Manual Nexus LoRaWAN

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Title: Manual Nexus LoRaWAN

1 Revision history

Version	Date	Changes
1.0	16-02-2017	First release
2.0	13-04-2017	Added OTAA for TTN

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3 Introduction

This document describes the commando's that are implemented in the Nexus_LoRaWAN sketch for the Nexus board from Ideetron. The sketch is designed for test and demonstration purposes. If you want to build an autonomous LoRaWAN mote, without a command structure you can use most of this sketch also.
Find it here: https://github.com/Ideetron/Nexus_LoRaWAN

4 Default settings

The following settings are the default setting on start-up of the Nexus board.

Radio connection	
Modulation	LoRa
Channel Tx	868.100 MHz
Datarate Tx	SF12 BW 125 kHz
Channel Rx	869.525 MHz
Datarate Rx	SF9 BW 125 kHz
Device Address	DS2401 unique number
Network session key	2B7E151628AED2A6ABF7158809CF4F3C
Application session key	2B7E151628AED2A6ABF7158809CF4F3C
Mote Class	A
Confirm	No
Channel Hopping	No
DevEUI	00 00 00 00 00 00 00 00
AppEUI	00 00 00 00 00 00 00 00
Application key	2B7E151628AED2A6ABF7158809CF4F3C

Table 1: Default settings

See chapter 7 if you want to change these settings.

Serial communication	
Datarate	9600 bps
Number of data bits	8
Parity	None
Number of stop bits	1

Table 2: Serial communication specifications

5 LoRaWAN introduction

The LoRaWAN communication takes place in two directions, up (from Nexus to gateway) and down (from gateway to Nexus). This sketch can transmit messages in the up direction and receive messages in the down direction.

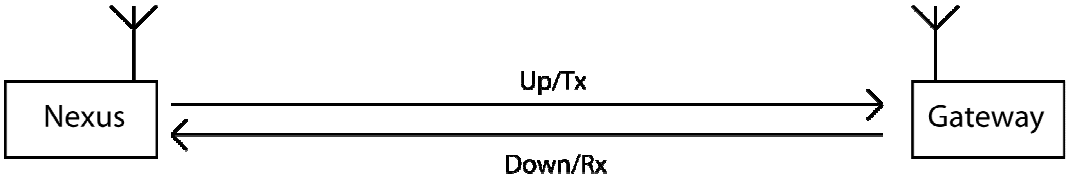


Figure 1: LoRaWAN communication

The channel and datarate for the both directions can be set.

Also the class of the Nexus board can be set to type A or C.

A type A mote can only receive messages from the gateway in a specific timeslot after sending a message.

A type C mote can receive a message from the gateway any time, except when the mote is transmitting a message.

6 Operation

If the Nexus receives a message it will check if the CRC and MIC is ok and if it is a message for this device. Then it will be broken down in the different fields. The Nexus will send the following information using to serial communication:

Message	Value	Description
CRC	OK/NOK	If the CRC of the received radio message is ok.
MIC	OK/NOK	If the MIC calculation of the LoRaWAN package is ok.
Address	OK/NOK	If the package contains the address for this mote
MAC Header	See Table 5	LoRaWAN MAC header
Sensor	4 bytes in Hex	Device address
Frame counter	2 bytes in Hex	Number of frame
Frame control	00 or 20	LoRaWAN Fctrl field
Data	Bytes in Hex	Data send from mote or gateway

Table 3: Message information

The MAC Header specifies the message type and the version of the LoRaWAN protocol used.

Bits	7 – 5	4 – 2	1 – 0
Field	Message type	Reserved	LoRaWAN protocol

Table 4: MAC Header fields

The LoRaWAN protocol field will always be 00.
The reserved field bits will always be 0.

The message type filed can have several values, in Table 5 the different values for the MAC header are listed.

MAC Header value Hex	Message type
60	Unconfirmed data down
A0	Confirmed data down

Table 5: Message types

The frame control field consists of different bits, the most important is bit 5 containing the ACK. Most of the times the other bits will be 0, so the frame control field can have the following values:

00 – No ACK
20 – ACK

For a full description of the frame control field see the LoRaWAN specification.

When the Nexus receives a Join Accept message after sending a Join request the following data will be shown:

- Device address
- Network session key
- Application session key

7 Commands

This chapter describes the commands that can be used to communicate with the Nexus using a terminal program. All commands and data is sent as ASCII characters. All data is one or more bytes of hexadecimal numbers represented by 2 ASCII characters. So all data exist of 2 ASCII characters that can be 0 – F. All other characters will be set to 0.

The following command structure is used

Command type	Parameter 1	Parameter 2	Value	Description
mac	data		Maximum of 51 bytes	Send LoRaWAN message with this data
	join		-	Send a Join Request message
	get/set	devaddr	4 bytes	The the device address
		nwkskey	16 bytes	The network session key
		appskey	16 bytes	The application session key
		drrx	1 byte	Transmit datarate
		drtx	1 byte	Receive datarate
		chrx	1 byte	Transmit channel
		chtx	1 byte	Receive channel
		pwridx	1 byte	Power index
		cnf	1 byte	Confirmation
		chhop	1 byte	Channel hopping
		class	1 byte	Mote class
		appkey	16 bytes	Application key
		deveui	8 bytes	Device EUI
		appeui	8 bytes	Application EUI

Table 6: Command structure

The command type, parameters and values are separated by a space.

7.1 mac data [data]

This command is used to send a LoRaWAN data message containing the data that is included in this command. The maximum number of bytes that a LoRaWAN message can contain is 51 bytes.

Example: mac data 00FF

The answer form the Nexus on this command will be:

Data: [data]

7.2 mac join

This command is used to send a LoRaWAN join request message. The join request message will used the following parameters:

- appkey
- deveui
- appeui

The join request message will use the set Datarate and Channel for transmit. And it will listen on the set receive Datarate and Channel for a Join accept message.

When a join accept message is received it will show the following

DevAddr: [device addresss]
NwkSKey: [network session key]
AppSKey: [application session key]

7.3 mac set/get devaddr

This command is used to read or write the device address.

To read the device address sent: mac get devaddr
To write the device address sent: mac set devaddr [device address]

[device address] is 4 bytes long: 00112233

The answer form the nexus is:

DevAddr: [device address]

7.4 mac set/get nwkskey

This command is used to read or write the network session key.

