

SEMI E144-0312

I SPECIFICATION FOR RF AIR INTERFACE BETWEEN RFID TAGS IN CARRIERS AND RFID READERS IN SEMICONDUCTOR PRODUCTION AND MATERIAL HANDLING EQUIPMENT

This Standard was technically approved by the Physical Interfaces & Carriers Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on December 24, 2011. Available at www.semiviews.org and www.semi.org in March 2012; originally published March 2005; previously published March 2006.

NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§) the symbols are used to reference more than one section or paragraph, respectively.

NOTICE: Paragraphs entitled 'NOTE:' are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

1 Purpose

1.1 This Specification provides public specifications for the required elements of new carrier radio frequency (RF) identification tags to make them 100% backward-compatible with existing (pre-2006) equipment installations.

1.2 This Specification addresses the RF air interface associated with such tags.

1.3 This Specification describes common communication protocols for the purposes of radio frequency identification for semiconductor production and material handling.

2 Scope

2.1 This Specification defines HDX RFID systems operating at a frequency of 134.2 kHz.

2.2 This Specification provides the requirements for such parameters as frequency, modulation, data rate, data format, read/write capabilities, memory capability, etc.

2.3 This Specification is based on the RFID parameters currently being used in the majority of semiconductor equipment production use applications.

2.4 This Specification is compatible with ISO/IEC 18000-2 except where noted. It extends and specializes this Standard for application in semiconductor device and integrated circuit manufacturing.

2.5 Other RFID-related physical parameters are beyond the scope of this Specification, and are to be addressed in standards yet to be developed.

2.6 This Specification describes common communications protocols for the purposes of radio frequency identification for semiconductor production and material handling.

2.7 This Specification defines two types of interfaces: Type 1) RI-TRP-DR2B HDX MPT and Type 2) ISO/IEC 18000-2 Type B (HDX).

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 None.

4 Referenced Standards and Documents

4.1 ISO® Standards¹

ISO 11785 — Radio Frequency Identification of Animals – Technical Concept

ISO/IEC 18000-2 — Information Technology — Radio-Frequency Identification for Item Management – Part 2: Parameters for Air Interface Communications Below 135 kHz.

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Abbreviations and Acronyms

- 5.1.1 *ASK* — amplitude shift keying
- 5.1.2 *BCC* — block check character
- 5.1.3 *Charge* — capacitor charge via RF
- 5.1.4 *CMD* — command
- 5.1.5 *CRC* — cyclic redundancy check
- 5.1.6 *CRCT* — transmit CRC
- 5.1.7 *CTL* — control signal
- 5.1.8 *DCRC* — data BCC
- 5.1.9 *EOF* — end of frame
- 5.1.10 *FCRC* — frame BCC
- 5.1.11 *HDX* — half duplex RFID system
- 5.1.12 *High bit* — binary bit ‘1’
- 5.1.13 *Lock* — permanently disable memory programming
- 5.1.14 *Low bit* — binary bit ‘0’
- 5.1.15 *LSB* — least significant bit
- 5.1.16 *MP* — multi page tag
- 5.1.17 *MSB* — most significant bit
- 5.1.18 *NRZ* — non return to zero
- 5.1.19 *OOK* — ON OFF keying
- 5.1.20 *R/O* — read only tag
- 5.1.21 *R/W* — read/write tag
- 5.1.22 *Read* — read data from the tag
- 5.1.23 *RF* — radio frequency
- 5.1.24 *RFU* — reserved for future use
- 5.1.25 *RX* — receiver
- 5.1.26 *SOF* — start of frame

¹ International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401-1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>. ISO trademark is owned by International Organization for Standardization.

5.1.27 *TX* — transmitter

5.1.28 *UID* — unique identifier

5.1.29 *Write* — send data to tag

5.2 Definitions

5.2.1 *tag* — an RFID-based device containing an information storage mechanism that reacts to a specific reader-produced field. Also called *transponder*.

