RYERSON UNIVERSITY

Faculty of Engineering, Architecture and Science

Department of Electrical and Computer Engineering

Course Number	ELE504
Course Title	Electronic Circuits II
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Instructor	Dr. Mike Kassam

ASSIGNMENT No. 4

Assignment Title	Linear Voltage-Controlled Function Generator (Milestone 1)

Submission Date	October 8, 2021
Due Date	October 8, 2021

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1. Introduction

The report for Milestone 1 of the ELE504 major project, is presented herein. The lab session for this experiment took place on October 8th, 2021.

2. Objectives

The objective of this lab was to compare frequency response limitations on A.C. signal performance of two different OP-AMPs (LM741CN and LM318 N OP-AMPs). This knowledge is then used to select appropriate OP-AMP type(s) for the design of a practical audio amplifier.
The objective of this milestone is to design, implement and verify a fixed-frequency waveform generator (square and triangular waveforms) with respect to the assigned frequency value.
From the Prelab assignment, design analysis and circuit design are completed as preparation for the simulation portion of this milestone. Through the use of the Multisim simulation environment, the design analysis is put to the test and appropriate verification measures are taken to finalize the design for this milestone.

3. Prelab Assignment Summary

For the Prelab assignment and the lab, the following data were provided by Mr. Perczak (section 4 TA) for calculations and experimentation, as presented in **Table 3.1**. The following data was used in the Prelab assignment (Parts a, b, and c), and the experiment as well.

Table 3.1: Parameter set provided for lab 3 of the ELE504 course.

f_o = 3100 Hz

Through the Prelab assignment, the given parameters and design requirements are taken into account when designing the fixed-frequency waveform generator. The OP-AMP saturation levels are assumed to be +/- 8.5 volts with the usage of +/- 10 volts of power supplies in the circuit. The general concept design for this milestone includes an inverting integrator connected to the noninverting bistable multivibrator. There are three voltage quantities that are observed: input voltage (maximized and minimized at L^+/L^-), inverting integrator's output which is fed to the noninverting bistable multivibrator (maximized and minimized at V_{TH}/V_{TL}), and the overall output voltage of the circuit (maximized and minimized at L^+/L^-). Since the frequency value is dependant on the positive saturation limit of the output voltage, the equation $f_o = L^+ / 2\,R\,C\,(V_{TH} - V_{TH}$)is used to find the values for the three resistors, the capacitor and the high and low threshold voltage levels. One thing to note is that for this milestone, the threshold voltage levels are sought to be below 8.5 volts (+/- 5.71 volts have been recorded for the design analysis) to have a proper waveform for the integrator's output, such that it doesn't "flip" too many times in a short time interval.

With regard to the choice of OP-AMPs used in the design analysis, the LM741CN OP-AMP has been used for initial analysis in this milestone, as its small slew rate of 0.5 volts/micro-seconds (typical value from datasheets) would allow for more time in the alternations between high and low threshold voltage levels for the integrator's output. In the experiment, however, other alternatives will be tested as well to appropriately verify the final design for this milestone.

4. Experimental Results and Observations

All circuits from the lab manual are created and tested using the Multisim Software environment. The final schematic drawn from the Prelab assignment is tested with two separate configuration cases: two LM741CN OP-AMPs, and one of each LM741CN and LM318N OP-AMPs in use. The reason being for this choice is to verify the initial design choice of two LM741CN OP-AMPs being used in the design analysis. The aim is to obtain a more accurate waveform with respect to the design expectations from the Prelab assignment. **Figures 4.1-4.2** contain the simulation results for the first design with the two LM741CN OP-AMPs. **Figures 4.3-4.4** contain the simulation results for the first design with the LM741CN and the LM318N OP-AMP in use. By comparing the two circuits, it is observed that using the second choice is more suitable as the correct frequency measurement (approximately 3034 Hz from the simulation) is much closer to the desired 3100 Hz parameter from the design analysis.

