

American University of Beirut

Course: EECE 312L

Assignment 2: Rectifier Circuits

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Due Date: Wednesday, November 25th, 1:00 pm

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- ii. Peak-to-peak output voltage measurement (using Scope).
- iii. Measurement of the mean of the output wave (using DMM) and snapshot.

c. For the Bridge full wave rectifier (Figure A-2), 5 V peak-to-peak, 1 KHz sinusoidal wave as input.

i. Snapshot of the output (using Scope)

ii. Peak-to-peak output voltage measurement (using Scope)

iii. Output wave's measurement (using DMM) and snapshot.

d. For the Bridge full wave rectifier with filter (Figure A-3), 5 V peak-topeak, 1 KHz sinusoidal wave as input.

- i. Snapshot of the output (using Scope)
- ii. Peak-to-peak output voltage measurement (using Scope)
- iii. Measurement of the mean of the output wave (using DMM) and snapshot.

e. Comparison of the outputs of the three circuit diagram in terms of shape and mean.

Introduction:

Although diodes have many uses in electrical engineering, their use in the design of rectifier circuits is the most common. Rectifier circuits are considered to be the building blocks of DC power supplies that are required to power our daily electronic devices. What a rectifier circuit does is that it changes an alternating, or bidirectional current or voltage to a unidirectional one. It is important to note that there are many types of rectifier circuits, and they range from the simplest configuration of a rectifier diode and a resistor, to a multiple of diodes connected to a smoothing capacitor and a resistor. In this assignment, we shall investigate 3 configurations of the rectifier circuit: diode-resistor, 4 diodes-resistor, and 4 diodes-resistor-capacitor.

Description of hardware setup:

- **Components used:**
- LabVIEW Software
- MyDAQ acquisition system



PCBreadboard



5.6 KΩ Resistor



✤ 1N4007 (Rectifier diode) x4



✤ 1 uf Capacitor



✤ Multi-meter wires



✤ USB port wire



Connecting wires



Circuit connections, Connections between myDAQ acquisition board and the circuit, and Input and output lines used:

For this assignment, all we needed was one input and one output from the myDAQ in order to complete all three experiments. The terminal that supplied our input was the AO 0 input on the myDAQ and complementary to it the AGND (ground), on the other hand, the terminal that provided our output was the AI 0 channel $(0^+ and 0^-)$. For all three circuits, we were required to apply a 5V peak-to-peak voltage and a 1 KHz sinusoidal wave as input.



Figure (a): Connections to myDAQ

N.B: The connection above was common between all three circuits

Circuit 1:

- Circuit 1 was the simplest among the 3 configurations since it only contained a diode and resistor connected in series to the source where the output across the resistor was measured.
- Circuit 1 represented a half-wave rectifier.



Figure (b): Theoretical connections in Paint



Figure 10.24 Half-wave rectifier with resistive load.

Figure (b'): Expected theoretical output from circuit 1



Figure (c): Real circuit on breadboard (circuit 1)

Circuit 2:

- Circuit 2 was slightly more difficult in terms of building and this is due to the fact that now the circuit included 4 diodes connected to resistor (bridge).
- This circuit served as a full-wave rectifier and the connections were as follows.



Figure (d): Theoretical connections of Circuit 2



Figure (d'): Expected theoretical output from circuit 2



Figure (e): Real circuit on breadboard (circuit 2)

Circuit 3:

- This circuit is the most practical circuit among the three, and this is due to the fact that a capacitor exists in the configuration, which in turn serves as a smoothing mean for the signal.
- The final result of the signal is a fluctuating ripple wave.



Figure (f): Theoretical connections of circuit 3



Figure (f'): Expected theoretical output from circuit 3



Figure (h): Real connections on breadboard for circuit 3

Description of the software setup:

b. Modules used and Configurations

FUNCTION GENERATOR (FGEN)

The NI ELVISmx Function Generator (FGEN) generates standard waveforms with options for the type of output waveform (sine, square, or triangle), amplitude selection, and frequency settings.

Waveform Settings Amplitude DC Offset Image: Settings Image: Settings Image: Settings Image: Settings Image: Setting Image: Settings	e
Sweep Settings Start Frequency Step Frequency Step Interval 100.0 (100,0)))))))) Step Interval Step Interval Iterval Iterval <thiterval< th=""> <th< td=""><td></td></th<></thiterval<>	
Instrument Control Device Signal Route Dev 1 (NI myDAQ) AO AO AO AD]

OSCILLOSCOPE (SCOPE)

The NI ELVISmx Oscilloscope (Scope) displays voltage data for analysis. This instrument provides the functionality of the standard desktop oscilloscope found in typical undergraduate laboratories. The NI ELVISmx Oscilloscope SFP has two channels and provides scaling and position adjustment knobs along with a modifiable time-base. The auto-scale feature allows you to adjust the voltage display scale based on the peak-to-peak voltage of the AC signal for the best display of the signal. The computer-based scope display has the ability to use cursors for accurate screen measurements.

