Panasonic
INDUSTRY

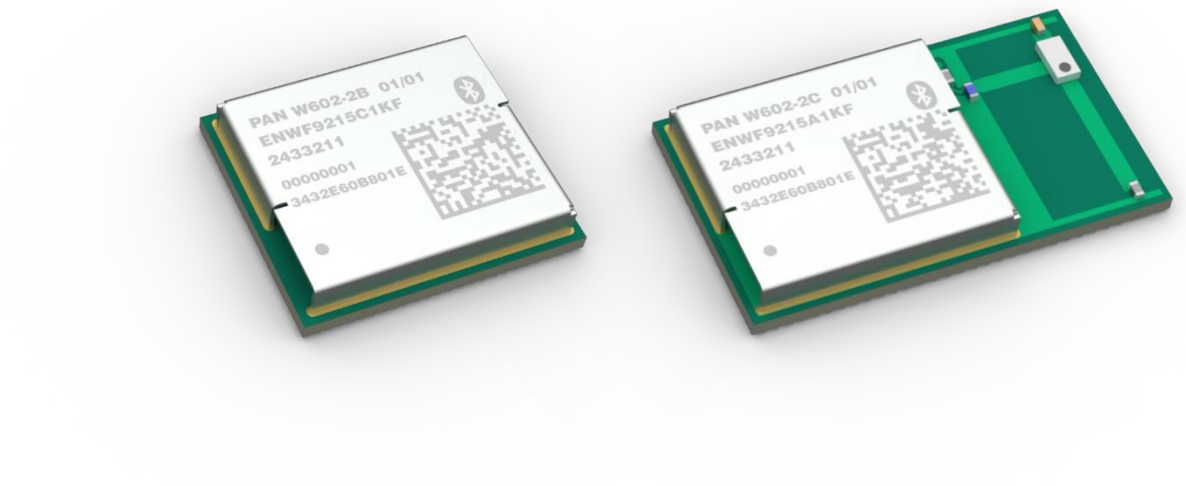
PAN W602-xx

Wi-Fi Single-Band 2.4 GHz and Bluetooth® Module

Wi-Fi Dual-Band 2.4/5 GHz and Bluetooth® Module

Module Integration Guide

Rev. 1.0



Wireless Connectivity

Overview

The PAN W602-1x is a single band 2.4 GHz companion module with integrated Bluetooth® Low Energy for cost-effective projects and is based on the chipset CC3301 from Texas Instruments.

The PAN W602-2x is a dual band 2.4 & 5 GHz companion module with integrated Bluetooth® Low Energy for projects which require more data rates or less interferences and is based on the chipset CC3351 from Texas Instruments.

In a compact form factor the module either comes with an integrated chip antenna or the option to connect an external antenna via the bottom Pad.

Latest technologies like multiuser MIMO and OFDMA improve the efficiency in large networks. Integrated power management, 802.11i/w security standard support, and high-speed data interfaces deliver the performance for the speed, reliability, and quality requirements of next generation products

Features

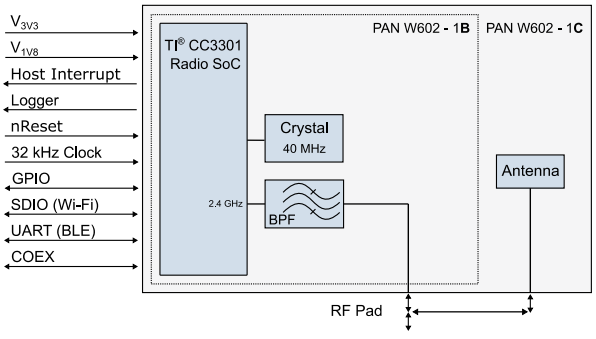
- Single or Dual band (2.4 GHz & 5 GHz) 802.11 a/b/g/n/ax Wi-Fi
- Bluetooth® 5.4 Low Energy (1M, 2M, LE Coded PHY)
- WPA3 Personal and Enterprise as station
- Multirole support: Access point & station
- WiFi 6: Target Wake Time (TWT), OFDMA, MU-MIMO (Downlink), Basic Service Set Coloring
- Simultaneous operation of Wi-Fi and Bluetooth®
- IEEE 802.11ax, 1×1 spatial stream with data rates up to 86 Mbps (MCS7, 20 MHz channel bandwidth)
- Enhanced security such as firmware authentication and anti-rollback protection
- Support for host processors running a Linux® operating system

Characteristics

- Integrated Antenna or Bottom Pad Version
- Dimensions [mm]
  - Bottom Pad: 8.8 x 10.0 x 1.8
  - Integrated Antenna: 8.8 x 15.25 x 1.8
- Host Interface
  - WiFi: SDIO 2.0 (1.8 V)
  - Bluetooth®: Highspeed UART (1.8 V)
- Coexistence: 3-wire or 1-wire PTA for external coexistence with additional 2.4-GHz radios
- Tx power: up to +16 dBm
- 20 MHz channel bandwidth
- Rx Sensitivity: -96 dBm at IEEE 802.11b 1 Mbps
- Power supply: 1.8 V (core and I/O) and 3.3 V (PA)
- Wide temperature range: -40 °C to +85 °C
- **Typical current consumption**
  - Tx: 115mA (V_{1V8}) and 215mA (V_{3V3}) @ 802.11ax (HE MCS7) 2.4 GHz, Rx: 62mA @ 2.4 GHz
  - Tx: 175mA (V_{1V8}) and 190mA (V_{3V3}) @ 802.11ax HE MCS7) 5 GHz, Rx: 110mA @ 5 GHz
- **Low Power Shutdown Mode**
  - 313 uA @ 2.4 GHz
  - 348 uA @ 5 GHz

Block Diagram

PAN W602 - 1x
Wi-Fi 6 & Bluetooth® Radio Module
IEEE 802.11 b/g/n/ax
Bluetooth® Low Energy



PAN W602 - 2x
Wi-Fi 6 & Bluetooth® Radio Module
IEEE 802.11 a/b/g/n/ax
Bluetooth® Low Energy

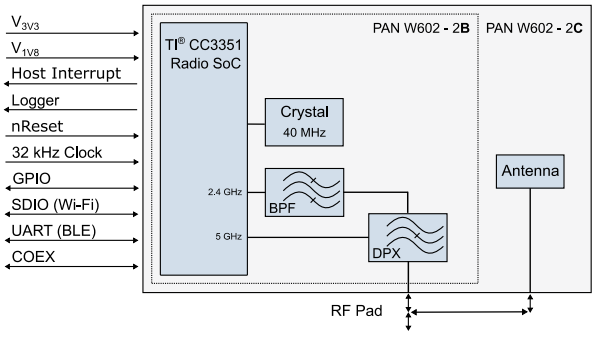


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Table of Contents

1 About This Document

1.1 Purpose and Audience

This Module Integration Guide is intended to support the easy integration of the PAN W602-xx into a product and to ensure the compliance with regulatory requirements.

This guide gives an overview of the hardware design requirements by providing a reference design, which is the evaluation board of the PAN W602-xx. It describes how to use the PAN W602-xx on the evaluation board with the software packages and tools provided by Texas Instruments (TI).

It is intended for hardware design, application, and Original Equipment Manufacturers (OEM) engineers.

The product is referred to as “PAN W602-xx” and “module” within this document.

1.2 Revision History

Revision	Date	Modifications/Remarks
1.0	2026-07-23	Initial release

1.3 Use of Symbols

Symbol	Description
	**Note** Indicates important information for the proper use of the product. Non-observance can lead to errors.
	**Attention** Indicates important notes that, if not observed, can put the product’s functionality at risk.
	**Tip** Indicates useful information designed to facilitate working with the software.
⇨ [chapter number] [chapter title]	**Cross reference** Indicates cross references within the document. **Example:** Description of the symbols used in this document ⇨ 1.3 Use of Symbols.
✓	**Requirement** Indicates a requirement that must be met before the corresponding tasks can be completed.
➔	**Result** Indicates the result of a task or the result of a series of tasks.
This font	**GUI text** Indicates fixed terms and text of the graphical user interface. **Example:** Click **Save**.

Symbol	Description
Menu > **Menu item**	**Path** Indicates a path, e.g. to access a dialog. **Example:** In the menu, select **File** > **Setup page**.
`This font`	**File names** Indicates file names displayed on the screen or to be selected by the user. **Examples:** `pan1760.c` contains the actual module initialization.

`This font`	**Messages, user input, code**
	Indicates messages, information, and code displayed on the screen or to be entered by the user.
	Examples:
	The message `Failed to save your data` is displayed.
	Enter the value `Product 123`.
	Copy firmware binaries to firmware library:
	`$> cd ${TOP}/…`
	`$> …`

Key	**Key** Indicates a key on the keyboard. **Example:** Press **F10**.

1.4 Related Documents

For related documents please refer to the Panasonic website ⇨ 11.2 Product Information.

2 Overview

The PAN W602-1x and PAN W602-2x are the single (2.4 GHz-Band) and dual-band (2.4 GHz 5 GHz-Band) variants of the PAN W602-xx module family. Both variants are available for external antenna use (PAN W602-xB) or the usage of an internal chip antenna (PAN W602-xC).

The module family is capable to support 802.11 a/b/g/n/ax and Bluetooth® Low Energy (LE) specifically designed for highly integrated and cost-effective applications. The independent operation of the standards enables 802.11ax data rates with high efficiency (HE) and low-power operation (Bluetooth® LE).

Latest technologies like multiuser MIMO and OFDMA improve efficiency in large networks, while the 64-QAM modulation allows high data rates. Integrated power management and SDIO high-speed data interface deliver the performance for speed, reliability, and quality requirements of products with cost and power sensible characteristic. Tx power calibration data and other system parameters were stored in a configuration file located at the Linux Host. Data like conf-Key and MAC addresses are pre-stored on the one-time-programmable memory of the PAN W602-xx during production at Panasonic. Thus, the module reduces design, test, and calibration effort resulting in reduced time-to-market compared to discrete solutions.

Integrating Wi-Fi and Bluetooth® wireless connectivity allows high throughput applications for industrial devices and appliances by keeping the highest flexibility for connectivity.

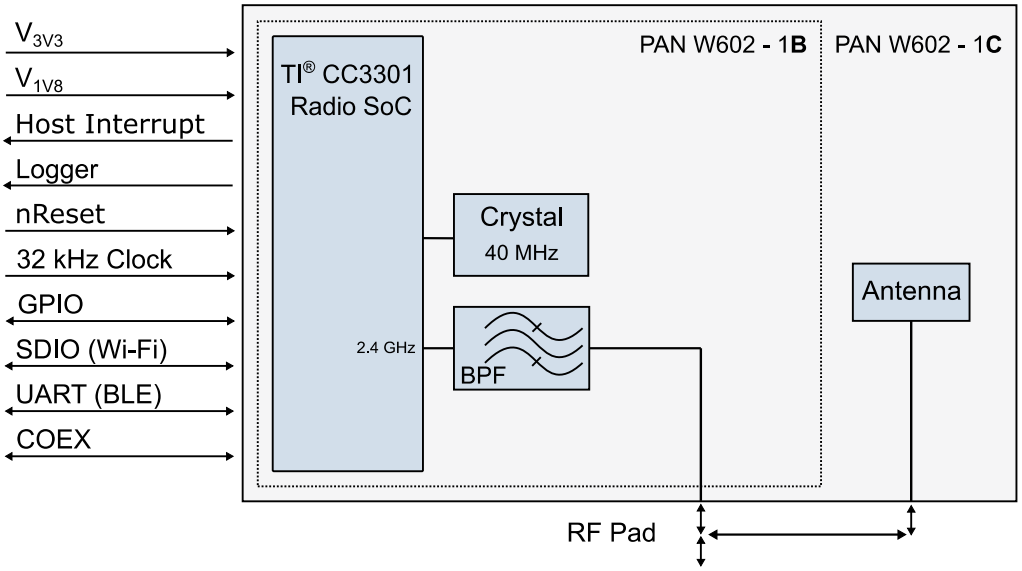
This Module Integration Guide applies to the PAN W602-xx WLAN and Bluetooth® combo module and the corresponding M.2 evaluation platforms (EVD). These EVD’s are only available for the dual band variants PAN W602-2B and PAN W602-2C, but they also cover all the functions of the single-band variants PAN W602-1B and PAN W602-1C.

For related documents please refer to ⇨ 11.2 Product Information.

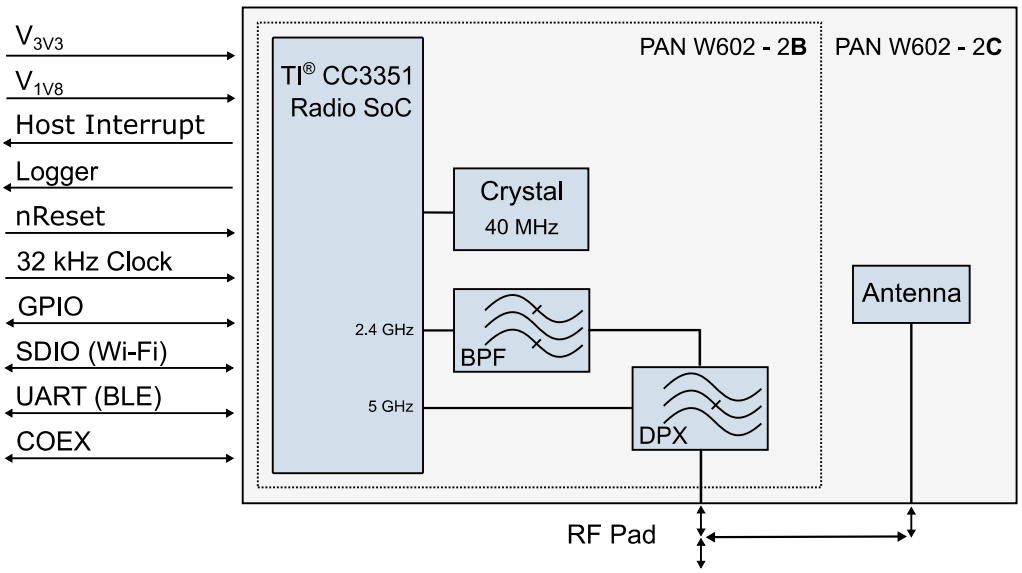
3 PAN W602-xx Module

3.1 Block Diagram

PAN W602 - 1x
Wi-Fi 6 & Bluetooth® Radio Module
IEEE 802.11 b/g/n/ax
Bluetooth® Low Energy



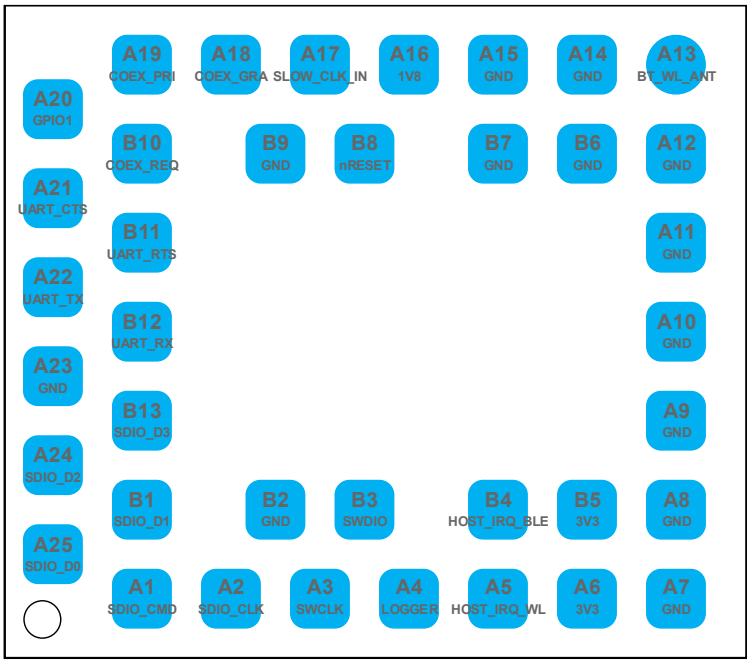
PAN W602 - 2x
Wi-Fi 6 & Bluetooth® Radio Module
IEEE 802.11 a/b/g/n/ax
Bluetooth® Low Energy



