



Smart Thermometer

Embedded systems

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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 $\pm 1^{\circ}\text{C}$ 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.

LM75AIMMX/NOPB															
 	<p>Mouser No: 926-LM75AIMMX/NOPB Mfr. No: LM75AIMMX/NOPB Mfr.: Texas Instruments Customer No: <input type="text" value="Customer No"/> Description: Board Mount Temperature Sensors 2C industry standard temperature sensor, I²C/SMBus interface 8-VSSOP -55 to 125 Datasheet: LM75AIMMX/NOPB Datasheet ECAD Model:   PCB Symbol, Footprint & 3D Model Download the free Library Loader to convert this file for your ECAD Tool. Learn more about the ECAD Model.</p>														
<p>+1 image</p> <p>Images are for reference only See Product Specifications</p> <p> Share</p>															
<p>In Stock: 4.471</p> <p>Stock: 4.471 Can Dispatch Immediately Factory Lead Time: 12 Weeks  Enter Quantity: <input type="text"/></p> <p>Minimum: 1 Multiples: 1</p>															
<p>Pricing (RON)</p> <table border="1"><thead><tr><th>Qty.</th><th>Unit Price</th></tr></thead><tbody><tr><td colspan="2"><i>Cut Tape / MouseReel™</i> </td></tr><tr><td>1</td><td>7,38 RON</td></tr><tr><td>10</td><td>5,54 RON</td></tr><tr><td>100</td><td>4,02 RON</td></tr><tr><td>500</td><td>3,38 RON</td></tr><tr><td>1.000</td><td>3,01 RON</td></tr></tbody></table>		Qty.	Unit Price	<i>Cut Tape / MouseReel™</i> 		1	7,38 RON	10	5,54 RON	100	4,02 RON	500	3,38 RON	1.000	3,01 RON
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1.000	3,01 RON														

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.

MAX66242ESA+T



Mouser No: 700-MAX66242ESA+T
Mfr. No: MAX66242ESA+T
Mfr.: Analog Devices / Maxim Integrated
Customer No:
Description: Security ICs / Authentication ICs DeepCover Secure Authenticator with ISO 15693, I C, SHA-256, and 4Kb User EEPROM
Datasheet: [MAX66242ESA+T Datasheet \(PDF\)](#)
ECAD Model:  PCB Symbol, Footprint & 3D Model

Images are for reference only
See Product Specifications

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In Stock: 2.009

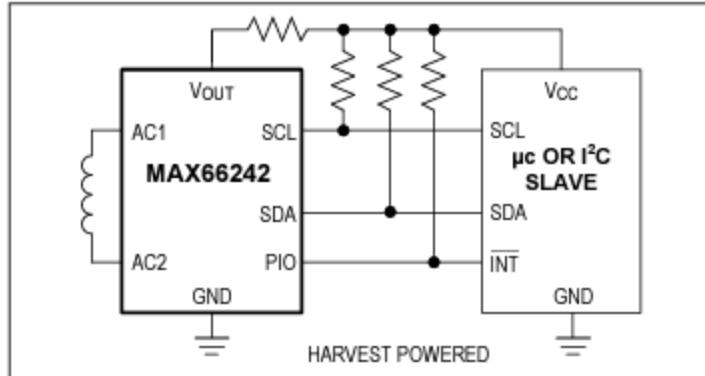
Stock:	2.009 Can Dispatch Immediately
Enter Quantity:	<input type="text"/>

Pricing (RON)

Qty.	Unit Price
1	13,96 RON
10	12,52 RON
100	10,25 RON
250	9,75 RON
500	8,76 RON

Figure 2: MAX66242 price

Typical Application Circuits



The diagram illustrates a typical application circuit for a harvest-powered slave using the MAX66242. On the left, a transformer with two secondary windings (AC1 and AC2) is connected to the MAX66242 chip. The MAX66242 has several pins labeled: V_{OUT}, SCL, SDA, PIO, GND, and AC2. The SCL and SDA pins are connected to a microcontroller or I²C slave device. The V_{OUT} pin is connected to the microcontroller's V_{CC} pin. The PIO pin is connected to the microcontroller's INT pin. The GND pin is connected to ground. The AC2 winding is connected to ground. On the right, the microcontroller or I²C slave device is shown with its own V_{CC}, SCL, SDA, and GND pins. The SCL and SDA lines are connected between the MAX66242 and the microcontroller. The INT line is also connected. The entire circuit is labeled "HARVEST POWERED" at the bottom.

