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## 1. General Introduction

This design of this Bluetooth badge is based on Bluetooth and LoRa technology. With the advanced LoRa technology and built-in Bluetooth module, the Bluetooth badge receives the Bluetooth beacon signal and reports it to the LoRa badge. The parameter settings, such as the heartbeat period, LoRa work modes are adjustable as per customers' requirements.

This badge supports the proximity detection function. It beeps and vibrates when the distance between it and other badges is less than 2 meters. The distance can be adjusted by setting Bluetooth for transmitting power and receiving threshold.

The badge supports a 'friend' feature. It does not beep or vibrate when it recognizes other friend badges. The badge supports two kinds of report interval: 10s instant report mode and 80s periodic report mode.

This document applies to the following products:

Product Description	Part Number
Badge, CN470, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02531
Badge, AS923, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02533
Badge, IN865, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02534
Badge, US915, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02535
Badge, RU864, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02536
Badge, AU915, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02537
Badge, EU868, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02538
Badge, KR920, Bluetooth5.0, buzzer, vibrator, PD, 97x62x7mm, 600mAh	100-02539

### Key features:

- Buzzer and vibrator
- Proximity detection; accuracy 2~3m
- Distance adjustment
- Friend feature
- Multiple auto-configuration modes
- Multiple contact history report mode
- Bluetooth tracking
- NFC for easy management
- LoRaWAN
- FOTA with Bluetooth

## 2. Abbreviation

- ABP: Activation by Personalization
- Bluetooth: Bluetooth Low Energy
- CRC: Cyclic Redundancy Check
- LoRa: Long Range modulation technique
- LoRaWAN: Long Range Network protocol

- OTAA: Over the Air Activation
- RSSI: Received Signal Strength Indicator
- BT: Beacon-in-tracker, the badge broadcasts Bluetooth information as a beacon when the proximity detection function is on.
- BB: Bluetooth Beacon
- RFU: Reserved for Future Use
- TP: Transmitting Power
- RT: Receiving Threshold
- OTA: Over the Air
- DFU: Device Firmware Upgrade
- IRM: Instant Report Mode
- PRM: Periodical Report Mode

### 3. Product Specifications

Table 1: Product Specifications

Parameter	Description
<b>Positioning Mode</b>	Bluetooth5.0
<b>Maximum Range</b>	30m
<b>Protocol</b>	LoRaWAN 1.0.2B
<b>Frequency</b>	US915, AU915, EU868, EU433, AS920-923, AS923-925, RU864, ID920, KR920, IN865, KZ865, CN470
<b>LoRa Sensitivity</b>	-139dBm @SF12, BW125kHz, 434MHz/470MHz -137dBm @SF12, BW125kHz, 868MHz/915MHz
<b>Operating Current</b>	8mAh@Bluetooth receiving Max. 140mA@19dBm
<b>Buzzer Decibel</b>	75dB
<b>Vibrator</b>	Rated speed: 12000±3000rpm Displacement: 1.5mm (p~p) Frequency: 10~54Hz Acceleration: 22m/s Period: 10min(10~55~10Hz), 10 Minutes log sweep(10~55~10Hz) This motion shall be applied for a period of 10 minutes in each of 3 mutually perpend axis Vibrator mechanical noise: <50dB
<b>Battery</b>	Rechargeable 600mAh polymer lithium battery
<b>Operating Temperature</b>	-10~+60°C
<b>Storage Temperature</b>	-20~+85°C
<b>Operating Humidity</b>	5%~95%
<b>Power Mode</b>	Micro-USB, DC 5V
<b>Communication Distance</b>	>1.5km in the urban area
<b>Application Context</b>	Contact tracing, Personnel tracking, proximity detection and report

## 4. Application Information

### 4.1 Function

The badge supports both OTAA and ABP mode and works in class A mode, and the data rate is limited from DR3 to DR5 to transmit big payload. The DevEUI, AppEUI, and AppKey, or DevAddr, NwkSKey, and AppSKey are stored in the badge. They are necessary for joining a network. Please find DevEUI or DevAddr labeled at the back of the device. Lansitec can help to configure clients' own parameters before shipping if required. After being powered on and joining the Lora network, the badge sends a registration message which includes the current parameter settings of the badge to the Customer Server (CS). If CS doesn't reply, it retries 3 times before working in default mode.

The badge starts working after receiving an acceptance response, or no CS reply is received after 2 registration trials. The badge reports the heartbeat message to CS periodically. The duty cycle is configurable by commands from CS. Coordinate acquisition and report period depend on the Bluetooth receiving results.

According to LoRaWAN specification, in Class A mode, downlink response time is decided by the uplink duty cycle. The badge uses a heartbeat message to control the downlink response time to avoid relying on the position message for a downlink configuration. The heartbeat period can be configured to be an integral multiple of 30 seconds. The default period is 5 minutes. The heartbeat message also contains the status information of the badge. It can be used by CS to monitor the badge.

### 4.2 Application Scenarios

The badge follows the general rules cited below:

- When a registration request is received from the badge,
  - If CS only wants the badge to work with default parameters, CS ignores the registration message and waits for the periodical coordinate report.
  - Or CS should record the first-time configuration, acknowledge the request. If CS contains some history configuration of the badge and a mismatch occurs, CS should send the new setting to the badge. Then the badge updates and starts to work with these new parameters.
- After registration, the user can change the configuration of the badge. CS needs to save the new parameters and CRC16 of the parameters. In case of receiving registration when the badge reset or periodical heartbeat message, CS needs to check if any configuration mismatch occurred. If necessary, CS should send the new configuration to the badge in the next downlink window.

