Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering
& Architectural Science

Course Title:	Electronic circuits
Course Number:	404
Semester/Year (e.g.F2016)	W2025

Instructor:	Md Waselul Haque Sadid

Assignment/Lab Number:	1
Assignment/Lab Title:	Diodes

Submission Date:	02/01/25
Due Date:	02/02/25

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Introduction and Objective:

The purpose of this lab is to examine the *v-i* characteristic of a 1N4148 silicon diode, while also simultaneously examining and calculating the small-signal resistance r_d and behavior of the silicon diode in the forward-bias region. The circuits to be analyzed in this experiment can be seen in Figure 1.0, where figure (a) is the diode circuit without a shunt resistor, and (b) is the circuit with the shunt resistor, which is varied throughout the experiment. The measured values throughout this experiment are V_{cc}, V_D, and V_{D2}, which are the source voltage, the voltage across the diode in circuit (a), and the voltage across the diode in circuit (b) respectively.

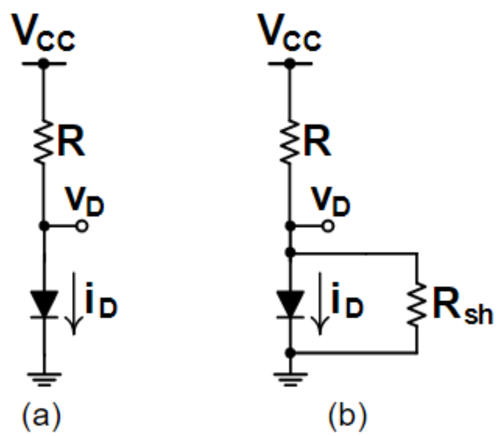


Figure 1.0 Diode circuits used in this experiment.

Experiment and results:

Table E1. Test results for the circuits of **Figure 2(a)** and **Figure 2(b)**.

$i_{D1} [mA]$	V_{CC} [V]	v_{D1} [V]	R_{sh} [kΩ]	v_{D2} [V]	Δv_D [V] $= v_{D2} - v_{D1}$	Δi_D [mA] $= -\frac{v_{D2}}{R_{sh}}$	r_d [Ω] $= \frac{\Delta v_D}{\Delta i_D} \times 1000$
10	10.799	0.729	1.5	0.726	-0.003	-0.484	6.1983
7	7.739	0.713	2.2	0.708	-0.005	-0.3218	15.537
5	5.700	0.694	2.7	0.689	-0.005	-0.2551	19.600
2	2.649	0.647	6.8	0.644	-0.003	-0.0947	31.671
1	1.620	0.614	12	0.612	-0.002	-0.0510	39.215

Table 1.0 Experiment results

Conclusions:

C1:

The graphs in P1(a) show how the voltage and current across the diode varies with time. The circuit used in this experiment is a half-wave rectifier, so it removes half of the AC voltage cycle across the diode, in this case, the positive half. The graphs also show that only the positive component of the AC current is allowed to flow through the diode, removing the negative half as can be seen In the graph. The v-i characteristic seen in graph P1(b) follows an exponential model, which is to be expected from the equation of the current across a diode, which is as follows:

$$i_D = I_S\left(e^{\left(\frac{v_D}{nV_T}\right)} - 1\right)$$

C2:

Using the equation for the current across a diode and the experiment values for 10 mA and 1 mA, the saturation current I_s and the ideality factor *n* can be calculated as follows:

$$i_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$$

$$10 = I_S\left(e^{\frac{0.729}{n25\times10^{-3}}} - 1\right) \qquad 1 = I_S\left(e^{\frac{0.614}{n25\times10^{-3}}} - 1\right)$$

$$\frac{10\times10^{-3}}{I_S} = \left(e^{\frac{0.729}{n25\times10^{-3}}} - 1\right) \qquad \frac{1\times10^{-3}}{I_S} = \left(e^{\frac{0.614}{n25\times10^{-3}}} - 1\right)$$

$$10\left(\frac{1\times10^{-3}}{I_S}\right) = \left(e^{\frac{0.729}{n25\times10^{-3}}} - 1\right)$$

$$10\left(e^{\frac{0.614}{n25\times10^{-3}}} - 1\right) = \left(e^{\frac{0.729}{n25\times10^{-3}}} - 1\right)$$

