Reflow soldering with the VL53L5CX

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Abstract

The project focuses on reflow soldering at home using common household equipment.

Two different PCBs were manufactured, testing different methods of soldering. One of the PCBs is a breakout board for the VL53L5CX 8x8 time of flight sensor IC. The board was desinged in KiCad.

With an older PCB comprising an Attiny the solder process was tested. In the next step the VL53L5CX was soldered.

Multiple lessons were learned about the reflow solder process.

1 Motivation

Components for electric circuits are becoming smaller every year. Over time it makes sense even for hobbyists to switch to surface mount technology, if just for the price.

With reflow soldering, the components are placed on their pads on solder paste. The paste is then melted, soldering all components at once.

The project is intented to test reflow soldering at home. There was a particular need, since the VL53L5CX can not be soldered with a soldering iron, nor with a heat gun, due to its temperature sensitivity.

2 Reflow Soldering

With reflow soldering, the components are placed on their pads on solder paste. The paste keeps them in place until the soldering process beginns. The PCB is then brought slowly up to temperature, staying just below the melting point of the solder paste. This way the different sized copper pours can heat up evenly.

Once the temperature exceeds the melting point of the solder paste, all components are soldered at once.

The downside of this method is that components can only be placed on one side of the board. On the bottom the components would fall off. There is the posibility to counter this by gluing the components to the PCB and then soldering them, but this is not feasable at home. Most hobby boards can be made with components only on one side of the PCB. Alternatively, components on the bottom side could be hand soldered after all.

3 Used Materials

- Old pan
- Hob
- Sand
- Solder paste (leaded)

Figure 1: Solder paste

4 Soldering the Attiny

4.1 Schematic and Layout

The Attiny Board was made in late 2019. It has an Attiny microcontroller, programming header and LEDs as indication.

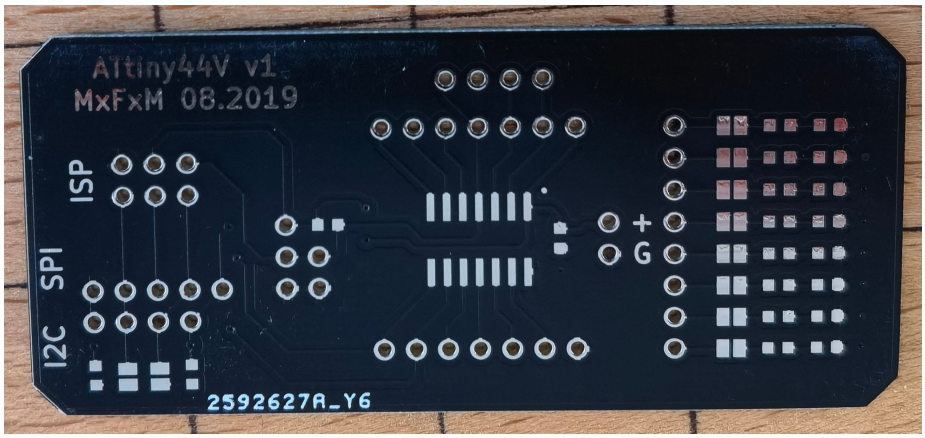

Figure 2: PCB for the Attiny

The board is suitable as a test, since the used component sizes (0603) match the used components on the VL53L5CX board. The microcontroller is easier to solder than the VL53L5CX.

4.2 Reflow Process

Befor soldering can start, the components have to be placed on the PCB. The solder paste is applied and then each resistor, LED, IC or other component can be carefully placed on top. Pressing slightly on the component makes it sink into the paste, giving it some stability.

