UHF RFID PCB Tags

Creating & Protecting Value in Electronics
In the beginning there was...
How can I solve my problems?

1. My product is copied by pirates
2. I need traceability
3. Problems with barcode labels
4. I want to reduce wrong deliveries
5. I want to reduce my stock
6. There are too many manual operations in my process
7. ...
By Adding Some Magic to Your PCB

Supply Chain Management

Traceability

Conventional PCB without RFID tag function

Smart PCB with RFID tag function

Add MAGICSTRAP® and your PCB will become a full RFID Tag!
Your Product will Become Fully RFIDed

Traceability

Supply Chain Management

Example!

MAGICSTRAP®
inside!

Portable RFID Reader

Access information inside the product over the whole supply chain!
CS = Stakeholder Oriented Value Creation

Traceability
Anti-Grey Channel
Anti-Counterfeit
CRM

Process control
Transparency
WEEE Recycling
Introduction

What the heck is RFID???

Radio Frequency IDentification

→ A **batteryless RF technology** (UHF@860 – 960Mhz)
  → making objects smart (providing unique ID + some data)
  → able to cover distances up to >5m
→ similar to a barcode label/datamatrix, but much better:
  → rewritable!
  → works also without optical connection (e.g. through carton box, product housing)
Introduction

Why UHF RFID for electronics???

Only UHF RFID is scalable enough and fits best to PCB/electronics application

→ able to cover distances up to >5m but also short range communication possible

  → HF limited to approx 0.5m

→ only UHF technology can cover all uses over the full value chain

  → HF RFID limited to process control / production

→ shorter wavelength of UHF results in minimal antenna space needed on PCB

  → HF RFID wavelength nearly 70x that of UHF RFID!
RFID System – Elements & Operation

3 Elements of an RFID System

1. Tag enters RF field of Reader
2. RF signal powers Tag
3. Tag transmits ID, plus data
4. Reader captures data
5. Reader sends data to computer
6. Computer sends data to reader
7. Reader transmits data to tag

Operation
RFID System – Tag Elements

MAGICSTRAP® is a Tag Component

a UHF - IC Module
Introduction

What is the Magic of the Magicstrap???
Rethinking Tags: Reduce to the MAGICSTRAP®

Efficiently use existing metallization (e.g. ground plane) as antenna

Instead of adding problems & cost…

- expensive
- non standard process & materials

…just add a standard SMD component

- standard process
- RFID is globally standardized
  → ISO, EPC Global

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What is inside of MAGICSTRAP®?

- RFID IC
- Antenna filter: covers worldwide RFID frequencies (EU, US and Japan)
- Antenna matching circuit
- ESD protection (<2kV M.M.)

Environmental Friendly: 100% GREEN materials
How does MAGICSTRAP® work on a PCB?

**Maximum efficiency: antenna matching included**

The antenna only has to receive the incoming RF
All other functions provided by MAGICSTRAP®

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**Table: Conventional vs. Murata MAGICSTRAP®**

<table>
<thead>
<tr>
<th>Function</th>
<th>Conventional</th>
<th>Murata MAGICSTRAP®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reception / reflection of RF wave</td>
<td>Antenna function</td>
<td>Antenna function</td>
</tr>
<tr>
<td>Impedance matching</td>
<td>Antenna function</td>
<td>Done by MAGICSTRAP®</td>
</tr>
<tr>
<td>Fix center frequency and bandwidth</td>
<td>Antenna function</td>
<td>Done by MAGICSTRAP®</td>
</tr>
</tbody>
</table>

* Patents pending
How does MAGICSTRAP® work on PCB?

1. Conventional Dipole Antenna

2. Dipole Antenna with wider area

3. PCB antenna with MAGICSTRAP®

MAGICSTRAP® recognizes the PCB as a dipole antenna.
4 Types of reference antenna on PCB

Type 1
0.5x0.5cm (0.25cm²)

Type 2
0.5x1.0cm (0.5cm²)

Type 3
1.2x1.0cm (1.2cm²)

Type 4
3.2x1.3cm (4.2cm²)

MAGICSTRAP®

Read range

0.7m
1.6m
3.6m
5m

(at 4W EIRP, 915MHz, with 6dBi directivity antenna and circularly polarized wave)
Change of board size will only affect communication range but not functionality.
Order Information

Corresponding MAGICSTRAP® Partnumbers

Each of the above antenna designs requires a particular MAGICSTRAP® partnumber. Please make sure that you order the correct corresponding part number.
The Magic Starterkit – Available Now!