3.2 Land Pattern

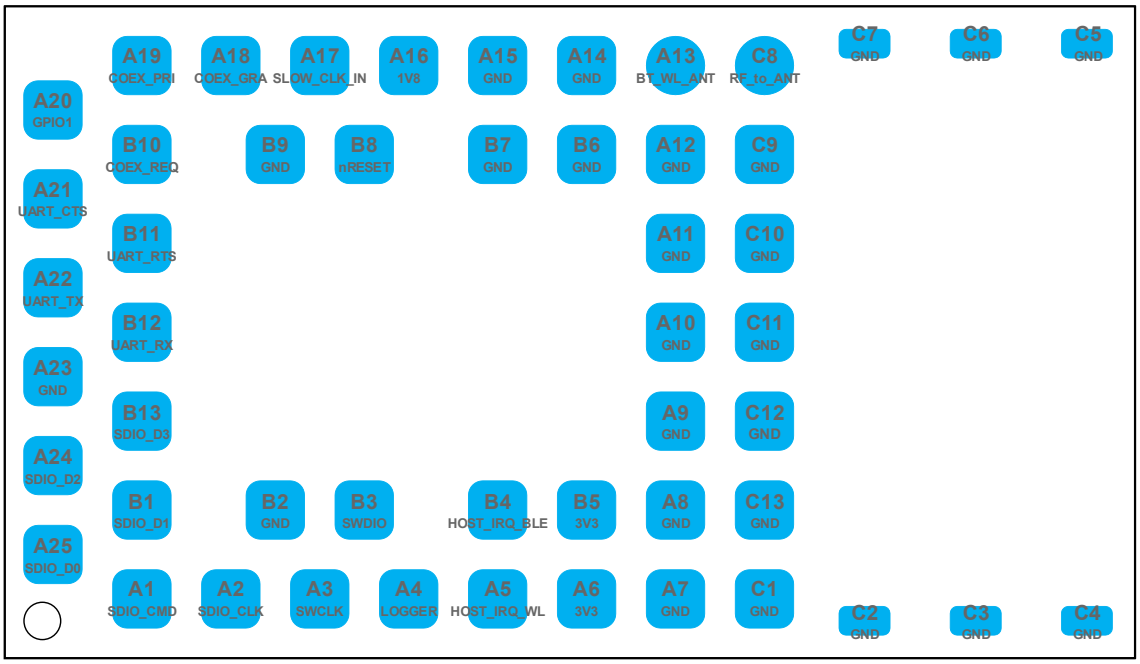
3.2.1 PAN W602-xB

Top View



3.2.2 PAN W602-xC

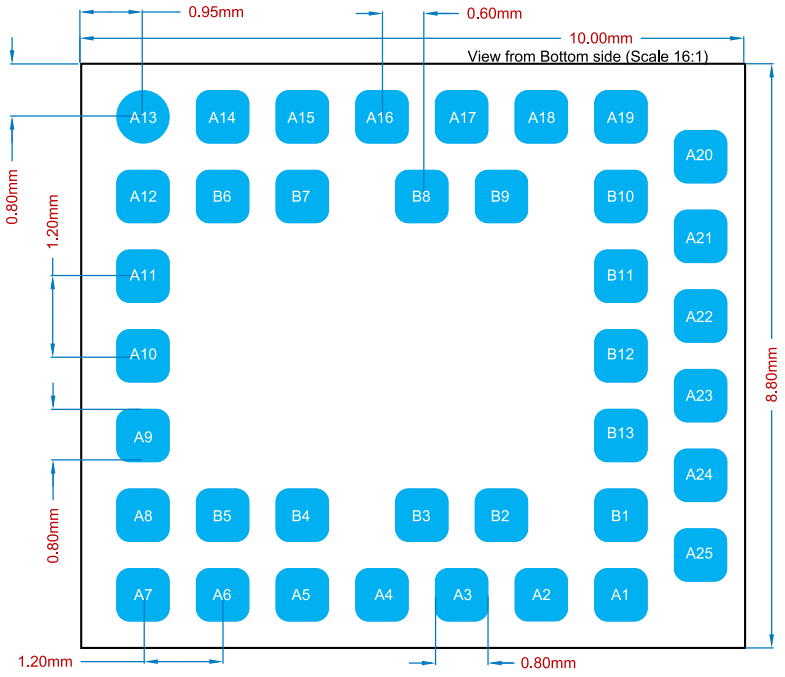
Top View



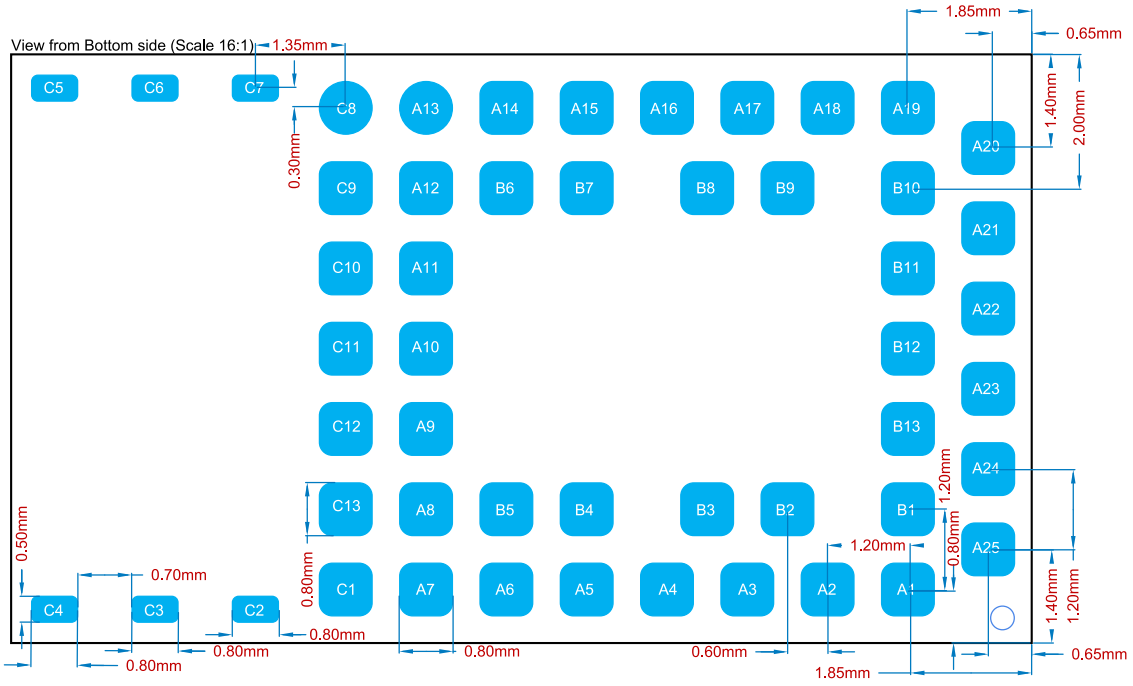
3.3 Footprint

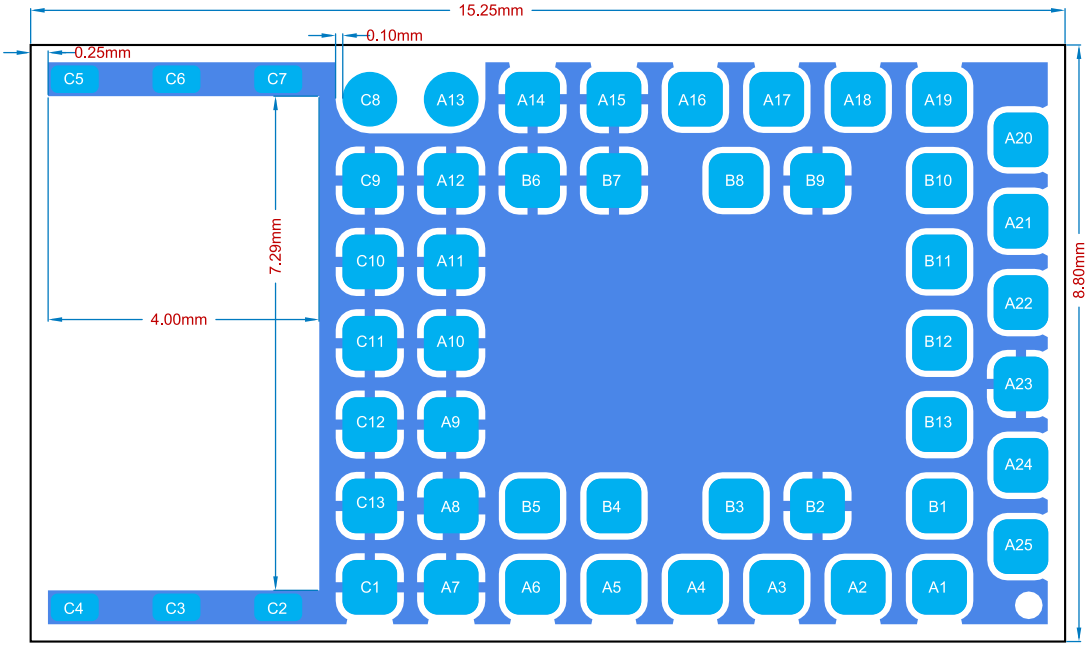
The dimensions are in millimeters. The outer dimensions have a tolerance of ±0.35 mm.

3.3.1 PAN W602-xB



3.3.2 PAN W602-xC





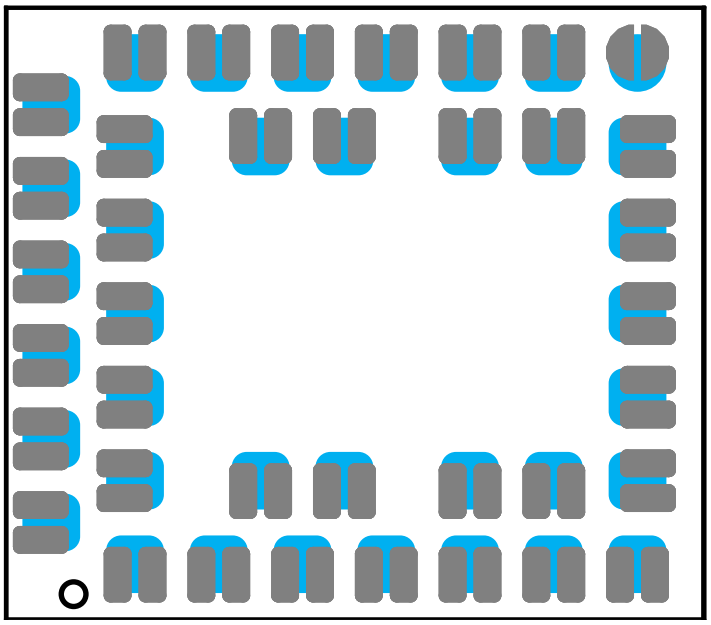
3.4 Solder Resist Mask and Solder Paste Stencil

It is recommended to use the following layout for the solder resist mask and the solder paste stencil to reduce voids on the pads.

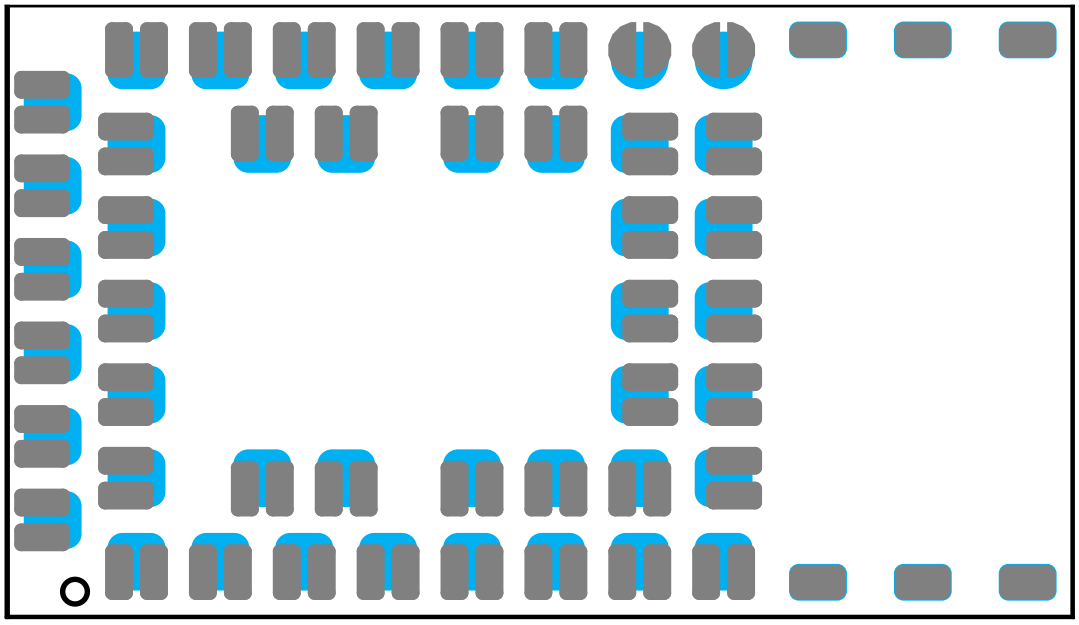
The following dimensions are recommended:

- ✓ The solder resist mask should be 50 µm bigger (circumferential) than the pad size (non-solder-mask-defined design).
- ✓ The solder paste stencil apertures should have the same size as the copper pads; they are separated into two equal parts with 100 µm distance and are shifted about 150 µm towards the outside.

Solder Paste Stencil Layout - PAN W602-xB - Top view



Solder Paste Stencil Layout - PAN W602-xC - Top view



4 Power Supply

4.1 General Guidance

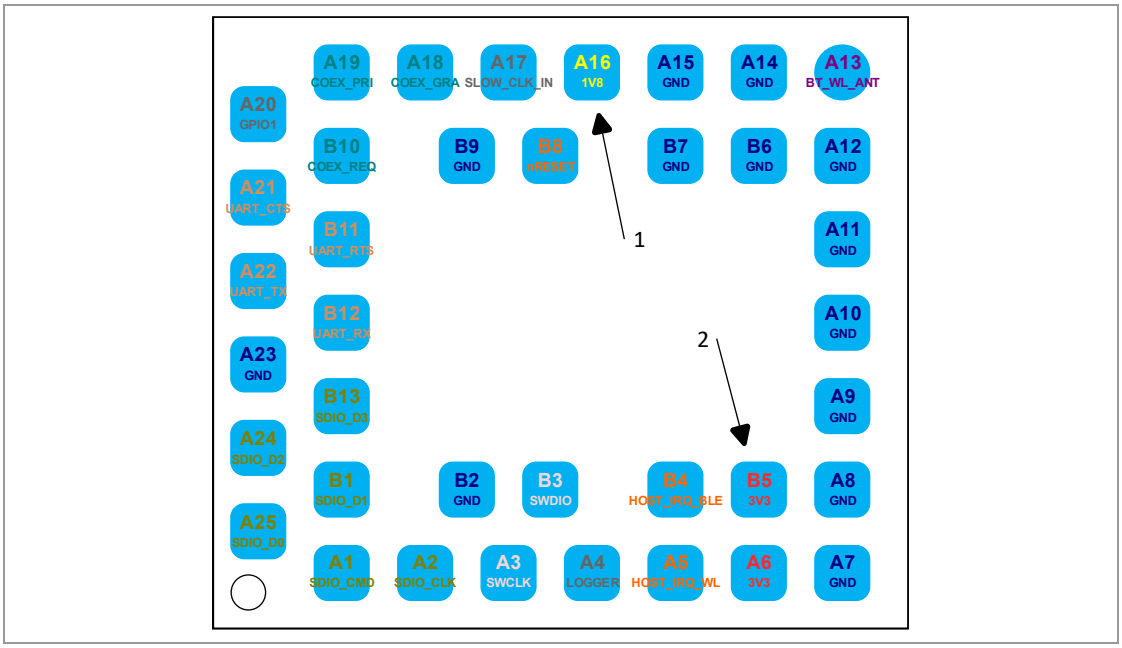
The following requirements must be met:

- ✓ The supply voltage must be free of AC ripple voltage (for example from a battery or a low noise regulator output). Please place a 0201 2 pF capacitor directly at the module's supply lanes to filter both 1.8 V and 3.3 V line. Additionally use a 100nF decoupling capacitor in combination with a higher-value capacitor for each supply lane. For noisy supply voltages, provide a extra decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47 µF).
- ✓ The supply voltage must not be exceedingly high or reversed. It must not carry noise and spikes.

4.2 Power Supply Terminals

The PAN W602-xx requires 1.8 V and 3.3 V supply voltages for operation. All supply pins are marked and enumerated in the figure below. All power signals are described in the subsequent table.

Top View



Enumeration	Name	Nominal Voltage	Description
1	1V8	1.8 V	Main power supply . The supply source should be capable to drive at least 350 mA peak.
2	3V3	3.3 V	Supply for Wi-Fi and BT PA . The supply source sould be capable to drive at least 450 mA.

5 Antennas

The PAN W602-xx is certified in combination with the following antenna types:

- Chip antenna
- External antenna

All approved antennas are listed in the corresponding subsection.

5.1.1 Chip Antenna

The chip antenna ANT162442DT-2001A2 is only available with the PAN W602-1C and PAN W602-2C.