Channel Source: Channels AI 0 and AI 1. Hence, analogue input lines (AI 0 or AI1) of myDAQ will be used to display the output signal from the circuit design built on the breadboard (AI 0 in my case).

😫 Oscilloscope - NI ELVISmx			- • ×
	8	Basic Settings Advanced Settings	
	Sample Rate:	Channel 0 Settings Channel 1 Settin	ngs
		AI 0 AI 1	-
		Tenabled Enabled	
		Probe Coupling Probe	Coupling DC 💌
		Scale Vertical Scale Volts/Div Position (Div) Volts/Div	Vertical Position (Div)
		\odot \bigcirc \odot	
			0
		Timebase Trigger	
		Time/Div Inmediate	
		Source Le	evel (V)
		Horizontal Position (%)	
CH 0 Meas: RMS: ? Fren: ?	Vn-n: 0.00 V	5 ms 💌	
		Instrument Control Device Acquisition Mode	2
		Dev1 (NI myDAQ) Run Continu	Jously
Cursors Settings	CH 0 CH 0 CH 1	Autoscale	

DIGITAL MULTIMETER (DMM)

NI ELVISmx Digital Multi-meter (DMM) is a stand-alone instrument2 that controls the basic DMM capabilities of NI myDAQ. This commonly used instrument can perform the following types of measurements:

- Voltage (DC and AC)
- Current (DC and AC)
- Resistance
- Diode test
- Audible continuity

This instrument has the following measurement parameters:

- DC voltage: 60 V, 20 V, 2 V, and 200 mV ranges
- AC voltage: 20 V, 2 V, and 200 mV ranges
- DC current: 1 A, 200 mA, and 20 mA ranges
- AC current: 1 A, 200 mA, and 20 mA ranges
- Resistance: 20 MΩ, 2 MΩ, 200 KΩ, 20 KΩ, 2 KΩ, and 200 Ω ranges
- Diode: 2 V range

We shall use the DMM interface to make voltage and resistance measurements.



🔀 Digital Multimeter - NI ELVISmx 📃 📼 🗾 🗠
LabVIEW
0.0 V
۰
Measurement Settings V= V~ A= A~ ∩ + 0000 ↔)) Mode Specify Range 60V ▼ Null Offset
Instrument Control Device Acquisition Mode Dev1 (NI myDAQ) Run Continuously Run Stop Help

Testing:

a. Measurement of the value of resistance.

5.51 kOhms
% FS
Measurement Settings V= V~ A= A~ Ω + Ω + N
Mode Specify Range Range 20Kohm v Null Offset
Instrument Control Device MyDAQ1 (NI myDAQ) Run Continuously Help

- b. Half wave rectifier
 - *i.* Output signal using scope:

NUMBER OF THE OWNER		Basic Settings	Advanced Settings		
LabVIEW	Sample Rate: 200.00 kS/s	Channel 0 Set	ttings	Channel 1 Settings	
		AI 0		AI 1	
		Probe	Coupling	Enabled Probe Coupling	
		1x 💌 Scale	DC Vertical	1x DC	
		Volts/Div	Position (Div)	Volts/Div Position (Div)	
		1 V 💌	0 🖨	1V 🗸 0 🖨	
		Timebase —	Trigger		
		Time/Div	Type Immediate	Slope	
		()	Source Chan 0 Source	Level (V)	
		500 us 👻	Horizontal Po	sition (%) 50 🗇	
CH0 Meas: RMS: 924.71 mV Freq: 1.0	00 kHz Vp-p: 1.976 V				
		Instrument Co Device	ontrol	Acquisition Mode	
		myDAQ1 (NI	myDAQ) 💌	Run Continuously	
Cursors Settings Displa	ay Measurements Graph Controls		Run Stop	Print Log Help	
C1 CH 0 C C2 CH 1 C	H 0 CH1 Graph Properties	Autoscale	Run		



ii. Peak-to-peak voltage using cursors:

iii. The mean output voltage (DC) using DMM:

LabVIEW
0.6 V DC
•
Measurement Settings V = V ~ A = A ~ Ω + L (2000) →)) Mode Specify Range 60V ▼ Null Offset
Instrument Control Device MyDAQ1 (NI myDAQ) Run Continuously Run Stop Help

c. Full-wave rectifier (without capacitor)