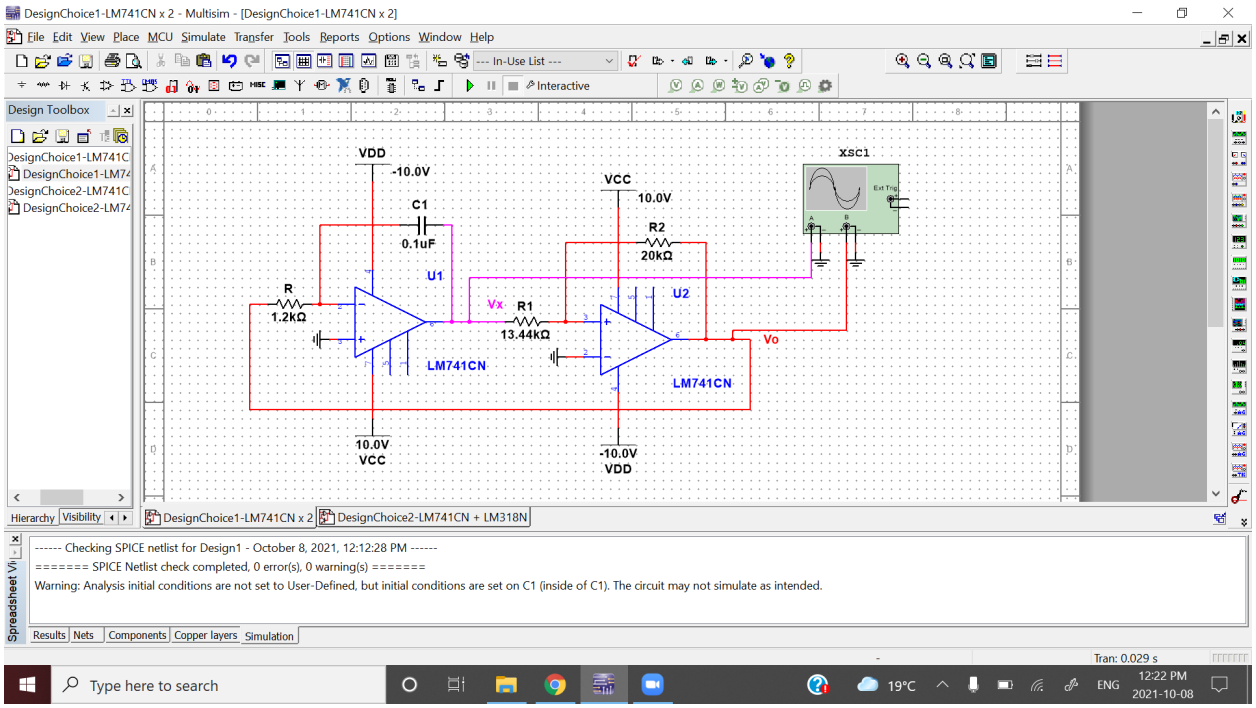

Figure 4.1: Multisim schematic of FFWG with two LM741CN OP-AMPs - part 1.

