AN1305: RS9116N Regulatory Test Application Note

Version 1.1

10/21/2020

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Acronyms

PER: Packet Error Rate
WLAN: Wireless Local Area Network
BT: Bluetooth Classic
BLE: Bluetooth Low Energy
EVB: Evaluation Board
Tx: Transmit
Rx: Receive
GUI: Graphical User Interface

About this Document

This document describes the guidelines for using the GUI Interface for PER testing of RS9116 Products in n-Link mode.

1 Overview

The RS9116 software provides application to test transmit and Receive Performance of RS9116 Module in PER test mode. The GUI interface eases the effort for the user in evaluating the product.

2 Hardware (EVB) Details

This section describes various components and connection headers of RS9116 EVB. n-Link® (Hosted) solutions support SDIO and USB interfaces only. The same EVB can also be used for WiSeConnect® (Embedded) solutions, where we support UART, SPI, USB and USB-CDC interfaces.

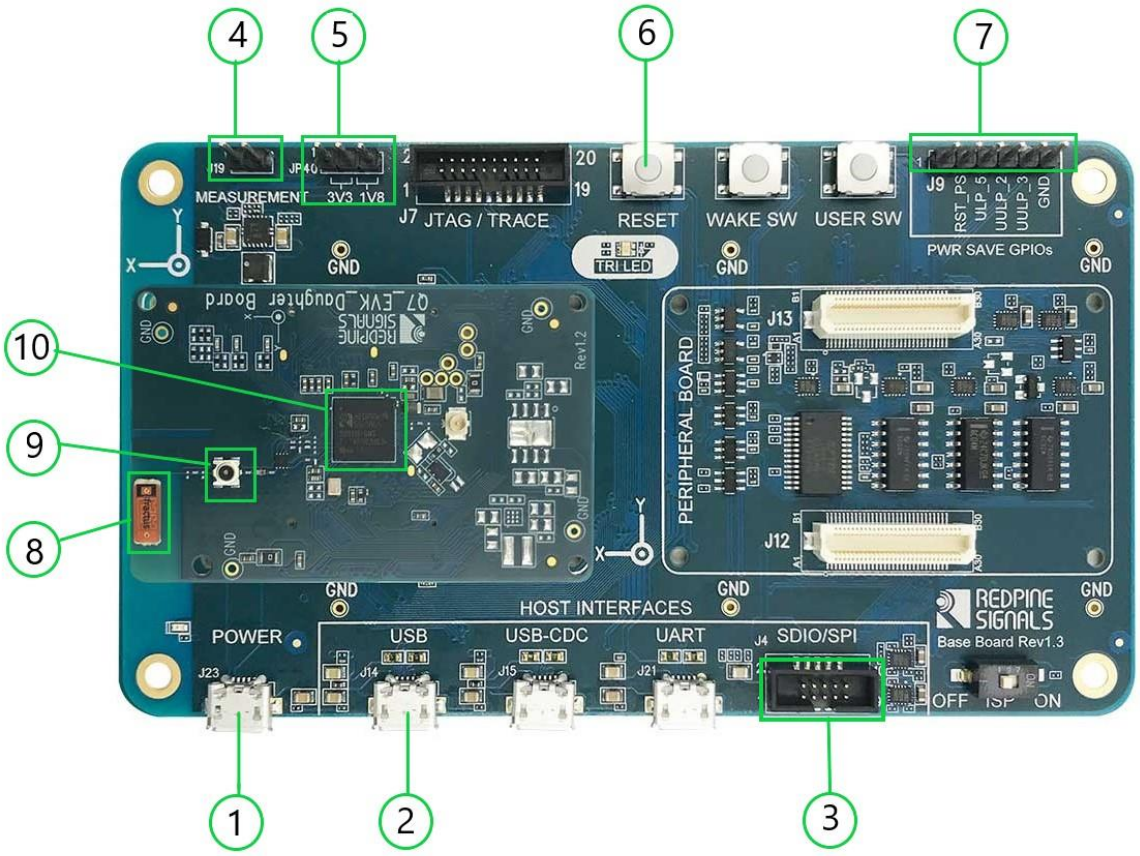


Figure 1: RS9116 EVB

Option	Feature name	Description
1	Power USB	It is used to supply power to the EVB. While using USB interface, connecting power USB is optional as power drawn from USB itself.
2	USB	It is the port for USB interface used to communicate with host.
3	SDIO/SPI	It is the common port for both SDIO and SPI interface, used to communicate with host. **Note**: In nLink only SDIO is supported.
4	Measurement	It is a provision to measure current consumption of chip using ammeter or Digital Multi meter.
5	3.3V/1.8V Voltage selection	It is a provision to select the operating voltage of chip. User need to set this to either 3.3V or 1.8V selection.
6	Reset Switch	Provision to reset chip

7	Power save GPIO's	These are GPIO's which need to be connected appropriately to the host, while using GPIO handshake in ULP or WOWLAN. Please refer TRM for more details.
8	Onboard antenna /Internal Antenna	This is an onboard antenna used for wireless communications
9	External Antenna UFL connector	Provision given to connect external antenna as per the requirement.
10	RS9116 SOC	Chip number will be printed on top of SOC which has below information included in it. M/N:M7DB6 RS9116-CC0-2 FCC ID:KFS-M7DBN6 For details, refer to https://www.silabs.com/wireless/wi-fi/rs9116-wi-fi-transceiver-socs

Power Supply and Interface Connectivity:

The board is designed to configure the module to use the interface on which power supply is detected. This is indicated through the LEDs mounted on the board. The SDIO interface requires power supply to be provided over the USB connector. Hence, for SDIO interface, it is required that the power USB be connected first (i.e power up first) followed by the SDIO or SPI connection.

Follow the below steps to use the EVB with possible host interface options:

1. USB: Connect the Micro A/B-type USB cable between a USB port of a PC/Laptop and the micro-USB port labeled USB on the EVB.
2. SDIO Mode: (For SDIO Header Pin Description, please refer to Appendix A. Appendix A: SDIO Header Pin Description.)

