

RS9113

PHYEvaluationTestUtility

UserGuideforLinux

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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 RS9113™ (RS9113) 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 RS9113 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 RS9113™ 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 describes the usage of the 'transmit' utility, which provides the options for setting various parameters to carry out transmit tests on the RS9113™ device.

Section 4 describes the usage of the 'receive' utility, which enables the user to perform receive tests on the RS9113™ device.

2. Test Setup Details

The diagram shown below, illustrates the test setup for evaluating receive and transmit performance of RS9113™ WLAN module.

As shown in the test setup, the RS9113™ evaluation board (EVB) is plugged into Linux based laptop either on the SDIO slot via SDIO connector or USB port via USB cable through port J6 on the EVB. The board is connected to a WLAN signal analyzer through a microwave coaxial cable to test the Tx performance.



Figure 1: Linux Based RF Evaluation Setup With USB Interface

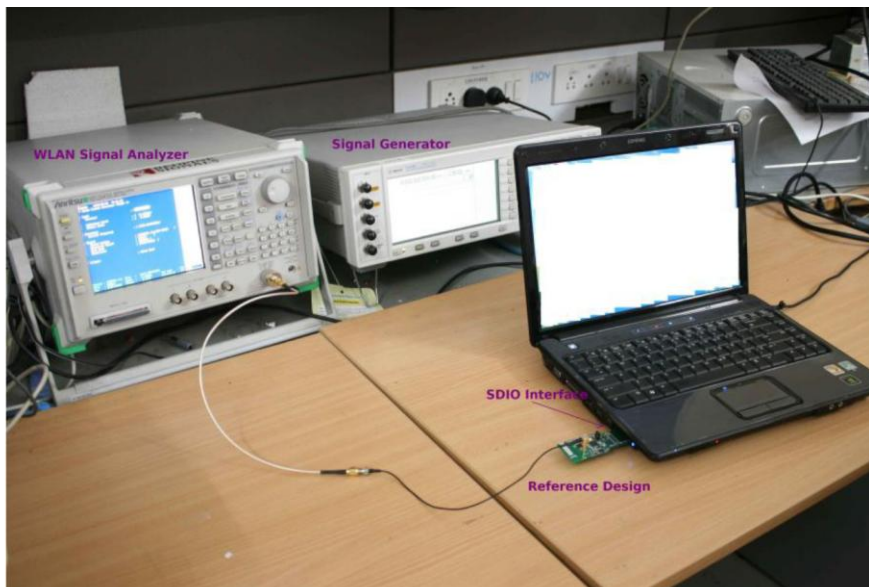


Figure 2: Linux Based RF Evaluation Setup With SDIO Interface

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 RS9113™ 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.

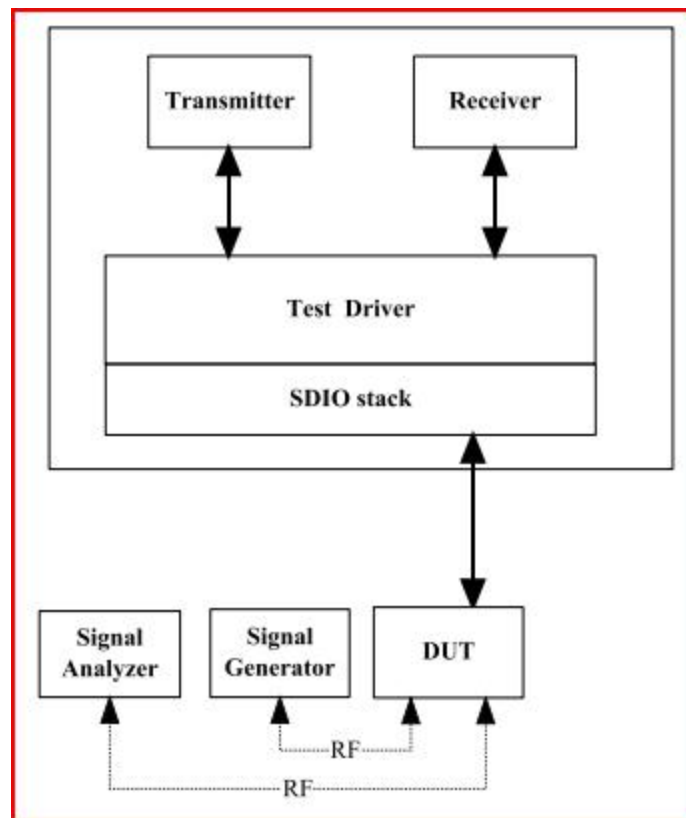
Please follow "RS9113-SW-Installation-Guide" for building and installing the RS9113™ driver.

To configure the driver in "PER" Mode, make sure to have the following line in "release/insert.sh".

