ECGR 3155

University of North Carolina at Charlotte
Department of Electrical and Computer Engineering

Laboratory Experiment Report 2-4

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Objectives :

Experiment 2

The objective of this experiment was to study sinusoidal waves in active circuits.

Experiment 3

The objective of this lab was to acquire an understanding of AC and DC amplification, input and output impedance, and some basic circuit analysis tools.

Experiment 4

The purpose of this experiment is to introduce diode rectifier circuits used in DC power supplies

Equipment List :

Experiment 2

- NI ELVIS II
- EMONA SIGEx Signal & Systems add-on board
- Assorted patch leads
- Two BNC – 2mm leads

Experiment 3

- DC power supplies
- 741 Op-amp
- Arbitraty function generator
- Capacitor: 0.01μF
- Resistors: 220Ω, 100Ω, 1000Ω,

Experiment 4

- 4 diodes
- Power Analyzer (2)
- Capacitor: 1μF, 400 VDC Non-polarized (3)
- Resistor: 1kΩ, 5W or 10W (3)

Relevant Theory/Background Information

Experiment 2

Linear Networks:
Linear networks exhibit a key property known as superposition, which means that the response of the circuit to a sum of individual input signals is equal to the sum of the responses of those input signals taken individually. In simpler terms, the output of a linear network is directly proportional to the input

signal. Linear circuits obey the principles of linearity, which include the properties of additivity and homogeneity.

In linear networks, when the input signal changes, the output signal changes in a predictable and proportional manner. This property allows for straightforward analysis and design using techniques from linear algebra and calculus. Common linear components include resistors, capacitors, and inductors, when used within certain limits.

Nonlinear Networks:
Nonlinear networks, on the other hand, do not follow the principles of linearity. The relationship between the input and output signals is not proportional and may exhibit complex behaviors. In nonlinear circuits, the output signal can change disproportionately with small changes in the input signal. This can lead to effects like distortion, harmonics, and even chaotic behavior.

Nonlinear components, such as diodes, transistors operating in their active region, and nonlinear amplifiers, introduce nonlinearities into circuits. These nonlinearities can be exploited for tasks like signal modulation, signal mixing, and waveform shaping. However, they also introduce challenges in analysis and design, often requiring advanced mathematical techniques and simulation tools to understand their behavior accurately.

Experiment 3

Operational Amplifiers (Op-Amps):
An operational amplifier, commonly referred to as an op-amp, is a versatile electronic component widely used in analog signal processing and amplification circuits. Op-amps are designed to have high gain, high input impedance, and low output impedance, making them essential building blocks in a variety of electronic applications.

Op-amps typically have two input terminals: the inverting (-) and non-inverting (+) inputs, and one output terminal. The fundamental principle behind op-amp operation is that the output voltage is a linear function of the voltage difference between the two input terminals. When negative feedback is applied, op-amps strive to minimize the voltage difference between their inputs, effectively making the inverting and non-inverting input voltages almost equal.

Op-amps have large open-loop gain, meaning that even a minimal voltage difference between the inputs can lead to a significant output voltage. This property is exploited in signal amplification, voltage following, and filtering as well as other applications. Op-amps can be configured as inverting amplifiers, non-inverting amplifiers, differential amplifiers, and integrators, to tailor their behavior to a desired behavior.

The versatility of op-amps comes from their ability to perform mathematical operations like addition, subtraction, differentiation, and integration on analog signals. Additionally, they can be used to compare voltages, create oscillators, generate reference voltages, and implement various control systems. Despite their inherent open-loop instability, op-amps are usually used in closed-loop configurations, where negative feedback ensures stable and predictable operation.

Experiment 4

Diodes:
A diode is a two-terminal semiconductor device with a crucial property: it allows current to flow in one direction while blocking it in the opposite direction. This behavior arises due to the diode's internal structure, which includes a P-N junction. In a P-N junction, one side (P-type) has an excess of positively charged "holes," while the other side (N-type) has an excess of negatively charged electrons. When a

voltage is applied in the forward bias direction (positive to the P-side, negative to the N-side), the diode allows current to flow as electrons move towards the positively charged region, creating a conductive path. In reverse bias, the diode blocks current due to the repulsion between the majority charge carriers and the applied voltage. This property makes diodes essential in various applications, such as rectification, voltage regulation, and signal demodulation.

Bridge Rectifiers:
A bridge rectifier is a circuit arrangement that efficiently converts alternating current (AC) to direct current (DC). It consists of four diodes configured in a bridge topology, which rectifies the AC input by allowing current to flow in only one direction. When the AC voltage is positive, two diodes conduct, creating a path for current to flow through the load. When the AC voltage is negative, the other pair of diodes conduct, again allowing current to pass through the load, but in the opposite direction. This arrangement effectively rectifies both halves of the AC waveform, producing a pulsating DC output. Additional filtering components, such as capacitors, can be used to smooth out the pulsations, resulting in a more constant DC voltage. Bridge rectifiers are widely used in power supplies and electronic devices that require a stable DC power source.

