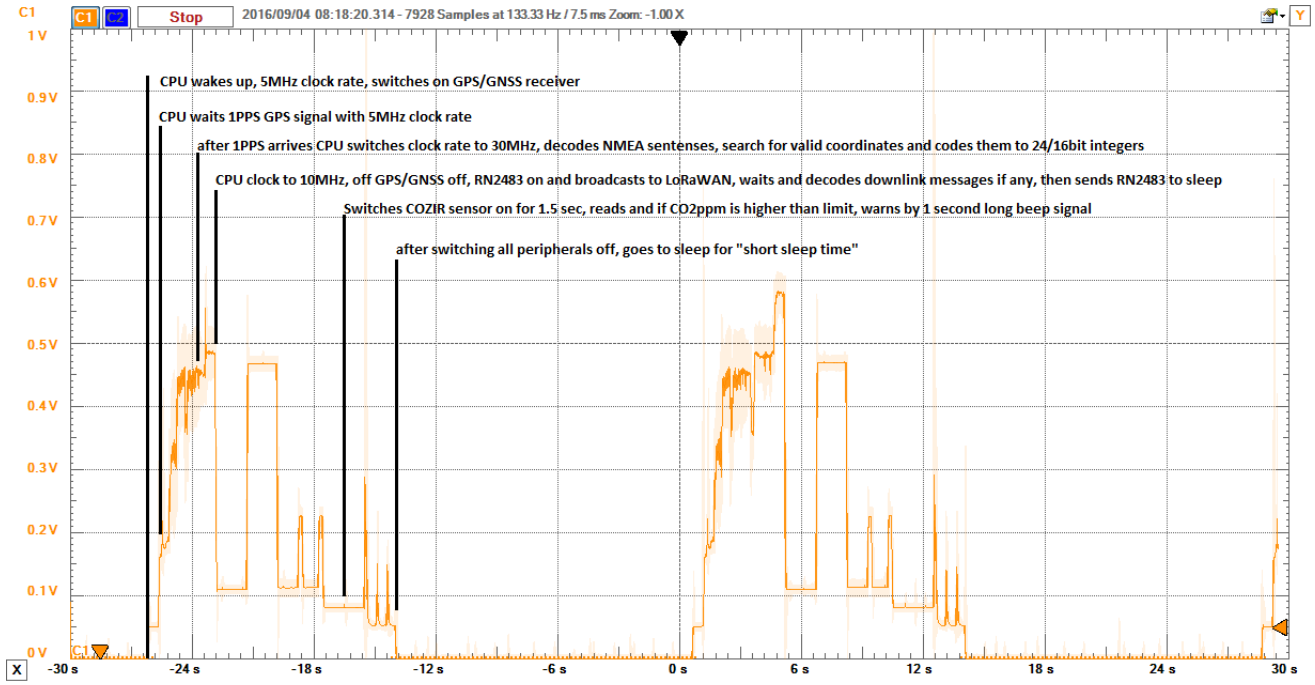
Micromite GPS LoRa MOTE

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 that allows very 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 a built in USB-UART bridge that allows a single USB connection to the free MMEdit integrated development environment. 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 CO2 sensors, however, users are encouraged to implement their own sensor support through two UART, one I2C 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: http://www.chipcad.hu/letoltes/MMGPSMOTE.zip

1. GPS Mode

Micromite GPS LoRa MOTE has a built in SQ-SEN-200 motion sensor that allows GPS operation in GPS Mode. While motion is detected the MOTE searches GPS/GLONASS satellites and if valid coordinates are captured then broadcasts them to LoRaWAN twice in every minute. After 5 minutes without motion the MOTE goes to sleep for unlimited time then only its SQ-SEN-200 motion sensor can wake it up. This feature provides in a moving vehicle that the Micromite GPS LORA MOTE operates continuously and after the vehicle stops the MOTE automatically puts itself in low power consumption mode. The frequency of GPS sensing and coordinate broadcast will strongly influence total power consumption. After each transmission the MOTE goes to sleep for **short sleep time** that is at



least 15 seconds but can be extended up to 270 seconds from the network server by downlink message. In the downlink message the **short sleep time** may set the total GPS measurement period from half to five minutes. The 5 minute cycle consumes 10 times less energy than 0.5 minute measurement so it extends battery life 10 times

longer. The above current consumption diagram was measured on the 10 Ohm internal Shunt resistor, the 0.1V vertical scale corresponds 10mA and it shows periodic GPS Mode operation of Micromite GPS MOTE.

