EUROPEAN RN2483A-I/RM105 Micromite GPS LoRa MOTE

Micromite GPS LoRa MOTE is targeted to design engineers to quickly evaluate LoRaWAN and its sensor applications. Micromite is a PIC32MX170 microcontroller firmware that is based on Geoff Graham's MMBasic interpreter (http://geoffg.net/micromite.html) that allows convenient application software development in BASIC language. Micromite through its serial console interface provides support for program editing, debugging plus communication with the BASIC application. This is an excellent environment for LoRaWAN applications because no other compiler, no other hardware debugger and programmer is required for software development. The console port of Micromite has built in USB-UART bridge (http://www.microchip.com/MCP2221A) that allows single USB connection to the free MM Edit integrated development environment (http://www.c-com.com.au/MMedit.htm). The USB connection is used also for charging the internal LiPo battery. The GPS Mode is intended to analyze how large is the geographic coverage of LoRaWAN even from a moving vehicle. The Sensor Mode is targeted for demonstration of fixed position sensor networks. Beside internal sensors the Micromite GPS LoRa MOTE has a peripheral connector for handling external sensors or actuators. This option is demonstrated by GSS COZIR CO_2 sensors (https://www.chipcad.hu/en/news/2018/August/kis-fogyaszts-gss-szndioxid-szenzorok-a-chipcad--128). However, users are encouraged to implement their own sensor support through two external UART, one I^2C and three digital/analog/PWM peripheral lines to discover LoRaWAN capabilities in their own Proof of Concept projects. The latest BASIC program version and full documentation of the MOTE can be downloaded from here:

https://www.chipcad.hu/letoltes/MMGPSMOTE.zip

Operation modes and changing between modes

- Console mode
  - Purpose: MMBasic program development.
  - MMBasic application can be broken by "control C" on Console
  - MMBasic application can be restart again by "run" command.
  - *See:* Micromite User Manual http://geoffg.net/Downloads/Micromite/Micromite%20Manual.pdf
  - Micromite Kézikönyv https://www.chipcad.hu/letoltes/MkII-magyar.pdf
- Service mode: *See: Appendix D, Service Mode*
- GPS Mode: *See below*
- Sensor mode: *See below*
- C Class operation, Multicast Demo: *See below*

Micromite GPS LoRa MOTE has one push button and three LEDs. The yellow LED lights while battery is charged from micro USB connector. The yellow light stops when battery is fully charged (4.2V). The built in **MCP73831T-2ACI/OT** battery charger circuit controls charging and during discharging disconnects itself from battery at 3.5V. It is recommended to disconnect battery if the MOTE is not used for a long time to avoid its deep discharge. The green and red LEDs are controlled by Micromite MMbasic application. While application is up and running, one of them is pulsing once in every second but both LEDs are dark during Micromite sleep. The green LED pulses during satellite acquisition and trace or sensor measurements then after valid values are captured red LED pulses till the end of LoRaWAN transmit. In GPS mode during satellite acquisition and trace Micromite program monitors if push button is pressed. The program differentiates between short, long and very long button presses:
- The **short press** lasts less than a second (<1sec), then red LED pulses, that starts **a single sensor measurement**.
- The **long press** lasts more than one second until red LED lights, then it changes **mode from GPS to Sensor**.
- The **very long press** until red and green LEDs light (over 4 secs), then it changes **mode from GPS to Multicast**.

In Sensor Mode the program spends most of its time in sleep mode to lower power consumption, the CPU is awakened periodically to measure sensors and transmit measurement data to LoRaWAN. Micromite checks push button state after wakeup and if it is pushed then lights green LED till its release. The **button release** changes **back to GPS mode**. The sleep time in sensor mode lasts at least one minute, that is why the maximum button press can be one minute to change Sleep mode to GPS mode.

In Multicast Mode RN2483A-I/RM105 keeps its RX2 widow opened and can decode downlink messages by its own devaddr/nwkskey/appskey and additionally by mcastdevaddr/mcastnwkskey/mcastappskey keys. Beside receiving Micromite checks push button state and if it is pushed then lights green LED till its release. The **button release** changes **back to GPS mode** similarly to Sensor mode termination.

Pushbutton is the easisest controller to change modes. However, the same functions and additionally many more can be done by download messages. The application server can change operation modes and operating parameters remotely. This is an important feature of LoRaWAN and users are encouraged to experiment downlink capabilities of Micromite GPS LoRa MOTE.

Activation into Network Server

From 5v00 release Micromite GPS LoRa MOTE is activated to Network Server by OTAA. OTAA keys are preprogrammed into RN2483 mode and added electronically in CSV bulk import file: *deveui*, *appeui* and *appkey*.

Keys are handled securely, however, final users are encouraged to change *appeui* code according to own application. The modified bulk import file should be imported then.

Service functions allow changing *appeui*, refer to description of Service functions in **Appendix D**.

Updating RN2483 module firmware to RM105

In case of latest 5V07 or above Micromite versions below firmware update steps are not required.

1. ICSP PCB holes of CS3 are provided to RN2483 firmware update. Connect PICKit4 or any similar PIC programmer to ICSP interface of the module then program its PIC18LF46K22 microcontroller with the latest firmware.
2. Micromite Interpreter can also be updated through PIC32MX170F256B-50I/SS ICSP interface of CS2 peripheral extender connector.
3. Latest Micromite BASIC program can be updated through USB and Micromite Chat program.
4. Both ABP and OTAA keys of RN2483 module should programmed in Pass Through service function.
5. Eight MultiSF channels and additionally DR6, DR7 channels should be open by “c to set LoRaWAN channels” service function.
6. RUN Micromite GPS LoRa MOTE program.

1. GPS Mode

Micromite GPS LoRa MOTE has a built in SQ-SEN-200 motion sensor that allows GPS operation in GPS Mode. While continuous movement is detected the MOTE searches GPS/GNSS satellites and if valid coordinates are captured then transmits them to LoRaWAN four times a minute. After 6 minutes inactivity the MOTE automatically goes to sleep for unlimited time then only its motion sensor can wake it up again. In a moving vehicle Micromite GPS LoRa MOTE operates continuously and after stopping vehicle the MOTE automatically puts itself in low power consumption sleep mode. The frequency of coordinate broadcasts will strongly influence total power consumption. After each transmit the MOTE goes to sleep for **short sleep time** that takes at least 5 seconds, but it can be extended up to 260 seconds by downlink message. In other words, the downlink message can modify cycle time of broadcasts from quarter minute to four minutes. Four-minute cycle time consumes 16 times less energy than quarter minutes, it extends battery life 16 times longer. See: *Appendix B: GPS Modes of operation.*

Micromite GPS LoRa MOTE can handle external sensors and as example an optional CO_2 COZIR sensor can be connected to peripheral connector. When Micromite GPS LoRa MOTE is operated in a car and an optional CO_2 sensor plus a buzzer is connected, the MOTE measures CO_2 concentration before going to sleep. When CO_2 value exceeds the programmable **CO_2 concentration limit** an audible alert sound is generated to warn vehicle driver to switch on incoming fresh air inflow for avoiding drowsiness and finally prevent accidents. The sound frequency in Hz is identical with CO_2 concentration in PPM.

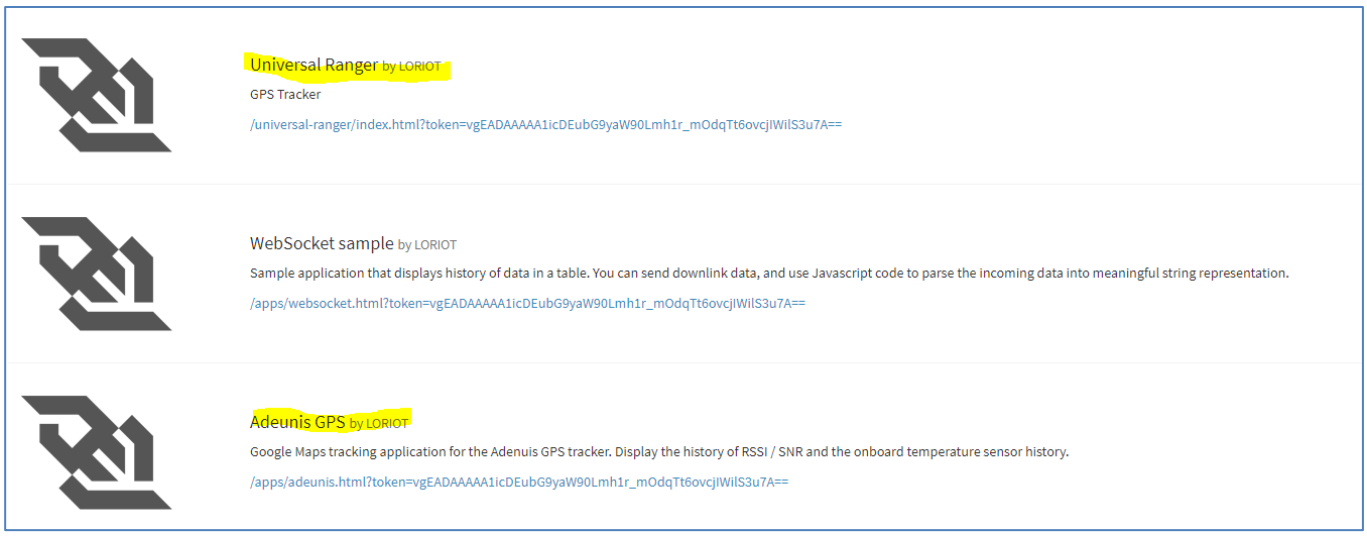
This danger is shown in BBC report with GSS. https://www.youtube.com/watch?v=bNXup6E7P1g

