TEXAS INSTRUMENTS

Tag-it™ HF-I Pro Transponder IC

Reference Guide

TI-RFid
A TEXAS INSTRUMENTS TECHNOLOGY

November 2005

SCBU007

Tag-it™ HF-I Pro Transponder IC

Reference Guide

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Read This First

Edition One – November 2006

This is the first edition of this reference guide. It contains a description of the Tag-it™ HF-I Pro Transponder IC, their specifications, dimensions, and instructions for further handling.

About This Guide

This reference guide for the Tag-it HF-I Pro Transponder IC is designed for use by TI partners who are engineers experienced with Radio Frequency Identification Devices (RFIDs) and the processing of wafers.

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 that must be met or a procedure that must be followed, which if not heeded, could cause permanent damage to the equipment or software.

Note: Indicates conditions that must be met or procedures that must be followed, to ensure proper functioning of any equipment or software.

Information:
Indicates information that makes usage of the equipment or software easier.

If You Need Assistance

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Introduction

This chapter introduces you to the Tag-it™ HF-I Pro Transponder IC.

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1.1 General

The Tag-it HF-I Pro Transponder IC is part of TI's 13.56-MHz product family which is based on the ISO/IEC 15693 standard for contactless integrated circuit cards (vicinity cards) and ISO/IEC 18000-3 standard for item management. The Tag-it HF-I Pro Transponder IC builds the basis for various available inlay shapes which are used as consumable smart labels in markets requiring quick and accurate identification of items, such as:

- Asset tagging
- Electronic ticketing
- Anti-counterfeit prevention
- Building access badges

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, it can only be changed by the password protected write command.

Multiple transponders, which appear in the Readers RF field, can be identified, read from and written to by using the Unique Identifier (UID), which is programmed and locked at the factory and cannot be changed.

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 1-1). 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).

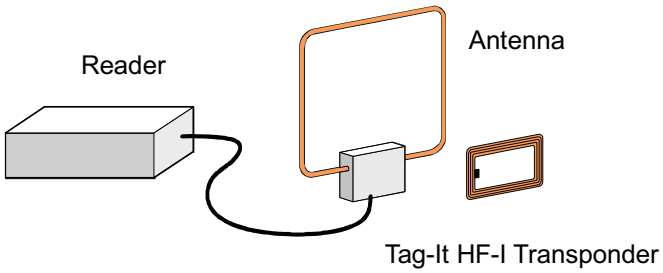


Figure 1-1. RFID System With Reader, Antenna, and Tag-it™ HF-I Transponder

1.3 Product Description

The Tag-it HF-I Pro Transponder IC is compliant to the ISO/IEC 15693 and ISO/IEC 18000-3 standard. To build a complete transponder, the Tag-it HF-I Pro Transponder IC has to build a resonance circuit with the antenna it is assembled on e.g., an etched aluminum antenna.

1.4 Functional Description

The Tag-it HF-I Pro Transponder IC is a low power, full duplex Transponder IC for use with passive contactless identification transponder systems. The Transponder IC is designed to operate with a 13.56-MHz 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 checksum secured. Each Tag-it HF-I Pro Transponder IC has a 'unique' address (UID) stored in two blocks that 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 Application Family Identifier (AFI) that is optional in the ISO15693 is supported by the Tag-it HF-I Pro Transponder.

For more details about the communication between Reader and Transponder, see ISO/IEC 15693 and the Tag-it HF-I Pro Extended Command Specification.

1.5 Memory Organization

User data is read and stored in a 256-bit nonvolatile user memory that is organized in eight 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. Factory Block locking irreversibly protects the locked data from any further reprogramming. User locked blocks can be reprogrammed by use of the password protected write command.

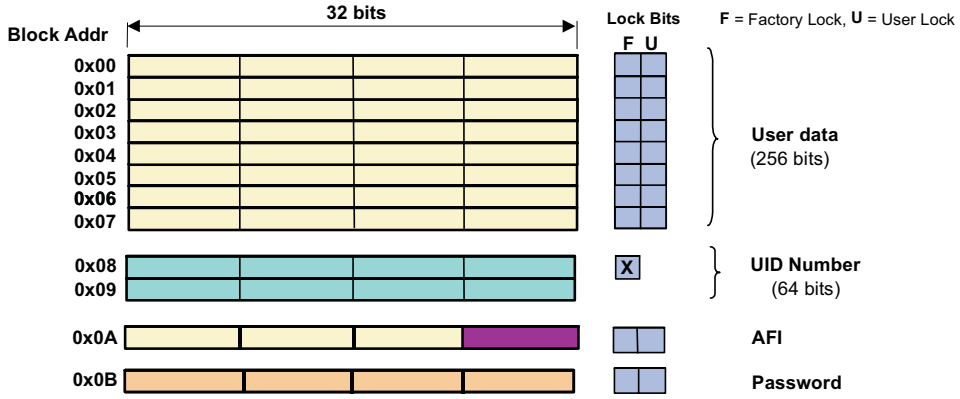


Figure 1-2. Memory Organization of the Tag-it HF-I Pro Transponder IC

1.6 Command Set

Table 1-1. Command Set for Tag-it HF-I Pro Transponder IC

REQUEST	REQUEST MODE[1]					
	REQUEST CODE	INVENTORY	ADDRESSED	NON-ADDRESSED	AFI	OPT. FLAG
ISO 15693 Mandatory and Optional Commands						
Inventory	0x01	ü	–	–	ü	0/–
Stay Quiet	0x02	–	ü	–	–	0/–
Read_Single_Block	0x20	–	ü	ü	–	–/1
Write_Single_Block	0x21	–	ü	ü	–	–/1
Lock_Block	0x22	–	ü	ü	–	–/1
TI Custom Commands						
Kill	0xA4	–	ü	–	–	–/1
WriteSingleBlockPwd	0xA5	–	ü	–	–	–/1

