AN12917
Compliance and Certification Considerations

Application Note

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Revision History

Revision	Date	Change details
Rev. 1	9-Jul-2020	Initial release

1 Introduction

This application note provides general guidance and tips on how to test products based on NXP Wi-Fi devices for regulatory compliance (FCC, ETSI, etc.).

Users of this document will work with regulatory test labs and module vendors as needed to achieve the certification of their product.

It is strongly recommended to review the content in this document prior to going to the lab for compliance testing.

1.1 Reference documents

Table 2: Reference documents

Document type	Description
Application note	Wi-Fi Tx Power Management in FreeRTOS

1.2 Using certified modules

If you are using a wireless module in your product that has already been regulatory certified, we recommend working closely with your module vendor when obtaining the regulatory certification for your product.

We also strongly recommend you use the same antenna used by your module vendor, or an antenna with lower gain. Doing so may help reduce the testing needed to demonstrate compliance, which will help reduce cost and delays to the project schedule.

2   Certification process overview

Regulatory certification is a multi-step process to be planned closely with regulatory test lab.

Start by determining the countries you plan to market your product. Each country may have their own regulations that can affect:

- The allowable frequencies (channels) and channel bandwidths that your product may operate on
- The maximum transmit power that is allowed for each channel
- Specific requirements for each operating frequency/channel (for example, adaptivity or Dynamic Frequency Selection)
- The test schedule. Some certifications, like Dynamic Frequency Selection (DFS) may require longer time to get certified.

Typical standards related to regulatory compliance include:

- FCC: Part 15C
- ETSI EN 300 328, ETSI EN 301 893, ETSI EN 300 400

After determining the target certifications, work with the regulatory test lab to determine a test plan to demonstrate compliance to the relevant requirements.

3   EMC/RF emissions

This section provides basic guidance for EMC/RF emissions tests. This test measures emissions transmitted at the antenna to determine if they exceed regulatory limits. The limits and test conditions for these tests:

- Are defined in the regulatory domain (for example, FCC vs ETSI)
- May vary with the frequency/channel of operation (for example, 2.4 GHz band requirements may be different from 5 GHz band requirements).
- May depend on the antenna gain

The regulatory requirements may restrict both in-band (for example, power spectral density) and out-of-band (for example, harmonics of the signal) emissions.

3.1   Related parameters

For EMC/RF emissions testing, the key parameter that can be adjusted to meet compliance requirements is the Wi-Fi transmit power. In general, the goal of compliance testing is to determine the highest transmit power level that can be used that still meets regulatory requirements.

If the regulatory requirements still cannot be met after reducing the transmit power level, consider using an antenna with lower gain. If you are using a certified module, contact your module vendor for assistance.

3.2   Test preparation

Prior to going to the lab for compliance testing, work with the regulatory test lab to put together a test plan. The test plan will be based on:

- The countries (regulatory domains) that you plan to get certified for
- The frequencies/channels of operation (for example, 2.4 GHz and/or 5 GHz bands)
- The channel bandwidths of operation (20, 40, 80 MHz, etc.)

The test plan should include test cases which specify

- Bands, channels, channel bandwidths
- Transmit power levels
- Data rates

If you are using a wireless module that was already certified, we recommend obtaining the power table from the module vendor. The power table includes information on transmit power levels that are compliant for the specific module design and relevant regulatory domain. This transmit power table should be the initial starting point for compliance testing for your product.

3.3   General test procedure

The test procedures and limits are generally defined by the relevant regulatory standard from FCC, ETSI, etc. The section below provides some general tips on how to configure the radio for these tests.

Step 1 - For each test case, configure the radio to the desired band, channel, channel bandwidth, transmit power level and data rate. Look up the transmit power level for that particular radio configuration in the module's transmit power table.

Step 2 - Enable continuous transmission mode.

Step 3 - Measure emissions, as required by the relevant standard, and determine margin compared to limits.   If test case fails, adjust power setting down by 1 dB and remeasure. Continue until test cases passes. Record final power setting and margin for passing condition.

Step 4 - Repeat the above process for all test cases.

3.4   After testing is completed

The Wi-Fi power table determines the transmit power levels used in normal operation out in the field. The power table specifies the target transmit power level based on channel, channel bandwidth and data rate.

During compliance testing, it is strongly recommended to record the transmit power levels that meet the regulatory requirements.

After compliance testing is completed, the entries in the power table may need to be adjusted to ensure that the correct transmit power levels are used in the field.

Refer to the application note *Wi-Fi Tx Power Management in FreeRTOS* for instructions on how to update the power table.

4   Channels and channel bandwidths

Each country defines the channels and channel bandwidth allowed for usage.

For example, in the 2.4 GHz band, generally only channels 1 through 11 are used for FCC. However, ETSI allows operation on channels 1 through 13.

