SAMR34 Getting Started LoRaWAN USB_CDC example Quick Start Guide

Introduction

This document is intended as a guide to help you understand the features, and to describe how to use the example project: **SAMR34 Getting Started LoRaWAN USB_CDC**

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1. Overview

The "**SAMR34 Getting Started LoRaWAN USB_CDC "** example application is an ASF 3 based project that is intended to be used with the SAMR34 XPRO evaluation kit.
The goal of this application is to allow a user to create a LoRaWAN end node application that supports the following capabilities:

- Console output directed to Target USB_CDC port, using the SAMR34 USB peripheral and ASF USB component drivers
- Configuration of parameters required to join a LoRawan Network (thru #defines at build time)
- Selection of the operational region thru a console menu at power up or reset.
- Report operational configurations thru the console serial connection. (Target USB connector)
- Periodically sends temperature sensor data to the network using unconfirmed transmission frames
- Allows manual transmission of temperature sensor data using confirmed transmission frames by way of a short press of the USER SW0 pushbutton, available on the SAMR34 XPRO eval board.
- Allows modifying the selected Data Rate used for transmission by a Long Press of the SW0 button.
- Allows modifying of the selected TX Power Index used for transmission by an Extended Long press of the SW0 button.
- Green and Amber led's to signify various operational states, and parameter settings.
- Provides serial console status information, thru the Target USB serial connection available on the SAMR34 XPRO evaluation board.

1.1 Supported hardware platforms and IDEs

Microcontroller	Supported Evaluation Kit	Supported IDE's
SAMR34J18B(SIP)	SAMR34 Xplained PRO [DM320111]	Atmel Studio 7

Note! Only SAMR34 device's support a USB peripheral, so this application would not be suitable for the SAMR35 device variant.

2. Development environment

This section provides information on the required tools needed to setup and build the example project , and the platform to run it on.

2.1. Atmel Studio 7

Atmel Studio 7 can be used to develop and debug applications for Microchip ARM-based platforms. Atmel Studio 7 is equipped with the GCC compiler, and does not require any additional external software tools to compile and debug SAMR34 LoRaWAN applications.

Below are a few reference links to documents that will help you get started with Studio 7.
https://www.microchip.com/mplab/avr-support/atmel-studio-7

http://ww1.microchip.com/downloads/en/DeviceDoc/Getting-Started-with-Atmel-Studio7.pdf

http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-Studio-7-User-Guide.pdf

Here are additional links to detailed documents to help you understand the SAMR34/35 LoRaWAN stack

http://ww1.microchip.com/downloads/en/DeviceDoc/SAM-R34-R35-Microchip-LoRaWAN-Stack-Software-API-Reference-Manual-DS70005382A.pdf

http://ww1.microchip.com/downloads/en/DeviceDoc/SAM-R34-MLS-Getting-Started-Guide-User-Guide-DS50002812A.pdf

2.2. SAMR34 Xplained Pro [DM320111]

Full information regarding the SAMR34 Xplained Pro evaluation kit can be found at the links provided:

https://www.microchip.com/DevelopmentTools/ProductDetails/DM320111

https://www.microchip.com/wwwproducts/en/ATSAMR34J18

http://ww1.microchip.com/downloads/en/DeviceDoc/ATSAMR34-Xplained-Pro-User-Guide-DS50002803A.pdf

3. Stack Configurations

This project takes advantage of configuration .h files to define and configure the behavior of the stack.
The configuration file that is important to the initial operation of this example project is:

