Outdoor Environment Monitoring Sensor

Featuring LoRaWAN®

EM500 Series

Communication Protocol

Revision History

Date	Doc Version	Description
June 8, 2021	V 1.0	Initial version
July 13, 2021	V 1.1	Add Soil Moisture Definition
April 12, 2022	V 1.2	Add reboot downlink command
May 25, 2023	V 2.0	Update based on hardware 2.x: Add downlink commands, history enquiry and temperature mutation threshold uplinks
April 8, 2024	V 2.1	1. Add distance shift threshold alarm 2. Add calibration, alarm dismiss, D2D downlink commands
Nov. 26, 2024	V 2.2	Add EM500-SMTC soil moisture threshold related commands

Contents

1. Overview

EM500 Series use the standard Milesight IoT payload format based on IPSO. All data are based on following format:

Channel1	Type1	Data1	Channel2	Type2	Data2	Channel 3	...
1 Byte	1 Byte	N Bytes	1 Byte	1 Byte	M Bytes	1 Byte	...

Note:

1) All explanations and examples in this document are based on HEX format.
2) Data part uses little endian.
3) For all Milesight IoT product decoder examples please find files on https://github.com/Milesight-IoT/SensorDecoders

2. Uplink Payload

Uplink payloads of EM500 series are made up of device information and sensor data.

2.1 Device Information

EM500 series report basic information of device whenever joining the network.

Item	Channel	Type	Description
Protocol Version	ff	01	01=>V1
Hardware Version		09	01 40 => V1.4
Software Version		0a	01 14 => V1.14
Power On		0b	Device is on
Device Type		0f	00: Class A, 01: Class B, 02: Class C
Device SN		16	16 digits
Measuring Range		1b	1a + Max. range (2B) + Min. Range (2B) **Note:** only EM500-PT100/SWL/UDL supports to report this packet.

Example:

1. Device information report

ff0101 ff090140 ff0a0114 ff166410908243750001					
Channel	**Type**	**Data**	**Channel**	**Type**	**Data**
ff	01(Protocol Version)	01=>V1	ff	09 (Hardware Version)	01 40 => V1.4
Channel	**Type**	**Data**	**Channel**	**Type**	**Data**

ff	0a(Software Version)	01 14 => V1.14	ff	16 (Device SN)	6410908243750001

2. EM500-SWL-L005 measuring range:

ff1b1a05000000		
Channel	**Type**	**Data**
ff	1b(Measuring Range)	Max. Range: 0500 => 00 05=5m Min. Range: 0000=0m

2.2 Sensor Data

Item	Channel	Type	Data Type	Unit	Model
Battery Level	01	75	UINT8	%	All
Temperature	03	67	INT16/10	℃	EM500-PT100, EM500-SMTC, EM500-CO_2
Humidity	04	68	UINT8/2	%RH	EM500-CO_2, EM500-SMT/SMTC
Barometric Pressure	06	73	UINT16/10	hPa	EM500-CO_2
Depth	03	77	UINT16	cm	EM500-SWL
Pressure	03	7b	UINT16	kPa	EM500-PP
CO_2	05	7d	UINT16	ppm	EM500-CO_2
Conductivity	05	7f	UINT16	us/cm	EM500-SMTC
Distance	03	82	UINT16	mm	EM500-UDL
Light	03	94	UINT32	Lux	EM500-LGT
Soil Moisture	04	ca	UINT16/100	%RH	EM500-SMT/SMTC

Note:

1. When the device fails to collect sensor data, it will report FFFF or FF;
2. When the device collect the sensor data out of measuring range, it will report FFFD.

Examples:

1. Battery Level packet:

1) Report once with sensor data after joining the network;
2) Report every 24 hours;
3) Report once when the battery level is below 10%.

