



**DEVICE
INTEGRATION
GUIDE**



Device Integration Guide (LoRaWAN)

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STANDARD DEVICE LIST

Sensor Type	Series	Standard model	Corrosion resistant	With built-in temperature	With GPS	ATEX Approved	Other models
Industrial Pressure	PT	PTS2-L	PTC2-L	PTD2-L	PTG3-L	PTSX-L	PTF2-L PTE2-L
Differential Pressure	PD	PDS2-L	-	-	-	PDSX-L	PDT2-L
Submersible Level	PL	PLS2-L	PLC2-L	PLD2-L	PLG3-L	PLSX-L	PLV2-L PLS3-L PLM2-L
Industrial Temperature	TT	TTS2-L	-	N/A	TTG3-L	TTSX-L	-

Flow	F	FTS2-L Standard water flowmeter	FMS2-L Water meter interface	-
Water Quality	C	CSD2-L Conductivity and salinity	CTR2-L Turbidity	CPH2-L pH
Displacement	D	DUS2-L Ultrasonic distance sensor	-	-
Load	L	LTS2-L (S-Type load cell)	LSS2-L (Foil strain gauge)	-
Geo-location	G	GTS3-L		
Sensor Interface	R	RS1-L Single channel sensor interface	RM1-L Multi-channel sensor interface	RM2-L 4 channel current sensor interface

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DEVICE TECHNICAL SUMMARY

LoRaWAN Specification Version	1.0.2
Supported Class	Class-A
Supported Frequency Plans	AS923, US915, EU868, AU915, [others upon request]
ADR	Supported and enabled by default
Confirmation	Disabled by default but can be enabled by sending a downlink command
RF Range (distance)	Many variables determine range, >15K is possible
Antenna Type	Sleeve dipole, omni directional
Antenna Gain	Approx. 2dB
Default TX Power (prior to successful join)	Max TX permitted by region.
Maximum Enabled Channels	8 at 125KHz, 1 at 500KHz bandwidth (only constrained by gateway capability)
Control Interface	OTA control commands
Default Uplink Interval	4 hours, configurable by a downlink command
Trigger LED via Downlink	“Device Reset” OTA command triggers an uplink after reset resulting LED flashes.

DEVICE COMMISSIONING INSTRUCTIONS (OTAA DEVICE)

Enter the device keys in corresponding LoRaWAN network server (make sure the device is switched off at this time). Turn on the device by pressing the push button switch (latching). The LED around the key should start blinking quickly instantly. Wait for a while, if the device successfully connects to the network the LED will blink quickly again 4 times followed by one. Otherwise, the connection is not successful, and you should investigate connection issues by following steps below:

- Make sure your gateway has internet connectivity and is correctly added to the network server you are trying to add the device.
- Make sure the device keys are correct and the device is added to the network server that your gateway is connected to.
- Check the frequency plan of the gateway including the sub-bands and adjust it to the frequency plan of the device if it is different.

Note: After each power cycle, you should wait at least 30 seconds to power on the device again.

DATA PAYLOAD FORMAT

For majority of sensor the device data payload format is up to 8 bytes as described below in hexadecimal notation, **the exception is for FMS2-L and RM1-L where the packet are described at the end of the table:**

0XAAAABBC₁C₁C₁C₂C₂C₂DD

- AAAA - 2 bytes: The last 2 bytes of the DevEui – maximum will be 0x7FFF
- BB - 1 byte: The type of data packet (00 for sensor readings)
C₁C₁C₁C₂C₂C₂ - 4 bytes as below: This field is only a valid sensor reading when type of data packet (BB) is 00, as described above.
 - For level/pressure sensor integrated with a temperature sensor, the level/pressure and temperature values are in the form of **PPPTTTT** where P represents 2 bytes for level/pressure and T is 2 bytes for temperature.
 - For level/pressure sensor without temperature reading, the level/pressure values are in the form of **PPPPXXX** where P represents 2 bytes for level/pressure.
 - **For salinity sensor (CSD2-L)**, it is replaced with **SSSTTTT**, where S represents 2 bytes for salinity and T is 2 bytes for temperature.
 - **For temperature sensor (TTS2-L)**, it is 8000TTTT where T is 2 bytes for temperature.
 - For **PLV2-L** it is replaced by **P₂P₂P₂P₁P₁P₁**, where **P₂P₂P₂** is the value from atmosphere pressure compensation sensor and **P₁P₁P₁** the value from the main level sensor

Note: The unit of level/pressure depends on the sensing element. See Table: CONVERSION FORMULA PER SENSOR TYPE for more information

- DD - 1 byte: The battery voltage in tenths of a volt.