The Micromite GPS LORA MOTE can handle a set of external sensors and as example an optional CO2 sensor can be connected to its peripheral connector. When Micromite GPS LORA MOTE is operated in a car and an optional CO2 sensor plus a buzzer are connected, the MOTE measures CO2 concentration before going to sleep and if CO2 value exceeds the programmable **CO2 limit** an audible warning sound is generated to warn car driver switching on incoming fresh air inflow for avoiding drowsiness and finally prevent car accidents, as this danger is shown in this BBC report.

Uplink massage in GPS Mode:

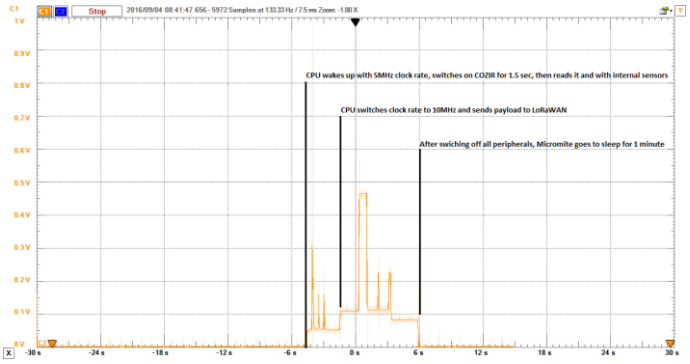
Seq #	Port	Payload
275	202	4370550d860b008301

Sequential number 275, port number 202
Payload:
latitude 24bit signed number, angle domain -90 to +90 degrees
longitude 24bit signed number, angle domain -180 to +180 degrees
height above sea level 16bit unsigned number, height domain 0 to 10000 meters
HDOP accuracy of L86 GPS/GNSS receiver, Dilution of Precision domain 1 to 15

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 it disconnects battery at 3.5V to avoid over discharge. The green and red LEDs are controlled by the MOTE. While Micromite is operating one of them is pulsing once in every second. The green LED flashes during satellite searching or sensor measurements then after valid values are captured the red LED is flashing till the end of LoRa transmission. LEDs are dark during Micromite sleep modes. During satellite search when green LED is pulsing the push button can shortly be pressed for less than a second or longer till the red LED light appears. The short button press initiates a sensor measurement and LoRa broadcast, the long button press changes from GPS Mode to Sensor Mode after button release.