Current Measurement:

There is a 2-pin inline jumper available for measuring the current being sourced by the module during different stages of operation. This is labeled as "MEASUREMENT" on the baseboard. The user may connect a power meter or an ammeter to this jumper to measure the current.

Note:

Make sure the ISP switch is in OFF state. If it is ON state you will not get the boot loader messages

3 Software Details

Driver: https://www.silabs.com/wireless/wi-fi/rs9116-wi-fi-transceiver-modules

RS9116.NB0.NL.GENR.LNX

The driver software is delivered as a tarball with a filename in the format: **RS9116.NXX.NL.GENR.LNX.x.y.z.zip**
Where the naming convention is as follows:

NXX – defines whether the package supports only Wi-Fi (N00) or Bluetooth Classic/Low Energy along with Wi-Fi(NB0).
x.y.z – identifies the software release package version.

The software package contains the following files/folders:

- Readme.txt
- Releasenotes.txt
- Documents
- Binary_files (optional)
- source (optional)

Either of the Binary files or source folders might be empty depending on the request we have sent to Silicon Labs and whether we have signed into a Software License Agreement for the source code.

If the source code has been provided, follow the instructions given below to compile.

3.1 Compilation Procedure

Go to source code path

```
# cd  RS9116.NXX.NL.GENR.LNX.x.y.z/source/host
```

Following are the options available in menuconfig of the driver:

- USB Interface support
- SDIO Interface support
- Operating system: Linux or Android
- Nl80211 support
- HOSTAPD Support
- WIFI
- BLUETOOTH
- ZIGBEE (ZigBee is not supported in current release)

1. To open menuconfig utility, untar the release package, go to source → host folder and enter the given command below

```
# make menuconfig
```

2. Below images explains usage of menuconfig utility. User has to select the required Protocol (Wi-Fi/BT) as per the User's end application.

