AN3178
Application note

Using a surface-mount inductor as an M24LRxx antenna

Introduction

The M24LRxx ICs are a family of Dual Interface EEPROMs from STMicroelectronics. Each EEPROM IC can be accessed as a single memory bank via a wired or RF interface.

The RF interface:

- Is based on a passive RFID technology supporting the ISO15693 standard.
- Communicates with ISO15693 RF systems (called RFID readers),
- Does not require any on-board power to operate. Both energy and data are received from the RFID reader.

In order for the RF interface of the IC to operate, an inductive antenna is required. This antenna must be connected to the IC RF port.

There are three different methods for implementing an inductive antenna.

1. **On-board etched antenna:** this method consists of designing an on-board inductive antenna etched on the PCB itself. It allows for a wide range of antenna sizes but has a cost in terms of PCB real estate. Refer to he application note AN2972 *Designing an antenna for the M24LR64 dual interface I²C/RFID device* for guidance. ST also provides antenna templates in Gerber format.
2. **Off-board antenna module:** this method consists of using an external antenna, connected to the M24LR64, and to the main PCB through an I²C connector. This allows for a larger antenna, resulting in a greater read range. The off-board antenna can be made of:
   a) A daughter board using simple PCB technology
   b) A flexible antenna, equipped with an M24LRxx device and a wired I²C connection.
3. **External surface-mount inductor:** this consists of connecting an external inductor to the M24LRxx. This can have a small footprint and requires no design effort, but it has a reduced read range.

This application note provides guidelines for the third option: using an external surface-mount inductor as an RF antenna for M24LRxx ICs.

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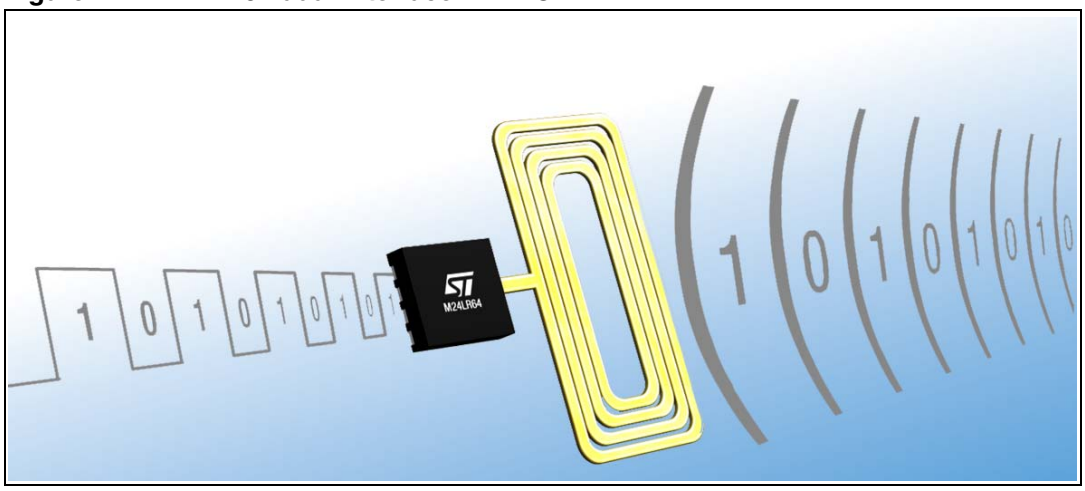
1 Basic principle - inductance value

Figure 1. M24LR64 dual interface EEPROM



The basic principle of the M24LRxx's antenna is very simple: the external antenna inductance ($L_{INDUCTOR}$) that needs to be integrated on the PCB should match the M24LRxx's internal tuning capacitor (C_{TUNING_IC}) in order to create a circuit resonating at 13.56 MHz. This is because ISO15693 RFID readers operate in the 13.56 MHz High Frequency band.

The equation is:

$$f_{TUNING} = \frac{1}{2\Pi \times \sqrt{L_{INDUCTOR} \times C_{TUNING\_IC}}}$$

Which implies:

$$L_{INDUCTOR} = \frac{1}{(4 \times \Pi^2 \times f_{RESONANCE}^2 \times C_{TUNING\_IC})}$$

This is how the inductance value is calculated: $f_{RESONANCE}$ = 13.56 MHz and in the case of an M24LRxx IC with an embedded 28 pF internal tuning capacitor, the theoretical value of the inductance is 4.92 µH.

