WiMOD LoRaWAN EndNode Studio

User Guide Version 0.19

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0.2	Draft Version Created For Review
0.3	Preliminary Version
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0.19	Updates according to new GUI version V0.48.0 and firmware version V2.0(Build 167)

Aim of this Document

This document describes the WiMOD LoRaWAN EndNode Studio, a Windows application which can be used in combination with the WiMOD LoRaWAN®[1] compatible radio modules (e.g. iM880A, iM880B, iU880A, iU880B) and its embedded WiMOD LoRaWAN EndNode firmware.

[1] LoRa is a registered trademark of Semtech Corporation. LoRaWAN is a registered trademark of the LoRa Alliance.

Table of Contents

1. Introduction

1.1 Overview

The WiMOD LoRaWAN EndNode Studio is a Windows application which allows to explore the capabilities of the WiMOD LoRaWAN EndNode firmware. The GUI offers a comfortable way to configure and control the features of the embedded radio stack:

- Node Activation by Personalization (ABP)
- Node Over the Air Activation (OTAA)
- Encryption & Authentication
- Unconfirmed Data Transmission
- Confirmed Data Transmission
- Data & ACK Reception (including Frame Pending bit)
- Adaptive Data Rate
- Power Saving
- Class A & Class C
- Multi Band Support

The communication between WiMOD LoRaWAN EndNode Studio and the connected radio modules is implemented by means of so called HCI messages (see [1]) which are exchanged over a serial interface.

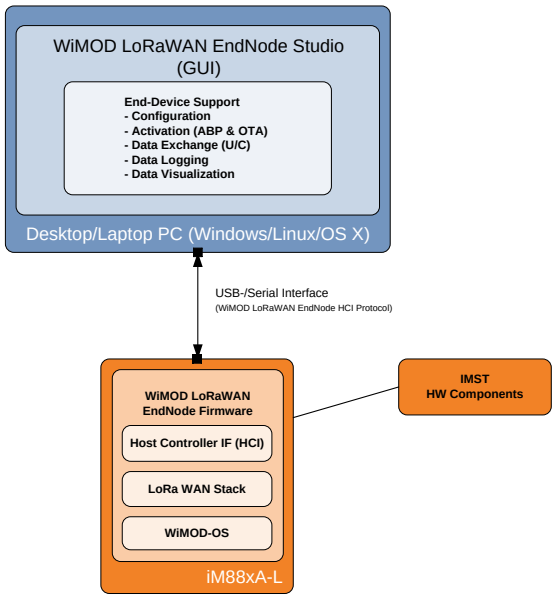

Figure 1-1: Overview

1.2 Installation

The WiMOD LoRaWAN EndNode Studio operates in combination with the pre-programmed radio modules plus demo board or USB sticks. The demo board provides a USB connector for communication and power supply purposes. An USB chip converts the serial interface signals from the radio module into USB signals. For communication over this USB interface a virtual COM port (VCP) driver must be installed on the host PC.

1.2.1 USB Driver

It is recommended to download the recent version from the USB drivers web site.

Run the CDM *version*.exe. A command box appears and the driver will be installed. Plug in the USB cable to the USB port on the demo board. Plug in the other end of the USB cable into the USB port of the host PC. Now the Windows OS will recognize the demo board as a USB serial converter.

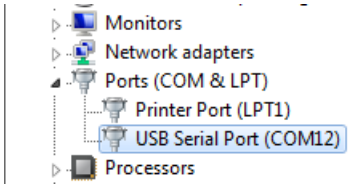

Figure 1-2: USB Driver Installation

To verify that the USB driver installation was successful, open the Windows Device Manager ("Start>Control>Panel>System>Hardware>Device Manager" or hit <WIN>+<PAUSE>). A new USB – Serial Port (COMxx) entry in section "Ports (COM & LPT)" should appear (see Figure 1-2).

Note: for firmware update purpose of old firmware and other custom firmware it is also necessary to install the D2XX driver of FTDI (see Firmware Update).

1.2.2 WiMOD LoRaWAN EndNode Studio

The EndNode Studio is based on Qt, a cross-platform application and GUI framework, compiled with MinGW and delivered as a bunch of files:

- WiMOD_LoRaWAN_EndNode_Studio.exe
  The executable Windows application file
- LoRaNodeStudio.ini
  The application INI file will be copied to the user's local application data folder: "C:\Users\$USER_NAME\AppData\Local\IMST\WiMOD_LoRaWAN_EndNode_Studio"
  Note: The application must be restarted after a modification of the INI file content
- WiMOD_LoRaWAN_EndNode_Studio_UserGuide.pdf
  This document
- Several Qt + mingw runtime libraries

Note: It might be necessary to install the Microsoft Visual C++ 2008 Redistributable Package (x86) in case the WiMOD LR Studio doesn't start. Click the download button on the Microsoft web page. Double click the vcredist_x86.exe to install runtime components of Visual C++ libraries on a computer that does not have Visual C++ installed.

1.2.3 Finish Installation

Mount the radio module on the Demo Board and connect the board by means of an USB cable to the PC. Start WiMOD_LoRaWAN_EndNode_Studio.exe and continue with the following chapter.

2. Getting Started

The EndNode Studio enables the user to evaluate the capabilities of the WiMOD LoRaWAN EndNode firmware. Several features of the embedded radio firmware can be controlled from different pages which are described in more detail in the following chapters.

2.1 Navigation

The GUI presents the embedded radio features on several pages. The navigation from one page to another is implemented by means of two navigation bars. The vertical bar on the left side is used to change between the following main sections:

- LoRaWAN Services
- Device Management
- Extras

Each section provides an individual horizontal bar on top which offers access to several pages e.g. *Device Information, Real Time Clock, Info* and so on.

