18000-63 / EPC^{TM} CLASS-1 GENERATION-2 (GEN2) RFID IC

DESCRIPTION

EM4126 is a UHF RFID IC compliant with both ISO/IEC 18000-63 (formerly known as 18000-6 Type C) and EPC^{TM} Class-1 Generation-2.

The EM4126 has 224 bits of non-volatile memory (16 bit PC Word and 208 bit UII/EPC Code) enabling the support of ISO or EPC data structures.

EM4126 achieves a typical read sensitivity of -19 dBm at the chip level, which translates into a typical -21 dBm sensitivity at the tag level for a dipole-like antenna with 2 dBi gain (25us TARI, 250 kHz BLF).

APPLICATIONS

l Supply chain management

l Tracking and tracing

l Container identification

l Access control

l Asset control

FEATURES

l ISO/IEC 18000-63 compliant

l EPC^{TM} Class-1 Generation-2 compliant

l 208-bit UII / EPC encodings are supported

l 32-bit Short Tag Identification (TID)

l -19 dBm (-21 dBm) typical IC (tag) read sensitivity

l Forward link data rates: 40 to 160 kbit/s

l Return link data rates: 40 to 640 kbit/s

l Support of near-field mode enabling reading e.g. through water

l Support of parallel-inductance matching for improved matching

l Extended temperature range: -40°C to +85°C
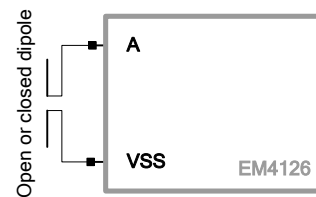
TYPICAL OPERATING CONFIGURATION

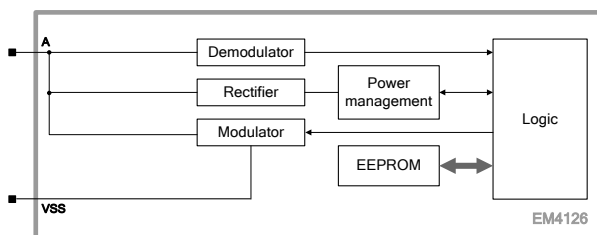**Fig. 1 Typical Operating Configuration**

IC BLOCK DIAGRAM

Fig. 2 IC Block Diagram

RAIN RFID is a trademark of the RAIN RFID Alliance.

EPC is a trademark of EPCglobal.

www.emmicroelectronic.com

TABLE OF CONTENTS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min.	Max.	Unit
Storage temperature	T_{STORE}	-50	125	°C
RF power at pad A [1]	P_{A_ABS}		30	dBm
Voltage on pad A	V_{A_ABS}	V_{SS}-0.2	V_{SS}+2.0	V
Voltage on pad TST1, TST3	V_{TST_ABS}	V_{SS}-0.2	V_{SS}+2.0	V
ESD hardness pad A [2]	V_{ESD_A}	-1000	1000	V
ESD hardness pad TST1, TST3 [2]	V_{ESD_TST}	-2000	2000	V

Table 1: Absolute maximum ratings

Note 1: IC impedance matched to antenna at read sensitivity

Note 2: Human Body Model

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.

OPERATING CONDITIONS

Parameter	Symbol	Min.	Max.	Unit
Operating temperature	T_{OP}	-40	+85	°C
RF power at pad A [3]	P_A		20	dBm
RF carrier frequency	f_A	860	960	MHz

Table 2: Operating conditions

Note 3: IC impedance matched to antenna at read sensitivity

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.

ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Incoming RF carrier modulation	K_M		65		100	%
Input impedance (between A and VSS) above activation threshold	Z_A	P_{DUT}= -17dBm T = 25°C f_A = 866MHz f_A = 915MHz f_A = 953MHz		25 – j276 22 – j261 20 – j251		Ω Ω Ω
Resistive load (between A and VSS) when modulator is on	R_{A_ON}	1mA into pad A T = 25°C		50		Ω
Read sensitivity for power matching (complex-conjugate matching)	P_{RD}	T = 25°C f_A=866MHz f_A=915MHz f_A = 953MHz		-19 [4] -19 [4] -19 [4]		dBm dBm dBm
Write sensitivity for power matching (complex-conjugate matching)	P_{WR}	T = 25°C f_A=866MHz f_A=915MHz f_A = 953MHz		-8 -8 -8		dBm dBm dBm