Work with the regulatory test lab to understand what channels are allowed for the countries for which you are certifying.

Refer to the application note *Wi-Fi Tx Power Management in FreeRTOS* for instructions on how to update the list of allowable channels.

5   Adaptivity

Adaptivity is required by the ETSI EN300 328 and ETSI EN 301 893 standards.

The adaptivity test confirms the ability of the radio to hold off transmitting when an interfering signal is present. Meeting this requirement proves the radio can safely share the spectrum with other users.

If the maximum product transmitting power is less than +10 dBm EIRP, the adaptivity requirements do not apply.

5.1   Related parameters

The key radio parameter that can be adjusted to meet the adaptivity requirement is the ED-MAC threshold. The ED-MAC threshold determines the sensitivity of the radio to interfering (non Wi-Fi) signals.

There is one ED MAC threshold used for all 2.4 GHz channels and another threshold used for all 5 GHz channels.

The ED MAC threshold can be enabled or disabled. By default, it is enabled by firmware for both the 2.4 and 5 GHz bands.

The ED-MAC threshold may need to be tuned in order to pass the adaptivity test. However, you should also avoid tuning the ED-MAC threshold to be unnecessarily sensitive, since doing so can impact performance.

5.2   Test preparation

Prior to going to the test lab for compliance testing, it is recommended to work with the lab to develop a test plan. It is also recommended to review the test procedure in the section below to become familiar with the related commands.

The test requires that the Unit Under Test (UUT) transmit data to a companion device. The purpose of the test is to demonstrate that the data transmissions are paused when an interfering signal is present. Hence, it is recommended to have a companion device (such as an Access Point) and a tool to generate data traffic (such as iperf) available for the test. See the test diagram below, from ETSI EN 300 328 standard.
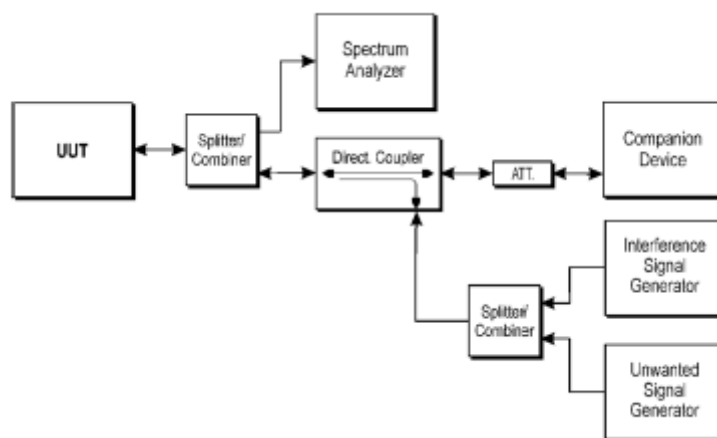

Figure 1: Test setup for verifying the adaptivity of an equipment

Below are some typical questions about the product that may be asked by the test lab. A complete list is contained in ETSI EN 301 893 standard, Annex G.

Q1:   Does the LBE equipment operate as a Supervising Device and/or a Supervised Device?

A1:   Client devices are referred to as Supervised Device, and AP devices are referred to as Supervising Devices. See ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.2.

Q2:   Does the LBE equipment makes use of note 1 in Table 7 or note 1 in Table 8?

A2:   Table 7 is for Supervised Devices and Table 8 for Supervising Devices.

Q3:   Does the LBE equipment operate as an Initiating Device and/or as a Responding Device?

A3:   A client device can be classified as a Responding or Initiating Device, or both. See ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.6 and ETSI EN 301 893 V2.1.1.1 clause 4.2.7.3.2.7.

Q4:   Which Priority Classes are implemented by the LBE equipment?

A4:   Priority clause 1 with COT of 6 ms. See ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.4.

Q5:   Does the LBE equipment implement option 1 or option 2 for the Energy Detection Threshold?

A5:   Option 1. The threshold is fixed at -75 dBm/MHz. See ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.5.

Q6:   Does the LBE equipment comply with the requirements contained in ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.6 and ETSI EN 301 893 V2.1.1 clause 4.2.7.3.2.7?

A6:   Yes. The channel access mechanism can be done by declaration.

Q7:   Does the LBE equipment implement option 1 or option 2 in case of multichannel operation?

A7:   Option 2. See ETSI EN 301 893 V2.1.1 clause 5.4.9.3.2.3.2,

Q8:   What is the maximum number of channels used for multichannel operation?

A8:   If the device supports 802.11n, 2 channels are supported. If the device supports 802.11ac, 4 channels are supported.

5.3   General test procedure

The test procedures and limits are generally defined by the ETSI standard. The section below provides some general tips on how to configure the radio for these tests.

