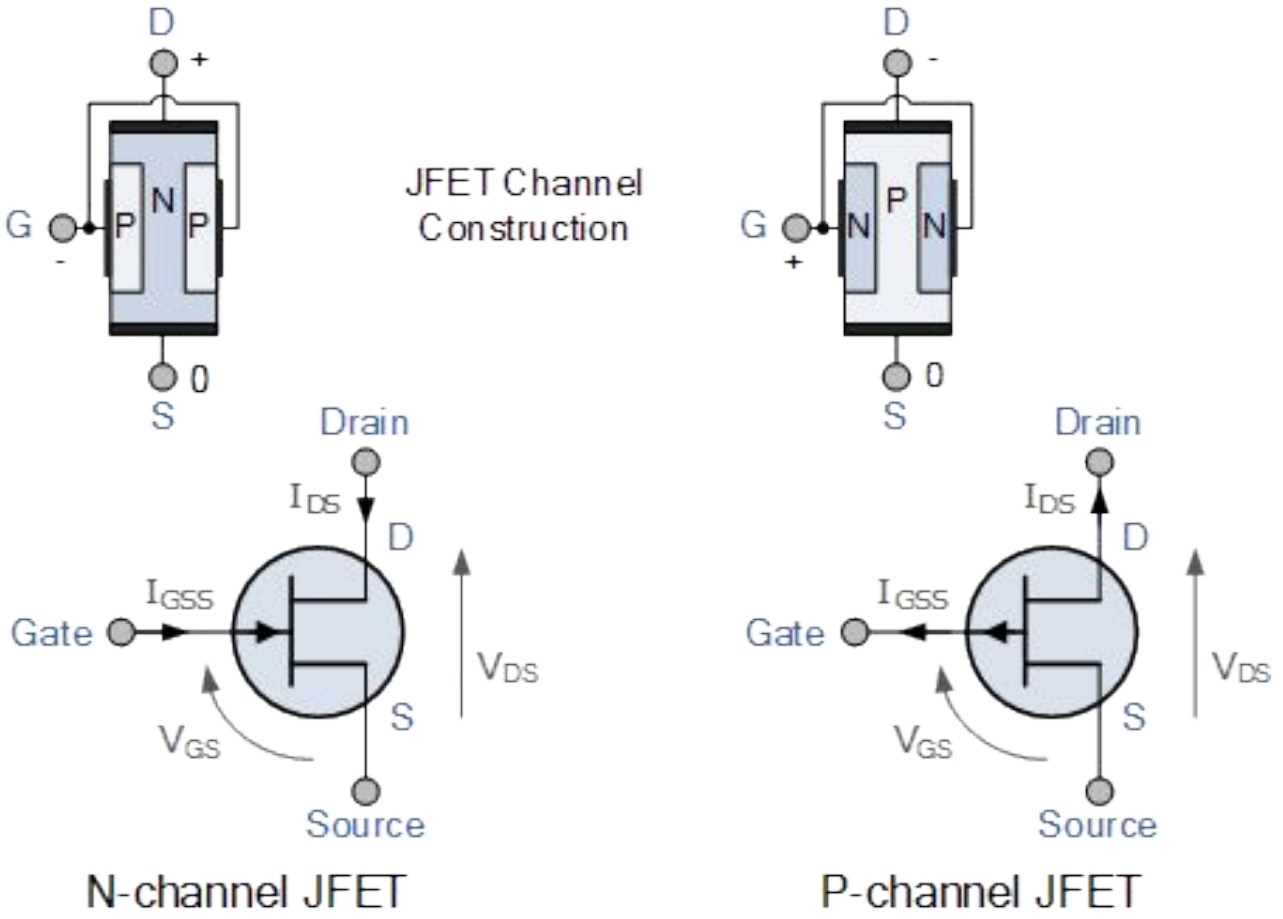
Characteristics of JFET (Common Source, Common Drain and Common Gate configurations) and uses
Differences between BJT and JFET

JUNCTION FIELD EFFECT TRANSISTOR (JFET)

BASICS

- There are two types of JFET's: n-channel and p-channel.
- The **n-channel** is widely used.

