

PIC32CM LS00/LS60 Ultra Low-Power Secure LoRa Demonstration

Abstract

This document describes the implementation of the features of the PIC32CM LS00/LS60 to demonstrate an ultra-low power and secure LoRa[®] Node. It also covers the following topics:

- Application requirements.
- How to build and load the application on a PIC32CM LS00/LS60 target device.
- Technical solution description and the key features of the PIC32CM LS00/LS60 used to build the demonstration.

The demonstration source codes are available for download along with this document.

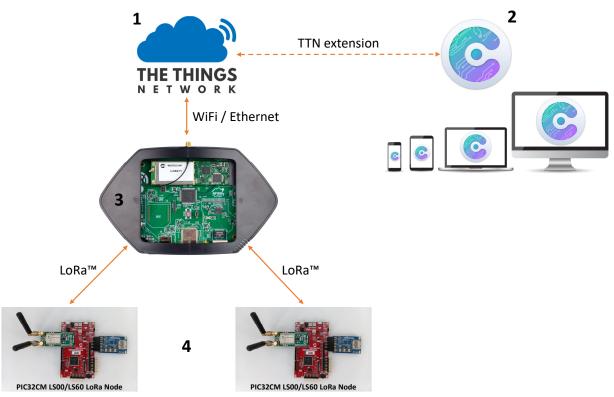
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1. Introduction

The different elements of the demonstration environment are based on a typical Internet of Things (IoT) network as shown in the following figure:

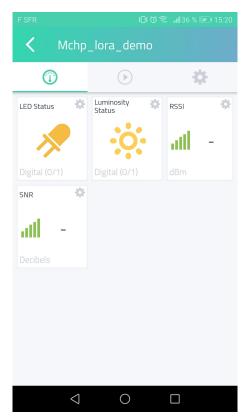
Figure 1-1. IoT Network



Each of these elements represents a specific part of an IoT network:

- The Things Network (TTN) A service for IoT networking exclusively on LoRa communications. It builds a large network with gateways, based on LoRaWAN[™] protocol, to increase the number of existing LoRa applications and users. This protocol allows multiple features suitable for IoT, Iow-battery usage, Iong range, Iow bandwidth, and Iow-noise attenuation. Refer to The Things Network Setup for additional information about TTN and device registration.
- Cayenne A front-end web site made to simplify the creating and developing of LoRa-enabled IoT solutions. It enables different features, such as Data visualization, SMS and email alerts, triggers, and remote monitoring. The figure below shows the Cayenne dashboard of the LoRa Node on a smartphone:

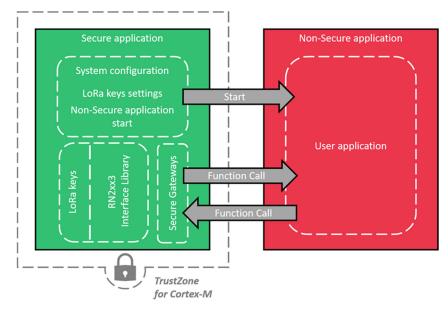
Figure 1-2. Cayenne Dashboard



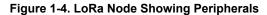
Refer to the chapter Cayenne for additional information about Cayenne configuration.

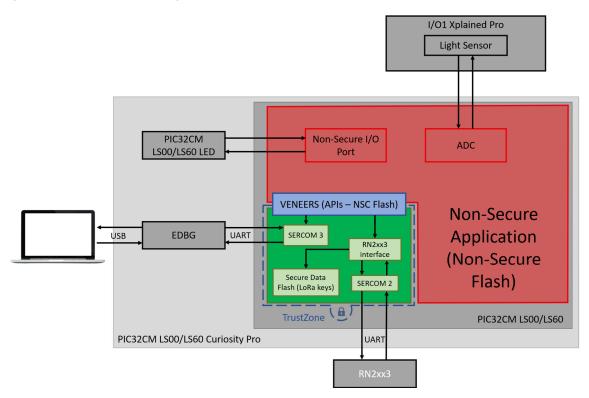
- 3. The Gateway Enables the PIC32CM LS00/LS60 LoRa Node (PIC32CM LS00/LS60 + RN2483 or RN2903 wireless LoRa modules) to connect to the Cloud (The Things Network). Many gateways exist for LoRa communication. The demonstration must work with every LoRa gateway solution made for 868 MHz or 915 MHz, which are compliant with TTN network. Refer to the following web site for additional information about The Things Gateway (TTGateway): www.thethingsnetwork.org/docs/gateways/
- 4. The PIC32CM LS00/LS60 LoRa Node The main part of the demonstration environment is based on the Microchip PIC32CM LS00/LS60 microcontroller connected with the LoRa Click Board[™] and the I/O1 Xplained Pro extension board. The following figure shows how the system makes use of the Arm[®] TrustZone[®] for ARMv8-M devices to store the LoRa keys and the RN2xx3 interface library into a Secure application, and manage interactions between the Secure and Non-Secure.

Figure 1-3. Secure and Non-Secure



The following figure shows detailed information on the peripherals used with the PIC32CM LS00/LS60 LoRa Node:





Data Flash is configured as a secure memory to store the LoRa keys, and the RN2xx3 interface library is stored in the secure part of the Flash. The following keys are used for the Over-The-Air Activation (OTAA) procedure:

- The Application EUI (AppEUI), that is, the application identifier
- The Device EUI (DevEUI), that is, the end device identifier
- The AppKey used to derive keys for security, for example, encryption

The SERCOM 2 in UART mode and SERCOM 3 in UART mode are used to communicate with the RN2483 or the RN2903 wireless LoRa module and the EDBG console.

In the Non-Secure project, the ADC is configured to measure data received from the light sensor of the I/O1 Xplained Pro. The PIC32CM LS00/LS60 on-board LED is used as a control LED to know when the PIC32CM LS00/LS60 is sending data.

The Non-Secure application uses the secure library provided by the Secure project to set up a secure low-power LoRa application. The secure library allows definition of the LoRa limitations of the demonstration and to reduce accesses to the Secure application from the Non-Secure application by providing a restricted set of APIs for the Non-Secure application. This application uses the PIC32CM LS00/LS60 LoRa Node to send luminosity status to the Cloud to inform the user (with text messages and emails) of the changes, allowing the user to take measures according to the information received. If no luminosity change is measured on the ADC, the PIC32CM LS00/LS60 LoRa Node is put in low-power mode (Standby mode for the PIC32CM LS00/LS60 and Sleep mode for the RN2483 or RN2903).

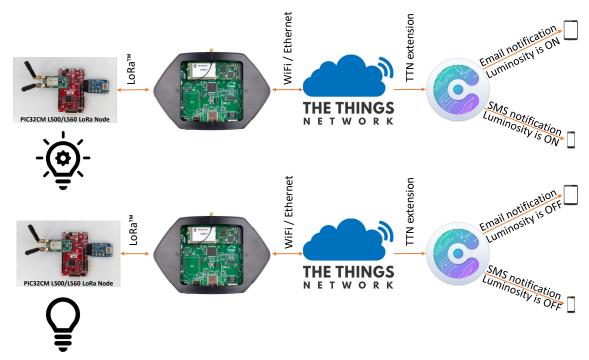


Figure 1-5. PIC32CM LS00/LS60 LoRa Node Set Up

Refer to 4. Demonstration Description for additional information about the Secure and Non-Secure applications.

2. Hardware and Software Requirements

Software Requirements:

- MPLAB[®] X IDE most up to date version
- MPLAB Code Configurator (MCC) for MPLAB Harmony v3 most up to date version
 - The csp package
 - The csp_apps_pic32cm_le_ls package
 - MPLAB Data Visualizer (standalone or MPLAB X IDE plugin version)
- The PIC32CM LS00/LS60 DFP package
- Tera Term: osdn.net/projects/ttssh2/releases/

Hardware requirements for the European region:

- 1 x Microchip PIC32CM LS00/LS60 Curiosity Pro
- 1 x Microchip I/O1 Xplained Pro extension (ATIO1-XPRO)
- 1 x MikroElektronika LoRa Click Board (includes Microchip RN2483 wireless LoRa module)
- 1 x 868 MHz antenna
- 1 x 868 MHz Gateway (compliant with TTN network)
- 1 x Micro USB cable (type-A/Micro-B)

Hardware requirements for the North American region:

- 1 x Microchip PIC32CM LS00/LS60 Curiosity Pro
- 1 x Microchip I/O1 Xplained Pro extension (ATIO1-XPRO)
- 1 x MikroElektronika LoRa click Board (includes Microchip RN2903 wireless LoRa module)
- 1 x 915 MHz antenna
- 1 x 915 MHz Gateway (compliant with TTN)
- 1 x Micro USB cable (type-A/Micro-B)

