

User Guide

Sterling-LWB STM Expansion Board

Version 2.0

Revision History

Version	Date	ECN	Notes	Contributors	Approver
1.0	11/17/2016	185-2016			
1.1	1/16/2017	5-2017			
1.2	2/9/2017	21-2017			
2.0	15 Apr 2025		Ezurio rebranding	Sue White	Dave Drogowski

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1 Introduction

1.1 Purpose & Scope

This document describes the Sterling-LWB STM Expansion Board and how to use it for development of embedded Wi-Fi and/or Bluetooth Low Energy applications. An overview of the hardware is provided, along with a description of setting up the software development environment, programming the board and some sample projects to get you started.

1.2 Applicable Documents

- Sterling-LWB Datasheet (330-0190)

1.3 Related Ezurio Products

Table 1: Part numbers for related Ezurio products

Ezurio Part Number	Description
450-0152	RF Module, Sterling-LWB, Chip Antenna
450-0159	SIP, Sterling-LWB
450-0148	RF Module, Sterling-LWB, U.FL
450-0173	Dev Board, Sterling-LWB, WICED

2 Sterling-LWB STM Expansion Board Description

The Sterling-LWB STM Expansion Board is designed for use with the ST Micro Discovery Board series. Specifically, the expansion board CON1 and CON2 are intended to be used with the 32F411EDISCOVERY board and can be mated directly to its P1 and P2 headers.

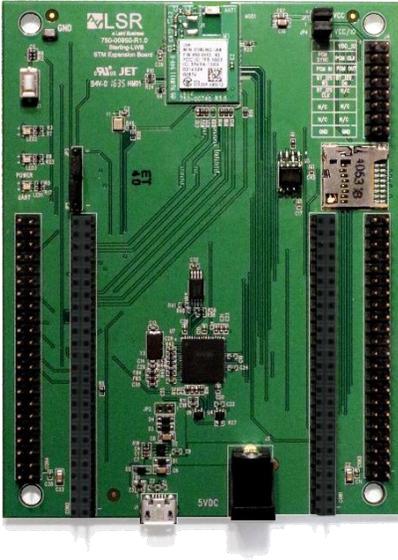


Figure 1: Sterling-LWB STM Expansion Board

2.1 Sterling-LWB STM Expansion Board Hardware

The hardware components on the Sterling-LWB STM Expansion Board are shown in the block diagram below. The expansion board routes pins from the STM32F4xx MCU to interface with the Sterling-LWB module. In addition, the Expansion Board includes SPI Flash and a USB/JTAG debugger.

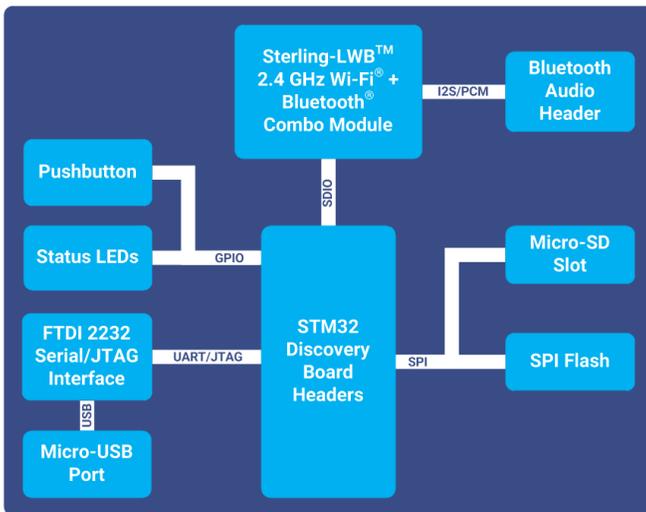


Figure 2: Sterling-LWB STM Expansion Board Block Diagram

2.2 Sterling-LWB Wi-Fi + Bluetooth Combo Module

The Sterling-LWB module provides 802.11b/g/n and Bluetooth 4.1 functionality when used with an STM32F4xx microcontroller compatible with the Cypress WICED SDK. The interfaces to the module are SDIO for Wi-Fi and UART for Bluetooth. The module antenna is either a chip antenna (on the module), or an external antenna connected to the U.FL connector (J1).

2.3 USB JTAG and Serial Interface

The board provides a single micro-USB interface for JTAG programming and access to the UART1 serial interface of the STM32F411 MCU. The JTAG interface is provided via a standard FTDI FT232H IC with its VID and PID updated to be a WICED debugger (VID: 0x0a5c PID: 0x43fa).

IMPORTANT:

The USB SWD debug interface on the Discovery board is not used. The WICED SDK assumes a JTAG debugger, which is provided on the Expansion Board.

To use the debug UART (UART 1), a conflicting capacitor must be removed on the Discovery board. The capacitor is C54 and it is connected to PA9 on the Discovery Board processor. Please refer to the schematic for the STM32F411E-DISCOVERY from STMicroelectronics.



Figure 3: Remove C54 From Discovery Board

2.4 SPI Flash

A 16Mbit SPI flash is used for the WICED SDK WLAN firmware. The WLAN firmware is approximately 356 kB. The remaining SPI flash space can be used by applications via the standard serial flash interface library within the WICED SDK.

2.5 User I/O

The board provides a pushbutton switch (S1) and several bi-color LEDs (LED1, LED2, LED3). The pushbutton switch S1 is attached to port PA1. LED1.green is power indication. LED1.red displays activity on UART1 activity. The LED2 red and green are connected to PD8 and PD9 respectively. LED3 red and green are connected to PD10 and PD11.

2.6 Micro-SD Slot

The board provides a Micro-SD slot attached to the SPI1 interface on the STM32F411 MCU. The interface mode is SPI and the chip select is connected to PA3 on the Discovery Board.

2.7 Bluetooth Audio Header

The Bluetooth Audio Header (J4) provides access to the I2S and PCM signals from the Sterling-LWB module.

