Spring 2021

Senior Design Mini Project Proposal

Signal Generator “Squáreinator”

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Team 11

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Summary

This mini project will create a simple, robust and modular signal generator that can supply a constant square wave output. Using a 555 timer and an LM339 comparator, this signal generator will be able to output square wave signals ranging various frequencies at 3 unique logic voltage levels. The signal generator circuit will be initially tested in a Spice simulator and implemented on a two layer PCB with CAD tools. This project adheres to all criteria for the EE 496A mini project.

Project Description and Block Diagram

The circuit will comprise 3 main parts that need design consideration, a 555 timer, resistor divider network and LM339 comparator array. All parts of the signal generator will use a standard 9V battery as a bus supply. Firstly, as seen in the left of the diagram below, a 555 timer will be configured in the astable mode to create a 7V square wave output. The frequency of this square wave signal will be determined by an RC time constant that can be modulated using a potentiometer from 10Hz to 1kHz. The output of the 555 timer will feed the inverting terminal of 3 separate LM339 comparators. The non-inverting terminal of these comparators will be biased using a resistor divider network to 1.8V, 3.3V and 5V respectively. To avoid output chatter, all three LM339 comparators will utilize a feedback resistor to induce hysteresis at the bias input of each comparator. The resulting output of this circuit will be 3 unique level shifted square wave signals. All three parts of the circuit described above will have output pin headers to examine and diagnose each part individually.

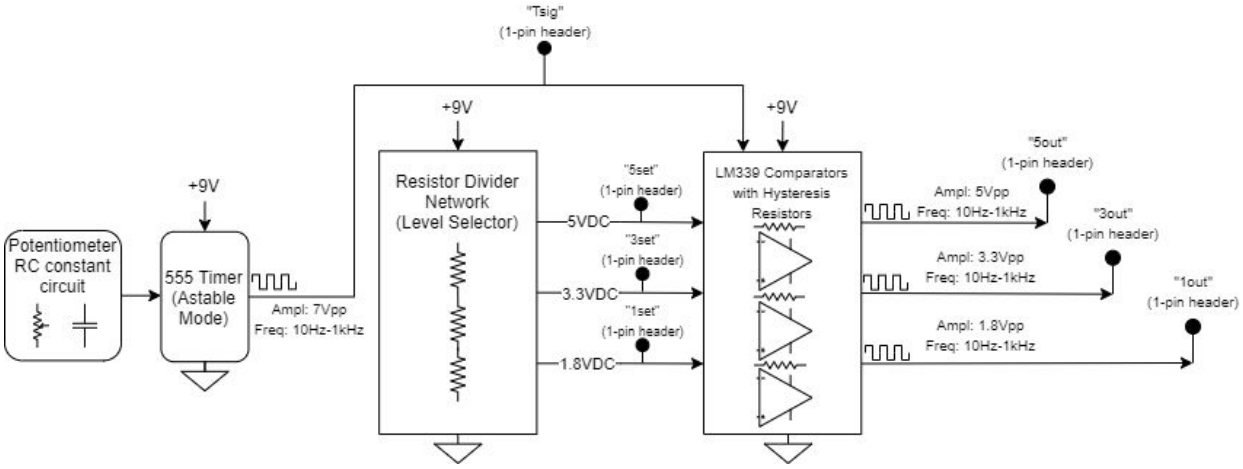

Figure 1: Block Diagram of Circuit Function

Specifications and Validations

Specification #1: With an input voltage between 8.7V and 9.2V, the device shall meet all performance specifications and draw no more than 5mA.

Validation #1: Using a multimeter we will measure the 9V bus and verify the input voltage and current at both 10Hz and 1kHz.

Specification #2: The signal generator should be able to output a square wave signal with ranging frequencies between 10Hz-1kHz set by an adjustable potentiometer.

Validation #2: By connecting an oscilloscope at the “Tsig” test-point at the input of the comparator, we will validate the required output as specified.

Specification #3: Non inverting bias voltages shall be within working ranges of 4.9 - 5.1v , 3.2 - 3.4 v, and 1.7 - 1.9 v.

Validation #3: Using a digital multimeter at test points “5set”, “3set” and “1set”, we will measure and verify the non-inverting bias voltages working within their specified range.