5.2.2 *transponders* — see *tag*. A data carrying device that reacts to a specific, reader produced, ‘inductively coupled’ or ‘radiated electromagnetic’ field, by delivering a data ‘modulated’ radio frequency response.

5.2.2.1 *Discussion* — An electronic TRANSMITTER/resPONDER which is attached to the object to be identified and, more commonly referred to as a ‘tag’ or ‘RF tag’. There are several different mechanisms used to provide communications: an ‘inductive’ or ‘electrically coupled’ transponder that delivers data by ‘modulating’ any parameters of an interrogator radiated magnetic or electric field respectively or by using a ‘backscatter’ principal.

5.3 Symbols

5.3.1 f_c — carrier frequency of the operating field

5.3.2 t_{bit} — bit duration

5.3.3 t_{ch} — capacitor charge time

5.3.4 t_{offH} — power off duration for ‘1’ bit

5.3.5 t_{offL} — power off duration for ‘0’ bit

5.3.6 t_{onH} — power on duration for ‘1’ bit

5.3.7 t_{onL} — power on duration for ‘0’ bit

5.3.8 t_{pr} — data programming time

5.3.9 t_{rd} — data read time

5.3.10 t_{wr} — data write time

5.4 Refer to ISO/IEC 18000-2 for RFID-related acronyms and terminology used in this Specification.

6 Requirements for Compatibility with Legacy (Type 1) RFID Air Interface Systems

6.1 In many areas, legacy semiconductor RF tag interface requirements parallel the Type B (HDX) requirements specified in ISO/IEC 18000-2. However there are several key differences between the two. This section outlines the critical specifications for meeting compliance to legacy semiconductor RFID air interfaces, including highlighting where deviations from ISO/IEC 18000-2 exist. Differences between Type 1 and Type 2 interfaces are indicated below by an asterisk (*) and are described in Tables 1 to 3. In those tables, columns marked “RI-TRP-DR2B HDX Type B” capture requirements of existing Legacy RFID Air Interfaces. Columns marked “ISO/IEC 18000-2 Type B” capture potential future requirements for semiconductor RFID Air Interfaces.

6.2 Interrogator-Tag communication interface shall operate in the 134.2 kHz frequency band (refer to § 7.2).

6.3 Tag shall be powered by interrogator, except during tag-to-interrogator transmission (refer to § 7.4).

6.4 In relation to master-slave communication concepts, tag shall serve as ‘slave’ side, allowing the interrogator (master) to coordinate the communication sequence (refer to § 7.1).

6.5 * The interrogator shall communicate with the tag via pulse width modulation (PWM), using the data coding times defined by ISO/IEC 18000-2 (refer to § 7.3.1).

6.6 The interrogator shall communicate with the tag using ASK modulation with modulation index of 100% (refer to § 7.3.1).

6.7 Interrogator shall allow a minimum of 1.2 ms between commands sent to the tag (refer to Table 1, reference M1-INT: 6a).

6.8 Interrogator shall wait a minimum of 2 ms after sending a command to the tag before triggering a time-out error (refer to Table 1, reference M1-INT: 6b).

6.9 Interrogator shall support a 'slow data rate' equal to 0.5 kbit/s.

6.9.1 Optionally, a 'fast data rate' equal to 2.3 kbit/s may be supported by interrogator (refer to § 7.3.2).

6.10 Interrogator shall always initiate requests with start of frame (SOF) headers, consisting of '1', '0', and 'Code Violation' patterns that serve to identify the beginning of a frame. These patterns shall match format defined by ISO/IEC 18000-2 (refer to § 7.3.2).

6.11 Interrogator shall communicate data to tag in a bit transmission order equal to least significant bit (LSB) first (refer to Table 1, reference M1-INT: 13 and Table 2, reference M1-TAG: 13).