To read the key sent: mac get nwkskey
To write the key sent: mac set nwkskey [key]

[key] is 16 bytes long: 00112233445566778899AABBCCDDEEFF

The answer form the nexus is:

NwkSKey: [key]

7.5 mac set/get appskey

This command is used to read or write the application session key.

To read the key sent: mac get appskey
To write the key sent: mac set appskey [key]

[key] is 16 bytes long: 00112233445566778899AABBCCDDEEFF

The answer form the nexus is:

AppSKey: [key]

7.6 mac set/get drrx

This command is used to read or write the receive datarate.

To read the datarate sent: mac get drrx
To write the datarate sent: mac set drrx [datarate]

[datarate] can have to values shown in Table 7.

[datarate]	Description
00	SF 12 BW 125 kHz
01	SF 11 BW 125 kHz
02	SF10 BW 125 kHz
03	SF9 BW 125 kHz
04	SF8 BW 125 kHz
05	SF7 BW 125 kHz
06	SF7 BW 250 kHz

Table 7: Datarate values

The answer form the nexus is:

Datarate Rx: [Datarate description]

7.7 mac set/get drtx

This command is used to read or write the transmit datarate.

To read the datarate sent: mac get drtx
To write the datarate sent: mac set drtx [datarate]

[datarate] can have to values shown in Table 7.

The answer form the nexus is:

Datarate Tx: [Datarate description]

7.8 mac set/get chrx

This command is used to read or write the receive channel.

To read the channel sent: mac get chrx
To write the channel sent: mac set chrx [channel]

[channel] can have to values shown in Table 8.

The answer form the nexus is:

Channel Rx: [channel description]

Value	Channel (MHz)
00	868.100
01	868.300
02	868.500
03	867.100
04	867.300
05	867.500
06	867.700
07	867.900
10	869.525

Table 8: Channel values

7.9 mac set/get chtx

This command is used to read or write the transmit channel.

To read the channel sent: mac get chtx
To write the channel sent: mac set chtx [channel]

[channel] can have to values shown in Table 8.

The answer form the nexus is:

Channel Tx: [channel description]

7.10 mac set/get pwridx

This command is used to set the transmit power. A higher transmit power will use more energy but you can communicate over greater distance.

To read the transmit power sent: mac get pwridx
To write the transmit power sent: mac set pwridx [power]

[power] can have a value from 00 to 0F, where 00 is the lowest power and 0F the highest power.

The answer form the nexus is:

Power: [power]

7.11 mac set/get cnf

With this command you can set the message type of the LoRaWAN message. It can be set to a confirmed or unconfirmed message. This determines if you request an acknowledge from the LoRaWAN service.

To read confirmation sent: mac get cnf
To write confirmation sent: mac set cnf [Confirm]

[Confirm] can have the following values:

00 Unconfirmed message type
01 Confirmed message type

The answer form the nexus is:

Confirm: [Confirm]

7.12 mac set/get chop

With this command you can chose if channel hopping is activated. When channel hopping is activated every data message will be send on the next channel. If the last message was sent on channel 07 it will go back to channel 00. See Table 8 for the different channels

To read channel hopping sent: mac get chhop
To write channel hopping sent: mac set chhop [Channel hopping]

[Channel hopping] can have the following values:

00 No channel hopping
01 Channel hopping active

The answer form the nexus is:

Channel Hopping: [Channel hopping]

7.13 mac set/get class

With this command you can set the device class for the Nexus. This sketch supports type A and C. A type A device will be inactive until you sent a message. After sending a message the type A device will switch on the receiver in the listen for a possible message in receive slot 2.
In a type C device the receiver is always switched on, and can receive a message any time.

To read the class sent: mac get class
To write the class sent: mac set class [Class]

[Class] can have the following values:

00 Class A
01 Class C

The answer form the nexus is:

Mote Class: A/C

7.14 mac set/get appkey

This command is used to read or write the application key.

To read the key sent: mac get appkey
To write the key sent: mac set appkey [key]

[key] is 16 bytes long: 00112233445566778899AABBCCDDEEFF

The answer form the nexus is:

AppKey: [key]

7.15 mac set/get deveui

This command is used to read or write the device EUI.

To read the EUI sent: mac get deveui
To write the EUI sent: mac set deveui [EUI]

[EUI] is 8 bytes long: 0011223344556677

The answer form the nexus is:

DevEUI: [EUI]

7.16 mac set/get appeui

This command is used to read or write the application EUI.

To read the EUI sent: mac get appeui
To write the EUI sent: mac set appeui [EUI]

[EUI] is 8 bytes long: 0011223344556677

The answer form the nexus is:

AppEUI: [EUI]

8 Examples

The examples written in this chapter are using the Semtech development site: iot.semtech.com and the site of The Thing Network: https://account.thethingsnetwork.org/users/login.
This site is free and can be fully used after registration.
The terminal program used is RealTerm, that can be downloaded here:

https://sourceforge.net/projects/realterm/files/Realterm/2.0.0.70/

8.1 Activation By Personalisation (ABP)

Activation by personalisation means that the following parameters are set in the mote:

- DevAddr
- NwkSKey
- AppSKey

To add a mote whit ABP to semtech follow these steps:

1. Sign in or create an account on iot.semtech.com
2. On the left side go to applications
3. Then click the number behind the defaultApp.

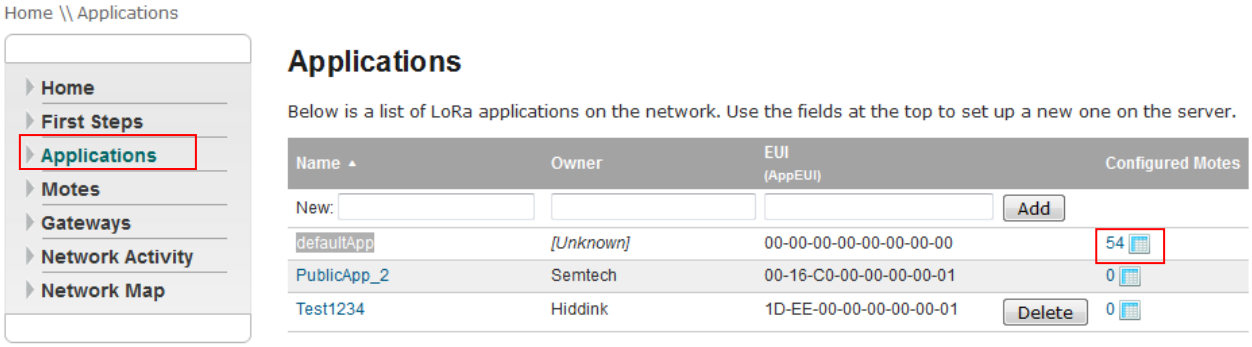


Figure 2: Selecting default app

4. To add the device you need to know the NwkSKey, AppSKey and DevAddr. For this example we use the default key's
   NwkSkey: 2b7e151628aed2a6abf7158809cf4f3c
   AppSkey: 2b7e151628aed2a6abf7158809cf4f3c
5. To get the Device addres from the nexus you need to connected the nexus and start realterm.
6. Then goto the tab port and make the following settings:
   Set baudrate to 9600
   Select the right port
   Toggle the open button

