Lab 3: MOSFET Drain Current Modelling

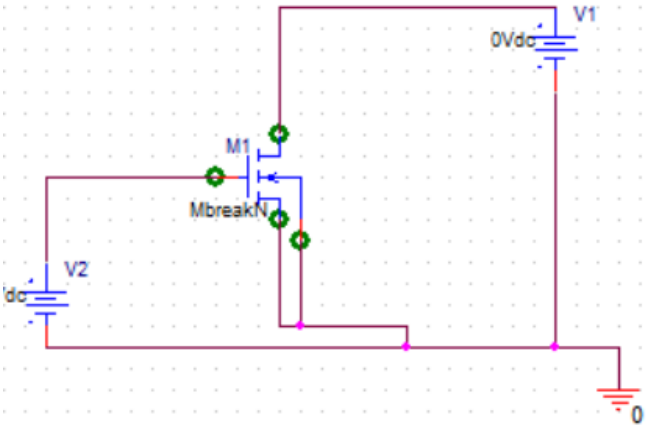
ELEC 3908 A-A3

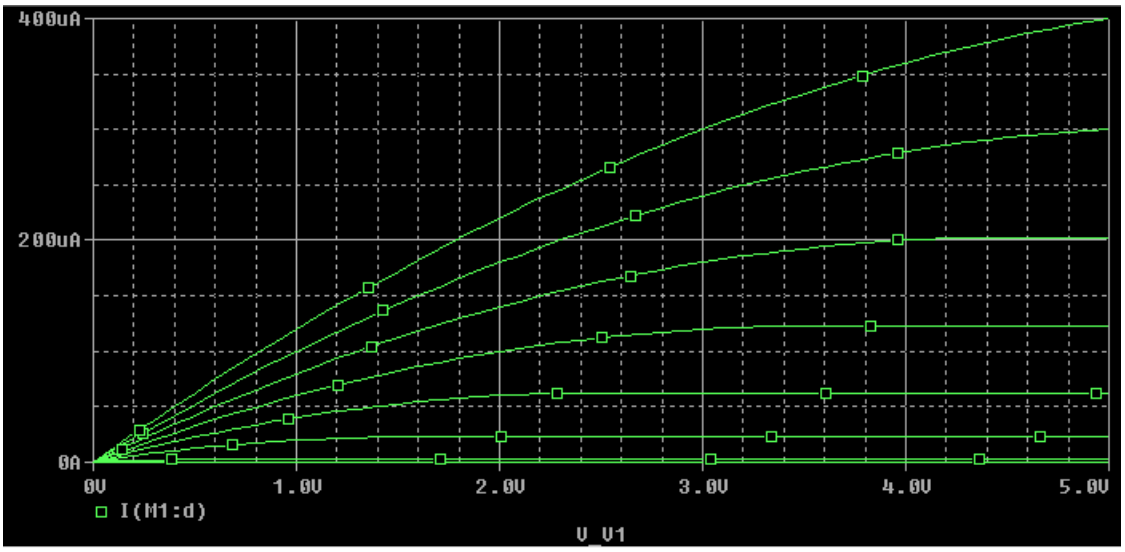
Name: Youssef Ibrahim

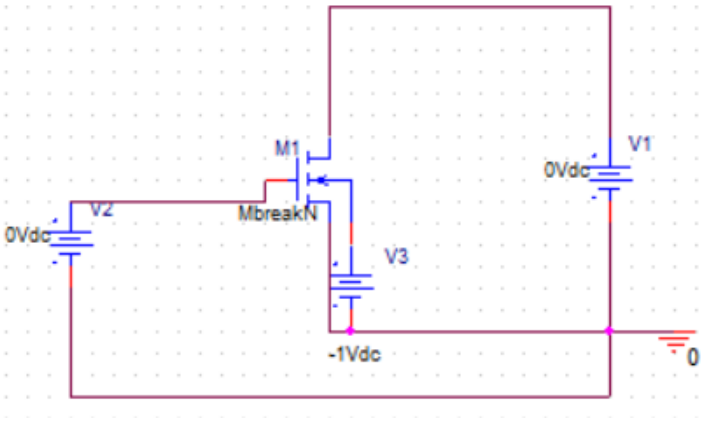
Date Performed: 11 - December - 2020

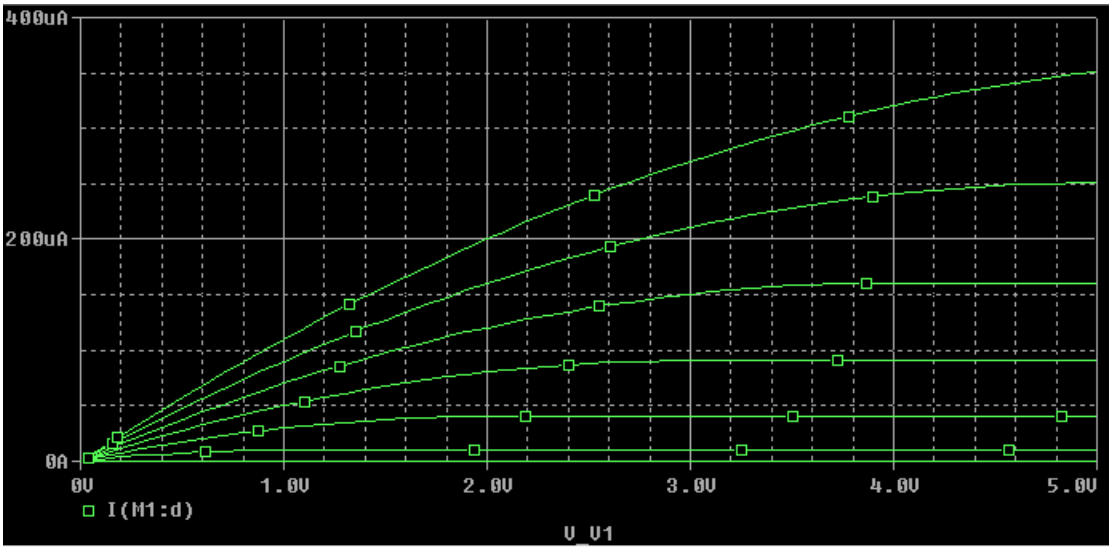
3.0 EXPERIMENT

3.1 $I_D - V_D$ Curves

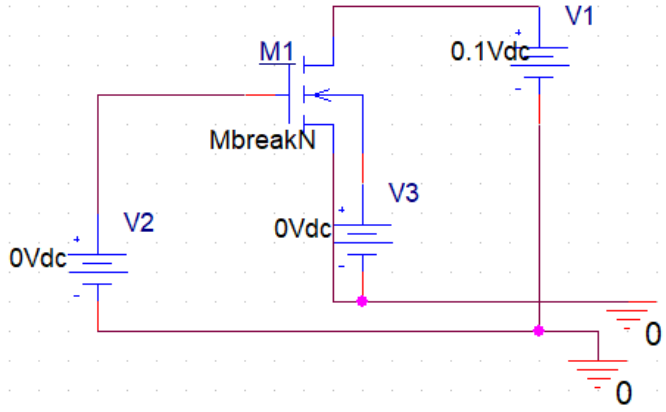


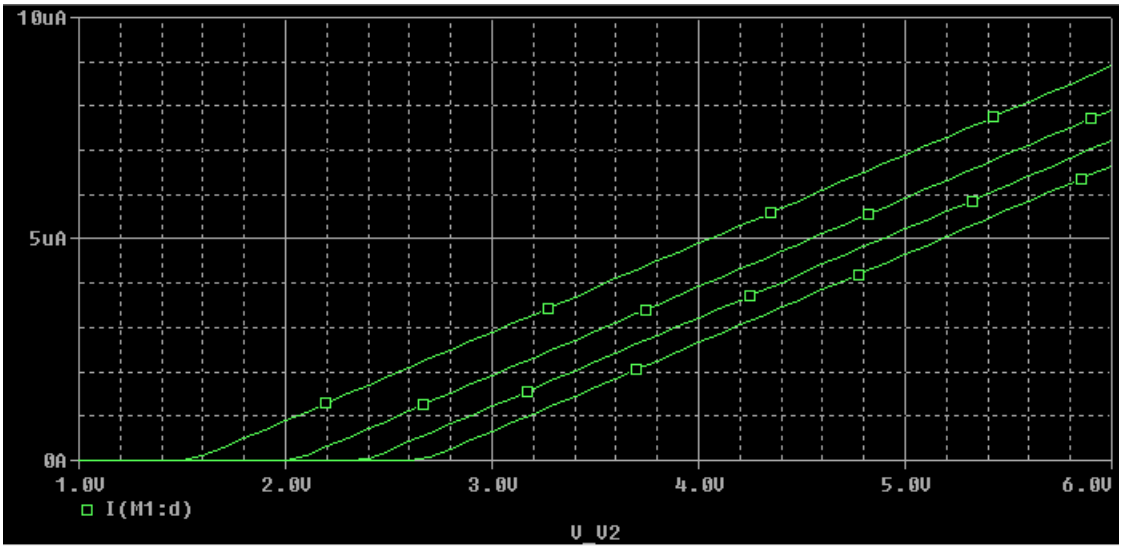



M1
V1
0Vdc
V2
MbreakN
0Vdc
V3
-1Vdc
0


400uA
200uA
0A
0V
1.0V
2.0V
3.0V
4.0V
5.0V
I(M1:d)
V_V1

3.2 $I_D - V_G$ Curves





4.0 DATA ANALYSIS

$$V_T = V_{To} + \gamma[\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B}]$$