Contains everything you need to immediately explore Magicstrap and the magic values of RFID!

Value Creation Process is Split in Separate Steps

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>Production</th>
<th>Logistics</th>
<th>Distribution</th>
<th>Point of Sales &amp; Marketing</th>
<th>After Market</th>
<th>Recycling</th>
</tr>
</thead>
</table>

Conventional PCB
A tagged PCB will provide a consistent ID

- R&D
- Production
- Logistics
- Distribution
- Point of Sales & Marketing
- After Market
- Recycling

MAGICSTRAP®
The PCB-tag will connect all elements of the chain
Simply pick the elements you need for your RFID system. The consortium offers scalable and flexible solutions over the whole chain. All members will help you to identify your possibilities to create value using RFID.
Process Integration = Value Creation

The PCB becomes Backbone of the Value Chain
Some more Magic
MAGICSTRAP® - The Smallest UHF Tag

Near Field Transmission with Loop Antenna

Reader Loop Antenna Shape

Read / Write 7mm+ read range

No Additional Antenna on PCB Required!

Easily control your process!
Magic Ranges

Loop Antenna of UHF-R/W

Output power

Read Range

1 W
100 mW
10 mW

2.8mm
4.9mm
7.8mm

No external antenna connected!

Partnumbers
LXMS31ACNA-012 (3.2 x 1.6mm) – in production
LXMS21NCNH-147 (2.0 x 1.2mm) – prototype, MP 2013

2.0 x 1.2 x 0.6 max
EPC global C1G2
**Magic Ranges (on Metal!)**

Loop Antenna of UHF-R/W

**Output power**
- 1W
- 100 mW
- 10 mW

**Read Range (on Metal)**

**Partnumbers**
- LXMS31ACNA-012 (3.2 x 1.6mm) – in production
- LXMS21NCNH-147 (2.0 x 1.2mm) – prototype, MP 2013

No external antenna connected!
Available Short Range Readers

All these standard readers and antennas:

already connect to the antennaless Magicstrap!
The Magic Behind

Contains Antenna Function for Short Range Communication!

Partnumbers
LXMS31ACNA-012 (3.2 x 1.6mm) – in production
LXMS21NCNH-147 (2.0 x 1.2mm) – prototype, MP 2013

Environmental Friendly: 100% GREEN materials
Magic Places

MAGICSTRAP®

Equipment

Medical

Consumer Goods

Metallic Mold

Tools

Bolt

...you could place your RFID tag anywhere!

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Future Magic – Embedding Now!

Embed MAGICSTRAP® into the PCB and make it invisible

1. Copy protection - perfectly invisible
2. Space saving

A cooperation with

Available Now!!
Future Magic – Embedding Now!
Solution 1 - Antennaless

Embedded MAGICSTRAP (R) without booster Antenna

+ no layout modification needed
+ protection of Magicstrap (R)
+ cost efficient
+ very early use of RFID

- read/write range limited (< 2cm)
- location limited to edge of PCB

© Gernot Seeger         Beta LAYOUT GmbH        SMT Hybrid Packaging 2012
Solution 2 – With Booster

Embedded MAGICSTRAP (R) with galvanic connection to booster antenna

+ protected
+ cost efficient
+ early use of RFID
+ ground plane can be used as antenna
+ long read/write range possible
- integration in layout necessary
- location limited to edge of PCB
One Last Magic...
The Magic Bridge – Magicstrap+ I²C

Applications
- Product Configuration
- Device customization
- Firmware downloads
- Return management
- Counterfeit protection and authentication
- Production information
- Theft protection and deterrence
- Production automation
- Shelf-life calculation
- Sensor applications
- Electronic shelf labels

Other Features (TBD)
- 3,328-bit user memory
- Dual front-end architecture
- Best-in-class RF sensitivity
- Up to 160-bit EPC
- 96-bit TID, including 48-bit serial number
- EPCglobal 1.2.0 standard
- Switchable RF and I²C interfaces
- Digital switch
- RF-to-I²C bridge mode (handshake)
- Interrupt output

A cooperation with

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The Magic Starterkit – Available Now!

