APC350F

PS01611

LoRaWANMIU Manual

V1.0

Document information

Info	Content
Keywords	*STee, LoRaWAN, MIU, SDK*
Abstract	This document describes the Spec of the MIU

Table of Contents

1 Introduction

MIU, LoRaWAN**S**ensor **I**nterface **U**nit, is a universal platform designed for different sensor providers who want to connect their sensors to the SNP WSN LoRaWAN system. This document will describe the MIU specifications and target applications.

2 Reference documents

LoRaWAN™ Specifications v1.0.1
WIRELESS SENSOR NETWORK TRIAL Specifications
SNP WSNSensor Integration SpecificationsRev 1.0
Physical Layer Specifications for LoRaWAN Operation in Singapore 920-925 MHz band v3.0
FCC 47cfr Part15.247

3 Abbreviations

MIUMeter Interface Unit
LoRaWAN Long Range Wide Area Network
FCC Federal communications commission
HW Hardware
SW Software
FW Firmware
IPxIngress Protection Level
SDK Software Development Kit
RF Radio Frequency
TX Transmitter
RX Receiver
Freq Frequency
CH Frequency Channel
SF Spreading Factor

4 Technical

MIU (Meter interface unit) is a LoRaWAN compatible with an ultralow power MCU STM32L0xx and high performance LoRa transceiver SX1276. MIU would be powered by internal battery.
NFC would be integrated into MIU for parameters configuration, like LoRaWAN configuration and others parametersconfiguration.

4.1 Electrical specifications

Table below list the key specifications of the LoRaWAN sensor interface unit.

Table 4-1 Electrical specifications of MIU

ITEMs	Parameter	Specifications	Unit
Electrical Characteristics	power supply (Internal)	3.6V type Battery voltage range 3.6 to 2.4V	V
	Sleep current	3.5uA	uA
	Band	920-925MHz	MHz
	Protocol	LoRaWAN Class A	
	LoRaWAN Mode	OTAA/ABP Configurable	
	TX current	125mA @19dBm type	mA
	RX current	16mA	mA
	Output power	18dBm max	dBm
	Sensitivity	-137dBm @SF12, BW125kHz,	dBm
	Harmonics	<-36dBm above 1GHz	dBm
	Antenna Gain (Internal)	1.5dBi type	dBi
Mechanical	Mechanical Size	TBD	mm
	IP Level	IP68	
Environment	Operating Temperature	-25 to +70℃	℃
	Storage Temperature	-40 to +85℃	℃
	Relative Humidity	20 – 90%	
Certification	FCC	FCC part 15 Class B FCC 15.247	
	IP68		

4.2 The MIU interfaceCharacteristics:

Items	Pin define	Specification	Color	remark
Port	GND		BLACK	
	Pulse	Digital input. pulse signal of meter	RED	Dry contact. Open: normal, close: pulse
	Direction	Digital input. flow direction of meter	YELLOW	Dry contact. Open: Forward, close: Reverse
	Cut wire	Digital input. Cut wire status of meter	WHITE	Dry contact. Open: alarm, close: normal

4.3 Mechanical Specifications and IPx

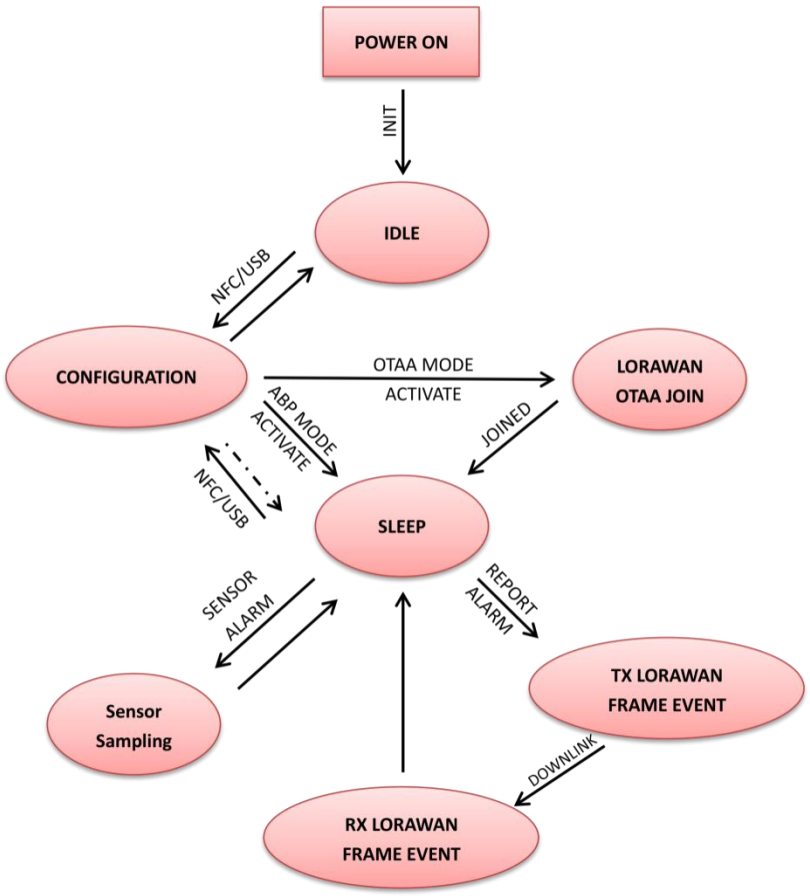
Mechanical size will be similar to 90x140x40 mm (TBD) or smaller.
The enclosure of the MIU should be IP6x. All the box mounting connectors and external connectors should be IP6x.Irrigation methods sealing glue will be used to achieve excellent water and dust effects.