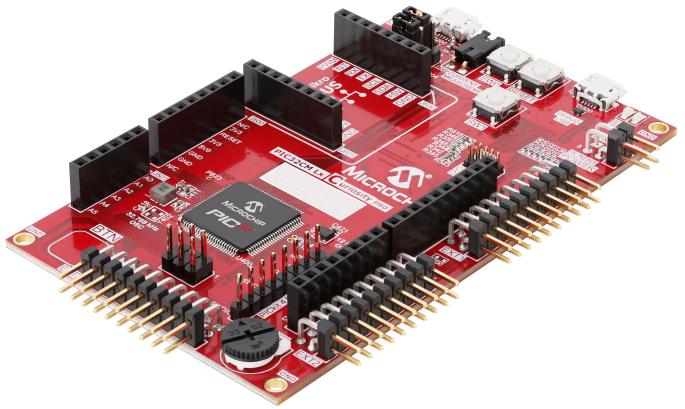
2.1 Hardware Requirements

2.1.1 Microchip PIC32CM LS00/LS60 Curiosity Pro

The Microchip PIC32CM LS00/LS60 Curiosity Pro evaluation kit is a hardware platform to evaluate the PIC32CM5164 LS00/LS60 100-pin microcontroller. Supported by the MPLAB X integrated development platform, the kit provides easy access to the features of the Microchip PIC32CM5164 LS00/LS60 and explains how to integrate the device in a custom design.

The Curiosity Pro MCU series evaluation kits include an onboard Embedded Debugger which overcome the need of external tools to program or debug the onboard microcontroller. The Curiosity Pro extension kits offer additional peripherals to extend the features of the board, and ease the development of custom designs. The following figure illustrates the features of the PIC32CM LS00/LS60 Curiosity Pro board.

Figure 2-1. PIC32CM LS00/LS60 Curiosity Pro Board



2.1.2 Microchip I/O1 Xplained Pro Extension Board

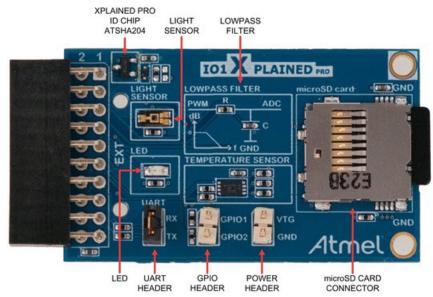
The Microchip I/O1 Xplained Pro extension board is a generic extension board for the Curiosity and Xplained Pro platform. It connects to any Xplained Pro standard extension header on any Curiosity or Xplained Pro MCU board.

The extension board uses the following functions on the standard Xplained Pro extension header to enhance the feature set of the Curiosity or Xplained Pro MCU boards.

• SPI

- MicroSD card connector
- 2 GB microSD card included
- PWM
 - LED control
 - $\hspace{0.1in} \mathsf{PWM} \rightarrow \mathsf{Low} \hspace{0.1in} \mathsf{pass} \hspace{0.1in} \mathsf{filter} \rightarrow \mathsf{ADC}$
- ADC
 - $\quad \mathsf{PWM} \to \mathsf{Low} \text{ pass filter} \to \mathsf{ADC}$
 - Light sensor
- UART
 - Loopback interface via pin header
- TWI
 - AT30TSE758 temperature sensor with EEPROM

Figure 2-2. I/O1 Xplained Pro Extension Board

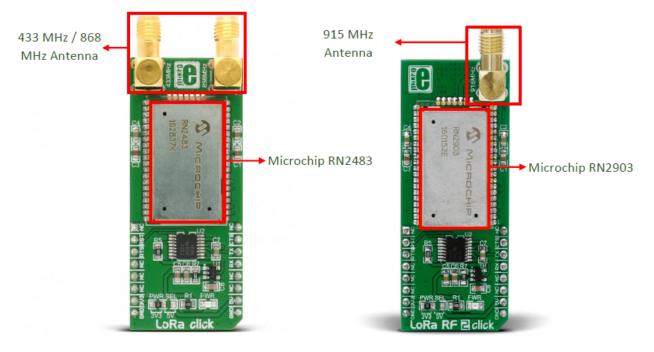


2.1.3 MikroElektronika LoRa Click Board (Includes Microchip RN2483 or RN2903)

The MikroE LoRa click board is a LoRa RF technology-based SRD transceiver, which operates at 433 MHz or 868 MHz in Europe (with embedded RN2483) or at 915 MHz in North America (with embedded RN2903). This click board is LoRaWAN Class A compliant, and provides a long-range spread spectrum communication with high interference immunity. The module used on this click board is a fully certified LoRa Sub GHz. The RN2483 is compliant with the European RED directive assessed radio modem, the RN2903 is certified for both FCC and IC requirements. These boards are combined with the advanced and simple command interface which enables an easy integration and reduced development time.

• UART - Communicate with RX, TX, RTS and CTS pins

Figure 2-3. RN2483 and RN2903 Boards



2.2 Software Requirements

2.2.1 MPLAB[®]X Integrated Development Environment

MPLAB X Integrated Development Environment (IDE) is an expandable, highly configurable software program that incorporates powerful tools to help you discover, configure, develop, debug, and qualify embedded designs or most of Microchip's microcontrollers and digital signals controllers. MPLAB X IDE works seamlessly with the MPLAB development ecosystem of software and tools.

Figure 2-4. MPLAB X IDE



Users can download MPLAB X IDE from the Microchip's website: www.microchip.com/mplab/mplab-x-ide.

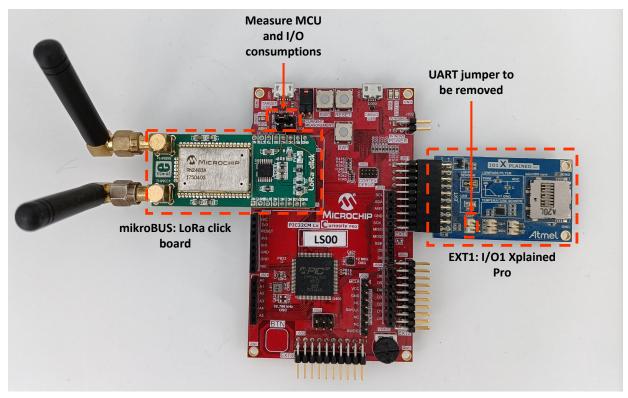
3. Demonstration Setup

The demonstration involves the following steps.

3.1 Hardware Setup

To setup the hardware, the user needs to perform these actions: Connect the I/O1 Xplained Pro extension board and LoRa click board to the PIC32CM LS00/LS60 Curiosity Pro board, and then set the board jumpers as shown in the following image. The demonstration hardware is now ready for evaluation.

Figure 3-1. Hardware Setup



Note: Ensure that the UART jumper on the I/O1 Xplained Pro board is removed, otherwise the PIC32CM LS00/ LS60 will not be able to communicate with the RN2483 or RN2903 module.

3.2 Network Setup

The Things Network (TTN) Setup

Refer to 7.1 The Things Network for additional information about TTN setup and device registration if TTN is not setup.

TTN-Compliant LoRa Gateway Setup

The following link provides a list of TTN compliant gateways and how to get started: www.thethingsnetwork.org/docs/gateways/.

Cayenne Setup

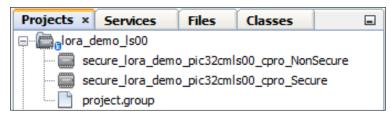
Refer to 7.2 Cayenne for additional information about device registration on Cayenne, payload format, and Cayenne intelligent features if Cayenne is not setup.

The network is now setup.

3.3 Software Setup

To open and load the demonstration project on the target hardware, follow these steps:

- 1. Open MPLAB X IDE.
- 2. Click Projects tab, and then expand the lora_demo_ls00 (or lora_demo_ls60) project group tree. Figure 3-2. MPLAB X Project Tree



- 3. Double-click the secure_lora_demo_pic32cmls00_cpro_NonSecure project to open it.
- 4. Left-click the secure_lora_demo_pic32cmls00_cpro_NonSecure project, and then select Set as Main Project.