3 Software Development with the Sterling-LWB STM Expansion Board

3.1 Required Equipment

To be used directly with the WICED SDK, the Sterling-LWB expansion board requires an STM32F411 Discovery Board. The board is plugged on to the CON1 and CON2 headers, and provides the Host MCU, user I/O and sensors.

The Sterling-LWB expansion board requires a 1A +5VDC power supply to operate. The barrel connector (J3) is configured for 5VDC center positive. J3 powers both the Sterling-LWB expansion board and the attached Discovery Board. For access to the JTAG and USB-to-serial adapter on the Sterling-LWB expansion board, attach a Windows PC via micro-USB cable to the micro-USB port on the Sterling-LWB expansion board (J1).



Figure 4: Discovery Board Connected to Expansion Board

3.2 Required Software

3.2.1 Cypress WICED Studio and WICED SDK

The Sterling-LWB depends on use of the Cypress WICED SDK for software development. Cypress provides an integrated development environment (IDE) based on Eclipse and the GCC toolchain for ARM. Included in the SDK are a network driver, RTOS, networking utilities, radio firmware and sample projects demonstrating use of Cypress radios. The Sterling-LWB is based on the Cypress BCM4343W radio and can be used with the WICED SDK by targeting the [LSRSTERLING_00950 target platform files](http://www.st.com/stm32f4-discovery).

What is included in the WICED SDK?

- Development environment based on eclipse IDE and the GCC toolchain for ARM
- Tools for programming and debugging embedded code on host MCU targets with several JTAG adapter options
- Makefiles designed to easily build projects based on a "build string" specified in the IDE
- RTOS abstraction layer allowing software developers to choose between ThreadX and FreeRTOS operating systems. The abstraction layer helps move applications between different RTOS configurations with minimal changes to application-level code.
- TCP/IP stack abstraction layer allowing software developers to choose between NetX and LwIP networking stacks for their application. This abstraction layer allows applications to target either stack with minimal changes to application-level code.

- Demos and code snippets showing how to perform common operations for Wi-Fi and Bluetooth applications
- WLAN and Bluetooth firmware and driver files required by Cypress radios

Who would use it?

- The SDK is intended for use by developers experienced in embedded C programming on microcontrollers. Familiarity with software engineering concepts such as make files, RTOS concepts, console debugging and basic hardware configuration/debugging skills is very helpful.
- Developers should also be familiar with basic Wi-Fi concepts and TCP/IP networking, including Wi-Fi security modes, station vs. access point operation, BSD sockets and networking utilities (DHCP, DNS, ping, telnet, etc.).
- When using the Bluetooth Low Energy features of the WICED SDK, developers should be familiar with Bluetooth concepts including central vs. peripheral roles, components of Bluetooth Low Energy profiles and services, BLE advertising and tradeoffs associated with BLE radio configuration parameters.

How do you use it?

- The WICED SDK provides tools for developers to create their own RTOS-based embedded software applications that utilize Wi-Fi and/or Bluetooth capabilities by including the appropriate libraries.
- We recommend developers start by building and testing the example “demo” and “snip” projects included with the WICED SDK. This provides a basic understanding of the IDE, build strings, JTAG programming and serial console debugging.

3.2.2 Downloading the Cypress WICED SDK

The WICED SDK can be downloaded from Cypress at its developer community page after signing up for a free developer account.

NOTE: Ezurio does not develop the WICED SDK or WICED Studio and does not provide technical support for them. For assistance with the WICED SDK and WICED Studio, please refer to the Cypress community page.

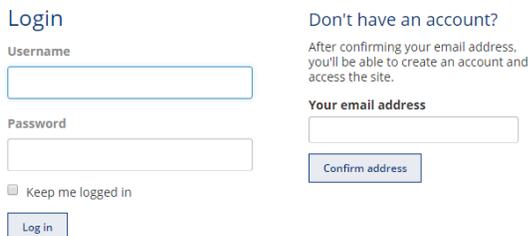
1. Visit <https://community.cypress.com/welcome> and click the “WICED Wi-Fi” button



2. Click the “Download SDK, Review Docs” button



3. Create or sign in with an existing Cypress Developer Community account



4. Scroll down to the section labeled “WI-FI SDKS” and choose a development environment

WICED Studio 4:

- WICED Studio 4.0 IDE Installer (Windows)
- WICED Studio 4 (OSX)
- WICED Studio 4 (Linux 64-bit)
- WICED Studio 4 (Linux 32-bit)

5. Scroll down and click the **Download** link to download the archive containing the IDE installer

3.2.3 Installing the Cypress WICED Studio and WICED SDK

To install WICED Studio and WICED SDK, extract and run the WICED-Studio-x.x.x.x-IDE-Installer.exe file from the downloaded archive. Choose a location to install WICED Studio and follow the remaining instructions in the installer to select a location for the WICED SDK files.

3.2.4 Adding the Sterling-LWB Platform to your WICED Installation

The WICED SDK ships with many platforms already configured in the “43xxx_Wi-Fi/platforms” folder. Each subfolder provides the configuration and interface code for a particular target platform (Wi-Fi Module + Processor + Development board).

For the Sterling-LWB STM Expansion Board, you will need to download the [Sterling-LWB Config Files WICED Board](#) file from the Sterling-LWB website. Expand the archive and copy the “LSRSTERLING_00950” into the “43xxx_Wi-Fi/platforms” folder within your WICED SDK installation before attempting to build and download code. See the [Software Downloads for Sterling-LWB WICED](#) section on the Ezurio website for the latest platform configuration files.

3.2.5 Using the Cypress WICED Studio

Start by launching the WICED Studio from its installed location from the previous step.



Figure 5: WICED Studio loading splash dialog

On the first run, you will see a README.txt file presented with some general information about the installed SDK release. Please read this file for details on what the installed release of the WICED Studio provides.

