Başkent University
Department of Electrical and Electronics Engineering
EEM 214 Electronics I
Experiment 4

Diode Rectifier Circuits

Aim:

The purpose of this experiment is to become familiar with the use of diodes for rectifying an AC input signal.

Theory:

Basic rectifier circuits convert AC input voltage to pulsating DC output voltage. Then, with a filter added to circuit, the AC component of the waveform is eliminated and nearly constant dc voltage output is produced. There are two types of rectifier, namely half wave and full wave. Each type can either be uncontrolled, half-controlled or fully controlled. An uncontrolled rectifier uses diodes, while a full-controlled rectifier uses thyristor. A half controlled rectifier uses both.

Half-Wave Rectifier

In practice, the half-wave rectifier is used most often in low-power applications because the average current in the supply will not be zero. While practical applications of half wave rectifier are limited, the analysis is important because it will enable us to understand more complicated circuits such as full wave- rectifiers.

Analysis of Basic Half Wave Rectifier

In the forward bias region (positive voltage v_D), i_D turns out to be exponentially related to v_D. For typically used values or the current, the resulting steepness of the i_D-v_D characteristic curve means that a large range of current variation can be obtained by varying the voltage in a narrow range. We will assume diode model is constant voltage drop model and v_{on}=0.7 in the discussion, but it should be kept in mind that other values my be more reasonable, depending on the diode type and current range used.

Consider now the circuit of Fig.1. The output voltage v_R cannot be negative since this would require a negative value for i_D, which can not pass through the diode. The voltage v_R can be positive, though, and this will occur when v_D is positive (i.e., when the diode conducts). In this case, v_D will be approximately equal to 0.7 V. From Kirchoff's voltage law, we have $v_D + v_R = v_S$, and thus the output will be $v_R = v_S - v_D$.

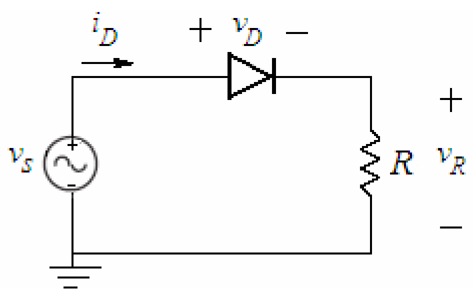


figure_1

Assume now that v_S in Fig.1 is a sinusoidal voltage. From the above observations, it can be seen that the output voltage waveform v_R is as shown in Fig. 2. The negative parts of each input cycle are cut off, since v_R cannot be negative. During conduction the positive parts of each input cycle appear at the output, but are lowered by the voltage of the forward-biased diode (assumed to be about 0.7 V in the figure). The circuit in Fig.1 is called a basic half wave rectifier.

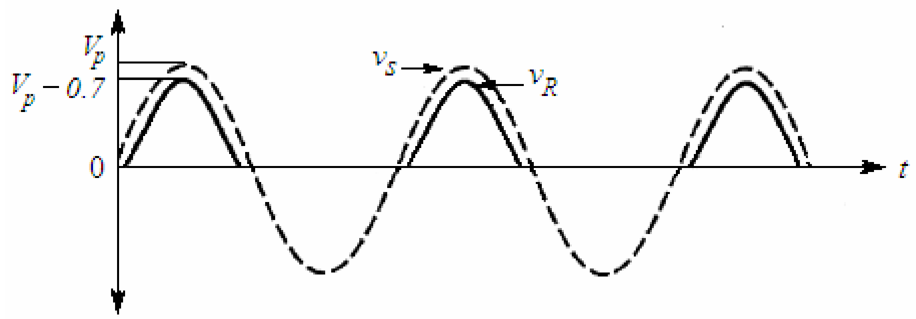


Figure_2

The Average and RMS values of Signal

$$V_{avg} = V_{DC} = \frac{1}{T}\int_0^T V(t)dt \qquad\qquad V_{rms} = \sqrt{\frac{1}{T}\int_0^T (V(t))^2 dt}$$

V(t) : Signal
T : Period of signal

Full-Wave Rectifier

Like half-wave, the objective of a full-wave rectifier is to produce a voltage or current which is purely DC or has some specified dc component. While the purpose of the full-wave rectifier is basically the same as that of the half-wave rectifiers, full wave rectifier has some fundamental advantages. The average current in the ac source is zero in the full-wave rectifier, thus avoiding problems associated with nonzero average source currents. The average (dc) output voltage is higher than half-wave. The output of the full-wave has inherently less ripple that the half-wave rectifier.

