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PROJECT REPORT
STYLUS CONTROLLED SYNTHESIZER

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ABSTRACT :

This project highlights the creation of a stylus-controlled analog synthesizer constructed completely on a breadboard without the use of any microcontroller. Employing potentiometers as voltage dividers and a stylus for direct signal selection, it drives a 555 timer-based oscillator to produce variable tones. Emulating a voltage-controlled oscillator (VCO), the circuit illustrates major concepts of analog electronics and frequency modulation. Though with fewer components, the system clearly demonstrates analog signal modulation, selection, and sound synthesis and hence serves as a mini and tutorial device for studying analog communication principles.

INTRODUCTION :

This project captures the creation of the design and development of a stylus-controlled analog synthesizer entirely constructed on a breadboard and without the utilization of any microcontroller. Based on the idea of voltage-controlled sound production, the synthesizer illustrates basic principles of analog electronics and analog communication systems [2]. The central mechanism employs potentiometers as variable voltage dividers with each producing a different control voltage [4]. These voltages are brought out via a line of contact pads, whereby a stylus - attached to the threshold pin of the 555 timer - is employed to select and direct a particular voltage into a 555 timer-based oscillator circuit manually [3].

The chosen control voltage varies the frequency of the resulting output waveform from the 555 timer, producing varying audible sounds when the signal is played on a speaker [2]. This reproduces the action of a voltage-controlled oscillator (VCO), a core element of analog synthesizers and frequency modulation (FM) systems [6]. The stylus itself serves as a real-time manual analog multiplexer, switching among continuous analog signals [5].