- ..\src\config\conf_app.h

Within the file conf_app.h you must initially configure the defines listed below:
The data for each of these defines must be modified to reflect the EUI's and Keys required by your selected Network Server.

```
/*Define the Sub band (where required) of Channels to be enabled by default for the application*/
#define SUBBAND 2

/* OTAA Join Parameters */
#define DEMO_DEVICE_EUI             { 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0xFA, 0xFC}
#define DEMO_APPLICATION_EUI        { 0x70, 0xB3, 0x00, 0x00, 0xD0, 0x00, 0x00, 0x00}
#define DEMO_APPLICATION_KEY        { 0x00, 0x00, 0x00, 0x00, 0xE7, 0xB0, 0x83, 0xBD, 0x79,0x5E, 0xF4, 0xB4,
                                    0x00, 0x00, 0x00, 0x00}


/* ABP Join Parameters */
#define DEMO_DEVICE_ADDRESS               0xdeafface
#define DEMO_APPLICATION_SESSION_KEY      {0x00, 0x00, 0x74, 0x69, 0x6C, 0x69, 0x74, 0x79, 0x00, 0x04,
                                          0xA3, 0x0B, 0x00, 0x04, 0xA3, 0x0B}
#define DEMO_NETWORK_SESSION_KEY          {0x00, 0x00, 0x00, 0x69, 0x6C, 0x69, 0x74, 0x79, 0x00, 0x04,
                                          0xA3, 0x0B, 0x00, 0x04, 0x00, 0x00}
```

By default, the example uses OTAA Join and *Unconfirmed* periodic transmissions, at an interval of 30 seconds.

Each SAMR34 XPRO board comes pre programmed with a unique device EUI. If during your development cycle you would like to use your own Device EUI, you can accomplish this by modifying a project setting as described below.

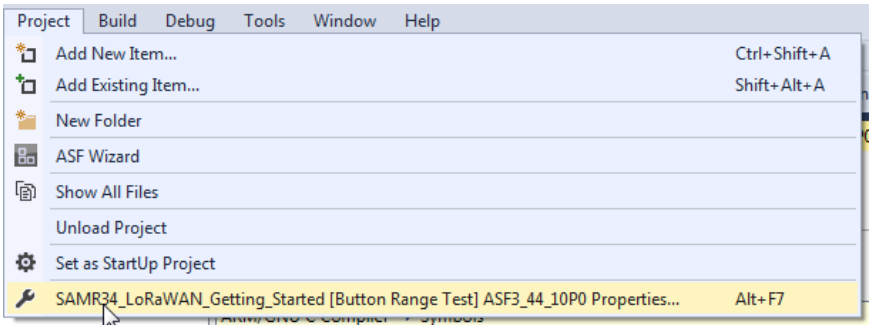
The DEMO APPLICATION EUI and DEMO APPLICATION KEY are provided by the Network Service you are attempting to work with . For Example, For TTN (The Things Network) these parameters are provided thru the TTN console.

4. Building applications in Atmel Studio

Atmel Studio 7 is used to develop and build SAMR34 applications.
To configure or review the project settings before building your project, follow the instructions below.

4.1. Setting Project / Properties

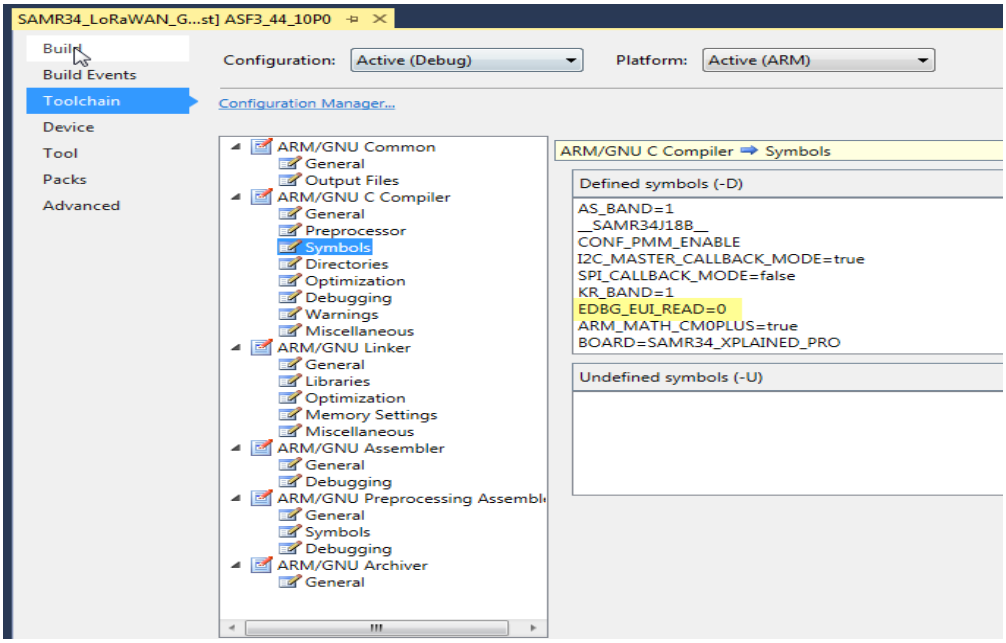
Project settings and properties can be configured thru the Project/Properties menu Tabs



To select which device EUI you will be using, select the Toolchain item under project properties.
Then select Symbols in the list of ARM/GNU C compiler options as shown below.