$$\gamma = \frac{V_T - V_{To}}{\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B}}$$

$$I_D = \mu_n \widehat{C_{ox}} \frac{W}{L}\left((V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right)$$

$$\mu_n = \frac{I_D}{\widehat{C_{ox}} \frac{W}{L}\left((V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right)} = \frac{\frac{dI_D}{dV_{GS}}}{\widehat{C_{ox}} * \frac{W}{L} * V_{DS}}$$

$$W = 350\,\mu m;\ L = 10\,\mu m;\ t_{ox} = 50\,nm;\ V_{DS} = 0.1\,V;\ \phi_B \approx 0.6\,V$$

$$y = mx + b = 1.69 \times 10^{-6}x - 2.93 \times 10^{-6}$$

$$2 \times 10^{-6}x - 3 \times 10^{-6} = \overline{\mu_n}\widehat{C_{ox}} \frac{W}{L}\left((V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right)(1 + \lambda V_{DS})$$

$$2 \times 10^{-6}x - 3 \times 10^{-6} = \overline{\mu_n}\widehat{C_{ox}} \frac{350\,\mu m}{10\,\mu m}\left((V_{GS} - V_T)V_{DS} - \frac{V_{DS}^2}{2}\right)(1 + \lambda V_{DS})$$

$$\widehat{C_{ox}} = \frac{\varepsilon_{ox}}{t_{ox}}$$

$$\varepsilon_{ox} = 3.9\varepsilon_o = 3.9 * 8.854 * 10^{-14} = 3.453 * 10^{-13}\ F/cm$$

1.

$$\widehat{C_{ox}} = \frac{3.453 * 10^{-13}}{50 * 10^{-7}} = 6.906 * 10^{-8}\ F/cm^2$$

$$\mu_n = \frac{\frac{dI_D}{dV_{GS}}}{\widehat{C_{ox}} * \frac{W}{L} * V_{DS}} = \frac{1.69 * 10^{-6}}{6.906 * 10^{-8} * \frac{350}{10} * 0.1} = 6.99\ cm^2/V * s$$

2.