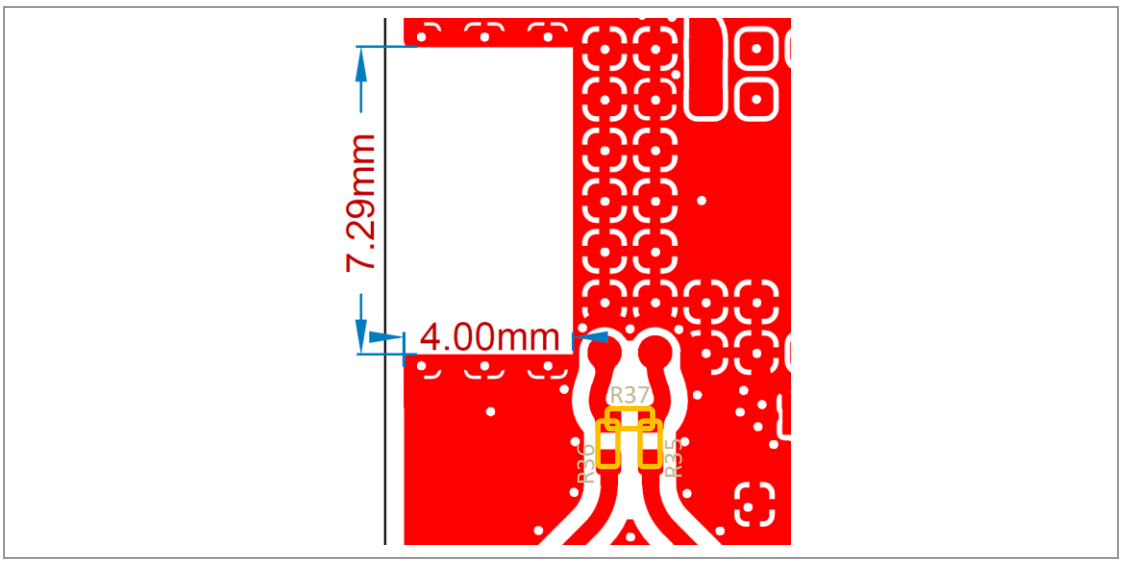
Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cable Variants
ANT162442DT-2001A2	TDK	Chip Antenna	2.1 dBi	2.3 dBi	50 Ohm trace

To use the internal chip antenna the pins A13 and C8 has to be connected with a 50 Ohm RF trace

To comply with the regulatory requirements, all instructions of this section must be followed.

5.1.1.1 Connection of the Antenna

To use the internal chip antenna the pins A13 and C8 **must be connected on the customer PCB** for the versions PAN W602-1C (ENWF9211A) and PAN W602-2C (ENWF9215A). Please see the picture below for possible placement options of the corresponding evaluation board.



R35	R36	R37	Description
0 Ω	DNP	DNP	Pin to access the onboard chip Antenna. Verify the correct tuning, please use for this the corresponding MHF4 connector on the evaluation card
DNP	0 Ω	DNP	Pin to access the amplifier output from the radio IC. With this a verification of the signal quality is possible.
DNP	DNP	0 Ω	To connect the radio IC power amplifier output and the onboard chip antenna. When integrating the module, please connect pins A13 and C8 using a 50-ohm trace, as shown in the picture above

It is recommended to verify the perfect position of the antenna in the target application before fixing the design.

5.1.1.2 Keepout Area

The antenna requires a cutout area of 4 mm × 7.29 mm. This “Keep out Area” shall be **in every layer under the antenna**. As an orientation please see the “Keep out Area” implementation for every layer of the corresponding evaluation board in chapter 8.4 PCB Layout. This area is also implemented in the module itself and must align with the “Keep out Area” of the customer PCB in all layers.

Antenna “Keep out Area”

Do not place any ground plane under the marked restricted antenna area in any layer! This would be affecting the performance of the chip antenna in a critical manner.

5.1.1.3 General Placement Notes

Impact of Placement on the Antenna Radiation Pattern

The placement of the module, surrounding material, and customer components has an impact on the radiation pattern of the antenna.

The recommendation for the surrounding ground plane is based on a FR4 Multi-Layer PCB.

The following requirements must be met:

- ✓ Keep this product away from heat. Heat is the major cause of decreasing life of these products.
- ✓ Keep this product away from other high frequency circuits.

5.1.2 External Antennas

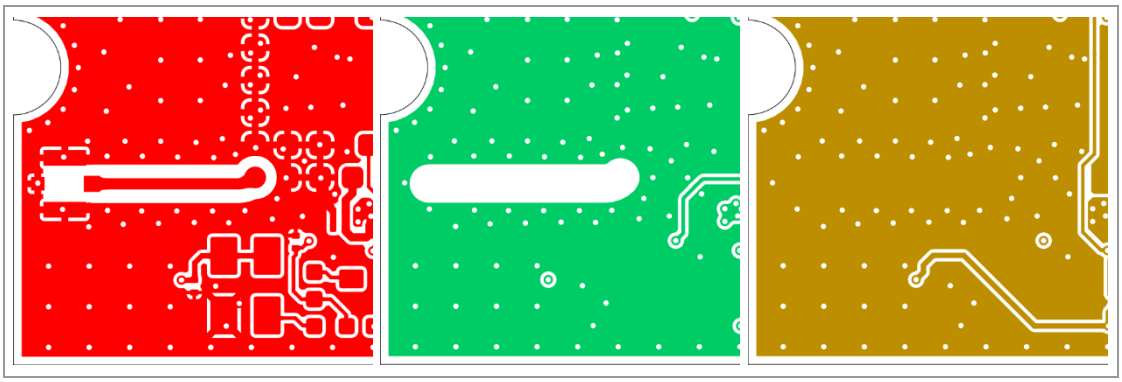
Antenna Warning

The PAN W602-xx is tested with a standard MHF4(L) connector and with the antennas listed in the “PAN W602-xx Product Specification”. When integrated into the OEM’s product, these fixed antennas require installation preventing end users from replacing them with non-approved antennas.

5.1.2.1 RF Trace

All external antennas listed in this Module Integration Guide require an MHF4(L) connector on the mother PCB. Follow the design described in this chapter for routing the module’s RF signal to the MHF4(L) receptable connector.

M.2 reference design

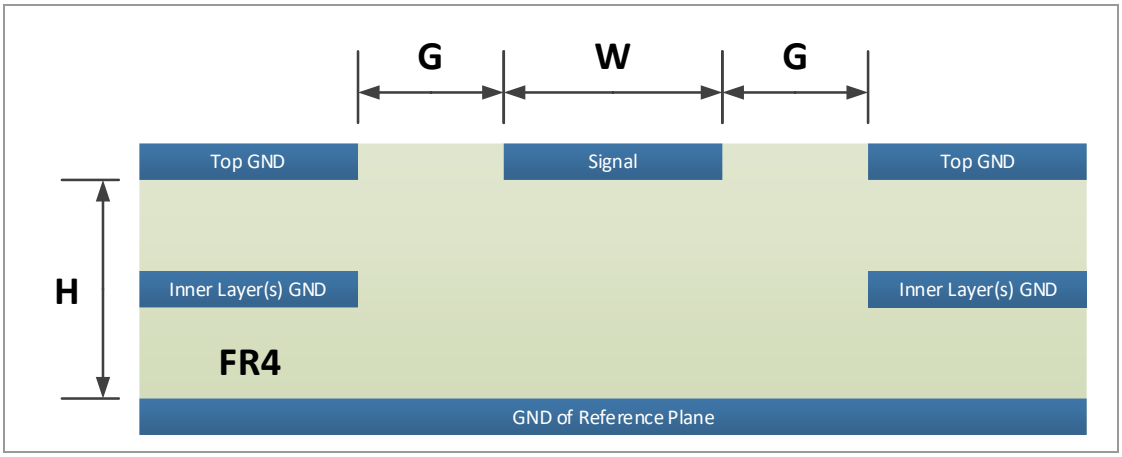


A 50 Ω trace shall be used for connecting the module to a MHF4(L) connector for external antenna usage.

50 Ω Coplanar Waveguide Design

The following requirements must be met:

- ✓ Trace impedance of 50 Ω
- ✓ Via fence around the trace
- ✓ Coplanar waveguide design
- ✓ Substrate Material: FR4
- ✓ All inner layers have the same copper-obstruct pattern as the GND on the top layer.


G
W
G
Top GND
Signal
Top GND
H
Inner Layer(s) GND
Inner Layer(s) GND
FR4
GND of Reference Plane

5.1.2.2 PCB Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cables [1]
2108792	TE Connectivity	Flex PCB	4.9 dBi	3.5 dBi	-6 (50 mm) -7 (100 mm) -8 (150 mm) -9 (200 mm)
2JF1002P	2J	Flex PCB	4.2 dBi	8.0 dBi	-005MC137-MHF4L (50 mm) -010MC137-MHF4L (100 mm) -015MC137-MHF4L (150 mm) -020MC137-MHF4L (200 mm) -025MC137-MHF4L (250 mm) -030MC137-MHF4L (300 mm)
2JF0102P	2J	Flex PCB	2.2 dBi	3.8 dBi	-005MC137-MHF4L (50 mm) -010MC137-MHF4L (100 mm) -015MC137-MHF4L (150 mm) -020MC137-MHF4L (200 mm) -025MC137-MHF4L (250 mm) -030MC137-MHF4L (300 mm)
FXP830	Taoglas	Flex PCB	2.5 dBi	4.7 dBi	.54.0055C (55 mm) .54.0100C (100 mm) .54.0150C (150 mm) .54.0200C (200 mm)
W3P35X8W04	Kyocera AVX	PCB	2.3 dBi	5 dBi	-H050D3B0A (50 mm) -H100D3B0A (100 mm) -H150D3B0A (150 mm)
W3F35X8W01	Kyocera AVX	Flex PCB	2.3 dBi	5 dBi	-H050D3B0C (50 mm) -H100D3B0C (100 mm) -H150D3B0C (150 mm)
1001932PT	Kyocera AVX	Flex PCB	2.0 dBi	4.5 dBi	-AC10L0050 (50 mm) -AC10L0100 (100 mm)

[1] Cable option with MHF4L connector; Product number: [Part Number][Cable Option]

5.1.2.3 Terminal Mount Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cables [2]
2108923-3 (black) 2108923-4 (white)	TE Connectivity	Terminal Mount	2.5 dBi	3.2 dBi	2016694-1 2016694-2 2016694-3 2016694-4
GW.51.5153	Taoglas	Terminal Mount	5.2 dBi	5.5 dBi	CAB.S140 (50 mm) CAB.S119 (100 mm) CAB.S141 (150 mm) CAB.S142 (200 mm) CAB.S143 (300 mm)
2JW1102-C943B	2J	Terminal Mount	4.1 dBi	3.9 dBi	C213GST-005MC137-MHF4L (50 mm) C213GST-010MC137-MHF4L (100 mm) C213GST-015MC137-MHF4L (150 mm) C213GST-020MC137-MHF4L (200 mm) C213GST-025MC137-MHF4L (250 mm) C213GST-030MC137-MHF4L (300 mm)
X9000294-W3DRMB	Kyocera AVX	Terminal Mount	3.2 dBi	4.5 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)
X9001748-W3DRMB	Kyocera AVX	Terminal Mount	3.2 dBi	3.6 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)

[2] MHF4L to RP-SMA (female) cable

Continued: Terminal Mount Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cables [2]
X9003019-W3DRMB (Black) X9003019-W3DRMW (White)	Kyocera AVX	Terminal Mount	2.8 dBi	4.9 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)

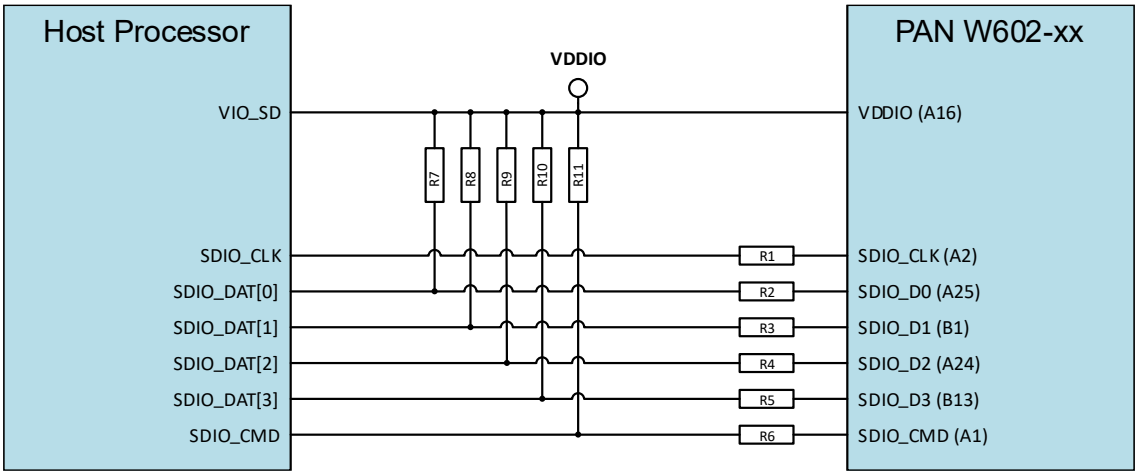
6 Host Interface

This section describes the interfaces to the host processor:

- SDIO for Wi-Fi
- UART for Bluetooth®

6.1 SDIO Interface

The SDIO interface of the PAN W602-xx is shown in the following block diagram:

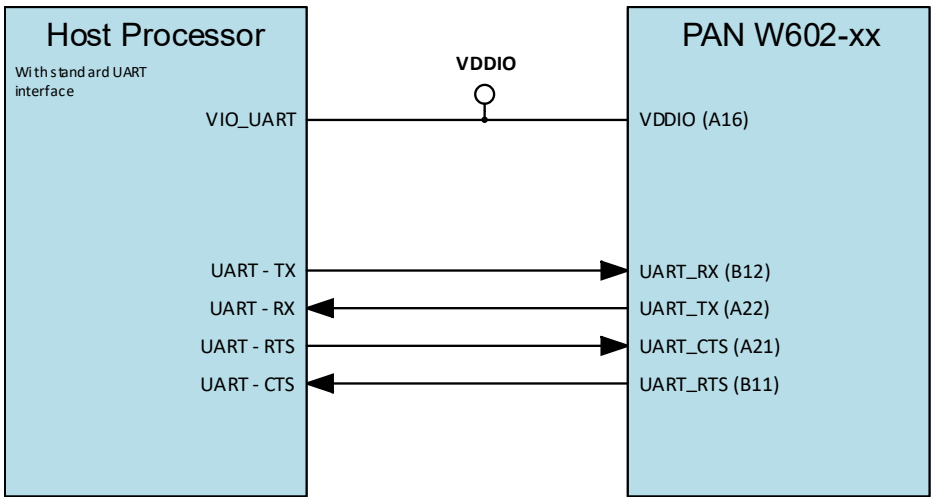


The block diagram includes pull-up resistors (R7 to R11) and series damping resistors (R1 to R6).

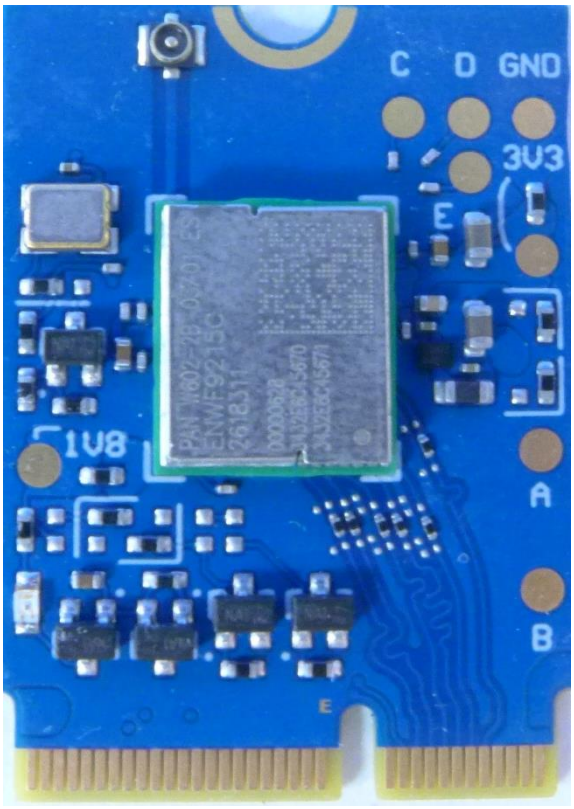
If the host processor includes internal pull-up resistors, resistors R11 to R16 are not required to be designed in. In the case the host does not provide pull-resistors, please add pull-up resistors with a resistance of 10 kΩ to 100 kΩ.

The resistors R1 to R6 are mandatory to help to reduce the under-/overshoot and emission reduction. 33 Ω resistors should be used.