(1) ü = Implemented, – = Not applicable

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 ≥10 ms before the Reader sends the End Of Frame (EOF) to request the response from the Transponder.

1.7 Ordering Information and Part Numbers

The Tag-it HF-I Pro Transponder IC is available with following finishing options.

Table 1-2. Part Numbers

PART NUMBER	BUMPING	INKING	GRINDING	SAWING
RF-HDT-SJMS-G1	Yes	Yes	Yes	Yes

Note: Other Finishing Options on request.

Specification

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

Topic **Page**

2.1 Electrical Specification

Table 2-1. Absolute Maximum Ratings

PARAMETER		NOTE	MIN	NOM	MAX	UNIT
Iant_dc	Antenna Input Current				10	mA
Vant_dc	Antenna Input Voltage				10	V
T_S	Storage Temperature		–40		125	°C
T_J	Junction (Chip) Temperature				150	°C
ANT1, ANT2 TDAT, GND	ESD Immunity	HBM	2.5 2.0			kV

Note: Stress beyond the limits of those listed under Absolute Maximum Ratings may cause permanent damage to the device. Functional operation of the device under these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended time may affect device reliability.

Table 2-2. Recommended Operating Conditions

PARAMETER		NOTE	MIN	NOM	MAX	UNIT
T_A	Operating temperature		–40		85	°C
fTX	Carrier frequency			13.56		MHz
VANT	Antenna input voltage	@ fTX unmodulated	2.5		Vlim	V
Z	Impedance of LC circuit		6.5		15.5	kΩ

Table 2-3. Electrical Characteristics

PARAMETER		NOTE	MIN	NOM	MAX	UNIT
C_{IN}	Input capacitance	@ $2V_{RMS}$	–10%	23.5	10%	pF
ICC	Operating Supply Current	VANT = min			25	µA
		Programming			35	
M_{PICC}	Uplink Modulation Index	VANT <7 V	0.1		0.3	
Vlim	Limiter Clamping Voltage				10	V
tDRET	Data Retention	55°C	10			Years
W&E	Write and Erase Endurance	T_A = 25°C	100,000			Cycles

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

2.2 Mechanical Wafer Specification

Table 2-4. General Mechanical Wafer Specification

PARAMETER	VALUE
Wafer diameter	200 mm ±0.3 mm (8 in)
Thickness	711 µm
Scribe line width	84 µm
Electrical connection of substrate	VSS potential
Complete dies per wafer	24172

Table 2-5. Mechanical Wafer Specification After Grinding, Sawing on FFC

PARAMETER		VALUE
Backside Material		Si
Roughness:	Ra	500 Angstrom
	Rtm	2500 Angstrom
Thickness		150 ± 13 µm