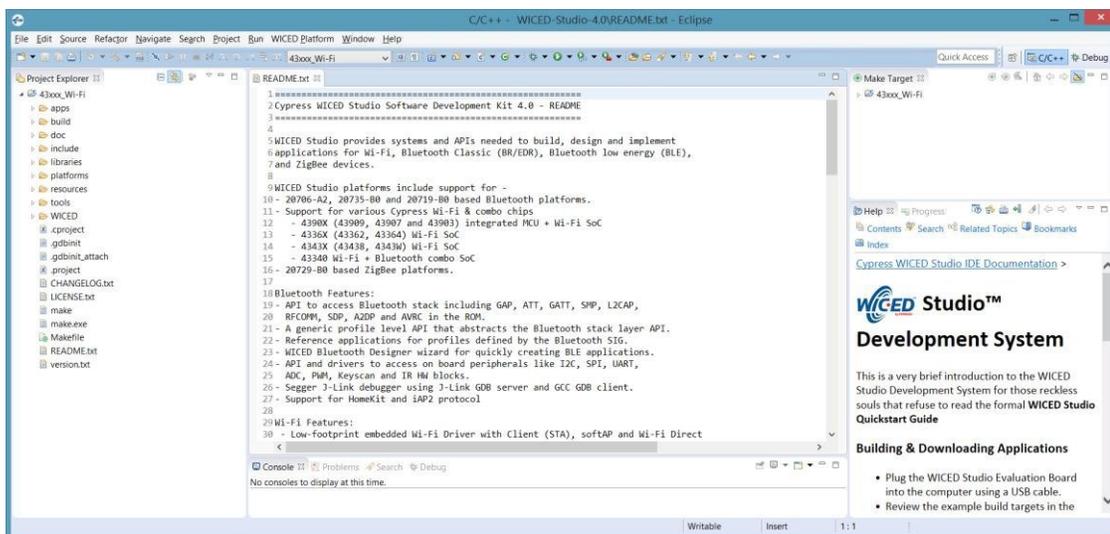


Figure 6: WICED Studio main window

A basic workflow for developing a Wi-Fi or Bluetooth application for use with the Sterling-LWB STM Expansion Board is provided in the next section of this guide; for more details please refer to the documents included as part of the WICED SDK installation.

3.2.6 Understanding the WICED SDK Folder Structure

The "Project Explorer" on the left-hand side of WICED Studio provides a hierarchical folder view rooted at "43xxx_Wi-Fi" within the SDK installation. All SDK files branch from the 43xxx_Wi-Fi subfolder.

Folder Name	Description
apps	contains source code for embedded applications that can be built by WICED Studio
doc	contains documentation included as part of WICED Studio and WICED SDK
include	WICED framework include path for targets being built within WICED Studio
libraries	contains various peripheral and protocol libraries that can be used by embedded applications built within WICED Studio
platforms	contains folders for each supported target platform supported by the WICED SDK. These folders are targeted by the build string specified in the "Make Target" view.
Resources	contains files stored within the flash filesystem for embedded applications, certificates, firmware and other resource files
Tools	contains programming and debugging tools such as OpenOCD and other scripts used by WICED Studio during the build process
WICED	contains the source files for the WICED framework, RTOS, networking and drivers

3.3 WICED Software Examples

3.3.1 Finding demo and code snippets

The **43xxx_Wi-Fi/apps** folder is the place to go for example code to run with your Sterling-LWB STM Expansion Board. Note that not all demo and snip projects distributed with the WICED SDK are designed for use with all radio modules.

This guide will highlight several that are known to work properly with basic Wi-Fi and Bluetooth functionality on the Sterling-LWB (BCM4343W). Some projects, may not be supported on the BCM4343W or may require code modifications to either the demo/snip code or the WICED SDK to function properly.

IMPORTANT: For snip or demo projects whose .mk file specifies a "VALID_PLATFORMS" entry, you must add the following line to the .mk file to allow building the project for the Sterling-LWB platform:

```
VALID_PLATFORMS += LSRSTERLING_00950
```

3.3.2 Snippets for learning the WICED framework

The table below shows several snippets that are useful for learning WICED framework concepts and APIs.

Subfolder of 43xxx_Wi-Fi/apps/snip	Description
stdio	Demonstrates how to use printf() and scanf() c library functions to interact with the debug UART
gpio	Demonstrates use of the WICED APIs for manipulating general purpose I/O (GPIO)
spi_slave	Demonstrates use of SPI for master and slave device configurations via the WICED SDK API
uart	Demonstrates use of UARTs via the WICED SDK API
dct_read_write	Demonstrates use of the Device Configuration Table (DCT) used throughout the WICED SDK

3.3.3 Snippets for Wi-Fi

The table below shows several snippets that are useful for learning how to operate the Sterling-LWB Wi- Fi radio for basic networking functionality.

Subfolder of 43xxx_Wi-Fi/apps/snip	Description
ping_powersave	Demonstrates Wi-Fi client mode, ICMP ping, MCU powersave and Wi-Fi powersave. Takes Wi-Fi network configuration from "43xxx_Wi-Fi/include/default_wifi_config_dct.h".
scan	Demonstrates performing a Wi-Fi AP scan. Results of the scan are displayed on the debug UART
apsta	Demonstrates use of "Soft AP" mode and "client" mode simultaneously
tcp_client	Basic example of a TCP/IP client
tcp_server	Basic example of a TCP/IP server
udp_transmit	Basic example of transmitting UDP packets
udp_receive	Basic example of receiving UDP packets

3.3.4 Snippets for Bluetooth

The table below shows several snippets that are useful for learning how to operate the Sterling-LWB Bluetooth Low Energy radio in both peripheral and central modes.

