# CC3220MODx and CC3220MODAx SimpleLink™ Wi-Fi® and IoT Solution With MCU LaunchPad™ Hardware

Start your design with the fully programmable FCC, IC, CE, MIC, and SRRC Certified wireless microcontroller (MCU) module with built-in Wi-Fi connectivity. Created for the IoT, the SimpleLink CC3220MODx (CC3220MODSM2MOB and CC3220MODSF12MOB) and CC3220MODAx (CC3220MODASM2MON and CC3220MODASF12MON) module family from Texas Instruments™ are wireless modules that integrates two physically separated on-chip MCUs.

- An application processor – ARM Cortex-M4 MCU with a user-dedicated 256KB of RAM, and an optional 1MB of Serial Flash.
- A network processor MCU to run all Wi-Fi and Internet logical layers. This ROM-based subsystem includes an 802.11b/g/n radio, baseband, and MAC with a powerful crypto engine for fast, secure internet connections with 256-bit encryption.

The CC3220MODx and CC3220MODAx come in a total of 4 variants:

- CC3220MODSM2MOB
    - Requires an external antenna
- CC3220MODSF12MOB
    - Requires an external antenna
    - Contains 1MB of Serial Flash
- CC3220MODASM2MON
    - Contains an Integral Antenna
- CC3220MODASF12MON
    - Contains an Integral Antenna
    - Contains 1MB of Serial Flash

The LAUNCHCC3220MODASF, is a low-cost evaluation platform for ARM Cortex-M4F-based MCUs. The LaunchPad design highlights the CC3220MODASF Internet-on-a-chip™ solution and Wi-Fi capabilities. The LAUNCHCC3220MODASF also features temperature and accelerometer sensors, programmable user buttons, one RGB LED for custom applications, and onboard emulation for debugging. The stackable headers interface demonstrate how easy it is to expand the functionality of the LaunchPad when interfacing with other peripherals on many existing BoosterPack™ add-on boards, such as graphical displays, audio codec, antenna selection, environmental sensing, and much more.

Free software development tools are also available, including TI's Eclipse-based Code Composer Studio™ (CSS) and IAR Embedded Workbench®. More information about the LaunchPad, the supported BoosterPacks, and the available resources are at TI's LaunchPad portal. Also visit the CC3220 Wiki page for design resources and example projects.

# Contents

# Manual Information to the End User

# Trademarks

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Wi-Fi CERTIFIED is a trademark of Wi-Fi Alliance.

Wi-Fi is a registered trademark of Wi-Fi Alliance.

# 1. Overview

Figure 1-1 shows a functional block diagram of the CC3220MODx module.
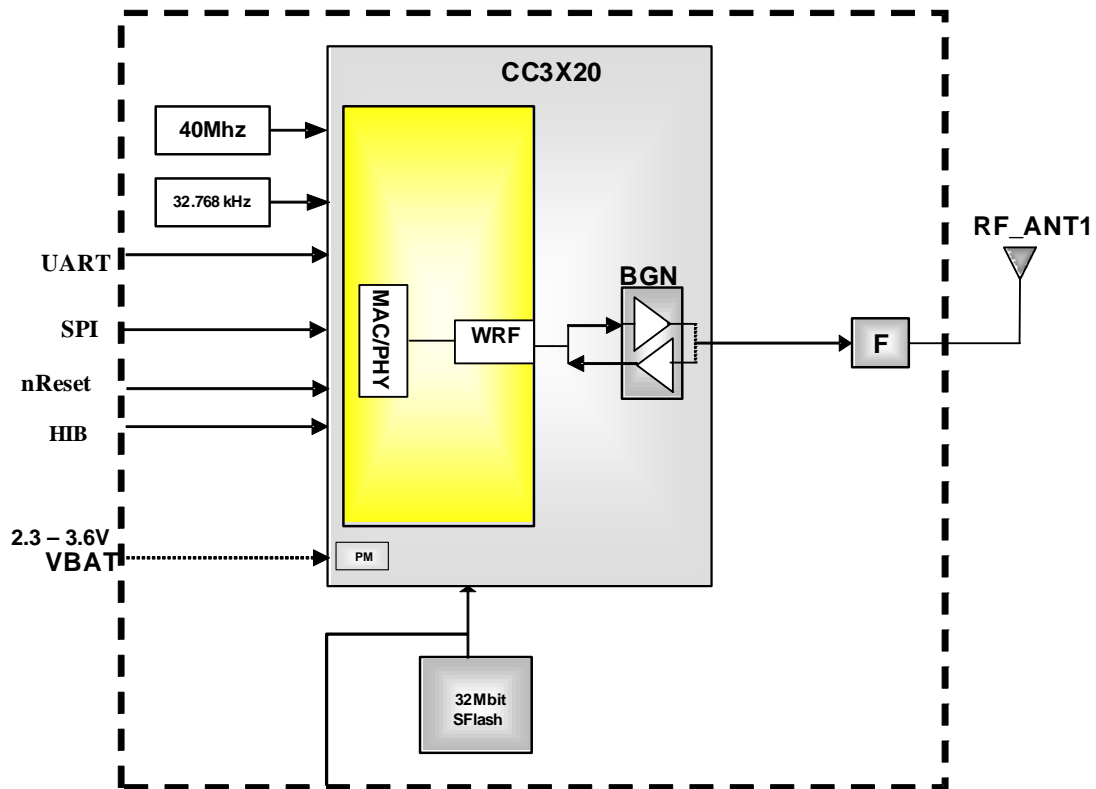


Figure 1-1: CC3220MODx Functional Block Diagram

Figure 1-2 shows a functional block diagram of the CC3220MODAx module.
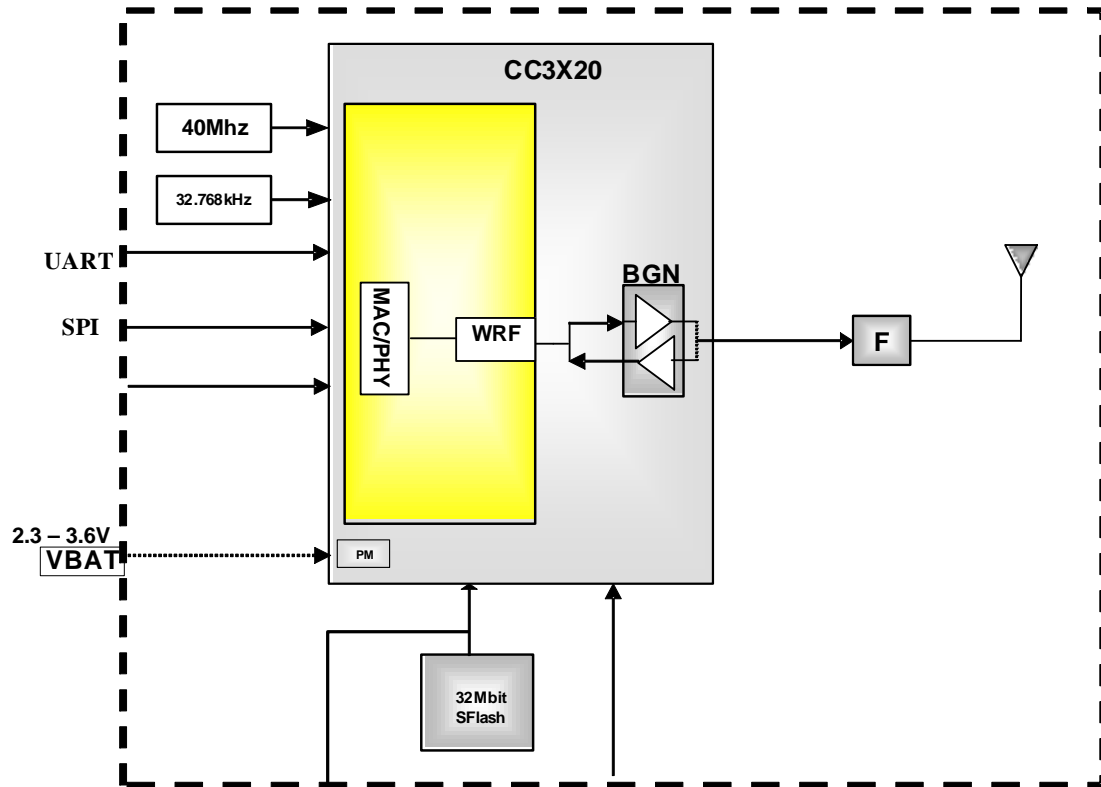
Figure 1-2: CC3220MODAx Functional Block Diagram

Figure 1-3 shows a functional block diagram of the LAUNCHCC3220MODASF SimpleLink LaunchPad
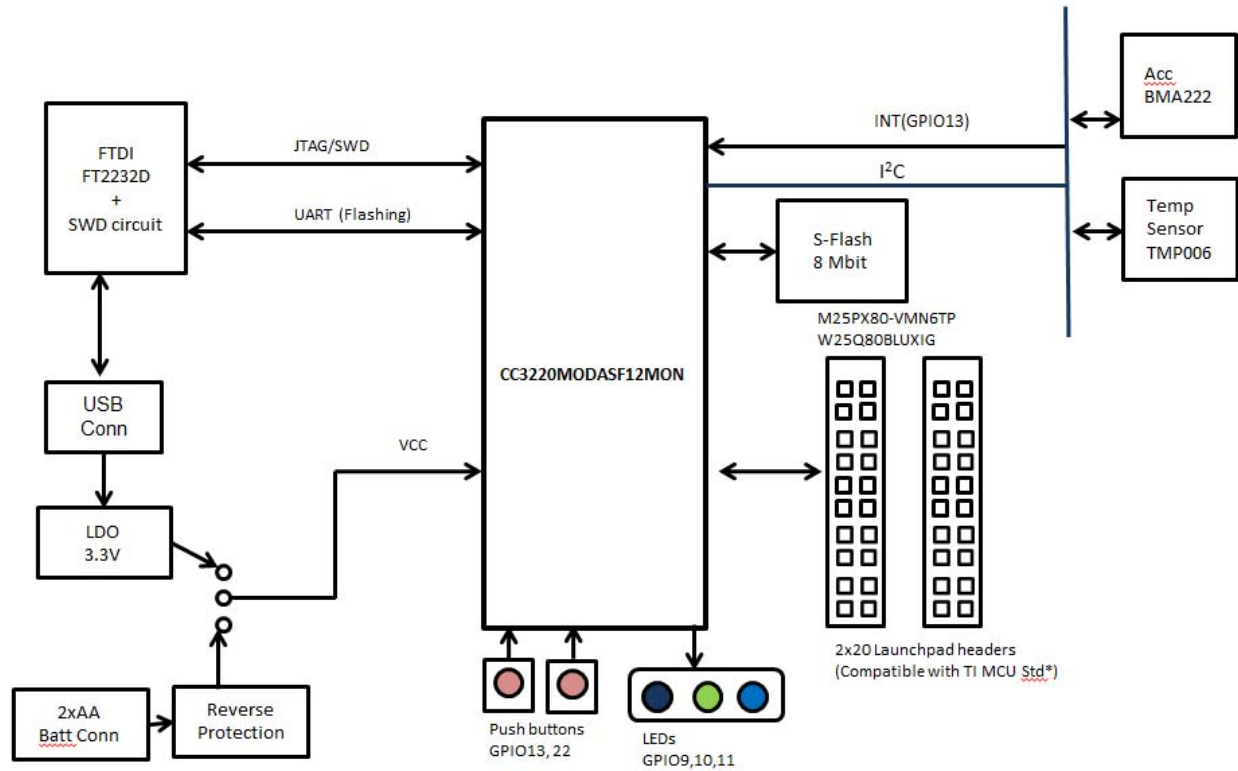
Figure 1-3: Functional block diagram of the LAUNCHCC3220MODASF SimpleLink LaunchPad

Figure 1-4 shows the hardware implementation of the LAUNCHCC3220MODASF
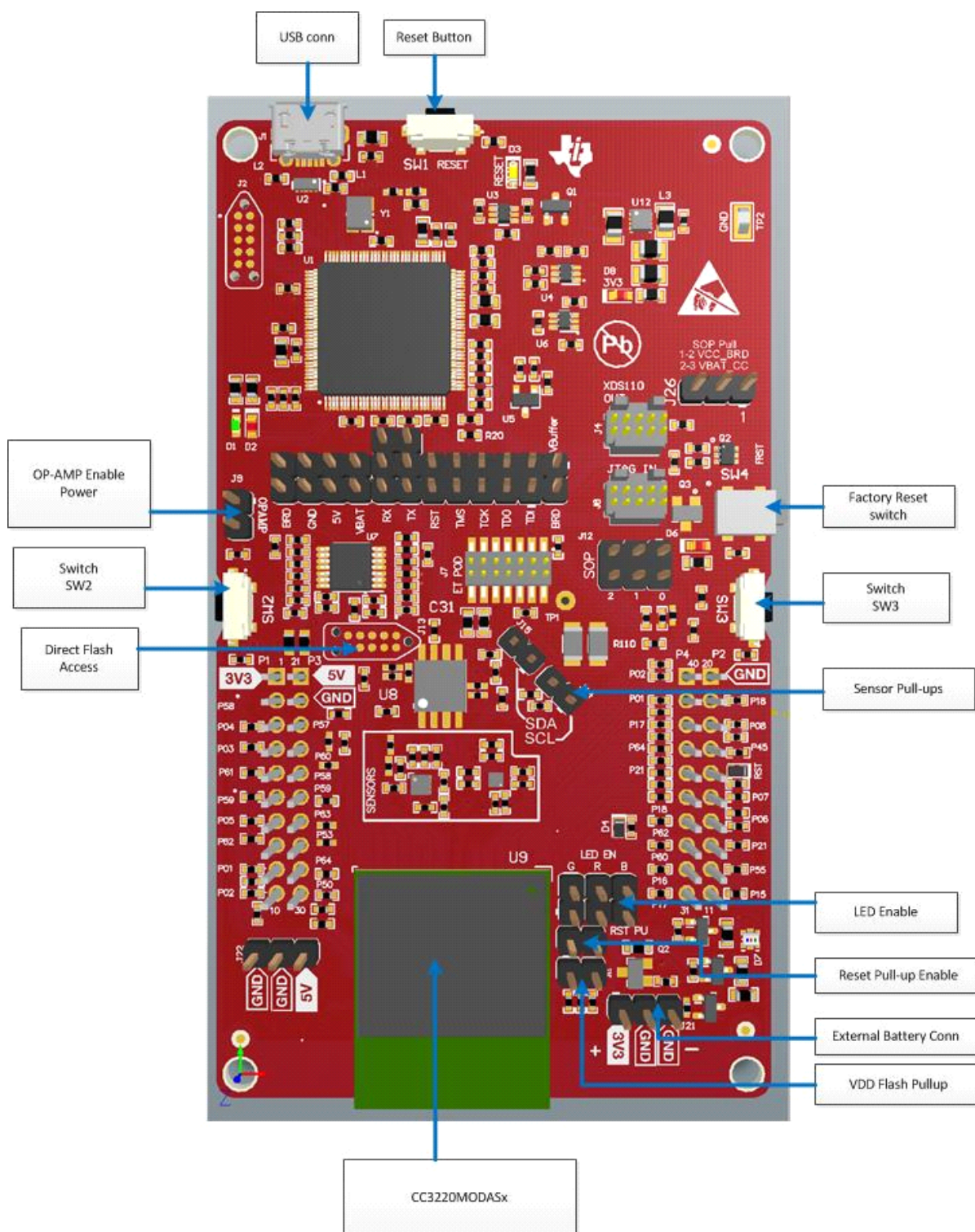
Figure 1-4: Hardware implementation of the LAUNCHCC3220MODASF