- Three terminals:
  - Drain (D) and Source (S) are connected to n-channel
  - Gate (G) is connected to the p-type material.
- Gate is always **reverse biased**
- Gate current, $I_G=0$



CONSTRUCTION, TYPES & SYMBOLS

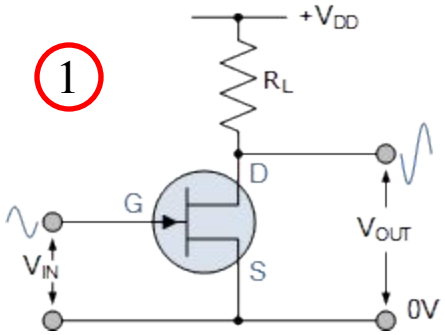
(Image source: www.electronics-tutorials.ws)

BASICS

JFET AMPLIFIER-CONFIGURATIONS

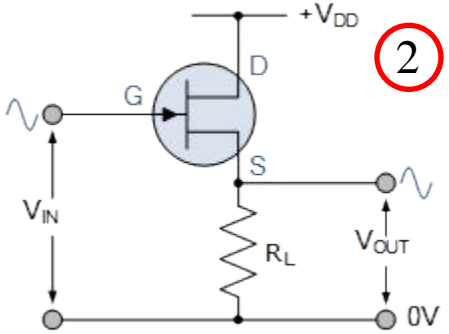
1. Common Source (CS) configuration (Good voltage amplifier)

- Mostly used, Similar to CE transistor
- Generally used in audio frequency amplifiers and in high input impedance pre-amplifier stages.



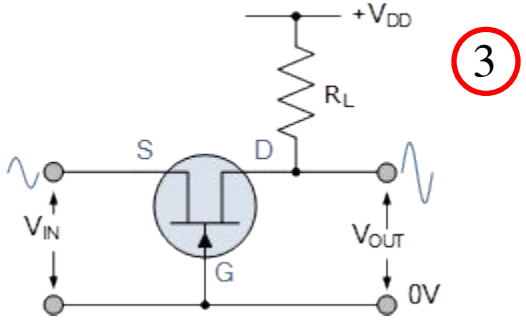
2. Common Drain (CD) configuration (Good voltage buffer)

- Source follower
- High input impedance and a low output impedance
- Approx. unity voltage gain-used in buffer amplifiers.
- referred to as “Common Drain” because there is no signal available at the drain connection.



3. Common Gate (CG) configuration (Good current buffer)

- Has a low input impedance, but a high output impedance.
- Applied in high frequency circuits or in impedance matching circuits where a low input impedance needs to be matched to a high output impedance
- Microphone amplifiers



