AST010
Sensor IC Datasheet

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1. Overview

The AST010 sensor chip is a new UHF RFID temperature sensing tag chip that can provide accurate temperature data under fast sensing rate.

RFID tag made of AST010 sensor chip, without additional external power supply, installed on the surface or inside of any object, combined with various types of UHF RFID reading devices can achieve a series of functions such as temperature monitoring and danger alarm through the air.
It is widely used in smart grid, industry 4.0 and other industrial scenarios, and provides for long-time online temperature monitoring of key nodes to meet users' needs for low-cost, miniaturization, embedded, passive wireless and maintenance-free monitoring products.
The AST010 sensor chip provides enough EPC ID storage space and the ready-only traceable TID. The chip has highly competitive sensitivity, high precision, high reliability, legibility and a range of advanced features.

The AST010 Sensor chip complies with GS1 UHF Gen 2v2 standard (ISO / IEC 18000-63).

1.1 Technical Data

- With the appropriate tag antenna, the select / read sensitivity is up to -20 dBm
- With the appropriate tag antenna, the sensor / write sensitivity is up to -19 dBm
- 96 bits of TID area space, of which 48 bits are the serial number
- 96 bits of EPC ID, of which 64 bits are editable serial number
- Sensitivity at 30 degrees is about 6dB better than at 150 degrees
- Temperature sensing range: -40℃ ~150℃
- Temperature sensing accuracy: ± 1℃ (-25℃ ~125℃); ± 2℃ (other temperature range); Please refer to the temperature sensing error curve for details
- Compatible with ISO / IEC 18000-63:2015 and EPC global Gen2v2

1.2 Function Summary

As the end point of the IOT network, in addition to the original functions of UHF RFID, The AST010 sensing chip provides multiple highly efficient but easy-to-use functions, which is convenient for customers to build a very competitive sensing data monitoring platform based on this chip.

- Easy Sensing:

Without a complex operation, the sensing data can be received.

- EPC ID Lock:

Prevent the sensor network failure caused by mis-operation or malicious attacks.

- Smart-Tune:

Effectively expanding bandwidth to adapt to more demanding and complex environments.

- Security Sensing Mode:

Prevent data leakage caused by sensor data being monitored.

- Energy Detection:

Detecting the actual energy received by the chip, providing convenience for sensor terminal deployment and leaving sufficient debugging margin.

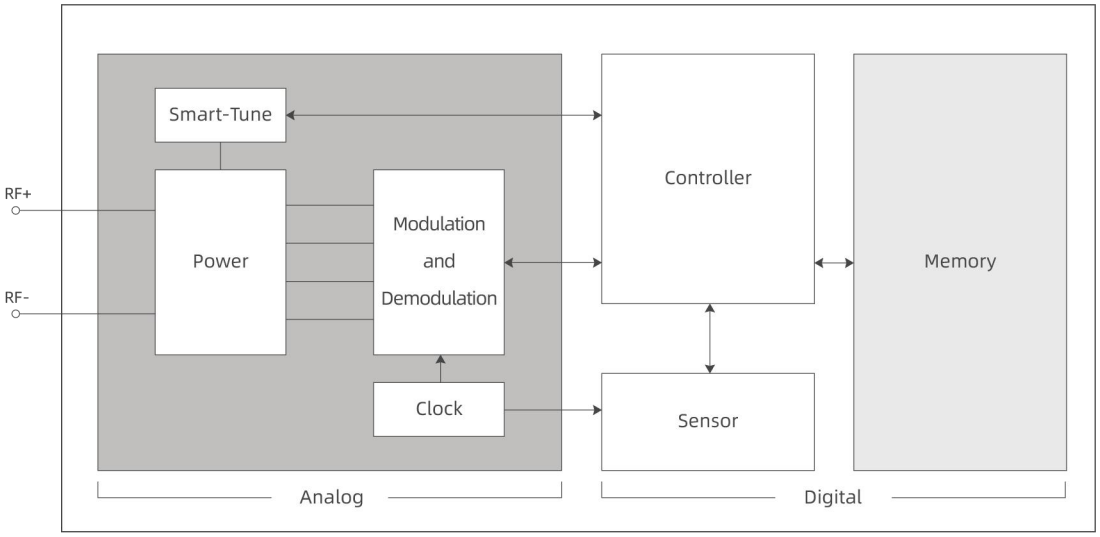
1.3 References

- EPC™ Radio-Frequency Identity Protocols Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz (Gen2v2 Specification, version 2.0.1 Feb 2016)
- EPC™ Tag Data Standards Specification 1.13

