MOSFET OPERATION REGION PREDICTION

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OBJECTIVE:

MOSFET operation region- Saturation Region, Cut off Region, Active Region prediction using Deep Learning.

METHODOLOGY:

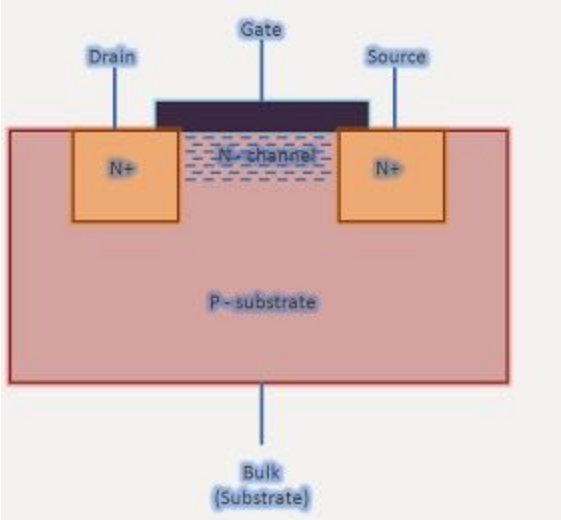
To predict operation region of MOSFET on the basis of values of VDD, VDS, and VGS.
There are 3 operating regions of **MOSFET**

1.LINEAR REGION OR OHAMIC REGION

2.SATURATION REGION

3.CUT OFF REGION

MOSFET, or simply, MOS) is a four terminal device. Figure 1 below shows the general representation of an N-MOS (for PMOS, simply replace N regions with P and vice-versa). MOS is a Voltage-controlled current source as the current through MOS is a function of relative voltage levels of its terminals. The relative voltages of gate, drain and source terminals (assuming bulk or substrate to be at same voltage as source) determine the magnitude of current flowing in MOS. In each of these regions, we can represent the current as a function of gate-to-source voltage (VGS) and drain-to-source voltage (VDS).



MOS transistor - a 4-transistor device

Cut off region – A MOS device is said to be operating when the gate-to-source voltage is less than Vth. Thus, for MOS to be in cut-off region, the necessary condition is –

$0 < VGS < Vth$ - for NMOS

$0 > VGS > Vth$ - for PMOS (as threshold voltage of PMOS is negative)

Linear or non saturation region – For an NMOS, as gate voltage increases beyond threshold voltage, channel is formed between source and drain terminals. Now, if there is voltage difference between source and drain, current will flow. The magnitude of current increases linearly with increasing drain voltage till a particular drain voltage determined by the following relations –

$VGS \geq Vth$

$VDS < VGS – Vth$

$Id(Linear) = \mu Cox\ W/L\ (Vgs – Vth – Vds/2)\ Vds.$

Similarly, for P-MOS transistor, condition for P-MOS to be in linear region is represented as:

$VGS < Vth$ OR $VSG > |Vth|$

And $VDS > VGS + Vth$ OR $VSD < VSG - |Vth|$

Saturation Region – For an NMOS, at a particular gate and source voltage, there is a particular level of voltage for drain, beyond which, increasing drain voltage seems to have no effect on current. When a MOS operates in this region, it is said to be in saturation. The condition is given as:

VGS ≥ Vth

VDS > VGS – Vth

DATA-GENERATION AND COLLECTION

Data set is prepared using the three voltage equations of MOSFETs which decides the operating region of MOSFET.

Cut Off	$V_{GS} \le V_T$	$I_{DS} = 0$
Linear	$V_{GS} > V_T,\ V_{DS} \le V_{GS} - V_T$	$I_{DS} = \mu_n C_{ox} \frac{W}{L}\left[(V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right](1 + \lambda V_{DS})$
Saturation	$V_{GS} > V_T,\ V_{DS} > V_{GS} - V_T$	$I_{DS} = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS} - V_T)^2(1 + \lambda V_{DS})$