Figure 1-5 shows the Top Overlay of the LAUNCHCC3220MODASF SimpleLink LaunchPad.
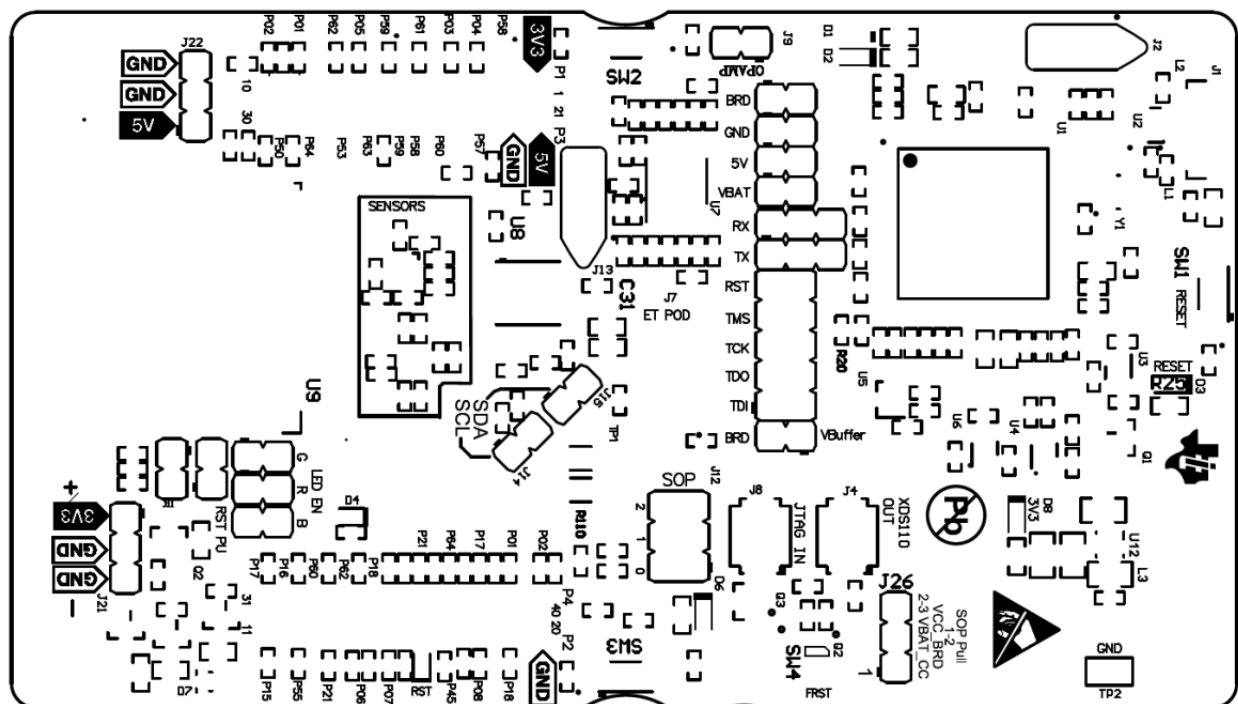
Figure 1-5: LAUNCHCC3220MODASF Top Overlay

Figure 1-6 shows the Top Solder of the LAUNCHCC3220MODASF SimpleLink LaunchPad.
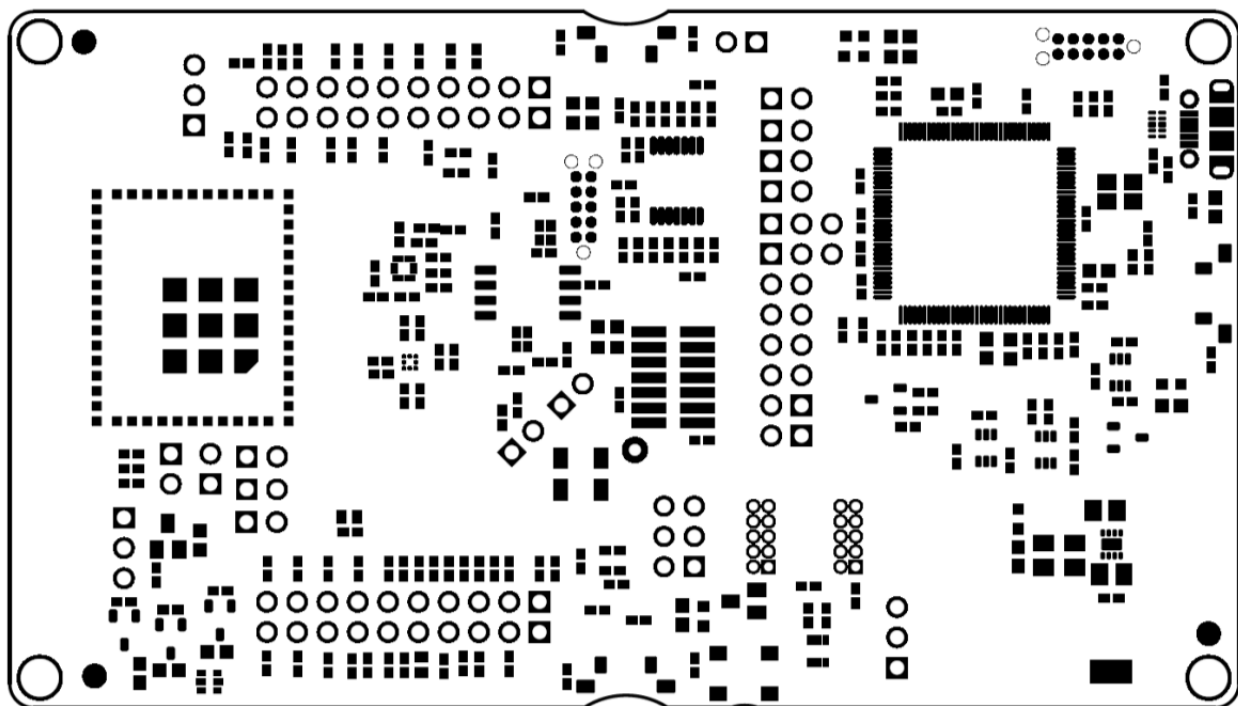


Figure 1-6: LAUNCHCC3220MODASF Top Solder

## 1.1 General Features

The LAUNCHCC3220MODASF SimpleLink LaunchPad includes the following features:

- CC3220MODASF, SimpleLink Wi-Fi, internet-on-a-chip solution with integrated MCU
- 40-pin LaunchPad standard that leverages the BoosterPack ecosystem
- TI Standard XDS110 based JTAG emulation with serial port for Flash programming.
- Supports both 4-wire JTAG and 2-wire SWD
- Two buttons and three LEDs for user interaction
- Virtual COM port UART through USB on PC
- On-board chip antenna with U.FL for conducted testing selectable using 0 Ohm resistors.
- On-board accelerometer and temperature sensor for out-of-box demo with option to isolate them from the inter-integrated circuit (I2C) bus
- Micro USB connector for power and debug connections
- Headers for current measurement and external JTAG connection. Option to use the on-board XDS110 to debug customer platforms.
- Bus-powered device with no external power required for Wi-Fi
- Long range transmission with highly optimized antenna (200m typical in open air using an Access point with 6dBi antenna AP)
- Can be powered externally, with 2xAA or 2xAAA alkaline batteries working down to 2.3V typical (typ)
- Four-layer PCB
- Dimensions: 103.1 mm (L) x 58.42 (W)

## 1.2 Key Benefits

The CC3220MODx and CC3220MODASx modules offer the following benefits:

- CC3220MODS and CC3220MODAS are Wi-Fi® Modules that Consist of the CC3220SM2ARGK While the CC3220MODSF and the CC3220MODASF Consist of the CC3220SF12ARGK Single-Chip MCUs, respectively. The Fully Integrated, Industrial Temperature Grade, Green Modules Include all Required Clocks, SPI Flash, and Passives.
- The CC3220MODAx Modules Include an Integral Antenna for Easy Integration Into the Host System.
- CC3220MODx and CC3220MODAx SimpleLink™ Wi-Fi Wireless Microcontroller Unit (MCU) System-on-Chip (SoC) is a Single-Chip With Two Separate Execution Environments:
    - User Application Dedicated ARM® Cortex®-M4 MCU
    - Network Processor MCU to Run All Wi-Fi and Internet Logical Layers
- FCC, IC, CE, MIC, and SRRC Certified
- Wi-Fi CERTIFIED™ Modules, Can Request Certificate Transfer for Wi-Fi Alliance Members
- 1.27-mm Pitch LGA Package for Easy Assembly and Low-Cost PCB Design
- Applications MCU Subsystem
    - ARM Cortex-M4 Core at 80 MHz
    - Embedded Memory

- CC3220MODS and CC3220MODAS Variant Includes 256KB of RAM
- CC3220MODSF and CC3220MODASF Variant is Flash-Based MCU with Integrated 1MB of Flash and 256KB of RAM
- Peripheral Drivers in ROM
  - o McASP Supports Two I2S Channels
  - o SD
  - o SPI
  - o I²C
  - o UART
  - o 8-Bit Synchronous Image Interface
  - o Four General-Purpose Timers (GPTs) With 16- Bit PWM Mode
  - o One Watchdog Timer Module
  - o 4-Channel, 12-Bit Analog-to-Digital Converters (ADCs)
  - o Debug Interfaces: JTAG, cJTAG, and SWD
- Wi-Fi Network Processor Subsystem
  - o Wi-Fi Internet-on-a-chip™ Dedicated ARM MCU Completely Offloads Wi-Fi and Internet Protocols from the Application MCU
  - o Wi-Fi Modes
    - 802.11b/g/n Station
    - 802.11b/g/n Access Point Supports up to Four Stations
    - Wi-Fi Direct® Client and Group Owner WPA2 Personal and Enterprise Security: WEP, WPA, WPA2 PSK, and WPA2 Enterprise (802.1x)
    - IPv4 and IPv6 TCP and IP Stack
    - Industry-Standard BSD Socket Application Programming Interfaces (APIs)
      - 16 Simultaneous TCP or UDP Sockets
      - 6 Simultaneous TLS and SSL Sockets
    - IP Addressing: StaticIP, LLA, DHCPv4, DHCPv6 With DAD
    - SimpleLink Technology Connection Manager for Autonomous and Fast Wi-Fi Connections
    - Flexible Wi-Fi Provisioning With SmartConfig™ Technology, AP Mode, and WPS2 Options
    - RESTful API Support Using Internal HTTP Server
    - Embedded Network Applications Running on Dedicated Network Processor
    - Wide Set of Security Features
      - Hardware Features:
        - o Separation Execution Environments
        - o Device Identity
        - o Hardware Crypto Engine for Advanced Fast Security, Including: AES, DES, 3DES, SHA2, MD5, CRC, and Checksum
      - Initial Secure Programming
        - o Debug Security
        - o JTAG and Debug Ports are Locked
      - Personal and Enterprise Wi-Fi Security
      - Secure Sockets (SSLv3, TLS1.0, TLS1.1, TLS1.2)
    - Networking Security
      - HTTPS Server
      - Trusted Root-Certificate Catalog

- - - TI Root-of-Trust Public Key
  - SW IP Protection
    - Secure Key Storage
    - File System Security
    - Software Tamper Detection
    - Cloning Protection
    - Secure Boot: Validate Integrity and Authenticity of Runtime Binary During Boot
  - Embedded Network Applications Running on Dedicated Network Processor
    - HTTP and HTTPS Web Server With Dynamic User Callbacks
    - mDNS, DNS-SD, and DHCP Servers
    - Ping
  - Recovery Mechanism: Can Recover to Factory Defaults or to Complete Factory Image
  - o Wi-Fi TX Power
    - 17.0 dBm at 1 DSSS
    - 16.5 dBm at MCS0
  - o Wi-Fi RX Sensitivity
    - –95.0 dBm at 1 DSSS
    - –73.5 dBm at 54 OFDM
  - o Application Throughput
    - UDP: 16 Mbps
    - TCP: 13 Mbps
- Power-Management Subsystem
  - o Integrated DC-DC Converter With a Wide-Supply Voltage:
    - $V_{BAT}$: 2.3 to 3.6 V
  - o Advanced Low-Power Modes:
    - Shutdown: 1 µA
    - Hibernate: 6 µA
    - Low-Power Deep Sleep (LPDS): 135 µA (Measured on CC3220MODS and CC3220MODSF with 256-KB RAM Retention)
    - RX Traffic (MCU Active): 59 mA (Measured on CC3220MODS; CC3220MODSF Consumes an Additional 15 mA) at 54 OFDM
    - TX Traffic (MCU Active): 223 mA (Measured on CC3220MODS; CC3220MODSF Consumes an Additional 15 mA) at 54 OFDM, Maximum Power
    - Idle Connected (MCU in LPDS): 710 µA (Measured on CC3220MODS and CC3220MODSF with 256-KB RAM Rentention) at DTIM = 1
- Additional Integrated Components
  - o 40.0-MHz Crystal
  - o 32.768-kHz Crystal (RTC)
  - o 32-Mbit SPI Serial Flash RF Filter and Passive Components
- LGA Package for Easy Assembly and Low-Cost PCB Design
  - o CC3220MODx: 1.27-mm Pitch, 63-Pin, 20.5-mm × 17.5-mm
  - o CC3220MODAx: 1.27mm Pitch, 63-Pin, 20.5-mm x 25.0-mm
- Operating Temperature
  - o Ambient Temperature Range: –40°C to +85°C

- Module Supports SimpleLink Developers Ecosystem

## 1.3    Key Benefits

The CC3220MODx and CC3220MODAx modules are designed for the following internet of Things (IoT) applications, including:

- Cloud Connectivity
- Internet Gateway
- Home and Building Automation
- Appliances
- Access Control
- Security Systems
- Smart Energy
- Industrial Control
- Smart Plug and Metering
- Wireless Audio
- IP Network Sensor Nodes
- Asset Tracking
- Medical Devices

# 2.    Connectors and Jumpers

Figure 2-1 shows the top view of the LAUNCHCC3220MODASF SimpleLink LaunchPad
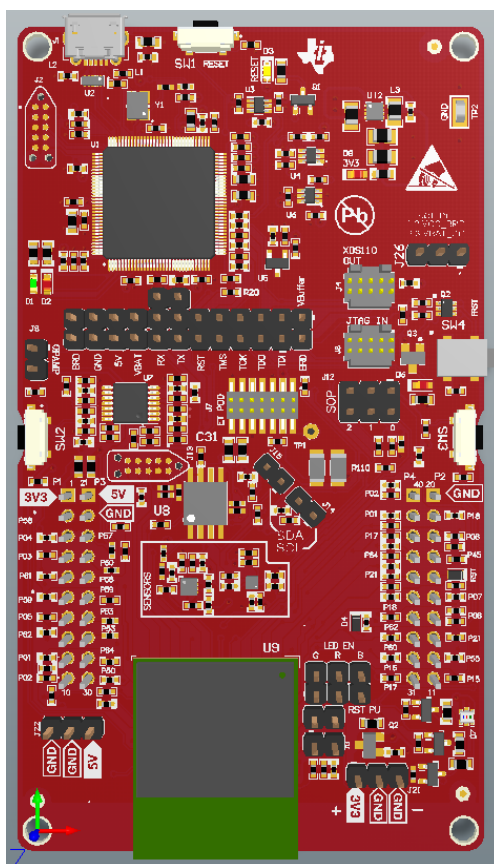
Figure 2-1: LAUNCHCC3220MODASF Top View

Figure 2-2 shows the bottom view of the LAUNCHCC3220MODASF SimpleLink LaunchPad
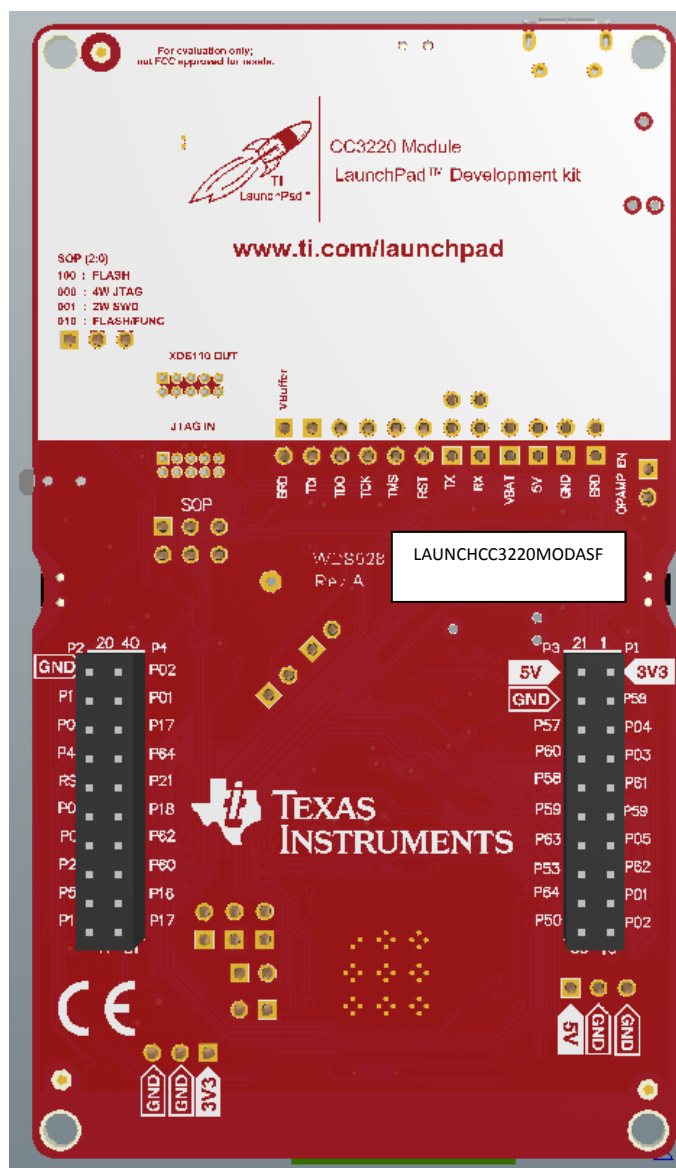
Figure 2-2: LAUNCHCC3220MDASF Bottom View

## 2.1 Jumpers, Switches and LEDs

### 2.1.1 JTAG Headers

The headers are provided on the board to isolate the CC3220MODASF module from the onboard XDS 110-based JTAG emulator. These jumpers are shorted by default when the board is shipped from TI (See Figure 2-3 below).
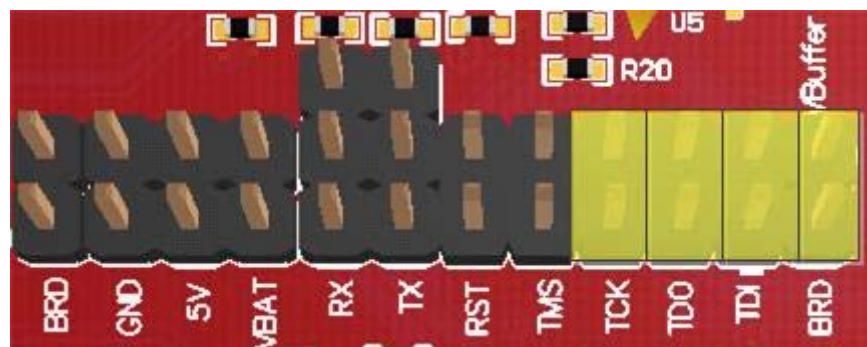
Figure 2-3: Jumpers on JTAG Lines

To connect and external emulator, remove these jumpers and place the external emulator on the JTAG IN connector (See Figure 2-4 below).



