Active RFID Reader and Tag Application Note

(Version 0.1)

Revision History

Revision	Release Date	Description of Change
Rev 0.1	2011/8/30	First release

Content Summary

1 Introduction

The documentation describes the functionalities and features of TAG and READER. TAG and READER are the low power RF modules working at sub-1G Hz ISM band.
There are two roles for TAG or READER devices.

1. Working as a tag device
2. Working as a reader device.

Generally, the functionality of the tag device is to transmit the tag information to the reader device. The functionality of the reader device is to receive the tag information and send to other application. The tag devices and the reader device can form a star network for one-to-many application like wireless sensor network application, and a broadcasting network for many-to-many application such as active RFID application or hybrid topology.

2 Network Discipline

In this Section will describe how the data packets can be transmitted and received between tag and reader device. Basically, two kinds of data transmission can be used. One is broadcast and another is unicast. On broadcast transmission, the tag device transmits the data packets to all available reader devices. On unicast transmission, the tag device transmits the data packets to the specific reader device. Before unicast transmission, tag-to-reader connection should be made and network membership need to be controlled.

2.1 Frame Structure

The Figure 1 shows the frame structure that transmitted and received by the tag and reader device.

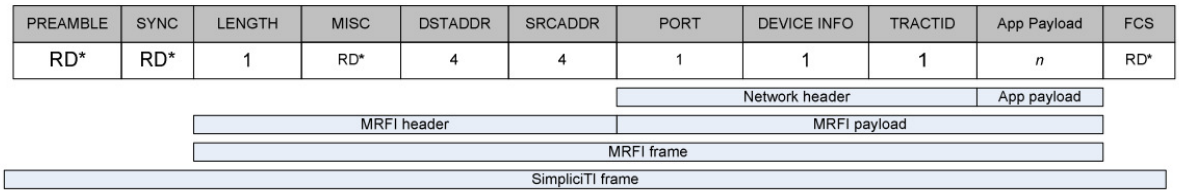

Figure 1: frame structure

The Table 1 describes the detail of each field on the frame structure.

Field	Definition	Comments
PERAMBLE	Radio synchronization	Inserted by radio HW.
SYNC	Radio synchronization	Inserted by radio HW.
LENGTH	Length of remaining packet in bytes	Inserted by FW on Tx. Partially filterable on Rx.
MISC	Miscellaneous frame fields	Differ for different radios. May be absent.
DSTADDR	Destination address	Inserted by FW. Filterable depending on radio.
SRCADDR	Source address	Inserted by FW.
PORT	Forwarded frame(7), Encryption Context(6), Application port number(5-0).	Inserted by FW. Port namespace reserves 0x20-0x3F for customer applications and 0-1F for NWK management.
DEVICE INFO	Sender/Receiver and platform capabilities	Inserted by FW. Details below.
TRACTID	Transaction id	Inserted by FW. Discipline depends on context. Need not be sequential.
APP PAYLOAD	Application data	0 ≤ n ≤ 50 for non-802.15.4 radios; 0 ≤ n ≤ 111 for 802.15.4 radios
FCS	Frame Check Sequence	Usually a CRC appended by the radio hardware.

Table 1: frame field summary

Device information byte provides information about the device issuing the frame. The device information bits are defined on Table 2:

Bit	Description	Comments
7	Acknowledgement request	This bit is set by the NWK layer when a user application requests and acknowledgment from the peer.
6	00: Controlled listen 01: Sleeps/polls	Receiver type Sleeping devices may either poll or periodically listen. If they are specified as polling devices the Access Point will provide store-and-forward support. Otherwise the device listens at its own schedule under its own control.
5-4	00: End Device	Sender Type

	01: Range Extender 10: Access Point 11: Reserved	Most important for Range Extender to prevent a RE from forwarding a frame from another RE. This mitigates broadcast storms. Refers to device sending the frame and may not be the same as the device whose source address is specified in the frame.
3	Acknowledgement reply	This bit is set when the NWK layer sends a frame in response to an acknowledgment request.
2-0	Hop count	Decremented by each transmitting device until 0. Then discarded.

