Texas Instruments

Tag-it HF-I Transponder Inlays

Reference Guide

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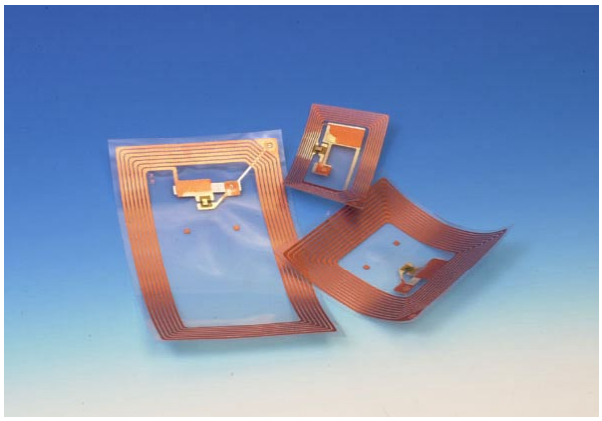
TI-RFid
A TEXAS INSTRUMENTS TECHNOLOGY

Edition Three – May 2002

This is the third edition of this reference guide. It contains a description of the Tag-it HF-I Inlays, their specifications, dimensions and instructions for further handling.



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About This Guide

This reference guide for the Tag-it HF-I Inlays is designed for use by TI partners who are engineers experienced with Radio Frequency Identification Devices (RFID).

Regulatory, safety and warranty notices that must be followed are given in Chapter 4.

Conventions

WARNING:

A WARNING IS USED WHERE CARE MUST BE TAKEN OR A CERTAIN PROCEDURE MUST BE FOLLOWED, IN ORDER TO PREVENT INJURY OR HARM TO YOUR HEALTH.

CAUTION:

This indicates information on conditions which must be met, or a procedure which must be followed, which if not heeded could cause permanent damage to the equipment or software.

Note:

Indicates conditions which must be met, or procedures which must be followed, to ensure proper functioning of the equipment or software.

Information:

Indicates information which makes usage of the equipment or software easier.

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http://www.ti-rfid.com.

Document Overview

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Chapter 1

Introduction

This chapter introduces you to the Tag-it HF-I Transponder Inlays.

Topic Page

1.1 General

The **Tag-it HF-I** Inlay family of Texas Instruments RFID transponders is based on the ISO 15693 standard for contactless integrated circuit cards (vicinity cards). This family of various available inlay shapes form also the basis of consumable smart labels for use in markets requiring quick and accurate identification of items, such as:

- express parcel delivery,
- airline boarding pass and baggage handling,
- electronic ticketing,
- anti-counterfeit prevention,
- distribution logistics and supply chain management
- building access badges
- asset tagging

The passive (no battery) transponder inlays are thin and flexible, offer a general purpose read/write capability and are designed to be easily converted into paper or plastic labels.

The inlay is supplied on a polymer tape substrate, one web wide and delivered on reels. This allows an easy integration into existing label manufacturing processes to produce disposable labels.

User data is written to and read from memory blocks using a non-volatile EEPROM silicon technology. Each block is separately programmable by the user and can be locked to protect data from modification. Once the data has been ‘locked’ then it cannot be changed.

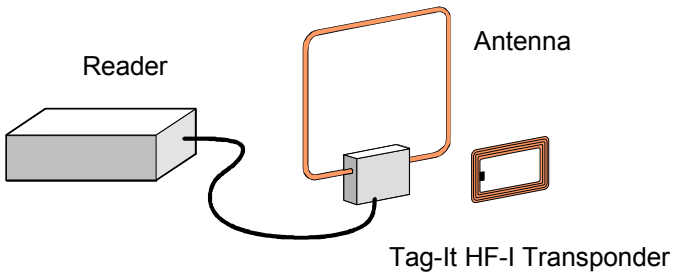
To give some examples, information about delivery checkpoints and timing, place of origin/destination, pallet assignments, inventory numbers and even transportation routes can be coded into the transponder.

Multiple Tag-it HF-I transponder Inlays, which appear in the Readers RF field, can be identified, read from and written to by using the **U**nique **Id**entifier (UID), which is programmed and locked at the factory.

1.2 System Description

For operation a reader with antenna is required to send a command to the transponder and to receive its response (see figure 1). The command of the Reader can be either in addressed or non-addressed mode. The Transponder does not transmit data until the reader sends a request (Reader talks first principle).

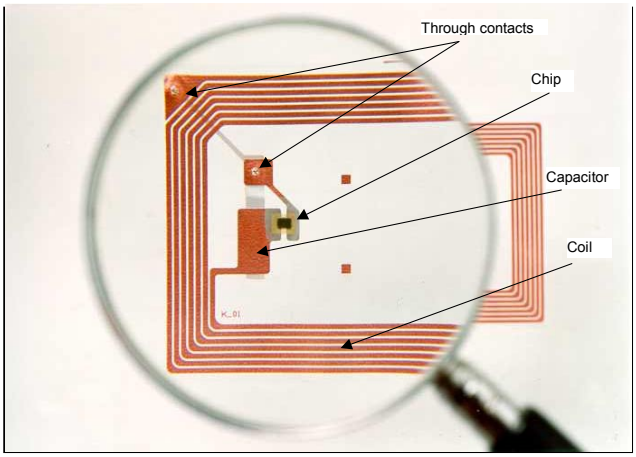
Figure 1 RFID System with reader, antenna and Tag-it HF-I Transponder



1.3 Product Description

The Tag-it HF-I Transponder is based on the ISO 15693 standard and is fully compliant to this standard. It consists of a resonance circuit assembled on a PET foil with a flip-chip mounted microchip. An aluminium antenna is used as inductor and 2 layers Aluminium on the top and bottom side of the foil function as capacitor. The two layers are contacted with through contacts (see figure 2). TI uses this capacitor to individually tune each device to a target resonance frequency. This compensates for any material and process tolerances and so ensures optimal performance of every single transponder inlay. The trim target includes frequency offset to compensate detuning that will occur after further integration into different materials such as paper or PVC. To protect the transponder from corrosive influences, the aluminium is covered with a gravure-resist ink.