Figure 2-4: JTAG Input Connector for Using External Emulator

Table 2-1 lists the JTAG headers.

| Reference | Usage | Comments |
|---|---|---|
| J3 5-6 (TCK) [1] | JTAG | Short : Routes the on-board emulator to the CC3220. Open: Isolate the on-board emulator from the CC3220. |
| J3 7-8 (TMS) [1] | | |
| J3 3-4 (TDI) | | |
| J3 1-2 (TDO) | | |

[1] For the SWD mode, only TCK and TMS need to be shorted to the CC3220.

Table 2-1: JTAG headers on the LAUNCHCC3220MODASF

## 2.1.2 I2C Connections

The board features an accelerometer and temperature sensor for the out-of-box demo. These are connected to the I2C bus and can be isolated using the jumpers provided (See Figure 2-5 below).
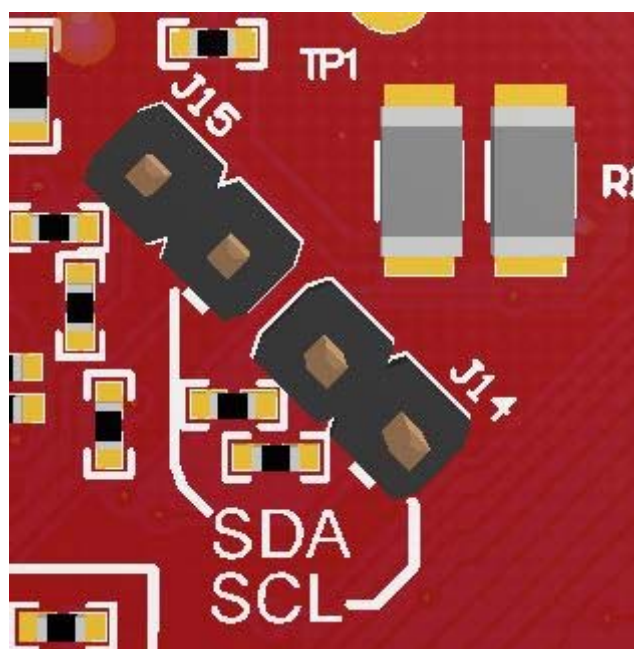
Figure 2-5: I$^2$C Connections on the LAUNCHCC3220MODASF

By removing J14 and J15, the accelerometer and the temperature sensors are isolated from the I$^2$C bus. Noe that this step also removes any pullup resistors from the I$^2$C bus and any sensors connected to the bus requires external pullups.

### 2.1.3 Jumper Settings

Table 2-2 lists the I$^2$C connection jumper settings.

| Reference | Usage | Comments |
|---|---|---|
| J15 | I2C SDA | Short : Connect the CC3220MODASX I2C bus to the on-board sensors with pull-up Open : Isolate the sensors from the CC3220 |
| J14 | I2C SCL | Short : Connect the CC3220MODASX I2C bus to the on-board sensors with pull-up Open : Isolate the sensors from the CC3220 |

Table 2-2: Jumper Settings

### 2.1.4 Default I²C Address

Table 2-3 lists the default I$^2$C address.

| Sensor Type | Ref | Part Number | Slave Address |
|---|---|---|---|
| Temp sensor | U10 | TMP006 | 0x41 |
| Accelerometer | U11 | BMA222E | 0x18 |

Table 2-3: Default I$^2$C address

### 2.1.5    Power Connections

The board can be powered by using the on-board micro USB connector. An on-board DC-DC converter provides 3.3 V for the CC3220MODASF and the rest of the boar to operate. This supply can be isolated from the DC-DC using the jumpers on the board. Table 2-4 lists the power jumper settings.

| Reference | Usage | Comments |
|---|---|---|
| J18 | Current measuremen | Measures the current flowing into the CC3220MODASX device. This also includes the serial flash and any stacked boosterpack. |
| J16 | Board power | Short: Supply the board power from the on-board DC-DC converter. The board power includes the sensors, LED and the OPAMP used for driving the ADC input. |
| J9 | OPAMP EN | If un-installed, it cuts off the power supply to the OPAMP. This can be used to enable low power measurements. |
| J23,J24,J25 | LED EN | Un un-installed, the LEDs connected to the GPIO would be disabled. This can be used to enable low power measurements. |
| J17 | VSENSE | This is used to power the level shifters located on the Emulator side of the board. The level shifters can be powered by shorting this jumper. Removing this jumper enables low current measurement. |
| J19 | 5 V power | 5 V output from the USB VBUS (has a diode drop of up to 0.4 V) |
| J21 | 3.3 V power input | Can be used to power the board from an external 2XAA battery pack. It has in-built reverse voltage protection to prevent the battery from being plugged in the |

Table 2-4: Power Jumper Settings

### 2.1.6    UART Signals

The board supports a USB-based virtual COM port, using the Tiva MCU. The LauchPad is shipped with the UART lines from the CC3220MODASF connected to the UART on the Tiva MCU (See Figure 2-6). The CC3220MODASF UART can also be routed to the 20-pin connector for use as a GPIO or an external UART (See Figure 2-7). The selection is performed using jumpers on the board.
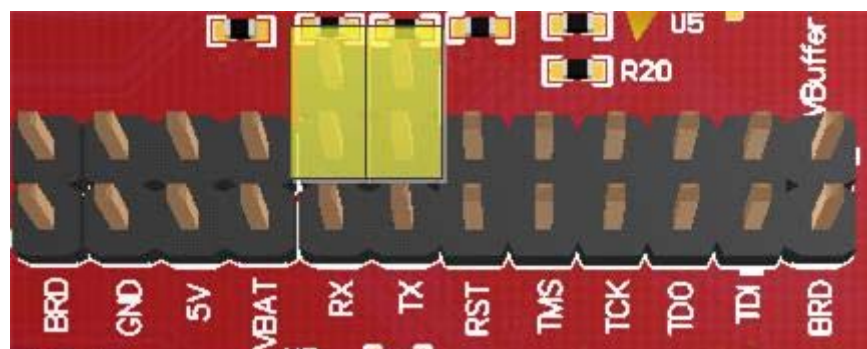


Figure 2-6: UART Routed on the USB COM PORT
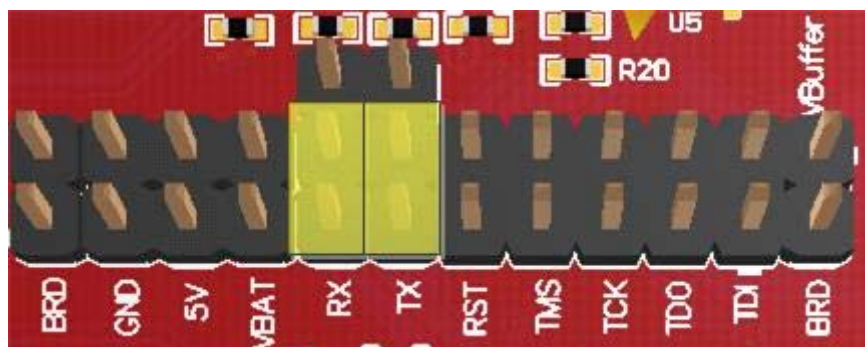
Figure 2-7: UART Routed on the 20-pin Connector

Table 2-5 lists the IART signals.

| Reference | Usage | Comments |
|-----------|-------|----------|
| J5, J6 | UART for Flash programming | Short 1-2: Route the signals to the 20 pin connector.<br>Short 2-3: Route the signals to the USB for Flash programming. |

Table 2-5 UART signals

## 2.1.7      Sense on Power

The CC3220MODASF can be set to operate in four different modes based on the state of the Sense on Power (SOP) lines. These are pins 23, 24 and 34 of the CC3220MODx and CC3220MODAx modules. The state of the module is described in Table 2-6.

| Value | Function |
|-------|----------|
| 100 | Flash programming. |
| 000 | Functional mode + 4 Wire JTAG |
| 001 | Functional mode + 2 Wire JTAG |
| 011 | Factory default |

Table 2-6: SOP [2:0] function

Note that SOP[2:0] corresponds to J12 on the Launchpad schematic design. Figure 2-8 shows the SOP jumpers.



Figure 2-8: SOP jumper Settings

Note that placing no jumpers on the block ensures that the line is pulled low using 100-K pulldown resistors. Placing the jumper pulls the pin high using a 1-K resistor.

### 2.1.8 Push Buttons and LEDs

Table 2-7 lists the push-button settings

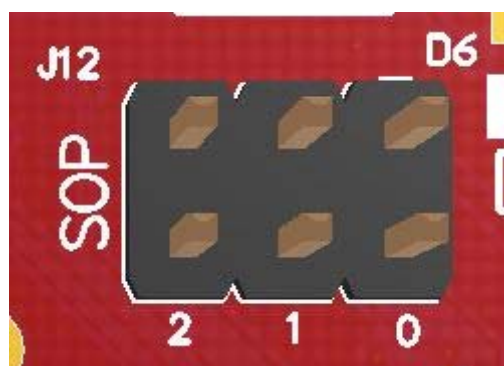| Reference | Usage | Comments |
|---|---|---|
| SW1 | RESET | This is used to RESET the CC3220MODASX device. This signal is also output on the 20-pin connector to RESET any external BoosterPack which may be stacked. The Reset can be isolated using the jumper block located at the center of the board. |
| SW2 | GPIO_13 | When pushed, the GPIO_13 will be pulled to VCC. |
| SW3 | GPIO_22 | When pushed, the GPIO_22 will be pulled to VCC. |
| SW4 | FACTORY DEFAULT | Pressing this button and toggling the RESET will restore the factory default image on the serial flash. This can be used to recover a corrupted serial flash, provided the s-flash was programmed with a recovery image. |

Table 2-7: Push Buttons

Table 2-8 lists the LED settings.

| Reference | Color | Usage | Comments |
|---|---|---|---|
| D3 | Yellow | nRESET | This LED is used to indicate the state of nRESET pin. If this LED is glowing, the device is functional. |
| D2, D1 | Green, Red | Debug | Indicates state of the JTAG emulator. For TI use only. |
| D8 | RED | Power | Indicates when the 3.3 V power is supplied to the board. |
| D7 | RGB | GPIO_11 [1] | Glows when the GPIO is logic-1 |
| | RGB | GPIO_10 [1] | Glows when the GPIO is logic-1 |
| | RGB | GPIO_09 | Glows when the GPIO is logic-1 |
| D6 | FRST | Factory Reset | Indicates that the Push-button for the factory Reset is pressed down. |

[1] GPIO_10 and GPIO_11 are used as I2C also. So whenever the pull-ups are enabled, the LEDs would glow by default without configuring the GPIOs.

Table 2-8: LEDs

## 2.2 2x20 Pin connector assignment

The signal assignment on the 2x20-pin connector is shown in Tables 2-8 thru 2-11.

> Note: All signals are 3.3V CMOS logic levels and are referred with respect to the CC3120 IC. For example, UART1_TX is an output from the CC3120 IC.
>
> For the SPI lines, the CC3120MOD always acts like a slave

Table 2-8 lists the P1 connector assignment.

| Pin Number | MCU Standard Definition | CC3220MODASx Pin Map | CC3220MODASx Pin Number | Primary function |
|---|---|---|---|---|
| P1.1 | VCC(3.3V) | VCC(3.3V) | ---- | VCC(3.3V) |
| P1.2 | ANALOG_IN | GPIO_03* | 58 | ADC_CH1 |
| P1.3 | UART_RX | GPIO_13 | 4 | UART0_RX |
| P1.4 | UART_TX | GPIO_12 | 3 | UART0_TX |
| P1.5 | GPIO | GPIO_06 | 61 | GPIO |
| P1.6 | ANALOG_IN | GPIO_04* | 59 | ADC_CH2 |
| P1.7 | SPI_CLK | GPIO_14 | 5 | SPI_CLK |
| P1.8 | GPIO | GPIO_07 | 62 | GPIO |
| P1.9 | I2C_SCL | GPIO_10 | 1 | I2C_SCL |
| P1.10 | I2C_SDA | GPIO_11 | 2 | I2C_SDA |

Table 2-8: LAUNCHCC3220MODASF P1 connector assignment

Table 2-9 lists the P2 connector assignment.

| Pin Number | MCU Standard Definition | CC3220MODASx Pin Map | CC3220MODASx Pin Number | Primary function |
|---|---|---|---|---|
| P2.1 | GND | GND | --- | GND |
| P2.2 | GPIO | GPIO_28 | 18 | GPIO |
| P2.3 | SPI_CW (Wireless) | GPIO_17 | 8 | SPI_CS |
| P2.4 | TEST | GPIO_31 | 45 | GPIO |
| P2.5 | RST | RESET_OUT | --- | RESET_OUT[1] |
| P2.6 | SPI_MOSI | GPIO_16 | 7 | SPI_DOUT |
| P2.7 | SPI_MISO | GPIO_15 | 6 | SPI_DIN |
| P2.8 | SPI_CS (Display)/GPIO | GPIO_25 | 21 | GPIO |
| P2.9 | SPI_CS(other)/GPIO | GPIO_01 | 55 | GPIO |
| P2.10 | GPIO | GPIO_22 | 15 | GPIO |

[1]Note : RESET output is an open drain type output and can only drive the pin low. The pull-up ensures the line is pulled-back high when the button is released. No external booster pack can drive this pin low.

Table 2-9: LAUNCHCC3220MODASF P2 connector assignment

Table 2-10 lists the P3 connector assignment.

| Pin Number | MCU Standard Definition | CC3220MODASx Pin Map | CC3220MODASx Pin Number | Primary function |
|---|---|---|---|---|
| P3.1 | +5V | 5V | --- | 5V |
| P3.2 | GND | GND | --- | GND |
| P3.3 | ANALOG_IN | GPIO_02 | 57 | ADC_CH0 |
| P3.4 | ANALOG_IN | GPIO_05 | 60 | ADC_CH3 |
| P3.5 | ANALOG_IN | GPIO_03 | 58 | ADC_CH1 |
| P3.6 | ANALOG_IN | GPIO_04 | 59 | ADC_CH2 |
| P3.7 | ANALOG_IN/AUD_FS | GPIO_08 | 63 | AUD_SYNC |
| P3.8 | ANALOG_IN/AUD_CLK | GPIO_30 | 53 | AUD_CLK |
| P3.9 | ANALOG OUT/AUD_OUT | GPIO_09 | 64 | AUD_DOUT |
| P3.10 | ANALOG OUT/AUD_IN | GPIO_00 | 50 | AUD_DIN |

Table 2-10: LAUNCHCC3220MODASF P3 connector assignment

Table 2-11 lists the P4 connector assignment.

| Pin Number | MCU Standard Definition | CC3220MODASx Pin Map | CC3220MODASx Pin Number | Primary function |
|---|---|---|---|---|
| P4.1 | PWM | GPIO_11* | 2 | PWM |
| P4.2 | PWM | GPIO_10* | 1 | PWM |
| P4.3 | PWM | GPIO_24* | 17 | PWM |
| P4.4 | PWM | GPIO_09* | 64 | PWM |
| P4.5 | CCAP | GPIO_25* | 21 | CCAP/GPIO |
| P4.6 | CCAP | GPIO_28* | 18 | CCAP/GPIO |
| P4.7 | GPIO | GPIO_07* | 62 | GPIO |
| P4.8 | GPIO | GPIO_05* | 60 | GPIO |
| P4.9 | GPIO | GPIO_23 | 16 | GPIO |
| P4.10 | GPIO | GPIO_24 | 17 | GPIO |

Table 2-11: LAUNCHCC3220MODASF P4 connector assignment

The signal mappings are as indicated in Tables 2-8 to 2-11. All the signals are referred to by the pin number in the SDK and Tables 2-8 to 2-11 show the default mappings. Some of the pins are repeated across the connector. For instance, pin 62 is available on P1 and P4, but only P1 is connected by default. The signal on P4 is marked with an asterisk (*) to signify that it is not connected by default. The signal on P4 can be routed to the pin by using a 0-Ω resistor in the path. For the exact resistor placement, please see the full design implementation of the LAUNCHCC3220MODASF at: http://www.ti.com/lit/zip/SWRC340.

