UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

Smart Thermometer

Embedded systems

Cristescu Vlad-Andrei

Contents

1. Introduction

This project aims to describe the development process of a smart thermometer that can be used in hospitals to measure the temperature of patients without directly exposing the medical personnel to potentially contagious patients. It is a very simple PCB with a temperature sensor and an NFC transceiver and antenna that facilitates remote transmission of the sensor reading.

2. Component selection

2.1. Temperature sensor

For measuring the temperature the LM75B is a suitable choice due to its range, –55°C to 125°C with ±1°C accuracy, its supply voltage, 2.7V to 5.5V, and the fact that it features a digital output for easy communication and an interrupt pin.

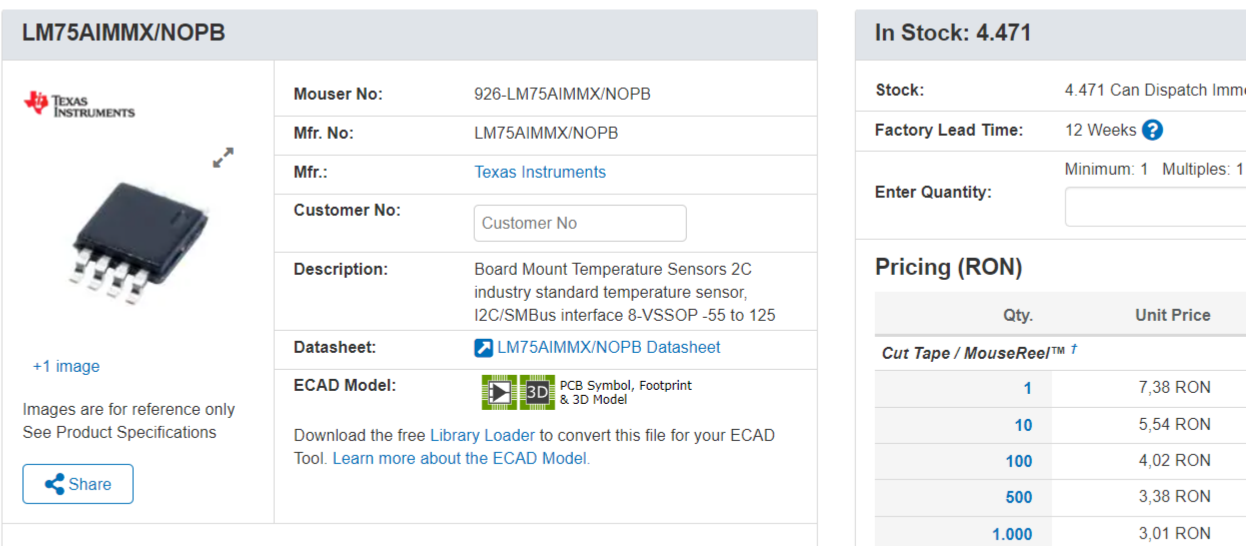

Figure 1: LM75 price

2.2. NFC transceiver

For sending the sensor reading wirelessly an antenna needs to be interfaced with the temperature sensor. A specialized IC like the MAX66242 not only incorporates both an I2C front-end and an RF front-end, but also enforces two-way authentication between a host system and itself using a bidirectional security model. When acting as a slave, the device can serve as an intermediary between a connected host and an RF reader. The MAX66242 can harvest energy from an active RF field. The configurable supply output can deliver up to 5mA given adequate field strength.