Table 3: Electrical characteristics

Note 4: 25 us TARI, 250 kHz BLF

Timing Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Erase / write endurance	T_{CYC}		10k			Cycles
Retention	T_{RET}	T_{OP} = 55°C	10			Years

Table 4: Timing characteristics

FUNCTIONAL DESCRIPTION

The EM4126 is used in passive UHF transponder applications operating at 860 MHz - 960 MHz. It is powered by the RF energy transmitted by the reader, which is received and rectified to generate a supply voltage for the IC. This device is in full compliance with ISO/IEC 18000-63 and EPC™ Class-1 Generation-2 specifications according to the following documents:

"ISO/IEC 18000-63:2012 Information technology – Radio frequency identification for item management – Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C"

"EPC Radio-Frequency Identity Protocols, Class-1 Generation-2 UHF RFID, Protocol for Communications at 860 MHz - 960 MHz, Version 1.2" from EPCglobal Inc.

"EPCglobal Tag Data Standards, Version 1.6" from EPCglobal Inc.

MEMORY ORGANIZATION

EM4126 memory is allocated to three memory banks: Reserved, TID and UII/EPC.

Memory Name	Memory Bank	Word Address	Contents	Memory Type
Reserved	00_2	0	Kill Password = 0000h	ROM
		1		
		2	Access Password = 0000h	
		3		
TID	10_2	0	Short TID Format	ROM
		1		
UII/EPC	01_2	0	CRC-16	RAM
		1	PC	NVM
		2	UII/EPC	
		3		
		4		
		5		
		6		
		7		
		8		
		9		
		10		
		11		
		12		
		13		
		14		

Table 5: Memory map.

Word	0			1		
Bits (MSB first)	15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0		15 14 13 12 11 10 9 8	7 6 5 4 3 2 1 0	
Content	ISO/IEC 15963 Allocation Class	Tag mask-designer identifier for EM		Tag model number		
	11100010_2 (ROM)	000000001011_2 (ROM)		$000011000xxx_2$ (ROM) where xxx is customer version and 000 is standard product		

Table 6: TID memory

DELIVERY STATE

The delivery state has the following default product configuration:

❑ UII/EPC memory is unlocked with a default 96-bit UII/EPC Code value 0000'0000'0000'0000'nnnn'nnnnh where nnnn'nnnn is the 32-bit IC serial number.

COMMANDS

Three sets of commands are defined:
❑ Mandatory
❑ Optional
❑ Custom

COMMAND CODES

The table below shows all implemented commands in EM4126. For the description of all mandatory and optional commands, please refer to the EPCglobal Class-1 Generation-2 standard. More detailed information on custom commands is given below.

Command code	Type	Function
'00'	Mandatory	QueryRep
'01'	Mandatory	ACK
'1000'	Mandatory	Query
'1001'	Mandatory	QueryAdjust
'1010'	Mandatory	Select
'11000000'	Mandatory	NAK
'11000001'	Mandatory	Req_RN
'11000010'	Mandatory	Read
'11000011'	Mandatory	Write
'11000100'	Mandatory	Kill [5]
'11000101'	Mandatory	Lock
'11000110'	Optional	Access
'11100000 00000000'	Custom	GetUID

Table 7: Command codes
Note 5: Kill password is hardcoded to zero so it is not possible to kill the tag.

CUSTOM COMMANDS

GetUID

GetUID	Command code	RN
# of bits	16	16
Description	11100000 00000000	Prior RN16 or handle

Table 8: GetUID Command

The custom command GetUID is implemented as in Table 9. It allows an interrogator to read the tag's 64-bit TID / UID with a single command. A tag in Reply, Acknowledged, Open or Secured state backscatters {'0', TID / UID, RN16, CRC-16} upon a GetUID command with a valid RN16 or handle (see Table 10). The state transition and link timing is the same as for the ACK command. The tag reply is analogous to the tag reply upon a Read command. A link timing example is shown in Figure 3.