Step 1 - Configure the radio to the desired operating mode (band, channel, channel bandwidth) for the test case.

Step 2 - Generate data traffic as required (using a tool such as iperf).

Step 3 - Confirm that the ED-MAC threshold is enabled by running the following command.

```
#wlan-get-ed-mac-mode
```

The command returns a message showing the status of ED-MAC (enabled or disabled) and the current threshold setting. The example message below shows the ED-MAC threshold is enabled for both 2.4 and 5 GHz bands, as well as the current threshold setting.

```
#EU adaptivity for 2.4GHz band : Enabled
#Energy Detect threshold offset : 0X9
#EU adaptivity for 5GHz band : Enabled
#Energy Detect threshold offset : 0X5
```

Step 4 - Run the adaptivity test to demonstrate compliance

Step 5 - If the test passes, you have completed this test case. Otherwise you need to adjust the ED-MAC threshold, using the command below:

Syntax: `#wlan-set-ed-mac-mode <ed_ctrl_2g> <ed_offset_2g> <ed_ctrl_5g> <ed_offset_5g>`

Where:

Parameter	Description
ed_ctrl_2g	Parameter used to enable or disable ED MAC threshold for 2.4 GHz
	0: disable
	1: enable
`ed_offset_2_g`	ED MAC threshold for 2.4 GHz band.
	Hexadecimal value in units of dB
	Range: 0x80 to 0x7F, (-128 to 127)
	Default value: 0
ed_ctrl_5g	Parameter used to enable or disable ED MAC threshold for 5 GHz
	0: disable
	1: enable
`ed_offset_5_g`	ED MAC threshold for 5 GHz band.
	Hexadecimal value in units of dB
	Range: 0x80 to 0x7F, (-128 to 127)
	Default value: 0

Example for 2.4 GHz band:

Read the current ED-MAC threshold offset using command below:

```
#wlan-get-ed-mac-mode
```

In the example below, the current ED MAC threshold for 2.4 GHz is set to a value of 9

```
#EU adaptivity for 2.4GHz band : Enabled
#Energy Detect threshold offset : 0X9
#EU adaptivity for 5GHz band : Enabled
#Energy Detect threshold offset : 0X5
```

Reduce the threshold value by 1 dB by typing in the command below:

```
#wlan-set-ed-mac-mode 1 0x8 1 0x5
```

Run the adaptivity test. If it still fails, reduce the threshold again and run the test again. Keep adjusting the threshold value and running the test until it passes. Record the value at which the test passes.

Example for 5 GHz band:

Read the current ED-MAC threshold offset using command below:

```
#wlan-get-ed-mac-mode
```

In the example below, the current ED MAC threshold for 5 GHz is set to a value of 5

```
#EU adaptivity for 2.4GHz band : Enabled
#Energy Detect threshold offset : 0X9
#EU adaptivity for 5GHz band : Enabled
#Energy Detect threshold offset : 0X5
```

Reduce the threshold value by 1 dB by typing in the command below:

```
#wlan-set-ed-mac-mode 1 0x9 1 0x4
```

Run the adaptivity test. If it still fails, reduce the threshold again and run the test again. Keep adjusting the threshold value and running the test until it passes. Record the value at which the test passes.

Step 6 – Repeat the steps 1 to 5 until the test passes for all cases. Record all the final offset value.

5.4   After testing is completed

If the ED-MAC threshold required tuning in order to pass the compliance test, it is important to log the passing value of the threshold.   As there is only one ED-MAC threshold for each band, choose the lowest passing value for that band.

The system software must then set the ED MAC threshold when the product boots, in order to ensure compliance when the product is used in the field, using the `wlan-set-ed-mac-mode` command.

Confirm the new offset values are correctly programmed by reading back the values using command below and confirm that the settings match.

```
#wlan-get-ed-mac-mode
```

6   DFS

Dynamic Frequency Selection (DFS) is required by FCC, ETSI and other countries when operating on certain channels. DFS is a scheme that allows wireless networks to operate in certain bands used by radar systems. The requirements and test procedure can vary by country.

When a DFS master (in a Wi-Fi network, this is typically the role of the Access Point) detects radar on the current channel, it stops operating on that channel and moves to a new channel.

The DFS master informs the DFS slaves (in a Wi-Fi network, this is typically the Stations, or Client devices) when a channel change is required.

DFS compliance testing is required to operate on channels that require DFS.

DFS slave operation is enabled by default in firmware.

Work with the test lab to prepare a test plan prior to going to the lab for certification.

Note: DFS master testing is not covered in this revision of the document.

7 Acronyms and abbreviations

Table 3: Acronyms and abbreviations

Acronym	Definition
DFS	Dynamic Frequency Selection
ED-MAC	Energy Detect - Media/Medium Access Controller
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
RF	Radio Frequency

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