# 3. Electrical Characteristics

For electrical characteristics for the CC3220MODx and CC3220MODASx modules, see the CC3220MOD SimpleLink™ Wi-Fi CERTIFIED™ Wireless Module Solutions (S an SF) [Datasheet](#).

# 4. Antenna Characteristics

The CC3220MODSM2MOB and the CC3220MODSF12MOB reference design make use of an on-chip antenna. For information on the antenna VSWR, efficiency, and electrical characteristics please see: [http://ds.yuden.co.jp/TYCOMPAS/ap/detail.do?productNo=AH316M245001-T&dataUnit=M.](http://ds.yuden.co.jp/TYCOMPAS/ap/detail.do?productNo=AH316M245001-T&dataUnit=M.)

The CC3220MODASM2MON and the CC3220MODASF12MON incorporated an integral antennal. This antenna has a nominal efficiency of 70% and a max gain of 2.5dBi. The measured S-parameters of the integral antenna on the CC3220MODAx is show in Figure 4-1 below.



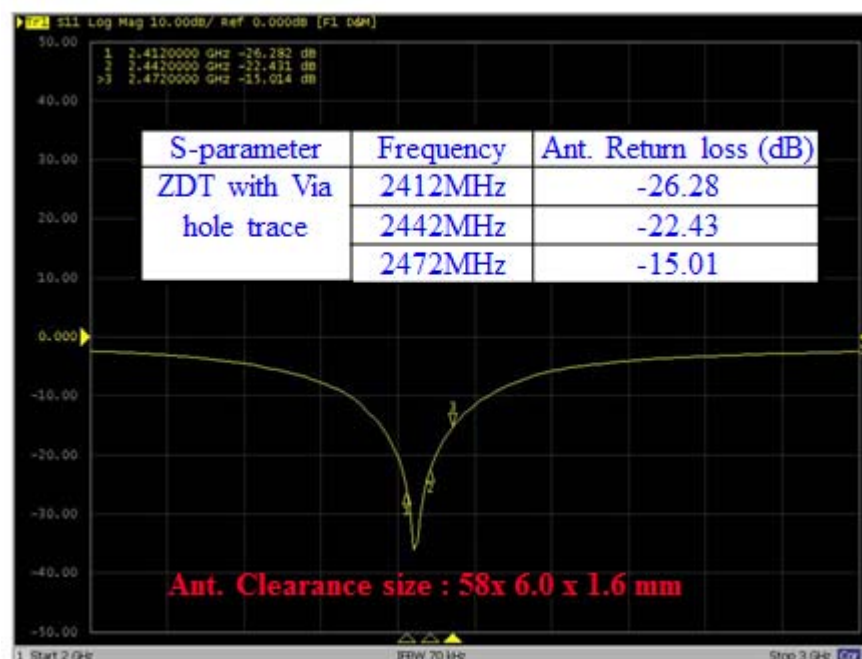| S-parameter | Frequency | Ant. Return loss (dB) |
|---|---|---|
| ZDT with Via hole trace | 2412MHz | -26.28 |
| | 2442MHz | -22.43 |
| | 2472MHz | -15.01 |

Figure 4-1: Measured S-parameters of the integral antenna on the CC3220MODAx Modules

The measured Radiation pattern, in the X-Z plane, of the integral antenna on the CC3220MODAx is show in shown in Figure 4-2 below.

Figure 4-2: X-Z radiated pattern of the integral antenna on the CC3220MODAx module

The measured Radiation pattern, in the Y-Z plane, of the integral antenna on the CC3220MODAx is show in shown in Figure 4-3 below.



Figure 4-3: Y-Z radiated pattern of the integral antenna on the CC3220MODAx module

The measured Radiation pattern, in the X-Y plane, of the integral antenna on the CC3220MODAx is show in shown in Figure 4-4 below.
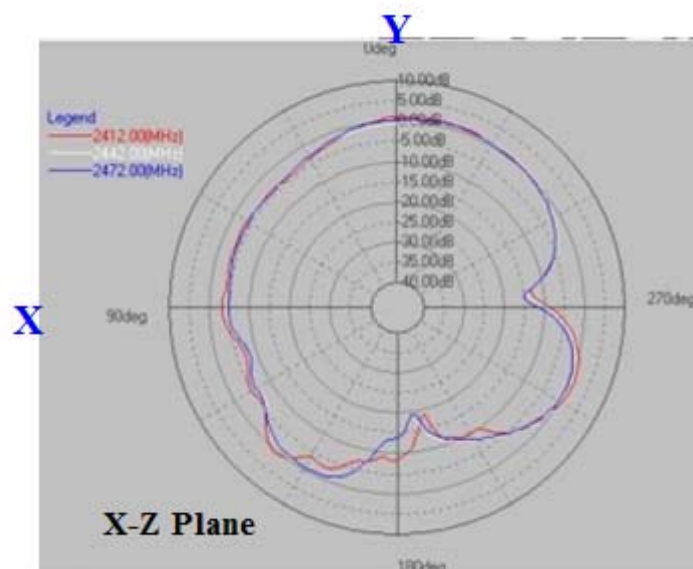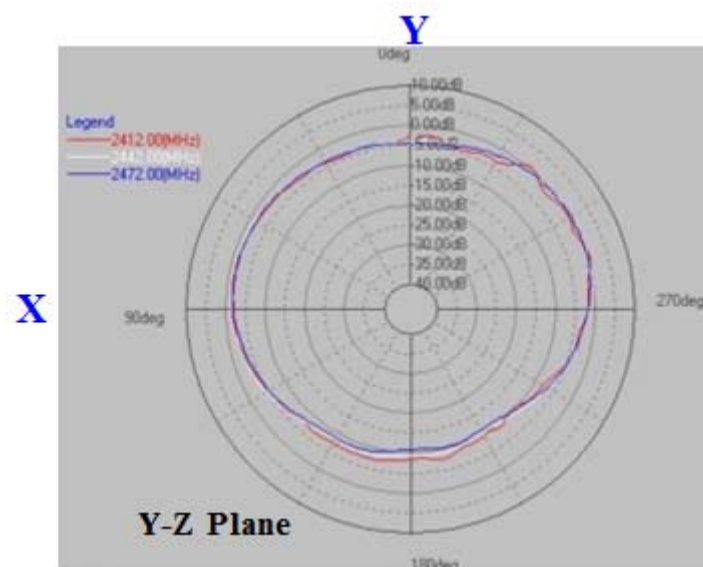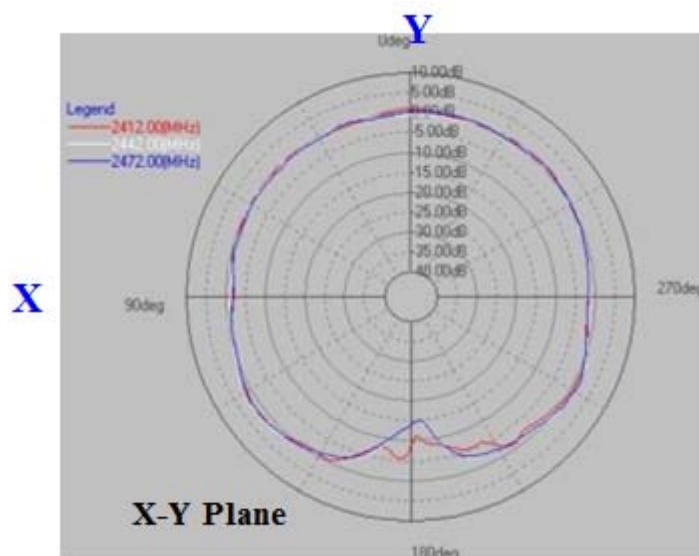
Figure 4-4: X-Y radiated pattern of the integral antenna on the CC3220MODAx module

# 5. Circuit Design

## 5.1.1 Reference schematic

The CC3220MODx and CC3220MODAx share the same reference schematic. The difference between the 2 references is the antenna and its matching circuitry. The CC3220MODAx will not have pin 31 assessable to the designer as the CC3220MODAx contains an integral antenna.

The CC3220MODx main engine area reference schematic is show in Figure 5-1 below. The full LAUNCHCC3220MODx reference schematic can be found at: http://www.ti.com/lit/zip/swrc340.

Figure 5-1: CC3220MODx Engine area reference schematic

## 5.2    Bill of Materials (BOM)

The CC3220MODx and CC3220MODAx share the same reference BOM. The difference between the 2 references is the antenna and its matching circuitry. The CC3220MODAx will not have pin 31 assessable to the designer as the CC3220MODAx contains an integral antenna.

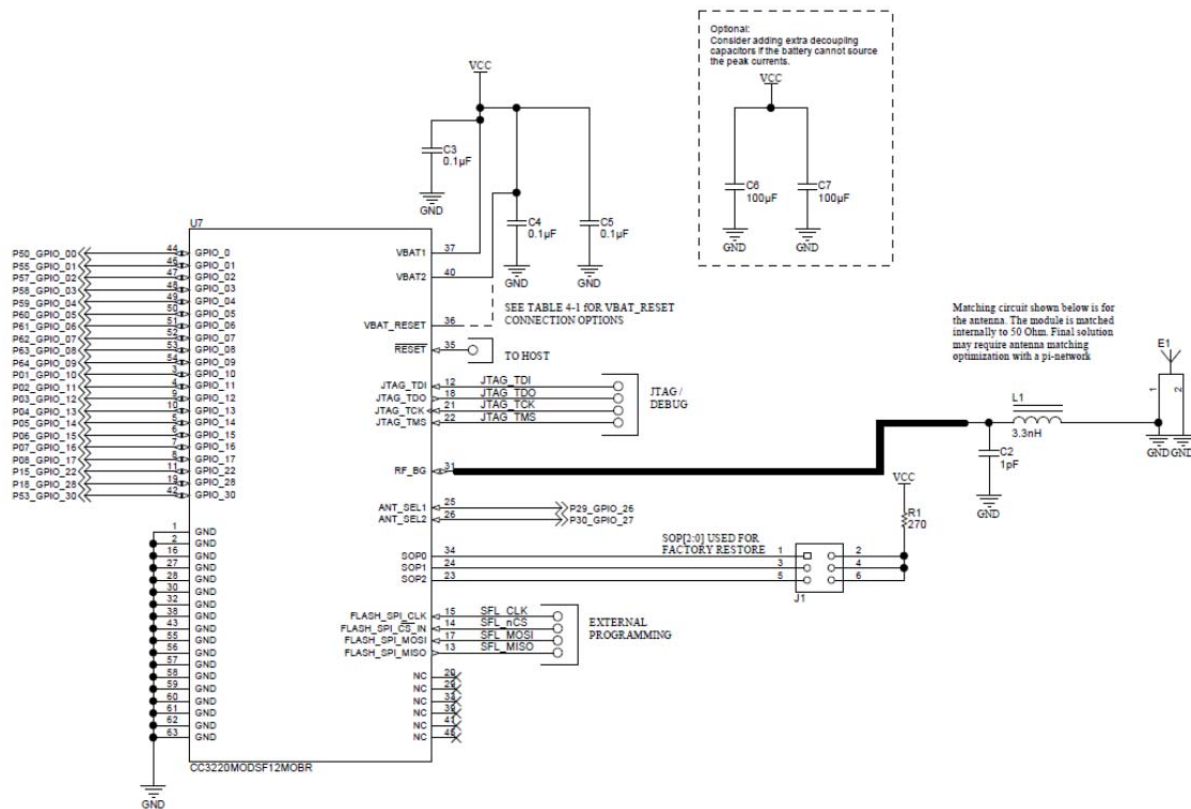The CC3220MODx main engine area reference BOM is show in Table 5-1 below. The full LAUNCHCC3220MODx reference BOM can be found at: http://www.ti.com/lit/zip/swrc340. Note that for the CC3220MODAx, C2, L1 and E1 will not be present.

| QTY | PART REFERENCE | VALUE | MANUFACTURER | PART NUMBER | DESCRIPTION |
|---|---|---|---|---|---|
| 1 | C2 | 1 pF | Murata | GRM1555C1H1R0BA01D | Capacitor, ceramic, 1 pF, 50 V, ±10%, C0G/NP0, 0402 |
| 3 | C3, C4, C5 | 0.1 µF | Murata | GRM155R61A104KA01D | Capacitor, ceramic, 0.1 µF, 10 V, ±10%, X5R, 0402 |
| 2 | C6, C7 | 100 µF | Murata | LMK325ABJ107MMHT | Capacitor, ceramic, 100 µF, 10 V, ±20%, X5R, AEC-Q200 Grade 3, 1210 |
| 1 | E1 | 2.45-GHz Ant | Taiyo Yuden | AH316M245001-T | Antenna Bluetooth WLAN ZigBee® WIMAX |
| 1 | L1 | 3.3 nH | Murata | LQG15HS3N3S02D | Inductor, multilayer, air core, 3.3 nH, 0.3 A, 0.17 Ω, SMD |
| 1 | R1 | 270 | Vishay-Dale | CRCW0402270RJNED | RES, 270, 5%, 0.063 W, 0402 |
| 1 | U1 | CC3220MODSF | Texas Instruments | CC3220MODSF12MOBR | SimpleLink Wi-Fi and Internet-of-Things Module Solution, a Single-Chip Wireless MCU, MOB0063A (SIP MODULE-63) |

Table 4-1: CC3120MOD Engine area reference BOM

# 6. Layout Guidelines

The integrator of the CC3220MODx and CC3220MODAx modules must comply with the PCB layout recommendations described in the following subsections to preserve/minimize the risk with regulatory certifications for FCC, IC, CE, MIC, and SRRC. Moreover, TI recommends customers follow the guidelines described in this section to achieve similar performance.

## 6.2 CC3220MODx Board Layout

The reference layout consists of a 4 layer design. Figure 6-1 shows CC3220MODx Top layer.

