AN1350: Single-Band Proprietary Sub-GHz Support with OpenThread

This document describes how to configure OpenThread applications to operate on a proprietary sub-GHz band using the Silicon Labs OpenThread software development kit (SDK) and Simplicity Studio® 5 with a compatible wireless starter kit (WSTK). It also provides details on the proprietary Radio PHY supported with this feature.

KEY POINTS

- Configure OpenThread applications for proprietary sub-GHz support
- Proprietary radio PHY specifications
- Working with proprietary sub-GHz network

1 Introduction

Sub-GHz radios, like 2.4 GHz ones, can offer relatively simple wireless solutions. When compared to 2.4 GHz, sub-GHz offers several advantages, depending on the target application.

Some notable advantages of using sub-GHz radios are:

- Longer range
- Less signal fading in congested environments
- Low interference
- Low power

This application note provides a step-by-step guide to creating, building, and running an OpenThread application on a sub-GHz band.

As Thread is a 2.4GHz protocol and the specification currently does not support a sub-GHz feature, sub-GHz support has been added using:

- Proprietary radio PHY made available with the SDK and,
- Proprietary radio configurations supported by the OpenThread stack.

Note: This feature currently supports single-band operation only and so requires all the nodes in a mesh to be operating on the same sub-GHz band.

Our newest embedded software platform, the Simplicity Software Development Kit (SDK), is designed specifically for our Series 2 and Series 3 devices. The Simplicity SDK is a significant advancement in IoT development, providing our customers with a cohesive development environment for wireless innovation. It enables wireless developers to utilize advanced features and capabilities with the most recent Silicon Labs IoT devices.

Meanwhile, our Gecko Software Development Kit (GSDK) will continue to be available for users of our Series 0 and Series 1 devices. For additional information on Series 0 and Series 1 devices please reference: Series 0 and series 1 EFM32/EZR32/EFR32 device (si-labs.com).

1.1 Proprietary Sub-GHz Radio PHY

For wireless applications to operate on a particular frequency band, the applications typically need the radio implementation to provide the necessary PHY support. For OpenThread applications supported on Silicon Labs platforms, the platform abstraction layer supports the 2.4GHz band by default. For the sub-GHz feature, proprietary radio PHY support has been added.

This section describes the proprietary radio PHY specifications that have been used to support this feature. The PHY specifications are compliant with the NA FCC Part 15.247 regulations.

1.1.1 Modulation Details

The proprietary radio PHY currently supported with the OpenThread SDK uses the following modulation specifications.

Table 1.1. Proprietary Sub-GHz Modulation Specification

Parameter	Configuration
Modulation	2-Level GFSK
Data Rate	500 kbps
Tx Filter BT	0.5 (Gaussian)
Modulation Index	0.76

1.1.2 Channel and Frequency Specifications

Similarly, the channel and frequency specifications for the proprietary radio PHY, and the center frequency for the supported channels have been captured in the following tables.

Table 1.2. Proprietary Sub-GHz PHY Band Parameters

Band Parameters	Value
Channel Page	23
Frequency Band (MHz)	902- 928
Channel Spacing (MHz)	1.0
Total Channels	25
Channel Numbers	0 – 24
1st Channel Center Freq. (MHz)	903.0

Table 1.3. Channels and Center Frequencies for 902-928 MHz Band

Chan. #	Fc (MHz)
0	903.0
1	904.0
…	…
23	926.0
24	927.0

1.1.3 PHR Length

The proprietary radio PHY supports 2-byte PHR. With a supported PSDU of 127 bytes, the last 7 bits of the 2nd byte represent the Frame Length.

1.1.4 Hardware Limitations

The proprietary sub-GHz feature is currently supported on radio boards supporting the 915 MHz band and using EFR32MG12 or EFR32MG13 parts only. Radio boards that could be used to test this feature are BRD4164a, BRD4170a and BRD4158a.