V_T *is same as* V_{To} *when* $V_{SB} = 0$

For $V_{SB} = 0\,V$

$$V_T = -\frac{b}{m} = -\frac{-2.93 * 10^{-6}}{1.69 * 10^{-6}} = 1.73\,V$$

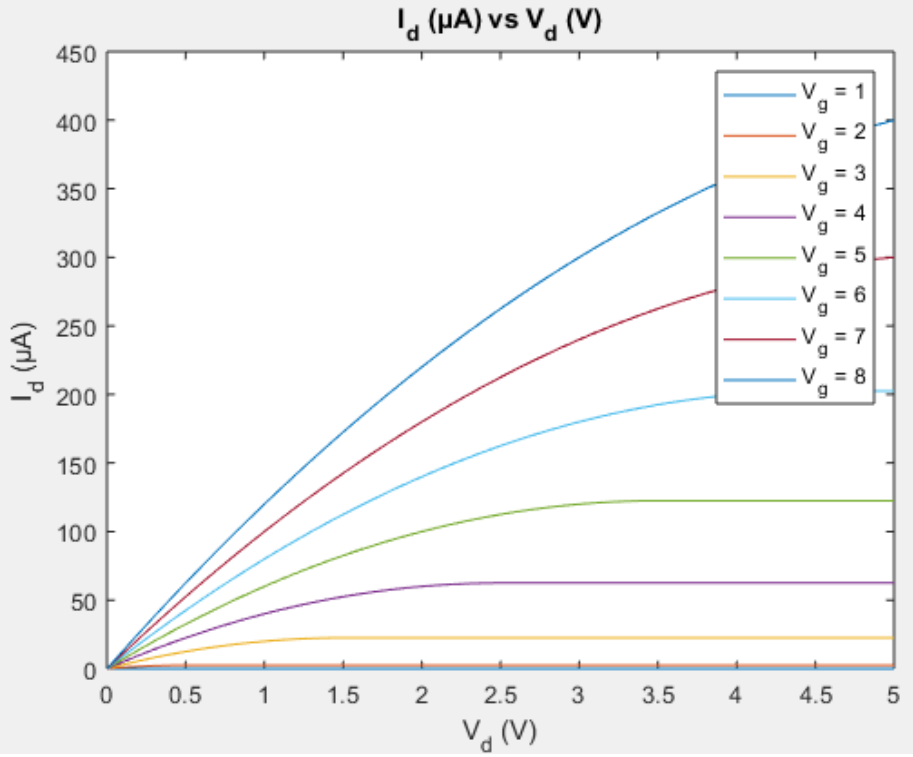
$$\gamma = \frac{V_T - V_{To}}{\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B}} = 0\sqrt{V}$$