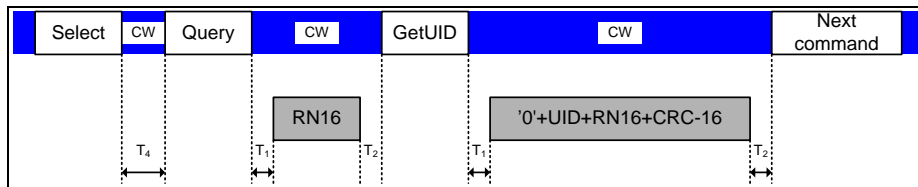|	Header	UID	RN	CRC-16
# of bits	1	32	16	16
Description	0	TID	RN16 (prior RN16 or handle)	CRC-16('0'+TID+RN16)

Table 9: GetUID backscatter format

Fig. 3: GetUID backscatter timing diagram

ELECTRONIC PRODUCT CODE (EPC) ENCODING

A common use for the EM4126 is to support item level tagging in retail applications and corresponds to the use of bar codes to uniquely identify a product. A bar code format (e.g. EAN-13) is used to encode a Universal Product Code (UPC) representing the Global Trade Item Number (GTIN) for the product. The common EAN-13 format has four components:

- The **GS1 Prefix**, the first three digits, usually identifying the national GS1 Member Organization to which the manufacturer is registered.
- The **Company Number**, consisting of three to seven digits depending on number of EAN-13's required by the manufacturer to identify different product lines.
- The **Item Reference**, consisting of two to six digits.
- The **Check Digit**, a single checksum digit.

The GS1 Company Prefix is the GS1 Prefix concatenated with the Company Number and indicates the manufacturer. The Item Reference indicates the product. The complete number is used as a reference key to look up information about the product in a database.

EPC encoding supports GTIN's and also provides the means to assign a unique identity to an instance of a trade item using serialization. This is done using the Serialized Global Trade Item Number (SGTIN) scheme which consists of the following elements:

- The **GS1 Company Prefix**, assigned by GS1 to a managing entity or its delegates. This is the same as the GS1 Company Prefix digits within a GS1 GTIN and typically represents a manufacturer.
- The **Item Reference**, assigned by the managing entity to a particular object class and typically represents a product. The Item Reference as it appears in the EPC is derived from the GTIN by concatenating the Indicator Digit of the GTIN (or a zero pad character, if the EPC is derived from a GTIN-8, GTIN-12, GTIN-13, or EAN-13) and the Item Reference digits, and treating the result as a single numeric string.
- The **Serial Number**, assigned by the managing entity to an individual object. The serial number is not part of the GTIN, but is formally a part of the SGTIN. The serial number may be either a numeric value in the range 1 – 274,877,906,943 or an alphanumeric string consisting of 1 – 20 characters.

To construct the EPC corresponding to an EAN-13 and a serial number, first convert the corresponding GTIN to a 14-digit number by adding one leading zero character as shown in the following example.

Start with EAN-13
EAN-13: 7611608234365
GS1 Company Prefix (manufacturer): 7611608
Item Reference (product): 23436
Check Digit: 5

Convert to GTIN
Prepend "0" indicator to construct full 14 digit format
GTIN = 0 7611608 23436 5

Prepare for EPC encoding
Move indicator to first digit of Item Reference
Drop check digit
GS1 Company Prefix (GCP) = 7611608
Indicator / Item Reference = 023436
Partition = 5 for 7-digit (24 bits) GS1 Company Prefix and 6-digit (20 bits) Indicator / Item Reference
Filter = 1 for Point of Sale (POS) Trade Item
EPC Header = 48 (SGTIN-96) or 54 (SGTIN-198)

The type of serialization determines which SGTIN scheme is used to perform the EPC encoding in tag memory. The SGTIN-96 encoding is used for numeric serialization for values less than 274,877,906,944. The SGTIN-198 encoding is used for alphanumeric serialization.

SGTIN-96						
Logical Segment	EPC Header	Filter	Partition	GS1 Company Prefix	Indicator / Item Reference	Serial
Logical Segment Bit Count	8	3	3	20-40	24-4	38
Coding Segment	EPC Header	Filter	GTIN			Serial
Coding Segment Bit Count	8	3	47			38
Bit Position	$b_{95}b_{94}...b_{88}$	$b_{87}b_{86}b_{85}$	$b_{84}b_{83}...b_{38}$			$b_{37}b_{36}...b_0$
Example	00110000	001	Partition = 101 GCP = 0111010000100100011011000 Indicator/Item Reference = 00000101101110001100			number

