RAINFC TRANSPONDER IC FOR INDUSTRIAL APPLICATIONS

DESCRIPTION

em|echo-i corresponds to the latest generation of EM Microelectronic RAINFC devices, bringing innovative features to the HF, NFC, and RAIN RFID™ worlds. The chip combines all functionalities on a single die, with NFC for proximity range, HF for vicinity range, and RAIN technology used for long range application purposes. All protocols make use of a shared memory and a common IC serial number.

em|echo-i includes the new and improved GS1 EPC™ Gen2v3 air interface protocol which provides better management of tag populations and more reliable communications.

APPLICATIONS

- Industrial, automotive, rail, and aerospace logistics
- Automated vehicle ID for tolling, parking, and registration

FEATURES

- Advanced RAIN RFID technology
- Tamper detection
- Shared memory
- Minimum 100k write cycles endurance
- Minimum 10 years data retention @ 70ºC, minimum 30 years data retention @ 55ºC
- Dual Frequency 1-step inlay manufacturing
- On-chip resonant capacitor: 50pF
- Extended temperature range: -40°C to +85°C
- Sawn wafers, 6-mil thickness, gold bumps

HF INTERFACE

- ISO/IEC 15693 and 18000-3 compliant
- Optional random ID and secure customer privacy
- Protected memory using password
- Tamper Alarm is readable

NFC INTERFACE

- NFC Forum Type 5 Tag compliant
- All HF interface features are available via NFC

UHF INTERFACE

- ISO/IEC 18000-63 compliant
- EPC™ Generation-2 Version 3 (Gen2v3) compliant:
  - Alteration EAS compliant
  - Tag Alteration (Core) compliant
- Read sensitivity up to -21dBm with a dipole antenna
- Write sensitivity up to -16dBm with a dipole antenna
- Tamper status is readable

MEMORY

- Shared unique IC serial number included in:
  - 64-bit UID (HF)
  - 96-bit TID (UHF)
- Memory partitions for Dual Frequency devices:
  - 1920-bit (240 bytes) HF USER memory
  - Up to 480-bit EPC/UII encodings
  - 2048-bit UHF USER memory
- 1-step tag encoding possible from either HF or UHF interface.

RAIN RFID is a trademark of the RAIN Alliance

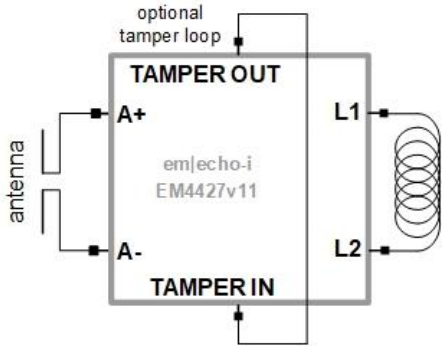
It is recommended to follow the RAIN Alliance best encoding practices for UHF EPC/UII memory (see https://rainrfid.org/cin)

EPC is a trademark of EPCglobal Inc.