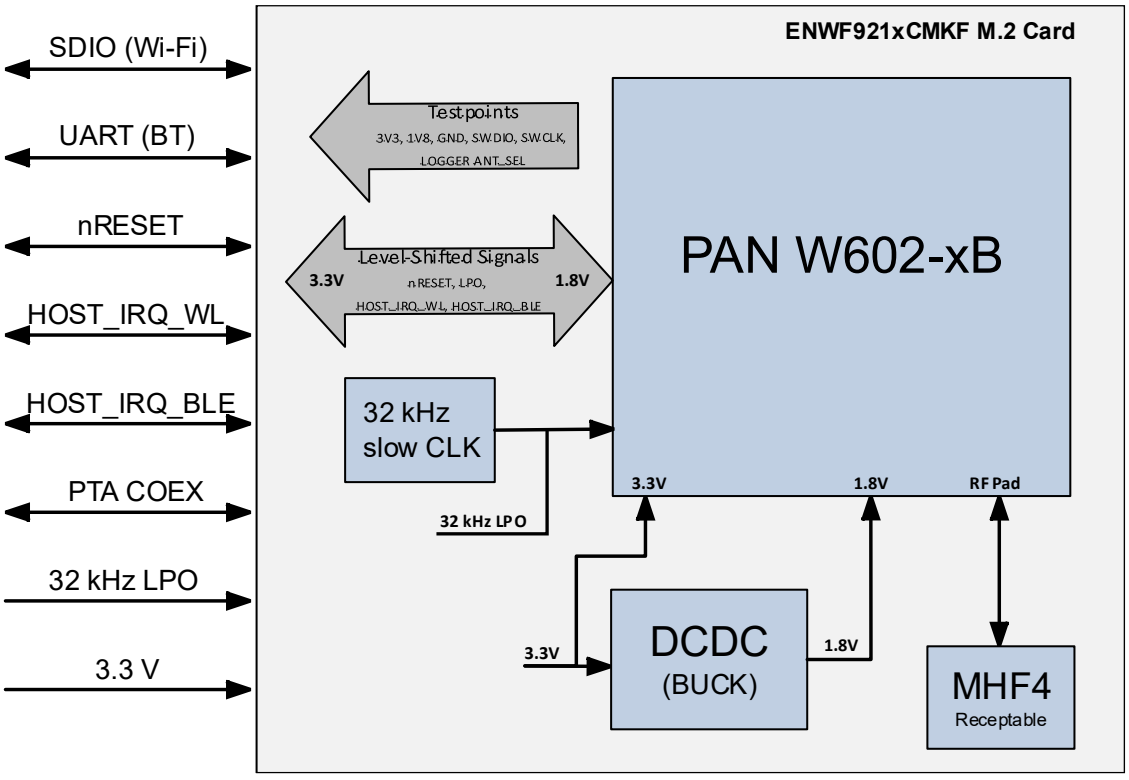
6.2 UART Interface



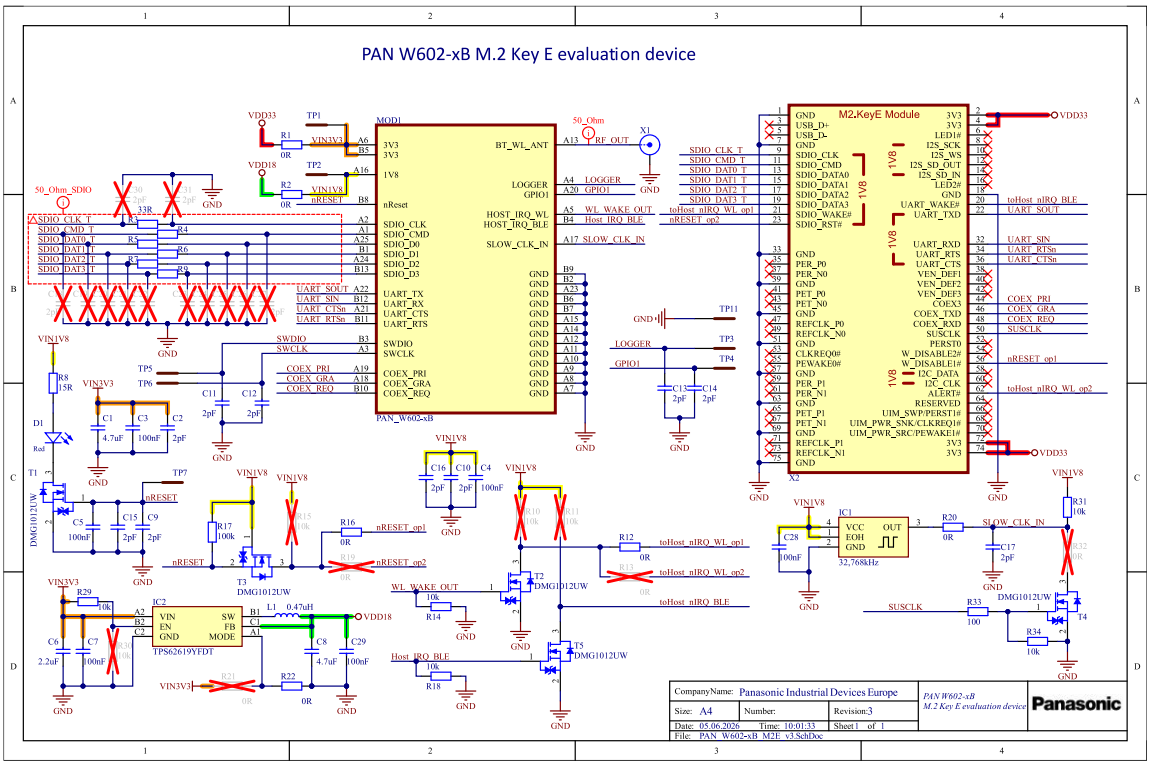
7 Reference Design - SDIO M.2 Card Key-E - Bottom Pad