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Example 1: for PLD2, the payload of 00 3f 00 16 26 09 6b 24:

- 003f is board serial (003F HEX = 63)
- 00 is sensor reading type of data packet
- 1626 is level/pressure sensor reading (1626 HEX = 5670 DEC) (Unit depends on sensing element type)
- 096B is temperature sensor reading (096B HEX = 2411 DEC) (Unit depends on sensing element type; in this example, it is 24.11 degrees Celsius),
- 24 is battery voltage level in 1/10V (24 HEX = 36 DEC x 0.1 = 3.6V)

Example 2 : for the payload of 00 3f 01 07 00 24

- 003f is board serial (003F HEX = 63)
- 01 is command echo type of data packet
- 0700 is the command received by the device via downlink, echoed back as a confirmation.
- 24 is battery voltage level in 1/10V (24 HEX = 36 DEC x 0.1 = 3.6V)

CONVERSION FORMULA PER SENSOR TYPE

Sensor Type	Output conversion formula	Temperature (°C)	
PTS2-L	Pressure(mbar) = Pressure sensor output (DEC)	N/A	Eg: for the following payload: 0XAAAABBBBBPTTTTDD If payload is: 01 82 00 12 FC 00 00 22 Pressure=DEC(12FC) = 4860mbar
PTC2-L			
PTF2-L			
PDS2-L			
PTD2-L	Pressure(mbar) = Pressure sensor output (DEC)	Sensor output (DEC) / 100	Eg: for the following payload: 0XAAAABBBBBPTTTTDD If payload is: 01 82 00 12 FC 09 6B 22 Pressure=DEC(12FC) = 4860mbar Temperature= DEC(096B)/100=24.11 Battery Voltage=DEC(22)/100=3.4

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PDT2-L	Differential Pressure(Pascal)= Sensor output(DEC) (Please note that if the pressure field is greater than 0x8000, the device reads a negative pressure which is equal to two's complement of the pressure field.)	Sensor output (DEC) / 100	Eg: for the following payload: 0XAAAABBBBBPTTTTDD Pressure=DEC(PPPP) Temperature=DEC(TTTT)/100
PLS2-L	Level(mm)= Pressure sensor output (DEC) /Liquid density	N/A	Eg: for the following payload: 0XAAAABBBBBPTTTTDD Level(mm)=DEC(PPPP)/ Liquid density
PLD2-L	Level(mm)= Pressure sensor output (DEC) /Liquid density	Temperature Sensor output(DEC)/ 100	Eg: for the following payload: 0XAAAABBBBBPTTTTDD Pressure=DEC(PPPP) / Liquid density Temperature=DEC(TTTT)/100
PLM2-L	Leve(m)= (Sensor range * ((Pressure sensor output(DEC)- 4000) / 16000))/ Liquid density Where the sensor range(m) is specific for each device	Sensor output(DEC)/ 100	Eg for the following payload: 0XAAAABBBBBPTTTTDD Level=(Sensor range * ((PPPP(DEC) - 4000) / 16000))/ Liquid density Temperature=DEC(TTTT)/100
PLC2-L		(only the board temperature)	
RS1-L	Sensor output (Sensor range * ((Pressure sensor output(DEC)- 4000) / 16000)) Where the sensor range is specific for each device	N/A	Eg for the following payload: 0XAAAABBBBBPTTTTDD output=(Sensor range * ((PPPP(DEC) - 4000) / 16000))/ Liquid density