In GPS Mode several payload formats are available. The short Micromite payload contains only latitude, longitude and altitude coordinates in a very efficient binary coding. The long Micromite GPS format combines sensor data with GPS coordinates. Beside two Micromite GPS formats two popular tracker formats can also be selected: Semtech GPS MOTE or Adeunis. Users are encouraged to create and test their own GPS formats beside below five GPS formats (maximum 15). In the BASIC program the default GPS format is set to Adeunis Legacy:

```
DIM GPSFormat=4
```

However, it can easily be modified in the program or by download message.

LORIOT network server has built in GPS tracking applications that allow on line tracking of all formats that Micromite GPS LoRa MOTE supports. The Universal Ranger is the most advanced application that provides information about gateways and trackers:



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8 bytes “**Short Micromite payload**” uplink format in GPS Mode:

Port	Payload
202	4370550d860b0083

Port number 202

Payload:

latitude 24bit signed number, angle domain -90 to +90 degrees

longitude 24bit signed number, angle domain -180 to +180 degrees

altitude 16bit unsigned number, height domain 0 to 15000 meters

LoRaWAN transmit cycle time range: 15sec - 270sec

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18 bytes “**Long Micromite payload**” uplink format in GPS Mode:

Port	Payload
202	4370550d860b0083008303FB0a1293141723

Port number 202

Payload:

latitude 24bit signed number, angle domain -90 to +90 degrees

longitude 24bit signed number, angle domain -180 to +180 degrees

altitude 16bit unsigned number, height domain 0 to 15000 meters

altitude 16bit unsigned number, height ASL, calculated by air pressure sensor, domain 0 to 1500 meters

QNH 16bit unsigned number, calculated pressure at sea level, that was used by Micromite SM1131 calibration (see 03 downlink command). QNH pressure domain: 800-1100hPa

HDOP 8bit unsigned number, ten times Dilution of Precision parameter, domain 1 to 250

Temperature 8bit signed number, internal CPU temperature, domain -128 to 127 degrees

Battery charge 2 BCD digits, percentage domain 1%-99%, relative charge between 3.5V-4.2V

GPS timestamp HHMMSS 3 bytes

LoRaWAN transmit cycle time range: 25sec - 280sec

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16 bytes Semtech GPS LoRa MOTE payload format is available to utilize online tracking application of LORIOT NS

Port	Payload
2	00000000000000514383a0d921d009a

Port number 2

Payload:

battery voltage 1-254 relative charge of battery

latitude 24bit signed number, angle domain -90 to +90 degrees

longitude 24bit signed number, angle domain -180 to +180 degrees

altitude 16bit unsigned number, height domain 0 to 15000 meters

LoRaWAN transmit cycle time range: 15sec - 270sec

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13 bytes Adeunis GPS format is available to utilize online tracking application of LORIOT NS

Port	Payload
1	d216472823900190503 00f111e

Port number 1
status 1 byte
temperature 1 byte
latitude 4 byte BCD, angle domain -90 to +90 degrees
longitude 4 byte BCD, angle domain -180 to +180 degrees
battery voltage 16bit binary [mv]
GPS quality Higher Hex Digit (good 1, average 2, poor 3), Lower Hex Digit (number of satellites)
LoRaWAN transmit cycle time range: 15sec - 270sec

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12 bytes “legacy” Adeunis GPS format is available to utilize online tracking application of LORIOT NS. The legacy format doesn’t contain GPS quality byte.

Port	Payload
1	d216472823900190503 00f11

Port number 1
status 1 byte
temperature 1 byte
latitude 4 byte BCD, angle domain -90 to +90 degrees
longitude 4 byte BCD, angle domain -180 to +180 degrees
battery voltage 16bit binary [mv]
Minimum LoRaWAN transmit cycle time range: 15sec - 270sec

In GPS Mode the MOTE transmits with DR=0 and DR=6 data rates alternately. The default DR0:DR6 ratio is 1:1, one DR6 packet is inserted between each DR0 packets. The number of inserted DR6 packets can be set from 0 to 15. When this number is 0 the transmit duty-cycle is 1% per channel at 15second transmit cycle time. When the number of inserted DR6 packets is 15, the transmit duty cycle is only 0.06% on Multi SF channels and only 0.025% on DR6 channel. The 17dB sensitivity difference between DR0:SF12/125kHz and DR6:SF7/250kHz can be significant in urban areas but it is usually compensated by high density of gateways. If radio propagation is influenced by reflected radio waves, then it is better to keep number of DR6 packets low. In case of airplanes or boats this number can be increased without increasing PER (packet error rate) significantly. Using mainly DR6 avoids interference problems with fixed sensor networks and lowers interference with other portable vehicles that are using mainly DR0. Users are encouraged to optimize tracking by this variable parameter. See 05 downlink command.

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10 bytes status of Micromite GPS LoRa MOTE. Status contains BASIC variables that are stored in Flash memory. Except program version number, all BASIC variables can be modified by downlink messages.

See in “4. Downlink: Control from application server” chapter.

Port	Payload
203	34360513000000ffff0500

Port number 203

GPSDeviceID: Higher hex digit. 0 walk, 1 bicycle, 2 bike, 3 vehicle, 4 train, 5 boat, 6 drone, 7 balloon, 8 airplane, 9 animal. Users may extend up to 15.

GPSFormat: Lower hex digit. 0 Micromite Short, 1 Micromite Long, 2 Semtech, 3 Adeunis and 4 Adeunis Legacy

OnePPSMin: Higher hex digit. The number of 1PPS pulses before GPS measurement. Domain 1 to 15

GPSFullOperationTime: Lower hex digit. Full ON power time in minutes. Domain 1 to 7

MaxTime: One byte. Inactivity time of motion sensor (in minutes) in GPS Mode before sleep. Domain 1 to 255

NRofDR6: Higher hex digit, number of DR6 between DR0 transmits in GPS Mode. Domain 0 to 15

NumberOfUncnfInSensorMode: Lower hex digit. One quarter of UNCNF number between CNF transmits: 1 to 15

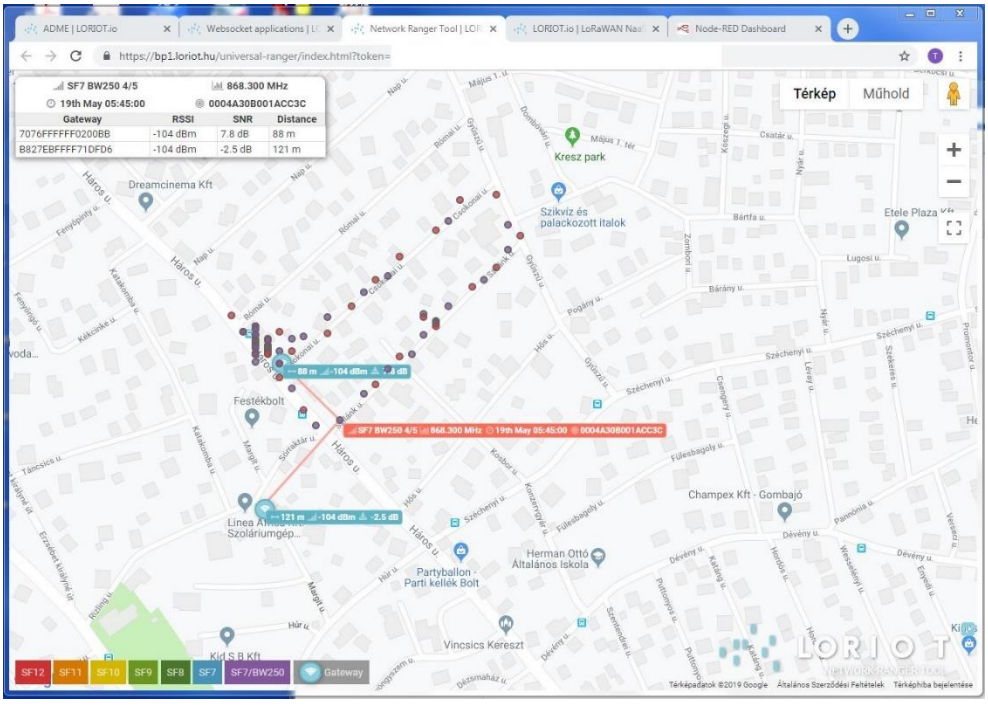
Short Sleep Time 8bit unsigned number. In second this time is added to sleep time of GPS mode: 0 to 255

Long Sleep Time 8bit unsigned number. In minute this time is added to sleep time of sensor mode: 0 to 255

CO2 limit 16bit unsigned number. If limit is above 10000 the CO_2 measurement is ignored in GPS mode and interim wakeups in sensor mode. Domain 0-65535. The limit value 65534 initiates beacon activity of sensor mode: after transmitting sensor payload, the node sends status plus stored GPS coordinates additionally. This is useful for checking operation of network server plus application servers. Beacon GPS payload coordinates are static, longitude and latitude are repeated from last GPS measurement. Instead of altitude in beacon mode the payload contains 32bit down counter.