`DRIVER_MODE=2`

After the card has been detected successfully (issue "`dmesg -c`" in terminal to check the status for the USB card it will show "new high-speed USB device detected" while for the SDIO it will show "new High speed SDIO card detected") the Tx and Rx tests can be started. Please follow the subsequent sections for executing the Tx and Rx tests.

Figure 3: Utility Diagram



When driver is compiled in "host" directory driver would be using binaries from "release".

If there are any modifications in "host" directory then driver compilation is required.

The RS9113 driver offers two main modes of operation:

1. End-end, or Wi-Fi mode
2. PER mode for PHY evaluation

To configure the driver in Wi-Fi or (END-to-END) Mode make sure to have the following line in "release/insert.sh".

`DRIVER_MODE=1`

In order to configure the driver in PHY Evaluation mode (PER mode) then make sure the "DRIVER_MODE" parameter should be set as `DRIVER_MODE=2`

3. Transmit Tests

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 'transmit' which is found under 'release' directory.

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

Transmit power

- ☐ Transmit data rate
- ☐ Packet length
- ☐ Transmit mode
- ☐ Channel number
- ☐ External PA-Enable/Disable
- ☐ Rate flags
- ☐ Aggregation flag
- ☐ Number of packets to send in burst mode
- ☐ Delay between the packets in burst mode

3.1 Application Usage

The application can be started in the following manner:

#cd release

#./transmit<g><r><l><m><c><p><f><a><n><d><g> refer to Tx gain value for controlling transmit power.

<r> refer to TxRate.

<l> refer to length of the Tx packet

<m> refer to Transmit mode.

0 –Burst Mode

1 –Continuous Mode

<c> refer to Channel number

<p> refer to External PA-Enable/disable

<f> refer to Short GI, Greenfield and Channel Width.

<a> refer to enable/disable aggregation

<n> refer to number of packets to send in burst mode.

<d> refer to delay between packets in burst mode

After starting this application, user has to enter the following command to stop the ongoing transmission:

#./transmit<m>

<m>- 0 for Burst Mode

1 for Continuous Mode

Set power value:

To set Tx gain value, enter a valid value for <p> parameter. The valid values are from 229 to 255 for RS9113 module U. The transmit power increases proportionately with increase in Tx gain value in OFDM and CCK modes. This support is not present in this release.

Set Data Rate:

To set transmit data rate, enter a valid rate for <r> parameter.

Valid values are (1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48, 54, mcs0, mcs1, mcs2, mcs3, mcs4, mcs5, mcs6, mcs7).

SetPacketLength:

For setting the transmission packet length, enter a valid value for <l> parameter.

Valid values are in the range of 24 and 1500. The values are in bytes.

SetTransmitMode:

For setting the transmission mode, you need to enter one of the following values for <m> parameter.

1 for continuous mode

0 for burst mode.

SetChannel number:

For setting the channel number in 2.4GHz you need to enter a value in the range 1–11 for <c> parameter.

The following table maps the channel number to the actual radio frequency in the 2.4GHz spectrum for 20MHz channel width.

Channel Numbers(2.4GHz)	Center frequencies for 20MHz channel width(MHz)
1	2412
2	2417
3	2422
4	2427
5	2432
6	2437
7	2442
8	2447
9	2452
10	2457
11	2462

Table 1 Channel Number and Frequencies for 20MHz Channel Width in 2.4GHz

Channel numbers in 5GHz are ranging from 36–165. The following tables map the channel number to the actual radio frequency in the 5GHz spectrum for 20MHz channel width.

Channel Numbers(5GHz)	Center Frequencies for 20MHz Channel Width (MHz)
36	5180
40	5200
44	5220
48	5240
149	5745
153	5765
157	5785
161	5805
165	5825

Table 2 Channel Number and Frequencies for 20MHz Channel Width in 5GHz

SetExternalPAenable/disable:

If the module contains an external PA, to enable the usage of the PA, enter a value of 1, else enter a value of 0. This support is currently not handled in driver.

SetRateflags:

Rate flags contain short GI, Greenfield and channel width values. Various fields in rate flags are divided as specified below

Fields	ShortGI	Greenfield	Channel Width	Reserved
Bits:	0	1	2–4	5-15

Table 3 Rate Flags

To enable short GI – set rate flags value as '1'

To enable Greenfield – set rate flags value as '2'

To set channel width use one of the values specified in the table below:

ChannelWidth	Rateflagvalues
20MHz	0

Table 4 Channel Width

We can enable multiple fields by setting rate flags value appropriately.

Set Aggregation flags:

This flag is for enabling or disabling aggregation support. Higher length packets can be transmitted by enabling aggregation flag. If this flag is set then it enables the TX aggregation. User can give maximum of length less than or equal to 30000 bytes when the aggregation is enabled. This maximum supported length may vary depending on the available buffers in TA. User given length is divided into chunks of size 1792 bytes. All these chunks are aggregated and sent. If this flag is not set then aggregation is not enabled and packets will be sent without any aggregation. And maximum length that can be sent in this case is 1536 bytes. Aggregation feature is supported only in burst mode. This field will be ignored in case of continuous mode.