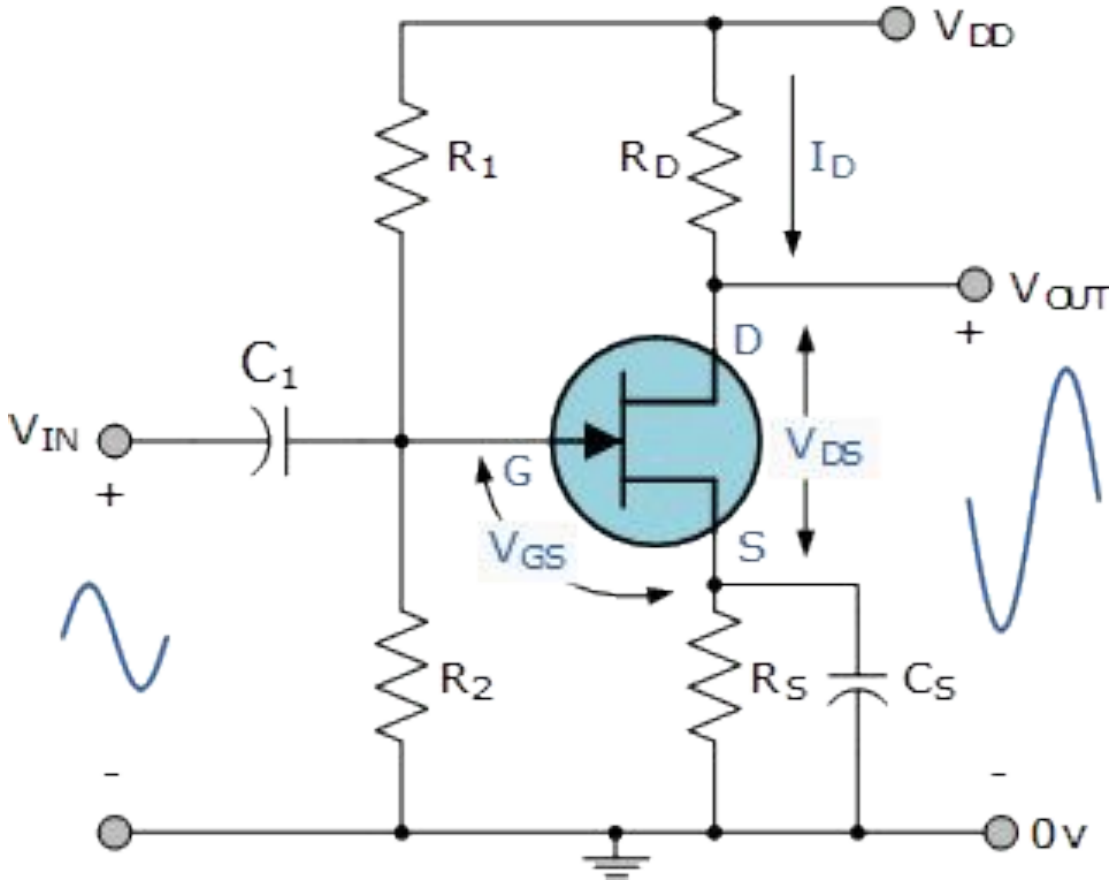
BASICS

COMMON SOURCE AMPLIFIER

- In CS configuration, the input is given to the gate and the output is taken from the drain.
- 180 degree phase shift between input and output.