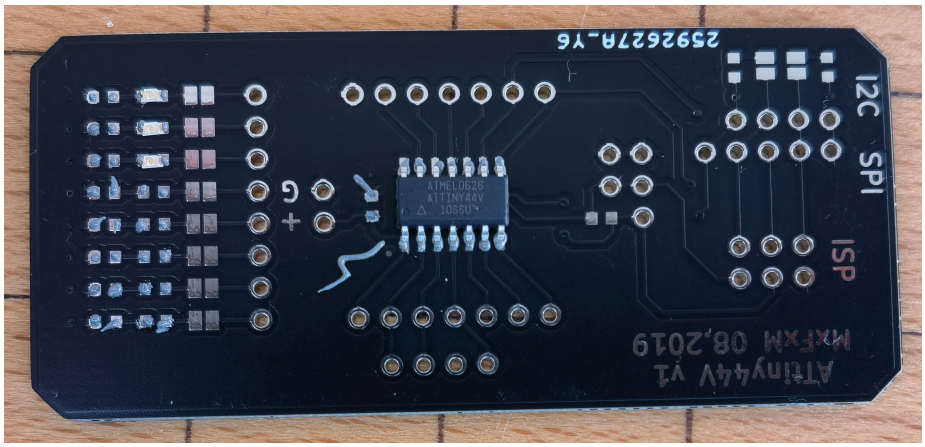

Figure 3: Solder paste is applied

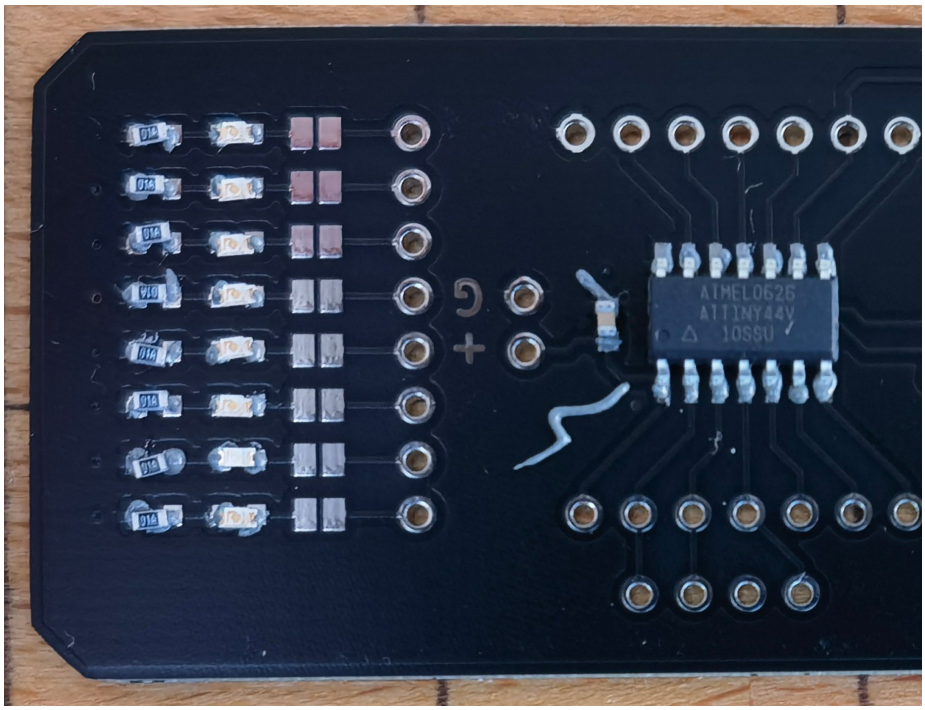

Figure 4: Components placed

After priming the nozzle there was an excess of solder paste. This lead to the z-shape paste next to the microcontroller.

Note, that the components are not perfectly aligned with the pads. It is not necessary to align them exactly. The surface tension of the molten solder paste will pull the components in place.

Figure 5: Setup outside

The reflow setup was built up outside. This helps the cooling process. Also the fresh air is good, since the solder paste is leaded. Lead free solder paste is also available, but is harder to work with.

The setup comprises a heating plate from a hob, an old pan filled with about 1cm sand and a thermometer to check the temperatures.