Figure 2 Schematic structure of Tag-it HF-I Transponders



1.4 Functional Description

The Tag-it HF-I transponder is a low power, full duplex transponder for use with passive contactless identification transponder systems.
The transponder is designed to operate with a 13.56MHz carrier frequency. The ISO standard defines for some communication parameters several modes in order to meet different international radio regulations and different application requirements. Therefore communication between the reader and the transponder (Down-Link communication) takes place using ASK modulation index between 10% and 30% or 100% and datacoding (pulse position modulation) '1 out of 4' or '1 out of 256'.
According to ISO 15693 Up-Link communication (Transponder to Reader) can be accomplished with one subcarrier (ASK modulation) or with two subcarrier (FSK modulation). Both modes (ASK and FSK) can operate with either high or low data rate. **The transponder will answer in the mode it was interrogated from the reader and supports all communication parameter combinations**.
Up- and Down-Link are frame synchronized and CRC check sum secured.
Each Tag-it HF-I transponder has a 'unique' address (UID) stored in two blocks which are factory-programmed and 64 bits long (=2^{64} different addresses). This can be used for addressing each transponder uniquely and individually for a one-to-one exchange between the reader and the transponder. A mechanism to resolve collisions of a multiplicity of transponders (Anticollision) is also implemented. This special feature allows multiple transponders to be read simultaneously and offers the capability to inventory in a very short time a large number of transponders by their unique address, provided they are within the reader operating range.

Also, the **A**pplication **F**amily **I**dentifier (AFI) and the **D**ata **S**torage **F**ormat **I**dentifier (DSFID) which are optional in the ISO15693 are supported by the Tag-it HF-I Transponder.

For more details about the communication between reader and transponder see ISO 15693.

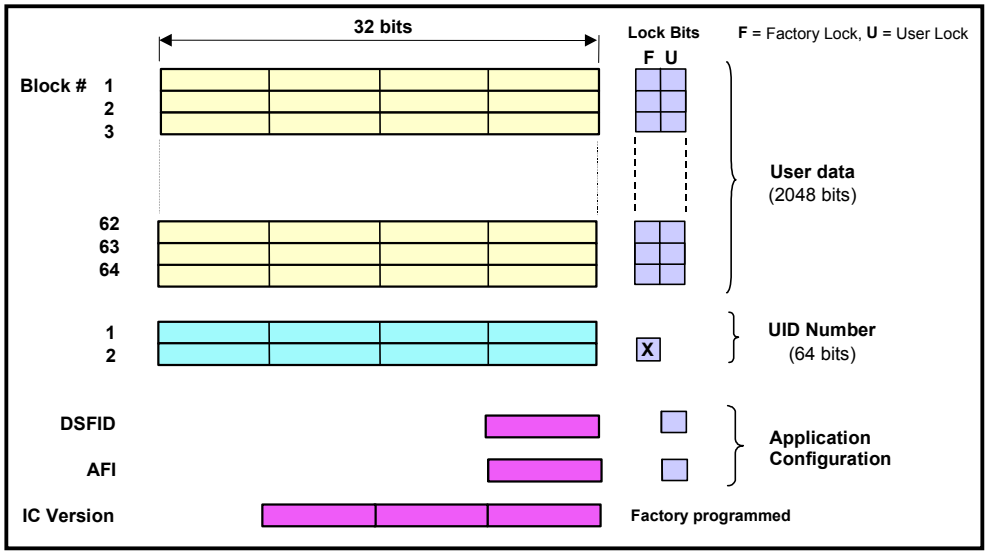
Beside the ISO15693 defined functionality the Tag-it HF-I transponder supports a range of additional specific functions, providing additional application flexibility for the customer:

- A second lock bit per block is designated for "Factory Lock". That means that every block of the user memory can be factory locked during production.
- The ISO Inventory Mode command has been defined in the standard as a stand-alone command to receive DSFID and UID. For more system flexibility Texas Instruments' Tag-it HF-I Transponder also allows the combination of the Inventory command with other commands (see Table 1).
- Beside the ISO 15693-3 defined commands TI has implemented additional manufacturer specific commands which are listed in Table 1.

1.5 Memory Organization

User data is read and stored in a 2kBit non-volatile user memory that is organized in 64 blocks. Each block with 32 bit is user programmable and can be locked individually to protect data from modification. Once set, the lock bit cannot be reset. The user memory is field programmable per block. Two levels of block locking are supported: Individual block locking by the user (U) or individual block locking of factory programmed data (F) during manufacturing. Bit 2 of the "Block Security Status" Byte defined in ISO 15693-3 is used to store the Factory Lock Status of the Block. Block locking irreversibly protects the locked data from any further reprogramming. A factory-programmed block contains the IC reference and the physical memory info (Block size and Number of Blocks)

Figure 3 Memory organization of the Tag-it HF-I Transponder



1.6 Command Set

Table 1 Command Set for Tag-it HF-I Transponder

		Request Mode					
Request	Request Code	Inventory	Addressed	Non Addressed	Select	AFI	Option Flag
ISO 15693 Mandatory Commands							
Inventory	0x01	✔	-	-	-	✔	-
Stay Quiet	0x02	-	✔	-	-	-	-
ISO 15693 Optional Commands							
Read_Single_Block	0x20	✔	✔	✔	✔	✔	0/1
Write_Single_Block	0x21	-	✔	✔	✔	-	1
Lock_Block	0x22	-	✔	✔	✔	-	1
Read_Multi_Blocks	0x23	✔	✔	✔	✔	✔	0/1
Write_Multi_Blocks	0x24	-	-	-	-	-	-
Select Tag	0x25	-	✔	-	-	-	-
Reset to Ready	0x26	-	✔	✔	✔	-	-
Write_AFI	0x27	-	✔	✔	✔	-	1
Lock_AFI	0x28	-	✔	✔	✔	-	1
Write DSFID	0x29	-	✔	✔	✔	-	1
Lock DSFID	0x2A	-	✔	✔	✔	-	1
Get_System_info	0x2B	✔	✔	✔	✔	✔	-
Get_M_Blk_Sec_St	0x2C	✔	✔	✔	✔	✔	-
TI Custom Commands							
Write_2_Blocks	0xA2	-	✔	✔	✔	-	1
Lock_2_Blocks	0xA3	-	✔	✔	✔	-	1

✔: Implemented
- : Not applicable
0/1: Option Flag needed

Note:

The Option Flag (Bit 7) of the ISO 15693 defined Request Flags must be set to 1 for all Write and Lock commands to respond properly.