⊡… <mark>© secure_lora_der</mark> ⊕ ① Device actio	New >
 Important Fi Impo	Add Existing Item
	Build Clean and Build Clean Batch Build Package Set Configuration >
	Run Debug Step into Learn more about scripting Make and Program Device
	Set as Main Project

Figure 3-3. Set NonSecure as Main Project

5. From the Solution Explorer panel, select *pic32cmls00_lora_demo_NonSecure > Properties*.

Figure 3-4. NonSecure Project Properties

🗈 🗐 Devi	New	>
🖶 💼 Head	Add Existing Item	
⊕~ 🕝 Impo ⊕~ 📄 Linke	Add Existing Items from Folders	
🕀 💼 Sour	New Logical Folder	
🕀 📻 Libra	Locate Headers	
🗄 🐻 Load	Add Item to Important Files	
	Export Hex	
	Build	
	Clean and Build	
	Clean	
	Batch Build	
	Package	
	Set Configuration	>
	Run	
	Debug	
	Step into	
	Learn more about scripting	
	Make and Program Device	
	Set as Main Project	
	Open Required Projects	>
	Close	
	Rename	
	Move	
	Сору	
	Delete	Delete
	Code Assistance	>
	Find	
	Analysis	>
	Show Code Coverage Summary	
	Git	>
	History	>
	Properties	

6. Select the connected board EDBG as the debugger/programmer. Figure 3-5. NonSecure Project Properties Window

itegories:	Configuration	
····· @ General	Family:	Device:
File Inclusion/Exclusion Conf: [pic32cm ls00_cpro]	All Families V	PIC32CM5164LS00100 ~
• • EDBG	Connected Hardware Tool:	Supported Debug Header:
···· · Loading ···· · · Libraries	PIC32CMLS00 Curiosity Pro-SN: MCHP3366030000 🗸 🗌 Show All	None 🗸
- O Building		
XC32 (Global Options)	Packs:	
@ xc32-as	PIC32CM-LS_DFP	
@ xc32-gcc		
○ xc32-g++	E. CMSIS	
0 xc32-ld	5.4.0	
© xc32-ar		
Analysis	Compiler Toolchain:	
	⊡XC32	
Manage Configurations		
Manage Configurations		

- 7. Click **Apply** to save the configuration, and then click **OK**.
- 8. From the toolbar, select *Production > Build Main Project* (), or F11 to build the demonstration. **Figure 3-6. Build Solution Menu**

Proc	duction Debug Team Tools	Window Help
T	Build Main Project	F11
1	Clean and Build Main Proje	ct Shift+F11
	Batch Build Main Project	
	Set Project Configuration	>
	Set Main Project	>
	Set Configuration Bits	
-	Check File	Alt+F9
\triangleleft	Validate File	Alt+Shift+F9
	Repeat Build/Run	Ctrl+F11
	Stop Build/Run	

9. Check whether any error message is displayed on the MPLAB X IDE output window.

Figure 3-7. IDE Output Window

```
      Output - secure_lora_demo_pic32cmls00_cpro_NonSecure (Clean, Build, ...) ×

      Image: BUILD_SUCCESSFUL (total time: 5s)

      Loading code from C:\DDs_Git\lifeguard-pic32cm_le_ls\lora_demo_ls00\NonSecure firm

      Program loaded with pack, PIC32CM-LS_DFP, 1.0.129, Microchip

      Loading completed
```



Important: Ensure that the Secure project is compiled if any error occurs during the compilation.

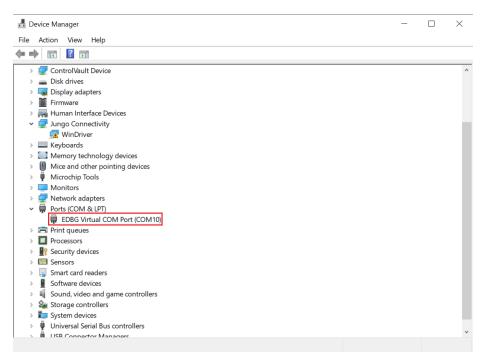
- 10. Flash the demonstration software on the hardware by clicking the \triangleright button.
- 11. Open the Tera Term tool or any equivalent tool.
- 12. Choose the COM port number allocated to the PIC32CM LS00/LS60 Curiosity Pro, and then click **OK**. Figure 3-8. Tera Term New Connection Window

○ T CP/IP	Host: myhost.exar History		
	Service: O Telnet	TCP port#: 22	
	⊚ SSH	SSH version: SSH2	
	\odot Other	Protocol: UNSPEC	; ~
Serial	Port: COM10: EDF	BG Virtual COM Port (CON	/1 1 ~

Note: The COM port number can be retrieved from Windows Device Manager.

The Device Manager Window will be displayed, as shown below.





13. In the Tera Term Serial Port Setup dialogue, configure the serial interface using the parameters given below, and then click **OK**.

Figure 3-10	. Tera	Term	Serial	Port	Setup
-------------	--------	------	--------	------	-------

Tera Term: Serial port setup			×
Port:	COM10	~	ок
Speed:	9600	~	
Data:	8 bit	\sim	Cancel
Parity:	none	~	
Stop bits:	1 bit	~	Help
Flow control:	none	\sim	
Transmit delay	char 0	mse	c/line

14. In the Tera Term Terminal Setup dialogue, choose values for Receive and Transmit, select "Local echo", and then click **OK**.

Figure 3-11. Tera Term Terminal Setup

Tera Term: Terminal setup		×
Terminal size 84 X 31 ✓ Term size = win size Auto window resize	Receive: CR ~ Transmit: CR ~	OK Cancel
Terminal ID: VT100 ~	✓ Local echo	Help
Answerback:	□ Auto switch (VT<->T	E K)
Coding (receive) UTF-8 v	Coding (transmit) UTF-8 v	
locale: american		

15. Reset the board by pressing the **RESET** button.

The demonstration will start by displaying the below messages on the terminal window. The displayed messages will depend on the different application keys have been provisioned on the device. Refer to Demonstration Description for additional information on demonstration behavior.

Figure 3-12. Terminal Window Displaying the Message

🔟 COM11 - Tera Term VT	_	\times
File Edit Setup Control Window Help		
		^
##		
- Low level initialization		
- Initialize RN2XX3 Module		
- Set RN2XX3 keys for Over-The-Air Activa	tion	
- Load Non-Secure Application		
		\sim



(the Data Visualizer icon) on the toolbar.

16. Open MPLAB Data Visualizer in MPLAB X IDE by clicking Figure 3-13. MPLAB Data Visualizer Icon



Note: The MPLAB Data Visualizer also has a standalone version that can be used instead of its MPLAB X IDE plugin version.

Figure 3-14. MPLAB Data Visualizer

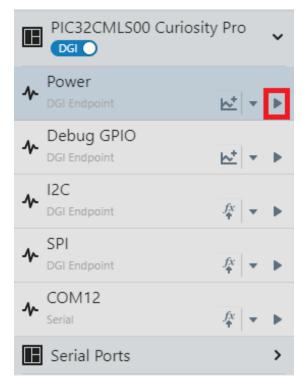
All Apps Documents Web More 🕶	<u>م</u>
Best match	
MPLAB Data Visualizer v1.2.956	MPLAB
Search work and web	MPLAB Data Visualizer v1.2.956
P mplab da - See work and web results >	Арр

17. In the PIC32CMLS00 Curiosity Pro, select **Channel A Current** as the source of the opened time plot. **Figure 3-15. Time Plot Configuration: Channel A Current on the PIC32CMLS00 Curiosity Pro Selection**

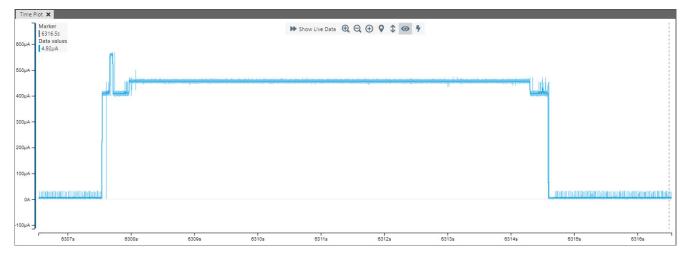
	Time Axis						
	Os	1	10s				₩
	🖈 Mark 👖	Snaps	hot				
0	Data Axis						
	Auto adjust	1	512				\$
					٠	•	亩
ſ	No Source		;	¢	Ŀ	٢	亩
	Debug GPIO 3 c Debug GPIO on 12C on PIC32CM Channel A Curre	ILSOO C	uriosity	Pr	0		>

18. Click (play icon) in the Power box to display the power consumption details.

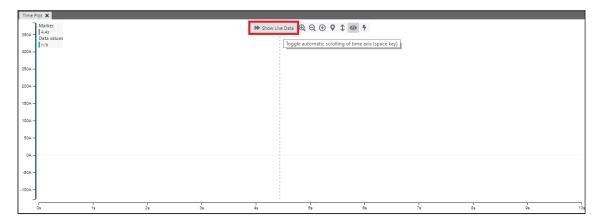
Figure 3-16. Power DGI Endpoint Display Start



19. The Data Visualizer will display the PIC32CM LS00/LS60 LoRa Node power consumption details. Figure 3-17. Data Visualizer Showing Power Consumption



Note: On the time plot window, if data is not appeared, click **Show Live Data**. **Figure 3-18. Time Plot Configuration: Show Live Data**

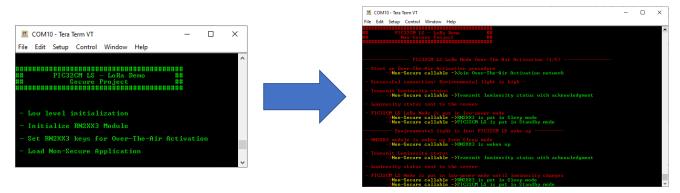


4. Demonstration Description

4.1 Applications Overview

The user can evaluate the standard TrustZone for ARMv8-M mechanism by executing the application. This Non-Secure application code uses the secure library provided by the Secure application code to build a smart lighting network with low-power based on LoRaWAN protocol.

