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CXUX
PHY Evaluation Test Utility
User Guide for Linux
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1. Introduction

The purpose of this document is to provide the usage of the applications for transmit and receive tests to evaluate the RF performance of the ALXC28 using a test driver in Linux environment. The evaluation board provides the necessary connectors so that you can measure transmit and receive performance of the PHY, using Spectrum Analyzer and Signal Generator in either 2.4GHz or 5GHz (For ALXC28 module).

In general, transmit performance of a radio can be analyzed in three steps.

Maximum power: The user can observe the RF output power for a given maximum gain supported by the RF.

EVM: The user can observe the EVM for a given rated RF power as supported by the RF transceiver.

Spectral Mask: The user can verify whether the ALXC28 module meets the spectral mask requirements defined by IEEE standard for a given maximum RF output power, in a particular mode of operation like 11a, 11b, 11g etc.

The receive performance of the PHY can be analyzed using Packet Error Ratio (PER) test.

The Rx performance is analyzed by the sensitivities at different data rates. In general, the sensitivity is observed as 10% Packet Error Ratio (PER) point in 11a and 11g, and 8% PER point in 11b.

The document contains two major sections.

Section 3.1 describes the usage of the 'transmit' utility, which provides the options for setting various parameters to carry out transmit tests on the ALXC28 device.

Section 3.2 describes the usage of the 'receive' utility, which enables the user to perform receive tests on the ALXC28 device.

2. Test Setup Details

The diagram shown below, illustrates the test setup for evaluating receive and transmit performance of ALXC28 WLAN module.

As shown in the test setup, the ALXC28 evaluation board (EVB) is plugged into Linux based laptop via RJ45. The board is connected to a WLAN signal analyzer through a microwave coaxial cable to test the Tx or Rx performance.

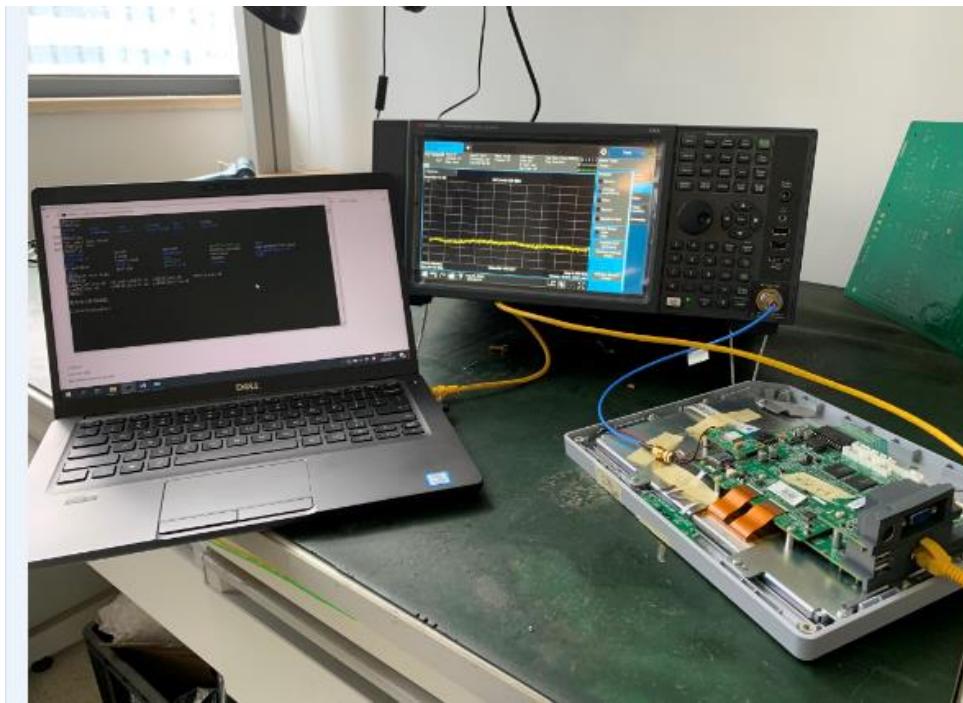


Figure 1: Linux Based RF Evaluation Setup With RJ45 Interface

Following diagram illustrates various software components involved in performing Tx and Rx tests using spectrum analyzer and signal generator respectively.

The ‘transmit’ utility is a command line application to perform Tx tests. Before running the Tx tests, the user is expected to connect ALXC28 module to a signal analyzer using the RF cable.

The ‘receive’ utility is also a separate command line application that can be used for displaying statistics on the received packets while carrying out the receive sensitivity tests.