Figure 6: The first batch of PCBs being soldered

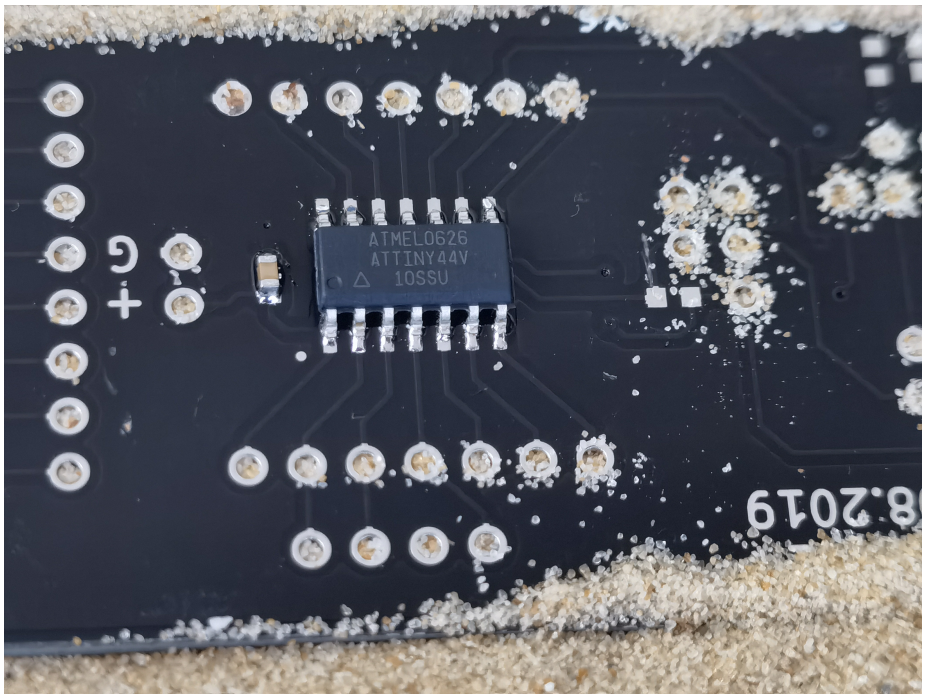

Figure 7: Molten solder paste on the pads

After the soldering process the PCBs were taken out of the pan and placed on the cold floor to cool down quickly.

