MeshBee®
Open Source ZigBee RF Module
User's Manual

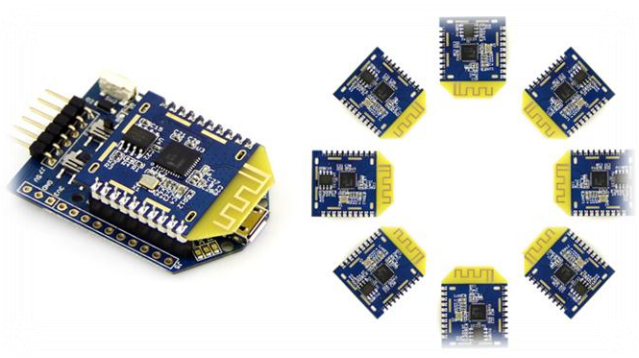

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Table Of Contents

Overview

About this document

This manual gives a single point of reference for information relating to the MeshBee. Including:

Chapt1: Key features;
Chapt2: Pin definition;
Chapt3: Operation mode;
Chapt4: AT commands;
Chapt5: API frames;
Chapt6: Functions that AUPS can call

Information shown in this document is all based on the firmware v1003. The manual should be used as a reference resource throughout MeshBee application development. It does not provide in-depth introduction of the MeshBee programming. Please refer to the MeshBee CookBook(*MB_2014_D02*) for further references on the firmware architecture and programming issue.

Introduction

MeshBee® is a 2.4 GHz wireless zigbee RF module together with high level open source software driven by community. It uses microchip JN516x from NXP that enables several different standards-based zigbee mesh networking. User can easily and cost-effectively integrate ZigBee functionality into target project. Our factory firmware supports latest fully **Zigbee Pro** stack.

MeshBee® is the best choice to make your connected thing.

Acronyms and Abbreviations

AUPS: Arduino-ful user programming space

SPM: Stream processing machine

CMI: Communication interface

ADS: Airport data server

UDS: Uart data server

HAL: Hardware abstract layer

SULI: Seeed Unified Library Interface

API: Application programming interface

MCU: Microcontroler

JenOS: Jennic operating system

1. Key Features

1.1 Physical features:

1) *Range: Indoor/Urban: up to 30m; Outdoor line-of-sight: up to 100m;*
2) *Receiver Sensitivity: -95dBm;*
3) *Working Frequency: unlicensed 2.4GHz band;*
4) *Data Transmission Rate: 4800, 9600, 19200, 38400, 57600, 115200 (bps);*
5) *Programmable 32-bit RISC CPU: 32M clock, 256KB Flash, 32KB RAM, 4KB EEPROM;*
6) *Socket compatible with the Xbee, so you can plug it into any Xbee socket as a quick replacement*

1.2 Operation features:

1) *Easy-to-Use Serial Interface and rich extendable ports;*
2) *Communication type: Point to Point, Start Network , Mesh Network;*
3) *Support for OTA(upgrade firmware over the air);*
4) *Easy-to-Use AT Command: Setup ZigBee network, set Serial Baud Rate, etc;*
5) *API configuration and control mode;*
6) *Arduino-ful user programming space;*
7) *Open source hardware and firmware;*

2. Pin definition

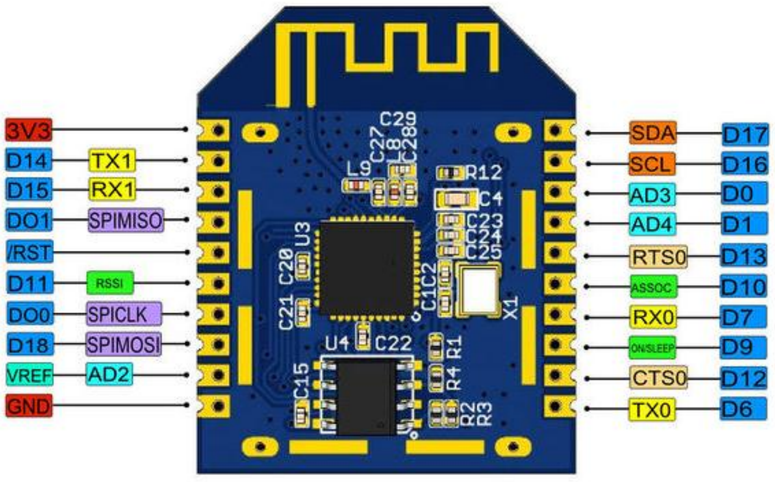


Figure 2.1: Pin definition of MeshBee

Note: please refer to datasheet of JN516x for more information about each pin.