BASIC program version number four BCD digit. This variable is set automatically by BASIC program of Micromite. Actual version is 5V00.

Online GP tracking of legacy Adeunis format by Universal Ranger:



2. Sensor Mode

Sensor Mode is targeted to fix position sensor applications. GPS/GNSS receiver is switched off, the MOTE uses its internal and optional external sensors. The internal CPU temperature and battery voltage sensors can be supplemented by external sensors through peripheral connector of the MOTE. For quick learning we offer a Micromite Peripheral Panel and an optional GSS COZIR sensor then users are encouraged to use their own sensors. In Sensor mode the MOTE periodically measures sensors then transmits their values to LoRaWAN. Between measurements Micromite switches off all peripherals and goes to sleep for **long sleep time** that is at least 1 minute but it can be extended up to 256 minutes by downlink message. The longer the **long sleep time** the lower the power consumption.

In Sensor Mode the MOTE uses adaptive data rate, automatically adopts to the highest bit rate that is required for reliable two-way communication. See Appendix E.

Though long sleep time can be extended up to 256 minutes Micromite wakes up once in every minute for a short while and checks if button is pressed or not. If it is pressed, then lights green LED and goes back to GPS Mode when button is released. The MOTE has an intelligent CO_2 concentration measurement option to optimize power consumption. An upper CO_2 limit can be set by downlink message. If CO_2 limit is not activated (0xffff), then it measures sensors only at the end of long sleep time. If upper CO_2 limit is activated, then CO_2 concentration is measured once in every minute. If measured value is higher than upper limit the MOTE transmits sensor data immediately whatever time is set for long sleep time. When measured value is less than the limit then MOTE goes back to sleep without transmitting it.

14 bytes uplink message in Sensor Mode:

Port	Payload
209	1275 02ed 01e9 12 12009c40 12 01e9

Port number 209
Temperature 8bit signed number, temperature domain -128 to 127 degrees
Battery voltage 8bit BCD number, percentage domain 1%-99%, relative charge, voltage between 3.5V-4.2V
The battery voltage is updated at every wakeup from sleep. The battery voltage is also available for network server to request through packet header. The 3.5V-4.2V battery voltage domain is normalized to 1 to 254 single byte value. The network server can request this value at any time, LORIOT network server requests battery voltage once a day.
COZIR CO_2 concentration 16bit unsigned number, ppm domain: 400 to 10000
COZIR relative humidity 16bit unsigned number, ‰ domain: 0-1000
COZIR temperature 8bit signed number, temperature domain: -128 to 127 degrees
Temperature of SM1131 8bit signed number, internal temperature, domain -50 to 85 degrees
Air-pressure of SM1131 24bit unsigned number, pressure domain 400 to 1800 hPa
TH06 temperature 8bit signed number, temperature domain: -128 to 127 degrees
TH06 **relative humidity** 16bit unsigned number, ‰ domain: 0-1000

3. C-Class operation, Multicast Demo Mode

C-Class, Multicast Mode demonstrates how to use RN2483 LoRa module in C-Class and how to put several nodes into Multicast operation at the same time. The RN2483 is preprogrammed with ABP or OTAA activation keys in A-Class. Additionally, during this demo Micromite MOTE activates preprogrammed multicast keyset and changes its class A to class C. Then Micromite sends dummy uplink messages that keep RX2 receive window open permanently while setting adaptive data rate on. Then the application server can send downlink messages selectively or multicast messages to group of nodes any time and nodes are capable to decode them. The demo uses an external RGB LED that is connected to MOTE PWM port allowing each color intensity settings by 1% resolution. Multicast downlink is a one-way communication, but in this demo application nodes confirm back received downlink messages by uplink messages using own keyset. Three dimensional randomizations are used for keeping confirmation uplink packet collisions low:

DR: Nodes use ADR that allows data rates to be diversified according to their gateway distances (0-5)
Channel: Nodes randomly select one of 8 Multi SF channels (0-7)
Time: Confirmation uplinks are randomly delayed (0-5 seconds)

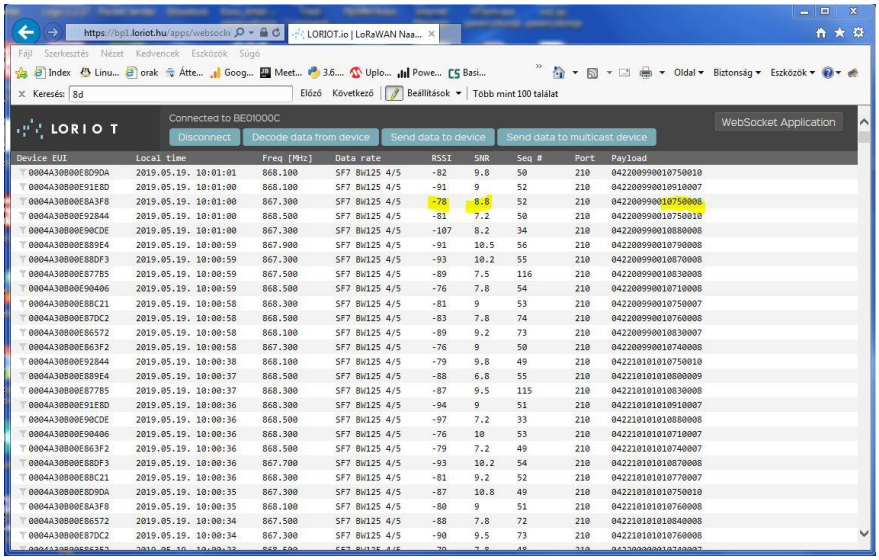
Randomization of uplink confirmations allow quick and reliable control even for large network of multicast nodes. However, time delay should be set according to density of nodes around gateways.

9 bytes uplink confirmation of received class-C/multicast message:

Port	Payload
210	04220101011056 0006

Port number 210
Echoed received command 5 bytes
Recived RSSI 2 bytes BCD number, highest digit 0/1 positive/negative sign, three lowest BCD digits RSSI in dB
Received SNR 2 bytes BCD number, highest digit 0/1 positive/negative sign, three lowest BCD digits SNR in dB

Micromite BASIC program initializes multicast downlink counter by zero allowing its value to be synchronized by the first received multicast message. Then RN2483 will automatically drop all received replicated messages that have lower or same downlink counter value than latest valid multicast downlink message. The second byte of multicast download message is a group filter that allows addressing 98 subnets with the same multicast keyset. **Never forget to change class to C during Multicast Mode on NS then to class A while returning to GPS or Sensor.**



In left uplink list 13 nodes in group 22 confirm commands to switch LEDs 10% white then to 99% green.

In the highlighted line the network server received confirmation uplink by RSSI=-78dB, SNR=8.8dB while the node reports it previous received multicast message by RSSI=-75dB and SNR=8dB.

Three dimensional randomizations and fast confirmation cycles can also be recognized.

4. Downlink: Control from application server

Operation parameters can be modified from application server. The MOTE interprets five bytes long downlink commands that use port 209 exclusively. The first byte is the command number that has a 4 bytes parameter.

Port	Payload
209	00caed07d0

Port number 209

Control: 8bit unsigned number

00: Sets Short Sleep Time, Long Sleep Time and CO_2 upper limit without other action. Both Sleep Times plus CO_2 upper limit are stored in Flash memory. Without updating Micromite BASIC program the variables that are stored in flash memory will be retrieved during reset.

