School of Electrical & Electronic Engineering

EE2002 Analog Electronics

Academic Year 2021-2022

L2002B

Diode Rectifier Circuits

Project Laboratory (S2-B4a-01/02)

Dress Code in the Laboratory

- Work shirt that covers the upper torso and arms.
- Lower body clothing that covers the entire leg.
- Closed-toe shoes that cover the top of the foot.

Last revision: 06 Aug 2021

Laboratory Manual

1. OBJECTIVE

The objective of this experiment is for you to become familiar with the operating principle of a diode and its applications. By connecting the circuits given in this laboratory manual, you will measure and observe:

a) The voltage waveforms of half-wave and full-wave rectifier circuits;
b) The use of capacitor to provide smoother DC voltage waveforms;
c) The effects of load resistance and filter capacitance on the rectified voltage waveforms;
d) The use of the diode in clipper circuits; and
e) The diode's *i-v* characteristics.

2. EQUIPMENT AND COMPONENTS

a)	Oscilloscope (OSC)		
b)	Digital Multimeter (DMM)		
c)	Function Generator		
d)	DC Power Supply		
e)	Soldering iron (use for heating up diode)		
f)	Breadboard		
g)	Mains Transformer 240V/12V	1 unit	12Vrms, 12VA
h)	Rectifier diodes*	4 units	1N4001
i)	Electrolytic Capacitors*	2 units	47μF, 50V
		1 unit	10μF, 50V
j)	Resistors	3 units	10kΩ, 1/4 W 5%
		2 units	560Ω, 1/2 W 5%
		1 unit	47Ω, 7W 5%

***Take note of the polarity**

Important notes:

1. **Always switch off the mains supply to the transformer when you are connecting the circuit.**
2. **Record the time and voltage scales of all the waveforms obtained from the oscilloscope.**

3. EXPERIMENT

3.1 Rectifier Circuits

3.1.1 Half-wave rectifier circuit (Suggested Time: 30 mins)

a) Connect the half-wave rectifier circuit as shown in Figure 1. Use CH1 and CH2 of the oscilloscope to observe the voltage waveforms across the transformer secondary and the resistor R1, respectively. Sketch the voltage waveforms in Graph 1. Record key voltage values.

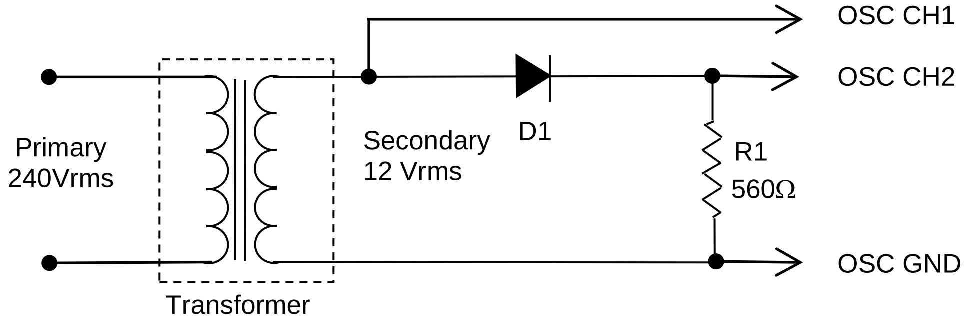
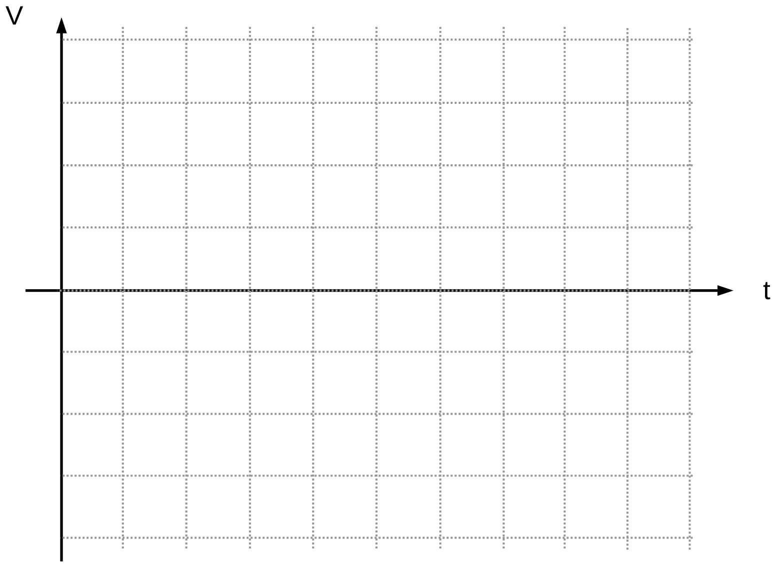
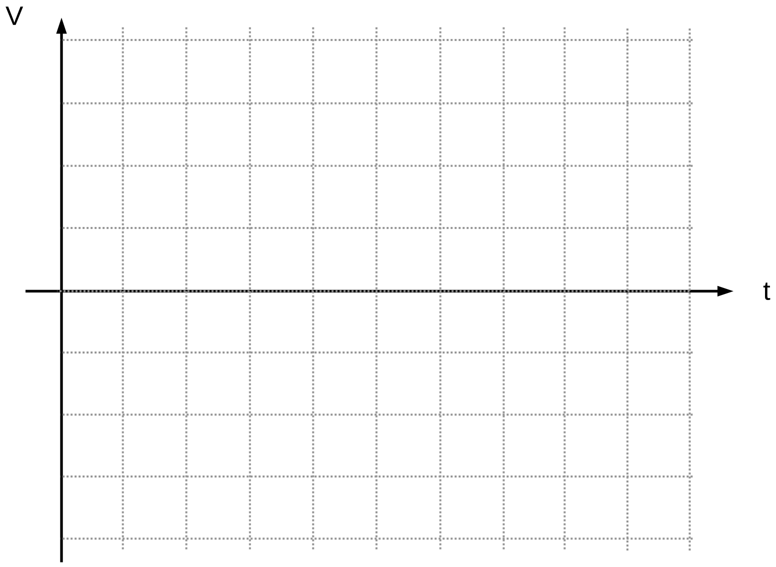


