Magnus-3LED Locator RFID Transponder IC

Visual location with LED

Introduction

The Magnus-3LED Locator RFID Transponder IC is a fully compliant UHF RAIN transponder IC with the added capability of lighting an LED in response to a Select command. This feature can be used to locate a tagged object with a known TID or EPC number or to locate a group of tags with a shared field in the TID or EPC. The Magnus-3LED Locator Transponder IC can be read by EPC class 1 gen 2 v2 and ISO/IEC 18000-63 compliant readers, and the LED can be controlled using a protocol compliant Select command.

Features:

- On-Chip Received Signal Strength Indicator (OCRSSI)
- Capability to drive an off-chip LED
- Battery-free wireless operation
- Worldwide UHF from 860 to 960 MHz
- Meets EPCglobal™ Gen2 (v. 2.)
- Meets ISO/IEC 18000-63
- User-accessible memory
    - 64-bit unique Tag ID (read-only)
    - 128-bit EPC
    - 192-bit user memory
- Extended temperature range -40 °C to +85 °C

Contents

1. Functional Description

The Magnus-3LED Locator Transponder IC can receive input commands by RF carrier modulation and will respond through RF Backscatter.

The Magnus-3LED Locator Transponder IC includes a signal strength indicator. The On-Chip Received Signal Strength Indicator (OCRSSI) indicates the amount of the transmitted RF power extracted by the chip. The RF OCRSSI CODE, an integer number generated by the chip to indicate the OCRSSI value, can be used to filter large populations of tags. It can also be used to determine when a tag is within the read range of the reader but is too far away to generate a visible output. The OCRSSI CODE can be retrieved by reading a specified memory location within the IC.

The Magnus-3LED Locator Transponder IC includes 192 bits of user memory and user-writeable EPC up to 128-bits in length. The IC also includes a 32-bit kill password, and a 64-bit factory programmed Tag ID (TID). The TID value is unique for each individual Axzon device and cannot be modified.

The Magnus-3LED Locator Transponder IC is capable of driving an off-chip LED while being powered by RF though a SELECT command

1.1. Wireless Communication Standard

The Magnus-3LED Locator Transponder IC fully supports all parts of the EPCglobal Class-1 Generation-2 RAIN/UHF protocol [1] for communications at 860 MHz to 960 MHz, Version 2, including all mandatory commands.

2. Magnus-3LED Locator Transponder Performance Data

Table 1: Absolute Maximum Ratings[1]

PARAMETER	Min	Max	Units	Notes
Storage temperature	-40	125	°C	
Assembly temperature		150	°C	1-Minute duration
Received RF Power[2]		+10	dBm	800-1000 MHz
ESD immunity		1000	V	Human Body Model (HBM)

NOTES:

1. Absolute maximum Ratings are limiting values of operating and environmental conditions, which should not be exceeded under the worst possible conditions. Operation at or near the absolute maximum ratings is not recommended and may cause damage or reduce device life.
2. At least maintain 15cm of distance between transmitting antenna and the tags powered by Magnus-3LED

Table 2: Recommended Operating Conditions

PARAMETER	Min	Max	Units	Notes
Operating temperature	-40	+85	°C	Can Support shorter excursions to 125 °C
Carrier Frequency	860	960	MHz	

Table 3: Performance Characteristics

PARAMETER	Min	Typ	Max	Units	Notes
Read sensitivity		-18		dBm	1
Write sensitivity		-12		dBm	1
Data retention	10			years	2
Write and erase endurance		10,000		cycles	2
Equivalent Input resistance, Rp		4,500		ohms	3
Equivalent Input capacitance, Cp		0.8		pF	3
OCRSSI CODE range	0		31	codes	
LED Visibility Range	5			ft	4
TID memory	96-bits				
EPC memory	160-bits supporting up to 128-bit EPC				
User memory	12-Words				

NOTES:

1. DSB-ASK modulation with 90% modulation depth and 25 μs Tari used for reader-to-tag communication. Miller M=4 encoding with 256 kbps BLF used for tag-to-reader communication. Ambient temperature: 25 °C.
2. Operate within -40 to +85 °C range to ensure minimum Data Retention Life of 10 years. Sustained operation at higher temperatures is not recommended.
3. At -18.0 dBm input power.
4. During broad day light inside an office, with a 1W output power and a 7.5dBi Antenna gain using a Low power LED. Actual Visibility Range depends on the LED characteristics such as luminosity and color, Inlay design, Reader's EIRP and the application environment.

3. Antenna Impedance Characteristics

To achieve optimum performance, the IC and the antenna must have impedances that "match".
In this context, matching means that the impedances are complex conjugates of each other. Finding a good match at a single frequency for a known environment is easily achieved, but the impedance of an antenna will vary with frequency and can be significantly affected by nearby liquids or metals.
The input impedance of Magnus-3LED Locator Transponder IC is modeled with the parallel resistance/capacitance circuit shown in Figure 1. The range of values are listed in Table 3: Performance Characteristics.

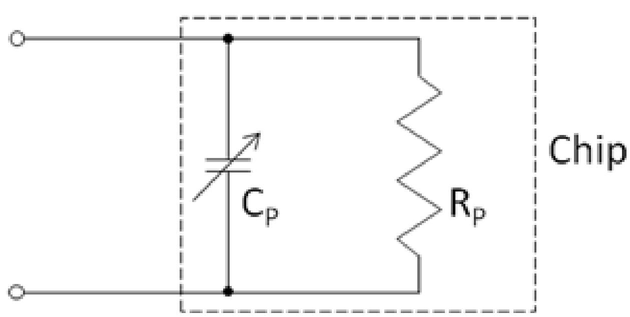


Figure 1: Equivalent input circuit of Magnus-3LED Locator Transponder IC input impedance.

4. On-chip RF RSSI

The Magnus-3LED Locator Transponder IC incorporates on-chip RF RSSI (Received Signal Strength Indicator) circuitry that measures the received power by the chip and converts it to a digital value. The OCRSSI CODE can be communicated to a reader and used for control purposes.

4.1. OCRSSI CODE

The OCRSSI CODE is stored in the five bits DBh-DFh of the word Dh in the Reserved Memory Bank. The OCRSSI CODE will be returned as the 5 LSBs when executing a READ command specifying Memory Bank 0h and word address Dh. At power up, the

Magnus-3LED Locator Transponder IC generates the OCRSSI values and stores it in word Dh of the Reserved Memory Bank (Oh). After power-up, the Magnus-3LED Locator Transponder IC will refresh the OCRSSI register after receiving an OCRSSI CODE Request from the reader. If the chip does not receive an On-Chip RF RSSI Request after power-up, the OCRSSI CODE obtained at power-up remains intact.

4.2. OCRSSI Requests

On-Chip RSSI Request allows the reader to specify that it wants to hear only from tags that have the desired RF signal strength. The requested RF signal strength range can be set for all power levels, or it can be narrowed to request above or below a specific RF signal strength threshold value. In normal use the OCRSSI request range is narrowed to specify so that only a limited set of tags respond to the command.

The User Memory Bank bit address $D0_h$ is used as the Select command's Pointer, and the OCRSSI Threshold values are encoded in the Select command's Mask field. The OCRSSI Threshold values are used to manage the operation of the IC. For example, a tag will backscatter if the OCRSSI CODE is less than a certain Threshold. The OCRSSI request is sent by the reader using a standard Gen 2 SELECT command. The 6-bits of OCRSSI Threshold Value/Control are communicated as part of the Mask sent to the tags.