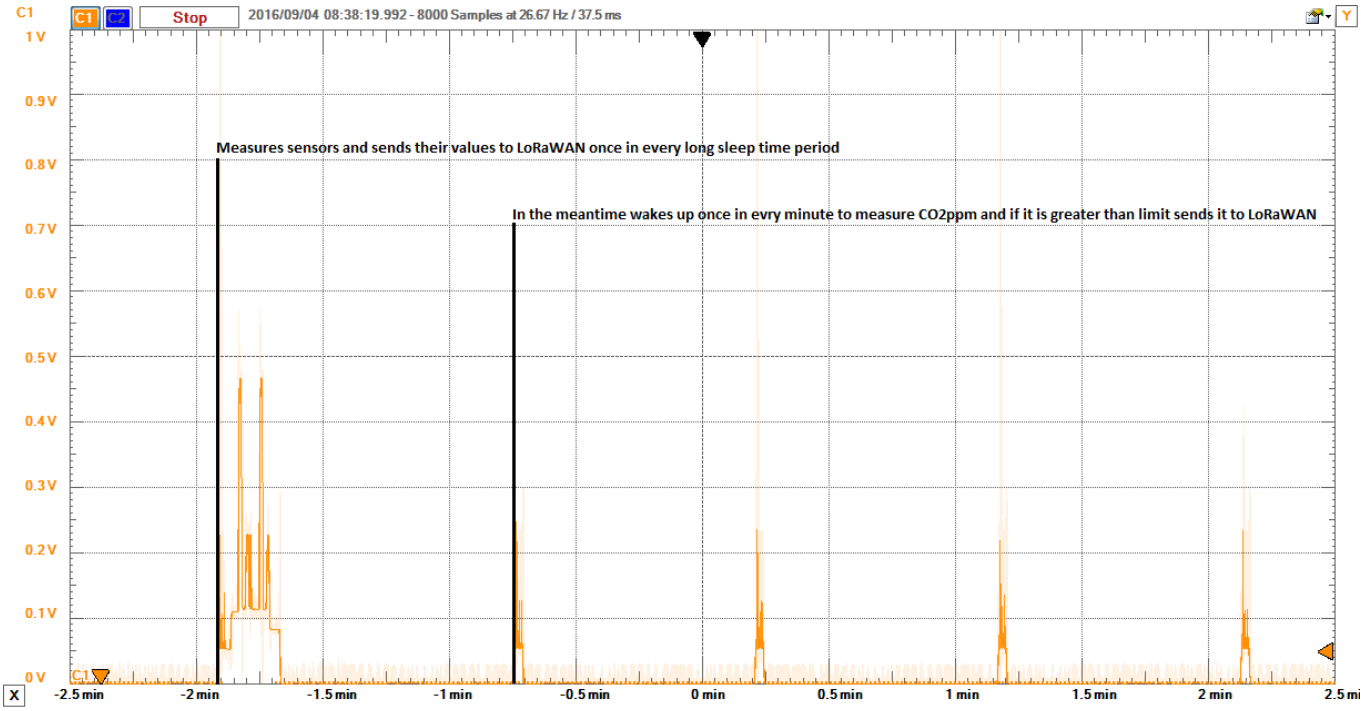
In GPS Mode the MOTE uses DR=0 with SF12 and 25mW. In this mode the transmission duration is between 0.008%-0,8% per channel depending upon the programmed sending frequency. However, after stopping the Micromite GPS LORA MOTE stops it operation or it can be switched to Sensor Mode, where the MOTE uses adaptive data rate and its transmission duration will automatically be lowered by orders of magnitude depending upon the MOTE distance from gateways. In Sensor mode the GPS receiver is stopped and measurement is continued by internal and the optional external sensors.

2. Sensor Mode



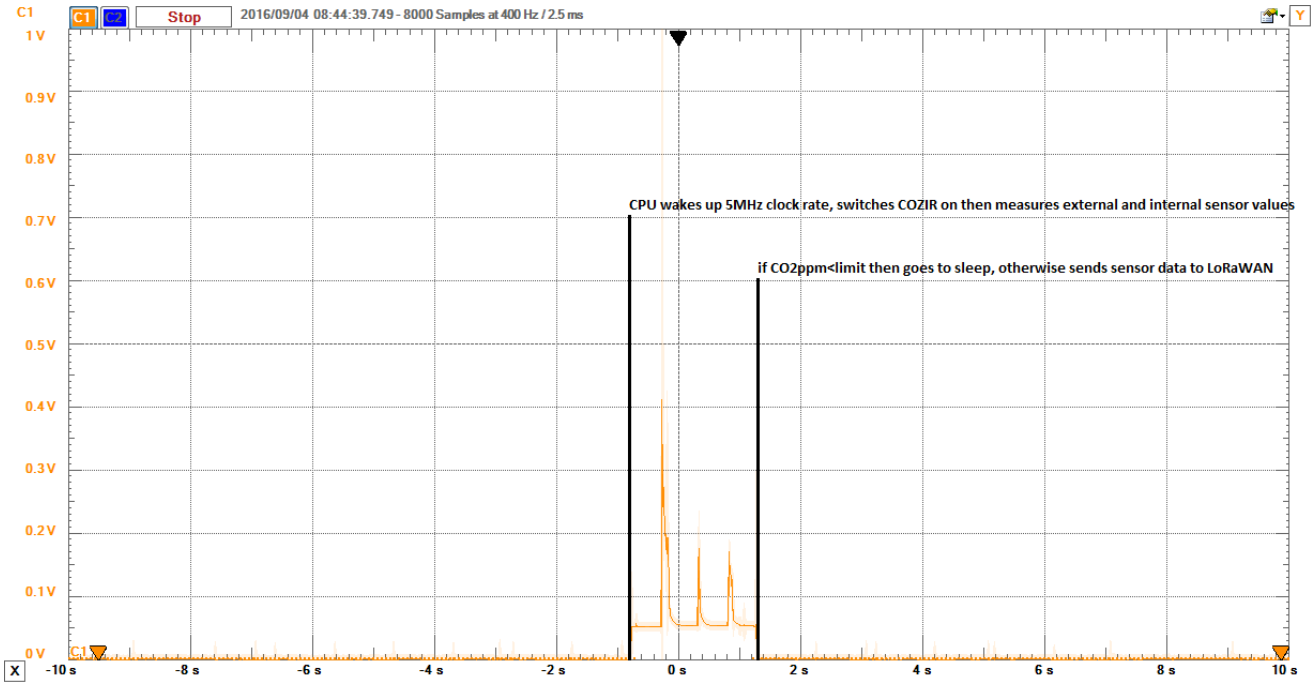
In Sensor Mode the MOTE uses internal and optional external sensors other than GPS/GLONASS receiver. The internal temperature and battery voltage sensors can be extended by GSS COZIR sensors. The MOTE periodically measures its sensors and broadcasts their measured values to LoRaWAN. Between measurements Micromite switches off all high power