2. Function Description

The AST010 sensing chip supports the majority of mandatory commands for the EPC global Gen2v2 protocol, and targeted adjustments have been made to the functionality of some commands.
Through these adjustments, the operation of the AST010 sensing chip has become easier, the usability has improved, and the construction of the sensing system has been accelerated.

2.1 Chip Block Diagram



2.1.1 Power Management

The AST010 sensor chip is similar to the conventional UHF RFID tag chip, activated by an RF electromagnetic field actively emitted by the reader.
When the tag enters the RF electromagnetic field emitted by the reader, the power management module converts the RF electromagnetic field energy into a DC voltage to power the entire chip.

2.1.2 Smart-Tune

The smart-tune module improves the energy harvesting capability by flexibly adjusting the impedance of the RF input port of the AST010 sensing chip.
The smart-tune module will calculate, analyze and make appropriate impedance adjustment at chip startup.
Flexible algorithms can significantly improve the sensitivity of tags over a wide bandwidth range.

2.1.3 Modulation and Demodulation

- The AST010 sensor chip is constantly adjusting the impedance data so that the tag generates two states of absorption and reflection ("1" / "0") to complete the modulation of the RF signal.
- The AST010 sensing chip can demodulate DSB-ASK, SSB-ASK, and PR-ASK.

2.1.4 Controller

The controller of the AST010 sensing chip completes four major functions: power on process control, memory control, sensor control, and protocol implementation.

2.1.5 Sensing Unit

The AST010 sensing chip is embedded with a low-power and high-precision sensing unit, which can receives data such as temperature and electromagnetic field strength at the chip's location.

2.1.6 Memory

The AST010 sensing chip is embedded with ultra-low power non-volatile memory, which can support over 100,000 write operation cycles and 100 years of data storage.

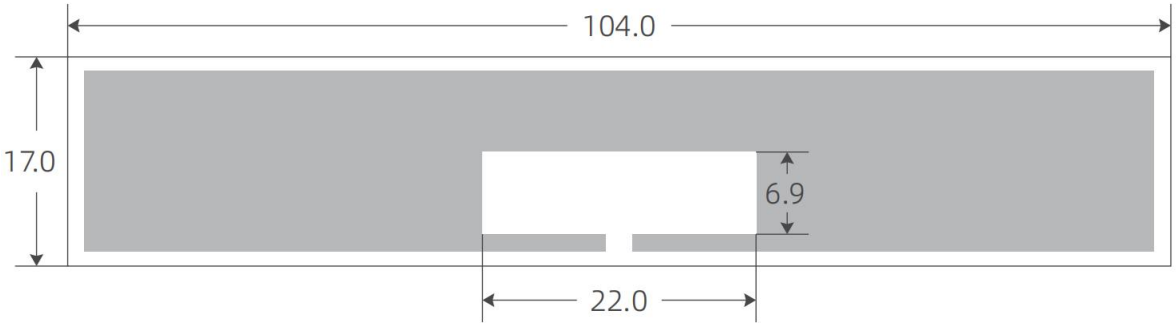
Memory	Description
TID (read-only)	Serial Number: 48bits
	Extended TID Header： 16bits
	Manufacturer Code and Model Code: 32bits
EPC	Serial Number: 48bits
	PC: 16bits
	CRC: 16bits
RESERVED	Chip Configuration
USER	-