Figure 4-1. Non-Secure Application Code

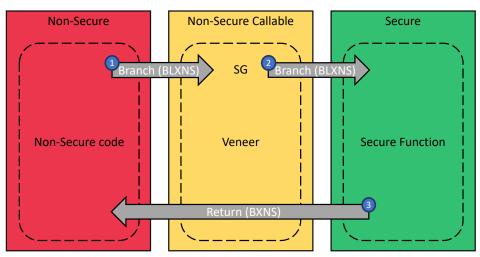


The following color schemes are used to display messages in the terminal window

- Red: Non-Secure
- Yellow: Non-Secure Callable
- Green: Secure

When system initialization is performed, and Non-Secure application code is started, access to the Secure library from the Non-Secure application is done through standard function calls to a predefined set of secure APIs. These secure APIs are defined by the secure code and stored in a Non-Secure Callable region of the PIC32CM LS00/LS60 device. They constitute a set of secure gateways (veneers) that limit the access to the secure software.

Figure 4-2. Non-Secure to Secure Function Call Mechanism



The following figures show an exhaustive list of secure gateways (veneers) provided by the Secure project:

Figure 4-3. Secure Gateway (Veneers)

* *******	Secure LoRa click-board NSC functions ********* */
NAME :	void nsc rn2xx3 break(void)
	(Secure Gateway) Send a break condition (0x55) to the rn2483
PARAMETERS :	
RETURN :	
	*/
xtern void nsc	_rn2xx3_break(void);
*	
	void nsc rn2xx3_sleep (char* sleep_duration)
	(Secure Gateway) Put the rn2483 module into sleep mode for "sleep durartion" milliseconds
	char* sleep_duration
RETURN :	None
xtern woid nec	rn2xx3 sleep (char* sleep duration);
ACEIN VOIG IISC	_hzxx5_steep (chat- steep_dutacton),
*	
NAME :	uint8_t nsc_rn2xx3_join_OTAA_network(void)
DESCRIPTION :	(Secure Gateway) Set all parameters to configure and launch an OTAA (Over-The-Air Activation) connection
PARAMETERS :	None
PARAMETERS : RETURN :	
RETURN :	rn2483_Status
RETURN : xtern <u>uint8 t</u>	<u>rn</u> 2483_Status */
RETURN : xtern <u>uint8 t</u> *	<u>rn</u> 2483_Status
RETURN : xtern <u>uint8 t</u> * NAME :	<pre>rn2483_Status</pre>
RETURN : xtern <u>uint8 t</u> * NAME : DESCRIPTION :	<pre>Im2483_Status</pre>
RETURN : xtern <u>uint8 t</u> * NAME : DESCRIPTION :	<pre>rm2483_status </pre>
RETURN : xtern <u>uint8 t</u> * NAME : DESCRIPTION :	<pre>rn2483_Status</pre>
RETURN : xtern uint8 t * NAME : DESCRIPTION : PARAMETERS :	<pre>rn2483_status</pre>
RETURN : xtern uint8 t * NAME : DESCRIPTION : PARAMETERS :	<pre>rn2483_Status</pre>

Figure 4-4. Gateway (Veneers)

```
/* -

    NAME : void <u>nsc periph</u> clock_<u>init(uint32_t pch_id, uint32_t gclk</u> source)
    DESCRIPTION : (Secure Gateway) Change peripheral clock settings

- PARAMETERS : uint32_t pch_id
- uint32_t gclk_source
- RETURN : None
                                               .____ */
extern void nsc_periph_clock_init(uint32_t pch_id, uint32_t gclk_source);
/* *********** Secure PIC32CM LSxx Low Power NSC functions ********** */
/* ---
- NAME : void <u>nsc_secure_enter_standby</u> (void)
- DESCRIPTION : (Secure Gateway) Put the PIC32CM LSxx in Standby mode (Low-power)
- PARAMETERS : None
- RETURN :
               None
                                                ---- */
extern void nsc secure enter standby (void);
/* ********** Secure console NSC functions ********** */
/* --
- NAME : void <u>nsc_secure_console_puts</u> (char *string)
- DESCRIPTION : (Secure Gateway) Write a string to the console
- PARAMETERS : char* string
- RETURN : None
                                              ----- */
extern void nsc_secure_console_puts (char *string);
/* ********** Secure PIC32CM LSxx Delay function ********** */
extern void nsc_SYSTICK_DelayMs ( uint32 t delay );
```

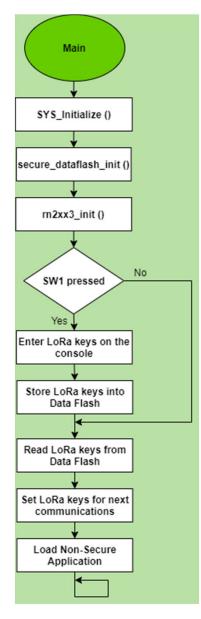
4.2 PIC32CM LS00/LS60 LoRa Demonstration: Secure Project

The Secure project executed at product startup manages the critical aspect of the application. It is stored and runs from the secure memories of the PIC32CM LS00/LS60, which are isolated from the Non-Secure software with the help of the Cortex-M23 TrustZone for ARMv8-M. It is in charge of performing the following tasks in the application:

- · Low-level system settings.
- Providing the library and associated veneers (APIs) for the RN2483 or RN2903 module (SERCOM) to the Non-Secure project.
- Store the application keys from the RN2483 or RN2903, and TTN.
- Loading the Non-Secure application.
- Manage the serial communication with the Host computer and the LoRa click-board.

The following is the flowchart of the Secure project main routine:

Figure 4-5. Secure Project Main Routine



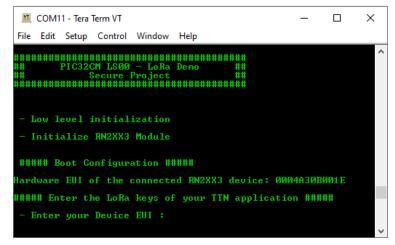
The above flowchart illustrates the different cases available in the Secure project. To start the key provisioning operation, the user must press the SW0 button during the Secure project start until the LoRa keys configuration screen appears for key provisioning. The LoRa keys to be provisioned must be in line with the user's TTN setup, and are stored in the secure memory region of the product Data Flash. After the provisioning sequence, the keys will be retrieved from the secure memory region of the product Data Flash during each application startup, until the product Data Flash is cleared (Full-chip erase). These keys will be used by the application to join the TTN and send data. These keys are accessible on the TTN after the device is registered.

4.2.1 Keys Not Provisioned

This section describes how key provisioning is realized during boot configuration. If LoRa keys are stored in the Data Flash, skip this section and proceed to Keys Provisioned.

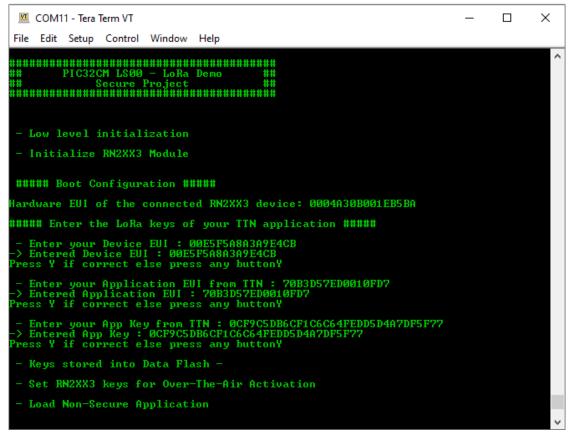
The following figure shows the messages displayed by the console after the LoRa keys configuration is entered by pressing the SW0 button after resetting the PIC32CM LS00/LS60 LoRa Node.

Figure 4-6. Console Displaying the Key Provisioning Entry Message



The user can enter DevEUI, AppEUI, and AppKey keys to be stored in Data Flash as shown in the following figure.

Figure 4-7. Console Displaying the Key Provisioning Process

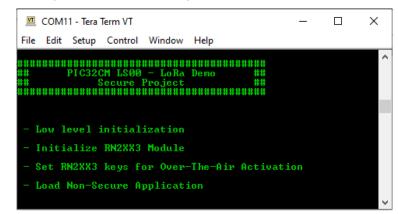


Keys are stored into the Data Flash and are set in the RN2483 or RN2903 module for the OTAA procedure.