Figure 1 Half-wave rectifier



Graph 1 Waveforms across transformer secondary and across R1

b) From the voltage waveforms obtained in procedure a) above, use the oscilloscope's **Math Function: CH1 minus CH2** to obtain the voltage waveform across diode D1. Sketch the waveform in Graph 2 and state the Peak Inverse Voltage (PIV) across the diode. **(Note: PIV is the maximum negative voltage across the diode)**



Graph 2 Waveform across D1

c) Add a 47 μF capacitor (C1) **(please take note of the polarity of the electrolytic capacitor)** to the rectifier circuit as shown in Figure 2. Repeat procedures a) and b) above and sketch the voltage waveforms in Graphs 3 and 4, respectively. What is the PIV across diode D1?

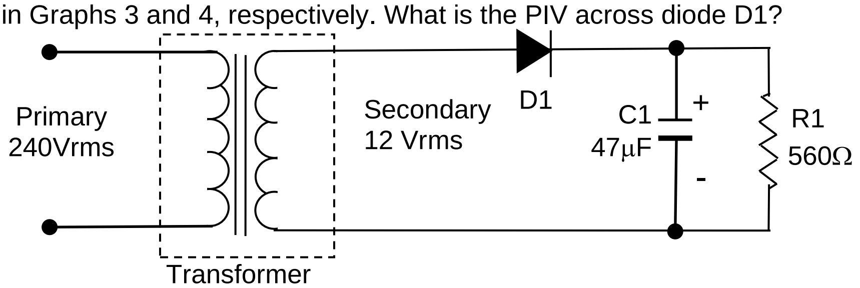
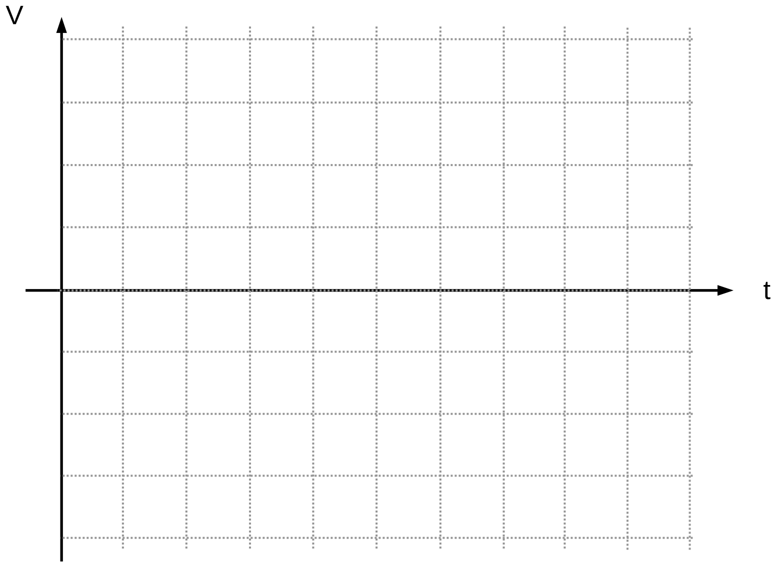
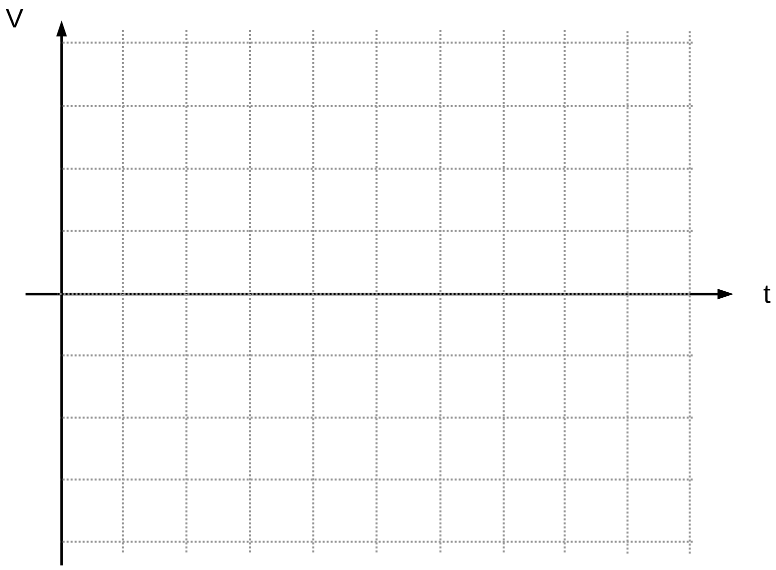