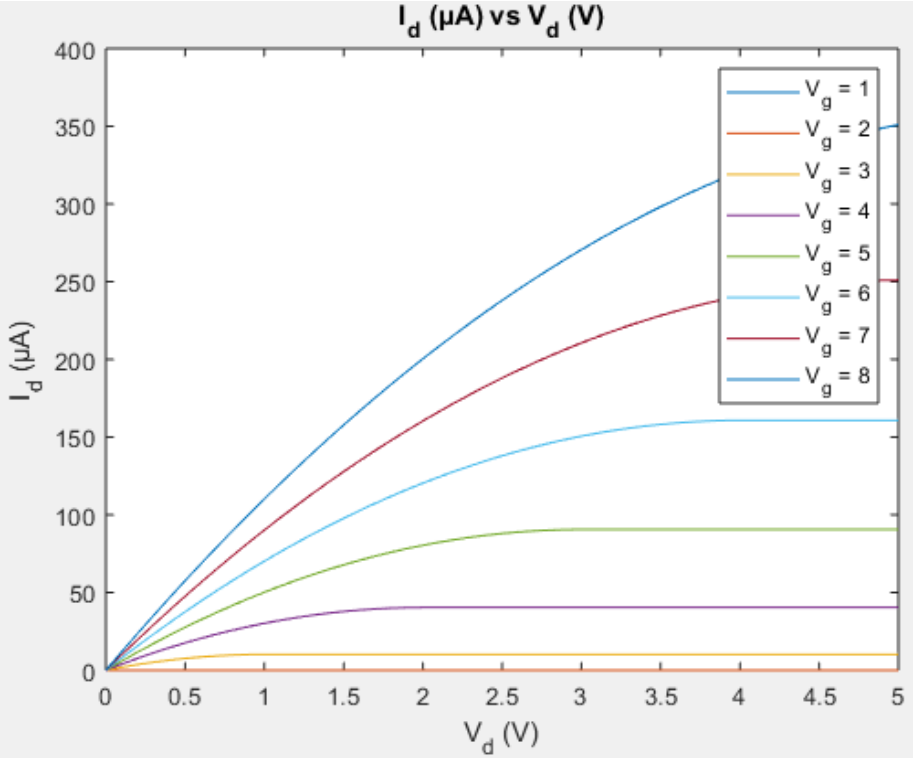
For $V_{SB} = 1\ V$

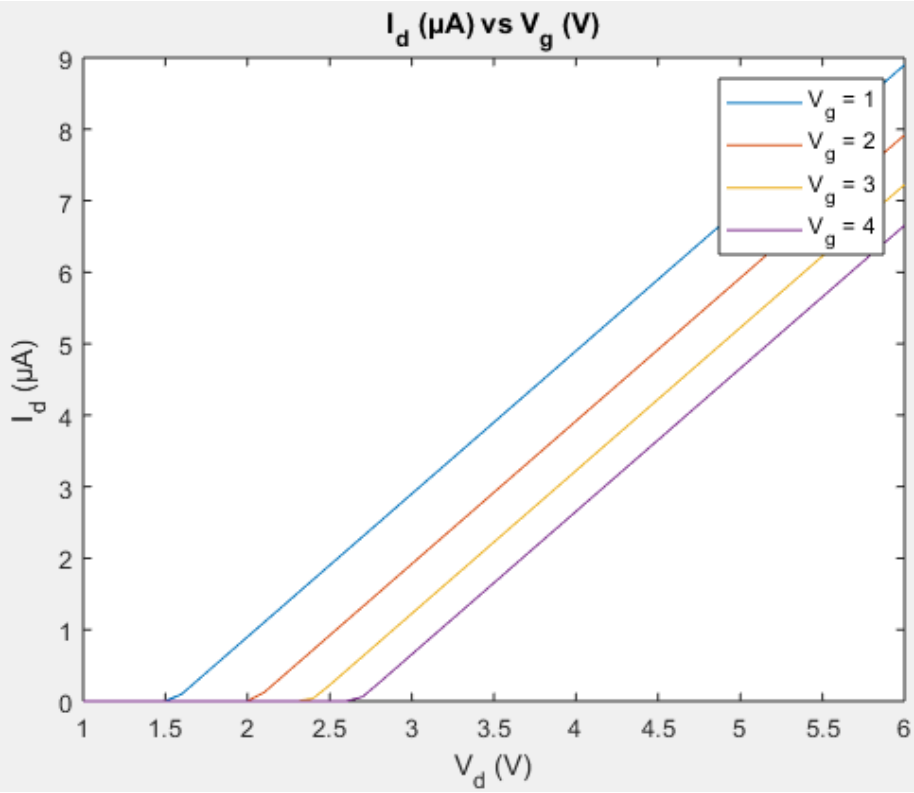
$$V_T = -\frac{-4.1 * 10^{-6}}{1.52 * 10^{-6}} = 2.70$$

$$\gamma = \frac{V_T - V_{To}}{\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B}} = \frac{2.70 - 1.73}{\sqrt{2(1) + 1} - \sqrt{2(0.6)}} = 1.52\sqrt{V}$$