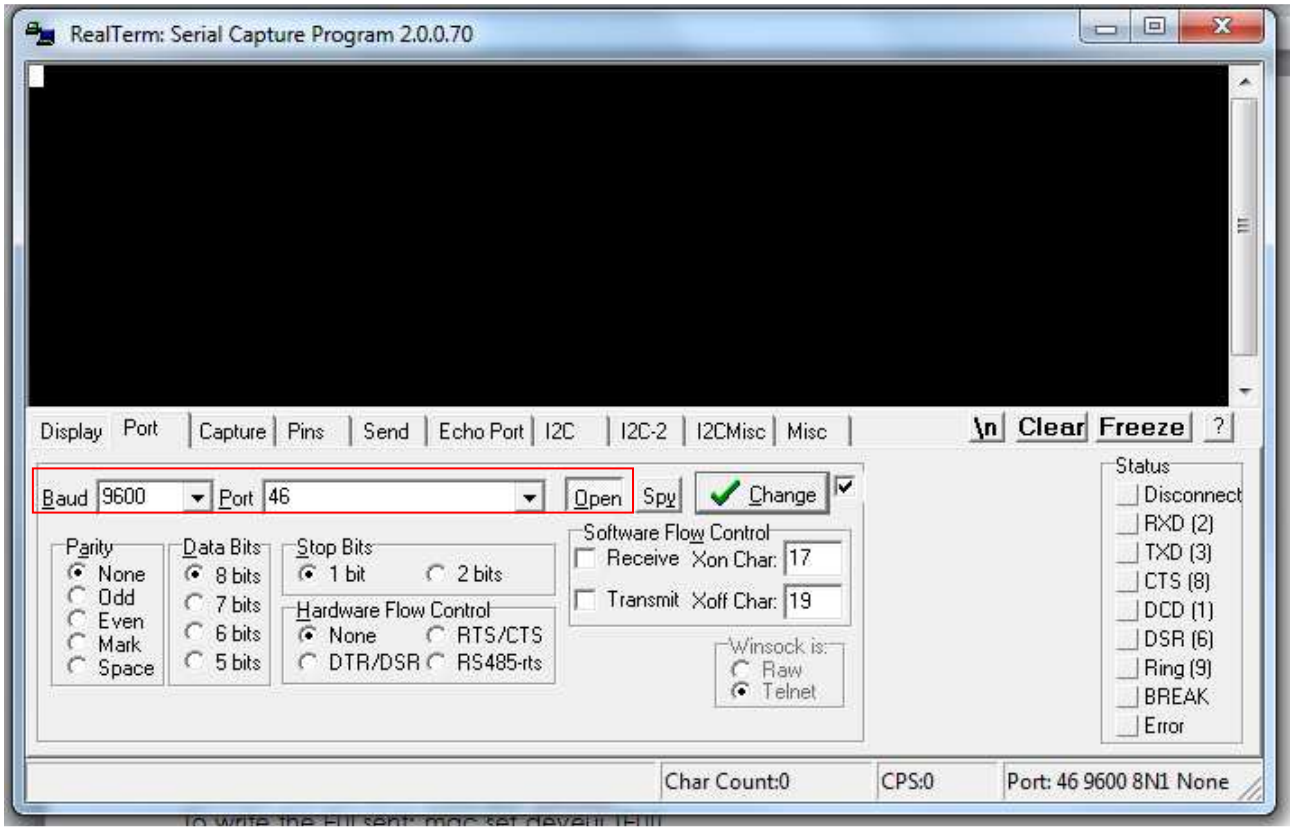


Figure 3: Opening a port with realterm

7. Then goto the tab Send.
8. Type the command: “mac get devaddr” in the field
9. Hit the Send ASCII button

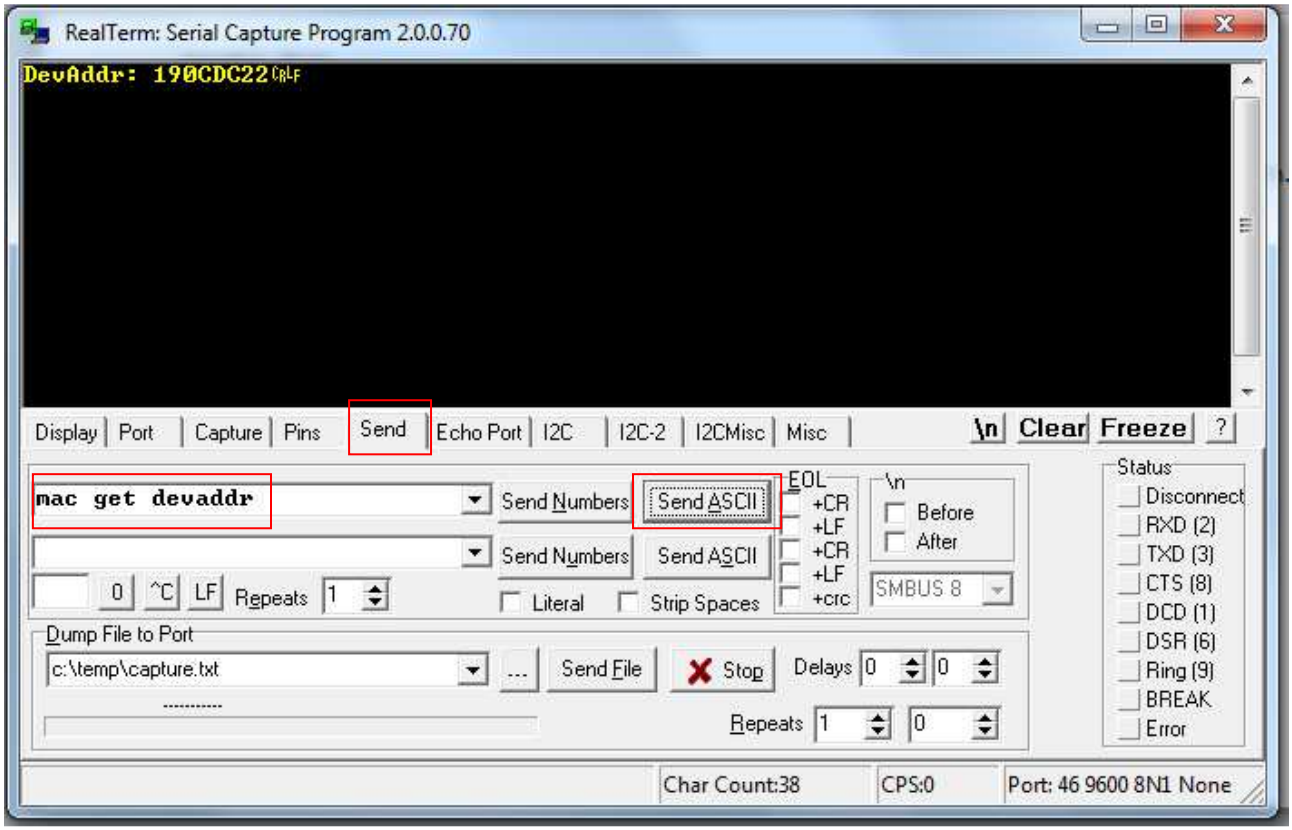


Figure 4: Sending command

10. Now you have all the information you need
11. Go back to the Semtech site and fill in the information into the correct fields
12. Then hit the add button

Figure 5: Add to semtech

13. Your mote is now added to the list below, find it and click on the number
