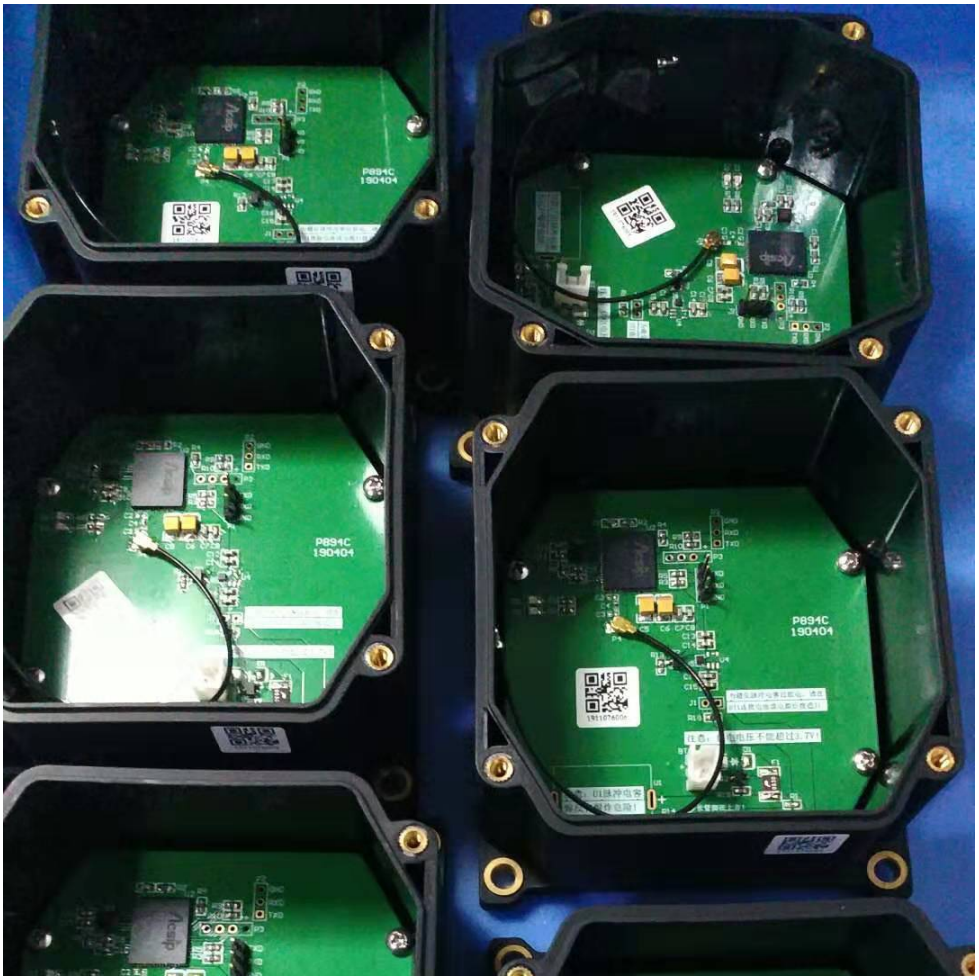
ZC Sensor

ZCT330M-SWP-L-CN470 LoRaWAN Tiltmeter Datasheet



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ZCT330M-SWP-L-CN470 LoRaWAN Tiltmeter

Datasheet

I. Overview

ZCT330M-SWP-L-CN470 is a high-accuracy tiltmeter based on MEMS technology and LoRaWAN wireless communication protocol. Developed and produced by Shanghai Zhichuan Electronic Tech Co., Ltd., the product is biaxial and of ±30 degree measurement range. It can be widely used in public utility, construction, telecommunications, electric power transmission and many other sectors.