2.1 Pin assignment

Pin No	Name	Direction	Description
1	3V3	—	Power supply
2	D14/TX1	Output	Digital IO14 or UART1 TX
3	D15/RX1	Input	Digital IO15 or UART1 RX
4	DO1/SPIMISO	Both	Digital Output 1 or SPI Master In Slave Out Input
5	RST	—	Reset pin
6	D11/PWM1	Both	Digital IO11 (default usage: RSSI Indicator) or PWM1 Output
7	DO0/SPICLK	Output	Digital Output 0 or SPI Master Clock Output
8	D18/ SPIMOSI	Both	Digital IO 18 or SPI Master Out Slave In Output
9	Vref/ ADC2	Input	Analogue peripheral reference voltage; ADC input 2
10	GND	—	GND
11	D6/TX0	Both	UART0 TX or Digital IO6
12	D12/CTS0	Both	Digital IO12 or UART0 clear to send input
13	D9	Both	Digital IO 9 (default usage: Mesh Bee ON/Sleep Indicator)
14	D7/RX0	Both	UART0 RX or Digital IO 7
15	D10	Both	Digital IO 10 (default usage: Network Association Indicator)
16	RTS0	Both	Digital IO 13 or UART0 request to send output
17	D1/SPISEL2/ADC4	Both	Digital IO 1; SPI Master Select Output 2; ADC input 4
18	D0/SPISEL1/ADC3	Both	Digital IO 0; SPI Master Select Output 1; ADC input 3
19	D16/SCL	Both	Digital IO 16 or I2C clock
20	D17/SDA	Both	Digital IO 17 or I2C data

3. Operation Mode

MeshBee has four different types of mode: AT, API, DATA, MCU, illustrated in figure below:

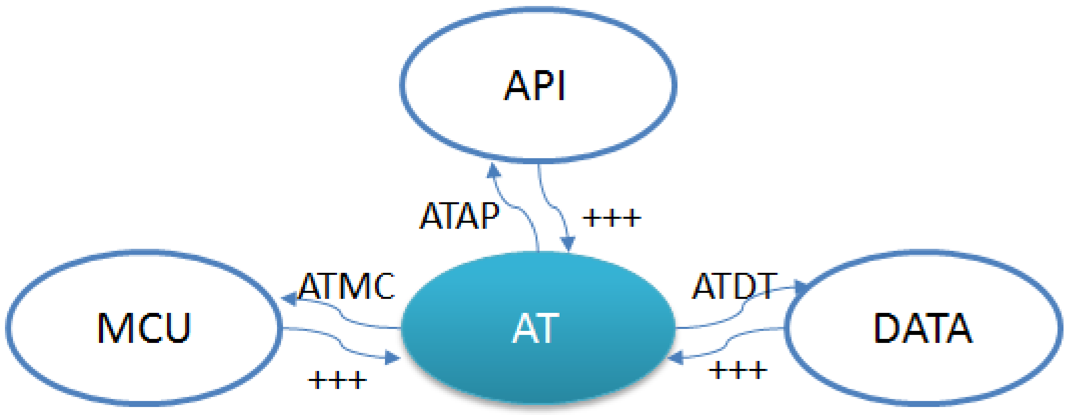


***Figure 3.1:** No matter which mode MeshBee works in, input "+++" can come back to AT command mode.*

3.1 AT mode

Mesh Bee communicates with outside through UART1 including data and command communicating. The default setting of UART1 is: *115200 baud rate, data bits 8, parity none, stop bit 1.* "+++<CR>" can put Mesh Bee into AT mode. The mode switch is illustrated in figure 3.1.

AT command can be classified into two types: register R/W AT and action AT.

The pattern of AT command is "ATXX[DDDD]<CR>" in which XX stands for the register/action name and DDDD stands for the written value of a register. All letters' case is ignored.

Register R/W AT can operate a virtual register of Mesh Bee. Absence of DDDD means reading the register value out and meanwhile ATXXDDDD means setting the register value to DDDD.

Action AT can trigger a specific action. The execution of command may be immediate or time-consuming.