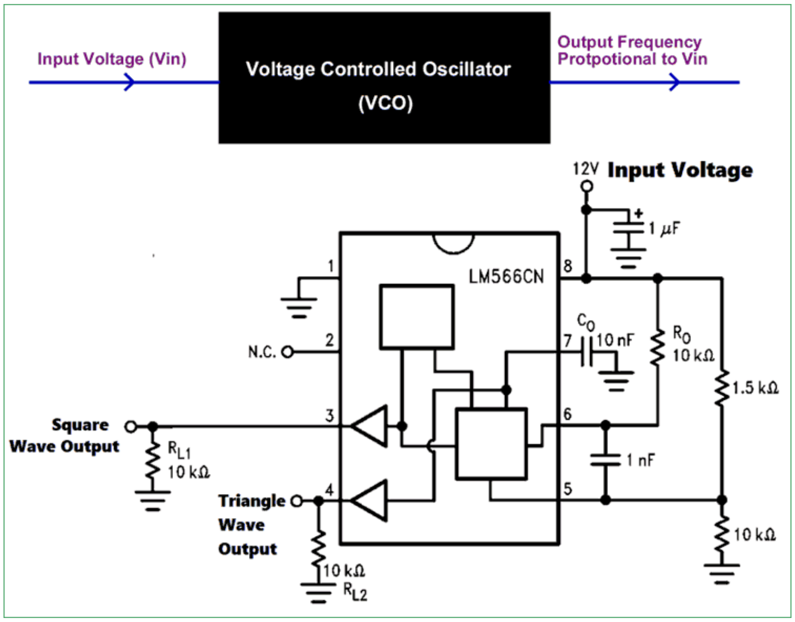

Figure 1 : Voltage Controlled Oscillator

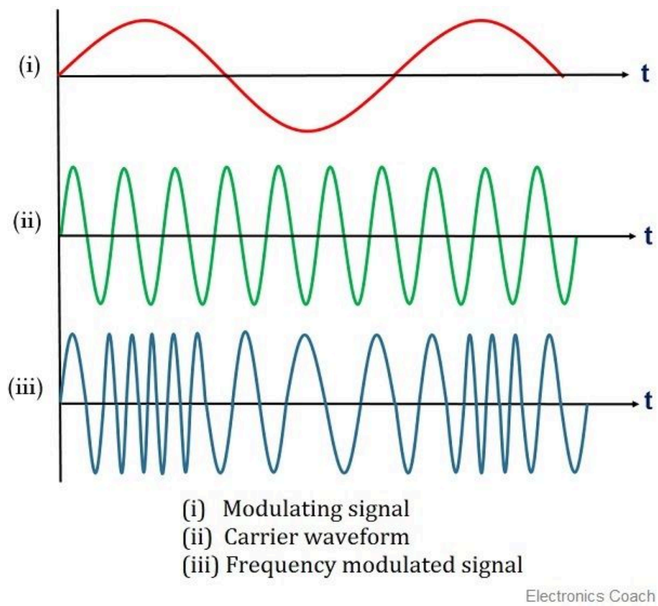

Figure 2 : Waveform comparison of a modulating signal, a carrier signal and a frequency modulated signal.

By minimizing components in the hardware prototype - i.e., employing three 4.7kΩ potentiometers rather than 25 - the project is configured to accommodate spatial limitations within a breadboard without sacrificing central functionality. As an outstanding tutorial tool, the synthesizer is an ideal demonstrator of analog voltage control, frequency modulation, and manual selection of signals, connecting practical circuit design to communicative theory concepts [3] [6]. It provides a hands-on introduction to how analog systems can be applied to create and modulate signals in an uncomplicated yet efficient manner, independent of digital processing [6].

METHODOLOGY :

The project inspiration that was considered had the circuit built on a customized PCB with 25 different notes using 25 potentiometers [1].

The project prototype was designed through a sequence of formal steps to achieve a working stylus-controlled analog synthesizer employing passive and active components alone on a breadboard. The approach is outlined below :

System Design
The design as a whole was focused on employing a stylus to manually pick input voltages from an array of potentiometers, which in turn would drive a 555 timer-based oscillator circuit. The goal was to create a minimal, hands-on analog interface for real-time sound generation and modulation without the use of a microcontroller.