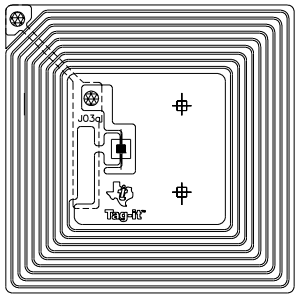
For reliable programming we recommend a programming time ≥ 10ms before the reader sends the End Of Frame (EOF) to request the response from the Transponder.

1.7 Inlay Formats and Part Numbers

To cover the specific requirements of different applications and conversion equipment, most Tag-it HF-I transponder Inlays are offered with metric or optionally with imperial pitch (the pitch is the distance of two antenna starting edges on a tape), in different shapes with frequency offset options for further integration into paper or PVC lamination.

Figure 4 Tag-it HF-I Transponder Inlay Square

Metric Pitch:
Partnumber: RI-I01-112A (frequency offset for further integration into paper)
Partnumber: RI-I01-112B (frequency offset for PVC lamination)



Imperial Pitch:
Partnumber: RI-I11-112A (frequency offset for further integration into paper)

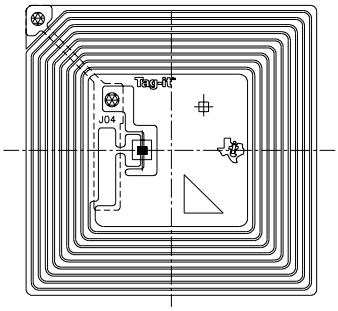
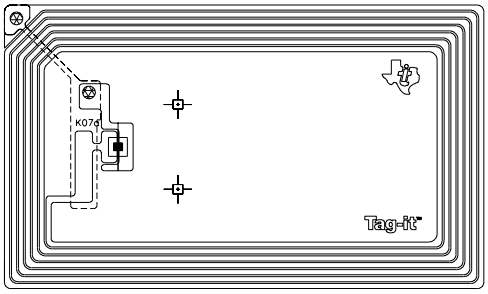


Figure 5 Tag-it HF-I Transponder Inlay Rectangle-Large

Metric Pitch:
Partnumber: RI-I02-112A (frequency offset for further integration into paper)
Partnumber: RI-I02-112B (frequency offset for PVC lamination)



Imperial Pitch:
Partnumber: RI-I12-112A (frequency offset for further integration into paper)

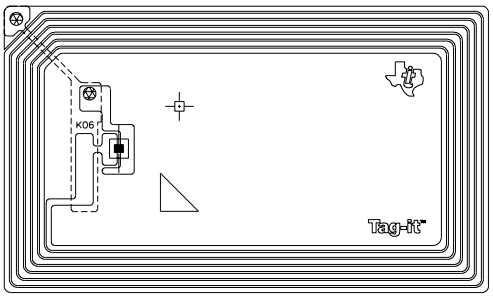
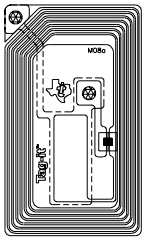


Figure 6 Tag-it HF-I Transponder Inlay Rectangle-Miniature

Partnumber: RI-I03-112A
(frequency offset for further integration into paper or PVC lamination)



Chapter 2

Specification

This chapter provides the electrical and mechanical specifications of the Tag-it HF-I Transponder Inlays.

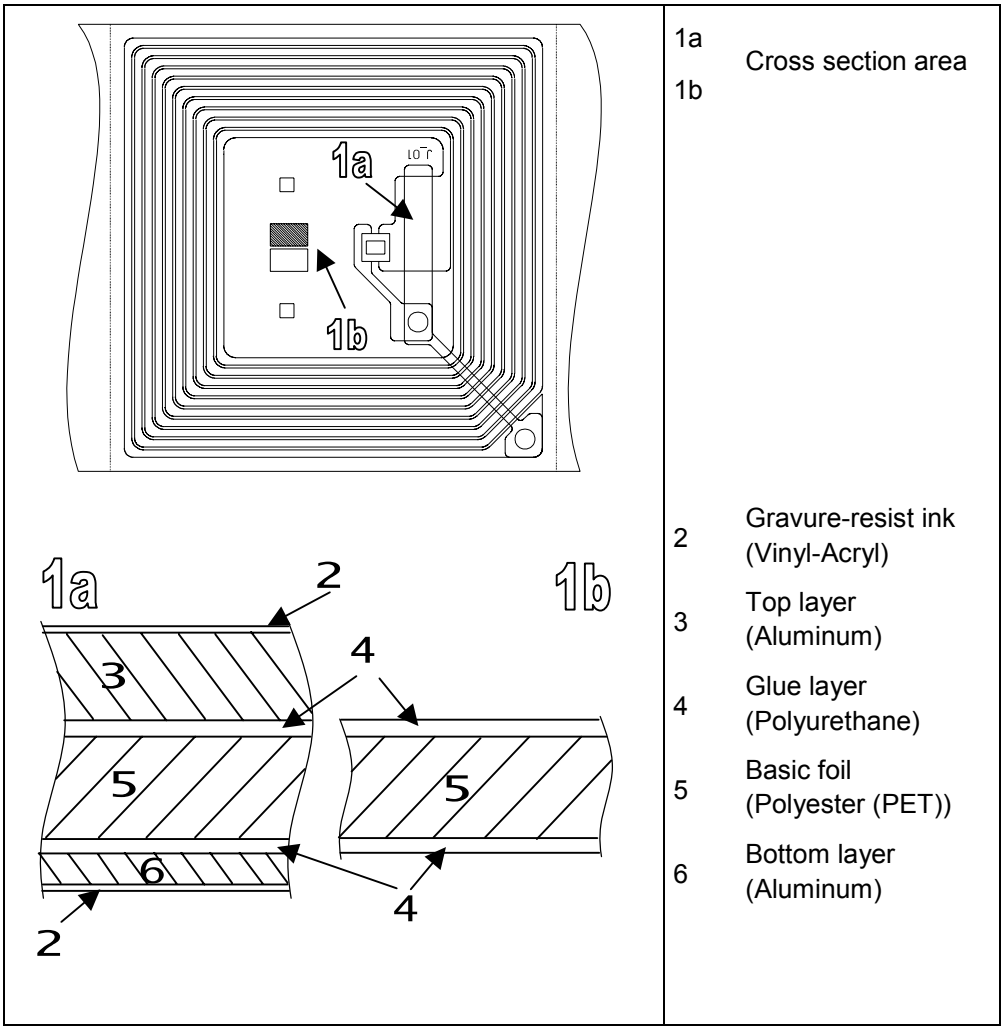
Topic Page

2.1 Material Composition

The coil tracks, chip pads and upper capacitor plate are etched from the top layer aluminum, the bridge and the bottom capacitor plate are etched from the bottom layer aluminum.