Refer to application note AN2972 *Designing an antenna for the M24LR64-R dual interface I²C/RFID device* for further information on the basics of the RFID technology, and for guidelines on antenna design, optimization and test.

2 Choosing the right type of surface-mount inductor

Because the inductor connected to the M24LRxx ICs is intended to capture the RF field from an external RFID reader, the coil of the selected inductor must not be shielded in order to be able to capture the emitted electromagnetic field. In other words, it must not be embedded inside any type of Faraday cage.

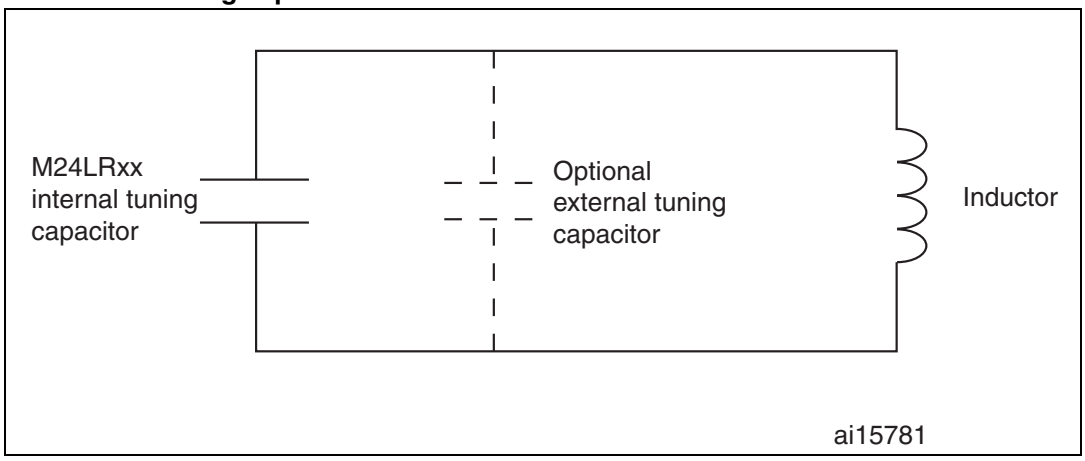
Table 1. Comparison of surface mount inductor types

Example of the right type of surface-mount inductor coil	Example of incorrect type of surface-mount inductor
	
– No metal shield prevents it from capturing the electromagnetic field emitted by the RFID reader	– Coil is protected by a metal shield acting as a Faraday cage, disabling its capability to capture the electromagnetic field emitted by the RFID reader

3 Implementation

To use an off-the-shelf inductor in your design, one option is to design the footprint of an optional external capacitor, in order to be able to fine-tune the antenna tuning frequency if needed.

Figure 2. Possible implementation using an external inductor and an external tuning capacitor



Refer to The application note AN2972 *Designing an antenna for the M24LR64-R dual interface I²C/RFID device* for further details on antenna design and optimization.

4 ANT3-M24LR-A reference design

ANT3-M24LR-A is a reference design proposed by ST as an example of using an external inductor.

The M24LR64-RMN6T/2 IC is installed on the ANT3-M24LR-A board. The external inductor's inductance value is 4.7 µH, and no external tuning capacitor is installed.

Please contact your local sales and marketing office for further information about this reference design.