In the list of Defined symbols shown , edit the symbol EDBG_EUI_READ to either
EDBG_EUI_READ=0 to use your own device EUI entered in file conf_app.h or
EDBG_EUI_READ=1 to use the pre-programmed Microchip assigned device EUI that is pre-programmed into the SAMR34 Xplained PRO evaluation board.

You will see a Properties page similar to what is shown below:

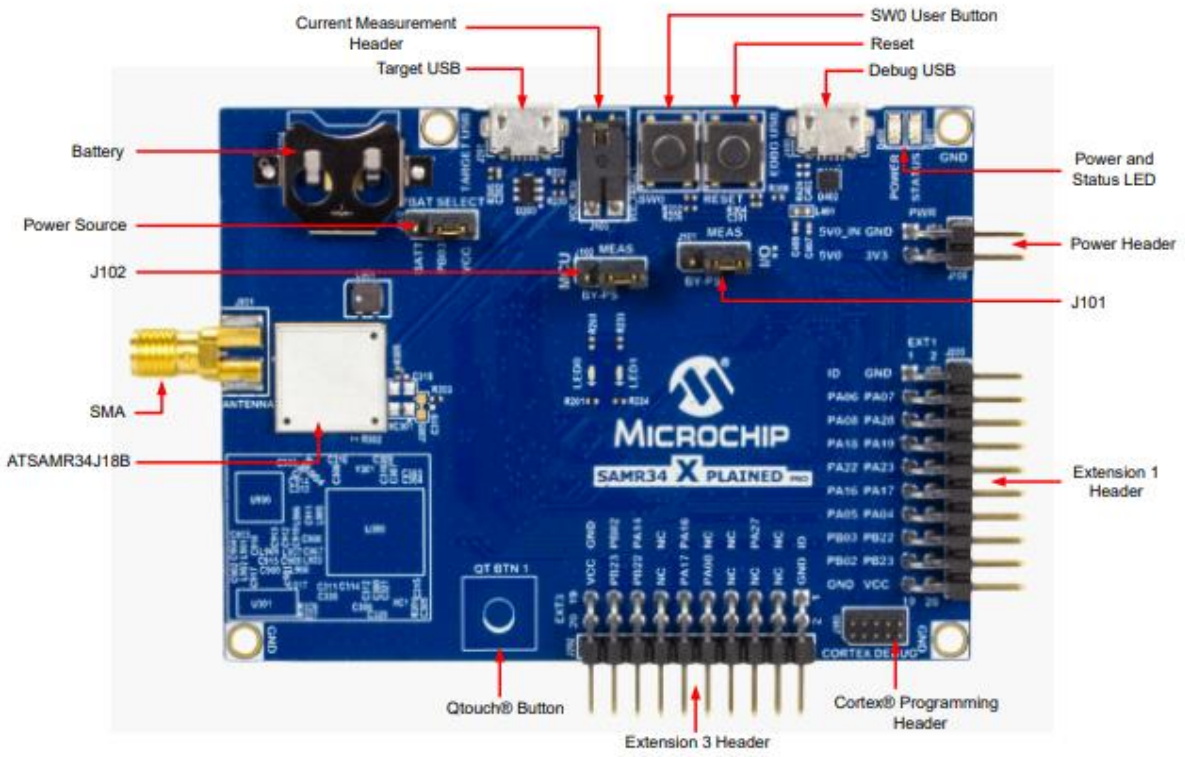


5. Hardware environment setup

5.1. Supported platform and eval board

The following board is used/supported in this release.

SAMR34 Xplained Pro Part# DM320111



This board can be powered from the Debug USB port located at the top right of the image shown above or by way of the 5v Power Header shown at the top right-hand edge of the above image.

