HANDOUT 1

1. The hex inverter - can you make it make a sound?

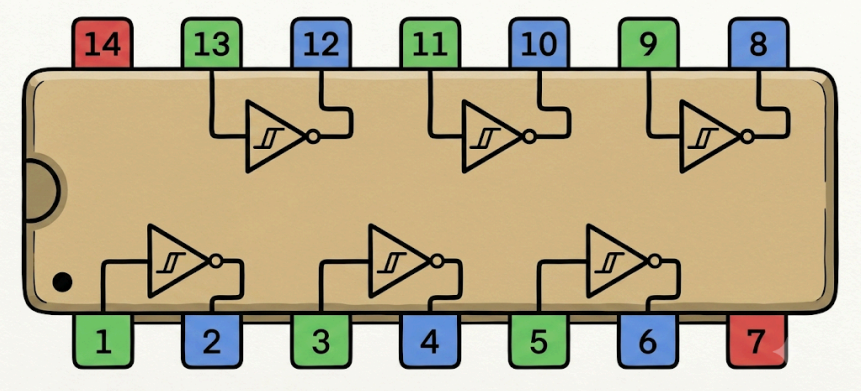


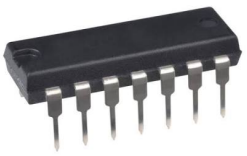
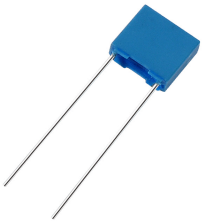
Figure 1.1 The hex inverter chip, pin setup

Pin #	Function & Explanation	Input / Output Behavior
1, (3, 5, 9, 11, 13)	**Inverter Inputs** Receives control voltage/feedback to flip the gate state.	**Input LOW** → Output goes HIGH (+9V) **Input HIGH** → Output goes LOW (0V)
2, (4, 6, 8, 10, 12)	**Inverter Outputs** Emits the flipped signal; primary node for audio output and feedback loop.	**High (+9V)** when matching Input is LOW **Low (0 V)** when matching Input is HIGH
7	**GND (Ground)** System 0V reference.	Connects to the negative battery terminal.
14	**VDD (Power)** Main power supply (+3V to +15V).	Connects to the positive (+9V) battery terminal.

Task 1: Make a sound

Use the elements - resistor, capacitor, 40106 chip, amplifier and loudspeaker, to make a sound. *Focus on the pin 1 and 2 of the 40106 chip.*

Elements

40106 chip 	**40106 Inverter (The Opposite Switch & Delay)** • **Inverter:** Flips signals. High input (+9V) becomes Low output (0V); Low input becomes High output. • **Schmitt Trigger:** A built-in delay. It waits until voltage hits a high or low threshold before flipping, giving electricity time to build up or drain.
Resistor 	**Resistor (The Brake)** • Squeezes electrical flow like a narrow pipe. • Small resistor = fast flow. Large resistor = tiny trickle.
Capacitor 	**Capacitor (The Bucket)** • Stores and dumps electrical energy. • Small capacitor = fills/empties fast (shot glass). Large capacitor = fills/empties slow (water bucket).

