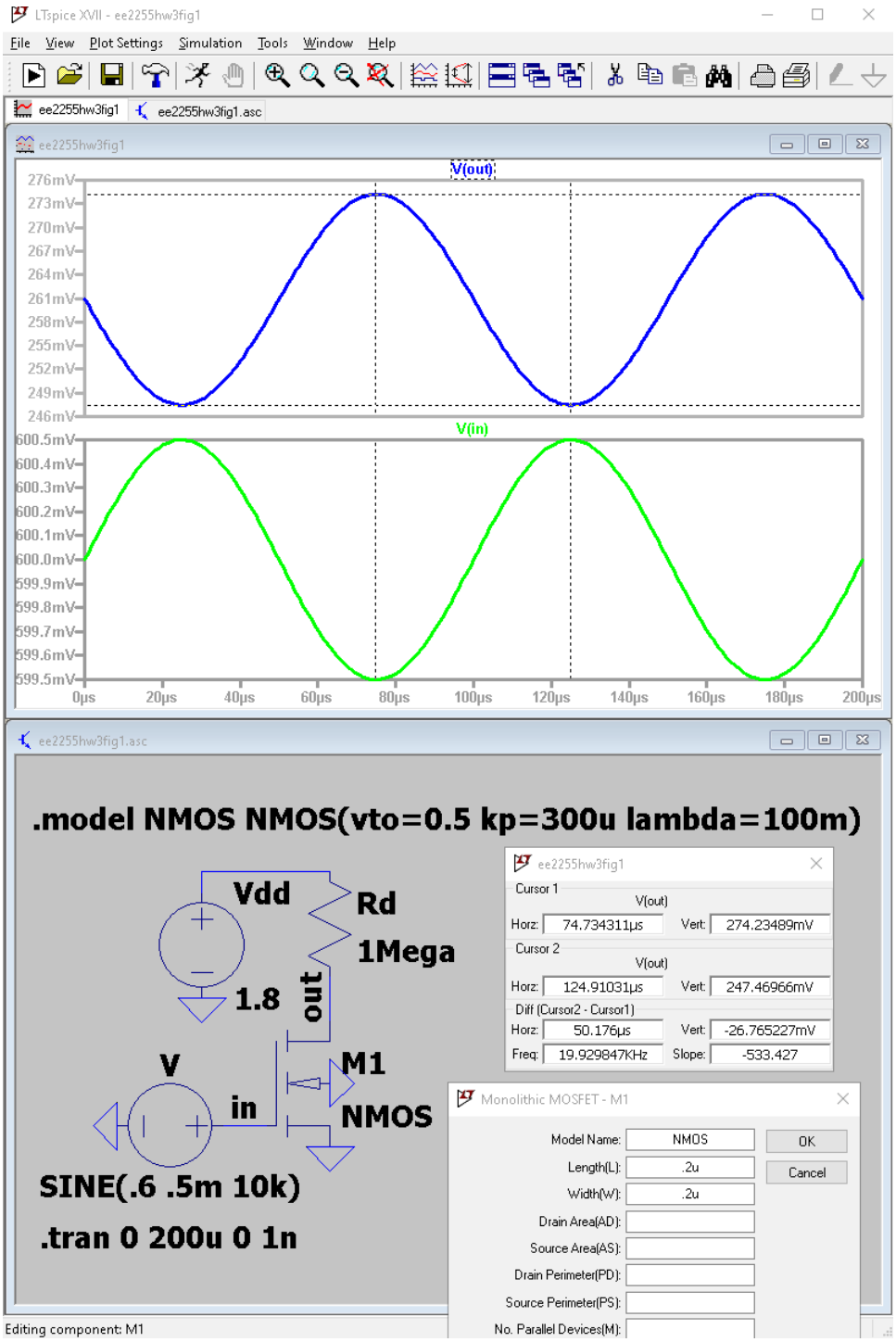
NTHU EE2255 Electronics HW3 林靖 108061112

1. (a)

W = L = 0.2 μm
Gate bias = 0.6 V
Loading resistor = 1 MΩ
Voltage gain = 26.765 > 10



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1. (b)

Vds = 0.260869 V
Vgs = 0.6 V
Vth = 0.5 V
0.260869 > 0.6 – 0.5
NMOS is in saturation region

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       --- Operating Point ---

V(n001):        1.8             voltage
V(out):         0.260869        voltage
V(in):          0.6             voltage
Id(M1):         1.53913e-006    device_current
Ig(M1):         0               device_current
Ib(M1):         -2.70869e-013   device_current
Is(M1):         -1.53913e-006   device_current
I(Rd):          1.53913e-006    device_current
I(Vdd):         -1.53913e-006   device_current
I(V):           0               device_current
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1. (c)