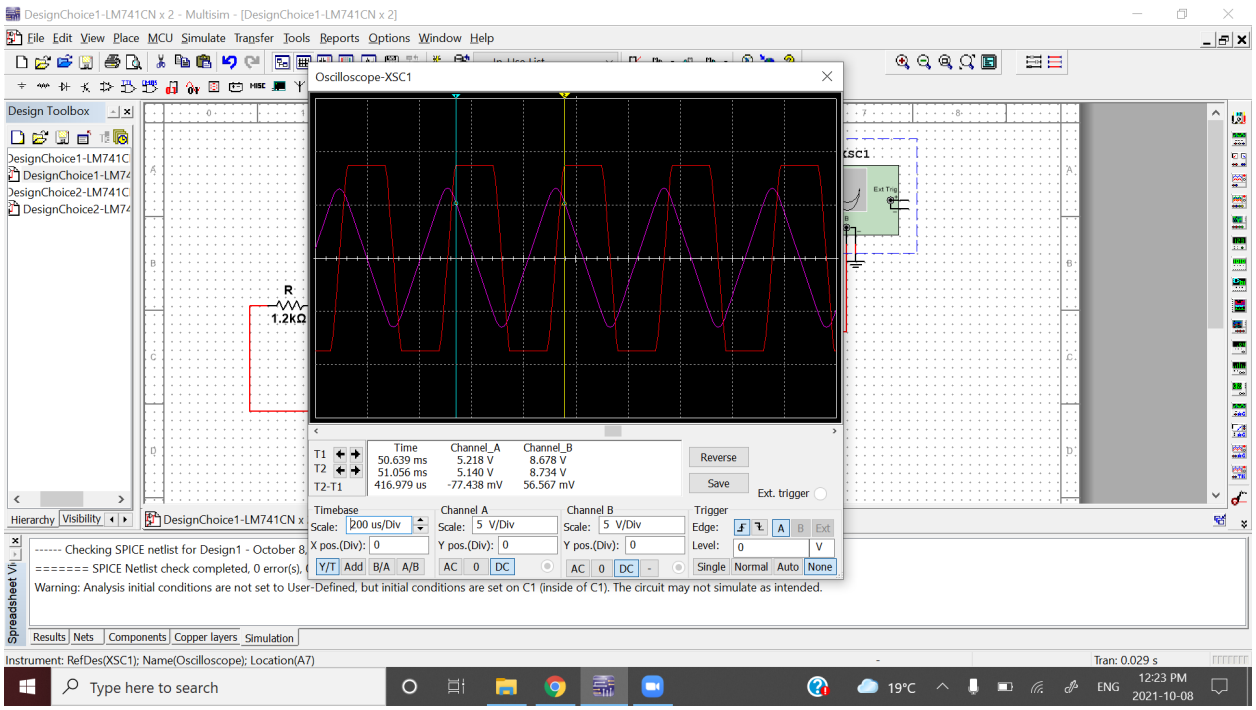

Figure 4.2: Multisim schematic of FFWG with two LM741CN OP-AMPs - part 2.

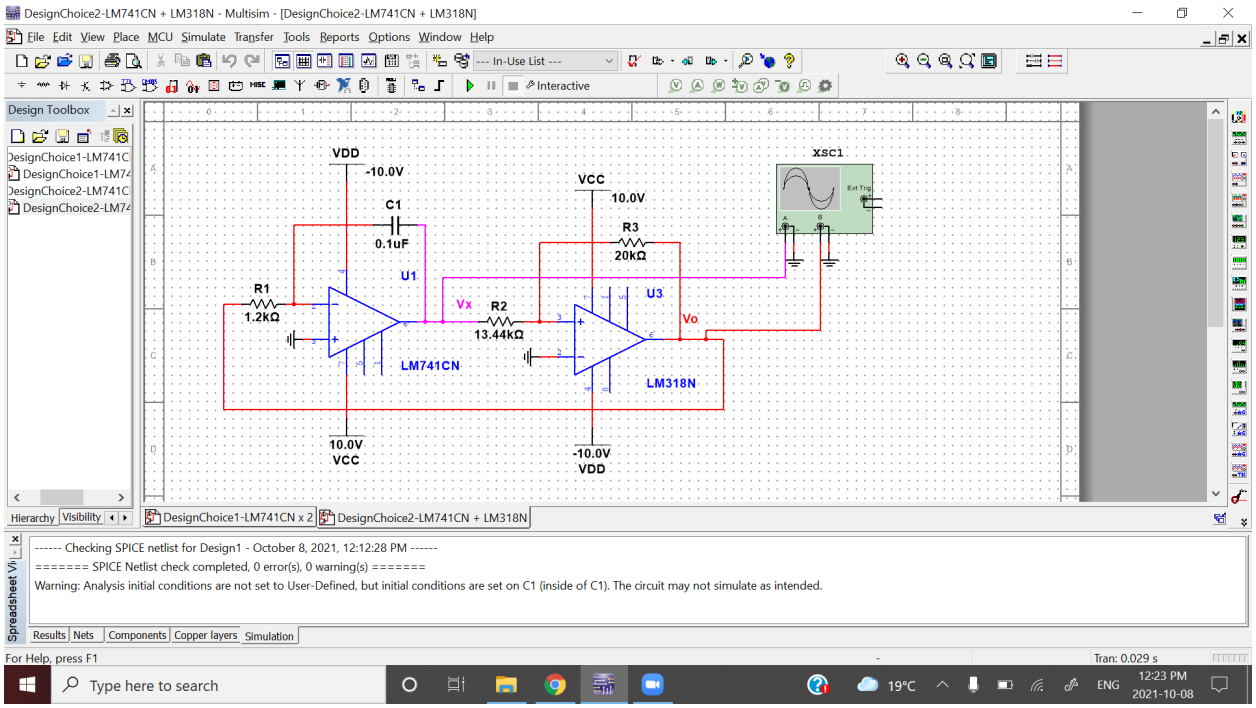

Figure 4.3: Multisim schematic of FFWG with one LM741CN and one LM318N OP-AMP - part 1.