<div align="center">Table 10: SGTIN-96 Encoding Scheme</div>

SGTIN-198						
Logical Segment	EPC Header	Filter	Partition	GS1 Company Prefix	Indicator / Item Reference	Serial
Logical Segment Bit Count	8	3	3	20-40	24-4	140
Coding Segment	EPC Header	Filter	GTIN			Serial
Coding Segment Bit Count	8	3	47			140
Bit Position	$b_{197}b_{196}...b_{190}$	$b_{189}b_{188}b_{187}$	$b_{186}b_{185}...b_{140}$			$b_{139}b_{138}...b_0$
Example	00110110	001	Partition = 101 GCP = 0111010000100100011011000 Indicator/Item Reference = 00000101101110001100			string

<div align="center">Table 11: SGTIN-198 Encoding Scheme</div>

SGTIN-198 uses alphanumeric serialization represented as a string of 1 – 20 7-bit characters. The string is left justified and unused characters are zero filled. The characters permitted in alphanumeric serialization are shown in the following table.

Graphic Symbol	Name	Hex Value	URI Form	Graphic Symbol	Name	Hex Value	URI Form
!	Exclamation Mark	21	!	M	Capital Letter M	4D	M
"	Quotation Mark	22	%22	N	Capital Letter N	4E	N
%	Percent Sign	25	%25	O	Capital Letter O	4F	O
&	Ampersand	26	%26	P	Capital Letter P	50	P
'	Apostrophe	27	'	Q	Capital Letter Q	51	Q
(	Left Parenthesis	28	(	R	Capital Letter R	52	R
)	Right Parenthesis	29	)	S	Capital Letter S	53	S
*	Asterisk	2A	*	T	Capital Letter T	54	T
+	Plus sign	2B	+	U	Capital Letter U	55	U
,	Comma	2C	,	V	Capital Letter V	56	V
–	Hyphen/ Minus	2D	–	W	Capital Letter W	57	W
.	Full Stop	2E	.	X	Capital Letter X	58	X
/	Solidus	2F	%2F	Y	Capital Letter Y	59	Y
0	Digit Zero	30	0	Z	Capital Letter Z	5A	Z
1	Digit One	31	1	_	Low Line	5F	_
2	Digit Two	32	2	a	Small Letter a	61	a
3	Digit Three	33	3	b	Small Letter b	62	b
4	Digit Four	34	4	c	Small Letter c	63	c
5	Digit Five	35	5	d	Small Letter d	64	d
6	Digit Six	36	6	e	Small Letter e	65	e
7	Digit Seven	37	7	f	Small Letter f	66	f
8	Digit Eight	38	8	g	Small Letter g	67	g
9	Digit Nine	39	9	h	Small Letter h	68	h
:	Colon	3A	:	i	Small Letter i	69	i
;	Semicolon	3B	;	j	Small Letter j	6A	j
<	Less-than Sign	3C	%3C	k	Small Letter k	6B	k
=	Equals Sign	3D	=	l	Small Letter l	6C	l
>	Greater-than Sign	3E	%3E	m	Small Letter m	6D	m
?	Question Mark	3F	%3F	n	Small Letter n	6E	n
A	Capital Letter A	41	A	o	Small Letter o	6F	o
B	Capital Letter B	42	B	p	Small Letter p	70	p
C	Capital Letter C	43	C	q	Small Letter q	71	q
D	Capital Letter D	44	D	r	Small Letter r	72	r
E	Capital Letter E	45	E	s	Small Letter s	73	s
F	Capital Letter F	46	F	t	Small Letter t	74	t
G	Capital Letter G	47	G	u	Small Letter u	75	u
H	Capital Letter H	48	H	v	Small Letter v	76	v
I	Capital Letter I	49	I	w	Small Letter w	77	w
J	Capital Letter J	4A	J	x	Small Letter x	78	x
K	Capital Letter K	4B	K	y	Small Letter y	79	y
L	Capital Letter L	4C	L	z	Small Letter z	7A	z