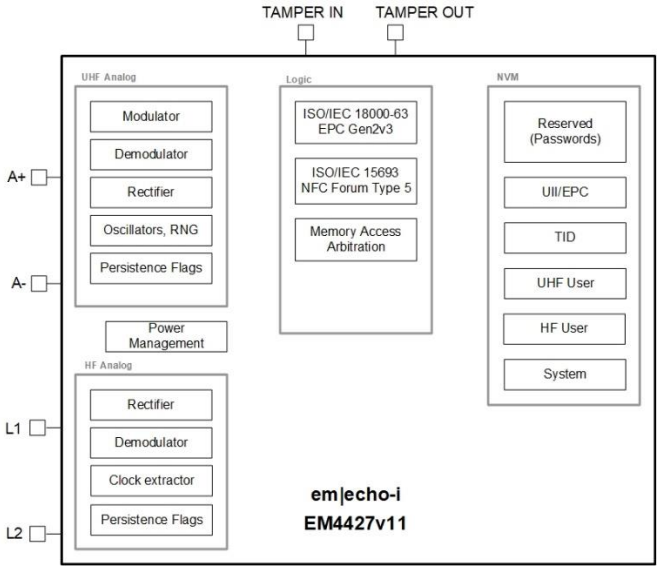
N-Mark is a trademark of the NFC Forum

TABLE OF CONTENTS

1. TYPICAL OPERATING CONFIGURATIONS



2. BLOCK DIAGRAM



3. ELECTRICAL SPECIFICATIONS

3.1. ABSOLUTE MAXIMUM RATINGS

Parameters	Symbol	Min.	Max.	Unit
Storage temperature	$T_{STORAGE}$	-50	125	°C
RF power at antenna attached to A+, A- [1)]	$P_{MAX-ABS}$		25	dBm
AC current induced on L1, L2	$I_{MAX-ABS}$		50	mA
Electrostatic discharge on all pads/pins [2)]	V_{ESD}	-2000	2000	V

Note 1: Antenna matched to IC impedance at read sensitivity (P_{READ})

Note 2: Human Body Model (HBM; 100pF; 1.5kOhm) for all combinations between pads/pins. ESD measurements are made with die mounted into CDIP packages

Stresses above these listed maximum ratings may cause permanent damages to the device. Exposure beyond specified operating conditions may affect device reliability or cause malfunction.

3.2. HANDLING PROCEDURES

This device has built-in protection against high static voltages or electric fields; however, anti-static precautions must be taken as for any other CMOS component. Unless otherwise specified, proper operation can only occur when all terminal voltages are kept within the voltage range. Unused inputs must always be tied to a defined logic voltage level.

3.3. OPERATING CONDITIONS

Parameters	Symbol	Min.	Max.	Unit
Operating temperature	T_{OP}	-40	+85	°C
RF power at antenna attached to A+, A- [1)]	P_{MAX-OP}		20	dBm
RF carrier frequency	f_A	860	960	MHz
AC peak current induced on L1, L2	I_{MAX-OP}		30	mA

3.4. ELECTRICAL CHARACTERISTICS – HF INTERFACE

Operating conditions (unless otherwise specified): V_{coil} = 4V (peak to peak), V_{SS} = 0V, fc = 13.56MHz sine wave, T_{OP} = 25°C.

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Operating frequency	fc		-	13.56	-	MHz
Resonance Capacitor	C_{r50}	fc = 13.56MHz; U = 2Vrms	47.5	50	52.5	pF

3.5. ELECTRICAL CHARACTERISTICS – UHF INTERFACE

Operating conditions (unless otherwise specified): T_{OP} = 25°C.

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
IC input capacitance	C_p	Parallel	-	0.66	-	pF
IC impedance [3)]	Z_{AB}	f_A=866MHz f_A=915MHz	- -	18.1-j279 17.2-j263	- -	Ω
Typical assembly capacitance [4)]	C_{ASSY}		-	0.2	-	pF
IC read (inventory) sensitivity [5)6)7)8)]	P_{READ}	Power Check Enables Inventory disabled; *Query* command; f_A=866MHz f_A=915MHz	 - -	 -19 -19	 - -	 dBm dBm
		Power Check Enables Inventory disabled; *QueryX* command; f_A=866MHz f_A=915MHz	 - -	 -16.3 -16.3	 - -	 dBm dBm
		Power Check Enables Inventory enabled; f_A=866MHz f_A=915MHz	 - -	 -15.5 -15.5	 - -	 dBm dBm
IC write sensitivity [5)6)7)8)]	P_{WRITE}	f_A=866MHz f_A=915MHz	-	-14 -14	-	dBm dBm

Note 3: Measured directly on wafer with a 100Ω differential network analyzer at minimum operating RF power level

Note 4: The antenna should be matched assuming 200fF additional input capacitance from assembly

Note 5: IC impedance conjugate matched to antenna at read sensitivity (P_{READ})

Note 6: IC is configured with tamper pads disabled and EPC/UII encoding of 96 bits

Note 7: HF field is not present

Note 8: Sensitivity values are for IC devices in die form and do not include antenna gain

3.6. TAMPER LOOP ELECTRICAL CHARACTERISTICS

Operating conditions (unless otherwise specified): T_{OP} = 25°C.