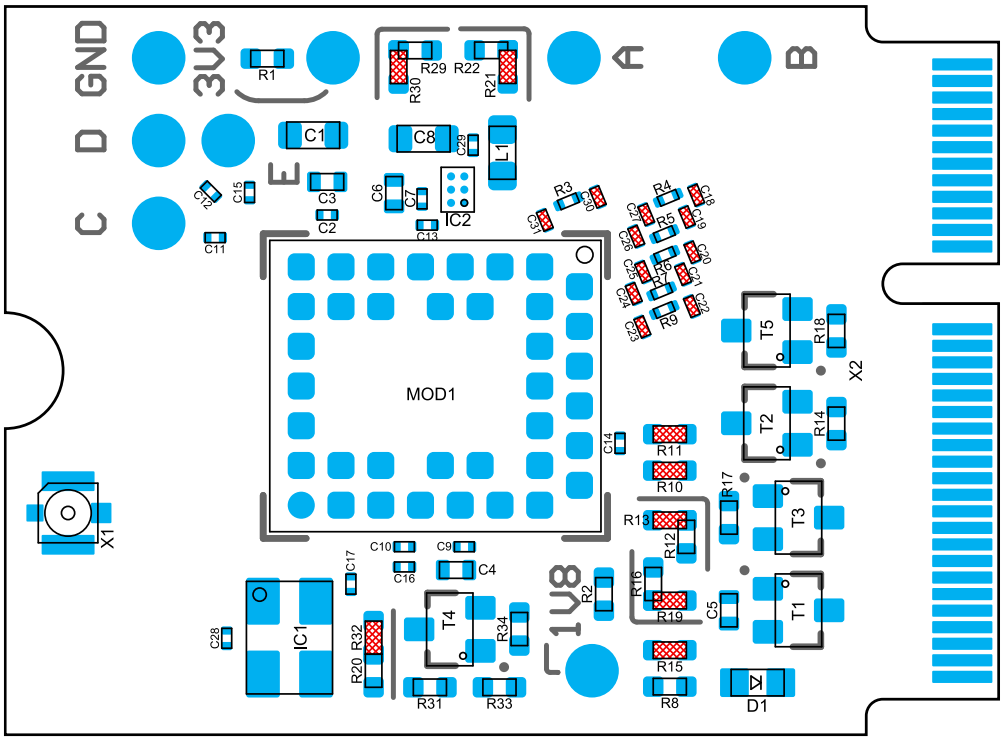
7.1 Block Diagram



7.2 Schematic

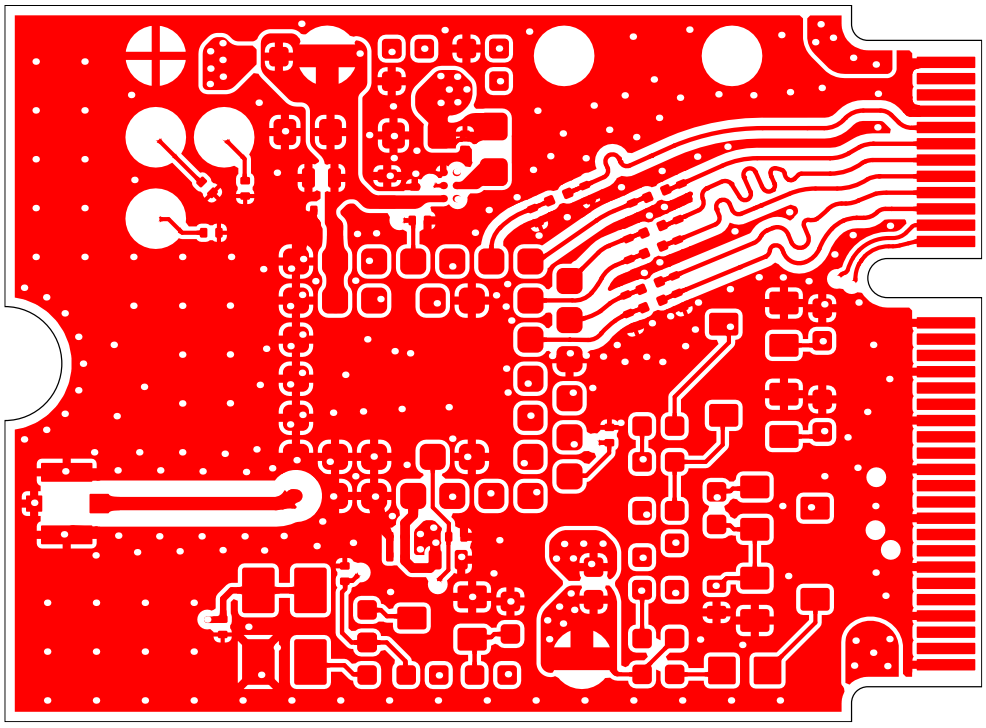


7.3 Placement

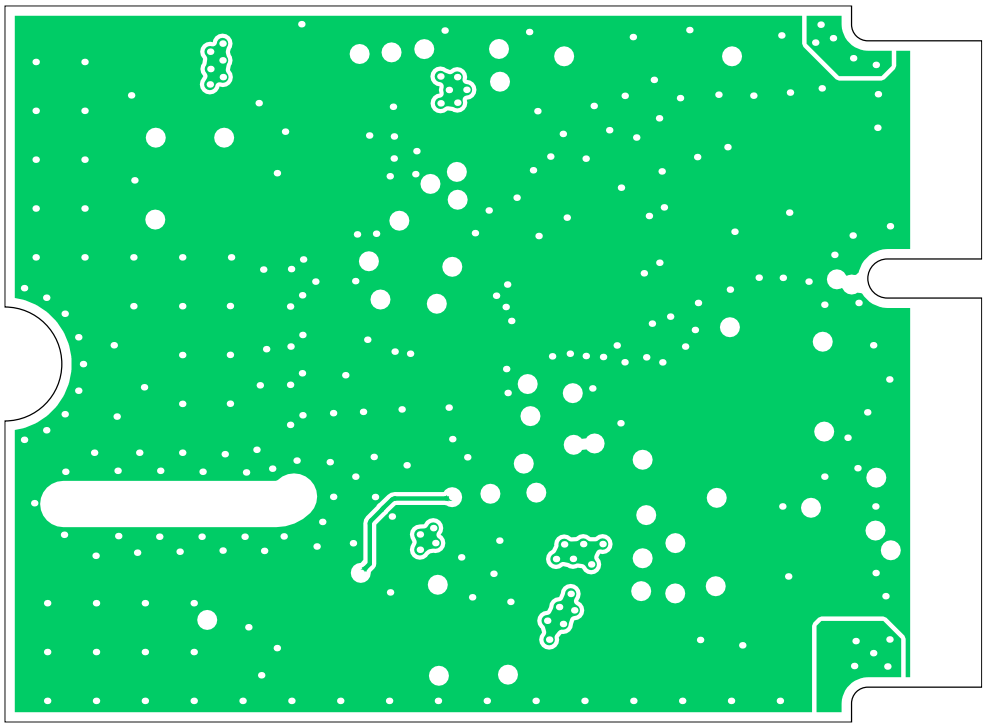


7.4 PCB Layout

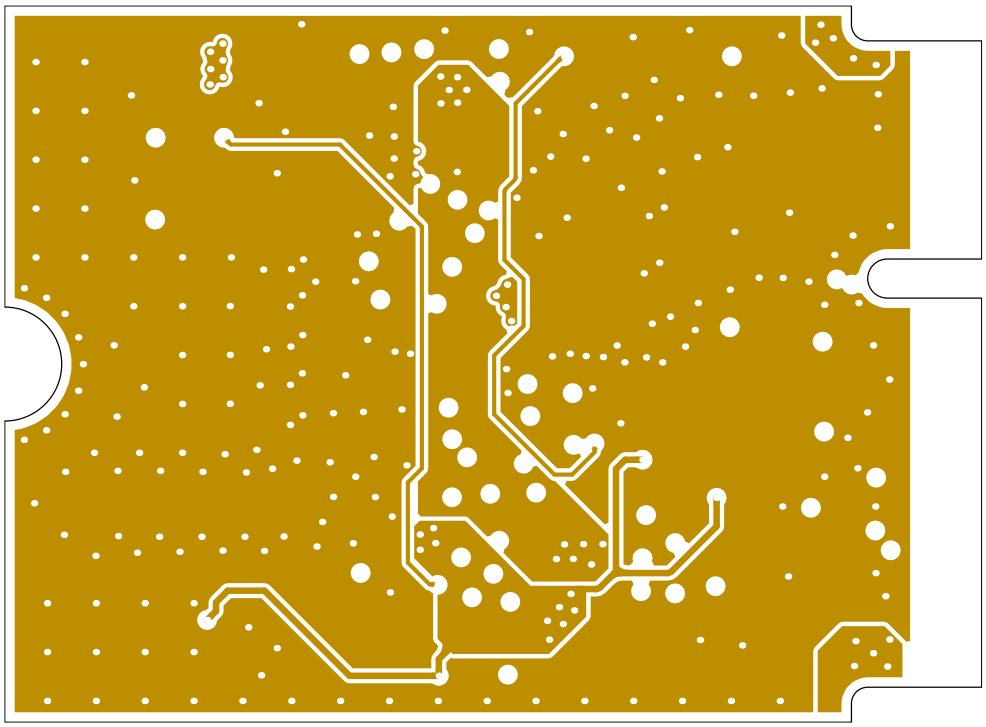
7.4.1 Top Layer



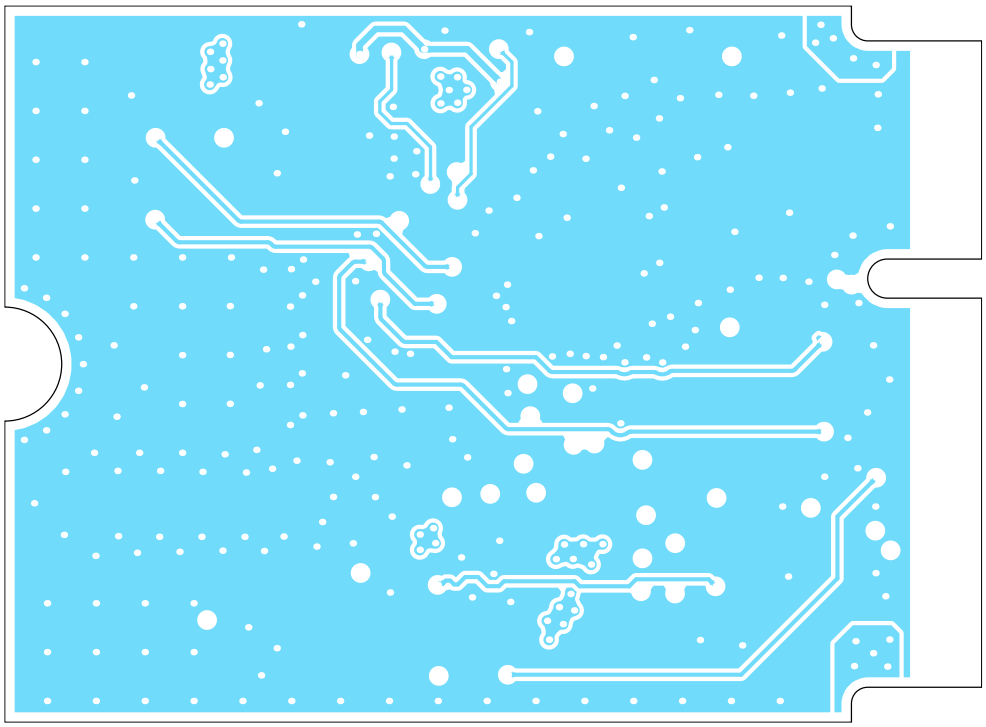
7.4.2 Second Layer



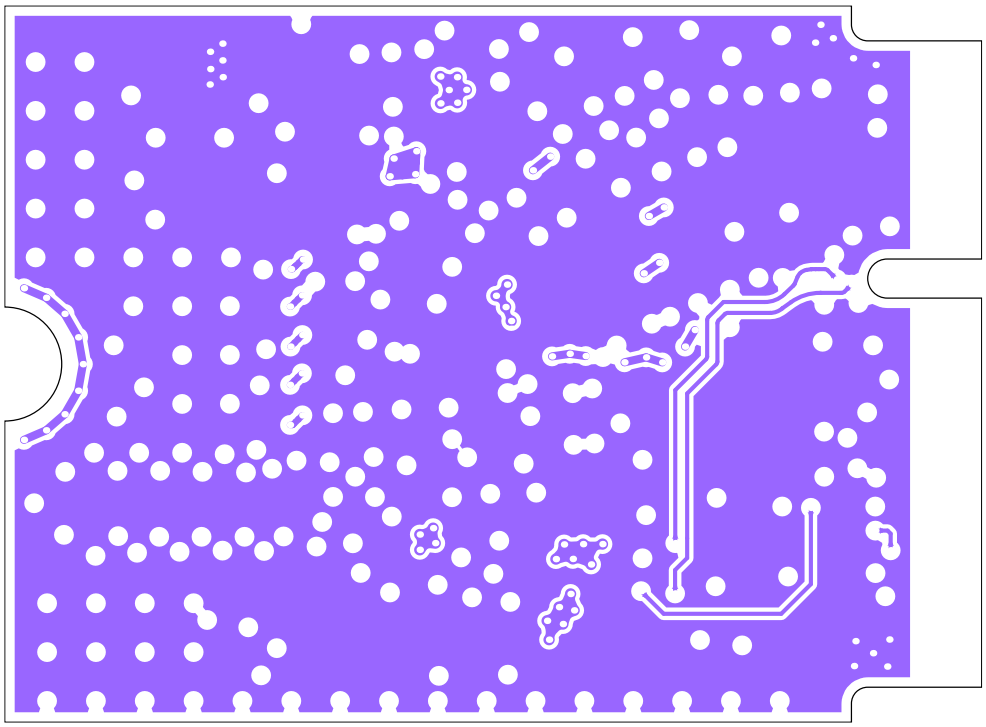
7.4.3 Third Layer



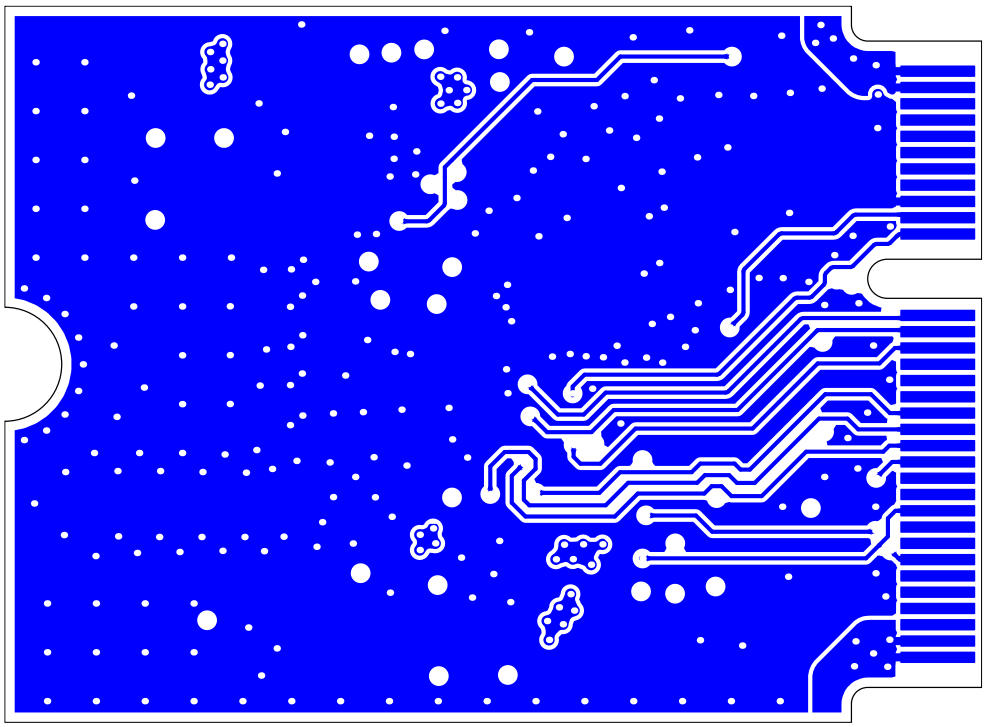
7.4.4 Fourth Layer



7.4.5 Fifth Layer

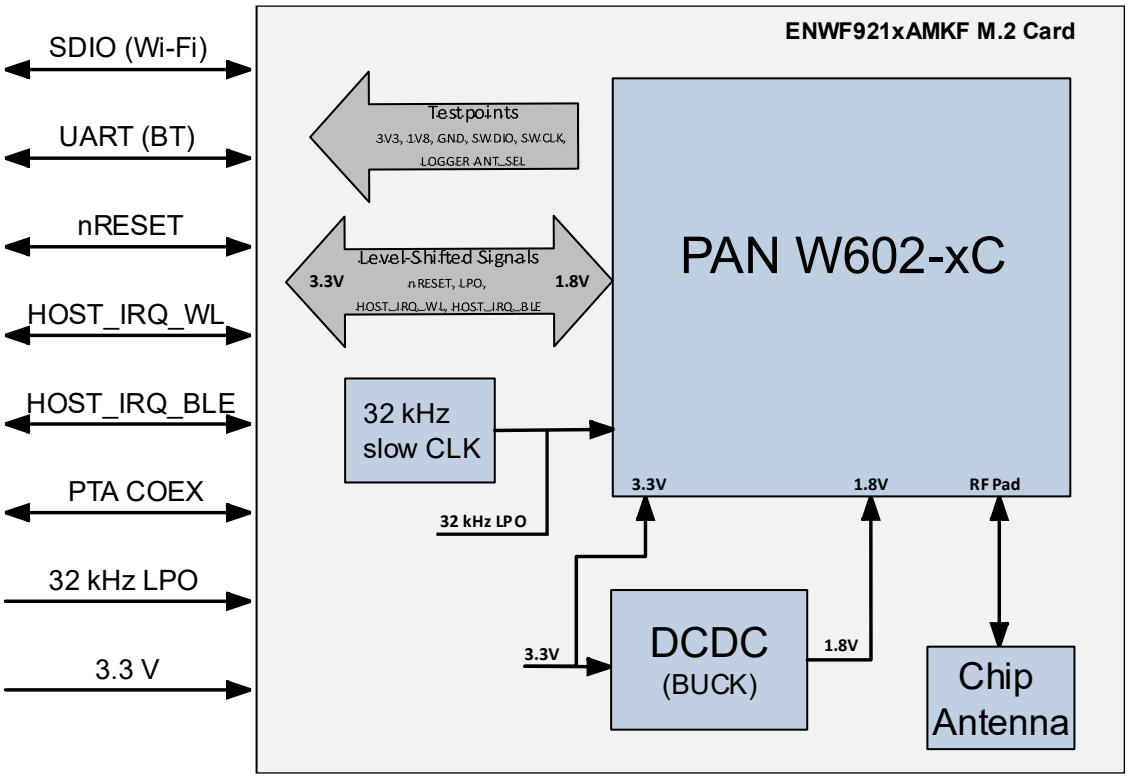


7.4.6 Bottom Layer

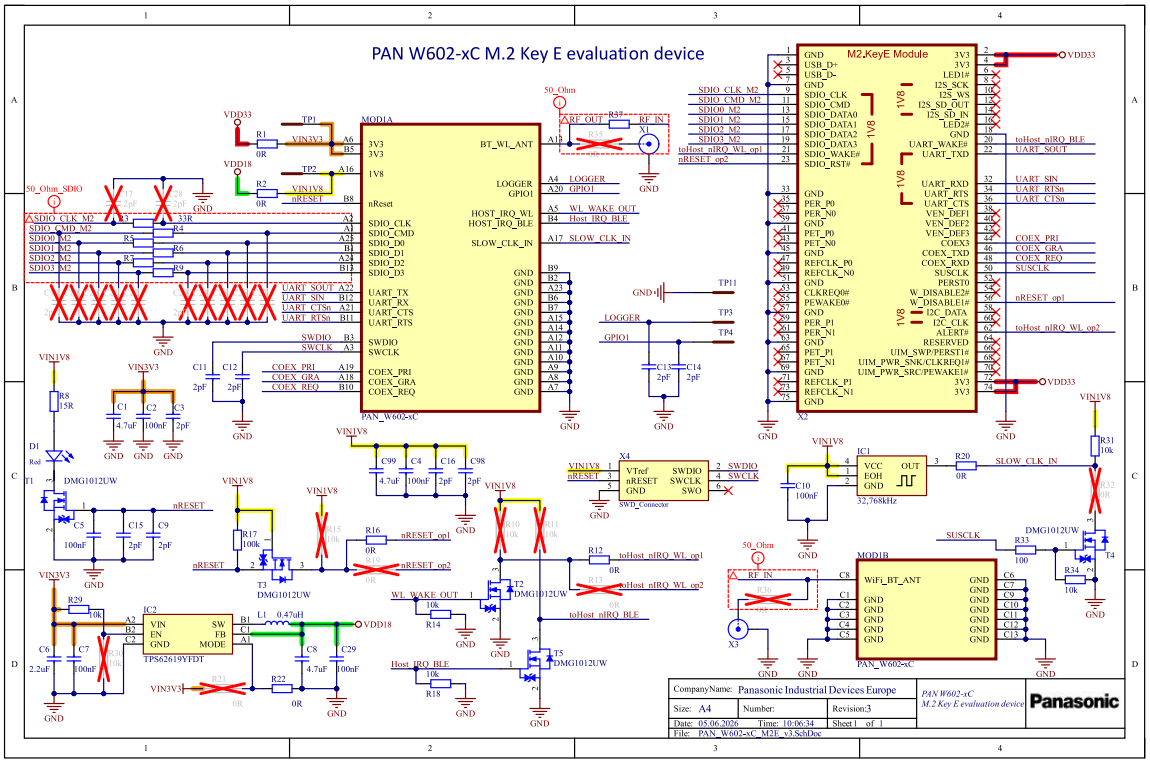


8 Reference Design - PCIe M.2 Card Key-E - Antenna

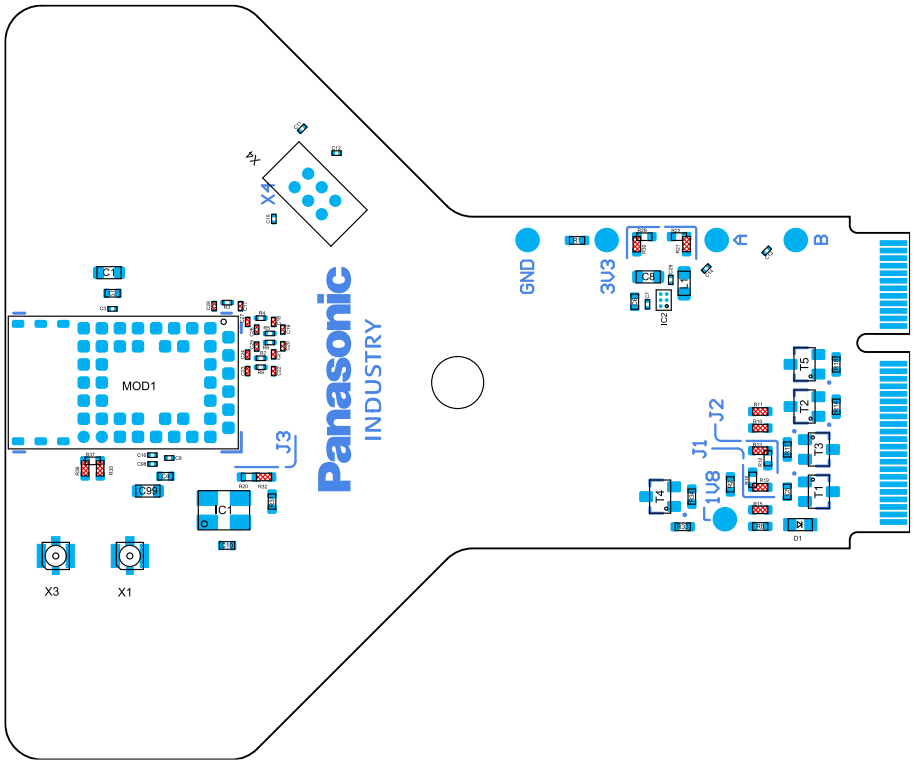
8.1 Block Diagram



8.2 Schematic

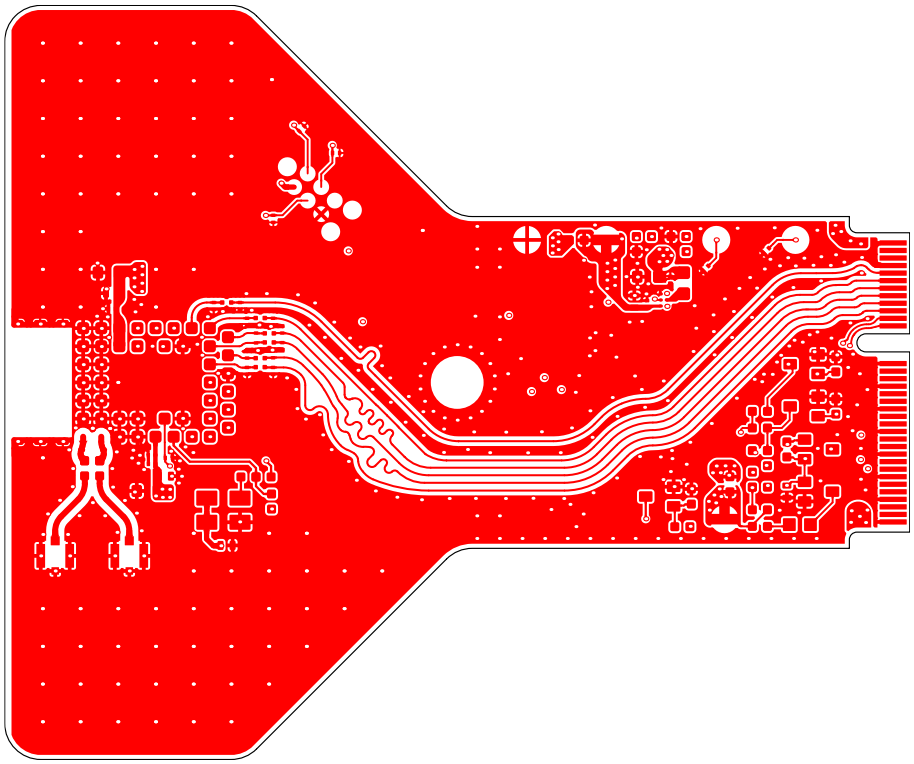


8.3 Placement

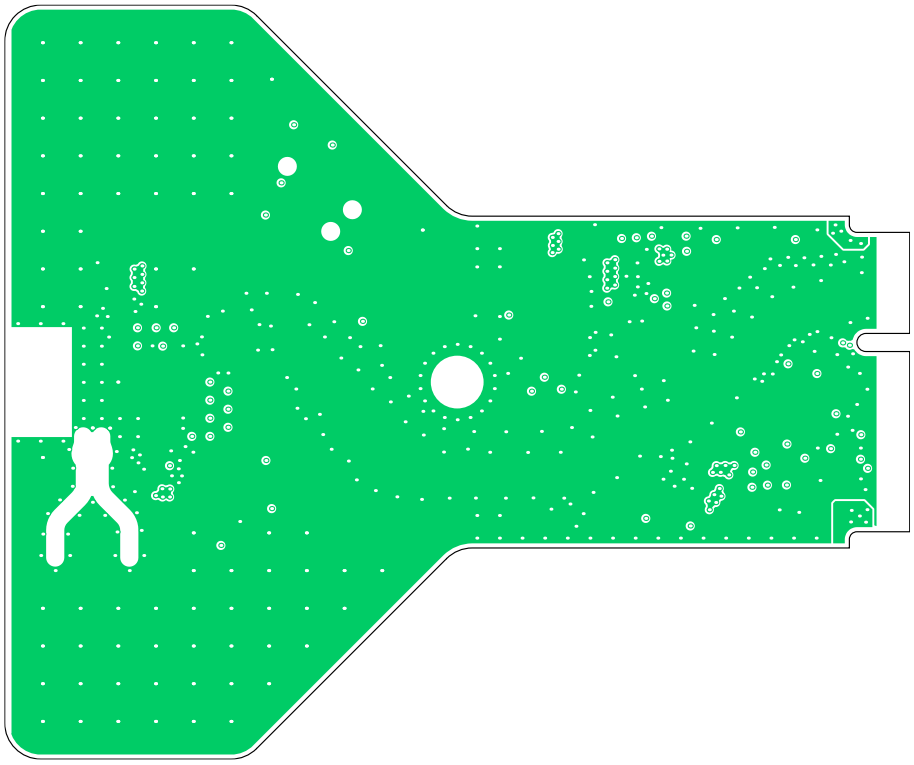


8.4 PCB Layout

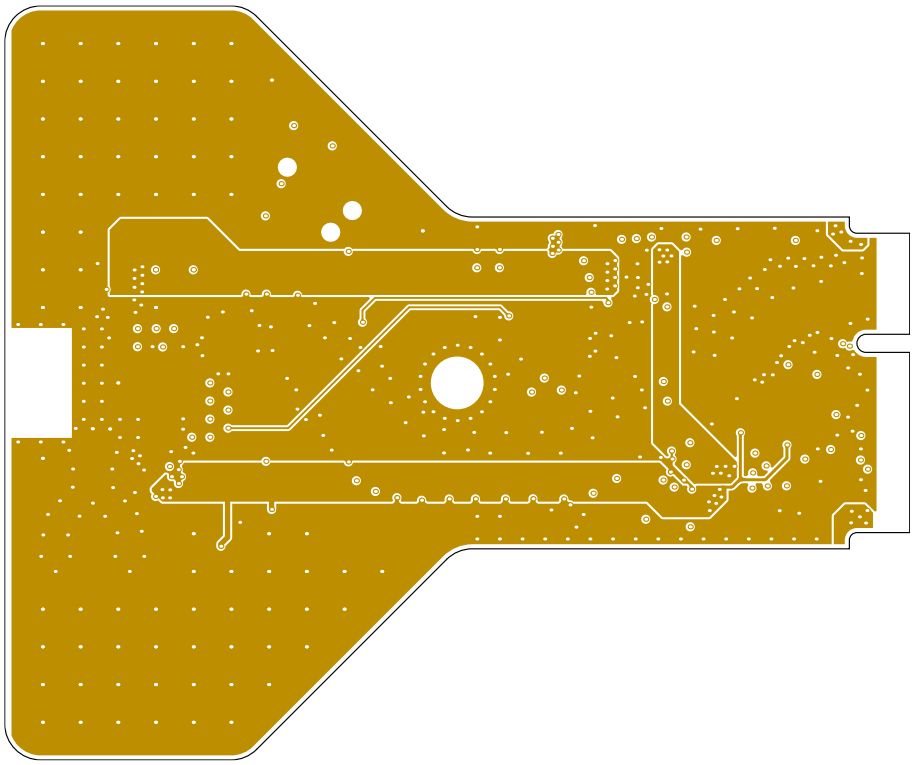
8.4.1 Top Layer



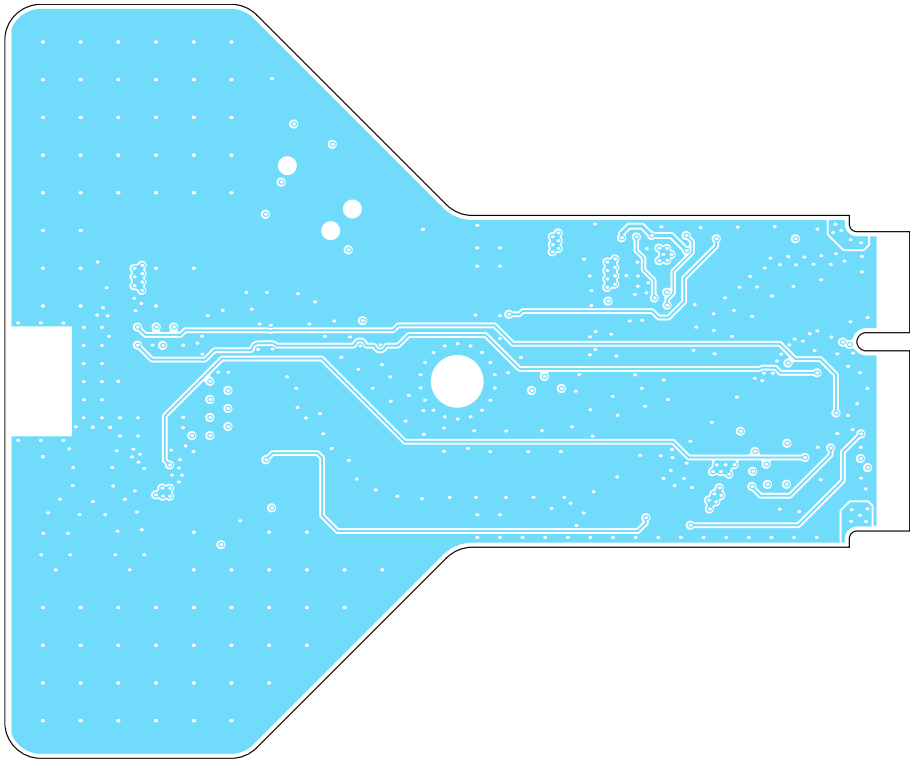
8.4.2 Second Layer



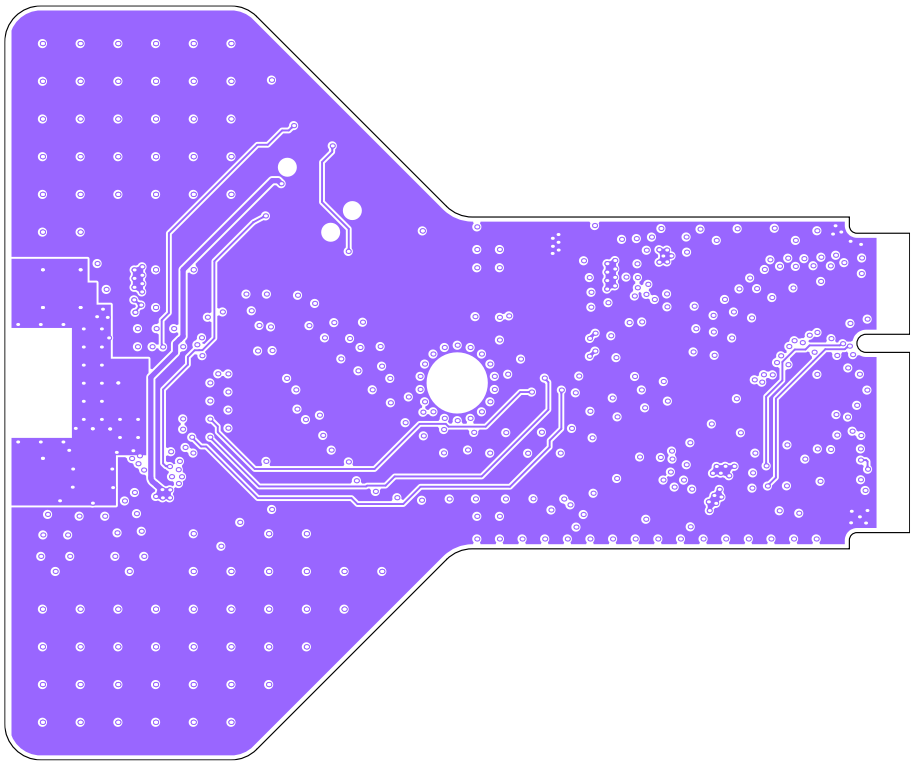
8.4.3 Third Layer



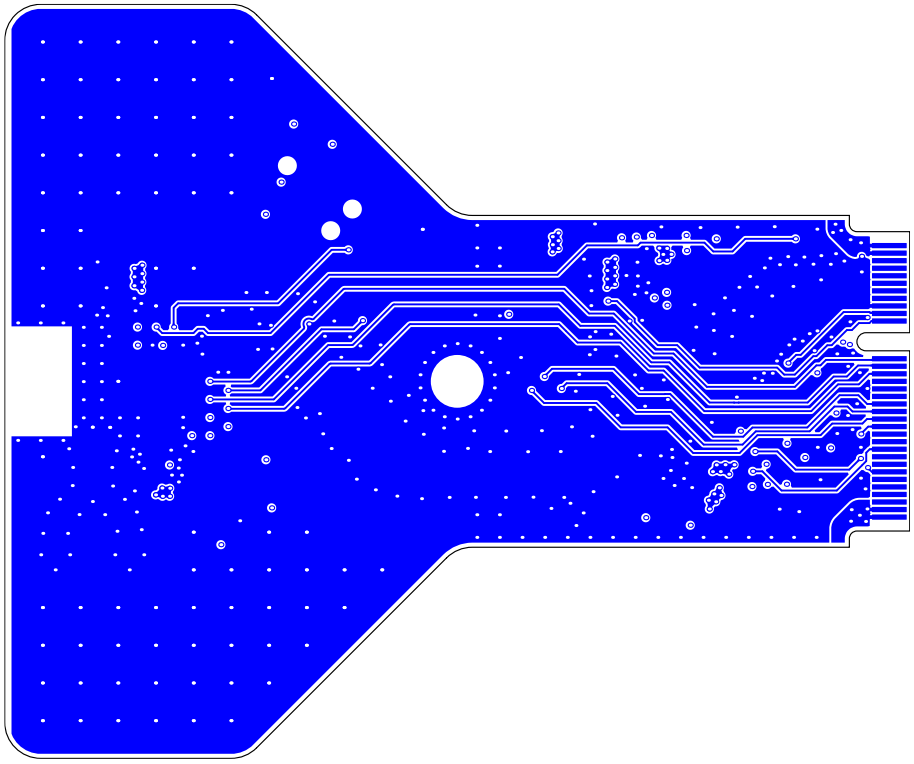
8.4.4 Fourth Layer



8.4.5 Fifth Layer

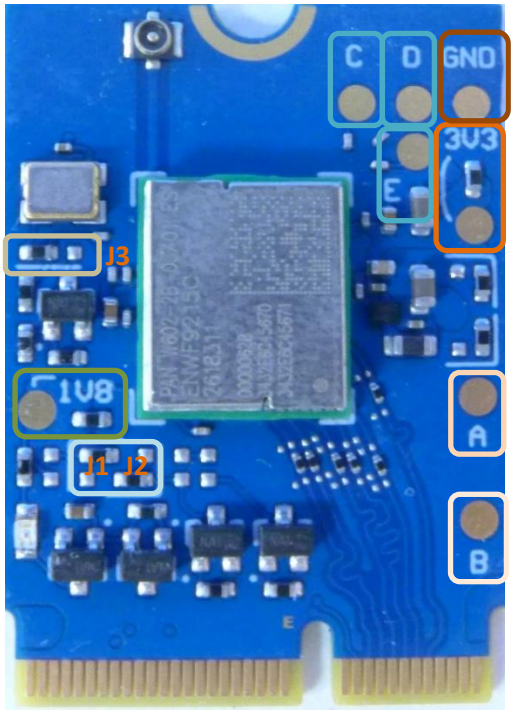


8.4.6 Bottom Layer



9 Test Options, Configuration Settings and Jumper

This chapter defines the function and meaning of all available test points. In general, the numbering scheme and feature set are identical for both variants. Minor differences exist in the marking and physical accessibility of the test points.



Jumper	Valid for which EVD	Description
J1	Antenna and Bottom Pad	nRESET
J2	Antenna and Bottom Pad	HOST_IRQ_BLE
J3	Antenna and Bottom Pad	Slow Clock

Test point	Valid for which EVD	Description
A	Antenna and Bottom Pad	GPIO1 (ANT_SEL)
B	Antenna and Bottom Pad	LOGGER
C	Bottom Pad	SWDIO (for antenna EVD part of the X4 6-Pin SWDIO Interface)
D	Bottom Pad	SWCLK (for antenna EVD part of the X4 6-Pin SWDIO Interface)
E	Bottom Pad	nRESET (for antenna EVD part of the X4 6-Pin SWDIO Interface)

Power	Valid for which EVD	Description
1V8	Antenna and Bottom Pad	Possibility to power the module independent from host board.
3V3	Antenna and Bottom Pad	Possibility to power the module independent from host board. If the usage of the M.2 included DCDC is not wanted

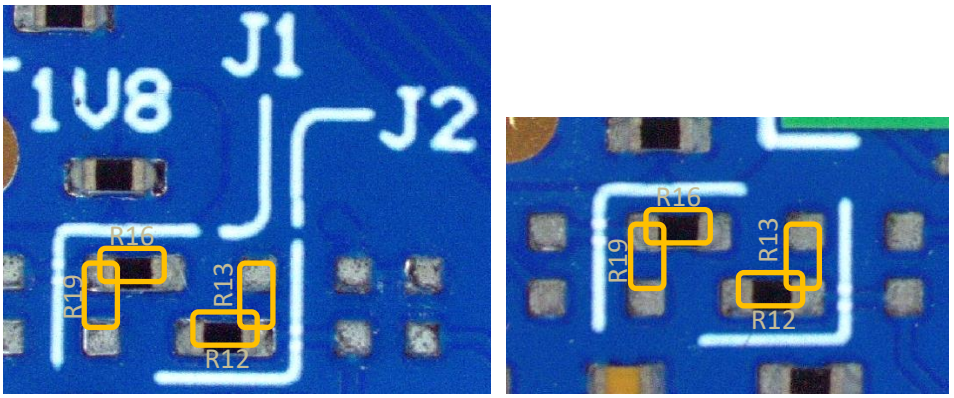
Please see chapter 9.2 for more information.

Interface	Valid for which EVD	Description
X4	Antenna	6-Pin SWDIO Interface (includes 1V8, SWDIO, SWCLK, GND, nRESET)

9.1 Jumper

9.1.1 nRESET and HOST_IRQ_BLE

There are two possible ways to route the signals nRESET and HOST_IRQ_BLE to the M.2 card interface pins. Which interface pin shall be used depends on the host platform which is used. Please check https://www.ti.com/lit/pdf/SWAU133. To switch the M.2 interface pin please use J1 and J2, see the table below.



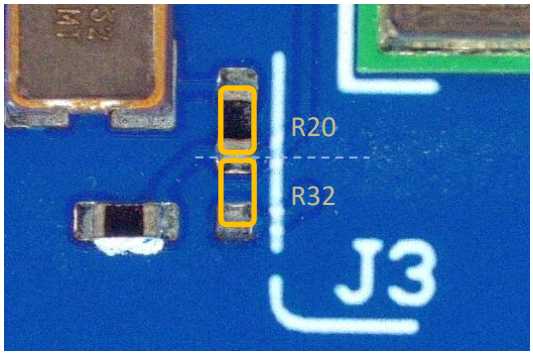