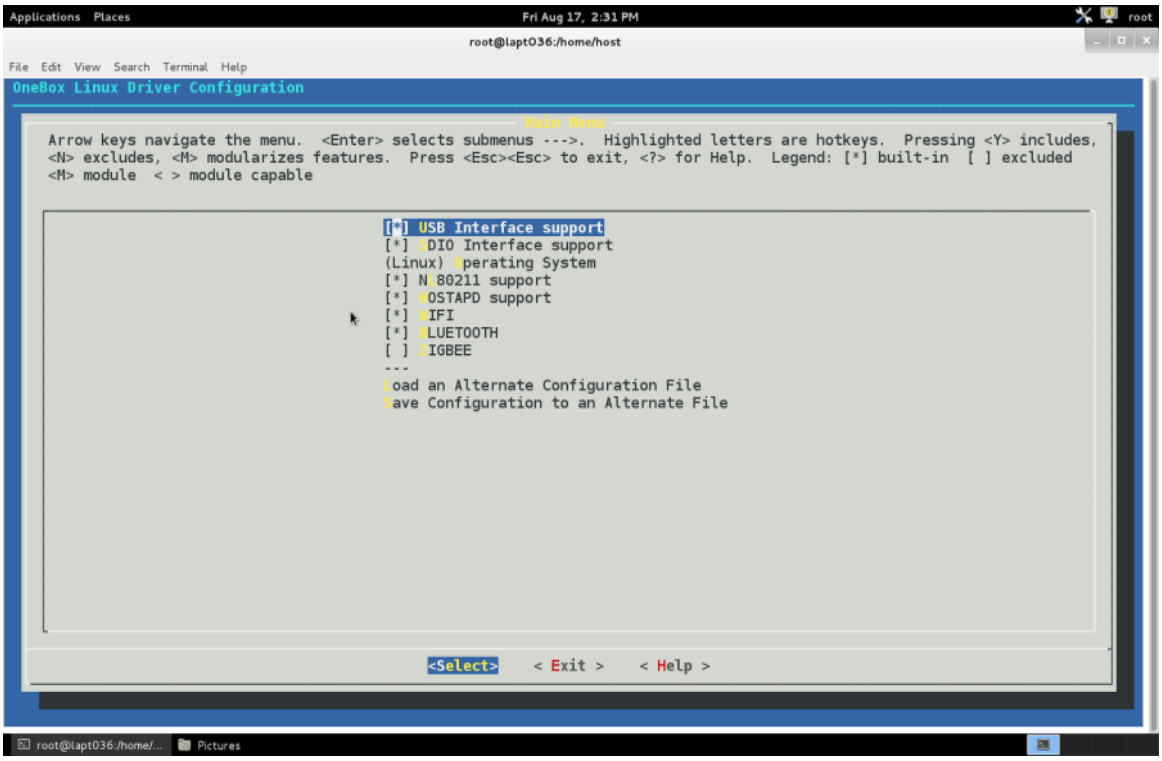


Figure 2: Menuconfig

3. Selecting the support for NL80211 as following

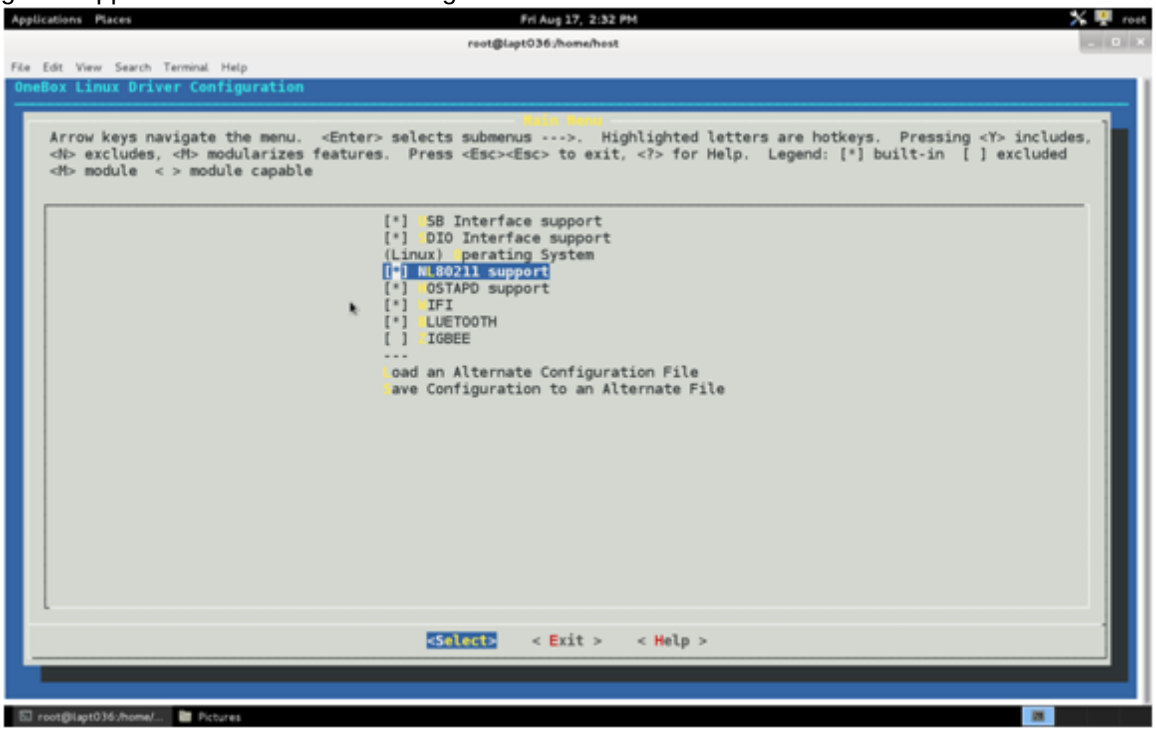


Figure 3: Interface Selection

4. After selecting the configuration, exit the menuconfig and save the configuration. Please refer below image of saving the configuration

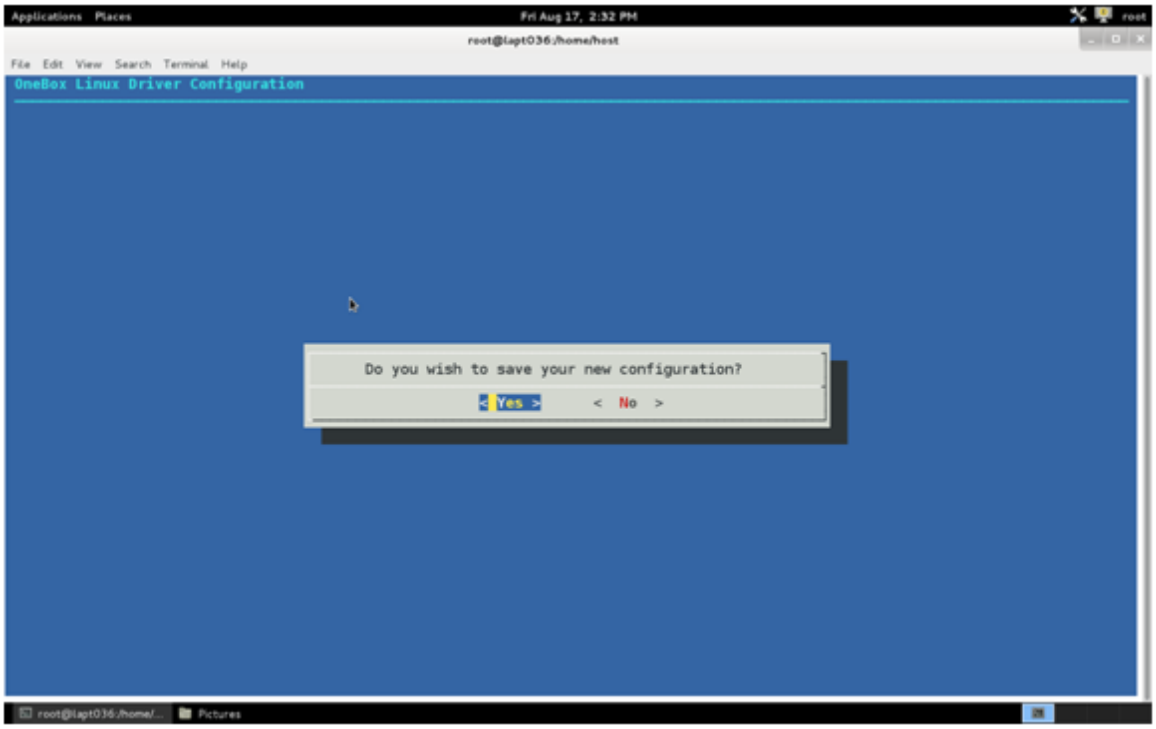


Figure 4: Save Config

5. By default the configuration is enabled with Wi-Fi only. If user wants to compile the driver for a particular protocol, he can enable or disable the desired protocols using menuconfig utility.
6. Now compile the driver using the command below

```
# make clean compile_driver onebox_utils
```

7. Upon successful compilation, you will see a print on the console "Compilation Done Successfully"

4 GUI Usage

1. Install tkinter package for Python using the below command
   - Ubuntu:

```
# sudo apt-get install python-tk
```

   - Fedora: yum install tkinter

```
# sudo yum install tkinter
```

2. Please navigate to the “release” directory in given package.
   Open the common_insert.sh file in the “release” directory using an editor like vim.
   Ensure the below parameters are set as specified:
   DRIVER_MODE=2
   POWER_SAVE_OPTION=0
   STANDBY_ASSOC_CHAIN_SEL=0
   LMAC_BEACON_DROP=0