Other methods are available, but not used for this example application.

Note! The small battery located at the top left is only for battery backup of the battery backup memory section and is NOT used to actually power the board or SAMR34 device. This battery is not required for this example application.

6. LoRaWAN USB_CDC example project

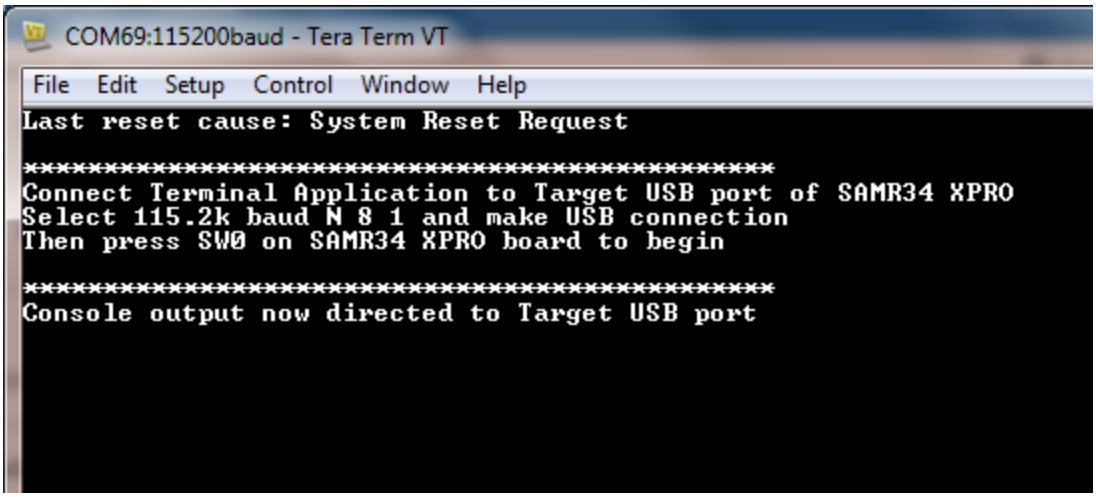
The USB_CDC example application code focuses on the elements required to use the on board USB peripheral as a communications console for a Lorawan end node.
The following features of the SAMR34 LoRaWAN solution are demonstrated:

- Establish a USB CDC serial console connection between the SAMR34 XPRO and a PC running a terminal application like TeraTerm or a similar app.
- Establish a LoRaWAN connection automatically between the SAMR34 end node and a LoRaWAN network server, by way of any available Gateways that are within radio range.
- Periodically transmit an unconfirmed data frame (every 30 seconds)
- Manually transmit a confirmed data frame upon the press of a pushbutton
- Allow adjustment of Data Rate (spreading factor) and Tx Power Levels by push button sequences. This is accomplished by using various duration button presses of the SW0 user button on the XPRO board.