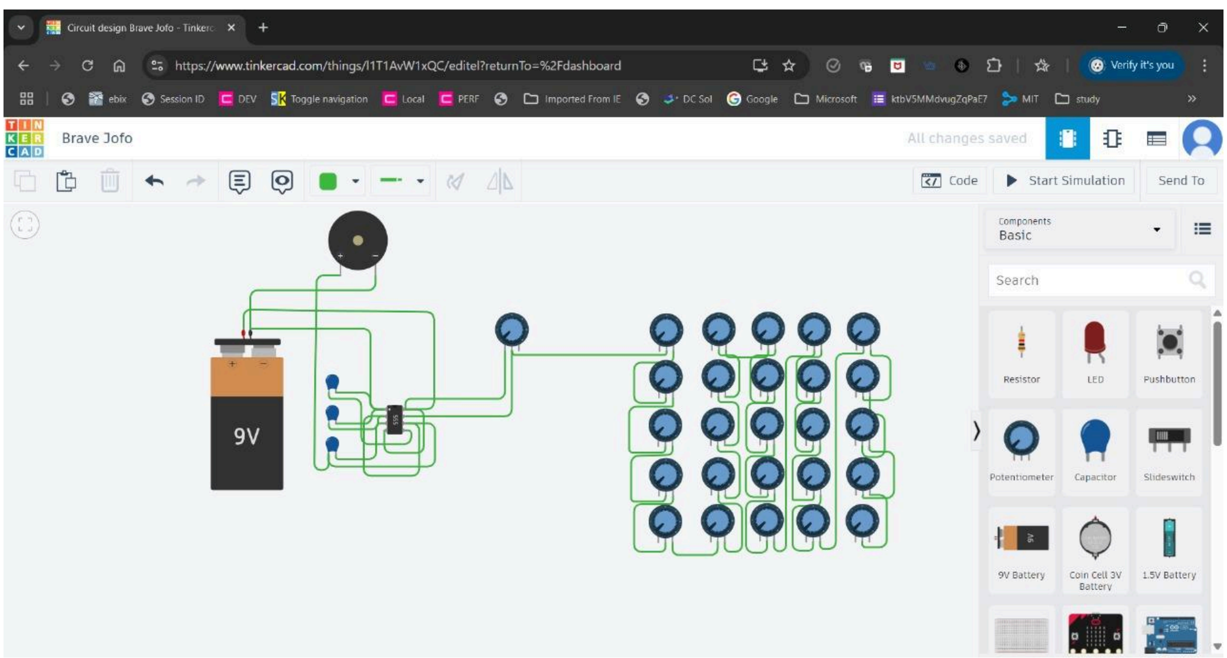

Figure 3 : Circuit Diagram on TinkerCad
https://www.tinkercad.com/things/l1T1AvW1xQC-acs-project-?sharecode=s4vTAFNl uClhd_HBU650Ax5Mm_6PkHHxlmnkJ2VSgnQ

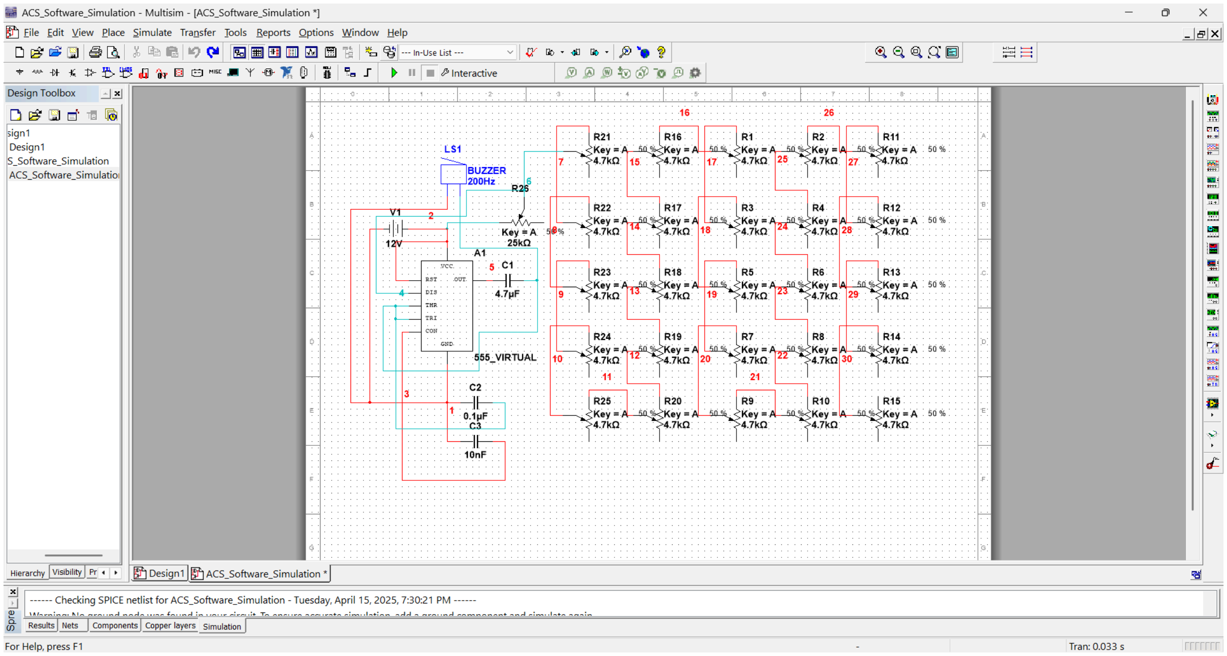

Figure 4 : Circuit Diagram on Multisim

Component Selection

A 555 timer IC was chosen as the central part of the oscillator because of its simplicity and flexibility in creating square wave outputs. Three potentiometers with a value of 4.7kΩ were utilized to supply variable voltages, which could each be used to impact the behavior of the oscillator. A buzzer or speaker acted as the sound output. More components like capacitors and resistors were also added to establish the timing properties of the oscillator and to ensure correct voltage directing.