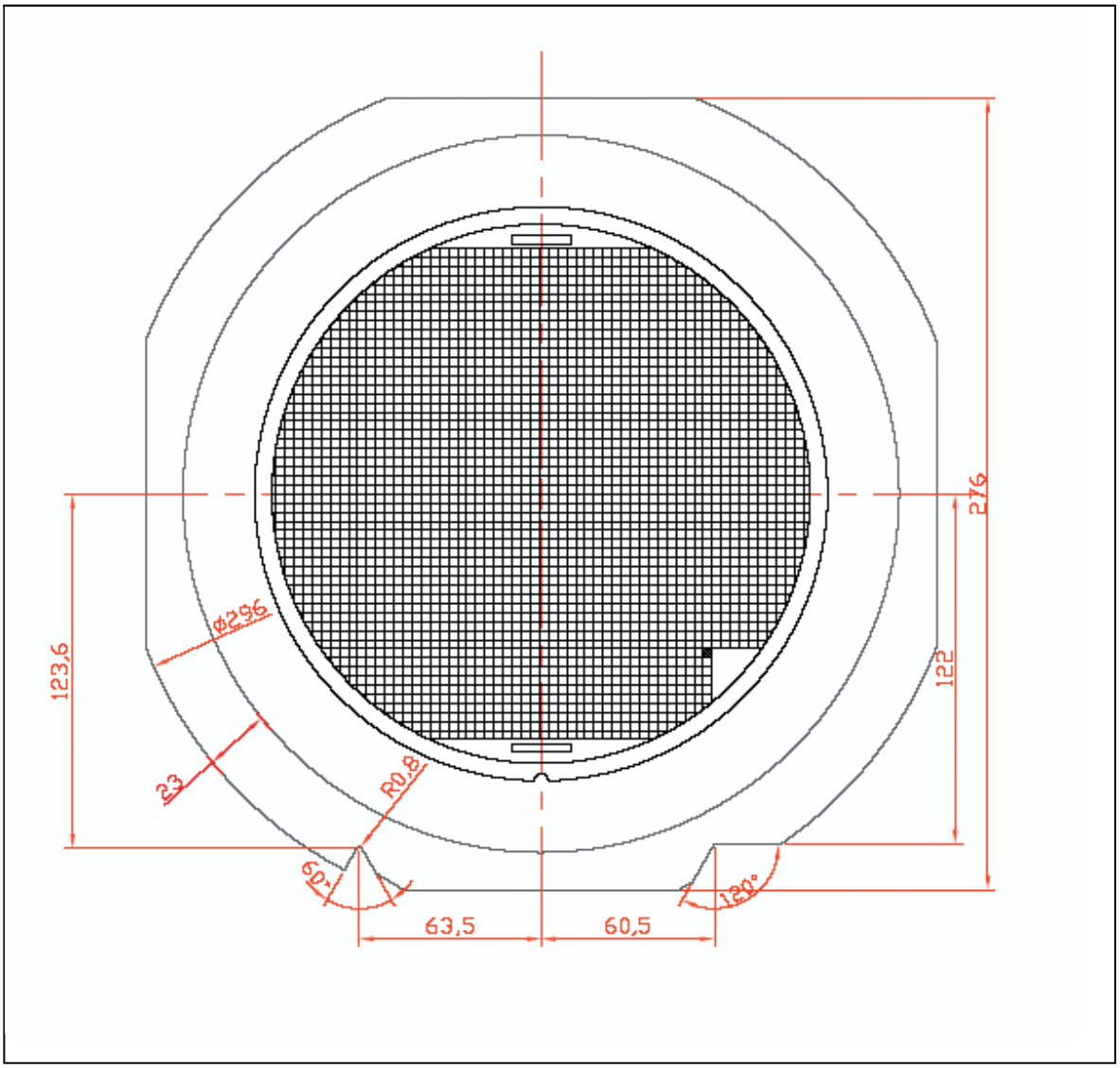


Figure 2-1. Wafer on FFC

2.3 Mechanical Die Specification

Table 2-6. Mechanical Die Specification

PARAMETER	VALUE
Bond pad metallization material	ALCu 0.5%
Bond pad metallization thickness	0.95 µm
Bond and test pad location	Table 2-7
Die dimension (including scribe line)	1080 µm × 1080 µm ±15 µm
Die dimension (excluding scribe line)	996 µm × 996 µm ±15 µm
Top side passivation material	SiNi
Passivation thickness	1.1 µm

Table 2-7. Antenna and Test Pad Location

PAD NO.	NAME	LLCx[µm]	LLCy[µm]	URCx[µm]	URCy[µm]
1	ANT1	30	30	n.a.	n.a.
2	ANT2	n.a.	n.a.	966	966
Test pad					
3	TDAT	118	866	168	936
4	GND	836	60	886	130

