PAN9019 / PAN9019A

Wi-Fi 6 Dual Band 2.4 GHz/5 GHz, Bluetooth® and 802.15.4 (PAN9019A only) Module

Module Integration Guide

Rev. 1.0

Overview

The PAN9019 and PAN9019A are 2.4 GHz and 5 GHz ISM band Wi-Fi, Bluetooth, and 802.15.4[1] radio modules, which allow easy integration of Wi-Fi, Bluetooth, and 802.15.4[1] based technologies into various electronic devices.
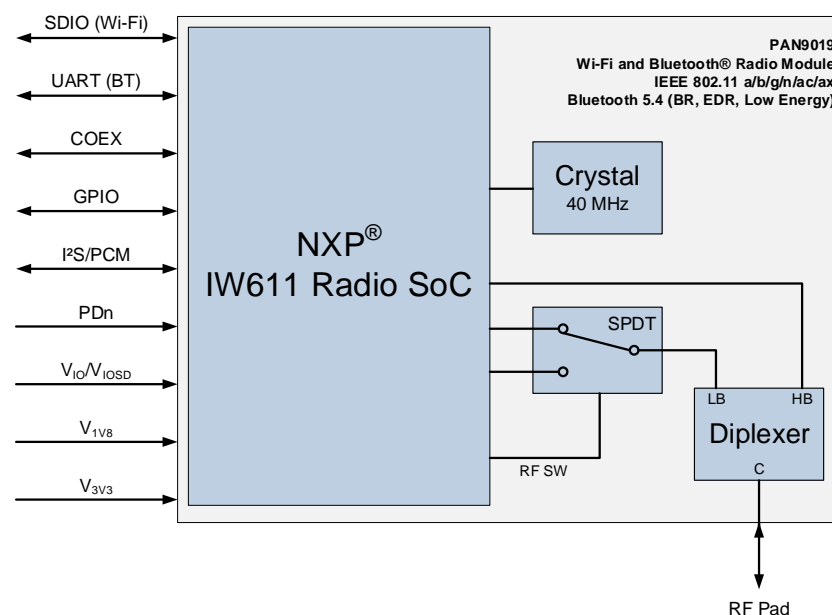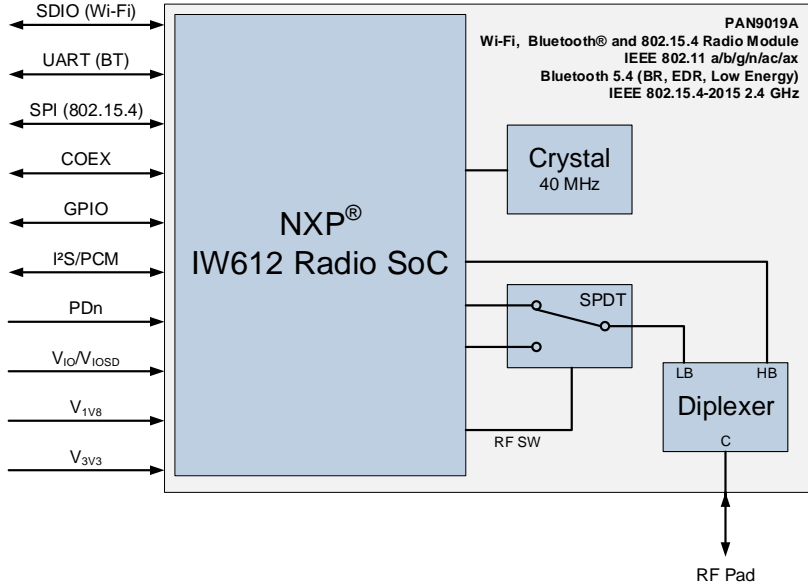
Features

- Dual band 2.4 GHz and 5 GHz 802.11 a/b/g/n/ac/ax Wi-Fi, Bluetooth, and 802.15.4[1] combo module
- Supports WPA3 security
- Secured boot and firmware
- 802.11e Quality of Service is supported for multimedia application
- IEEE 802.11ax, 1×1 spatial stream with data rates up to 600 Mbps (MCS11, 80 MHz channel bandwidth)
- OFDMA (UL/DL) and MU-MIMO (UL/DL)
- Bluetooth 5.4 (including LE and long range)
- WCI-2- and 5-wire PTA coexistence interfaces
- Generic interfaces include SDIO 3.0, high-speed UART and SPI[2] for host processor connection
- OS driver support for RTOS, Linux®, and Android™

Characteristics

- Surface Mount Type (SMT): 15.3 mm × 12 mm × 2.5 mm
- PAN9019: NXP® IW611 WLAN 2.4 GHz and 5 GHz, Bluetooth single-chip solution inside
- PAN9019A: NXP IW612 WLAN 2.4 GHz and 5 GHz, Bluetooth and 802.15.4 single-chip solution inside
- Rx sensitivity: -98 dBm at IEEE 802.11b 1 Mbps
- IEEE 802.11ax 20 MHz, 40 MHz, 80 MHz channel bandwidth
- Power supply: 1.8 V and 3.3 V
- SDIO 1 bit or 4 bit
- Wide temperature range: -40 °C to 85 °C

Block Diagram

SDIO (Wi-Fi)
UART (BT)
SPI (802.15.4)
COEX
GPIO
I²S/PCM
PDn
V_{IO}/V_{IOSD}
V_{1V8}
V_{3V3}

NXP®
IW612 Radio SoC

PAN9019A
Wi-Fi, Bluetooth® and 802.15.4 Radio Module
IEEE 802.11 a/b/g/n/ac/ax
Bluetooth 5.4 (BR, EDR, Low Energy)
IEEE 802.15.4-2015 2.4 GHz

Crystal
40 MHz

SPDT

LB   HB
Diplexer
C

RF SW

RF Pad

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[1] 802.15.4 is only supported by the PAN9019A.

[2] SPI is available as 802.15.4 host interface (only on PAN9019A).

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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 PAN9019 and PAN9019A into a product and to ensure the compliance with regulatory requirements.

This guide gives an overview about the hardware design requirements by providing a reference design, which is the evaluation board of the PAN9019 and PAN9019A.

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

The product is referred to as "PAN9019 / PAN9019A" and "module" within this document.

1.2 Revision History

Revision	Date	Modifications/Remarks
0.1	2023-08-04	First preliminary version
0.2	2023-11-22	• Added antenna lists ⇨ 5.2 Antennas • Added subsections ⇨ 5.2.2 External Antennas • Added section ⇨ 5.2.1.3 Design Verification • Changed reference matching and tuning components ⇨ 5.2.1.2 Antenna Layout • Updated pictures ⇨ 5.2.1.2 Antenna Layout
1.0	2024-05-22	• Added ⇨ 8 Software Integration • Corrected direction of SPI_FRM ⇨ 6.3 SPI Interface • Updated Block diagrams: Bluetooth 5.2 → Bluetooth 5.4 • Added IND_RST_15.4 to SPI diagram ⇨ 6.3 SPI Interface • Corrected cross references • Updated formatting and structure

1.3 Use of Symbols

Symbol	Description
(i)	**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.

Symbol	Description
✓	**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**.
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 ⇨ 9.2 Product Information.

2   Overview

The PAN9019 / PAN9019A is a dual band 2.4 GHz and 5 GHz 802.11 a/b/g/n/ac/ax Wi-Fi radio module with integrated Bluetooth BR/EDR/Low Energy (LE) and 802.15.4[3] radio, specifically designed for highly integrated and cost-effective applications. The independent operation of the three standards enables 802.11ax data rates with high efficiency (HE) and low-power operation (Bluetooth LE and 802.15.4[3]).

Latest technologies like multiuser MIMO and OFDMA improve the efficiency in large networks, while the 1024-QAM modulation allows high data rates. Integrated power management, a fast dual-core CPU, 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.

Tx power calibration data and Wi-Fi/Bluetooth/802.15.4[3] system parameters are pre-stored on the one-time-programmable memory of the PAN9019 / PAN9019A 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, Bluetooth, and 802.15.4[3] wireless connectivity allows high throughput applications for industrial devices and appliances. The combination of Wi-Fi, Bluetooth, and 802.15.4[3] provides the highest flexibility for connectivity. This Module Integration Guide applies to the PAN9019 / PAN9019A WLAN and Bluetooth combo module and the PAN9019 / PAN9019A M.2 evaluation platforms.

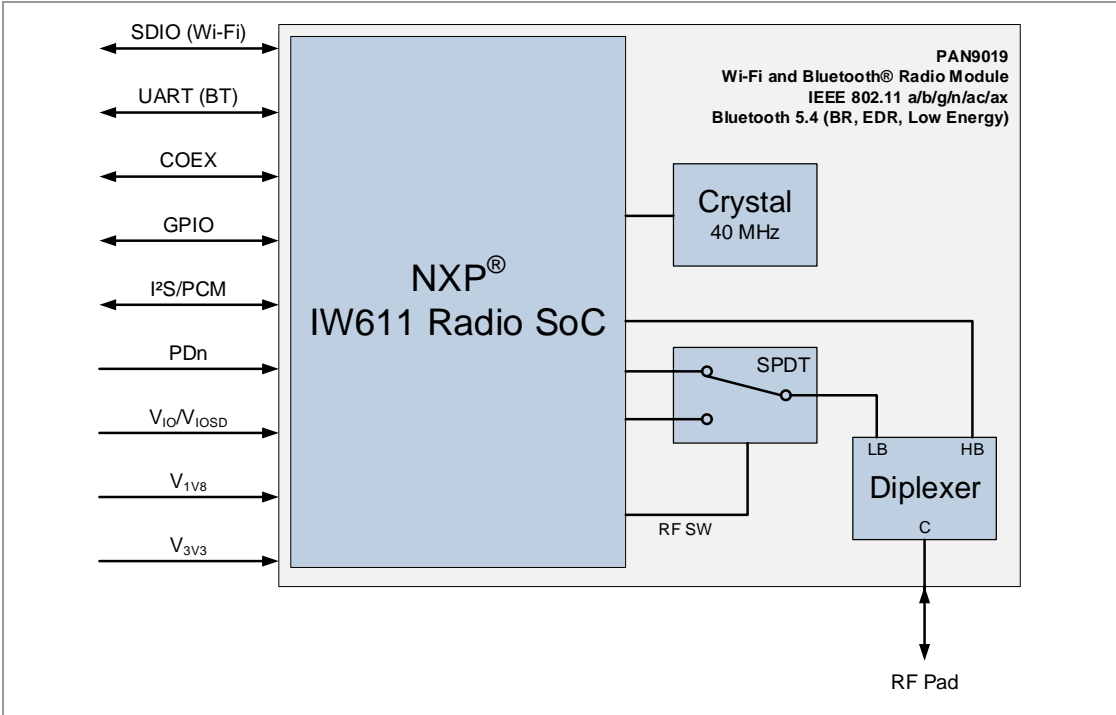For related documents please refer to ⇨ 9.2 Product Information.

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[3] 802.15.4 is only supported by the PAN9019A.

3   PAN9019 / PAN9019A Module

3.1   Block Diagram

PAN9019 (ENWF9501C1KF)

PAN9019A (ENWF9511C1KF)
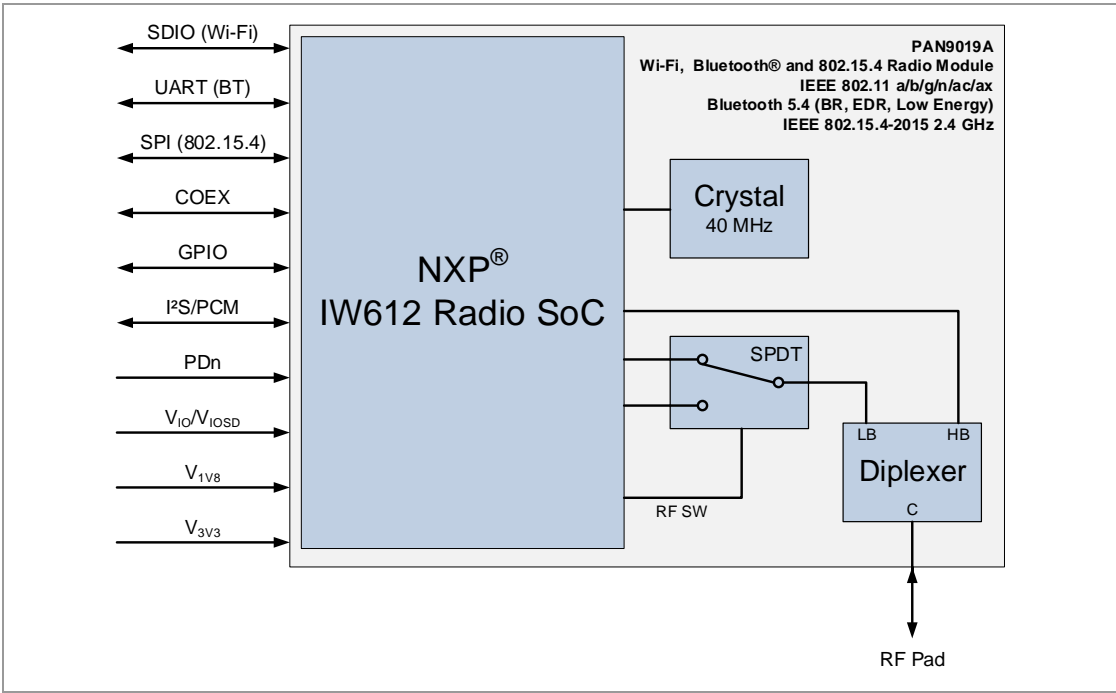
3.2 Land Pattern

