Application Report
TIDA026–September 2018

How to Configure Different Frequency Bands for the 6LoWPAN Mesh TI Designs

Wonsoo Kim

ABSTRACT

The sub-1 GHz radio frequency regulations differ by regions. The SimpleLink™ CC13xx SDK TI-15.4 stack, which is the baseline for the 6LoWPAN mesh example, provides an easy way to configure a different band plan in software. This article will review available sub-1 GHz frequency band plans and discuss how to configure a different frequency band with data rate in the 6LoWPAN mesh software example. The corresponding TI designs are TIDA-01547, TIDA-010003, and TIDA-010024.

Contents

List of Figures

List of Tables

Trademarks

1 TI-15.4 Frequency Band Options

Table 1 summarizes the frequency bands and data rate options supported by the TI-15.4 stack. The PHY ID #1, #129 and #132 are for the FCC band with three different data rate options. The PHY ID #1 has 129 channels with the channel spacing of 200 kHz and the center frequency of 902.2 MHz for the first channel. This means that the available frequency bands starts from 902 MHz upto 928 MHz. The PHY ID #3, #131 and #133 are defined for the ETS band with three different data rate options. The PHY ID #128 and #130 are for the China band.

Table 1. TI-15.4 Stack PHYs and Channel Frequencies

PHY ID	PHY Data Rate	Channel #0 Frequency	Number of Channels	Channel Spacing
1	50 kbps	902.2 MHz	129	200 kHz
3	50 kbps	863.125 MHz	34	200 kHz
128	50 kbps	433.3 MHz	7	200 kHz
129	5 kbps	902.2 MHz	129	200 kHz
130	5 kbps	433.3 MHz	7	200 kHz
131	5 kbps	863.125 MHz	34	200 kHz
132	200 kbps	902.4 MHz	64	400 kHz
133	200 kbps	863.225 MHz	17	400 kHz

Figure 1 shows the details of the frequency band plan with the PHY ID #1. The channel #0 starts at the center frequency of 902.2 MHz with the channel spacing of 200 KHz. The next channel (#1) will then start at the center frequency of 902.4 MHz, which is calculated 902.2 MHz + 1*200 KHz. As the PHY ID #1 supports 129 channels in total, the center frequency for the 129th channel is 927.8 MHz (= 902.2 MHz + 128 * 200 kHz). For the PHY ID #132, as the channel spacing is twice to that for the PHY ID #1, the total number of channels reduces by half and thus it is 64. This option increases the data rate twice by increasing the channel space twice (that is, the available channel numbers by half). The PHY ID #129 is the same frequency band plan as the PHY ID #1 but with reduced data rate with the robust encoding. The similar combinations are available for the 863-MHz and 433-MHz frequency bands.

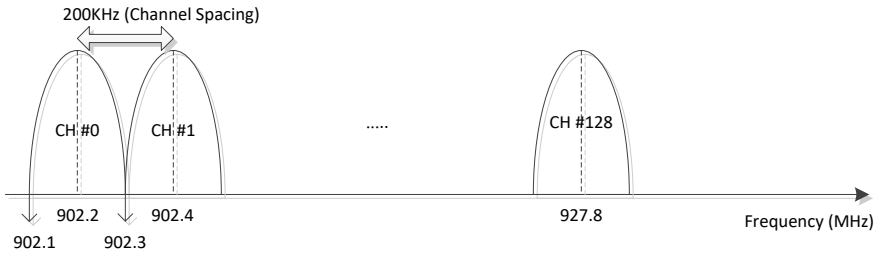

Figure 1. PHY ID #1 (FCC Band: 902 MHz to 928 MHz)