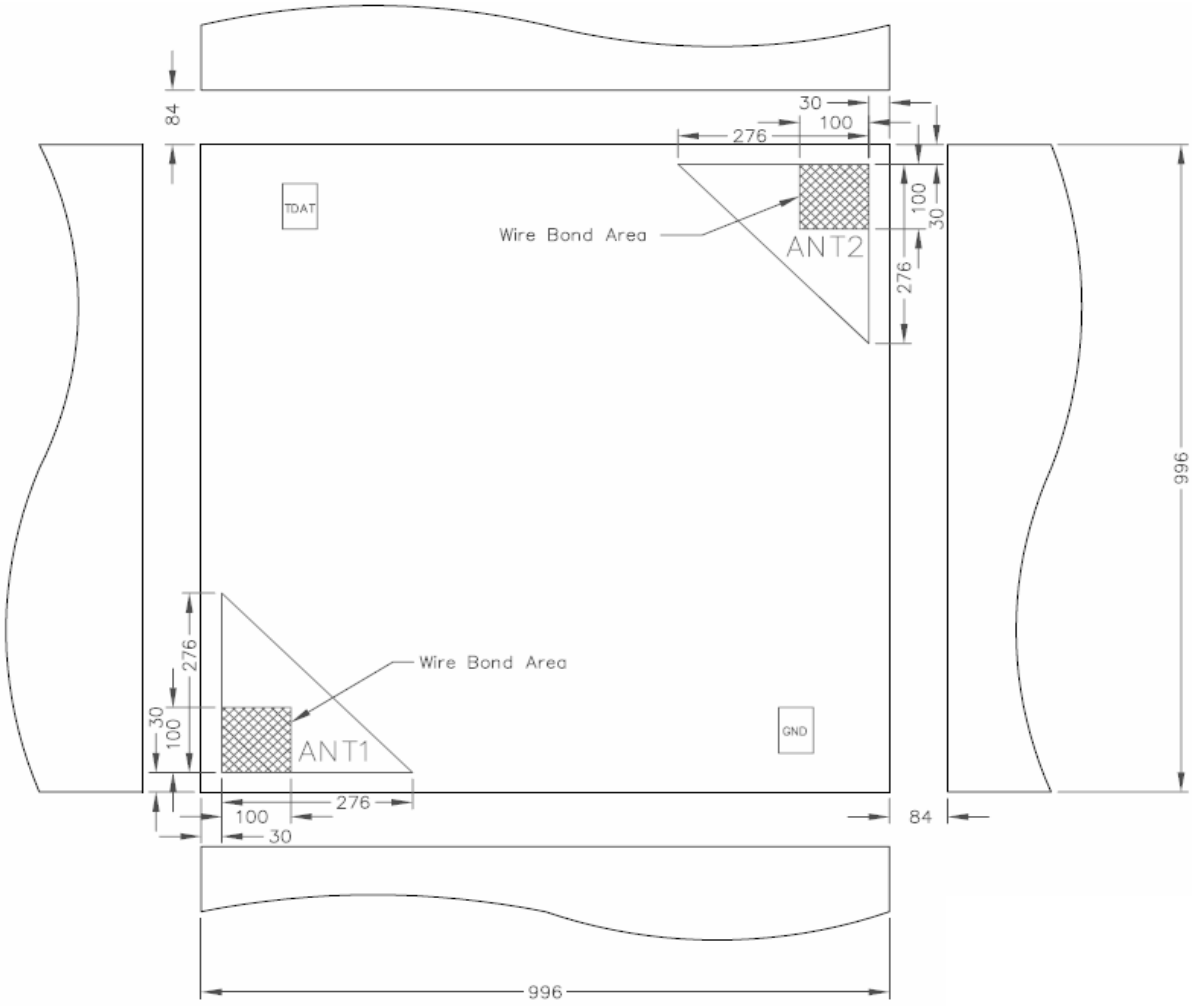


Figure 2-2. Antenna and Test Pad Location

2.4 Bump Specification

Table 2-8. Bump Specification

PARAMETER	VALUE
Bump material	NI covered with AU, chemical process
Bump height	25 µm ±10%
Bump hardness	>HV 450
Surface roughness	<1 µm
Shear strength	>150 cN
Contact resistance between bump and AL-Substrate	<25 mΩ

Note: Test pads are not bumped. Contact between the test pads and the antenna is not allowed as it can have an impact on the electrical performance of the Transponder.

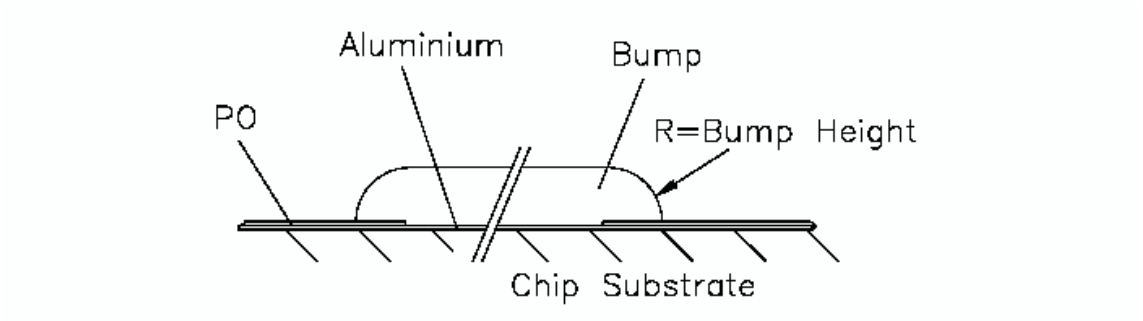


Figure 2-3. Cross Section of Bump

Shipping, Packing, and Further Handling

Topic Page

3.1 Lot Definition

A definite quantity of wafers from the same diffusion batch produced under presumed uniform conditions. Occasionally a lot equals 25 wafers.

3.2 Wafer Identification

Each wafer is marked with laser marking to identify the wafer. The wafer map file is linked to the wafer id. There are 2 marks on the wafer.

The following figure shows the position of the wafer identification codes. The reference die is the black marked die in the corner at the right lower position of the wafer.