Top View
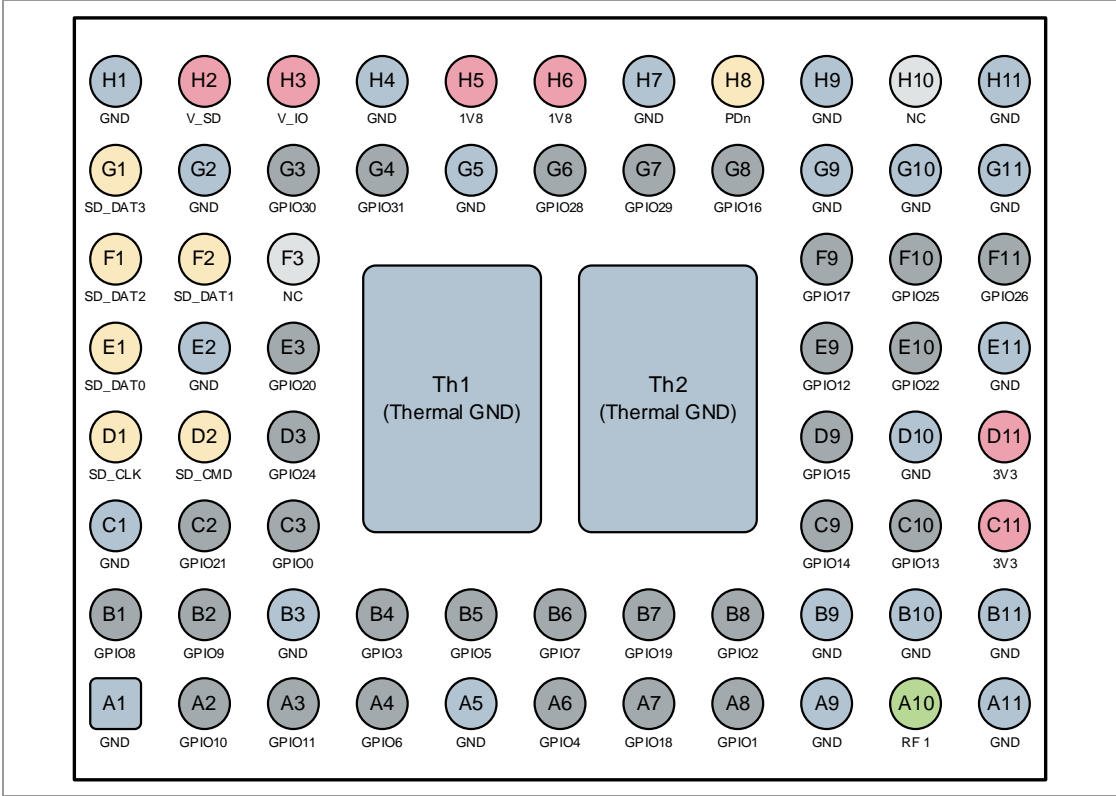
3.3 Footprint

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

Top View
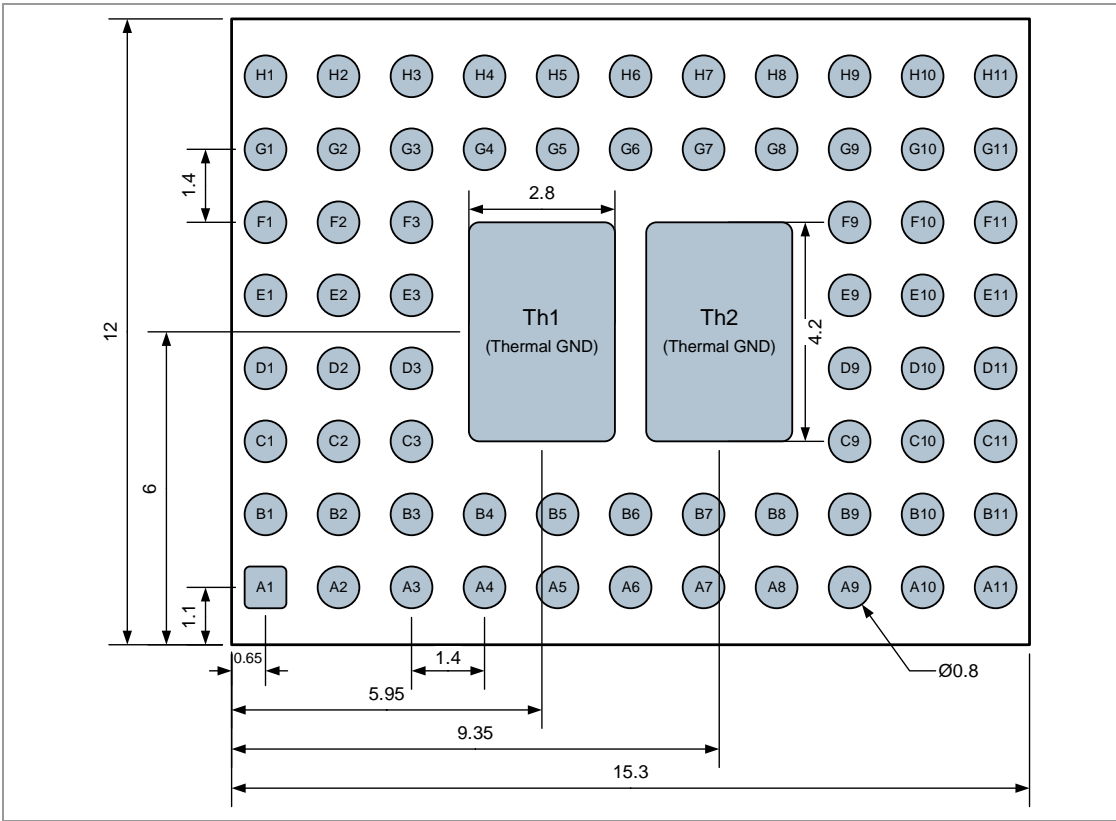
3.4   Solder Resist Mask and Solder Paste Stencil

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 in two semi circles with 300 µm distance and are shifted about 150 µm towards the outside.

> ⓘ   For details on the dimensions of the copper pads please refer to
> ⇨ 3.3 Footprint.

Solder Paste Stencil Layout
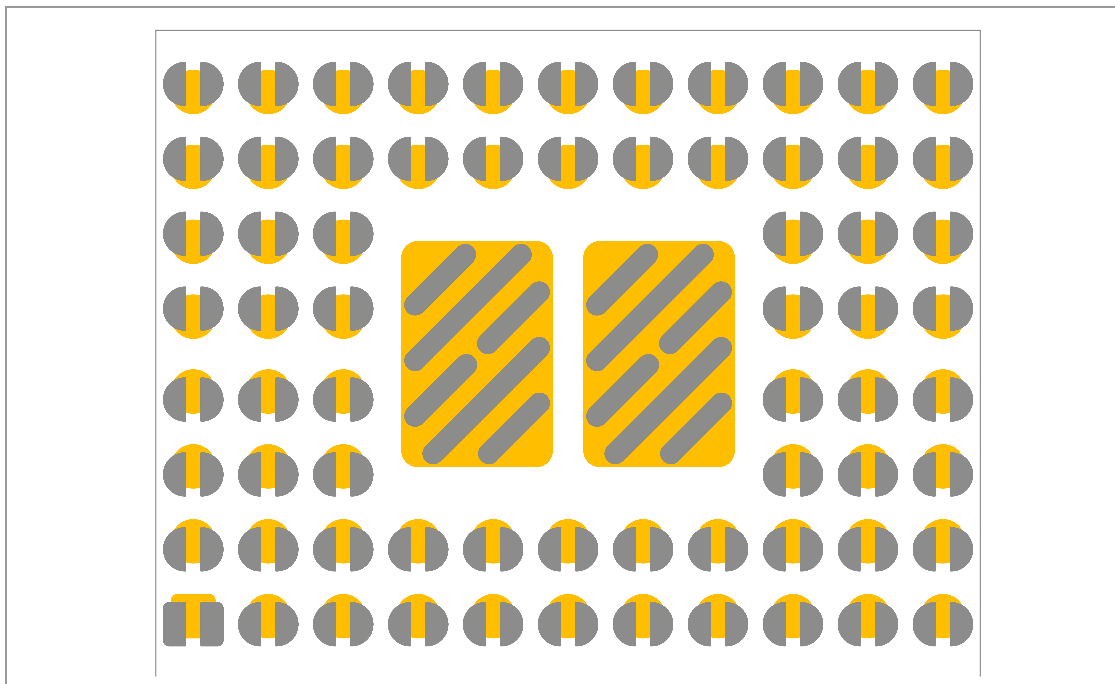
4 Power Supply

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). For noisy supply voltages, provide a decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47 µF directly at the module).

✓ The supply voltage must not be exceedingly high or reversed. It must not carry noise and spikes.

4.2 Power Supply Terminals

The PAN9019 / PAN9019A 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
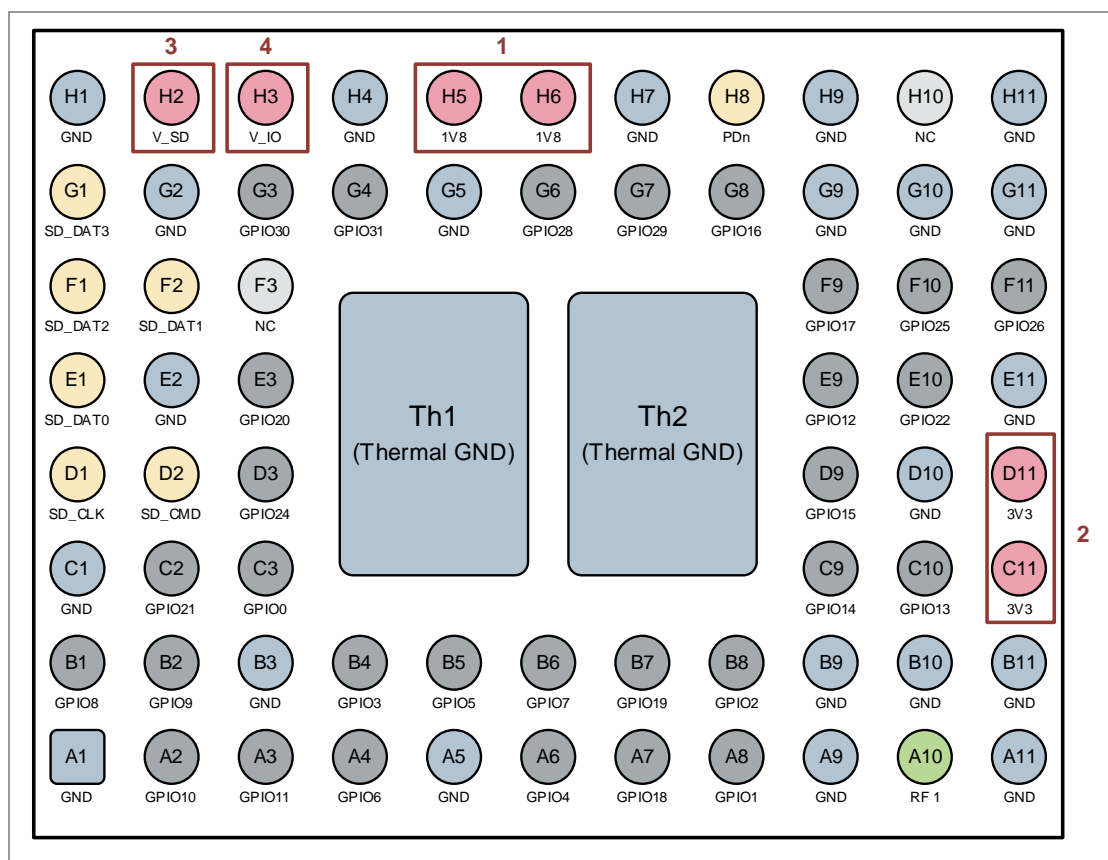
Enumeration	Name	Nominal Voltage	Description
1	1V8	1.8 V	Main power supply
			The supply source should be capable to drive at least 1 A.
2	3V3	3.3 V	Supply for Wi-Fi PA and internal RF control pins
			The supply source sould be capable to drive at least 500 mA.
3	V_SD	1.8 V or 3.3 V	Reference voltage for the digital SDIO interface
4	V_IO	1.8 V or 3.3 V	Reference voltage for all other digital IO interfaces

5   RF Interface

The PAN9019 / PAN9019A can be used in combination with various antennas that are listed in this document. The design rules given in this document must be followed to meet the regulatory requirements.

5.1   RF Trace

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

This section describes the required design of the trace.

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

✓ Height (H) of dielectric: typ. 250 µm ± 10 µm

✓ Trace Width (W): typ. 450 µm ± 10 µm

✓ Copper Gap (G): typ. 500 µm, min. 450 µm

✓ All inner layers have the same copper-obstruct pattern as the GND on the top layer.