## 4.3 On/Off, LED Status and Low Battery Alert

### 4.3.1 On/off and LED status

- 1) Turn on: Long press the button for four seconds; the red LED flashes four times, and the green LED is on.
- 2) Turn off: Long press the button for four seconds, the red LED is on for four seconds and then goes off.
- 3) Reboot: LED status is the same as being turned on; the red LED flashes four times, and the green LED is on.
- 4) Joining the network: the green LED is on.
- 5) After joining the network and pressing the button:
  - a) Green LED is on: successfully joined.
  - b) Green LED is off: joining failed, or the badge is in off state.
- 6) In on state, press the button three times, and green LED blinks three times, the badge rejoins the network.
- 7) Charge: red LED flashes every second.
- 8) Charge done: solid LED.

### 4.3.2 Buzzer and Vibrator

- 1) By default, the buzzer synchronizes with the vibrator who follows the same warning mechanism.
- 2) When the badge detects the proximity of another badge, the buzzer, and the vibrator beep and vibrate. At this point, double-clicking the button within 1 second puts the badge to mute (no beep, no vibrate) for 5 minutes. Then, if you double click the button again within 5 minutes, the badge restores to warning immediately. Click the button once to check the current warning status. If it beeps once, it means that the badge's warning is enabled. If only green led flashes once, it means warning is disabled. If only red led flashes once, it means warning is disabled and it has friend badges.
- 3) The buzzer and the vibrator can be turned on/off separately with the auto-config beacon.
- 4) The buzzer and the vibrator can be controlled by either a downlink command or an auto-config beacon described in the chapter 4.7.
- 5) The buzzer beeps once after a reboot. It does not beep when it's powered on during charging.

### 4.3.3 Low battery alert

The buzzer beeps when the battery level is lower than 20% to remind the user to charge it.

- 1) When the battery level is between 5%~20%, it beeps once per two minutes.
- 2) When the battery level is between 5%~10%, Bluetooth receiving is off. The badge only sends heartbeat messages and broadcasts Bluetooth information so that other badges can detect it, but it turns off Bluetooth receiving and can't detect other badges.
- 3) When the battery level less than 5%, the badge powers off automatically.

## 4.4 Proximity Detection

The buzzer beeps and vibrates when badges are within approximately two meters from each other.

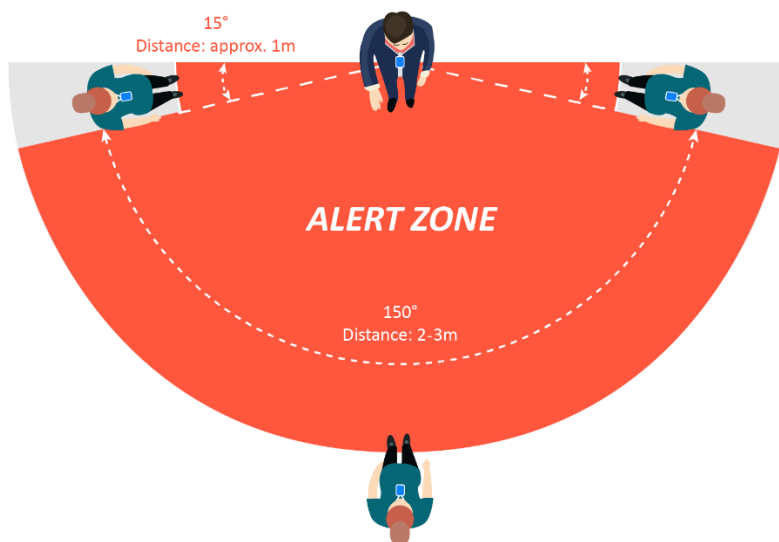
Below is the default state:

- 1) Bluetooth receiving: 1s in every 3s
- 2) LoRa transmit interval: 10s instant report mode or 80s periodic report mode
- 3) Bluetooth transmitting power: 0dBm (configurable)
- 4) Bluetooth receiving threshold: -70dBm <sup>note 1</sup> (configurable)
- 5) Bluetooth broadcasts once every 200ms. This is not configurable.
- 6) The proximity detection function is on in default
- 7) The default distance is 1.5~2.5m.

Note 1. We may change the default setting in the later version.

**Figure 1: Coverage Area** shows the coverage of the badge. The distance can be 2~3m (depending on the setting) when two people are within 150° in front of each other. When one is on the other side, from 0° to ~15°, the distance is half.

The figure is a reference of the coverage and the distance and degree could change in different environments.



**Figure 1: Coverage Area**

The Bluetooth broadcasts as a Bluetooth beacon when Bluetooth is not receiving. It is a beacon-in-tracker. UUID is F2A52D43E0AB489CB64C4A83001467FD. The last 4 bytes in DevEUI are Major and Minor. For example, if the DevEUI is 70B3D5A4D310023E. The major is D310 and the minor is 023E.

The badge turns on Bluetooth receiving at a random time within the 3 seconds. The beacon-in-tracker broadcasts at every 100ms. The receiving badge receives each of them multiple times within 1 second. Then, the badge calculates the averages RSSI received. If the RSSI is larger than the receiving threshold, the buzzer beeps and vibrates simultaneously. The badge sends Bluetooth's major, minor and RSSI to the LoRa gateway.

About accuracy, several factors influence the accuracy distance measuring with BLE RSSI.

- 1) Shadow effect: signals can be reflected by walls and glasses around many times during the transmission. If there is an object moving due to diffraction, the signal path will be changed. This results in receiving unstable signal strength.
- 2) There are many devices on 2.4G, Wi-Fi, Bluetooth, Zigbee. The signal may overlap with each other which makes the received signal strength unstable.
- 3) We have run tests to find out the best threshold stands for 2m. However, the result maybe 1.5 or 2.5m. For example, when someone turns his back at the same location, the signal strength changes while the distance has not changed.

Therefore, the distance only applies to our lab. The clients should try the distance upon receiving and change the receiving threshold or Bluetooth transmitting power. They can be adjusted by either a downlink command or an auto-config beacon.

In this way, CS can calculate the duration of two or more people contacting each other by the unit of 10s. For example, if CS gets 6 reports of 3 groups of RSSIs, Majors, and Minors, these 3 people are close to each other for 1 minute.