Figure 2 Half-wave rectifier with capacitor



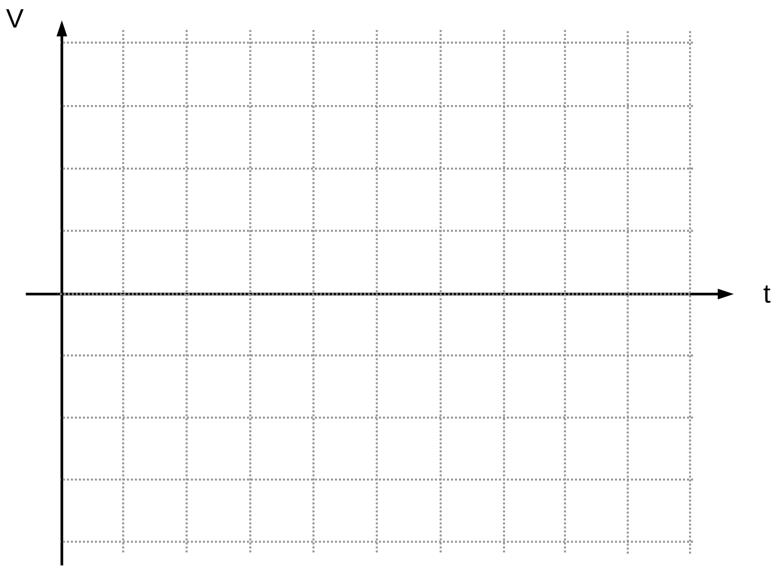
Graph 3 Waveforms across transformer secondary and across R1 (one 47μF capacitor added)



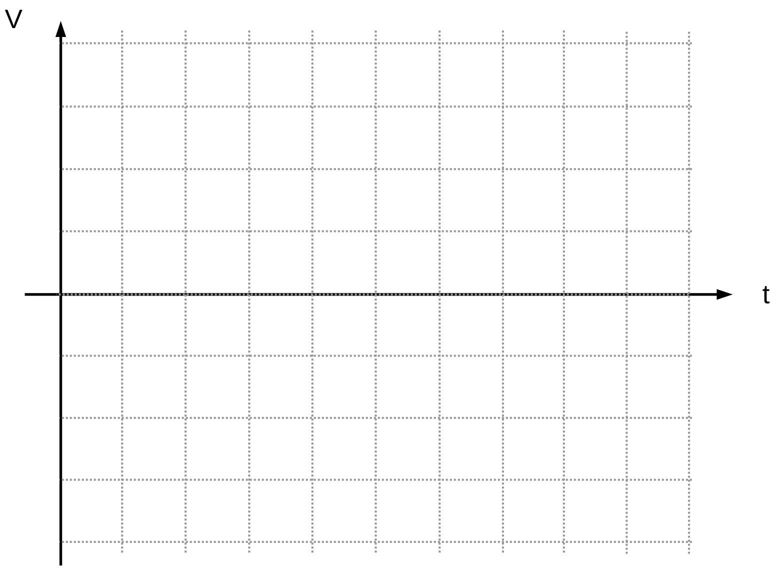
Graph 4 Waveform across D1 (one 47 μF capacitor added)

d) Add another 47 μF capacitor in parallel with C1. Repeat procedure a) above and sketch the voltage waveform across R1 in Graph 5.

e) Add another 560 Ω resistor in parallel to R1. Repeat procedure a) above and sketch the voltage waveform across R1 in Graph 6.



Graph 5 Waveform across R1 (two 47 μF capacitors added)



Graph 6 Waveform across R1 (two 47 μF capacitors and one 560 Ω resistor added)

Questions:

1. Is the PIV of the diode higher or lower after adding the capacitor in the rectifier circuit? Explain why the change in PIV of the diode.

2. What are the effects of load resistance and filter capacitance value on the smoothness of the rectified voltage?

3.1.2 Full-wave rectifier circuits (Suggested Time: 50 mins)

a) Connect the full-wave rectifier circuit as shown in Figure 3.

b) Use CH1 of the oscilloscope to measure the voltage waveform at point A with respect to point C (this is the voltage waveform across the transformer secondary). Sketch the waveform in Graph 7.

c) Use CH1 of the oscilloscope to measure the voltage waveform at point B with respect to point C and use CH2 of the oscilloscope to measure the voltage waveform at point D with respect to point C. Apply the oscilloscope's **Math Function: CH1 minus CH2** to obtain the voltage waveform across the resistor R1. Sketch the waveform in Graph 7.