consumption peripherals and goes to sleep for **long sleep time** that is at least 1minute but it can be extended up to 256 minutes by a downlink message. Extending the **long sleep time** will significantly lower power consumption. The application server can dynamically modify the CO2 measurement frequency to meet application requirements.



For example, in outdoor citywide environment during nights the frequency can be lowered while in rush hours it can be increased to accurately measure pollution of vehicles in changing traffics.

Above chart shows a four minutes **long sleep time** setup where the MOTE sends sensor data once in every five-minute period but reads sensors in every minute.



Sensor Mode uses adaptive data rate, automatically employs the highest bit rate for its LoRaWAN communication with the lowest power consumption. In Sensor Mode the MOTE is not moving and it keeps transmission duration and battery consumption automatically on the lowest possible level.

In sensor mode the push button can also be used. But because the MOTE is unable to recognize button presses in sleep mode, the short button press is not implemented. The MOTE can recognize long button press right after wakeup and changes its Sensor Mode back to GPS Mode. A long green LED flash confirms the Mode change button press. The minimum long sleep time is 1 minute but can be extended by a downlink message up to 256 minutes. During long sleep time Micromite wakes up periodically once in every minute and measures CO2 concentration. If it is lower than the programmable **CO2 limit** concentration it goes back to sleep without transmission but if actual concentration exceeds **CO2 limit** it sends sensor data to application server whatever is long sleep time value. Additionally, during the short awaken state Micromite can recognize if button is pressed then can switch back to GPS Mode. If we want to manually change mode, the button should be pressed while LEDs are dark and release after green LED lights.

Uplink message in Sensor Mode:

Seq #	Port	Payload
275	209	12ca02ed01e91c

Sequential number 275, port number 209

Payload:

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

Battery voltage 8bit BCD number, percentage domain 1%-99%, relative charged voltage between 3.5V-4.2V

The battery voltage is updated at 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.

COZIR CO2 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

3. Control from application server in both modes

The operation parameters can be modified from application server in GPS and Sensor Modes by downlink message:

Port	Payload
209	01caed07d0

Port number 209

Control: 8bit unsigned number

00 no mode change, no sensor data request

01 in GPS Mode the application server requests a single sensor measurement. Same as short push button press in GPS Mode.

02 mode change. In GPS Mode changes to Sensor mode and in Sensor mode back to GPS Mode.