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2(1+\lambda V_{DS})$$

$$I_D = \frac{1}{2}\,300\cdot10^{-6}\,\frac{0.2\cdot10^{-6}}{0.2\cdot10^{-6}}\,(0.6-0.5)^2\,(1+100\cdot10^{-3}\times V_{DS}) \quad ①$$

$$V_{dd} - V_{DS} = I_D R_D$$

$$1.8 - V_{DS} = I_D\cdot 10^6 \quad ②$$

解聯立 ① ② 得 $V_{DS} = 0.26087$ V

$$r_o = \left[\frac{\partial}{\partial V_{DS}} I_D\right]^{-1}$$

$$= \left[\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2\lambda\right]^{-1}$$

$$= \left[\frac{1}{2}\,300\cdot10^{-6}\,\frac{0.2\cdot10^{-6}}{0.2\cdot10^{-6}}\,(0.6-0.5)^2\,100\cdot10^{-3}\right]^{-1}$$

$$= 6666667 \ \Omega$$

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1. (d)

$$g_m = \frac{\partial}{\partial V_{GS}} I_D$$

$$= \frac{\partial}{\partial V_{GS}} \left[\frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH})^2 (1 + \lambda V_{DS}) \right]$$

$$= \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{TH}) (1 + \lambda V_{DS})$$

$$= 300 \cdot 10^{-6} \frac{0.2 \cdot 10^{-6}}{0.2 \cdot 10^{-6}} (0.6 - 0.5)(1 + 100 \cdot 10^{-3} \times 0.26087)$$

$$= 0.000030782\,61 \quad \Omega^{-1}$$

$$A_V = -g_m (R_D \parallel r_o)$$

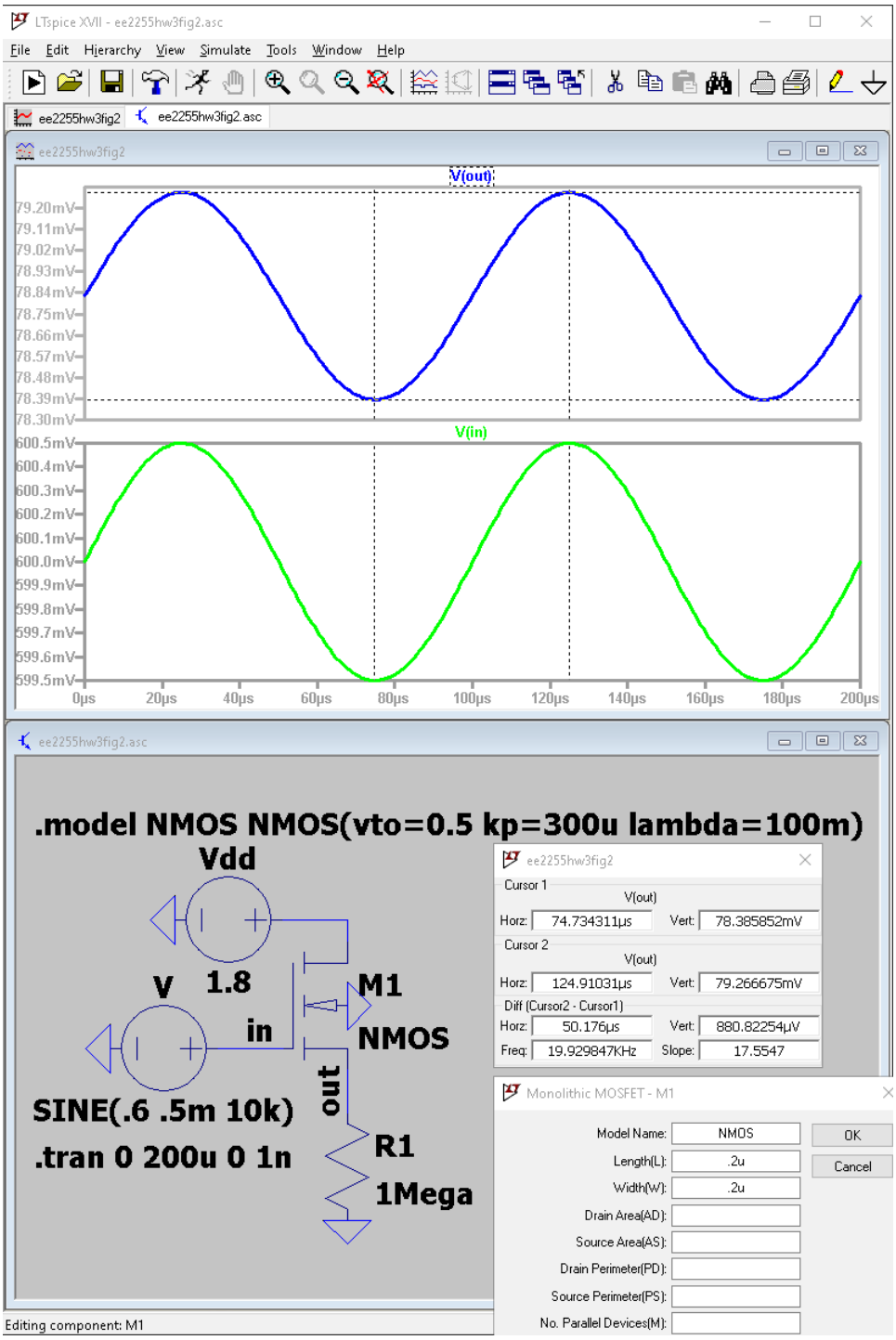
$$= -0.000030782\,61 \times \frac{10^6 \times 6666667}{10^6 + 6666667}$$