Short Sleep Time: 8bit unsigned number. In GPS Mode the sleep time will be this parameter plus 5 seconds at short payload and 15 seconds at long payload formats. Time domain: 0 to 255 seconds

Long Sleep Time: 8bit unsigned number. In Sensor Mode sleep time will be this parameter plus 1 minute. Time domain: 0 to 255 minutes.

CO_2 upper limit: 16bit unsigned number. Concentration domain: 0 to 65535 ppm or 6.5535%

01: Requests a sensor data in GPS Mode. Same as short push button press in GPS Mode. Additionally, it sets Short Sleep Time, Long Sleep Time and CO_2 upper limit BASIC variables.

02: Change Modes of operation. In GPS Mode changes to Sensor Mode and in Sensor Mode back to GPS Mode. Same as long push button press. Additionally, it sets Short Sleep Time, Long Sleep Time and CO_2 upper limit BASIC variables.

03: Calibrates SM1131 air pressure for barometric altitude calculation

Port	Payload
209	03008E03FB

Height ASL: 16bit binary height of calibration location. Domain 0 to 1500 meter

QNF: 16bit binary air pressure calculated for see level on the calibration location. Domain 800 to 1100hPa

04: In GPS or Sensor Mode the first 04 command sets Group Filter then changes to C-Class Multicast Mode. In C-Class Multicast mode sets intensities of Red, Green and Blue color LEDs when command filter is identical to the group filter of the node. If Filter=00 the MOTE restarts in GPS or Sensor Mode depending from which it was initiated.

Port	Payload
209	04221010

Port number 209
Filter: Two BCD digits. Filter domain: 0 to 99. Zero restarts in GPS Mode, 1-99 Group Filter.
Red LED: Two BCD digits. Intensity percentage domain: 0 to 99%.
Green LED: Two BCD digits. Intensity percentage domain: 0 to 99%.
Blue LED: Two BCD digits. Intensity percentage domain: 0 to 99%.

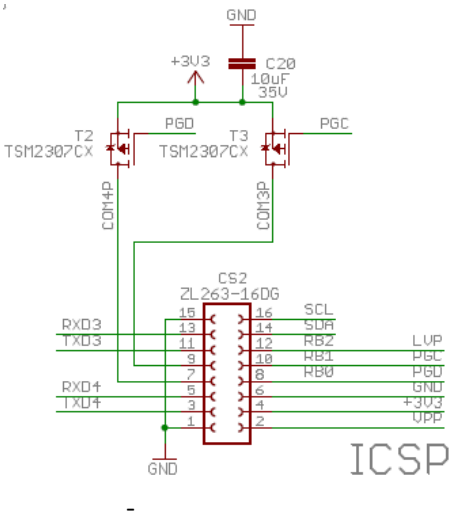
05: Sets BASIC variables and stores them in Flash memory.

Port	Payload
209	0534350613

Port number 209
GPSDeviceID: Higher hex digit. 0 walk, 1 bicycle, 2 bike, 3 vehicle, 4 train, 5 boat, 6 drone, 7 balloon, 8 airplane, 8 animal. Users may extend up to 15.
GPSFormat: Lower hex digit. 0 Micromite Short, 1 Micromite Long, 2 Semtech, 3 Adeunis and 4 Adeunis Legacy
OnePPSMin: Higher hex digit. The number of 1PPS pulses before GPS measurement. Domain 1 to 15
GPSFullOperationTime: Lower hex digit. Full ON power time in minutes. Domain 1 to 7
MaxTime: One byte. Inactivity time of motion sensor (in minutes) in GPS Mode before sleep. Domain 1 to 255
NRofDR6: Higher hex digit, number of DR6 between DR0 transmits in GPS Mode. Domain 0 to 15
NumberOfUncnfInSensorMode: Lower hex digit. One quarter of UNCNF number between CNF transmits: 1 to 15

In GPS mode after sending 05 command, Micromite MOTE confirms it by sending all BASIC variables to 203 port, see its payload definition above.

5. Using external peripheral connector



Micromite GPS LoRa MOTE has a 16pin connector that is aimed for several purposes:

Pin 1 of CS2 is the upper left position near the USB micro socket

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- C**2: 2, 4, 6, 8, 10, 12 ICSP pins** can accommodate a PICKit4 (or 3) programmer for Micromite firmware update.

- **C2: 1, 2 reset pins**. Micromite GPS LoRa MOTE spends most of its time in sleep mode. Hardware reset may help to initiate Micromite console mode faster, even from sleep. No reset button is provided but with an external wire jumper the MOTE can easily be reset.

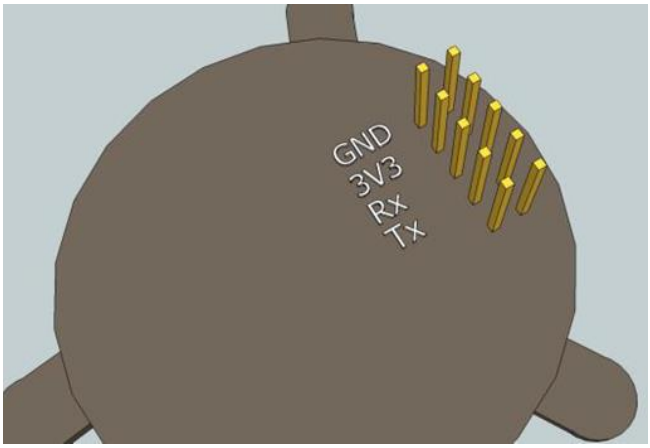
- **C2: 9, 11, 13, 15 COM3 port**. COM3 sensor can be operated from switched COM3P 3.3V power supply to minimize its power consumption.

- **C2: 1, 3, 5, 7 COM4 port**. COM4 sensor can be operated from switched COM4P 3.3V power supply to minimize its power consumption.

- **C2: 14, 16 I^{2}C bus**.

- **C2: 8, 10, 12 digital, analog I/O or three PWM channels** (for driving RGB LED).

6. Connection of COZIR CO_2 sensor and buzzer



COZIR CO_2 sensors uses 9600 baud UART serial communication with 3.3V logical level that matches to Micromite. The Micromite GPS LoRa MOTE uses COM3 for COZIR sensor on its COM3 UART port:

C2:15 COZIR GND
C2:09 COZIR 3V3
C2:11 COZIR RX
C2:13 COZIR TX

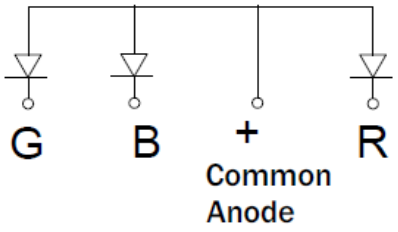
Micromite can drive a buzzer in GPS mode when a COZIR CO_2 sensor is connected. After sending GPS/GNSS coordinates to LoRaWAN the Micromite measures CO_2 concentration and if it is higher than upper limit then drives a buzzer with one second warning signal. The buzzer frequency is equal in Hertz with the CO_2 concentration in PPM value. Car drivers can easily test the effect of closing fresh air inflow to the car. The warning buzzer can be connected to C2 peripheral connector:

C2: 8 buzzer
C2:12 buzzer

7. Connection of RGB LED in Multicast Demo

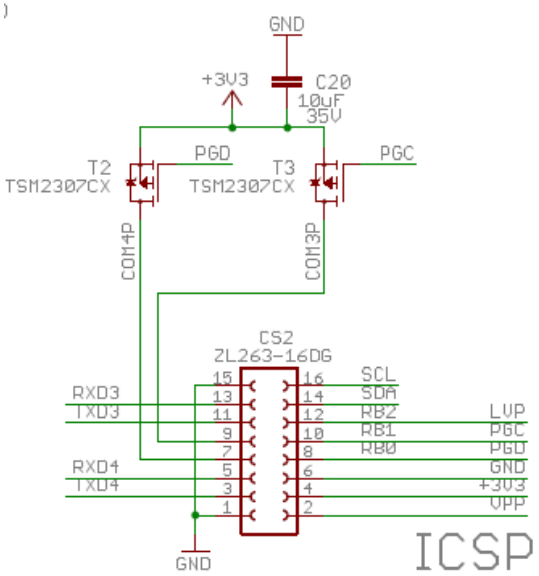
We recommend a low power FYL-5019RBGW1C-CA RGB LED with serial cathode resistors to connect directly to MOTE's peripheral connector:

C2: 4	Common anode 3.3V	
C2: 8	Red	130 Ohm
C2: 10	Blue	33 Ohm
C2: 12	Green	33 Ohm