Sl. No.	Component Used	Quantity
1.	9V Power Supply	1
2.	555 Timer	1
3.	10nF Capacitor	1
4.	4.7uF Capacitor	1
5.	0.1uF Capacitor	1
6.	25k Ohm Potentiometers	1
7.	4.7k Ohm Potentiometers	25 (3 used for demonstration

		in the hardware prototype)
8.	Piezoelectric Buzzer	1
9.	Connecting Wires	As per requirement

Figure 5 : Components Required for the circuit

Circuit Implementation

The whole circuit was built on a breadboard. The potentiometers were configured as voltage dividers and their wiper pins left out on individual contact pads. The stylus, whose connection to the power rail had a resistor, was used to touch the pads, hence selectively choosing one voltage at a time. The selected voltage was routed to the timing input of the 555 timer, varying its output waveform frequency, which was routed to a speaker.

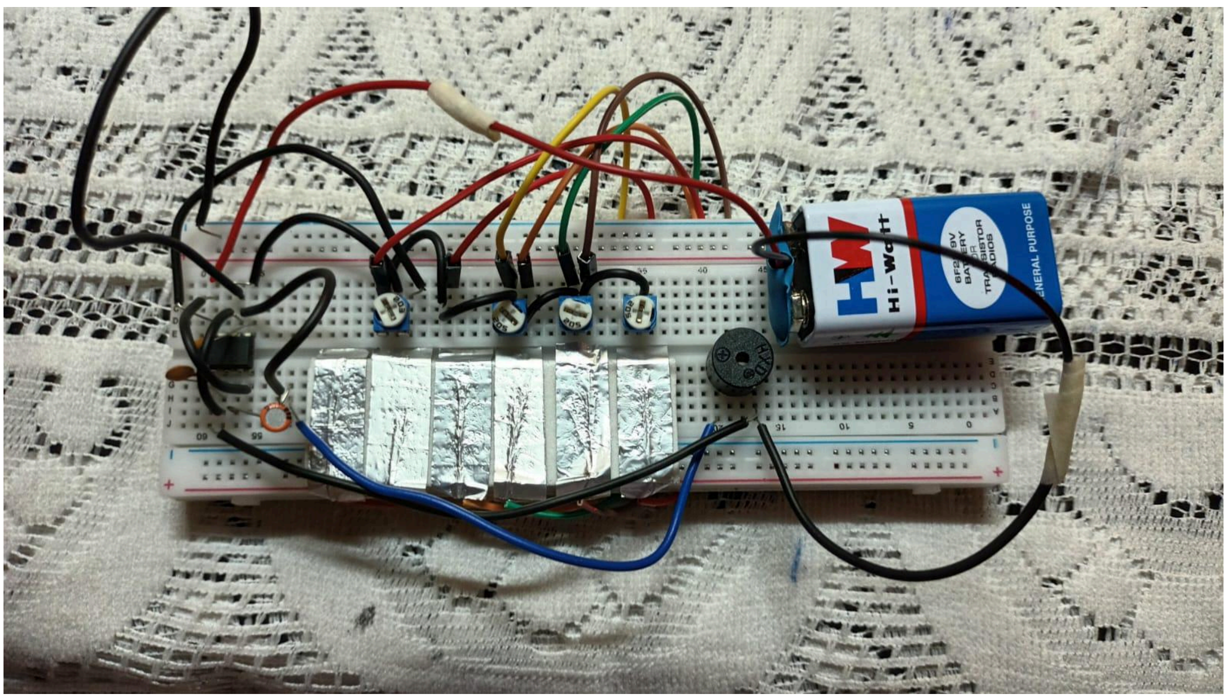

Figure 6 : Hardware Set-up of the Project

Testing and Calibration

The synthesizer was tested by varying the contact points with the stylus and adjusting the potentiometers to change pitch and tonal characteristics. The voltage ranges were iteratively adjusted to generate clear, audible tones over a musically useful range. Although only three potentiometers (for space reasons) were employed, the configuration had enough variation in sound.

Future Scope
Future improvements like adding waveform shape switches, envelope shaping, or filtering stages were suggested for future implementations. This analog synthesizer provides a solid platform for building upon more intricate sound synthesis endeavors.