The Bluetooth transmitting power and receiving threshold can be configured with commands in 4.6.6.

The buzzer function can be turned off by sending a command to the badge to be less annoying. The data report function stays as described above. Refer to 4.6.6

The proximity detection can be turned off by sending a command to the badge. Refer to 4.6.6

## 4.5 Uplink Message

### 4.5.1 Register

Bytes	1	1	1	1	2	1	2	2
Item	Type	SMODE	Power	CFG	POS	HB	BT	CRC

Type Field (the most significant byte)

Bit	Name	Value	Description
7~4	Type	0x1	Message type. CS uses it to identify different uplink messages. Bit7 is the significant bit.
3	ADR	0: OFF 1: ON	ADR (Adaptive Data Rate) status. The default value is OFF.
2~0	Mode	0x01~0x07	The current working scheme, which should be one of SMODE. 0x1: AU915 0x2: IN865 0x3: CN470 0x4: AS923 0x5: EU433

			0x6: EU868 0x7: US915
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## SMODE Field

Bit	Name	Value	Description
7~0	SMODE	0x01: AU915 0x02: IN865 0x04: CN470 0x08: AS923 0x10: EU433 0x20: EU868 0x40: US915	Data scheme (regional frequency) supported by the badge. This field is preserved by Lansitec and will be configured before shipping. European: EU868 China mainland: CN470 Southeast Asia: AS923 North America: US915. Australia and South America: AU915  Currently, the badge only supports one mode. Please notify us the mode and channels (in AU915, US915 and CN470) after the order.

## Power Field

Bit	Name	Value	Description
7~3	Power	0~31	LoRa transmitting power (dBm). The default value depends on regional frequency, and in default, it's the biggest one of the powers allowed. For example, if the mode is EU868, the default value of POWER should be 14dbm.
2~0	Reserved	0x0	Reserved for future use.

## CFG Field

Bit	Name	Value	Description
7~4	DR	0~15	Data Rate (DR0~DR15). The default value is DR2. If ADR is disabled, the badge works in this data rate.
3~0	Reserved	0x0	Reserved for future use.

Data rate ranges from DR0 to DR5. Refer to the table below for each payload length limitation (bytes).

DR	EU868	US915	AU915	CN470	AS923	KR920	IN865	STE920
0	51	11	51	51	51	65	51	51
1	51	53	51	51	51	151	51	51
2	51	126	51	51	51	242	51	51
3	115	242	115	115	115	242	115	115
4	242	242	242	242	242	242	242	242
5	242	-	242	242	242	242	242	242

## POS Field

Bit	Name	Value	Description
15~0	POS	0~65535	The period of position report, unit 5s. 0 means OFF. (Big endian) The default value is 10s.

## HB Field

Bit	Name	Value	Description
7~0	HB	1~255	The period of heartbeat message, unit 30s. Heartbeat can't be disabled. The default value is 0xA.

## BT Field

Bit	Name	Value	Description
15~12	RFU	0000	Reserved for future use
11	Buzzer and vibrator	0: OFF 1: ON	This bit indicates the status of the buzzer and vibrator.
10~8	Bluetooth transmitting power	001: 4 dBm 010: 0 dBm 011: -4 dBm 100: -8 dBm 101: -12 dBm 110: -16 dBm 111: -20 dBm	CS uses it to identify Bluetooth transmitting power.
7	BT function and proximity detection	0: OFF 1: ON	This bit indicates the status of the proximity detection.
6~0	Bluetooth receiving threshold	0x0~57	CS uses it to identify the Bluetooth receiving threshold.

## CRC Field

Bit	Name	Value	Description
15~0	CRC		CRC16 of previous fields with Type bits set to 0, the polynomial is $x^{16} + x^{15} + x^2 + 1$ . CS only needs to compare this data field with the one CS stored to judge whether the configuration is changed.

The default value of the badge configuration depends on specific products.

#### 4.5.2 Heartbeat

HB message requires ACK from the server. The badge retries twice if it can't receive ACK after the first time. It randomly delays 3 - 10s between each retry.

Bytes	1	1	1	2	1	1	2	2	MAX:25
Item	Type	VOL	RSSI	SNR	REV	CHGSTAT	CRC	BTSTATUS	Friend

## Type Field

Bit	Name	Value	Description
7~4	Type	0x2	Message type, CS uses it to identify different uplink messages.
3~0	Version	1	The version of the message type, the current version is 1.

## VOL Field

Bit	Name	Value	Description
7~0	VOL	0~100	Battery level in percentage. It indicates how much it is left. If the badge is an indoor type, this field is 0. (Unit: %)

## RSSI Field

Bit	Name	Value	Description
7~0	RSSI	0~160	The downlink Received Signal Strength Indication, detected and calculated by the badge. (unit: -1dBm)

## SNR Field

Bit	Name	Value	Description
2Bytes	SNR	-3000~3000	Signal Noise Ratio, *0.01, i.e., 30.00~30.00

## Software Revision Field (REV)

Bit	Name	Value	Description
7~0	Revision	0x0	This field is used to indicate software revision. It adds one when new firmware is released.

## CHGSTAT Field

Bit	Name	Value	Description
7~0	CHGSTAT	0x0: Not charging 0x5: Charging 0x6: Charge completed	Status of battery.

## CRC Field

Bit	Name	Value	Description
15~0	CRC		The same CRC16 as calculated in the register message. It can be used for server to check for a configuration mismatch.