14. Now go back to Realterm and send a message by using the mac data command

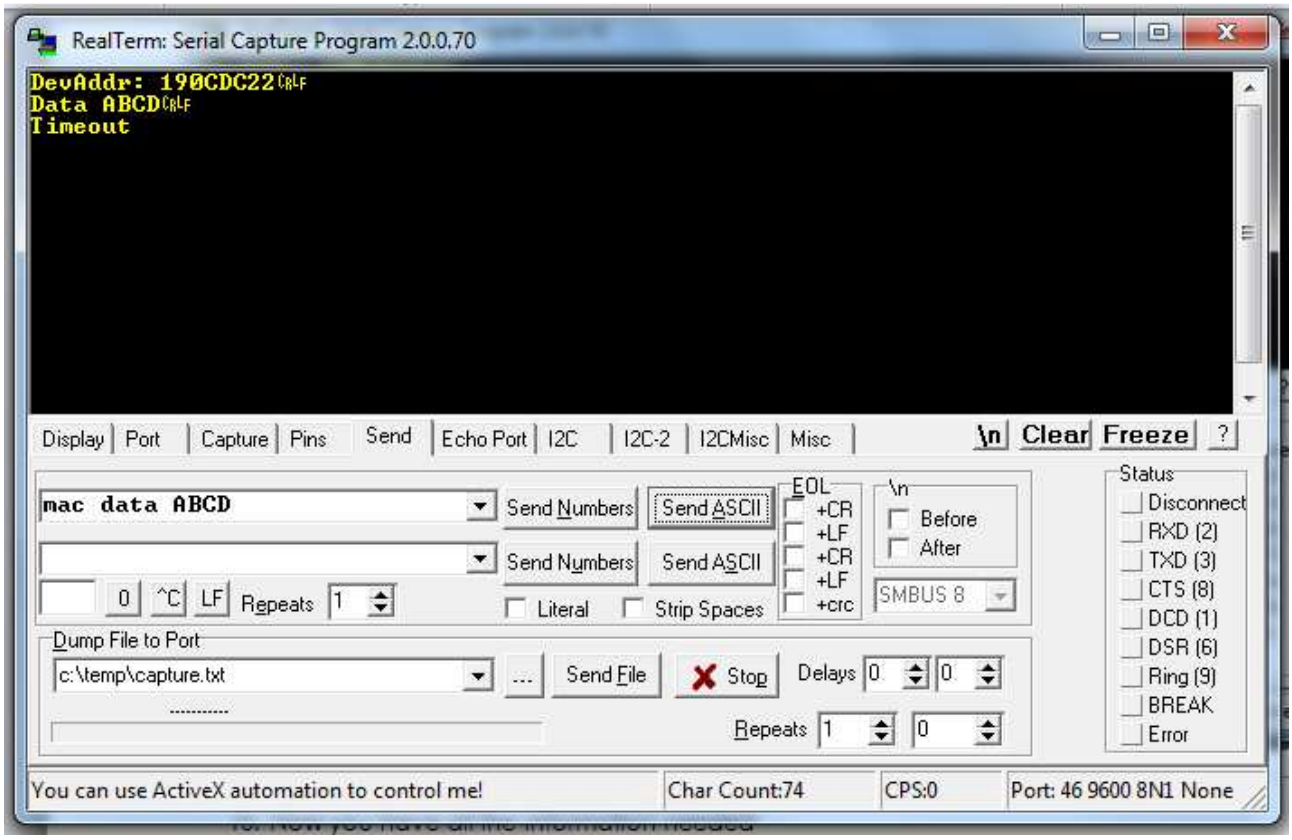


Figure 6: Send data command

15. Now go back to the semtech site and check if the message has arrived. This may take some time +/- 1 min
16. To see the data you can click "View data from application defaultApp"
17. To see the radio settings for a message click "View transmission performance"

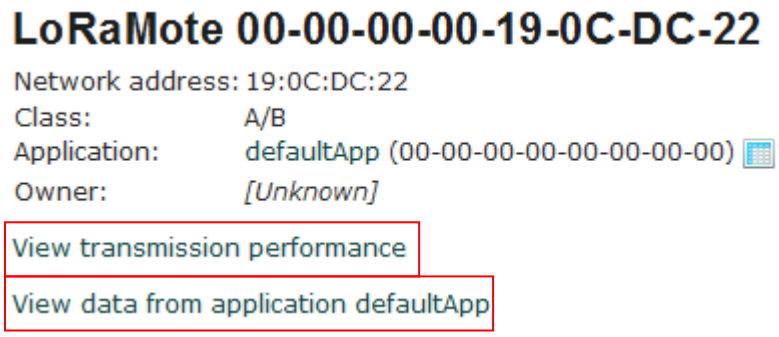
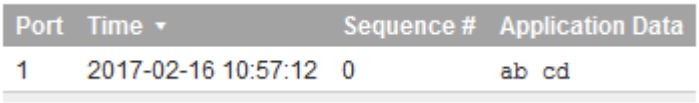