8. Connection of SM1131 barometric air-pressure sensor

C2: 9 switched 3.3V power supply to VDD
C2:15 GND to Vss
C2:16 SCL
C2:14 SDA



Pin Configuration

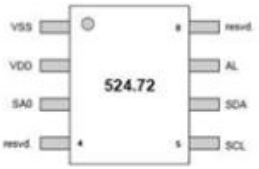


Figure 1: Pin Configuration

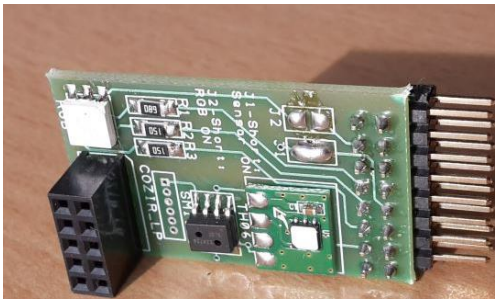
Pin Description

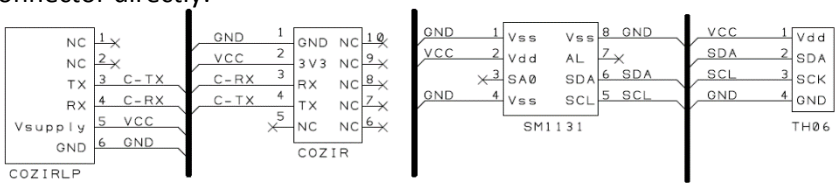
Pin	Name	Type	Description
1	VSS	S	Ground (Negative device supply)
2	VDD	S	Supply voltage
3	SA0	D_I	I2C secondary slave address, pin coding
4	resvd.	-	reserved, connect to VSS (on PCB)
5	SCL	D_I	I2C clock input
6	SDA	D_B	I2C data I/O
7	AL	D_O	Alarm output (optional)
8	resvd.	-	reserved, connect to VSS (on PCB)

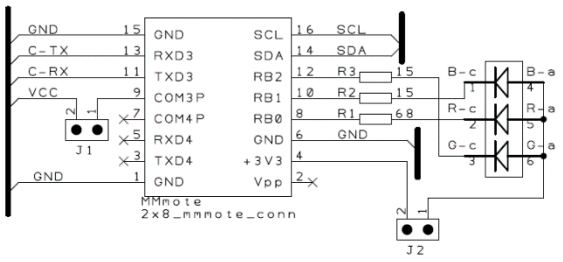
Note: A = Analog, D = Digital, S = Supply, I = Input, O = Output, B = Bidirectional, NC - not connected

9. Micromite Sensor Board

For easy connection of all external sensors we created Micromite Sensor Board that contains SM1131 barometric air pressure sensor, TH06 temperature and humidity sensor, RGB LED and additionally it can be populated by COZIR sensor. It can be connected to peripheral connector directly:







RB0/RB1/ and RB2 pins of Micromite have different functions in Sensor and Multicast Modes. In sensor mode J1 is closed and J2 open. In Multicast Mode J1 is open and J2 closed. Because these modes are not frequently changed J1 and J2 switches provide long time function to the board that can be modified by soldering. Closing both J1 and J2 will not harm anything but results little higher power consumption in Sensor mode.

10. Opening and closing plastic case of Micromite GPS LoRa MOTE

The Micromite GPS LoRa MOTE is housed in a black plastic case (78mm*40mm*22mm). The case has a base and a cover part and for the push button a plastic mechanical button extender. The case has no screw to fix it but the PCB board is mechanically fixed among case part. The cased Micromite GPS LoRa MOTE can easily be moved to its locations and is resistive against environment stresses.

When the case is open the firmware of RN2483 module can be updated by a PICKit 4 or 3 programmer through ICSP pads beside the module.

The measurement of power consumption is supported by a 10 Ohm Shunt resistor that is short circuit with a jumper. After opening the case the jumper can be removed and a storage oscilloscope can be connected in place of the jumper.

The PCB and the 750mAh standard LiPo battery can easily be placed in the case but with one trick. Let's put an insulator strip, or rubber tape onto the outer surface of the upper case to fully cover the slot of push button. Insert the mechanical button extender in the inner side of the cover and push firmly to allow the tape to hold it. Place the PCB and battery into the case playing attention that the battery wires face to LoRa antenna position and wires come to upper side battery connector on the PCB. Place the cover case onto bottom case part and firmly push them together. In its normal position the push button can easily be pressed and the case holds the PCB properly.

11. Packing list of Micromite GPS LoRa MOTE package

- Micromite GPS LoRa MOTE (cased with 750mAh battery)	1 piece
- ISM-868 SMA ant. + swivel 868MHz monopole antenna	1 piece
- Reset wire	1 piece
- micro USB cable	1 piece

The Micromite GPS LoRa MOTE is activated and tested in ChipCAD LoRaWAN but later it can easily be moved to other networks.

Appendix

A: Micromite GPS LoRa MOTE version history.

V1 was developed for ChipCAD IoT Conference June 6th 2016 but was never released to market, only used for demonstrations and in house experiments. It was exclusively designed as a LoRaWAN GPS tracker.
V2 combined LoRaWAN GP tracker with sensor functions, it was released to market on August 5th 2016, MMTR-06A_SCH.pdf.

V3 released to market on March 22nd 2017, MMTR-07_SCH.pdf. Major software release improves GPS power management for accurate localization. It has minor hardware modification also: instead of CTS/RTS control, Micromite became able to reset RN2483 module. However, since then it hasn't been required to assure reliable operation.

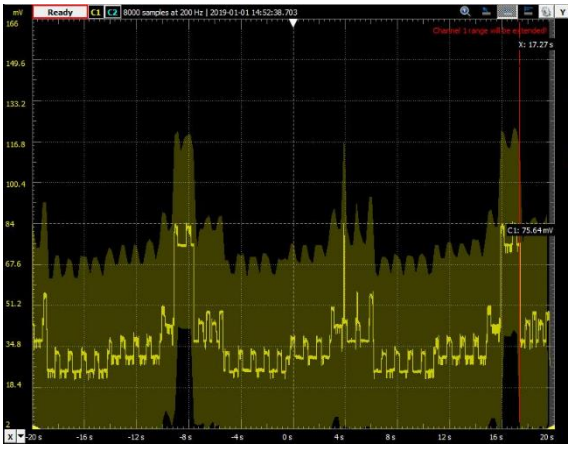
V4 software

V5 released on January 27th 2019. MMBASIC fully supports Class A, Class C and Multicast of RN2483A-I/RM105.

Micromite firmware should be 5.5 lite version or higher.

B: GPS modes of operation.

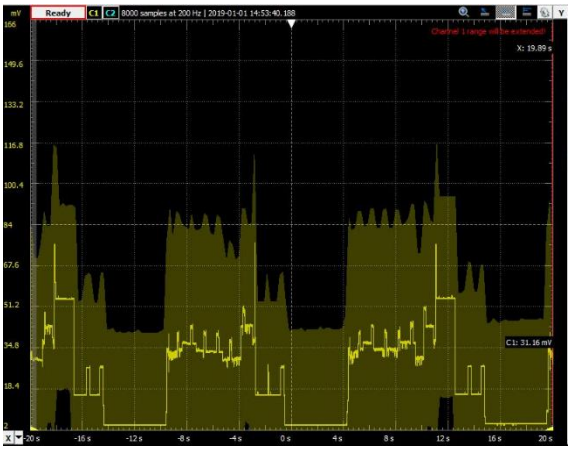
Removing jumper of R13 10 Ohm Shunt resistor, current consumption can be measured. The 10mV vertical scale of below scope diagrams corresponds to 10mA supply current. After waked up by motion sensor the GPS receiver gets continues power for 5 minutes in FULL ON mode. Then for saving battery power after receiving valid coordinates Micromite sends periodically GPS/GNSS receiver into STANDBY mode.



GPS power FULL ON.
While motion sensor senses continuous motion Micromite controls a periodic sequence:

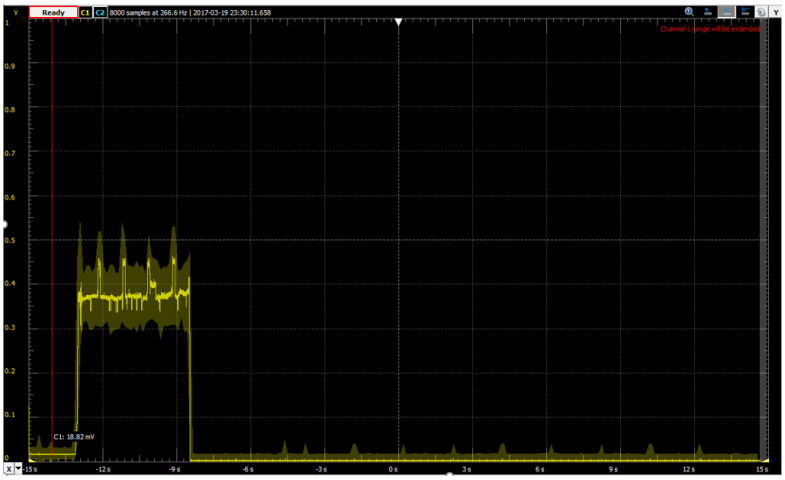
1. sleeps for short sleep time
2. reads valid GPS/GNSS coordinates
3. sends coordinates to LoRaWAN
4. sends RN2483 to sleep mode
5. goes to sleep for sleep time

During power FULL ON sequence GPS/GNSS gets continuous power for five minutes after waked up by motion sensor.