NAMES -		8	Basic Settings	Advanced Settings	
LabVIEW	Sample	e Rate: 200.00 kS/s	Channel 0 Set	ttings	Channel 1 Settings
			AI 0	•	AI 1
			Carlot Enabled Probe Ix Carlot Scale Volts/Div	Coupling DC Vertical Position (Div)	Enabled Coupling Ix DC Scale Vertical Volts/Div Position (Div) I I
				Trigger	
			Time/Div	Type Immediate Source Chan 0 Source Horizontal Po	Slope Level (V) e 0 50 60
CH0 Meas: RMS: 904.61 mV Fre	eq: 2.000 kHz Vp-p: 1.4	56 V Timeout	- Instrument Co Device myDAQ1 (NI	myDAQ)	Acquisition Mode Run Continuously
Cursors Settings C1 CH 0 V C2 CH 1 V	CH 0 CH 1	Graph Graph Properties	Autoscale	Run Stop	Print Log Help

i. Output signal using scope:

ii. Peak-to-peak voltage using cursors:



LabVIEW ⁻	
0.7	V DC
	····· %
Measurement Settings V= V~ A= A~ C Mode Banar Specify Range • 60V • Null Offset	1 + 1000 + 1) na Jack Connections
Instrument Control Device myDAQ1 (NI myDAQ)	Acquisition Mode Run Continuously Run Stop Help

iii. The mean output voltage (DC) using DMM:

d. Full-wave rectifier with smoothing capacitor

i. Output voltage measurement using Scope:

ADMENE OF	L BUTTLINGT								Ð	Basic Settings	s /	Advanced Settings		
🔛 La	bVIE\	N ⁻				Sa	ample Rat	æ: 200.0	0 kS/s	Channel 0	Setti	ngs	- Channel 1 Set	tings
										AI 0		•	AI 1	-
										Probe	d	Coupling	Enabled Probe	Coupling
										1x Scale Volts/Div	-	Vertical Position (Div)	Scale Volts/Div	Vertical Position (Div)
		~~~~		~~~~					~~~_	0	)		9	
										1 V	•	0 🖨	1 V 💌	0 🌲
										Timebase		Trigger		
										Time/D	iv	Type Immediate	Ţ	Slope
										$\mathcal{O}$		Source Chan 0 Source	ie 🖵	Level (V)
										500 us	•	Horizontal Po	osition (%)	50 🗢
CH0 Mea	is: RI	MS: 1.26	7 V I	Freq: ?		Vp-p:	95.26 m		Timeout	Ti	meba	se		
										Device myDAQ1	t Con	yDAQ)	Acquisition M Run Continue	ode
Cursors	s Settings			Displa	y Measur	ements	Graph	Controls	_		_	Run Stop	Print	Log Help
Curs	sors On	C1 CH U C2 CH 1	<b>v</b>	<b>V</b> C	H O 🗔	CH1	Pro	Graph operties		Autoscal	le		\$	2

### *ii.* The mean output voltage (DC) read from DMM:

LabVIEW
1.3 V DC
, <mark>-</mark>
Measurement Settings $V = V \land A = A \land \Omega + 0 $
Mode Specify Range 60V Null Offset
Instrument Control Device myDAQ1 (NI myDAQ) Run Continuously Help

#### e. COMPARISON BETWEEN OUTCOMES OF THE TESTED CIRCUITS:

After performing the above experiments, it is rather noticeable to us the fact that the increasing complexity of the circuits speaks for itself when it comes to the comparison of the results.

For the half wave rectifier, we notice that the output showed a half-sine wave, in which all the negative part of the signal disappeared making the signal look unidirectional.

As for the full wave rectifier (without smoothing capacitor), we notice that all of the output signal is now positive such that the negative part and positive part of the signal are adjacent to one another.

Considering the full wave rectifier with the smoothing capacitor, we notice that the signal is a kind of shy horizontal line having small fluctuations tending to the shape of a DC signal.

The numerical comparison is what we can call the "Meat and Potato" of the whole purpose of the experiment. Starting from experiment one the peak-topeak voltage was 1.976 V (from scope) and as we moved to experiment two the peak-to-peak voltage went down to 1.456 V, and as we moved further to experiment three the peak-to-peak voltage went down dramatically to 95.26 mV. As we can see the peak-to-peak voltage is decreasing as we move from one experiment to the other.

On the other hand, if we consider the mean voltage measurements that we've done using the DMM, we notice that for experiment one  $V_{DC} = 0.6 V$ , then it becomes  $V_{DC} = 0.7 V$  for experiment two, after which it becomes  $V_{DC} = 1.3 V$  for experiment three, which is a relatively high value compared to the peak-to-peak voltage.

Henceforth, as we further proceed in rectifying the signal, it starts losing its AC properties, and starts exhibiting DC properties.

#### **References:**

- Documents posted on Moodle
- EECE 312 Lecture notes: Dr. Lama Hamandi
- <u>http://www.paleoelectronics.com/2011/03/sidebar-rectification-and-filtering/</u>
- <u>http://electronics.stackexchange.com/questions/68526/what-</u> <u>can-the-source-of-100hz-noise-be</u>