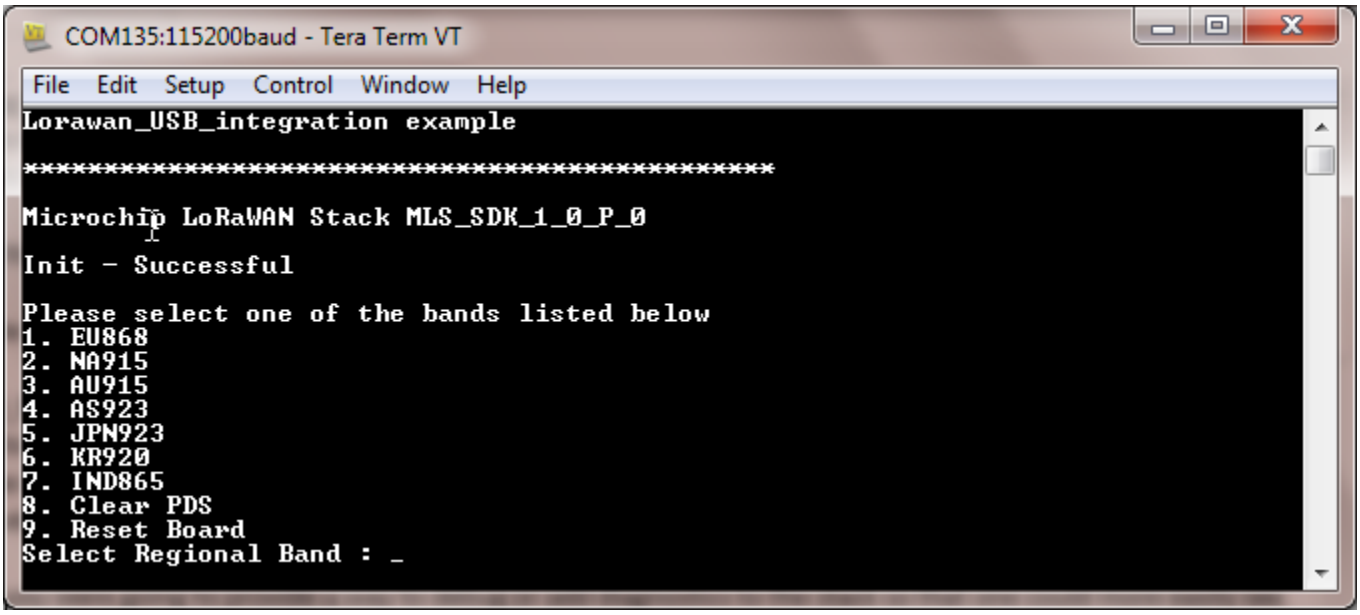
To run the example application, follow the instructions given below

1. Connect the XPRO board to your computer using two USB cables. Connect one USB cable to the EDBG connector on the XPRO board and the additional USB cable between the PC and the Target USB connector on the XPRO board.
2. Program the SAMR34 XPRO board with the USB_CDC [Button] application firmware using Atmel Studio 7.
3. For the initial setup, connect a terminal application like Teraterm to the EDBG port of the XPRO board. This will be used for the initial startup up console output during the setup phase.
   NOTE! You will connect an additional Terminal window application to the Target USB port later, once the application has started, as directed by instructions displayed thru the EDBG port to the Terminal window.
4. Setup the terminal Application for 115200 baud N 8 1
5. Once you have the Terminal app connected to the XPRO board, start the SAMR34 application if running in Studio debugger, or press reset on the XPRO board, if running standalone.

   If it is the *first time execution* of the application after initial programming , then with a terminal program connected, you will see the startup screen shown below:



Once you have started the second Tera Term terminal and configured it for the proper baud rate and enabled CRLF line terminations, you can then press the SW0 button on the SAMR34 XPRO board. You will then see a screen similar to the one shown below in the terminal window connected to the TARGET USB connector.



Enter a number between 1 and 7 to select the rf band or region that you intend to operate within.
Menu Selection 8 will allow you to clear the persistent data storage memory, to start again.
Menu Selection 9 performs a reset to the application and stack.

Generally, to start over (and remove all previous settings) you would select 8, and then 9
Note! If you do perform a reset, you will again have to short press the SW0 button to see the startup screen.
And depending upon which operating system you are using on the pc, you may have to reconnect the terminal app to the selected port again, before pressing the SW0 button.

Once you have selected the region of operation, you will then be presented with the following screen

```
**********Join Parameters**********

DevEUI  : 0x000425191801d47b

AppEUI  : 0x0000000000000005

AppKey  : 0x00000000000000000000000000000005

TxPower Index      = 05
Current Data rate  = DR0
ADR                = OFF

Confirmed Retries  : 04
SUBBAND            = 02

Join Request Sent for NA915
```

Here you will find the parameters that will be used to join the LoRaWAN network
The DevEUI is read from the preprogrammed NVM (non volatile memory) of the XPRO board.
This is a unique EUI supplied by Microchip.

The AppEUI and AppKey were the parameter's that you configured in the conf_app.h file, before you built the Program, as described in section 3.0 of this document.

Following the display of the above screen, a join request is sent using the displayed parameters/attributes

If the Join operation is **not** successful, you will be shown a screen similar to the one shown below

```
Join Request Sent for NA915

Joining Denied
Join Attempt was on CH  13
Awaiting next Join attempt

************************************************
```

In this case, a join attempt on Channel 13 (North America band) has failed.
A delay is performed before the next Join attempt.