✓ The minimum trace length in ⇨ 5.2.1 Chip Antenna is met.
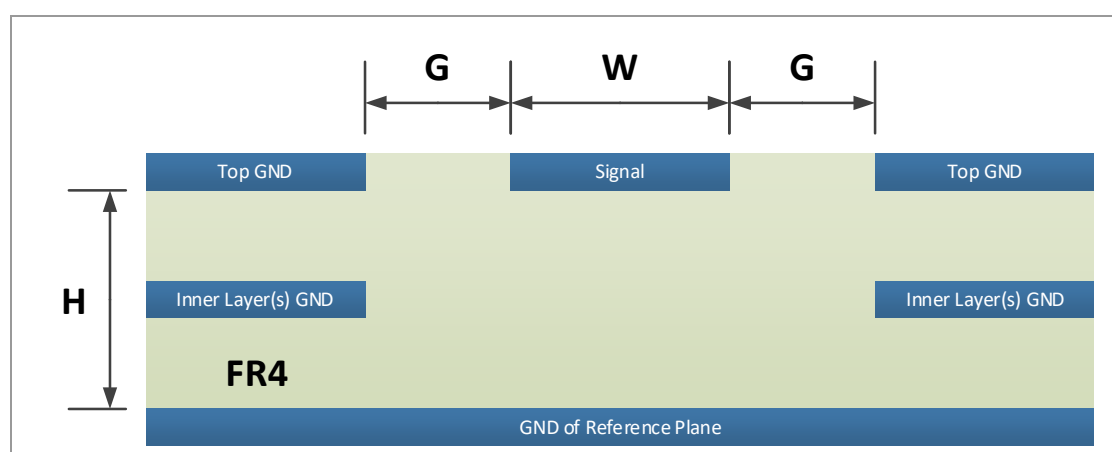
5.2   Antennas

The PAN9019 / PAN9019A are certified in combination with the following antenna types:

- Chip antenna
- External flex PCB antenna
- External terminal antenna

All approved antennas are listed in the corresponding subsection.

5.2.1   Chip Antenna

One option of the RF interface is to use the chip antenna ANT162442DT-2001A2 directly on the carrier PCB.

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 • Min. length: 15 mm • Design follows ⇨ 5.2.1.1 RF Path

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

5.2.1.1   RF Path

Please follow the design described in ⇨ 5.1 RF Trace for connecting the antenna. The trace length should be at minimum 15 mm.

The following figure illustrates the connection on the reference design.
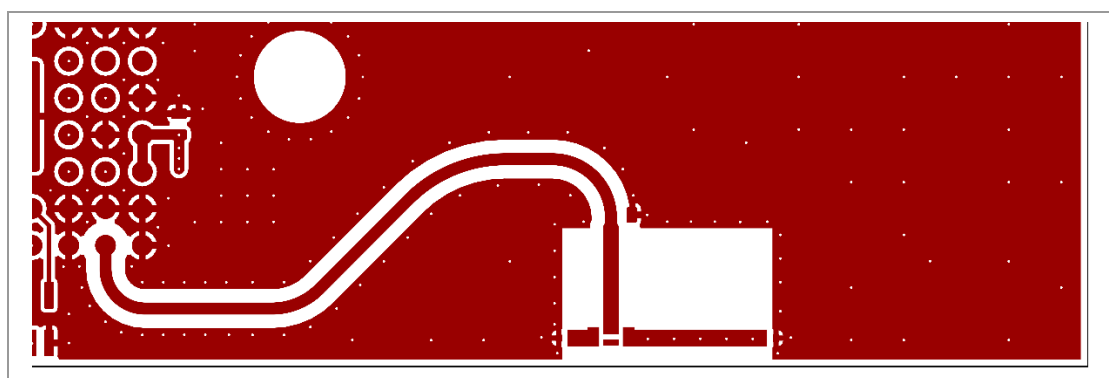
5.2.1.2   Antenna Layout

⚠	Please note that the stackup must follow the design instructions described in ⇨ 5.1 RF Trace!

This section describes the layout on the module's carrier PCB that must be followed.

A reference DXF file can be obtained from Panasonic.

The following requirements must be met:

✓   The top copper layer complies with the following dimensions:
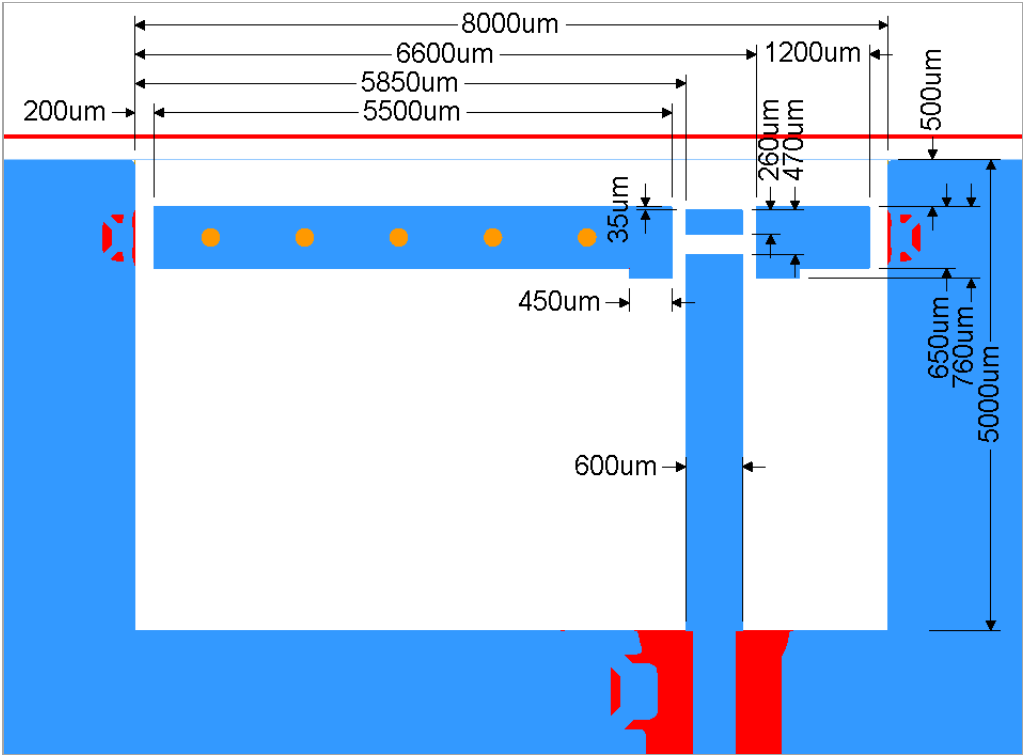
✓ On the lower layer, the shown metal structure is placed.
   The shape is connected to the top layer with vias at the marked positions.
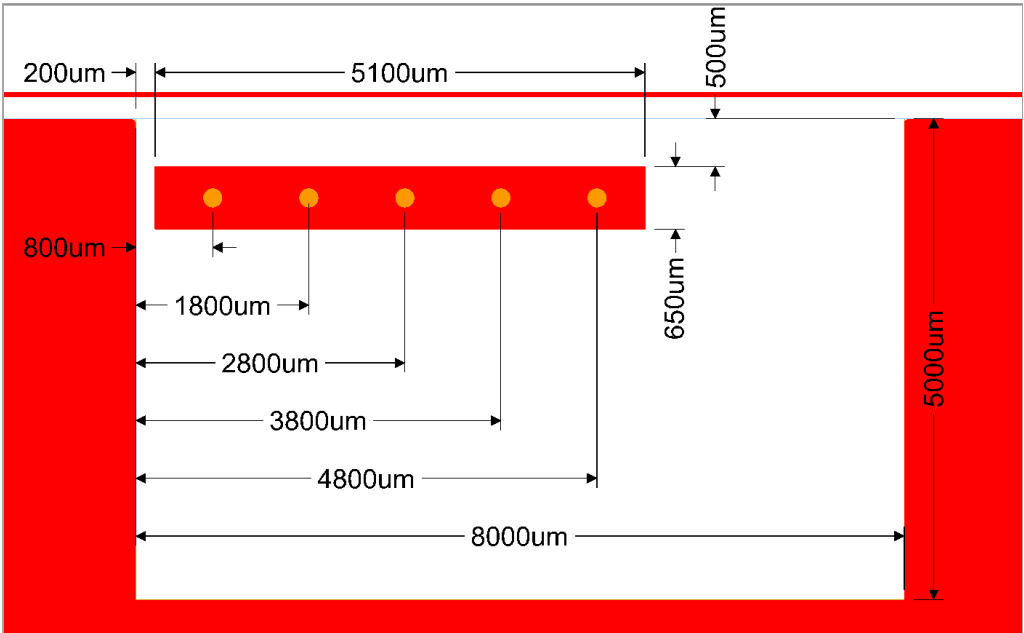
✓ Besides the metal structures, no other metal objects are placed within the antenna area of 8 mm × 5 mm (shown in the pictures above).

✓ To obtain an optimum performance of the antenna, the GND areas next to the antenna on the top and bottom of the PCB are at least 12 mm long:
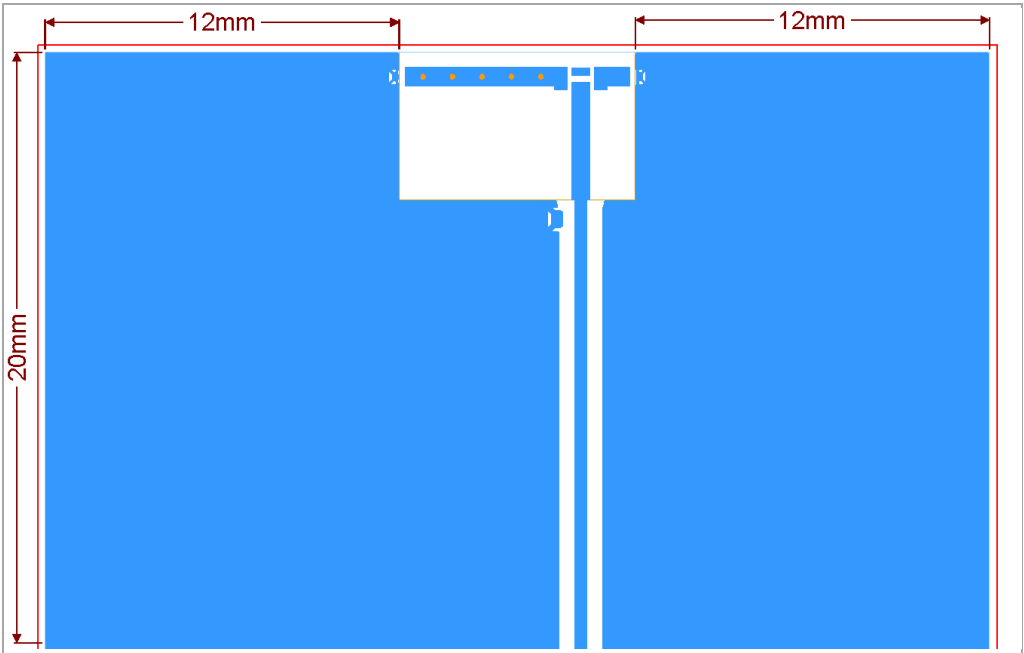
✓ The GND areas has a minimum depth of 20 mm towards the inside of the PCB (shown in the pictures above).

Three components are used for impedance matching and tuning of the antenna. The following table shows the reference design's component specifications.

Component	Size (inch)	Type	Value	Characteristics	Part No.
Ft 2.4 GHz	0201	Capacitor	3.9 pF	± 0.1 pF, C0G	GJM0335C1E3R9BB01D
Ft 5 GHz	0201	Capacitor	0.6 pF	± 0.1 pF, C0G	GJM0335C1ER60BB01D
Mt	0402	Inductor	1 nH	± 0.1 nH, $f_r \geq 10$ GHz	LQG15HS1N0B02D
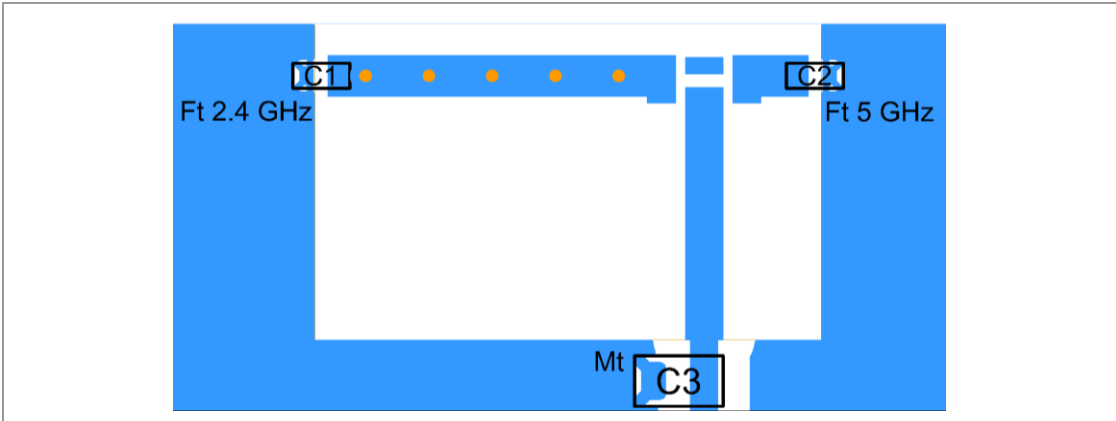
5.2.1.3 Design Verification

It must be verified that the antenna is tuned and matched correctly. This can be done by measuring the return loss at the RF entry point on the mother PCB.

Verify the Design

Connect a 50 Ohm probe to the RF1 landing pad and GND (e.g. a semi-rigid cable can be soldered onto the footprint's pads).

