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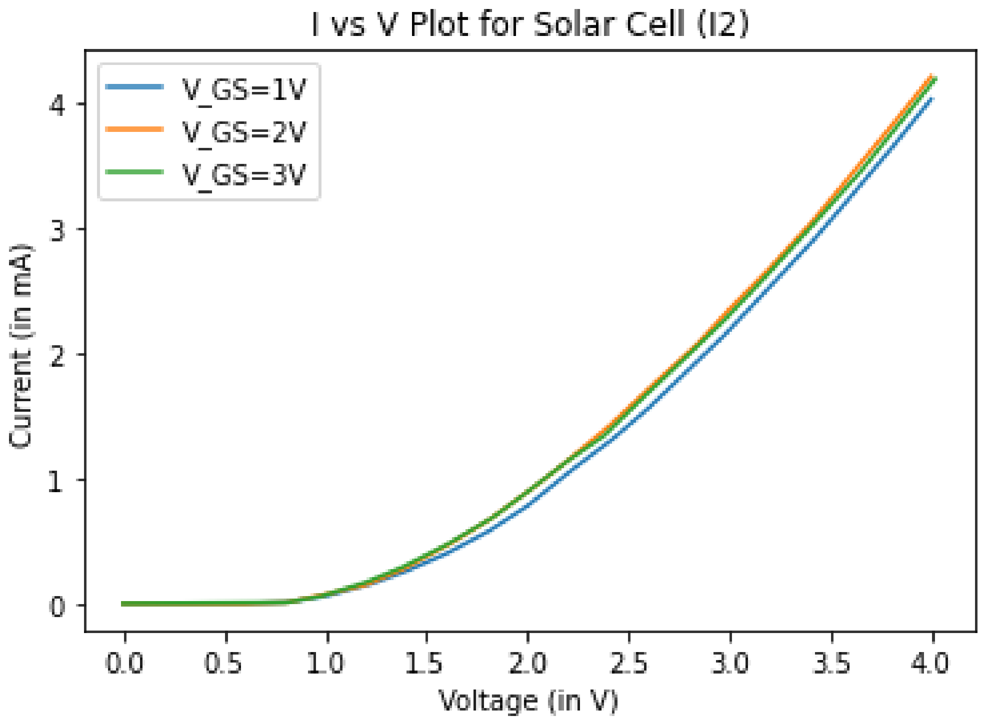
[1]:
```python
import matplotlib.pyplot as plt
import numpy as np
```

1 Q-2a

[19]:
```python
I_D_1 = [0, 0, 0, 0, 0.01, 0.06, 0.16, 0.26, 0.4, 0.58, 0.78, 1.08, 1.31, 1.56,␣
 ↪1.87, 2.15, 2.53, 2.89, 3.19, 3.65, 4.03]
V_DS_1 = [0, 0.2, 0.38, 0.6, 0.8, 1, 1.23, 1.4, 1.6, 1.81, 2, 2.23, 2.42, 2.6,␣
 ↪2.8, 2.98, 3.2, 3.41, 3.57, 3.81, 4]
I_D_2 = [0, 0, 0, 0, 0.01, 0.07, 0.15, 0.28, 0.49, 0.68, 0.94, 1.13, 1.41, 1.
 ↪76, 2.07, 2.35, 2.68, 3.05, 3.4, 3.85, 4.21]
V_DS_2 = [0, 0.21, 0.38, 0.6, 0.81, 0.99, 1.2, 1.39, 1.63, 1.82, 2.04, 2.19, 2.
 ↪4, 2.63, 2.84, 3, 3.2, 3.41, 3.59, 3.82, 4]
I_D_3 = [0, 0.01, 0.06, 0.17, 0.29, 0.47, 0.69, 0.88, 1.14, 1.34, 1.67, 1.99, 2.
 ↪27, 2.63, 3, 3.45, 3.73, 4.19]
V_DS_3 = [0, 0.81, 0.98, 1.2, 1.38, 1.6, 1.83, 1.99, 2.2, 2.38, 2.59, 2.8, 2.
 ↪98, 3.19, 3.4, 3.65, 3.79, 4.02]
```

[20]:
```python
plt.plot(V_DS_1, I_D_1)
plt.plot(V_DS_2, I_D_2)
plt.plot(V_DS_3, I_D_3)
plt.title("I_D vs V_DS Plot for varying V_GS")
plt.xlabel("Voltage (in V)")
plt.ylabel("Current (in mA)")
plt.legend(["V_GS=1V", "V_GS=2V", "V_GS=3V"])
plt.show()
```