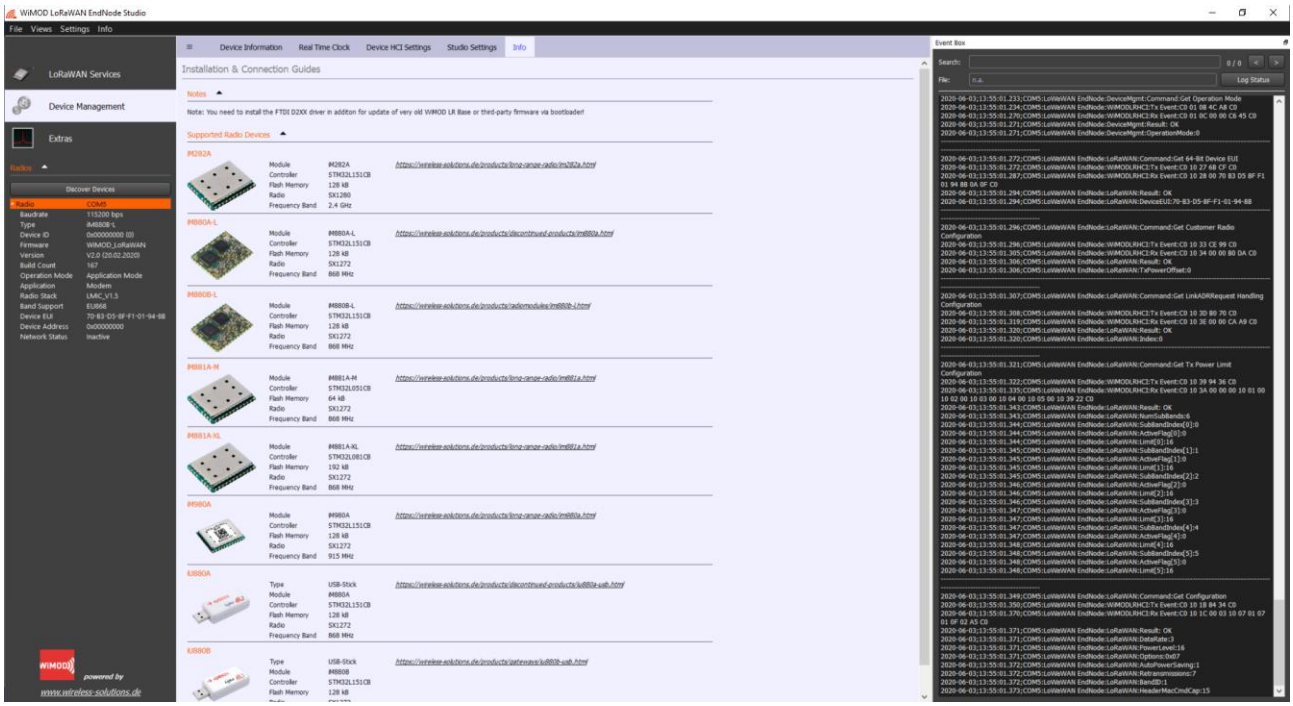

Figure 2-1: Navigation Bars

2.2 Connection to Radio Modules

The EndNode Studio provides an automatic device discovery procedure. A new connected radio module and its associated serial COM port will be displayed in the list box *Radios* (left side) after successful identification. The box provides additional information about the radio configuration and its firmware version. The application allows connecting multiple devices at the same time. Note that commands are always sent to the selected device in the list box.

Figure 2-2: Connected iM880B on serial com port

The box shows the following properties per connected device:

- COM x : used COM port
- Baudrate: baudrate for the serial communication
- Type: connected hardware component
- Device ID 32-Bit serial number
- Firmware: firmware name
- Version: firmware version (build date)
- Build Count: firmware build counter
- Operation Mode: operation mode (e.g. application/customer mode)
- Application: application name
- Radio Stack: embedded LoRaWAN radio stack version
- Band Support: supported band (e.g. EU868)
- Device EUI: configured 64-Bit LoRaWAN Device EUI
- Device Address: 32-Bit device address used in radio packets
- Network Status: inactive – not activated
  active(ABP) – activated by personalization
  active(OTAA) – activated over the air
  joining (OTAA) – joining over the air

2.3 Disconnect/Remove Radio Modules

The *Radios* box allows to remove a connected device by *right-click* mouse operation. The device will become available for a second instance of EndNode Studio afterwards. Reconnecting to the same Studio requires to unplug and to plug again.

2.4 Status Box

The right area of the main window contains a *Status Box* which is used to display events or the result (success/error) of any issued command. The *Status Box* can be picked by its title bar and moved to any other area on the screen. The content of this box can be cleared from the context menu (*right-click* mouse operation).

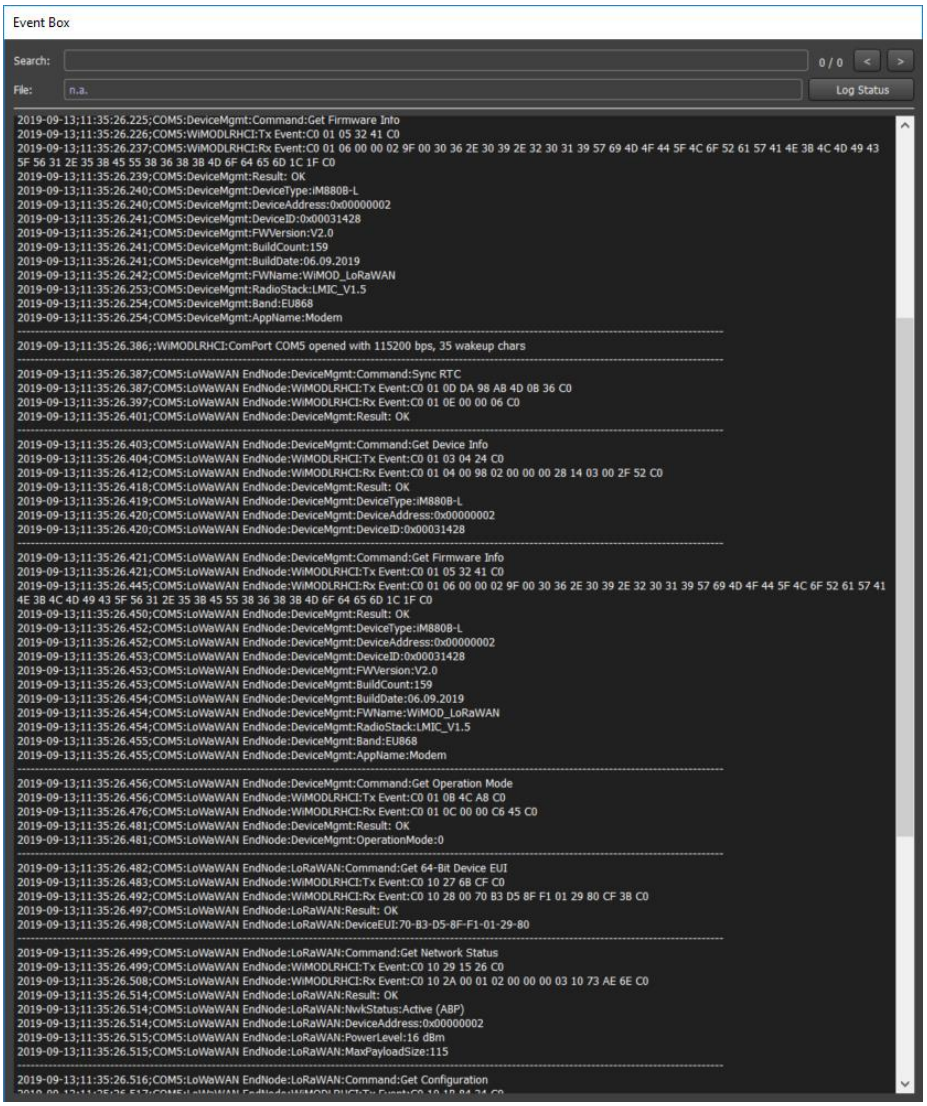

Figure 2-3: Status Box (left side)

The *Log Status* feature allows to save every status line into a human readable ASCII text file. The created text file can be opened with any kind of text editor.

2.5 Firmware Update

The EndNode Studio includes the possibility to update the firmware of the connected device through the *File* menu.

Figure 2-4: Firmware Update - Menu

The bootloader activation is implemented in different ways and explained during the update procedure. Latest WiMOD LoRaWAN EndNode firmware includes a HCI command which activates the bootloader fully automatically from the firmware itself. Older firmware or customer firmware might require a signal on the dedicated bootloader signal pin of the radio module. For USB-Sticks and modules on the Demoboard this signal can be controlled via FTDI. Beside the VCP driver an additional D2XX driver must be installed for proper operation.