Figure 7: View message



Port	Time	Sequence #	Application Data
1	2017-02-16 10:57:12	0	ab cd

Figure 8: Received data

Sequence #	Freq (MHz)	Modulation	BW (Hz)	SF	Coding Rate	ADR	Gateway	Time	Precise	Chan	RSSI (dBm)	SNR (dB)
0	868.1	LoRa	125000	SF12	4/5	off	1D-EE-12-A4-A2-DF-A6-A6:0	2017-02-16 10:57:12	N/A	0	-76	9

Figure 9: Transmission preformance

8.2 Over The Air Activation with Semtech (OTAA)

Over the Air Activation means that the following parameters are set in the mote:

- AppKey
- DevEUI
- AppEUI

During the activation the mote will receive this session data:

- DevAddr
- NwkSkey
- AppSkey

Use the following settings to join

Description	Setting	Value
Transmit channel	chtx	00
Transmit datarate	drtx	00 – 02
Receive channel	chrx	10
Receive datarate	drrx	03

Table 9: Channel and datarate settings Semtech

To add a mote whit OTAA to semtech follow these steps:

1. Sign in or create an account on iot.semtech.com
2. On the left side go to applications
3. Now add a new application to fill in the fields and press add

Figure 10: Create new application

4. Now click the number behind the new application
5. Now add an over the air mote. The DevEUI and AppEUI are generated with the website www.random.org