Probe Connection on the Reference Design
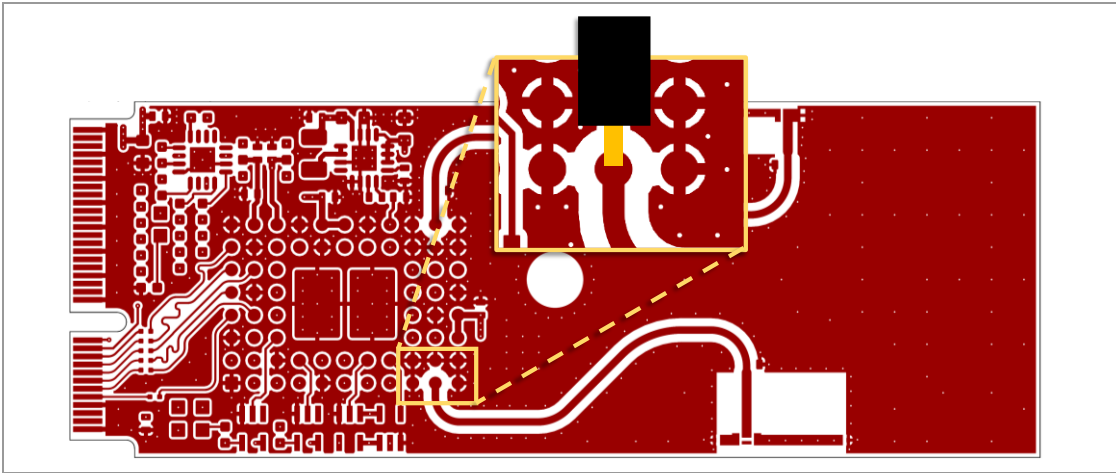
➔ The measured return loss should look similar as shown:
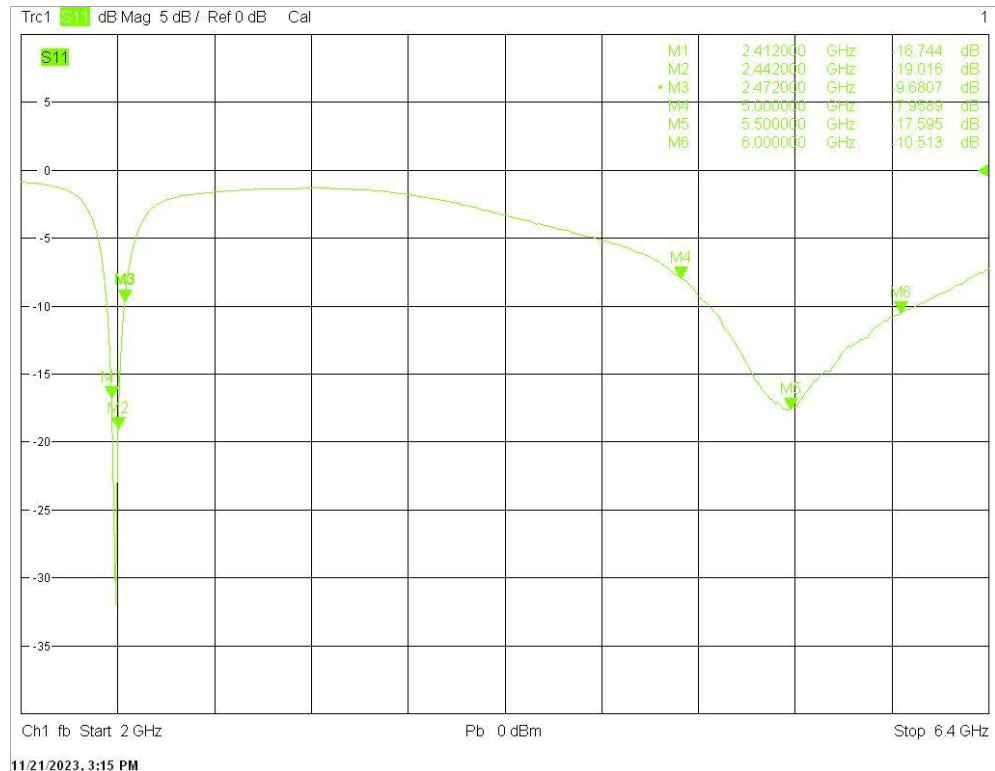
It ensures that the antenna is correctly tuned and thus the antenna radiates in the correct bands. Moreover, the effective impedance is close to 50 Ohm and the reflection towards the module is low, which is a precondition for the Tx power amplifier and Rx low noise amplifier to work as specified.

5.2.2   External Antennas

⚠	**Antenna Warning** The PAN9019 / PAN9019A is tested with a standard MHF4(L) connector and with the antennas listed in the "PAN9019 / PAN9019A Product Specification". When integrated into the OEM's product, these fixed antennas require installation preventing end users from replacing them with non-approved antennas. Any antenna not listed in the "PAN9019 / PAN9019A Product Specification" must be tested to comply with FCC section 15.203 for unique antenna connectors and with section 15.247 for emissions.

5.2.2.1   RF Path

All external antennas listed in this Module Integration Guide require an MHF4(L) connector on the mother PCB. Follow the design described in ⇨ 5.1 RF Trace for routing the module's RF signal to the MHF4(L) receptable connector.

M.2 reference design
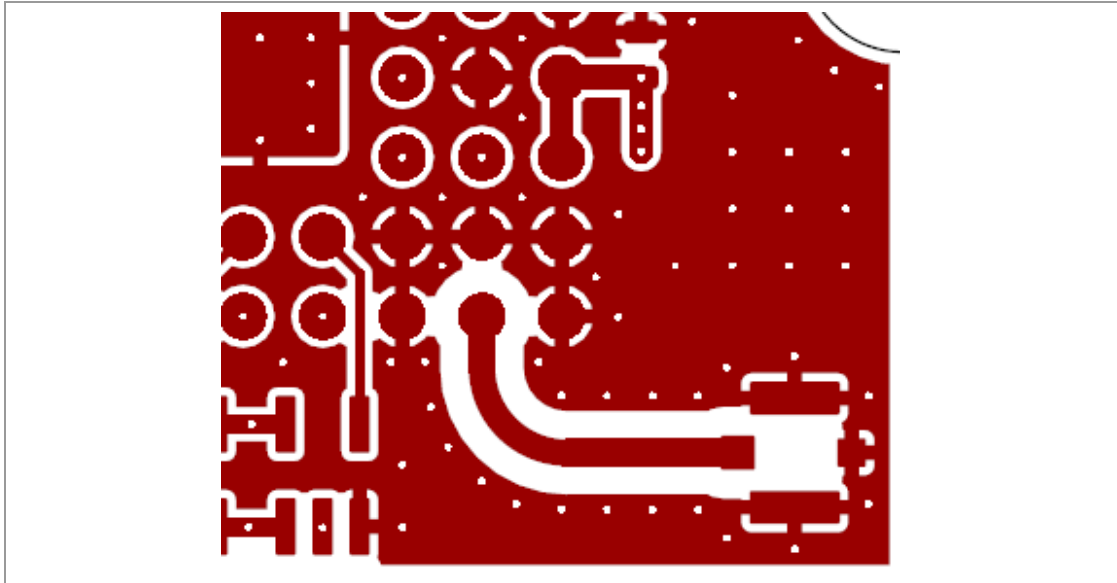
5.2.2.2   PCB Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cable Options[4]
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)

---

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

5.2.2.3 Terminal Mount Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cables[5]
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)
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)

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

6   Host Interfaces

This section describes the interfaces to the host processor:

- SDIO for Wi-Fi
- UART for Bluetooth
- SPI for 802.15.4

6.1   SDIO Interface

The SDIO interface of the PAN9019 / PAN9019A is shown in the following block diagram:
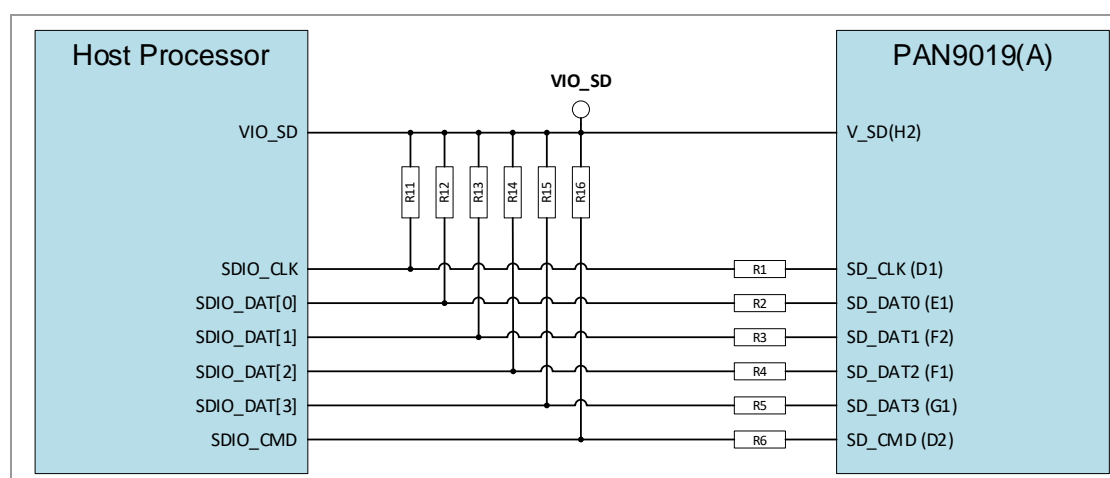
The block diagram includes pull-up resistors (R11 to R16) and series damping resistors (R1 to R6).

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.

If long ribbon cables are used for connecting the PAN9019 / PAN9019A, the damping resistors R1 to R6 can help to reduce the under-/overshoot. If required, 33 Ω resistors should be used. If the signal integrity shows good performance, it is not required to design-in these resistors.

6.2   UART Interface

The PAN9019 / PAN9019A includes a standard UART interface with flow control for operating the Bluetooth radio. In the following, two connection scenarios to host processors are described.

Serial Data Communication Equipment (DCE)

If a host is operated as serial Data Communication Equipment (DCE), the CTS and RTS hardware flow control lines have a different direction than the standard UART interface.

> ⚠️ **Host Pin Assignment in DCE Mode**
>
> Please be aware that hosts that operate the serial interface as DCE (Data Communication Equipment) or DTE (Data Terminal Equipment) usually switch the pins for Tx and Rx based on the mode. Ensure that the pins are used as assigned in DCE mode.

Data Communication Equipment (DCE)
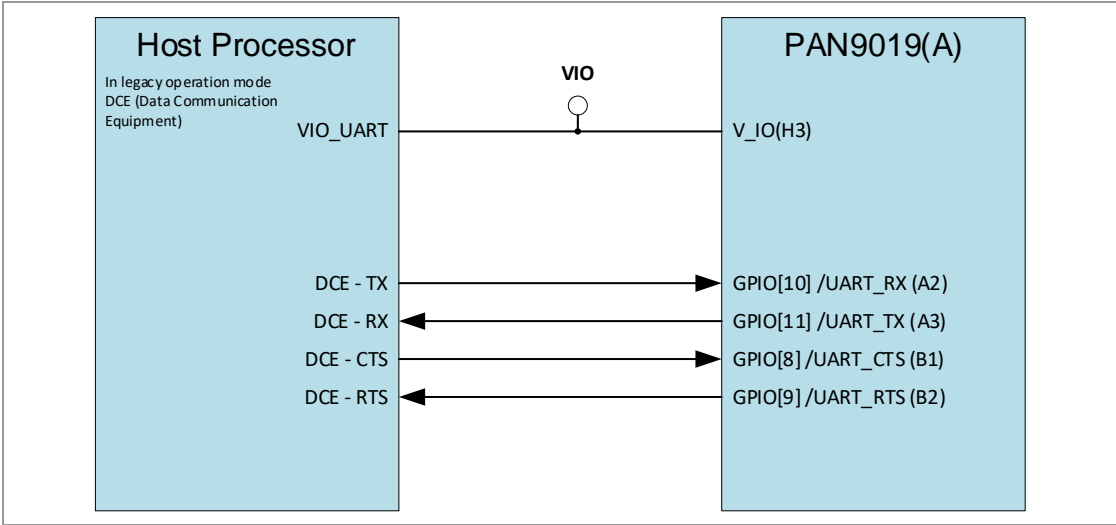
Standard UART Interface

If the host processor provides a standard UART interface, the pins have a static pin assignment, and the interface's lines are "crossed" by the hardware connection.

Standard UART Connection
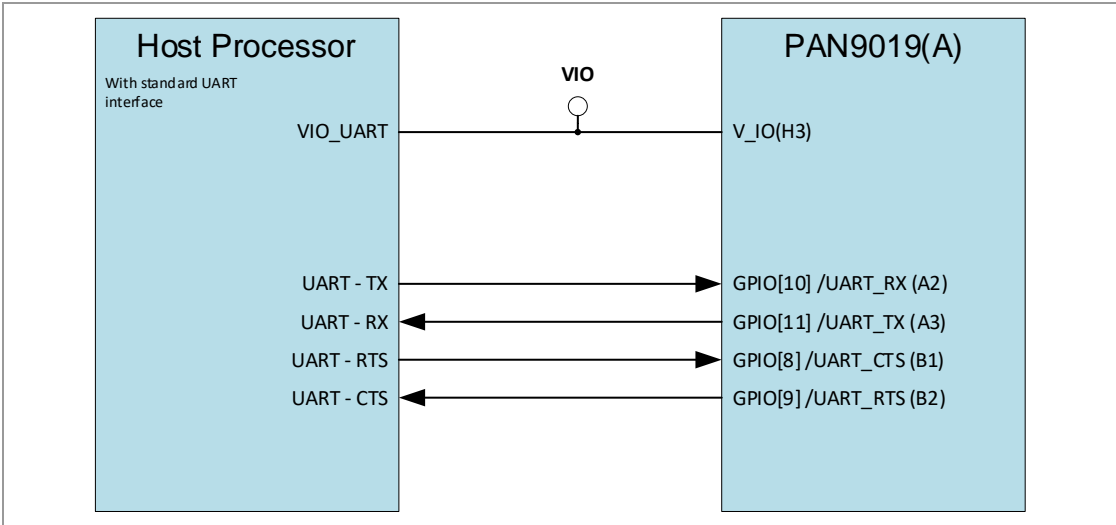
6.3 SPI Interface

In addition to the SDIO and UART interfaces, there is a Serial Peripheral Interface (SPI) on the PAN9019A. This is used for operating the 802.15.4 radio. Besides the usual four SPI lines, there are the SPI_INT and IND_RST_15.4 lines.