Subfolder of 43xxx_Wi-Fi/apps/snip	Description
bluetooth/ble_hello_sensor	Demonstrates a simple BLE peripheral that advertises a simple "hello" service for learning the WICED SDK BLE apis. For more information on the BLE APIs, see 43xxx_Wi-Fi/doc/API.html
bluetooth/bt_dualmode_server	Demonstrates simultaneous BLE GATT and Bluetooth Classic RFCOMM servers
< BLE Central Role >	<i>At the time of publishing this document, there is not a snippet that demonstrates BLE central role even though the SDK supports it. To find API features related to BLE central role, refer to the "43xxx_Wi-Fi/doc/API.html" documentation under the "Components->Bluetooth->Device Management->BLE" section for details.</i>

3.4 Editing and Building Applications using WICED Studio

3.4.1 Application Makefiles and Source Files

Applications can be edited by adding/editing files from the "Project Explorer" view on the left side of WICED Studio. For example, to view the "snip.scan" source files, expand the "apps" folder, then "snip" and finally "scan" to see the scan.c and scan.mk files. All projects have an .mk file associated with them to specify the source files and other options to the WICED Studio builder. This file MUST be named with the same name as the folder containing it (e.g. the folder for the application is named 'scan', therefore the build environment looks for a file named 'scan.mk' within that when building the scan application).

The .mk file provides at least the NAME of the application and a list of source files required to build it i.e.

\$(NAME)_SOURCES. See the 'scan.mk' file for a simple example.

There are many other options that can be set in the project .mk file, but describing these is outside the scope of this document. To learn more about this, take a look at the comments in the top-level 43xxx_Wi-Fi/Makefile or check out the numerous project.mk files provided with the SDK in 43xxx_Wi-Fi/apps/snip/* and 43xxx_Wi-Fi/apps/demo/*.

3.4.2 Building an Application

To build an application, a make target must be created containing a build string that specifies the application name, target platform, operations and other flags if necessary. To create a new make target, right-click "43xxx_Wi-Fi" in the "Make Target" tab and select "New...".

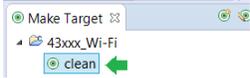


For "Target name:", enter the name of the application starting with the subfolder of "apps" and using dot (.) as the path separator (e.g. 'snip.scan'), followed by a dash (-), followed by target name (e.g.

LSRSTERLING_00950), followed optionally by the RTOS (e.g. ThreadX), networking stack (e.g. NetX) and interface (e.g. SDIO) all separated by dashes. This should be followed by a space, then one or more commands to execute such as 'download', 'download_apps' and/or 'run'. For a detailed listing of the possible options for build strings, see the USAGE_TEXT defined in '43xxx_Wi-Fi/Makefile' near the top of the file.

To build the snip.scan application:

1. Double-click the "clean" make target to clean any previously built target files.



2. Create a make target with the following build string:

snip.scan-LSRSTERLING_00950-ThreadX-NetX-SDIO

3. Double-click the make target created in step 2. The "Console" tab near the bottom of the WICED Studio window will display the status of the build. Once the build is complete, the output files will be located in the 43xxx_Wi-Fi/build folder.

3.5 Downloading an Application to your Sterling-LWB STM Expansion Board

3.5.1 Installing the WICED JTAG Adapter Driver

For your PC to recognize the Sterling-LWB STM Expansion Board as a WICED-compatible JTAG adapter, you must first install drivers included with the WICED SDK. To install these drivers, go to the “Device Manager” and locate “Other devices → USB <-> Serial Converter” and right-click it, then click “Update Driver Software”.



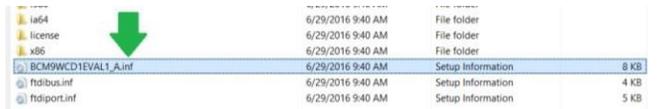
Next, click “Browse my computer for driver software”



In the next dialog, click “Let me pick from a list of device drivers on my computer”



Select “Show All Devices”, then click “Next”. Click the “Have Disk” button and use the “Browse...” button to navigate to the location where you installed the WICED SDK, then select the “43xxx_Wi- Fi/tools/drivers/BCM9WCD1EVAL1/BCM9WCD1EVAL1_A.inf” file and click “Open”. Click “OK” to select this as the driver for the USB <-> Serial Converter.



Select “WICED USB JTAG Port” and click “Next”



Finally, click “Close” to finish installing the WICED USB JTAG Port. If the installation succeeded, you should now see a WICED USB JTAG Port in the device manager.



3.5.2 Performing a “Build and Download” from WICED Studio

The programming process depends on the OpenOCD programming utility, bundled with the WICED SDK from Cypress. During development, the programming process can be started directly from within WICED Studio. This is done by double-clicking a make target with the “download” directive specified as part of the build string. For more information about build strings within the WICED environment, refer to the README.txt in the top level 43xxx_Wi-Fi folder of your WICED SDK installation.

For example, to build and download the **snip.scan** application to your Sterling-LWB STM Expansion Board, do the following:

1. Double-click the “clean” make target to clean any previously built target files.



2. Create a make target with the following build string:

```
snip.scan-LSRSTERLING_00950-ThreadX-NetX-SDIO download download_apps run
```

3. Double-click the make target created in step 2. The “Console” tab near the bottom of the WICED Studio window will display the status of the build and download. Once the build is complete, the output files will be located in the 43xxx_Wi-Fi/build folder.
4. If the USB cable is attached to the PC and the JTAG driver is installed as described in 3.5.1, WICED Studio will proceed with programming the STM32F411 MCU after the build.
5. In this example the ‘download_apps’ command was specified. This instructs the IDE to also download the WLAN firmware to the external SPI flash (once this is done for your board, “download_apps” may be omitted if you are just updating the application and not the WLAN firmware).

3.5.3 Downloading WLAN firmware as part of the “Build and Download” step

As stated in the previous section, if you have never programmed the external SPI flash with WLAN firmware (this will be the case for brand new Sterling-LWB STM Expansion Boards), you must do so at least once before attempting to build and run any applications on the STM32F411 that use the Sterling- LWB module.