- The surface of the foil is free of contamination by oil or grease (no fingerprints). However, there could be residuals of silicon dust, gravure resist on the substrate and dried residuals of PGMEA
  (= Propylene-Glycol-Monomethyl-Ether-Acetate).
- The wetability (surface energy) of the foil substrate is typically 42 mN/m

Figure 7 Cross Section Area of Tag-it HF-I Transponder Inlay



1a 1b	Cross section area
2	Gravure-resist ink (Vinyl-Acryl)
3	Top layer (Aluminum)
4	Glue layer (Polyurethane)
5	Basic foil (Polyester (PET))
6	Bottom layer (Aluminum)

2.2 Specification Summary

The following table applies to all Tag-it HF-I Transponder Inlay types.

Table 2 General Specification

Recommended Operating frequency	13.56 MHz
Factory programmed Read Only Number	64 bits
Memory (user programmable)	2k bits organized in 64 x 32-bit blocks
Typical programming cycles (at +25°C)	100,000
Data retention time (at +55°C)	> 10 years
Simultaneous Identification of Tags	Up to 50 tags per second (reader/antenna dependant)
Foil width	48 mm ± 0.5 mm (1.89 in ± 0.02 in)
Thickness	Chip area: 0.355mm (~0.014 in) Antenna area: 0.085mm (~0.0033 in)
Base material	Substrate: PET (Polyethylenetherephtalate) Antenna: Aluminum
Smallest bending radius allowed	18 mm (~0.71 in)
Tape tension (F), linear	max. 10 N
Operating temperature	-25°C to +70°C
Storage temperature (single inlay)	-40°C to +85°C (warpage may occur with increasing temperature)
Storage temperature (on reel)	-40°C to +40°C
ESD Immunity	min. 3.5kV (Human Body Model) min. 200V (Machine Model)
Delivery	Single row tape wound on cardboard reel with 500 mm diameter Reel outer width: approx. 60 mm (~2.36 in); Reel inner width: approx. 50 mm (~1.97 in) Hub diameter: 76.2 mm (3 in)
Typical quantity of good units per reel	5,000

Note:

For highest possible read-out coverage we recommend to operate readers at a modulation depth of 20% or higher.

In FSK mode and at high fieldstrength an increase of frequency fs2 (484.28kHz) can occur.

The following tables consists device specific parameters:

Table 3 Specification for RI-I01-112A, RI-I01-112B

Partnumber	RI-I01-112A	RI-I01-112B
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper)	14.4 MHz ± 200kHz (includes frequency offset to compensate PVC lamination)
Typ. required activation field strength read (at +25°C)	98 dBµA/m #	98 dBµA/m *
Max. required activation field strength read (at +25°C)	101 dBµA/m # (preliminary value)	101 dBµA/m * (preliminary value)
Typ. required activation field strength write (at +25°C)	101 dBµA/m #	101 dBµA/m *
Antenna size	45 mm x 45 mm (~1.77 in x ~1.77 in)	
Foil pitch	48 mm +0.1mm/-0.4mm (~1.89 in)	

* After PVC lamination

After integration into paper

Table 4 Specification for RI-I11-112A

Partnumber	RI-I11-112A
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper)
Typ. required activation field strength read (at +25°C)	98 dBµA/m #
Max. required activation field strength read (at +25°C)	101 dBµA/m (preliminary value) #
Typ. required activation field strength write (at +25°C)	101 dBµA/m #
Antenna size	45 mm x 45 mm (~1.77 in x ~1.77 in)
Foil pitch	50.8 mm +0.1mm/-0.4mm (2 in)

After integration into paper

Table 5 Specification for RI-I02-112A, RI-I02-112B

Partnumber	**RI-I02-112A**	**RI-I02-112B**
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper)	14.4 MHz ± 200kHz (includes frequency offset to compensate PVC lamination)
Typ. required activation field strength read (at +25°C)	94 dBµA/m #	94 dBµA/m *
Max. required activation field strength read (at +25°C)	97 dBµA/m # (preliminary value)	97 dBµA/m * (preliminary value)
Typ. required activation field strength write (at +25°C)	97 dBµA/m #	97 dBµA/m *
Antenna size	45 mm x 76 mm (~1.77 in x ~2.99 in)	
Foil pitch	96 mm +0.1mm/-0.4mm (~3.78 in)	

* After PVC lamination

After integration into paper

Table 6 Specification for RI-I12-112A

Partnumber	**RI-I12-112A**
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper)
Typ. required activation field strength read (at +25°C)	94 dBµA/m #
Max. required activation field strength read (at +25°C)	97 dBµA/m (preliminary value) #
Typ. required activation field strength write (at +25°C)	97 dBµA/m #
Antenna size	45 mm x 76 mm (~1.77 in x ~2.99 in)
Foil pitch	101.6 mm +0.1mm/-0.4mm (4 in)

After integration into paper

Table 7 Specification for RI-I03-112A

Partnumber	**RI-I03-112A**
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper or PVC lamination)
Typ. required activation field strength read (at +25°C)	109 dBµA/m *
Max. required activation field strength read (at +25°C)	112 dBµA/m (preliminary value) *
Typ. required activation field strength write (at +25°C)	112 dBµA/m *
Antenna size	22.5 mm x 38 mm (~0.89 in x ~1.5 in)
Foil pitch	48 mm +0.1mm/-0.4mm (~1.89 in)

* After integration into paper or PVC lamination

2.3 Mechanical Drawings

Figure 8 Dimensions of Tag-it HF-I Transponder Inlay Square (Metric Pitch) (RI-I01-112B, RI-I01-112B)