01 75 64		
Channel	**Type**	**Value**
01	75(Battery)	64 => 100%

2. Periodic packet or threshold alarm packet:

EM500-CO_2

03671001 046871 057d6704 06736827					
Channel	**Type**	**Data**	**Channel**	**Type**	**Data**
03	67 (Temperature)	10 01=>01 10 =272/10=27.2°C	04	68 (Humidity)	71=>113/2=56.5 %
Channel	**Type**	**Data**	**Channel**	**Type**	**Data**
05	7d (CO_2)	67 04 => 04 67 =1127 ppm	06	73 (Barometric Pressure)	68 27=>27 68=10088/10= 1008.8 hPa

EM500-LGT

039432870000		
Channel	**Type**	**Value**
03	94(Light)	32 87 00 00=>00 00 87 32 =34610 Lux

EM500-PP

037b0a00		
Channel	**Type**	**Value**
03	7b(Pressure)	0a 00=>00 0a=10 kPa

EM500-PT100

0367faff		
Channel	**Type**	**Value**
03	67 (Temperature)	fa ff=>ff fa= -6/10=-0.6°C

EM500-SMT/SMTC

03671001 04cad804 057ff000					
Channel	**Type**	**Data**	**Channel**	**Type**	**Data**

03	67 (Temperature)	10 01=>01 10 =272/10 =27.2°C	04	ca (Soil Moisture)	d8 04=>04 d8=1240/100 =12.4%
Channel	**Type**	**Data**			
05	7f (Conductivity)	f0 00 => 00 f0=240 μs/cm			

Note: if hardware version is 1.x and firmware version is below 2.34, the soil moisture type ID is 68 and resolution is 0.5% RH.

EM500-SWL

03770200		
Channel	**Type**	**Value**
03	77(Depth)	02 00=>00 02 =2 cm

EM500-UDL

03821e00		
Channel	**Type**	**Value**
03	82(Distance)	1e 00=>00 1e =30 mm

2.3 Temperature Mutation Threshold

EM500-CO_2/PT100/SMTC supports to report temperature mutation threshold alarm which has a different format with normal threshold alarm.

Item	Channel	Type	Description
Temperature Mutation Threshold	83	d7	Temperature(2B) + Mutation Value(2B) + 02

Example:

1. Normal Temperature Threshold Alarm Packet or Alarm Dismiss Packet

03675201 01		
Channel	**Type**	**Value**
03	67 (Temperature)	52 01 => 01 52 => 338/10 = 33.8°C

2. Temperature Mutation Alarm Packet

83d722010c0002		
Channel	**Type**	**Value**
83	d7	Temperature: 22 01 => 01 22 => 290/10

	(Temperature Mutation Threshold)	= 29°C Mutation Value: 0c 00 => 00 0c => 12/10=1.2°C 02 => Mutation Alarm

2.4 Distance Shift Threshold

EM500-UDL supports to report distance shift threshold alarm which has a different format with normal threshold alarm.

Item	Channel	Type	Description
Distance Shift Threshold	83	e9	Distance(2B) + Shift Value(2B) + 02

Example:

1. Normal Distance Threshold Alarm Packet or Alarm Dismiss Packet

03821e00		
Channel	**Type**	**Value**
03	82(Distance)	1e 00=>00 1e=30 mm

2. Distance Shift Threshold Alarm Packet

83e9467d206c02		
Channel	**Type**	**Value**
83	e9(Distance Shift Threshold)	Distance: 46 7d => 7d 46 => 32070mm Shift Value: 20 6c => 2c 60 => 27680mm 02 => Mutation Alarm

3. Downlink Command

Downlink is used for controlling the EM500 via network server remotely. Downlink port (Application port) is 85 by default and can be configured via ToolBox.

Note: only device with hardware V2.x and later supports below commands.

3.1 Basic Settings

Item	Channel	Type	Description
Collecting Interval	ff	02	2 Bytes, unit: s
Reporting Interval		03	2 Bytes, unit: s
Reboot		10	ff (Reserved)
Time Zone		17	INT16/10
Sensor Collection		18	Sensor Type (1B) + Status (1B) Status: 00: disable, 01: enable

			EM500-CO_2 Sensor Type: 00: all 01: temperature 02: humidity 05: CO_2 06: barometric pressure **EM500-SMTC Sensor Type:** 00: all 01: temperature 02: moisture 03: electric conductivity
Data Storage		68	00: disable, 01: enable
Data Retransmission		69	00: disable, 01: enable
Data Retransmission Interval		6a	3 Bytes Byte 1: 00 Byte 2-3: interval time, unit:s range: 30~1200s (600s by default)

Example:

1. Set Reporting Interval as 20 mins

ff 03 b0 04		
Channel	**Type**	**Data**
ff	03(Set Reporting Interval)	b0 04 => 04 b0 = 1200s=20 mins

