

# RAINFC AUTHENTICITY TRANSPONDER IC

## DESCRIPTION

em|echo-V 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.

Targeted applications and market segments include retail, product authentication, consumer engagement, industrial, automotive, and aerospace logistics.

A tag or label based on the em|echo-V provides multiple benefits and usages via the RAIN communication interface like stock inventory, product returns, and data privacy. The same tag or label also enables new consumer services like product authentication, product information, or loyalty programs using an NFC enabled smartphone.

The chip is a dual frequency device supporting ISO/IEC 15693, ISO/IEC 18000-3 Mode 1, NFC Forum Type 5 Tag, ISO/IEC18000-63, EPC™ Gen2v2, and ISO/IEC 29167-10.

The em|echo-V offers a user configurable non-volatile memory which is accessible by NFC, HF, and UHF air interfaces.

## APPLICATIONS

- | Inventory and supply chain management
- | Customer engagement, coupons, loyalty programs
- | Product authentication with tamper evidence detection
- | Industrial, automotive, and aerospace logistics

## FEATURES

- | Advanced RAIN RFID technology
- | AES-128 crypto for NFC web based authentication
- | Digital signature for authenticity
- | Tamper Detection
- | Shared memory
- | Dual Frequency 1-step inlay manufacturing
- | Minimum 100k write cycles endurance
- | Minimum 50 years data retention
- | 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
- | Control of UHF privacy features with password
- | Tamper Alarm

## NFC INTERFACE

- | NFC Forum Type 5 Tag compliant
- | Optional app-free web based crypto authentication
- | Optional app-free tamper detection
- | Optional ACCESS counter increased at first reading
- | Optional app access of protected memory with password protection
- | Optional app control of UHF privacy features with password protection

## UHF INTERFACE

- | ISO/IEC 18000-63 compliant
- | EPC™ Generation-2 Version 2 (Gen2v2) certified:
  - Alteration EAS certified
  - Tag Alteration (Core) certified
- | Read sensitivity up to -20dBm with a dipole antenna
- | Write sensitivity up to -14.5dBm with a dipole antenna
- | Optional NFC ACCESS counter is readable
- | Tamper Alarm

## MEMORY

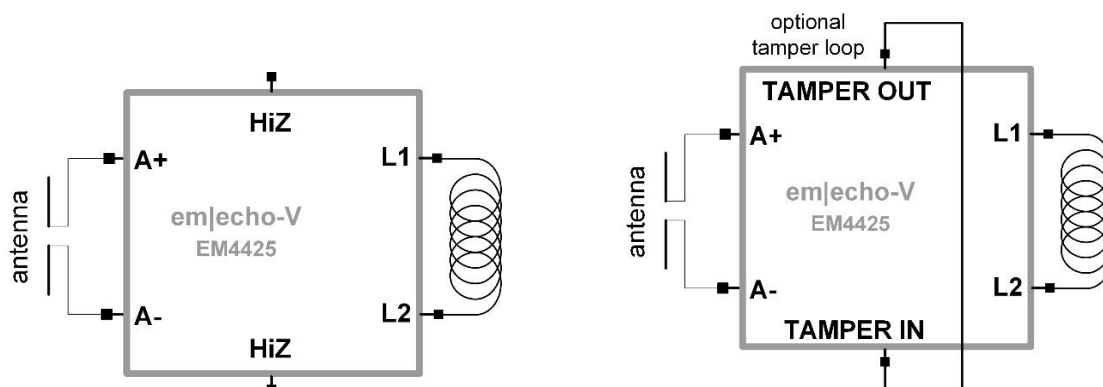
- | Shared unique IC serial number included in:
  - 64-bit UID (HF)
  - 96-bit TID (UHF)
- | Configurable 2048-bit memory used for:
  - HF USER memory
  - Up to 480-bit EPC/UII encodings
  - UHF USER memory
  - Optional Digital Signature (none, 256b, 384b, 512b)
- | 1-step tag encoding possible from either HF or UHF interface.