6.12 The tag shall communicate with the interrogator via inductive coupling and FSK modulation with frequencies as defined by ISO/IEC 18000-2 (134.2 kHz/123.2 kHz $\pm$ 4 kHz) (refer to § 7.4.1).

6.13 The tag shall use NRZ method for data coding, and support average data transfer rate of 8 kbit/s (refer to Table 2, M1-TAG: 8-9).

6.14 The tag shall always pre-pend a 6 bit SOF header to any response provided to interrogator. This SOF header will match the format defined by ISO/IEC 18000-2 (bit pattern = '111101') (refer to Table 1 M1-TAG: 11c).

6.15 * The communication interface assumes that the tag supports at least 17 pages of R/W memory (refer to § 7.6).

6.16 * Both tag and interrogator shall minimally support the following commands (subset of ISO/IEC 18000-2 mandatory set): "READ SINGLE BLOCK", "READ SINGLE BLOCK WITH SECURITY STATUS", "WRITE SINGLE BLOCK", "LOCK BLOCK" (refer to § 7.7).

6.17 Tag and interrogator will optionally support the following commands (subset of ISO/IEC 18000-2 mandatory set): "READ MULTIPLE BLOCKS", "READ MULTIPLE BLOCKS WITH SECURITY STATUS", "WRITE SINGLE BLOCK", "WRITE MULTIPLE BLOCKS" (refer to § 7.7).

6.18 CRC Error detection as defined in ISO/IEC 18000-2 shall be used for Tag to Interrogator communication as well as the Interrogator to Tag communication (refer to ¶ 7.6.1 and Table 2, reference M1-TAG: 1).

6.19 Additional details concerning these requirements are summarized in Tables 1 to 3.

Table 1 Parameter Comparison: Interrogator to Tag Link

Reference	Parameter	RI-TRP-DR2B HDX	ISO/IEC 18000-2 Type B	Options/Comments
	Charge Time	Typ. 50 ms		
M1-INT: 1a	Default Operating Frequency	134.2 kHz		
M1-INT: 1c	Default Operating Frequency	Within ± 0.1 kHz		
M1-INT: 2	Occupied Channel Bandwidth	± 8 kHz		3 db Bandwidth
M1-INT: 2a	Minimum Receiver Bandwidth	± 8 kHz		3 db Bandwidth
M1-INT: 3	Interrogator Transmit Maximum EIRP Power Limits Within Communication Zone	Meet the National Regulations		
M1-INT: 3	Interrogator Transmit Spurious Emissions	Meet the National Regulations		

Reference	Parameter	RI-TRP-DR2B HDX	ISO/IEC 18000-2 Type B	Options/Comments
	Charge Time	Typ. 50 ms		
M1-INT: 4b	Interrogator Transmit Spurious Emissions, Out-of-Band	Meet the National Regulations		
M1-INT: 5	Interrogator Transmitter Spectrum Mask	Meet the National Regulations		
M1-INT: 6a	Transmit to Receive Turn Around Time	1.2 ms		Interrogator has to wait min. 1.2 ms before sending next command.
M1-INT: 6b	Receive to Transmit Turn Around Time			Interrogator has to wait min. 2 ms for answer of tag before signaling a timeout error.
M1-INT: 6c	Dwell Time or Interrogator Transmit Power On Ramp	<2 ms		
M1-INT: 7	Modulation	OOK (100% ASK)		
M1-INT: 7d	Modulation Index	100%		
M1-INT: 8	Data Coding	Pulse width encoding (PWE)	Pulse interval encoding (PIE)	
M1-INT: 9	Bit Rate	Average 0.5 kbps	1 to 2.3 kbps (optional)	
M1-INT: 11d	Frame Sync Sequence	NO	Start of frame pattern (SOF)	
M1-INT: 11e	Postamble	None	6 bits end of frame pattern (EOF)	
M1-INT: 13	Bit Transmission Order	LSB first.		
M1-INT: 14	Wake-up Process	The dialogue between the Interrogator and the RF tag (one or more RF tags may be present at the same time) is conducted through the following consecutive operations: • activation of the RF tag by the RF operating field of the interrogator, • RFID tag waits silently for a command from the interrogator, • transmission of a command by the interrogator, • transmission of a response by the RFID tag.		