Set Number of packets to send:

This field is used to set the number of packets to be sent in burst mode. If the value given is 'n' then 'n' number of packets will be sent on air, after that transmission will be stopped. If this field is given as 'zero' then packets will be sent continuously until user stops the transmission using transmit utility. This field will be ignored in case of continuous mode.

Set Delay between the packets:

This field is used to set the delay between the packets in burst mode. Delay should be given in microseconds. i.e. if the value is given as 'n' then a delay of 'n' microseconds will be added for every transmitted packet in the burst mode.

If this field is set to 'zero' then packets will be sent continuously without any delay.

This field will be ignored in case of continuous mode.

Examples:

□

\$./transmit405.5750111010 00

Above command starts continuous transmission with the following configuration:

Tx gain - 40

Data rate - 5.5Mbps

Transmit mode=1, which means continuous transmit.

Channel number= 11

External PA=0, disable

Rate flags=1, Short GI is enabled with 20MHz Channel width

Aggregation flag=

0, disable (ignored in continuous mode) Number of packets to send=

0 (ignored in continuous mode) Delay between the packets=

0 (ignored in continuous mode)

\$. /transmit6536100006 0250010000

Above command starts burst mode transmission with the following configuration:

Tx gain=65

Data rate= 36Mbps

Packet Length=1000 bytes

Transmit mode=0, which means burst mode transmission.

Channel number= 6 (Center frequency)

External PA=0, disable

Rate flags= 25

Aggregation flag=0, disable

Number of packets to send= 1000

Delay between the packets= 0

4. Programmable PER packet

PER packet can be programmable using utility called 'transmit_packet' utility. This utility takes the PER packet content from the file called 'per_packet.txt'.

'transmit_packet' utility and per_packet.txt can be found under 'release' directory.

Before running this utility, user has to fill the required packet content into 'per_packet.txt' file starting from the MAC header. Once 'per_packet.txt' is filled, user can run 'transmit_packet' utility for configuring the PER packet. This utility configures the PER packet only. It will not start transmission. User has to run the 'transmit' utility as described in the previous section after running 'transmit_packet' utility.

If user does not want to configure the PER packet, then 'transmit' utility can be run directly without running 'transmit_packet' utility. In this case, the default PER packet will be sent.

Configure the following parameters through 'transmit_packet' application before running the 'transmit' utility.

ProgrammablePER PacketEnable
 ProgrammablePER PacketLength
 Sequencenumberflag

4.1 ApplicationUsage

Before running
 application PER packet content has to be entered into the 'per_packet.txt' file.

Then the application can be started in the following manner:

#cd release

#./transmit_packet <e> <l> <s>

<e> refers to enable or disable flag for PER packet configuration.

<l> refers to length of

the packet that has to be configured in bytes. <s> refers to sequence number flag.

Enable flag:

This flag is used to enable or disable the PER packet configuration.

1-Enable, 0-Disable

If this flag is enabled, newly configured PER packet can be transmitted when user runs 'trasmit' utility.

If this flag is disabled, default PER packet can be transmitted when user runs 'trasmit' utility.

Length:

This field refers to the number of bytes to be configured from the 'per_packet.txt' file into PER packet. i.e. if this field is given as 'n' (maximum value of n is 1536 bytes), then 'n' number of bytes can be configured from 'per_packet.txt' file into PER packet.

Maximum allowed

value for this field is 1536 bytes. i.e. PER packet can be programmable up to 1536 bytes only.

Sequence numberFlag:

This flag is used to enable or disable the sequence number from the 'per_packet.txt' file.

If this flag is set as '1' then it will take the sequence number from the 'per_packet.txt' file. And each transmitted packet contains same sequence number without any increment.

If this flag is set as '0' then

it ignores the sequence number value from 'per_packet.txt' file and sequence number will be incremented starting from '0'.

Default value for this flag is '0'.

If the Length field in 'transmit_packet' utility is given as 'm' and Packet length in 'transmit' utility is given as 'n'

Then

1. If $m < n$ then, first 'm' bytes can be taken from 'per_packet.txt' file into PER packet and the rest of packet (m-n length) contains default content.
2. If $m > n$ then, 'n' bytes can be taken from 'per_packet.txt' file into PER packet and transmitted.
3. If $m = n$ then, 'm' bytes can be taken from 'per_packet.txt' file into PER packet and transmitted.

User has to take care while filling per_packet.txt. i.e. contents should be in hex format only.