Experimental Data/Analysis

Experiment 2:

1. Write down a formula to express the square of a sinusoid in terms of a double angle argument.

2. What is the meaning of differential linearity?

3. Consider the two conditions for linearity for a system S defined by y = S(x). How would you apply these formulas in testing systems for linearity in this Lab ? How many replicas of the system are needed for the additivity test?

Table 2.1		
Input Amplitude	LIMIT Amplitude	REC Amplitude
1	3.2	0.66
2	3.25	1.25
3	3.25	1.72
4	3.35	2.2
5	3.35	2.25
6	3.34	2.75
7	3.34	3.26
8	3.34	3.7
9	3.34	4.2
10	3.34	4.68

Table 2.2	
Input Amplitude	Mult Amplitude

1	0.26
2	1.09
3	2.62
4	4.46
5	7
6	10
7	10.84
8	10.84
9	10.84
10	10.84

Table 2.3	
Input Voltage	Output frequncy(kHz)
-3	1.188
-2	1.221001221
-1	1.298701299
0	2.040816327
1	2.43902439
2	2.78551532
3	3.174603175

Table 2.4		
Input Freqency	Square wave	Sin wave
1000	0.99	0.99
2000	0.99	0.99
3000	0.99	0.99
4000	0.99	0.99
5000	0.99	0.99
6000	0.99	0.99
7000	0.99	0.99
8000	0.99	0.99
9000	0.99	0.99
10000	0.99	0.99

Experiment 3:

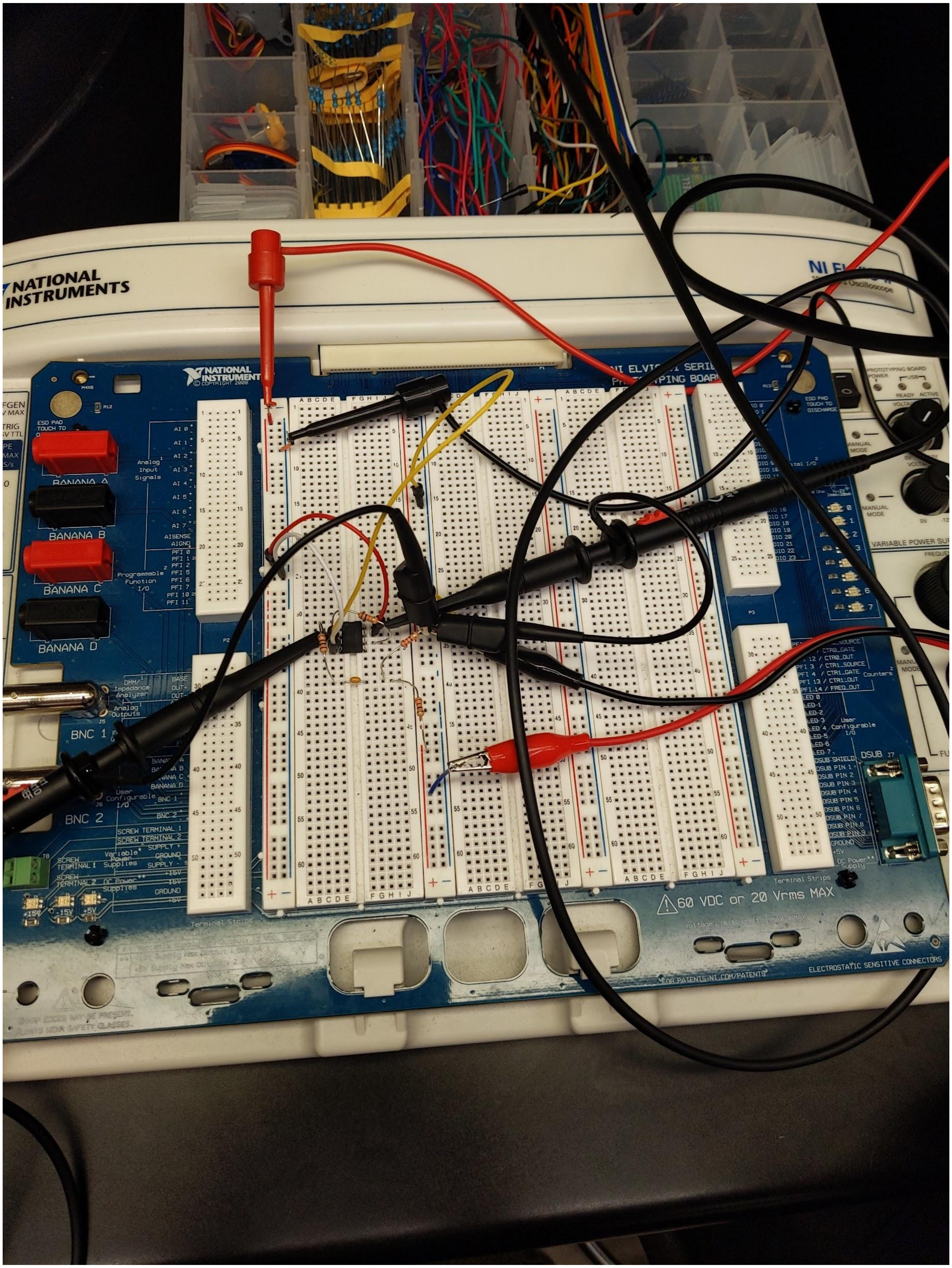
PRELAB
1. Referring to Figure 3-4, develop a formula that will give the voltage gain, Vo/Vi, in terms of R1 and the feedback resistance, Rf. Assume the voltage difference between pins 2 and 3 to be zero, and that the current flowing into these pins is also zero. Figure 3-4 Inverting Amplifier ECGR 3155 Signals and Electronics Laboratory EXPERIMENT 3 – OPERATIONAL AMPLIFIERS 4