## BTSTATUS Field

Bit	Name	Value	Description
15~12	Mode	0x0: No action	Indicates the badge's working

		<p>0x1: Charging mode (to be developed)</p> <p>0x2: Off duty mode (to be developed)</p> <p>0x3: Turn off (to be developed)</p>	<p>mode. Currently, it's only 0x0. Reserved for future use.</p>
<b>11~8</b>	Vibrator and buzzer	<p>0x0: No action.</p> <p>0x1: vibrator disable and buzzer mute (restore)</p> <p>0x2: vibrator disable and buzzer half sound level (to be developed)</p> <p>0x3: vibrator disable and buzzer full sound level</p> <p>0x4: vibrator enable and buzzer mute</p> <p>0x5: vibrator enable and buzzer half sound level (to be developed)</p> <p>0x6: vibrator enable and buzzer full sound level</p> <p>0x7: vibrator disable and buzzer mute (no restore)</p> <p>0x8: disable beacon-in-tracker and proximity detection</p>	<p>Indicates the badge's vibrator and buzzer status.</p>
<b>7</b>	Range	<p>0x0: Not changed</p> <p>0x1: Range up</p>	<p>Indicates the badge's Bluetooth receiving threshold range.</p> <p>If 0x0 is set, the range is -73dBm ~ -87dBm.</p> <p>If 0x1 is set, the range is -58dBm ~ -72dBm.</p>
<b>6~4</b>	Bluetooth Transmitting Power	<p>0x0: Not changed</p> <p>0x1: 4 dBm</p> <p>0x2: 0 dBm</p> <p>0x3: -4 dBm</p> <p>0x4: -8 dBm</p> <p>0x5: -12 dBm</p> <p>0x6: -16 dBm</p> <p>0x7: -20 dBm</p>	<p>Indicates the badge's Bluetooth transmitting power.</p>
<b>3~0</b>	Bluetooth Receiving Threshold	<p>0x0: Not changed</p> <p>0x1: -73 dBm</p> <p>0x2: -74 dBm</p> <p>0x3: -75 dBm</p> <p>0x4: -76 dBm</p> <p>0x5: -77 dBm</p> <p>0x6: -78 dBm</p> <p>0x7: -79 dBm</p> <p>0x8: -80 dBm</p> <p>0x9: -81 dBm</p>	<p>Indicates the badge's receiving threshold.</p>

		0xA: -82 dBm 0xB: -83 dBm 0xC: -84 dBm 0xD: -85 dBm 0xE: -86 dBm 0xF: -87 dBm	
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Friend Field

<b>Bytes</b>	<b>1</b>	<b>2</b>	<b>2</b>	...
<b>Item</b>	Type	Major	Minor	...

Type Field

Bit	Name	Value	Description
7~4	Type	0xC	Indicate friend badge field beginning.
3~0		1~6	The number of friend badges.

Major Field

Bit	Name	Value	Description
15~0	Major	0XXXXX	Friend badge's major.

Minor Field

Bit	Name	Value	Description
15~0	Minor	0XXXXX	Friend badge's minor.

**4.5.3 10s Instant Report Mode**

10s instant report mode is the default one. The badge reports the data every 10s in this mode. Please find the report mode information on the tag at the back of the badge.



Figure 2: Tag, 10s IRM

Number of the badge's in one uplink message

DR	EU868 Message Size (number of badge's in one uplink message)	US915 Message Size (number of badge's information in one uplink message)
0	51 (9)	11 (1)
1	51 (9)	53 (9)
2	51 (9)	126 (15)

<b>3</b>	115 (15)	242 (15)
<b>4</b>	242 (15)	242 (15)
<b>5</b>	242 (15)	-

For Bluetooth beacons which broadcast major and minor instead of MAC.

Bytes	1	2	2	1	2	2	...	N
Item	Type	Major	Minor	RSSI	Major	Minor	...	TOFF
								Byte0
								Byte1
								...
								B0
								B1
								B2
								B3

Type Field

Bit	Name	Value	Description
<b>7~4</b>	Type	0x8	Message type, CS uses it to identify different uplink messages.
<b>3~0</b>	Length	M (1~15)	The number of beacons received in this message.

The badge can receive 100 beacons within one second. It transmits 15 beacons in one message at the most. The rest are transmitted 15 by 15 in the next cycle if there are more than 15. At this moment, it supports  $DR > 2$ .

A beacon can be received by the badge multiple times. There are two types of beacons: Bluetooth beacon (BB, UUID must be F2A52D43E0AB489CB64C4A8300146720) and Beacon-in-tracker (BT).

About BB, when the badge receives less than 5 messages from a BB, it just calculates the RSSI average of all current BBs and reports them. When  $BB \geq 5$ , it discards the largest and the smallest RSSI of each BB and calculates the average. It only reports the top 5 BB messages with the highest average RSSI.

About BT, it just calculates the RSSI average of current all BT and reports them.

Two types of beacon's messages are transmitted in one flow, in which BT message is transmitted first, BB message keeps up with BT message's tail. In addition, the badge only sends the BTs whose RSSI is higher than the threshold to the LoRa gateway.

The badge does not beep when it encounters the BB.

Major Field

Bit	Name	Value	Description
<b>15~0</b>	Major	short	Major of Bluetooth beacon.

Minor Field

Bit	Name	Value	Description
<b>15~0</b>	Minor	short	Minor of Bluetooth beacon.

RSSI Field

Bit	Name	Value	Description
<b>7</b>	Beacon type	1: Bluetooth beacon 0: Beacon-	This bit is used to indicate the type of beacon received. 1 is Bluetooth beacon for indoor positioning. 0 is the badge with proximity detection function on.

		in-tracker	
6~0	RSSI	byte	Received Signal Strength Indication of the beacon, the server utilizes it to calculate the distance. When it's beacon-in-tracker, the RSSI value should be raw value subtract 0x80. (unit: -1dBm) Example: 0x2B: BT RSSI = -85dBm 0xAB: BB RSSI = -85dBm

## TOFF Field

Bytes	Name	Value	Description
N	TMOFF		Time offset means the delta between the time every beacon received and the time message is sent. $N = (M+1) / 2$ Byte0: bit7 bit6 bit5 bit4   bit3 bit2 bit1 bit0 Beacon0            Beacon1 Byte1: bit7 bit6 bit5 bit4   bit3 bit2 bit1 bit0 Beacon2            Beacon3 ... Example: If there are 4 beacons in the message, then M will be 4, and N will be 2. Suppose the message is sent at 15:04:27, the beacon1 is received at 15:04:25, beacon2 at 15:04:23, beacon3 at 15:04:26, beacon4 at 15:04:27, then TMOFF should be 0x2410. This field is designed for precise positioning, and if multi badges receive a beacon at the same time, the server can calculate the distance between the beacon and badges, then calculate the position of the beacon.