II. Advantage

Industrial class components used
Stable and reliable
Ultra-low power consumption

III. Applications

Structural health monitoring
Security control
IoT

IV. Technical parameters (unless otherwise specified, the following parameters are typical values at 25 ℃)

1. Working parameters:

Item	Conditions	Minimum value	Typical value	Maximum value	Unit
Power supply voltage	Battery powered (3.6V C-size Lithium ion battery with pulse capacitor)(1	2.7	3.6	3.8	VDC
Static working current (standby)	Enable		210	220	uA
	Disable		1.5	5	
Peak current			150	300	mA
Operating temperature range		-40		+85	℃
Storage temperature range(2	Battery included	-40		+85	℃
	Battery not included	25		30	℃
weight	With battery		245		g

Note 1: Lithium ion batteries should never be recharged, otherwise they may explode. When a battery is out of power, please replace it in time, do not charge it!

Note 2: The self-discharge rate of the battery is less than 3% a year, if it is stocked at room temperature (25°C). The self-discharge rate becomes higher if the battery is stocked at a higher temperature.

2. Performance parameters:

Item	Test conditions	Minimum value	Typical value	Maximum value	Unit
Range	Biaxial	-30		30	degree
Resolution(1			0.001		degree
Accuracy	-15°～+15°		±0.005	±0.01	degree
	-30°～+30°		±0.01	±0.02	degree
Zero temperature drift	-40℃～+85℃		±0.002		degree/℃
				±0.2	degree
Zero point deviation			±0.05		degree
Heartbeat interval(2		60	86,400 (default)	131,071	second
Alarm angle	The XY axis is consistent		3		degree
Alarm accuracy(3	-5°～+5°		±0.01	±0.03	degree
	-15°～+15°		±0.03	±0.1	degree
	-30°～+30°		±0.1	±0.3	degree
Alarm delay time(4		0.3	2 (default)	25.5	second
Battery life(5			3		year
Protection level	Housed		IP65		

Note 1: Resolution refers to the minimum variation that can be detected by the sensor while working in its valid range.

Note 2: Heartbeat interval refers to the time interval at which the device periodically uploads data to the server.

Note 3: Alarm accuracy refers to the angular error when the product triggers an alarm. Suppose the alarm angle is 3 degree and the alarm accuracy is 0.03 degree, if X and Y axis angle are smaller than 2.97 degree, alarm will not be triggered, if X or Y axis angle is between 2.97 and 3.03 degree, alarm may or may not be triggered, if X or Y axis angle is larger than 3.03 degree, the alarm will be triggered for sure.

Note 4: Alarm delay time refers to the time when the product continues to tilt beyond the alarm angle to trigger an alarm.

Note 5: Suppose the ambient temperature is 25℃, the alarm is enabled, the battery capacity is 8,500mah, the battery loss coefficient is 0.7 and the heartbeat interval is 24 hours, below please find the calculation:

Average working current = (0.21 * (86400-3-5) + 150 * 3 + 13 * 5) / 86400 = 0.215941mA.

Note: 0.210 is the dormancy current (0.21mA), 86400 is the heartbeat interval (86,400 seconds, or 24 hours), 150 is the current consumed for transmitting data (150mA), 3 is the time consumed for transmitting data (3 seconds), 13 is the current

consumed when the product waits to receive data after completing data transmission (13mA), 5 is the waiting time (5 seconds).

Battery life = 8.5 * 1000 * 0.7 / 0.215941 / 24 / 365 = 3.145 years.
Note: 8.5 is the battery capacity (8.5 Ah) and 0.7 is the battery loss coefficient (70%). Under the same conditions, the battery can work for more than 10 years if the alarm function is disabled.

V. Function description

The tiltmeter can actively detect tilt angle and send heartbeat data at a set interval, and can trigger alarm as well. The default alarm threshold is based on absolute horizontal plane as zero point, however, in practice the installation position can be set as relative zero point. In case a relative zero point is set, if the tilt exceeds the alarm angle and keeps exceeding it for a period that is more than the alarm delay time, alarm will be triggered and the tiltmeter will upload the alarm frame to the server. If an alarm frame fails to get uploaded, the tiltmeter will stop updating its content and will automatically upload the alarm frame for 3 more times. If the three trials fail too, the tiltmeter will keep trying at a 60 minute interval, as long as the tilt exceeds the alarm angle. The tiltmeter will stop uploading the alarm frame when the tilt gets smaller than the alarm angle, meanwhile the original alarm function will be automatically restored.