Syntax for sending AT commands:

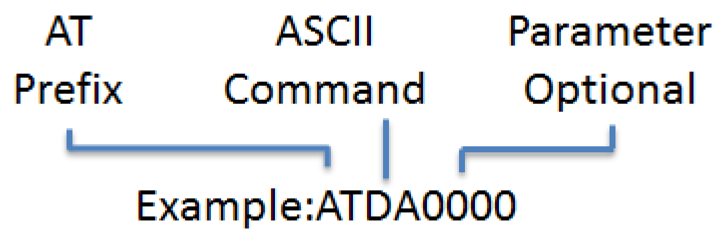


Figure 3.2: syntax for AT commands

3.2 API Mode

API is simply a set of standard interfaces created to allow other MCU to interact with MeshBee. For our purposes, API supports local operation and remote operation. For example, a host application can send an "ATIO" frame to Coordinator A, A will set its GPIO when it receives this frame. The most important thing to note is that APIs are specifically engineered to enable MeshBee to talk efficiently to other MCU. The target of API-mode is to transmit highly structured data quickly and reliably.

3.3 MCU Mode

In order to simplify the development of application for user, we create an Arduino-ful user programming space(AUPS).

In AT mode, using "ATMC" to enter MCU mode, then the arduino_loop will be executed periodically.

Write your own code in *"ups_arduino_sketch.c"*.

Example :

```
IO_T led_io;
int16 state = HAL_PIN_HIGH;
void arduino_setup(void)
{
    setLoopIntervalMs(1000);                    //set loop period
```

```
        suli_pin_init(&led_io, 9);                    //init led
        suli_pin_dir(&led_io, HAL_PIN_OUTPUT);
}

void arduino_loop(void)
{
      suli_pin_write(&led_io, state);                 //set led
      if(state == HAL_PIN_HIGH)
             state = HAL_PIN_LOW;
      else
             state = HAL_PIN_HIGH;
}
```

Note: In MCU mode, Uart1 is under the control of the AUPS, user should not send API frame to MeshBee.

3.4 Data Mode

When operating in Data mode, the modules act as a serial line. All UART data received through the UART1 is transmitted to a specified remote device.

To use a transparent connection, take the following steps:

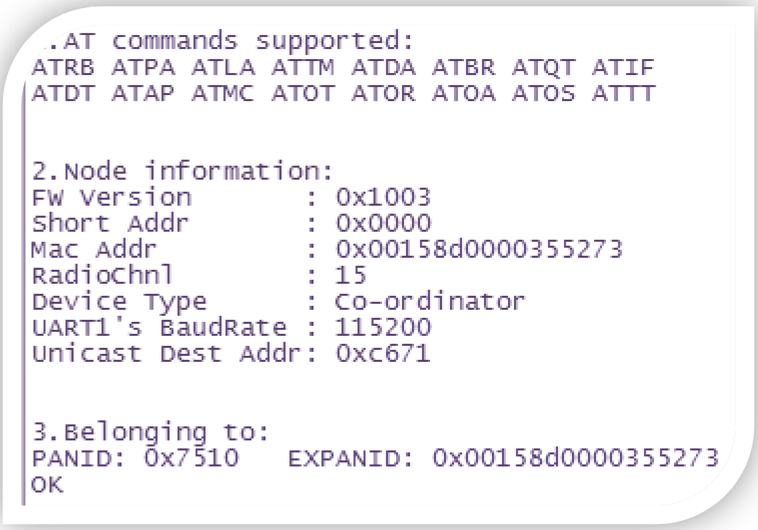
1) Set unicast address: *ATDAxxx*
2) Enter Data Mode: *ATDT*

4. AT commands

4.1 Node information commands

ATIF

1) Action AT， immediate execution， for any zigbee role.
2) Get node InFormation
3) ATIF command will print information of node including: supported AT commands, node's firmware version, node's zigbee short address, node's MAC address, node's radio channel, node's zigbee role, etc.
4) Example：