$$(0.614 - 0.729) = n\cdot 25\times10^{-3}\left(\ln\left(\tfrac{9}{10}\right) - \ln(10)\right)$$

$$n = 1.965$$

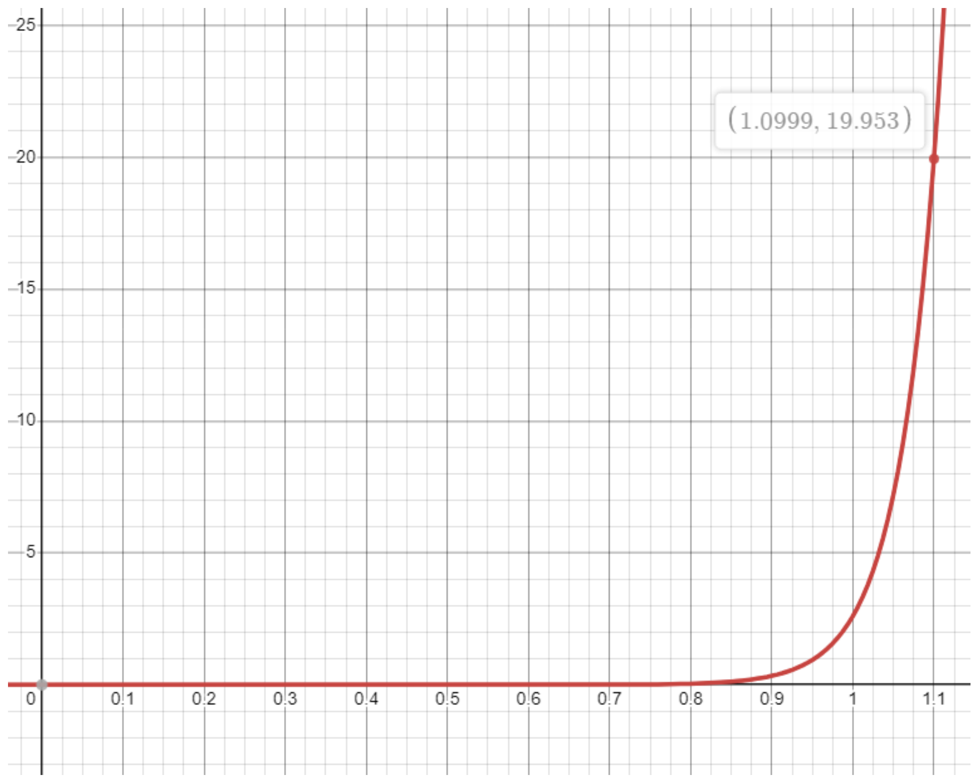
$$\frac{1\times10^{-3}}{I_S} = \left(e^{\frac{0.614}{n25\times10^{-3}}} - 1\right)$$

$$I_S = 3.769\times10^{-9}\ A$$

Which results in a final equation for the current across the diode as:

$$I_D = 3.769 \times 10^{-9}(e^{\frac{V_D}{1.965 \times 25mV}} - 1)$$

Which when plotted, gives the following:



Graph 1.0 Graph of the current across the diode.

C3:

$$e\% = \frac{theoretical\ value - measured\ value}{measured\ value} \times 100$$

Table C2. Theoretical and measured values of the small-signal resistance of the diode.

Quiescent Current, I_D [mA]	**10**	**7**	**5**	**2**	**1**
Theoretical value of r_d (from $r_d = nV_T/I_D$)	4.913	7.018	9.83	24.56	49.13
Measured value of r_d (Table E1)	3.08	8.39	5.08	17.89	47.059
Percent error, $e\%$	59.51	16.35	93.50	37.28	4.40

C4:

From question C2, we find the value of $n = 1.965$. The diode voltage increases by 60n mV for every decade. Therefore using this theory both V_{D1} and V_{D2} should increase 0.1179V in a decade.

Vd1 = 0.729 - 0.614 = 0.115

Vd2 = 0.726 - 0.612 = 0.114

For both V_{D1} and V_{D2} the percent error is below 5%. This makes the statement that the Diode voltage increases by about 60n mV per one decade true.