3. To Start the GUI please enter the following command

```
# python PER_TEST_GUI.py
```

4.1 PER TEST Home

The figure below shows the home page for the PER Tests

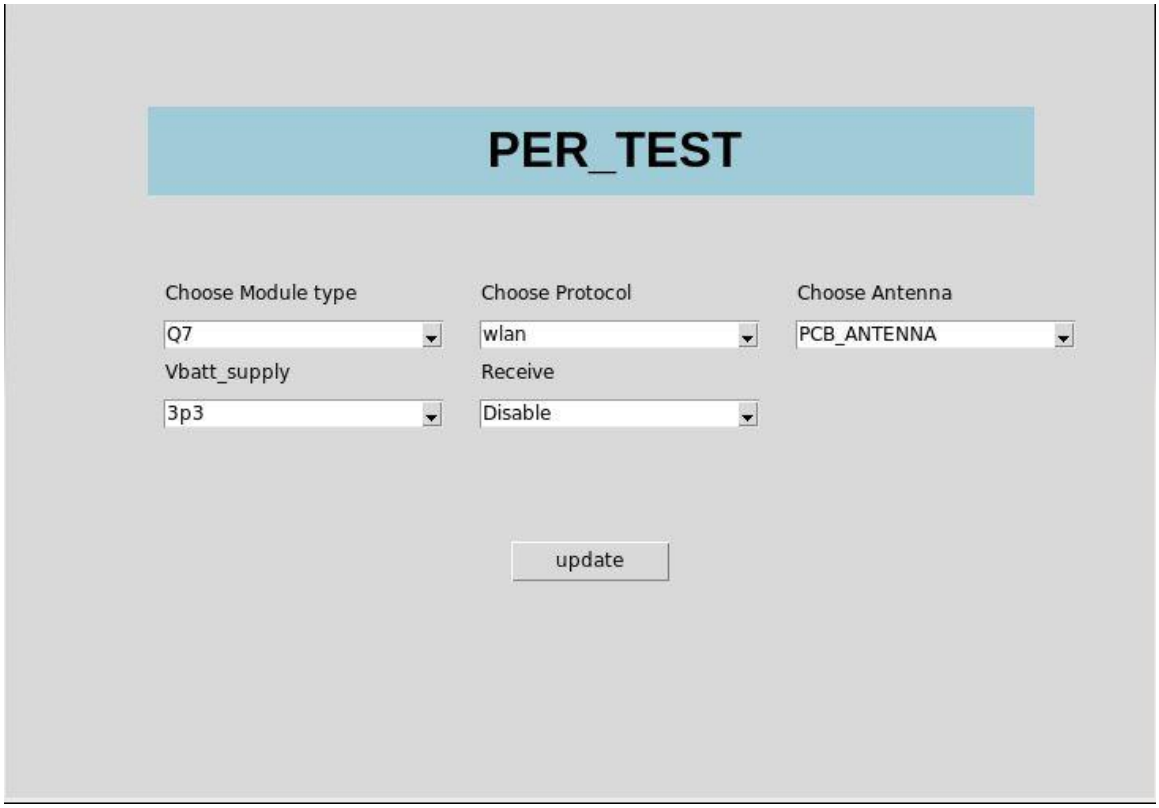


Figure 5: PER_Test Home Page

In the PER_TEST page we can select following options

1. **Choose Module type:** Select type of sample connected via USB port to Linux PC
   a) Q7
   b) M15SB
   c) M7DB
2. **Choose Protocol:** Select the protocol to test
   a) wlan:IEEE 802.11a/b/g/n
   b) bt: BT Core v2.1+EDR
   c) ble: BLE/BLR Core v5.0
3. **Choose Antenna:** Select antenna to which output from chip should be redirected
   a) PCB_ANTENNA: Enables onboard PCB antenna
   b) EXTERNAL_ANTENNA: Enables u.FL port to connect external antenna or Instruments
4. **Vbatt_supply:** Select the sample operating voltage
   a) 3p3
   b) 1p8
5. **Receive:** Select the mode of test
   a) Disable: Transmit test
   b) Enable: Receive test

After selecting the intended options click **update** and wait till driver is loaded and redirects to specific test case page based on selected options.

4.2 WLAN TEST

If the protocol selected in PER_TEST page is <wlan>, the application redirects to WLAN Transmit or Receive page based on the <Receive> option selected in PER_TEST page

