

Dual-Oscillator Digital Synthesizer on STM32-L432KC

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Introduction

Many synthesizers require expensive, complex hardware. Despite this, we built a dual oscillator digital synthesizer using the built-in DAC on the STM32-L432KC and an external speaker.

With 13 buttons, you can play notes from C4 to B4 and switch between oscillators A and B, as well as waveforms (square, triangle, sawtooth, and off) in real time.

Background

The STM32-L432KC's **digital-to-analog convertor** (DAC) converts 12-bit digital values into analog voltages. To use it, we enable the DAC clock, configure PA4 and PA5 as analog, activate the DAC via DAC_CR, write values to the 12-bit data register, and trigger conversions using a timer.

Custom wavetables feed samples into the DAC with timing delays based on note frequency. These signals drive a speaker. Notes are slightly out of tune due to timer imprecision.

Hardware

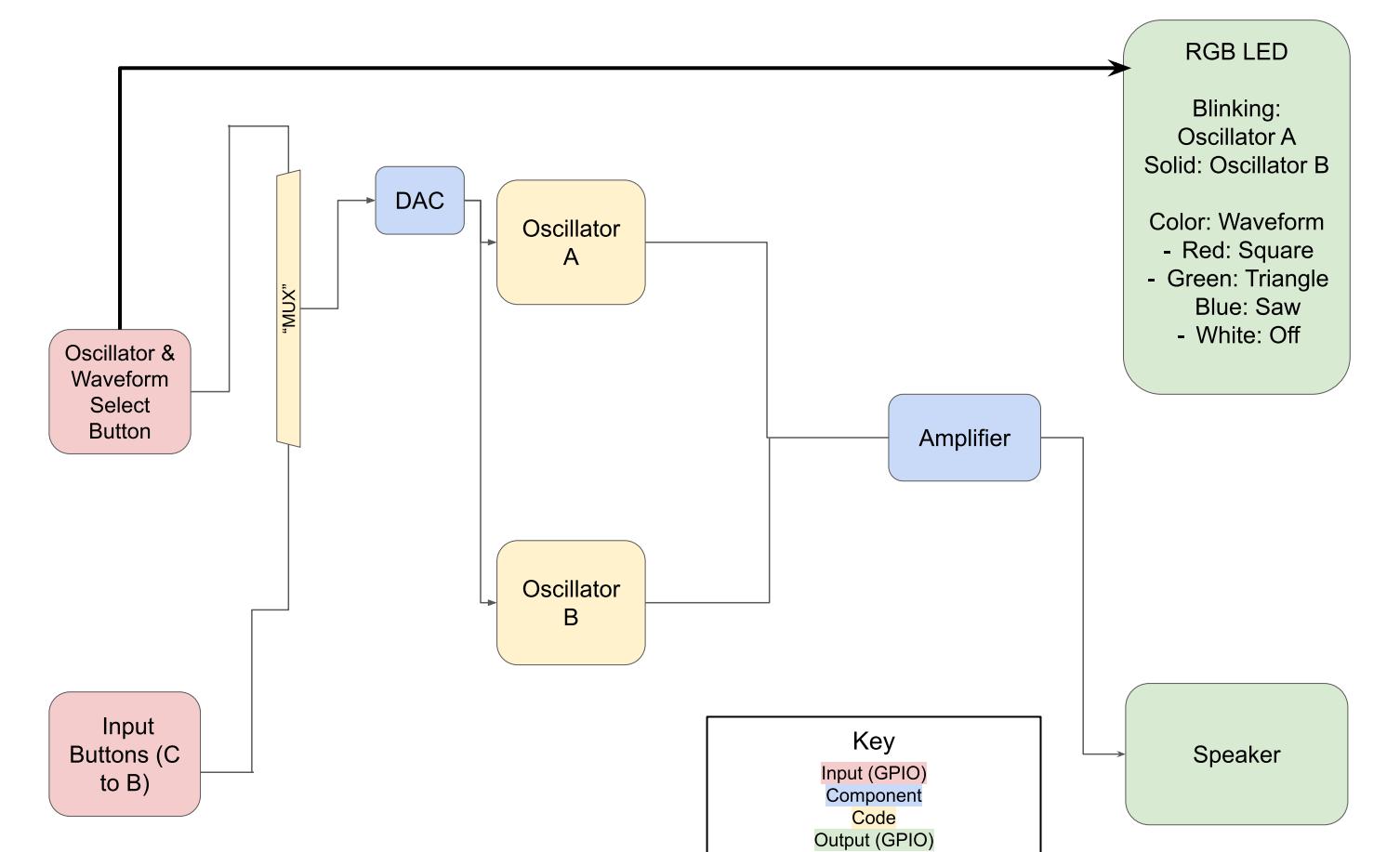


Figure 1: Hardware map of the synthesizer, including the oscillators, waveform selection buttons, RGB LED, DAC, and speaker.