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DUS2-L (ultrasonic Distance Sensor)	Distance(cm)= $DEC(C_1C_1C_1C_1)$ Level(mm)=L-Distance L=Tank height (cm) (L is provided by the customer)	N/A	Eg: for the following payload 01 33 00 00 DC 00 78 22 Highlighted in red is the sensor output D=00 DC (HEX)= 220(DEC)= distance in cm If tank height =500cm Level=500-220=280cm
PLV2-L	Leve(m)= $((L1 - L2 * 10) /$ LiquidDensity)+BuoyDepth $L1 = (C_2C_2C_2C_2 (DEC) - 1638.3) * \text{Sensor}$ range / 13106.4 $L2 = (K * C_1C_1C_1C_1 (DEC) * m) + b$ Where K,m,b, Sensor range and BouyDepth are specific for each sensor and will be send with each device.	N/A	Eg: for the below payload, AAAABBC ₁ C ₁ C ₁ C ₁ C ₂ C ₂ C ₂ DD =00 f9 00 09 d3 1f 94 22 If: K=0.01907, m=0.007, b=-0.34 Sensor Range=10m BuoyDepth=0.12 LiquidDensity=1 $10 * L2 = 10 * DEC(09d3) * k * m + b =$ -0.14 $L1 = 10 * (DEC(1f94) -$ 1638.3) / 13106.4 = 4.91m Level = 4.91 + 0.14 + 0.12 = 5.18m
PLS3-L	Leve(m)= $((L1 - L2 * 10) / \text{LiquidDensity})$ $L1 = (C_2C_2C_2C_2 (DEC) - 1638.3) * \text{Sensor}$ range / 13106.4 $L2 = (K * C_1C_1C_1C_1 (DEC) * m) + b$ Where K, m, b and Sensor range are specific for each sensor and will be send with each device		Eg: for the below payload, AAAABBC ₁ C ₁ C ₁ C ₁ C ₂ C ₂ C ₂ DD =00 f9 00 09 d3 1f 94 22 If: K=0.01907, m=0.007, b=-0.34 Sensor Range=10m LiquidDensity=1 LiquidDensity=1 $10 * L2 = 10 * DEC(09d3) * k * m + b =$ -0.14

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			$L1 = 10 * (\text{DEC}(1f\ 94) - 1638.3) / 13106.4 = 4.91\text{m}$ $\text{Level} = 4.91 + 0.14 = 5.06\text{m}$
TTS2-L	N/A	Temperature(C)= Sensor output (DEC)/ 100	Eg: for the following payload: AAAABBC ₁ C ₁ C ₁ C ₂ C ₂ C ₂ DD00 Temperature=DEC(C ₂ C ₂ C ₂ C ₂)/100
RS1-L-AS-A-D3-P-E-S-E			
PTE2-L	Pressure (Kg/cm ²) = (Sensor range * ((Pressure sensor output(DEC)- Zero) / (Span-Zero)) Where Zero, Span and Sensor range are specific for each sensor and will be send with each device	N/A	Eg for the following payload: 0XAAAABBPPTTTTDD Pressure = (Sensor range * ((PPPP(DEC) - Zero) / Span))
CSD2-L	Conductivity(μS/cm)= DEC(C ₁ C ₁ C ₁ C ₁)	Temperature(C)= Sensor output DEC(C ₂ C ₂ C ₂ C ₂) / 100	Eg for the following payload: AAAABBC ₁ C ₁ C ₁ C ₁ C ₂ C ₂ C ₂ DD =05 99 00 70 42 09 78 22 Conductivity(μS/cm)= 28738 Temperature(C)=24.24
CPH2-L	PH= DEC(C ₁ C ₁ C ₁ C ₁)	Temperature(C)= Sensor output DEC(C ₂ C ₂ C ₂ C ₂) / 100	Eg for the following payload: AAAABBC ₁ C ₁ C ₁ C ₁ C ₂ C ₂ C ₂ DD = 06 a1 00 00 07 0a 7e 22 PH= 7 Temperature(C)=26.86
FMS2-L	Device data payload format is up to 8 bytes as described below in hexadecimal notation: 0xAA- C₁C₁C₁C₁- C₂C₂C₂C₂ C₂C₂C₂C₂-DD AA - 1 bytes: Packet type - 0x80 for pulse counting devices C₁C₁C₁C₁ - 2 bytes: This field return raw value of the second connected sensor (For the conversion formula related to the second sensor (C ₁ C ₁ C ₁ C ₁), please refer to the sensor types in this table)	N/A	For example, for the payload of 80 16 26 00 00 5b 22 24: 80 is packet type 1626 is pressure sensor reading (1626 HEX = 5670 DEC) (Unit depends on sensing element type) 00005b22 is pulse counter value (00005B22 HEX = 23330 DEC) (Unit depends on sensing element type)