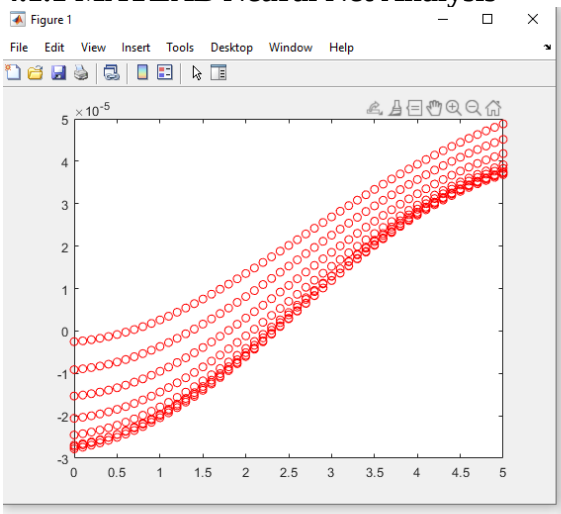
4.1 MATLAB Analysis

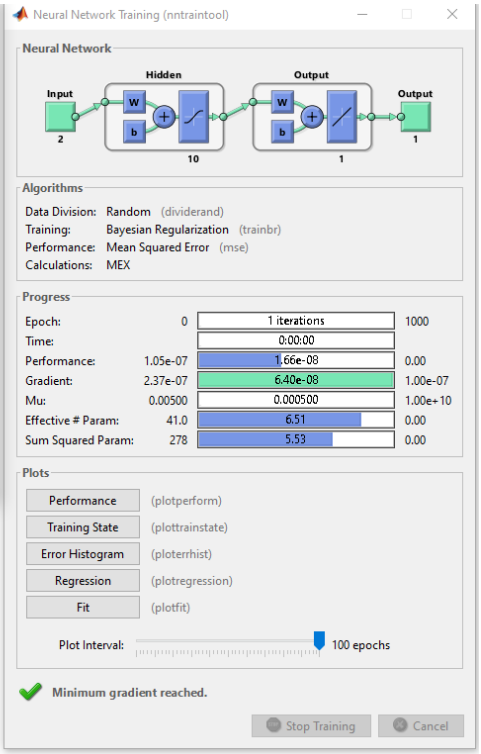


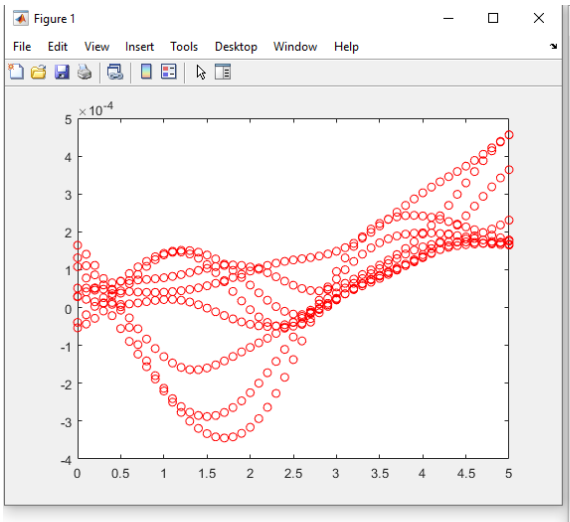

I_d (μA) vs V_d (V)
I_d (μA)
V_d (V)
V_g = 1
V_g = 2
V_g = 3
V_g = 4
V_g = 5
V_g = 6
V_g = 7
V_g = 8
0
50
100
150
200
250
300
350
400
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