The PAN9019A uses SPI_INT to indicate that there is data to transmit. The host needs to start the communication in this case. Asserting IND_RST_15.4 will reset the 802.15.4 radio[6]. The 802.15.4 is usually operated via the spinel protocol, which requires the SPI_INT and IND_RST_15.4 functionalities.
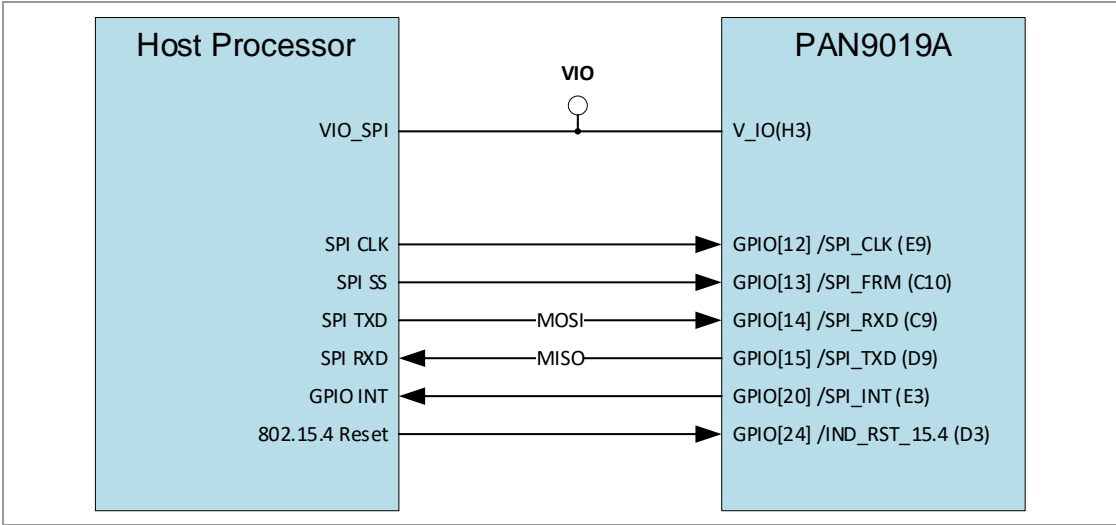
---

7   M.2 Reference Design

> ⚠️ **No SDIO Pull-Ups on the M.2 Designs**
>
> Please note that the M.2 reference designs do not contains pull-up resistors on the SDIO lines, because the host processor platforms usually provide these. For details please refer to ⇨ 6.1 SDIO Interface.

7.1   Reference Schematics

7.1.1   M.2 Reference Design with MHF4 Connector

PAN9019
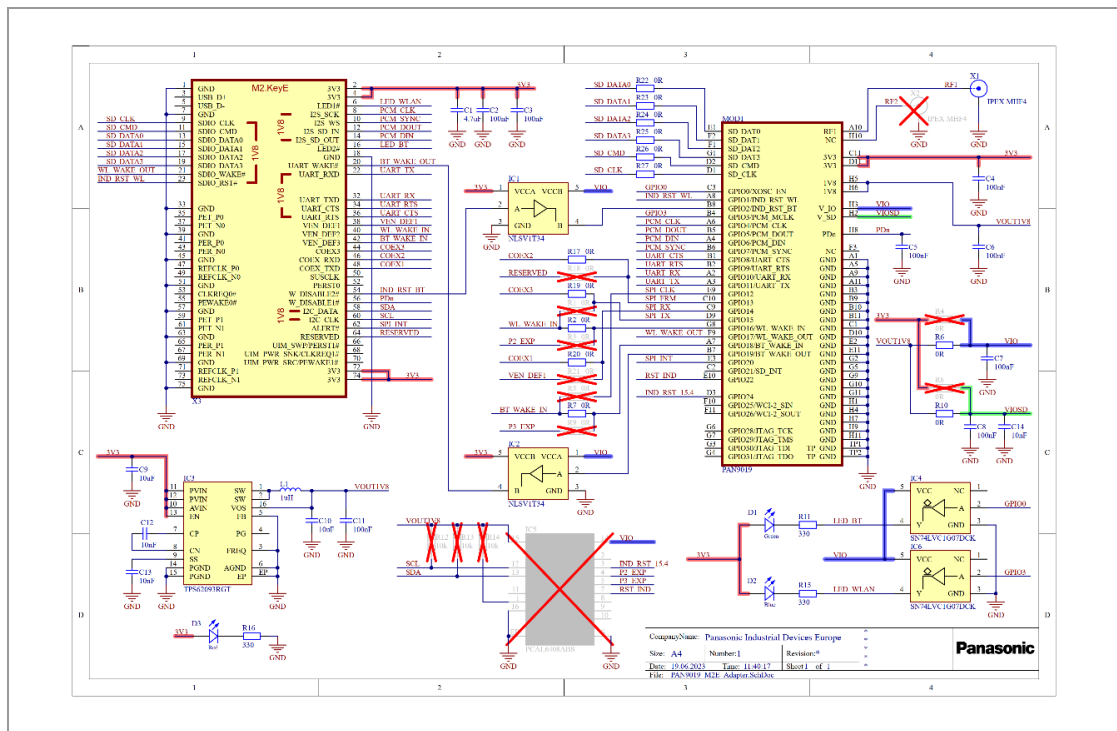
PAN9019A
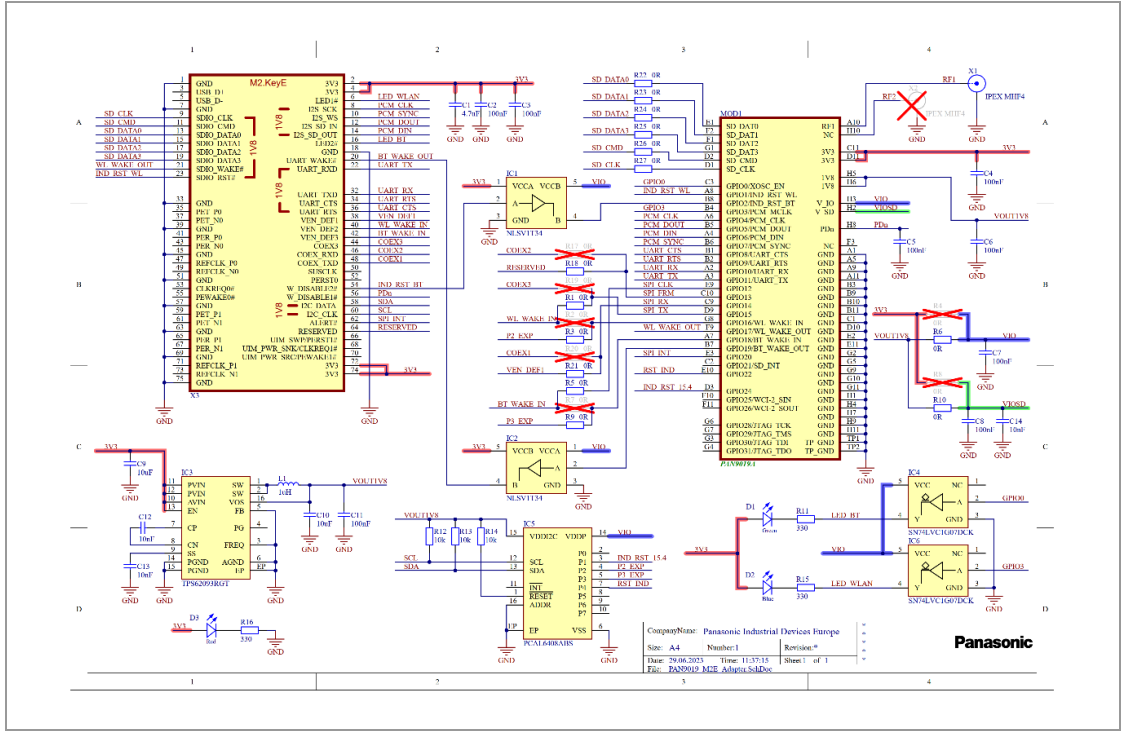
7.1.2   M.2 Reference Design with Chip Antenna

PAN9019
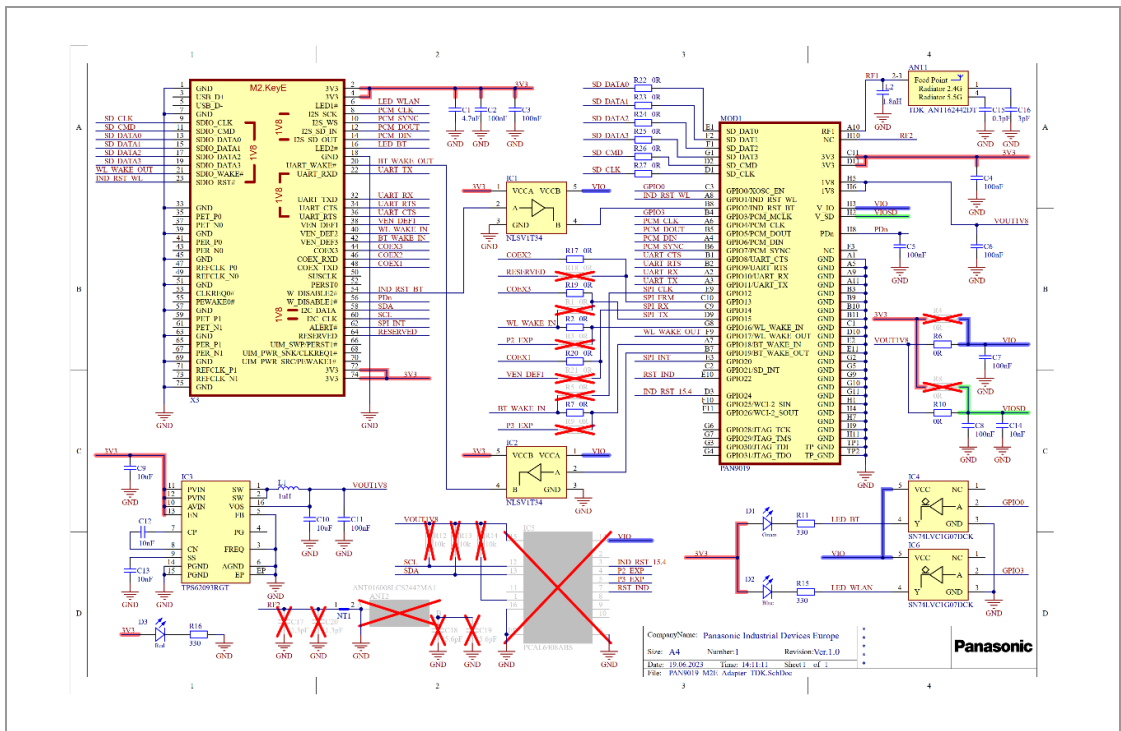
PAN9019A
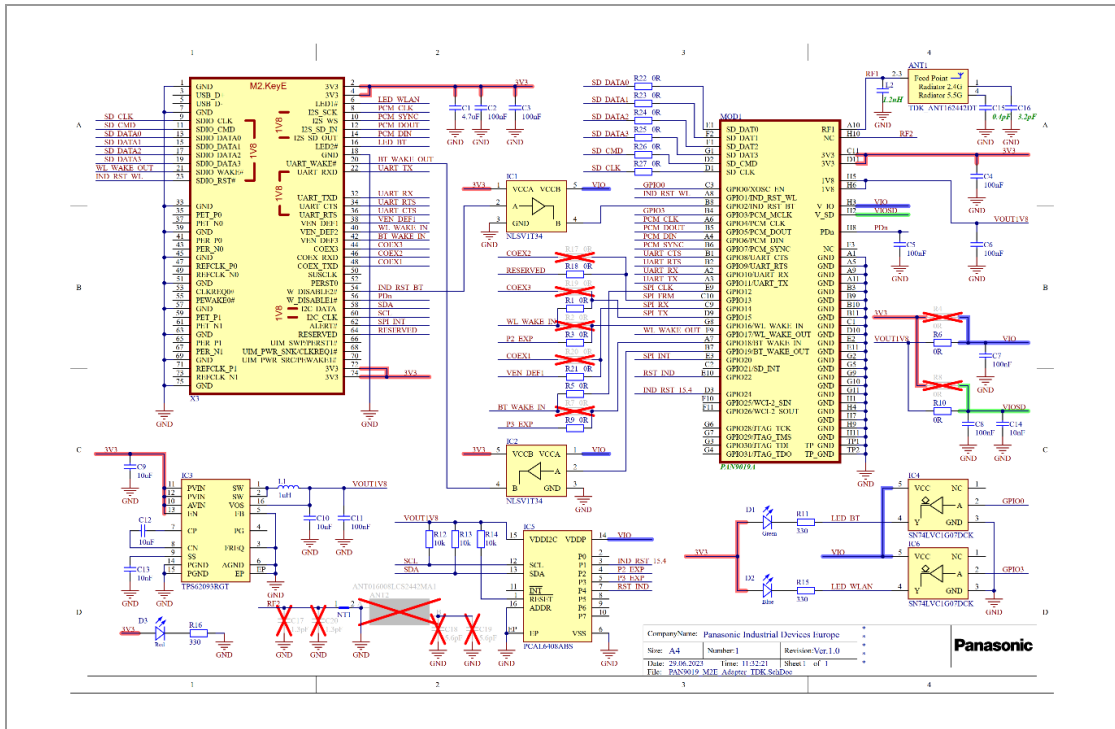
7.2   Reference Layout

This section shows the reference layout for a design with the described chip antenna. A layout for conducted RF interfaces can also use the information from the documented reference design.