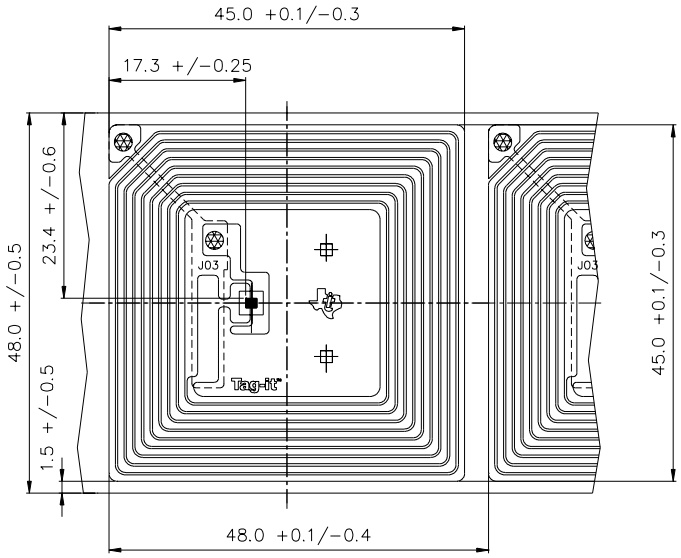


Figure 9 Dimensions of Tag-it HF-I Transponder Inlay Square (Imperial Pitch) (RI-I11-112A)

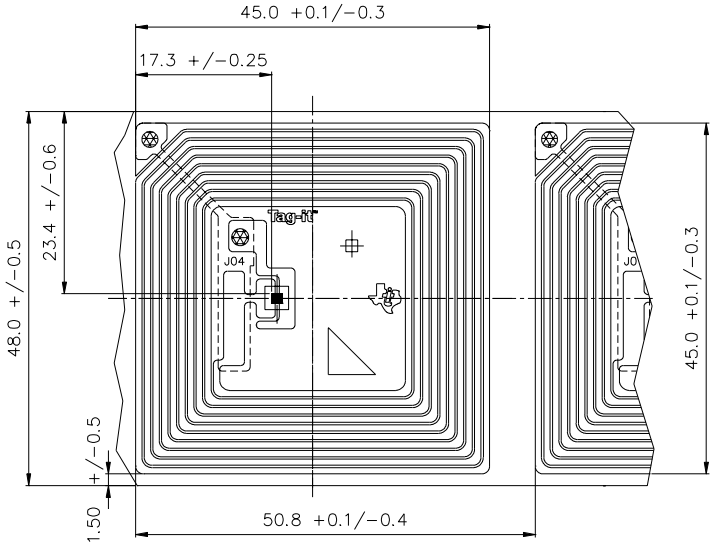


Figure 10 Dimensions of Tag-it HF-I Transponder Inlay Rectangle-Large (Metric Pitch) (RI-I02-112A, RI-I02-112B)

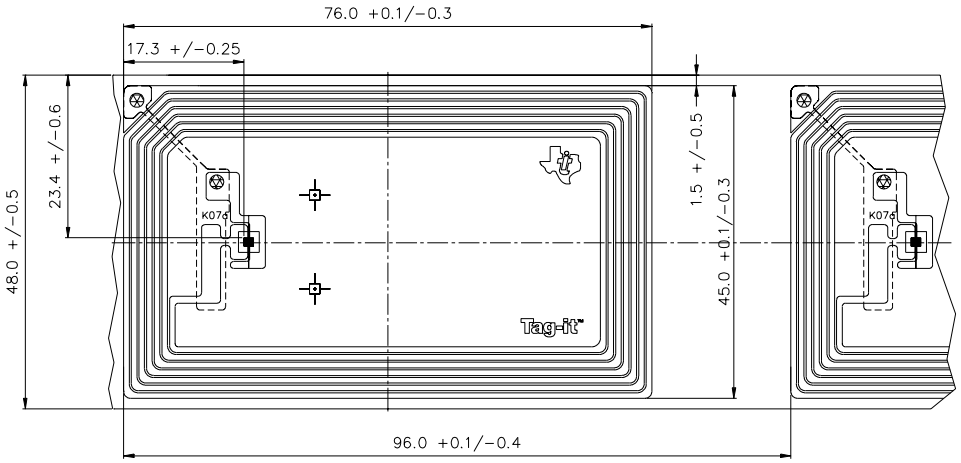


Figure 11 Dimensions of Tag-it HF-I Transponder Inlay Rectangle-Large (Imperial Pitch) (RI-I12-112A)

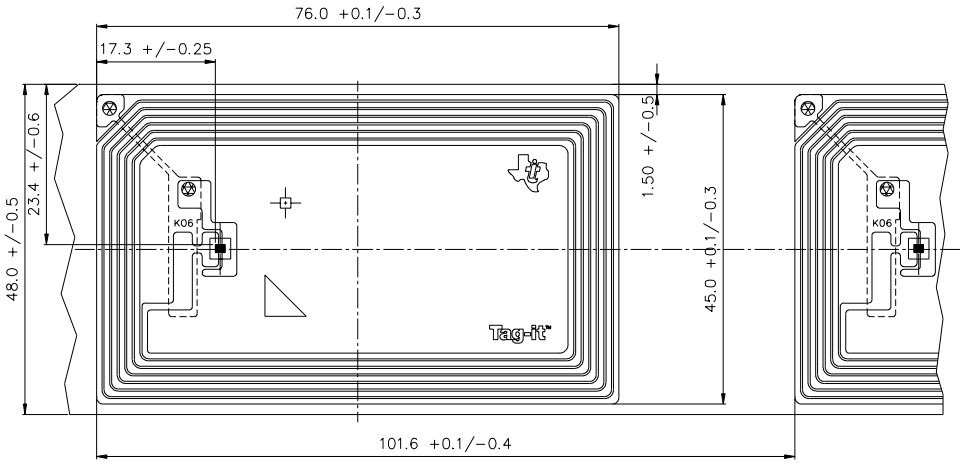
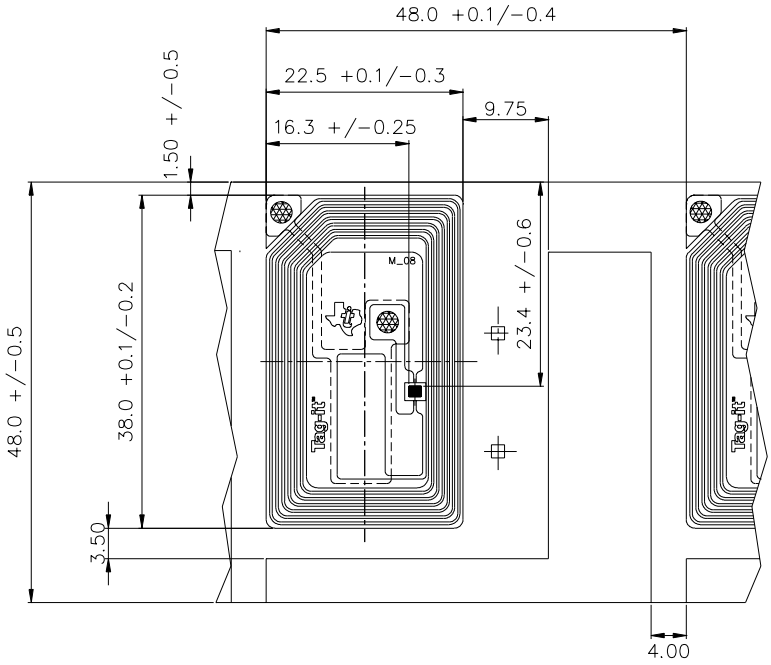