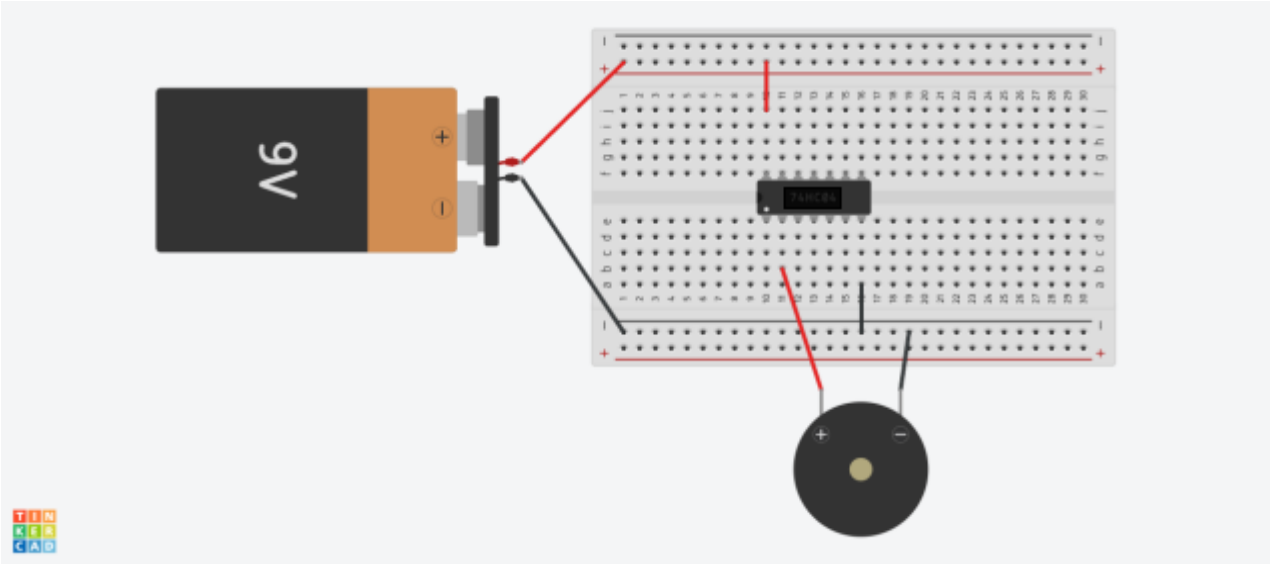
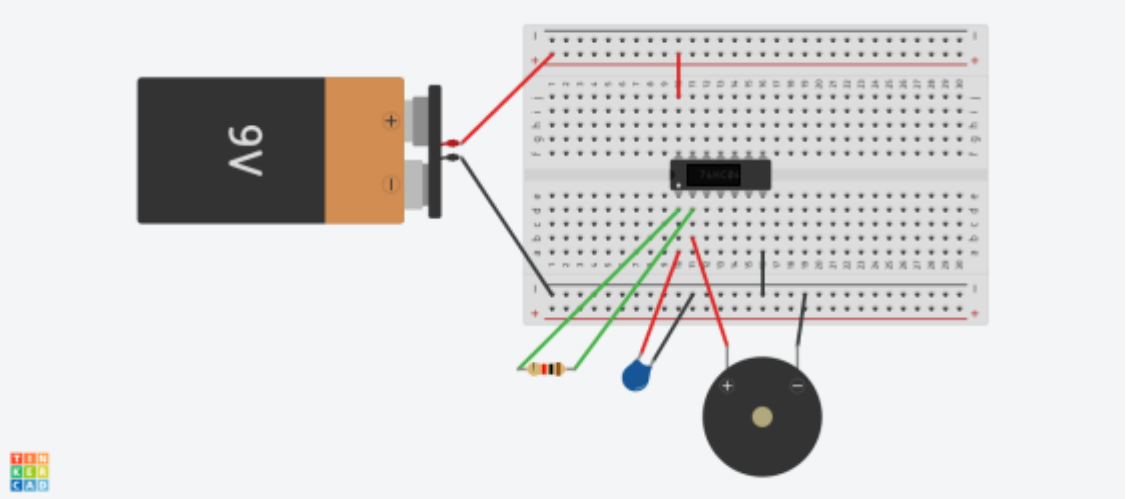


Fig. 1.2 Basic setup. Breadboard + battery + 40106 + speaker.

HANDOUT 2

1. The VCO (voltage controlled oscillator)



- Put one leg of the resistor at the input 1; the other leg at the output; This creates a loop between the two, resulting in a very very high pitched oscillation. Maybe bats can hear it.
- Put one leg of the capacitor at the input 1, the other leg to ground. This slows down the oscillation and brings it into the range of human hearing.

Task 2: Pitch variations

Use different resistors and capacitors and test out different combinations.
Note the resulting pitch.