4.2.1 WLAN_TX_PER

The figure below shows the WLAN Transmit Test page

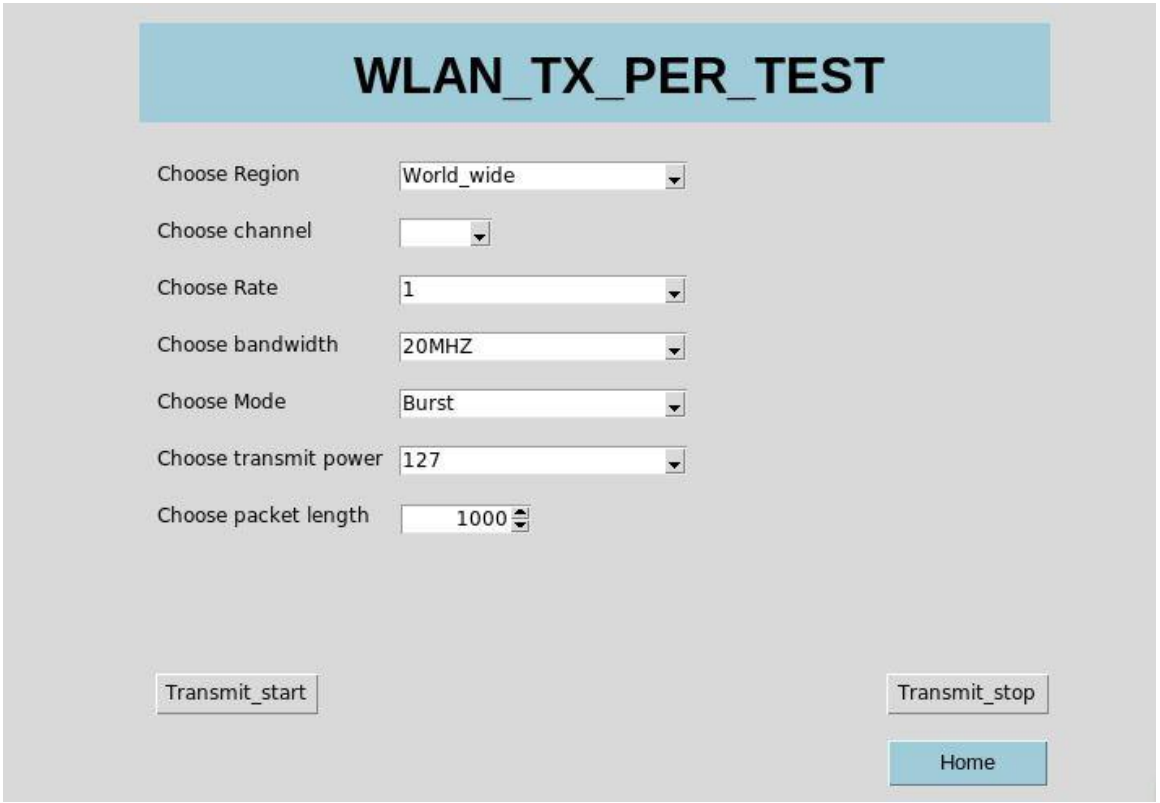


Figure 6: WLAN_TX_PER_TEST Page

In the WLAN_TX_PER_TEST page we can select following options

1. **Choose Region:** Select region of operation
   a) World_wide
   b) FCC(US)
   c) ETSI(Europe)
   d) JP(japan)

2. **Choose channel:** Select the Band for the list of channels available as specified by IEEE 802.11 standard.

The following table maps the channel numbers to the center frequencies for 20MHz and 40MHz bandwidth modes in 2.4 GHz and 5 GHz bands.

Band (GHz)	Bandwidth (MHz)	Channel Number	Center Frequency (MHz)
2.4	20	1	2412
2.4	20	2	2417
2.4	20	3	2422
2.4	20	4	2427
2.4	20	5	2432
2.4	20	6	2437
2.4	20	7	2442
2.4	20	8	2447
2.4	20	9	2452
2.4	20	10	2457
2.4	20	11	2462
2.4	20	12	2467
2.4	20	13	2472
2.4	40	3	2422
2.4	40	4	2427
2.4	40	5	2432
2.4	40	6	2437
2.4	40	7	2442
2.4	40	8	2447
2.4	40	9	2452
2.4	40	10	2457
2.4	40	11	2462
4.9	20	184	4920
4.9	20	188	4940
4.9	20	192	4960
4.9	20	196	4980
5	20	8	5040
5	20	12	5060
5	20	16	5080
5	20	36	5180

5	20	40	5200
5	20	44	5220
5	20	48	5240
5	20	52	5260
5	20	56	5280
5	20	60	5300
5	20	64	5320
5	20	100	5500
5	20	104	5520
5	20	108	5540
5	20	112	5560
5	20	116	5580
5	20	120	5600
5	20	124	5620
5	20	128	5640
5	20	132	5660
5	20	136	5680
5	20	140	5700
5	20	149	5745
5	20	153	5765
5	20	157	5785
5	20	161	5805
5	20	165	5825
5	40	38	5190
5	40	42	5210
5	40	46	5230
5	40	50	5250
5	40	54	5270
5	40	58	5290
5	40	62	5310
5	40	102	5510

5	40	106	5530
5	40	110	5550
5	40	114	5570
5	40	118	5590
5	40	122	5610
5	40	126	5630
5	40	130	5650
5	40	134	5670
5	40	138	5690
5	40	151	5755
5	40	155	5775
5	40	159	5795
5	40	163	5815

Figure 7: WLAN Channel List

3. **Choose Rate:** Select transmission data rate
   a) 1,2,5.5,11: IEEE 802.11b Rates
   b) 6,9,12,18,24,36,48,54: IEEE 802.11a/g Rates
   c) mcs0-mcs7: IEEE 802.11n Rates
4. **Choose bandwidth:** Select transmission bandwidth
   a) 20MHz
   b) 40MHz
5. **Choose Mode:** Select mode of transmission
   a) Continuous: Transmits in a continuous manner
   b) Burst: Transmits in bursts
6. **Choose transmit power:** Select the Tx Output Power in dBm
   a) 0-22: Tx Output Power in dBm
   b) 127: Default(Max Possible) Tx Output Power
7. **Choose packet length:** Length of the packet to be transmitted in bytes
   a) For 802.11b & 802.11a/g Rates, Maximum allowed length is 1536 bytes
   b) For 802.11n Rates, Maximum allowed length is 4096 bytes

4.2.1.1 Tx Start

Once the Transmit settings are configured as above, click on "**Transmit_start**", to start the WLAN transmission.

4.2.1.2 Tx Stop

Click on "**Transmit_stop**" to stop the WLAN transmission.