3. Application Usage

In general, before performing any tests configure the PHY to operate in the appropriate band. The transmit tests can be performed through a utility called ‘bcmddhd_active.sh’ which is found under ‘wifi’ directory.

Configure the following parameters through this application before running the tests.

- Transmit power
- Transmit data rate
- Transmit mode
- Channel number

3.1 Tx Application Usage

The application can be started in the following steps:

plug RJ45 cable into the device and laptop, set the laptop's ip and the ip of device in the same network segment, and then Login to the device, send the command via laptop cmd window.

```
# cd /etc/wifi
# sh ./bcmddhd_active.sh
```

Then we can start RF test, test different mode TX performance send command as blow

11b mode start transmit command :

```
/system/etc/firmware/wl down
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band b
/system/etc/firmware/wl chanspec -c 1 -b 2 -w 20 -s 0(see note 1)
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl ampdu 1
/system/etc/firmware/wl bi 65000
/system/etc/firmware/wl frameburst 1
/system/etc/firmware/wl rateset 11b
/system/etc/firmware/wl up
/system/etc/firmware/wl txant 0
/system/etc/firmware/wl antdiv 0
/system/etc/firmware/wl nrate -r 1(see note 2)
/system/etc/firmware/wl phy_watchdog 0
/system/etc/firmware/wl disassoc
/system/etc/firmware/wl txpwr1 -o -d 18(see note 3)
/system/etc/firmware/wl pkteng_start 00:90:4c:aa:bb:cc tx 40 1000 0
```

Note 1: chanspec -c 1 -b 2 -w 20 -s 0, 1 means channel 1, we can change it to 1-13

Note 2: nrate -r 1, 1 means CCK 1M, we can change it to 1,2,5.5,11

Note 3: txpwr1 -o -d 18, 18 means target power is 18dBm, we can change it to 0-20

11g mode start transmit command :

```
/system/etc/firmware/wl down
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band b
/system/etc/firmware/wl chanspec -c 1 -b 2 -w 20 -s 0(see note 1)
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl ampdu 7
/system/etc/firmware/wl bi 65000
/system/etc/firmware/wl frameburst 1
/system/etc/firmware/wl rateset 18b
/system/etc/firmware/wl up
```

```
/system/etc/firmware/wl txant 0
/system/etc/firmware/wl antdiv 0
/system/etc/firmware/wl nrate -r 54(see note 2)
/system/etc/firmware/wl phy_watchdog 0
/system/etc/firmware/wl disassoc
/system/etc/firmware/wl txpwr1 -o -d 15(see note 3)
/system/etc/firmware/wl pkteng_start 00:90:4c:aa:bb:cc tx 40 1000 0
```

Note 1: chanspec -c 1 -b 2 -w 20 -s 0, 1 means channel 1, we can change it to 1-13

Note 2: nrate -r 54, 54 means OFDM 54M, we can change it to 6,9,12,18,24,36,48,54

Note 3: txpwr1 -o -d 15, 15 means target power is 15dBm, we can change it to 0-18

2.4g 11n (20M) mode start transmit command :

```
/system/etc/firmware/wl down
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band b
/system/etc/firmware/wl chanspec -c 1 -b 2 -w 20 -s 0(see note 1)
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl ampdu 1
/system/etc/firmware/wl bi 65000
/system/etc/firmware/wl frameburst 1
/system/etc/firmware/wl rateset 18b
/system/etc/firmware/wl up
/system/etc/firmware/wl txant 0
/system/etc/firmware/wl antdiv 0
/system/etc/firmware/wl nrate -m 7 -s 0(see note 2)
/system/etc/firmware/wl phy_watchdog 0
/system/etc/firmware/wl disassoc
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl phy_activecal
/system/etc/firmware/wl txpwr1 -o -d 14(see note 3)
/system/etc/firmware/wl pkteng_start 00:90:4c:aa:bb:cc tx 40 1000 0
```

Note 1: chanspec -c 1 -b 2 -w 20 -s 0, 1 means channel 1, we can change it to 1-13

Note 2: nrate -m 7 -s 0, 7 means MCS7, we can change it to 0-7

Note 3: txpwr1 -o -d 14, 14 means target power is 14dBm, we can change it to 0-18

11a mode start transmit command

```
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl up
/system/etc/firmware/wl pkteng_stop rx
/system/etc/firmware/wl pkteng_stop tx
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band a
/system/etc/firmware/wl rate 54(see note 1)
/system/etc/firmware/wl channel 149(see note 2)
/system/etc/firmware/wl phy_forcecal 1
```

```
/system/etc/firmware/wl scansuppress 1
/system/etc/firmware/wl phy_txpwrctrl 1
/system/etc/firmware/wl txpwr1 -o -d 15(see note 3)
/system/etc/firmware/wl down
/system/etc/firmware/wl up
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl pkteng_start 00:90:4c:aa:bb:cc tx 100 1024 0
```

Note 1: nrate -r 54, 54means OFDM 54M,we can change it to 6,9,12,18,24,36,48,54

Note 2: channel 149, we can change 149 to 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 149, 153, 157, 161, 165.