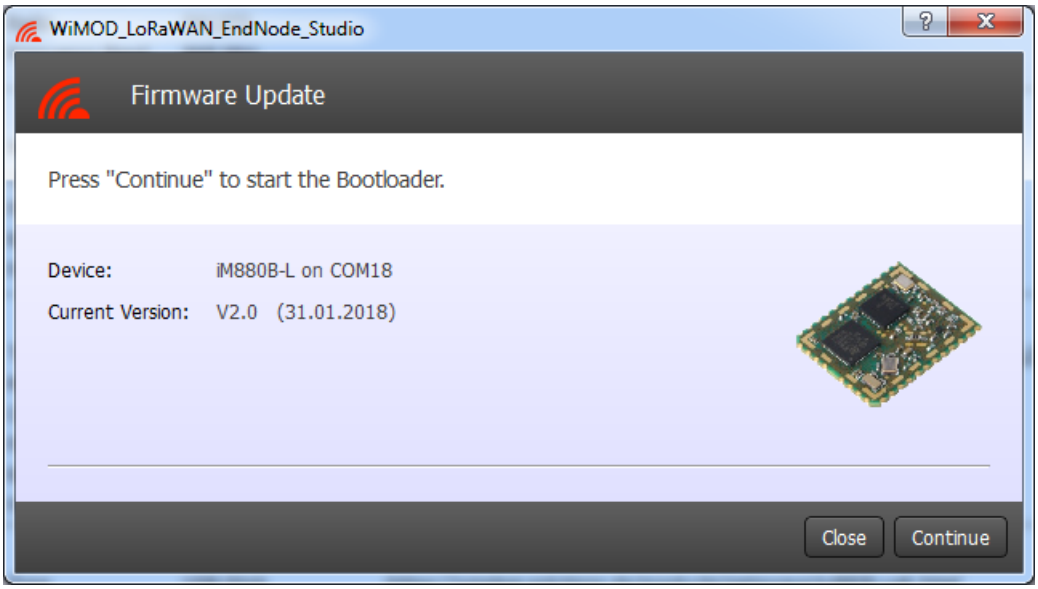

Figure 2-5: Firmware Update

3. Feature Section

The software features are presented on the following main sections (left navigation bar):

- LoRaWAN Services
- Device Management
- Extras

3.1 LoRaWAN Services

This section includes the following pages:

- LoRaWAN Services
- LoRaWAN Configuration

3.1.1 LoRaWAN Services

This page provides the activation of an end-device and the exchange of LoRaWAN radio packets with a LoRaWAN server over the air.

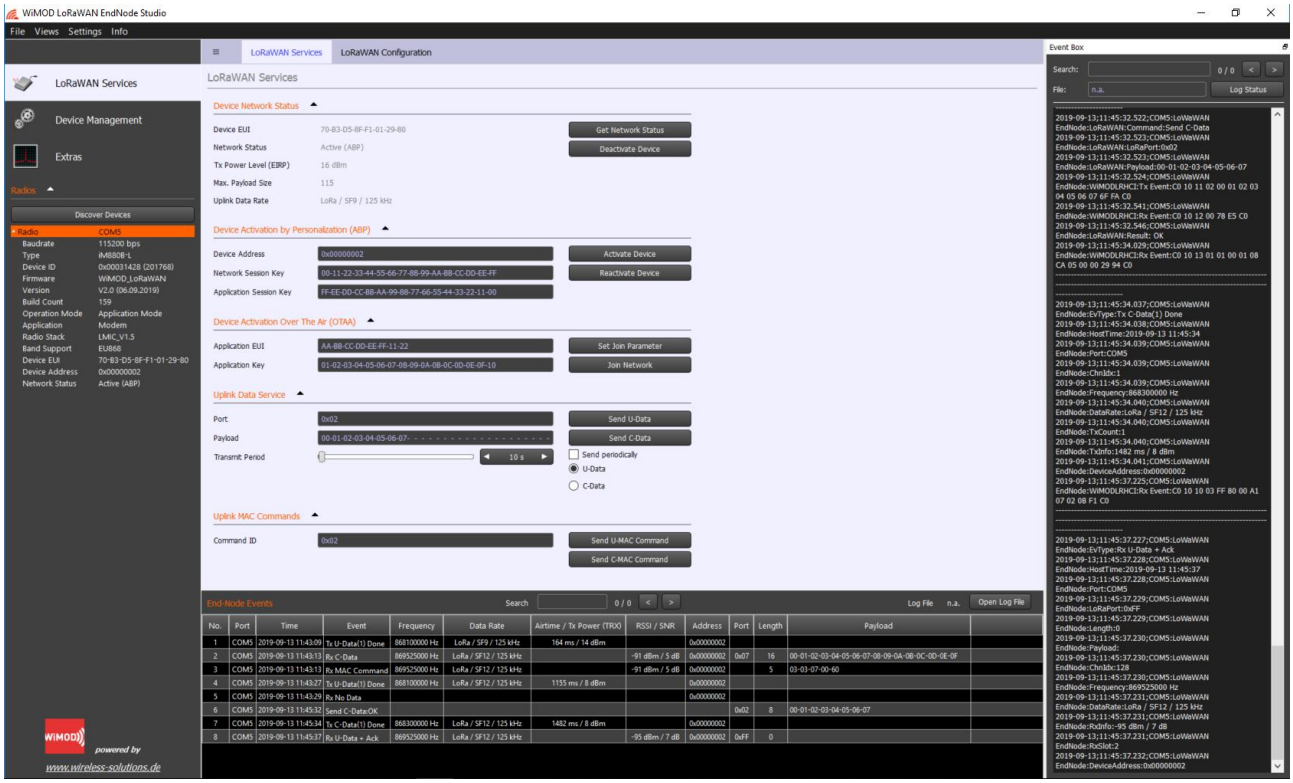

Figure 3-1: LoRaWAN Services

Device Network Status

The section displays the current activation status and Device-EUI of a connected device and allows to deactivate a device if required. Additionally the current transmission power level, maximum payload size and uplink data rate are shown.

Note: The Device-EUI can be configured through section *Extras/Customer Settings*.

Device Activation

An end-device must be activated before it can communicate with a server. The following two activation options can be used:

- Direct Device Activation by Personalization (ABP)
  Enter the three required parameters Device Address (32-bit), Network Session Key (128-bit) and Application Session Key (128-bit) into the fields, press *Activate Device* to write them into the connected end-device.
- The *Reactivate Device* option allows the activation of the end-device using the previously stored ABP parameters.
- Device Activation Over The Air (OTAA)
  The second method uses the join procedure over the air. Enter the two parameters Application EUI (64-bit) and Application Key (128-bit), press *Set Join Parameter* to write the parameters into the connected end-device. Finally press *Join Network* to start the join procedure and observe the **Status Box** and **Event Table**.

Uplink Services

Within this section it is possible to send unconfirmed or confirmed data to the server. Enter a LoRaWAN Port and some test payload into the fields and press the appropriate button to send a packet.

It offers also the possibility to initiate a periodically transmission of radio packets.

Uplink MAC Commands

This feature allows the transmission of a single MAC command to the server. For this, the desired command ID and its parameters should be entered. An unconfirmed or confirmed empty data frame is sent, depending on the selected button.

End-Node Events

Several radio events which are exposed via HCI are printed into the **Status Box** and in addition into the **Event Table** for observation and logging purpose.

3.1.2 LoRaWAN Configuration

This page provides a comfortable way to change some radio stack parameters.