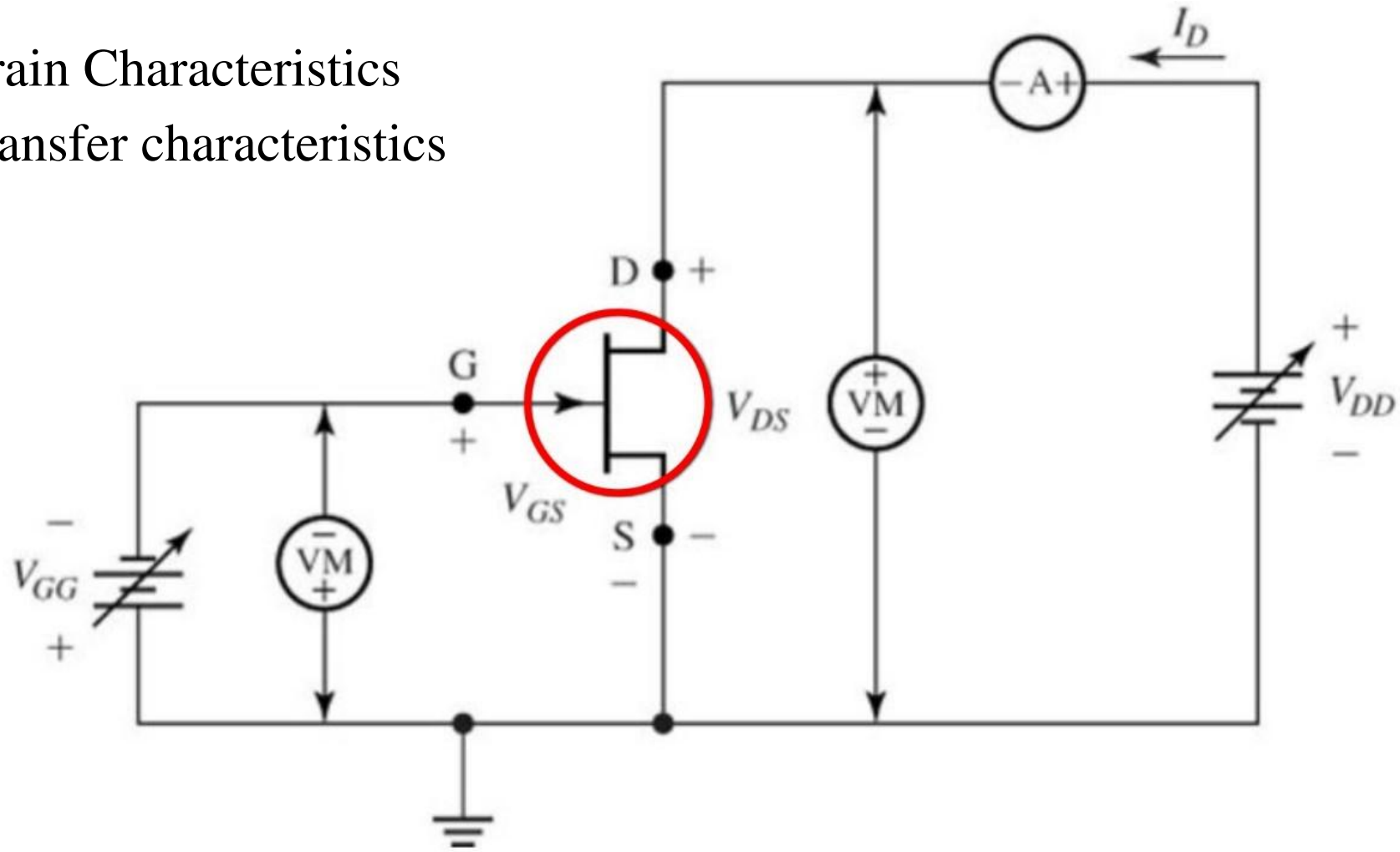
Features

- Large voltage gain
- Good voltage amplifier
- Better transconductance amplifier
- High input resistance
- Medium / high output resistance



CONNECTION DIAGRAM FOR DETERMINING THE CS AMPLFIER CHARACTERISTICS

- Drain Characteristics
- Transfer characteristics



CS AMPLIFIER CHARACTERISTICS

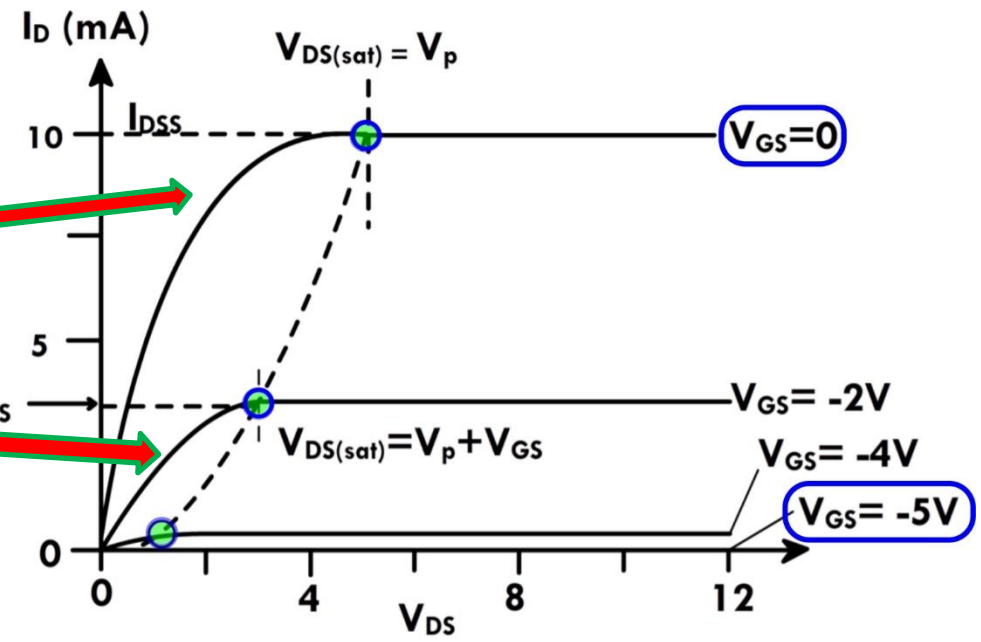
Drain or V-I characteristics

- Output characteristics
- Relationship between Drain current (I_D) and Drain to source voltage (V_{DS}) for different values of gate to source voltage (V_{GS})

Operation analysis includes

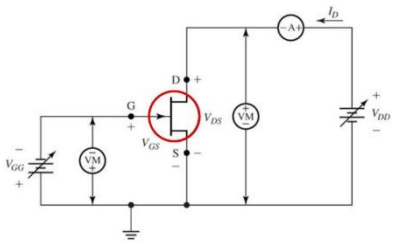
- Without external bias: (V_{GS} =0)
- With external bias.