Contains everything you need to immediately explore Magicstrap and the magic values of RFID!

Take a R(F)IDe with me…

MURATA BOY rides ……
together with the future and dreams of electronics.

And this is all just the beginning…

aschmoldt@murata.nl  http://www.murata.com/products/rfid/index.html
Appendix
MAGICSTRAP®

How to use

mini PCB sample

[Images of PCB samples]
Basically Murata recommends to apply one of the 4 recommended antenna patterns to your PCB when using the MAGICSTRAP®.

We understand that you might want to gather some practical experience or test possible performance before touching the layout of your PCB and adding one of these patterns permanently. Therefore we have developed a solution, which enables you to do first steps. We call this solution mini PCB.
Magic mini PCB

- This is one of the mini PCBs which consists of an antenna matching pattern on which a MAGICICSTRAP® is already mounted. It has two terminals for the connection to the ground plane of your PCB.

Order here:
www.beta-layout.com
There are three available types of mini PCB, corresponding to three of the four recommended MAGICSTRAP® antenna patterns. The four patterns form a compromise between board space requirement and achievable read range. That means, pattern 1 will require least board space but will also show the smallest read range. Pattern 3 will give you bigger range.

You can order these mini PCBs from www.beta-layout.com,
4 Types of reference antenna on PCB

Read range

0.7m 1.6m 3.6m 5m

These are the ranges you can reach with the 4 PCBs under the given specifics. R/W power and PCB size and shape and should give you a first rough indication of the performance differences between the 4 designs.
How to apply the mini PCB

Please simply attach the mini PCB to your PCB. This is an easy way to get a first estimation of RFID tag performance by using MAGICSTRAP® in combination with one of the recommended antenna patterns. The mini PCB should ideally be used at the location where you plan to later integrate the MAGICSTRAP® antenna pattern in your layout.

1) Position where you plan to place MAGICSTRAP™ at mass production

You can of course compare the performance of different locations on your PCB, if you place it differently on additional PCBs.

2) mini PCB

3) Remove resist

4) Soldering
Finding the right location

MAGICSTRAP® should be mounted as close as possible to the middle of the PCB. Maximum read range will be achieved in MAGICSTRAP® is mounted at the center of the longer side of the PCB. The same is valid for the mounting position of the mini PCB.

<table>
<thead>
<tr>
<th>length X [cm]</th>
<th>Read Range [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3.6</td>
</tr>
<tr>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>1</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Example of horizontal attachment

Both examples (A) and (B) will show similar sensitivity and polarity. Mini PCBs are sensitive to the environment underneath, so please don’t place metal underneath mini PCB or don’t stack mini PCB on main PCB.

Overlapping area
In case of attachment (A), please limit the overlapping area (a) to the minimum for best performance. Moving the area (b) over the main PCB, will cause a shielding effect and reduce the possible communication distance, worst case down to zero.
Example of vertical attachment

You might also consider a vertical attachment of the mini PCB. In this case, please keep the following points in mind.

- different polarization:
  - mounting the mini PCB horizontally will result in a different polarization, compared to mounting the MAGICSTRAP® directly on the PCB
- fragility:
  - mounting the mini PCB vertically will be mechanically difficult to handle
- range:
  - you might get a performance advantage compared to horizontal mounting
Measurement Precautions

Please DON’T place on metal

- Metal environment
  - Please do not place the PCB with the connected mini PCB on or close to metal. This will drastically reduce the read range performance and could lead to not being able to communicate with the Magicstrap.