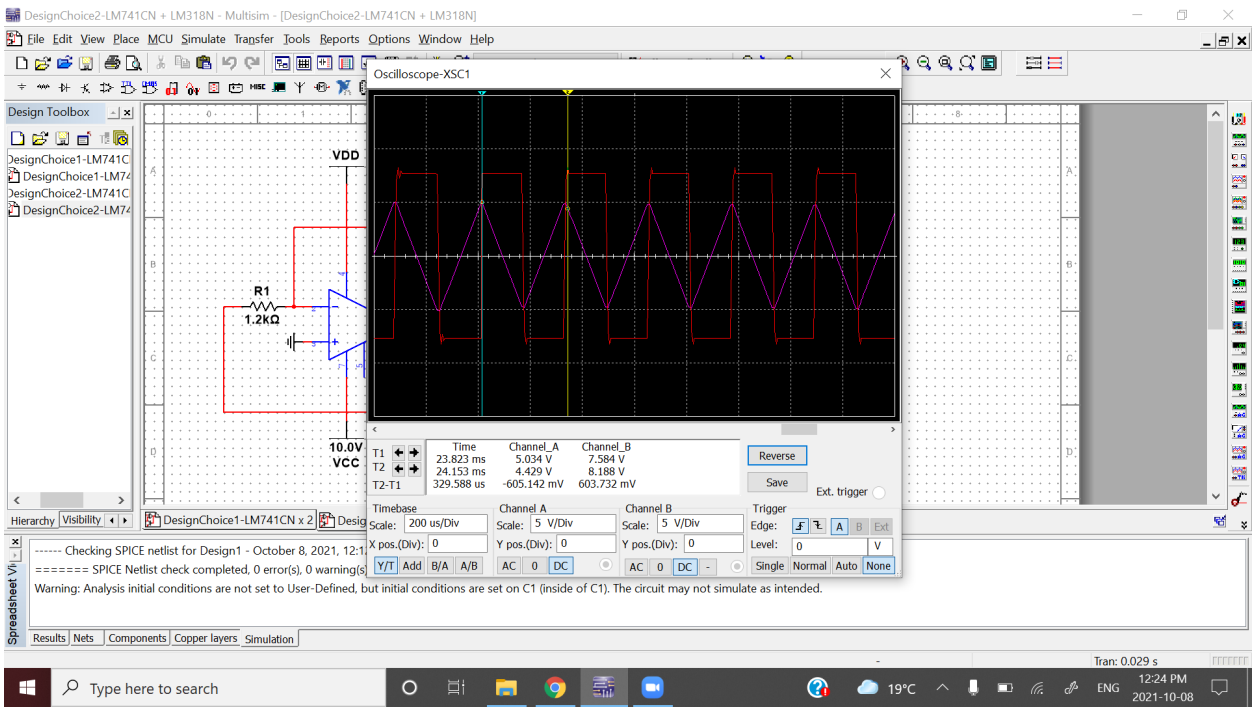

Figure 4.4: Multisim schematic of FFWG with one LM741CN and one LM318N OP-AMP - part 2.

5. Conclusions and Remarks

When comparing the theoretical (Prelab assignment) and the experimental (Multisim) results of this experiment, the results appear to be very consistent for the most part, with slight variation. The first design choice has a major issue with regards to the waveforms and the frequency, as the frequency measured is far off of the assigned parameter (3100 Hz) and the output voltage waveform is not as straightly shaped like the desired waveform from the Prelab assignment. The second design choice, however, the frequency measurement is much closer to the provided parameter for this milestone and the waveform for output voltage looks much more clear and straightly shaped like the expected waveform from the Prelab assignment. Therefore, through the validation process of this report, it has been decided that the final design for this milestone is the second circuit, with one LM741CN and one LM318N OP-AMP being used respectively for the inverting integrator and the noninverting bistable multivibrator.