4.3 Reflow Soldering Results

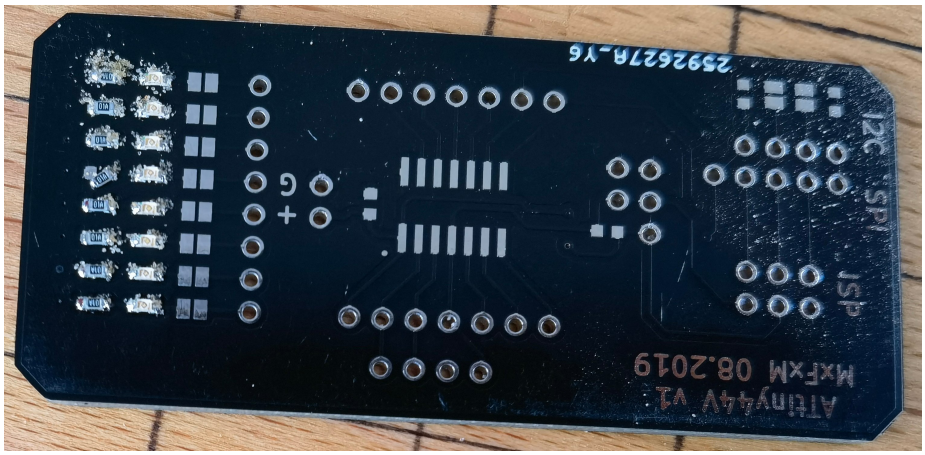

Figure 8: Sandy PCBs after soldering

Figure 9: Rotated component

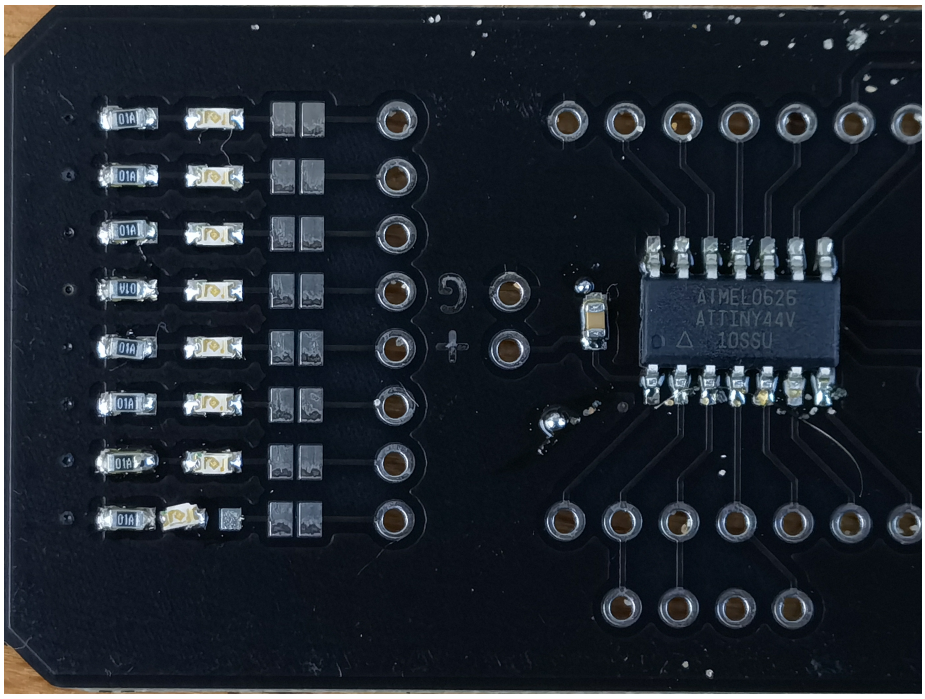

Figure 10: Shifted component

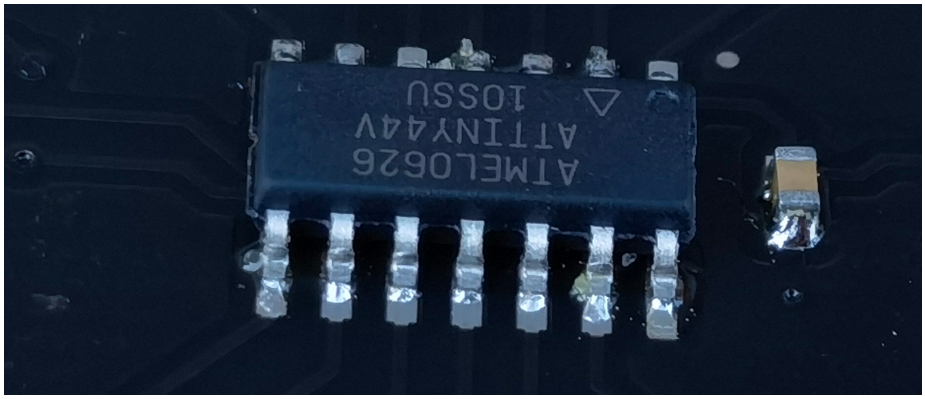

Figure 11: Solder joint quality

4.4 Lessons Learned

- Solder paste amount is hard to judge.
  There are tools that help dispense the same amount of solder for each pad. For this project, the solder pasted was applied by hand, resulting in inconsistent paste amount across the pads. In general, the amount of paste used was too much.

- Sand helps to slow down the heat transfer.
  The sand in the pan takes some time to heat up itself. While it helps to slow down the heat transfer and bring everything up to temperature evenly, 1cm is too much. In fact, for small boards there is not too much copper to heat up, so even without sand it can work.

- Components not aligned enough.
  Allthough the surface tension does pull the components towards the pads, if they are too far out of place, this can fail.