4.4 FCC compliant

MIU should be FCC compliant.
EMC would comply with FCC part 15 Class B.
Radio requirement should comply with FCC 15.247.

5 MIU Application Layer Design

The part presents the application layer protocol implemented in the MIU. The application layer leverages on the LoRaWANspecifictions v1.0.1 released 2016. Figure 5 1 show the LoRaWANMIU flow chart in operation.



5.1 LoRaWAN Activation

After the MIU is activated and powered it will try to join an available LoRaWAN network in its vicinity. After joining the LoRaWAN at the LoRa MAC level the MIU will send a status message to create a link with the sensors' network NMS.

Based on LoRaWAN specifications section 6.2 and 6.3, During a session between the end-device and the gateway two encryption key are used, NwkSKey and AppSKey. There two options for the end-device to acquire those keys, Over the Air Activation (OTAA) or Activation By Personalization (ABP):

- In OTAA mode the keys are generated in the join procedure and it unique to every end-device.
- In ABP mode, the device must know the NwkSKey and AppSKey keys in advance. All end-devices have the same keys, so if the keys are revealed then the transmissions of all end-device will be unsecured.

The MIU can support both ABP and OTAA modes, however we recommend using only the OTAA activation mode since it is more secured.

5.2 MIU Data Transmission

MIU will transmit message in a predefined duty cycle or a sensor event is triggered. The transmission follows below rules.

- The MIU will set random offset for each transmission period in case of packet collision;
- The MIU will listen at selected channel to make sure the channel is free, RSSI level is less than a predefined THRESHOLD (e.g.: -80dBm)
- The MIU will store latest 72+ messages, these data is readable through NFC interface
- To make sure data integrity and decrease downlink bandwidth
- The MIU is high security benefits from the AES-128 encryption

5.3 Variable define:

Variable Data:	
Meter ID	As string. Max as 10 characters. Configure via NFC
Total Pulse Data	As unsigned long. Can configure its initial value via NFC
Meter Factor code	As Byte. Configure via NFC
Sample Interval (min)	As short. Default is 60min.
Transmit Interval	As byte. N Times of sample interval (1 to 6). Default is 4.
Meter Status	As Byte. Temper/Cut Wire, Battery Low, Back Flow.
Time Counter	As long. Increate 1 per second
Battery value	As Byte. Battery voltage rate to the full. 0 – 100%
Alarm Status	Meter Status Alarm. Bit0: cut wire, Bit1: Battery low

5.4 Water Meter Accumulation:

1. When initial mater value transfer from the NFC (float data), it will convert to the pulse data by Meter factor. Then save as the Total Pulse Data.
2. When there is one pulse detected, if the direction is forward, then add one to the Total Pulse Data. If the direction is reverse, then minus one from the Total Pulse Data.
3. When sample data, it will use the Total Pulse Data convert to Meter Data (factor).

5.5 Water Meter Status:

1. Cut Wire: as bit0. Set as “0” if the input is short to GND.
2. Battery Low: as bit 1. Set as “1” if the battery is lower than 80%.
3. Direction: as bit 2. Set as “1” if the input is open to the GND. (forward)

5.6 Sample Data:

1. Meter Value: as float. Total Pulse value/Factor.
2. Meter Status: as byte. Cut Wire as bit0, Battery Low as bit1, Back Flow as bit2.
3. Time Counter: as unsigned long.