Layer 1 (Top)
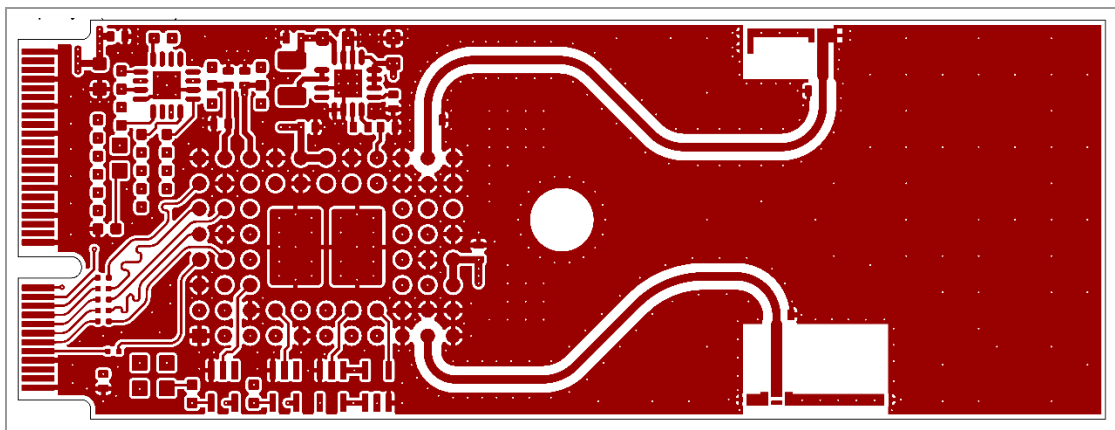
Layer 2
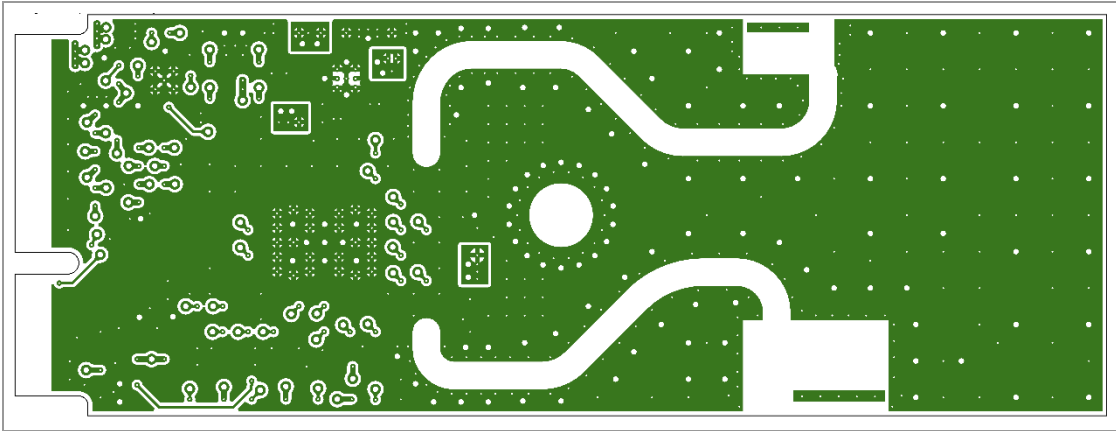
Layer 3
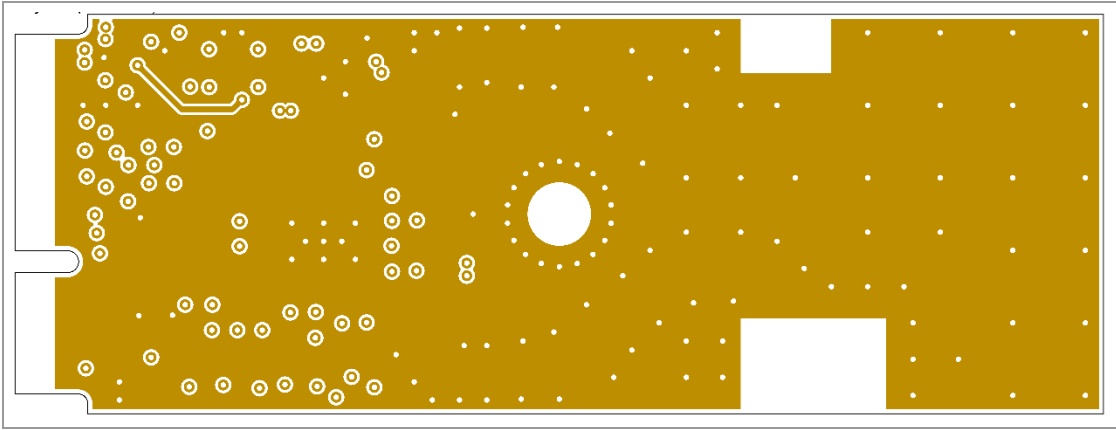
Layer 4
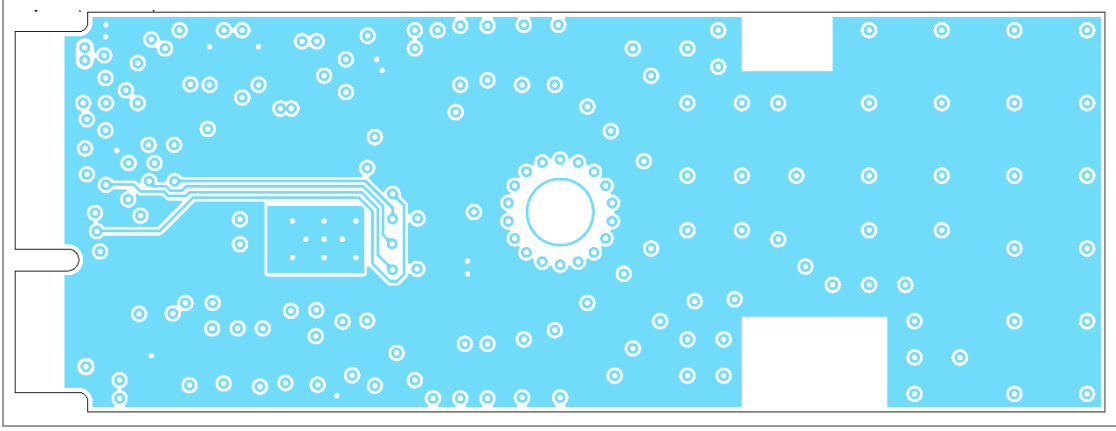
Layer 5
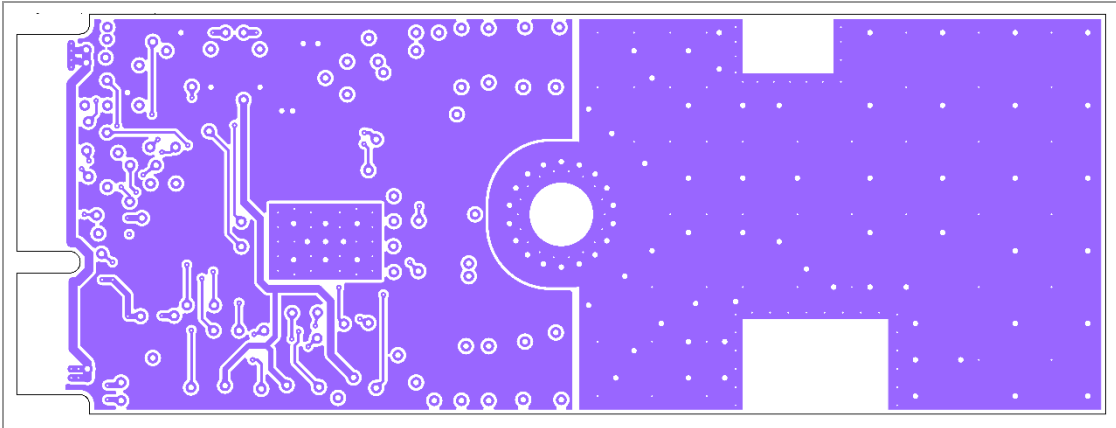
Layer 6 (Bottom)
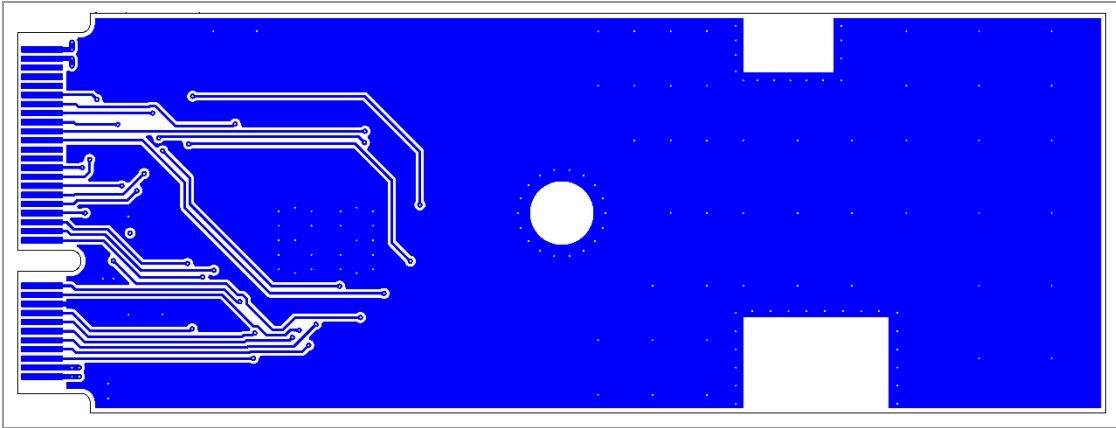
8   Software Integration

The following chapters describe how the radio interfaces can be brought up in such way that the regulatory requirements are met. The instructions must be followed for the modular approval to be valid.

8.1   Wi-Fi – Regulatory Compliant Bring Up

8.1.1   Concept

> ⚠️ **Self-Managed Interface Must be Used**
>
> Please be aware that the regulatory grant is only valid if the driver is installed with the parameter `cntry_txpwr=2`. This ensures that the self-managed interface is used. A security key inside the PAN9019 / PAN9019A ensures that the system is only operable, if valid regulatory files are used.

For keeping the modular approval of the PAN9019 / PAN9019A valid, it is only allowed to use the self-managed interface. This interface requires the so-called rgpower files that contain regulatory settings, like e.g. Dynamic Frequency Selection (DFS) parameters and power settings for all modulations and channels.

The self-managed interface is used, if the driver (`moal.ko`) was installed with the parameter `cntry_txpwr` set to 2. Moreover, valid rgpower files must be present on the host system. After the start-up, the world-wide rgpower file (`rgpower_WW.bin`) is loaded. If the file cannot be loaded because it is not available or invalid, the start-up fails and it is not possible to operate the module.

In the intended case that the valid file is available, the device is ready for operation with the world-wide settings initially applied. For extending the capabilities, the country code shall be changed to the country of operation by using the command `iw reg set` (US is used as an example). After the change was initiated, the related rgpower file is looked up. If this is available and valid, the settings are loaded and applied. In contrast, the world-wide file is loaded as a fallback, if the US file is not available or not valid. This behavior is illustrated in the figure below.

> ℹ️ The drivers and firmware files are provided by NXP Semiconductors. Please ensure that the driver and firmware with a version greater than or equal to 6.1.55-2.2.0 are used.

> ℹ️ The regulatory files (`rgpower_XX.bin`) are provided by Panasonic.
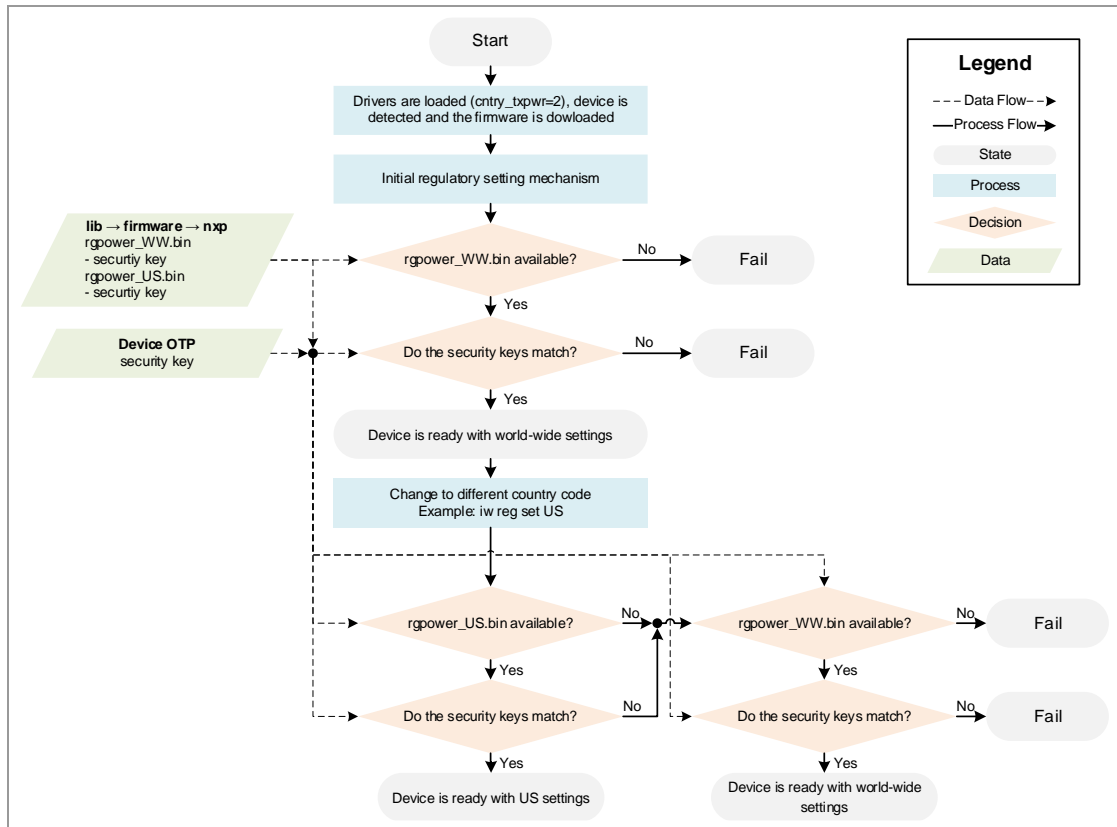
The required rgpower files are provided by Panasonic and contain a security key. The same key is stored in the PAN9019 / PAN9019A One Time Programable (OTP) memory. This ensures that only files can be used, which comply with the respective regulations and standards.