Note 3: txpwr1 -o -d 15, 15 means target power is 15dBm, we can change it to 0-18

5g 11n (20M) mode start transmit command

```
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl up
/system/etc/firmware/wl pkteng_stop rx
/system/etc/firmware/wl pkteng_stop tx
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band a
/system/etc/firmware/wl nrate -m 0 -s 0(see note 1)
/system/etc/firmware/wl channel 36(see note 2)
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl scansuppress 1
/system/etc/firmware/wl phy_txpwrctrl 1
/system/etc/firmware/wl txpwr1 -o -d 15(see note 3)
/system/etc/firmware/wl down
/system/etc/firmware/wl up
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl pkteng_start 00:90:4c:aa:bb:cc tx 100 1024 0
```

Note 1: nrate -m 0 -s 0, 0 means MCS0 , we can change it to 0-7

Note 2: channel 149, we can change 149 to 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 149, 153, 157, 161, 165.

Note 3: txpwr1 -o -d 15, 15 means target power is 15dBm, we can change it to 0-18

Stop transmit command :

```
/system/etc/firmware/wl pkteng_stop tx
```

2.4g single ton start transmit command

```
/system/etc/firmware/wl down
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band b
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl up
```

```
/system/etc/firmware/wl out
/system/etc/firmware/wl fqacurcy 1(see note 1)
```

Note 1: fqacurcy 1, 1 means channel 1, we can change it to 1-13

5g single ton start transmit command

```
/system/etc/firmware/wl down
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band a
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl up
/system/etc/firmware/wl out
/system/etc/firmware/wl fqacurcy 36(see note 1)
```

Note 1: fqacurcy 36, 36 means channel 36, we can change it to 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 149, 153, 157, 161, 165

single ton stop transmit command

```
/system/etc/firmware/wl fqacurcy 0
/system/etc/firmware/wl down
/system/etc/firmware/wl up
```

3.2 RX Application Usage

The Rx performance is analyzed by the sensitivities at different data rates. In general, the sensitivity is observed as 10% Packet Error Ratio (PER) point in 11a and 11g, and 8% PER point in 11b.

PER: Packet Error Ratio (PER) is calculated by measuring the number of packets received correctly and comparing with the number of packets expected.

%Packet error rate = $100 * (1 - (\text{Received packets} / \text{expected packets}))$

For carrying out the receive test, connect the EVB to a Vector Signal Generator (VSG). Then set the RF amplitude, signal waveform and the channel in the signal generator before starting the receive tests.

You need to configure the channel (as mentioned below) in the EVB with the same channel which is set in Signal Generator.

This application can be started in the following steps:

plugged RJ45 cable into the device and laptop, set the laptop's ip and the ip of device in the same network segment, and then Login to the device, send the command via cmd window.

```
# cd /etc/wifi
# sh ./bcmddhd_active.sh
```

Then we can start Rx test, test command as blow :

2.4g Rx command

```
/system/etc/firmware/wl down
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl phy_watchdog 0
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band b
/system/etc/firmware/wl channel 1(see note 1)
/system/etc/firmware/wl up
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl scansuppress 1
/system/etc/firmware/wl pkteng_start 01:00:00:C0:FF:EE rxwithack
```

Note: channel 1,1 we can change it to 1-13

5g Rx command

```
/system/etc/firmware/wl down
/system/etc/firmware/wl mpc 0
/system/etc/firmware/wl phy_watchdog 0
/system/etc/firmware/wl country ALL
/system/etc/firmware/wl band a
/system/etc/firmware/wl channel 36(see note 1)
/system/etc/firmware/wl up
/system/etc/firmware/wl phy_forcecal 1
/system/etc/firmware/wl scansuppress 1
/system/etc/firmware/wl pkteng_start 01:00:00:C0:FF:EE rxwithack
```

Note 1: fqaccuracy 36, 36 means channel 36, we can change it to 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 149, 153, 157, 161, 165

After send Rx command, send blow command, we will get the receive packet, then we can calculate the PER.

```
/system/etc/firmware/wl pkteng_stop rx
/system/etc/firmware/wl counters
```

Reset counters command

```
/system/etc/firmware/wl reset_cnts
```

Integration instructions for host product manufacturers according to KDB 996369 D03 OEM Manual v01r01

2.2 List of applicable FCC rules

CFR 47 FCC PART 15 SUBPART C has been investigated. It is applicable to the modular transmitter

2.3 Specific operational use conditions

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system.