To include programming of the WLAN firmware to the SPI flash in your build and download process, add “download_apps” after the “download” command in your build string. This will trigger additional steps during the programming process to utilize the sflash_write application to write the WLAN firmware to the external SPI flash.

4 Troubleshooting

4.1 Understanding the Role of OpenOCD

WICED Studio depends on several tools that are bundled as part of the ‘43xxx_Wi-Fi’ folder installed on your system. One of the important tools is OpenOCD which is used to communicate with target hardware for programming and debugging operations.

OpenOCD is located in the ‘43xxx_Wi-Fi/tools/OpenOCD’ folder and provides not only binaries for several platforms but also .cfg and .tcl files that control the programming process. These files are used to inform OpenOCD how to perform each step during the programming and debugging process and are very specifically provided for only certain target MCUs and JTAG adapters. If you are using a platform that is not listed in the .cfg files bundled with the OpenOCD utility inside the WICED SDK, you will need to provide .cfg files and .tcl scripts that work for your platform.

The Sterling-LWB utilizes the BCM9WCD1EVAL1.cfg file for the JTAG adapter definitions and stm32f4x.cfg for board configuration. These files are chosen for you automatically when your build string is set to use the LSRSTERLING_00950 platform; no modifications to these files are necessary.

If you prefer to program the MCU from the command line, you can take a look at the make targets defined in ‘43xxx_Wi-Fi/tools/Makefiles/standard_platform_targets.mk’ to get an idea of how the command line arguments are being sent to the OpenOCD executable. If you execute these command lines from the 43xxx_Wi-Fi folder, you can perform programming operations outside of WICED Studio which is useful for situations like manufacturing processes where you don’t want to install the entire WICED Studio package to perform a programming operation.

4.2 OpenOCD Log

During a build and download process initiated in WICED Studio by double-clicking a make target, several files are output into the ‘43xxx_Wi-Fi/build’ folder. One file that is particularly useful for debugging problems with JTAG programming is the ‘43xxx_Wi-Fi/build/openocd_log.txt’ file. This file provides a full dump of all steps that were attempted during the programming process and can be useful for tracking down issues. Check here first if you have trouble programming your board

5 Sterling-LWB Cloud Sensor Demo featuring TiWiConnect

To demonstrate the use case of a cloud-connected sensor, Ezurio has developed a sample project that can be used with the Sterling-LWB WICED Expansion board for reporting accelerometer, gyro and magnetometer sensor data from an attached **STM32F411 Discovery Board** to a web and mobile application.

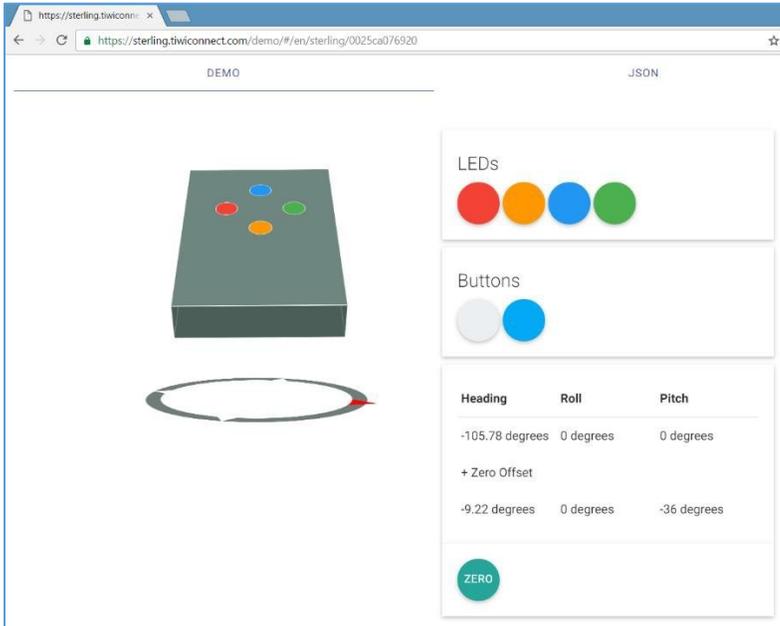


Figure 7 TiWiConnect web application showing sensor data reported from the Sterling-LWB

IMPORTANT: This demo application is designed for use with the STM32F411 Discovery Board and may not operate as expected with other discovery boards. The BLE and Wi-Fi capabilities may continue to operate normally but if the sensors are not found, the code will use a pseudo-random number generator to produce sensor values.

5.1 Downloading the Sensor Demo Source Code

This sample code for use with WICED Studio can be downloaded from the Sterling-LWB “Software Downloads” section of the Ezurio website. The project source code provides developers an overview of the steps involved when developing a typical BLE+Wi-Fi enabled sensor including:

- Defining and implementing custom BLE profiles for communicating with a mobile app
 - Simple Sensor Profile
 - Wi-Fi Configuration Profile
 - LIFT Configuration Profile (for provisioning cloud API access)
- Steps required to assign Wi-Fi credentials to the device over a BLE connection
- Steps required to assign cloud authentication credentials to the device over a BLE connection
- Basic driver for interfacing with sensors over I2C and SPI bus and LED control
- Steps required to post sensor data to a cloud API via HTTP (HTTPS option included)
- Steps required to receive remote cloud API commands to perform an action (e.g. toggle LEDs)
- Persistent storage of credentials to Device Configuration Table (DCT) in Flash

5.2 Building and Downloading the Sensor Demo

To start using the sample project, place the “sterling_demo” folder from the downloaded archive into the ‘43xxx_Wi-Fi/apps/demo’ subfolder of your WICED SDK installation. Make sure you have already installed the Sterling-LWB platform files as described in section 3.2.4.