I_D VS V_{DS} FOR V_{GS} = constant



V_{GS} ↑ Depletion layer ↑ I_D ↓

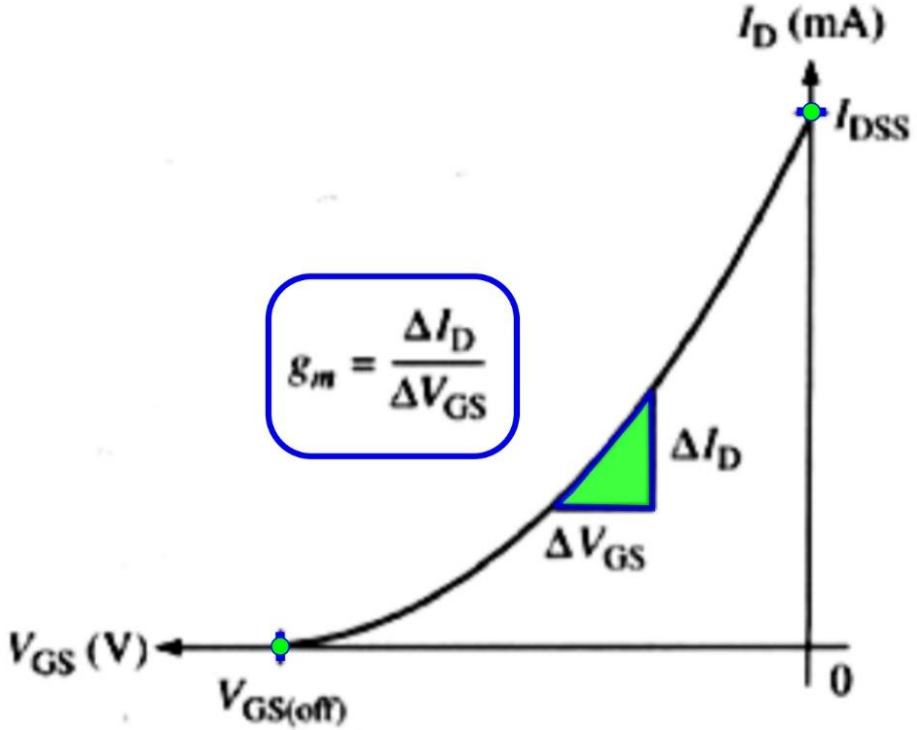
CS AMPLIFIER CHARACTERISTICS



The transfer characteristics

- The plot of the drain current Vs gate-source voltage for different values of drain to source voltage (V_{GS})
- It is observed that the value of drain current varies **inversely** with respect to gate-source voltage when the drain-source voltage is constant.

The transfer characteristics is drawn between input voltage and output current.