Figure 3. $L_{INDUCTOR}$ = 4.7 µH - diameter = 4.5 mm

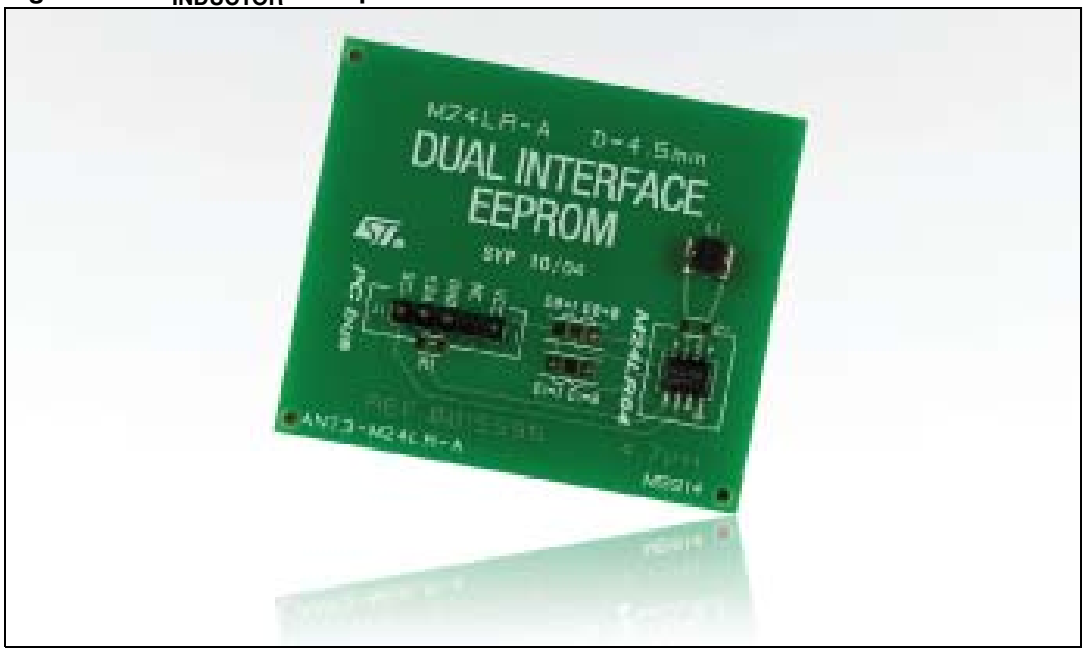


Figure 4. $L_{INDUCTOR}$ = 4.7 µH - diameter = 5.8 mm

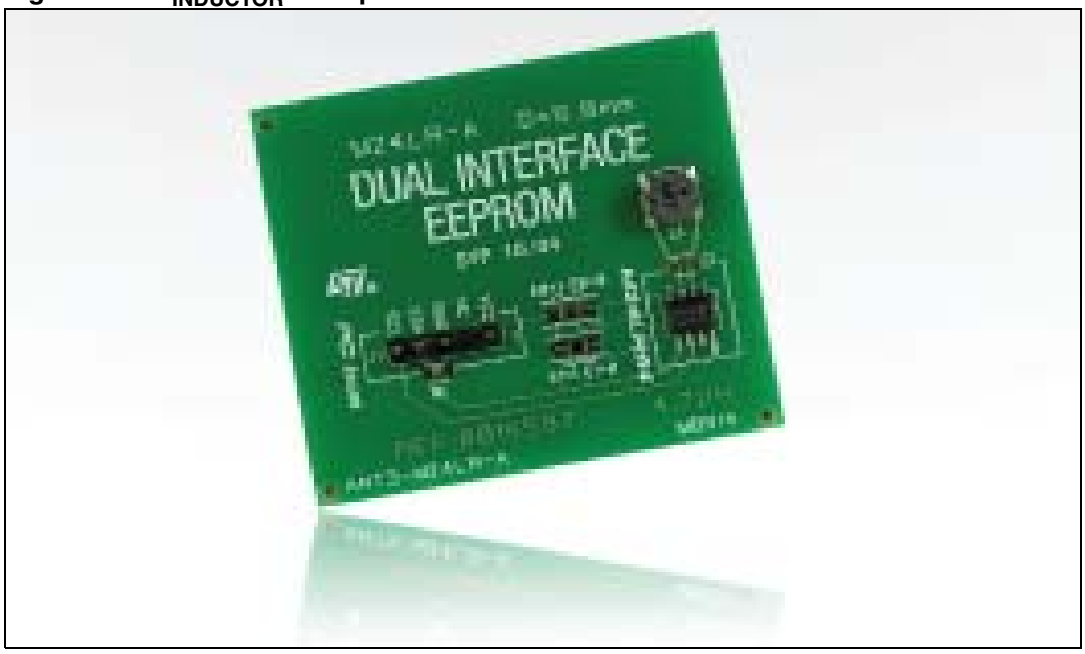


Figure 5. $L_{INDUCTOR}$ = 4.7 µH - diameter = 7.8 mm (STMicroelectronics reference design: ANT3-M24LR-A)