Preliminary Work:

1) Review the sections 3.13,.3.14, 3.15,3.16 from text book.

2) **a.** For the half wave rectifier circuit in Fig.3a, draw the input and output voltage waveforms (explain briefly how you obtain), assume diode model is constant voltage drop, $v_i(t)$=5sin(200πt) and R_L=1kΩ.
Construct and simulate the circuit using PSPICE and get the waveform of the output and input voltage at same plot and get the waveform of diode current in different plot also obtain DC(average) and RMS values of the output voltage using PSPICE **add trace button**. Check your drawing with the simulation.

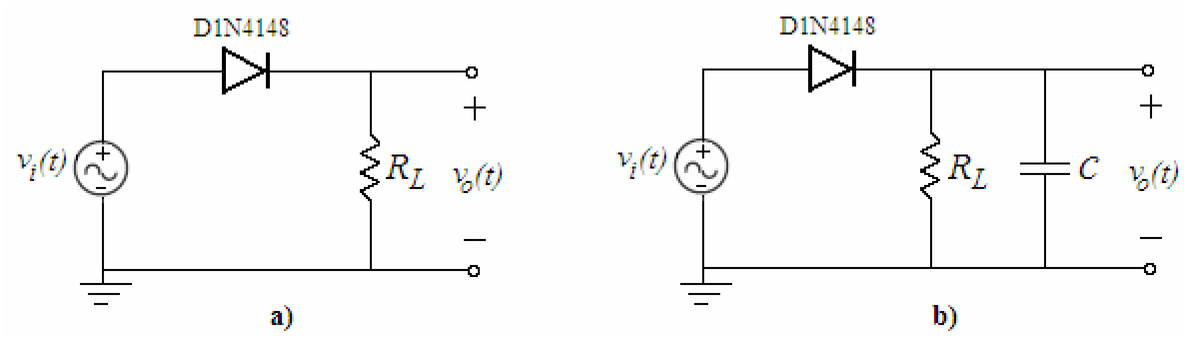


figure_3

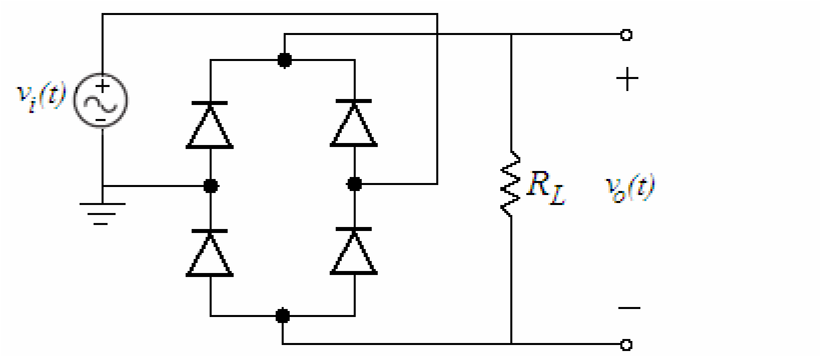
b. For the half wave rectifier circuit with capacitive load in Fig.3b, draw the waveform of the input and output voltage (explain briefly how you obtain), assume diode model is constant voltage drop, $v_i(t)$=5sin(200πt), C=10μF and R_L=1kΩ. Find the PIV ratings of diodes.
Construct and simulate the circuit using PSPICE and get the waveform of the input and output voltage at same plot and diode current in different plot also obtain DC(average) and RMS values of the output voltage using PSPICE **add trace button**. Check your drawing with the simulation.

c. Compare the circuit of Fig.3a and Fig.3b according to diode currents and RMS values of the output voltages.

3) **a.** For the full wave bridge rectifier circuit in Fig..4a, draw the waveform of the input and output voltage (explain briefly how you obtain), assume diode model is constant voltage drop, $v_i(t)$=5sin(200πt) and R_L=1kΩ. Calculate the DC(average) and RMS values of the output signal.
Construct and simulate the circuit using PSPICE and get the waveform of the input and output voltage at same plot and get the diode current in different plots also obtain DC(average) and RMS values of the output voltage using PSPICE **add trace button**. Check your drawing with the simulation.

b. For the full wave bridge rectifier circuit with capacitive load in Fig.4b, draw the waveform of the input and output voltage (explain briefly how you obtain), assume diode model is constant voltage drop, $v_i(t)$=5sin(200πt), C=10μF and R_L=1kΩ. Find the PIV ratings of diodes.