- Solder paste does not stick to pad.
  The solder paste does stick a little by itself. This helps the surface tension effect described above. It is however possible, that the solder paste does not stick to the pad enough and the surface tension effect does not take place. This can be compensated for by smearing the paste on the pad (rather than just laying it on top) and adding a little more pressure when placing the component.

- Solder paste does stick to sand.
  It is also possible, that this is the effect of the flux in the paste.

5 VL53L5CX

The VL53L5CX is a Time-of-Flight (ToF) multizone ranging sensor. It integrates a SPAD array, physical infrared filters, and diffractive optical elements (DOE) to perform in various ambient lighting conditions.

The sensor provides ranging up to 400 cm and can work at speeds up to 60 Hz The FoV can be reduced by software.

5.1 Evaluation Board

As with most of their components, ST has an evaluation board available for their sensor. It was used to develop the firmware on the microcontroller and the software on the PC to visualize the readings.

5.2 Teensy Firmware

ST offers a library to interface its sensor. Someone on Github made and adaption to that library so it can run on an Arduino, or in this case on a Teensy.

5.3 PC Software

The software on the PC reads the serial data coming from the microcontroller.

Each line of text represents the reading of one of the 64 zones. After splitting the values in the line, the measurement is put in the array at its zone number.

To display the measurements, the array is reshaped into an 8x8 matrix and displayed as an image using OpenCV.

Errors in the communication are caught using the try-statement of Python.

```
newline = ser.readline()

try:
    linedata = newline.decode("utf-8").split(',')

    zone = int(linedata[0])
    status = int(linedata[1])
    distance = int(linedata[2])

    if distance > 255:
        distance = 255

    data[zone] = distance

    lines = lines + 1

except Exception as _:
    pass

data_matrix = data.reshape(8,8).astype(np.uint8)
cv2.imshow("img", data_matrix)
```