2. Reboot the device.

ff10ff		
Channel	**Type**	**Value**
ff	10 (Reboot)	ff (Reserved)

3. Set the time zone as UTC-2.

ff17ecff		
Channel	**Type**	**Value**
ff	17	ec ff => ff ec = -20/10=-2 the time zone is UTC-2

4. Disable humidity collection of EM500-CO_2 sensor.

ff180200		
Channel	**Type**	**Value**
ff	18	02=Humidity, 00=Disable

3.2 Calibration Settings

Item	Channel	Type	Description
Numerical Calibration	ff	f1	Sensor Type (1B) + Enable (1B) + Calibration Value (2B)

Code	Sensor Type	Calibration Value
00	Temperature	INT16/10, unit: °C
01	Soil Moisture	INT16/100, unit: %RH
02	Distance(UDL)	INT16, unit: mm
03	Pipe Pressure	INT16, unit: kPa
04	CO_2	INT16, unit: ppm
05	Barometric Pressure	INT16/10, unit: hPa
06	Depth (SWL)	INT16, unit: cm
07	Conductivity	INT16, unit: us/cm
08	Light	INT16, unit: lux
09	Humidity	INT16/2, unit: %RH

EM500-CO_2 Only:

Item	Channel	Type	Description
CO_2 Calibration	ff	1a	00: Factory Calibration Restored 03: Manual Calibration
CO_2 Auto Background Calibration		39	5 Bytes, **Byte 1:** 00-disable, 01-enable **Bytes 2-3:** calibration period, range: 1-65534h, default: 168h **Bytes 4-5:** calibration value, range: 1-65534 ppm, default: 400ppm
CO_2 Barometric Pressure/Altitude Compensation		87	3 Bytes, **Byte 1:** 00-disable, 01-barometric pressure compensation, 03-altitude compensation

			Byte 2-3: altitude, range: 0-5000 m, unit: m

Examples:

1) Enable temperature calibration and set calibration value.

fff1 01 01 fdff		
Channel	**Type**	**Value**
ff	f1 (Numerical Calibration)	01=temperature 01=Enable fdff=>fffd=-3/10=-0.3 °C

3.3 Threshold Settings

<table>
<tr><th>Item</th><th>Channel</th><th>Type</th><th>Description</th></tr>
<tr><td>Threshold Alarm</td><td>ff</td><td>06</td><td>9 Bytes, CTRL (1B) + Min. Threshold (2B) + Max. Threshold/Mutation Threshold(2B) +00000000(4B)
CTRL:
Bit2~0:
000 - disable
001 - below (minimum threshold)
010 - over (maximum threshold)
011 - within
100 - below or over
101- mutation
Bit 5~3: sensor type
Bit 7~6: 01=enable, 00=disable
<table>
<tr><th>Model</th><th>Sensor Type</th><th>Threshold Value</th></tr>
<tr><td>EM500-CO2</td><td>001: CO2 threshold
010: temp. Threshold
011: temp. Mutation threshold</td><td>CO2 Unit: ppm
Temp. Unit: 0.1 °C</td></tr>
<tr><td>EM500-LGT</td><td>01</td><td>Unit: lux</td></tr>
<tr><td>EM500-SMTC</td><td>001: conductivity</td><td>Conductivity : us/cm</td></tr>
</table>
</td></tr>
</table>

				threshold 010: temp. Threshold 011: temp. Mutation threshold 100: soil moisture threshold	Temp. Unit: 0.1 °C
			EM500-PP	01	Unit: kPa
			EM500-PT100	001: temp. Threshold 010: temp. Mutation threshold	Unit: °C
			EM500-SWL	001	Unit: cm
			EM500-UDL	001: distance threshold 010: shift threshold	Unit: mm
Alarm Reporting Times		f2	2 Bytes		
Alarm Dismiss Report		f5	00: disable, 01: enable		

Examples:

1) Enable temperature threshold alarm of EM500-PT100 and set the below threshold value as 10°C.

ff06 49 6400 000000000000		
Channel	**Type**	**Value**
ff	06(Threshold Alarm)	CTRL: 49=>01001001 01=enable, 001=temperature threshold 001=below Threshold: 64 00=>00 64=100*0.1=10 °C

2) Enable temperature mutation threshold of EM500-PT100 and set mutation value as 1°C.

ff06 55 0000 0a00 00000000

Channel	Type	Value
ff	06(Threshold Alarm)	CTRL: 55=>01010101 01=enable, 010=temperature mutation threshold 101=mutation Mutation value: 0a 00=>00 0a=10*0.1=1°C

3.4 Milesight D2D Settings

EM500-PP/PT100/SMTC/UDL supports to work as Milesight D2D controllers.