Construct and simulate the circuit using PSPICE and get the waveform of the input and output voltage at same plot and get diode current in different plot also obtain DC(average) and RMS values of the output voltage using PSPICE **add trace button**. Check your drawing with the simulation.



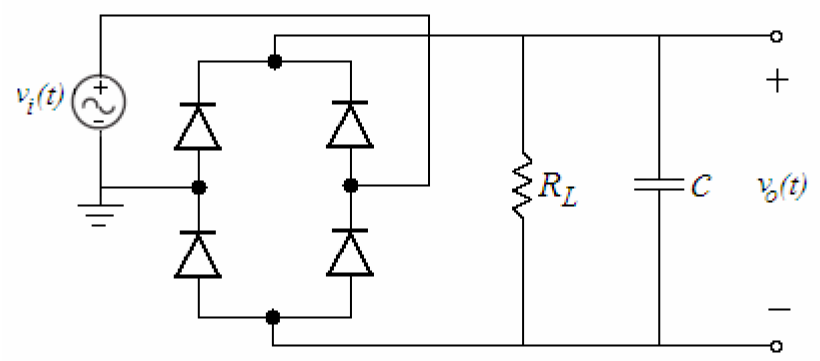


figure_4

4) Compare the circuit of Fig.3b and Fig.4b according to

- PIV Ratings
- Diode currents
- Complexity of circuits

5) Read the experiment.

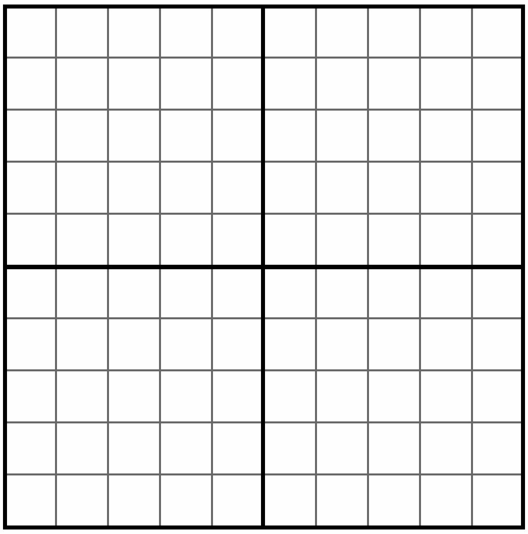
Design Problem: Consider the full wave bridge rectifier circuit with capacitive load in Fig.4b, assume diode model is constant voltage drop, $v_i(t)$=10sin(200πt) and C=100μF. It is desired that the peak to peak ripple voltage V_r to be less than 1% of the peak output voltage. Determine the value of R_L and draw output voltage and compute the DC value. Show all your calculations and assumptions.

Construct and simulate the circuit using PSPICE and obtain the waveform of the output voltage also obtain DC(average) and RMS values of the output voltage. Measure the peak to peak ripple and check whether your design is correct or not.

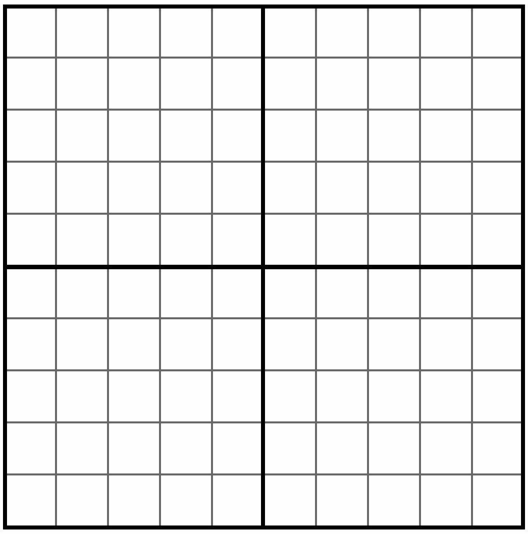
Experimental Work:

1) **a.** Setup the circuit of Fig.3a. Set the input voltage signal to a sinusoid with 100 Hz frequency and 10V peak-to-peak amplitude with R_L=1kΩ. Obtain and plot the input and output voltage waveforms; compare the peak values of the input and the output. Measure the DC and RMS values of the output voltage.