4.2.2 Keys Provisioned

The following image shows the information displayed by the console after a PIC32CM LS00/LS60 reset when the keys are provisioned:

Figure 4-8. Console Showing Standard Boot Message



The low-level settings are configured in the Secure project, which controls performance level, clock sources, clock domains, wait states, and the TrustZone manager. Peripherals like SERCOM are used to communicate with the RN2483 or RN2903, console, and Data Flash for keys storage.

The RN2483 or RN2903 module is initialized in the Secure project and the Over-The-Air Activation (OTAA) LoRa keys are read from the Data Flash and set for joining TTN and next transmissions.

4.3 PIC32CM LS00/LS60 LoRa Demonstration: Non-Secure Project

The Non-Secure application makes use of the secure library provided by the Secure project to set up the secure low-power LoRa application. This application uses the PIC32CM LS00/LS60 LoRa Node to send the luminosity status to the cloud to inform the user (using text messages or emails) of the changes. To reduce the overall application power consumption on both the PIC32CM LS00/LS60 and the RN2483 or RN2903, the devices are placed in low-power mode when an ambient luminosity change is not detected.

When the PIC32CM LS00/LS60 is in Standby mode, it uses SleepWalking feature to reduce the power consumption. SleepWalking gives the capability for the PIC32CM LS00/LS60 to wake up temporarily and asynchronously a peripheral without waking up the CPU.

The following figure illustrates the demonstration behavior and the benefits of SleepWalking on power consumption:

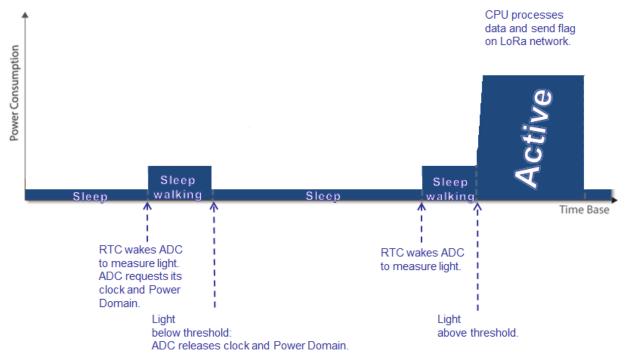
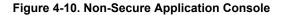


Figure 4-9. SleepWalking on Power Consumption

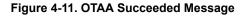
The ADC is woke up every ten seconds by the RTC to convert the ambient luminosity level and compare the result with a preset threshold value. Due to the SleepWalking feature, the CPU will be woken up only if the threshold is exceeded. This allows the PIC32CM LS00/LS60 to remain in Standby mode for a long time.

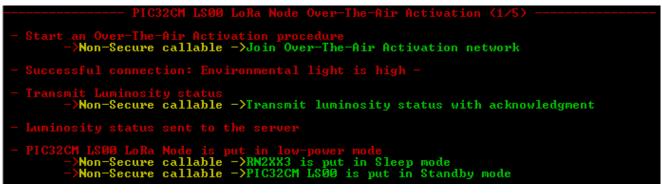
The following figure shows the message displayed on the console by the Non–Secure application in successful connection case:



🔟 COM11 - Tera Term VT	_	×
File Edit Setup Control Window Help		
######################################		^
PIC32CM LS00 LoRa Node Over-The-Air Activation <1/5>		
Start an Over-The-Air Activation procedure ->Non-Secure callable ->Join Over-The-Air Activation network		
- Successful connection: Environmental light is high -		
- Transmit Luminosity status ->Non-Secure callable ->Transmit luminosity status with acknowledgment		
- Luminosity status sent to the server		
 PIC32CM LS00 LoRa Node is put in low-power mode ->Non-Secure callable ->RN2XX3 is put in Sleep mode ->Non-Secure callable ->PIC32CM LS00 is put in Standby mode 		
Environmental light is low: PIC32CM LS00 woke up		
- RN2XX3 module is woken up from Sleep mode ->Non-Secure callable ->RN2XX3 is woken up		
- Transmit Luminosity status ->Non-Secure callable ->Transmit luminosity status with acknowledgment		
- Luminosity status sent to the server		
 PIC32CM LS00 Node is put in low-power mode until luminosity changes ->Non-Secure callable ->RN2XX3 is put in Sleep mode ->Non-Secure callable ->PIC32CM LS00 is put in Standby mode 		
		\sim

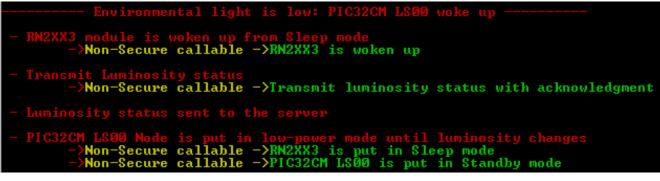
For this example, the LoRa Node tries and succeeds to join the OTAA network. The starting ADC value is used for the first transmission to refresh the cloud values, and then the RN2483 or RN2903 module and the PIC32CM LS00/LS60 are placed in low-power mode:





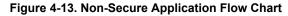
Low luminosity is detected by the ADC, and the RN2483 or RN2903 module is woke up from Sleep mode to send the status of ambient luminosity. Luminosity status is transmitted to the cloud, which transmits back an acknowledge to the RN2483 or RN2903 module. Until high luminosity is detected, the RN module and PIC32CM LS00/LS60 are put in Low-Power mode:

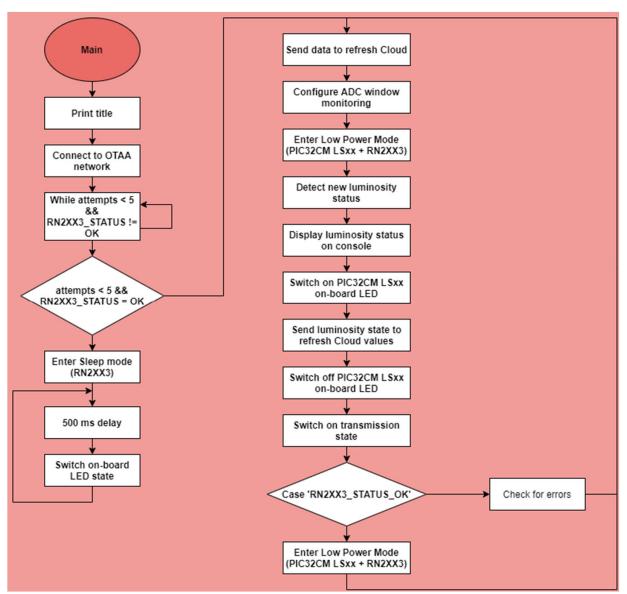




Note: Sometimes the luminosity status does not appear on the Cayenne dashboard, in that case, users must refresh their browser.

The following figure illustrates the flow chart of the Non–Secure application:





4.4 Power Consumptions of the LoRa Node

When the application is running, the dynamic current consumption of the whole application can be measured with the MPLAB Data Visualizer plugin from MPLAB X IDE (or it's standalone version). The current consumption of the application will vary according to the ambient light intensity. This variation is due to the analog light sensor technology implemented on the I/O1 Xplained Pro extension board

When the last status of ambient luminosity is low, the MPLAB Data Visualizer will display the following screen:

Figure 4-14. PIC32CM LS00 IoT Node Power Consumption in Standby Mode

Time	e Pic	×										
	7									Power An	o o 🖬	8
250µ.A	- /	B 589.3s 599.2s								А	в	
	- 11	Δ0s Δ9.96s								589.3 s	599.25	∆9.96s
		lata values 7.35µA 7.36µA								Average 6.48µA	Min -507nA	Мах 236µА
200µA	1	Δ0A Δ4.37nA								Total Char 17.9nAh		
										17.9nAh	n/a	
150µA												1
												1
												1
100µ.A	-											1
												1
												1
50µ.A	-											1
		i i te i ngan ta ta na si i ta i ta na si i ta na si i ta i ta na si i ta i	and the trained	an Enhald Sharaha II.a	h di katika di karan karak katalah da	ana Andra Ind	Ann Al-Indindal Alle	a hina da kina		rit de contra	it in the second	hillini
0A					ALARY MAY - MARKED - MARKED - MARKED - MARKED		and the second second					-
	Т											1
												1
	J	1			-							
		590s	591s	592s	593s	594s	595s	590s	597s	598s		599s

Note: The measured power consumption in Standby mode is a bit less than $6.5 \,\mu$ A.

Note: Equivalent power consumption are expected and measured on the PIC32CM LS60 LoRa IoT Node. To reduce the power consumption, some modifications are made on the RN2483 or RN2903 module and the I/O1 Xplained Pro extension board. Refer to the Hardware Modifications section for additional information about these modifications.