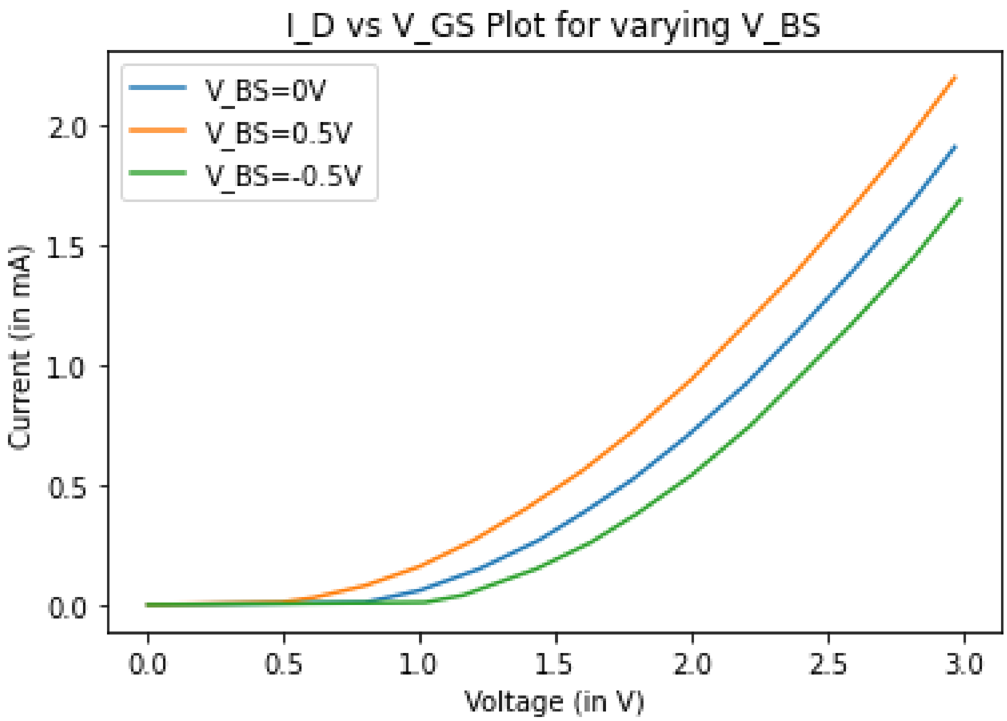
2 ro = 585.37 Ohms

3 Q-2b and Q-2c

[25]:
```
I_D_0 = [0, 0.01, 0.06, 0.15, 0.27, 0.39, 0.52, 0.7, 0.92, 1.14, 1.4, 1.69, 1.
 ↪91]
V_GS_0 = [0, 0.8, 1, 1.22, 1.44, 1.61, 1.78, 1.98, 2.2, 2.39, 2.6, 2.82, 2.97]
I_D_point5 = [0, 0.01, 0.03, 0.08, 0.16, 0.27, 0.4, 0.56, 0.72, 0.94, 1.17, 1.
 ↪38, 1.68, 1.9, 2.2]
V_GS_point5 = [0, 0.49, 0.61, 0.8, 1, 1.2, 1.39, 1.6, 1.78, 2, 2.2, 2.38, 2.61,␣
 ↪2.77, 2.97]
I_D_minuspoint5 = [0, 0.01, 0.04, 0.15, 0.26, 0.38, 0.54, 0.75, 1.01, 1.17, 1.
 ↪45, 1.69]
V_GS_minuspoint5 = [0, 1.02, 1.16, 1.43, 1.63, 1.8, 2, 2.22, 2.45, 2.59, 2.82,␣
 ↪2.99]
```

[27]:
```
plt.plot(V_GS_0, I_D_0)
plt.plot(V_GS_point5, I_D_point5)
plt.plot(V_GS_minuspoint5, I_D_minuspoint5)
plt.title("I_D vs V_GS Plot for varying V_BS")
plt.xlabel("Voltage (in V)")
plt.ylabel("Current (in mA)")
```

```
plt.legend(["V_BS=0V", "V_BS=0.5V", "V_BS=-0.5V"])
plt.show()
```