v_{in}



v_{out}

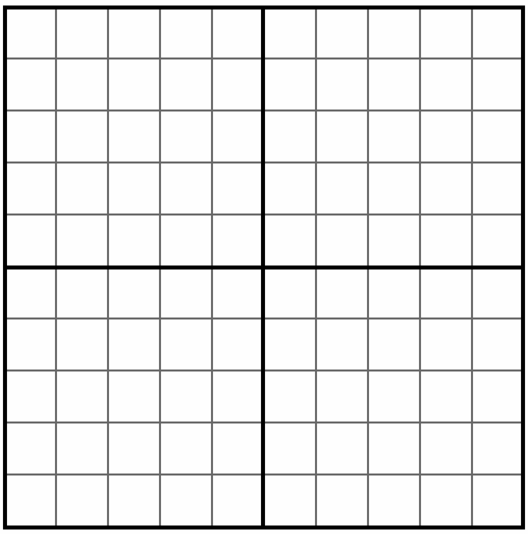


$v_{out\text{-}DC}$ =

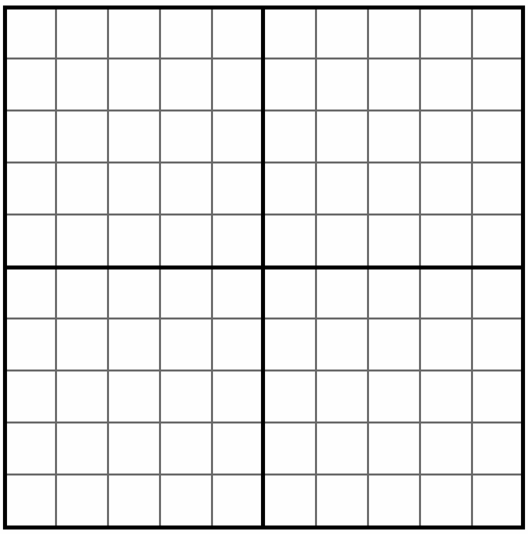
$v_{out\text{-}RMS}$ =

b. Setup the circuit in Fig.3b which has capacitive load other than circuit in Fig.3a. Set the input voltage signal to a sinusoid with 100 Hz frequency and 10V peak-to-peak amplitude with C=10µF and R_L=1kΩ. Obtain and plot the input and output voltage waveforms; compare the peak values of the input and the output. Measure the DC and RMS values of the output voltage. Obtain the frequency of the "ripple voltage" across the load resistor and measure the peak to peak ripple voltage. Also try the cases with C=1µF. **Comment on result.**

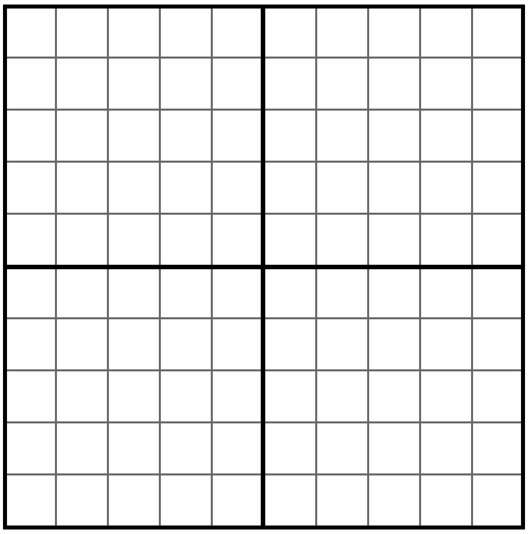
v_{in}



v_{out} (C =10µF)



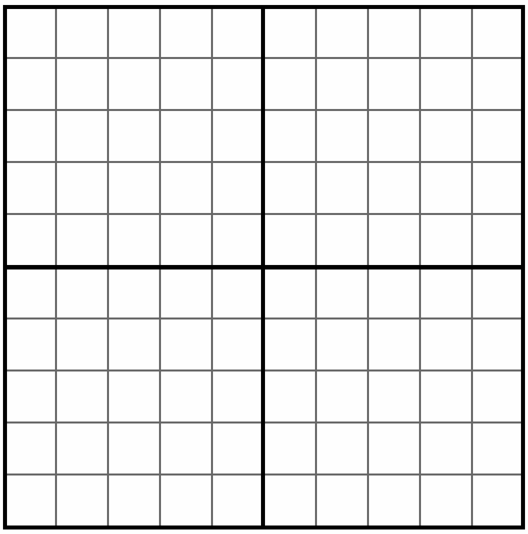
v_{out} (C =1μF)