After each different configuration the module PAN W602-xx needs to be power cycled

R16	R19	Description
0 Ω	DNP	Usage of the first M2 Key-E pin assignment option (Pin 56) for nRESET
DNP	0 Ω	Usage of the second M2 Key-E pin assignment option (Pin 23) for nRESET

R12	R13	Description
0 Ω	DNP	Usage of the first M2 Key-E pin assignment option (Pin 21) for HOST_IRQ_BLE
DNP	0 Ω	Usage of the first M2 Key-E pin assignment option (Pin 62) for HOST_IRQ_BLE

This is both for the Bottom Pad module PAN W602-xB evaluation board and for the antenna module PAN W602-xC evaluation board the case.

9.1.2 Slow Clock



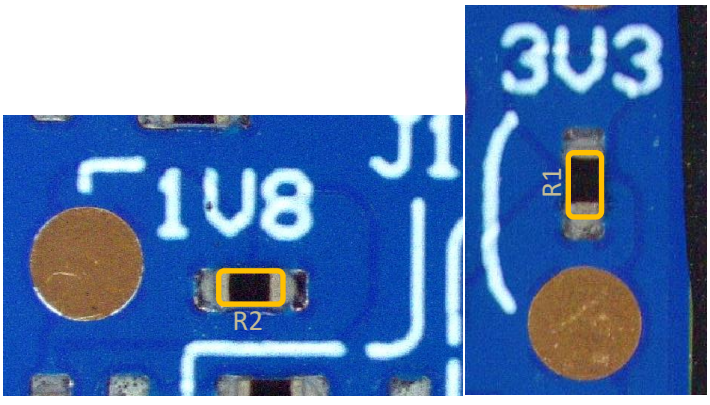
After each different configuration the module PAN W602-xx needs to be power cycled.

R20	R32	Description
0 Ω	DNP	Usage of an internal 32 kHz slow clock (M.2 Key-E Card)
DNP	0 Ω	Usage of an external 32 kHz slow clock (Host Platform)

9.2 Power

When the PAN W602-xx shall be supplied externally please use the test pads which were shown in the picture below.

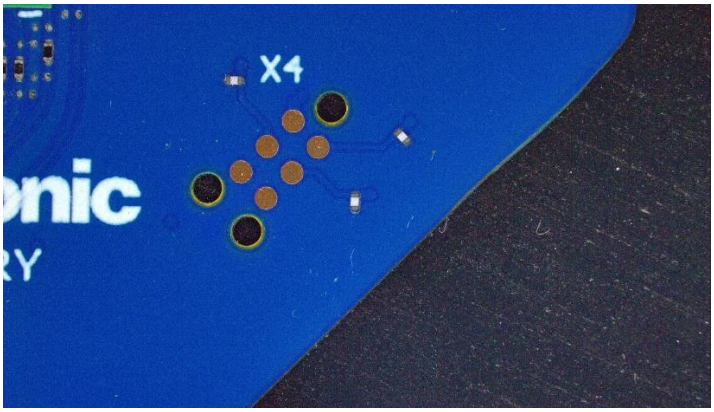
When the evaluation board is still inserted in a host board, then please remove the two chip jumpers R1 and R2 which were seen below, to disconnect the EVD's power planes from the M.2 Interface and with that from the host board supply.



9.3 Interfaces

For more information please see https://www.segger.com/products/debug-probes/j-link/accessories/adapters/6-pin-needle-adapter/ or https://www.ti.com/tool/de-de/SIMPLELINK-WIFI-TOOLBOX

To use TI's radio tool it is possible to connect the powered PAN W602-xx via the 6-pin SWD Needle Adapter. This is only possible with the PAN W602-xC. For the PAN W602-xB please use the test points as described also in ⇨ 9 Test Options, Configuration Settings and Jumper.



10 Software Integration

The following chapters describe how the radio interfaces of the PAN W602-xx shall be brought up in such way that the regulatory requirements are met.

10.1 Regulatory Compliant Bring Up

10.1.1 Concept

The CC33xx Linux driver used for PAN W602-xx is based on the standard cfg80211/mac80211 architecture of the Linux wireless subsystem. In this architecture, mac80211 implements the software MAC layer, while the hardware performs lower-level PHY and MAC functions. The cfg80211/mac80211 framework provides the interface to user space and enforces regulatory requirements. The central component is the CC33XX-LINUX-MPU device driver, which serves as the interface between the Linux kernel and the PAN W602-xx hardware.

Regulatory compliance is achieved through a two-layer concept consisting of hardware capability limits and regulatory policy limits. These layers are complementary and non-overlapping, ensuring operation within certified hardware capabilities and applicable regional regulations.