Figure 3: Harvest powered slave typical application

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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 $6.56\mu\text{H}$ 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.

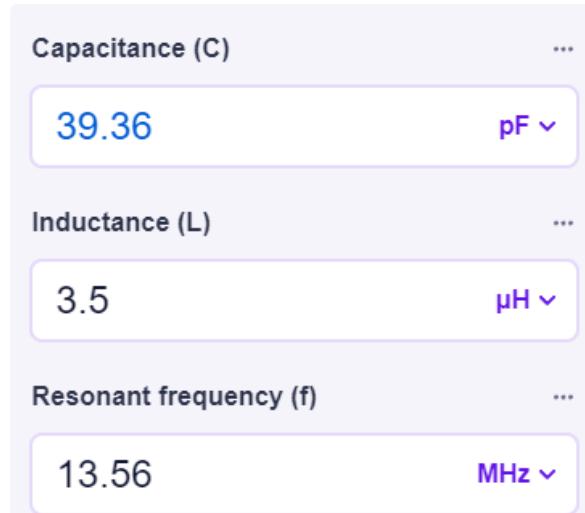


Figure 4: Component sizing

Therefore we only need a $3.5\mu\text{H}$ antenna if we add a 18pF capacitor in parallel. The physical dimensions can be calculated using an online ST tool.