When Sample interval reached, the MIU will get the Total pulse value and Meter status as one sample with the time counter value.

5.7 Transfer Data:

When Transmit interval reached, the MIU will create the report with the samples. (If Transmit interval same as sample interval, only one sample in the report.) MIU should use confirmed method to report as uplink. If the MIU cannot get the reply from the server, it needs to resend the data again by once.

5.8 Store Data and Backup:

When Transmit the data, if the MIU cannot receive the reply from the server, it should store the samples data. The max stored the samples data is 150. When full, replace old with new as FIFO. When MIU backup the stored data via NFC, it will use tools system time with the time counter as Time Stamp. After stored data has been backup, the stored data will be deleted.

5.9 NFC Function:

1. Active/ Deactivate the LoRa Transmit with Security Key and without Key.
2. Configure Meter ID, Total Initial Data as m^3, Meter Factor code. Sensor Type
3. Get the Current Status, Current Data.
4. Backup Stored Data, after backup the stored data will be deleted.

5.10 Alarm

When Cute Wire, Battery Low happened, it will trigger an alarm. MIU will create the Alarm report and transmit uplink at once. And then clear the alarm bit.

1. Cut Wire: bit 0. Set to “1” if the status is from “0” to “1”.
2. Battery Low: bit 1. Set to ‘1’ if the status from “0” to “1”.

5.11 Low Power Design

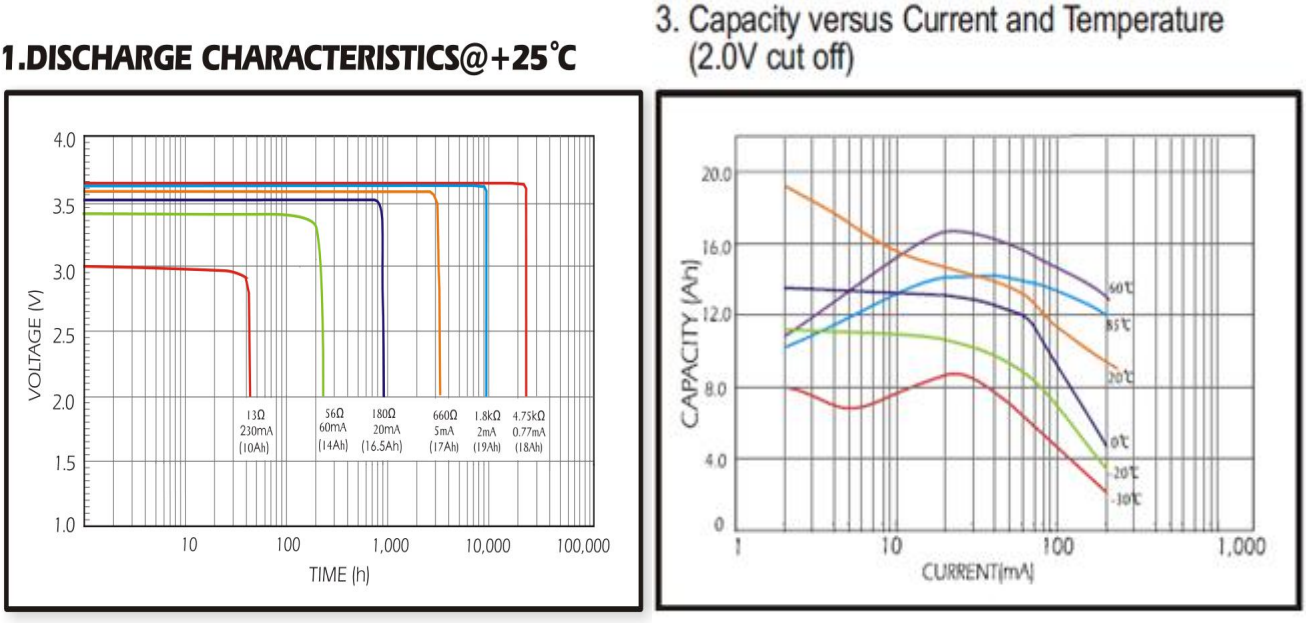
The MIU is a low power device, and the application software is designed to save power as much as possible. The software is designed as an event trigger structure, the main function will enter sleep mode if there is no processing event, after sleep the MIU will wait alarm or interrupt to wake up to process necessary event.