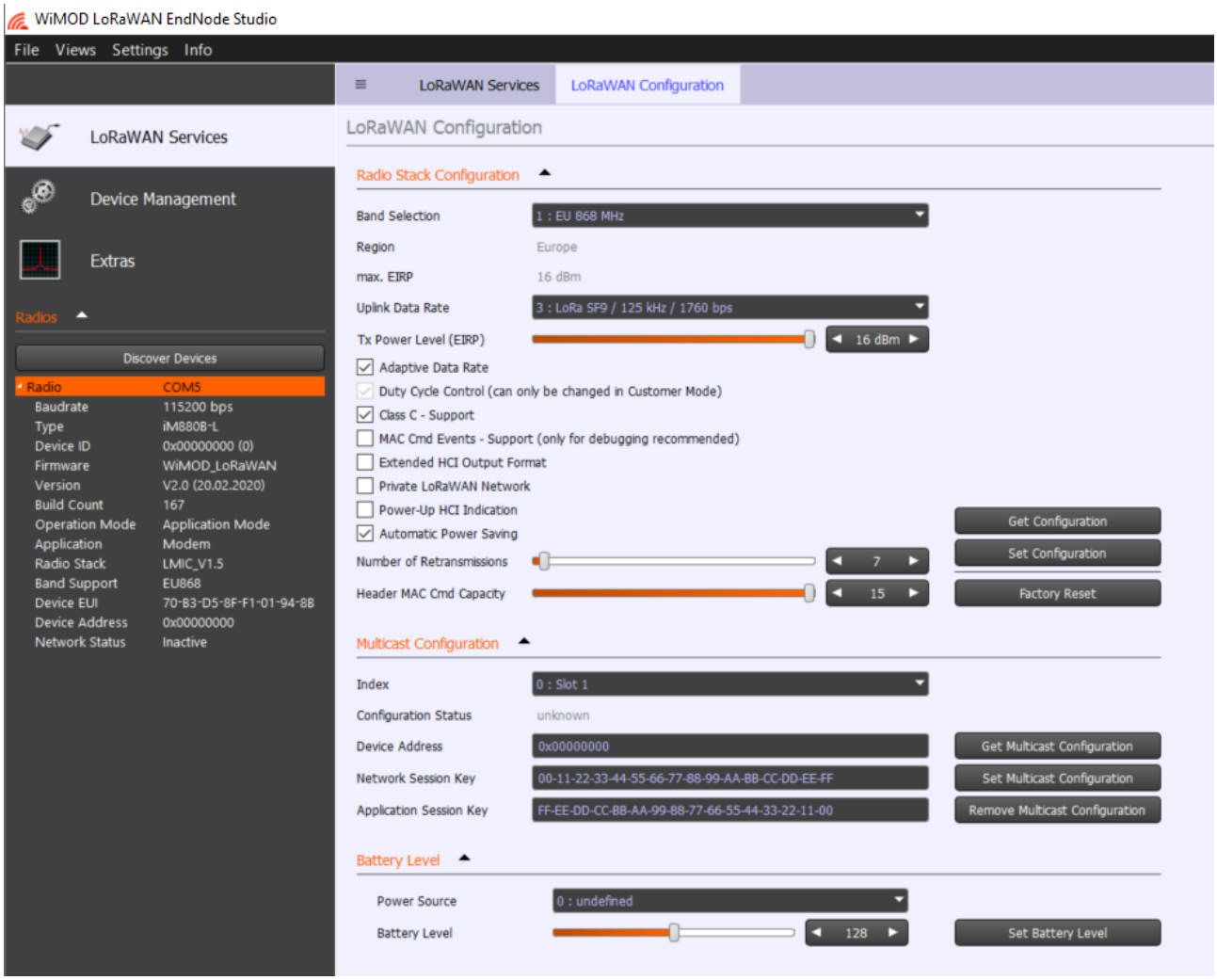

Figure 3-2: Radio Stack Configuration

Band Selection

This value is used to configure the radio band. In case a change in the radio band is requested, the end-device will be automatically deactivated.
The *Region* and *max. EIRP* will be updated accordingly.
Note that the maximum supported EIRP depends on the radio module and the configured RF Gain value (for more information refer to [2]).

Uplink Data Rate

This value is used for unconfirmed and confirmed LoRaWAN data packets. The selected data rate will be used in the next uplink and might be changed automatically by the end-device and/or server too.

Tx Power Level (EIRP)

This value is used in the next uplink and may change automatically.

Adaptive Data Rate

This feature can be enabled to allow an automatic data rate adaption from server side (see LoRaWAN server/Data service).

Duty Cycle Control

This value is used to enable/disable the duty cycle control (for test purposes).
Note that this parameter can only be modified if the *Customer Mode* is selected on the end-device.

Class C - Support

This feature enables the Class C operation mode.

MAC Cmd Events - Support

This feature enables the visualization of the MAC command received by the end-device, in the Event Table.

Extended HCI Output - Support

This feature enables the extended RF packet output format, where the Tx/Rx channel info is attached (see [1]).

Private LoRaWAN Network

This feature enables he configuration of a private LoRaWAN network, which implies a change on the sync word.

Power-Up HCI Indication

This feature enables a HCI message informing to the host when the module is ready to communicate after a power-up reset.

Automatic Power Saving

This feature can be enabled to activate the automatic power saving mode. The module will enter a low power mode whenever possible.

Number of Retransmissions

This value sets the maximum number of retries for a reliable radio packet where an acknowledgment is not received.

Header MAC Cmd Capacity

This value is used to configure the maximum length of the MAC commands to be piggybacked in the header within the next uplink. If the length of the reply exceeds this value, they will be sent immediately using the port 0.

Factory Reset

This services can be used to restore all settings which have been configured during production at IMST. It also includes the Device-EUI, Application-EUI and the LoRaWAN security keys.

Note: Modules which have been updated from WiMOD-LR Base firmware to WiMOD LoRaWAN EndNode firmware do not support this feature.

Multicast Configuration

This services provides access to the multicast configuration. The end-device will use these parameters once it is successful activated (by ABP or OTAA) and the class C support is enabled.

Battery Level Configuration

This option offers the possibility to update the status of the battery level of the end-device. The last configured value will be sent to the LoRaWAN server in the reply to the DevStatusReq MAC command.

3.2 Device Management

This section includes the following pages:

- Device Information
- Real Time Clock
- Info

3.2.1 Device Information

This page provides some basic information about the connected end-device and its firmware.

