# AZUltra v0.01

(Preliminary) Hardware Review 0002 - Version 1

**AZUltra is a microcontroller-enabled buzzer with eight user-programmable modes.**

This document is intended as a review of the v0.01 hardware design. It will focus on the successes and failures of the first revision and detail a plan for future improvements if another revision is deemed necessary. This is only a review of the *hardware.*



**CURRENTLY UNDER WRITING**
**EXPECT CHANGES**

# CONTENTS

# CHANGELOG

V0 - Initial Commit - 10/02/26 - AZ
V1 - Layout Review Complete - 11/02/26 - AZ

# ABBREVIATIONS

uC - Microcontroller
(GP) IO - (General Purpose) Input/Output
PCB - Printed Circuit Board
TVS - Transient Voltage Suppression
EM - Electromagnetic
ESD - Electrostatic Discharge
PMOS - P Channel Metal Oxide Semiconductor Field Effect Transistor
IC - Integrated Circuit

# INTRODUCTION

## Context

The idea for this project arose from the disappointment of a “cricket noise maker” I ordered from aliexpress. This product was comically quiet and when placed into the intended environment - could be barely heard. Additionally, it used soldered batteries meaning it was difficult if not impossible to repair. It also was not user programmable due to a one time programmable microcontroller being used. This greatly inspired me to make my own improved version.

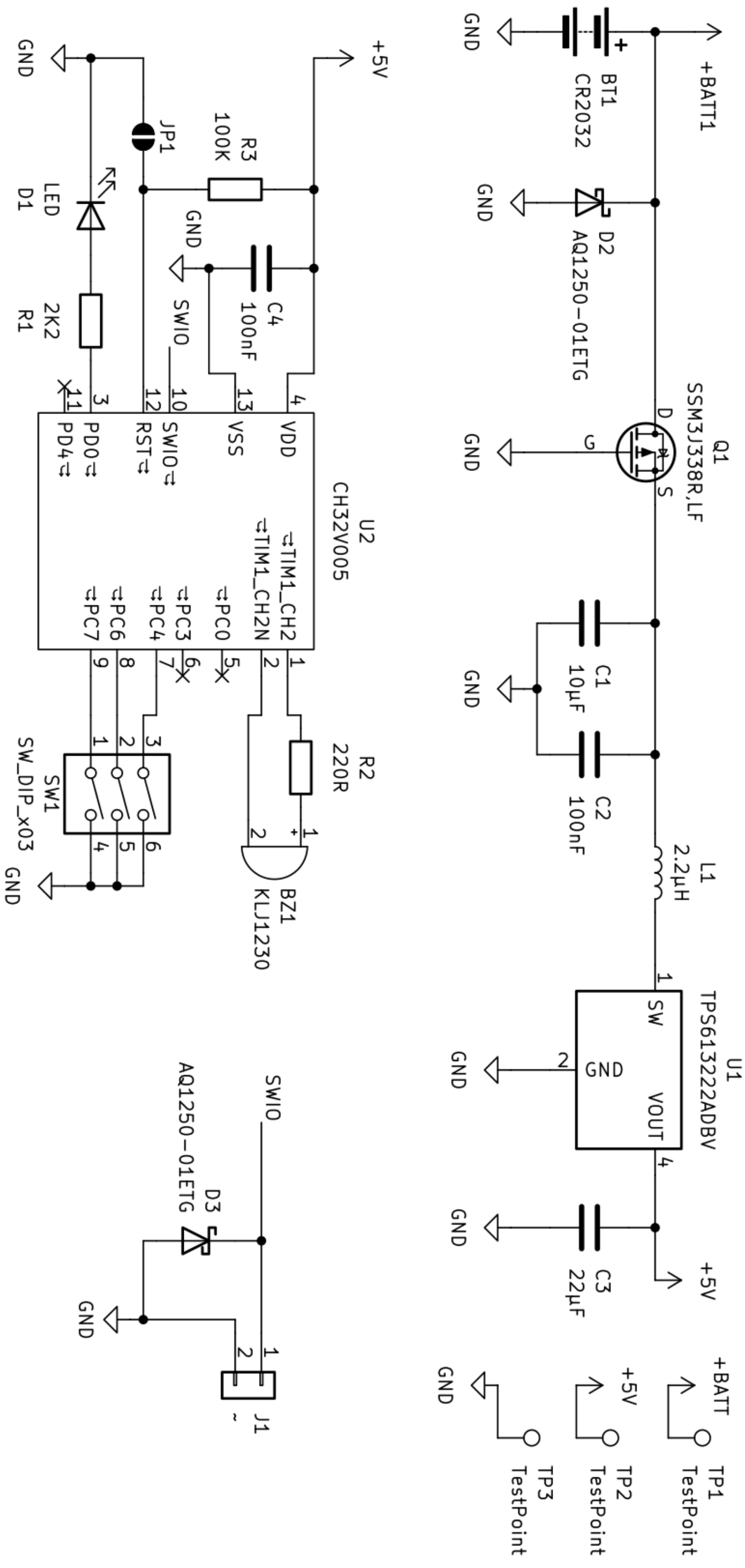
## Design Intent

To design a reliable, noticeable and repairable sound maker that would surpass options currently available on the market while maintaining a small form factor and low cost of manufacture.