Figure 12 Dimensions of Tag-it HF-I Transponder Inlay Rectangle-Miniature (Metric Pitch) (RI-I03-112A)



Chapter 3

Shipping, Packing & further Handling

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3.1 General

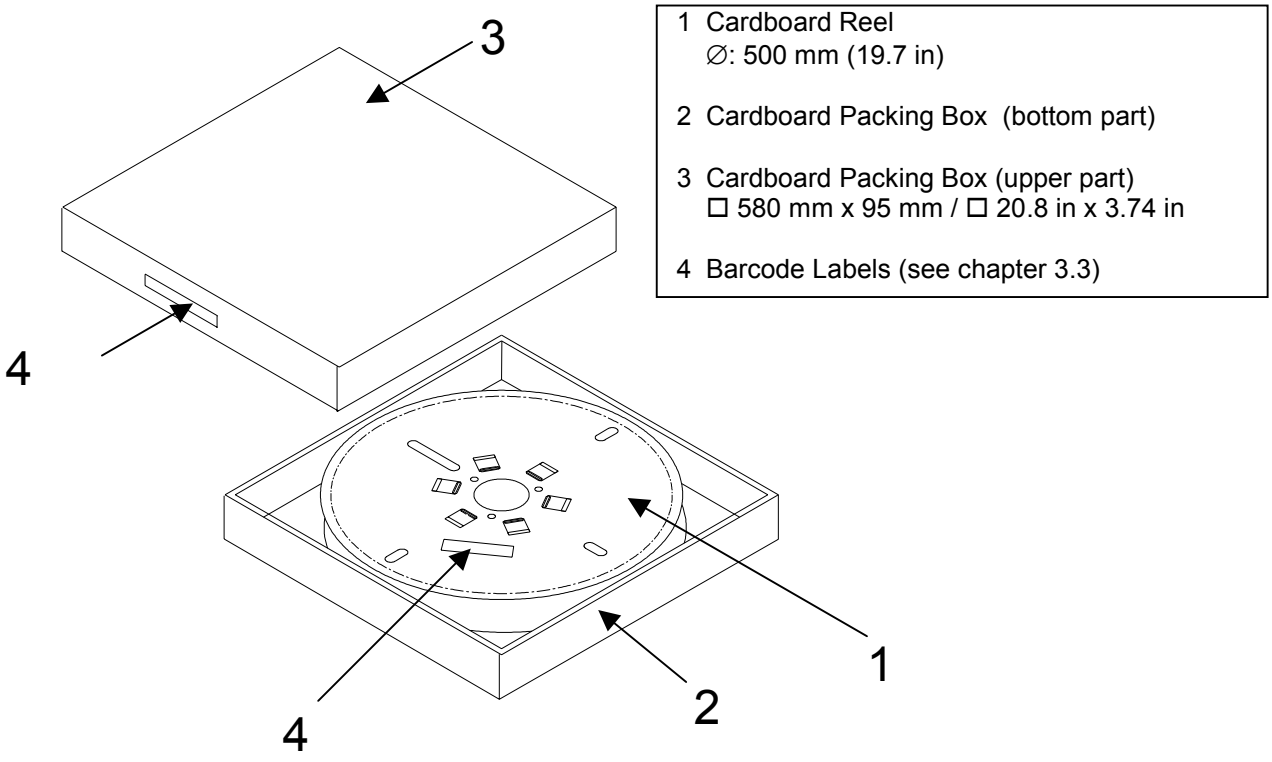
The Tag-it HF-I Transponder Inlays are delivered as single row tape wound on cardboard reels. Each is packed separately in a packing box.

Note:

Delivery may contain non-functional inlays.
These inlays are marked as described in chapter 3.5.

3.2 Packing

Figure 13 Packing



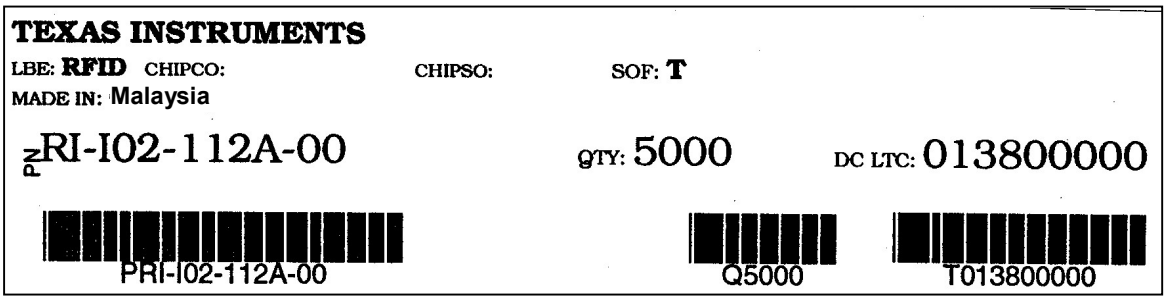
3.3 Barcode Label

The following figure shows the Barcode Label that is placed on the top side of the reel and on the front side of the upper part of its packing box.