Note: This has to be done before Tx Start is initiated again

4.2.2 WLAN_RX_PER

The figure below shows the WLAN Receive Test page

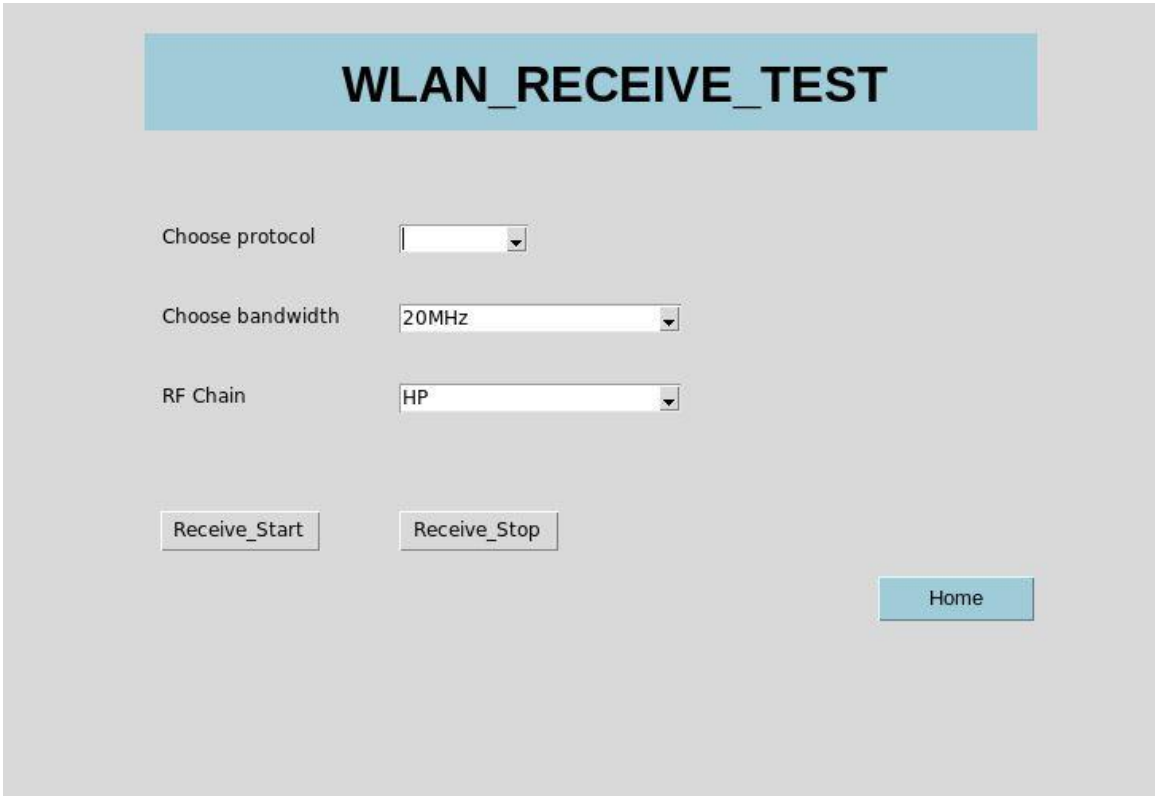


Figure 8: WLAN_RECEIVE_TEST Page

In the WLAN_RECEIVE_TEST page we can select following options:

1. **Choose Protocol:** Select the Band for the list of channels available as specified by IEEE 802.11 standard.

a) WLAN_2G: WLAN - 2.4GHz Band. Channels available are 1-14
b) WLAN_5G: WLAN - 5GHz Band. Channels available are 36-165

2. **Choose bandwidth:** Select transmission bandwidth
   a) 20MHz
   b) 40MHz
3. **RF Chain:** Select receive chain.
   a) HP: Uses HP Chain for reception
   b) LP: Used LP Chain for reception

4.2.2.1 Rx Start

Once the Receive settings are configured as above, click on "**Receive_start**" to start the WLAN reception.

4.2.2.2 Rx Stop

Click on "**Receive_stop**" to stop the WLAN reception.
Note: This has to be done before Rx Start is initiated again

4.3 BT TEST

If the protocol selected in PER_TEST page is <bt>, the application redirects to BT Transmit or Receive page based on the <Receive> option selected in PER_TEST page

4.3.1 BT_TX_PER

The figure below shows the BT Transmit Test page

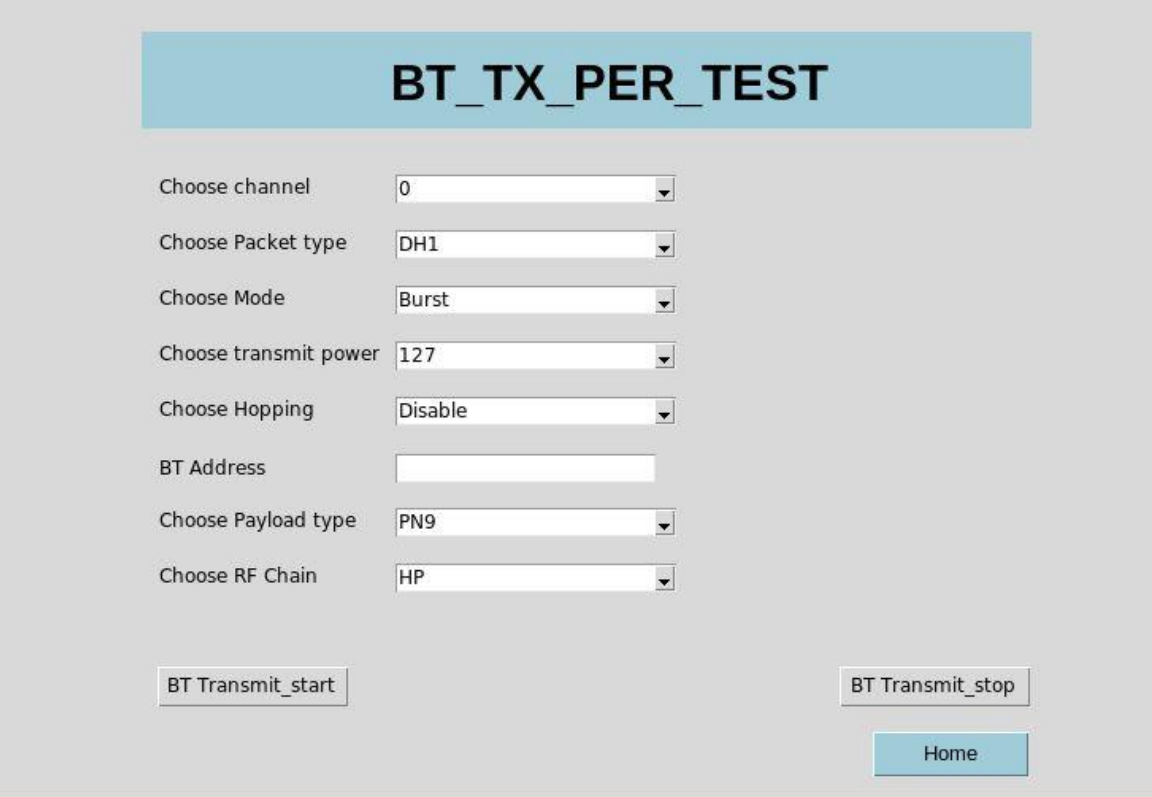


Figure 9: BT_TX_PER_TEST Page

In the BT_TX_PER_TEST page we can select following options

1. **Choose channel:** Select the Channel Index for the BT transmission as per Bluetooth Core v2.1+EDR Standard