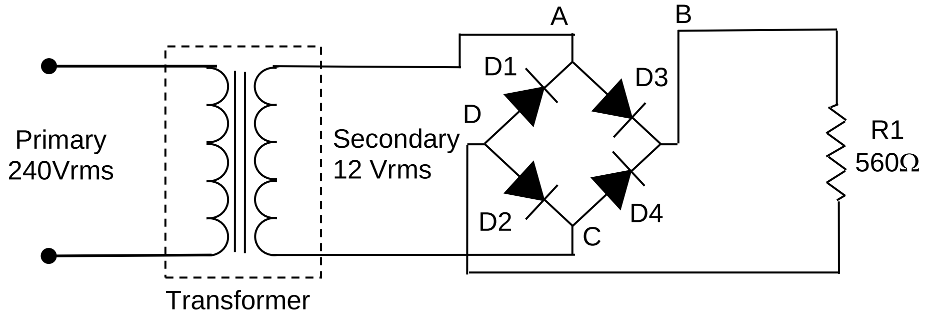
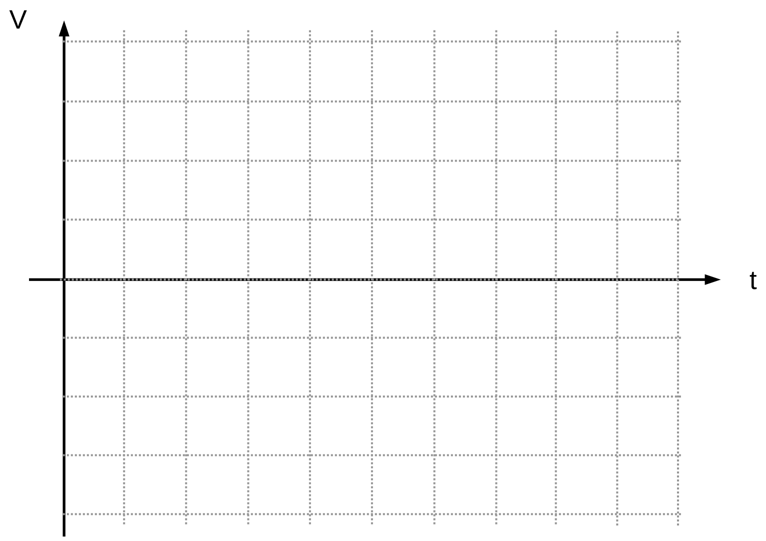
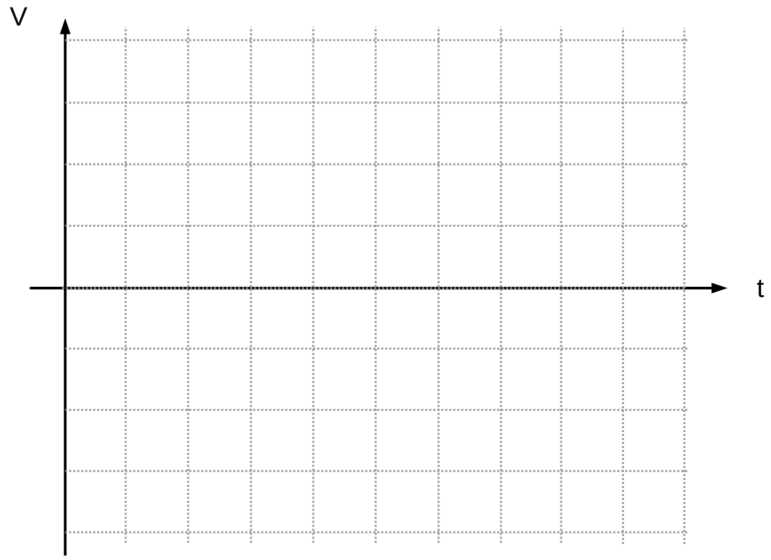


Figure 3 Full-wave rectifier circuit without capacitor



Graph 7 Waveforms across the transformer secondary and across R1

d) Use CH1 of the oscilloscope to measure the voltage waveform at point D with respect to point C (this is the voltage waveform across the diode D2). Sketch the waveform in Graph 8. State the Peak-Inverse Voltage (PIV) across diode D2.



Graph 8 Waveform across diode D2

e) Add a 47 μF capacitor (C1) **(please take note of the polarity of the electrolytic capacitor)** to the rectifier circuit as shown in Figure 4. Repeat procedure c) above and sketch the voltage waveform across resistor R1 in Graph 9.