Examples:

\$/transmit_packet 110000

Above command configures the PER packet

PER configuration Enable- 1

Length- 1000 (1000 bytes can be configured from the 'per_packet.txt' file)

Sequence number flag- 0 (Sequence number will be incremented)

\$/transmit_packet 15001

Above command configures the PER packet

PER configuration Enable- 1

Length- 500 (500 bytes can be configured from

the 'per_packet.txt' file) Sequence number flag-

1 (Sequence number will not be incremented)

After starting this application, user has to enter the following command to stop the ongoing transmission:

\$/transmit_packet 0

Above command disables the PER packet configuration. i.e. default PER packet will be sent when user runs 'transmit' utility.

5. Receive Tests

There receive tests can be invoked from an application called 'receive' which is found under 'release' directory. Use this application for displaying the following information

Total number of CRC PASS

packets Total number of CRC FAIL packets and Total number of FALSE CCA

The Rx performance is analyzed by the sensitivities at different data rates. In general, the sensitivity is observed as 10% Packet

ErrorRatio(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.

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

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.

The application can be started as follows to start receiving the packets from EVB. Goto 'release' folder.

\$./receive<file><channel number><start-stop><channel width>

<file> is the name of the file in to which the above information will be written. In addition, you can see this information on the console.

<channel number> is the channel number on which receive tests are to be done. For 2.4 GHz channels, please refer table 1 and for 5 GHz channels, please refer table 2.

<start-stop value> is to either start or stop receive application. To start set this value to '0' and '1' to stop receive application.

<channel width> is the value of the operating bandwidth of the channel. Channel width values are specified in the following table.

Channel Width	Value
20MHz	0

Table 5 Channel Width

Example:

#!/receive stats600

The above mentioned command will start the receive application File-stats

Channel number- 6

Start-Stop-0, Start

Channel Width-0(20MHz)

The test utility displays the following information:

Total number of

received packets (with correct CRC). Total number of packets with CRC errors.

Total number of FALSE CCA's received.

Compute the PER using the formula mentioned above.

#./receivestats610

Theabovecommandwillstop thereceiveapplicationFile-stats

Channelnumber- 6

Start-Stop-1,Stop

ChannelWidth-0(20MHz)

Thiswillstopthereceiveapplication.

Integration instructions for host product manufacturers according to KDB 996369 D03 OEM Manual v01

2.2 List of applicable FCC rules

FCC Part 15 Subpart C 15.247 & 15.209

2.3 Specific operational use conditions

The module can be used for mobile or portable applications with a maximum 4.69dBi antenna. The host manufacturer installing this module into their product must ensure that the final composite product complies with the FCC requirements by a technical assessment or evaluation to the FCC rules, including the transmitter operation. The host manufacturer 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 shown in this manual.

2.4 Limited module procedures

Not applicable. The module is a Single module and complies with the requirement of FCC Part 15.212.

2.5 Trace antenna designs

Not applicable. The module has its own antenna, and doesn't need a host's printed board microstrip trace antenna etc.

2.6 RF exposure considerations

The module must be installed in the host equipment such that at least 20cm is maintained between the antenna and users' body; and if RF exposure statement or module layout is changed, then the host product manufacturer required to take responsibility of the module through a change in FCC ID or new application. The FCC ID of the module cannot be used on the final product. In these circumstances, the host manufacturer will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

2.7 Antennas

Antenna Specification are as follows:

Type: Monopole Antenna

Gain: 4.69dBi Max.

This device is intended only for host manufacturers under the following conditions:

The transmitter module may not be co-located with any other transmitter or antenna;

The module shall be only used with the internal antenna(s) that has been originally tested and certified with this module. The antenna must be either permanently attached or employ a 'unique' antenna coupler.

As long as the conditions above are met, further transmitter test will not be required. However, the host manufacturer is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

2.8 Label and compliance information

Host product manufacturers need to provide a physical or e-label stating "Contains FCC ID: **SMQ9113**" with their finished product.

2.9 Information on test modes and additional testing requirements

Host manufacturer must perform test of radiated & conducted emission and spurious emission, etc according to the actual test modes for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

Only when all the test results of test modes comply with FCC requirements, then the end product can be sold legally.

2.10 Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is **only** FCC authorized for FCC Part 15 Subpart C 15.247 & 15.209 and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Federal Communication Commission Statement (FCC, U.S.)

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 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.

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.

FCC Caution:

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

IMPORTANT NOTES

Co-location warning:

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

OEM integration instructions:

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

The transmitter module may not be co-located with any other transmitter or antenna. The module shall be only used with the external antenna(s) that has been originally tested and certified with this module.

As long as the conditions above are met, further transmitter test 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 (for example, digital device emissions, PC peripheral requirements, etc.).

Validity of using the module certification:

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module 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 Transmitter Module **FCC ID: SMQ9113**".

Information that must be placed in the end user manual:

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.