a) Channels available are 0-78
2. **Choose Packet type:** Select the type of packet for the transmission as per Bluetooth Core v2.1+EDR Standard
3. **Choose Mode:** Select mode of transmission
   a) Continuous: Transmits in a continuous manner
   b) Burst: Transmits in bursts
4. **Choose transmit power:** Select the Tx Output Power in dBm
   a) 0-22: Tx Output Power in dBm for HP RF Chain
   b) 127: Default Tx Output Power for HP RF Chain
   c) 31: Default Tx Output Power for LP RF Chain
5. **Choose Hopping:** Select the Mode of frequency hopping
   a) Disable: Disables hopping across frequencies
   b) Enable: Enables hopping across fixed frequencies
   c) AFH_Enable: Enables hopping across frequencies provided
6. **BT Address:** Provide the 48-bit Bluetooth Address in hexadecimal format
7. **Choose Payload type:** Select type of the payload to be transmitted
   a) 0x00:
   b) 0xFF:
   c) 0xF0: Used for measuring Modulation Characteristics (Delta F1 Average)
   d) 0x55: Used for measuring Modulation Characteristics (Delta F1 Max, Delta F2 Average, Drift characteristics)
   e) PN9: Used for measuring EVM, Output Power, etc
8. **Choose RF Chain:** Select the RF Chain to be used for the transmission
   a) HP: Uses HP Chain for the transmission
   b) LP: Uses LP Chain for the transmission

4.3.1.1 Tx Start

Once the Transmit settings are configured as above, click on "**BT Transmit_start**" to start the BT transmission.

4.3.1.2 Tx Stop

Click on "**BT Transmit_stop**" to stop the BT transmission.

Note: This has to be done before Tx Start is initiated again

4.3.2 BT_RX_PER

The figure below shows the BT Receive Test page:

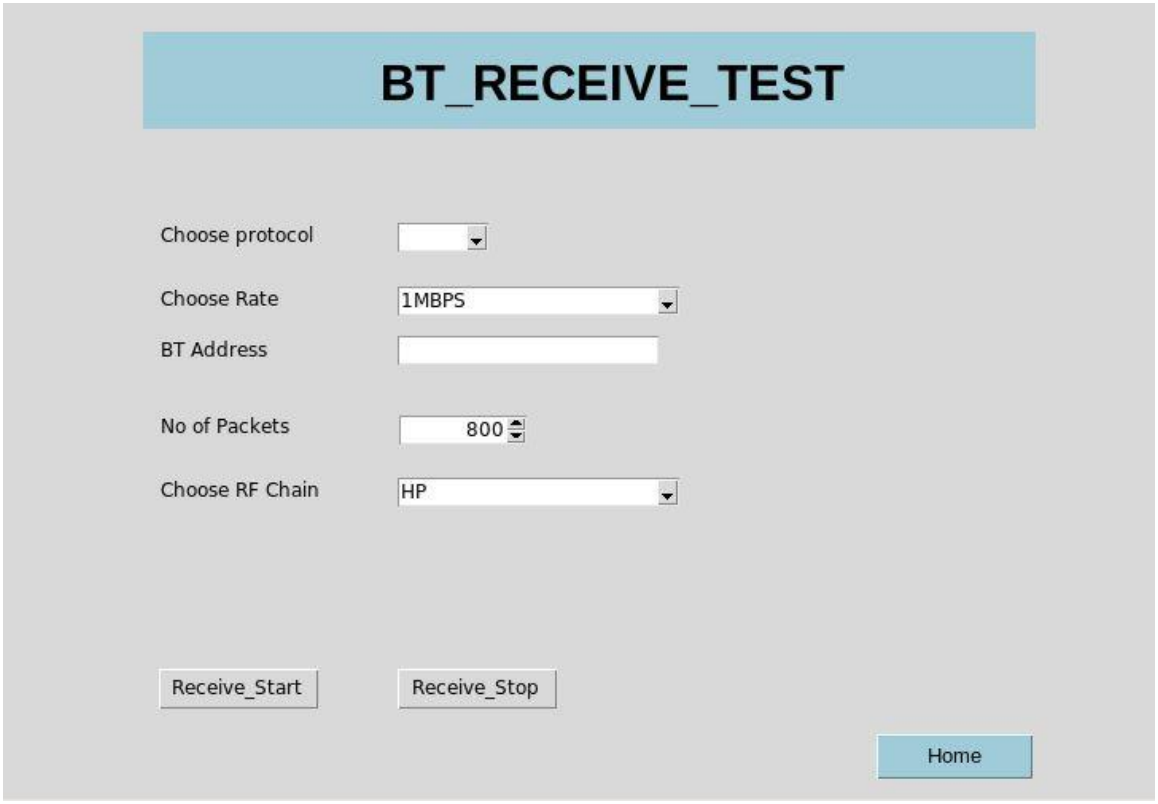


Figure 10: BT_RECEIVE_TEST Page

In the BT_RECEIVE_TEST page we can select following options

1. **Choose protocol:** Select the protocol as BT for the list of channels available as specified by Bluetooth standard
   a) BT: Bluetooth v2.1+EDR. Channels available are 0-78
2. **Choose Rate:** Select the rate of the packet to be received
   a) 1MBPS: Basic Data Rate
   b) 2MBPS/3MBPS: Enhanced Data Rate
3. **BT Address:** Provide the 48-bit Bluetooth Address in hexadecimal format
4. **No of Packets:** Indicates the number of expected packets per second

   Note: This is needed to provide the accurate PER in the Statistics
5. **Choose RF Chain:** Select receive chain.
   a) HP: Uses HP Chain for reception
   b) LP: Uses LP Chain for reception

4.3.2.1 Rx Start

Once the Receive settings are configured as above, click on "**Receive_start**" to start the BT reception.