## Specification

- At least 28 days of runtime on a single battery given one 200ms sound every 30 minutes.
- Programming capability without expensive equipment
- Versatile I/O allowing for connection to other equipment
- Peak sound loudness of at least 80dB at 10cm
- A maximum PCB size of 50mmx50mm
- All small surface mount components on one side of the board (smaller than 15x15mm)

# *Schematic*



+BAT1
BT1
CR2032
GND
D2
AQ1250-01ETG
Q1
SSM3J338R,LF
D
G
S
C1
10µF
C2
100nF
L1
2.2µH
U1
TPS613222ADBV
SW
GND
VOUT
C3
22µF
+5V
+BATT
TP1
TestPoint
TP2
TestPoint
TP3
TestPoint
R3
100K
JP1
C4
100nF
SWIO
LED
D1
2K2
R1
U2
CH32V005
VDD
VSS
SWIO
RST
PD0
PD4
TIM1_CH2
TIM1_CH2N
PC0
PC3
PC4
PC6
PC7
R2
220R
BZ1
KLJ1230
SW1
SW_DIP_x03
D3
AQ1250-01ETG
J1

# REVIEW

## Schematic

The circuit (as seen in the previous page) is fairly simple. I chose the power source to be a CR2032 as they are fairly power dense, commonly available, do not require charging circuitry and the holders come in a small footprint. An alternative would be the CR2450 as it has a much larger capacity, although they are more expensive, larger, and less common.

The battery (and programming I/O) has a TVS diode to prevent damage from ESD events. I also implemented the Q1 PMOS for low loss reverse polarity protection. The specified part should be substituted for a cheaper alternative if absolute cost-saving is a priority. I used the specified PMOS mostly due to the fact that I already had stock and that it had good properties. Namely, low RDS_on and gate voltage.

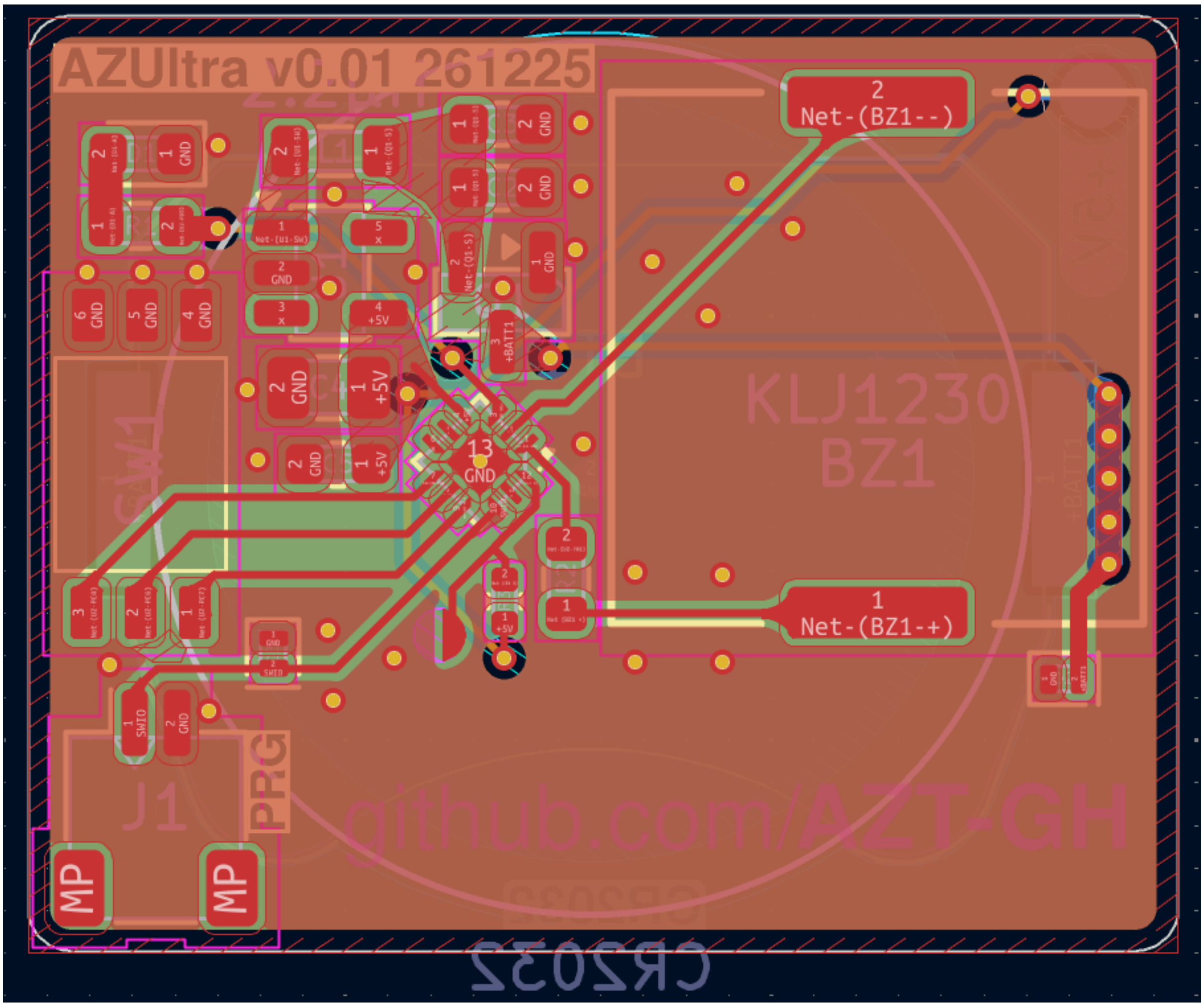
This feeds into a boost converter boosting to 5V. The input caps are fairly standard and a low ESR power inductor with sufficient saturation current should be used for L1. In worst-case scenarios (low ambient temp and low quality, old cells) the converter would switch into PFM mode and leak noise through the uC timer peripheral into the piezo causing unwanted noise. For this reason a relatively large 22uf output cap was chosen in an attempt to mitigate the noise while keeping a relatively small package and cost. The boost converter was chosen as it had acceptable quiescent current and high efficiency . All with a very low bom count and implementation difficulty. A system voltage of 5V was chosen as it was near the maximum acceptable operating voltage for the uC and enabled the piezo to stay at a consistent (and higher) loudness. There are also three test points to easily measure if the power is working.