## 4.5.4 Acknowledge

Bytes	1	1
Item	Type	MSGID

## Type Field

Bit	Name	Value	Description
7~4	Type	0xF	Message type, CS uses it to identify different uplink messages.
3~0	Result	0: success 1: failure	Process result of any downlink message that needs acknowledging.

## MSGID Field

Bit	Name	Value	Description
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<b>7~0</b>	MSGID	0~255	The MSGID field of corresponding downlink message.
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**4.5.5 80s Periodic Report Mode**

The badge reports the data every 80s in this mode. Please find the report mode information on the tag at the back of the badge.



**Figure 3: Tag, 80 PRM**

Number of badge's in one uplink message

DR	EU868 Message Size (number of badge's in one uplink message )	US915 Message Siz (number of badge's information in one uplink message)
<b>0</b>	51 (10)	11 (2)
<b>1</b>	51 (10)	53 (10)
<b>2</b>	51 (10)	126 (15)
<b>3</b>	115 (15)	242 (15)
<b>4</b>	242 (15)	242 (15)
<b>5</b>	242 (15)	-

For Bluetooth beacons which broadcast major and minor instead of MAC.

Overall data structure:

Bytes	1	5	5	...	2	3	3	...
Item	Type	Badge 1	Badge 2	...	Beacon type marker: 0xFFFF	Beacon1	Beacon 2	...

0xFFFF -- Beacon type marker, which indicates that the following data are beacons'.

When a badge receives more than 15 badges or beacons combined, badges are put at the beginning of the queue, and beacons are put at the end. It sends the first 15 badges' messages at the end of the 80s, and the rest are combined with the messages received in the next 80s and are sent at the end of the 2nd 80s.

Type Field

Bit	Name	Value	Description
<b>7~4</b>	Type	0xC	Message type, CS uses it to identify different uplink messages.
<b>3~0</b>	Length	M (1~15)	The number of beacons received in this message.

1) Definition of the badge data

<b>2</b>	<b>2</b>	<b>1</b>	...
<b>Major</b>	Minor	TimeMark_Badge	...

TimeMark\_Badge represents the time record counting from the current time when the badge is detected, 80 seconds per cycle, every 10 seconds per unit.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
79s~70s	69s~60s	59s~50s	49s~40s	39s~30s	29s~20s	19s~10s	9s~0s

When a bit is 1, the badge is detected in this time period (counting from the current time).

Example: C2D011002EF9D011002D8F

2 badges are detected:

Badge 1: Major is D011, Minor is 002E, TimeMark\_Badge is 0xF9 (1111 1001) which represents that the badge is detected in the period of 0-9 seconds, 30-39 seconds, 40-49 seconds, 50-59 seconds, 60-69 seconds, 70-79 seconds (the time period is counted from the current time).

Badge 2: Major is D011, Minor is 002D, TimeMark\_Badge is 0x8F; it represents that the badge is detected in 0-9 seconds, 10-19 seconds, 20-29 seconds, 30-39 seconds, 70-79 seconds (the time period is counted from the current time).

2) Definition of the beacon data

<b>2</b>	<b>1</b>	...
<b>Minor</b>	TimeMark_Beacon	...

TimeMark\_Beacon represents the time record counting from the current time when the Bluetooth beacon (UUID: F2A52D43E0AB489CB64C4A8300146720) is detected, 80 seconds per cycle, every 10 seconds per unit. The badge only reports the beacon with the highest RSSI.

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
<b>79s~70s</b>	69s~60s	59s~50s	49s~40s	39s~30s	29s~20s	19s~10s	9s~0s

When a bit is 1, it means that the beacon is detected in this time period (counting from the current time), and of all the beacons detected during this period, this beacon has the strongest RSSI.

Example: C2FFFF019BDF00F020

2 beacons are detected, FFFF—Beacon type marker, which indicates that the subsequent data belongs to the beacons. The beacon's major **MUST** be set to FFFF. The badge sends maximum 8 beacons' information. Beacon 1: Minor is 019B, TimeMark\_Beacon is DF, represents that the beacon is detected in 0-9 seconds, 10-19 seconds, 20-29 seconds, 30-39 seconds, 40-49 seconds, 60-69 seconds, 70-79 seconds (the time period is counted from the current time), and of all the beacons detected during this period, this beacon has the strongest RSSI.

Beacon 2: Minor is 00F0, TimeMark\_Beacon is 20, represents that the beacon is detected in 50-59 seconds (the time period is counted from the current time), and of all the beacons detected during this period, this beacon has the strongest RSSI.

The badge does not beep when it encounters the BB.

## 4.6 Downlink Message

### 4.6.1 Register Acceptance

<b>Bytes</b>	1
<b>Item</b>	Type

Type Field

Bit	Name	Value	Description
7~4	Type	0x1	Message type, the badge uses it to identify different downlink messages.
3~0	Result	0: success 1: illegal badge 2: server busy	Register result. In the current badge, if the result is not 0, the badge goes on to send a Register message.

### 4.6.2 LoRa Configuration

<b>Bytes</b>	1	1	1
<b>Item</b>	Type	DR	Mode

Type Field

Bit	Name	Value	Description
7~4	Type	0x8	Message type, the badge uses it to identify different downlink messages.
3	ADR	0: OFF 1: ON	ADR (Adaptive Data Rate) status.
2~0	U915 BAND SELECT or AU915 BAND SELECT (To be developed)	0x0: Band 1; 0x1: Band 2; 0x2: Band 3; (To be developed) 0x3: Band 4; (To be developed) 0x4: Band 5; To be developed) 0x5: Band 6; (To be developed) 0x6: Band 7; 0x7: Band 8; (To be developed)	This field only takes an effect when LoRa scheme is US915 or AU915. It updates the band by a downlink message. It reboots automatically once a sub-band is set.