![Texas Instruments]
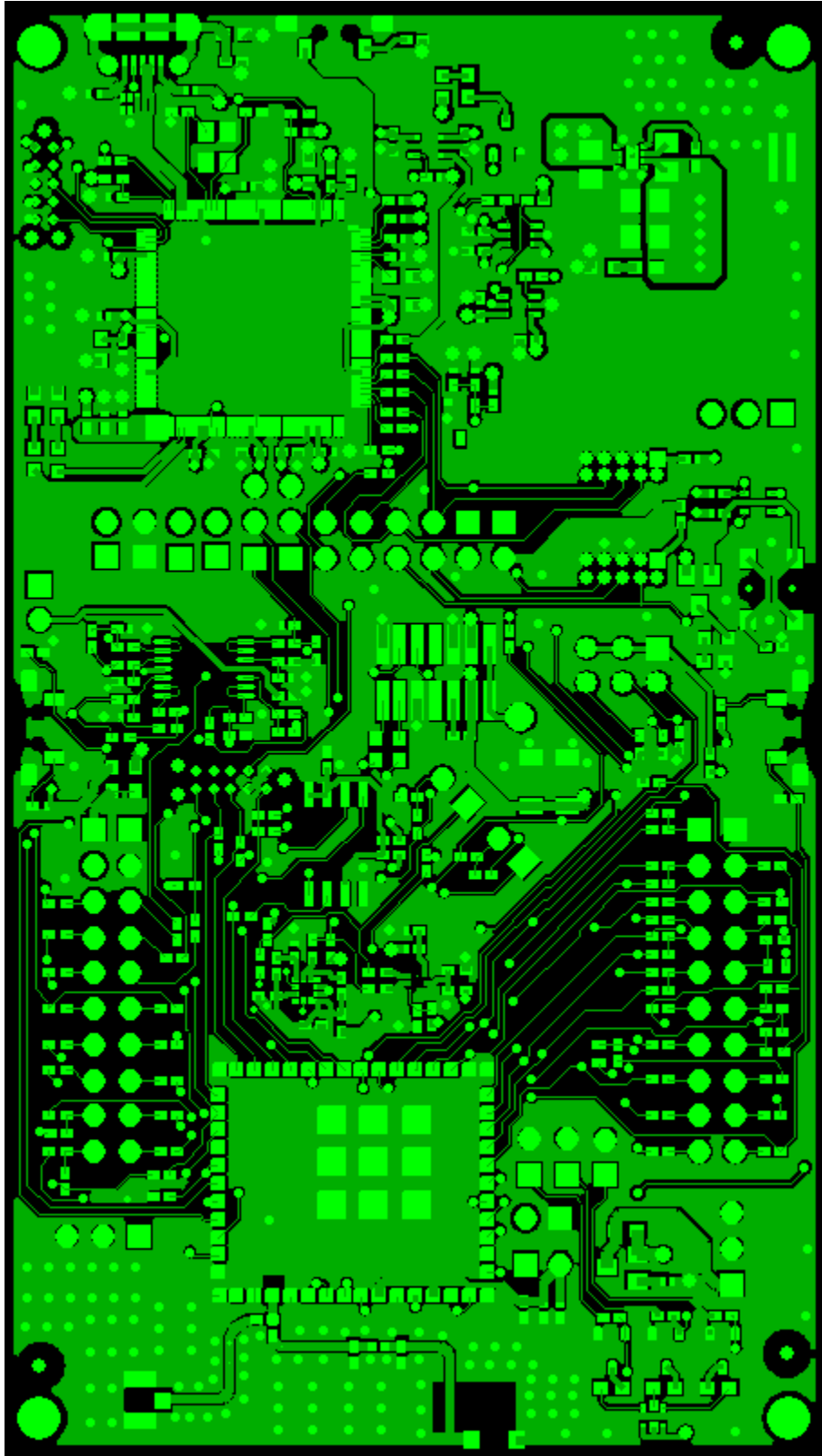


Figure 6-1: CC3220MODx Top Layer

Figure 6-2 shows the CC3220MODx Inner Layer 1.
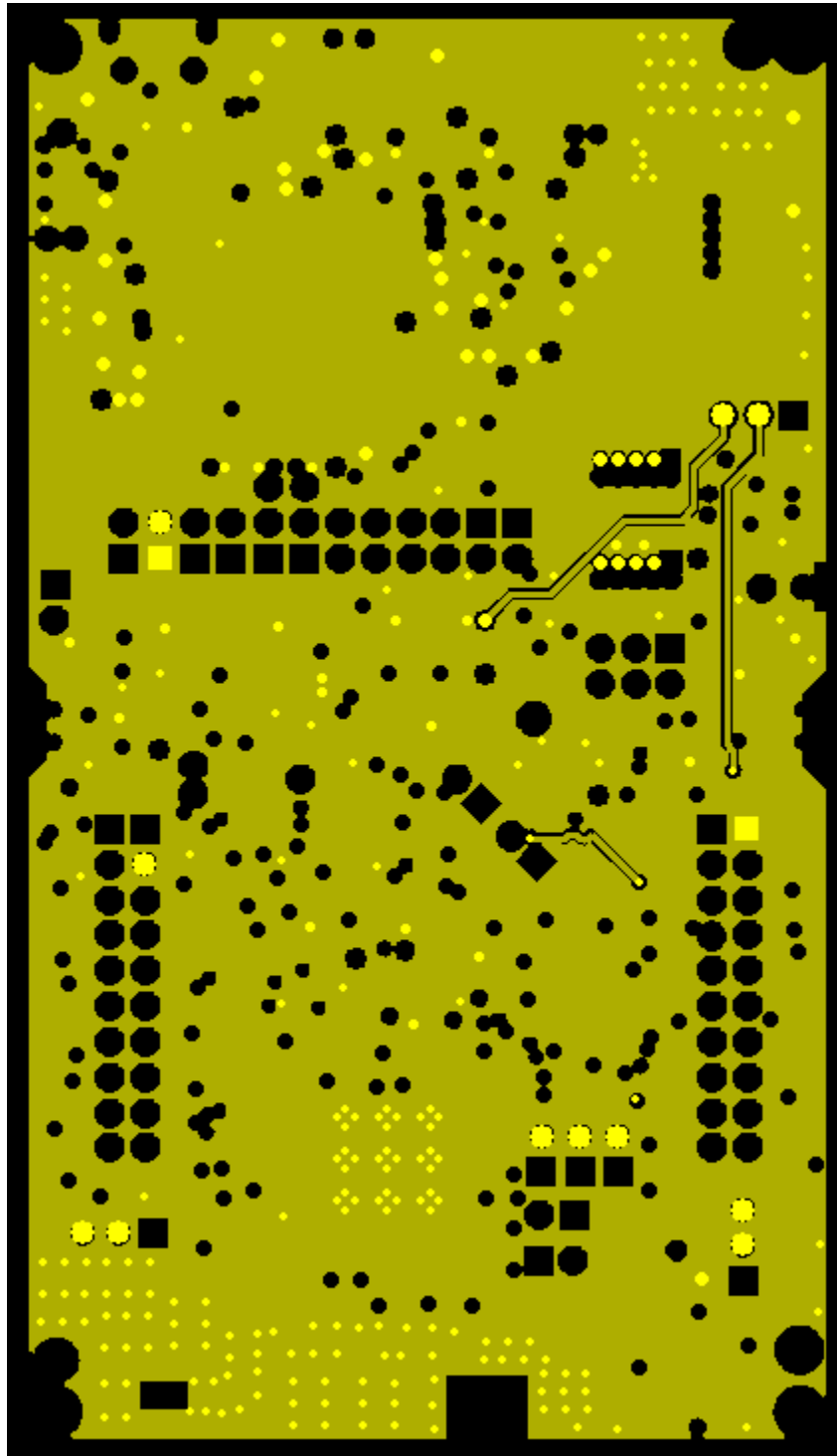


Figure 6-2: CC3220MODx Inner Layer 1

Figure 6-3 shows the CC3220MODx Inner Layer 2.
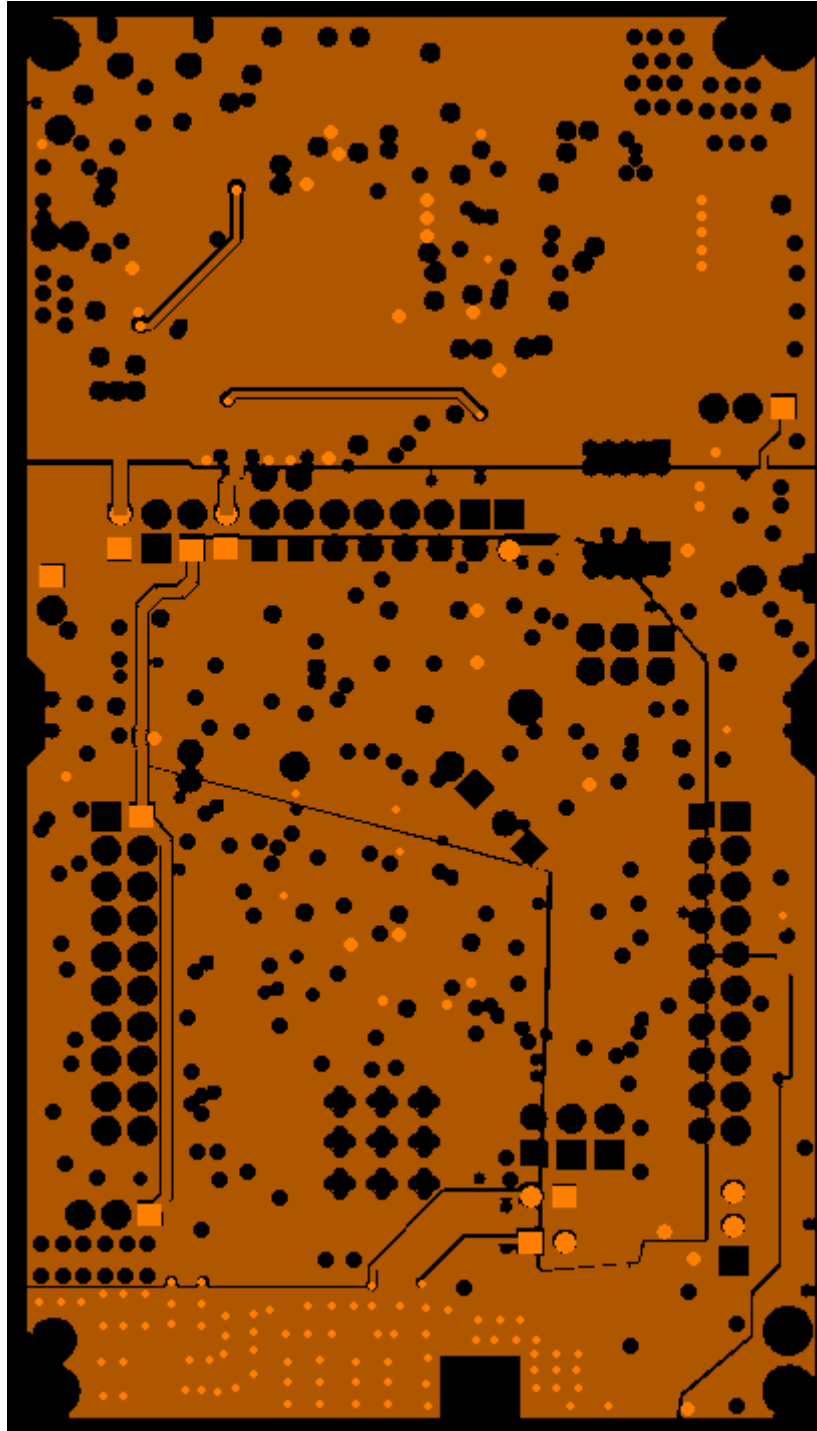


Figure 6-3: CC3220MODx Inner Layer 2

Figure 6-4 shows the CC3220MODx Bottom Layer.
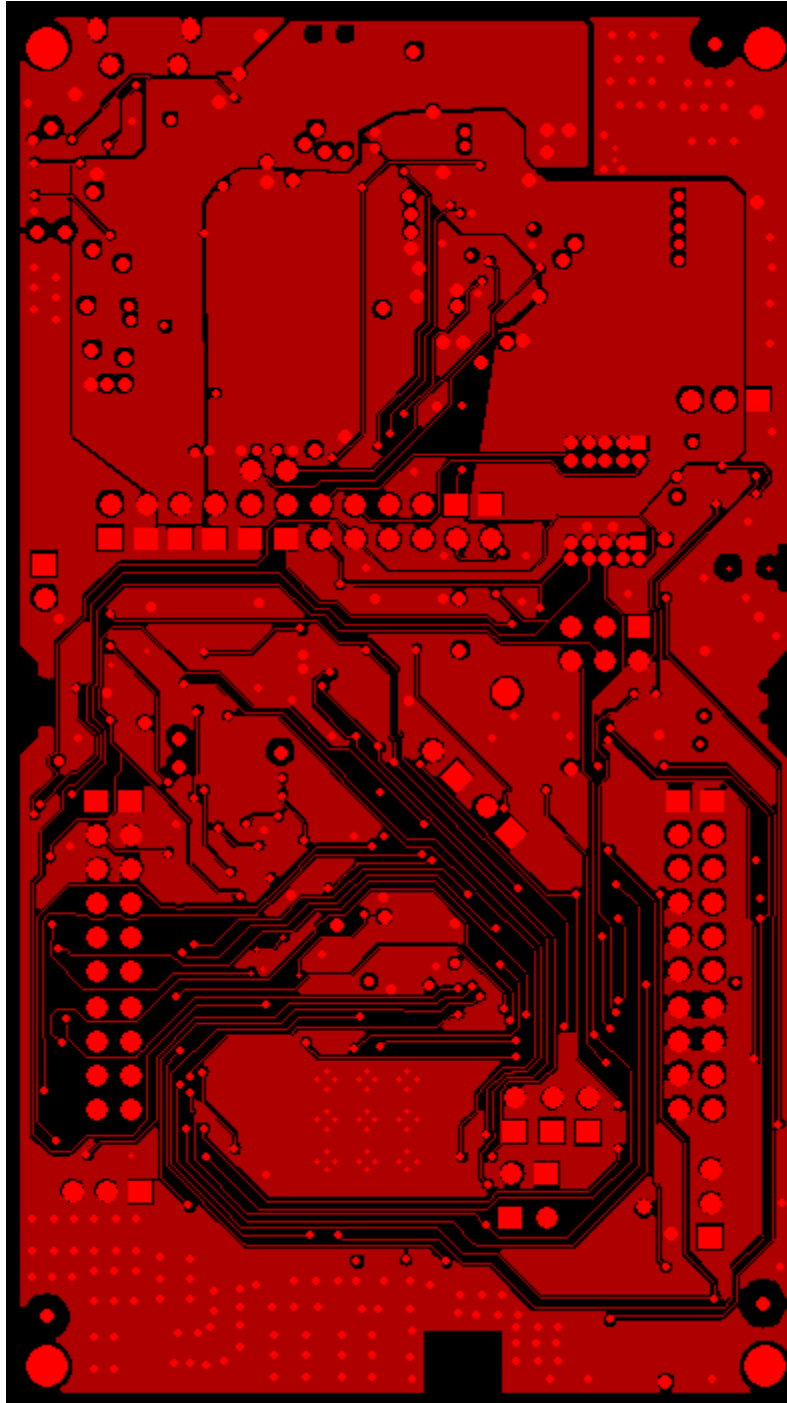
Figure 6-4: CC3220MODx Bottom Layer

## 6.3    CC3220MODAx Board Layout

The reference layout consists of a 4 layer design. Figure 6-5 shows LAUNCHCC3220MODASF Top layer.

Figure 6-5: LAUNCHCC3220MODASF Top Layer

Figure 6-6 shows LAUNCHCC3220MODASF Inner Layer 1.

Figure 6-6: LAUNCHCC3220MODASF Inner Layer 1

Figure 6-7 shows LAUNCHCC3220MODASF Inner Layer 2.