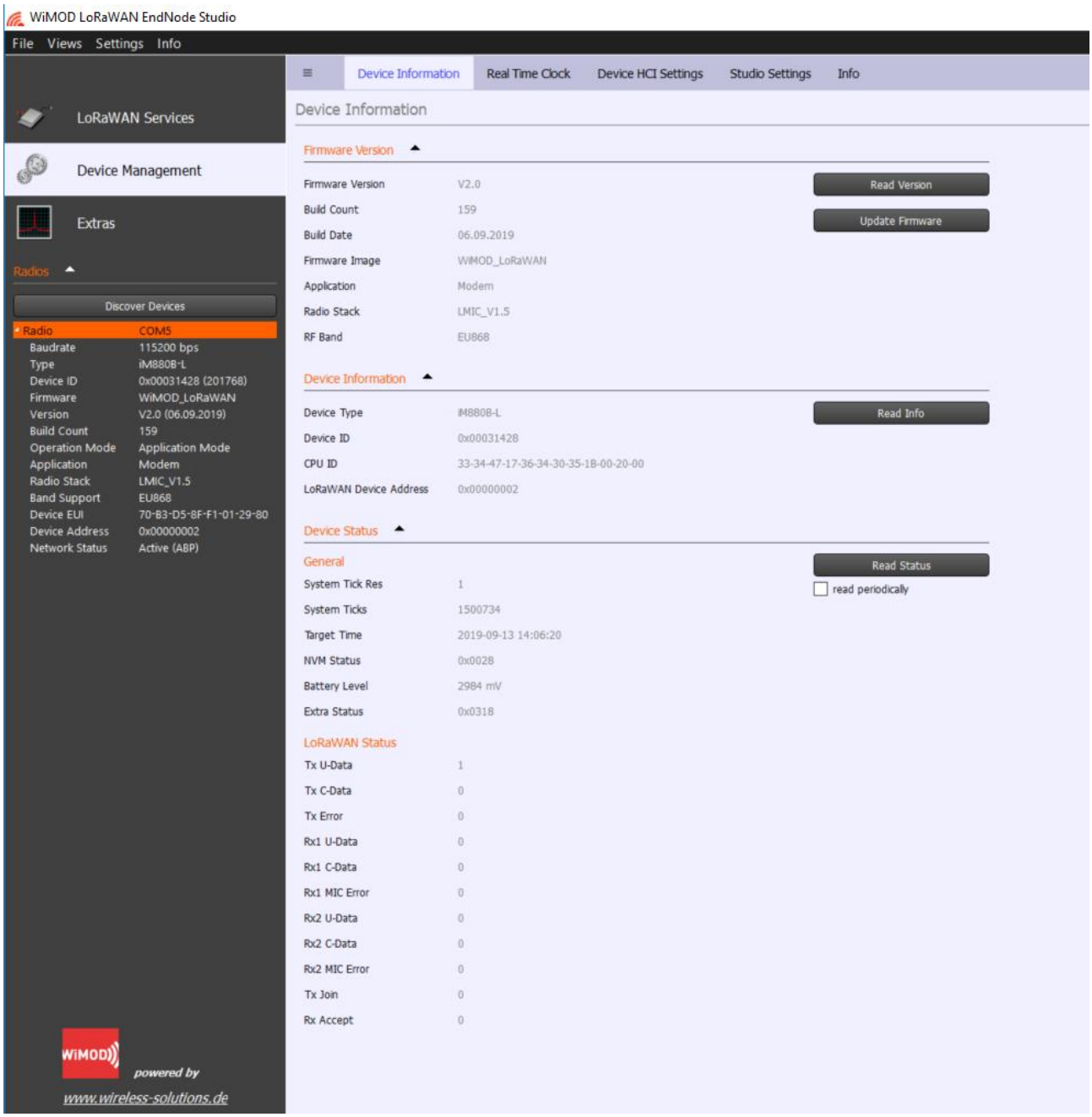

Figure 3-3: Device Information

3.2.2 Real Time Clock

This page allows synchronization and read-out of the embedded Real Time Clock of the connected device.

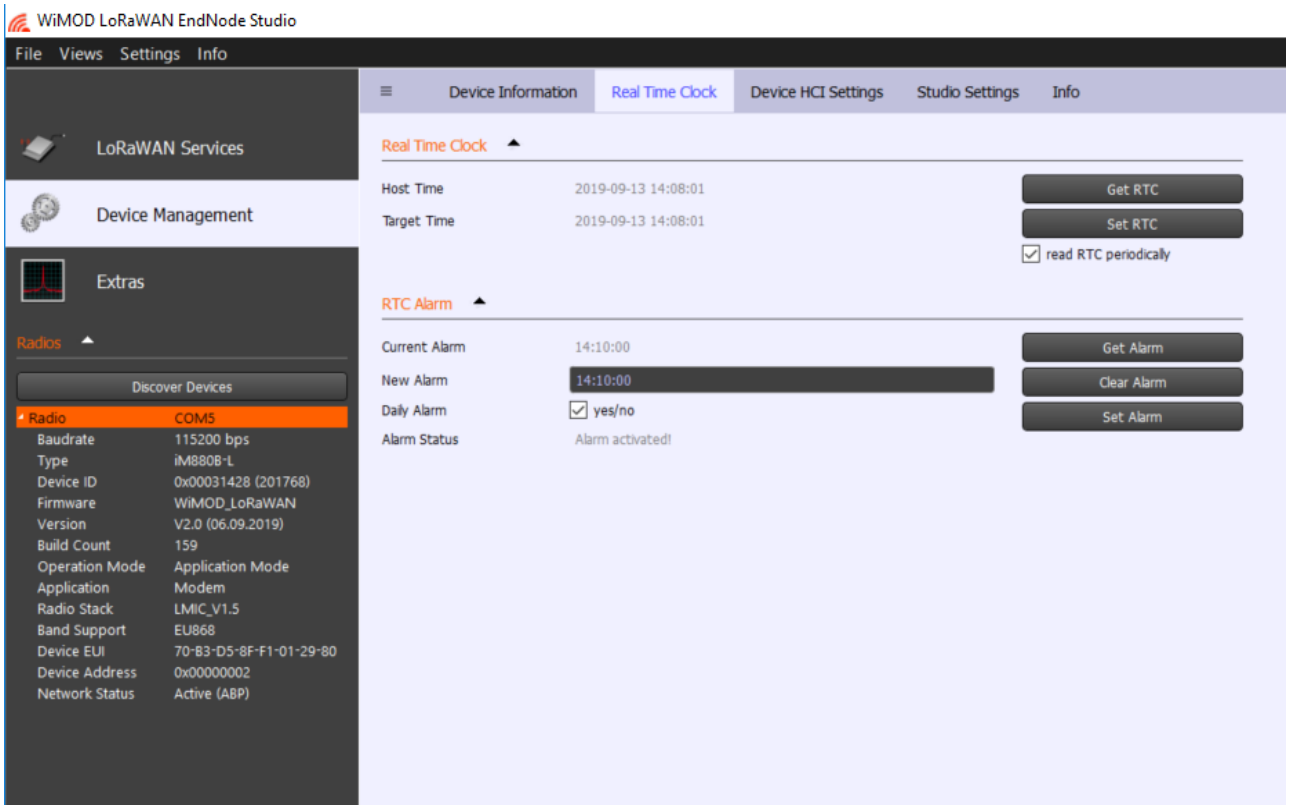

Figure 3-4: Real Time Clock

RTC Alarm

This services provides access to the RTC alarm handling:

- Set Alarm: sets a daily or single RTC alarm
- Clear Alarm: clears a pending RTC alarm
- The following window will be opened to indicate a RTC alarm event.

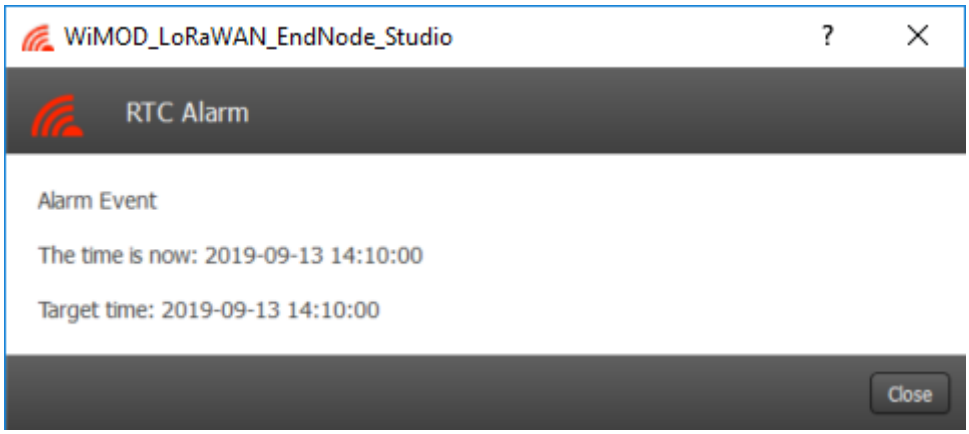

Figure 3-5: Real Time Clock Alarm Indication

3.2.3 Device HCI Settings

This page provides the possibility to modify following HCI Parameters on the end-device:

Baudrate

This value sets the baudrate to be used for the serial communication.