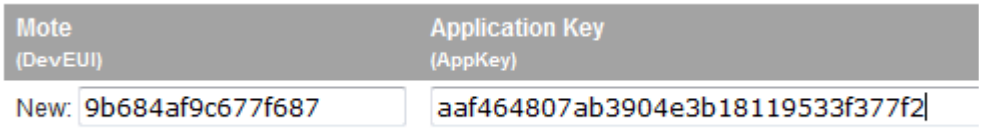


Figure 11: Add a mote

6. Now start up realterm term and set the parameters

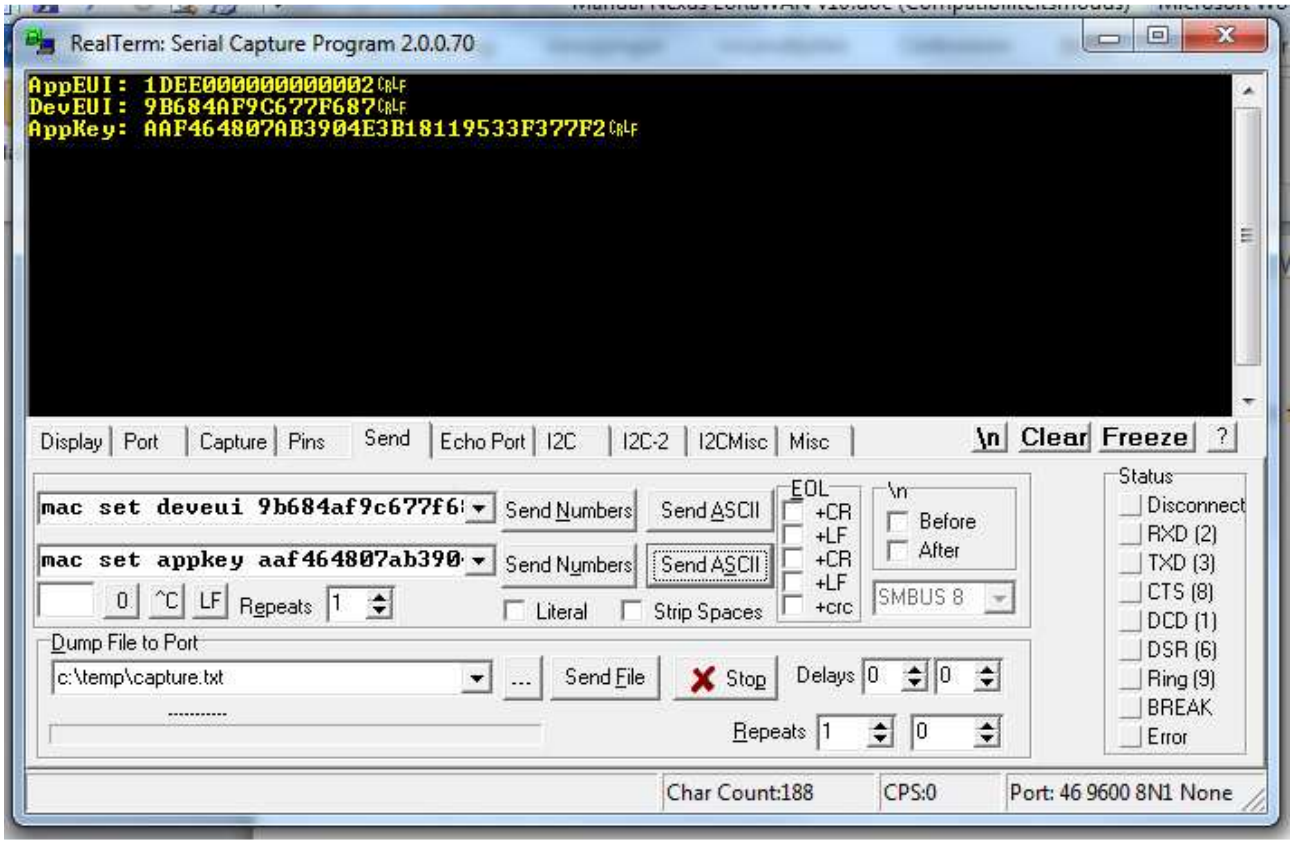


Figure 12: Set parameters

7. Send the join command and wait for a reply

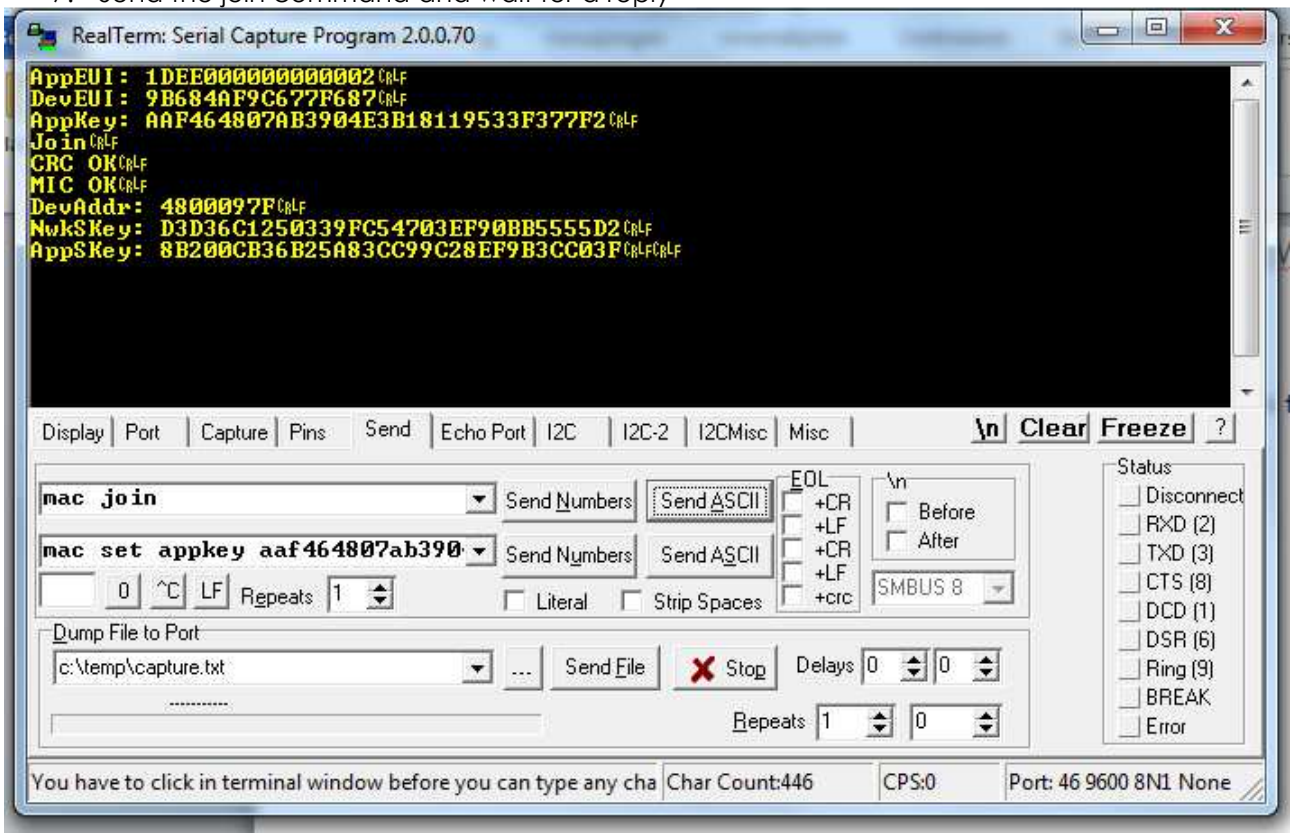


Figure 12: OTAA response

8. Now the mote is joined, try to send some data with the data command
9. Check the received data in semtech

8.3 Over The Air Activation with The Things Network (OTAA)

Over the Air Activation means that the following parameters are set in the mote:

- AppKey
- DevEUI
- AppEUI

During the activation the mote will receive this session data:

- DevAddr
- NwkSkey
- AppSkey

Use the following settings to join:

Description	Setting	Value
Transmit channel	chtx	00
Transmit datarate	drtx	00 – 02
Receive channel	chrx	10
Receive datarate	drrx	00

Table 10: Channel and datarate settings TTN

To add a mote whit OTAA to TTN follow these steps:

1. Sing in or create an account on the TTN site.
2. Goto Applications.
3. Click “add application”.

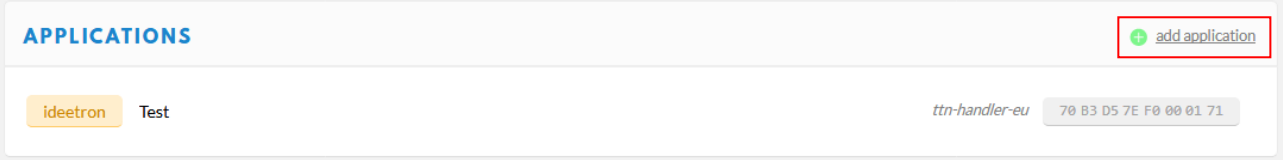


Figure 13: Create new application

4. Fill in the fields and press “Add application”.
5. After registering the application you will see a screen with all the information regarding the application. Now click “register device”.