The following code shows the list of available PHY ID options defined in Application/api_mac.h.

```
/*! PHY IDs - 915MHz US Frequency band operating mode # 1 */
#define APIMAC_STD_US_915_PHY_1                 1
/*! 863MHz ETSI Frequency band operating mode #1 */
#define APIMAC_STD_ETSI_863_PHY_3               3
/*! 433MHz China Frequency band operating mode #1 */
#define APIMAC_GENERIC_CHINA_433_PHY_128        128
/*! PHY IDs - 915MHz LRM US Frequency band operating mode # 1 */
#define APIMAC_GENERIC_US_LRM_915_PHY_129       129
/*! 433MHz China LRM Frequency band operating mode #1 */
#define APIMAC_GENERIC_CHINA_LRM_433_PHY_130    130
/*! 863MHz ETSI LRM Frequency band operating mode #1 */
#define APIMAC_GENERIC_ETSI_LRM_863_PHY_131     131
/*! PHY IDs - 915MHz US Frequency band operating mode # 3 */
#define APIMAC_GENERIC_US_915_PHY_132            132
/*! 863MHz ETSI Frequency band operating mode #2 */
#define APIMAC_GENERIC_ETSI_863_PHY_133          133
```

2 Configuring a Different Band Plan for the 6LoWPAN Mesh Software Examples

Changing the frequency band plan is simple by updating a single line in the software example. The following codes show the code lines to be updated to usea frequency band plan. The first is the code line to be modified for the TIDA-010003 and TIDA-010024, which is found in Application/subg/config.h. The second is for the TIDA-01547. This code line is found in 6lowpan_lib/host-api/host_api.c.

```
/*! TIDA-010003/TIDA-010024: Setting for Phy ID */
#define CONFIG_PHY_ID               (APIMAC_STD_US_915_PHY_1)
```

```
// TIDA-01547: change this if using different bands/modes
hostConfig.phyID=APIMAC_STD_US_915_PHY_1;
```

3 Activating Sub-Channels in a Given Frequency Band Plan

The software example allows activating a partial set of sub-channels in the given frequency band. For TIDA-010003 and TIDA-010024 TI designs, this can be done by modifying the channel masks defined in the Application/config.h. The codes below show the two channel masks to be updated: CONFIG_FH_CHANNEL_MASK and FH_ASYNC_CHANNEL_MASK. The CONFIG_FH_CHANNEL_MASK is the frequency hopping channels for data transmissions and the CONFIG_ASYNC_CHANNEL_MASK is for asynchronous transmissions in the device discovery stage. It is recommended to set both to the identical channel masks. By default, the software example provides the masks activating all the sub-channels available in the given frequency band plan.

```
#define CONFIG_FH_CHANNEL_MASK        { 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, \
                                        0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, \
                                        0xFF, 0xFF, 0xFF, 0xFF, 0xFF}

#define FH_ASYNC_CHANNEL_MASK         { 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, \
                                        0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, \
                                        0xFF, 0xFF, 0xFF, 0xFF, 0xFF }
```

The size of the channel mask is 17B that covers the maximum number of channels defined in the FCC band (129 channels) and each bit represents the sub-channel number. The channel number increases from the lowest bit to the highest in each byte. As an example, for the frequency band of APIMAC_STD_US_915_PHY_1, the channel mask of {0x01, 0x01, … , 0x00} activates two sub-channels of #0 (902.2 MHz) and #8 (903.8 MHz=902.2 MHz + 8 * 200 kHz) in the given frequency band. With this, developers can activate the selective sub-channels in a given frequency band plan based on the regional regulation.

For the TIDA-01547, which is a two-chip based 6LoWPAN mesh data collector design, the same concept can be applied but with the external host messaging protocol defined for the TI-15.4 co-processor software. The FH channel mask for data transmissions can be configured via MAC_FH_SET_REQ with the PIB IDs of MAC_FHPIB_UC_EXCLUDED_CHANNELS and MAC_FHPIB_BC_EXCLUDED_CHANNELS. The asynchronous FH channel mask can be configured via MAC_WS_ASYNC_REQ message. For the details, refer to ti-15.4-stack-cop-interface-guide.pdf in the [SimpleLink SDK CC13xx install path]\docs \ti154stack. Note that, for the FH channel mask for the data transfer, the bit-mask should be inverted since the PIB denotes the excluded channels, not the activated channels.

4 References

1. Simple 6LoWPAN Mesh Data Collector Improves Network Performance Reference Design (TIDA-01547)
2. Simple 6LoWPAN Mesh End-Node Improves Network Performance Reference Design (TIDA-010003)
3. Secured 6LoWPAN Mesh End-Node with Enhanced Network Capacity Reference Design (TIDA-010024)

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265