2.2 Protocol

Commands/Functions	Description
Select	Regardless of the value of the length data , once the mem-bank data is 00_2 or 11_2, it is un-matching. Truncation function is not supported.
Query	Compatible with Gen2v2 Protocol
Query Rep	Compatible with Gen2v2 Protocol
Query Adjust	Compatible with Gen2v2 Protocol
ACK	The data sent back is 32 bits more than the L data of the PC (for sensing data and calibration data, please refer to the sensing chapter)
NAK	Compatible with Gen2v2 Protocol
Req_RN	Compatible with Gen2v2 Protocol
Read	Compatible with Gen2v2 Protocol
Write	Compatible with Gen2v2 Protocol
T2 Timeout	Compatible with Gen2v2 Protocol
Interrogator Power-up Settling Time	>15ms
EBV	EBV function is not supported.
Transmission Rate	Supports up to 320KHz subcarrier rate transmission
Session	Support commands for data related to S0~S3, but the characteristics of S1~S3 are the same as S0, with the power on state permanently maintained but restored to state A after power off.
Data validation	All write operations need to be powered off and then powered on again to take effect

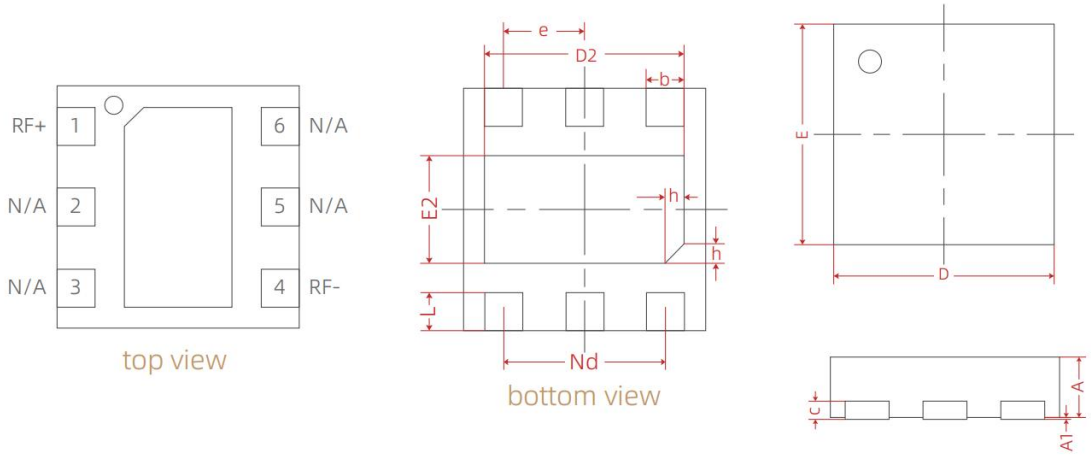
2.3 Antenna Design and Antenna Connection

The AST010 sensing chip is equipped with two external antenna interfaces, RF+ and RF -, which must be securely connected to both pads of the antenna.



2.4 Packaging and Appearance

The packaging form of AST010 is DFN6L (0202X0.75-0.65), and the packaging dimensions and pin definitions are as follows:



Characteristic	Minimum(mm)	standard(mm)	maximum(mm)
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.25	0.30	0.35
c	0.18	0.20	0.25
D	1.95	2.00	2.05
D2	1.00	1.23	1.45
e	0.65BSC		
Nd	1.30BSC		
E	1.95	2.00	2.05
E2	0.50	0.68	0.85
L	0.25	0.30	0.40
h	0.10	0.15	0.20

Pin Definition:

Pin No.	Name	Description
1	RF+	Connecting the antenna
2	N/A	N/A
3	N/A	N/A
4	RF-	Connecting the antenna
5	N/A	N/A
6	N/A	N/A

3 Memory

3.1 Memory map

Bank	Address	Description	R/W
TID	$5F_h$-50_h	TID[15:0]	R
	$4F_h$-40_h	TID[31:16]	R
	$3F_h$-30_h	TID[47:32]	R
	$2F_h$-20_h	2000_h	R
	$1F_h$-10_h	$6A10_h$	R
	$0F_h$-00_h	$E284_h$	R
EPC	$5F_h$-50_h	EPC[15:0]	R/W
	$4F_h$-40_h	EPC[31:16]	R/W
	$3F_h$-30_h	EPC[47:32]	R/W
	$2F_h$-20_h	EPC[63:48]	R/W
	$1F_h$-10_h	PC	R/W
	$0F_h$-00_h	CRC-16	R
RESERVED	$2F_h$-20_h	Chip Configuration	R/W
	$1F_h$-10_h	Chip Configuration	R
	$0F_h$-00_h	Chip Configuration	R