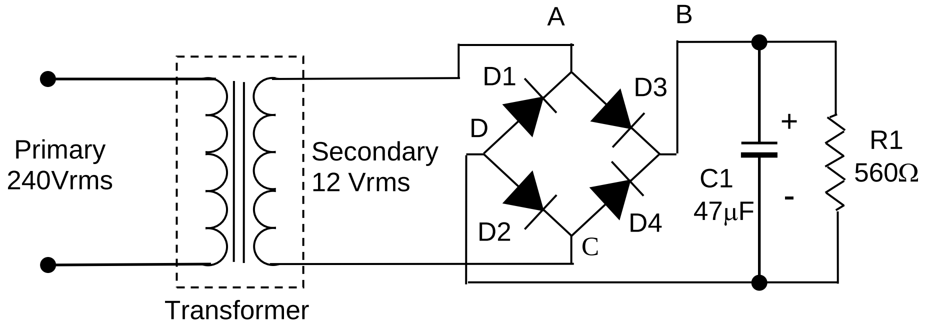
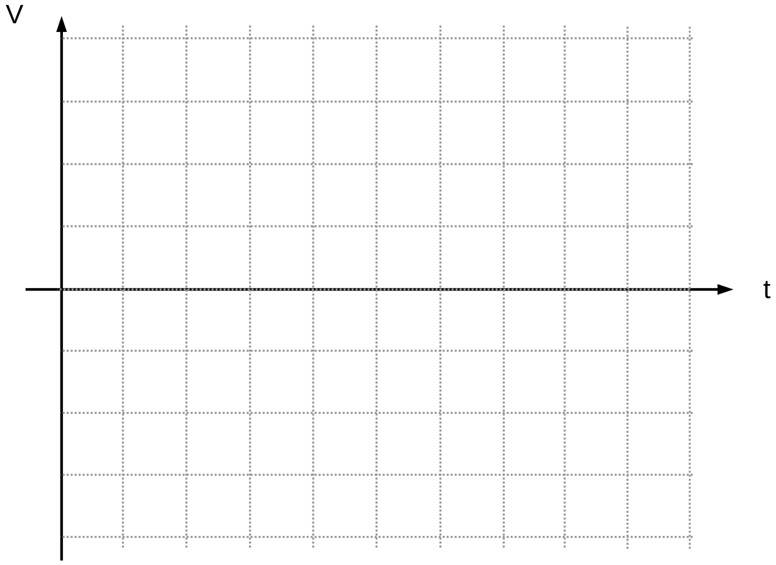
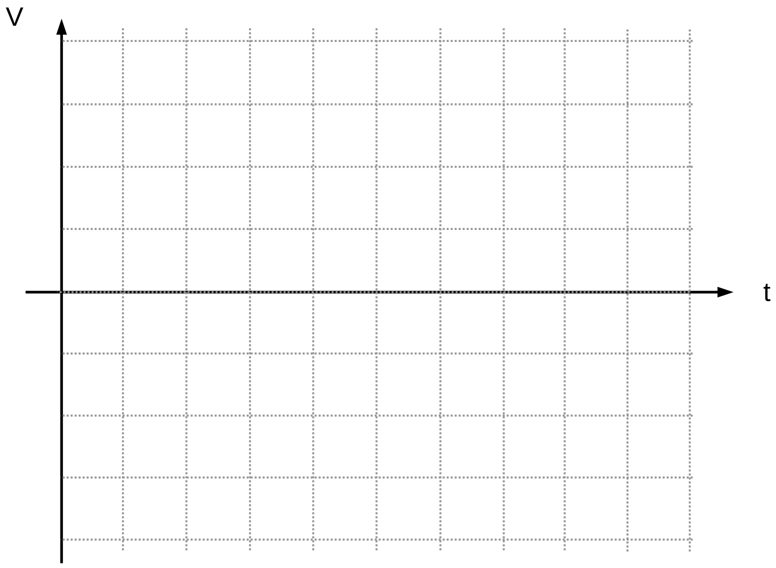


Figure 4 Full-wave rectifier circuit with capacitor



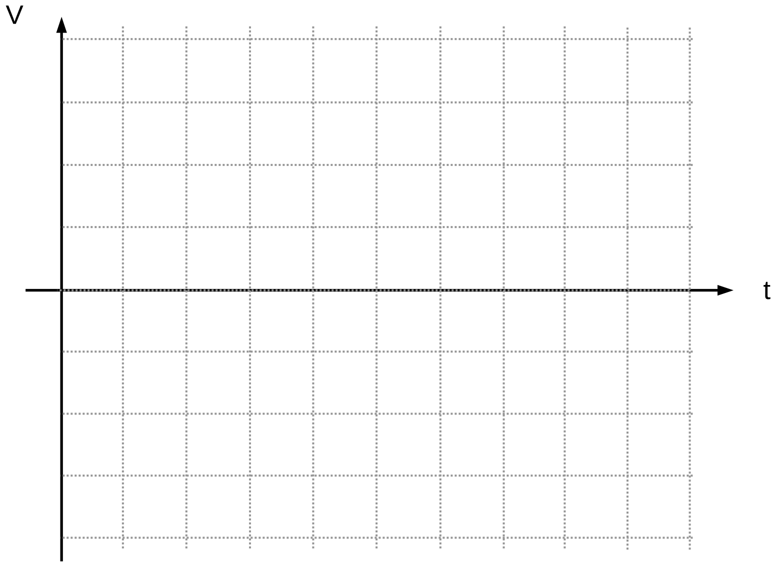
Graph 9 Waveform across R1 (one 47 μF capacitor added)

f) Repeat procedure d) above and sketch the voltage waveform across diode D2 in Graph 10. State the Peak-Inverse Voltage (PIV) across diode D2.



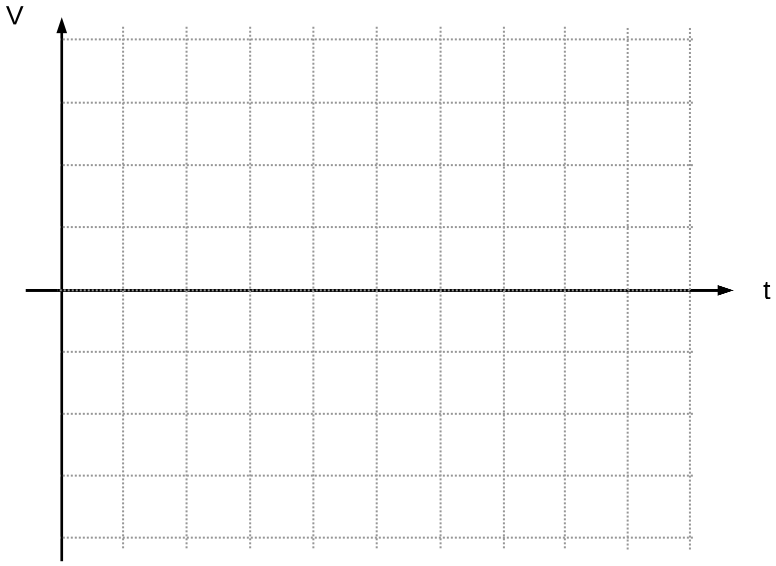
Graph 10 Waveform across diode D2 (one 47 μF capacitor added)

g) Add another 47 μF capacitor in parallel with C1. Observe the voltage waveform across R1 using procedure c) above and sketch it in Graph 11.