5. System Resources and Software Project Configuration

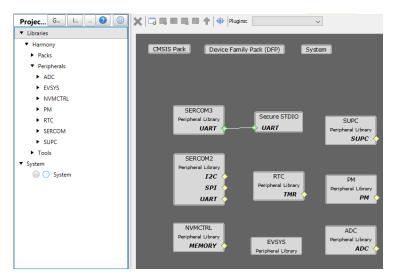
The demonstration application is built on MPLAB Harmony v3. After opening the demonstration project under MPLAB X IDE, the configuration used to generate the project under the MPLAB Code Configurator for Harmony v3 can be viewed by clicking the MCC icon, which is available in the MPLAB X IDE toolbar.

5.1 MPLAB Code Configurator (MCC) for MPLAB Harmony v3 View

5.1.1 MCC Project Setup

The Secure and Non-Secure projects are built on top of the following drivers and middleware:

Figure 5-1. MCC Project Graph and Active Components

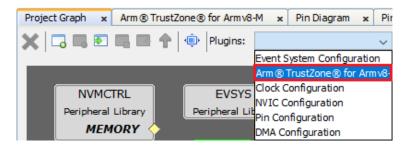


- SERCOM3 (with Secure STDIO): Used for displaying application output information on the terminal.
- SERCOM2: Interface for the RN2483 or RN2903 USART. This is used to send and receive commands and data to and from the RN2483 or RN2903 module.
- ADC: Used to measure environmental light from the I/O1 Xplained Pro that embeds a light sensor.
- RTC: Used to generate an event 10s after the start of the timer count.
- NVMCTRL: Used to generate an event 10s after the start of the timer count.
- **EVSYS:** Used to generate an event 10s after the start of the timer count.

Note: The Secure SYSTICK is also enabled to generate delays for synchronization in some commands. For additional information, go through the 'System' in the Project Graph (or Active Components) window.

The Project Graph and Active Components views show all the peripherals used in the IoT node application, including Secure and Non-Secure applications. The memory configuration and the security attribution for peripherals are assigned through the Arm[®] TrustZone[®] for Armv8-M tool, which is available in the MCC toolbar: select *Plugins* > *Arm[®] TrustZone[®] Armv8-M*.

Figure 5-2. MCC TrustZone[®] for Armv8-M Tool



The Arm[®] TrustZone[®] for Armv8-M manager sets the memory configuration of the PIC32CM LS00/LS60 device and the configuration of the peripherals.

5.1.1.1 Arm® TrustZone® for Armv8-M Manager: Memory Configuration

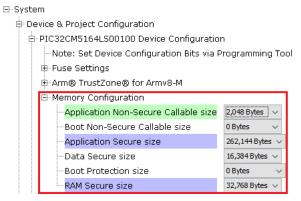
The memory configuration of the device is set as follows for the PIC32CM LS00/LS60 IoT Node demonstration:

Figure 5-3. Arm® TrustZone® for Armv8-M Manager: Memory Configurator



The memory configuration is also available by following these steps: In the Project Graph Window, click and expand *System > Device & Project Configuration > Memory Configurator*.

Figure 5-4. MCC System Block: Memory Configurator



5.1.1.2 Arm[®] TrustZone[®] for Armv8-M Manager: Peripheral Configuration

The peripherals configuration of the device is set as follows for the PIC32CM LS00/LS60 LoRa IoT Node demonstration:

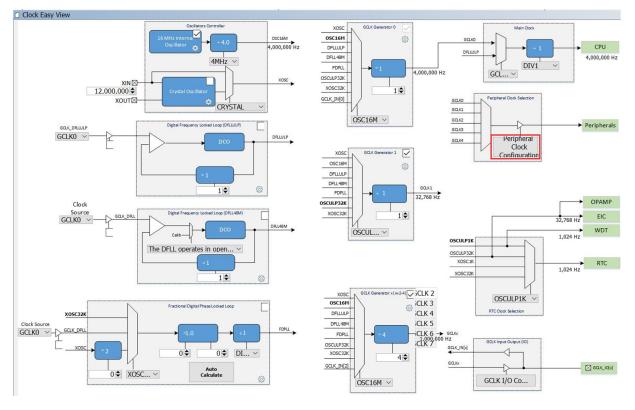
TRUSTZONE	Note: Click on perip	herals to change f	rom Secure (green	color) to Non-Secu	ure (red color) vice	e versa.	
Memory Configuration	Peripherals						
Peripheral Configuration	AC	ADC	CCL.	DAC	DMAC	DSU	FREQM
	125	ОРАМР	РМ	РТС	RSTC	RTC	SERCOM0
	SERCOM1	SERCOM2	SERCOM3	SERCOM4	SERCOM5	SUPC	TCO
	TC1	TC2	TCC0	TCC1	TCC2	тосз	TRAM
	TRNG	USB	WDT				
	Mix-Secure Periphe	erals					
	EIC	EVSYS	NVMCTRL	РАС	PORT		
	System Resources						
	GCLK	IDAU	MCLK	OSC32KCTRL	OSCCTRL		

Figure 5-5. Arm[®] TrustZone[®] for Armv8-M Manager: Peripheral Configuration

5.1.2 MCC Project Clock Configuration

The clock configuration is available in the toolbar:

Figure 5-6. MCC Project Clock Configuration



- The OSC16M is configured to run at 4 MHz and feeds the Generic Clock Generator 0 (GCLK0) and GCLK2. GCLK0 runs at 4 MHz and GCLK2 runs at 1 MHz.
- The OSCULP32K is configured to provide a 32 kHz source clock to the GCLK1.
- The GCLK is used to route oscillators to the peripherals. The GCLK0 provides a 4 MHz source clock to the CPU, EVSYS, and active SERCOMs. The GCLK1 provides a 32 kHz clock to SERCOMs' slow clocks and GCLK2 clocks the ADC peripheral.

Note: For additional information on peripherals source clocks, select **Peripheral Clock Configuration** block, as highlighted in the figure above.

5.1.3 MCC Project Pin Configuration

The pin configuration is accessible in the MCC toolbar. The following pins are set for the LoRa IoT Node application:

Figure 5-7. Pin Settings

Pin Settin] Pin Settings																
Order: Pir	Order: Pins View Easy View																
Pin Number	Pin ID	Custom Name	Function		Mode	Direction		Latch	Pu	ill Up) Pu	l Do	own	Drive Streng	jth	Security Mo	ode
7	PA02	ADC_AIN0	ADC_AIN0	\sim	Analog	High Impedance \smallsetminus		n/a						NORMAL	\sim	NON-SECURE	\sim
9	PB04	RN2483_RST	GPIO	\sim	Digital	Out 🗸	·	Low						NORMAL	\sim	SECURE	\sim
59	PC19	LED0	GPIO	\sim	Digital	Out 🗸	·	Low						NORMAL	\sim	NON-SECURE	~~
60	PC20	SW0_button	GPIO	\sim	Digital	In 🗸	r	High		\checkmark				NORMAL	\sim	SECURE	\sim
68	PB20	SERCOM3_PAD0	SERCOM3_PAD0	\sim	Digital	High Impedance \smallsetminus	·	n/a						NORMAL	\sim	SECURE	\sim
69	PB21	SERCOM3_PAD1	SERCOM3_PAD1	\sim	Digital	High Impedance \smallsetminus		n/a						NORMAL	\sim	SECURE	\sim
72	PA22	SERCOM2_PAD0	SERCOM2_PAD0	\sim	Digital	High Impedance \smallsetminus		n/a						NORMAL	\sim	SECURE	\sim
73	PA23	SERCOM2_PAD1	SERCOM2_PAD1	\sim	Digital	High Impedance \smallsetminus	·	n/a						NORMAL	\sim	SECURE	\sim

- The PA02 and PC19 pins are set as Non-Secure pins, and they drive the ADC AIN0 Input and the LED0.
- The others are set as secure pins:
 - The PB04 pin is set as a GPIO Output Low to drive the RN2483 (or RN2903) reset pin.
 - The PC20 pin drives the on-board switch button SW0.
 - The PB20 and PB21 pins drive the Rx and Tx SERCOM3 pins to display information (and receive characters) to/from a terminal.
 - The PB22 and PB23 pins drive the SERCOM2 Rx and Tx pins to establish the communication channel between the RN2483 (or RN2903) board and the PIC32CM LS00/LS60 microcontroller.