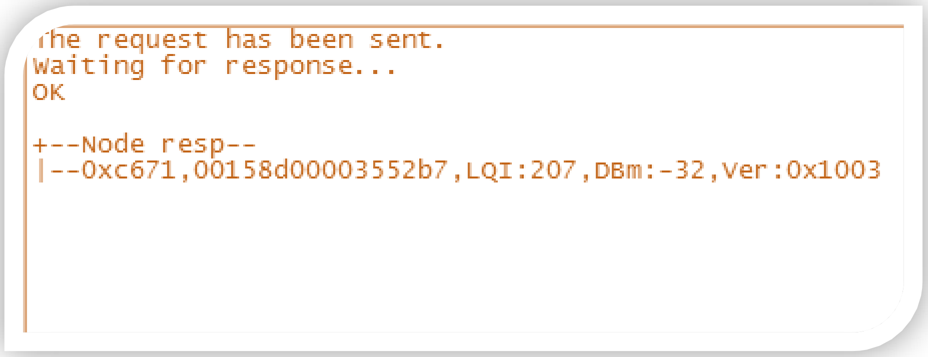
```
.AT commands supported:
ATRB ATPA ATLA ATTM ATDA ATBR ATQT ATIF
ATDT ATAP ATMC ATOT ATOR ATOA ATOS ATTT


2.Node information:
FW Version         : 0x1003
Short Addr         : 0x0000
Mac Addr           : 0x00158d0000355273
RadioChnl          : 15
Device Type        : Co-ordinator
UART1's BaudRate : 115200
Unicast Dest Addr: 0xc671


3.Belonging to:
PANID: 0x7510    EXPANID: 0x00158d0000355273
OK
```

Figure 3.3: ATIF screen shot

ATLA

1) Action AT, time-consuming execution, for any zigbee role
2) List All nodes within the network

3) ATLA will broadcast a topology query packet into the whole network. The node that's still alive may response to that. The querying node will print responding nodes' short address, MAC address, Link-Quality-Indication (LQI), etc. LQI is a positive integer, the bigger LQI the better link quality.



```
The request has been sent.
Waiting for response...
OK

+--Node resp--
|--0xc671,00158d00003552b7,LQI:207,DBm:-32,Ver:0x1003
```

Figure 3.4: ATLA screen shot

ATQT

1) Action AT, immediate execution, for any zigbee role
2) Get on-chip temperature.

4.2 Data transmit commands

ATTM

1) Register R/W AT, for any zigbee role
2) Bits:1, decimal, max:1, default:0
3) Set node's TX Mode
4) 0 - broadcast, 1- unicast (need setting destination address by ATDA command first).

ATDA

1) Register RW AT, for any zigbee role
2) Bits:4, hex, max: ffff, default:0000
3) Set node’s unicast destination address
4) This address will also be used as the OTA target address, means that this destination address will be used for ATOT and ATOS command. It has a pattern of HHHH that is 4 bits of HEX number ignoring case.
5) Example： ATDA14ad<CR>

ATBR

1) Register R/W AT, for any zigbee role
2) Bits:1, decimal, max:5, default:5
3) Set UART1’s Baud Rate
4) 0- 4800, 1-9600, 2-19200, 3-38400, 4-57600, 5-115200.
5) Example: ATBR5<CR>

4.3 Network formation commands

ATPA

1) Register RW AT, for any zigbee role but with different effect.
2) Bits:1, decimal, max:1, default:0
3) Set node’s Power up Action
4) The node’s default power-up behavior is restoring the last network state before power down. But when setting PA register to 1 and then reboot, the node will not restore the last network. In this case, coordinator node will re-create a network and router/End device will re-scan the network. The PA register will be cleared to 0 after reboot.

ATRS

1) Action AT, time-consuming execution, for router/End device
2) Re-Scan network
3) The scanning process will take a while and you can use ATLN command to monitor the scan result. If node finds nothing after a long time scanning, retry ATRS command or reset Mesh Bee. The node will automatically join the first found network when AJ register has a value of 1.

ATLN

1) Action AT, immediate execution, for router/End device
2) List Network scanned
3) The index value will be used by ATJN command.

ATJN

1) Register R/W AT, for router/End device
2) Bits:1, decimal, max:8, default:0
3) Join a Network with specific index
4) ATJN command is also an action trigger command. The node will join the network specified by the index of ATLN output. ATJN will return error when the node's already in that network.