To obtain access to the files please contact your local sales representative ⇨ 9.1 Contact Us.

The world-wide file must be always present on the host system to act as fallback with minimum settings (2.4 GHz Ch 1-11 only).

If required, additional restrictions can be applied via the WPA supplicant. For instance, indoor-only channels can be disabled, if the end-product shall be operated outdoor.

8.1.2   File Overview

The file structure on the linux host system is illustrated below. Following parts are present inside the `lib/firmware/nxp` folder:

```
/
└── lib
    ├── firmware
    │   └── nxp
    │       ├── sduart_nw61x_v1.bin.se
    │       ├── sd_w61x_v1.bin.se
    │       ├── uartspi_n61x_v1.bin.se
    │       ├── rgpower_WW.bin
    │       ├── rgpower_US.bin
    │       └── wifi_mod_para.conf
    └── modules
        └── <kernel_version>
            └── extra
                ├── mlan.ko
                └── moal.ko
```
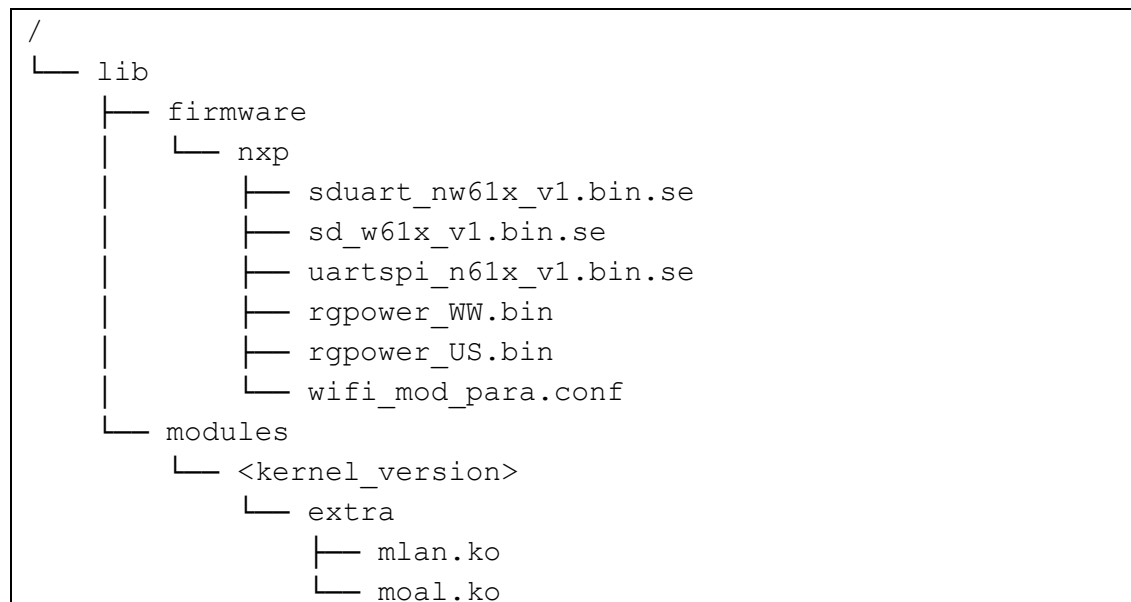
- The firmware files
  - `sduart_nw61x_v1.bin.se`: Wi-Fi, Bluetooth + 802.15.4 combo firmware
  - `sd_w61x_v1.bin.se`: Wi-Fi only firmware
  - `uartspi_n61x_v1.bin.se`: Bluetooth + 802.15.4 only firmware

- The rgpower files
  - `rgpower_WW.bin`: World-wide file
  - `rgpower_US.bin`: File for the country of operation (US in this case)

- The driver parameter configuration file
  - `wifi_mod_para.conf`: Configuration file that contains parameters for the driver installation (see ⇨ 8.1.3 Driver Parameters and ⇨ 8.1.4 Installing Drivers)

- The drivers are located in the folder `extra`.

8.1.3   Driver Parameters

Three important parameters must be handed over during the installation of the driver. They are specified in the SDIW612 section of the `wifi_mod_para.conf` configuration file:

```
...
SDIW612 = {
    cal_data_cfg=none
    cntry_txpwr=2
    fw_name=nxp/sduart_nw61x_v1.bin.se
}
...
```

Further parameters can be added, if required.

Important parameters:

- `cal_data_cfg` must be always `none` to use the calibration data from the module's OTP memory
- `cntry_txpwr` must be always set to **2** to use the self-managed interface
- `fw_name` contains the firmware file name that shall be downloaded onto the module

8.1.4   Installing Drivers

Two driver parts need to be installed: `mlan.ko` and `moal.ko`.

If the drivers are installed manually, `mlan.ko` must be installed first. Use `modprobe` for installation to check the file location and dependencies automatically, which simplifies the installation process.

The example below uses `modprobe` to install `moal` with a parameter configuration file as introduced in ⇨ 8.1.3 Driver Parameters. All contained parameters are applied, when loading the drivers.

```
$ modprobe moal mod_para=nxp/wifi_mod_para.conf
mlan: loading out-of-tree module taints kernel.
wlan: Loading MWLAN driver
wlan: Register to Bus Driver...
wlan: Register to Bus Driver Done
wlan: Driver loaded successfully
```

After the installation, the driver modules can be listed with the command `lsmod`. Moreover, the size and dependency of the modules is displayed.

```
$ lsmod
module                          Size      Used by
moal                            831488    0
mlan                            577536    1 moal
```

➔ If the PAN9019 / PAN9019A was detected, the driver modules are loaded with the defined parameters, the firmware is loaded into the module, and the system is set up for world-wide operation (`rgpower_WW.bin` is loaded).

A log file of these steps:

```
wlan: Loading MWLAN driver
wlan: Register to Bus Driver...
wlan: Register to Bus Driver Done
wlan: Driver loaded successfully
mmc0: new ultra high speed SDR104 SDIO card at address 0001
vendor=0x0471 device=0x0205 class=0 function=1
Attach moal handle ops, card interface type: 0x109
rps set to 0 from module param
SDIW612: init module param from usr cfg
card_type: SDIW612, config block: 0
cal_data_cfg=none
cntry_txpwr = 2
fw_name=nxp/sduart_nw61x_v1.bin.se
SDIO: max_segs=128 max_seg_size=65535
rx_work=1 cpu_num=4
Attach mlan adapter operations.card_type is 0x109.
wlan: Enable TX SG mode
wlan: Enable RX SG mode
Request firmware: nxp/sduart_nw61x_v1.bin.se
Wlan: FW download over, firmwarelen=918016 downloaded 841816
WLAN FW is active
on_time is 1653984027625
VDLL image: len=76200
fw_cap_info=0x487cff03, dev_cap_mask=0xffffffff
uuid: 707e337f287b5c19ac00ddf0c9b83a9f
max_p2p_conn = 8, max_sta_conn = 16
Trying download country_power_tble: nxp/rgpower_WW.bin
Request firmware: nxp/rgpower_WW.bin
call regulatory_set_wiphy_regd WW
call regulatory_set_wiphy_regd WW
Register NXP 802.11 Adapter mlan0
wlan: uap%d set max_mtu 2000
Register NXP 802.11 Adapter uap0
call regulatory_set_wiphy_regd WW
```

```
Register NXP 802.11 Adapter wfd0
wlan: version = SDIW612---18.99.2.p19.17-MM6X18408.p2-GPL-(FP92)
```

The detection and identification of the module is handled by the MMC-controller. Related detection modes are configured by the following properties in the device tree.

CD Property	Items	Description
non-removable (recommended)	None	The MMC-controller looks for a connected device at the start-up of the system. If detected, the device is identified. This mode is intended for statically fixed devices as the PAN9019 / PAN9019A. Please note that the module cannot be found if it is not present at start-up, or if it is restarted (e.g. by power cycling or asserting the PDn line) without rebooting the host system.
broken-cd	None	The MMC-controller regularly polls for a device. If detected, the device is identified. Please note that timing or stability issues can occur if this mode is used.
cd-gpio	CD GPIO	The MMC-controller checks the interface for a device after the card detect signal was asserted. The card detect signal is conneted to the GPIO, which is defined as item of the property. The mode is usually used for removable SD cards and it is not recommended for non-removable devices as the PAN9019 / PAN9019A.

8.1.5   Loading rgpower Files

After a module was detected and the drivers were loaded, the system utilizes the world-wide settings.

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

   ➔ The settings of the global interface are displayed first and the more important configuration of the self-managed interface at the end.

```
$ 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)
    (2457 - 2482 @ 20), (N/A, 20), (N/A), AUTO-BW, PASSIVE-SCAN
    (2474 - 2494 @ 20), (N/A, 20), (N/A), NO-OFDM, PASSIVE-SCAN
    (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
    (5490 - 5730 @ 160), (N/A, 20), (0 ms), DFS, PASSIVE-SCAN
    (5735 - 5835 @ 80), (N/A, 20), (N/A), PASSIVE-SCAN
    (57240 - 63720 @ 2160), (N/A, 0), (N/A)
```

```
phy#2 (self-managed)
country 00: DFS-UNSET
     (2402 - 2427 @ 20), (N/A, 19), (N/A)
     (2412 - 2462 @ 40), (N/A, 19), (N/A)
     (2447 - 2472 @ 20), (N/A, 19), (N/A)
```

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

```
$ iw reg set US

Trying download country_power_tble: nxp/rgpower_US.bin
Request firmware: nxp/rgpower_US.bin
```

➔ Now the self-managed interface has changed by calling `iw reg get`.

```
$ 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 - 5730 @ 160), (N/A, 24), (0 ms), DFS
     (5730 - 5850 @ 80), (N/A, 30), (N/A), AUTO-BW
     (5850 - 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)

phy#2 (self-managed)
country US: DFS-FCC
     (2402 - 2427 @ 20), (N/A, 19), (N/A)
     (2412 - 2462 @ 40), (N/A, 19), (N/A)
     (2447 - 2472 @ 20), (N/A, 19), (N/A)
     (5170 - 5250 @ 80), (N/A, 19), (N/A)
     (5250 - 5330 @ 80), (N/A, 19), (0 ms), DFS, PASSIVE-SCAN
     (5490 - 5730 @ 80), (N/A, 19), (0 ms), DFS, PASSIVE-SCAN
     (5735 - 5815 @ 80), (N/A, 19), (N/A)
     (5815 - 5835 @ 20), (N/A, 19), (N/A)
```

8.2   Bluetooth – Regulatory Compliant Bring Up

This chapter describes the Bluetooth bring up using the standard Linux Host Controller Interface (HCI) driver.

> ⓘ   Please note that the NXP Bluetooth UART driver (btnxpuart) is not covered.

The following requirement must be met:

✓   The Wi-Fi/Bluetooth combo firmware is loaded successfully through the module driver
(⇨ 8.1 Wi-Fi – Regulatory Compliant Bring Up)
or the Bluetooth (802.15.4) only firmware is loaded successfully with NXP's firmware loader
(not covered in this document).

1.   Attach the Host Controller Interface to the corresponding UART interface with the following parameters for the HCI.
(The initial UART baud rate is 115 200. For a description on how the baud rate can be changed afterwards please refer to ⇨ 8.2.2 Changing the UART Baud Rate.)

No.	Parameter	Description
1	Serial Hardware Device	Specifies the serial device that shall be attached (e.g. `ttymxc0`)
2	Type	Should be `any` for hardware independent attachment
3	Baudrate	Select the baudrate of the module (initially 115 200)
4	Flow Control	Use the keyword `flow` for hardware flow control (required)

```
# Example HCI attach
$ hciattach /dev/ttymxc0 any 115200 flow
Setting TTY to N_HCI line discipline
Device setup complete
```

2.   Use the command `hciconfig` to display the HCI configuration.

➔   The following reply is received after successful `hciattach` but with the HCI still down.

```
$ hciconfig
hci0: Type: Primary Bus: UART
      BD Address: 34:32:E6:34:40:E7 ACL MTU: 1021:7 SCO MTU: 120:6
      DOWN
      RX bytes: 740 acl:0 sco: 0 events:43 errors:0
      TX bytes: 469 acl:0 sco: 0 commands:43 errors:0
```

3. Use the following command to start-up the HCI:

```
$ hciconfig hci0 up
```

➔ Reading out the HCI configuration shows the interface up and running.

```
$ hciconfig
hci0: Type: Primary Bus: UART
      BD Address: 34:32:E6:34:40:E7 ACL MTU: 1021:7 SCO MTU: 120:6
      UP RUNNING
      RX bytes: 1544 acl:0 sco: 0 events:95 errors:0
      TX bytes: 1285 acl:0 sco: 0 commands:95 errors:0
```

Now the module's Bluetooth system can be operated (e.g. via the hcitool or a Bluetooth stack like e.g. BlueZ).