HARDWARE SET-UP :

The hardware component selection in this stylus-controlled analog synthesizer was done with the rules of simplicity, availability, and breadboard-friendliness guiding the process. The main aim was to construct a working analog sound generator capable of illustrating voltage-controlled audio synthesis without requiring microcontrollers or digital control. (Refer to *Figure 6* in order to compare and identify the used components)

555 Timer IC :
The 555 timer was selected as the central oscillator because of its dependability and flexibility in generating square wave outputs in astable mode. It is easily modulated in its frequency response using resistance and capacitance changes, which makes it well-suited for voltage-controlled sound generation.

Potentiometers (3 x 4.7kΩ) :
The sound's pitch and tonal variation was controlled by three potentiometers that acted as variable voltage dividers. Despite the design requiring four, physical space constraints resulted in three being utilized, which was still enough for functional demonstration.

Potentiometers (25kΩ) :
The 25kΩ potentiometer is placed in the timing part of the 555 timer oscillator, and it determines the frequency of the output wave-form directly, and hence also the pitch of the sound.

Buzzer (as Audio Output) :
A piezoelectric buzzer was employed instead of a conventional speaker because it is small and easy to integrate with low-power circuits. It was used to sound out the output signal from the 555 timer, essentially converting frequency changes into audible tones.

Passive Components :
Conventional resistors and capacitors were employed for defining the timing parameters of the oscillator circuit and for simple signal conditioning.

Stylus (Conductive Probe) :

A basic conductive probe, known as the stylus, was attached to the positive voltage rail via a current-limiting resistor. This was applied to manually tap contact points corresponding to the wipers of potentiometers, essentially directing control voltages into the oscillator.

This choice of components kept the circuit simple, low in cost, and entirely analog, yet still allowed for real-time sound control and variation.

RESULTS AND DISCUSSION :

The analog synthesizer controlled by a stylus was successfully built and tested on a breadboard with a minimal number of components, the most prominent being the 555 timer IC, three 4.7kΩ potentiometers, and a piezoelectric buzzer. The project met its fundamental goal: to show real-time analog sound synthesis without digital processing or microcontroller involvement.

Functionality and Output Behavior
Upon construction, the circuit generated a variety of audible sounds determined by user manipulation of the stylus. Upon bringing the stylus to touch various conductive points wired to the wiper terminals of the potentiometers, it directed varying control voltages into the timing network of the 555 timer. The voltages modulated the frequency of the output waveform of the oscillator. The sound thus produced, being emitted through the buzzer, changed pitch based on the voltage level chosen.

The three potentiometers provided a decent control of tonal change. The system provided audible frequency changes, and thus the synthesizer was dynamic and responsive. One potentiometer had its main effect on pitch, while the other two provided subtle tonal shaping and fine-tuning over the limited voltage span. The buzzer reacted as expected, providing clean square-wave tones that well matched the ideal behavior of a 555 timer in astable mode.

Analog Communication Principle in Action
The analog synthesizer excellently illustrated voltage-controlled oscillation, which directly relates to the frequency modulation (FM) phenomenon in analog systems of communication. By manually regulating voltages employing the stylus and potentiometers, one simulated the analog FM signal process of generating—analog input modulation of the carrier frequency. Here, the 555 timer implemented a reduced-circuit voltage-controlled oscillator (VCO), the key element common to both the synthesizers as well as to analog transmitters.

In addition, the stylus was a manual analog multiplexer, choosing between continuous voltage levels. This type of signal routing, even if manual here, is indicative of fundamental concepts in signal processing, where control voltages or modulating signals are switched or mixed dynamically to determine system output.

Testing and Calibration Insights

Under testing, the circuit showed a consistent and stable response to potentiometer position changes. Potentiometer wiper adjustments caused expected pitch changes, verifying correct voltage control behavior. A little calibration was required to make sure that the useful voltage range was within limits that enabled the 555 timer to oscillate properly. At extremely high or low resistance levels, the circuit would cease to oscillate or generate inaudible sounds.

