T-HEAD

Yuzhen611
UHF RFID Tag Chip

Chip Model: TH6101

【Revision】

Document ID	Release Date	Document Status
1.0	2022/6/10	Initial version
1.1	2022/10/10	Parameters are modified and instructions for ordering are added.
1.2	2022/10/27	Parameters are modified.
1.3	2023/5/5	Parameters are modified.
1.4	2023/12/25	Parameters are modified.

【List of Abbreviations】

Abbreviation	Description
CRC	Cyclic Redundancy Check
CW	Continuous Wave
DSB-ASK	Double Side Band-Amplitude Shift Keying
DC	Direct Current
EAS	Electronic Article Surveillance
NVM	None Volatile Memory
EPC	Electronic Product Code (containing Header, Domain Manager, Object Class and Serial Number)
FM0	Bi phase space modulation
IC	Integrated Circuit
PIE	Pulse Interval Encoding
RF	Radio Frequency
UHF	Ultra High Frequency
TID	Tag Identifier

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【1 Chip Overview】

T-Head Yuzhen611 is a low-power-consumption, high-performance, UHF RFID tag chip that complies with EPCglobal G2 V2 and ISO/IEC 18000-6C protocols. With ultra-low-power circuit design and impedance self-tuning, it is suitable for application scenarios such as apparel and shoes industry, retail, smart logistics, supply chain management, and asset management.

【2 Characteristic Parameters】

【2.1 Characteristic Parameters】

- Compliant with EPCglobal G2 V2 and ISO/IEC 18000-6C protocol specifications
- Read sensitivity -23dBm, write sensitivity -20dBm
- Key features
  - Self-Tune support for complex applications;
  - Wide-Pad packaging, providing reliability of antenna and chip Bonding connection
  - Innovative ghost tag filtering technology to reduce the probability of ghost tags
- ESD: HBM ±10kV
- Operating temperature: -40℃ to +85℃
- Memory:
  - 128-bit EPC
  - 96-bit TID permanent lock (with 48-bit serial number)
  - 32-bit shared Access and Kill password

【3 Application Scenarios】

【3.1 Target Markets】

- Apparel and shoes industry
- Retail
- Smart logistics
- Smart warehousing
- Supply chain management
- Library and archives management
- Air parcel tracking
- Asset management

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【4 System Block Diagram】

The Yuzhen611 chip consists of three main modules, as shown in Figure 1.

- Analog & RF module
- Digital controller
- Memory

The analog & RF module provides a stable power supply and demodulates the data received from the reader, which is then processed by the digital controller. In addition, the backscatter in the analog & RF module sends the modulated data back to the reader. The digital controller includes protocol control logic, memory controller and test logic and is responsible for processing the EPC protocol and completing the communication with the reader.

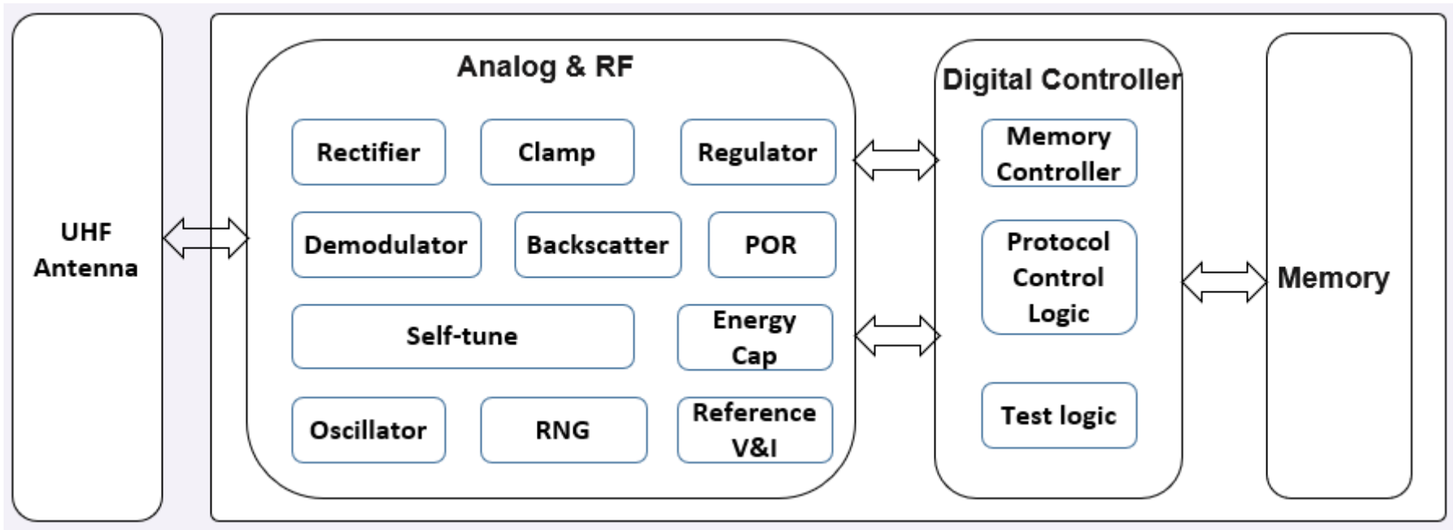

Figure 1 Yuzhen611 functional block diagram

【5 Pin Information】

Yuzhen611 uses Wide-Pad packaging technology, and the overview is shown in Figure 2.