Table 4 below from the Gen 2 version 2.0.1 spec shows the format of a SELECT command. To send an OCRSSI Request, the reader issues a SELECT command with:

- MemBank set to 3h (11b)
- Bit address ($D0_h$) placed in the Pointer field
- MASK Length set to 00001000_b (the OCRSSI request value consists of the lower 6 bits of an 8-bit Mask)
- The OCRSSI request in the lower 6 bits of the Mask, consisting of a leading control bit followed by 5 bits for the OCRSSI CODE at which the reader wants to define the tags response/no-response threshold.

If the control bit is set to 0, the SELECT will be considered matching when the OCRSSI CODE is less than or equal to the threshold value. If the control bit is 1, the SELECT will be considered matching when its OCRSSI CODE is greater than the threshold. Otherwise, the SELECT will be considered non-matching.

The OCRSSI value is internally generated at power-up or when the Magnus-3LED Locator Transponder IC receives a SELECT command with the parameters described above. Whether the tag responds for the subsequent inventory round depends on whether the SELECT matches the tag or not.

4.3. Off Chip LED

Using a SELECT command, the Magnus-3LED Locator Transponder IC is capable of driving an off-chip LED. Depending on the MASK setting, the LED will turn on in the presence of RF energy if the SELECT is considered matched. The matching can be done on the EPC, TID or USER banks with a MASK length of 8 bits or more.

An application requiring reading or writing the tag without the need to turn the LED on should not use SELECT commands with masks of 8 or more bits.

Should the need of using a SELECT command with a MASK length of 8 bits or more arises, the application should split the command into multiple ones; each with a MASK length of 7 bits or less per Gen2 specs.

Table 4: SELECT Command Specification

	Command	Target	Action	MemBank	Pointer	Length	Mask	Truncate	CRC-16
Number of bits	4	3	3	2	EBV	8	Variable	1	16
Description	1010	000: Inventoried (S0) 001: Inventoried (S1) 010: Inventoried (S2) 011: Inventoried (S3) 100: SL 101, 110, 111: RFU	See Gen 2 spec, Table 6.20	00: RFU 01: EPC 10: TID 11: User	Starting Mask Address	Mask Length (bits)	Mask value	0: Disable truncation 1: Enable truncation	

5. Memory Map

The Magnus-3LED Locator Transponder IC memory map is shown in Table 6, where the OCRSSI CODE is included in the Reserved Memory Bank.

5.1. EPC Memory and Control

As required by the Gen-2 specification, EPC memory contains a 16-bit cyclic-redundancy check word (StoredCRC) at memory addresses 00h to 0Fh, the 16 protocol-control bits (StoredPC) at memory addresses 10h to 1Fh, and an EPC value beginning at address 20h.

The protocol control fields include a 5-bit EPC length, a 1-bit user-memory indicator (UMI), and a 1-bit extended protocol control indicator.

On power-up, the IC calculates the StoredCRC over the stored PC bits and the EPC specified by the EPC length field in the StoredPC. For more details about the StoredPC field or the StoredCRC, see the Gen 2 specification.

The StoredCRC, StoredPC, and EPC are stored MSB first (i.e., the EPC's MSB is stored in location 20_h).

5.2. Tag Identification (TID) Memory

The read-only TID memory contains the Axzon-specific data detailed in Table 5. The shaded bit locations in TID memory locations 00_h-07_h store an 8-bit ISO/IEC 15963 allocation Class ID ($E2_h$). The logic 1 in 08h, highlighted with a solid black border, is XTID (X) indicator (whether a Tag implements Extended Tag Identification, XTID consisting of a 16-bit header and a 48-bit serialization). 09h is Security (S) indicator (whether a Tag supports the Authenticate, and/or Challenge commands), and 0Ah is File (F) indicator (whether a Tag supports FileOpen command). The 9-bit Axzon Mask Designer ID (MDID) is 024_h (bits $0B_h$ to 13_h). The Magnus-3LED Locator Transponder IC Tag model number (TMN) is defined in bits 14_h to $1F_h$, highlighted by the dashed line. The bits above 1Fh are as defined in the TDS standard section 16.2

5.3. Kill Password

The Kill Password is a 32-bit value stored in Reserve Memory 00h to 1Fh, MSB first. The default value is all zeroes. A reader can use a Kill Password once to kill the tag and render it silent after that. A tag will not execute a Kill command if its Kill Password is all zeroes.