2.4 Limited module procedures

Not applicable

2.5 Trace antenna designs

Not applicable

2.6 RF exposure considerations

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

2.7 Antennas

This radio transmitter FCC ID: SMQCXUX has been approved by Federal Communications Commission to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Type	Antenna type	Frequency Range	Antenna Gain
LBS-019C	FPC antenna	2.4GHz – 2.5 GHz 5.15GHz – 5.85 GHz	2.51dBi 2.91dBi

2.8 Label and compliance information

The final end product must be labeled in a visible area with the following " Contains FCC ID: SMQCXUX ".

2.9 Information on test modes and additional testing requirements

Host manufacturer is strongly recommended to confirm compliance with FCC requirements for the transmitter when the module is installed in the host.

2.10 Additional testing, Part 15 Subpart B disclaimer

Host manufacturer is responsible for compliance of the host system with module installed with all other applicable requirements for the system such as Part 15 B.

2.11 Note EMI Considerations

Host manufacturer is recommended to use D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties.

2.12 How to make changes

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system. According to the KDB 996369 D02 Q&A Q12, that a host manufacturer only needs to do an evaluation (i.e., no C2PC required when no emission exceeds the limit of any individual device (including unintentional radiators) as a composite. The host manufacturer must fix any failure.

“Contains transmitter module FCC ID: SMQCXUX. Additionally, the following statement should be included on the label and in the final product's user manual: “This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

- (1) This device may not cause harmful interferences, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.”

The module is limited to installation in mobile or fixed applications. Separate approval is required for all other operating configurations, including portable configuration with respect to Part 2.1093 and different antenna configurations.*****

The requirement for KDB 996369 D03:

List of applicable FCC rules

FCC CFR Title 47 Part 15 Subpart C Section 15.247, Part 15 Subpart E Section 15.407

Summarize the specific operational use conditions

This module has been granted Single Modular Approval for mobile applications. OEM integrators for host products may use the module in their final products without additional FCC certifications if they meet the following conditions. Otherwise, additional FCC approvals must be obtained.

The host product with the module installed must be evaluated for simultaneous transmission requirements

The user's manual for the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the 2dBi.

A label must be affixed to the outside of the host product with the following statement: This device contains FCC ID: SMQCXUX

The final host/Module combinations may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

Information on test modes and additional testing requirements

Date transfer module demo board can control the EUT work in RF test mode at specified test channel.

Additional testing, Part 15 Subpart B disclaimer

The module without unintentional-radiator digital circuit, so the module does not required an evaluation by FCC Part 15 Subpart B. The host be evaluated by the FCC Subpart B.

