SPS1M002

Smart Passive Sensor™ for Direct Moisture Sensing

The SPS1M002 is a battery−free wireless sensor for moisture level detection on non−metal surfaces. Smart Passive Sensors use the Magnus−S2® Sensor IC from RF Micron, a UHF RFID chip that is powered by RF energy harvesting from the UHF reader. The Magnus−S2 utilizes the patented self−tuning Chameleon engine that adapts the RF front−end to optimize performance in various environmental conditions. Changes in antenna detuning due to moisture contact are digitized by the sensor which can then be read by a standard EPC Gen 2 compliant reader. These sensor tags function in either the FCC defined UHF band or the ETSI UHF band

The small form factor and battery−free capabilities of Smart Passive Sensors allow them to be designed into applications where size and accessibility are at a premium.

Features

- Single IC, Smart Passive Sensing
- Small Form Factor Packages
- Direct Moisture Contact Sensing
- On−chip RSSI Sensor
- 64 bit TID and 128 bit EPC + 144 bit User Defined Memory
- EPC Class 1 Gen 2 v.2.0.0 ISO 18 000−6C Compliant
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- Medical
- Industrial
- Facilities Management

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Max	Unit
Human Body Model (Note 1)	ESD	±1	kV

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Junction and Storage Temperature Range (Note 2)	T_J, T_{stg}	−40 to +85	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Non−repetitive current pulse at T_A = 25°C, per JS−001 waveform.
2. Shelf Life − minimum 2 years from date of manufacturing.

This document contains information on some products that are still under development. ON Semiconductor reserves the right to change or discontinue these products without notice.

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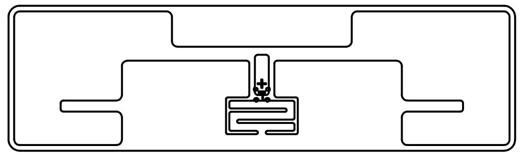


RF TAG 101.60X31.75 MM
CASE 888AD/AE

ORDERING INFORMATION

See detailed ordering and shipping information on page 3 of this data sheet.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Parameter		Min	Max	Units
Operating Frequency (Note 3)	FCC	902	928	MHz
	ETSI	866	868	MHz
Read Sensitivity (Note 4)		−16		dBm
Sensor Code		5		bits
RSSI Code		5		bits
TID		64		bits
EPC (Note 5)		128		bits
User Memory (Note 5)		144		bits

3. Sensors with “A” suffix operate in the FCC defined band and sensors with “B” suffix operate in ETSI band
4. Measured in free space, anechoic chamber with a linearly polarized antenna at 50 cm read distance
5. User Memory can be configured to be an EPC extension, effectively making a 272 bit EPC code

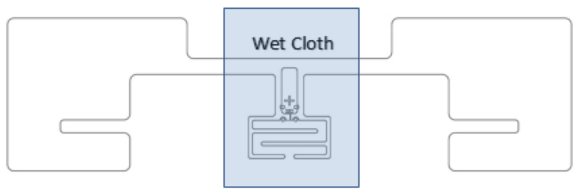


Figure 1. Moisture Contact Test Area

Moisture Sensing

The SPS1M002 generates sensor codes from 0 to 31, with a free space sensor code average of 18. Figure 1 shows the moisture sensitive portion of the tag used to collect the data in Figure 2. The SPS1M002 with a damp cloth over the sensor yields a sensor value 5 codes lower than the dry test. Due to the Smart Passive Sensors’ self−tuning capability, the sensor code does shift over frequency as it tunes itself to maximize reflected power to the reader. This makes it important to account for the frequency at which the sensor was read. For both the wet and dry tests seen in Figure 1, the resulting sensor values shifted around 5 codes over the FCC frequency range of 902−928 MHz. This factor must be accounted for in the reader software in order to ensure reliable wet vs. dry reads. For more information on how Smart Passive Sensors generate sensor codes, please refer to Application Note AND9209/D.