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	C ₂ C ₂ C ₂ C ₂ C ₂ C ₂ C ₂ - 4-bytes: Pulse counter value. DD - 1 byte: The battery voltage in tenths of a volt.		24 is battery voltage level in 1/10V (24 HEX = 36 DEC x 0.1 = 3.6V)
RM1-L-B1C1E8	The packet format is as below: X82PPPPPPAAAABBBBDD Where: 82 >>> packet type PPPPPP >>> Number of total pulses AAAA >>> uA reading BBBB >>> 0-10V reading (in mV) DD/10 >>> battery voltage	Example: 82 00 00 10 0f df 20 28 22 PPPPPP= 00 00 10 (HEX) = 16 AAAA = 0FDF (HEX) = 4063 uA BBBB = 2082 = 8322 mV DD = 22(HEX) = 3.4V	

Devices with the logging Feature (only for EU868 frequency devices):

The payload format for the devices with the logging feature is the same as other devices without logging feature for an 8 byte payload. If the payload is bigger than 8bytes (they can be either 16,24,32,40, and 48 bytes), the extra bytes are used for the data that are logged in the device memory when the gateway was unavailable and are returned when the gateway is accessible again.

The conversion formula for the extra bytes is the same as the first 8 bytes of data and also the same as the devices without the logging feature with the following difference:

- For the first 8 bytes, the payload conversion formula is the same as the others.
- For the next 8 bytes, the first2 bytes for the Device Eui are replaced with number of the packet that is missed
- The below example will explain such payloads in more details:

Device Eui	Sequence number(FC)	Payload	Payload size
70B3D5CD00020554	31	055400162708de22	8 byte packet
70B3D5CD00020554	32	055400164a08de22	8 byte packet
70B3D5CD00020554	34	055400161b08de22	8 byte packet
70B3D5CD00020554	35	05540015bd08de2200210 0161508de22	16 byte packet
70B3D5CD00020554	36	05540015e908de22	8 byte packet

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As you can see the frame number 33 is missed when the gateway was unavailable, it is returned with the 16 bytes payload when the gateway is available again. If we split the 16 bytes payload into two separate 8 bytes:

05540015bd08de22002100161508de22

- 05540015bd08de22 >> 0554 is the last two bytes of the Device Eui the same as all of the devices
- 002100161508de22 >> the first two bytes are replaced with 0021(HEX)= 33 (DEC) which is the sequence number of the missed packet

Pulse counting devices with the logging Feature (only for EU868 frequency devices):

The payload format for pulse counting devices with the logging feature is the same as normal pulse counting device FMS2-L (without logging feature) with an 8 byte payload (please refer to FMS2-L row in this table). If the payload is bigger than 8bytes (they can be either 16,24,32,40, and 48 bytes), the extra bytes are for the data that are logged in the device memory when the gateway was unavailable and they are returned when the gateway is accessible again.