## DR Field

Bit	Name	Value	Description
7~4	DR	0~15	Data Rate (DR0~DR15). If ADR is on, this value will not take an effect. If ADR is off, the badge will work in this data rate.
3~1	Reserved	0	Reserved for future use.
0	Band switch	0x0: Disable 0x1: Enable	Enable/disable band switch when LoRa scheme is US915.

## Mode Field

Bit	Name	Value	Description
7~5	Mode	0x1: AU920 0x2: IN865 0x3: CN470 0x4: AS923 0x5: EU434 0x6: EU868 0x7: US915	Configure mode. This field is reserved and can't be changed currently.
4~0	Power	0~31	Configure transmitting power (unit dBm)

## LoRa Transmitting Power (dBm)

EU868	US915	AU915	CN470	AS923	KR920	IN865	STE920
16	20	20	20	16	14	20	20
14	18	18	18	14	12	18	18
12	16	16	16	12	10	16	16
10	14	14	14	10	8	14	14
8	12	12	12	8	6	12	12
6	10	10	10	6	4	10	10
4	8	8	8	4	2	-	-
2	6	6	6	2	-	-	-

## 4.6.3 Badge Configuration

Bytes	1	2	1
Item	Type	POS	HB

## Type Field

Bit	Name	Value	Description
7~4	Type	0x9	Message type, the badge uses it to identify different downlink messages.
3	DFU Mode Switch	0x0: Disable 0x1: Enable	Enable: when there is a Windows 10 computer with the OTA app and a Bluetooth upgrade dongle nearby, the

			<p>badge enters DFU mode automatically. The user does not need to operate anything to upgrade his/her badge. The badge can still be upgraded within 3 minutes after power is on with the OTA app (Windows 10, Android and iPhone).</p> <p>This switch is disabled automatically after upgrading.</p> <p>Note 2.</p> <p>Disable: the badge can only be upgraded within 3 minutes after power is on with the OTA app (Windows 10, Android and iPhone).</p> <p>Firmware 13.26 and above support this feature.</p> <p>Document 991-01356, Bluetooth OTA for Windows 10, Rev 1.0.2 and above support this feature.</p>
<b>2~1</b>	Buzzer & Vibrator	<p>00: Buzzer mute, vibrator off</p> <p>01: Buzzer mute, vibrator on</p> <p>10: Buzzer on, vibrator off</p> <p>11: Buzzer on, vibrator on</p>	<p>Set the badge's default status of buzzer and vibrator. It takes an effect only when Proximity_warning is 1.</p>
<b>0</b>	Power off manually	<p>0x0: Enable</p> <p>0x1: Disable</p>	<p>Enable/disable: power off the badge manually.</p> <p>Enable: the user can switch off or on the power of the badge.</p> <p>Disable: The user cannot power off the badge when disabled. A downlink command can (refer to 4.6.4). The user can power on the badge.</p>

Note 2. Whether the upgrading is successful or not, the badge reboots after upgrading and DFU mode switch are disabled. The badge reports the current revision number to the server. The server should enable DFU\_Mode\_Switch again if the number is not the desired one.

When DFU\_Mode\_Switch is enabled, it does not affect any other features and the badge does not consume more power.

DFU\_Mode\_Switch status is not saved in the flash memory, it restores to 0 after reboot. **CS should compare the revision number reported by the badge when there is a new firmware to be upgraded.**

POS Field

Bit	Name	Value	Description
<b>15~0</b>	POS	0~65535	<p>The default setting is 0x002, 10s.</p> <p>This feature is reserved for future use. DO NOT CHANGE</p>

			THIS FIELD.
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## HB Field

Bit	Name	Value	Description
7~0	HB	1~255	The period of the heartbeat message, unit 30s. This value must be larger than 0.

## 4.6.4 Command Request

The Bluetooth receiving window can't be configured.

Bytes	1	1	1
Item	Type	MSGID	Value

## Type Field

Bytes	Name	Value	Description
Item	Type	0xA	Message type, the badge uses it to identify different downlink messages.
3~0	Command	0x2: register request 0x3: device reboot 0x4: RFU 0x5: RFU 0x6: RFU 0x7: RFU 0x8: Power off the badge 0x9: Extention configuration	Requested command. 0x2, request the badge to send a register message. 0x3, reboot the badge. 0x8, power off badges by LoRa downlink message, can be powered on manually. 0x9, contact warning delay, friend switch and report mode select. Refer to the value field (command = 0x9) below for details.

## MSGID Field

Bit	Name	Value	Description
7~0	MSGID	0-255	The server generates a sequence number of downlink messages that need MSGID. The badge responds ACK with this number. Otherwise, CS should resend the message.

## Value Field (command = 0x2~0x8)

Bit	Name	Value	Description
7~0	Value	-127-127	If the command is 6, this field is used to set the value of advancing or delaying time. If the value is positive, the receive starting time will delay, else will advance. If the command is 7, this field sets the value of the new receive time.

Value Field (command = 0x9)

Bit	Name	Value	Description
7~3	Value	0	Reserved for future use.
2	Contact warning delay 6s	0x0: Warning instantly after contact 0x1: Warning 6s later after contact	0x0: the delay is disabled in default. The badge starts to beep and vibrate whenever contact happens. It reports every 10s or 80s depending on the report mode. 0x1: the badge starts to beep and vibrate when the badges contact with each other continuously for longer than 6s. It still reports every 10s or 80s depending on the report mode.
1	Friend button switch	0x0: Disable 0x1: Enable	User can use the button to add or remove friends when enabled. When disabled, the user can't use the button to add or remove friend(s). If there are friends in the badge, they are still valid after the switch has been disabled. This could avoid mis-operation on the button. Whether the switch is disabled or not, the server can send a downlink command to add or remove friends. Friend feature is disabled in default.
0	Report mode select	0x0:10s Instant Report Mode 0x1:80s Periodic Report Mode	10s instant report mode is in default.