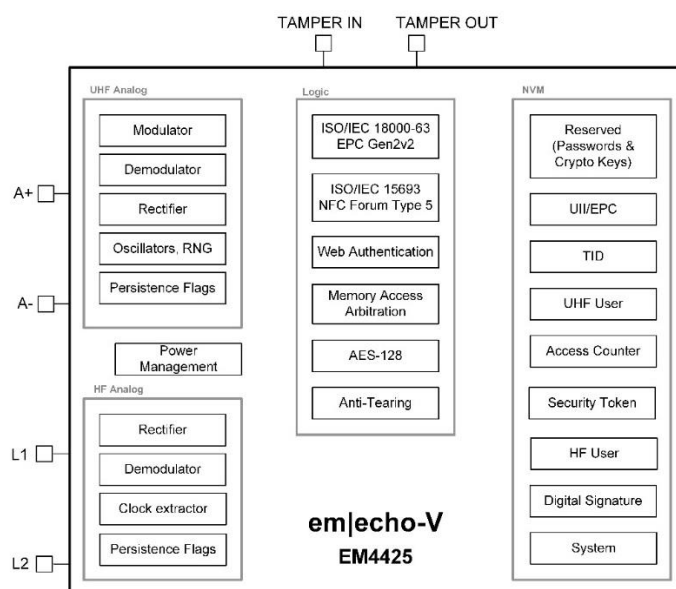
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**EPC is a trademark of EPCglobal Inc.**

## 1. TYPICAL OPERATING CONFIGURATIONS



## 2. BLOCK DIAGRAM



## 3. ELECTRICAL SPECIFICATIONS

### 3.1. ABSOLUTE MAXIMUM RATINGS

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

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

**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- <sup>1)</sup>	$P_{MAX-OP}$		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),  $V_{SS} = 0V$ ,  $f_c = 13.56MHz$  sine wave,  $T_{OP} = 25^\circ C$ .

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

### 3.5. ELECTRICAL CHARACTERISTICS – UHF INTERFACE

Operating conditions (unless otherwise specified):  $T_{OP} = 25^\circ C$ .

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
IC input capacitance	$C_p$	Parallel	-	0.57	-	pF
IC impedance <sup>3)</sup>	$Z_{AB}$	$f_A = 866MHz$ $f_A = 915MHz$	-	19.1-j286 17.6-j273	-	$\Omega$
Typical assembly capacitance <sup>4)</sup>	$C_{ASSY}$	$f_A = 915MHz$	-	0.2	-	pF
IC read sensitivity <sup>5)6)7)8)9)</sup>	$P_{READ}$	$f_A = 866MHz$ $f_A = 915MHz$	-	-18 -18	-	dBm dBm
IC write sensitivity <sup>5)6)7)8)9)</sup>	$P_{WRITE}$	$f_A = 866MHz$ $f_A = 915MHz$	-	-12.5 -12.5	-	dBm dBm

**Note 3:** Measured directly on wafer with a 100 $\Omega$  differential network analyzer at minimum operating RF power level

**Note 4:** Estimated 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:** Interrogator using PR-ASK modulation with link parameters  $T_{ari} = 25 \mu s$ ,  $PR = 1.5$ ,  $BLF = 256 KHz$  with Miller-4 encoding

**Note 8:** HF field is not present

**Note 9:** 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):  $T_{OP} = 25^{\circ}\text{C}$ .

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Tamper loop maximum capacitance	$C_{max}$	Measured between tamper pads			12.5	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	M $\Omega$
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			M $\Omega$
Input impedance between TAMPER_IN and TAMPER_OUT	$Z_{TAMPER}$	RF power = $P_{READ}$ ; Pads configured for HI-Z; $f_A = 866\text{MHz}$		5.2-j106		$\Omega$
		RF power = $P_{READ}$ ; Pads configured for Tamper Loop; $f_A = 866\text{MHz}$		17.5-j106		$\Omega$
		RF power = $P_{READ}$ ; Pads configured for HI-Z; $f_A = 915\text{MHz}$		5.1-j101		$\Omega$
		RF power = $P_{READ}$ ; Pads configured for Tamper Loop; $f_A = 915\text{MHz}$		16.1-j101		$\Omega$