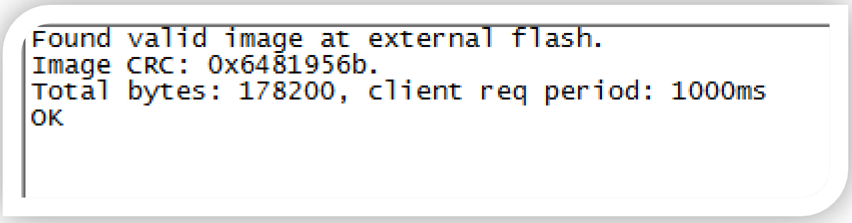
ATAJ

1) Register RW AT, for router/End device
2) Bits:1, decimal, max:1, default:1
3) Whether Auto Join network scanned
4) If AJ register has a value of 1, the node will automatically join the first network scanned after ATRS command or power up with PA register equals to 1.

4.4 OTA commands

ATOT

1) Action AT, immediate execution, for coordinator
2) OTA Trigger
3) Non-coordinator nodes can upgrade firmware over-the-air. This is called OTA. ATOT command will trigger the OTA upgrade download of a destination node. OTA architecture consists of OTA server and client. Coordinator will be the server side and router/End device is the client side. To OTA a client node, you should firstly enter the AT mode on server side and set the unicast destination address (DA register) to the short address of the client node, and then execute the ATOT command. And now trace serial port (usually UART0) will print some information about OTA process if trace is enabled. After downloading all image blocks which are saved in the external Flash, the client node will trigger the upgrade process automatically. The process is: mark the internal firmware invalid, then reboot, and then the bootloader will copy the new image from the external Flash into the internal Flash, and then run the new firmware.



```
Found valid image at external flash.
Image CRC: 0x6481956b.
Total bytes: 178200, client req period: 1000ms
OK
```

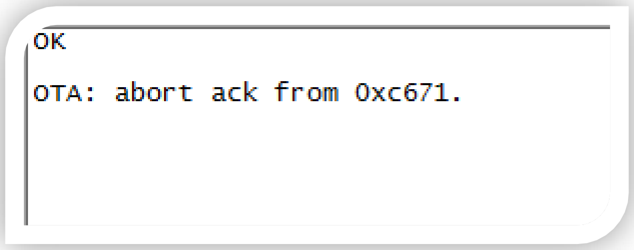
Figure 3.5: ATOT screen shot

ATOR

1) Register RW AT, for coordinator
2) Bits:5, decimal, max:60000, default:1000
3) OTA block request Rate
4) Set the interval of two image block requests. The value’s unite is milliseconds. The smaller, the faster.

ATOA

1) Action AT, immediate execution, for coordinator
2) OTA Abort
3) Abort the OTA downloading process of a specific node specified by the DA register.
4) Example:

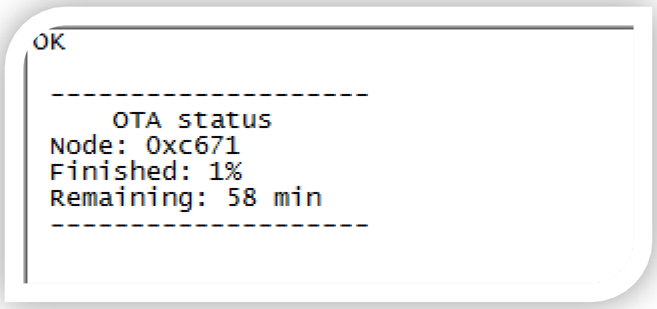


```
OK

OTA: abort ack from 0xc671.
```

Figure 3.6: ATOA screen shot

ATOS

1) Action AT, time-consuming execution, for coordinator
2) Query OTA Status
3) Query the status of the OTA downloading process of a specific node specified by the DA register.



```
OK

 --------------------
     OTA status
 Node: 0xc671
 Finished: 1%
 Remaining: 58 min
 --------------------
```

Figure 3.7: ATOS screen shot

5. API frame

5.1 Structure of API Frame

Every transfer of information requires a protocol. We defined the API frame like this(structure was defined in firmware_at_api.h):

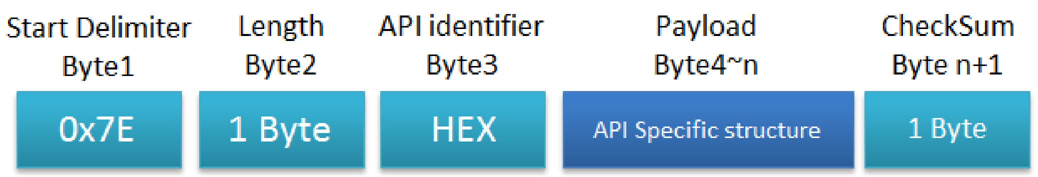


Figure 5.1: API Frame structure

5.1.1 API structure types

API_LOCAL_AT_REQ

API identifier value: 0x08

These packet types are useful only if the host wants to send commands to its local MeshBee. You don't need to specify the unicast address.