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Tamper loop maximum capacitance	C_{max}	Measured between tamper pads			47	pF
Tamper loop maximum inductance	L_{max}	Measured between tamper pads			40	nH
Resistance connected between TAMPER_IN and TAMPER_OUT to assure a closed (short) loop	R_{CLOSED}	Cloadmax between tamper pads/pins = 12.5pF; Tamper loop enabled			1	MΩ
Resistance connected between TAMPER_IN and TAMPER_OUT to assure an open (broken) loop	R_{OPEN}	Cloadmax between tamper pads/pins = 12.5pF; Tamper loop enabled	10			MΩ
Input impedance between TAMPER_IN and TAMPER_OUT	Z_{TAMPER}	RF power = P_{READ}; Pads configured for HI-Z; f_A = 866MHz		5.2-j106		Ω
		RF power = P_{READ}; Pads configured for Tamper Loop; f_A = 866MHz		17.5-j106		Ω
		RF power = P_{READ}; Pads configured for HI-Z; f_A = 915MHz		5.1-j101		Ω
		RF power = P_{READ}; Pads configured for Tamper Loop; f_A = 915MHz		16.1-j101		Ω

3.7. NVM ELECTRICAL CHARACTERISTICS

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Erase / write endurance	T_{CYC}	T_{OP} = 25ºC	100,000			Cycles
Retention	T_{RET}	T = 70°C	10			Years
		T = 55°C	30			

3.8. TIMING

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power-up timing to receive first command	T_{PWR_UP}	Supports both Gen2v2 and Gen2v3 timing requirements			1.5	ms
HF interface execution time to write a value into NVM	T_{WRITE}	All commands except for *Write Multiple Blocks*			10.9	ms
		Write Multiple Blocks when writing two physical blocks			15.4	ms

4. PRODUCT OVERVIEW

em|echo-i is used in passive transponder applications and provides support for use as either a Dual Frequency product (HF + UHF, NFC + UHF, or HF/NFC + UHF) or a UHF Only product.

Both the HF / NFC and UHF interfaces have access to all of memory although access operations may be protected and require the use of passwords or crypto. No priority is given to either air interface. The memory cannot be accessed in parallel and memory access arbitration is performed on a per command basis as the commands are received over the air interfaces.

The user has the option to select the security features appropriate for their application(s).

The user has the option to enable the tamper detection feature which checks impedance of a continuity loop at power-up between two pads/pins to determine if the loop is intact (closed) or broken (open).

4.1. OVERVIEW (HF)

em|echo-i corresponds to the latest generation of ISO/IEC 15693 and 18000-3 Mode 1 devices offering innovative and enriched features.

The IC supports data rates at 6kbps, 26kbps, and 53kbps.

Each em|echo-i chip is delivered with a unique 64-bit inalterable UID number programmed at wafer level to ensure full traceability.

em|echo-i supports the optional *Write Multiple Blocks* command, enabling rapid tag encoding.

The HF memory is also accessible through the UHF interface as specified later in this document.

The HF specific mechanisms and features do not influence UHF functionality excluding memory sharing and mechanisms which are explicitly described.

4.2. OVERVIEW (NFC)

em|echo-i corresponds to the latest generation of NFC Type 5 devices offering innovative and enriched features.

The IC supports data rates at 26kbps.

The HF / NFC memory contains the NFC Capability Container, the NDEF message, and other proprietary data.

The HF / NFC memory is also accessible through UHF interface as specified later on in this document.

The NFC specific mechanisms and features do not influence UHF functionality excluding memory sharing and mechanisms which are explicitly described.

4.3. OVERVIEW (UHF)

em|echo-i is a RAIN RFID IC compliant with ISO/IEC 18000-63 and GS1 EPC Gen2v3. It supports the Tag Alteration (Core) and Alteration EAS application requirements to provide data privacy and EAS capability.

Each em|echo-i chip is delivered with a 96-bit inalterable TID number programmed at wafer level to ensure full traceability.

em|echo-i supports the optional *BlockWrite* command, enabling rapid tag encoding.

The UHF memory is also accessible through HF / NFC interface as specified later on in this document.

The UHF specific mechanisms and features do not influence HF / NFC functionality excluding memory sharing and mechanisms which are explicitly described.

4.4. FUNCTIONAL DESCRIPTION

As soon as the em|echo-i enters an RF operating field (HF / NFC or UHF), the energy from the operating field is extracted to provide power for the IC. Both fields can be present simultaneously.

em|echo-i initialization occurs during power-up (BOOT) and the device reads initial values from NVM to configure the tag for normal operation. The em|echo-i stays quiet and ignores all incoming communication during BOOT.