GPS Power STANDBY Mode.
While motion detector senses continuous movement Micromite controls this sequence periodically:

1. temporally switches on power for GPS/GNSS
2. reads valid GPS/GNSS coordinates
3. switches GPS/GNSS to STANDBY
4. sends coordinates to LoRaWAN
5. sends RN2483 to sleep mode
6. goes to sleep for short sleep time



GPS sleep mode.

While MOTE is moving its motion sensor restarts an inactivity motion timer. When MOTE stops its motion-detector allows inactivity timer to reach limit. After reaching inactivity time limit Micromite switches power off for all peripherals and goes to sleep for unlimited time. Only motion sensor can wake Micromite up again and the whole sequence starts FULL ON first then STANDBY modes.

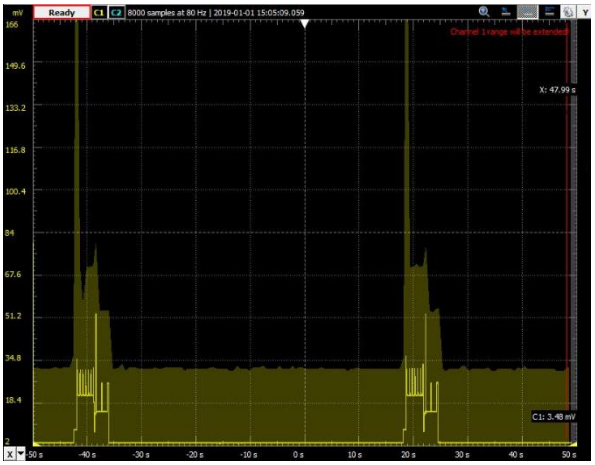
Refer to these documents about modes of GPS receiver, its accuracy and power consumptions:
Quectel: L86 Hardware Design (Rev. L86_Hardware_Design_V1.0)
Quectel: L86 GNSS Protocol Specification (Rev. L86_GNSS_Protocol_Specification_V1.1)

C: Sensor mode

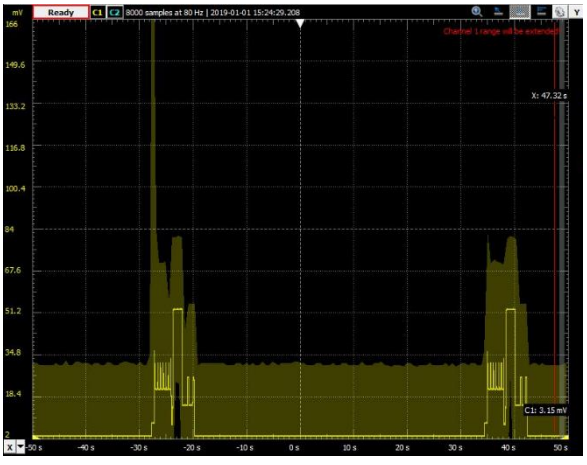
In sensor mode MOTE measures its internal and external sensors then sends results to LoRaWAN. Between measurements the MOTE switches off its sensor peripherals and goes to sleep for long sleep time. The minimum sleep time value is one minute but can be extended with additional 255 minutes by a download message. MOTE is using ADR on all Multi SF channels with fixed payload lengths. In Europe transmit duty cycle is limited in ISM bands and it can easily be controlled by the length of long sleep time. Its value can be set according to requirements of DR0 transmit time and the desired battery life. **Micromite GPS LoRa MOTE switches off transmit duty cycle control of RN2483, however, responsibility of user remains to setting up transmit frequency and duty cycle of final sensor products.**

Time measurement of transmit cycles and worst-case calculations of the design can easily and reliably substitute duty cycle control of RN2483 modules.

DR5: transmit time is 95 milliseconds

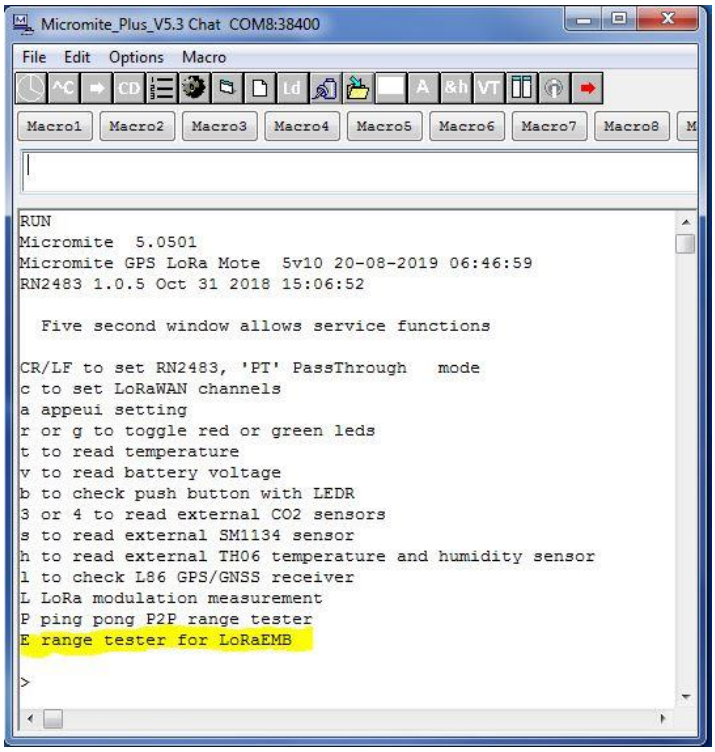


DR0: transmit time is 1.8 seconds



D: Console in Service mode

Service mode can be accessed after resetting Micromite. During a five second service time window service functions can be initiated from console:



- **CR/LF** to set RN2483 — 'PT' Pass Through allows manual control of RN2483.

  This service subroutine call can be finished by pressing ^C or pressing  button of toolbar. Then RUN the BASIC program again.
  'PT' subroutine can also be terminated by 'quit' command from console.
- **c** to set LoRaWAN channels — Configures 10 LoRaWAN channels according to Semtech EU868 standard. This service runs automatically then continues to GPS Mode.
- **a** *appeui* setting — Allows modification of *appeui* of RN2483 to *appeui* of network server.
- **r** or **g** to toggle red or green LEDs — This service function keeps for additional 5 second after pressing r or g.
- **t** to read temperature — This service function keeps for additional 5 second after pressing t.
- **v** to read battery voltage — This service function keeps for additional 5 second after pressing v.
- **b** to check push button with LEDR — Pushing button switches red LED on. This service function can be finished by pressing ^C or pressing  button of toolbar in Micromite Chat window. Then RUN the BASIC program again.
- **3** or **4** to read external CO_2 sensors — COZIR sensors can be tested on either COM3 or COM4. This service mode can be finished by pressing ^C or pressing  button of toolbar in Micromite Chat window. Then RUN the BASIC program again.

- **s** to read external SM1113 sensor — Sends SM1113 temperature and pressure values to console. This service mode can be finished by pressing ^C or pressing ^C button of toolbar in Micromite Chat window. Then RUN the BASIC program again.

- **h** to read external TH06 sensor — Sends TH06 temperature and humidity values to condole. This service mode can be finished by pressing ^C or pressing ^C button of toolbar in Micromite Chat window. Then RUN the BASIC program again.

- **l** to check L86 GPS/GNSS receiver — After switching GPS/GNSS receiver on, its records are transferred to console port till pressing ^C or pressing ^C button of toolbar in Micromite Chat window.

- **L** LoRa modulation measurement — A periodic LoRa modulated signal with 1mW power is available on antenna connector for RF signal measurement. Users are encouraged to modify this program according to needs of signal measurements. This service mode can be finished by pressing ^C or pressing ^C button of toolbar in Micromite Chat window. Then RUN the BASIC program again.

- **P** Ping-pong range testing mode — Micromite MOTE is switched to ping-pong mode. Two Micromite MOTES can answer to each other continuously while they are in two-way radio communication range. During receiving green LED is lit and while transmitting the red LED is lit. The frequency of LEDS flashing indicates existence of two-way communication or its absence. This service mode can be finished by pressing ^C or pressing ^C button of toolbar in Micromite Chat window. Then RUN the BASIC program again.