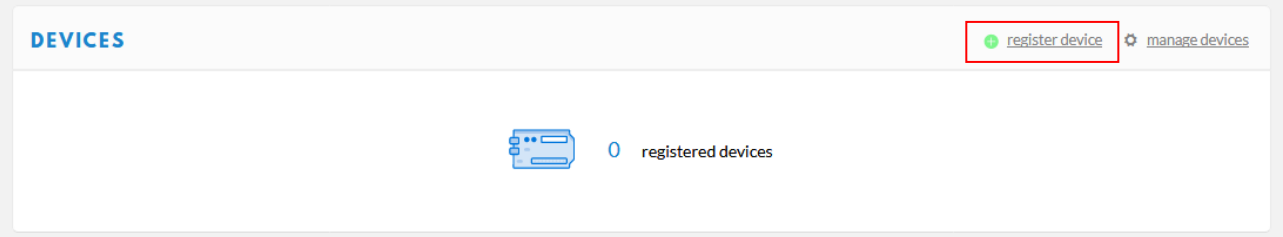


Figure 14: Register a device

6. Fill in the Device ID. Set the Device EUI to be generated.

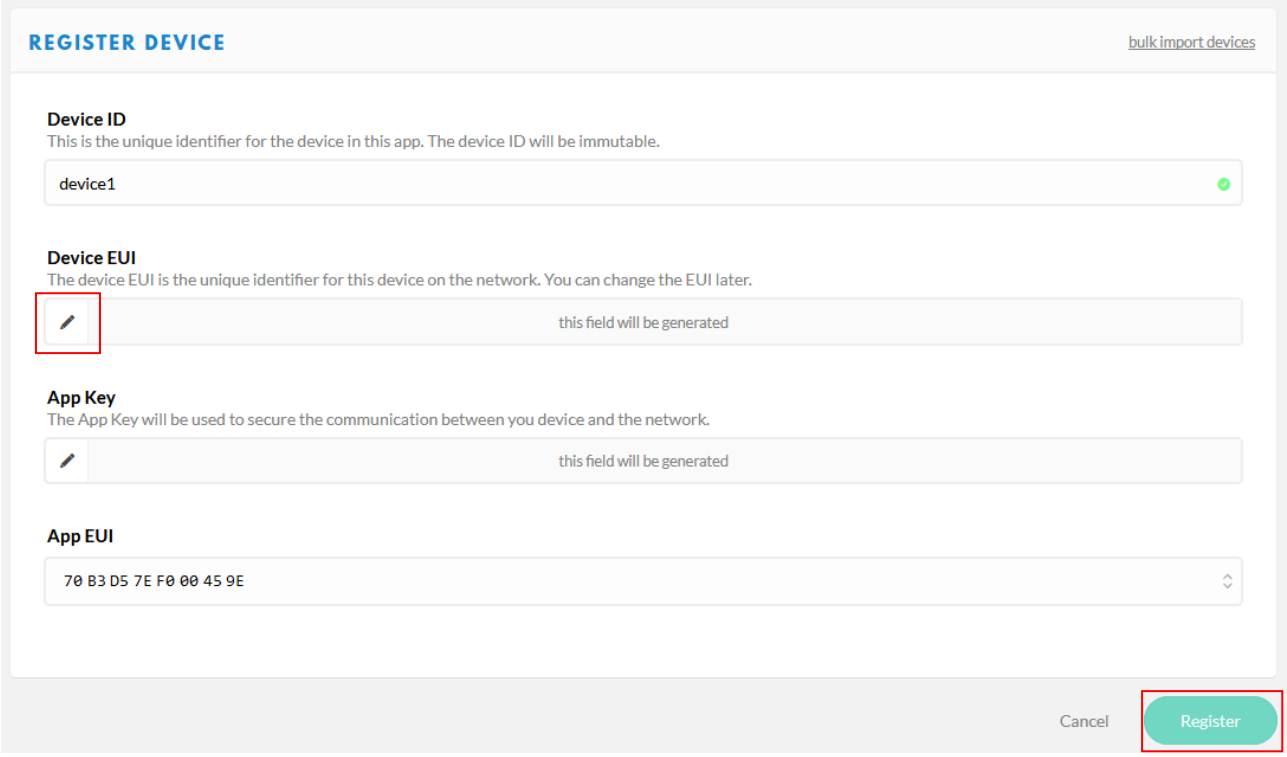


Figure 15: Device form

7. After registering the device, you will see an overview of the device settings. You will see the Device EUI, Application EUI and Application Key.