5.11.1 Life Span Calculation

5.11.1.1 Assumption

5.11.1.1.1 Battery

This report uses Evebattery's 19Ah ER34615 type as reference, the discharge characters as showed below.



This follow table assumes MIU device works in LoRaWAN class A mode.

STM32 MCU supply a low power pulse detector, which allow MCU counts the pulse in low power mode.

Name	Current	Time period	Average current
CPU activate	3mA	5ms/1s	15uA
CPU sleep	3.5uA	--	3.5uA
RF send (SF12, BW125k, TX 19dBm, resend once)	125mA	1.5 * 1.65s / 4h	21.5uA

RF received	15mA	5s / 4h	5.2uA
IO interface	20uA	--	30uA
Battery leakage	5uA	--	5uA
Total consumption	--	--	80.2uA

***Battery Capacity *0.5(50%)	19000maAH*0.5= 9600mAH
Theory calculate Time for years	9600/0.0802 = 120000h= 13year

***Note: Consider the current used and temperature range; the capacity will be drop to 50%.

5.12 MIU Data Format Reference

5.12.1 Uplink

5.12.1.1 Configuration Report

Field	Len	Value
Code	1	0x8F (user define report)
Length	1	17
Sensor type	1	0x10
Report interval	1	In minutes
Location longitude	4	As set in the activation
Location latitude	4	As set in the activation
Alert enable	1	1 / 0 – Enable / Disable
Alert threshold	2	RFU
FW Version	2	xx.xx

5.12.1.2 Meter Information Report

Field	Len	Value
Code	1	0x8E (Configure report)
Length	1	2 + 4 + N + 2
Separate	1	#
Meter ID	N	Max to 16 characters
Separate	1	#
Meter Sensor type	1	
Meter Factor code	1	
CRC	2	CRC check

5.12.1.3 Water Meter Report

Field	Len	Value
Code	1	0x80 (time interval)
Length	1	31

Sequence number	2	Cyclic number, increment for every report
Battery voltage	1	%
Elapsed time	2	Seconds from measurement to transmission
Water Meter code	1	0x10
Number of data	1	4
Meter Total Pulse 1 sample	4	(float) Total consumption as m^3
Meter status	1	Status
Meter Total Pulse 2 sample	4	(float) Total consumption as m^3
Meter status	1	Status
Meter Total Pulse 3 sample	4	(float) Total consumption as m^3
Meter status	1	Status
Meter Total Pulse 4 sample	4	(float) Total consumption as m^3
Meter status	1	Status
CRC	2	CRC check

5.12.1.1 Water Meter Alarm Report

Field	Len	Value
Code	1	0x81 (alarm report)
Length	1	11
Alarm Sequence number	2	Cyclic number, increment for every report
Battery voltage	1	%
Elapsed time	2	Seconds from measurement to transmission
Meter Alarm	1	Bit0: Cut wire, Bit1: Battery Low**,** Bit:2 Back flow
Meter status	1	Status
CRC	2	CRC check

5.12.2 Downlink

5.12.2.1 Configuration Request

Field	Len	Value
Code	1	0x21
Length	1	2

5.12.2.2 Meter information Request

Field	Len	Value
Code	1	0x22
Length	1	2

5.12.2.3 Change Report Interval

Field	Len	Value
Code	1	0x20 (event command)
Length	1	7
Event Type	1	0x00
Report interval	2	New report interval in minutes. Default is 60min
Transmit interval	2	N times Sample. Default 4.

6 Application information

MIU is a sensor interface unit based on LoRaWAN protocol v1.0 (refer to “Physical Layer Specifications for LoRaWAN Operation in Singapore 920-925 MHz band”). With this universal platform which is embedded with LoRaWAN protocol stack and also some essential APIs, the customer could integrate their own sensors and run LoRaWAN operation.
Sections below will give some example to show how to connect kinds of sensors.

6.1 MIU + pulse counter

MIU is possible to be accessed into with two pulse signal from two counters/meters. So the payload in application will be composed of two groups of data from these two meters.