Table 2: DEVICE INFO bit values

The different functionalities of network and user application are controlled by DST/SRC address and PORT.

2.2 Broadcast Transmission

On broadcast transmission, the destination address is 0xFFFFFFFF and different PORT can be used to support different functionalities of network or user application. For example, joining application uses port 0x2 for network join function. 0xFF port is used to send user broadcast data.

2.3 Unicast Transmission

Because DST/SRC address will be exactly the same as tag and reader device on unicast transmission, network membership needs to be controlled and device pairing need be made.

2.3.1 Network Membership

Join Token, Link Token, and Peer Tokens are used to control the network membership. The Join Token is used to control the device pairing. If the Join Token is the same between tag and reader, the device pairing process is allowed to proceed. The Link Token is the identification of the tag or reader. It will be used on DST or SRC address field. The Peer Tokens are the identification of paired devices. The data packets can be transmitted or received if the peer token is presented on its own device. Let us take an example to describe how Join Token, Link Token, and Peer Tokens control the network membership.
The following example shows the data transmission from tag to reader. First of all, the tag device need to form a packet that source address is the link token of the tag and the destination address is the link token of the reader. How does the tag know the link token of the reader? It must be located at peer token of the tag. When the tag sends the packet and the reader receives the packet, the reader will check if the destination address is the same as its own link token and if the source address is located at on its own peer tokens. The user application can receive the packet otherwise the packet will be discarded. The tag and reader can use device pairing mechanism to exchange the link token and store to its own peer token.

2.3.2 Device Pairing

The main purpose of device pairing is to exchange the link token of tag and reader device. The process of device pairing goes follows:

- The reader switches to Join Mode.
- The tag sends a join request with join token.
- When the reader receives the join request, it will check if the join token is the same or not.
- If the join token is the same, the reader will send a join reply with the link token of the reader.
- The tag and reader will store the link token of the reader and tag to its own peer token.

Reader can store 8 tag devices and tag can store 8 reader devices. Although tag device can store 8 readers, it can send tag information to one reader only at one time. The peer index is used to indicate which reader device can be communicated. The reader can receive max 8 unicast and broadcast tag devices.

2.4 Network Topology

To use broadcast and unicast transmission, the tag devices and reader device can form a star, broadcast, or hybrid topology.

2.4.1 Star Topology

The Figure 2 shows the star topology. All tag devices pair with one reader device. The tag devices send information to paired reader device only by unicast transmission.

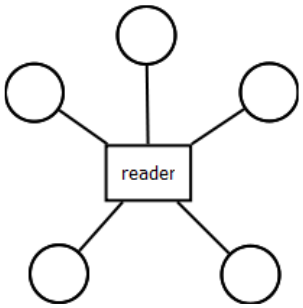

Figure 2: Star Topology

2.4.2 Broadcast Topology

The Figure 3 shows the broadcast topology. All tag devices do not pair with any reader. The tag devices send information to all available reader devices by broadcast transmission.

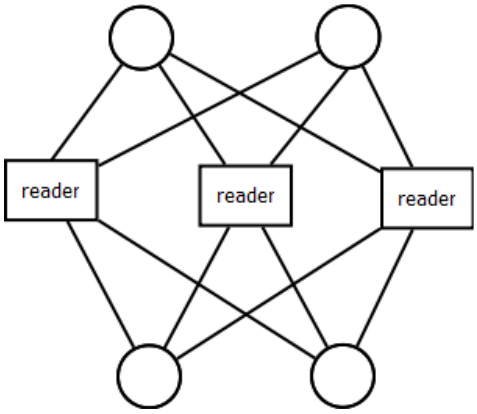

Figure 3: Broadcast Topology

2.4.3 Hybrid Topology

The Figure 4 shows the hybrid topology. Some tag devices pair with the reader and some are not. The reader can receive tag information of paired device by unicast transmission and unpaired device by broadcast transmission.