Department of Electrical, Computer, & Biomedical Engineering
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Ryerson University

Course Title:	Electronic Circuits 1
Course Number:	ELE404
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Instructor:	Md Waselul Haque Sadid

Assignment/Lab Number:	Pre-Lab #1
Assignment/Lab Title:	Diodes Pre-Lab

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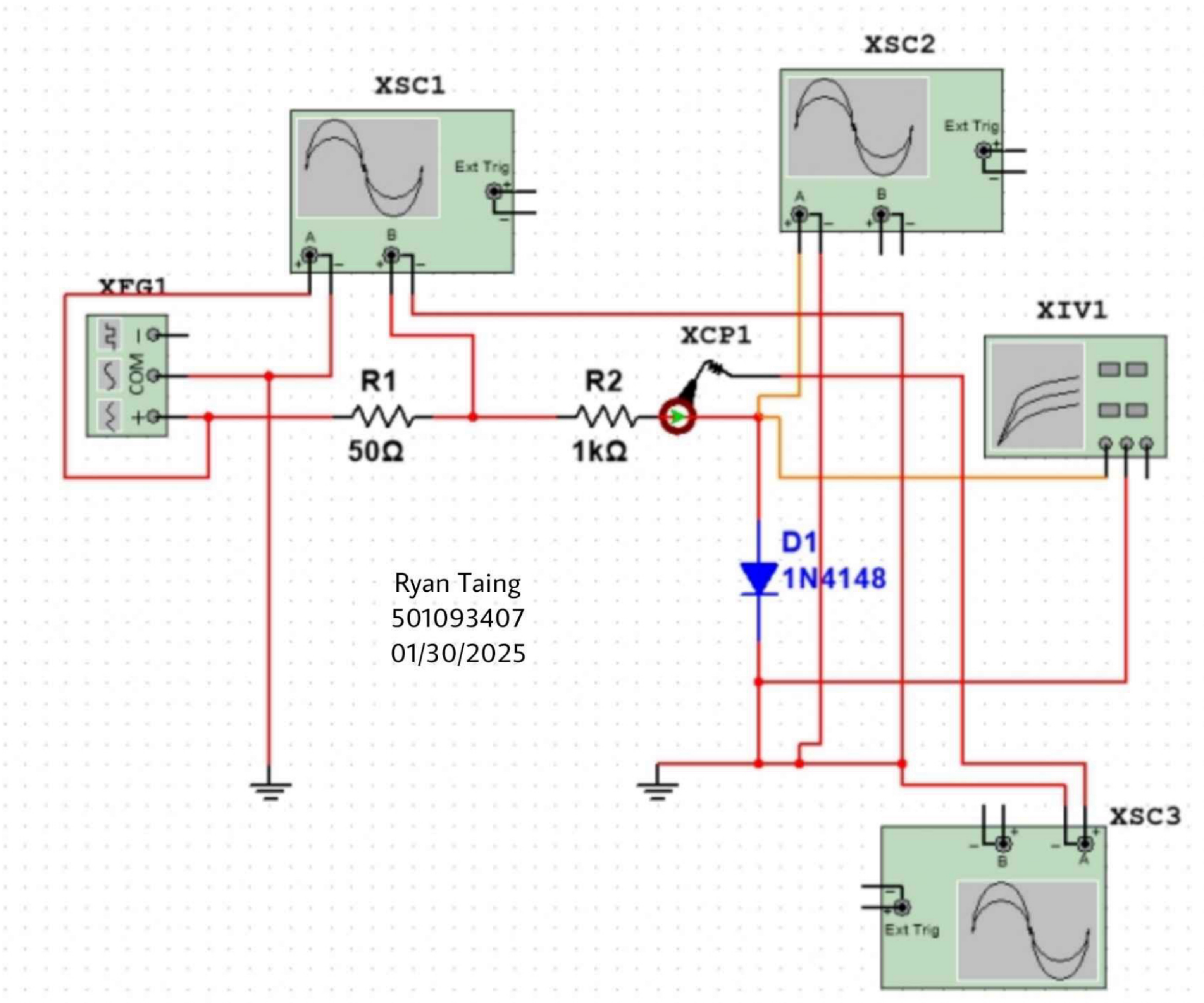