Table 5: Tag Identification (TID) Bit Mapping

Memory Bank #	Bit Address	Bit number															
10	$50\text{-}5F_h$	TID serial number [15:0]															
	$40\text{-}4F_h$	TID serial number [31:16]															
	$30\text{-}3F_h$	TID serial number [47:32]															
	$20\text{-}2F_h$	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	$10\text{-}1F_h$	0	1	0	0	0	0	0	1	0	0	1	1	1	0	1	1
	$00\text{-}0F_h$	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0

Table 6: Memory Map

Memory Bank	Bank Name	R/W	Bit Address	Description LSB MSB	Default	Comments
11	USER	READ ONLY	D0-DF	Reserved	0	See Sec. 4.
			C0-CF	Reserved	0	
		READ/WRITE	B0-BF		0	
			A0-AF		0	
			90-9F		0	
			80-8F		0	
			70-7F		0	
			60-6F		0	
			50-5F		0	
			40-4F		0	
			30-3F		0	
			20-2F		0	
			10-1F		0	
			00-0F		0	
10	TID	READ ONLY	50-5F	TID[15:0]		See Sec 6.2
			40-4F	TID[31:16]		
			30-3F	TID[47:32]		
			20-2F	Extended TID Header		
			10-1F	Tag Model Number		
			00-0F	Manufacturer ID		
01	EPC	READ/WRITE	90-9F	EPC#[15:0]	0	See Sec 6.1
			80-8F	EPC#[31:16]	0	
			70-7F	EPC#[47:32]	0	
			60-6F	EPC#[63:48]	0	
			50-5F	EPC#[79:64]	0	
			40-4F	EPC#[95:80]	0	
			30-3F	EPC#[111:96]	0	
			20-2F	EPC#[127:112]	0	
			10-1F	StoredPC[15:0]	0	
			00-0F	StoredCRC[15:0]	0	
00	RESERVED	READ ONLY	D0-DF	OCRSSI CODE	0	See Sec. 4.
			C0-CF	Reserved	0	
		READ/WRITE	50-5F	Reserved For Future Use	0	
			40-4F	System Control Word	0780h	
			10-1F	KILL Password[15:0]	0	See Sec. 6.3
			00-0F	KILL Password[31:16]	0	

6. Physical Dimensions

6.1. Die Dimensions

Table 7: Die Dimensions

Parameter	Dimension
Die Size (including Scribeline)	854 µm x 760 µm
RFP/RFN Bump Size	66 µm x 66 µm
Signal Bump Size	60 µm x 60 µm
Minimum Bump Spacing	344 µm
Scribeline width dimensions	80u x 80u

6.2. Pad Descriptions

Bumped die pad locations are shown in Figure 2. Pad descriptions are provided in Table 8.