Hardware-specific RF limits and system parameters are defined by the configuration file `cc33xx-conf.bin`. This file is mandatory for operation and is loaded after the firmware from `/lib/firmware/ti-connectivity/cc33xx-conf.bin`. It contains parameters not included in the firmware, such as Wi-Fi transmit power limits, Bluetooth® Low Energy configuration (enable/disable and transmit power), UART and system interface settings, regulatory domain pre-configuration fields, and additional chipset-specific controls. These parameters define the maximum capabilities of the device and must not be exceeded. Since they are region-dependent, configuration files are provided in variants specific to each regulatory domain. To prevent unauthorized modification, the device is configured to accept only authorized configuration files.

Regulatory policy limits are defined by the Linux wireless regulatory database (`regulatory.db`), which specifies permitted frequency bands, channels, channel bandwidths, and maximum EIRP values for each regulatory domain. As a soft-MAC device, the PAN W602-xx relies on cfg80211/mac80211 to enforce these limits in software. During operation, the effective transmission parameters are determined by the minimum of the hardware limits and the regulatory limits, ensuring compliance with both legal requirements and certified device capabilities. Starting from Linux kernel version 4.15, the regulatory database is loaded by the kernel as a firmware file from `/lib/firmware/`. For PAN W602-xx, a custom regulatory database restricted to certified domains must be provided.

To ensure authenticity and prevent the use of outdated or unauthorized data, the regulatory database is distributed together with a PKCS#7 signature file (`regulatory.db.p7s`) and an associated X.509 certificate in hex-encoded form. These components enable verification of the integrity and authenticity of the database and must be integrated into the system to ensure proper validation and regulatory compliance.

Add following files to locations in Linux system:

- *regulatory.db* → `/lib/firmware/`
- *regulatory.db.p7s* → `/lib/firmware/`
- *cc33xx-conf.bin* → `/lib/firmware/ti-connectivity`

Add following file to kernel source location before building the Linux kernel:

- *panasonic.hex* → `/net/wireless/certs/`

For detailed guidance on adding the required files, refer to section ⇨ 10.1.4 Integration - Regulatory and ⇨ 10.1.3 Integration - Configuration File.

Listed files were generated specifically for the PAN W602-xx. To obtain access to files please see chapter ⇨ 10.1.2.2 Panasonic - Regulatory Package.

User Access Restrictions

The integrator of the PAN W602-xx must ensure that the end user cannot access or manipulate any of the software components mentioned in this document.

10.1.2 Software Packages

10.1.2.1 Texas Instruments - Software Development Package for CC33XX

The CC33XX-SOFTWARE package is a *collection of software development sources aimed to facilitate quick setup, out-of-box experience, and accelerate development in Linux environments for the CC33XX devices.*

Visit Texas Instruments website at ⇨ www.ti.com, search for **`CC33XX-LINUX-MPU`** and download the installer for matching operating system.

Precompiled Image Restrictions

Texas Instruments offers pre-built Images (**.wic.xz*) for Linux platforms like AM62, AM62P, and AM335. However, since the custom PAN W602-xx regulatory database certificate is not included in these images and must be compiled into the kernel, running PAN W602-xx with these images is not permitted.

TI's Linux CC33XX User's Guide

For comprehensive guidance on all required and Linux-related integrations, refer to *TI's Linux CC33XX User's Guide* located at „`cc33xx-linux-mpu/cc33xx/docs/CC33XX-linux-User-Guide.html`“, which is included in the CC33XX-LINUX-MPU software package, downloaded before.

TI's Linux CC33XX User's Guide provides an overview of all software components and integration steps required for deploying CC33XX devices in a Linux environment. It includes detailed information on driver architecture, kernel and device-tree integration, firmware installation, WLAN bring-up, hostapd and supplicant configuration, debugging, calibration tools, parameter configuration and hardware setup guidance for evaluation platforms.

Overall, *TI's Linux CC33XX User's Guide* is organized into a collection of specific guides, including a

- Getting Started Guide,
- Software Examples (Wi-Fi- and BLE-Fundamentals and Demos),
- Migration Guide,
- Kernel Porting Guide,
- CC33Conf Tool Guide,
- Calibrator Tool Guide,
- Driver Debug Guide,
- Vendor-Specific HCI Guide,

as well as additional supporting documents.

Minimum CC33XX-SOFTWARE Package Version

The cc33xx driver and firmware binaries are provided by Texas Instruments.

Ensure that a software package with a released version greater or equal to **1.0.2.14** is used, what includes the following versions:

- FW version: 1.7.16.323
- Driver version: 1.7.2.239
- PHY version: 1.2.0.47.6.8.40.69
- RAM Bootloader version: 1.0.0.31

10.1.2.2 Panasonic - Regulatory Package

File Overview

```
panw602-regulatory-package.zip
│
├── regulatory-database
│      ├── regulatory.db
│      ├── regulatory.db.p7s
│      ├── panasonic.hex
│      ├── db.txt
│      ├── db_clean.txt
│      └── README.md
│
└── configuration
       ├── ETSI-DE
       │    ├── cc33xx-conf.bin
       │    └── cc33xx-conf.ini
       ├── FCC-US
       │    ├── cc33xx-conf.bin
       │    └── cc33xx-conf.ini
       ├── WorldWide-00
       │    ├── cc33xx-conf.bin
       │    └── cc33xx-conf.ini
       …
       └── README.md
```

The following file overview describes the file structure of the `panw602-regulatory-package.zip` package:

regulatory-database

- `regulatory.db` – The main regulatory database containing region-specific wireless rules.
- `regulatory.db.p7s` – Signature file used to verify the authenticity and integrity of regulatory database.
- `panasonic.hex` – A hex-encoded X.509 certificate, that must be integrated for the kernel build process.
- `db.txt` – A human-readable text dump of the regulatory database.
- `db_clean.txt` – A simplified text version of the database with non-essential entries removed.
- `README.md` – Provides additional details, instructions, and version information.

configuration

- `cc33xx-conf.bin` – Required by the firmware and must be present for proper operation.

- `cc33xx-conf.ini` – Provides a human-readable representation of the information contained in the binary file.
- `README.md` – Contains additional details about changes, usage notes, and package versioning.

The following steps describe how to get the regulatory package.

1. Visit PAN W602 Product Website.
2. Fill out contact form “Request support or certification documents”.
3. Select “Regulatory Package, Certification & Test Reports” in Inquiry section.
4. The technical support team will review your request and provide you with the necessary information and files.
5. Receive the `panw602-regulatory-package.zip` configuration package.

Sections ⇨ 10.1.3 Integration - Configuration File and ⇨ 10.1.4 Integration - Regulatory Files Integration - Regulatory providing detailed guidance on how these files are incorporated, configured, and used within the Linux environment.

10.1.3 Integration - Configuration File

The `panw602-regulatory-package.zip` mentioned and described in chapter ⇨ 10.1.2.2 Panasonic - Regulatory Package consist of different configuration folders, each with an own `cc33xx-conf.bin` file. The folders are named with the following pattern `<RegDomain>-<CountryCode>` for example `FCC-US`.

Note that next to the `cc33xx-conf.bin` for every region, also the `cc33xx-conf.ini` file is provided. This INI file provides a human readable form of parameters inside the `cc33xx-conf.bin`. Texas Instruments offers utilities such as *INI Composer* and the *CC33Conf Tool* (refer to *TI's Linux CC33XX User's Guide*) for reading and converting between binary and INI formats. However, be aware that parameter modifications will not succeed due to enabled key handling.

Use Correct Region File

The `cc33xx-conf.bin` file contains region-specific power tables, which define the transmitting power for different channels. These power levels vary by region.

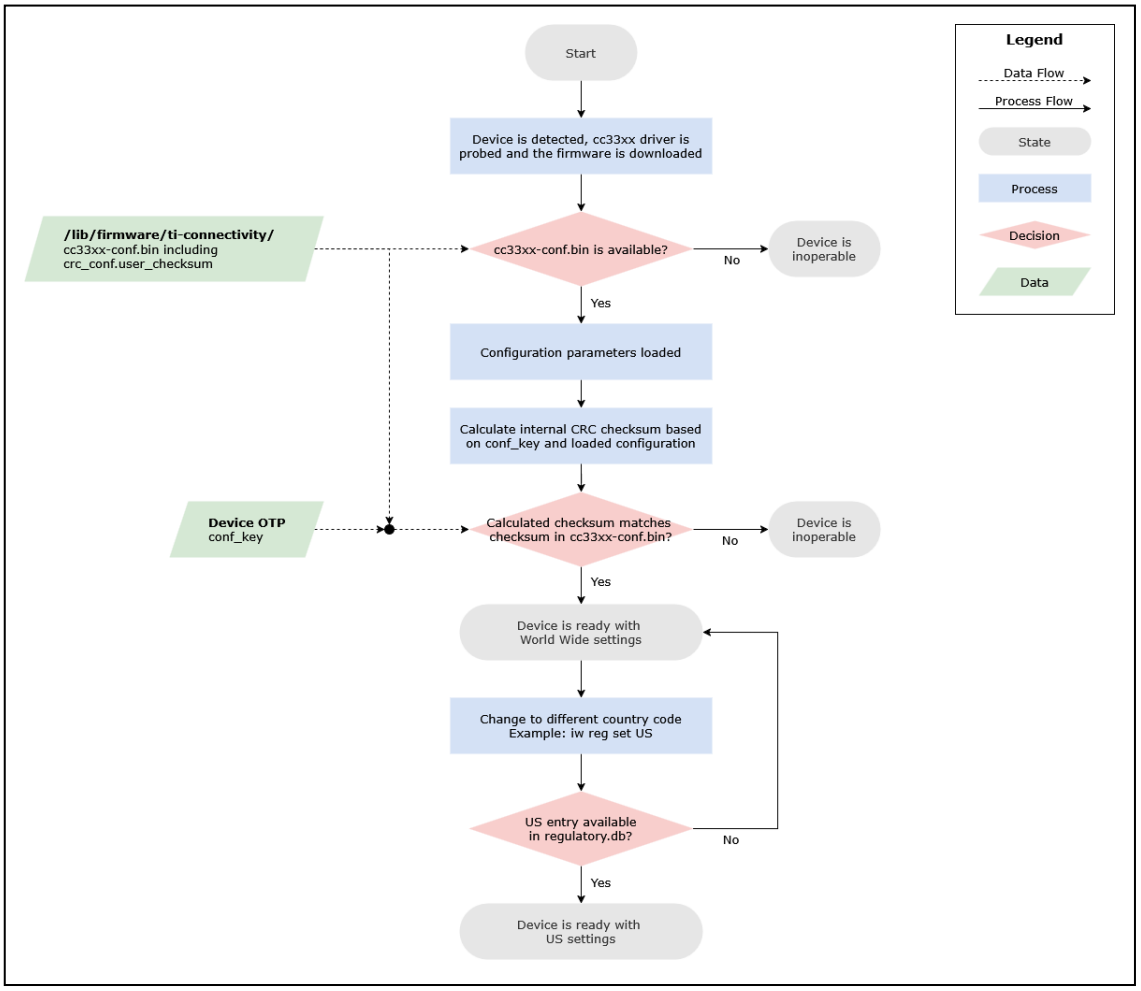
Always ensure that you use the correct `cc33xx-conf.bin` file for your region.

Using a configuration file intended for a different region is **strictly prohibited**.

To prevent unauthorized modification of any `cc33xx-conf.bin`, the device is locked to accept only the delivered configuration files. This is done using a configuration key (`conf_key`), which

is permanently programmed into the device's OTP and cannot be read back. If key and loaded configuration do not match, the device halts and firmware load fails.

The following flow chart illustrates how the cc33xx firmware ensures that only a valid `cc33xx-conf.bin` file from delivered package is accepted for device operation. After validation, a country code (using the US as an example) is subsequently applied.



10.1.4 Integration - Regulatory Files

For `regulatory.db` and `regulatory.db.p7s`, the signature verification is done inside the Linux kernel, and the trusted X.509 certificate for this check is compiled into the kernel, not installed at runtime.

So only option for using provided X.509 certificate from Panasonic (`panasonic.hex`) is to compile the kernel with the certificate before using the device. Do the following steps:

1. Download the Panasonic `panw602-regulatory-package.zip` package, including the following regulatory files:
    - `regulatory.db`

- `regulatory.db.p7s`
- `panasonic.hex`

2. Add X.509 certificate (`panasonic.hex`) to kernel source folder under `/net/wireless/certs/`

> **Remove obsolete X.509 Certificates**
>
> Take care the provided X.509 certificate (`panasonic.hex`) is the only certificate in `/net/wireless/certs` and remove other, obsolete certificates left from previous builds or standard configuration.
>
> Otherwise, other `regulatory.db`/`regulatory.db.p7s` files than the ones intended for PAN W602-XX are allowed to load. This must strictly be avoided.

3. Integrate regulatory files into firmware folder on Linux System on location

`/lib/firmware/regulatory.db`

`/lib/firmware/regulatory.db.p7s`

> **Remove obsolete regulatory files**
>
> Ensure that any already existing regulatory files (`regulatory.db`/`regulatory.db.p7s`) are replaced with the regulatory files provided by `panw602-regulatory-package.zip`.
>
> Otherwise, they mismatch with loaded X.509 certificate and following error log occurs during Linux System start-up:
>
> ```
> cfg80211: loaded regulatory.db is malformed or
> signature is missing/invalid
> ```
>
> This must strictly be avoided.

4. Enable regulatory checking on Linux System with configurations

```
CONFIG_CFG80211_REQUIRE_SIGNED_REGDB=y
CONFIG_CFG80211_USE_KERNEL_REGDB_KEYS=y
```

The configuration CONFIG_CFG80211_REQUIRE_SIGNED_REGDB is a Linux kernel configuration option that forces the kernel to accept only `regulatory.db` files that are signed with a valid PKCS#7 signature using certificates built into the kernel.

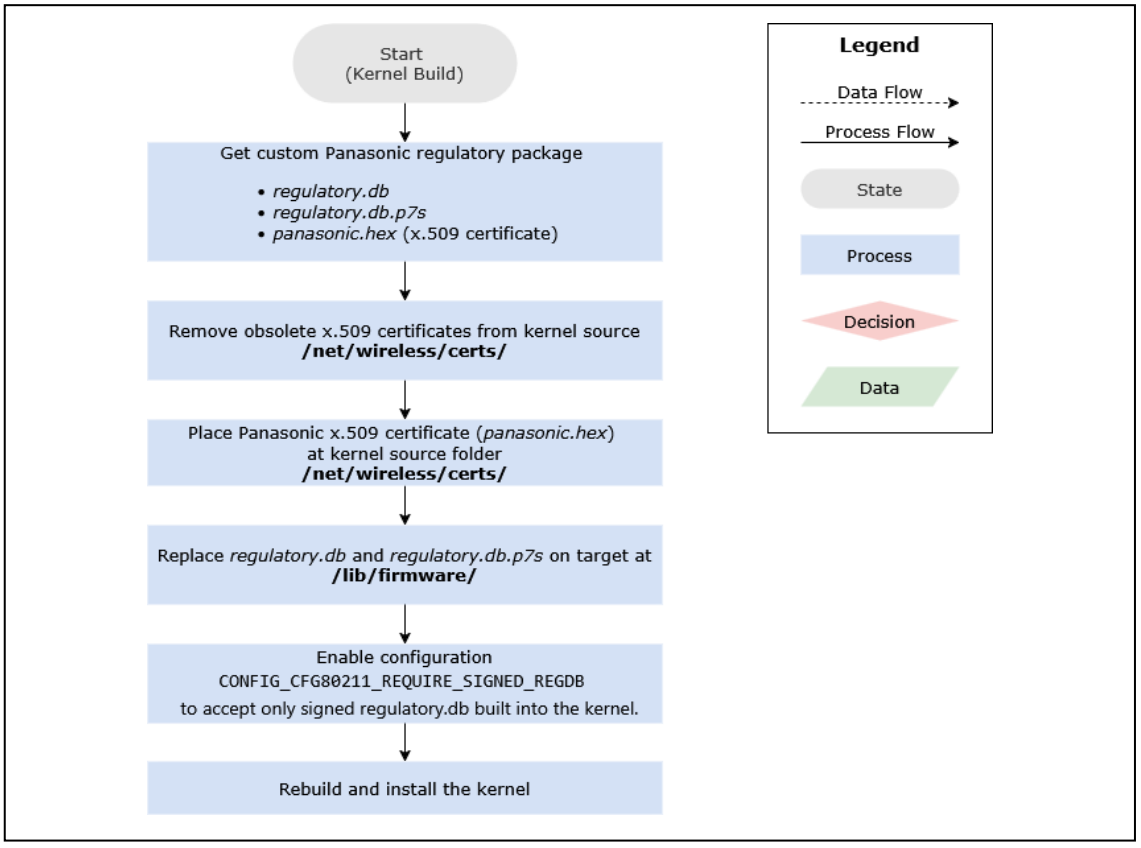
Configuration Dependencies

The option CONFIG_CFG80211_REQUIRE_SIGNED_REGDB has required dependencies that must be configured accordingly. All dependent settings must be enabled to support verification of signed regulatory database files.