6 Soldering the VL53L5CX

6.1 Schematic and Layout

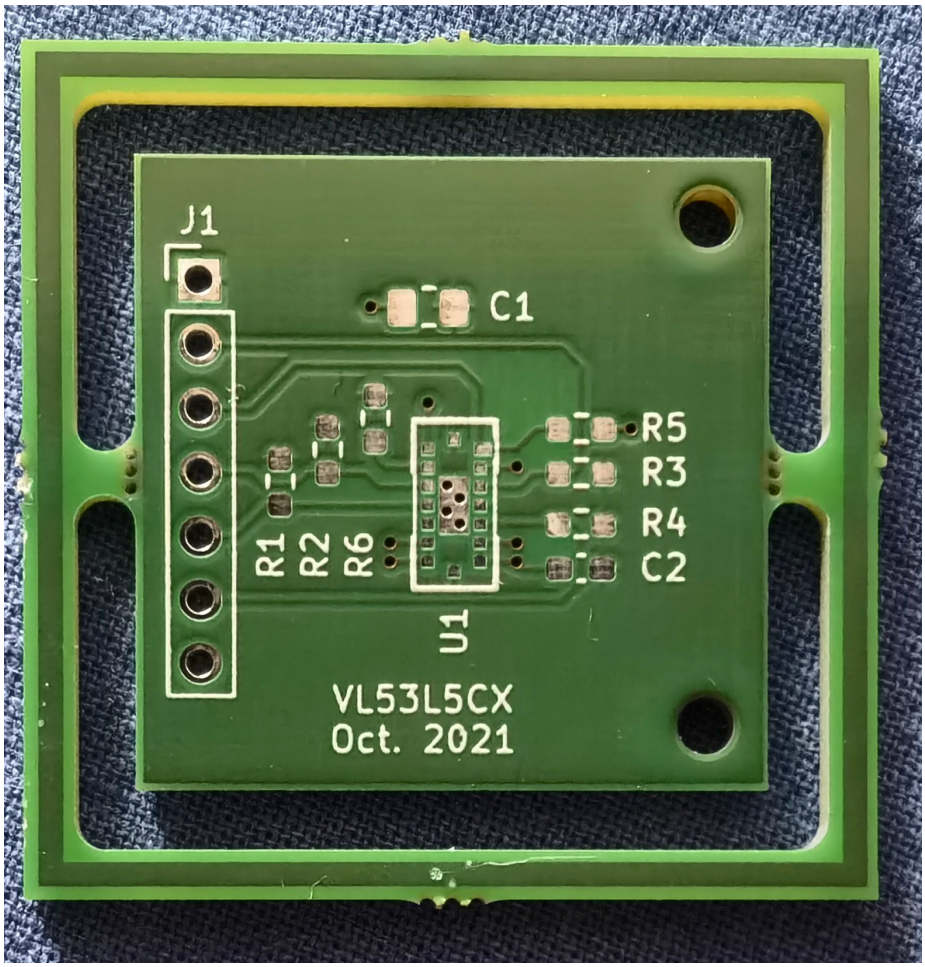

Figure 12: VL53L5CX PCB

The breakout board only contains the minimum amount of external components required to work with the VL53L5CX. Actually, one of the pins on the header is not even used, so there is still room for improvement.

Power is routed on the copper plains on the top and bottom layer. The 3v3 supply voltage is routed on top while the bottom side is ground only.

By routing some of the signals between the two pads of a 0603 component, it was possible to layout the whole circuit on one side only.

The vias in pad to transfer the heat away of the sensor were just placed by hand without any problems. The footprint and schematic symbol for the VL53L5CX were made by hand.

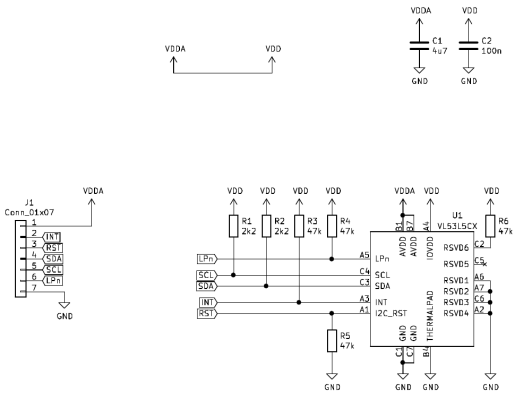

Figure 13: VL53L5CX Schematic

6.2 Reflow Process

The pads on the VL53L5CX are even smaller than before, making it harder to apply the correct amount of solder paste.

It was decided to reflow these boards without the sand in the pan. If there were grains of sand to come under the chip, the soldering process would fail.

After the reflow soldering, the pin headers were soldered on by hand.