5.2 Generated Projects Source Code

The Secure and Non-Secure project source codes are generated by the MCC using the previous configuration:

Figure 5-8. Secure Project Architecture

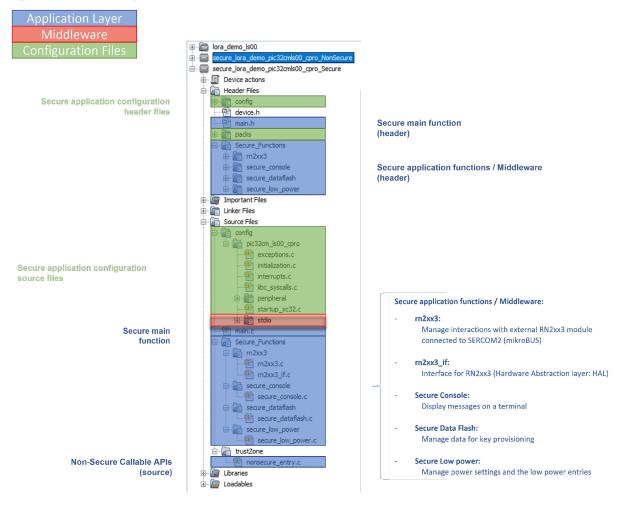
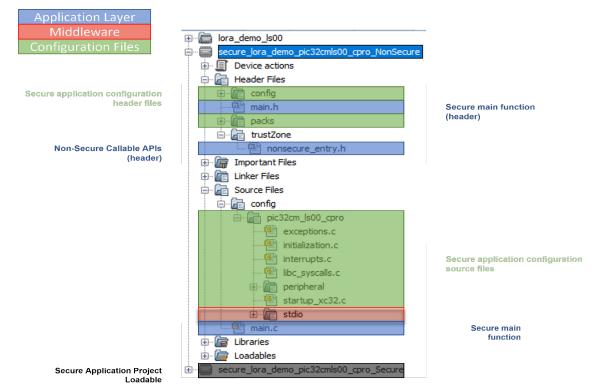


Figure 5-9. Non-Secure Project Architecture



5.2.1 Creating the Application

To create an application, follow these steps:

- 1. Before configuring the gateway, users must create the application and register the devices.
- 2. Create a user account on the TTN. The TTN can be downloaded from the following location: www.thethingsnetwork.org/. The TTN main window is shown below:

Figure 5-10. The Things Network Main Page

	CREATE AN ACCOUNT
Crea	ate an account for The Things Network and start exploring the world of Internet of Things with us.
	USERNAME
	This will be your username – pick a good one because you will not be able to change it.
R (
	EMAIL ADDRESS
	You will occasionally receive account related emails. This email address is not public.
<u>S</u> (
	PASSWORD
	Use at least 6 characters.
-	
A (

- 3. Enter the Username, Email Address, Password, and then Click Create account.
- 4. After creating the TTN account, follow the steps to create an application.
- 5. The TTN window will display the newly created account.



Figure 5-11. TTN Showing a Newly Created Account

- 6. Click Console.
- Select the application cluster (Europe1 cluster is used for this example).
 Figure 5-12. TTN Cluster Selection



8. The TTN user console will be displayed as shown below. Click Go to applications.

Figure 5-13. TTN Console Window

THE THINGS NET WORK	THE THINGS STACK Community Edition	Dverview Application	s 🛋 Gateways	Organizations	EU1 Community No SLA applicable	
		Welcom	e back,			
				ations and/or gateways. <u>ientation</u> ^{II} or <u>Get Support</u>	۵.	
		000		Ĩ	°	
		~~ • =				
	Go to a	pplications		Go	to gateways	

Click add application. The Add Applications window will be displayed.
 Figure 5-14. Add Applications Area

Applications (1)		Q Search by ID	+ Add application
ID \$	Name 🗢		Description
mchp-lora-demo-app			

10. Enter user-specific information for Application ID, Application name, and Description.

Figure	5-15.	Add	Applications	Window
iguic	0-10.	Aud	Applications	

Add application	
Owner*	
· ~	
Application ID *	
my-new-application	
Application name	
My new application	
Description	
Description for my new application	
ھ Optional application description; can also be used to save notes about th	e application
Create application	

11. Click **Create application** to add the TTN application.

6. Appendix

6.1 The Things Network Setup

The Things Network is a service for IoT networking, that is, building a large network with gateways for LoRa communication, based on the LoRaWAN protocol, to increase the number of existing LoRa applications and users. This protocol allows multiple features that are perfect for IoT, such as low-battery usage, long range, low bandwidth, and low-noise attenuation.

6.1.1 Device Registration

After the application is created, the device can be registered in the new application using these steps:

1. From the TTN console, click **Go to applications**.

Figure 6-1. TTN Console: Go To Applications

THE THINGS NET WORK	THE THINOS STACK Community Edition	Overview Applications	🚽 Gateways	Srganizations	EU1 Community No SLA applicable	•
			o your applica	ations and/or gateways. <u>entation</u> © or <u>Get Support</u>	ø.	
					0	
	Go to app	lications		Go	o to gateways	

2. Click on the application to have an overview, and then click **Add end device**.

Figure 6-2. TTN Application: Add End Device

mchp-lora-demo-app ID: mchp-lora-demo-app								
Last seen info unavailable	🙏 0 End devices 🛛 🚉 1 Collaborator 🛛 😽 0 API key	/S				Created 32 minutes ago		
General information			• Live data			See all activity \rightarrow		
Application ID	mchp-lora-demo-app		15:05:35	mchp-lora Creat	e application			
Created at	Jun 24, 2021 15:05:35							
Last updated at	Jun 24, 2021 15:05:35							
End devices (0)				Q Search by ID	≡ + Import end devices	+ Add end device		

3. In the Register end device dialogue, click the **Manually** tab, and select the Over The Air Activation (OTAA) and the firmware version of the connected RN2483/RN2903 LoRaWAN device (MAC v1.0.3 for this example), and then click **Start**.

Figure 6-3. Register end Device: Preparation

	Manually	
Preparation		
Activation mode ⑦ *		
Over the air activation (OTAA)		
Activation by personalization (ABP)		
Multicast		
O not configure activation		
LoRaWAN version ⑦*		
MAC V1.0.3		\sim
MAC V1.0.3 Network Server address		\sim
		~
Network Server address		
Network Server address eu1.cloud.thethings.network		
Network Server address eu1.cloud.thethings.network Application Server address		
Network Server address eu1.cloud.thethings.network Application Server address eu1.cloud.thethings.network		
Network Server address eu1.cloud.thethings.network Application Server address eu1.cloud.thethings.network External Join Server [®]		

4. Enter information for the End Device ID, AppEUI, and DevEUI, and then click **Network layer settings**.

Fiaure 6-4.	Reaister	End Device:	Basic	Settinas

Register end device		
From The LoRaWAN Device Repository	Manually	
1 Basic settings End device ID's, Name and Description	2 Network layer settings Frequency plan, regional parameters, end device class and session keys.	 Join settings Root keys, NetID and kek labels.
End device ID ⑦ *		
my-new-device		
AppEUI 🗇 *		
DevEUI ⑦*		
End device name ⊘		
My new end device		
End device description ⑦		
Description for my new end device		
Optional end device description; can also	be used to save notes about the end device	
		Network layer settings >

Note: The DevEUI and AppEUI must be defined by the user. Fill the blank boxes below the AppEUI and DevEUI with key values.

5. Set the application's Frequency plan, and then click **Join settings**.

Basic settings End device ID's, Name and Description	2 Network layer settings Frequency plan, regional parameters, end device class and session keys.	3 Join settings Root keys, NetID and kek labels.
Frequency plan ⑦ *		
Europe 863-870 MHz (SF12 for RX2)		
LoRaWAN version ⑦*		
MAC V1.0.3		
Regional Parameters version ⑦ *		
PHY V1.0.3 REV A	\sim	
LoRaWAN class capabilities ⑦		
Supports class B		
Supports class C		
Advanced settings 🗸		
< Basic settings		Join settings >

Figure 6-5. Register End Device: Network Layer Settings

Note: The advanced settings drop-down menu can be used for the network layer configuration.

6. Enter information for the AppKey, and then click **Add end device**.

From The LoRaWAN Device Repository	Manually	
Basic settings End device ID's, Name and Description	- Network layer settings Frequency plan, regional parameters, end device class and session keys.	Join settings Root keys, NetID and kek Iabels.
oot keys ppKey⊘*		
	····· ¢	
dvanced settings 🗸		
< Network layer settings		Add end device
		0

Figure 6-6. Register End Device: Join Settings

Note: The AppKey can be generated either by TTN or set by the user. Click on the **L** icon to switch between choices.

6.1.2 Cayenne Integration

The user must create a link between the TTN application and the Cayenne dashboard. After creating the link, the device must be registered with Cayenne. Follow these steps to register the device with Cayenne.

- 1. From the TTN console, click Go to applications.
- 2. Select the application end device to have an overview, and then click Payload Formatters.