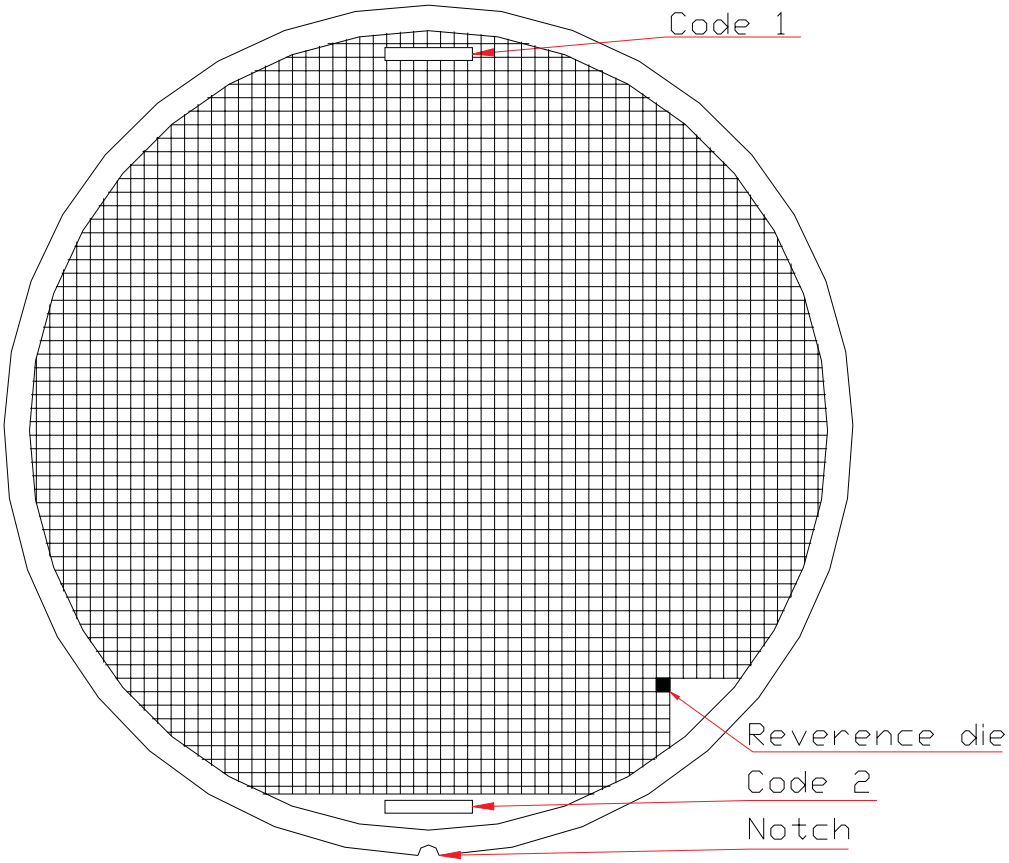


Figure 3-1. Position of Wafer Identification Code

Code 1: Wafer Lot Number Naming Rule

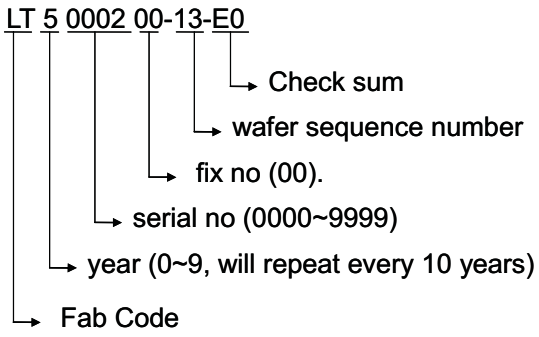


Figure 3-2. Wafer Identification Code 1

Code 2: Wafer Lot Number Naming Rule

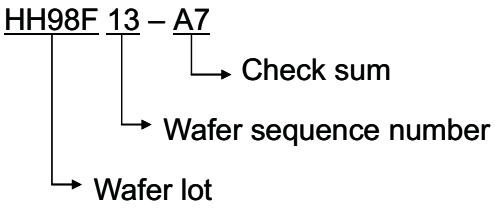
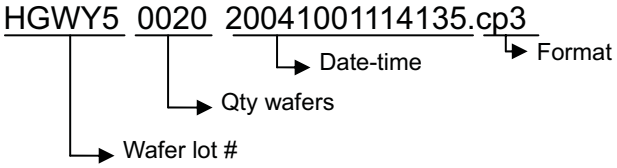


Figure 3-3. Wafer Identification Code 2

3.3 Wafer Map File

All lots are supplied with wafer mapping file. This mapping file is stored on a CD and enclosed in the pack box.

The mapping file is stored for 3 years, if any problem might occur. We handle our TI worldwide wafer map standard. The wafer file name is explained as follows:



The standard TI worldwide wafer map file is .cp3, this is an ASCII format. The most important facts are sorted out in a list like the below example shows. The lot definition can be found also in this list. Also the tested dies and pass dies are shown.

```
CUSTOMER ID     : TIG
FAB ID          : FAB8E
PRODUCT ID      : W37112B3
CUST PRODUCT ID : W37112B3
FAB PRODUCT ID  : H3337F-NZWN
LOT ID          : HGWY5.00
CUST LOT ID     :
FAB LOT ID      : N47HGWY5.00
WAFER ID        : 20
FLOW ID         : CP3
PRODUCT VERSION : 6
START TIME      : 2004/10/01 11:41:35
STOP TIME       : 2004/10/01 11:53:41
SUBCON          : UMC01
TESTER NAME     : J750#76
TEST PROGRAM    : TMS37112BP3C1
LOAD BOARD ID   :
PROBE CARD ID   : JATCYH03
SITE NUM        :
DUT ID          :
DUT DIFF NUM    :
OPERATOR ID     : 8341
GROSS DIE       : 16268
TESTED DIE      : 16268
PASS DIE        : 15723
YIELD           : 96.65%
PROBING NOTCH   : DOWN
MAP NOTCH       : DOWN
MAP ROW         : 154
MAP COLUMN      : 137
MAP BIN LENGTH  : 2
SHIP            : YES
```

3.4 Ink Dot Specification

All Tag-it HF-I Pro Transponder ICs are electrically tested, and dies that fail the probe test will be inked. Bump failures are not marked with an ink dot.