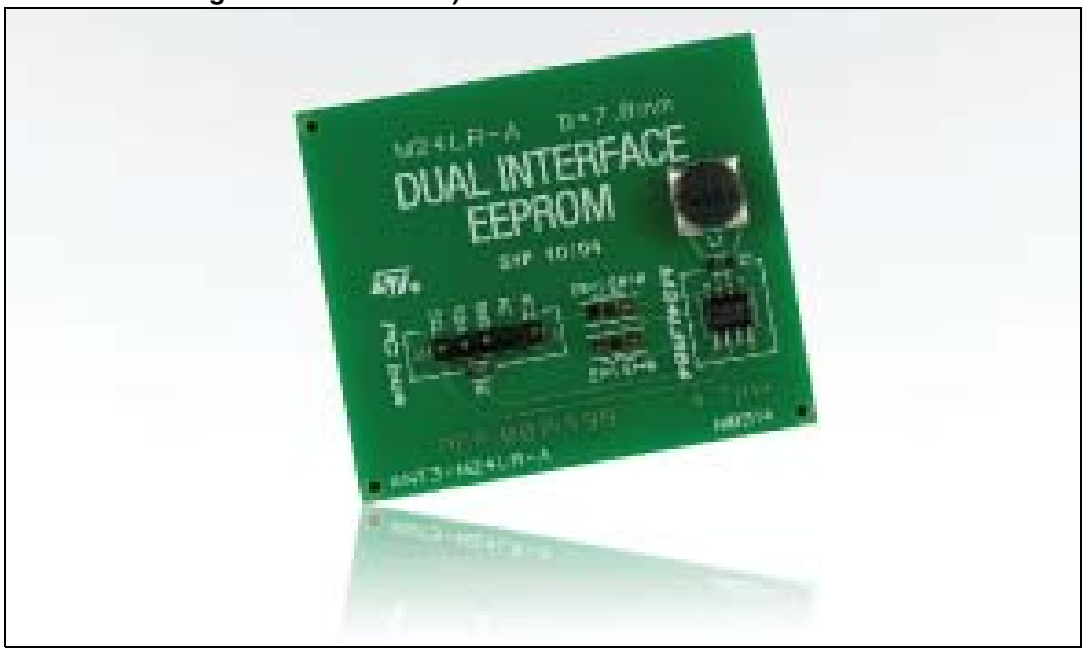
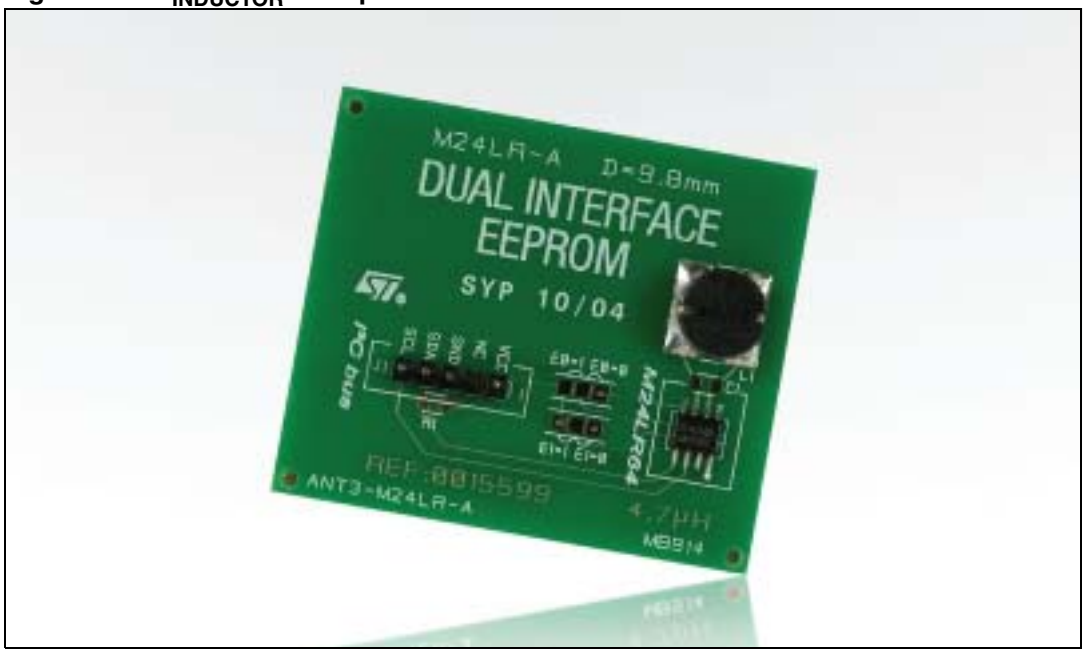