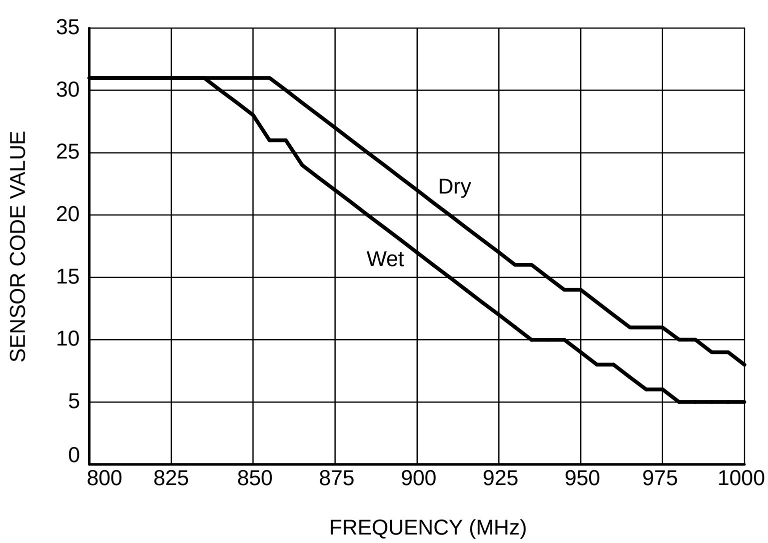


Figure 2. Sensor Code for Wet and Dry Conditions

MEMORY MAP

Bank #	Bank Name	R/W	Bit Address	Description LSB MSB	Default Value
11	USER	N/A	A0−AF	On−chip RSSI Threshold	N/A
		READ/WRITE	80−8F	User Memory	0
			70−7F	User Memory	0
			60−6F	User Memory	0
			50−5F	User Memory	0
			40−4F	User Memory	0
			30−3F	User Memory	0
			20−2F	User Memory	0
			10−1F	User Memory	0
			00−0F	User Memory	0
10	TID	READ ONLY	50−5F	TID[15:0]	
			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	WRITE ONLY	140−14F	EPC Configure	0
		READ/WRITE	90−9F	EPC#[15:0]	0
			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
		READ ONLY	00−0F	StoredCRC[15:0]	0
00	RESERVED	READ/WRITE	F0−FF	Sensor Overwrite	0
		READ ONLY	D0−DF	On−chip RSSI Code	N/A
			B0−BF	Sensor Code	N/A
		READ/WRITE	50−5F	Analog Overwrite	0
			30−3F	Access Password[15:0]	0
			20−2F	Access Password[31:16]	0
			10−1F	Kill Password[15:0]	0
			00−0F	Kill Password[31:16]	0

ORDERING INFORMATION

Device	Feature	UHF Band	Attach Material	Package Case Code	Shipping†
SPS1M002A	Moisture	FCC 902−928 MHz	Non−metal	888AD	500 / Reel
SPS1M002B	Moisture	ETSI 866−868 MHz	Non−metal	888AE	500 / Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

Tag Memory

Memory Configuration

Memory is organized according to the EPCglobal Generation−2 UHF RFID specification. There are two possible configurations for the EPC ID:

- 8−word EPC code and 9 free words in the USER memory bank, as shown in the Memory Map
- 17−word EPC code and no free USER memory (EPC lengths above 11 words may not be supported on all readers.)

The 8−word configuration is the default. To change to the 17−word configuration, write 0001_h to the EPC Bank, word address 14_h. The memory can be reset to the default 8−word EPC configuration by writing 0000_h to the same location. This EPC configuration can be configured and reconfigured repeatedly as long as the EPC memory bank is not permanently locked by a LOCK command. Once the EPC memory bank is permanently locked, it cannot be reconfigured.

Reserved Memory − Passwords

Reserved Memory contains the ACCESS and KILL passwords. There is a 32−bit Access Password and a 32−bit Kill Password. The default for both Kill and Access Passwords is 0000_h.

Access Password

The Access Password is a 32−bit value stored in Reserved Memory 20_h to $3F_h$ MSB first. The default value is all zeroes. Tags with a non−zero Access Password will require a reader to issue this password before transitioning to the secured state.

Kill Password

The Kill Password is a 32−bit value stored in Reserve Memory 00_h to $1F_h$, MSB first. The default value is all zeroes. A reader shall use a tag's kill password once to kill the tag and render it silent thereafter. A tag will not execute a kill operation if its Kill Password is all zeroes.