The conversion formula for the extra bytes is the same as the first 8 bytes of data and also the same as the devices without the logging feature with the following difference:

- For the first 8 bytes, the payload conversion formula is the same as the others.
- For the next 8 bytes, the first2 bytes for the Device Eui are replaced with number of the packet that is missed.
- The below example will explain such payloads in more details:

Device Eui	Sequence number(FC)	Payload	Payload size
70B3D5CD00020555	1251	8000000002D4D822	8 byte packet
70B3D5CD00020555	1252	8000000002D5212204D F000002D3B42204E100 0002D4462204E200000 2D48F22	32 byte packet
70B3D5CD00020555	1253	8000000002D56A22	8 byte packet
70B3D5CD00020555	1255	8000000002D5FC22	8 byte packet
70B3D5CD00020555	1256	8000000002D6452204E 6000002D5B322	16 byte packet

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As you can see the frame number 1254 is missed when the gateway was unavailable, it is returned with the 16 bytes payload (count 1256) when the gateway is available again. If we split the 16 bytes payload into two separate 8 bytes: 8000000002D6452204E6000002D5B322

- 8000000002D64522 >> 80 is the payload type which is pulse counting devices in this case
- 04E6000002D5B322 >> the first two bytes are replaced with 04E6(HEX)= 1254 (DEC) which is the sequence number of the missed packet

HOW TO CHANGE DEVICE SAMPLING RATE

After each power cycle, the devices send **10 initial samples every 5 minutes** for troubleshooting, then it reverts to its default sampling rate (4 hours).

To change sampling rate, the "sleep period" needs to be changed by sending a downlink data to port 5 using the format 10YYXXXX:

- YY: 00 for seconds, 01 for minutes
- XXXX: hexadecimal value of seconds/minutes you want to set
- For example, setting sleep period to 180 minutes (3 hours), the command will be 100100B4, while for setting to 45 seconds, it will be 1000002D. Currently, minimum sleep period is 60 seconds. Contact support if periods below this is required,

After an OTA command is received and correctly recognized by the end device, it will echo its value back.

The payload of the message echoed back will comprise a hex number 0xAAAABBBBBCCDD interpreted as follows:

- AAAA - The board serial number
- BB - 0x01 - the type of message - 0x01 indicates a configuration event message
- CCCC - The command that was sent
- DD - The battery voltage in tenths of a volt

Please be careful when sending OTA commands to the device. Incorrect commands may change sensitive properties which may result in the device malfunction.

HOW TO ENABLE/DISABLE CONFIRMATION VIA DOWNLINK

To switch confirmations on, send message data 0x0701

To switch confirmations off, send message data 0x0700

Over the air commands have to be sent to Port 5.

After an OTA command is received and correctly recognised by an end device, it will echo its value back.

The payload of the message echoed back will comprise a hex number 0xAAAABBBBBCCDD interpreted as follows:

- AAAA - The board serial number
- BB - 0x01 - the type of message - 0x01 indicates a configuration event message
- CCCC - 0x0700 or 0x0701 - The command that was sent
- DD - The battery voltage in tenths of a volt

Please be careful when sending OTA commands to the device. Incorrect commands may change sensitive properties which may result in the device malfunction.

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HOW TO RESET THE DEVICE VIA DOWNLINK

If the end-device is remote and needs to be restarted there is an OTA downlink command to do so: 0xFF00. Sending this to port 5 will reset the device.

Please be careful when sending OTA commands to the device. Incorrect commands may change sensitive properties which may result in the device malfunction.

HOW TO CHANGE PERIODIC AUTO-RESET SETTINGS

This feature forces the device to reset itself after sending 'n' samples. The default value is 0000 which means the device will not automatically reset. To change the number of transmissions before a reset send 0x16xxxx to receiving port (use 5), where xxxx is a 16-bit unsigned integer indicating number of transmissions before reset. E.g. 0x160BB8 sets the count to 3,000. If the count is set to 0000 then auto-reset is disabled.

Format of returned value is 0xAAAABBCCCCDD where:

- AAAA - The board serial number
- BB - 0x16 - type of message (this will be 0x01 for FW versions before 0.1.17)
- CCCC - Number of samples before reset
- DD - The battery voltage in tenths of a volt

Note 1: In OTA devices, this will initiate joining process after reset

Note 2: In ABP devices, this will reset the frame counter

Note 3: If the requested value is less than the current sample number, this will result in immediate reset

All details are subject to change without prior notice

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