Figure 6-7: LAUNCHCC3220MODASF Inner Layer 2
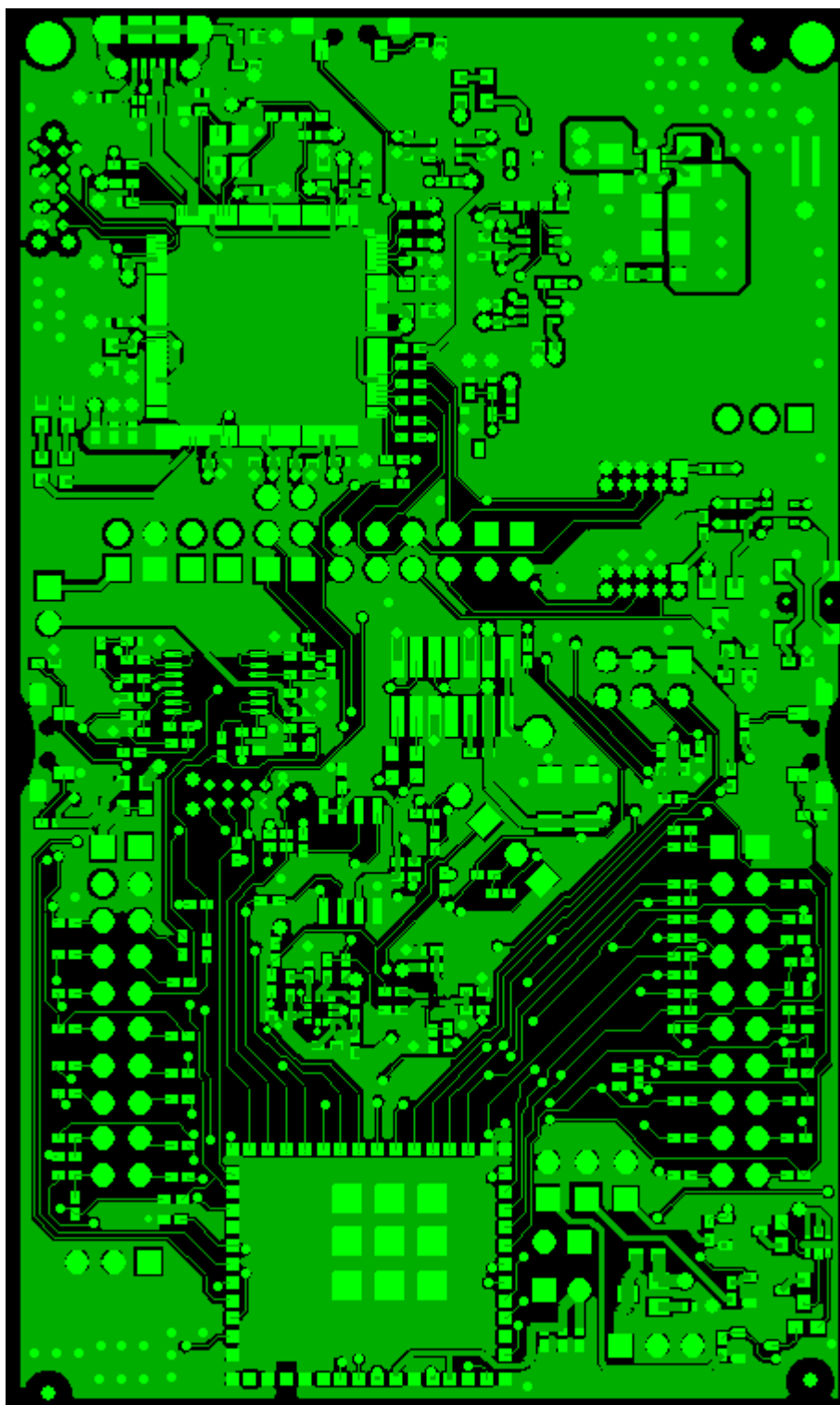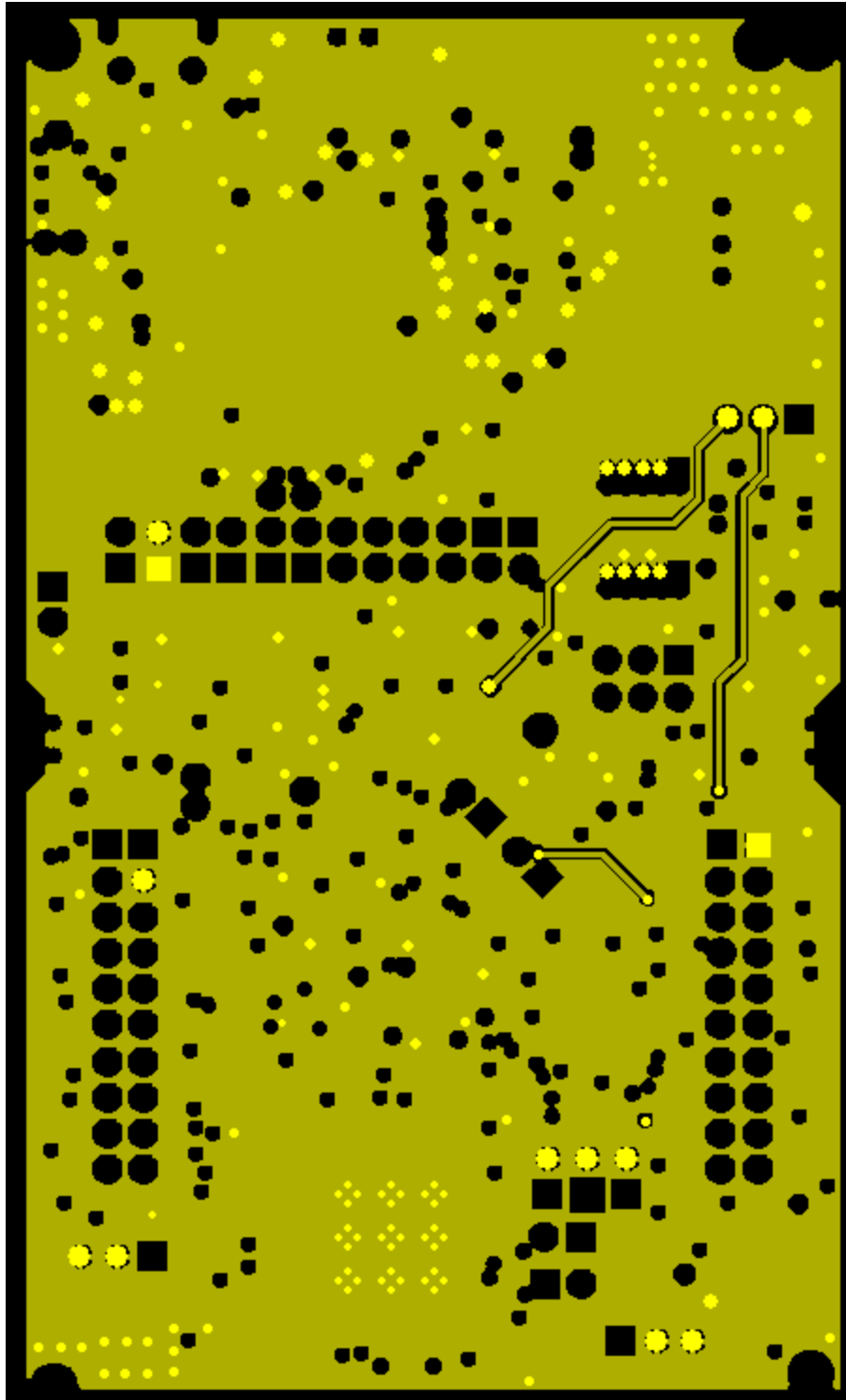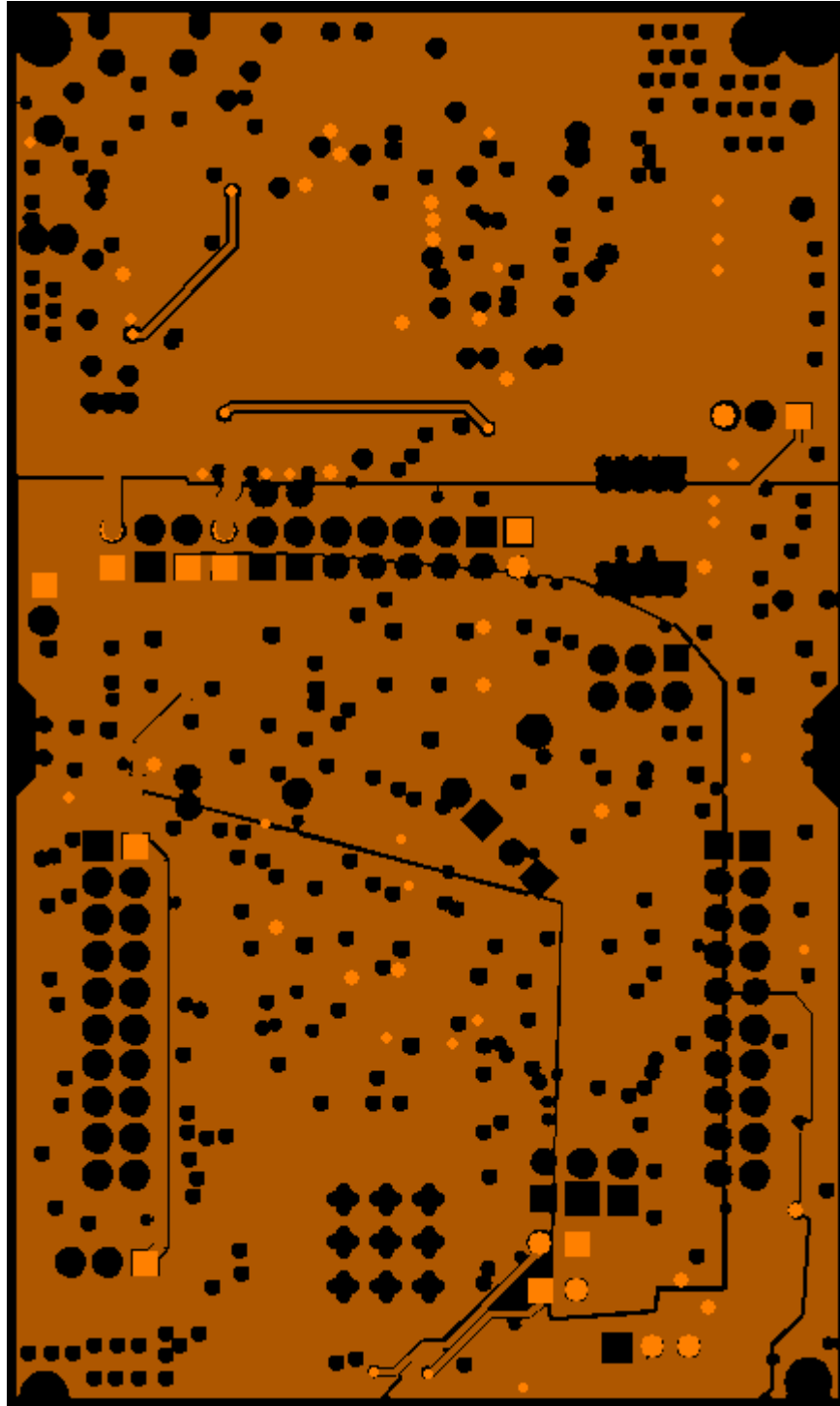
Figure 6-8 shows LAUNCHCC3220MODASF Bottom layer.
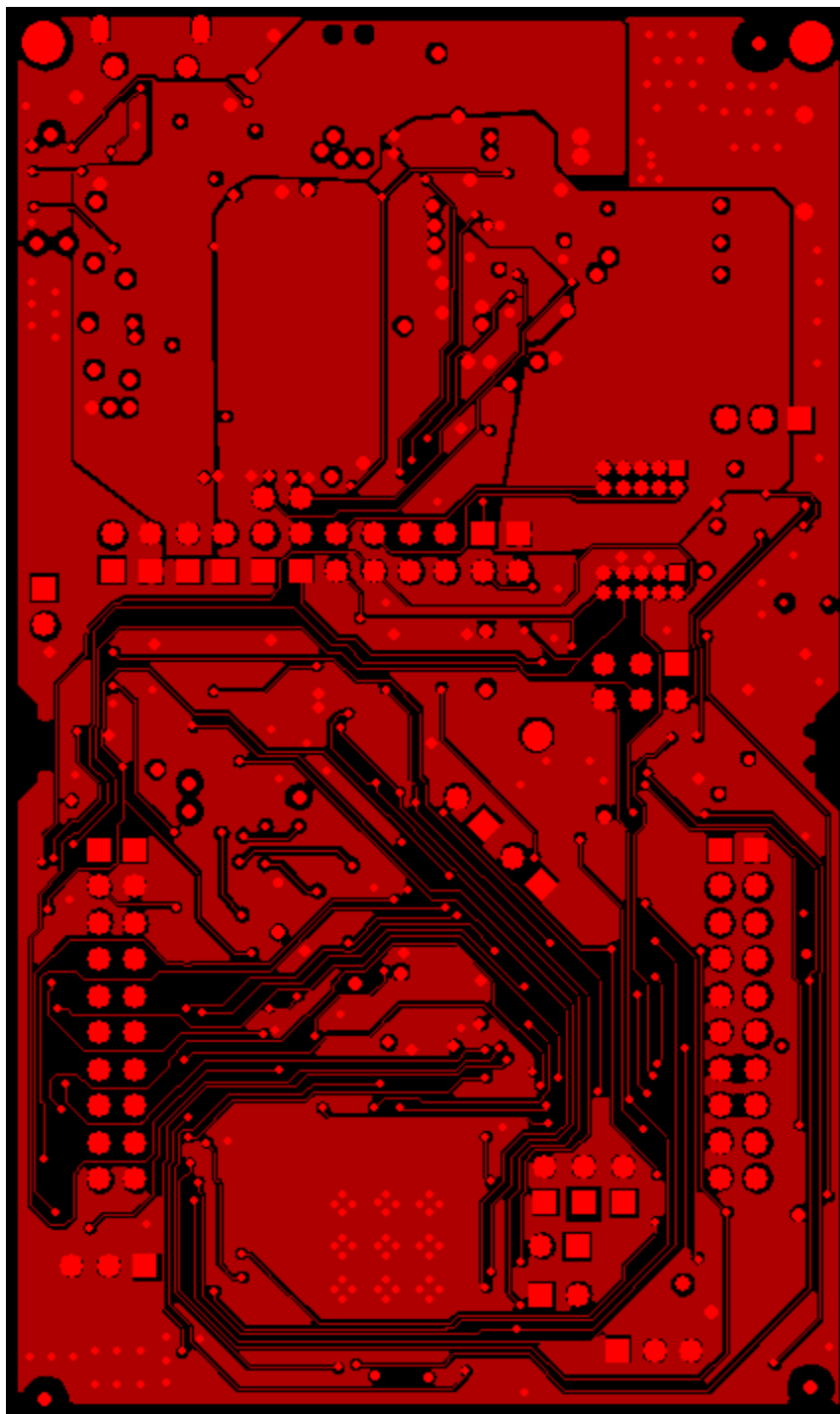
Figure 6-8: LAUNCHCC3220MODASF Bottom Layer

## 6.4    General Layout Recommendations

Ensure that the following general layout recommendations are followed:

- Have a solid ground plane and ground vias under the module for stable system and thermal dissipation.
- Do **not** run signal traces underneath the module on a layer where the module is mounted.
- RF traces must have 50-Ω impedance.
- RF trace bends must be made with gradual curves, and 90 degree bends must be avoided.
- RF traces must **not** have sharp corners.
- There must be no traces or ground under the antenna section.
- RF traces must have via stitching on the ground plane beside the RF trace on both sides.
- RF traces must be as short as possible. The antenna, RF traces, and the module must be on the edge of the PCB product in consideration of the product enclosure material and proximity.

## 6.5    RF Layout Recommendations for the CC3220MODx

The RF section of this wireless device gets top priority in terms of layout. It is very important for the RF section to be laid out correctly to ensure optimum performance from the device. A poor layout can cause low-output power, EVM degradation, sensitivity degradation, and mask violations.

Figure 6-9 shows the RF placement and routing of the CC3220MODx module.



Figure 6-9: RF Section Layout

For optimal RF performance, ensure the copper cut out on the top layer under the RF-BG-pin (pin 31), is as shown in Figure 6-10 below:
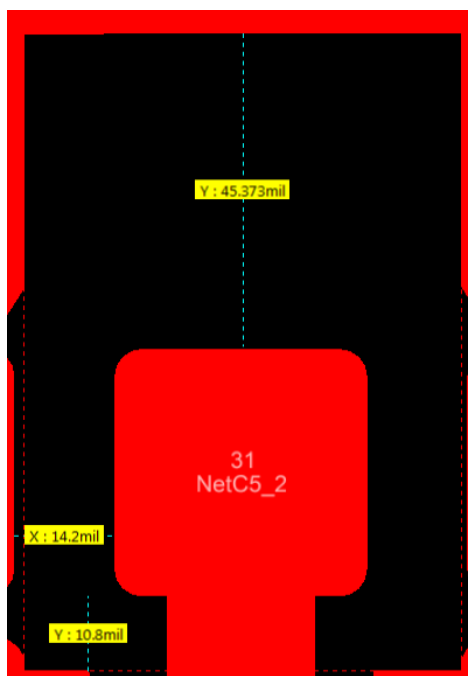
Figure 6-10: Top layer copper pull back on RF pads
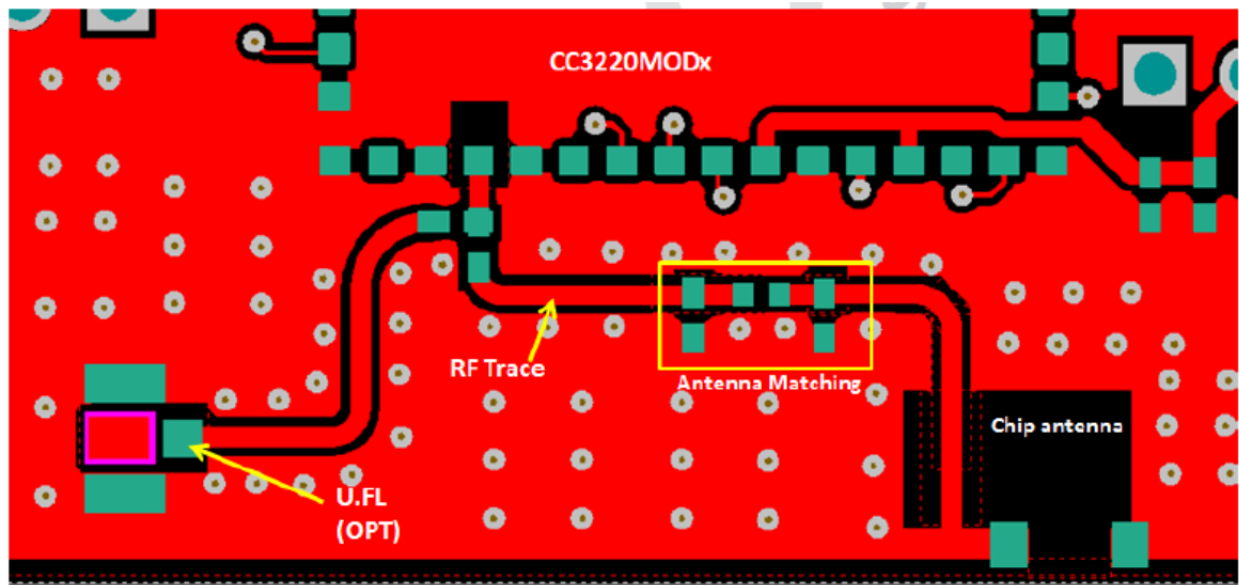
## 6.6 Antenna Placement and Routing for the CC3220MODx