### 3.7. NVM ELECTRICAL CHARACTERISTICS

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Unit
Erase / write endurance	$T_{CYC}$	$T_{OP} = 25^{\circ}\text{C}$	100,000			Cycles
Retention	$T_{RET}$	$T_{OP} = 55^{\circ}\text{C}$	50			Years

## 4. PRODUCT OVERVIEW

emlecho-V is used in passive transponder applications and provides support for use as either an HF / UHF product, an NFC / UHF product, or as an HF / NFC / UHF product.

The user defines the IC memory partitions which determine the size of HF User memory, UHF User memory, UHF EPC/UII memory, and Digital Signature memory.

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. 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 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).

This device is in full compliance with the following documents:

### HF :

- "ISO/IEC 15693-2:2006 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 2: Air interface and initialization", Publication Date: 2006-12
- "ISO/IEC 15693-3:2009 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 3: Anticollision and transmission protocol", Publication Date: 2009-04
- "ISO/IEC 15693-3:2009/Amd 2:2017 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 3: Anticollision and transmission protocol AMENDMENT 2: Clarification of use of Data Elements", Publication Date: 2015-08
- "ISO/IEC 15693-3:2009/Amd 4:2017 Identification cards – Contactless integrated circuit cards – Vicinity cards – Part 3: Anticollision and transmission protocol AMENDMENT 4: Security framework", Publication Date: 2017-05
- "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 :

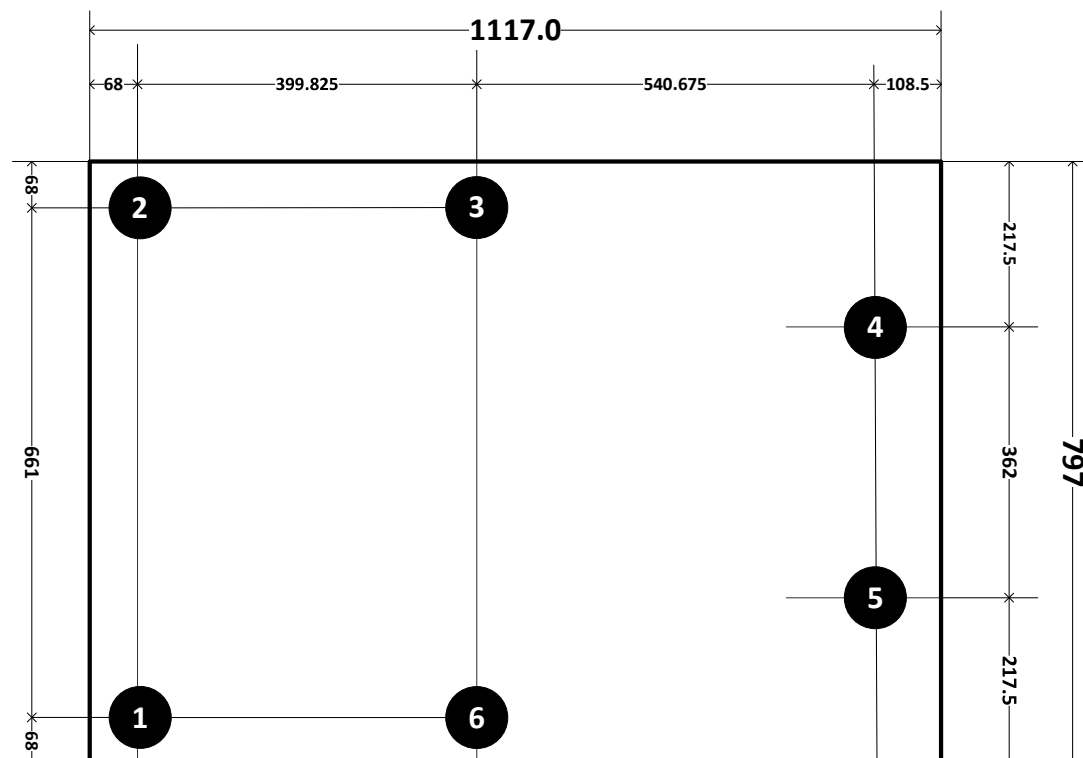
- "NFC Forum Analog, Technical Specification, Version 2.1", Publication Date: 2018-02-19
- "NFC Forum Activity, Technical Specification, Version 2.0", Publication Date: 2017-04-30
- "NFC Forum Digital Protocol, Technical Specification, Version 2.0", Publication Date: 2017-05-09
- "NFC Forum Type 5 Tag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