VI. Internal indicator light description

The red light and the green light flash at the same time for three times as power-on initialization begins. If initialization succeeds, the green light gets on; if it fails, the red light gets on. The green light gets on when the tiltmeter is awaken by heartbeat or alarm. When the tiltmeter sends data, the red light will be on for a while then goes off. Both lights will be off to save power when the tiltmeter enters standby mode.

VII. Protocol format

The protocol format is in line with IoT Tilt Sensing Devices Communication Protocol of Shanghai Zhichuan Electronic Tech Co., Ltd. Version 1.1. Refer to Appendix for details.

1. Data structure table

Valid data ID and parameter range supported by the product						
Data ID	ID Descriptions	Data Type (Data Length)	R/W	Range	Default	Remark
0x00[1]	Sequence number	DWord(4)	R	/	0	The ID can be carried when platform downstream reads device and sets device parameters. The device returns the same data. Refer to examples in Appendix.
0x01	P/N	DWord(4)	R	/	/	/
0x02	Product model	Byte(1)	R	32	0x40	Factory code: 0x40
0x03	X-axis angle	Float(4)	R	-90°~90°	/	Current output angle of X axis
0x04	Y-axis angle	Float(4)	R	-90°~90°	/	Current output angle of Y axis
0x09	Relative angle of X axis	Float(4)	R	-90°~90°	0	Return X-axis angle when relative zero point is set
0x0A	Relative angle of Y axis	Float(4)	R	-90°~90°	0	Returns Y-axis angle when relative zero point is set
0x0C	Sensor temperature	Word(2)	R	-32768~32767	/	Sensor temperature = data/100 Unit: ℃
0x0D	Power supply voltage	Word(2)	R	0~65535	/	Power supply voltage = data/100 Unit: V
0x11	Enable / disable	Byte(1)	R/W	0~255	1	0 = disable 1 = enable Write 0x52 to clear this alarm and enable the next alarm immediately (not readable, not saved)
0x12	Alarm delay time	Byte(1)	R/W	3~255	20	The device waits for a certain period of time, after the tilt exceeds the alarm angle, before alarming. Unit: 0.1 second
0x13[2]	Restore factory settings	Byte(1)	R/W	0~255	0	0 = no operation 1 = restore sensor related parameters
0x21	Heartbeat interval	DWord(4)	R/W	60~131071	86400	The time interval for the device to periodically upload data to the server Unit: second
0x25	Software restart	Byte(1)	R/W	0x52	0	When 0xA5 is written, the tiltmeter will restart and the readout will always be 0.

0x3A	Set relative zero point command	Byte(1)	R/W	0~255	0	0 = absolute angle mode 1 = set current angle to zero, relative angle mode (0x09 and 0x0A value will be written to the current angle)
0x44	Alarm angle	Float(4)	R/W	0.1°~30°	3°	Alarm angle for X-axis and Y-axis are the same. (in case the user has set relative zero point, the maximum settable alarm angle will be the maximum alarm angle minus the larger relative zero point angle (X-axis or Y-axis), otherwise the alarm function may fail.

- A single data ID or a combination of commands can be sent to the device according to the format of the communication protocol.

Note 1: When carrying a sequence number, the data packet must contain 1 byte of data ID, 1 byte of data length, and 4 bytes of data content. Please refer to Appendix.

Note 2: When the device is reset to default factory settings, the heartbeat interval, alarm angle, alarm delay time, relative angle and enable/disable status will be restored to the default values, while the other parameters will remain unchanged.