Graph 11 Waveform across R1 (two 47 μF capacitors added)

h) Add another 560 Ω resistor in parallel with R1. Observe the voltage waveform across R1 using procedure c) above and sketch it in Graph 12.



Graph 12 Waveform across R1 (two 47 μF capacitors and one 560 Ω resistor added)

Questions:

1. Compare the output voltage waveforms (across resistor R1) with those obtained for half-wave rectifier circuit. Give your observations and comments.

2. For the same R-C components, why there is a difference in the output ripple voltage of the full-wave rectifier circuit as compared to that of half-wave rectifier circuit?

3.2 **Diode clipper circuits** (Suggested Time: 15 mins)

3.2.1 Diode clipper

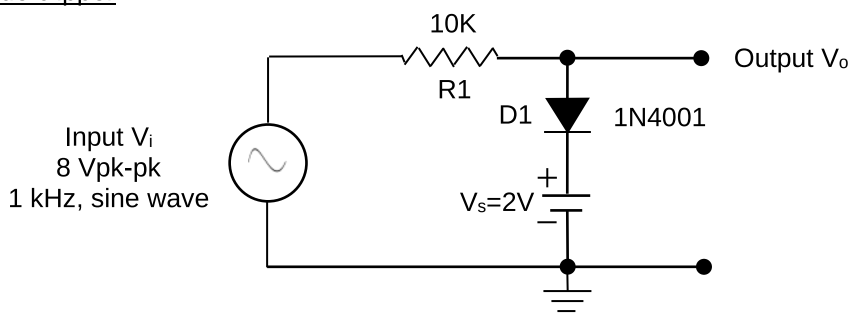


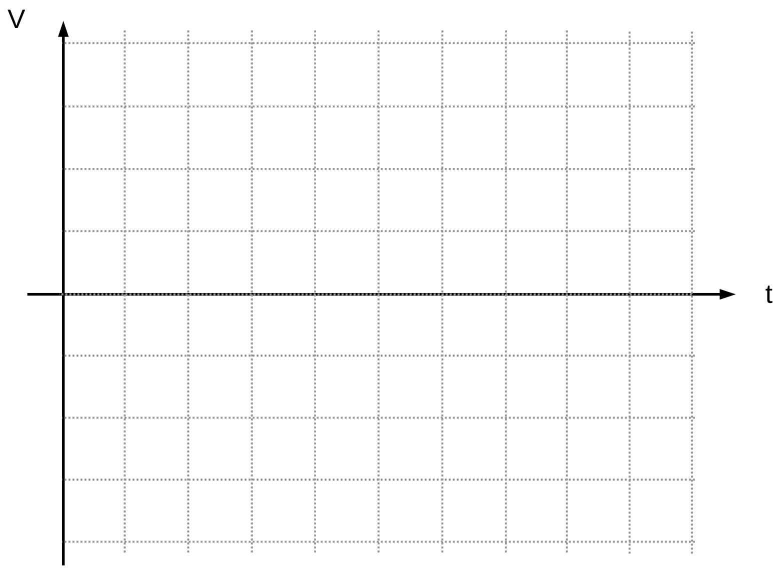
Figure 5 Diode clipper circuit

a) Connect the circuit as shown in Figure 5. The input signal is obtained from the function generator and the DC voltage (Vs = +2V) is obtained from the DC power supply. **Note: the common terminal of function generator and the negative terminal of the DC power supply are connected together as the circuit ground.**

b) Set the function generator to provide an input signal V_i with 1 kHz, 8 V peak-to-peak sine wave.

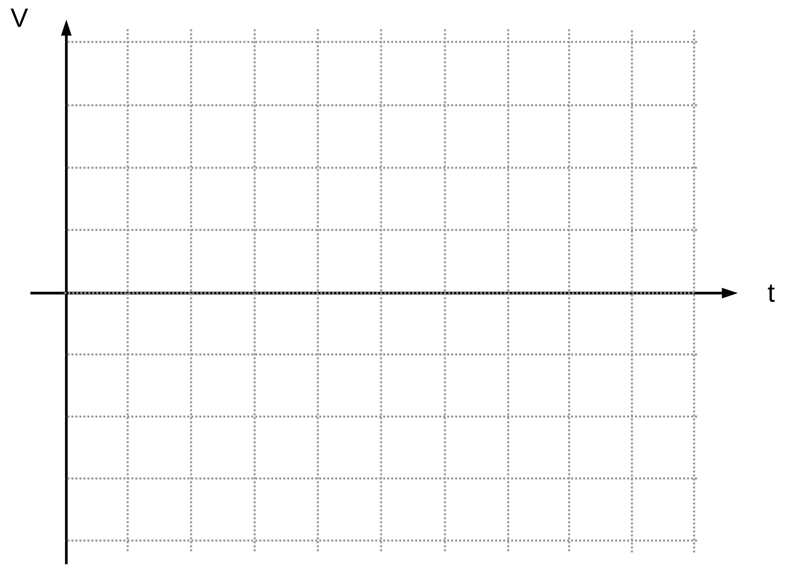
c) Use CH1 to measure the input signal V_i and CH2 to measure the output signal Vo. Set both CH1 and CH2 to **DC** coupling on the oscilloscope.

d) Observe and sketch both the input and output voltage waveforms in Graph 13. Record key voltage values.