EPC Memory − EPC data, Protocol Control Bits, and CRC16

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

The protocol control fields include a five−bit EPC length, a one−bit user−memory indicator (UMI), a one−bit extended protocol control indicator, and a nine−bit numbering system identifier (NSI).

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, please see the Gen 2 specification.

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

Tag Identification (TID) Memory

The read−only Tag Identification memory contains the manufacturer−specific data. The manufacturer Mask Designer ID (MDID) is 824_h (bits 08_h to 13_h). The logic 1 in the most significant bit of the MDID indicates the presence of an extended TID consisting of a 16−bit header and a 48−bit serialization. The Magnus 2 S model number is in bits 14_h to $1F_h$ and the EPCglobal Class ID ($E2_h$) is in 00_h to 07_h.

Sensor Functions

Accessing the Sensor Code

The Magnus−S2 Chameleon engine stores tuning information in a user−accessible memory register. The “Sensor Code” register ($B0_h$−BF_h in the Reserved memory bank) contains the current setting and controls the tuning capacitors that are used to adjust the input impedance.

To get the results of the self−tuning operation, a READ command may be issued for the Sensor Code ($B0_h$ −BF_h in the Reserved memory bank). Because the tuning network offers 32 different levels of impedance, only the 5 least significant bits (BB_h −BF_h) in the register are actually implemented and used. (The 32 levels represent increasing amounts of capacitance added to the input impedance, with the lowest capacitance applied at level 0.) Returned results will be in the form 0000 0000 000x xxxx, where the 5 LSBs define the current tuning.

For use in sensing applications, the Sensor Code register can be monitored for changes over time or at different locations, or it can be checked for changes to a baseline reading that is taken when the tag is placed into service. Depending on the needs of the application, the reference or baseline value(s) may be written back into regular user memory or may be stored elsewhere on the user’s network.

The SPS1M002 may require more than its minimum sensitivity power in order to sense values near the ends of the code range (0−5 and 27−31). The minimum required power tends to increase gradually as the Sensor Code moves from 5 to 0 or from 27 to 31.

Overriding Default Chameleon® Behavior

By default, the Chameleon engine will self−tune when Magnus−S2 powers up, and the tuning capacitance chosen will be held constant until the chip powers down. There are also two additional modes: Chameleon can tune continuously – not just at power up – and Chameleon can be forced to a user−chosen setting.

To cause Chameleon to adjust continuously while Magnus−S2 is powered up, write 0800_h to the Analog Overwrite word (address 50_h−$5F_h$ in the Reserved Bank) using a standard WRITE command.

To force Chameleon to a desired setting, write 4000_h to the Analog Overwrite word, and the tuning value to the Sensor Overwrite word (address $F0_h$−FF_h in the Reserved Bank) with standard WRITE commands. The tuning value format is 0000 0000 000x xxxx, where x_xxxx represents the desired 5−bit tuning. When the above sequence is executed correctly, the setting x_xxxx will be transferred into the Sensor Code register and will be held constant until the next power−up or until the user writes a different value into the Sensor Overwrite word.

The Analog Overwrite word is non−volatile: values written will persist through chip power cycles. The Sensor Overwrite word is volatile: if a fixed Chameleon setting is desired, it must be re−written every time Magnus−S2 is powered up.

On−Chip RSSI Code

Magnus−S2 incorporates circuitry that measures incoming signal strength and converts it to a digital value: the On−Chip RSSI (Received Signal Strength Indicator) Code. This can be communicated to a reader and used for control purposes. The On−Chip RSSI Code has a 32−level range, represented by a 5−bit number.

The On−Chip RSSI Code, in word $D0_h$−DF_h in the Reserved Bank, will be returned as the 5 LSBs of a response to a standard READ command specifying word address D_h. Magnus−S2 must first receive an On−Chip RSSI Request before the On−Chip RSSI Code becomes available.

On−Chip RSSI Requests

On−Chip RSSI Request is a tool for a reader to specify that it wants to hear only from tags that are seeing a desired amount of received signal strength. It allows a reader to limit its communications only to nearby tags – or conversely, to “mute” nearby tags in order to attempt communication with tags receiving weak signals.