2. Setting result code

Result code	Analysis
1	Set successfully
2	Parameter length incorrect (handled as protocol error if no return from device)
3	Incorrect parameter range
4	Data ID not writable

VIII. Network access parameter setting command

3.3V TTL interface (P1 interface inside the product), baud rate = 115200, check bits = none, data bits = 8, stop bits = 1. No other character (escape character, carriage return etc.) is needed to be attached to the end of the data being sent.

1. ***COMMAND** = enter configuration mode;
2. **#RESET** = software restart command;
3. **mac get_jointype** = query node access mode;

4. **mac set_jointype otaa** = set node access mode to OTAA;
5. **mac set_jointype abp** = set node access mode to ABP;
6. **mac get_deveui** = read node DEVEUI;
7. **mac set_deveui *ffffff1000003d7c***
   = set node DEVEUI to ffffff1000003d7c;
8. **mac set_appeui *0000000000000001***
   = set node APPEUI to 0000000000000001;
9. **mac get_appeui** = read node APPEUI;
10. **mac set_appkey *98929b92f09e2daf676d646d0f61d250***
    = set node APPKEY to 98929b92f09e2daf676d646d0f61d250
11. **mac get_appkey** = read node APPKEY;
12. **mac set_devaddr *30376533*** = set DEVADDR to 30376533
13. **mac set_appskey *6d15d1bf56cb5746641c44b43a29a1bd***
    = set APPSKEY to 6d15d1bf56cb5746641c44b43a29a1bd
14. **mac set_nwkskey *7926152f4ef5e7159e61a198ac84dc31***
    = set NWKSKEY to 7926152f4ef5e7159e61a198ac84dc31
15. **mac get_devaddr** = read node DEVADDR;
16. **mac get_appskey** = read node APPSKEY;
17. **mac get_nwkskey** = read node NWKSKEY;
18. **mac set_start_Channel *8***
    = set the channel number where LoRa frequency point begins to 8 (Channel 8~15);
19. **mac get_start_Channel**
    = read the channel number where LoRa frequency point begins;
20. **mac set_nwkid *0*** = set NETWORK ID to 0;
21. **mac get_nwkid** = read NETWORK ID;

OTAA network access setting: send commands 1. → 4. → 7. → 8. → 10. → 18. → 2. After the commands are sent, the product will be restarted. Note:

a. The configuration parameters in bold italics need to be modified according to specific user application;
b. The tiltmeter normally has default OTAA network access values, which will be used directly. Otherwise, the value should be set by the user himself.

ABP network access setting: send commands 1. → 5. → 12. → 13. → 14. → 18. → 2. After the commands are sent, the product will be restarted. Note:

a. The configuration parameters in bold italics need to be modified according to specific user application;
b. After restart, node ABP upstream and downstream sequence numbers are reset to 0, they should also be reset to 0 on the application server, so data uploaded by the node can be successfully received.)

IX. Installation procedure

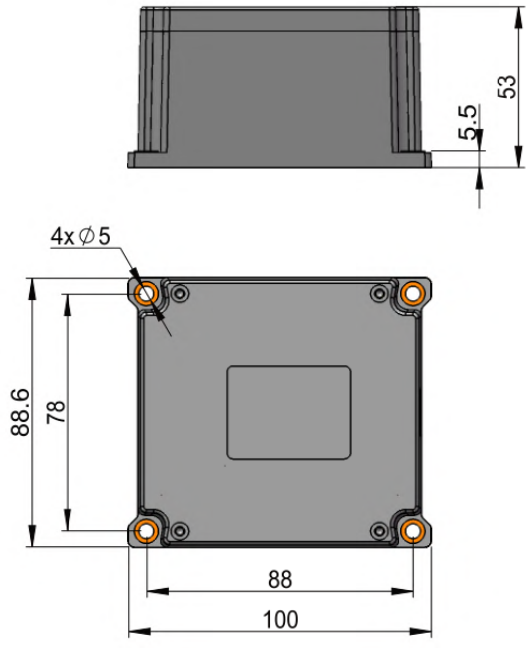
a. Open the lid of the tiltmeter and plug in the battery. Before the tiltmeter sleeps (in about 30 seconds), configure ABP network access parameters or OTAA network access parameters through the 3.3V TTL interface. After successful network access, put back the lid and tighten screws.

b. Before installation, if the user needs to confirm if the tiltmeter works okay, he can tilt it by more than 3 degrees for 5 seconds. If alarm data can be seen uploaded to the server platform, he knows that tiltmeter works okay.