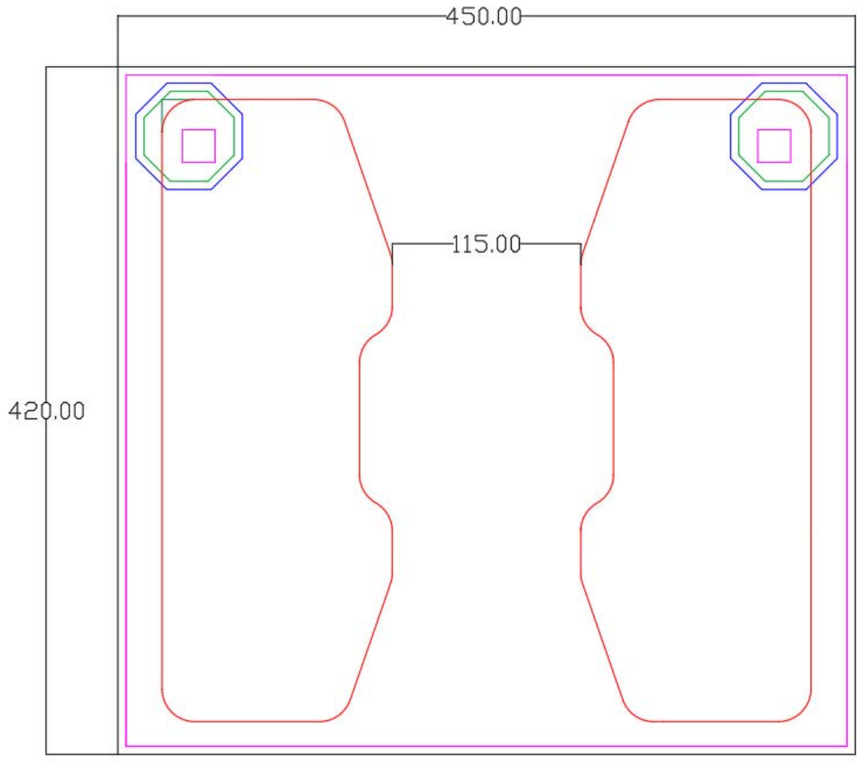

Figure 2 Yuzhen611 package overview (unit: μm)

【5.1 Pin Information Description】

Table 1: Yuzhen611 pin information

Symbol	Description
RF1N	Port1 RF negative input
RF1P	Port1 RF positive input

【6 Wafer and Chip Parameters】

The Yuzhen611 chip has a typical thickness of 125 μm, including a 10 μm Polyimide layer. The introduction of the Polyimide layer significantly reduces the coupling between the antenna and the chip, which improves the chip performance to a certain extent.

【 6.1 Wafer and Die Specifications】

Table 2: Yuzhen611 wafer and chip main specifications

Wafer	Specification
Diameter	200 mm (8")
Thickness	125 μm ± 15 μm
Number of pads	2
Pad location	placed in chip corners
Wafer backside	
Material	Si
Chip dimensions	
Die size excluding scribe	0.420mm*0.450mm = 0.189mm²
Scribe line width	x-dimension = 25 μm
	y-dimension = 25 μm
Passivation on front	
Type	Sandwich structure
Material	PE-Nitride (on top)
Thickness	1.75 μm total thickness of passivation
Polyimide spacer	10 μm ± 2 μm
Au pads	
Pad material	> 99.9 % pure Au
Pad height	3 μm ± 1 μm
Bump size	380um *140um

【 7 Function Description】

【 7.1 Air Interface Standard】

Yuzhen611 complies with the specification “EPCTM Radio-Frequency Identity Protocols Generation-2 UHF RFID, RFID Air Interface Specification, 860MHz to 960MHz Communication Protocol, Version 2.1" and ISO/IEC 18000-6C specifications.

Yuzhen611 supports all necessary commands contained in the Select and Inventory command groups, including Select, Query, Query_Adj, Query_Rep, ACK, NAK, Read, Write, Access, Lock, and Kill.

【 7.2 Energy Transfer】

The reader provides the tag with the UHF RF field and the tag antenna receives energy from the RF field and transmits the energy to the chip. In order for the chip to get the maximum power transfer, the impedance of the antenna and the chip need to be matched.