If the Join attempt is successful, you will be presented with a screen as shown below:

```
Joining Successful
Joined on Channel 15

DevAddr: 0x26022944

**************Application Configuration**************

DevType             : CLASS A

ActivationType      : OTAA

Transmission Type   : UNCONFIRMED

FPort               : 1

TxPower Index       : 05
SUBBAND             = 02

Confirmed Retries   : 04

*****************************************************
```

The successful Join, shown above, occurred on channel 15.
The DevAddr assigned by the Network Server (during an OTAA join) is displayed.
The remainder of the display reports the current application configuration.

This information is useful when trying to confirm that the settings of the end node are proper, and match the configuration used when registering a node with your LoRaWAN network service provider.

Once you have joined the network successfully, the end node application will periodically send a data frame containing temperature sensor data.
The screen below illustrates two periodic transmissions that occur 30 seconds apart.
The first transmission occurred on channel 8 and the second on channel 10

The TX power index of 05 represents the highest ***SAMR34 TX power level*** available for North America.
DR0 represents SF10BW125 for North America, and is the lowest data rate available in North America. This is also the configuration that will provide the highest link budget (highest TX power and best RX sensitivity) to achieve the longest range .

```
**************************************************
Temperature: 18.0° C  / 64.4° F

Tx Data Sent
Transmission Success
Active Channel 8
Active TxPower Index = 05
Active Data rate = DR0
**************************************************

wakeup from sleep_ok 27469 ms
**************************************************
Temperature: 17.0° C  / 62.6° F

Tx Data Sent
Transmission Success
Active Channel 10
Active TxPower Index = 05
Active Data rate = DR0
**************************************************
```

6.1 Changing Data Rate / Spreading factor

It is possible to adjust the Data Rate/spreading factor by way of the SW0 pushbutton, on the SAMR34 XPRO evaluation board. Changing of the Data Rate can be performed by a long press of the SW0 pushbutton. Press and hold the pushbutton until you see the green led turn on. Then release the button.
This action will increment the Data Rate by one step, moving from a lower data rate to a higher data rate.

The new data rate will be indicated by the blinking of the green led after you stop pressing the pushbutton.
The chart at the end of this section lists the number of blinks to expect for the various Data Rates available.

With the serial console connected, a message as shown below is displayed on the console.
In this case the Data Rate was changed from DR0 to the new setting of DR1

```
wakeup from sleep_ok 5286 ms
Set DateRate = DR1 Success
```

As you can see from the console listing below, the next transmission was made using DR1

```
**************************************************
Temperature: 18.0° C  / 64.4° F

Tx Data Sent
Transmission Success
Active Channel 9
Active TxPower Index = 05
Active Data rate = DR1
**************************************************
```

Region	Data Rate	Spreading factor	Bandwidth	bps	LED blink count
North America	DR0	SF10	125Khz	980	1
	DR1	SF9	125Khz	1760	2
	DR2	SF8	125Khz	3125	3
	DR3	SF7	125Khz	5470	4

Region	DataRate	Spreading factor	Bandwidth	bit/s	LED blink count
Europe 868	DR0	SF12	125Khz	250	1
	DR1	SF11	125Khz	440	2
	DR2	SF10	125Khz	980	3
	DR3	SF9	125Khz	1760	4
	DR4	SF8	125Khz	3125	5
	DR5	SF7	125Khz	5470	6

NOTE: Only 125Khz channels are used in this application

6.2 Changing TX power index

The initial Tx power index setting is set to the maximum TX output power allowed for the region selected.
For North America this would be a Tx power Index of 5. The SW0 user button on the SAMR34 XPRO can be used to modify this parameter while making field range measurements.
An Extended Long press of the SW0 pushbutton will increment the TX power index and thus reduce the TX output power used for future transmissions.
Press the SW0 button until the amber LED turns on. (***Note!*** First the green LED will turn on, and you must continue to hold/press the button until the amber led also turns on.
Release the button when you see both the green and amber LED's on.

When you release the SW0 button, the amber led will blink a specific number of times to indicate which Tx power index setting you adjusted to. See table below for relationship between the number of blinks and the Tx power index that you have set.

If you happen to have the console connected at this point in program operation, you will also see screens similar to those shown below.