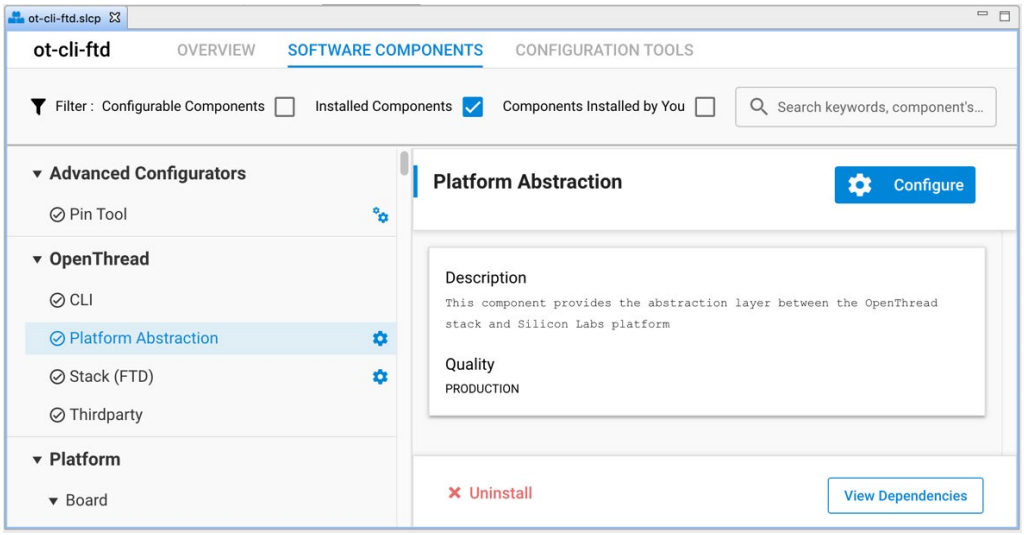
2 Building an OpenThread Sample App for Proprietary Sub-GHz

To build an OpenThread sample application for sub-GHz, you will need Simplicity Studio 5 (SSv5) and the Gecko SDK 3.2 (or higher) development environment with the OpenThread SDK package installed.

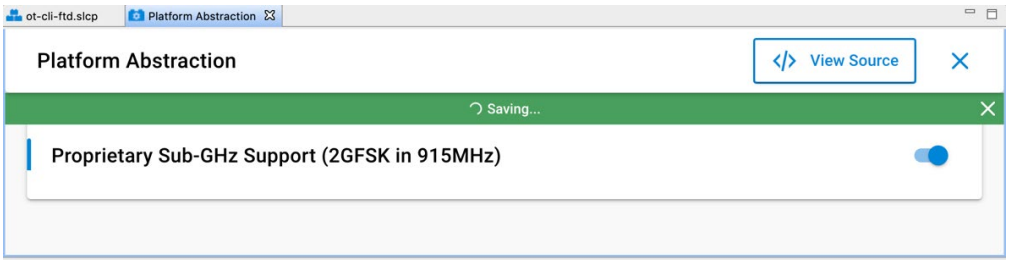
This document assumes that you have installed SSv5 and the OpenThread SDK, and that you are familiar with SSv5 and configuring, building, and flashing applications. If not, see *QSG170: Silicon Labs OpenThread Quick-Start Guide*.

1. Connect your target development hardware (supporting proprietary sub-GHz as discussed in section 1.1.4 Hardware Limitations) connected, open SSv5's File menu and select New > Silicon Labs Project Wizard. The Target, SDK, and Toolchain Selection dialog opens. Your target hardware should be populated. Click **NEXT**.
2. The Example Project Selection dialog opens. Use the Technology Type and Keyword filters to search for a specific example, for example **ot-cli-ftd**. Select it and click **NEXT**.