Figure 6. $L_{INDUCTOR}$ = 4.7 µH - diameter = 9.8 mm



5 Read range considerations

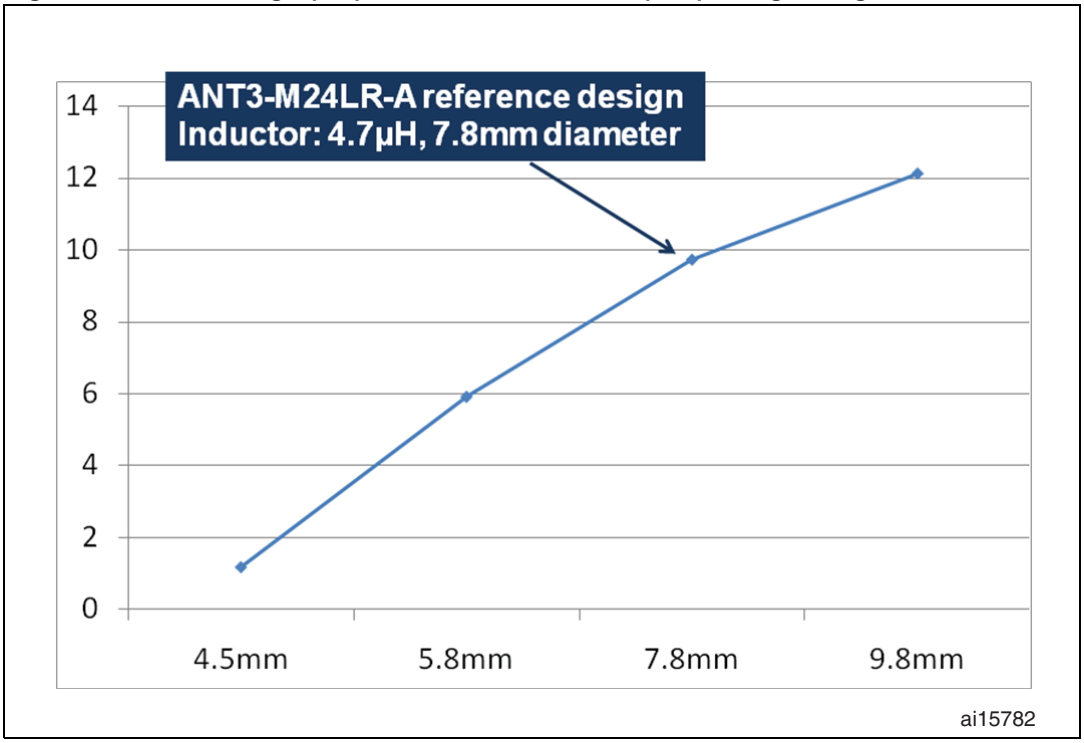
The read range is the maximum distance between an RF reader and the M24LRxx antenna.

First and foremost, you must choose the right inductor value so that the resulting antenna is properly tuned to your application.

However, for a given inductance value, the read range varies depending on the actual size of the inductor. The bigger the inductor, the bigger the active surface of the inductance, the more energy and data are captured by the M24LRxx devices and the better the read range.

To illustrate this, ST has measured the effect of various sizes of inductor on the ANT3-M24LR64 reference antenna, using a Feig MR101 ISO15693 reader. The inductance value is the same for all inductors: 4.7 µH.

Figure 7. Read range (cm) vs inductor diameter (mm) using a Feig MR101 reader



6 Revision history

Table 2. Document revision history

Date	Revision	Changes
15-Mar-2010	1	Initial release.
19-Jul-2010	2	Corrected document number in page headers.