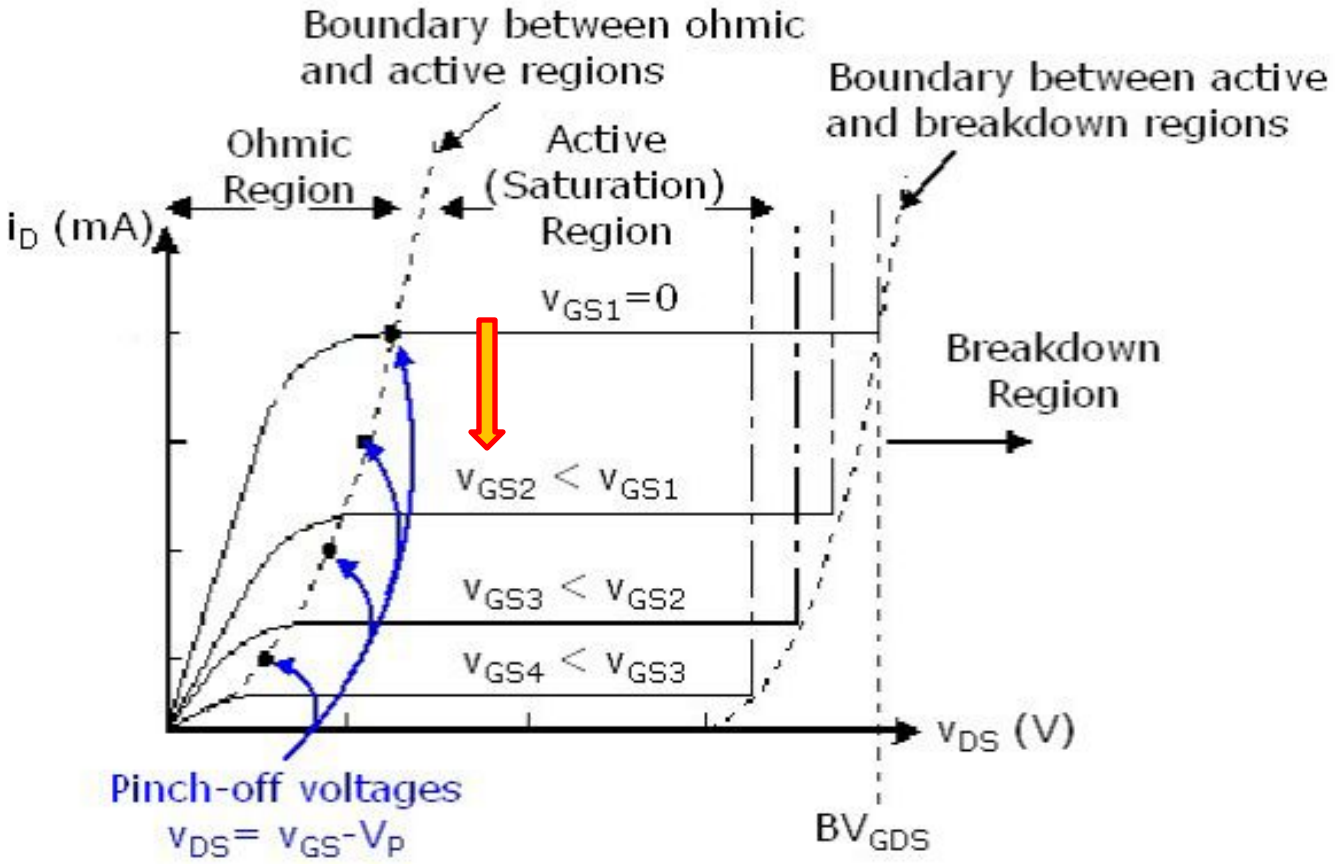
I_D VS. V_{GS} FOR V_{DS} = constant

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

CS AMPLIFIER CHARACTERISTICS

At the pinch-off point,

- V_{GS} at pinch-off is denoted as V_p
- any further increase in V_{DS} does not produce any increase in I_D
- I_D is at saturation or maximum. It is referred to as I_{DSS}.



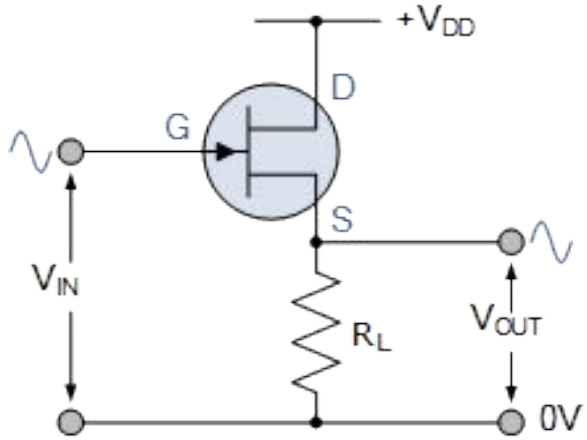
(Image source: www.rezzonics.blogspot.com)