Note:

The data provided below is an example and should only be viewed as guide values. A packlist will be enclosed with the delivery, which identifies the exact shipping details.

Figure 14 Barcode Label



PN	Part Number
QTY	Quantity of functional inlays per reel total quantity (incl. non-functional units) may exceed this number
DC LTC	Datecode; Lot Number

3.4 Unwind from Transport Reel

The reel is wound up with a tension of 3 N. Each tape has a chipless leader and a trailer which is approx. 3 m long.

Note:

Pullstrength during unwind needs to be controlled.

Figure 15 Transport (unwind) Direction

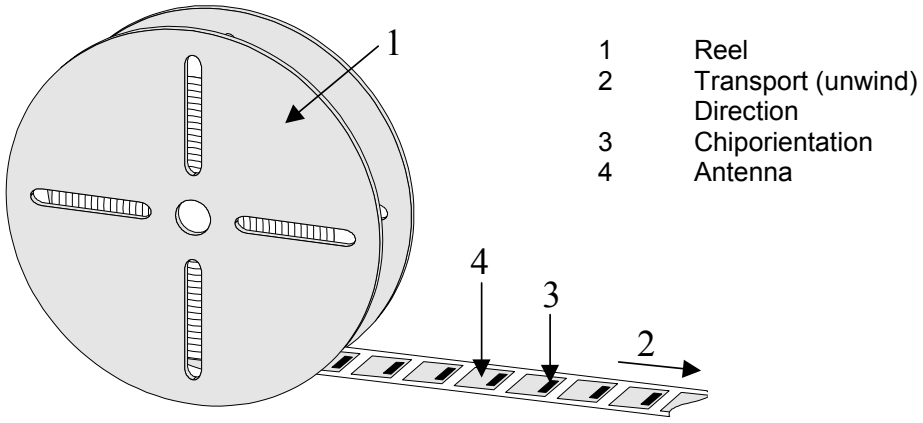


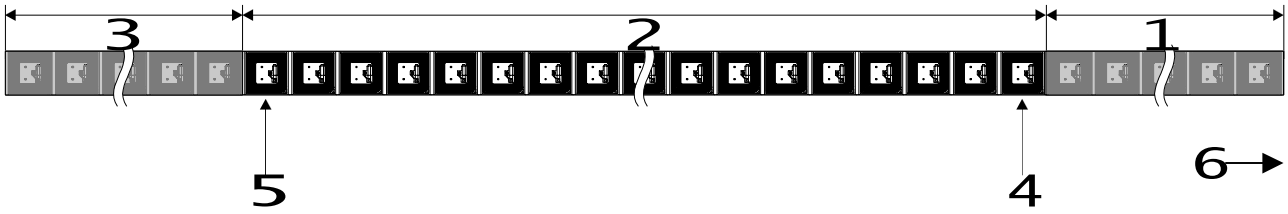
Figure 3 shows the transport reel and the leader of the Tag-it inlays being pulled off the reel.

CAUTION:

A high current density of an electrostatic discharge from the foil can damage the chip (IC). Therefore it is recommended to use ionizer or antistatic rollers in the manufacturing process. Any conductive parts in touch with Tag-it HF-I Inlays should have a high impedance discharge to ground. We recommend approx. 1MΩ to avoid ESD damage.

3.5 Chipless Leader and Trailer

Figure 16 Leader and Trailer configuration on the reel

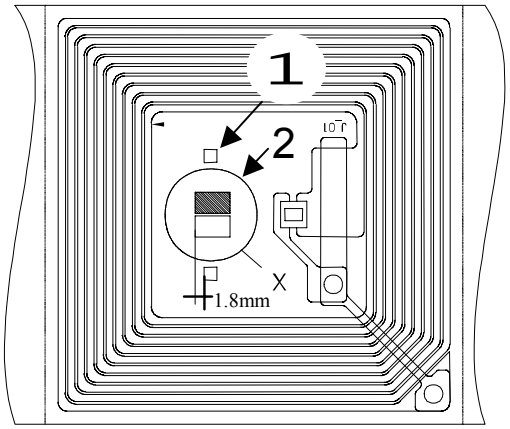


1	Chipless Leader	4	First functional Transponder Inlay
2	Transponder Inlays	5	Last functional Transponder Inlay
3	Chipless Trailer (Inlay not tested)	6	Transport direction

3.6 Marking of Inlays

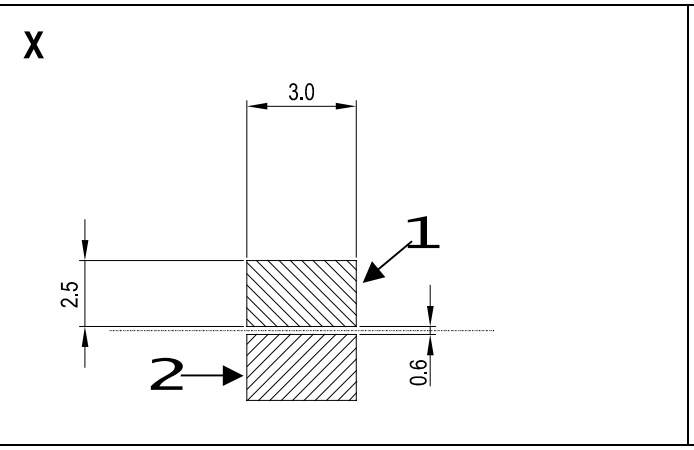
- The foil inlay has positioning marks for optical detection by a singulating or handling tool.
- Non-functional foil inlays are marked with a rectangular black mark near the center of the foil inlay.

Figure 17 Positioning, Function and Indication-Marks



1	Positioning Marks
2	Indication and Function Marks
X	Marking view (see figure 16)

Figure 18 Marking View



1	Indication mark (start section and end section)
2	Function mark (functional or non-functional)

In tested area (not trailer/leader section) the following combination for indication and function marks are possible:

Case 1:		Functional Inlay (except first or last functional inlay on reel)
Case 2:		Functional Inlay (first or last functional inlay on reel)
Case 3:		Non-functional Inlay (except first or last tested inlay)
Case 4:		Non-functional Inlay (if last inlay)

3.7 Static Pressure

Table 8 Static Pressure on the Chip Area

Static pressure on the chip area	max. 4 N/mm^2

CAUTION:

Higher pressure than that specified may result in chip cracks.