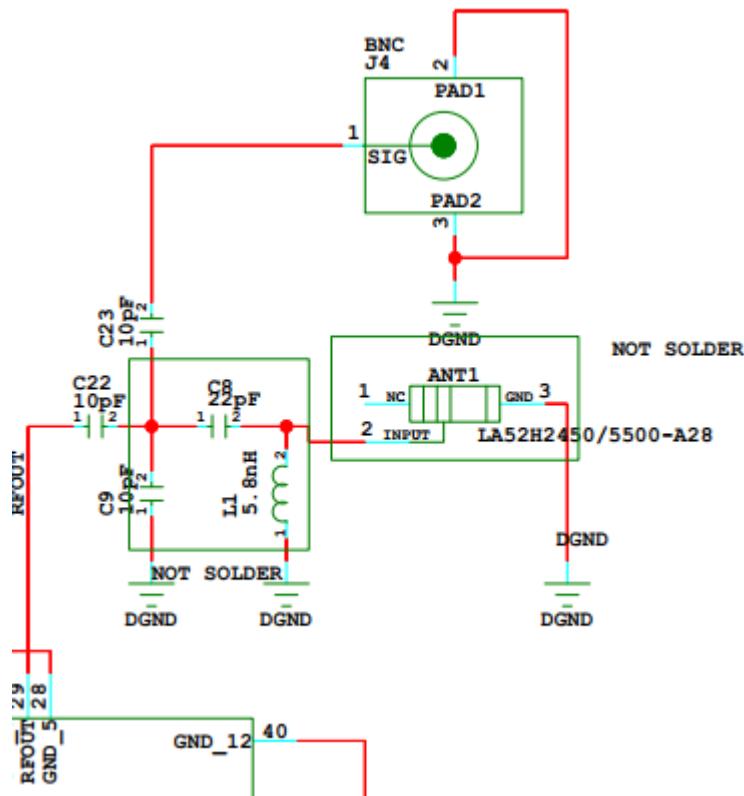
Single module procedures

The module has meet the requirements to satisfy the conditions.

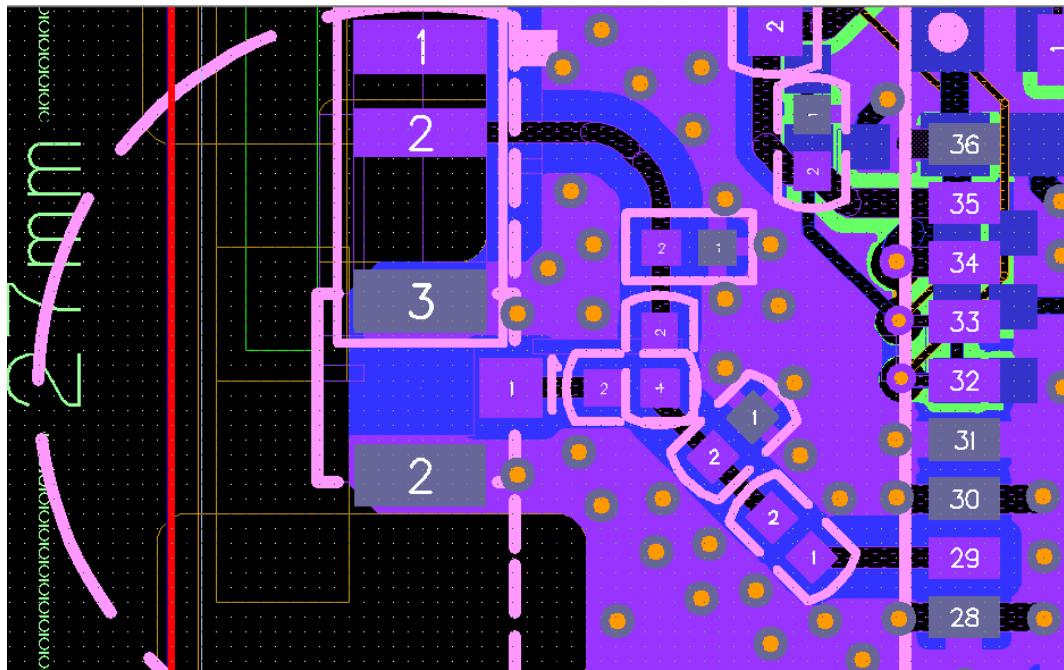
Trace antenna designs

Please refer to Picture 1 for the RF Link's schematic diagram and refer to Picture 2 for PCB Layout. The designed antenna meets the wifi hardware module's requirements via the connection between ipex connector and module.

Picture 1



Picture 2



RF exposure considerations

The host device manufacturer should confirm that a separation distance of 20cm or more should be maintained between the antenna of this host device and persons during the host device operation.

Antennas

The device itself has antenna, customer can use the PIFA antenna with antenna gain isn't greater than 5 dBi.

Label and compliance information

If this certified module is installed inside the host device, then the outside of the host must be labeled with "Contains FCC ID: "SMQCXUX "

Federal Communications Commission (FCC) Statement

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

● Consult the dealer or an experienced radio/TV technician for help.

Warning: Changes or modifications made to this device not expressly approved by Edan Instruments, Inc. may void the FCC authorization to operate this device.

Note: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

RF exposure statement:

The transmitter must not be co-located or operated in conjunction with any other antenna or transmitter. This equipment complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a Minimum distance of 20cm between the radiator and any part of your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. Country Code selection feature to be disabled for products marketed to the US/Canada.

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

1. The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2. The transmitter module may not be co-located with any other transmitter or antenna,
3. For all products market in US, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change. (if modular only test Channel 1-11)

As long as the three conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Important Note:

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

End Product Labeling

The final end product must be labeled in a visible area with the following " Contains FCC ID: SMQCXUX"

Manual Information to the End User

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

The end user manual shall include all required regulatory information/warning as show in this manual.