4 g_m = 0.8983 mS

5 V_T = 0.8V for V_BS = 0V

6 V_T = 0.49V for V_BS = 0.5V

7 V_T = 1.02V for V_BS = -0.5V

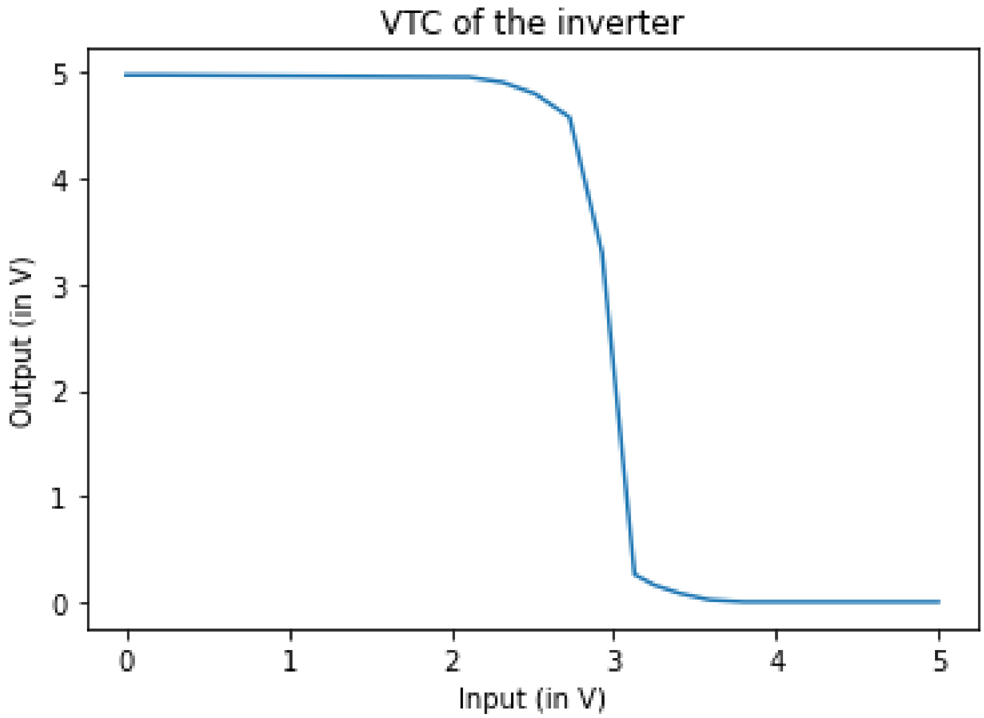
8 r_o = 585.37 Ohms

9 Q-3i

[28]:
```
Inv_in = [0, 0.2, 2.11, 2.32, 2.52, 2.73, 2.93, 3.13, 3.25, 3.41, 3.59, 3.8, 5]
Inv_out = [4.98, 4.98, 4.96, 4.91, 4.8, 4.58, 3.3, 0.26, 0.16, 0.08, 0.02, 0, 0]
```

[29]:
```
plt.plot(Inv_in, Inv_out)
plt.title("VTC of the inverter")
plt.xlabel("Input (in V)")
plt.ylabel("Output (in V)")
```

```
plt.show()
```



10 Fall Time = 500us

11 Rise Time = 400us

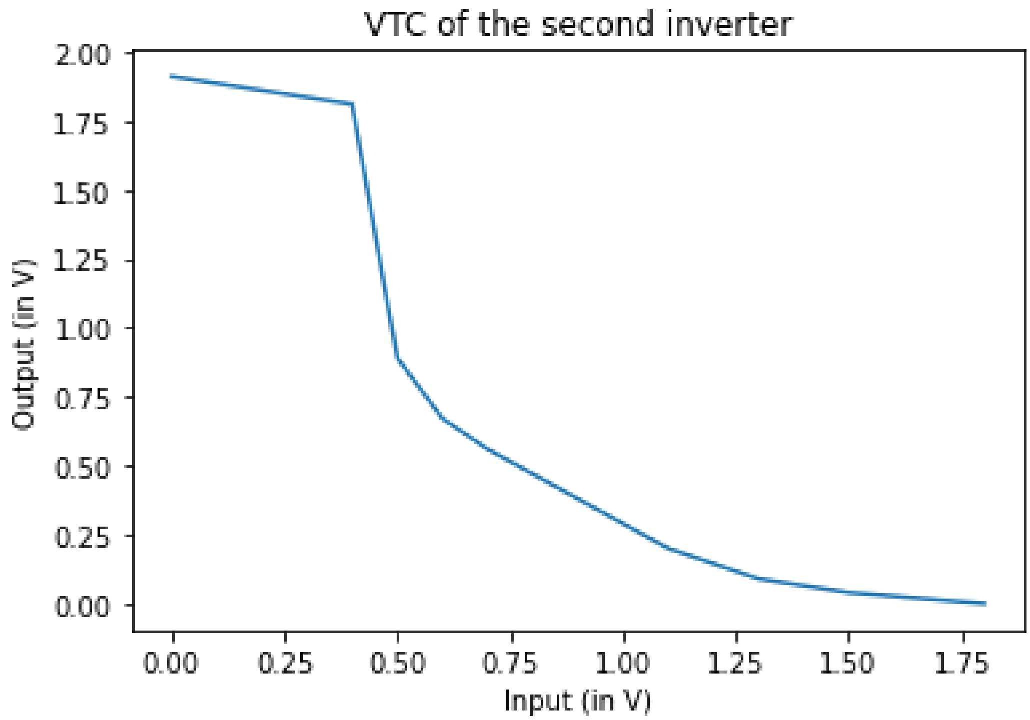
The ratio of rise and fall times is given by mu_n * W_n / mu_p * W_p Here, mu_n / mu_p = 2 So, we get W_p / W_n = 2.5

12 W_p / W_n = 2.5

13 Q-3ii

[30]:
```
Inv2_in = [0, 0.2, 0.4, 0.5, 0.6, 0.7, 0.9, 1.1, 1.3, 1.5, 1.8]
Inv2_out = [1.91, 1.86, 1.81, 0.89, 0.67, 0.56, 0.38, 0.2, 0.09, 0.04, 0]
```

[31]:
```
plt.plot(Inv2_in, Inv2_out)
plt.title("VTC of the second inverter")
plt.xlabel("Input (in V)")
plt.ylabel("Output (in V)")
plt.show()
```


VTC of the second inverter
Output (in V)
Input (in V)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75