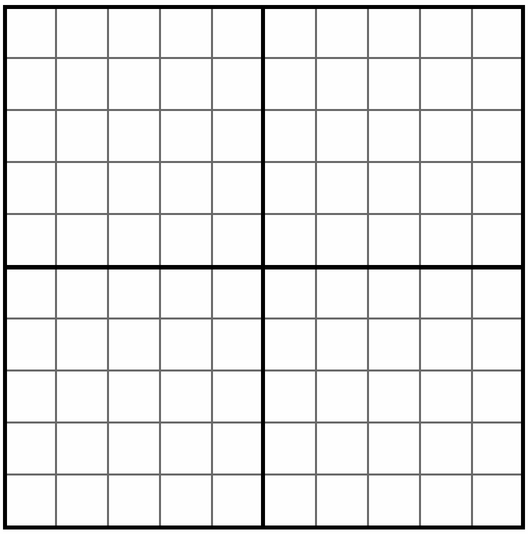
	C =10μF	C =1μF
$v_{out\text{-}DC}$		
$v_{out\text{-}RMS}$		
f_{ripple}		
$v_{peaktopeak\text{-}ripple}$		

2) **a.** Setup the circuit of Fig.4a. Set the input voltage signal to a sinusoid with 100 Hz frequency and 10V peak-to-peak amplitude with R_L=1kΩ. Obtain and plot the input and output voltage waveforms; compare the peak values of the input and the output. Measure the DC and RMS values of the output voltage.

v_{in}



v_{out}

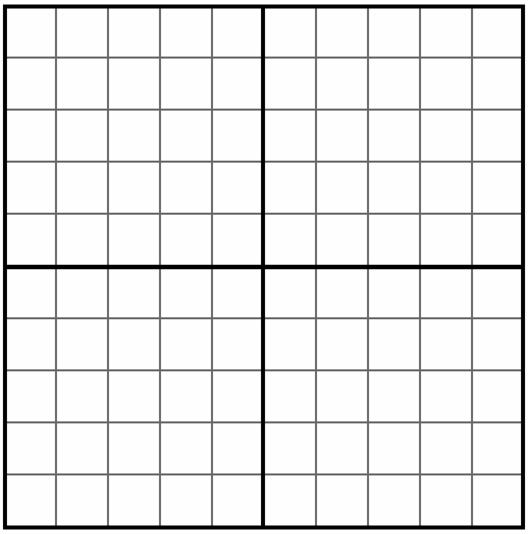


$v_{out\text{-}DC}$ =

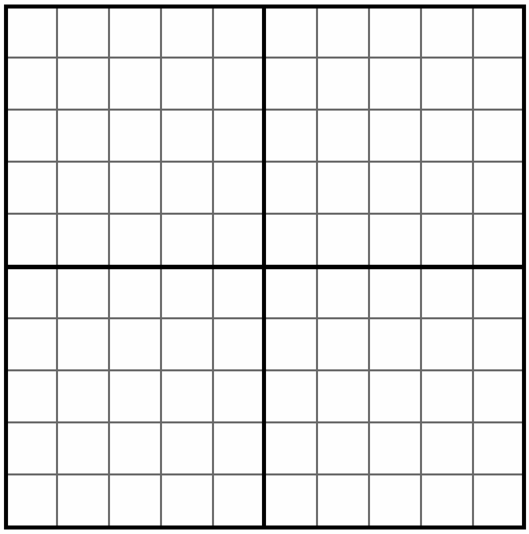
$v_{out\text{-}RMS}$ =

b. Setup the circuit in fig.4b which has capacitive load other than circuit in Fig.4a. Set the input voltage signal to a sinusoid with 100 Hz frequency and 10V peak-to-peak amplitude with C=10µF and R_L=1kΩ. Obtain the input and output voltage waveforms; compare the peak values of the input and the output. Measure the DC and RMS values of the output voltage. Obtain the frequency of the "ripple voltage" across the load resistor and measure the peak to peak ripple voltage. Also try the cases with C=1µF. **Comment on result.**