The first section indicates that in this example, the Tx power index was changed to 6

And the second section illustrates that on the next sensor transmission a Tx power index of 6 was actually used.

```
wakeup from sleep_ok 7897 ms
Set Tx Power Index = 6 Success
```

```
wakeup from sleep_ok 29989 ms
**************************************************
Temperature: 19.0° C  / 66.2° F

Tx Data Sent
Transmission Success
Active Channel 8
Active TxPower Index = 06
Active Data rate = DR1
**************************************************
```

Region	Tx Power Index	Tx Power dBm *[30-(2*PwrIndex)]*	LED blink count
North America	**5**	**+20**	**6**
	6	**+18**	**5**
	7	**+16**	**4**
	8	**+14**	**3**
	9	**+12**	**2**
	10	**+10**	**1**

Note! Tx power dBm is related to output pins of SAMR34 and does not include any loss in output matching or interface circuitry.

Region	Tx Power Index	Tx Power dBm	LED blink count
Europe 868	**0**	**+16 max**	**8**
	1	**+14 max -2**	**7**
	2	**+12 max -4**	**6**
	3	**+10 max -6**	**5**
	4	**+8 max -8**	**4**
	5	**+6 max -10**	**3**
	6	**+4 max -12**	**2**
	7	**+2 max -14**	**1**

Note! Tx power dBm is related to output pins of SAMR34 and does not include any loss in output matching or interface circuitry.

6.3 Restoring to default (initial) Data Rate and TX power levels

After making changes to either the Data rate, Tx power index or both while making range measurements, there may be a need to quickly reset both parameters to their original default settings (lowest data rate and higher Tx power level).
This can be achieved by performing an extra long SW0 pushbutton press allowing a reset to default operation. Press and hold the SW0 pushbutton as you watch the leds. The green led comes on first, (continue holding) while the amber led also turns on, and again continue holding until both leds turn off. You may then release the SW0 pushbutton and both Data Rate and Tx power level will be set back to the initial default values for the region you had selected initially.

```
wakeup from sleep_ok 5473 ms
Set DateRate to default  DR0 Success
Set default Tx Power Index  5 Success
```

6.4 Manual PushButton sensor transmission

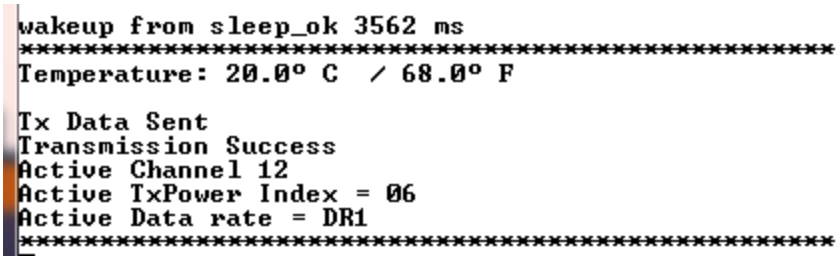
Although the application will periodically transmit a frame containing temperature sensor data, there are times when one would want to manually initiate a sensor transmission by pressing the SW0 pushbutton.
A short press of the pushbutton will initiate a sensor transmission using the confirmed message format.

Upon short pressing the button, the green led will start blinking, and it will remain blinking until the transaction has completed successfully or fails.
If all went well, the green led will stop blinking and the amber led will be off.

If there is a failure, or no acknowledgement is obtained, then the amber led will remain on to indicate a failure.
The amber led will be cleared on the next successful transmission attempt.

NOTE! The SW0 pushbutton is right next to the RESET pushbutton .. Be very careful that you do not press the RESET pushbutton by mistake! This will easily happen if you are not paying attention to which pushbutton you are pressing.

If the console is connected when initiating a manual message transmission, the following will be shown on the screen.