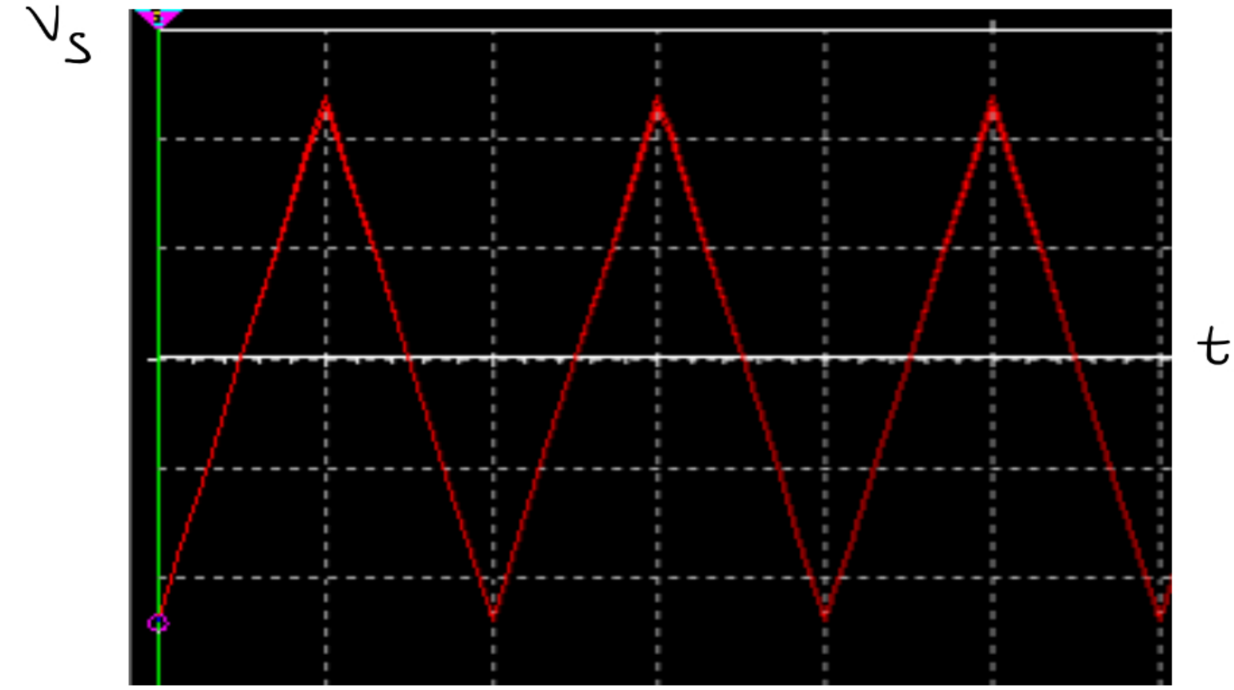
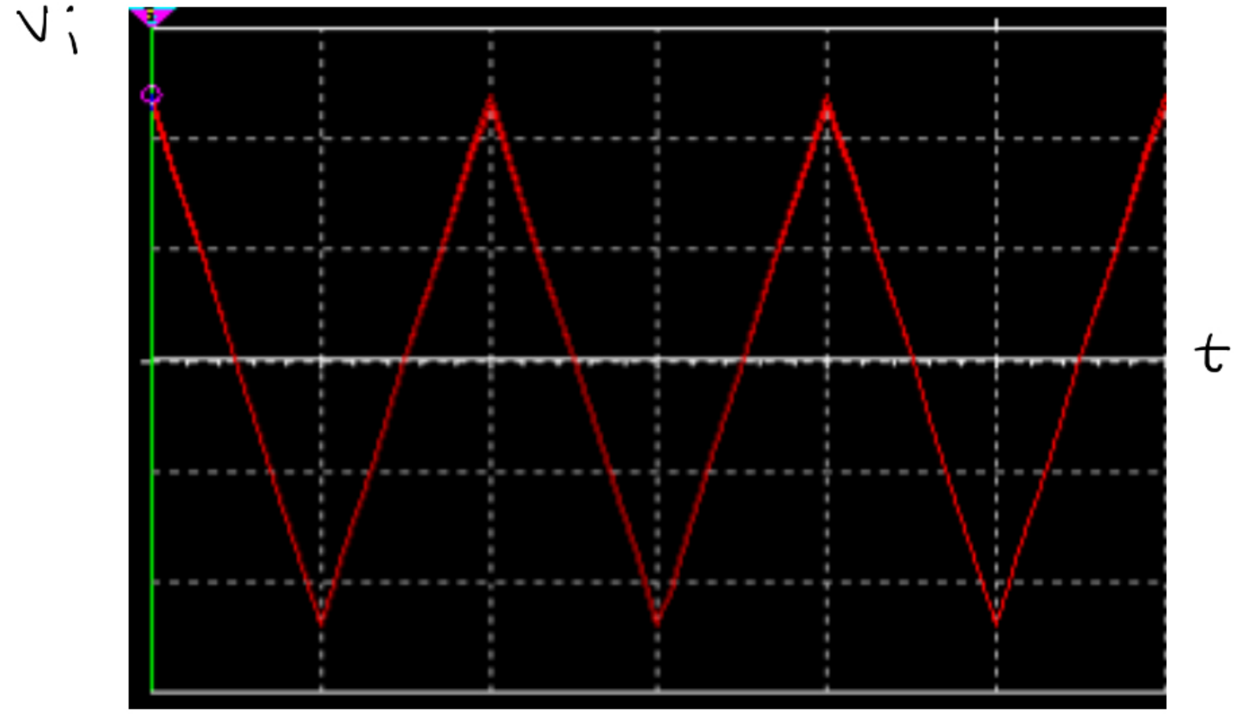
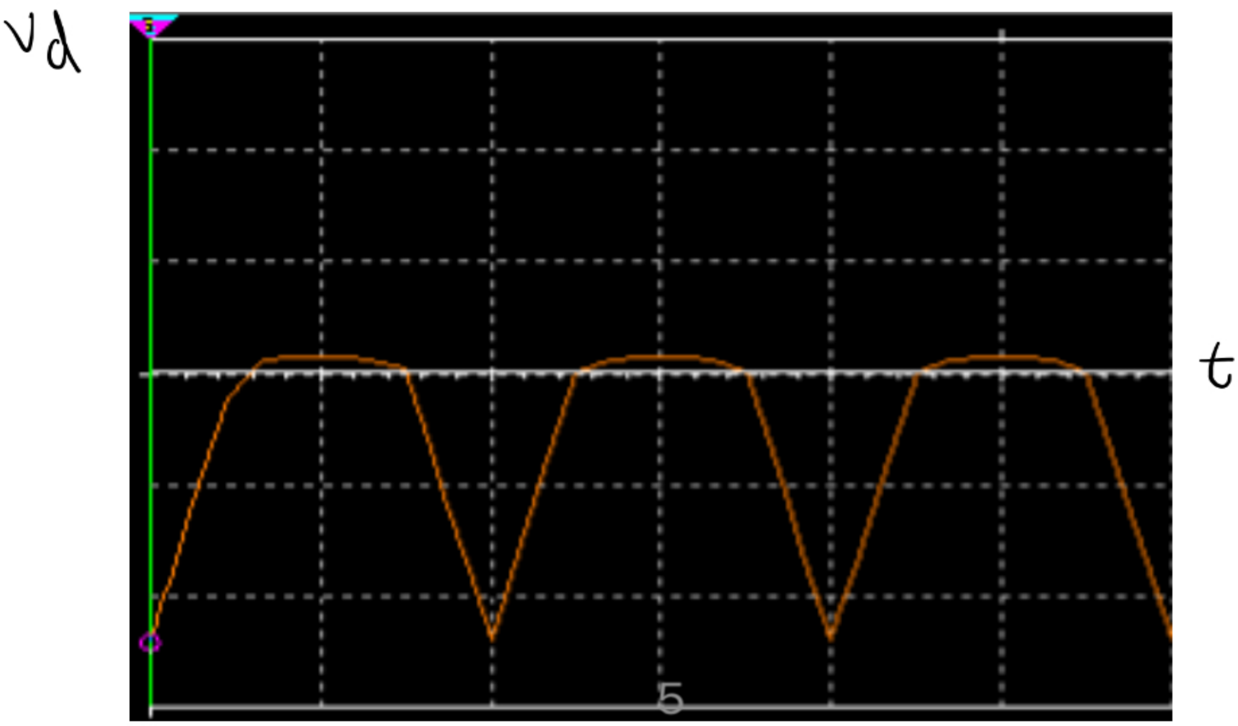
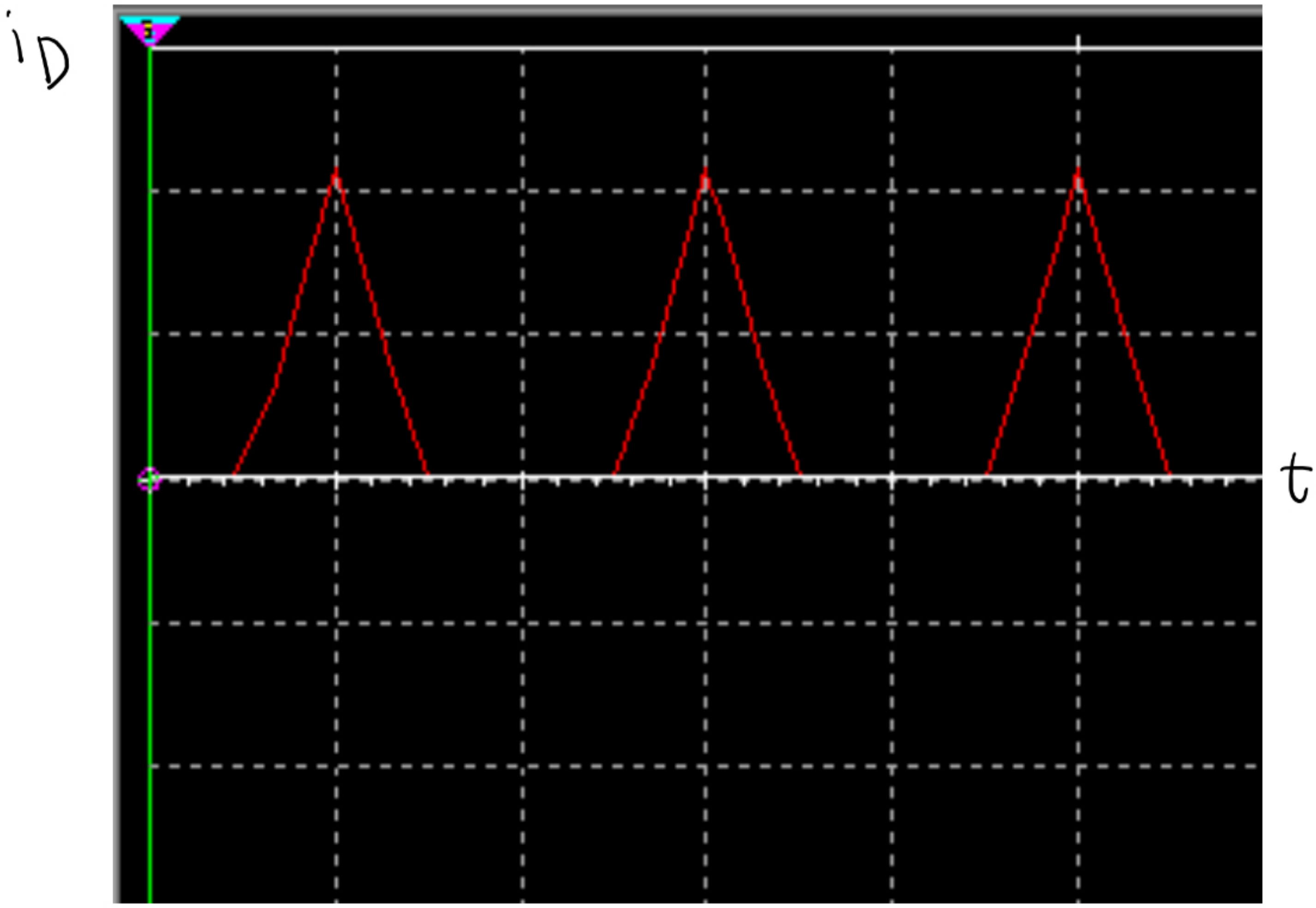