Graph 13 Input and output waveforms (Vs = +2V)

e) Change Vs to -2V by interchanging the positive and negative terminals of the DC power supply **(Note: the common terminal of the function generator is now connected to the positive terminal of the DC power supply as the circuit ground).** Repeat procedure c) above and sketch the input and output voltage waveforms in Graph 14. Record key voltage values.



Graph 14 Input and output waveforms(Vs = -2V)

3.2.2 Diode clipper with voltage divider (Suggested Time: 15 mins)

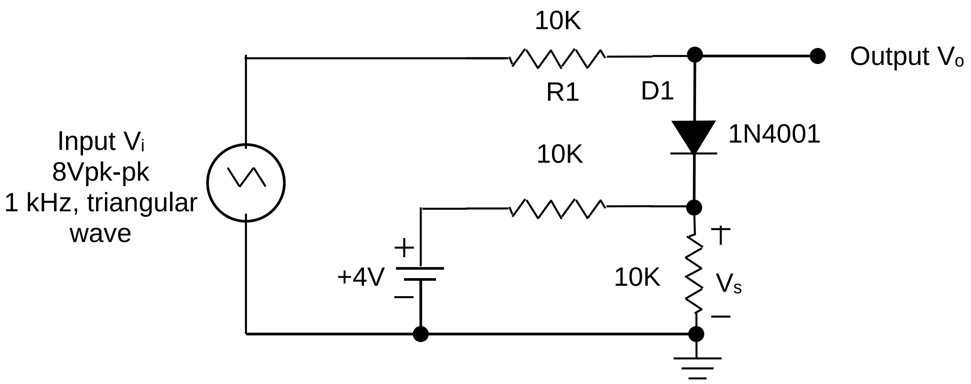


Figure 6 Diode clipper circuit with voltage divider

a) Connect the circuit as shown in Figure 6.
b) Set the function generator to provide an input signal with 1 kHz, 8V peak-to-peak triangular wave.
c) Use CH1 to measure Vi and CH2 to measure Vo. Set both CH1 and CH2 to DC coupling on the oscilloscope.
d) Sketch the voltage waveforms of Vi and Vo in Graph 15. Record key voltage values.

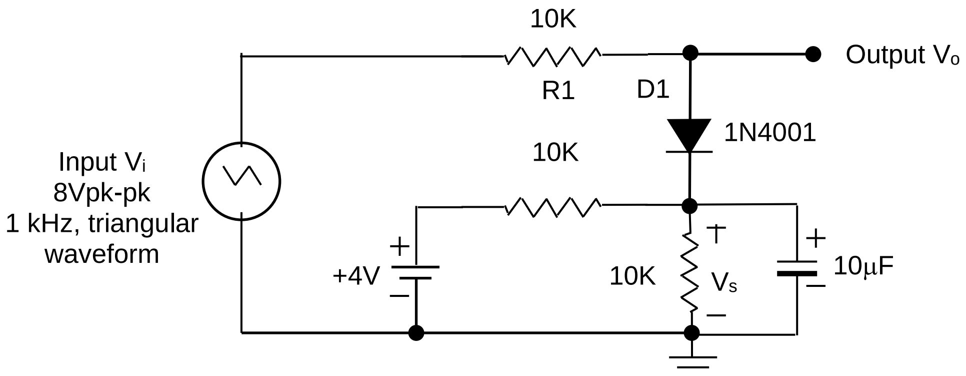
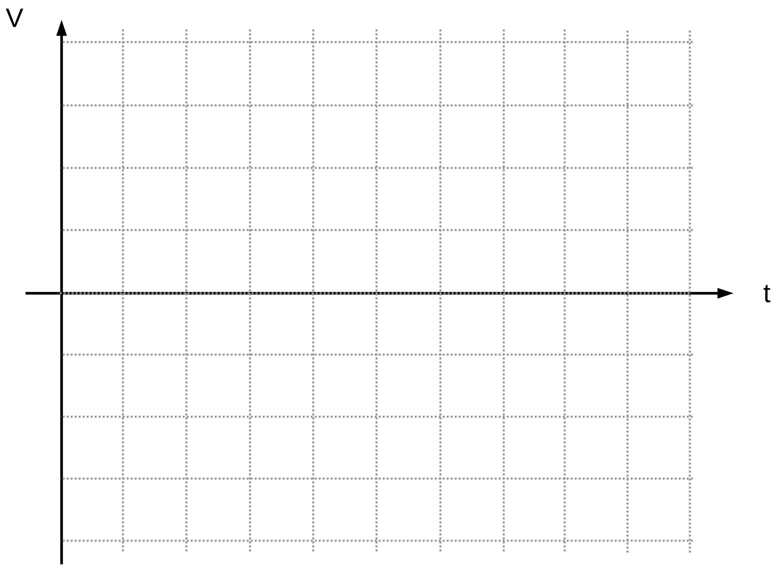
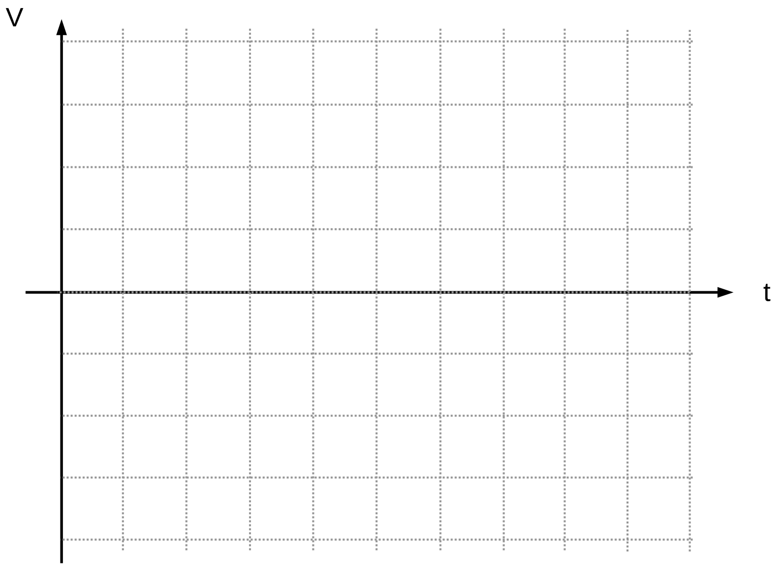