Waveform Output

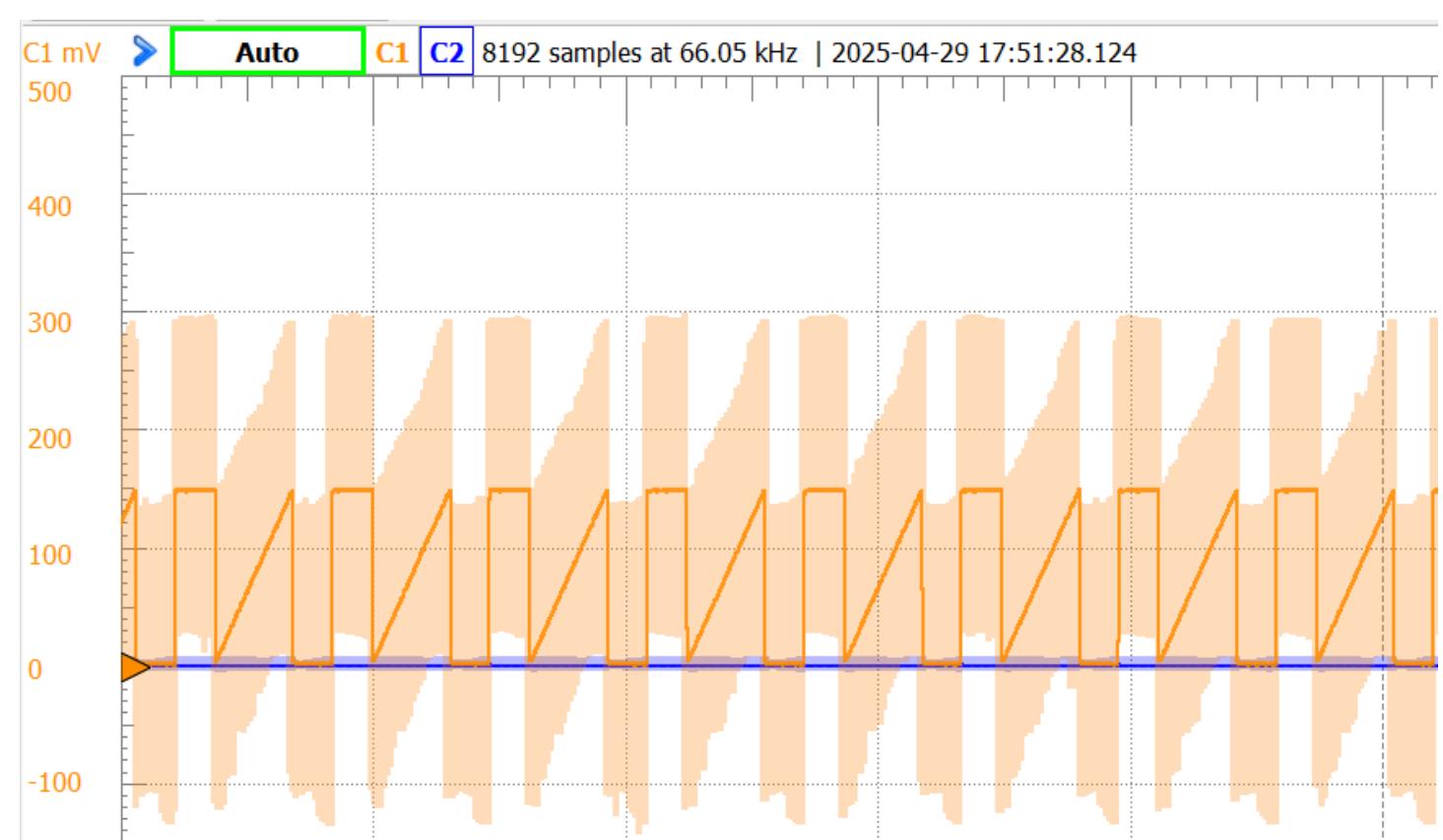


Figure 2: Combined output of oscillator A (square) and oscillator B (sawtooth). The DAC alternates samples from both oscillators.