The On−Chip RSSI Threshold “address” ($A0_h$ of the User Bank) is used only by Magnus−S2 to interpret a SELECT command and is not an actual memory location. It is sent by the reader using a standard Gen 2 SELECT command. The 6−bits of On−Chip RSSI Threshold Value/Control are communicated as part of the Mask sent to the tags.

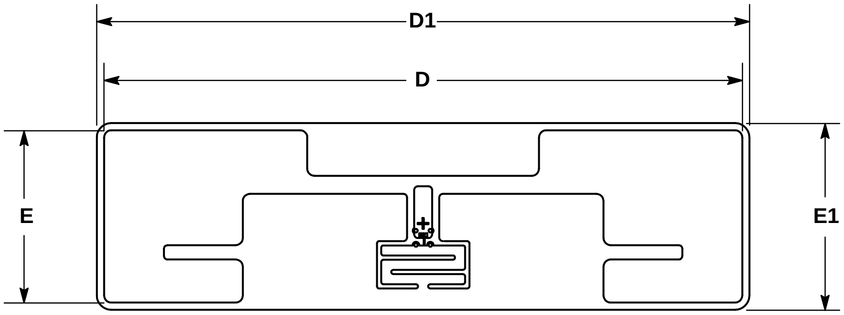
Table 4 below from the Gen 2 version 2.0.0 spec shows the format of a SELECT command. To send an On−Chip RSSI Request, the reader issues a SELECT command with:

- MemBank set to 3_h (11_b)
- The On−Chip RSSI Threshold address ($A0_h$) in the Pointer field
- Length set to 00001000_b (the On−Chip RSSI request value consists of the lower 6 bits of an 8−bit Mask)
- The On−Chip RSSI request in the lower 6 bits of the Mask, consisting of a leading bit for control followed by 5 bits for the On−Chip RSSI Code at which the reader wants to define the tags’ response/no−response threshold.

The control bit determines whether the threshold value is interpreted by Magnus−S2 as a lower or upper threshold. Specifically, if the control bit is set to 0, it will respond if its internally generated On−Chip RSSI Code is less than or equal to the threshold value. If the control bit is 1, it will respond if its On−Chip RSSI Code is greater than the threshold.

PACKAGE DIMENSIONS

RF TAG 91.5x26.5mm
CASE 888AD
ISSUE O

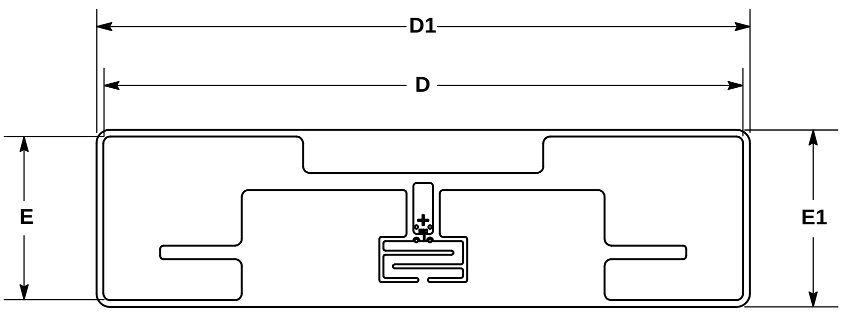


TOP VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. ANTENNA SIZE DETERMINED BY DIMENSIONS D AND E.
4. LABEL SIZE DETERMINED BY DIMENSIONS D1 AND E1.
5. LABEL IS 0.076 THICK PET TAPE. ANTENNA IS 0.009 THICK ALUMINUM.

	MILLIMETERS	
DIM	MIN	MAX
D	88.90	89.10
E	23.90	24.10
D1	90.50	91.50
E1	25.50	26.50

RF TAG 101.60x31.75MM
CASE 888AE
ISSUE A



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5. LABEL IS 0.076 THICK PET TAPE. ANTENNA IS 0.009 THICK ALUMINUM.

	MILLIMETERS		
DIM	MIN	NOM	MAX
D	93.90	94.00	94.10
E	23.90	24.00	24.10
D1	101.10	101.60	102.10
E1	31.25	31.75	32.25

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PUBLICATION ORDERING INFORMATION

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