I_d (μA) vs V_g (V)
I_d (μA)
V_d (V)
V_g = 1
V_g = 2
V_g = 3
V_g = 4
0
1
2
3
4
5
6
7
8
9
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

4.1.1 MATLAB Neural Net Analysis







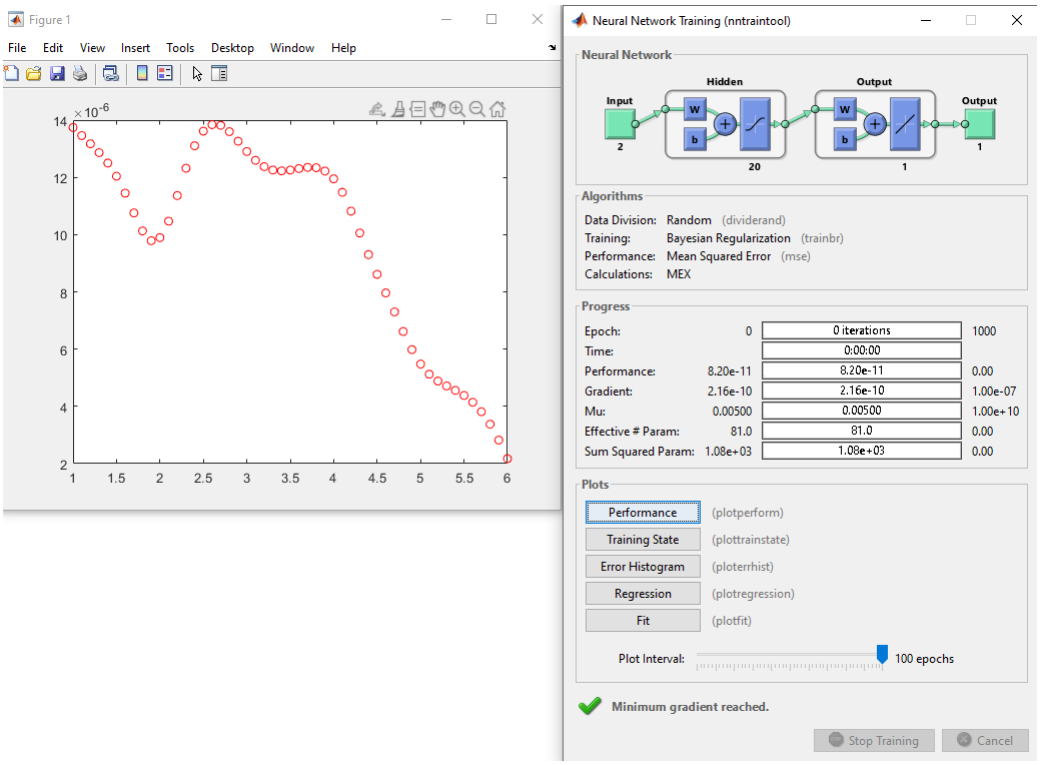


Figure 1
File Edit View Insert Tools Desktop Window Help
×10^-6
14
12
10
8
6
4
2
1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6

Neural Network Training (nntraintool)
Neural Network
Input
Hidden
Output
Output
W
b
2
20
1
1
Algorithms
Data Division: Random (dividerand)
Training: Bayesian Regularization (trainbr)
Performance: Mean Squared Error (mse)
Calculations: MEX
Progress
Epoch: 0 0 iterations 1000
Time: 0:00:00
Performance: 8.20e-11 8.20e-11 0.00
Gradient: 2.16e-10 2.16e-10 1.00e-07
Mu: 0.00500 0.00500 1.00e+10
Effective # Param: 81.0 81.0 0.00
Sum Squared Param: 1.08e+03 1.08e+03 0.00
Plots
Performance (plotperform)
Training State (plottrainstate)
Error Histogram (ploterrhist)
Regression (plotregression)
Fit (plotfit)
Plot Interval: 100 epochs
Minimum gradient reached.
Stop Training
Cancel