   Note that, if you do not see the application, your connected hardware may not be compatible. To verify, in the Launcher Perspectives My Products view enter EFR32MGxx and select one of the boards. Go to the Examples tab, filter by Thread technology and verify you can see the app.
3. The Project Configuration dialog opens. Here you can rename your project, change the default project file location, and determine if you will link to or copy project files. Note that if you change any linked resource, it is changed for any other project that references it. Unless you know you want to modify SDK resources, use the default selection. Click **FINISH**. The Simplicity IDE opens with the **ot-cli-ftd** project open in the Project Configurator.
4. To configure proprietary sub-GHz support, on the SOFTWARE COMPONENTS tab, select Installed Components and select the **Platform Abstraction** component under OpenThread. Note that you can also search for a component by name in the search field.



5. Click **Configure** and enable the **Proprietary Sub-GHz Support** configuration option.



   Note: If you do not see the **Configure** control or the 'Proprietary Sub-GHz Support' configuration option associated with the Platform Abstraction component, your hardware may not be compatible with the proprietary radio specifications discussed above.
6. Build the project. The generated ot-cli-ftd.s37 image may now be uploaded to your board using an SSv5 tool such as the flash programmer or Simplicity Commander.

3 Working with a Proprietary Sub-GHz Network

Silicon Labs radio boards supporting the sub-GHz ISM band are designed to the operate in the US FCC 902-928 MHz band with an external whip antenna. Accordingly, when working with this feature, connect the external whip antenna using the SMA antenna connector on your radio board. For more information about this requirement, please refer to your radio board's reference manual.

3.1 Creating a Proprietary Sub-GHz Network

As mentioned in section 1 Introduction, the proprietary sub-GHz feature currently supports single band use only and so requires every node in the mesh to be running an application with the sub-GHz feature enabled. Accordingly, to create a sub-GHz network:

1. Build the **ot-cli-ftd** example with the proprietary sub-GHz feature enabled as discussed in section 2 Building an OpenThread Sample App for Proprietary Sub-GHz and flash the same application on all your nodes.
2. Use the standard OpenThread CLI commands to form and attach to a network. An example of this step is provided in Section 3.5 of *QSG170: Silicon Labs OpenThread Quick Start Guide*.
3. The resulting network formed has nodes operating on the sub-GHz band (with channels supported between 0 – 24, covering 902 – 928 MHz)

3.2 Enabling Proprietary Sub-GHz Support on an OpenThread Border Router

This section assumes that you are familiar with the basic build and install instructions for an OpenThread Border Router. If not, refer to *AN1256: Using the Silicon Labs RCP with the OpenThread Border Router*.

To enable proprietary sub-GHz support on an OpenThread Border Router:

1. Build an RCP image using Simplicity Studio 5 with the sub-GHz feature enabled. Start with the **ot-rcp** example and follow the steps described in Section 2 Building an OpenThread Sample App for Proprietary Sub-GHz.
2. For the Border Router Host you can either:
    1. Use a pre-built docker image (Recommended)

       https://hub.docker.com/r/siliconlabsinc/openthread-border-router-proprietary-na-915/tags

    2. Or, manually build the border router image for your host with the following OpenThread proprietary radio configurations set. This option requires you to modify the OT BR build scripts (details of which are beyond the scope of this document)

Configuration	Value
OPENTHREAD_CONFIG_PLATFORM_RADIO_PROPRIETARY_SUPPORT	1
OPENTHREAD_CONFIG_RADIO_2P4GHZ_OQPSK_SUPPORT	0
OPENTHREAD_CONFIG_RADIO_915MHZ_OQPSK_SUPPORT	0
OPENTHREAD_CONFIG_PLATFORM_RADIO_PROPRIETARY_CHANNEL_PAGE	23
OPENTHREAD_CONFIG_PLATFORM_RADIO_PROPRIETARY_CHANNEL_MIN	0
OPENTHREAD_CONFIG_PLATFORM_RADIO_PROPRIETARY_CHANNEL_MAX	24
OPENTHREAD_CONFIG_PLATFORM_RADIO_PROPRIETARY_CHANNEL_MASK	0x1ffffff
OPENTHREAD_CONFIG_DEFAULT_CHANNEL	0