Figure 6-7. Payload Formatters

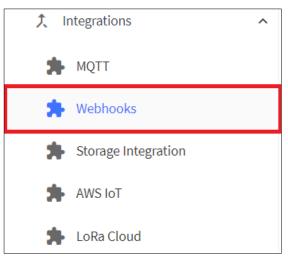
	chp-lora- mchp-lora-iot-	iot-node				
• Last seen inf	o unavailable	个 n/a √	∕n/a			
Overview	Live data	Messaging	Location	Payload formatters	Claiming	General settings

3. In the Payload Formatters Setup dialogue box, from the **Formatter type** drop-down menu, select **Cayenne** LPP.

Figure 6-8. Payload Formatters: Setup

Setup	
Formatter type *	
Use application payload formatter	\sim
This option will affect both uplink and downlink formatter Javascript	
GRPC service	
CayenneLPP	
Repository	

4. Under Integrations drop-down menu, select Webhooks. Figure 6-9. Integrations: Webhooks



5. In the Webhooks, click Add webhook. Figure 6-10. Integrations: Add Webhook

Webhooks (0)		+ Ad	d webhook
ID	Base URL	Template ID	Format
	No items found		

6. In the Add custom webhook dialogue, select a Webhook ID for the Cayenne integration, and then click **Create Cayenne Webhook**.

Figure 6-11. Integrations: Create Cayenne Webhook

Add custom webhook	
Template information	
Cayenne	
Drag-and-Drop IoT Project Builder	
About Cayenne 🖾 Documentation 🖾	
Template settings	
Webhook ID*	
Webhook ID* my-new-cayenne-webhook	
my-new-cayenne-webhook	

6.2 Cayenne

Cayenne is a front end web site that simplify the action of creating and developing of LoRa-enabled IoT solutions. It allows features such as, Data visualization, SMS, email alerts, triggers, and remote monitoring. Cayenne is available on multiple platforms, such as IOS, Android^{\mathbb{M}}, and Windows[®].

Cayenne is available for download form the following location: https://mydevices.com/. The Cayenne main page is shown below:

Figure 6-12. Cayenne Main Page

Start Bui	lding Today	
First Name	Last Name	
Email Address	Password	0
Email Address	Password	0
I agree to the myDevices Cayenne terms.		

The user must create a free account on Cayenne. After creating the account, users must follow these steps to setup Cayenne for the demonstration.

6.2.1 Registering Device

To register the devices on Cayenne, follow these steps:

1. Log on using the newly created Cayenne account, and then click LoRa.

Figure 6-13. Cayenne Main Page



2. Scroll down to the LoRa section, and then click **The Things Network**.

Figure 6-14. LoRa Section

Network	
Search	٩
Acklio	
Actility	
Everynet	
Kerlink	
Loriot	
Objenious	
OrbiWise	
Pixel Networks	
Sagemcom	
Semtech	
Senet	
SenRa	
Spark	
Stream	
Swisscom	
The Things Network	

- 3. Scroll down and click Cayenne LPP.
- 4. Enter *DevEUI* of the device registered in the TTN application, change the device name if required, and then click **Add device**.

Figure 6-15. Cayenne Settings

Enter Settings	5
LPP	Cayenne Cayenne LPP Cayenne Low Power Payload
This device uses Ca	
Name_examp	
DevEUI	
Activation Mode Already Regist	vered 💌
Tracking	
Location This device mo	oves 🗸
	Add device

5. The device is registered in Cayenne.

6.2.2 Configure Triggers

The Trigger feature enables automation of the LoRa application using 'If or Then' statements, which are based on real-time data and actions. Follow these steps to build the automation of the LoRa:

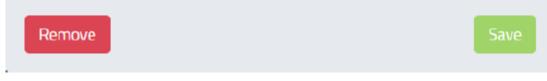
1. To configure the widgets that are displayed on the Cayenne dashboard, click (wheel icon) on the widget. block.

Figure 6-16. Widget Block		
🕂 Overview 😂 Data		
Digital Input (2)	SNR 🌣	RSSI
₩-))	.00.ehr	ull -25.00
	Decibels	dBm

Note: The widget appears only after the first connection of the node on the network.

- 2. Configure Digital Input (2) with different parameters as shown in the following figure.
 - Figure 6-17. Widget Configuration Window

	Luminosity Status	
	General	
Widget Name Luminosity Status		
Channel 2		
Choose Widget		
0/1 2 state		•
Choose Display		
lcon		•
Choose Icon		_
Cuminosity		
Choose Unit		_
Digital (0/1)		•



- 3. Click Save.
- 4. After widgets are configured, under Add new, click **Trigger**. **Figure 6-18. Add New Trigger section**

idd new	*	Dota	
Event		Luminosity Status	SNR
Trigger			
Project			7.00 الله
All root	_		Decibels
al SNR			000000
🧧 RN2483 - 2 - LoRa clic	\sim		
💈 RN2903 - LoRa click v	~		

5. Drag and drop the device into the *if* box, and then click **setup notification** in the *then* box.

Figure 6-19. IF and Then Section

My Triggers					New Trigger
Name your trigger					
if	Drag your device he 🧕 हार2483-LaRa cick v	×	then	Drag your device here or setup notification or setup webhook	×

When *if* and *then* boxes are filled, reproduce the following triggers.
 Figure 6-20. Reproducing the Triggers

mchp_lora_demo_trigger_on_off	
if Dhend Iora demo	* then notify
Luminosity Status ~	Add custom recipient
🖾 On (1)	email.example@gmail.com
□ Off (0)	+33 1 23 45 67 89
	Add more recipients?
	 Select All Send Text Message (requires mobile phone number) Send Email

mchp_lora_demo_trigger_off_on	
x Mchp_lora_demo	* then notify
Luminosity Status 🗸	Add custom recipient
- On (1)	email.example@gmail.com
Off (0)	+33 1 23 45 67 89
	Add more recipients?
	Select All Send Text Message (requires mobile phone number) Send Email

Note: Notifications through text message or emails can be chosen by selecting *Select All, Send Text Message* or *Send Email* options, or under 'Add Custom Recipient' enter mobile number and email address.

- 7. Click **Save** to save the triggers.
- 8. The triggers are now configured in Cayenne. The board can be reset to have the demonstration running.

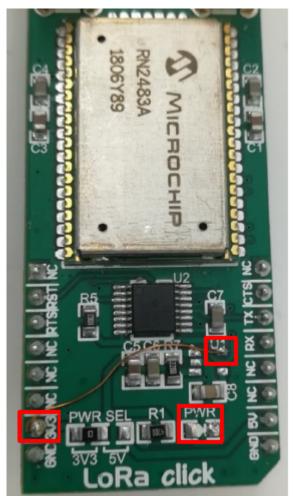
6.3 Hardware Modifications

To reduce the consumption of the global demonstration, some modifications are applied to the MikroElektronika LoRa click board and the I/O1 Xplained Pro extension board.

6.3.1 MikroElektronika LoRa Click Board

The embedded voltage regulator and power LED populated on the Mikroelektronika LoRa click board are not used by our application, and it can be removed to reduce the overall application power consumption. This embedded voltage regulator can be removed and bypassed using a wire connected from the MikroBus 3.3V pin to the regulator output soldering pad. All modifications made on the RN2483 or RN2903 module are shown in the image below. The embedded regulator output voltage pin is connected to the 3.3 voltage pin.

Figure 6-21. RN2483A Showing Modifications

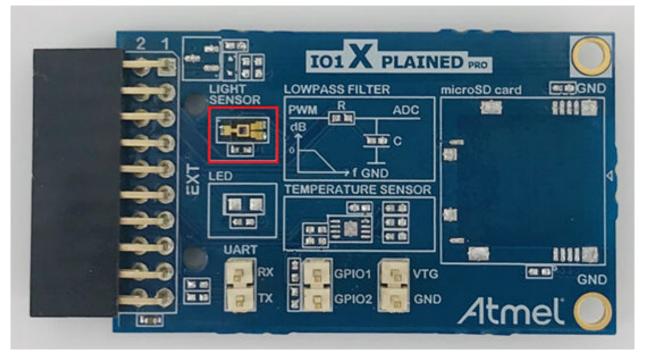


6.3.2 I/O1 Xplained Pro Extension Board

The power consumption of the overall application can be reduced by isolating the light sensor on the I/O1 Xplained Pro board, that is removing all components on the board except light sensor and the associated resistor.

The following figure illustrates the I/O1 Xplained Pro board.

Figure 6-22. I/O1 Xplained Pro Board



7. Revision History

Revision C - 04/2022

Removed all "Confidential NDA" verbiage from the document for this release.

Revision B - 01/2022

The following updates were made throughout this document.

- References to the MHC were updated to MCC
- Updated figure 5-2 with a new image and reworded the title

Revision A - 08/2021

This is the initial release of this document.

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