#### 4.6.5 Acknowledge

Bytes	1	1
Item	Type	MSGID

Type Field

Bit	Name	Value	Description
7~4	Type	0xF	Message type, the badge uses it to identify different downlink messages.
3~0	Reserved	0x0	Reserved for future use.

MSGID Field

Bit	Name	Value	Description
7~0	MSGID	0~255	The message ID of the corresponding uplink message, e.g., alarm report

#### 4.6.6 Set Friend Badges

A single badge can set up to 6 friend badges. Thus, the maximum size of this downlink message is 25 bytes. If the badge has made friends before, this message will erase all previous friends and add new friends according to this message's content. Since previous friends will be erased upon receiving the message, to preserve them, please include the previous friends when sending the command. Sending "0x00000000" to the badge will clear the friend list. When the adding friend process is complete, a heartbeat message will be immediately sent to indicate friend badges' information.

<b>Bytes</b>	<b>1</b>	<b>2</b>	<b>2</b>	...
<b>Item</b>	Type	Major	Minor	...

##### Type Field

Bit	Name	Value	Description
7~4	Type	0x5	Friend badge downlink message type.
3~0		1~6	The number of friend badges.

##### Major Field

Bit	Name	Value	Description
15~0	Major		Friend badge's major.

##### Minor Field

Bit	Name	Value	Description
15~0	Minor		Friend badge's minor.

#### 4.6.7 BT Bluetooth Transmitting Power and Receiving Threshold

The setting in this section is saved in flash and it remains the same after rebooting.

Bit	Name	Value	Description
15~12	Type	0xD	Message type, the badge uses it to identify different downlink messages.
11	Proximity_warning	0: OFF 1: ON	Enable/disable proximity warning, if it's 0, there should be no beep and no vibration. The badge still reports beacon-in-tracker received.
10~8	Bluetooth transmitting power	001: 4 dBm 010: 0 dBm 011: -4 dBm 100: -8 dBm 101: -12 dBm 110: -16 dBm 111: -20 dBm	This is used to set Bluetooth transmitting power. 0dBm is in default. (unit: dBm)
7	BT function and proximity detection	0: OFF 1: ON	Turn on or off beacon-in-Tracker function and proximity detection

<b>6~0</b>	Bluetooth receiving threshold	0x0~57	This is used to set the Bluetooth receiving threshold. 0x46 (-70dBm) is in default. (unit: -1dBm)
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### 4.7 Auto-configuration

This chapter describes how to configure the badge with a Bluetooth beacon. Please refer to the document 990-01123 "How to configure a Bluetooth beacon". When the badge receives a beacon with the following fields, it changes the settings accordingly. These settings are saved in RAM and they restore after rebooting. Beacon UUID is: 7B9BC50BCF6D42788D4D5FA6EA468517. Roles of each field in (Major, Minor):  
Badge's Bluetooth receiving window is 1s; so, it is recommended that the Bluetooth beacon's transmit interval is less than 500ms. The smaller the better.

Major	Minor				
<b>Bit15~0</b>	Bit15~Bit12	Bit11~Bit8	Bit7	Bit6~Bit4	Bit3~Bit0
<b>Reserved</b>	Management	Vibrator and Buzzer	Range	Bluetooth Transmitting Power	Bluetooth Receiving Threshold

#### Management Field

Bit	Name	Value	Description
<b>15~12</b>	Management	0x0: No action 0x1: Charging mode (to be developed) 0x2: Off duty mode (to be developed) 0x3: Turn off (to be developed)	Control badge's working mode when the auto-config beacon is detected. <b>0x0:</b> No action. <b>0x1:</b> Turns off Bluetooth broadcasting. It only turns on Bluetooth detection for 3 seconds, every 30 seconds. If the badge fails to detect this beacon in three periods, it recovers to normal mode. This feature could be used when many badges are in the same place for charging. <b>0x2:</b> Turns off the LoRa and Bluetooth broadcasting. It only turns on Bluetooth detection for 1 second, every 8 seconds. If the badge detects other beacons, it recovers to normal mode. This feature could be used to save power when people are off from work. <b>0x3:</b> Turns off all functions, including Lora and Bluetooth, automatically, and it can only be turned on by pressing the button for 4 seconds.

## Buzzer and Vibrator Field

Bit	Name	Value	Description
11~8	Vibrator and Buzzer	0x0: No action 0x1: vibrator disable and buzzer mute (restore) 0x2: vibrator disable and buzzer half sound level (to be developed) 0x3: vibrator disable and buzzer full sound level 0x4: vibrator enable and buzzer mute 0x5: vibrator enable and buzzer half sound level (to be developed) 0x6: vibrator enable and buzzer full sound level 0x7: vibrator disable and buzzer mute (no restore) 0x8: disable beacon-in-tracker and proximity detection (no restore) 0x9: disable beacon-in-tracker and proximity detection(restore)	Control the badge's vibrator enable/disable and buzzer's volume when the auto-config beacon is detected. When two or more such beacons are received, the badge uses the last one received. So please ensure there is only one beacon working in case of being set in chaos. Restore mean when the badge receives a beacon and changes the setting accordingly. When it can't receive the beacon, it restores the previous settings. No restore means it keeps the setting until the corresponding settings are changed with another beacon or downlink command. In "0x1: vibrator disable and buzzer mute," it keeps the setting until it can't receive the corresponding beacon, then it restores to the setting right before entering 0x1. If TP and RT are set in this mode, their settings return to the previous ones too when this beacon can't be received. The badge reports the corresponding setting when changed by the beacon in a heartbeat message.

## Extended Range Field

Bit	Name	Value	Description
7	Range	0x0: Not changed 0x1: Range up	Control the badge's Bluetooth receiving threshold range when the auto-config beacon is detected. If 0x0 is set, the range is -73dBm ~ -87dBm. If 0x1 is set, the range is -58dBm ~ -72dBm.