Table 2 Parameter Comparison: Tag to Interrogator Link

Reference	Parameter Name	RI-TRP-DR2B HDX	ISO/IEC 18000-2 Type B	Options/Comments
M1-TAG: 1	Operating Frequency Range Subcarrier Frequencies	134.2 ± 1.5 kHz 124.2 ± 2 kHz using FSK technique	134.2 ± 4 kHz 123.7 ± 4 kHz (FSK)	
M1-TAG: 1a	Default Operating Frequency	134.2 kHz		
M1-TAG: 2	Occupied Channel Bandwidth	± 15 kHz		

<i>Reference</i>	<i>Parameter Name</i>	<i>RI-TRP-DR2B HDX</i>	<i>ISO/IEC 18000-2 Type B</i>	<i>Options/Comments</i>
M1-TAG: 6a	Transmit to Receive Turn Around Time	Refer to M1-INT: 6b		
M1-TAG: 6b	Receive to Transmit Turn Around Time	Refer to M1-INT: 6a		
M1-TAG: 8	Data Coding	NRZ		
M1-TAG: 9	Bit Rate	NRZ '0': 8.4 kbps NRZ '1': 7.8 kbps	NRZ '0': 8.4 kbps NRZ '1': 7.7 kbps	
M1-TAG: 11c	Bit Sync Sequence	SOF pattern, 8 bits EOF pattern, NO	SOF pattern, 6 bits EOF pattern, 6 bits	
M1-TAG: 13	Bit Transmission Order	LSB first		
M1-TAG: 16	Minimum tag Receiver Bandwidth	± 10 kHz	± 15 kHz	-3 dB

Table 3 Parameter Comparison: Protocol

<i>Reference</i>	<i>Parameter Name</i>	<i>RI-TRP-DR2B HDX</i>	<i>ISO/IEC 18000-2 Type B</i>	<i>Options/Comments</i>
M1-P: 1	Who talks first	Interrogator talks first		
M1-P: 2	Tag addressing capability	Yes		
M1-P: 3	tag ID	NO (possible)	Yes possible	
M1-P: 3a	UID Length	NO UID programmed	The UID consists of 64 bits	
M1-P: 3b	UID Format	NO	8 bit Allocation Class 8 bit Manufacturer Code 48 bit Manufacturer Serial Number	
M1-P: 4	Read size	10 bytes	Minimum read size is 4 bytes Maximum read size is 1 Kbyte (in multiple of 4 bytes)	
M1-P: 5	Write Size	8 byte	See above	
M1-P: 8	Error detection	Tag to interrogator: CRC with length 16 Interrogator to tag: CRC with length 16	Tag to interrogator: CRC with length 16 (dependent on request flag CRCT setting) Interrogator to tag: CRC with length 16 (at the option of the interrogator)	
M1-P: 9	Error correction	No		
M1-P: 10	Memory size	1360 bit (17 pages*80 bit)	The maximum memory size is 1 kByte	
M1-P: 11	Command structure and extensibility	NO	The maximum number of commands is 64 (6 bits). 3 mandatory and 13 optional commands are specified. Thus, 48 commands are available for future extensions, custom and proprietary commands.	

7 Physical Layer Type 1 Tag: RI-TRP-DR2B HDX MPT

7.1 Power Transfer

7.1.1 Power transfer to the tag is accomplished by radio frequency via coupling antennas in the tag and in the interrogator. The RF operating field supplies power at the beginning of the request from the interrogator to the HDX tag. For communication between interrogator and tag, the field is modulated.

7.2 Frequency

7.2.1 The carrier frequency of the RF operating field is $f_c = 134.2$ kHz.