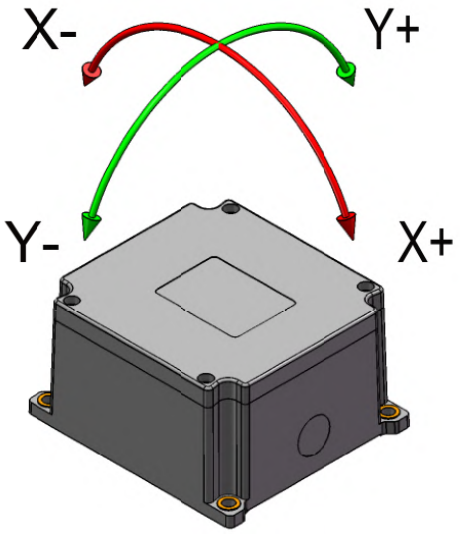
c. Install the sensor horizontally on the measured object, wait till the next heartbeat comes, and a frame of heartbeat data can be seen on the server platform.

X. Product dimensions and measurement directions

1. Dimensions



2. Measurement directions



XI. Instructions on ordering: ZCT330M-SWP-L-CN470

1. The frequency band of ZCT330M-SWP-L-CN470 tiltmeter is CN470.
2. The default battery capacity (customizable) is 8,500maA.

APPENDIX I

Chapter I Basic Agreement

1.1 Basic agreement

The protocol uses small-end mode network bytes to transfer bytes, words, double words, quadruple words and floats.

- Bytes are transmitted in a byte stream;
- Words are transmitted by sending the lower 8 bits first and then the upper 8 bits;
- Double words (DWords) are transmitted by sending the lower 8 bits first, then the upper 8 bits, then the upper 16 bits, and finally the high 24 bits.
- Quadruple words (Qwords) are transmitted by sending the lower 8 bits first, then the upper 8 bits, then the upper 16 bits, and so on, and finally the upper 56 bits;
- Floats are transmitted by sending the lower 8 bits first, then the upper 8 bits, then the upper 16 bits, and finally the high 24 bits.

1.2 Upstream

Refers to the direction the IoT device (tiltmeter) uploads data to the server platform (device → platform).

1.3 Downstream

Refers to the direction the server platform downloads data to the IoT device (tiltmeter) (platform → device).

1.4 Protocol format

Frame Data Format					
Frame Header	Protocol Version	Function Code	Data Length	Data Packet	Check Bits
1 byte	1 byte	1 byte	2 byte	N byte	CRC

Frame header: 0x5A;
Protocol version: 0x0A for V1.0, 0x0B for V1.1, and so on, protocol version = version number *10;
Function code: 0x03, 0x06, 0x07, 0x08, see Chapter 2 for details;
Data length: the length of the packet content (n), low byte first, high byte follows;
Packet: See Chapter 2 for details. Data transmission follows the rule that low byte first and high byte follows;
Check bits: The length of the checked data is from the first byte to the byte before the check bits. Modbus CRC16 method is applied. Low byte first, high byte follows.

Chapter II Protocol Format

2.1 Upstream data format

Frame Content						Description
Frame Header	Protocol Version	Function Code	Data Length	Data Packet	Check Bits	
0x5A	0x0B	0x07	length	...	Modbus CRC16	Upstream heartbeat frame
		0x08				Upstream alarm frame
		0x03				Upstream return read parameter frame
		0x06				Upstream return write parameter frame

2.2 Downstream data format

Frame Content						Description
Frame Header	Protocol Version	Function Code	Data Length	Data Packet	Check Bits	
0x5A	0x0B	0x03	length	...	Modbus CRC16	Downstream read parameter frame
		0x06				Downstream write parameter frame

- When the downstream data includes frame header error, function code error or CRC error, the device does not respond.