3.3 Verifying Sub-GHz Operation

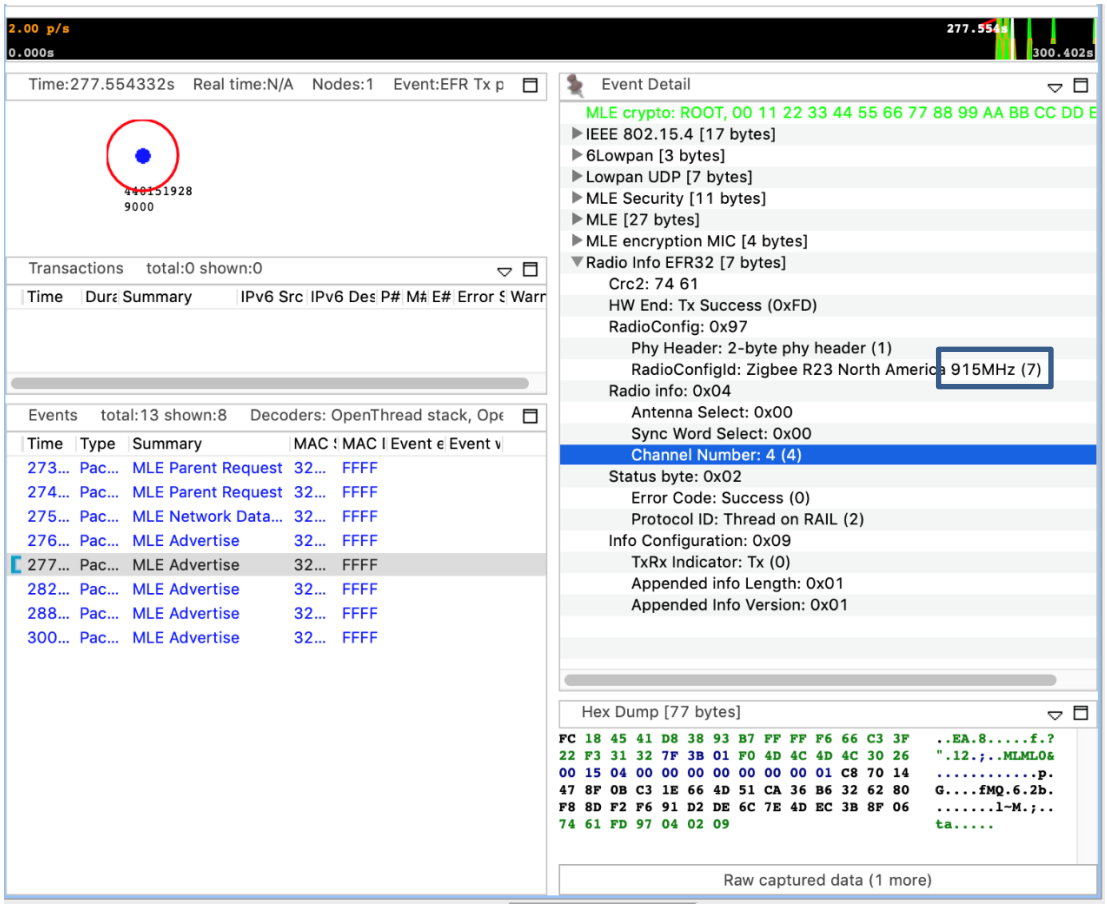
To verify if your application has been configured correctly to operate on the sub-GHz band,

1. Execute the following CLI command on your node, to retrieve the supported channel mask:

```
> channel supported
0x1ffffff
Done
```

For proprietary sub-GHz applications, the result of this command is `0x1ffffff`, indicating channels 0-24 supported for this configuration. For 2.4 GHz applications, the output returned is `0x7fff800`, indicating channels 11-26 supported for that band.

2. Alternately, for a node running the sub-GHz application and that is part of an OpenThread network, you can also verify the radio information using Silicon Labs Network Analyzer.



For more details on how to capture OpenThread packers using Silicon Labs Network Analyzer, refer to section 5.4 of *QSG170: Silicon Labs OpenThread Quick Start Guide*.

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