CS AMPLIFIER CHARACTERISTICS

Important terms in JFET drain characteristics

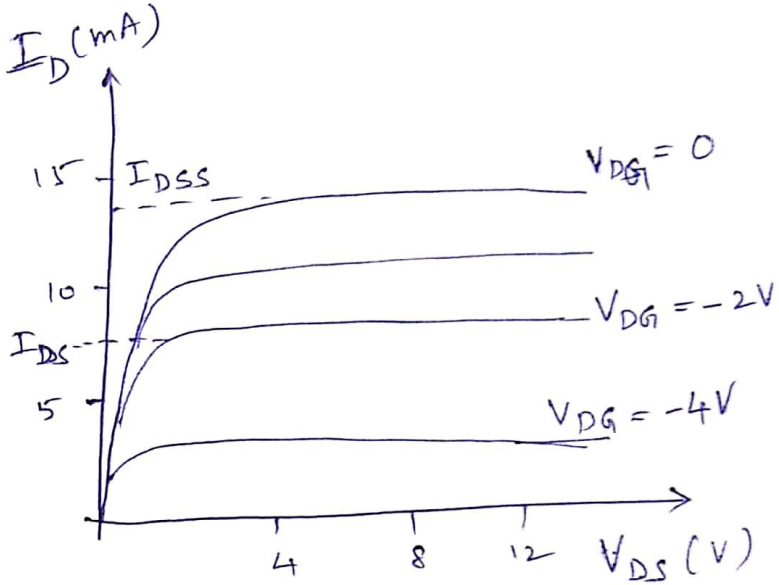
- **Knee Point**: Where the variation of drain current with drain-source voltage appears to be linear. But beyond this point, the linearity changes into a curve.
- **Channel Ohmic Region**: The region to the left of the knee point in the characteristics curve.
- **Pinch-off point**: The point in the curve beyond which the drain current will not increase further no matter how much we are increasing the drain to source voltage.
- **Pinch-off Voltage**: The voltage at the pinch-off point is termed as pinch-off voltage because at this voltage, the current is completely turned to be constant.
- **Drain-Source Saturation Current**: The drain to source saturation current is the current which becomes constant and enters into a saturation state.

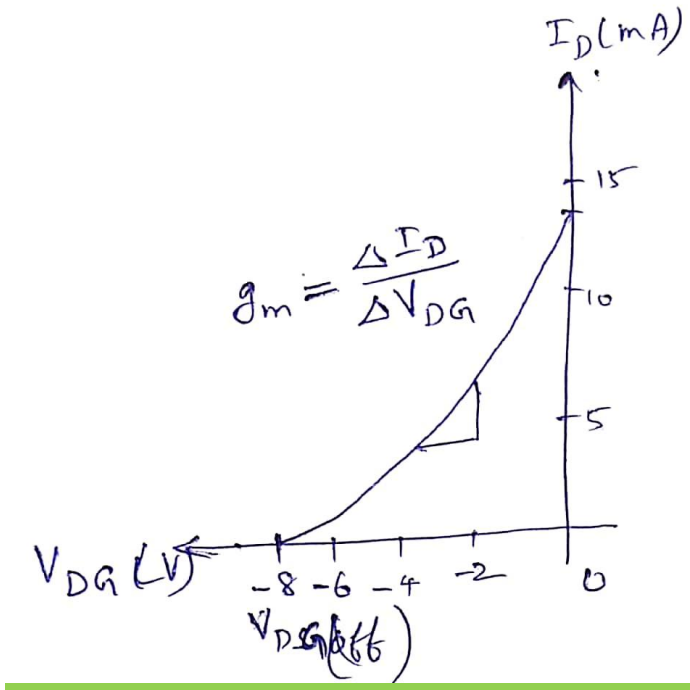
COMMON DRAIN JFET AMPLIFIER (Source follower)



Connect voltmeters and ammeters to measure the necessary voltages and currents (as explained in CS amplifier connections)