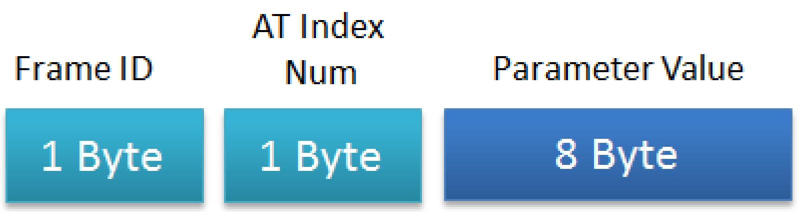


Figure 5.2: local AT require

Frame ID: *To Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement).*

AT index Num: *Index of the AT commands.*

Parameter value: *Parameter value to be set.*

API_LOCAL_AT_RESP

API identifier value: 0x88

The API type "local AT response" is an ACK frame which is returned to the host from MeshBee after handling a local AT request frame. To set a register, these frame types indicate whether the request execution is successful or not. To read a register, it contains the value of the register you query.

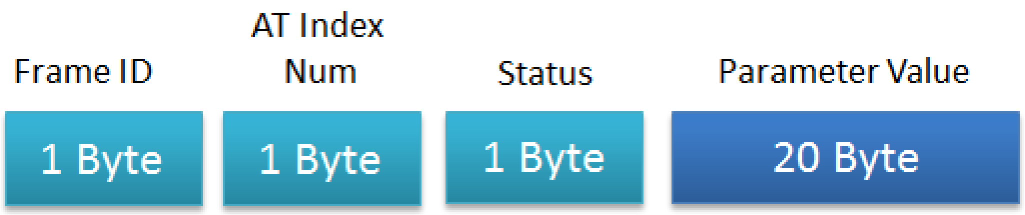


Figure 5.3: local AT response

Frame ID: *To Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement).*
AT index Num: *Index of the AT commands.*
Status: *Command execution status.*
Parameter value: *Return register value.*

API_REMOTE_AT_REQ

API identifier value: 0x17

These types allows for module parameter registers on a remote device to be queried or set, or perform an action (example: reboot) on a remote device.

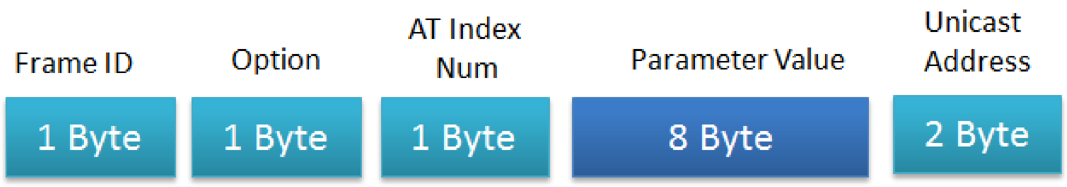


Figure 5.4: remote AT require

Frame ID: *To Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement).*

Option:

[8:0]:ACK Mode, 0 with ACK; 1 without ACK.

[8:1]:Cast Mode,0 unicast; 1 broadcast.

AT index Num: *Index of the AT commands.*

Parameter value: *Parameter value to be set.*

Unicast Address: *Set to the 16- bit network address of the remote.*

API_REMOTE_AT_RESP

API identifier value: 0x97

The API type "remote AT response" is an ACK frame which is returned to the host from the remote node after handling a remote AT request frame.

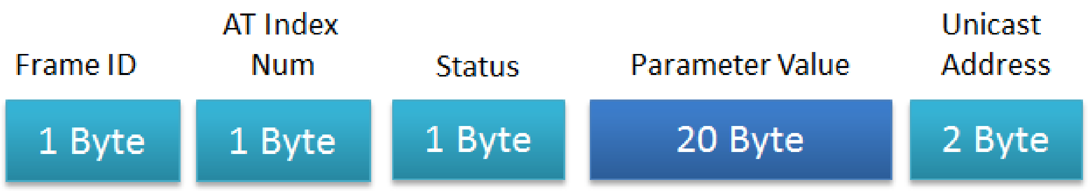


Figure 5.5: remote AT response

Frame ID: *To Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement).*

AT index Num: *Index of the AT commands.*

Status: *Command execution status.*

Parameter value: *Return register value.*

Unicast Address: *16- bit network address of the remote.*

API_DATA_PACKET

API identifier value: 0x02

The API type "data packet" is a user data frame. This request message will cause the module to send RF Data as an RF Packet.