### UHF :

- "ISO/IEC 18000-63:2015 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: 2015-10
- "EPC™ Radio-Frequency Identity Protocols, Generation-2 UHF RFID, Specification for RFID Air Interface Protocol for Communications at 860 MHz - 960 MHz, Release 2.1, Ratified, Jul 2018" from GS1
- "EPC Tag Data Standard, defines the Electronic Product Code™ and specifies the memory content of Gen 2 RFID Tags, Release 1.13, Ratified, Nov 2019" from GS1

## 5. PAD LOCATION DIAGRAM

All dimensions in  $\mu\text{m}$  and 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	Coil terminal for HF
5	L2	Coil terminal for HF
6	TAMPER OUT	Tamper loop output

## 6. ORDERING INFORMATION

<p><b>Circuit Nb:</b> EM4425</p> <p><b>Version:</b> See table below</p> <p><b>Die form:</b> WW = Wafer WS = Sawn Wafer/Frame</p>	<p><b>Customer Version:</b> %%% = only for custom specific version</p> <p><b>Bumps</b> " " = No bumps "U" = Gold bumps + Polyimide</p> <p><b>Thickness:</b> 6 = 6 mils = 152<math>\mu\text{m}</math></p>
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## 6.1. PRODUCT SELECTION GUIDE

VERSION	SETUP FOR THE APPLICATION				
	Air Interface	SMARTPHONE	HF READER	UHF READER	HF Crypto
V10	Dual Frequency	✓	-- 13)	✓	None 14)
V11		-- 12)	✓	✓	None
V12		✓	-- 13)	✓	Web Authentication
V13		✓	-- 13)	✓	Web Authentication + AES
V14		-- 12)	✓	✓	ISO 29167-10 (AES)
V15	NFC Only	✓	-- 13)	X	None 14)
V16		✓	-- 13)	X	Web Authentication

**Note 12:** Android compatibility requires version 9.0 or higher.

**Note 13:** Only HF readers that support use of Dual Subcarrier and/or Low Data rate.

**Note 14:** HF Crypto Mode = 01<sub>2</sub> = Web Authentication, but all memory substitution is disabled and no crypto support exists.

## 6.2. STANDARD VERSIONS AND SAMPLES

The versions below are 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.

Part Number	Package / Die Form	Delivery Form
EM4425V10WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V11WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V12WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V13WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V14WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V15WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame
EM4425V16WS6U	Sawn wafer / Gold bumped +PI – thickness of 6 mils	Wafer on frame

## 7. PRODUCT SUPPORT

This document is a short datasheet, an extract from a full datasheet with the same product type number(s) and title. It is intended to be used as a quick reference only and therefore should not be relied upon to contain detailed and full information.

For detailed and complete information see the relevant full datasheet, which is available on request through our website at [www.emmicroelectronic.com](http://www.emmicroelectronic.com) by using the contact form. Questions can be submitted to [rfidsupport@emmicroelectronic.com](mailto:rfidsupport@emmicroelectronic.com).

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