If you have WICED Studio open, you may need to refresh the Project Explorer view by right-clicking the top-level folder and clicking “Refresh”. At this point, you will see a new project available under the 43xxx_Wi-Fi/apps/demo/sterling_demo folder. You can review the sterling_demo.c file for more details on what this project demonstrates. To build, download and run the project, create a new make target:

demo.sterling_demo-LSRSTERLING_00950-ThreadX-NetX-SDIO download download_apps run

This will trigger a series of steps that can be monitored in the WICED Studio console view. After building the source code, if your expansion board is attached via USB and drivers are installed the application will be programmed onto the STM32F411 Discovery Board and start running once the process has completed.

5.3 Monitoring the Debug Output of the Sensor Demo

Once the sensor demo is running on your discovery board, you can open a serial terminal on the USB Serial adapter associated with your expansion board (see Device Manager for a list of COM ports on Windows) to view debug output. The serial terminal settings should be set to 115200 baud, 8 data bits, no parity, 1 stop bit. The debug output gives developers a view into the steps the application is taking such as enabling Wi-Fi, enabling BLE, joining a Wi-Fi network, reading sensor data and reporting to the cloud.

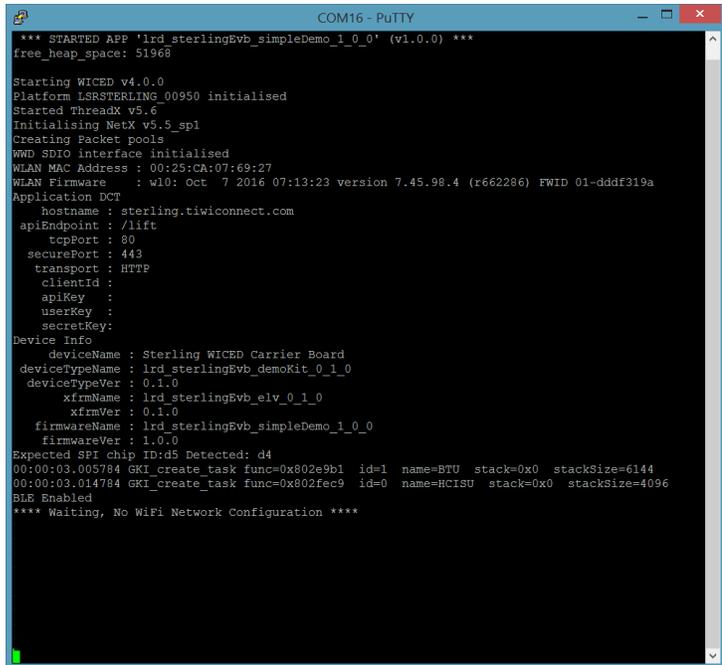


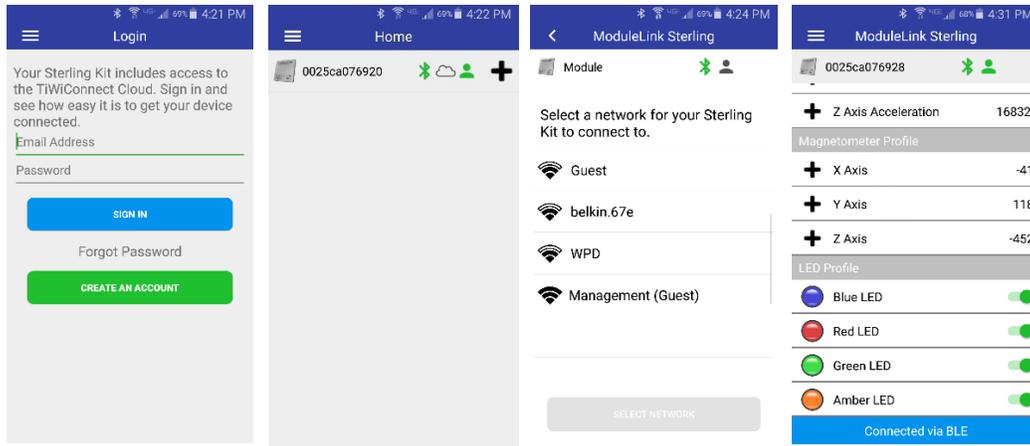
Figure 8 Debug output from sterling_demo application

5.4 ModuleLink Sterling Mobile App

In order to configure the Sterling-LWB for your local Wi-Fi network and get it connected to the cloud, Ezurio provides the [ModuleLink Sterling Mobile App, available for Android devices on the Google Play store](#). This application walks you through:

- Creating an account on the TiWiConnect cloud
- Scanning and connecting to your Sterling-LWB over BLE
- Scanning for, selecting and providing the passphrase for the Wi-Fi network to your Sterling-LWB
- Monitoring of sensors on the STM32F411 Discovery Board
- Control of the LEDs on the STM32F411 Discovery Board

Download and install the ModuleLink Sterling-LWB Mobile application on a compatible Android device to get started.



5.4.1 Creating a TiWiConnect Account

Within the application the first screen will ask you to sign up for a free account on Ezurio's TiWiConnect service. This account will be used to ensure only you have access to your device's sensor data and will provide access to future enhancements to Sterling-LWB for use with the TiWiConnect service. Note that even if you have used TiWiConnect services for other Ezurio parts (e.g. TiWi-C-W), you will still need to create a new account in order to use this app.

5.4.2 Device List View

Once you've created an account and/or have logged in, the app presents a list containing devices previously registered on your account and devices discovered nearby in a BLE scan. The icons indicate whether the device is seen over Bluetooth, whether the device reports as being "online" and whether the device is registered to your user account.

5.4.3 Configuring your Sterling-LWB for Wi-Fi

To configure your Sterling-LWB for Wi-Fi, locate your Sterling-LWB in the list of devices and click the plus '+' button on the right-hand side of the view. This will start the Wi-Fi commissioning process. The app requests nearby Wi-Fi networks from the Sterling-LWB and presents them in a list. Select the Wi-Fi network you'd like to use to connect your Sterling-LWB to the internet and press "Select Network".