3.2 TID Memory

- EPC global™ Class ID ($E2_h$) is stored in bit $0F_h$ - 08_h of the TID bank.
- Bit 07_h is the extended TID (XTID) flag bit, The AST010 sensing chip uses an extended TID, including 16 bits extended TID head (stored in the $2F_h$-20_h bits of the TID bank) and a 48 bits unique serial number (stored in the $2F_h$-20_h, $1F_h$-10_h, $0F_h$-00_h bits of the TID bank).
- The values of bit 06_h and bit 05_h indicate that the AST010 sensing chip does not support the Authenticate, Challenge, and FileOpen commands.
- The 9 bits manufacture ID (MDID) assigned to Along Star Technology by GS1 is 001000110_2, where MDID [8:4] is stored in bits 04_h-00_h of the TID bank, MDID [3:0] is stored in bits $1F_h$-$1C_h$ of the TID bank.
- The model identifier $A10_h$ of the AST010 sensing chip is stored in bits $1B_h$-10_h in the TID bank.

3.3 EPC Memory

According to the Gen2v2 protocol description, the tag chip storage area should store 16 bits cyclic redundancy check codes (CRC16) at bit $0F_h$-00_h, store the 16 bits protocol control bits (PC) at bit 1Fh-10h, and start storing the EPC ID at bit $2F_h$.

3.3.1 CRC

The AST010 sensing chip will calculate the corresponding CRC value based on the EPC length value agreed upon in the PC and the corresponding EPC ID value at the beginning of operation.

3.3.2 PC

- This section only explains the L data and UMI data in the PC part of the Gen2v2 protocol, Due to the fact that the AST010 sensing chip does not support the remaining data of the PC part, all other data are set to "0".
- The L data: The AST010 sensing chip supports a maximum of 64 bits of EPC ID, so the maximum value of L data is 4. If attempting to write a value greater than 4, the AST010 sensing chip will modify the L data with a value of 4.
- UMI: The AST010 sensing chip does not include a user bank, so UMI is "0".
- The Other data: All attempts to write other data are invalid, and the AST010 sensing chip will ignore the data writing requirements of this part and only perform writing actions on the L data part.

3.4 Reserved Memory

3.4.1 Function switches

- The EPC ID lock switch is stored in the reserved bank at bit 21_h: "1" is on, "0" is off, default off, and cannot be turned off again after being turned on.
- The smart-tune switch is stored in the reserved bank at bit 22_h: "0" is on, "1" is off, default on, and can be freely switched between on and off states.
- The sensing mode switch is stored in the reserved bank at bit 26_h: "1" is on, "0" is off, default is temperature sensing mode, and can be freely switched between temperature sensing mode and energy detection mode.

4 Sensing Mode

The switch between two modes uses the Write command to write to the reserved bank address 26_h.
The operation of the mode switch uses the "Toggle" form. If the value of the corresponding bit is written as "1", the current mode switch state will be flipped; if the value of the corresponding bit is written as "0", the current mode switch state will remain unchanged.
If the current mode cannot be confirmed, the Read command can be used to receives the corresponding data of the reserved bank's address 26_h for confirmation.

4.1 Temperature Sensing

4.1.1 Activation Method

The sensing activation method of the AST010 sensing chip is very simple and does not require support from external protocol commands. Just adjust the "Interrogator Power up Setting Time" data of the reader to at least 15 milliseconds.
As shown in the following figure:

4.1.2 Data Reception

The AST010 sensing chip received temperature data and calibration data through traditional inventory processes.

- The reader received data in the following order: EPC, sensing data, and calibration data.

The L Data in PC	Reader Receives
0	EPC, Sensing Data, Calibration Data
1	EPC[63:48], Sensing Data, Calibration Data
2	EPC[63:32], Sensing Data, Calibration Data
3	EPC[63:16], Sensing Data, Calibration Data
4	EPC[63:0], Sensing Data, Calibration Data

- ACK commands return from Gen2v2 protocol: The new PC after adding 2 to the written PC, EPC , Sensing data, calibration data and CRC-16.