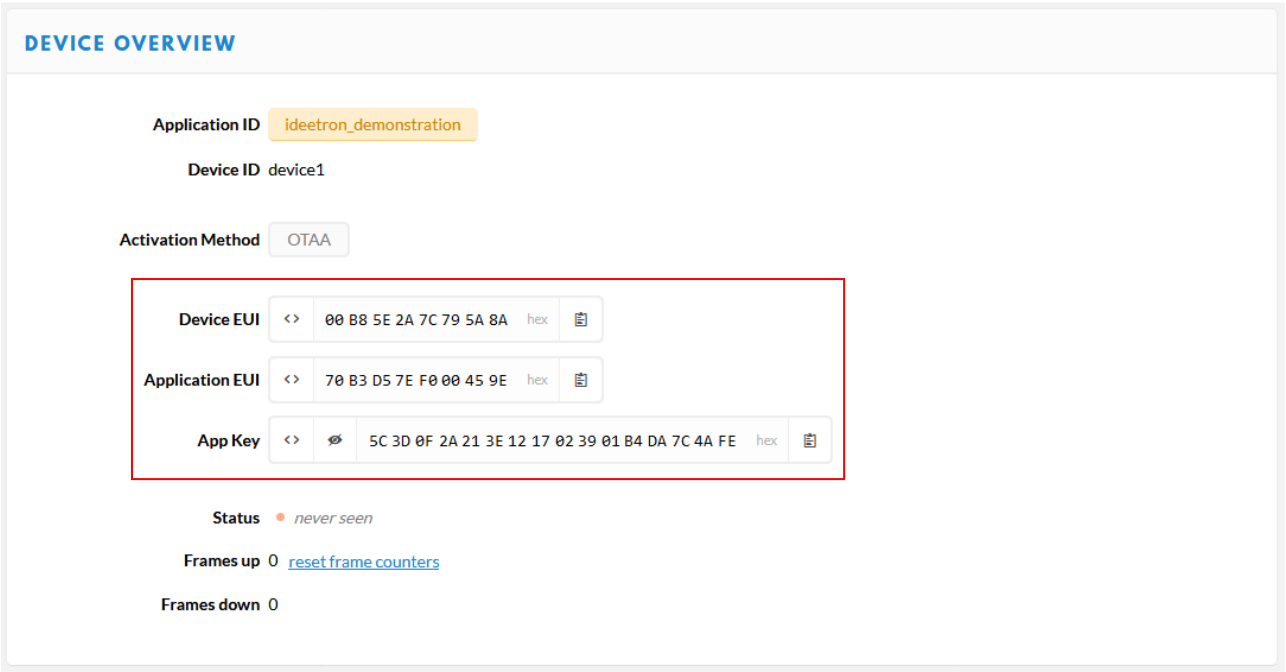


Figure 16: Device overview

8. Start up realterm and set the parameters.

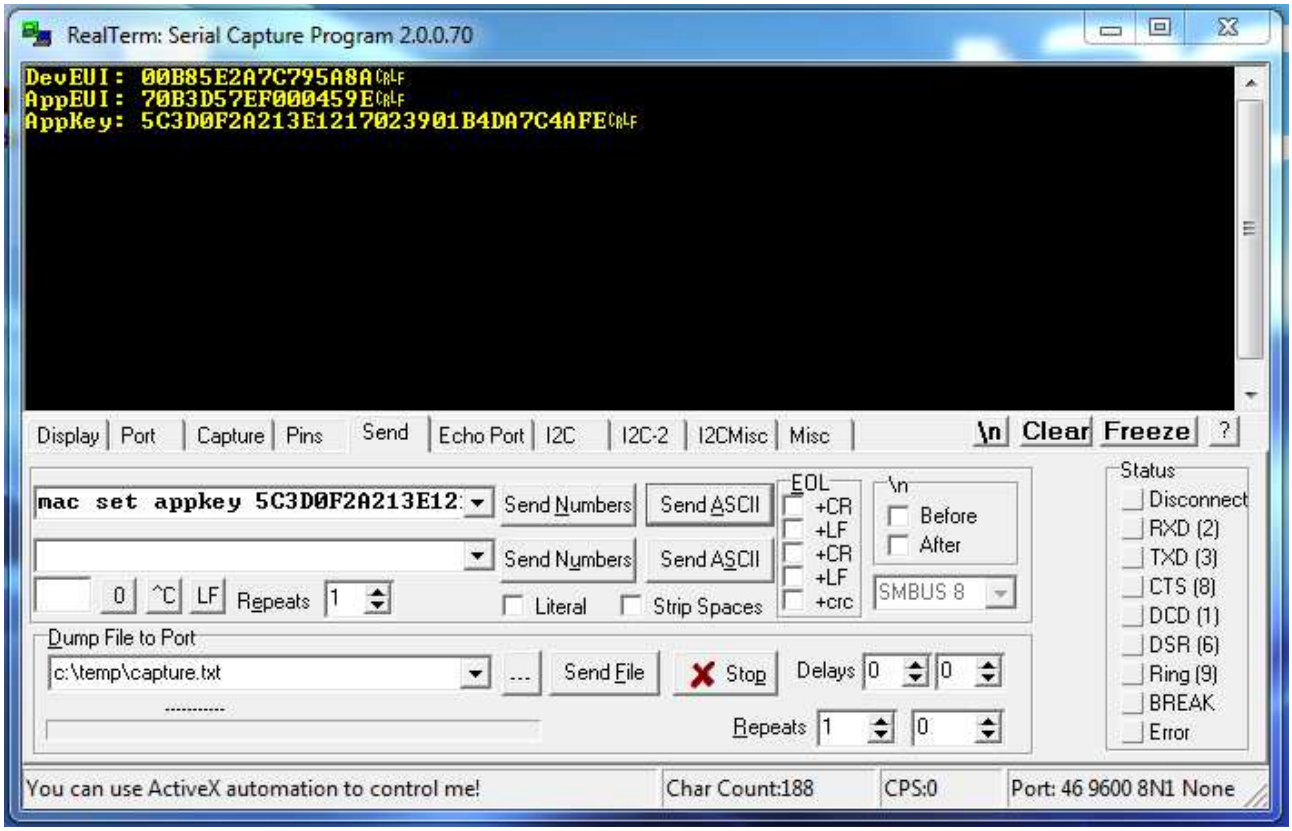


Figure 17: Set parameters

9. Send the join command and wait for reply.

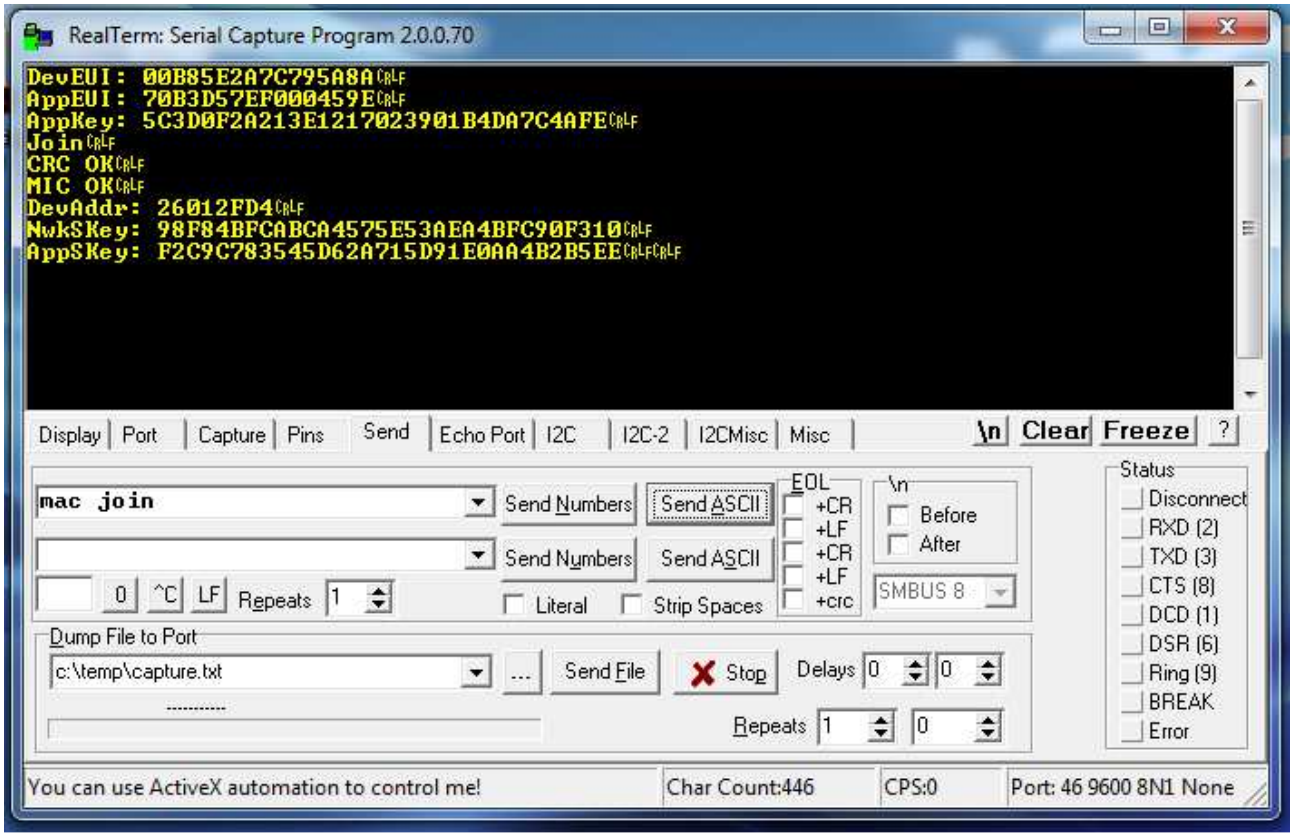


Figure 18: OTAA response