3.8 Tape Tension and Bending

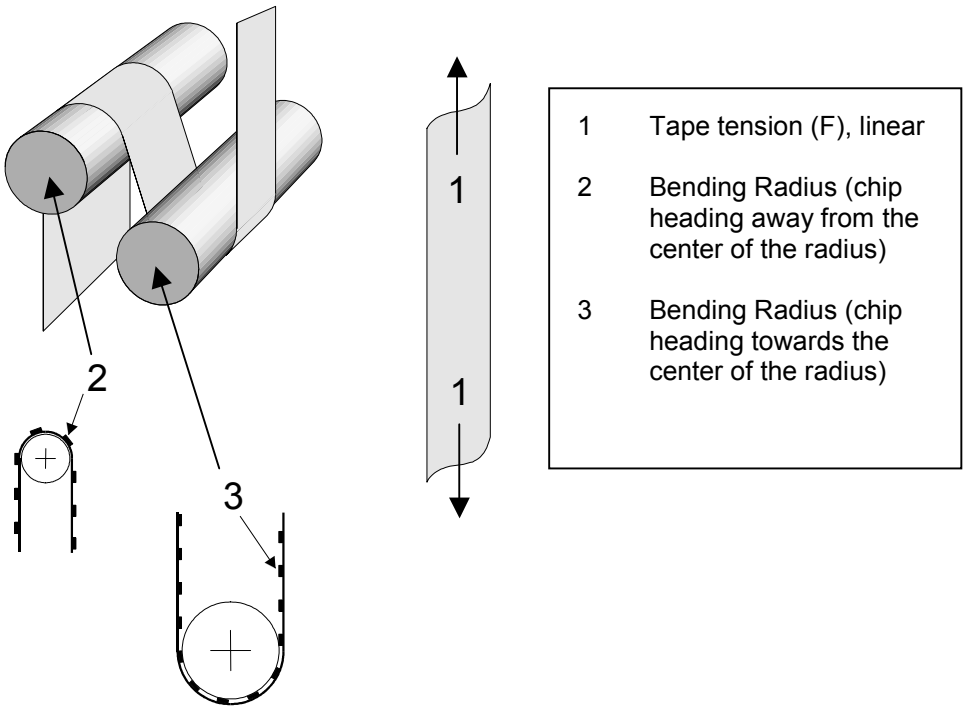
Table 9 Tape Tension and Bending

1	Tape tension (F), linear	max:	10 N
2	Bending Radius (chip heading away from the center of the radius at 7.5 N foil tape tension)	min:	18 mm
3	Bending Radius (chip heading towards the center of the radius at 7.5 N foil tape tension)	min:	18 mm

Note:

- The Tag-it Transponder Inlay shall not be folded. Pullstrength during unwind needs to be controlled.

Figure 19 Tape Tension and Bending



Chapter 4

Regulatory, Safety and Warranty Notices

This chapter describes important safety precautions and safety regulations.

Topic Page

4.1 Regulatory, Safety and Warranty Notices

An RFID system comprises an RF transmission device, and is therefore subject to national and international regulations.

A system reading from or writing to these transponders may be operated only under an experimental license or final approval issued by the relevant approval authority. Before any such device or system can be marketed, an equipment authorization must be obtained form the relevant approval authority.

The Tag-it HF-I Transponder Inlay has been manufactured using state-of-the-art technology and in accordance with the recognized safety rules.

Observe precautions in operating instructions

- Condition for the safe processing, handling and fault-free operation of the Tag-it HF-I Transponder Inlay is the knowledge of the basic safety regulations.
- All persons who operate with the Tag-it HF-I Transponder Inlay must observe the guidelines and particularly the safety precautions outlined in this document.
- In addition, basic rules and regulations for accident prevention applicable to the operating site must also be considered.

4.2 Warranty and Liability

The "General Conditions of Sale and Delivery" of Texas Instruments Incorporated or a TI subsidiary apply. Warranty and liability claims for defect products, injuries to persons and property damages are void if they are the result of one or more of the following causes:

- improper use of the transponders
- unauthorized assembly, operation and maintenance of the transponders
- operation of the transponders with defective and/or non-functioning safety and protective equipment
- failure to observe the instructions given in this document during transport, storage, assembly, operation, maintenance and setting up of the transponders
- unauthorized changes to the transponders
- insufficient monitoring of the transponders' operation or environmental conditions
- repairs
- catastrophes caused by foreign bodies and acts of God.

CAUTION:

Tag-it HF-I Transponder Inlays are 100% thoroughly tested. It is the responsibility of TI´s customer to evaluate their packaging process for compatibility with the Tag-it HF-I Transponder Inlay properties and to ensure through appropriate process controls that determined machine and material parameter are met on an ongoing basis.
TI does not accept warranty claims for material that has already undergone packaging or conversion process.

4.3 Hazards from Electrostatic Discharge ESD

During unwinding the foil and the separator tape are charged electrostatically (depending on the unwinding speed and the tensile stress). For the proper operation of the machine it is necessary to de-ionize the foil to remove the electrostatic charge.

WARNING:

ELECTRONIC DEVICES CAN ALSO BE DESTROYED BY ELECTROSTATIC ENERGY.

4.4 Danger of Cutting Injuries

WARNING:

TAKE CARE WHEN UNWINDING THE FOIL. THE GREATER THE UNWINDING SPEED AND THE TENSILE STRESS, THE GREATER THE RISK OF RECEIVING A CUT WHEN THE EDGE OF THE FOIL IS TOUCHED.

4.5 Thermal Effects

Temperatures > +85 °C on the foil inlay during the packaging process may result in a significant and permanent material deformation and a possible change of color of the foil inlays, as well as a change in the electrical characteristics.

4.6 Handling

The settings for foil unwinding and for the attendant forces must be in accordance to the information in Section 'Tape Tension and Bending' of Chapter 3.

APPENDIX A

Terms & Abbreviations

A list of the abbreviations and terms used in various TI-RFID manuals can now be found in a separate manual:

TI-RFID Product Manuals - Terms & Abbreviations

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