Table 3-1. Ink Dot Specification

PARAMETER	VALUE
Diameter	Minimum 400 µm
	Maximum 700 µm
Height	Maximum 25 µm
Colour	Black
Position	Central, not on bond pads

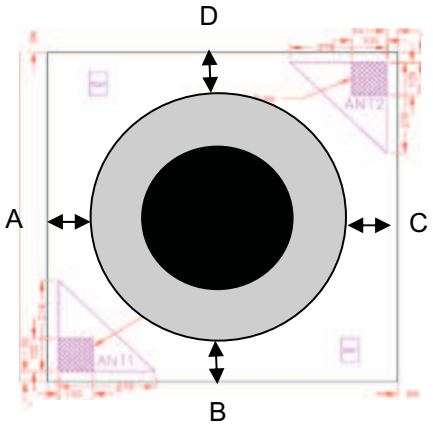


Figure 3-4. Ink Dot Drawing

Table 3-2. Ink Dot Placement

NO.	MAX	MIN	REMARK
A	550	200	
B	400	200	
C	550	200	
D	400	150	
Ink	700	400	Size limit

3.5 Packing for Wafers

The wafers are packed for transportation to protect them against shock, static discharge and contamination in a wafer shipper box up to 25 wafers. This box is packed in an antistatic moisture bag with silica gel and in a double layered carton box.

Note: When the silica gel has changed the color to blue it is an indication that moisture has entered the bag.

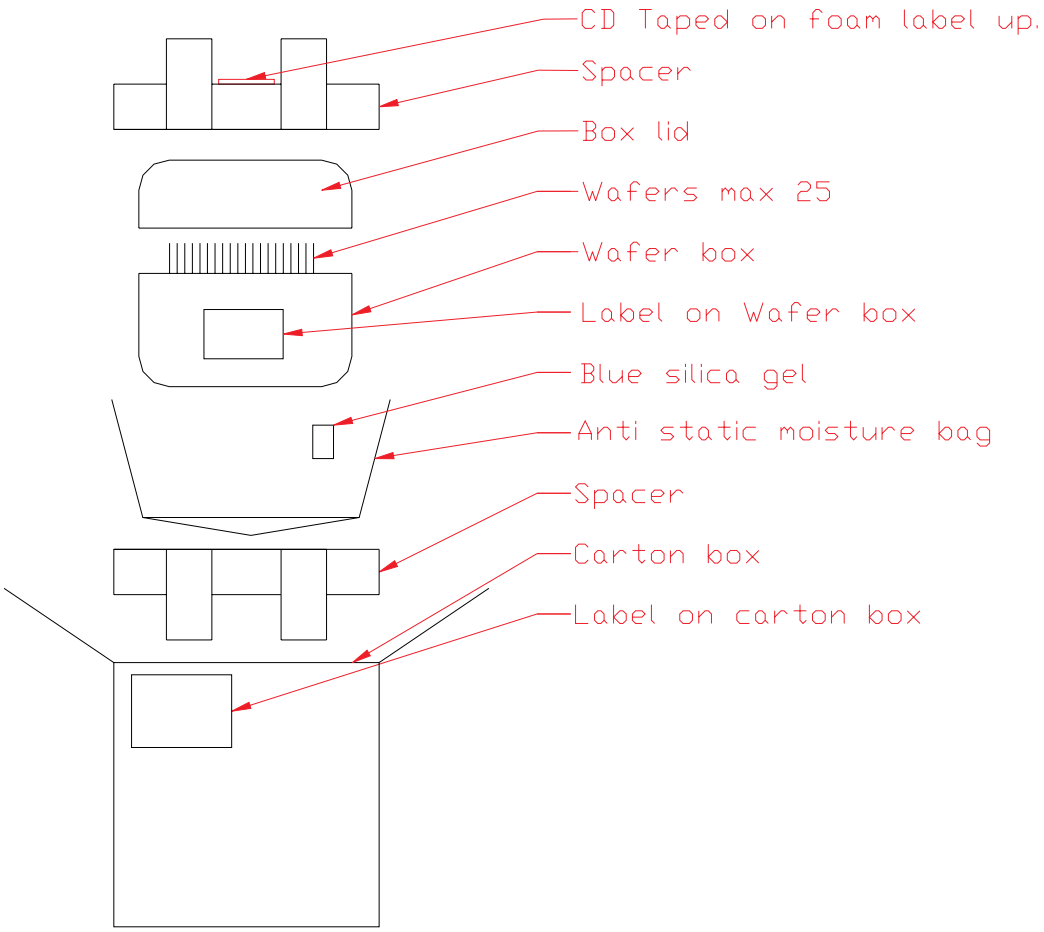


Figure 3-5. Packing of Wafers

3.6 Packing for Sawn Wafers

Sawn wafers are mounted on foil and delivered on standard 8” disco wafer frame (see Figure 2-1). A special plastic container is used to store up to 25 wafers in frames. This plastic container is packed in an antistatic moisture bag with silica gel and in a double layered carton box.

Note: When the silica gel has changed the color to blue it is an indication that moisture has entered the bag.