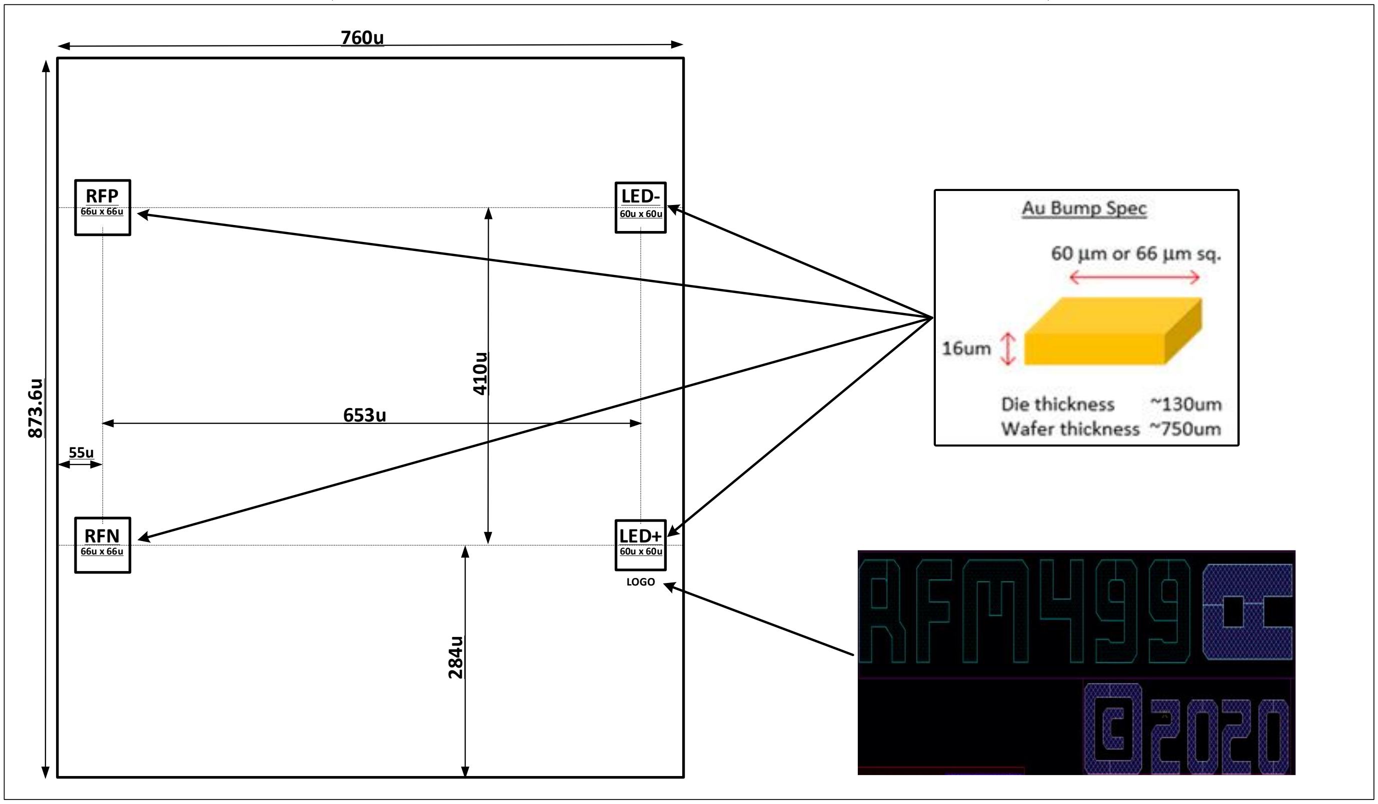
Table 8: Pad Descriptions

Pad	Description
RFN	Antenna connection
RFP	Antenna connection
LED+	Photodiode Anode
LED-	Photodiode Cathode

Figure 2: Magnus-3LED Locator Transponder IC Bumped Pad and Logo Information

The Bumped Pad is square in shape with either 60 or 66 µm on the side.

(All dimensions in microns; All dimensions are not to scale)



7. References

[1] EPCglobal, “EPC™ Radio-Frequency Identity Protocols Generation-2 RAIN/UHF, Version 2.0.1”, (November 2013).

8. Revision History

1.0	Initial release	10/28/2021
1.1	Updated Off-chip LED section and Spec table. Added pages for ordering info and Notices.	5/1/2023

9. Ordering Information

Packaging format, are indicated by the part number as shown below.

AZN306-K-AG	100 Bumped Die in GelPak
AZN306-AW	Finished 8-inch Wafer (Tested, Bumped, Thinned to ~130um, Diced)

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