Software

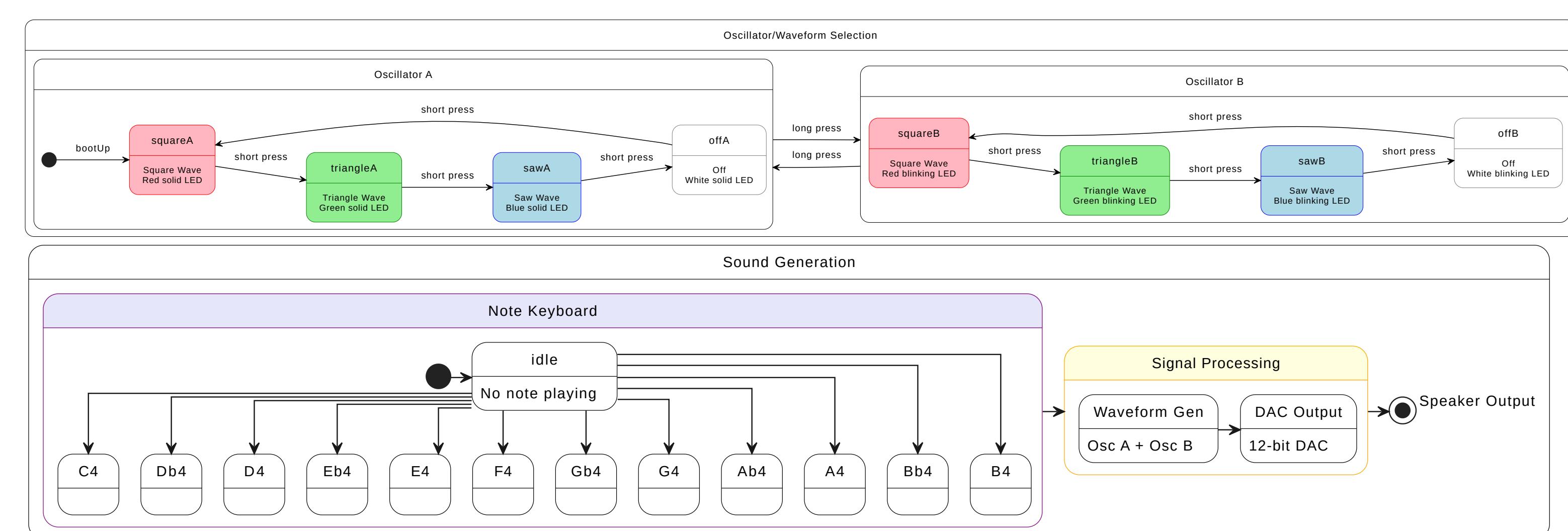


Figure 3: State machine showing oscillator and waveform selection in addition to sound generation logic.