Another reason for the development of this board was to test the CH32v00x platform of very cost efficient, feature-packed microcontrollers. The CH32v005 is one of the newer revisions and costs close to £0.25 per unit. They are available in a large range of packages, in this case I chose a very small QFN-12 unit. As for passives all it requires is a 100nF decoupling cap and a pull up on the reset pin. I chose a 100k pull up to balance noise immunity and power losses, I implemented the reset as an unlabelled jumper that can be bridged with a screwdriver or similar. This is so that the device cannot be reset by third parties (without operating knowledge) in operation which is very useful for my use case. Ironically, this document removes that layer of security but if whoever finds this goes to the length of reading this then they deserve to know how to reset the board.

I dedicated one GPIO pin to an LED that can be used to verify programming and then can be used by the user for whatever purposes they desire. I also used three GPIO pins for a 2 way dip switch to enable the user to switch between up to 8 modes on the fly. This could very easily be switched out for a female connector to enable for the device to act on information from other devices (or expansion boards). As for connectors, the programming connector is a common JST-SH, Only two terminals are required due to the unique single wire programming process (data and ground).

Finally, I chose a piezo buzzer due to their low current consumption and high loudness. The buzzer is connected push-pull to the complementary outputs of the advanced timer, timer1 on the ch32. This doubles the peak to peak potential difference compared to single end drive which greatly increases volume (~1.4x). I  also added a series resistor to reduce ringing and noise (like aforementioned) while not drastically reducing volume.

*Layout*



## Layout

I chose a four-layer PCB as it was the same cost from my supplier as a two-layer, and as I was concerned about the noise immunity of the PCB and thought that additional ground planes would help. The stack is signal - ground - mixed - ground. The third layer consists of mostly a ground plane and some minimal power and signal routing.

The PCB's minimum size was constrained by the size of the CR2032 holder that I chose (Keystone 3034). I chose this holder as it was the easiest to solder by hand and also the smallest. A drawback was that the battery is not very securely secured and that there is potential for soldermask on vias on the battery contact to be scraped, potentially causing shorts.

After defining the PCB edge, I roughly placed each component to ease routing later. Importantly, the passives that are a part of the DCDC switching loop are very close to the IC to reduce the loop area and EM emissions. They also all had ground vias placed near ground pins to reduce the current loop and hence EM emissions. I also used copper fills for power connections to reduce their resistance thereby reducing power loss by ohmic losses.

The uC was placed centrally on the board to allow easy connection to all sides of the board. Similarly, the uC was rotated by 45 degrees to increase the ease of routing and enable larger separation between traces for noise immunity. Namely, the 3 dip switch needed 3 traces connected to the uC which were all spaced as much as possible to improve signal integrity. Finally (as for functional considerations), I placed the programming connector near the edge of the PCB to allow for easy connections.

Considering aesthetical factors, I put an easily legible board label at the top, including name, version and date in knockout silkscreen. Similarly I labelled the programming header with "PRG". Also on the front side of the PCB, I removed the solder mask to expose my github on the ENIG/HASL. (github.com/AZT-GH) On the other side of the PCB I placed and labelled the 5V test point and put silkscreen for the battery type on the battery entry.

## Improvements

For some reason unknown to me I forgot to change the inner power traces to pours, in the next revision I would use pours to reduce the resistance as mentioned above. I would also change the JST-SH connector for a more easily crimpable connector as after a lot of effort I was unable to crimp connectors and had to purchase precrimped wire.

In the next revision I would also replace the 3 position dip switch with a connector so that other boards could communicate to the AZUltra to enable environment based buzzing.

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