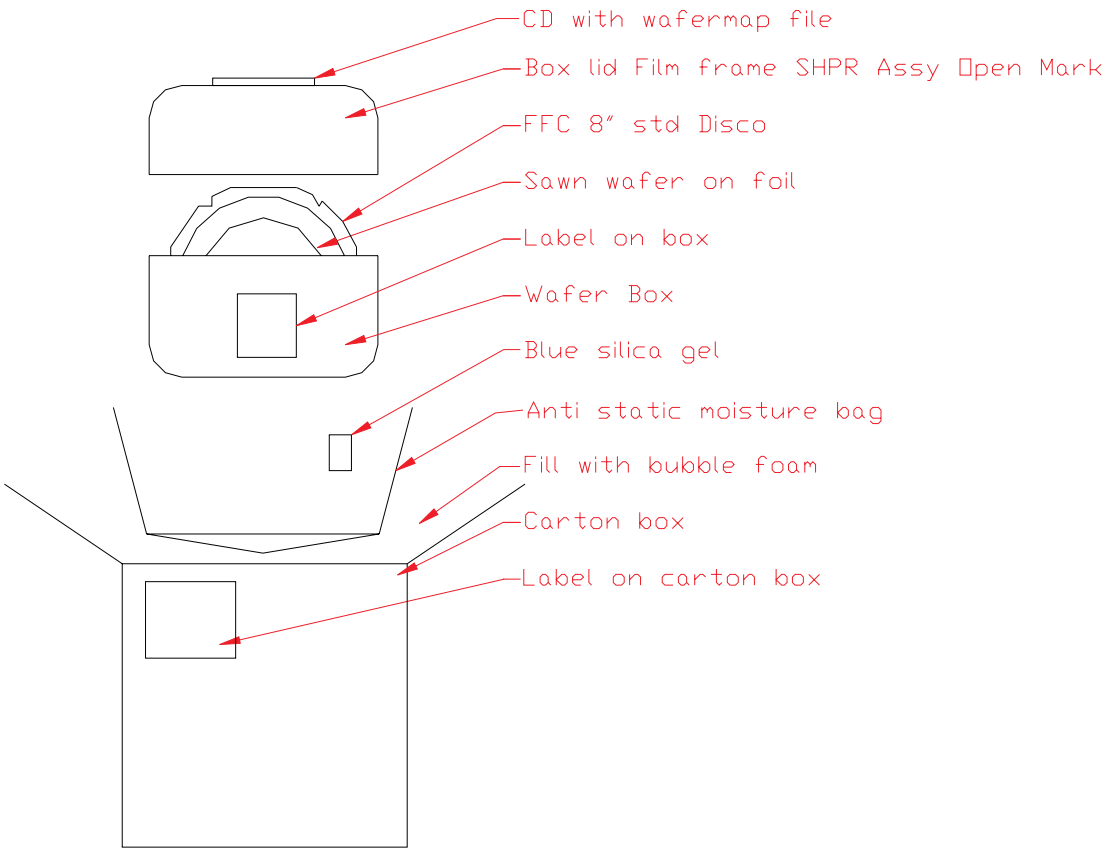


Figure 3-6. Packing of Sawn Wafers

3.7 Barcode Label

The following figure shows the Barcode Label that is placed on the packing box, the wafer container and the CD with the Map File.

Note: The data provided below is an example and should only be viewed as guide values.