【7.3 Data Transmission】

【7.3.1 Reader-to-Tag Link】

The reader transmits information to the Yuzhen611 tag by modulating the UHF RF signal. The Yuzhen611 tag is passive and receives information and energy from this RF signal. The Yuzhen611 tag chip supports demodulation of three modulation formats, DSB-ASK, SSB-ASK and PR-ASK, using PIE encoding.

【 7.3.2 Tag-to-Reader Link】

After sending a valid command, the reader receives the information from the Yuzhen611 tag by sending an unmodulated RF carrier and listening for a backscatter response. Yuzhen611 backscatters by switching the reflection coefficient of its antenna between two states depending on the data sent. The encoding format for responding to reader commands is baseband FM0 or Miller Subcarrier.

【 7.4 Memory】

The Yuzhen611 tag chip uses non-volatile memory technology and is specifically optimized for RFID applications. The overall memory size is 256 bits and the memory content will be programmed before delivery. The mapping is shown in Table 3. Yuzhen611 does not support the user area, and any command that uses the user area as a parameter is considered invalid. Invalid commands do not change any state.

Table 3: Yuzhen611 memory map

Membank	ADDR	BIT-15	BIT-14	BIT-13	BIT-12	BIT-11	BIT-10	BIT-9	BIT-8	BIT-7	BIT-6	BIT-5	BIT-4	BIT-3	BIT-2	BIT-1	BIT-0	Read/Write/Lock
RES (00b)	0x0	Shared Kill Password[31:16]																R/W/L
	0x1	Shared Kill Password[15:0]																R/W/L
	0x2	Shared Access Password[31:16]																R/W/L
	0x3	Shared Access Password[15:0]																R/W/L
	0x4	System Configuration	S0	S2	S3	SL	ST	System Configuration										ST switch:W Others: RO
	0x5	System Configuration																RO
	0x6	System Configuration																RO
	0x7	System Configuration	STR[2:0]			System Configuration												RO
EPC (01b)	0x0	CRC-16[15:0]																RO
	0x1	PC[15:0]																R/W/L
	0x2	EPC[127:112]																R/W/L
	0x3	EPC[111:96]																R/W/L
	0x4	EPC[95:80]																R/W/L
	0x5	EPC[79:64]																R/W/L
	0x6	EPC[63:48]																R/W/L
	0x7	EPC[47:32]																R/W/L
	0x8	EPC[31:16]																R/W/L
	0x9	EPC[15:0]																R/W/L
TID (11b)	0x0	0xE284																RO
	0x1	0x3611																RO
	0x2	0x2000																RO
	0x3	TID serial number[47:32]																RO
	0x4	TID serial number[31:16]																RO
	0x5	TID serial number[15:0]																RO

【7.4.1 Reserved Area】

The reserved area contains a 32-bit shared password, that is, the Kill password is the same as the Access password. Changing the Kill password will change the Access password and vice versa. The factory status of the 32-bit shared password defaults to all zeros.

The reserved area contains the switch and tuning results for the self-tune function, and see the Self-Tune chapter for details.

The reserved area contains the current state of S0, S2, S3, and SL at [14:11] of address 0x4. S0, S2, and S3 are in A state if 0 is displayed. Otherwise, they are in B state. SL is in the non-SL (unselected) state if 0 is displayed, otherwise it is in the SL (selected) state.

【7.4.2 TID Area】

The MDID assigned by GS1 to T-HEAd Semiconductor Co., Ltd. is 001000011, located at TID0[4:0] and TID1[15:12].

【7.4.3 EPC Area】

During power-on, the CRC-16 calculates the constraint on the EPC length according to the L parameter in the PC.

Only the L parameter can be modified in the PC of Yuzhen611, and the rest is 0. The maximum value of the L parameter is 8. If an attempt is made to write a value greater than 8 to the L parameter, an error code is returned. The default factory value of the L parameter is 6.

【7.5 Special Description】

【7.5.1 Session】

Yuzhen611 supports SL, S0, S1, S2, and S3.

【7.5.2 EBV】

The format of Extensible Bit Vector (EBV) is:

- Every 8-bit is a block
- The MSB of each block is not used as a value, but only as an indication of whether it is the last EBV block
- If the MSB of each block is 1, it means that it is not the last EBV block; if the MSB of each block is 0, it is the last EBV block

Examples of EBV are as follows:

	0	0	0000000				
	1	0	0000001				
$2^7 - 1$	127	0	1111111				
2^7	128	1	0000001	0	0000000		
$2^{14} - 1$	16383	1	1111111	0	1111111		
2^{14}	16384	1	0000001	1	0000000	0	0000000

There is no limit to the number of EBV blocks in Yuzhen611.