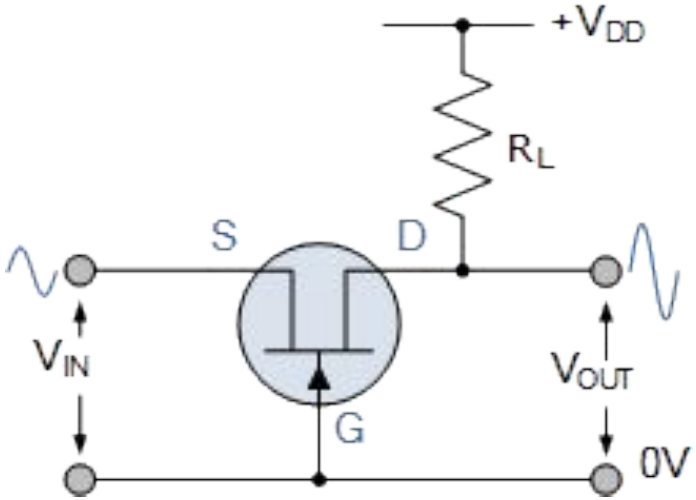
The output characteristics





The transfer characteristics

COMMON GATE JFET AMPLIFIER-CHARACTERISTICS



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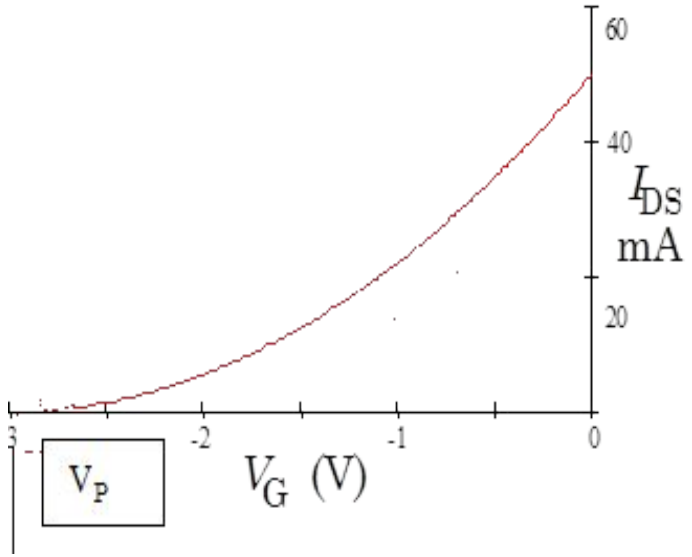
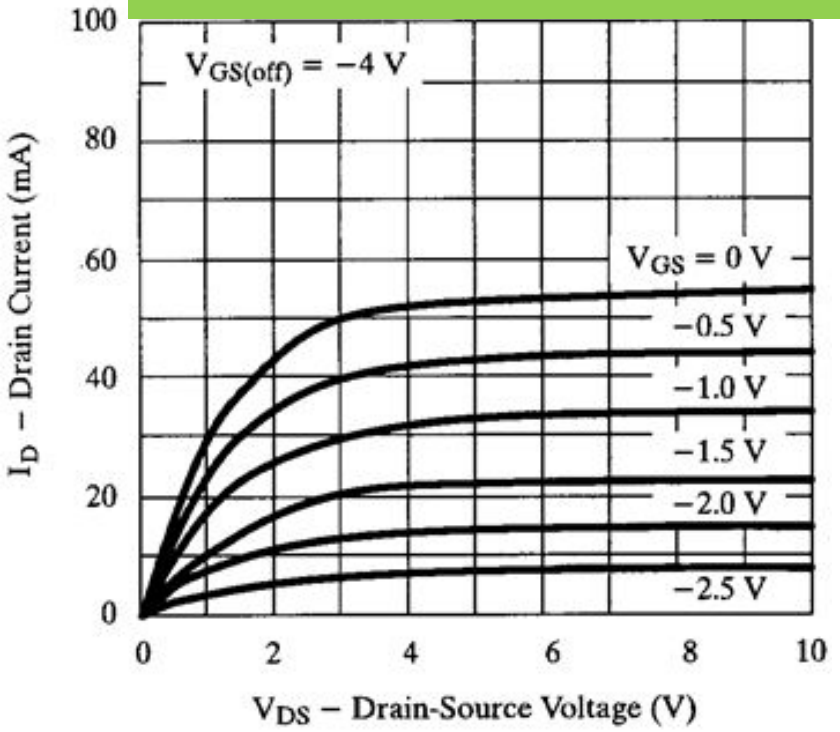


The transfer characteristics

The output characteristics



COMPARISON BETWEEN BJT AND JFET

BJT	JFET
Bipolar device (current condition, by both types of carriers, i.e. majority and minority-electrons and hole).	Unipolar device (current conduction is only due to one type of majority carrier either electron or hole).
The operation depends on the injection of minority carries across a forward biased junction.	The operation depends on the control of a junction depletion width under reverse bias.
Current controlled device. The base current controls the output current.	Voltage controlled device. The gate voltage controls output current.
High noise level. (current conduction through junctions)	Low noise level. (current conduction is through n-channel or p-channel and no junction crossing)
Low input impedance (due to forward bias at input side).	High input impedance (due to reverse bias).
Gain is characterized by voltage gain.	Gain is characterised by transconductance.
Low thermal stability. (positive temperature coefficient at high current levels lead to thermal breakdown)	Better thermal stability.(NTC at high current levels prevent thermal breakdown)
Cheaper	Relatively costly

REVIEW QUESTIONS

Source follower is a circuit that provides_____

In CS amplifier, the drain-source current is largest when the gate-source voltage V_{GS} is____

Which JFET amplifier configuration is used in microphone amplifiers?

JFET is a ___ controlled device