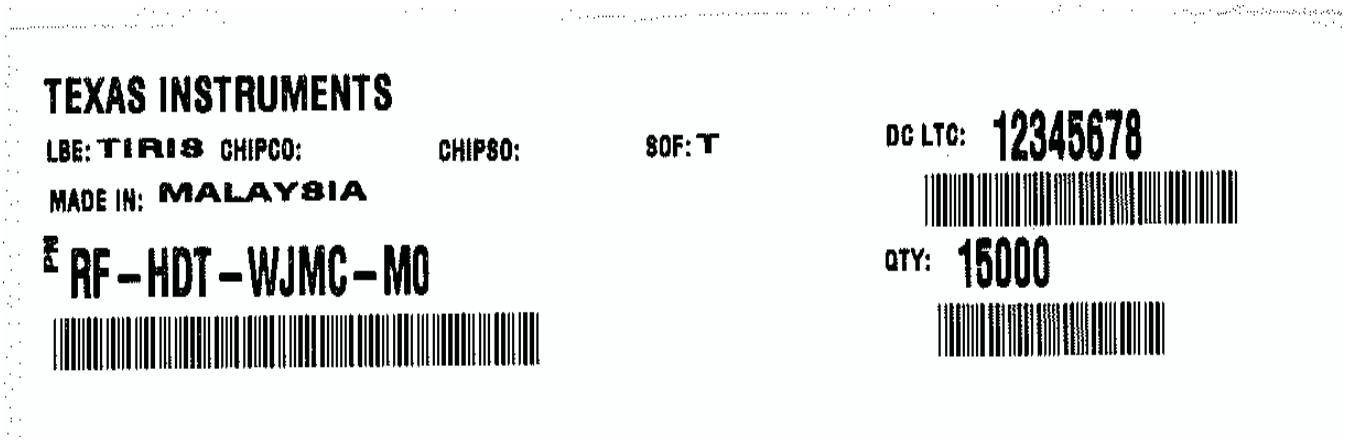


Figure 3-7. Barcode Label

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

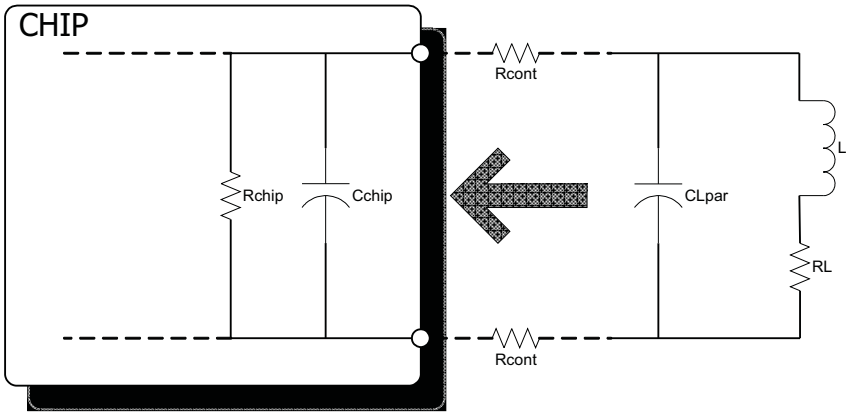
3.8 Storage Conditions

The wafers should be kept in the original packing during storage.

Table 3-3. Storage Conditions

PARAMETER	VALUE
Temperature	20°C ± 5°C
Atmosphere	Dried N_2 or dried air with 40%–60% r.h.
Duration	Maximum 6 months

3.9 Antenna Calculation



Rchip: IC Input Impedance
Cchip:IC Input Capacitance
Rcont: Pad/assembly contact resistance
CLpar: Parasitic capacitance of antenna
RL: Series resistance of antenna
L: Antenna Inductance

Resonance frequency: $$fres = \frac{1}{2 \times \pi \times \sqrt{L \times Cchip}}$$

Total Quality factor: $$qres = \frac{Qc \times Q1}{Qc + Q1}$$

Input Impedance: $$Z = Qres \times \sqrt{\frac{L}{Cchip}}$$

Based on an IC capacitance of 23.5 pF, the impedance shall be matched to be in the specified impedance range of 6.5 kΩ to 15.5 kΩ to fit the IC capabilities.

Note: If Z > 15.5 kΩ, reduced performance of read range must be considered.

Table 3-4. Antenna System Parameters

PARAMETER	MIN	NOM	MAX	TOLERANCE [%]	TEST CONDITIONS	COMMENT
Cchip (pf)	21.15	23.50	25.85	10	13.56 MHz at 2 Vrms	
Qchip	80.00	100.00	120.00	20		
L (µH)	5.74	5.86	5.98	2	13.56 MHz at 2 Vrms	
QL	15.00	40.00	44.00	10		
fres (MHz)	12.80	13.56	14.44			
Qres	12.63	28.57	32.20			
Z (kΩ)	6.58	14.27	15.48			

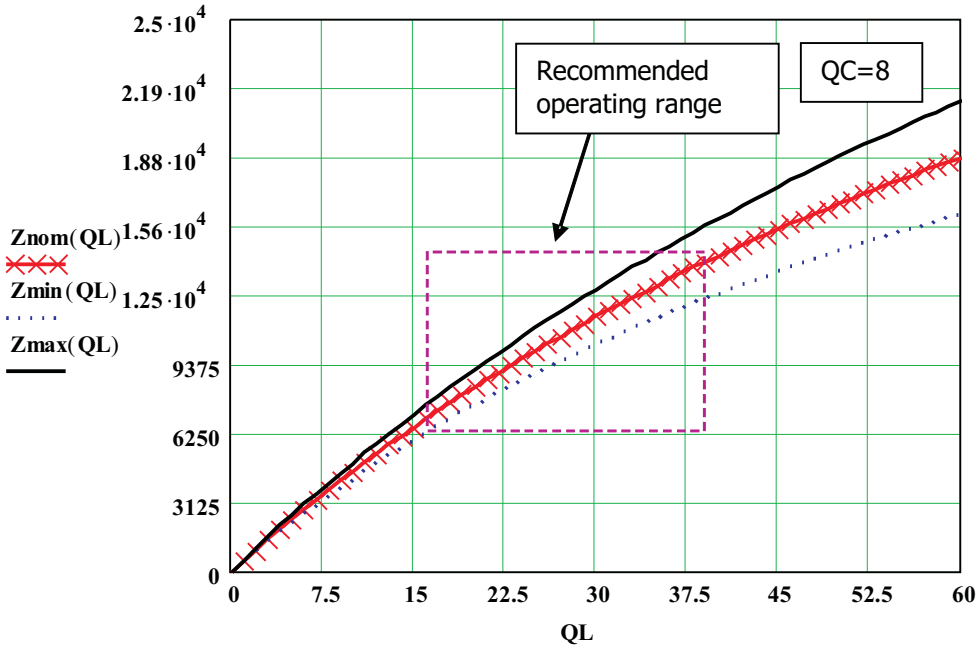


Figure 3-8. Recommended Operating Range – Impedance vs Antenna Q

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 Pro Transponder IC 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 Pro Transponder IC is the knowledge of the basic safety regulations.
- All persons who operate with the Tag-it HF-I Pro Transponder IC 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 Transponder IC
- Unauthorized assembly, operation and maintenance of the Transponder IC
- Operation of the Transponder IC 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 Transponder IC
- Unauthorized changes to the Transponder IC
- Insufficient monitoring of the Transponder IC operation or environmental conditions
- Repairs
- Catastrophes caused by foreign bodies.

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