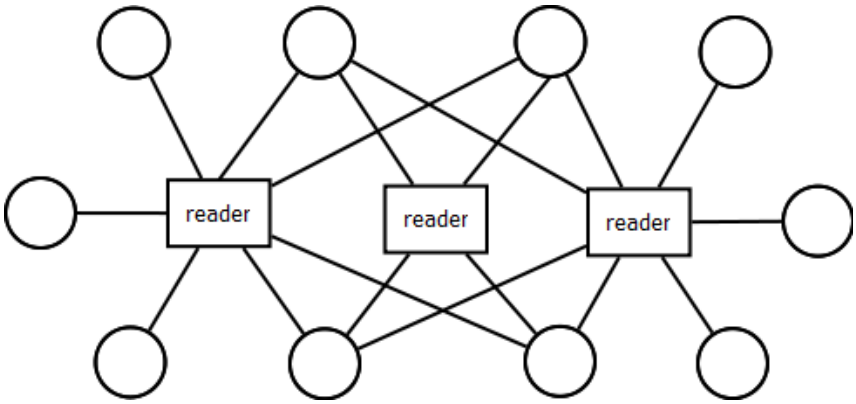

Figure 4: Hybrid Topology

3 Application Feature

On this application, the main feature is the tag devices transmit their own information to the reader device by RF and the reader device sends tag information to other applications by UART interface. The main information of the tag device is tag id. Other information can be sent by the tag device like ADC value or Digital IO input.
The tag device can operate on two kinds of mode, un-pairing and pairing mode.

3.1 Un-pairing Tag Mode

On the un-pairing tag mode, the tag device will send its information by broadcast transmission periodically. All readers can receive the information of the tag and send to other applications. The information to other applications will include reader information as well.

3.2 Pairing Tag Mode

On the pairing tag mode, the tag device will send its information by unicast transmission periodically. Only the pairing reader will receive the tag information.
Once the tag is pairing to one reader, the key button can used to send information at any time. When the key button is pressed, the tag will send the data immediately to the reader and ask the reader to ACK. If the tag does not get the ACK from the reader, the tag will transmit the tag information by broadcast transmission.

3.3 Reader

The reader can get tag information from maximum 8 unicast tag devices or any broadcast tag devices.

3.4 Other Information

Other information can be included on tag information like ADC value or Digital IO. Please refer to the data format and cli command to configure the other information.

4 Joining and Set-On-Air

The reader device provides two operation modes, Joining and “Set-On-Air”. Joining is used on device pairing. During the device pairing process, the reader device must be on the Joining mode to allow the tag device to join. “Set-On-Air” is used to configure the tag device remotely.

4.1 Joining

During device pairing, the tag device will send a join request to the reader device. The join request is a broadcast transmission to all reader devices. Only the available joining reader device responses the joining request of the tag device. It means the Joining mode is used to control the reader device allows the tag device to join or not. When the reader device is on the joining mode, the tag device can press key1 and key2 simultaneously or “JN” command to join the reader device.

4.2 Set-On-Air

The reader device provides another mode called “Set-On-Air” to configure the tag device remotely. When the reader device is set to “Set-On-Air” mode, the tag device can be configured by the reader device remotely. To press the key1 and key2 simultaneously or use “RS” command on the tag device, the tag device will try to allow the reader device control remotely.

5 Data Format

The reader can send tag or its own information to the other application by UART interface. Tag information is received by RF from tag devices. The reader information is from the reader itself and can be sent periodically to indicate the reader alive or information.
The following example is the data format of the message:

$0,100.100.100.10,NODE1,100.100.100.11,AP1,0,0,1,0,32,-13#

The data format of the message starts with a “$” character, ends with a “#” character, and separates with Comma. The detailed description of the fields is on Table 3.