2.3 Data packet structure

Type A:

Data ID
1 byte

- Applied to the frame structure of downstream read parameters. The data packet needs to include Data ID only, except for Data ID-00 (sequence number). Refer to the data structure table for data ID.

Type B:

Data ID	Data Length	Data Range
1 byte	1 byte	n bytes (determined by data length)

- Applied to the frame structure of upstream heartbeat frame, upstream alarm frame, upstream return read parameter frame and downstream write parameter frame. Refer to the data structure table for data ID, data length and data range.

Type C:

Data ID	Set Result
1 byte	1 byte

- Applied to the upstream return write parameter frame. Refer to the data structure table for data ID, refer to the setting result table for setting result. Note:

1. If the downstream read parameter contains sequence number, the packet must be formed according to Type B;
2. If the protocol does not support the data ID, the returned data length is 0.

Chapter III Examples

3.1 Upstream heartbeat frame

Frame header	Protocol version	Function code	Data length		Packet 1			Packet 2						Packet 3					
5A	0B	07	1A	00	02	01	40	03	04	13	E8	A9	BF	04	04	8C	E0	1A	BF

Packet 4				Packet 5				Packet 6			Check bits	
0C	02	D7	06	0D	02	49	01	11	01	01	CC	44

Analysis:

Packet 1: product model, 0x40;

Packet 2: X-axis angle, -1.3274 deg;

Packet 3: Y-axis angle, -0.6050 deg;

Packet 4: sensor temperature, 17.5 °C;

Packet 5: power supply voltage, 3.3V;

Packet 6: alarm enabled.

3.2 Upstream alarm frame

Frame header	Protocol version	Function code	Data length		Packet 1			Packet 2						Packet 3					
5A	0B	08	17	00	02	01	40	03	04	1D	83	23	41	04	04	D8	A0	07	41

Packet 4				Packet 5				Check bits	
0C	02	EE	06	0D	02	46	01	C6	5A

Analysis:

Packet 1: product model, 0x40;

Packet 2: X-axis angle, +10.2195 deg;

Packet 3: Y-axis angle, +8.4768 deg;

Packet 4: sensor temperature, 17.7°C;

Packet 5: power supply voltage, 3.3V.

3.3 Set heartbeat interval

Frame header	Protocol version	Function code	Data length		Packet 1						Check bits	
5A	0B	06	06	00	21	04	10	0E	00	00	6E	20

Analysis:

Packet 1: set heartbeat interval to 3,600 seconds.

After the setting is successful, the node returns:

Frame header	Protocol version	Function code	Data length		Packet 1			Check bits	
5A	0B	06	03	00	21	01	01	AB	B4

Analysis:

Packet 1: heartbeat interval successfully set.

3.4 Set alarm delay time and alarm angle

Frame header	Protocol version	Function code	Data length		Packet 1			Packet 2						Check bits	
5A	0B	06	09	00	12	01	30	44	04	00	00	A0	40	6F	5F

Analysis:

Packet 1: set the alarm delay time to 4.8 seconds;

Packet 2: set the alarm angle to 5.000 deg.

After the setting is successful, the node returns:

Frame header	Protocol version	Function code	Data length		Packet 1			Packet 2			Check bits	
5A	0B	06	06	00	12	01	01	44	01	01	43	59

Analysis:

Packet 1: alarm delay time successfully set;

Packet 2: alarm angle successfully set.

3.5 Set relative angle measurement

Frame header	Protocol version	Function code	Data length		Packet 1			Check bits	
5A	0B	06	03	00	3A	01	01	DB	B3

Analysis:

Packet 1: set the current angle as relative zero point.

