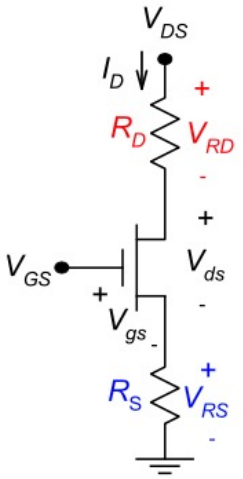
EDA/CAD FOR NANOELECTRONICS 2020/21

M. Helena Fino

- **Model 2**
  - **Contact Resistances:**



$$V_{gs} = V_{GS} - R_s I_D$$

$$V_{ds} = V_{DS} - (R_s + R_D) I_D$$

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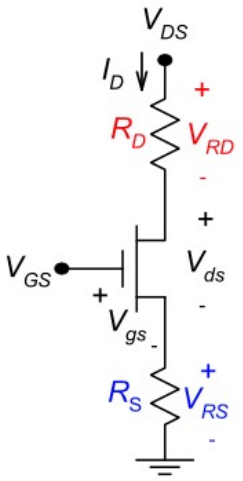

These equations have to be integrated into model1 equations

$$V_{gs} = V_{GS} - R_s I_D$$

$$V_{ds} = V_{DS} - (R_s + R_D) I_D$$

$$I_D = \mathrm{K}\left(V_{gs} - V_T\right)^{\mathrm{m}}(1 + \lambda V_{ds})$$

See: Rodolfo Rodriguez-Davila et. al, *A New Integration-Based Procedure to Extract the Threshold Voltage, the Mobility Enhancement Factor, and the Series Resistance of Thin- Film MOSFETs"*

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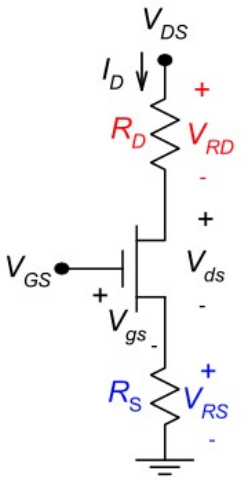

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Ignore this …

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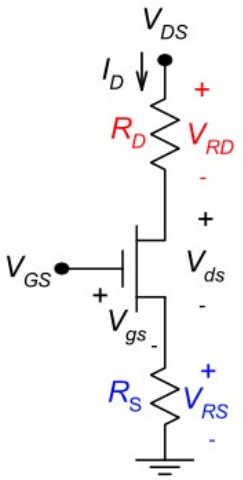

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These equations have to be integrated into model1 equations

$$I_D = \mathrm{K}\left(V_{GS} - R_S I_D - V_T\right)^{\mathrm{m}}$$

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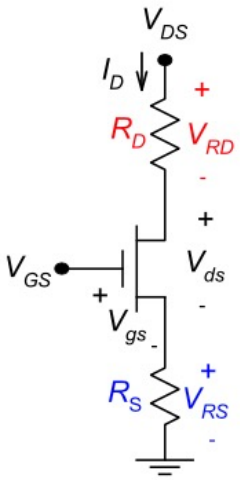

This is an implicit function

$$V_{gs} = V_{GS} - R_s I_D$$

$$I_D = \mathrm{K}\left(V_{gs} - V_T\right)^{\mathrm{m}}$$

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How to deal with fitting and implicit functions, in Python ?

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How to deal with fitting and implicit functions, in Python ?

- Example:
  - Diode:
    - $I_D = I_s\left(e^{vd/vx} - 1\right) with\ \ vx = \eta\, U_T$
    - $vd = Vd - r_d . I_d$

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How to deal with fitting and implicit functions

- Example:
  - Diode:
    - $I_D = I_s\left(e^{vd/vx} - 1\right) with\ vx =$
    - $vd = Vd - r_d . I_d$

```
@author: hfino
"""
import numpy as np
from scipy.optimize import curve_fit
import matplotlib.pyplot as plt
import pandas as pd

df_diode0=pd.read_csv("diode 1.txt",header=1, sep="\t")
df_diode=df_diode0.to_numpy()

x=df_diode[:,1]
print(x)
y=df_diode[:,0]
print(y)
plt.plot(x,y,'+')

def diode(data, Rd, Ix, Vx):
    v, j = data
    return Ix*(np.exp((v - j * Rd) / Vx)-1)


parameters, parameterscovariance = curve_fit(diode, (x,y), y, maxfev=4000,
                                             bounds = ([0, 0, 0],
                                                       [10, 1e-3, 1]))
Rd=parameters[0]
Is=parameters[1]
Vx=parameters[2]
print('Is=',Is)
print('Rd=',Rd)
print('Vx=',Vx)
plt.plot(x, diode((x,y), parameters[0], parameters[1], parameters[2]))

plt.show()
```