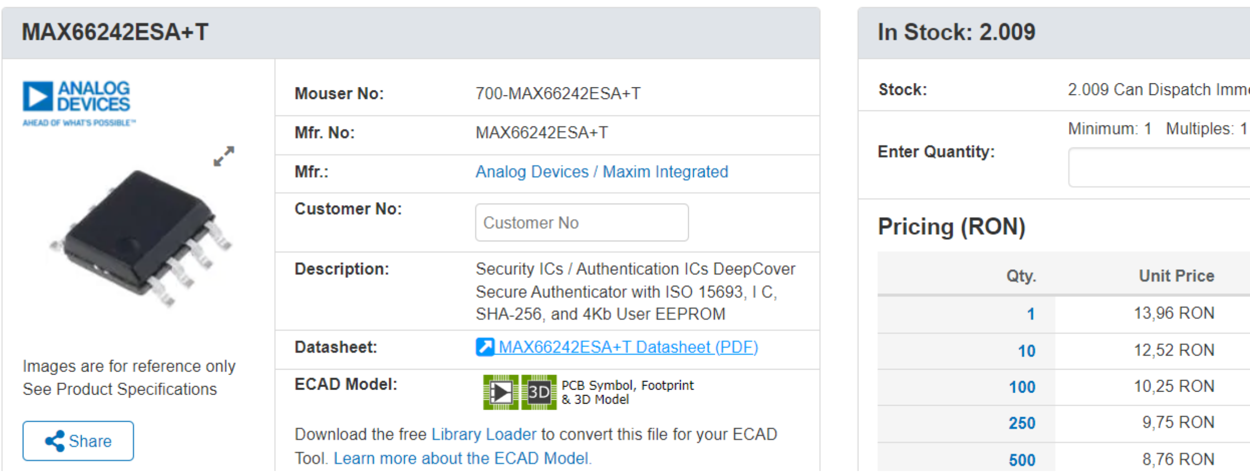

Figure 2: MAX66242 price

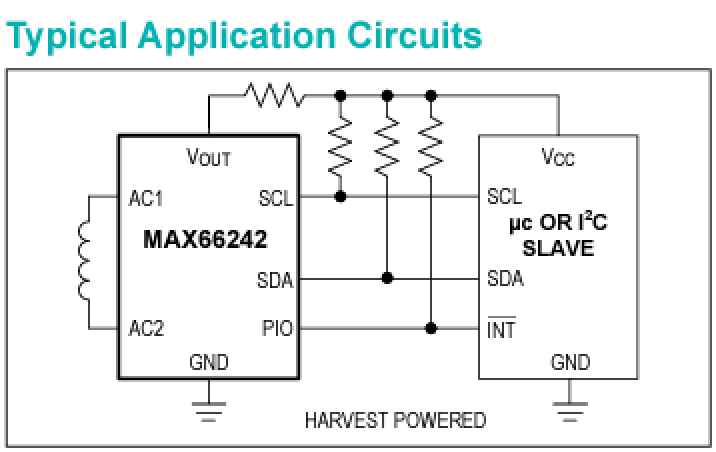

Figure 3: Harvest powered slave typical application

Its datasheet features an example of a typical application where a slave is powered completely by the energy harvested from the RF field. It is woken up using the interrupt pin and only reads data from the LM75 when an active RF fields is in the proximity. This will result in a very compact PCB without the need for any additional power supply circuitry, so this is the starting point of the project.

2.3. Antenna

The antenna needs to be fine-tuned around the resonance frequency, which is 13.56MHz when it comes to NFC. This results from the value of the equivalent capacitance and inductance. The datasheet of the NFC transceiver specifies the value of the internal capacitance as 21pF. This would result in a necessary inductance of 6.56µH in order to reach the desired resonance frequency, which is quite large and would result in a very bulky antenna. After playing around with the values in both a resonance frequency calculator and an NFC antenna inductance calculator I have concluded that I should add an external parallel capacitor to reduce the inductance of the antenna and therefore its footprint.

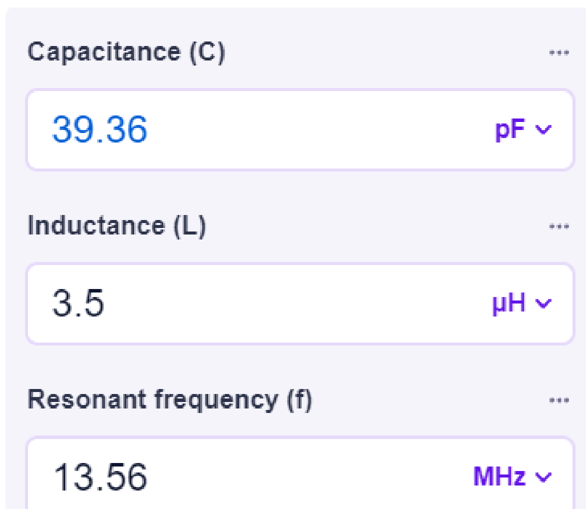

Figure 4: Component sizing

Therefore we only need a 3.5µH antenna if we add a 18pF capacitor in parallel. The physical dimensions can be calculated using an online ST tool.