The L Data in PC	ACK Commands Return
0	New PC, Sensing Data, Calibration Data, CRC-16
1	New PC, EPC[63:48], Sensing Data, Calibration Data, CRC-16
2	New PC, EPC[63:32], Sensing Data, Calibration Data, CRC-16
3	New PC, EPC[63:16], Sensing Data, Calibration Data, CRC-16
4	New PC, EPC[63:0], Sensing Data, Calibration Data, CRC-16

4.1.3 Temperature calculation

The formula is divided into two parts, with different parameters when
(ADC Cali)<6052 and when (ADC Cali) ≥ 6052

(ADC-Cali)<6052	
p1	0.0001517
P2	-0.003199
P3	1.551
P4	-62.8

(ADC-Cali)≥6052	
p1	0.0003351
P2	-0.7194
P3	54.94
P4	-1388.07

ADC: Sensing data (converted to decimal)
Cali: Calibration data (converted to decimal)
T: Sensing temperature(℃)

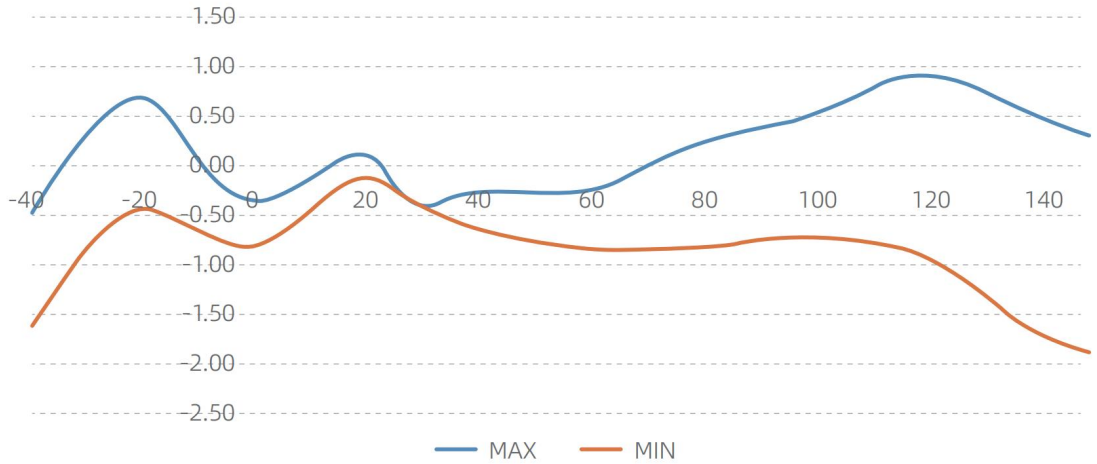
X=(ADC-Cali)/100+10
$T=p1*X^3+p2*X^2+p3*X+p4$

For Example:
Reader received： B0030FBB109C
EPC=B003,
Sensing data =0FBB, converted to decimal ADC=4027
Calibration data=109C The first bit is the flag bit，09C is the true Calibration data
$Cali=09C_h-256=156-256=-100$

X=(ADC-Cali)/100+10=(4027-(-100))/100+10=51.27
$T=T=p1*X^3+p2*X^2+p3*X+p4=28.76℃$

4.1.4 Accuracy

The accuracy ranges from -40 ℃ to 150 ℃ is as follows:



Within the range of -25 ℃ to 125 ℃, with an accuracy of ± 1 ℃
Other temperature ranges have an accuracy of ± 2 ℃

4.2 Energy Detection

4.2.1 Activation Method

The activation method of energy detection is almost identical to that of temperature sensing. Just adjust the value of the sensing mode switch to "1".

4.2.2 Data Reception

AST010 sensing chip received energy detection data through traditional inventory process.

- The reader received data in the following order: EPC, energy detection data, and calibration data.

The L data in PC	Reader Receives
0	Sensing Data, Calibration Data
1	EPC[63:48], Energy Detection Data, Calibration Data
2	EPC[63:32], Energy Detection Data, Calibration Data
3	EPC[63:16], Energy Detection Data, Calibration Data
4	EPC[63:0], Energy Detection Data, Calibration Data

- ACK commands return from Gen2v2 protocol: The new PC after adding 2 to the written PC, EPC, Energy detection data, calibration data and CRC-16.