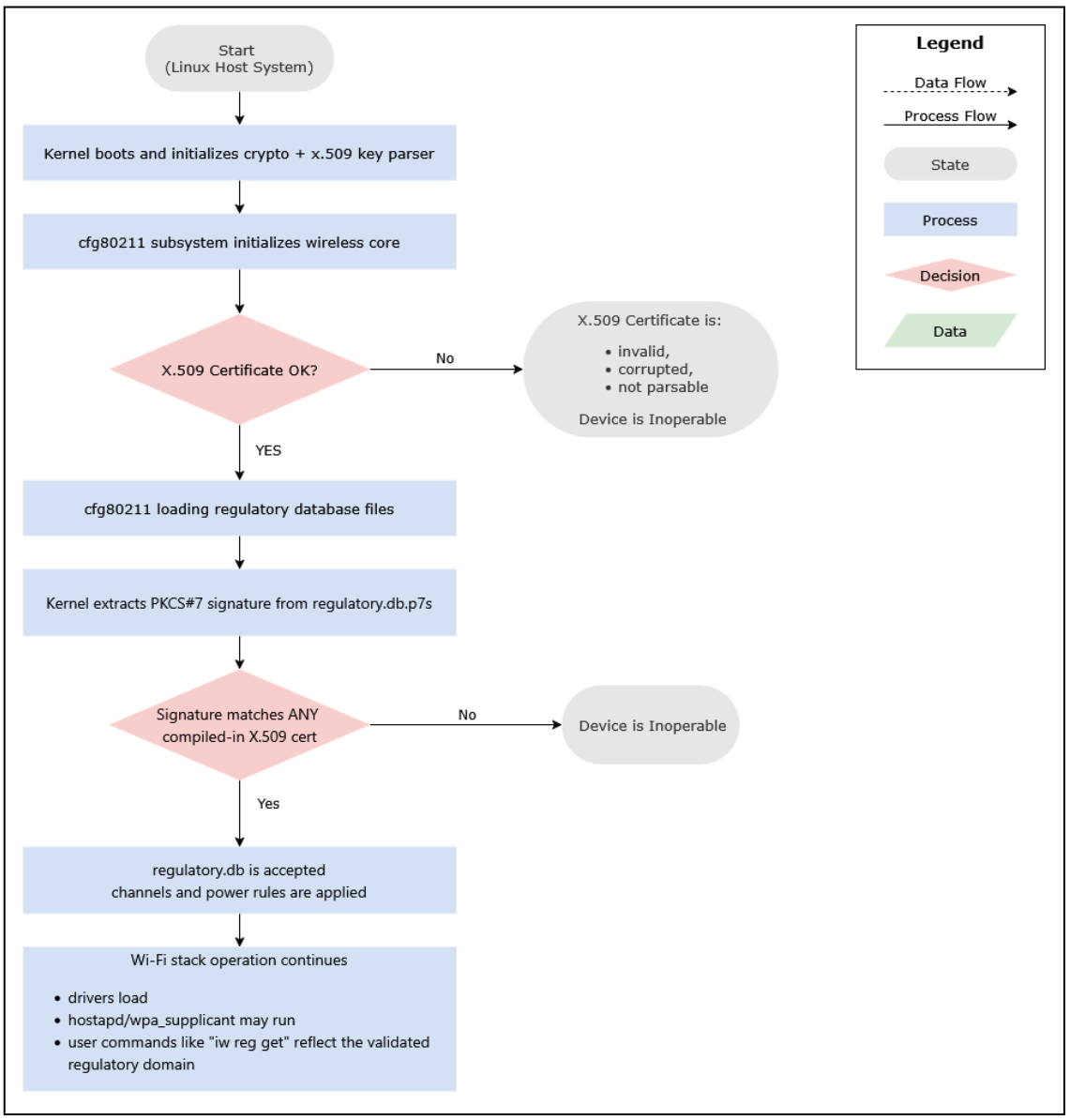
5. Build/Rebuild and install the kernel

The previously outlined procedure, which involves building the kernel and incorporating the certificate into the kernel, remains the sole method for adding trusted keys to the regulatory database.

The following flow charts illustrate necessary steps for building the Linux Kernel with Panasonic's provided regulatory files.



The following flow chart illustrates steps during Kernel boot with Panasonic's provided regulatory files.



10.1.5 Integration – Firmware, Driver and Device Tree

The source code for the CC33XX driver and firmware binaries are developed and distributed by Texas Instruments. To get access please see ⇨ 10.1.2.1 Texas Instruments - Software Development Package for CC33XX

Driver Distribution Format

The CC33XX Linux driver is provided as a patch-based source package within the TI CC33XX-SOFTWARE distribution. The main driver patch is located at:

`cc33xx\patches\cc33xx_kernel.patch`

and contains the complete CC33XX WLAN/BLE driver implementation as a unified kernel diff. This patch is applied directly to the target Linux kernel source tree to enable driver integration for supported kernel versions.

Please see chapter "*Patch Kernel with CC33xx Driver"* in *TI's Migration Guide* which is part of *TI's Linux CC33XX User's Guide* for more detailed information about driver integration.

Forward-Port Patches

For expanded kernel version support, TI maintains an official forward-port repository containing version-specific update patches. These patches are available at the TI Sandbox CC33xx Linux MPU Ports repository: Texas-Instruments-Sandbox-cc33xx-linux-mpu-ports.

This repository ensures ongoing compatibility with evolving kernel architectures and allows developers to integrate CC33xx devices into a broad range of embedded Linux platforms.

CC33xx Migration

For Linux Host Systems natively supported within the CC33XX-SOFTWARE package, such as AM62 or AM335x, relevant patches for device tree and defconfig configuration can be found in the `cc33xx/patches/` directory.

It is advisable to consult the patches within `cc33xx/patches/` as a reference template to understand the necessary modifications required for other environments.

Review *TI's Migration Guide* provided in *TI's Linux CC33XX User's Guide*. This guide offers a thorough, step-by-step overview of the required integration procedures, including:

• *Kernel Configuration*

Instructions on how to modify the target's defconfig to disable legacy WLCORE support and enable the CC33xx driver modules. This includes selecting the appropriate CC33xx SDIO or SPI interfaces and enabling all necessary wireless subsystem components.

• *Device Tree Configuration*

Detailed examples illustrate how to incorporate the CC33XX into the system's device tree. A complete MMC/SDIO integration example is provided, demonstrating how to properly integrate the CC33xx node within the MMC controller:

- Configuring the power-supply regulator node
- Defining and assigning regulator GPIOs for enable/interrupt pins
- Choosing between SDIO in-band or out-of-band interrupt signaling
- Selecting whether Bluetooth® Low Energy operates over UART or SDIO

• *Hostapd and Supplicant Integration*

Guidance on enabling AP and STA functionality through hostapd and wpa_supplicant, including required configuration parameters, driver interface options, and runtime considerations.

• *WLAN Bring-Up*

A walkthrough of the sequence required to initialize and bring up the CC33xx WLAN interface, including interface enumeration, firmware loading, regulatory setup, and validation steps.

10.1.6 General File Overview

The file structure on the Linux host system is illustrated below. The following files must be present inside the root file system:

```
/
└── lib
    ├── firmware
    │   ├── ti-connectivity
    │   │   ├── cc33xx_fw.bin
    │   │   ├── cc33xx_2nd_loader.bin
    │   │   ├── cc33xx_nvs.bin
    │   │   └── cc33xx-conf.bin
    │   ├── regulatory.db
    │   └── regulatory.db.p7s
    └── modules/<kernel_version>/kernel/drivers
        ├── net/wireless/ti/cc33xx
        │   ├── cc33xx.ko
        │   ├── cc33xx_sdio.ko
        │   ├── cc33xx_spi.ko
        └── bluetooth
            ├── btti.ko
            ├── btti_sdio.ko
            └── btti_uart.ko
```

- The `/lib/firmware/ti-connectivity` directory on Linux System contains the firmware binary and configuration files from ⇨ 10.1.2.1 Texas Instruments - Software Development Package for CC33XX in folder `cc33xx/cc33xx_rootfs/lib/firmware/ti-connectivity`. These following bullet points only include those files that are either not included in the specified software package or need to be replaced with custom files.
  - `cc33xx-conf.bin` – Use region dependent configuration file, like described in chapter ⇨ 10.1.3 Integration - Configuration File and **NOT** the default one delivered in the TI-Software package.
  - `cc33xx_nvs.bin` – (Optional) See chapter "*Override Default MAC Address*" in "*Software Examples – WiFi Fundamentals*" which is part of *TI's Linux CC33XX User's Guide*. An address in the NVS file with value "00:00:00:00:00:00" is reserved and the default address written in OTP will be used. Use e.g. following call for generation of file:

    ```
    echo -n -e '\x00\x00\x00\x00\x00\x00' > /lib/firmware/ti-connectivity/cc33xx-nvs.bin
    ```

  See chapter "*Install Firmware"* in *TI's Migration Guide* which is part of *TI's Linux CC33XX User's Guide* for more detailed information.
- For regulatory files `regulatory.db(.p7s)` please see chapter ⇨ 10.1.4 Integration - Regulatory Files

- Wi-Fi Drivers (`cc33xx`)
  Directory: `net/wireless/ti/cc33xx/`
  - `cc33xx.ko` – The core TI CC33xx Wi-Fi driver.

    This module implements the main MAC/PHY functionality for TI's CC33xx wireless chipset family. It provides core features such as Wi-Fi management, data path handling, regulatory support, power-management integration, and communication with the underlying transport drivers (cc33xx_sdio or cc33xx_spi).
  - `cc33xx_sdio.ko` – SDIO bus interface driver for the CC33xx chipset.

    This module enables the CC33xx Wi-Fi device to communicate over the **SDIO** (Secure Digital I/O) bus. It acts as the transport layer, handling SDIO transactions, interrupt management, and data transfer between the main CC33xx driver and the hardware.
  - `cc33xx_spi.ko` – SPI bus interface driver for the CC33xx chipset.

    This transport driver enables communication over the **SPI** bus. It provides the low-level SPI communication routines required by the main cc33xx module when the Wi-Fi chip is wired via SPI instead of SDIO.
- Bluetooth Drivers (`btti`)
  Directory: `bluetooth/`
  - `btti.ko` – The core TI Bluetooth controller driver.

    This module provides the main Bluetooth stack integration for TI's Bluetooth controller used alongside CC33xx-based platforms. It handles controller initialization, HCI protocol handling, power management, and communication with transport-specific modules (btti_sdio, btti_uart).
  - `btti_sdio.ko` – SDIO transport driver for TI Bluetooth. Implements the HCI-over-SDIO communication path between the Bluetooth controller and the Linux Bluetooth subsystem. It handles SDIO data transfer, interrupts, and transport-layer reliability.
  - `btti_uart.ko` – UART transport driver for TI Bluetooth. Provides an HCI-over-UART interface for TI Bluetooth controllers. This module is used when the Bluetooth chip is connected via a serial UART line, typically on embedded SoCs or development boards. Handles baud-rate setup, flow control, and HCI framing.

10.1.7 Wi-Fi – Bring-Up

After the Linux kernel boots, the CC33XX driver should now be loaded and the `wlan0` interface should be shown in the output.

```
$ ip address
[…]
3: wlan0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq qlen 1000
    link/ether 34:32:e6:aa:bb:cc brd ff:ff:ff:ff:ff:ff
[…]
```

➔ The `wlan0` network interface is listed.

Bring the `wlan0` interface up by executing the following command.

```
$ ip link set dev wlan0 up
```

➔ At this point the device is ready for operation. Check `ip address show wlan0` for more detailed information

Check with `lsmod` if modules mentioned in chapter ⇨ 10.1.6 General File Overview are loaded as expected. For example:

```
$ lsmod
Module                  Size  Used by
btti_uart              20480  0
btti_sdio              20480  0
btti                   16384  1 btti_sdio
cc33xx                192512  0
cc33xx_sdio            16384  0
…
mac80211              561152  1 cc33xx
cfg80211              421888  2 mac80211,cc33xx
```

Please refer to the chapter "*WiFi Fundamentals*" in section "*Software Examples*" included in *TI's Linux CC33XX User's Guide* for additional steps that can be used to verify the build for both STA and AP roles.

10.1.8 Setting the Country Code

The following requirements must be met:

✓ The CC33xx driver was installed and the `wlan0` interface was brought up as described in ⇨ 10.1.7 Wi-Fi – Bring-Up

The device initially comes up with the world-wide (`country 00`) setting. Thanks to the custom signed regulatory database provided by us, the world-wide file remains available on the host system as a fallback with minimum settings (2.4 GHz Ch 1–11 only).

To set the country code for a specific region (e.g., US) execute the following steps:

1. Use the command `iw reg get` to read out the current configuration.

```
$ iw reg get
global
country 00: DFS-UNSET
        (755 - 928 @ 2), (N/A, 20), (N/A), PASSIVE-SCAN
        (2402 - 2472 @ 40), (N/A, 20), (N/A)
        (5170 - 5250 @ 80), (N/A, 20), (N/A), AUTO-BW, PASSIVE-SCAN
        (5250 - 5330 @ 80), (N/A, 20), (0 ms), DFS, AUTO-BW, PASSIVE-SCAN
        (57240 - 63720 @ 2160), (N/A, 0), (N/A)
```

2. Use the command `iw reg set` to change to the configuration of the country or region, in which the device is operated. The following example initiates a change to the US configuration:

```
$ iw reg set US
```

➔ When executing the `iw reg get` command again the updated US configuration of the device is displayed.

```
$ iw reg get
global
country US: DFS-FCC
        (902 - 904 @ 2), (N/A, 30), (N/A)
        (904 - 920 @ 16), (N/A, 30), (N/A)
        (920 - 928 @ 8), (N/A, 30), (N/A)
        (2400 - 2472 @ 40), (N/A, 30), (N/A)
        (5150 - 5250 @ 80), (N/A, 23), (N/A), AUTO-BW
        (5250 - 5350 @ 80), (N/A, 24), (0 ms), DFS, AUTO-BW
        (5470 - 5725 @ 160), (N/A, 24), (0 ms), DFS
        (5730 - 5850 @ 80), (N/A, 30), (N/A), AUTO-BW
        (5855 - 5895 @ 40), (N/A, 27), (N/A), NO-OUTDOOR, AUTO-BW, PASSIVE-SCAN
        (5925 - 7125 @ 320), (N/A, 12), (N/A), NO-OUTDOOR, PASSIVE-SCAN
        (57240 - 71000 @ 2160), (N/A, 40), (N/A)
```

For operation in the US, you must use the country code `US`

For operation in the EU use the country code `DE`

10.1.9 Bluetooth – Bring Up

The PAN W602-xx module variants equipped with CC3301 or CC3351 chipsets offer Bluetooth functionality. The host system manages the Bluetooth device through the Host Controller Interface (HCI). The PAN W602-xx utilizes either the SDIO or UART interface as the transport mechanism for HCI communication. For comprehensive guidance on configuration, please refer to the chapters "*BLE over SDIO*" and "*BLE over UART*" in *TI's Migration Guide* which is included in *TI's Linux CC33XX User's Guide* (⇨ 10.1.2.1 Texas Instruments - Software Development Package for CC33XX). These resources provide detailed instructions and examples for configuring both the device tree and defconfig settings for each option.

The Bluetooth transmit power is set in the `cc33xx-conf.bin` (⇨ 10.1.3 Integration - Configuration File) and does not need to be set manually.

The following requirements must be met:

- ✓ The cc33xx module was loaded (needed for enabling Bluetooth via SDIO)
- ✓ The btti main Bluetooth stack integration for TI's Bluetooth controller was loaded
- ✓ The btti_uart or btti_sdio module for HCI transport was loaded

To bring up the Bluetooth device, execute the following steps:

1. Get current used PHY index.

```
$ PHY=`ls /sys/class/ieee80211/`
```

2. Enable Bluetooth with previously `phyx` version.

```
$ echo "1" > /sys/kernel/debug/ieee80211/$PHY/cc33xx/ble_enable
```

3. Bring up the Bluetooth device using the `hciconfig` command.

```
$ hciconfig hci0 up
```

➔ The Bluetooth device is now ready for operation. By executing the `hciconfig -a` command it can be verified that the device is up and running.

```
$ hciconfig -a
hci0:   Type: Primary  Bus: UART
        BD Address: 34:32:E6:AA:BB:CD  ACL MTU: 255:10  SCO MTU: 0:0
        UP RUNNING
        RX bytes:319 acl:0 sco:0 events:28 errors:0
        TX bytes:198 acl:0 sco:0 commands:28 errors:0
```

Several command line utilities are available for executing BlueZ commands, with common options including hcitool, btmgmt, and bluetoothctl. Each utility offers a unique set of commands and can generally be used interchangeably to manage the Bluetooth stack.

Please refer to the chapter “*BLE Fundamentals*” in the “*Software Examples*” section of *TI's Linux CC33XX User's Guide* (⇨ 10.1.2.1 Texas Instruments - Software Development Package for CC33XX). This section provides comprehensive coverage of advanced topics such as Advertising, Scanning, Connecting, and Pairing.

11 Contact Details

11.1 Contact Us

For any technical inquiries, please use our dedicated contact form https://pideu.panasonic.de/en/contact/?subject=Wireless%20Connectivity.

For information on worldwide sales channels and authorized distributors, please visit our distribution overview https://pideu.panasonic.de/en/wireless-connectivity#distributors.

11.2 Product Information

For the latest product information, documentation, and updates, please visit our product overview https://pideu.panasonic.de/en/all-products/.

For access to evaluation tools, schematics, software resources, and additional development support, please visit the Panasonic Wireless Connectivity Development Hub https://pideu.panasonic.de/development-hub/.