Figure 7 Diode clipper circuit with voltage divider and capacitor

e) Connect a 10 µF capacitor as shown in Figure 7 (note the polarity) and repeat procedures c) and d) above.



Graph 15 Input and output waveforms (Vs from voltage divider)



Graph 16 Input and output waveforms (Vs from voltage divider with 10µF capacitor)

Questions:

1. Explain the working principle of the clipper circuit on the basis of an ideal diode, then consider the effect of diode forward vollatge drop.

2. What is the purpose of the capacitor in Figure 7?

3.3 <u>Diode's *i-v* characteristic (Optional)</u> (Suggested Time: 15 mins)

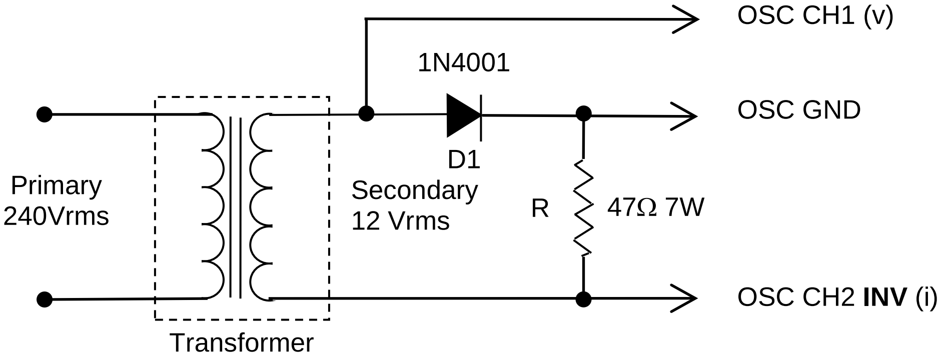


Figure 8

a) Connect the circuit as shown in Figure 8 (**Note: the 47 Ω resistor is mounted on a heat sink**).

b) Connect CH1 across the diode D1 and connect CH2 across resistor R. Please take note of the common reference point, which is the oscilloscope ground (OSC GND).

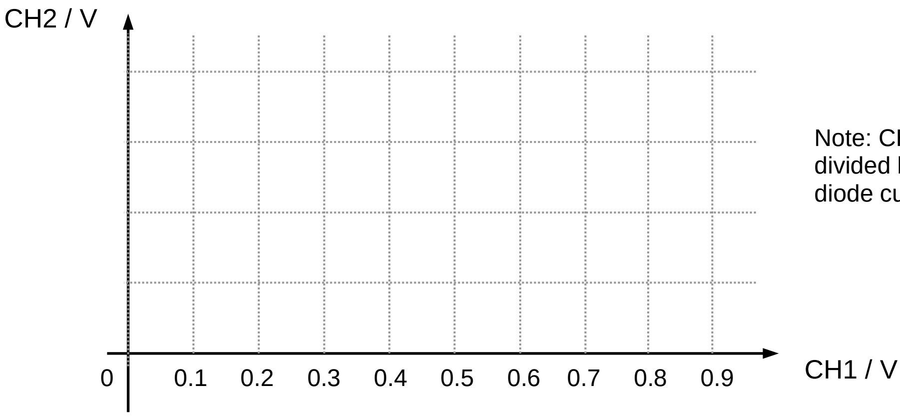
c) Set Ch2 of the oscilloscope to **INV**.

d) Set CH1 and CH2 of the oscilloscope to **GND** and adjust the horizontal traces of both channels to middle of the display screen.

e) Set CH1 and CH2 of the oscilloscope to **DC** coupling and ensure correct waveforms are observed on the display screen.

f) Set the oscilloscope to **X-Y mode**. Adjust the oscilloscope scales to obtain the best display. Sketch the diode's *i-v* characteristic in Graph 17.

g) Apply heat to the rectifier by placing the tip of a hot soldering iron on the cathode lead of the diode for approximately 10 seconds. Observe the change of diode's *i-v* characteristic on the oscilloscope.



Note: CH2 voltage divided by R will give the diode current

Graph 17 Diode's *i-v* Characteristic

Questions:

1. What is the estimated turn-on forward voltage of the diode?

2. With the chose value of resistor R, what is the peak diode current?

3. How the ambient temperature affect the diode's *i-v* characteristics?