After the setting is successful, the node returns:

Frame header	Protocol version	Function code	Data length		Packet 1			Check bits	
5A	0B	06	03	00	3A	01	01	DB	B3

Analysis:

Packet 1: current angle successfully set to relative zero.

3.6 Read relative angle setting value

Frame header	Protocol version	Function code	Data length		Data ID 1	Data ID 2	Check bits	
5A	0B	03	02	00	09	0A	23	91

Analysis:

Data ID 1: X-axis relative angle zero point data ID;

Data ID 2: Y-axis relative angle zero point data ID.

After the query is successful, the node returns:

Frame header	Protocol version	Function code	Data length		Packet 1						Packet 2						Check bits	
5A	0B	03	0C	00	09	04	09	CC	A5	BF	0A	04	8E	0D	10	BF	3D	82

Analysis:

Packet 1: the X-axis relative zero point angle is -1.2971 deg;

Packet 2: the Y-axis relative zero point angle is -0.5567 deg.

3.7 Software restart command

Frame header	Protocol version	Function code	Data length		Packet 1			Check bits	
5A	0B	06	03	00	25	01	A5	EB	CE

Analysis:

Packet 1: restart the node.

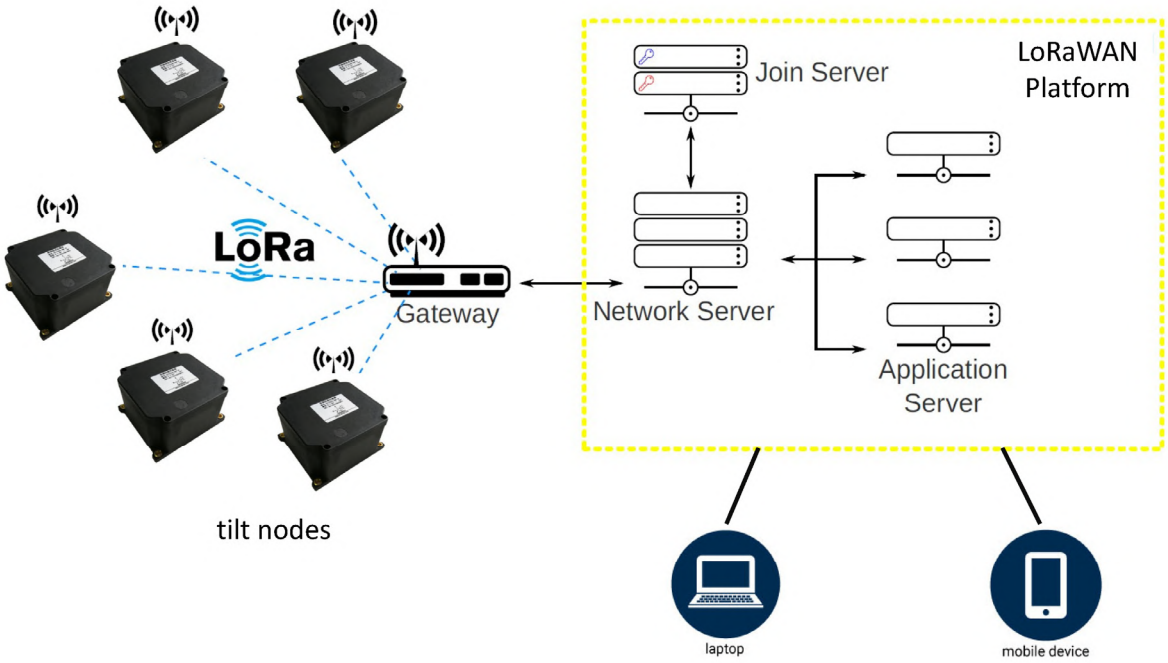
After successful setting, the node returns:

Frame header	Protocol version	Function code	Data length		Packet 1			Check bits	
5A	0B	06	03	00	25	01	01	EA	75

Analysis:

Packet 1: node restart setting is successful, node will restart in about 5 seconds.

APPENDIX II



LoRaWAN System Drawing