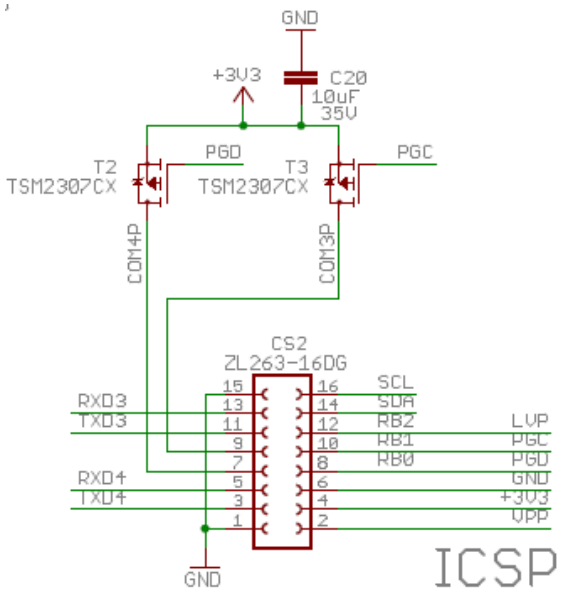
Short Sleep Time: 8bit unsigned number. In GPS Mode the sleep time will be this parameter plus 15 seconds.

Time domain: 0 to 255 seconds

Long Sleep Time: 8bit unsigned number. In Sensor Mode the sleep time will be this parameter plus 1 minute.

Time domain: 0 to 255 minutes.

CO2 limit: 16bit unsigned number. Concentration domain: 0 to 65535 ppm or 6.5535%



4. Using external peripheral connector

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

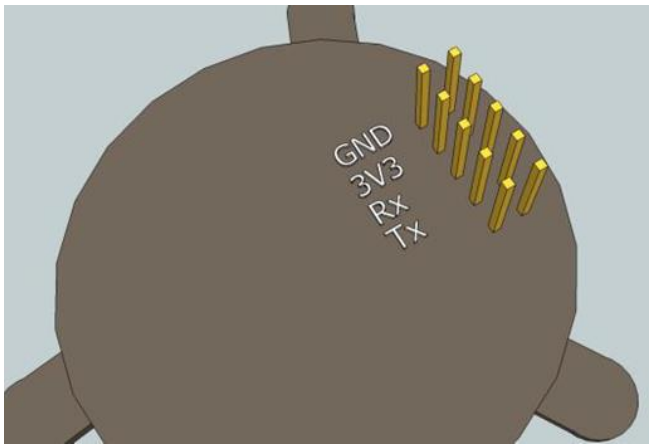
- **C2: 2, 4, 6, 8, 10, 12 ICSP pins** can accommodate a PICKit3 programmer for Micromite firmware update.

- **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 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 I2C bus**.
- **C2: 8, 10, 12 digital, analog I/O or three PWM channels** (for driving RGB LED).

5. Connection of COZIR CO2 sensor and buzzer

COZIR CO2 sensors uses 9600 baud UART serial communication with 3.3V logical level that matches to Micromite, only a 4-wire M2F is required. The Micromite GPS LORA MOTE uses COM3 for COZIR sensor on its COM3 UART port:

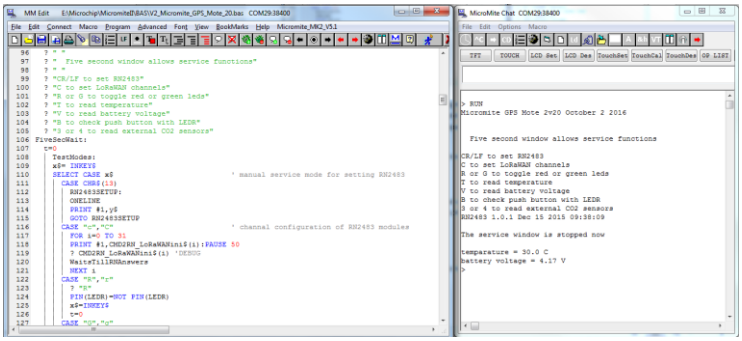


C2:15 COZIR GND
C2:09 COZIR 3V3
C2:11 COZIR RX
C2:13 COZIR TX

Micromite can drive a buzzer in GPS mode when a COZIR CO2 sensor is connected. After sending GPS/GNSS coordinates to LoRaWAN the Micromite measures CO2 concentration and if it is higher than the preprogrammed upper limit then drives a buzzer with one second warning signal. The buzzer frequency is equal in Hertz with the CO2 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

6. Console mode and MMEdit development environment



Micromite User Manual can be downloaded from here:
http://geoffg.net/micromite.html

Micromite BASIC programs can be edited, then downloaded to Micromite with MMEdit.
Install MMEdit from here:
http://www.c-com.com.au/MMedit.htm

MM Edit provides an efficient editing and debugging environment for Micromite BASIC programs. Nice feature of Micromite that BASIC programs can be suspended and in its console mode it is possible to set all of its peripherals, BASIC functions and subroutines can separately be run and tested manually.