Number of Tx Wakeup Chars

This feature configures the number of Wakeup characters (SLIP_END = 0xC0) to be sent in the transmitted HCI messages by the end-device.

Tx Hold Time

The Tx Hold Time begins with the last transmitted character of a HCI message. Any new HCI message will be transmitted without additional Wakeup Characters during this time.

Rx Hold Time

The Rx Hold Time begins with the last received character of a HCI message. Any new HCI message will be transmitted without additional Wakeup Characters during this time.

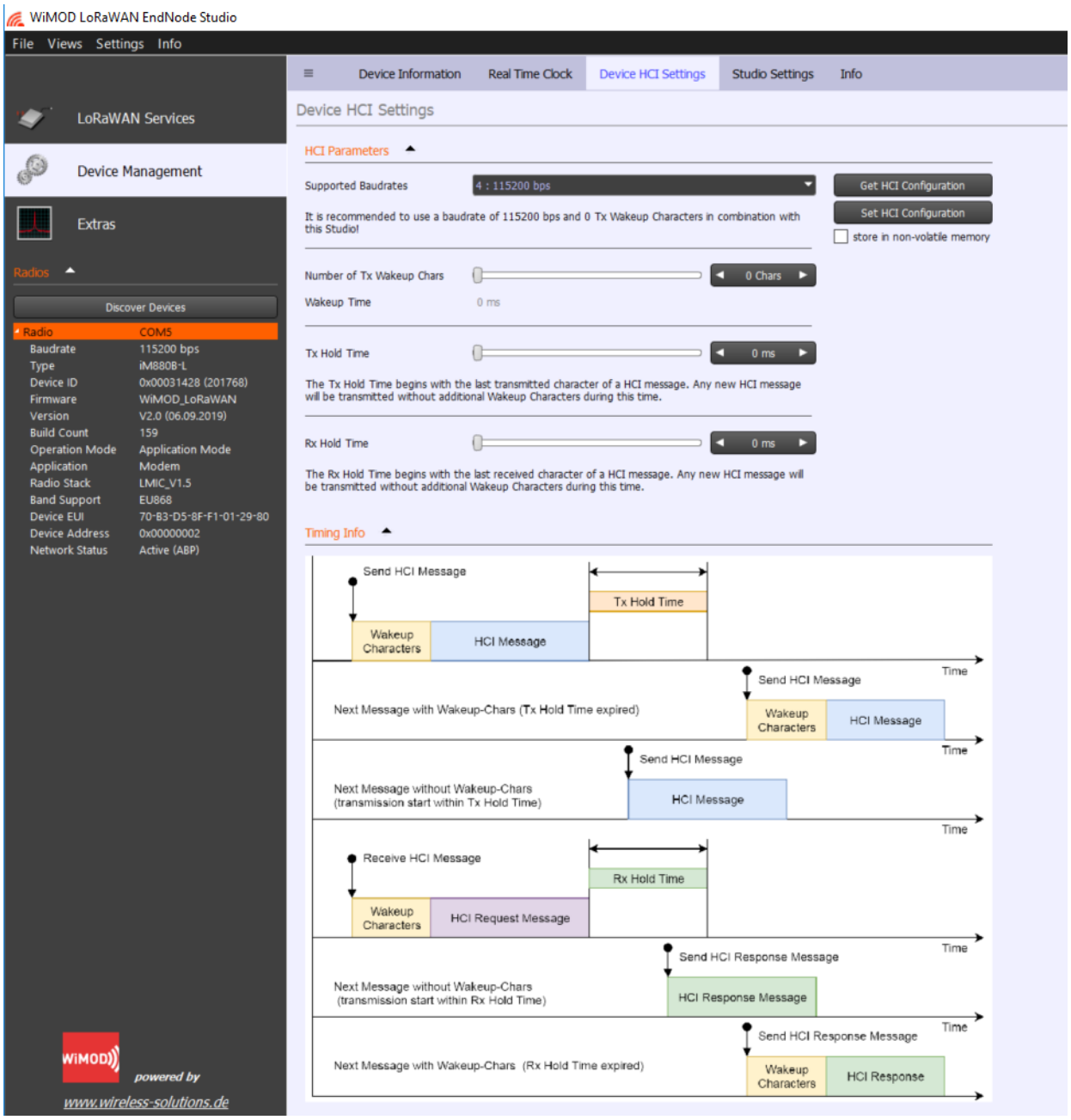

Figure 3-6: Device HCI Settings

3.2.4 Studio Settings

This page offers some settings related to the WiMOD LoRaWAN EndNode Studio, including the baudrate configuration for the serial communication and the configuration of the Virtual Com Port Drivers and Extra COM Ports.