8.2.1　Setting the Bluetooth Power Limit

> ⓘ　The configurations described in this chapter are volatile and need to be applied after each boot-up.

The PAN9019 / PAN9019A is prequalified and listed at the Bluetooth Special Interest Group (SIG). The output power must be limited to meet the listed power class and the regulatory requirements of the respective country/region. The following configuration are mandatory for compliance:

Country/Region	Bluetooth mode	Power Class	Configured Maximum Power (dBm)
US	Basic Rate / Enhanced Data Rate	1	8
	Low Energy	1	8
	Low Energy	1.5	4
CA	Basic Rate / Enhanced Data Rate	1	8
	Low Energy	1	8
	Low Energy	1.5	4
EU	Basic Rate / Enhanced Data Rate	1	3
	Low Energy	1.5	3
UK	Basic Rate / Enhanced Data Rate	1	3
	Low Energy	1.5	3
NZ	Basic Rate / Enhanced Data Rate	1	3
	Low Energy	1.5	3
AU	Basic Rate / Enhanced Data Rate	1	3
	Low Energy	1.5	3

Country/Region	Bluetooth mode	Power Class	Configured Maximum Power (dBm)
JP	Basic Rate / Enhanced Data Rate	1	3
	Low Energy	1.5	3

If the product shall be operated in the range of Bluetooth power classes 2 or 3: the regulatory requirements are met, if the power is set according to the Bluetooth Core Specification's requirements.

There are already Bluetooth settings that are stored in the one-time-programable (OTP) memory of the module at delivery. This includes the initial power, which is set to 3 dBm, and the NXP power class, which is set to class 1.5.

To check, if the configurations are correct, they can be read out by the custom host controller interface (HCI) command `3F 62 37` as shown below.

The initial power is the green marked byte; the power class is encoded in the red byte.

```
$ hcitool -i hci0 cmd 3f 62 37


HCI Event: 0x0e plen 33
01 62 FC 00 01 37 [CRC] 1C 00 00 00 00 00 01 [crystal] 03 03 08 00 00
00 00 C2 01 00 [BD0] [BD1] [BD2] [BD3] [BD4] [BD5] F0 00
```

Two bits of the red byte determine the NXP power class:

Bit	Name	Description
0	Force Class 2 Operation	If enabled, NXP class 2 is used. If disabled, NXP class 1.5 or 1 is used depending on bit 9.
9	Class 1 Operation Support	If bit 0 is zero: • Disabled: NXP class 1.5 is used • Enabled: NXP class 1 is used

NXP Power Classes

(Not identical to the Bluetooth power classes.)

NXP Power Class	Minimum Configurable Power (dBm)	Maximum Configurable Power (dBm)	Notes
1	-13	+19	Bluetooth Enhanced Data Rate Power is reduced by appr. 9 dB
1.5	-20	+13	Bluetooth Enhanced Data Rate Power is reduced by appr. 3 dB
2	-20	+3	Bluetooth Enhanced Data Rate Power is equal to the Basic Rate Power

Bluetooth Power Classes

The given maximum equivalent isotropically radiated power (E.I.R.P.) is not a measurement limit, but the theoretical value resulting from the configured maximum power and the antenna gain.

Technology	Bluetooth Power Class	Maximum E.I.R.P. (dBm) (shall be greater than)	Maximum E.I.R.P. (dBm) (shall be smaller than)
Basic Rate & Enhanced Data Rate	1	4	20
	2	0	4
	3	-	0
Low Energy	1	10	20
	1.5	4	10
	2	0	4
	3	-	0

From the tables above and an antenna gain range of 2.0 dBi to 5.2 dBi, it can be derived that the NXP power class 1.5 covers all Bluetooth power classes. Therefore, it is recommended to use NXP power class 1.5. It is not recommended to use the NXP power class 1, because this shows a higher power difference between the Enhanced Data Rate and Basic Rate PHYs.

The preconfigured settings of the NXP class 1.5 and an initial power of 3 dBm can be kept to meet the regulatory requirements after startup and being still able to adjust the power limit depending on the country.

In case that the Bluetooth settings shall be changed anyway, this can be done by using the HCI command `3F 61`. Please note that the settings do also include device related settings like e.g. the BD (Bluetooth device) address and XTAL calibration value. Therefore, the OTP data shall be read out and the device related settings shall be adopted when writing the new data. It is not required to calculate the CRC as this field is ignored when writing new data.

```
##### Optional Change of the Bluetooth Configuration Data #####
# Read out the OTP data
$ hcitool -i hci0 cmd 3f 62 37
< HCI Command: ogf 0x3f, ocf 0x0062, plen 1
  37
> HCI Event: 0x0e plen 33
  01 62 FC 00 01 37 [CRC] 1C 00 00 00 00 00 01 [crystal] 03 03 08 00
  00 00 00 C2 01 00 [BD0] [BD1] [BD2] [BD3] [BD4] [BD5] F0 00


# Write the new Bluetooth data
$ hcitool -i hci0 cmd 3F 61 00 00 01 1C 37 [CRC] 1C 00 00 00 00 00
  01 [crystal] [Init. Power in dB] 03 [Configuration Byte] 00 00 00
```

```
  00 C2 01 00 [BD0] [BD1] [BD2] [BD3] [BD4] [BD5] F0 00
< HCI Command: ogf 0x3f, ocf 0x0061, plen 32
  00 00 01 1C 37 00 1C 00 00 00 00 00 01 [crystal] [Init. Power in
  dB] 03 [Configuration Byte]00 00 00 00 C2 01 00 [BD0] [BD1] [BD2]
  [BD3] [BD4] [BD5] F0 00
> HCI Event: 0x0e plen 4
  01 61 FC 00


# Reset the HCI Inteface
$ hcitool -i hci0 cmd 03 03
< HCI Command: ogf 0x03, ocf 0x0003, plen 0
> HCI Event: 0x0e plen 4
  01 03 0C 00
```

8.2.1.1 Configuring the Bluetooth Basic Rate and Enhanced Data Rate Power Limit

The power limit can be changed by the HCI command `3F EE`. If not applied, the initial power is used as limit. Please note that the power for Bluetooth Enhanced Data Rate is reduced depending on the NXP power class (about 3 dBm with class 1.5).

The command has following parameters:

Parameter	Name	Description
1	Maximum Power Selction	• 0x00: Default behavior. Maximum power is set to physical maximum power level • 0x01: Updates Maximum power based on parameter 2 • Other values: Invalid. HCI_ERR_INVALID_PARAMETERS error is returned
2	User-defined Maximum Power Value	The parameter is ignored when the first parameter (maximum power selection) is 0. • 127: Maximum power is updated by the power value calculated from the Initial power and FE loss parameters stored in Cal-data. • Signed value of TX power (dBm) in the range -20 to 19 • Other values: Error is returned

The following example shows the configuration of a 3 dB power limit:

```
# Configure 3 dBm as power limit
$ hcitool -i hci0 cmd 3f ee 01 03
< HCI Command: ogf 0x3f, ocf 0x00ee, plen 2
  01 03
> HCI Event: 0x0e plen 4
  01 EE FC 00

# Reset the HCI Inteface
$ hcitool -i hci0 cmd 03 03
< HCI Command: ogf 0x03, ocf 0x0003, plen 0
> HCI Event: 0x0e plen 4
  01 03 0C 00
```

For regions like the US, the power limit can be enlarged to 8 dBm:

```
# Configure 8 dBm as power limit
$ hcitool -i hci0 cmd 3f ee 01 08
< HCI Command: ogf 0x3f, ocf 0x00ee, plen 2
  01 08
> HCI Event: 0x0e plen 4
  01 EE FC 00

# Reset the HCI Inteface
$ hcitool -i hci0 cmd 03 03
< HCI Command: ogf 0x03, ocf 0x0003, plen 0
> HCI Event: 0x0e plen 4
  01 03 0C 00
```

8.2.1.2 Configuring the Bluetooth Low Energy Power Limit

The power limit for Bluetooth low energy can be changed by the HCI command `3F 87`. If not applied, the initial power setting is used as limit. There is only one parameter, which is the power limit in dBm.

Following this, the power can be limited to 3 dBm by using following command sequence:

```
# Configure 3 dBm as power limit
$ hcitool -i hci0 cmd 3f 87 03
< HCI Command: ogf 0x3f, ocf 0x0087, plen 1
  03
> HCI Event: 0x0e plen 4
  01 87 FC 00


# Reset the HCI Inteface
$ hcitool -i hci0 cmd 03 03
< HCI Command: ogf 0x03, ocf 0x0003, plen 0
> HCI Event: 0x0e plen 4
  01 03 0C 00
```

For regions like the US, the power limit can be enlarged to 8 dBm:

```
# Configure 8 dBm as power limit
$ hcitool -i hci0 cmd 3f 87 08
< HCI Command: ogf 0x3f, ocf 0x0087, plen 1
  08
> HCI Event: 0x0e plen 4
  01 87 FC 00


# Reset the HCI Inteface
$ hcitool -i hci0 cmd 03 03
< HCI Command: ogf 0x03, ocf 0x0003, plen 0
> HCI Event: 0x0e plen 4
  01 03 0C 00
```

8.2.2   Changing the UART Baud Rate

> (i) This section describes the baud rate change on the HCI layer to provide an example procedure. Please note that there are also other ways like a raw UART communication or using the NXP Bluetooth UART driver (btnxpuart).

At delivery, the device operates the UART interface with the baud rate 115 200. This ensures that host devices with limited UART interface capabilities can operate the PAN9019 / PAN9019A.

While granting a wide compatibility, the low baud rate limits the data throughput and thus excludes some features like audio profiles. Therefore, the baud rate must be enlarged if a high data throughput is required.

To enlarge the baud rate use the HCI command `3F 09`. The command expects the baud rate in hexadecimal format with the least significant byte at the first position. A command complete event is returned at the old baud rate before the module is operable at the new baud rate after 5 ms.

After the change took place, the HCI must be detached from the UART interface and attached again with the new baud rate.

> (i) Please note that the command `killall` must be used with option `-9` to force the process to end.

An example that changes the baud rate to 3M:

```
# The HCI was attached with the initial baud rate of 115200.
# => Change the baud rate to 3M
# hcitool -i hci0 cmd 3f 09 [Baud0] [Baud1] [Baud2] [Baud3]
$ hcitool -i hci0 cmd 3f 09 C0 C6 2D 00
< HCI Command: ogf 0x3f, ocf 0x0009, plen 4
  C0 C6 2D 00
# The command returns an Command Complete Event with the old
# baud rate
> HCI Event: 0x0e plen 4
  01 09 FC 00


# It takes up to 5 ms until the module operates at the new baud rate


# Shut down the HCI attachment immediately (option -9)
# Please note that HCI frame errors can be reported due to the
# kill process
```

```
killall -9 hciattach


# Attach the HCI to the UART interface with the new baud rate (3M)
hciattach /dev/ttymxc0 any 3000000 flow
Setting TTY to N_HCI line discipline
Device setup complete


# Start the HCI interface
hciconfig hci0 up
```

> (i) For further information please refer to the Panasonic Wireless Connectivity Development Hub: https://pideu.panasonic.de/development-hub/.

8.3 802.15.4 – Regulatory Compliant Bring Up

When using 802.15.4, the maximum output power must be configured to meet the regulatory requirements of the respective country/region.

The following configuration are mandatory for compliance:

Country / Region	Configured Maximum Power (dBm)
US	8
CA	8
EU	4
UK	4
NZ	4
AU	4
JP	4

Setting the 802.15.4 Power

This section describes how the maximum power levels can be configured.

At delivery of the module, the power is not limited by software. OEMs must limit the power in there software according to the limits stated in this document and depending on the country/region of operation. A configuration using the open thread stack is documented in the following.

The open thread command `txpwrlimit` expects the power limit in steps of 0.5 dB.

Use the following command to limit the power to 8 dBm:

```
$ ot-ctl txpwrlimit 16
```

Use the following command to limit the power to 4 dBm:

```
$ ot-ctl txpwrlimit 8
```

The power limit must be configured directly after start-up and before performing any 802.15.4 operation. Moreover, the limit must be kept through the entire operation. To configure and vary the Tx power during operation, the command `txpower` can be used. This expects a power value in dB. It is not possible to configure a Tx power that is higher than the power limit.

As an example, the configuration of a Tx power of 6 dBm is shown:

```
$ ot-ctl txpower 6
```

9 Contact Details

9.1 Contact Us

Please contact your local Panasonic Sales office for details on additional product options and services:

For Panasonic Sales assistance in the **EU**, visit
https://eu.industrial.panasonic.com/about-us/contact-us
Email: wireless.connectivity@eu.panasonic.com

For Panasonic Sales assistance in **North America**, visit the Panasonic website
"Sales & Support" to find assistance near you at
https://na.industrial.panasonic.com/distributors

For information about evaluation tools, schematics, software development, and more, please visit the "Panasonic Wireless Connectivity Development Hub"
https://pideu.panasonic.de/development-hub/.

9.2 Product Information

For further information on our products and related documents please refer to the Panasonic Wireless Connectivity website:

For complete Panasonic product details in the **EU**, visit
https://industry.panasonic.eu/

For complete Panasonic product details in **North America**, visit
http://www.panasonic.com/rfmodules