The antenna is the element used to convert the guided waves on the PCB traces to the free space electromagnetic radiation. The placement and layout of the antenna are the keys to increased range and data rates. Table 6-1 provides a summary of the antenna guidelines.

| Item | Guidelines |
|------|------------|
| 1 | Place the antenna on an edge or corner of the PCB. |
| 2 | Ensure that no signals are routed across the antenna elements on all the layers of the PCB. |
| 3 | Most antennas, including the chip antenna used on the booster pack, require ground clearance on all the layers of the PCB. Ensure that the ground is cleared on inner layers as well. |
| 4 | Ensure that there is provision to place matching components for the antenna. These must be tuned for best return loss when the complete board is assembled. Any plastics or casing must also be mounted while tuning the antenna because this can impact the impedance. |
| 5 | Ensure that the antenna impedance is 50 Ω because the device is rated to work only with a 50-Ω system. |
| 6 | In case of printed antenna, ensure that the simulation is performed with the solder mask in consideration. |
| 7 | Ensure that the antenna has a near omni-directional pattern. |
| 8 | The feed point of the antenna is required to be grounded. This is only for the antenna type used on the CC3220MODx reference design. Refer to the specific antenna data sheets for the |

| recommendations. |
| --- |

Table 6-2: Antenna Guidelines

## 6.7    Transmission Line Considerations for the CC3220MODx

The RF signal from the device is routed to the antenna using a Coplanar Waveguide with ground (CPW-G) structure. The CPW-G structure offers the maximum amount of isolation and the best possible shielding to the RF lines. In addition to the ground on the L1 layer, placing GND vias along the line also provides additional shielding. Figure 6-11 shows a cross section of the coplanar waveguide with the critical dimensions.
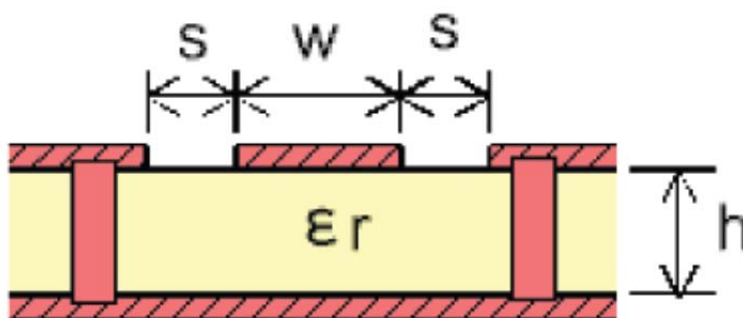
Figure 6-11: Coplanar Waveguide (Cross Section)

Figure 6-12 shows the top view of the coplanar waveguide with GND and via stitching.
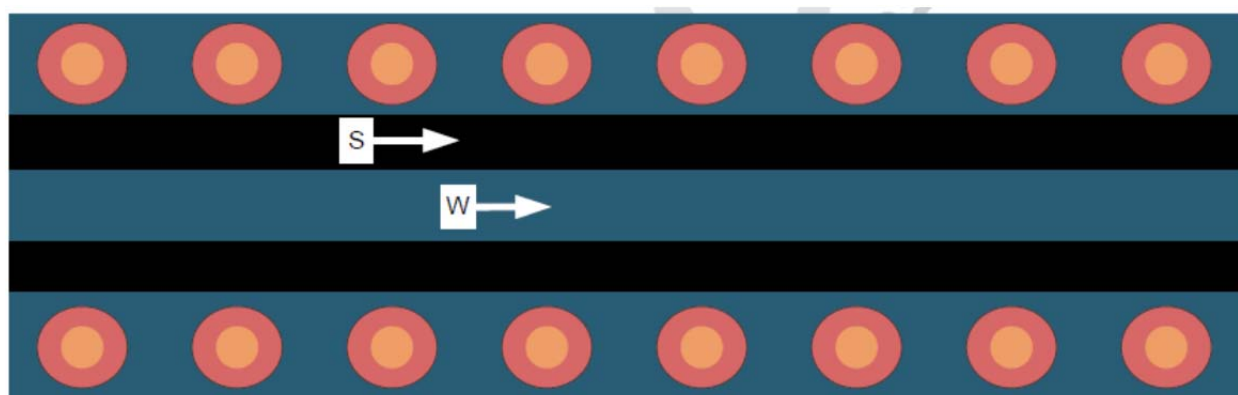
Figure 6-12: CPW with GND and via stitching (Top view)

The recommended values for the PCB are provided for 2-layer boards it Table 6-2 and 4-layer boards in Table 6-3.

| PARAMETER | VALUE | UNIT |
|---|---|---|
| W | 24.5 | mils |
| S | 6.5 | mils |
| H | 42.1 | mils |
| Er (FR-4 substrate) | 4.8 | |

Table 6-2: Recommended PCB Values for 2-Layer Board (L1 to L2 =42.1 mils)

| PARAMETER | VALUE | UNITS |
|---|---|---|
| W | 21 | mils |
| S | 10 | mils |
| H | 16 | mils |
| Er (FR-4 substrate) | 4.5 | |

Table 6-3: Recommended PCB Values for 4-layer Board (L1 to L2 = 16 mils)

## 6.3    RF Layout Recommendations for the CC3220MODAx

Use the following guidelines to lay out the CC3220MODAx module

- The module must have an overhang of 1mm from the PCB edge as show in Figure 6-13 below.
- The module must have a 6mm clearance on all layers (no copper) to the left and right of the module placement as show in Figure 6-13.
- There must be at least one ground reference plane under the module on the main PCB.
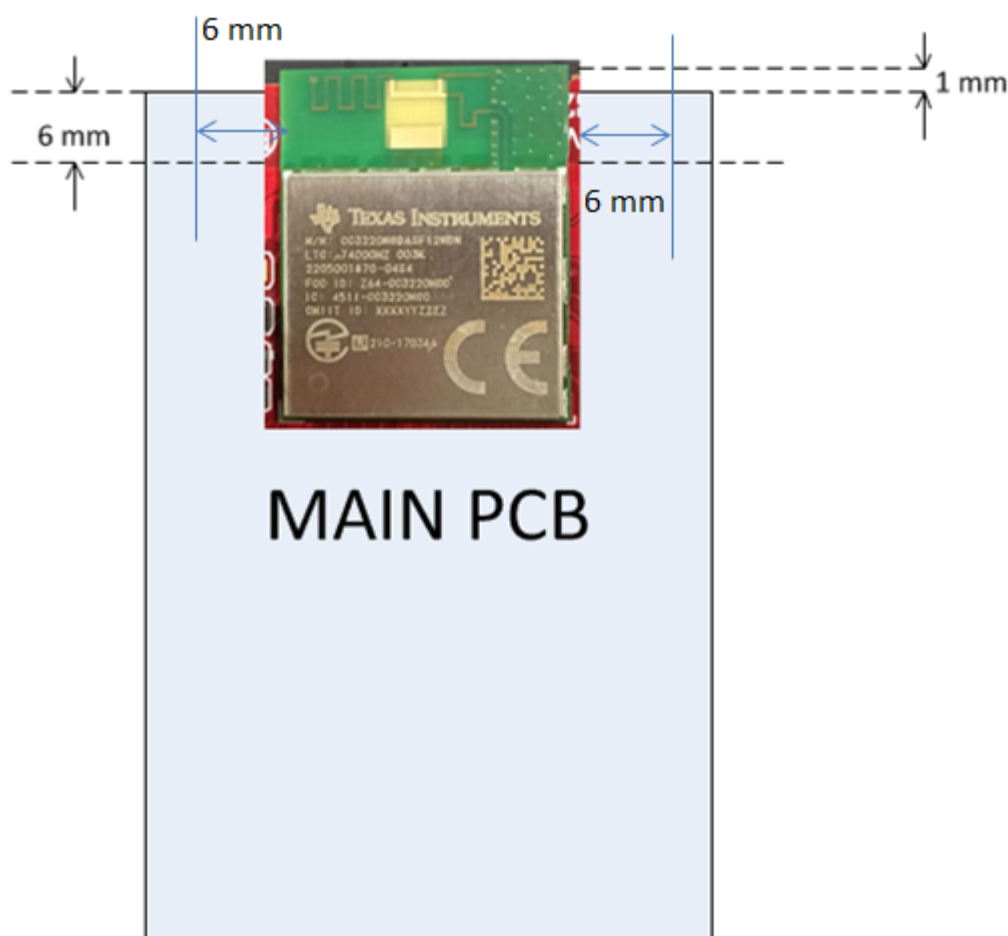
Figure 6-13: CC3220MODAx module placement rules.

# 7.    LAUNCHCC3220MODASF Operational Setup and Testing

A compatible BoosterPack can be stacked on top of the LaunchPad using the 2 × 20-pin connectors. The connectors do not have a *key* to prevent the misalignment of the pins or reverse connection. Ensure that the VCC and 5-V pins are aligned with the BoosterPack header pins. On the CC3220MODASx LaunchPad, a small white symbol is provided near pin 1 (see Figure 7-1) to orient all BoosterPacks.

Figure 7-1: Pin 1 Marking on the LaunchPad (Tag with 3V3 Mark)

## 7.1 Power

The LaunchPad is designed so that it can be powered by the USB connection or by external 2xAA or 2xAAA batteries.

### 7.1.1 USB Power

The LaunchPad is designed to work from the USB provided power supply. The LaunchPad enumerates as a bus-powered device on the computer. When the board is powered from the USB connector, ensure that the jumpers are placed on the following headers, as shown in Figure 7-1.
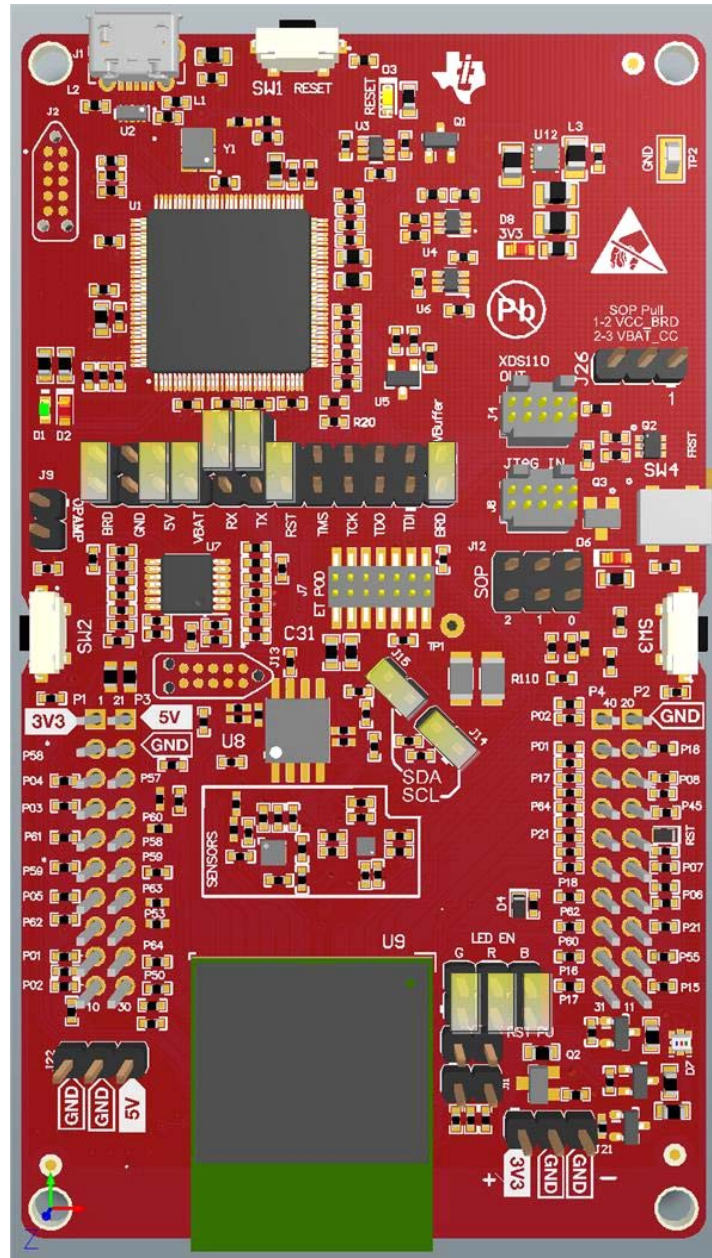
Figure 7-1: Powering from USB (Yellow Blocks Show Jumpers Placed)

## 7.1.2 Battery Power (2x 1.5 V)

The LaunchPad can also be powered from an external battery pack by feeding the voltage on the J21 header. This input features reverse voltage protection to ensure that the board is not damaged due to an accidental reverse voltage. Take the following precautions while using the board with a battery.

1) Remove the USB cable.
2) Plug-in the battery pack on J20 with correct polarity (see Figure 7-2 below).

Figure 7-3: Battery Power

### 7.1.3 Battery Powering Only the CC3220MODASF and Serial Flash

In cases, there may be a requirement to power only the CC3220MODASF module and the serial flash from the battery. The use may not require LEDs, or OPAMP for the ADC and the sensors. In such a condition, the other sections can be powered off by removing the appropriate jumpers. Figure 7-4 shows how the board would look with the correct jumpers on.
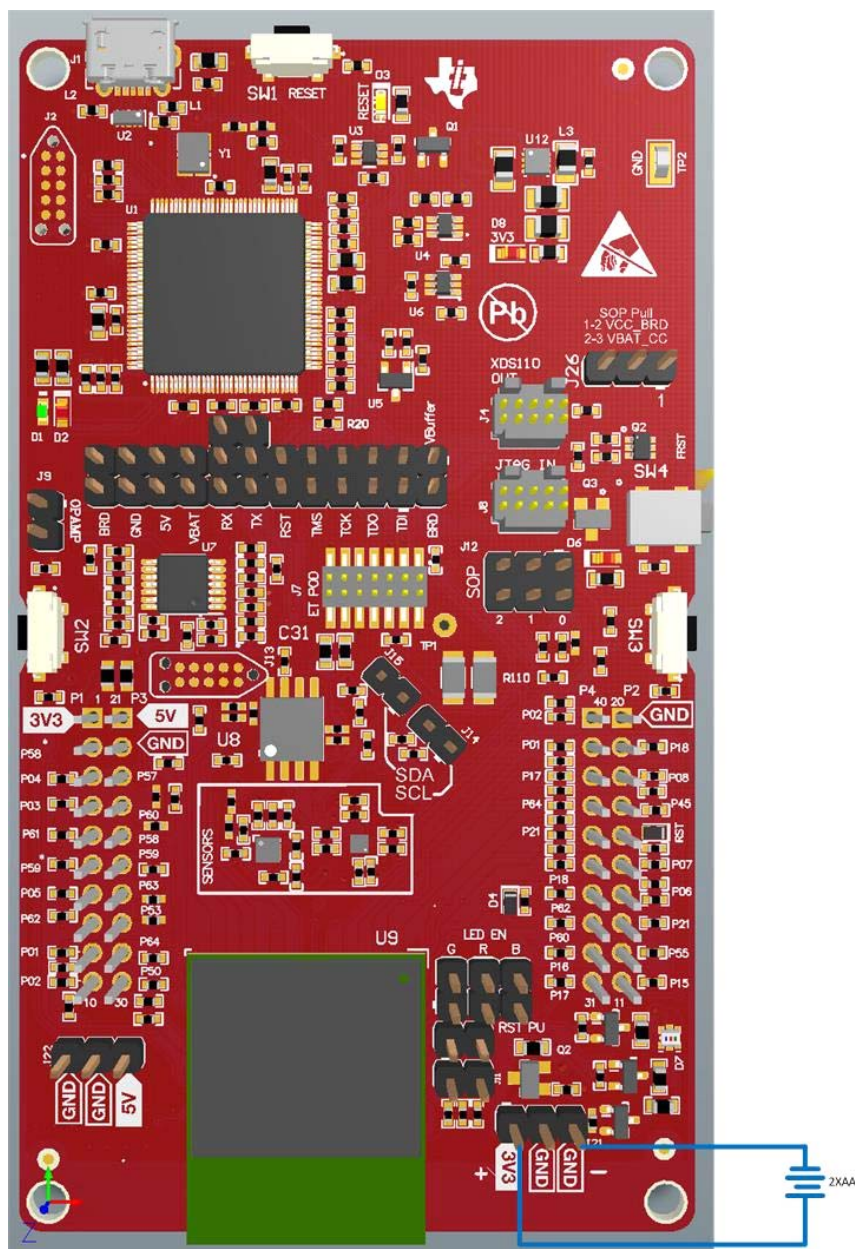
Figure 7-4: Battery Powering Only the CC3220MODASF and Serial Flash

## 7.2    Measuring the CC3220MODAx Current Draw

To measure the current draw of the CC3220 device, use the VBAT jumper on the jumper isolation block (J18). The current measured in this mode includes only the CC3220MODASx device and the serial flash current and no external blocks. However, if a GPIO of the CC3220MODASx is driving a high current load like the LED, then that is also included in this measurement.