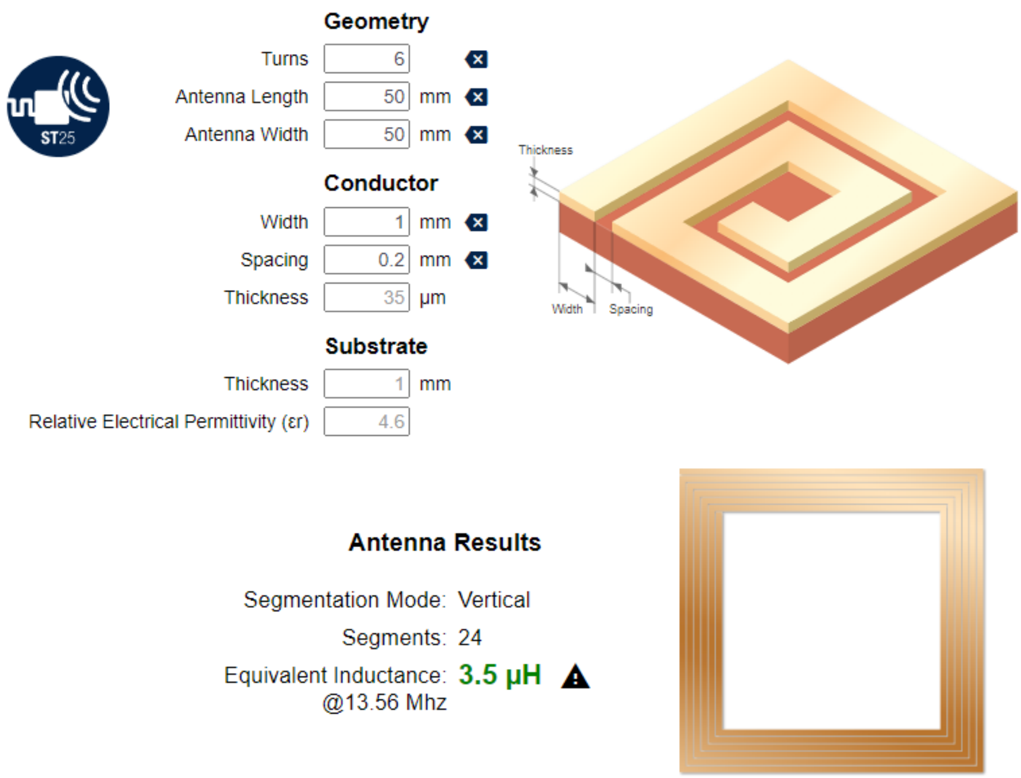

Figure 5: Antenna physical dimensions

2.4. Schematic

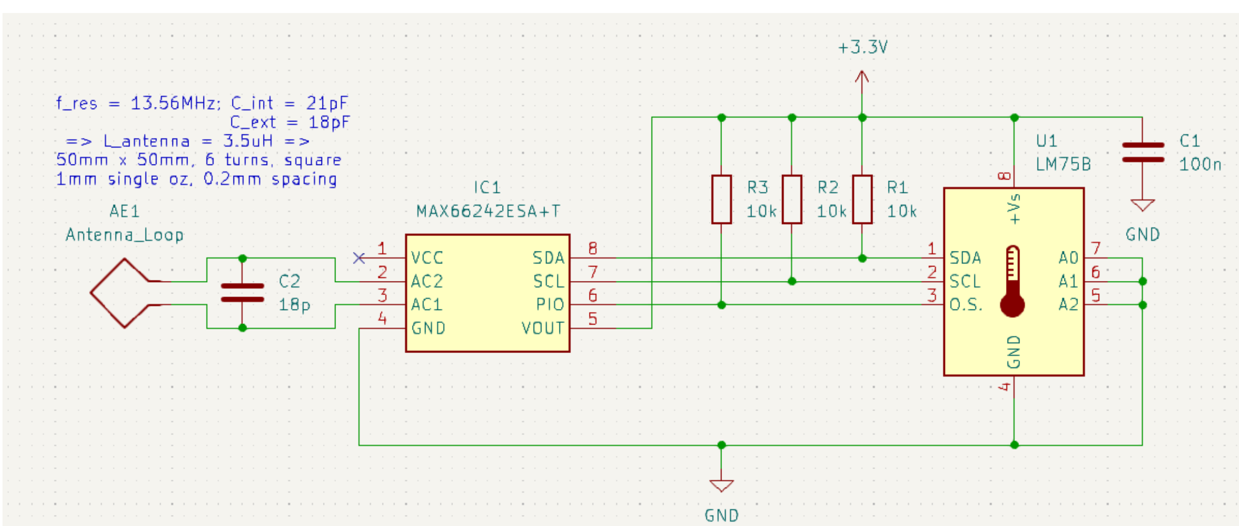

Figure 6: Circuit schematic

3. PCB layout

Considering the low number of components, this design can easily be implemented on a 2-layer, single sided board, with the antenna and all the components on the top side and a solid ground plane on the bottom side.