Enter the passphrase, then press "Save" to commit the Wi-Fi credentials to the module. The app will then register the device with the TiWiConnect cloud service and the Sterling-LWB will attempt to connect and begin reporting sensor data on a periodic basis.

5.4.4 Interacting with your Sterling-LWB over BLE

In the device list, if your Sterling-LWB is within range for a BLE connection and you select it from the list, the app will attempt to communicate directly over BLE to report sensor data and provide control over the LEDs on the discovery board. When you select the device (touch the list item but not on the plus '+'), the app will display a list view showing sensor values updating periodically as they are reported by the discovery board. You can control the LEDs by touching the switches on the right hand side of the view to toggle them on/off. Note at the bottom of the screen, the app will indicate "Connected via BLE".

5.4.5 Interacting with your Sterling-LWB via the Cloud

If your Sterling-LWB is not within range to make a BLE connection and you have gone through the Wi-Fi configuration process in 5.4.3, you can still monitor and control the discovery board if it is online by communicating via the TiWiConnect cloud. To monitor/control via the cloud, use the same process as you would for BLE by selecting the device from the list (touch the list item but not on the plus '+' if it is visible). The app will make a connection to the TiWiConnect service and begin receiving updates from your kit over the internet just like it would via BLE. You also still have control over the LEDs in this mode, however the commands are being tunneled through the internet connection so there may be a slight delay. Note at the bottom of the screen, the app will indicate "Connected via Websockets". If for testing purposes you would like to force connection over Websockets rather than over BLE, check the box labeled "Disable BLE Connections" in the "Settings" menu and re-connect to the device from the device list view.

5.5 TiWiConnect Web Application

Once your Sterling-LWB is connected to the Wi-Fi network and reporting its data to the cloud, you can also interact with it from a web browser. As part of this demonstration, Ezurio has developed a simple web application providing a visual interface to viewing sensor data, monitoring button states and sending remote commands to turn the discovery board LEDs on/off.

NOTE: When changing LEDs on/off from the web application the state of the on/off switches in the mobile app will not update over BLE (this is a limitation of the LED Status BLE profile used for this demo).

5.5.1 Accessing TiWiConnect Web Application

We recommend using the Google Chrome browser to ensure the best experience. To bring up the TiWiConnect Web Application, visit the following URL:

<https://sterling.tiwiconnect.com/demo/#/en/sterling>

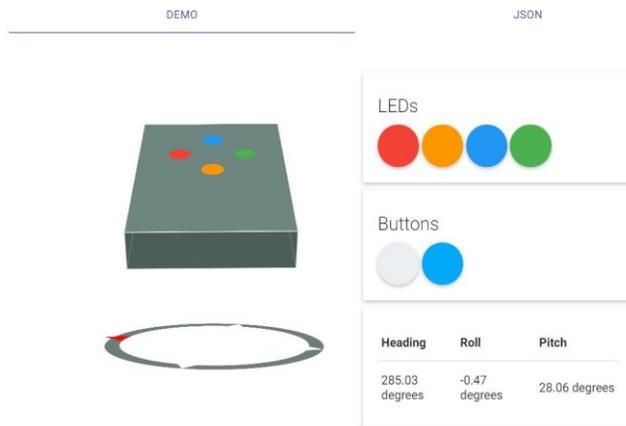
5.5.2 Using the TiWiConnect Web Application

To view the interface for your specific Sterling-LWB:

1. Enter the Bluetooth address of your Sterling-LWB module with no spaces or semicolons and in lowercase (e.g. 0025ca076920), then press the SELECT button.



2. If your Sterling-LWB is online and reporting (you can verify this by watching the serial debug output to see if there are sensor values being displayed periodically), you should see values updating in real-time for Heading, Pitch and Roll.



3. As you slightly rotate and adjust the orientation of your expansion board, you will see the box on the web application re-orient to reflect the new reported sensor settings. This demonstrates monitoring sensor data from the web application.
4. You can control the state of four LEDs on the discovery board (red, orange, blue, green) by clicking the circles under the heading LEDs on the web application. Allow a few seconds before clicking again to make sure the command has time to propagate through the cloud to your Sterling-LWB. The state of the LEDs is reflected on the web app by “dimming” the circle of that LED’s color. This demonstrates remote control of a device via the web application.
5. If you press and hold the Blue “User” button on the STM32F411 discovery board, you’ll notice the blue circle under the “Buttons” heading will shrink slightly. When you let go, it will grow to its original size. Pressing the white pushbutton labeled “S1” on the Sterling-LWB expansion board will do the same for the white circle under the “Buttons” heading. This demonstrates monitoring a simple on/off condition from a GPIO on the STM32F411 from the web application.



- To view the JSON data being reported from the Sterling-LWB, click the tab labeled "JSON" in the upper right portion of the web application. To go back to the default view, click back to the tab labeled "DEMO".

```

DEMO | JSON
-----
0025ca076920
{
  "_id": "",
  "clientId": "0025ca076920",
  "clientId_case": "0025ca076920",
  "createdAt": "2016-11-22T14:35:03.779Z",
  "shadow": {
    "devTypeIds": [
      "Ird_sterlingEzb_demoKit_0_1_0"
    ],
    "profiles": {
      "simpleSensor": {
        "button": {
          "is": false,
          "userbutton": false
        },
        "led": {
          "orange": true,
          "blue": true,
          "green": true,
          "red": true
        },
        "gyro": {
          "z": -24,
          "y": 66,
          "x": 46
        },
        "mag": {
          "z": -446,
          "y": 132,
          "x": -51
        },
        "accel": {
          "z": 16788,
          "y": 320,
          "x": -256
        }
      },
      "_meta": {}
    }
  }
}

```

-

6 Appendix A Using WICED/Sterling-LWB with STM32F4xx Processors

The Sterling-LWB Cloud Sensor Demo was developed assuming the host processor is a STM32F411VET6U with 512 kB Flash and 128 kB RAM. The processor/hardware/interfaces are defined in what WICED calls a platform. The target platform to use is specified in the WICED build string. For example, the build string for the Sterling Demo is:

```
demo.sterling_demo-LSRSTERLING_00950-ThreadX-NetX-SDIO download download_apps run
```

The platform is LSRSTERLING_00950. This platform is provided in the Sterling Demo application and the folder containing the platform must be copied to the WICED\WICED-Studio-4.0\43xxx_Wi-Fi\platforms directory for it to be found by the build system.