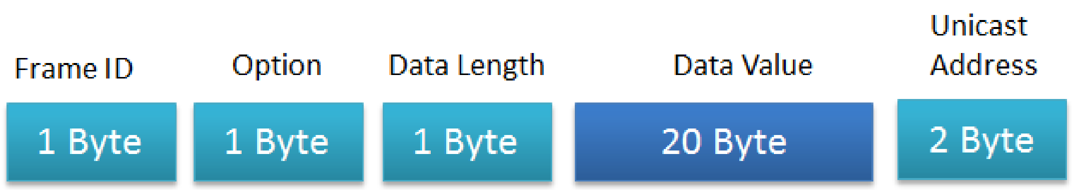


Figure 5.6: Data packets TX require

Frame ID: *To Identifies the UART data frame for the host to correlate with a subsequent ACK (acknowledgement).*

Option:

[8:0]:ACK Mode, 0 with ACK; 1 without ACK.

[8:1]:Cast Mode,0 unicast; 1 broadcast.

Data length: *the length of data payload.*

Parameter value: *Data value.*

Unicast Address: *Set to the 16- bit network address of the remote.*

API_TOPO_REQ

API identifier value: 0xfb

This API type allows module to query the network topology.

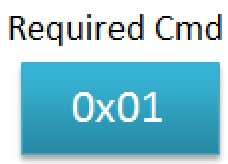


Figure 5.7: Structure of network Topo Require

API_TOPO_RESP

API identifier value: 0x6b

In response to an "API_TOPO_REQ" message, the module will send a response message.

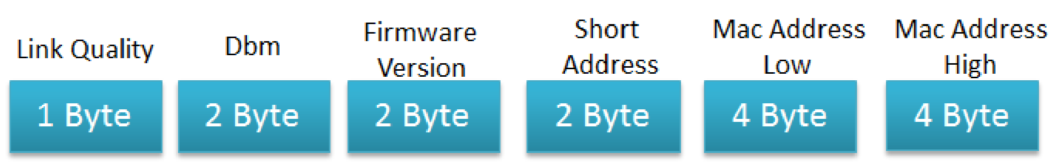


Figure 5.8: Structure of network topology response

Link Quality: *Indicate link quality of node.*

Dbm: *Power intensity.*

Firmware Version: *Firmware Version.*

Short Address: *source address of this response.*

Mac Address Low: *MAC address of the node, low byte.*

Mac Address High: *MAC address of the node, high byte.*

6. AUPS Function list

This chapter contains the information of functions that AUPS can call.

6.1 Set run-time parameters

setLoopIntervalMs

void setLoopIntervalMs(uint32 ms);

Description:

This function can be used to set the period of "*arduino_Loop()*".

Parameter:

ms : millisecond

Return:

None

setNodeState

void setNodeState(uint32 state);

Description:

This function can be used to set the working state of MeshBee.

Parameter:

state : working state

E_MODE_AT

E_MODE_API

E_MODE_DATA

E_MODE_MCU

Return:

None

6.2 Send RF data

bSendToAirPort

bool API_bSendToAirPort(uint16 txMode, uint16 unicastDest, uint8 *buf, int len);

Description:

This function can be used to send RF packets.

Parameter:

txMode: mode of transmit

UNICAST

BROADCAST

unicastDest: short address of unicast

buf: the pointer of data

len: length of the data

Return:

OK

ERR

6.3 Suli API

suli_pin_init

void suli_pin_init(IO_T *pio,   PIN_T pin);

Description:

This function can be used to initialize a digital IO of MeshBee.

Parameter:

pio: pointer of the IO_T entity

pin: pin No

D0, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20, DO0, DO1.

Return:

none

suli_pin_dir

void suli_pin_dir(IO_T *pio, DIR_T dir);

Description:

This function can be used to set direction of digital IO.

Parameter:

pio: pointer of the IO_T entity

dir: direction

HAL_PIN_INPUT

HAL_PIN_OUTPUT

Return:

none

suli_pin_write

void suli_pin_write(IO_T *pio, int16 state);

Description:

This function can be used to write a digital IO.