The L data in PC	ACK Commands Return
0	New PC, Energy detection data, calibration data, CRC-16
1	New PC, EPC[63:48], Energy detection data, calibration data, CRC-16
2	New PC, EPC[63:32], Energy detection data, calibration data, CRC-16
3	New PC, EPC[63:16], Energy detection data, calibration data, CRC-16
4	New PC, EPC[63:0], Energy detection data, calibration data, CRC-16

4.2.3 Data Analysis

- The following diagram shows the relationship between energy intensity and distance
- The Y-axis represents energy intensity, and the X-axis represents distance
- The energy detection data is lower below 3500.

4.3 Abnormal Analysis

If the temperature sensing or energy detection receive data is 0000_h, its means that the sensing process self-check of the AST010 sensing chip is abnormal, you need to try again or adjust like tag position, angle, or carrier frequency.

5 Advanced Function

The operation of the mode switch described in this section uses the "toggle" form, If the value of the bit is written as "1", the mode switch state will be flipped (from "1" to "0" or from "0" to "1"); If the value of the bit is written as "0", the mode switch state will unchanged.

5.1 EPC ID LOCK

- The purpose of EPC ID lock is to prevent functional failure caused by accidental writing during use.
- EPC ID lock switch is stored in the reserved bank for 21_h bit: "1" is on, "0" is off, and it defaults to the off state. Once this function is enabled, it cannot be turned off again. Please do not enable this function without modification requirement exists.
- Example of enabling this function: write data 0002_h to the reserved bank (00_b), Pointer=2_h.

5.2 Smart-Tune

- Smart-tune can dynamically adjust the port impedance of the AST010 sensing chip, effectively expanding the effective working bandwidth of the sensing tag. This feature enables sensor tags to adapt to more complex and demanding application environments.
- Smart-tune switch is stored in a reserved bandk of 22_h bit: "0" is on, "1" is off, default is on. This function can be freely switched between on and off states.
- Example of enabling this function: write data 0004_h to the reserved bank (00_b), Pointer=2_h.If the current status is "0" (on), it will be "1" (off) after execution; If the current status is "1" (off), it will be "0" (on) after execution.

5.3 Encryption Sensing Mode

Sensing data transmitted directly through the Gen2v2 protocol is easily monitored, The unique security sensing mode of the AST010 sensing chip can encrypt sensing data and transmit it through a configurable security sensing password.

6 Parameters

6.1 Common parameters

Parameter	Units	Min	Typ	Max	Notes
Impedance	-	-	14-140j	-	Room Temperature @920MHz
Read Sensitivity	dBm		-20		
Write Sensitivity	dBm		-19		
Sensitivity Decrease	dBm		6		@150℃
Operation Temperature	℃	-40		150	
Temperature Accuracy	℃		±1		-25~125
Temperature Accuracy	℃		±2		Others
ESD	KV		±2		HBM
Data Retention	Years		100		Static State
Life Time	Years		10		
Program Endurance	Cycles		100000		

6.2 Link Signal Parameters

6.2.1 Reader to Tag Link

Parameter	Units	Min	Typ	Max
Carrier Frequency	MHz	840		960
Maximum Field Strength	dBm		+20	
Modulation Mode			DSB-ASK SSB-ASK PR-ASK	
Encoding Mode			PIE	
Link Frequency Jitter	%			5
Modulation Depth	%	80		100
Tari	us	6.25		25
PIE Ratio		1.5:1		2:1
Duty Cycle	%	48		82.3
Pulse Width	us	Max(0.265Tari,2)		0.525Tari

6.2.2 Tag to Reader Link

Parameter	Units	Min	Typ	Max
Modulation Mode			ASK	
Encoding Mode			FM0; Miller2,4,8	
Duty Cycle	%	45	50	55
Subcarrier Rate	KHz	40		320

6.3 Verified air communication parameters

Encoding Mode	BLF
FM0	40KHz
Miller4	250KHz
Miller4	300KHz

7 Ordering Information

Product	Package	Chip	Minimum Order Quantity	Type
AST010-F	DFN0202-6L	AST010	10K	tray

8 Contact information

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9 Disclaimers

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