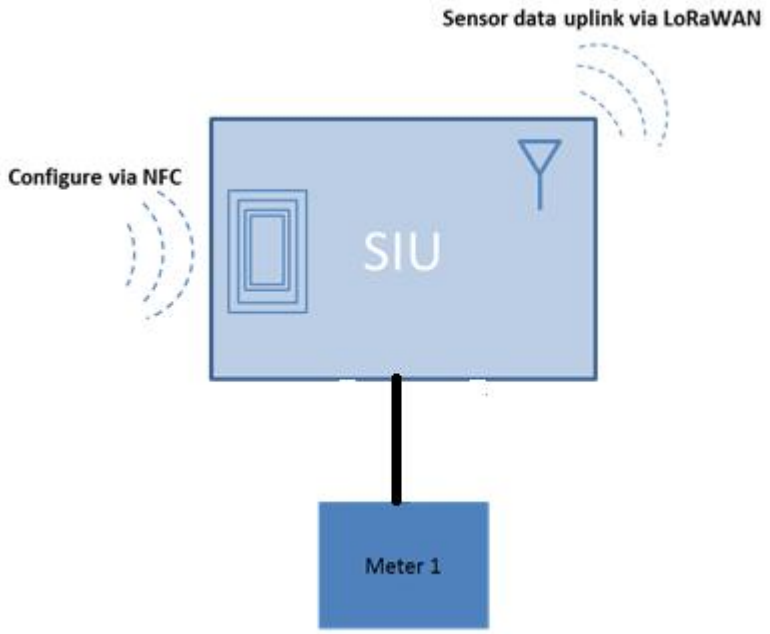


Figure 6- 2LoRaWAN pulse counter

7 Append

7.1 NFC Application Layer Design

7.1.1 NFC Application Authentication:

When open the NFC Application, it should login Password for Authentication. There is an option to choose whether with Security Key file or not.

- Log in with Security Key file: the **password** will be the key that encrypted the Security Key file.
- Log in without Security Key file: The password will be store in the binary file at the pre-define folder.

7.1.2 Device changing new key via NFC:

When user wants to changing the new Security Key for the Device, it needs to do as the follow:

- Generate the encrypted key file. (ST will create this key file)
- Choose "Login with Key file" and login using the key for the encryption key file as password.
- Decrypted the key file using the password.
- Scan the device to get the DevEUI from the device via NFC.
- Get the key using the DevEUI from Key file.
- Activation the Device. The new key will be passed via the NFC.
- Save the new key into the Device.

7.1.3 NFC App Activation and Deactivation Device:

To activation/ the device, the NFC Application needs to do as the follows:

- Scan the device to get the DevEUI.
- Choose the Activation/Deactivation the device.
- Execute NFC transfer to active/deactivate the Device.
- Scan again to confirm the Device has been Activation/Deactivation.
- Every time when finish the transfer via NFC, there should have sound to indicate finish and the transfer result should be display.

7.1.4 Download Store Data Via NFC

It needs to get the stored data from the device via NFC and then save it to a CSV file.

7.1.5 NFC key file and encrypt.

The new Key CSV files as example as follow:

ABP mode:

DevEUI	NetSKey	AppSKey
0080000000000CCEF	0123456789ABCDEF0123456789ABCDEF	0123456789ABCDEF0123456789ABCDEF
……	……	……

OTAA mode:

DevEUI	AppEUI	AppKey
0080000000000CCEF	0123456789ABCDEF	0123456789ABCDEF0123456789ABCDEF
……	……	……

The Encrypted and Decrypted method please refer to the file “key encryption”.

7.2 Total consumption calculates

- Meter data = Total Pulses / Meter factor.
- Total Pulses = Meter data * Meter factor.

Meter factor: pulses/m^3. It should get from the Meter Factor List.

Table 3: Meter Factor

Gallon/Liter per Pulse	Factor (division ratio)	No	Bit 3	Bit 2	Bit 1	Bit 0
10	100	0	0	0	0	0
5	200	1	0	0	0	1
50	20	2	0	0	1	0
0.1	10000	3	0	0	1	1
20	50	4	0	1	0	0
100	10	5	0	1	0	1
1000	1	6	0	1	1	0
500	2	7	0	1	1	1
10000	0.1	8	1	0	0	0
0.25	4000	9	1	0	0	1
2.5	400	10	1	0	1	0
0.5	2000	11	1	0	1	1
1	1000	12	1	1	0	0
2	500	13	1	1	0	1
200	5	14	1	1	1	0
N/A	N/A	15	1	1	1	1

FCC Statement

1. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference.

(2) This device must accept any interference received, including interference that may cause undesired operation.

2. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help

RF Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This equipment should be installed and operated with minimum distance of 20cm between the radiator and your body.