Specification #4: Circuit shall generate three separate digital logic voltage levels at 1.8V, 3.3V and 5V at a desired frequency.

Validation #4: Using an oscilloscope at test points “5out”, “3out” and “1out”, we will measure and verify the frequency and amplitude of each generated waveform at the output.

Satisfaction of Course Requirements

Requirement	Our Solution
Project completed with the team	We have a 5 person group. This is further elaborated in the “Team Skill Assessment” section.
Performs a testable operation	By connecting an oscilloscope to the output of the LM339, our generated output will show a square wave proportional to our resistor divider voltage.
Has an analog component	Circuit utilizes LM339 comparators.

Has a digital IC	Circuit utilizes a 555 digital IC
Budget under $15	Total cost of parts does not exceed $15 as shown in Table 2
Has at least one PCB connector	PCB will utilize a 9V battery clip for power input and several single-pin headers for test points
Has four mounting holes in a rectangle	4 mounting holes at each corner of the PCB board will be included in our PCB draft.

Table 1: Satisfaction of Course Requirements

Team Skill Assessment

This project requires knowledge of how all components can be used and to work together efficiently in order to create our project; specifically, the LM339 comparators, the NE555 timer, capacitors, and resistors. The project also requires knowledge of LTSpice, KiCAD, operating oscilloscopes and DMMs, and soldering.

Omar - Good knowledge of communication signals. Can do KiCAD and Matlab. Will learn more about LM339 and NE555. Needs more practical experience.

Hannah - Well versed with digital logic circuits. Will be in charge of designing the NE555 timer's frequency using the RC and potentiometer components.

Justin - Conducting research and information gathering on the LM339 comparator, its possible uses, and applications regarding the other components used in our project. Has experience using LTSpice, Verilog HDL, operating oscilloscopes and DMMs, and soldering, with minimal experience using KiCad.

Daniel - Experience using test equipment and well equipped for schematic design. Experience using LTspice, and matlab for frequency response calculations.

Cade - Proficient in circuit design, LTSpice and KiCAD and has system level knowledge of all components involved. Will be orchestrating integration of individual components and assembly. Understands how to use an oscilloscope and multimeter and how to test a circuit for deficiencies.

This project's biggest challenge will be designing the induced hysteresis effect without improperly loading the circuit. Utilizing LTSpice and provided Matlab scripts, we are confident our team will be able to design around these issues and build a working circuit. Our team consists of many different backgrounds and demonstrates the ability to apply our knowledge in order to complete the project efficiently. While there may be the

need to do research on minor things, along with revisiting specific topics or skills, we believe that the team can manage and execute this project in order to meet all specifications.

Cost

Part	Price
NE555P Timer IC	$0.45 (1)
LM339	$0.43 (1)
Cap 10nF	$0.14 (2)
BAT 9V	$2.13 (1)
Potentiometer	$0.76 (1)
9V Battery Clip	$0.55 (1)
PCB Manufacturing (Campus Print)	$0.00
TOTAL	$4.60

Table 2: Total Cost of all Purchased Parts

Customer Sign-off Sheet

Specifications	Validations	Date of Validation
With an input voltage between 8.7V and 9.2V, the device shall meet all performance specifications and draw no more than 5mA.	Using a multimeter we will measure the 9V bus and verify the input voltage and current at both 10Hz and 1kHz.	Date: _____
The signal generator should be able to output a square wave signal with ranging frequencies between 10Hz-1kHz set by an adjustable potentiometer.	By connecting an oscilloscope at the “Tsig” test-point at the input of the comparator, we will validate the required output as specified.	Date: _____
Non inverting bias voltages shall be within working ranges of 4.9 - 5.1v , 3.2 - 3.4 v, and 1.7 - 1.9 v.	Using a digital multimeter at test points “5set”, “3set” and “1set”, we will measure and verify the non-inverting bias voltages working within their specified range.	Date: _____
Circuit shall generate three separate digital logic voltage levels at 1.8V, 3.3V and 5V at a desired frequency.	Using an oscilloscope at test points “5out”, “3out” and “1out”, we will measure and verify the frequency and amplitude of each generated waveform at the output.	Date: _____

Table 3: Summary of Specifications and Validations along with Date of Validation

This project has successfully demonstrated and met all requirements for all specifications:

Signature: _____ Team: _____ Date: _____