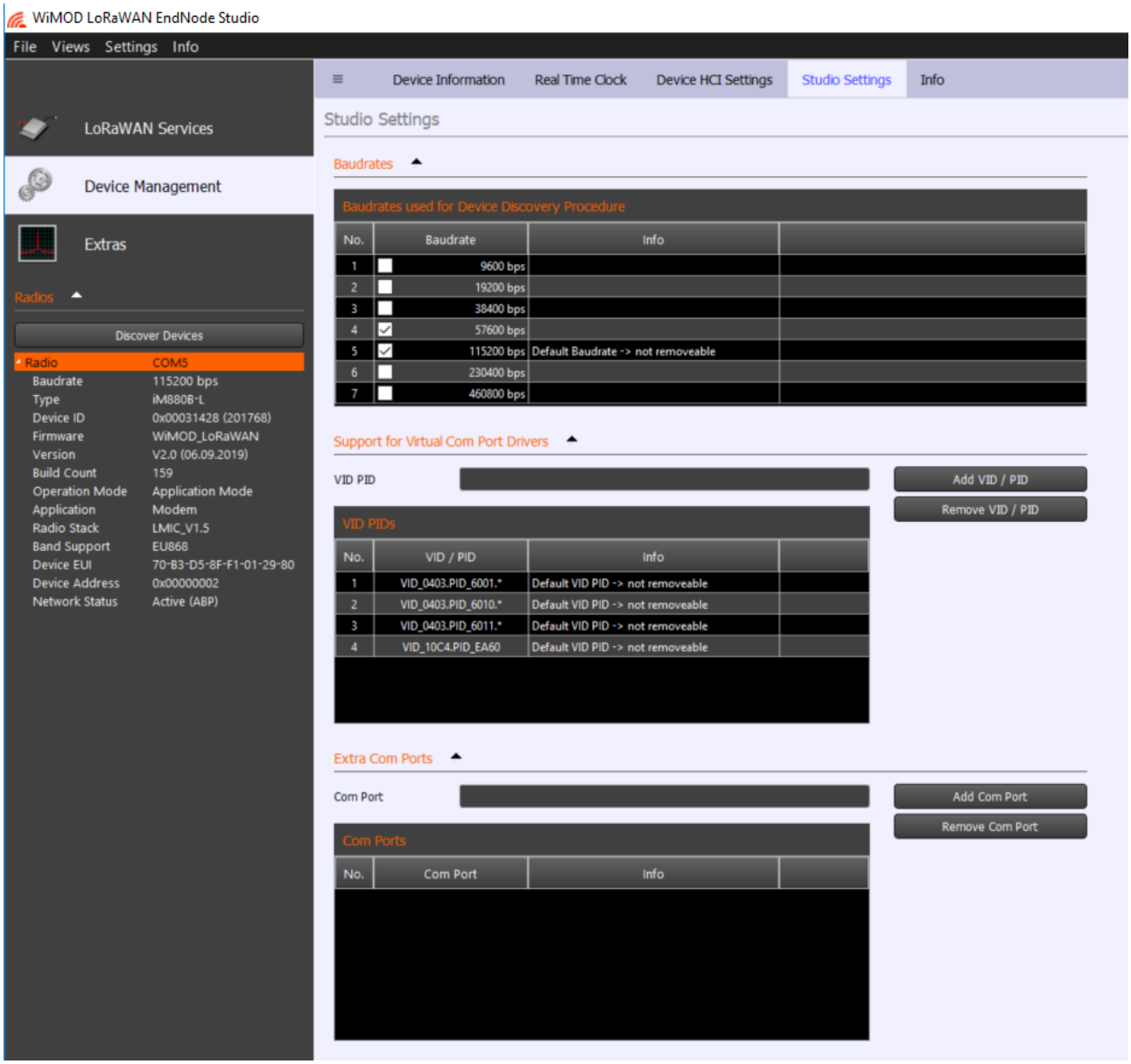

Figure 3-7: Studio Settings

3.2.5 Info

This page shows general information, such as additional notes and a list of the supported radio devices.

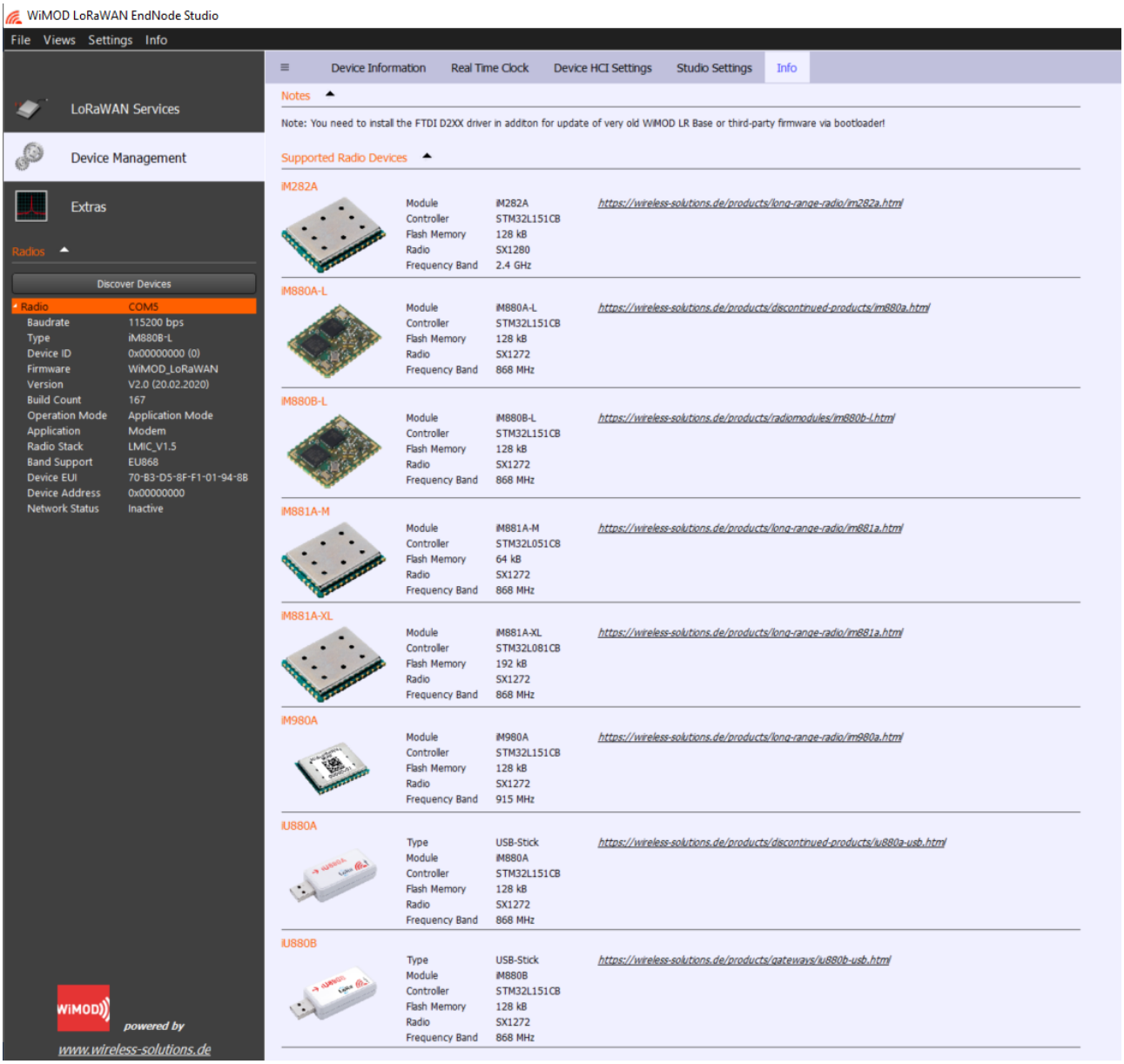

Figure 3-8: Info

3.3 Extras

This section includes the following pages:

- HCI Logging
- Customer Settings
- Studio Settings

3.3.1 HCI Logging

HCI Logging

This feature enables the display of the SLIP encoded/decoded streams of all HCI messages, which will be listed in the **HCI Messages Table**.

Note that the **Status Box** contains more details about their interpretation.