Number	Name	Description	Example
1	Node Type	This field is used to indicate if the data is from Master or Slave node.	0: Slave 1: Master
2	TAG Address	This field is 32 bits address of the node which represented by IP address format.	100.100.100.10
3	TAG ID	This field is 4 bytes id of the node.	NODE1
4	Reader Address	This field is 32 bits address of the AP which represented by IP address format.	100.100.100.11
5	Reader ID	This field is 4 bytes id of the AP.	AP1
6	RX Type	This field is used to indicate if this message is broadcast or unicast.	0: broadcast 1: unicast
7	Message Type	This field is used to indicate if this message is periodic report or panic indication.	0: periodic report 1: panic indication
8	Digital IO Input	This field is used to indicate if digital IO input is high or low when digital IO input is set.	0: digital IO is low or digital IO is output 1: digital IO is high
9	ADC Value	This field is used to indicate the ADC value if ADC v is greater than 0	0: ADC Value is less than ADC threshold 1-1024: ADC value is greater than threshold

10	Voltage	This field is battery voltage. The actual voltage is 1/10 of this field.	32 means 3.2V on battery.
11	RSSI	This field is RSSI value between sensor and collector node.	-13 means -13dbm

Table 3 Data Format

6 Typical Application Schematic

All available commands on tag and reader device are on the Table.

Command	Description	Options	Default Value
JT	Set Join Token by IP address format	0.0.0.0 ~ 255.255.255.255	0x05060708
LT	Set Link Token by IP address format	0.0.0.0 ~ 255.255.255.255	0x01020304
PT	Set Peer Token by IP address format with Peer Index	Peer Index: 0-7 Peer Token: 0.0.0.0 ~ 255.255.255.255	0 0.0.0.0
RF	Read configuration data from flash memory.		
WF	Write configuration data to flash memory.		
CN	Configure channel number.	1: 922 2: 924 3: 926 4: 928	2:924
CP	Configure channel power.	1: -10 2: 0 3: 10	2:0
RP	Configure report period.	0-86400 Sec	3
BRP	Configure battery report period.	0-86400 Sec	3
COMBR	Configure Baud Rate of COM port.	1: 4800 2: 9600 3: 19200 4: 38400 5: 57600 6: 115200 7: 230400	2:9600
COMCL	Configure control of COM port.	Bit 7 Parity enable 0: Parity disabled 1: Parity enabled Bit 6 Parity select 0: Odd parity 1: Even parity Bit 4 Character length 0: 8-bit data 1: 7-bit data Bit 3 Stop bit select 0 One stop bit 1 Two stop bits	0 Parity disabled Odd parity 8-bit data One stop bit
ADCCL	Configure ADC Control. If ADC Control is 0, ADC is off without detection. If ADC Control is 1, ADC value is greater than ADC threshold and then ADC value will be reported. If ADC Control is 2, ADC value is smaller than ADC threshold and then ADC value will be reported. If ADC Control is 3, ADC value will be reported.	0: ADC off 1: > 2:< 3: any	0: ADC off
ADCTH	Configure ADC Threshold.	0-1023	0
SHOW	Display all configuration setting.		
DIO	Configure Digital IO setting.	0: Digital IO is set to input. 1: Digital IO is set to	0

		output	
ID	Configure Tag ID	8bytes ASCII Character	“”
RB	Reboot the device.		
JS	On reader device, JS is used to configure join setting. There are three kinds of join setting. If join setting is 0, the reader does not allow to join or Set On Air. If join setting is 1, the reader allows tag to join the device. If join setting is 2, the reader can be used to set the tag device on air. On tag device, JS is used to join or Set On Air by reader device depending on JS setting on reader device. If reader allows the tag device to be set, the tag device will be configured by reader remotely. If reader allows the tag device to join, the tag device will join to the reader.	0: Normal 1: Join 2: Set	0: Normal

Table 4: Commands on tag and reader devices

7 Appendix