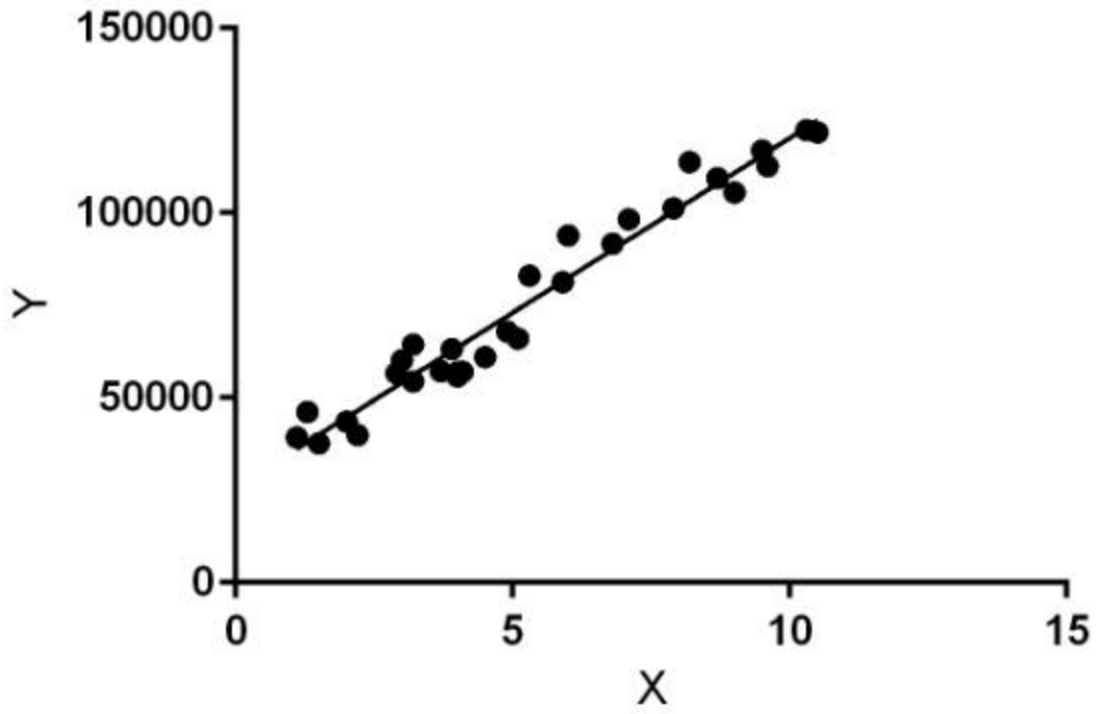
In this dataSet Linear region is represented by 1, Saturation region by 2 and cut off region by 3.

A	B	C	D
Output	VT	VGS	VDS
1	0.6	3.7	0.9
1	0.6	3.8	1.1
1	0.6	3.9	1.4
1	0.6	4	1.4
1	0.6	4.1	1.6
1	0.6	4.2	1.6
1	0.6	4.3	1.8
1	0.6	4.4	1.9
1	0.6	4.5	2.1
2	0.6	0.7	3.7
2	0.6	0.8	3.8
2	0.6	0.9	3.9
2	0.6	0.8	4
2	0.6	1	4.1
2	0.6	1.1	4.2
2	0.6	1.1	4.3
2	0.6	1.2	4.4
2	0.6	1.3	4.5
2	0.6	1.4	1.6
2	0.6	1.5	1.8
2	0.6	1.8	2
3	0.6	0.1	0.5
3	0.6	0.15	0.1
3	0.6	0.2	0.9
3	0.6	0.25	0.3
3	0.6	0.3	0.4
3	0.6	0.35	0.8
3	0.6	0.4	1.3
3	0.6	0.45	1.2
3	0.6	0.5	0.1
3	0.6	0.55	0.3
3	0.6	0.56	0.7
3	0.6	0.57	0.8
3	0.6	0.58	0.1

NETWORK LAYERS:

Linear Regression has been used in this model for prediction of Linear, Saturation and Cutoff region of Operation of MOSFET on the basis of input parameters.

Linear Regression is a machine learning algorithm based on **supervised learning**. It performs a **regression task**. Regression models a target prediction value based on independent variables. It is mostly used for finding out the relationship between variables and forecasting. Different regression models differ based on – the kind of relationship between dependent and independent variables, they are considering and the number of independent variables being used.



Linear regression performs the task to predict a dependent variable value (y) based on a given independent variable (x). So, this regression technique finds out a linear relationship between x (input) and y(output). Hence, the name is Linear Regression.

In the figure above, X (input) is the work experience and Y (output) is the salary of a person. The regression line is the best fit line for our model.

Hypothesis function for Linear Regression :

$$y = \theta_1 + \theta_2.x$$

OUTPUT RESULTS:

```
print(linear_regressor.predict(input_fn=3.5))
```

```
<generator object Estimator.predict at 0x7fd8946b9f68>
the region is linear
```