Resistor / Capacitor				

Test combinations of resistor - capacitor, and note down the result in Hz (use a smartphone to analyse the pitch)

HANDOUT 3

Task 3: More oscillators

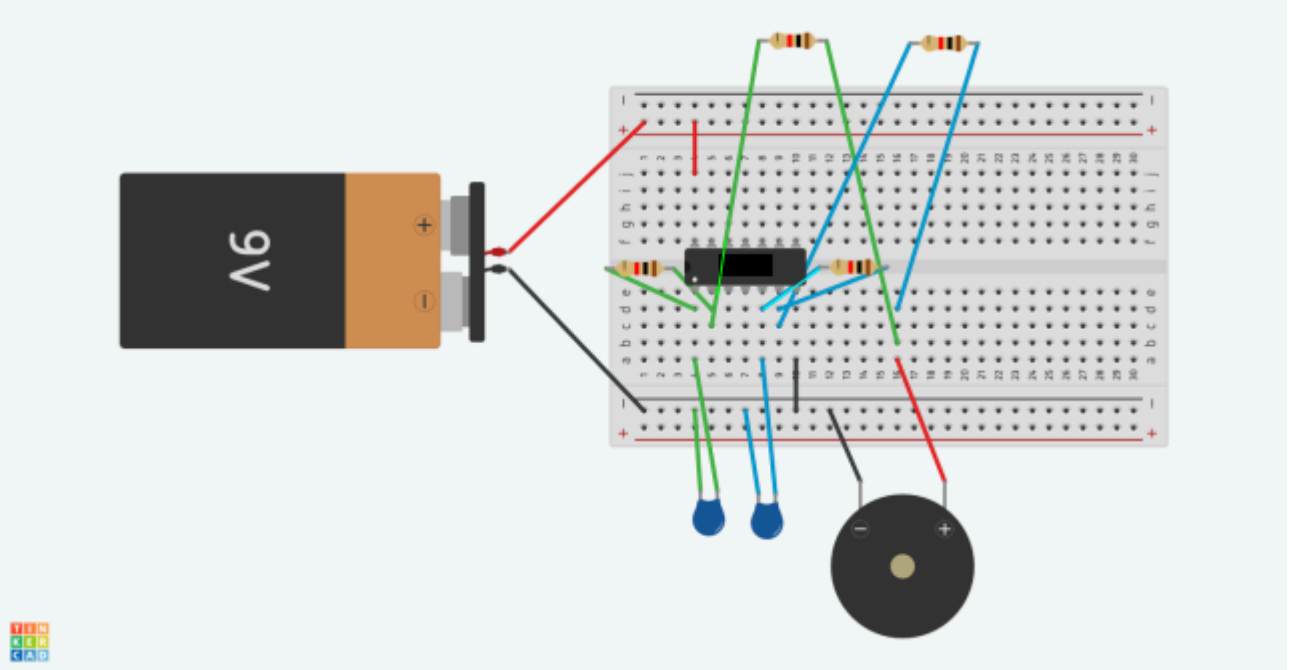
The 40106 chip has 6 individual in/out pairs. Now it's time to make more oscillators!
Try to combine them so you hear more than one pitch at a time!

Write down your combinations and their results:

Oscillator 1	Oscillator 2	Wiring	Result
combination of resistor + capacitor	*combination of resistor + capacitor*	*cables / fingers / resistors / capacitors*	*What do you hear?*

HANDOUT 4

- Two oscillators



In order to send the two oscillator outputs to one single audio channel, you need to use resistors. If you connect directly - what happens?

HANDOUT 5

Task 4: Photoresistors!! - Theremin(?)

With photoresistors, the range of possibilities explodes, and your synth becomes a sensitive instrument, responding super fast and faithfully to your finger's movements.