Tutorial

The **RGB LED** indicates the current synthesizer configuration:

- **Hold mode button** to switch oscillators:
 - **Solid**: Oscillator A
 - **Blinking**: Oscillator B
- **Tap mode button** to cycle through current oscillator's waveform:
 - **Red**: Square
 - **Green**: Triangle
 - **Blue**: Sawtooth
 - **White**: Off

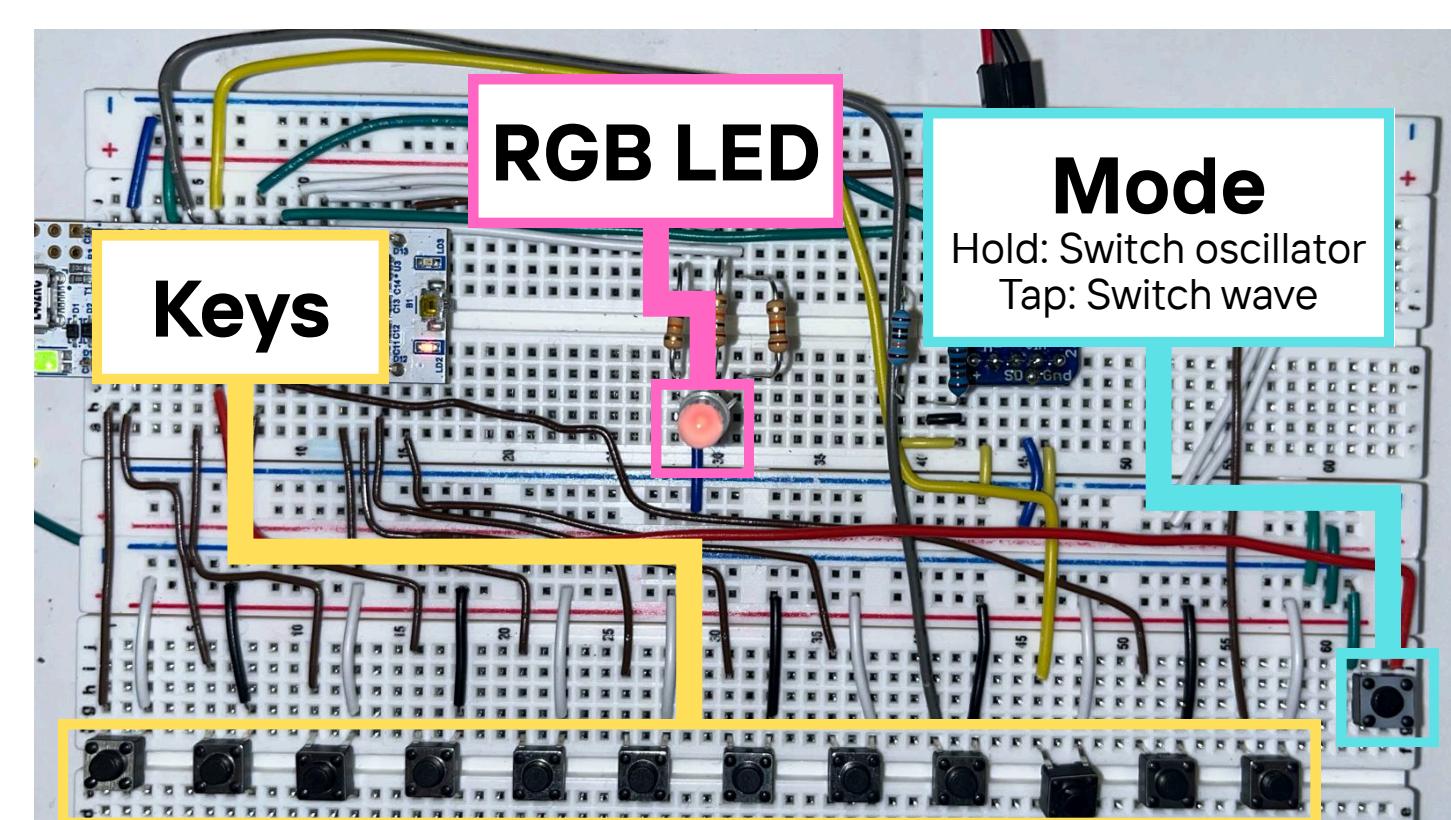


Figure 4: Physical layout of the circuit.

- **White-wired buttons**: white piano keys
- **Black-wired buttons**: black piano keys