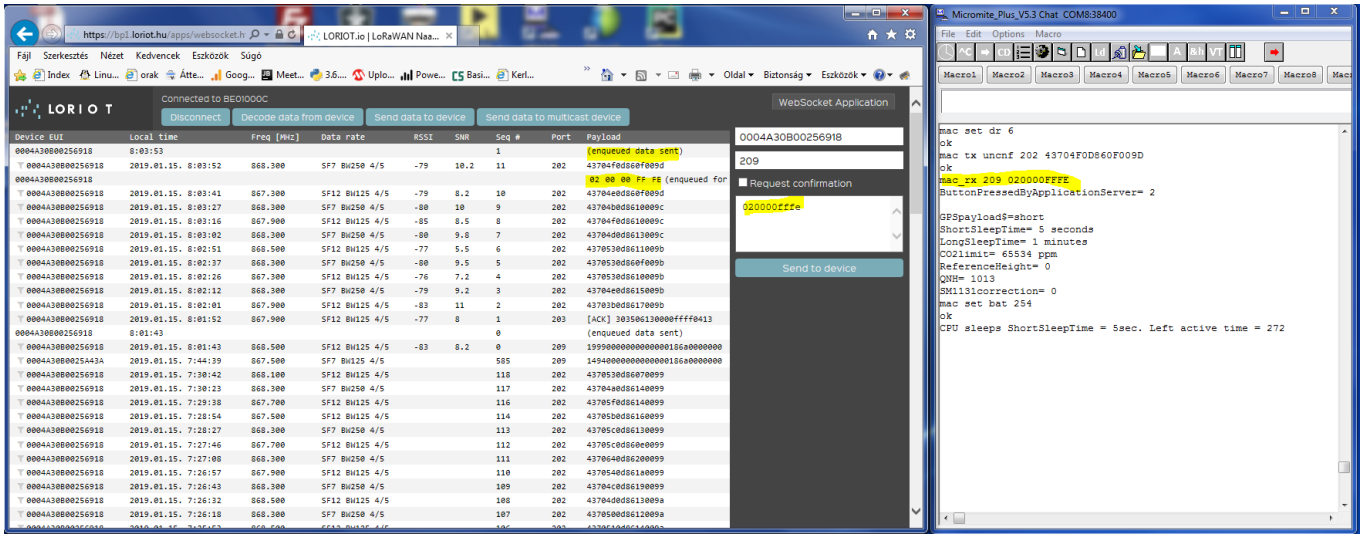
- **E** range tester for LoRaEMB — ChipCAD started to distribute EMBIT LoRa modules in August 2019: EMB-LR1272E and EMB-LR1276S.

Both modules have a command interpreter on serial Embit Binary Interface. The UART interface supports LoRaWAN and LoRaEMB protocols. During **E range testing** Micromite COM3 port is connected to LR1276S-EVK. Pressing push button of Micromite initiates one packet to LoRaWAN by its RN2483 module and other one to LoRaEMB through LR1276S. Both packets will have the same uplink counter values that provides comparable range test results.

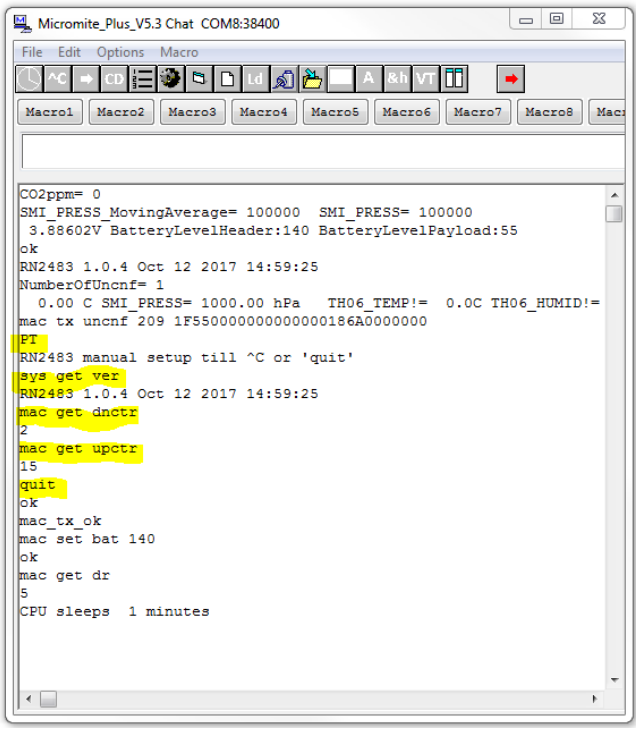
For further information refer to **Range Tester for LoRaWAN and LoRaEMB Networks** document.

E: Using Micromite Console in GPS, Sensor and Multicast modes

Micromite echoes internal messages to console during all operation modes. This helps understanding LoRaWAN communications. Users are recommended to utilize this for learning and for debugging their own applications:



GPS, Sensor and Multicast modes are designed for standalone operations that don't require user intervention from Micromite console. All operation parameters can be modified by downlink messages. Operation modes can be altered by downlink messages or different length button presses.



For debugging purpose Pass Through function, the manual RN2483 control can be called in all modes of operation. Entering "PT" console command will always be interpreted before sending uplink messages or immediately in Multicast mode. The "PT" command will break normal operation and calls Pass Through subroutine.

This is useful feature that allows read and write of mac parameters.

Type "PT" first in console then wait till LED flashes (Micromite waken up) then hit enter. Micromite will check console buffer and breaks if "PT" request is there.

Pass Through mode can be terminated by "quit" command that continues application program.

^C will break BASIC program and allows manual console operations.

F: Adaptive Data Rate, ADR

Adaptive Data Rate is a nice feature of LoRaWAN. It assures reliable two-way communication between end device and network server in slowly changing environments. The process allows adaption of LoRa modulation (bit rate, spreading factor, data rate) to different radio conditions and even to changing topologies of gateways.

The ADR is a combined process of network server plus end device. In LORIOT network server the process needs these steps:

- ADR process can only be enabled and disabled by end devices. In GPS Mode ADR is always switched off and in Sensor Mode and Multicast modes it is on.

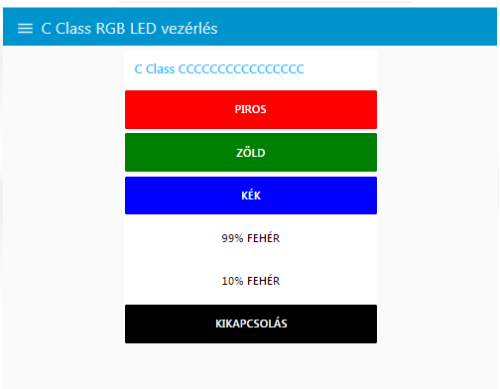
- When ADR is enabled, this information is transmitted in one bit of every uplink message header byte. LORIOT network server checks radio reports of gateways of ADR enabled end nodes and after receiving 12 uplink messages successfully it may increase the data rate of the end device by sending a mac command message. This decision calculates enough decoding margin to gateways. The mac layer of RN2483 understands this and will increase its data rate.

- The opposite data rate correction is made by the mac layer of RN2483. Whenever an uplink message requires confirmation, the RN2483 repeats the message if it lacks confirmation. First the repeated message is using the same data rate but on a different channel. Then if the second message is not confirmed either, it lowers data rate by one and repeats. This process can iterate down till gets the reliable data rate for given conditions. Users should pay attention on the parameters of repetition, the number of available channels and transmission duty cycle control of the module. Important to know that gateways are half duplex modems, while they transmit they can't receive on RX channels. The more a gateway confirms the less it can listen! **Don't use confirmation requests too frequently!** Every 10th or even less portions of uplink messages may request confirmation if there is no important event behind. This number may depend on number of end devices and density of gateways, on the robustness of the whole LoRa network. In Sensor Mode of Micromite GPS LoRa MOTE, with downlink a command the UNCNF/CNF uplink ratio can be modified between 4 to 64 depending upon requirements of application and network topologies.

The ADR process is not very quick. ADR makes no sense in mobile applications because mobile node movements maybe much faster than ADR process. But instead of ADR for mobile end device it is recommended to use higher data rates beside DR0. Micromite GPS LoRa MOTE is alternating DR6 and DR0 in GPS modes.