Table 12: Characters Permitted in Alphanumeric Serial Numbers
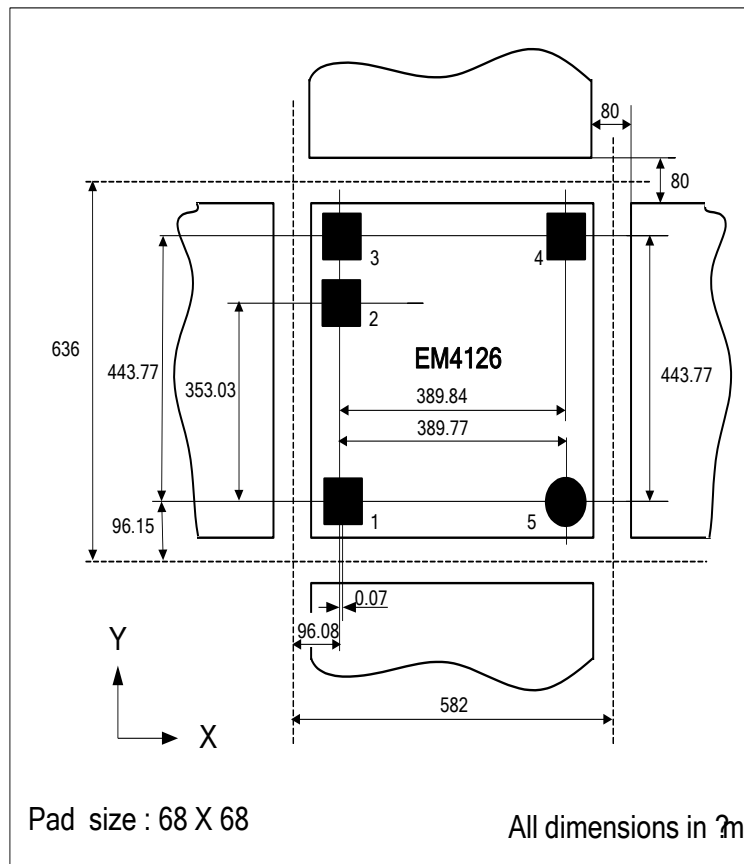
FLOOR PLAN AND PIN DESCRIPTION

Fig. 4: Chip dimensions and pins locations

Pin	Name	Pad Type	Description
1	VSS	Bumped	Antenna -
2	TST1 [2]	Un-bumped	N/A - Test purpose only
3	TST2 [2]	Bumped	N/A - Test purpose only
4	TST3 [2]	Bumped	N/A - Test purpose only
5	ANT	Bumped	Antenna +

**Table 13: Pin description. Pins TST2, TST3, VSS can be shorted to ease inlay assembly.
TST1 must not be shorted to any other pins.**

ORDERING INFORMATION

The following charts show the general offering. For detailed Part Number to order, please see the table "Standard Versions" below.

Die form

EM4126 V% WS 6

Circuit Nb:
EM4126

Customer Version*:
V0 = Standard product
(*refer to Table 6)

Bumping:
U = with Gold Bumps & Polyimide

Die form:
WW = Wafer
WS = Sawn Wafer/Frame

Thickness:
6 = 6 mils (152um)
7 = 7 mils (178um)
11 = 11 mils (280um)
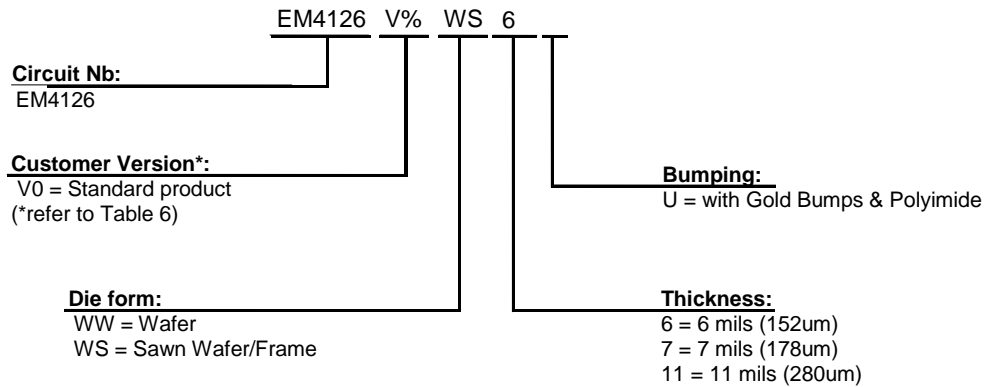
Fig. 5: Ordering information

Remarks:
- ❑ For ordering, please, use table of "Standard Version" table below.
- ❑ For specifications of Delivery Form, including gold bumps, tape and bulk, as well as possible other delivery form or packages, please, contact EM Microelectronic-Marin S.A.

STANDARD VERSIONS & SAMPLES:

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

Part Number	Package/Die Form	Delivery Form
EM4126V0WS6U	Sawn wafer / bumped die – thickness of 6 mils	Wafer sawn on frame
EM4126V%YYY	custom	Custom

Table 14: Standard EM4126 versions readily available

PRODUCT SUPPORT

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