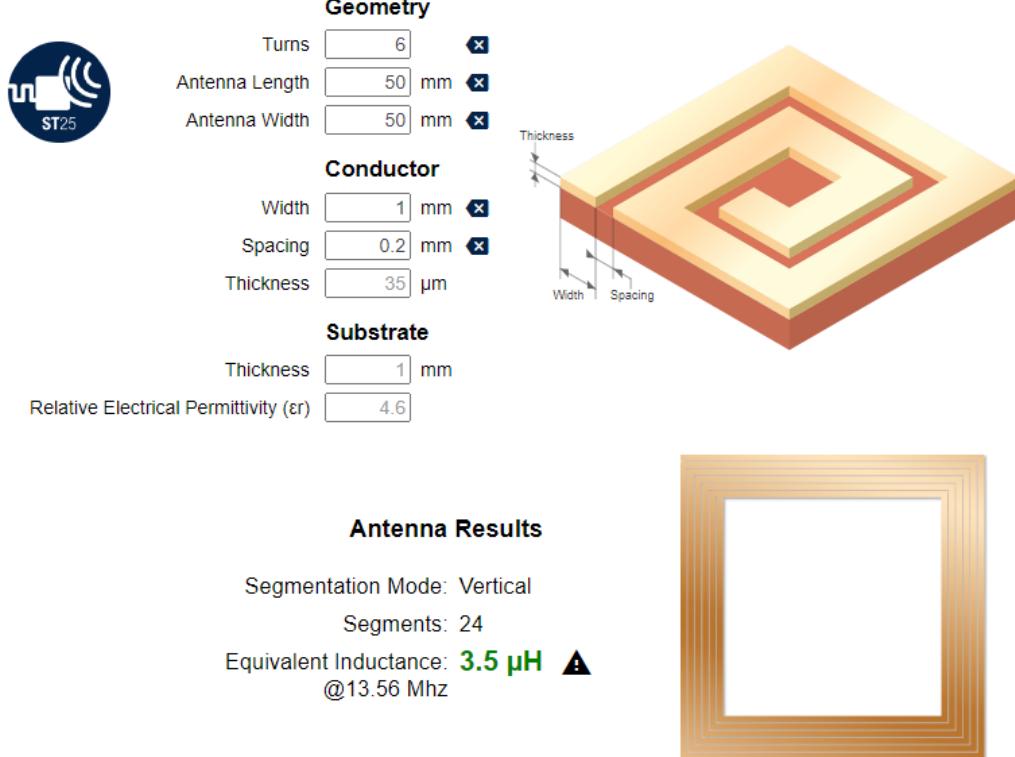


Figure 5: Antenna physical dimensions

2.4. Schematic

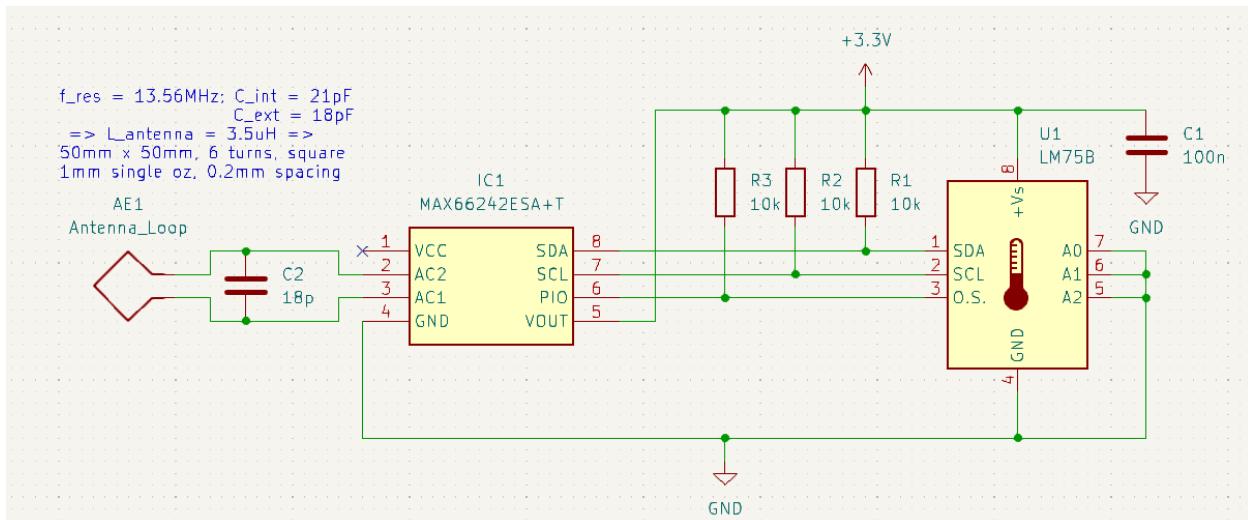


Figure 6: Circuit schematic

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.

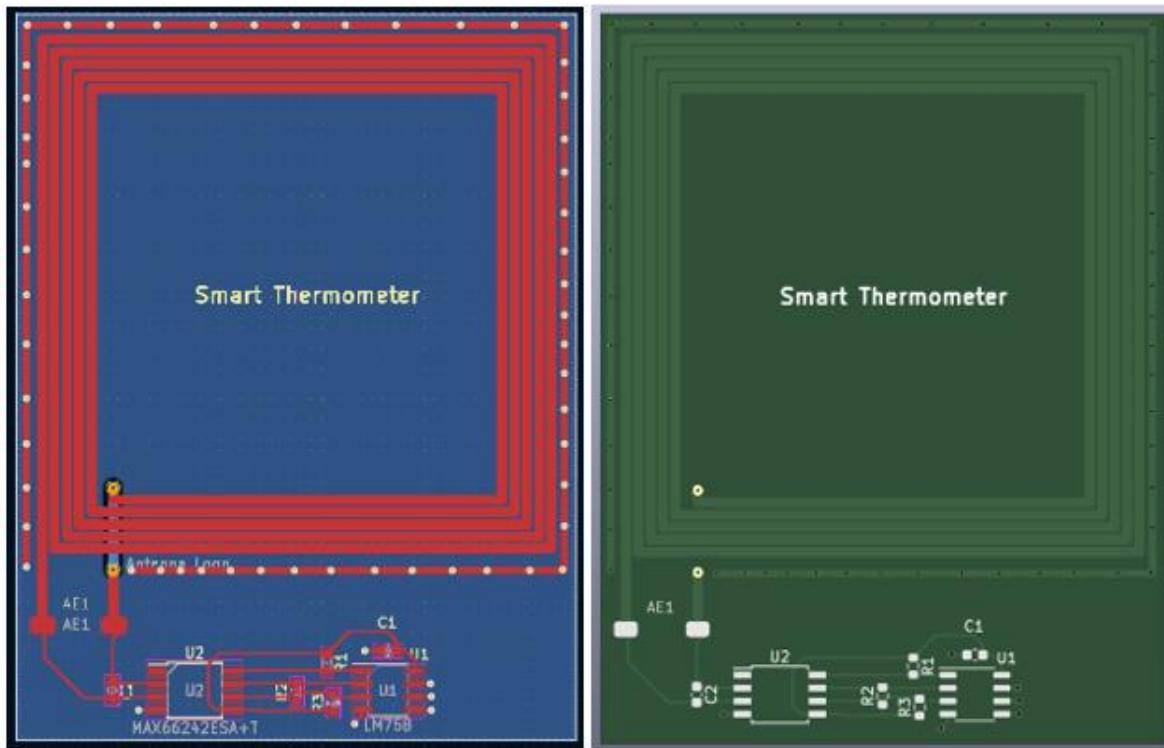


Figure 7: PCB layout and 3D view

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

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