Item	Channel	Type	Description
D2D Feature	ff	84	00: disable, 01: enable
D2D Key		35	First 16 digits, last 16 digits are fixed as 0
D2D Controller		96	**Byte 1:** 00-threshold triggered 01-threshold not triggered 02-temperature mutation threshold/distance shift threshold triggered 03-SMTC conductivity threshold triggered 04-SMTC conductivity threshold not triggered 05-SMTC soil moisture threshold triggered 06-SMTC soil moisture threshold not triggered **Byte 2:** 00-disable, 01-enable **Byte 3:** 00-disable LoRa Uplink, 01-enable LoRa Uplink **Byte 4-5:** D2D control command **Byte 6-8:** 000000

Examples:

1. Set D2D Key as 5572404C696E6B4C0000000000000000.

ff355572404C696E6B4C		
Channel	**Type**	**Value**
ff	35 (Set D2D Key)	5572404C696E6B4C

2. For EM500-SMTC, when temperature threshold triggers, and D2D command e004 to Milesight D2D agent.

ff96 00 01 01 04e0 000000

Channel	Type	Value
ff	96 (D2D Controller)	00=> temperature threshold triggers, 01=> Enable, 01=>Enable LoRa Uplink, 04 e0=>e0 04, Control Command is e004

4. Historical Data Enquiry

EM500 series support sending downlink commands to enquire historical data for specified time point or time range. Before that, ensure the device time is correct and data storage feature was enabled to store the data.

Command format:

Channel	Type	Description
fd	6b (Enquire data in time point)	4 Bytes, unix timestamp
fd	6c (Enquire data in time range)	Start time (4 bytes) + End time (4 bytes), Unix timestamp
fd	6d (Stop query data report)	ff
ff	6a (Report Interval)	3 Bytes Byte 1: 01 Byte 2-3: interval time, unit:s range: 30~1200s (60s by default)

Reply format:

Channel	Type	Description
fc	6b/6c	00: data enquiry success 01: time point or time range invalid 02: no data in this time or time range
20	ce (Historical Data)	Data time stamp (4 Bytes) + Data (Mutable)

Data format:

Sensor	Description
EM500-CO_2	CO_2 (2B) + Pressure (2B) + Temperature (2B) + Humidity (1B)
EM500-LGT	Light (4B)
EM500-PP	Pressure (2B)
EM500-PT100	Temperature (2B)
EM500-SMT	Moisture(2B)
EM500-SMTC	Electric Conductivity (2B) + Temperature (2B) + Moisture(2B)

EM500-SWL	Depth (2B)
EM500-UDL	Distance (2B)

Note:

1. The device only uploads no more than 300 data records per range enquiry.
2. When enquiring the data in time point, it will upload the data which is closest to the search point within the reporting interval range. For example, if the device reporting interval is 10 minutes and users send command to search for 17:00's data, if the device find there is data stored in 17:00, it will upload this data; if not, it will search for data between 16:50 to 17:10 and upload the data which is closest to 17:00.

Example:

1. Enquire historical data between 2023/03/09 17:00:00 to 2023/03/09 17:10:40.

fd6c 2cc26164 84c46164		
Channel	**Type**	**Value**
fd	6c (Enquire data in time range)	Start time: 2cc26164 => 6461c22c = 1684128300 =2023/05/15 13:25:00 End time: 84c46164 => 6461c484 = 1684128900 =2023/05/15 13:35:00

Reply:

fc6c00		
Channel	**Type**	**Value**
fc	6c (Enquire data in time range)	00: data enquiry success

20ce b1c36164 c9036427010175			
Channel	**Type**	**Time Stamp**	**Value**
20	ce (Historical Data)	b1c36164 => 6461c3b1=2023/05/15 13:31:00	CO2: c9 03 => 03 c9 = 969ppm Pressure: 64 27 => 2764=10084*0.1=1008.4 hPa Temperature: 0101=>101=257*0.1=25.7°C Humidity: 75=>117*0.5=58.5%

-END-