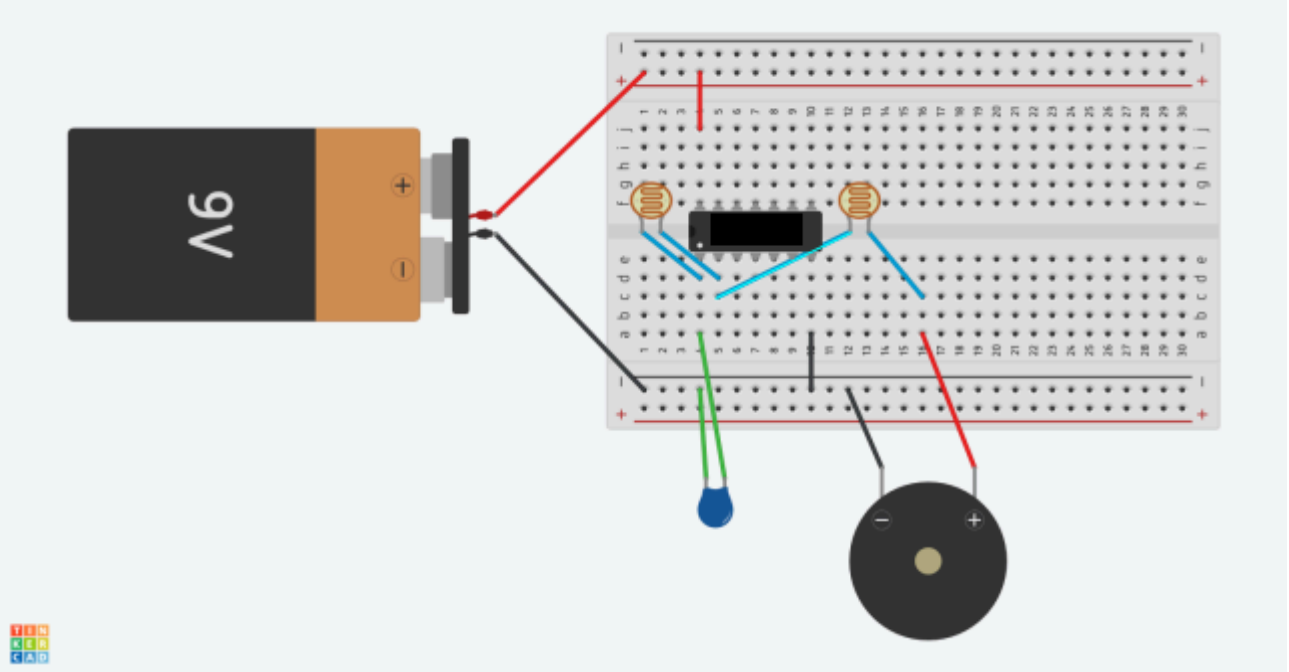
Can you use the photoresistors so you can control pitch and amplitude? What else can you come up with?

Write down your combinations and their results:

Oscillator 1	Oscillator 2	Wiring	Result
combination of resistor + capacitor	*combination of resistor + capacitor*	*cables / fingers / resistors / capacitors*	*What do you hear?*

HANDOUT 6

- The ‘theremin’



To be able to manually control the pitch and amplitude of the oscillator, you simply exchange the normal resistors with photoresistors. If you want to narrow the range of the photoresistors, you can add a normal resistor in parallel, that is, place the two legs of the resistor in the same place as the legs of the photoresistor.

APPENDIX A

COLOR	BAND 1 (1st digit)	BAND 2 (2nd digit)	MULTIPLIER (3rd digit)	TOLERANCE
Black	0	0	× 1	-
Brown	1	1	× 10	±1%
Red	2	2	× 100	±2%
Orange	3	3	× 1k	-
Yellow	4	4	× 10k	-
Green	5	5	× 100k	±0.5%
Blue	6	6	× 1M	±0.25%
Violet	7	7	× 10M	±0.1%
Gray	8	8	Not used	±0.05%
White	9	9	Not used	-
Gold			× 0.1	±5%
Silver			× 0.01	±10%

Four-band resistor color code chart

APPENDIX B

(For the facilitator: Cut out the cards and distribute, if needed)

Card 1: The Concept

The Endless Loop

Observation: A light switch turns on when you push it once. A speaker needs a signal that pushes back and forth hundreds of times a second.

Challenge: An inverter reverses whatever signal it gets. How can you make an inverter trigger *itself* over and over in an endless loop?

Card 2: The Speed Problem

Too Fast to Hear

Observation: If the inverter is constantly flipping itself, it happens in a fraction of a microsecond. Human ears can only hear sound vibrations between 20 and 20,000 times a second.

Question: How can you limit the rate at which charge reaches the input threshold so the cycle drops into an audible frequency?

Card 3: The Reservoir

Filling the Bucket

Observation: An inverter flips state in nanoseconds. A bare wire lets energy travel at full speed, causing the loop to cycle millions of times per second—far too fast for human ears to hear as sound.

Reflection: Which component acts as a constraint to slow down the rate at which energy flows back into the system?

Card 4: Tap the Signal

Where is the Voice?

Observation: Your engine might be running, but an engine needs an exhaust pipe to send its power out.

Challenge: Your amplifier needs to "hear" the flipping voltage. Which node on your chip actually emits the changing signal?