7. Service functions of Micromite GPS LoRa MOTE

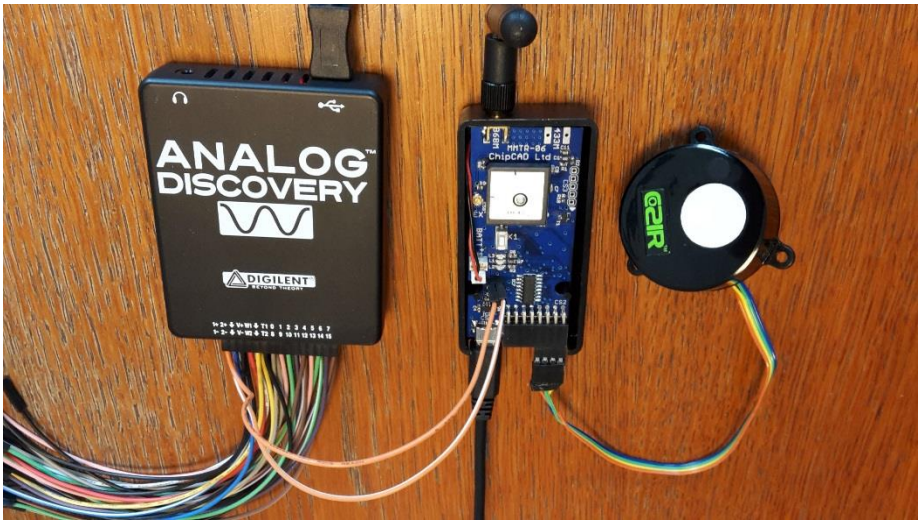
After reset the GPS LORA MOTE provides a five second service window. If during this period a valid command comes from the console, test functions are accessible.

The list of valid commands:

- **CR/LF** to set RN2483	Allows manual control of RN2483. This service function can be finished by pressing ^C, or pressing ^C button of toolbar in Micromite Chat window. Then RUN the BASIC program again.
- **C** to set LoRaWAN channels	Configures 8 LoRaWAN channels according to Semtech EU868 standard. This service runs automatically then continues to GPS Mode .
- **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 button	This service function can be finished by pressing ^C, or pressing ^C of toolbar in Micromite Chat window. Then RUN the BASIC program again.
- **3** or **4** to read external CO2 sensors	COZIR sensors can be tested on either COM3 or COM4. 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 on GPS/GNSS receiver, its records are transferred to console port till pressing ^C, or pressing ^C button of toolbar in Micromite Chat window.

8. Opening and closing plastic case of Micromite GPS MOTE

The Micromite GPS LORA MOTE 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 the case parts but the PCB board is designed to be mechanically fixed in the case. The cased Micromite GPS LORA MOTE then can easily be moved to its locations and is resistive against environment stresses. However, the PCB is designed to meet additional requirements. The cased device can accommodate a 750mAh LiPo battery but if longer duration is required the board can be powered from a 2000mAh battery instead, but due to its much larger size without its standard case. The GPS/GNSS receiver uses its internal patch antenna but the PCB can accommodate external antenna also. For example, in bicycle tracking one of the main design challenges is how to hide electronics against sabotage. The external antenna connector of both GPS/GNSS and LoRa radios can support experiments with hidden electronics and antenna designs in such Proof of Concept projects right away.



When the case is open the firmware of RN2483 module can be updated by a PICKit 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 into its place.

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.

9. Packing list of Micromite GPS LORA MOTE package

- Micromite GPS MOTE (cased with 750mAh battery)	1 piece
- AN-6 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.