The buzzer, substituted for a full-range speaker, was a workable and space-saving solution for output. Though it did not have the frequency range and tonal richness of a specialized audio speaker, it was adequate for convincingly communicating pitch changes and confirming the operation of the circuit.

Limitations and Challenges

One limitation was the use of only three potentiometers, which limited the range and diversity of tones that could be produced slightly in comparison with the full 25-potentiometer version. Nevertheless, with proper tuning, the circuit still provided a pleasing range of audio responses. Also, since the system is all-analog and does not have digital stability, output frequencies might drift a little because of temperature or component tolerances.

Another problem was maintaining clean contact between the stylus and the conductive pads. Inadequate contact might result in inconsistent or intermittent tones, highlighting the importance of secure wiring and solid physical components.

In order to visualise the circuit with 25-potentiometers and different notes, an online simulation of the same has been uploaded on a drive link attached in the report.

Our take on the project

The online project that was used for reference suggested that the project is not breadboard friendly but for the prototype it has been replicated on a breadboard. It is also cost effective and easier to construct when compared to the original idea.

The working of the project on the hardware setup and the software simulation have been added to the following Google Drive link :
https://drive.google.com/drive/folders/1nVebQmPEqNN9uUbV3C1_Y0J2ok6qVM9x?usp=drive_link

CONCLUSION :

The stylus-operated analog synthesizer project effectively illustrated the potential to produce a working sound-generating circuit from simple electronic parts without involving digital systems or microcontrollers. By applying a 555 timer IC, potentiometers, and a buzzer, the system generated variable tones dependent on user-controlled control voltages. The project was a hands-on investigation of voltage-controlled oscillation and analog frequency modulation concepts. In spite of limited hardware and space, it was able to demonstrate real-time analog sound synthesis and manual signal control and thus is a useful teaching tool in learning basic concepts of analog electronics and communication.

REFERENCES :

1. For the idea, the inspiration was taken from this project available online : https://www.allaboutcircuits.com/projects/create-your-own-stylus-controlled-synthesizer/

2. Study of Timer IC 555 : https://www.me.psu.edu/cimbala/me345/Lectures/The_555_Timer_IC.pdf?utm_source=chatgpt.com
   Authors: S. P. Jadhav, S. S. Jadhav
   Published: 2021
   Summary: This paper elaborates on the operational modes of the 555 timer IC, including astable, monostable, and bistable modes. It discusses the IC's applications in various electronic circuits, emphasizing its role as an oscillator and timer.

3. Fifty Years of the 555 Timer – A Tribute from a Didactic IC Design Perspective : https://www.researchgate.net/publication/373820294_Fifty_Years_of_the_555_Timer_-_A_Tribute_from_a_Didactic_IC_Design_Perspective?utm_source=chatgpt.com
   Authors: Estevão Teixeira et al.
   Published: 2023
   Summary: This article commemorates the 50th anniversary of the 555 timer, discussing its enduring popularity and versatility in electronic design. It provides insights into the IC's design and its applications in educational contexts.

4. The Potentiometer : https://www.researchgate.net/publication/243715606_The_Potentiometer

Author: Thomas B. Greenslade, Jr.
Published: 2023
Summary: This article traces the historical development of the potentiometer, explaining its original purpose as a device for measuring electric potential differences and its evolution into a variable resistor used in modern electronics.

5. Principles, Current Practice, and Applications of Potentiometers Based on Poggendorff's Second Method : https://www.researchgate.net/publication/373820294_Fifty_Years_of_the_555_Timer_-_A_Tribute_from_a_Didactic_IC_Design_Perspective
Author: R. F. Dziuba
Published: 1967
Summary: This research article delves into the principles and applications of potentiometers, particularly focusing on their use in precise voltage measurements and standardization techniques.

6. An Imprint of IC 555 Timer in the Contemporary World : https://www.ijeat.org/wp-content/uploads/papers/v4i6/F4137084615.pdf?utm_source=chatgpt.com
Author: Nanditha Nandanavanam
Published: 2015
Summary: This paper discusses the fundamental principles of the 555 timer IC, its working mechanisms, and its widespread applications in modern electronic circuits.