2. Referring to Figure 3-5, develop a formula that will give the voltage gain, Vo/Vi in terms of R1 and the feedback resistance, Rf. Assume the voltage difference between pins 2 and 3 to be zero, and the current flowing into these pins also to be zero. Figure 3-5 Non-Inverting Amplifier

3. In the circuit of Figure 3-6, what is the relationship between Vo and Vi?

AC

AC driver - Inverter				
resistor	Vin	Vout		
100	55mv	46mv		
1000	110mv	110mv		
AC driver - Noninverting				
resistor	Vin	Vout		
100	56mv	4.48V		
1000	56mv	540mV		
AC driver - Voltage follower				
resistor	Vin	Vout		
0	456mV	480mV		


NATIONAL INSTRUMENTS
BANANA A
BANANA B
BANANA C
BANANA D
BNC 1
BNC 2
DSUB
60 VDC or 20 Vrms MAX
ELECTROSTATIC SENSITIVE CONNECTORS
VARIABLE POWER SUPPLIES

Experiment 4:

1. For the full wave rectifier of Figure 4-4. If C = 330 μF, RL = 3.3kΩ, Vin=5VRMS @60 Hz and each diode's forward voltage drop is 0.7 volts, calculate
    a. Ripple frequency, fr
    b. Peak output voltage Vp (This is not the sinusoidal input voltage's peak.)
    c. Peak-to-peak ripple voltage, Vr
    d. Load current, IL (A good approximation is obtained by neglecting ripple.)
    e. Average diode current, IDav f. Maximum diode current, IDmax
2. Repeat Question 1, but for a full-wave bridge rectifier when one of the diodes (D1 from Figure 4-4) is blown (open). This is equivalent to a half-wave rectifier but with two diodes in series. (It may be helpful to re-draw the circuit in order to visualize this.)

Avg frequncy of full wave recitfyer:		
60Hz		
Average Voltage of full wave rectifyer:		
0.0105	V	
Capacitor discharge time:		
0.018	s	
V/time=		
0.5833333333		
Capactor value:		
0.33	F	
I		
0.1925	A	
I_rs		
0.0000000206	AAC	
Scaling factor		
~10^(8)		
Current across the load resistor;		
0.04044	A	
V_out/R_out		
0.000003181818182		

Conclusions:

Experiment 2

This explores signal linearity by analyzing sine waves. The Sig Ex functions that were applied to the sine wave were the
Limiter, Multiplier, and Rectifier. These transforms were applied to make sure that both attributes from linearity are
satisfied. The Limiter and Rectifier both test for the additivity principle. The multiplier checks for homogeneity.

postlab:
1.
The output does not pass the linearity test. Because the output does not scale proportionally.
2)
Yes, the voltage is proportional to the input.
3)
No as the values received from the multiplier increased in magnitude, there is uneven
scaling throughout the test.
4)
V_co is linear. because the input and output are
5)

- Music electronics
- Power systems

6)

Experiment 3

In this experiment it was shown that the

Postlab

problem 1:

A coupling capacitor is designed to prevent DC components from passing through, while still allowing AC components to pass. Bypass capacitors operate inversely to coupling capacitors, by suppressing the AC components passing DC components of the signal signal.

Problem 2:

No, it is not possible. The Maximum voltage should be the Value of V(Peak to Peak).

Problem 3:

V_out should not exceed V.p.p. using the equation $\frac{-V_{p-p}}{R} < V_{in} < \frac{V_{p-p}}{R}$

Problem 4:

Internal capacitance and inductance are sources of errors when the setting the circuit to high

$\frac{V_a}{R} + \frac{V-V_o}{R_f} = 0$

$V_a * (\frac{1}{R} + \frac{1}{R_f}) = \frac{V_o}{R_f}$

Experiment 4

Diodes and Bridge rectifiers are used to manipulate circuits in order to generate several different output waveforms. Introducing a capacitor keeps the system effectively at a high dc value, rather than providing a fluctuating (AC) waveform. This is important for when a system needs a consistent DC value for AC voltage system to operate properly. Similar results can be achieved by using a half wave rectifier (though we did not implement one).

Postlab 1:
a)
Rf = 2 * f = 120hz

b)
Vp-p =