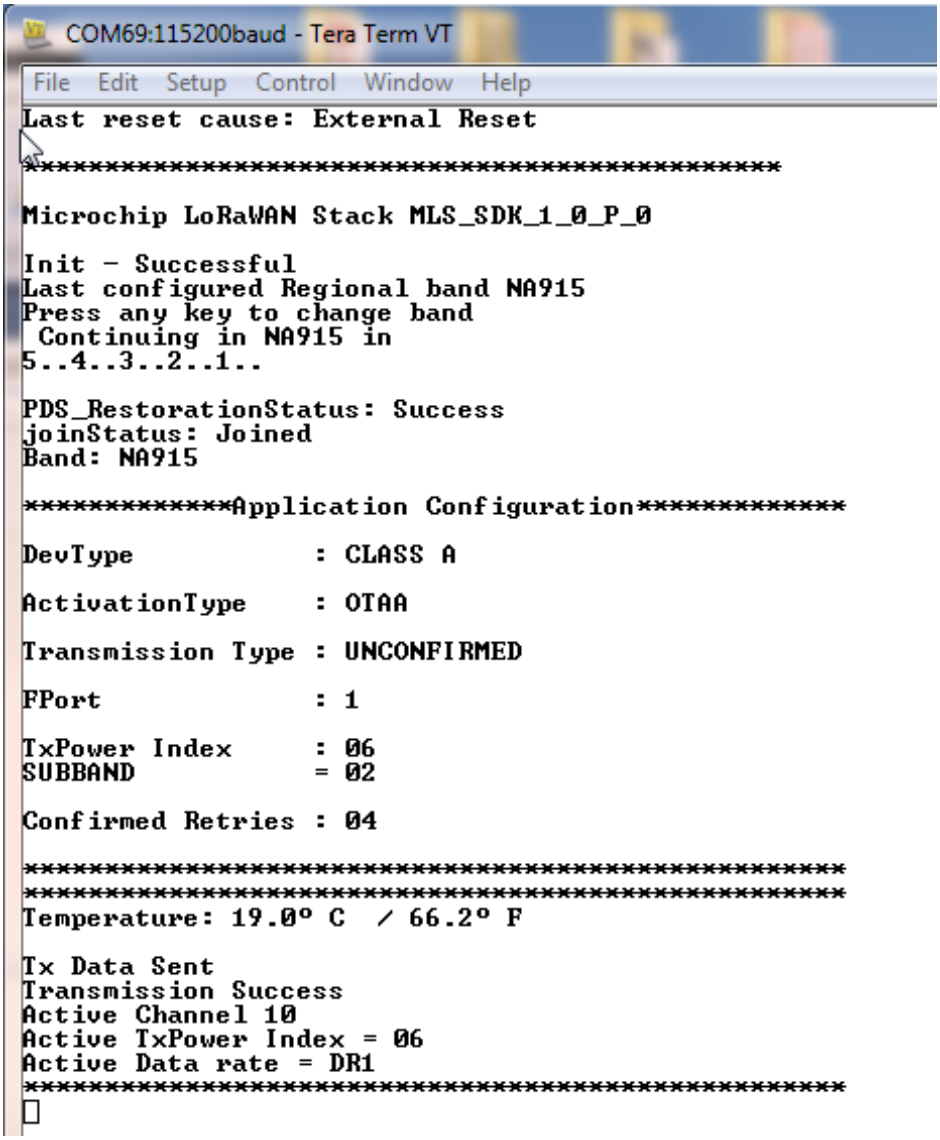
This screen illustrates that the device had been asleep for 3562 ms at the time the pushbutton was pressed. The pressing of the pushbutton woke up the device from sleep, and initiated a manual sensor transmission.
NOTE! When operating in the European 868mhz band or other bands that incorporate duty cycle restrictions, you may see a NO CHANNEL FOUND message indicating that previous transmissions have used the available time, and you will have to wait and try again later when duty cycle allows.

6.5 Restarting / Restoring configuration upon power cycle/reset

The initial selecting of Region is only necessary during the initial setup.
Once the application has be run once, the required parameters and attributes are stored in non volatile memory (persistent storage)

Upon a power cycle or reset of the device, a check is made to determine if there is previously stored information that can be used to restore operation to settings that were in use before the reset or power cycle.

The console screen below illustrates what occurs upon a restoration from a power cycle or reset.



Operation will occur on the same band that was used the last time the application executed.
There will be a count down of approximately 5 seconds to allow the user to press a console key to abort the restoration process and go back to the main menu , where a new region can be selected if needed.
For field testing, all one needs to do Is initially configure the application, and from that time on, the settings last used will be applied.