Figure 1: A voltage source driving through a series resistance.

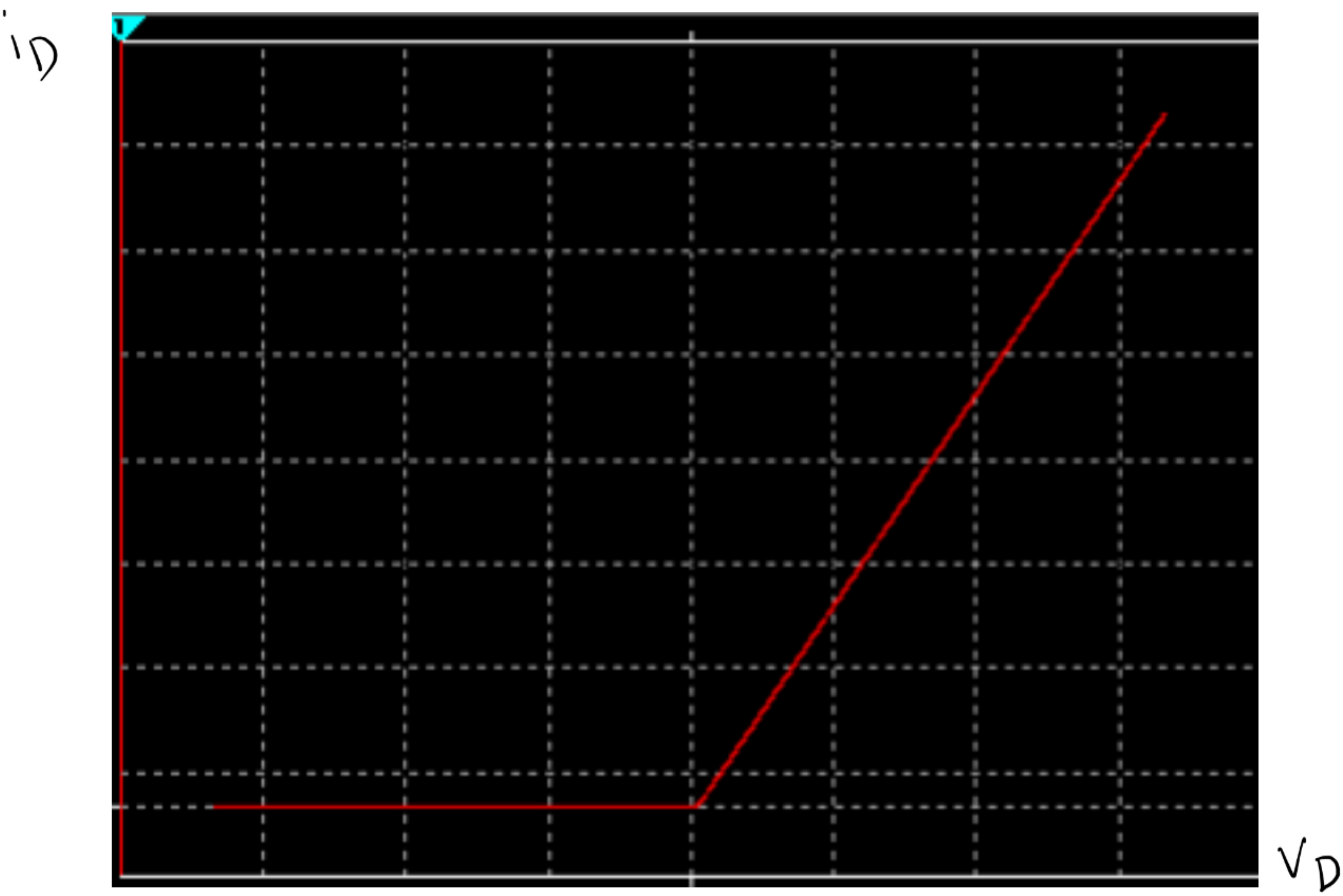

v_s
t


v_i
t


v_d
t



Graph P1(a). Simulated waveforms for Vs, Vi, Vd and iD of the circuit of Figure 1.



Graph P1(b). Voltage-current characteristics of the diode.