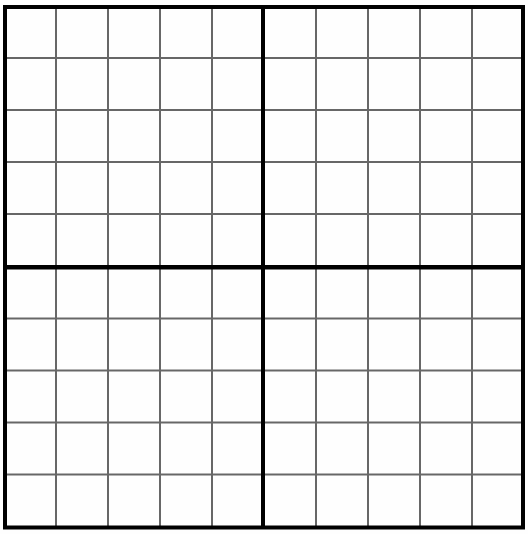
v_{in}



v_{out} (C =10µF)



v_{out} (C =1µF)



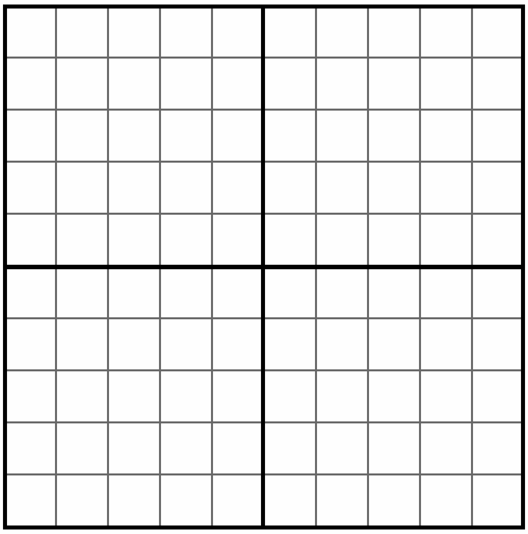
	C =10µF	C =1µF
$v_{out\text{-}DC}$		
$v_{out\text{-}RMS}$		
f_{ripple}		
$v_{peaktopeak\text{-}ripple}$		

3) In half or a full wave rectifier with capacitive load, how can you improve the ripple if the output resistance is constant?

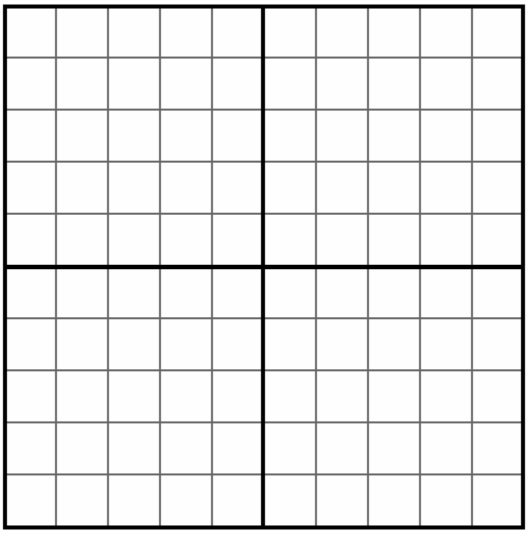
4) Setup the circuit of Fig.5, Set the input voltage signal to a sinusoid with 100 Hz frequency and 20V peak-to-peak amplitude with C=22μF, R=100, R_L= 1kΩ.

a. Disconnect the zener diode. Obtain and plot input and output voltages. Measure and record the DC value of the output voltage and peak to peak ripple voltage. **Comment on result.**