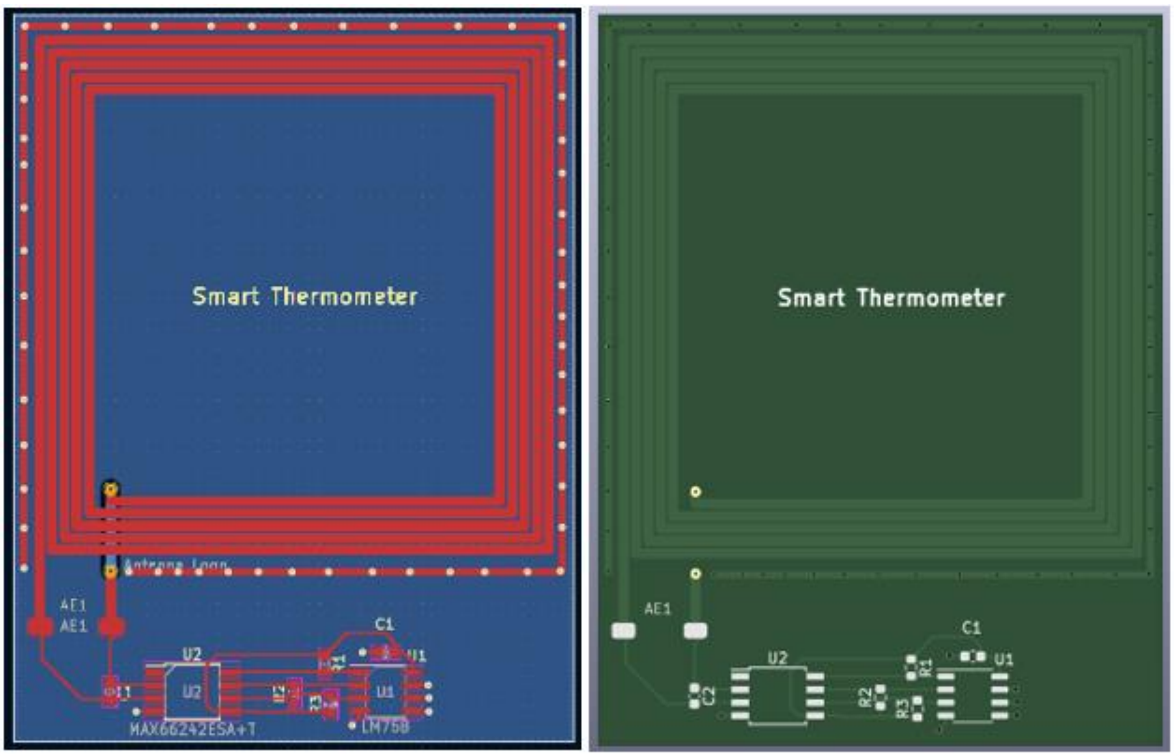

Figure 7: PCB layout and 3D view

The antenna is surrounded by a grounded copper trace filled with vias for shielding purposes.

4. Conclusions

The project culminates in a 55mm x 70mm device that can be placed in contact with the patient’s skin and transmit the temperature reading wirelessly through NFC to the doctor’s phone or tablet with minimal exposure risk. The device can even be manufactured on a flexible PCB and attached to the patient's body for constant monitoring thanks to its reduced size, all thanks to the power harvesting capabilities of the NFC transceiver, requiring no external battery, power supply connections or voltage regulation circuitry.

Bibliography

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ti.com/lit/ds/symlink/lm75a.pdf?ts=1717660722164&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252Fde-de%252FLM75A

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://ro.mouser.com/datasheet/2/609/MAX66242-3130703.pdf

https://www.omnicalculator.com/physics/resonant-frequency-lc

https://www.analog.com/jp/resources/technical-articles/need-nfcrfid-tomorrow-is-today-in-this-constant-state-of-innovation.html

https://www.raypcb.com/nfc-pcb-manufacturer/