- Single Read
  - In case you want to be sure to communicate with one MAGICSTRAP® only, make sure that there is no other RFID Tag present in the field of your reader. Due to the nature of UHF RFID, any tag in the field of the reader antenna will be detected. If you want to test bulk read function of course, place as many tags in the field as you want.
  - Of course you can also ensure communication with one MAGICSTRAP® when using its close coupling feature, which we call „antennaless“, while using a reader with a loop antenna. For more details, pls see the application notes called „antennaless“ MAGICSTRAP® and the relevant video on the Murata website.
The results of the actual measurements with your board, should help you to determine which pattern you should apply to your board. These antenna patterns will give you enough range in most of the cases. In case you are not satisfied with the result or need a longer performance due to a particular reason, an improvement can be achieved by a custom antenna design. (See also the presentation of Dr. Iliev of Kathrein on our website). Please contact one of our partners for custom antenna design support, if necessary.
Order Information

Each of the above antenna designs requires a particular MAGICSTRAP® part number. Please make sure that you order the correct corresponding part number.

Corresponding MAGICSTRAP® Part Numbers

- Type 1: LXMS31ACNA-009
- Type 2: LXMS31ACNA-010
- Type 3: LXMS31ACNA-011
- Type 4: LXMS31ACNA-012
For further information, please visit:

RFID (Radio Frequency IDentification) is a way of Auto ID (automatic identification) technologies such as Barcode, finger-printing, etc.

- **Auto ID**
  - RFID
    - Passive
      - Battery less
    - Active
      - With Battery
  - Barcode
  - 2D code
  - Biometrics
  - Magnetic strips
  - OCR
  - Machine vision
## Comparison RFID Frequencies

<table>
<thead>
<tr>
<th></th>
<th>LF</th>
<th>HF</th>
<th>UHF</th>
<th>2.4G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>~135kHz (usually 128kHz)</td>
<td>13.56MHz</td>
<td>860~960MHz</td>
<td>2.4GHz</td>
</tr>
<tr>
<td><strong>Read range</strong></td>
<td>A few cm</td>
<td>A few 10cm</td>
<td>~5m</td>
<td>~3m</td>
</tr>
<tr>
<td><strong>Tag price</strong></td>
<td>Expensive</td>
<td>Fair</td>
<td>Good</td>
<td>Could be cheap</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>but Expensive</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>Fair</td>
<td>Good</td>
<td>Global Standard</td>
<td>Custom</td>
</tr>
<tr>
<td><strong>Directivity</strong></td>
<td>Wide</td>
<td>Wide-ish</td>
<td>Wide</td>
<td>Narrow</td>
</tr>
<tr>
<td><strong>Antenna size</strong></td>
<td>Huge</td>
<td>Big</td>
<td>Small</td>
<td>Very small</td>
</tr>
<tr>
<td><strong>Useability on PCB</strong></td>
<td>Bad</td>
<td>Fair</td>
<td>Very Good</td>
<td>TBD</td>
</tr>
</tbody>
</table>
1. **Cost Saving**
   - Faster data capture (very short read time)
   - Read multiple tags at once (>100 tags / s)
   - Elimination of manual operation

2. **Reliability**
   - Higher reading accuracy
   - Less manual operations needed

3. **Flexibility**
   - No visual connection needed: read through package!
   - Information stored in MAGICSTRAP® can be altered
   - Additional user memory available (e.g. indicate software version, maintenance information…)
   - Wide „Read“ angle
   - Less space on PCB occupied (replace multiple Barcode Labels)

4. **Simplicity**
   - One Standard accepted world wide (EPC Global)
1. **100% compatible to EPC Global C1G2**
   - Standard Product Number for World Wide use
   - Compatible to any EPC Global C1G2 compliant equipment
   - 240 bit EPC for serial#

2. **Additional Memory – 512 bit**
   - Freely add your own information (production date, version ID...)
   - Keep your own numbering system internally

3. **ISO 18000-6 compliant**
   - UHF Air interface standardized
Global Use – World Wide SCM

**Mesurement condition**
- Free Air

**Antenna:** 4 inch for SCM

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**Cost Saving:** One Tag for anywhere in the world!

**Broad band coverage!**