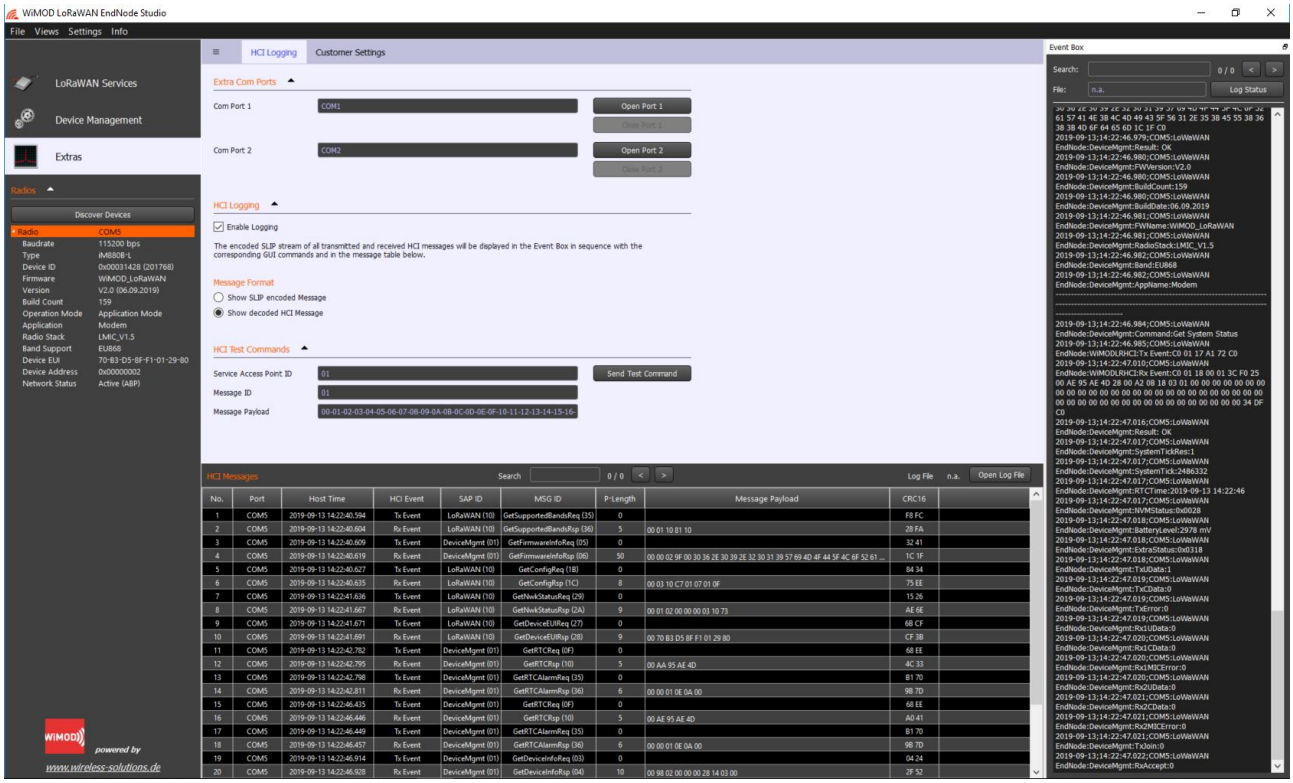

Figure 3-9: HCI Logging

HCI Test Commands

This feature allows to send a user defined HCI message.
Note that any triggered response messages will be handled as unexpected by the GUI.

3.3.2 Customer Settings

This page provides the access to the Operation Mode, the Device EUI configuration and other customer settings.

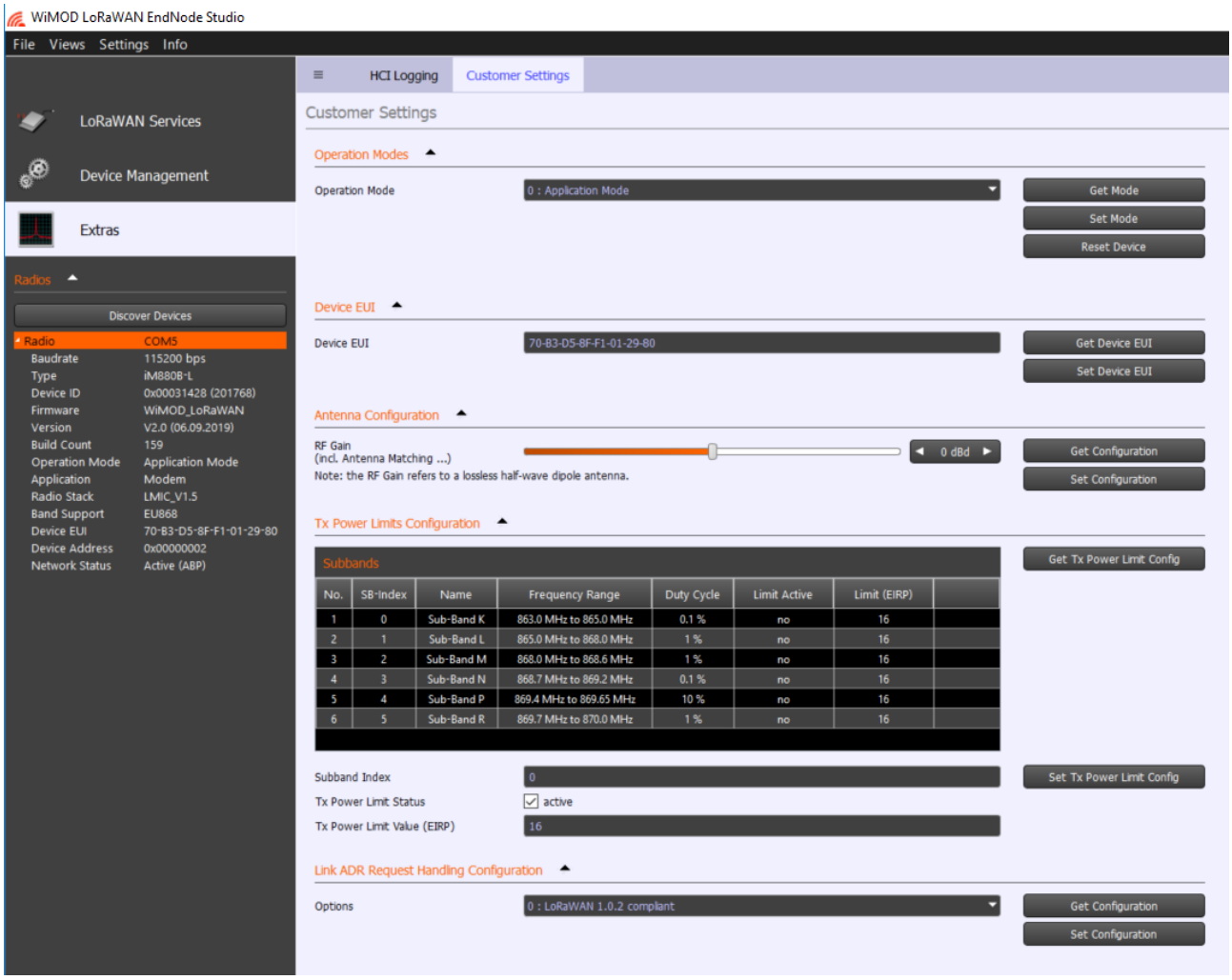

Figure 3-10: Factory Settings

Operation Modes

This section allows to switch between the Application and Customer Mode. Additionally, an option to reset the device is included.

Device EUI

This feature offers the configuration of a new Device-EUI. For this, the *Customer Mode* is required.

Antenna Configuration

This feature allows the configuration of the RF Gain for the final product to define an offset to be used to compensate possible transmission losses/gains in the final product, including circuit, matching and antennas (for more information refer to [2]). For this, the *Customer Mode* is

required.

Tx Power Limits Configuration

This feature can be used to configure a transmit power limit for each sub-band included in the operating ISM band. If the status flag is activated, the configured transmit power limit value will be applied, otherwise the default values will be used (for more information refer to [1]). For this, the *Customer Mode* is required.

Note that this feature is only available for the regions supporting different RF sub-bands definitions (see corresponding regional HCI specification, e.g. [3]).

Link ADR Request Handling Configuration

This feature allows different configurations to handle the LinkADRReq MAC Command sent by the LoRaWAN network server. This setting takes place if the Adaptive Data Rate feature is disabled (for more information refer to [2]). For this, the *Customer Mode* is required.

4. Appendix

4.1 List of Abbreviations

ABP	Activation by Personilization
FSK	Frequency Shift Keying Modulation
FW	Firmware
GUI	Graphical User Interface
HCI	Host Controller Interface
HW	Hardware
LoRa	Long Range
OTAA	Over The Air Activation
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
RTC	Real Time Clock
SNR	Signal to Noise
SW	Software
UART	Universal Asynchronous Receiver/Transmitter
WAN	Wide Area Network

4.2 List of Figures

4.3 References

[1] WiMOD_LoRaWAN_EndNode_Modem_HCI_Spec.pdf

[2] WiMOD_LoRaWAN_EndNode_Modem_Feature_Spec.pdf

[3] WiMOD_LoRaWAN_EndNode_Modem_EU868_HCI_Spec.pdf

5. Regulatory Compliance Information

The use of radio frequencies is limited by national regulations. The applicable regulation requirements are subject to change. IMST GmbH does not take any responsibility for the correctness and accuracy of the aforementioned information. National laws and regulations, as well as their interpretation can vary with the country. In case of uncertainty, it is recommended to contact either IMST's accredited Test Center or to consult the local authorities of the relevant countries.

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