6.3 Reflow Soldering Results and Testing

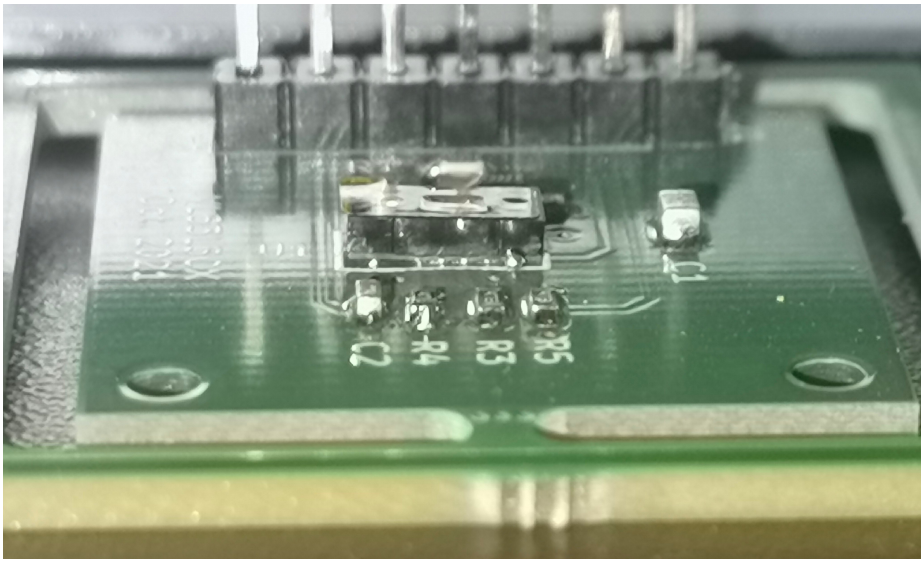

Figure 14: Lifted VL53L5CX sensor

One of the VL53L5CX was angled upwards. Most likely this is due to too much solder under one side of the IC. On the left hand side of the IC, there is one solder connection missing. The paste was not sticking to the pad correctly.

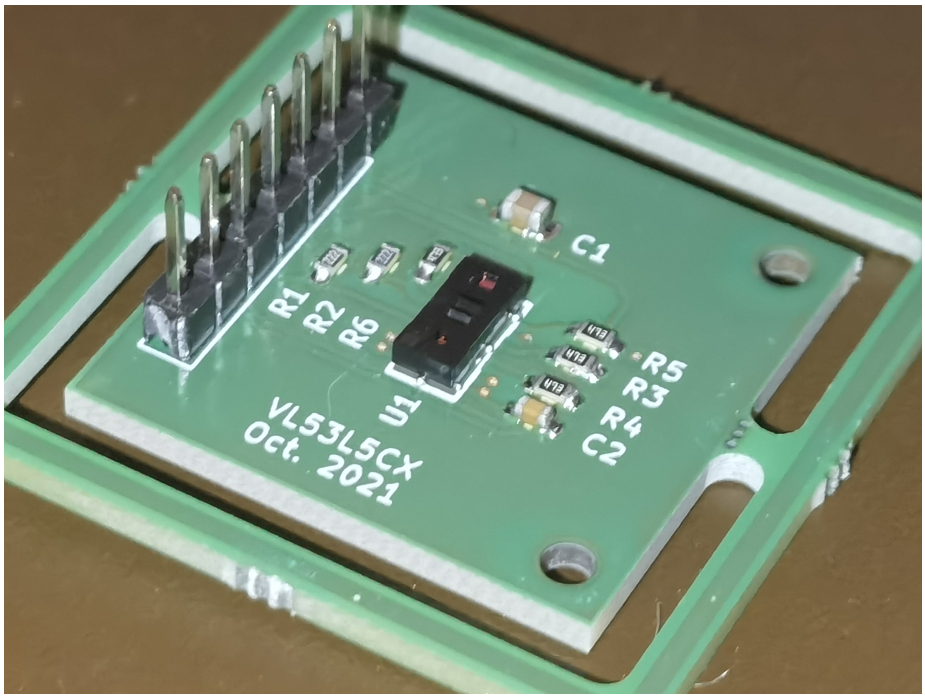

Figure 15: Working VL53L5CX breakout board

2 of the 3 boards were working.

The board with the angled IC does not work. The most obvious observation is the angled IC with the missing solder connection. Additionally there is a short circuit between the supply voltage and one of the pins on the header. Probably due to a short underneath the IC.

6.4 Lessons Learned

- Via in pad is no problem for Aisler.
- Too much solder under LGA will flow to the side.
  In this case, this lead to solder balls forming next to the IC package, which is no problem. Under a larger chip, with multiple rows of pads, this can lead to a short.
- Uneven amount of solder paste can lift LGA components.
  The VL53L5CX has pads underneath that are being soldered. In comparison to a BGA package, there is no solder applied by the manufacturer. If the amount of paste applied on one side is too much, it can lift the chip up during reflow, not allowing connections on the other side to be made.
- Think about the side the headers go on.
  The pin headers were placed on the top side, making the cables interfering with the sensors field of view. This problem can be solved by bending the headers or putting them on the bottom side.

7 Links

Links to used or useful ressources

VL53L5CX from ST
https://www.st.com/en/imaging-and-photonics-solutions/vl53l5cx.html

Arduino compatible library for the VL53L5CX
https://github.com/simondlevy/VL53L5