6.1 STM32F411/LSRSTERLING_00950

The LSRSTERLING_00950 platform is derived from the WICED BCM94343WWCD1 platform. The BCM94343WWCD1 platform is used with the Cypress / WICED reference hardware which is also based on the STM32F411. Comparing the files in the BCM94343WWCD1 and LSRSTERLING_00950 platform directories can provide a useful example of the changes that are typically required when the target has a different processor and/or support hardware.

The .mk (makefile) is named to match the platform, the other files normally have the same names across different platforms.

6.1.1 LSRSTERLING_00950.mk

This file defines the top level definitions that affect the processor and file system. Note that the value of HSE_VALUE=8000000 to match the 8.00 MHz crystal on the STM32F411 discovery board.

6.1.2 platform.h

This file defines the I/O configuration of the host processor, including the pins used for peripherals (such as SDIO and I2C) as well as GPIO. The table in the comments at the top of the file provides a list of the pins and pin functions used by the platform.

6.1.3 platform.c

This file contains the c structure instances and functions that map the definitions in the platform.h file to the WICED hardware abstraction layer. The functions in this file are called by the WICED initialization code to configure the hardware.

6.1.4 platform_config.h

This file contains additional interface and processor configuration information not defined in the makefile.

6.2 STM32F412

There are significant differences between the STM32F411 and STM32F412 Discovery boards. The F412 board has different sensors, and LCD touchscreen display and an SD card slot. Due to these differences, many of the interface header pins are used for different functions on the F412 board compared to the F411 board. For this reason the STM32F412 Discovery board **CANNOT** be used with the Sterling-LWB Expansion board without extensive modifications.

The STM32F411VET6U are very STM32F412VET6U similar parts. The main differences are, up to 1 Meg byte Flash and 256 k byte RAM and additional peripherals (FSMC, QSPI, DFSDM and CAN).

The Sterling Demo Board does not use the additional peripherals. In general, a platform that was based on the STM32F411 VEH6 can be updated to support the STM32F412VET6U with the following changes to the .mk file

```
HOST_MCU_VARIANT    := STM32F412
HOST_MCU_PART_NUMBER := STM32F412VEH6
```

WICED has STM32F4xx processor specific files located in the path: WICED\WICED-Studio-4.0\43xxx_Wi-Fi\WICED\platform\MCU\STM32F4xx. These files contain definitions for the STM32F412 and the WICED build system will pick the correct ones based on the MCU variant and part number.

6.3 STM32F407

The STM32F407 is similar to the F411. It is available with up to 1 Meg byte of Flash and 192 k byte RAM. A 64 k byte block of Core Coupled Memory (CCM) is typically used for the parallel camera interface, although it can also be used as general purpose RAM.

WICED does have support for the F407/F417 in the MCU files and the MCU Variant and Part Number can be set to STM32F417. However the 64 k CCM RAM block is not contiguous with the other on chip RAM blocks and it cannot easily be used by the GCC linker as part of the SRAM data segment.

To use the 64 k byte CCM RAM for WICED applications, it is suggested to take the following steps.

1. Change the `HOST_MCU_VARIANT := STM32F417` and the `HOST_MCU_PART_NUMBER := STM32F417VGT` in the platform makefile. For example near line 38 in the file `\43xxx_Wi-Fi\platforms\LSRSTERLING_00950\LSRSTERLING_00950.mk`
2. Add a memory section definition to the file `WICED\platform\MCU\STM32F4xx\GCC\app_with_bootloader.ld` that will allocate RAM to the named section.
3. Allocate static RAM blocks to the CCM RAM

This is an example of a memory section definition that could be added to `app_with_bootloader.ld`

```
.ccmram : /* CCM SRAM section available on the STM32F407, 417 */
{
  . = ALIGN(4);
  ccmram_start = .; /* create a symbol at CCM_SRAM start */
  *(.ccmram)
  *(.ccmram*)
  *(.bss*)
  *(COMMON)
  . = ALIGN(4);
  ccmram_end = .; /* create a symbol at CCM_SRAM end */
}> CCM_SRAM AT>CCM_SRAM :bss
```

To make use of this in the application code, add something like:

```
#define MY_BUF_LEN 16384
uint8_t my_static_buffer_in_ccm[MY_BUF_LEN] __attribute__((section (".ccmram")));
```

This code will allocate a static block of 16384 bytes into CCM_SRAM, which will leave more space in the contiguous RAM block on the STM32F407/417 for system buffers, stacks, and the heap.

Notes:

- Many of the peripherals on the STM32F407/417 in the WICED code, use DMA to transfer data to/from RAM. DMA transfers are configured for the contiguous RAM block. Using CCM_RAM for peripheral interface buffers would require significant changes to the WICED initialization code.
- When using the STM32F407/417 it has been found that when connecting with OpenOCD (the default WICED JTAG debugger) connection reliability is improved if reset halt is changed to `soft_reset_halt`. See: `WICED\WICED-Studio-4.0\43xxx_Wi-Fi\tools\OpenOCD\stm32f4x.cfg`

6.4 Other Processors

The WICED interface code to the BCM94343 (Wi-Fi/BLE) chip in the Sterling Module) is very specific to the STM32F4xx family of parts, particularly the SDIO interface for Wi-Fi. BLE source code is not provided which complicates using a different UART. Differences in processors and peripherals should be carefully reviewed when considering a different host processor family.

7 Additional Information

Please contact your local sales representative or our support team for further assistance:

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