【7.5.3 Error Codes】

Yuzhen611 has the following error codes:

Error Code	Name	Description	Possible Commands
0000_0000b	Other Error	Other Error	Kill
0000_0001b	Not Supported	Not Supported	Lock
0000_0011b	Memory Overrun	Read or write location overrun	Read、Write
0000_0100b	Memory Locked	Read or write location locked	Read、Write
0000_1011b	Insufficient Power	Insufficient power in operation	Write、Lock、Kill、Test

【7.5.4 Self-Tune】

Yuzhen611 has a self-tune mechanism that adapts the chip sensitivity to its maximum in a variety of complex scenarios. This function is enabled by default.

Self-Tune can be turned on or off by writing relevant commands. By writing Membank=00b andWordPtr=0x04, write data to [10] of [15:0] for the ST switch position. Write 0 to turn on the switch;write 1 to turn off the switch.When the commands Membank=00b and WordPtr=0x04 are written, writing data to [15:0] except for [10] is irrelevant. That is, any value can be written, and the values in other locations of Membank=00b and WordPtr=0x04 will not be affected.

The self-tune switch can be written in the OPEN or SECURED state.

The results of self-tune (STR) can be obtained by reading [14:12] of RES7 with the Read command.

The possible results are 0, 1, and 3.

【7.5.5 Wide-Pad Connection Scheme】

The Wide-Pad design of Yuzhen611 allows for a more reliable connection to the antenna. This Wide-Pad design allows greater freedom in terms of processing accuracy. The recommended configuration for connecting the RF port to the antenna is shown in Figure 3.

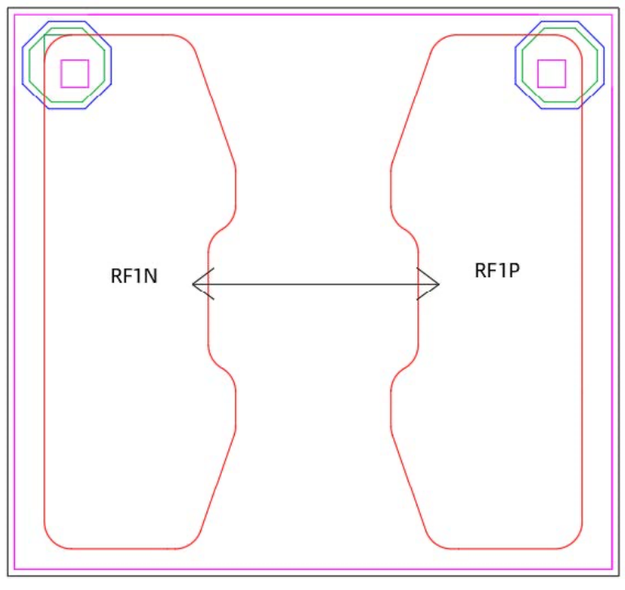

Figure 3 Connection method between chip and antenna

【7.5.6 Single-Port Connection】

In the single-port configuration, signals act on the antenna port RF1P and RF1N of Yuzhen611 and the antenna needs to be connected to the PAD, as shown in Figure 4.

Figure 4 Single-port antenna design

【8 Limit Parameters】

Table 4: Limit parameters of the Yuzhen611 chip

Symbol	Parameter	Conditions	Min	Max	Unit
Bare die limit value					
T_{stg}	Storage temperature	NA	-55	+125	°C
T_{amb}	Operating Temperature	NA	-40	+85	°C
V_{ESD}	ESD	human body model (HBM)	±10	-	kV
Pad limit value					
P_i	Input power	Max input power consumption, PORT1/ PORT2 pad	-	100	mW

【9 Performance Parameters】

Table 5: Yuzhen611 RF port characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
f_i	Input frequency			840	-	960	MHz
$P_{i(min)}$	Min RF input power	Single-port dipole antenna	[1]	-	-23	-	dBm
$P_{i(max)}$	Max RF input power	Max. input power		-	-	20	dBm
C_i	Chip input capacitance	Chip parallel equivalence	[3][5]	-	0.96	-	pF
R_P	Chip resistance	Chip parallel equivalence	[2][5]	-	5	-	KΩ
Z	Chip impedance	RF operating frequency 915MHz	[4][5]	-	7.14-j181	-	Ω

[1] Assume tag sensitivity on a 2.15dBi gain dipole antenna
[2] Min operating power
[3] Self-tune center capacitor
[4] The antenna should match this impedance
[5] Assume 50fF additional package capacitance

Table 6: Yuzhen611 memory characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Memory characteristics						
t_{ret}	Retention time	$T_{amb} \leq 55℃$	10	-	-	year

【10 Order Instuction】

Product	Model	Wafer Size	Remark
Yuzhen611	TH6101	8 inch	Wide Pad