## TX Power Field

Bit	Name	Value	Description
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6~4	Bluetooth transmitting power	0x0: Not changed 0x1: 4 dBm 0x2: 0 dBm 0x3: -4 dBm 0x4: -8 dBm 0x5: -12 dBm 0x6: -16 dBm 0x7: -20 dBm	Control the badge's Bluetooth transmitting power when the auto-config beacon is detected.  The badge reports these parameters by heartbeat message.
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Receiving Threshold Field

Bit	Name	Value	Description
3~0	Bluetooth Receiving Threshold	0x0: Not changed 0x1: -73 dBm 0x2: -74 dBm 0x3: -75 dBm 0x4: -76 dBm 0x5: -77 dBm 0x6: -78 dBm 0x7: -79 dBm 0x8: -80 dBm 0x9: -81 dBm 0xA: -82 dBm 0xB: -83 dBm 0xC: -84 dBm 0xD: -85 dBm 0xE: -86 dBm 0xF: -87 dBm	Control the badge's receiving threshold when the auto-config beacon is detected.  The badge reports these parameters by heartbeat message.

## 4.8 Friend Group Function

The badge supports one friend group with maximum 7 members (6 friends and itself). It does not beep or vibrate when some badges are friends with each other. The Friend relationship is preserved after rebooting.

### 4.8.1 How to start the process?

If the badge wants to make friends, long-press the button for 1s to 3s when the badge is powered on, then release the button. At this moment, the red LED and the green LED flash alternately for 10s, which indicates that the badge is in the process.

In these 10s, nothing will happen if the user does not do anything. Then the red LED and the green LED will stop flashing alternately after 10s pass.

If you long-press the button for more than 3s, the badge will be powered off as usual.

#### 4.8.2 How to add a friend?

Click the button once when the red LED and green LED flash alternately. The badge will enter adding-friend process. At this moment, the green LED starts flashing.

Put friend badges with green LED flashing together (in 0.5-meter diameter circle) immediately, and it takes 30s for the badge to judge and accept friend badges, which is indicated by the green LED flashing for 30s. After the 30s, when the red LED starts flashing, and there is no beeping or vibrating (please make sure there is no other badge close by), such a phenomenon means adding-friend process has succeeded.

When friend badges are near in the future, the red LED will start flashing to indicate the relationship.

If you click the button once, then the red LED flashes once, which means that the badge has friend badges. If the green led flashes once, that means the badge does not have any friend badges.

When the badge has friend badges, the heartbeat message includes friend badges' (major, minor) on the tail.

Repeat the above-mentioned procedure to add more friends.

#### 4.8.3 How to remove friends?

As the red LED and green LED flash alternately, double click the button within 1s. Then the badge enters the removing-friend process. At this moment, the badge turns on the red LED for 3s to indicate removing successfully. This operation removes all friends.

If one friend (A) removes other friends while others do not, then when they are close to each other, badge A beeps and vibrates while other badges do not.

### 4.9 OTA DFU with Bluetooth

The badge supports OTA DFU. Please refer for detailed information:

991-01340 Bluetooth OTA for iPhone

991-01341 Bluetooth OTA for Android

991-01356 Bluetooth OTA for Windows 10

## 5. Packaging Information

Below is the packaging for the badge:

When shipped as samples:

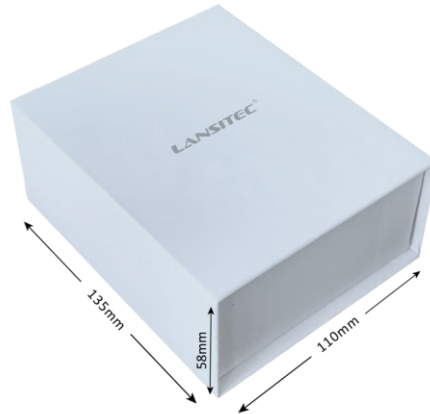
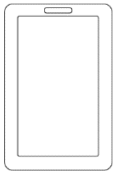
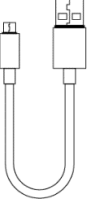





Figure 4: Sample packaging

Packing list:

 <p><b>Badge Bluetooth Badge</b> (97*62*7mm) x 1</p>	 <p><b>Micro USB Charging Cable</b> (1.2m) x 1</p>	 <p><b>Lanyard (0.45m) x 1</b></p>
 <p><b>PVC Sticker</b> (45*79*0.18mm) x 1</p>	 <p><b>NFC Tag (D=25mm) x1</b> NFC tag is pasted inside the housing at the bottom left corner. The tag has DevEUI information in default.</p>	

When shipped in batches:

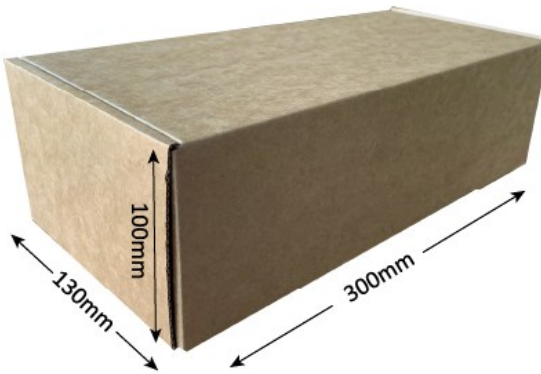


Figure 5: Batch packaging

Packing list:

	<p>Badge Bluetooth Badge (97*62*7mm) x 10</p>
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Accessories for each badge (shipped in another package):

<p>USB Charger x 1</p>	<p>Micro USB Charging Cable (1.2m) x 1</p>	<p>Lanyard (0.45m) x 1</p>
<p>PVC Sticker (45*79*0.18mm) x 1</p>	<p>NFC Tag (D=25mm) x1 NFC tag is pasted inside the housing at the bottom left corner. It has DevEUI information in default.</p>	

End of document