$$= -26.767$$

26.765 和 26.767 的誤差為 0.7‰
很準確

2. (a)

W = L = 0.2 μm
Gate bias = 0.6 V
Loading resistor = 1 MΩ
Voltage gain = 0.88082 > 0.8



2. (b)

Vds = 1.8 - 0.078826 = 1.721174 (V)
Vgs = 0.6 - 0.078826 = 0.521174 (V)
Vth = 0.5 V
1.721174 > 0.521174 – 0.5
NMOS is in saturation region

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       --- Operating Point ---

V(n001):        1.8             voltage
V(in):          0.6             voltage
V(out):         0.0788262       voltage
Id(M1):         7.88282e-008    device_current
Ig(M1):         0               device_current
Ib(M1):         -1.89835e-012   device_current
Is(M1):         -7.88263e-008   device_current
I(R1):          7.88262e-008    device_current
I(Vdd):         -7.88281e-008   device_current
I(V):           0               device_current
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2. (c)

$$V_{DD} = V_{DS} + V_S$$
$$1.8 = V_{DS} + V_S \quad ①$$
$$V_S = I_D \times R_S$$
$$V_S = I_D \times 10^6 \quad ②$$
$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$
$$I_D = \frac{1}{2}\,300\cdot10^{-6}\,\frac{0.2\cdot10^{-6}}{0.2\cdot10^{-6}}\,(0.6 - V_S - 0.5)^2(1 + 100\cdot10^{-3}V_{DS}) \quad ③$$

解聯立 ① ② ③ 得 $V_{DS} = 1.72117\ V$, $V_S = 0.078826\ V$

$$r_o = \left[\frac{\partial}{\partial V_{DS}} I_D\right]^{-1}$$
$$= \left[\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_G - V_S - V_{TH})^2\lambda\right]^{-1}$$
$$= \left[\frac{1}{2}\,300\cdot10^{-6}\,\frac{0.2\cdot10^{-6}}{0.2\cdot10^{-6}}\,(0.6 - 0.078826 - 0.5)^2\,100\cdot10^{-3}\right]^{-1}$$
$$= 1.48697\cdot10^8$$

2. (d)

$$g_m = \frac{\partial}{\partial V_{GS}} I_D$$

$$= \mu_n C_{ox} \frac{W}{L} (V_G - V_S - V_{TH})(1 + \lambda V_{DS})$$

$$= 300 \cdot 10^{-6} \frac{0.2 \cdot 10^{-6}}{0.2 \cdot 10^{-6}} (0.6 - 0.07882_6 - 0.5)(1 + 100 \cdot 10^{-3} \times 1.72117)$$

$$= 7.4455 \cdot 10^{-6}$$

$$A_V = \frac{R_D \parallel r_o}{g_m^{-1} + (R_D \parallel r_o)}$$

$$= \frac{\frac{10^6 \times 1.48697 \cdot 10^8}{10^6 + 1.48697 \cdot 10^8}}{(7.4455 \cdot 10^{-6})^{-1} + \frac{10^6 \times 1.48697 \cdot 10^8}{10^6 + 1.48697 \cdot 10^8}}$$

$$= 0.88089$$

0.88082 和 0.88089 的誤差為 0.8‰
很準確