### 7.2.1 Low-Current Measurements (<1mA)

Follow these steps to measure ultra-lower power (See Figure 7-5 below)

1. Remove the 3V3 jumper (J18) and attach an ammeter across this jumper.
2. Ensure that the CC3220MODASx device is not driving any high current loads directly, like an LED, because that can cause large current drawn.
3. Begin target execution and set the device to low-power modes (LPDS or hibernate).
4. Measure the current. Remember that if the current levels are fluctuating, it may be difficult to get a stable measurement. It is easier to measure quiescent states
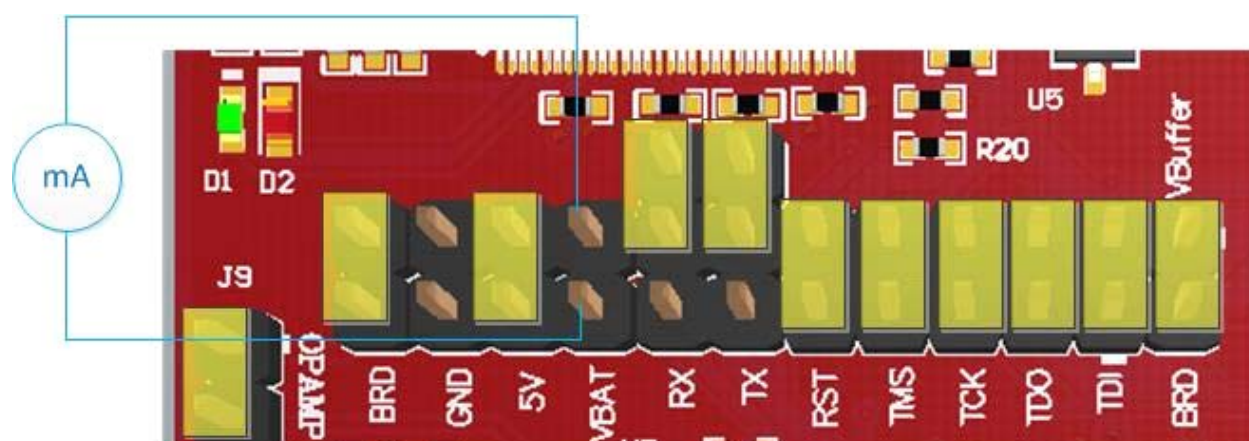


Figure 7-5: Low-Current Measurement

### 7.2.2 Active Current Measurements

Follow these steps to measure active power (See Figure 7-6 below)

1. Remove the VBAT jumper (J18).
2. Solder a 0.1-$\Omega$ resistor on a wire which can be connected to a voltmeter/oscilloscope, as shown in Figure 14. Or, attach a jumper across J18 so that it can be used with a current probe.
3. Measure the voltage across the resistor using an oscilloscope with a differential probe. For the current probe, coil the wire around the sensor several times for good sensitivity.
4. An ammeter can also be used for this measurement, but the results may be erroneous due to the switching nature of the current.
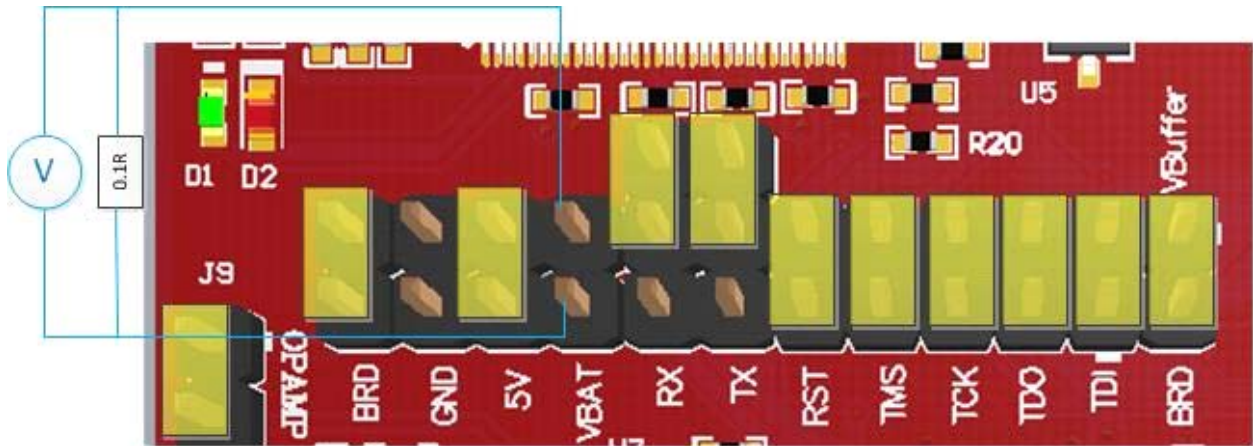
Figure 7-6: Active Current Measurement

## 7.3    Clocking

All of the required clocks are inside the module. There is no need to supply any external clock.

## Manual Information to the End User

The OEM integrator must be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual must include all required regulatory information/warning as shown in this manual.

## 1. RF Function and Frequency Range

The CC3220MODSM2MOB, CC3220MODSF12MOB, CC3220MODASM2MON and CC3220MODASF12MON are designed to operate in the WLAN 2.4GHz band. The CC3220MODSM2MOB, CC3220MODSF12MOB, CC3220MODASM2MON and CC3220MODASF12MON support the following channels dependent on the region of operation:

- FCC / IC: Channels 1 through 11 (2142 MHz to 2462 MHz)
- EU: Channels 1 through 13 (2142 MHz to 2472 MHz)
- JP: Channels 1 through 13 (2142 MHz to 2472 MHz)

Note that the CC3220MODx and CC3220MODAx do not support determination of its region thru any external mechanism. The region is set by the application SW or at the time of programming of the device. The end user is unable to change the region of operation at any time.

| NOTE: |
|---|
| The maximum RF power transmitted in each WLAN 2.4GHz band is 18 dBm. |

## 2. FCC /IC Certification and Statement

This device is intended for OEM integrators under the following conditions:

- The antenna must be installed such that 20 cm is maintained between the antenna and users,
- The transmitter module may not be co-located with any other transmitter or antenna.
- To comply with FCC / IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile exposure condition must not exceed:

  - 2.5 dBi in WLAN 2.4G

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC / IC authorization is no longer considered valid and the FCC / IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC / IC authorization.

## 2.1 FCC

The TI CC3220MODx and CC3220MODAx modules are certified for FCC as a single-modular transmitter. The module is an FCC-certified radio module that carries a modular grant.

You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation of the device.

| CAUTION |
| --- |
| **FCC RF Radiation Exposure Statement:**<br>This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and your body. |

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from the one the receiver is connected too.
- Consult the dealer or an experienced radio or TV technician for help.

The antenna listing in Section 3.5 of this document were verified in the compliance testing. Use only the antennas on this list. A separate approval is required for all other operating configurations, including different antenna configurations

## 2.2 CAN ICES-3(B)/NMB-3(B) Certification and Statement

The TI CC3220MODx and CC3220MODAx modules are certified for IC as a single-modular transmitter. The TI CC3220MODx and CC3220MODAx modules meet IC modular approval and labeling requirements. The IC follows the same testing and rules as the FCC regarding certified modules in authorized equipment.

This device complies with Industry Canada license-exempt RSS standards.

Operation is subject to the following two conditions:

- This device may not cause interference.
- This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

- L'appareil ne doit pas produire de brouillage
- L'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

---

**CAUTION**

**IC RF Radiation Exposure Statement:**
This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 cm between the radiator and your body.

**Déclaration d'exposition aux radiations:**
Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

---

This radio transmitter (451I-CC3120MOD) has been approved by Industry Canada to operate with the antenna types listed in Section 3.5 of this document with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

The antenna listing in Section 3.5 of this document were verified in the compliance testing. Use only the antennas on this list. A separate approval is required for all other operating configurations, including different antenna configurations.

## 2.3  End Product Labeling

This module is designed to comply with the FCC statement, FCC ID: Z64-CC3220MOD. The host system using this module must display a visible label indicating the following text:

- Contains FCC ID: Z64-CC3220MOD

This module is designed to comply with the IC statement, IC: 451I-CC3220MOD. The host system using this module must display a visible label indicating the following text:

- Contains IC: 451I-CC3220MOD

This module is designed to comply with the JP statement, 201-170386. The host system using this module must display a visible label indicating the following text:

- Contains transmitter module with certificate number 201-170386

## 2.4    Device Classifications

Since host devices vary widely with design features and configurations module integrators shall follow the guidelines below regarding device classification and simultaneous transmission, and seek guidance from their preferred regulatory test lab to determine how regulatory guidelines will impact the device compliance. Proactive management of the regulatory process will minimize unexpected schedule delays and costs due to unplanned testing activities.

The module integrator must determine the minimum distance required between their host device and the user's body. The FCC provides device classification definitions to assist in making the correct determination.  Note that these classifications are guidelines only; strict adherence to a device classification may not satisfy the regulatory requirement as near-body device design details may vary widely.  Your preferred test lab will be able to assist in determining the appropriate device category for your host product and if a KDB or PBA must be submitted to the FCC.

Note, the module you are using has been granted modular approval for mobile applications.  Portable applications may require further RF exposure (SAR) evaluations.  It is also likely that the host / module combination will need to undergo testing for FCC Part 15 regardless of the device classification.  Your preferred test lab will be able to assist in determining the exact tests which are required on the host / module combination.

## 2.5    FCC Definitions

**Portable: (§2.1093)** — A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is / are within 20 centimeters of the body of the user.

**Mobile: (§2.1091) (b)** — A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.  Per §2.1091d(d)(4) In some cases (for example, modular or desktop transmitters), the potential conditions of use of a device may not allow easy classification of that device as either Mobile or Portable. In these cases, applicants are responsible for determining minimum

distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength, or power density, whichever is most appropriate.

## 2.6     Simultaneous Transmission Evaluation

This module has not been evaluated or approved for simultaneous transmission as it is impossible to determine the exact multi-transmission scenario that a host manufacturer may choose.  Any simultaneous transmission condition established through module integration into a host product must be evaluated per the requirements in KDB447498D01(8) and KDB616217D01,D03 (for laptop, notebook, netbook, and tablet applications).

These requirements include, but are not limited to:

- Transmitters and modules certified for mobile or portable exposure conditions can be incorporated in mobile host devices without further testing or certification when:
- The closest separation among all simultaneous transmitting antennas is >20 cm,

Or

- Antenna separation distance and MPE compliance requirements for ALL simultaneous transmitting antennas have been specified in the application filing of at least one of the certified transmitters within the host device.  In addition, when transmitters certified for portable use are incorporated in a mobile host device, the antenna(s) must be >5 cm from all other simultaneous transmitting antennas.
- All antennas in the final product must be at least 20 cm from users and nearby persons.

## 3.     EU Certification and Statement

### 3.1     RF Exposure Information (MPE)

This device has been tested and meets applicable limits for Radio Frequency (RF) exposure. To comply with the RF exposure requirements, this module must be installed in a host platform that is intended to be operated in a minimum of 20 cm separation distance to the user.

### 3.2     Simplified DoC statement

Hereby, Texas Instruments declares that the radio equipment type CC3220MODSM2MOB, CC3220MODSF12MOB, CC3220MODASM2MON and CC3220MODASF12MON is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address:

- CC3220MODSM2MOB: http://www.ti.com/lit/pdf/SSZQ061
- CC3220MODSF12MOB: http://www.ti.com/lit/pdf/SSZQ062

- CC3220MODASM2MON: http://www.ti.com/lit/pdf/SSZQ063
- CC3220MODASF12MON: http://www.ti.com/lit/pdf/SSZQ064

## 3.3 Waste Electrical and Electronic Equipment (WEEE)

| | |
|---|---|
| | **Waste Electrical and Electronic Equipment (WEEE)**<br><br>This symbol means that according to local laws and regulations your product and/or battery shall be disposed of separately from household waste. When this product reaches its end of life, take it to a collection point designated by local authorities. Proper recycling of your product will protect human health and the environment. |

## 3.4 OEM / Host manufacturer responsibilities

OEM/Host manufacturers are ultimately responsible for the compliance of the Host and Module. The final product must be reassessed against all the essential requirements of the RED before it can be placed on the EU market. This includes reassessing the transmitter module for compliance with the Radio and EMF essential requirements of the RED. This module must not be incorporated into any other device or system without retesting for compliance as multi-radio and combined equipment.

## 3.5 Antenna specifications

In all cases, assessment of the final product must be met against the Essential requirements of RE Directive Article 3.1(a) and (b), safety and EMC respectively, as well as any relevant Article 3.3 requirements.

1. The following antennas were verified in the conformity testing, and for compliance the antenna shall not be modified. A separate approval is required for all other operating configurations, including different antenna configurations.

| | Antenna Information | | | |
|---|---|---|---|---|
| | **Brand** | **Antenna Type** | **Model** | **2.4GHz gain** |
| 1 | FoxCon | PCB | T77H533 | 2.5dBi |
| 2 | Ethertronics | Dipole | 1000423 | -0.6dBi |
| 3 | LSR | Rubber Whip / Dipole | 001-0012 | 2dBi |
| 4 | | | 080-0013 | 2dBi |
| 5 | | | 080-0014 | 2dBi |
| 6 | | PIFA | 001-0016 | 2.5dBi |
| 7 | | | 001-0021 | 2.5dBi |
| 8 | Laird | PCB | CAF94504 | 2dBi |
| 9 | | | CAF9405 | 2dBi |
| 10 | ACX | Multilayer Chip | AT3216-BR2R7HAA | 0.5dBi |
| 11 | | | AT312-T2R4PAA | 1.5dBi |
| 12 | TDK | Multilayer Ceramic Chip Antenna | ANT016008LCD2442MA1 | 1.6dBi |
| 13 | | | ANT016008LCD2442MA2 | 2.5dBi |
| 14 | Mitsubishi Material | Chip Antenna | AM03DP-ST01 | 1.6dBi |
| 15 | | Antenna Unit | UB18CP-100ST01 | -1.0dBi |
| 16 | Taiyo Yuden | Chip Antenna / Herical Monopole | AF216M245001 | 1.5dBi |
| 17 | | Chip Antenna /Monopole Type | AH212M245001 | 1.3dBi |
| 18 | | | AH316M245001 | 1.9dBi |
| 19 | Antenna Technology | Dipole | AA2402SPU | 2.0dBi |
| 20 | | | AA2402RSPU | 2.0dBi |
| 21 | | | AA2402A-UFLLP | 2.0dBi |
| 22 | | | AA2402AU-UFLLP | 2.0dBi |
| 23 | Staf | Mono-pole | 1019-016 | 2.14dBi |
| 24 | | | 1019-017 | 2.14dBi |
| 25 | | | 1019-018 | 2.14dBi |
| 26 | | | 1019-019 | 2.14dBi |
| 27 | Map Electronics | Rubber Whip | MEIWX-2411SAXX-2400 | 2.0dBi |
| 28 | | | MEIWX-2411RSXX-2400 | 2.0dBi |
| 29 | | | MEIWX-282XSAXX-2400 | 2.0dBi |
| 30 | | | MEIWX-282XRSXX-2400 | 2.0dBi |
| 31 | | | MEIWF-HP01RS2X-2400 | 2.0dBi |
| 32 | Yageo | Chip | ANT3216A063R2400A | 1.69dBi |
| 33 | Mag Layers Scientific | Chip | LTA-3216-2G4S3-A1 | 1dBi |
| 34 | | | LTA-3216-2G4S3-A3 | 2dBi |
| 35 | Advantech | Rubber Whip / Dipole | AN2450-5706RS | 2.38dBi |

2. If any other simultaneous transmission radio is installed in the host platform together with this module, or above restrictions cannot be kept, a separate RF exposure assessment and CE equipment certification is required.