Parameter:

pio: pointer of the IO_T entity

state: state of IO

HAL_PIN_LOW

HAL_PIN_HIGH

Return:

none

suli_pin_read

int16 suli_pin_read(IO_T *pio);

Description:

This function can be used to read a digital IO.

Parameter:

pio: pointer of the IO_T entity

Return:

state: state of IO

HAL_PIN_LOW

HAL_PIN_HIGH

suli_analog_init

void suli_analog_init(ANALOG_T * aio, PIN_T pin);

Description:

This function can be used to initialize an analog pin.

Parameter:

aio: pointer of the ANALOG_T entity

pin: pin No

A1 : ADC1

A2 : ADC2

A3 : ADC3

A4 : ADC4

TEMP: On-chip temperature ADC

VOL : On-chip voltage ADC

Return:

none

suli_analog_read

int16 suli_analog_read(ANALOG_T *aio);

Description:

This function can be used to read the ADC value.

Parameter:

aio: pointer of the ANALOG_T entity

Return:

ADC value

suli_i2c_init

<u>void suli_i2c_init(void * i2c_device);</u>

Description:

This function can be used to initialize I2C of MeshBee (D16, D17).

Parameter:

i2c_device: any dummy value

Return:

none

suli_i2c_write

<u>uint8 suli_i2c_write(void * i2c_device, uint8 dev_addr, uint8 *data, uint8 len);</u>

Description:

This function can be used to write a buff to I2C.

Parameter:

i2c_device: any dummy value

dev_addr: device address

data: data array

len: length of the data

Return:

The number of bytes already been written

suli_i2c_read

<u>uint8 suli_i2c_read(void *i2c_device, uint8 dev_addr, uint8 *buff, uint8 len);</u>

Description:

This function can be used to read a buff from I2C.

Parameter:

i2c_device: any dummy value

dev_addr: device address

data: pointer of data array

len: length of the data

Return:

The number of bytes already been read

suli_uart_init

void suli_uart_init(void * uart_device, int16 uart_num, uint32 baud);

Description:

This function can be only used to initialize uart1of MeshBee. Because uart0 is under the control of the system.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

baud: baud rate

4800

9600

19200

38400

57600

115200

Return:

none

suli_uart_send

void suli_uart_send(void * uart_device, int16 uart_num, uint8 *data, uint16 len);

Description:

This function can be only used to send data through uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

data: pointer of the data array

len: length of the data

Return:

none

suli_uart_send_byte

void suli_uart_send_byte(void *uart_device, int16 uart_num, uint8 data);

Description:

This function can be only used to send one byte through uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

data: data byte

Return:

none

suli_uart_write_float

void suli_uart_write_float(void *uart_device, int16 uart_num, float data, uint8 prec);

Description:

This function can be only used to send float data through uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

data: float data

Return:

none

suli_uart_write_int

void suli_uart_write_int(void *uart_device, int16 uart_num, int32 num);

Description:

This function can be only used to send int data through uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

num: int value

Return:

none

suli_uart_printf

void suli_uart_printf(void *uart_device, int16 uart_num, const char *fmt, ...) ;

Description:

This function can be only used to send formatted string to uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

fmt: format of string

Return:

none

suli_uart_read_byte

uint8 suli_uart_read_byte(void * uart_device, int16 uart_num);

Description:

This function can be only used to read a byte from uart1.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

Return:

Returned byte

suli_uart_readable

uint16 suli_uart_readable(void * uart_device, int16 uart_num);

Description:

This function can be only used to judge if uart1 is readable.

Parameter:

uart_device: any dummy value

uart_num: any dummy value

Return:

The number of bytes which can be read

Appendix a: AT command index

Command Name	AT Index	usage
ATRB	*0x30*	*reboot*
ATPA	*0x32*	*power up action*
ATAJ	*0x34*	*Auto Join Network*
ATRS	*0x36*	*Re-Scan Network*
ATLN	*0x38*	*List scanned network*
ATJN	*0x40*	*Join specified Network*
ATLA	*0x42*	*List All nodes*
ATTM	*0x44*	*Transmit mode*
ATDA	*0x46*	*Unicast Address*
ATQT	*0x48*	*Query Chip temperature*
ATIO	*0x50*	*Handle IOs*
ATIF	*0x52*	*Node information*

Note: *v1003 firmware compatible*

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