If UHF field is present, then UHF mode is available (if not killed) after BOOT and UHF interface is ready to execute commands.
If HF field is present, HF / NFC mode is available (if not killed) after BOOT and HF / NFC interface is ready to execute commands.
If both fields are present, then both HF / NFC mode and UHF mode are available and commands will be executed on a first-in, first-served basis.

This device is in full compliance with the following documents:

HF :

- "ISO/IEC 15693-2:2019 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 2: Air interface and initialization", Publication Date: 2019-04
- "ISO/IEC 15693-3:2019 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 3: Anticollision and transmission protocol", Publication Date: 2019-04
- "ISO/IEC 18000-3:2010 Information technology – Radio frequency identification for item management – Part 3: Parameters for air interface communications at 13,56 MHz", Publication Date: 2010-11

NFC :

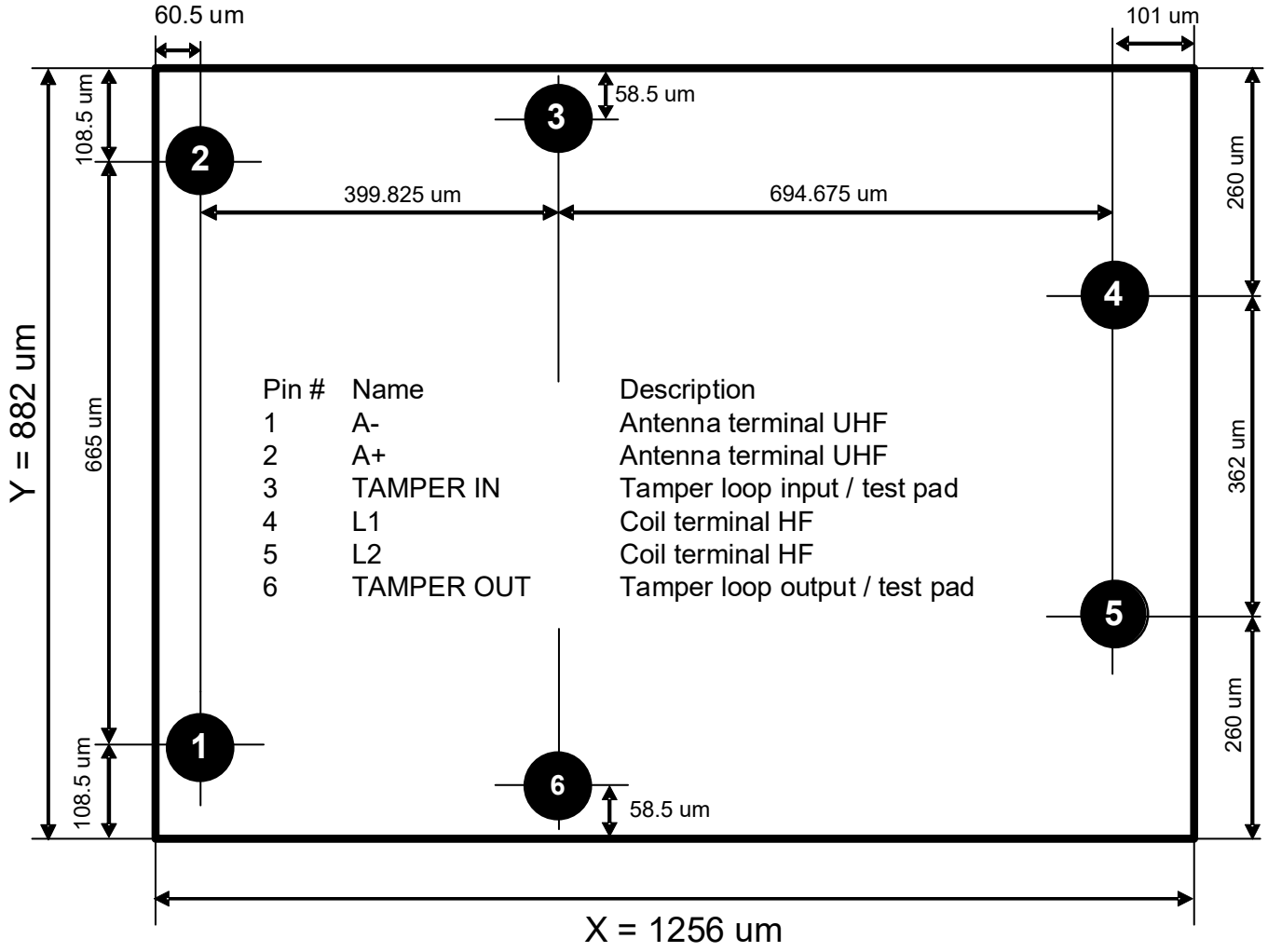
- "NFC Forum Analog, Technical Specification, Version 2.1", Publication Date: 2018-02-19
- "NFC Forum Activity, Technical Specification, Version 2.0", Publication Date: 2017-04-30
- "NFC Forum Digital Protocol, Technical Specification, Version 2.0", Publication Date: 2017-05-09
- "NFC Forum Type 5 Tag Operation, Technical Specification, Version 1.0", Publication Date: 2015-07-07