v_{in}



v_{out}

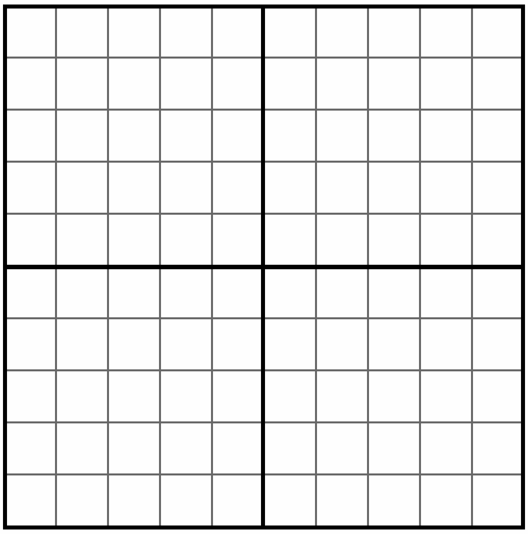


$v_{out\text{-}DC}$ =

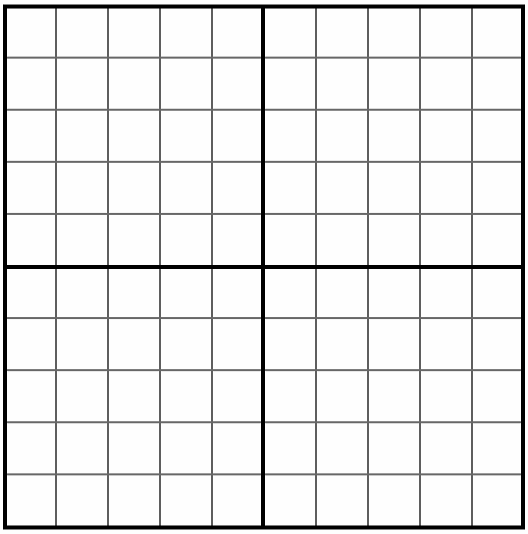
$v_{peaktopeak\text{-}ripple}$ =

b. Connect the zener diode. Obtain and plot input and output voltages. Measure and record DC value of the output voltage and peak to peak ripple voltage. **Comment on the results.**

v_{in}



v_{out}



$v_{out\text{-}DC}$ =

$v_{peaktopeak\text{-}ripple}$ =

c. Briefly explain what is the circuit used for?

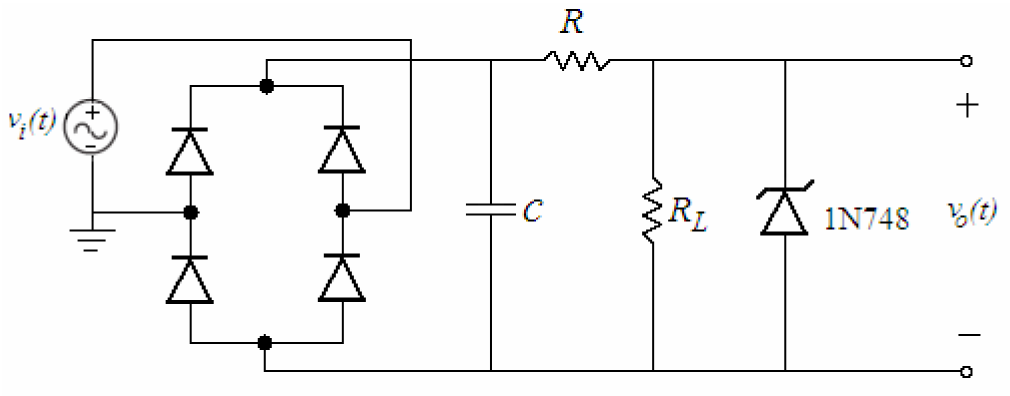


figure_5

Lab Instruments:	Components:			
Breadboard	4	1N4148	1	1μF
Oscilloscope	1	1N748	1	100Ω
Signal Generator	1	10μF	1	1kΩ
Multimeter	1	22μF		

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Experiment Results

Part1	***a.***	$v_{out\text{-}DC}$ = $v_{out\text{-}RMS}$ =	
	b.		

Part1 b.	***C* =10μF**	***C* =1μF**
$v_{out\text{-}DC}$		
$v_{out\text{-}RMS}$		
f_{ripple}		
$v_{peaktopeak\text{-}ripple}$		

Part2	***a.***	$v_{out\text{-}DC}$ = $v_{out\text{-}RMS}$ =	
	b.		

Part2 b.	***C* =10μF**	***C* =1μF**
$v_{out\text{-}DC}$		
$v_{out\text{-}RMS}$		
f_{ripple}		
$v_{peaktopeak\text{-}ripple}$		

Part4	***a.***	$v_{out\text{-}DC}$ = $v_{peaktopeak\text{-}ripple}$ =	
	b.	$v_{out\text{-}DC}$ = $v_{peaktopeak\text{-}ripple}$ =	

Student Name :

Number :

Signature……………………………