G: Node-RED for Micromite GPS LoRa MOTE application

We created Node-RED applications for Sensor Mode Dashboard and C Class control, their JSON source files are included here: https://www.chipcad.hu/letoltes/MMGPSMOTE.zip



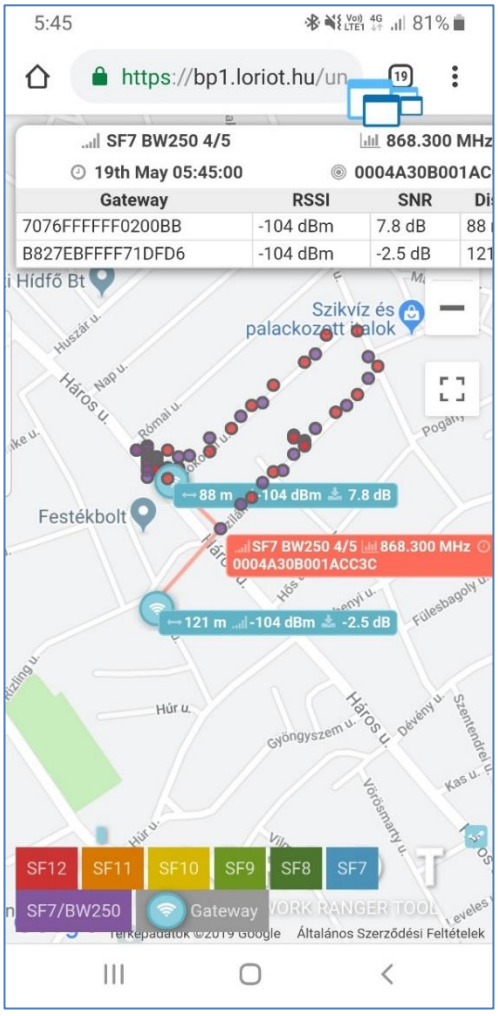
H: Micromite GPS LoRa MOTE for LoRaWAN field tests

There is common need to test geographic coverage of LoRa networks. Often radio parameters must be measured before sensor installation whether radio decoding margins in a given location are good enough or geographic coverage of our network for mobile applications is large enough. Sometimes it can also be important to know whether direct pear to pear (P2P) communication between sensor locations can be assured or not.

Micromite GPS LoRa MOTE can answer these questions in spite its simple user interface, only one push button and three pieces color LEDs. However, with a smart phone and together with built in applications of LORIOT Network Server this device can easily be used as a convenient and efficient field tester in LoRaWAN networks.

Chapter four showed how flexible parameter settings can modify operations of Micromite MOTE. But in field conditions these can hardly be utilized, only one push button plus green/red LEDs are available for controlling. While microcontroller is sleeping no LED is lit but in active state one LED is always pulsing once in every second. During radio transmission red LED is pulsing and green LED otherwise. With single button press we can change operation modes:

-GPS to Sensor while **green LED** is pulsing press button long until **red LED** is lit then release (1sec<t<4sec)
-Sensor to GPS while none LED is pulsing press button long until **green LED** is lit then release (t<1minutes)
-GPS to Multicast while **green LED** is pulsing press button long until **both LEDs** are lit then release (t>4sec)
-Multicast to GPS while **green LED** is pulsing press button short until **green LED** is lit then release (t<1sec)

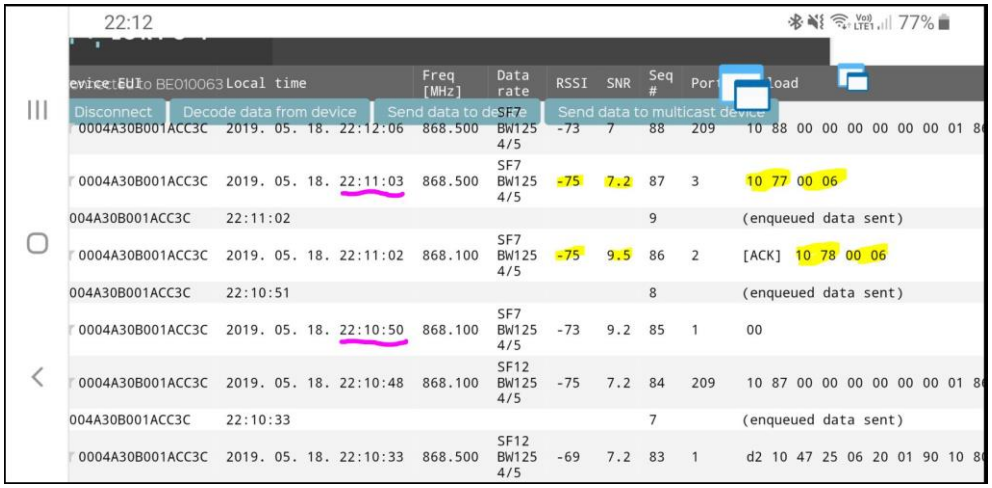


In GPS mode the Universal Ranger application of LORIOT NS can be opened in a browser of our smart phone. Red points show DR0 and purple points DR6 uplink positions. From Micromite GPS LoRa MOTE BASIC program 5v09 the default GPS format is legacy Adeunis that will automatically be processed by Universal Ranger.

During our movement Micromite MOTE transmits coordinates four times a minute that provides enough resolution. Trace points will be stored by LORIOT application that can be analyzed later, however it is convenient to follow our online tracks while we are moving.

Mobile Micromite GPS LoRa MOTE is not using adaptive data rate process in GPS mode but sends coordinates alternating DR0 and DR6 data rates. Using the lowest and highest speed LoRa modulations we get visual geographic coverage about our network. In robust network, multiple gateways provide reliable and low PER connection between our network and mobile device even in dense urban areas. In poor conditions DR6 uplinks will be lost first then DR0 later.

In fixed location sensor applications adaptive data rate process is mandatory to assure long term and reliable network coverage. Micromite GPS LoRa MOTE is capable to measure radio parameters of our network in a given location. Let's place Micromite GPS LoRa MOTE to the desired location then switch its mode from GPS to Sensor! Micromite switches on ADR process, selects DR5 then sends two uplinks requesting confirmation.

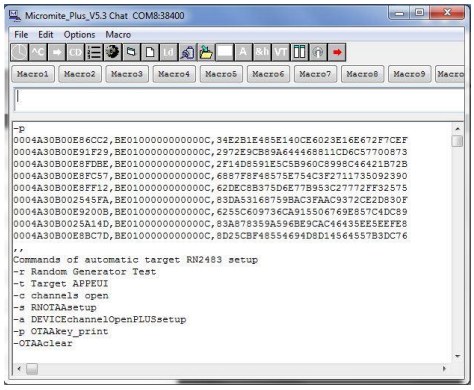


Let's open Sample LORIOT application on our smart phone browser before switching to Sensor mode!

After Micromite GPS LoRa MOTE receives confirmation from NS it answers by uplinks (first to port 2 then second to port 3). RSSI and SNR values of its radio are BCD coded into the payload. Plus/minus sign are coded into highest digit of four-digit BCD value, the three lower BCD digits contain absolute RSSI and SNR. In the first highlighted line NS received the uplink with RSSI=-75dB and SNR=7.2dB. In the payload Micromite GPS LoRa MOTE reports radio parameters RSSI=-78dB and SNR=6dB about the previous received downlink confirmation message. We learn from this uplink also, that SF7-BW125-CR4/5, the fastest DR data rate can be used by our sensor from this location.

Two Micromite GPS LoRa MOTEs can be used to test distance of P2P communication. In Service function select "P2P ping pong range testing"! See appendix D. For the P2P range test nothing else is required than two Micromite GPS LoRa MOTEs. They use message exchange on 869,625MHz with SF12 LoRa modulation and 25mW transmit power. Both devices flash green LEDs for 10 second during receiving and 1 second red LED during transmitting. If they can receive each other than they response immediately. The frequent green-red flashes indicates two-way radio communication and long green light shows its lack. LoRaWAN gateways are usually installed on high positions (30-50m above ground) while sensor nodes on lower positions (1-2m above ground). This height difference causes that in average LoRaWAN covers much larger geographic areas (10-15km) than P2P communication (2-5km).

I: Micromite GPS LoRa MOTE for bulk programming



Secure key provisioning for LoRa products is important during production. Micromite runs on 32bit PIC32MX microcontroller that has enough computation power and memory to generate and store keys for medium scale RN2484 based production. We provide two Micromite BASIC programs for bulk programming of RN2483 keys:

RN2483-ABP_config_1v6.bas
RN2483-OTAA_config_1v0.bas

We prefer OTAA key application that we recommend for our clients to customize according to their own security requirements.

COM3 port of Micromite GPS LoRa MOTE should be connected to serial port of RN2483 in target application. The RN2483-OTAA_config_1v0 application generates keys and together with channel configuration parameters programs them to target RN2483 module in a few seconds. After programming keys to maximum 100 target systems OTAA key are stored RAM memory of Micromite that can easily be exported into an OTAA bulk import file. The OTAA bulk import file then can directly be used for network device configuration in LORIOT NS. However, instead of using APPEUI of manufacturer we recommend for final users to change it to their own APPEUI in the bulk import file. The final users should also be able to change APPEUI of sensors to their own APPEUI before activating.