UHF :

- "ISO/IEC 18000-63:2021 Information technology – Radio frequency identification for item management – Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C", Publication Date: 2021-11
- "EPC® Radio-Frequency Identity Generation-2 UHF RFID Standard, Specification for RFID Air Interface Protocol for Communications at 860 MHz – 930 MHz, Release 3.0, Ratified, Jan 2024" from GS1
- "EPC Tag Data Standard TDS, defines the Electronic Product Code™ and specifies the memory content of Gen 2 RFID Tags, Release 2.2, Ratified, Feb 2025" from GS1
- "GS1 Digital Link URI: Compression Standard, An algorithm for compressing and decompressing GS1 Digital Link URIs, Release 1.0, Ratified, July 2025" from GS1

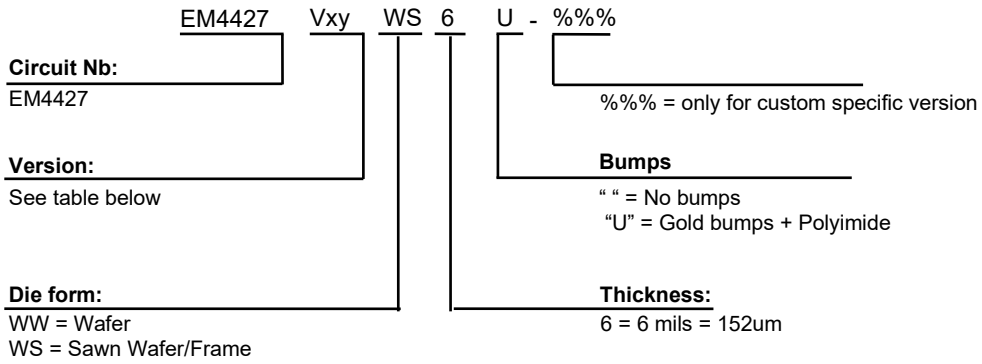
5. PAD LOCATION DIAGRAM

All dimensions in µm and do not include the scribe line.



Pad	Name	Description
1	A-	Antenna terminal for UHF
2	A+	Antenna terminal for UHF
3	TAMPER IN	Tamper loop input
4	L1 / NC	Dual Frequency: Coil terminal for HF UHF Only: No connect
5	L2 / NC	Dual Frequency: Coil terminal for HF UHF Only: No connect
6	TAMPER OUT	Tamper loop output

6. ORDERING INFORMATION



6.1. VERSION

xy	Brand Name	Air Interfaces	Supports Crypto
11	em|echo-i	Dual Frequency	no

6.2. STANDARD VERSIONS AND SAMPLES

The version below is considered standard and should be readily available. For other delivery form, please contact EM Microelectronic-Marin S.A. For samples, please order exclusively from the standard versions.

Brand Name	Part Number	Package / Die Form	Delivery Form
em|echo-i	EM4427V11WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame

7. PRODUCT SUPPORT

Check our website at www.emmicroelectronic.com under Products/RF Identification section. Questions can be submitted to rfidsupport@emmicroelectronic.com .