4.3.2.2 Rx Stop

Click on "**Receive_stop**" to stop the BT reception.
Note: This has to be done before Rx Start is initiated again.

4.4 BLE TEST

If the protocol selected in PER_TEST page is <ble>, the application redirects to BLE Transmit or Receive page based on the <Receive> option selected in PER_TEST page

4.4.1 BLE_TX_PER

The figure below shows the BLE Transmit Test page

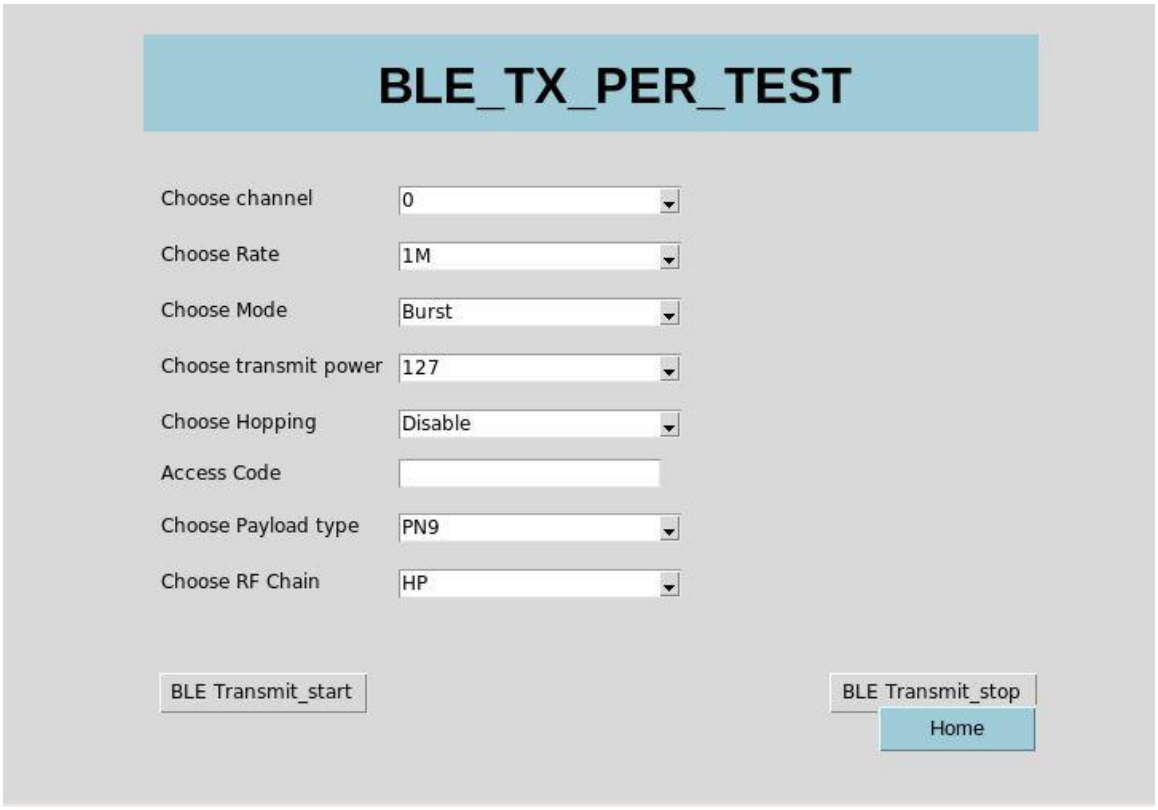


Figure 11: BLE_TX_PER_TEST Page

In the BLE_TX_PER_TEST page we can select following options

1. **Choose channel:** Select the Channel Index for the LE transmission as per Bluetooth Core v5.0 Standard
   a) Channels available are 0-39
2. **Choose Rate:** Select the rate of packet for the transmission as per Bluetooth Core v5.0 Standard
   a) 1M: Enables transmission of BLE-1Mbps
   b) 2M: Enables transmission of BLE-2Mbps
   c) 125K: Enables transmission of BLR-125Kbps
   d) 500K: Enables transmission of BLR-500Kbps
3. **Choose Mode:** Select mode of transmission
   a) Continuous: Transmits in a continuous manner
   b) Burst: Transmits in bursts
4. **Choose transmit power:** Select the Tx Output Power in dBm
   a) 0-22: Tx Output Power in dBm for HP RF Chain
   b) 127: Default Tx Output Power for HP RF Chain
   c) 31: Default Tx Output Power for LP RF Chain
5. **Choose Hopping:** Select the Mode of frequency hopping
   a) Disable: Disables hopping across frequencies
   b) Enable: Enables hopping across fixed frequencies
   c) AFH_Enable: Enables hopping across frequencies provided
6. **Access Code:** Provide the 32-bit Access Code in hexadecimal format.
   Note: The standard Access Code for LE Reference packet is "**71764129**".
   This is used in Direct Test Mode of Bluetooth 5.0 Standard.
7. **Choose Payload type:** Select type of the payload to be transmitted
   a) 0x00:
   b) 0xFF:
   c) 0xF0: Used for measuring Modulation Characteristics (Delta F1 Average)
   d) 0x55: Used for measuring Modulation Characteristics (Delta F1 Max, Delta F2 Average, Drift characteristics)
   e) PN9: Used for measuring EVM, Output Power, etc
8. **Choose RF Chain:** Select the RF Chain to be used for the transmission

a) HP: Uses HP Chain for the transmission
b) LP: Uses LP Chain for the transmission

4.4.1.1 Tx Start

Once the Transmit settings are configured as above, click on "**BLE Transmit_start**" to start the BLE transmission.

4.4.1.2 Tx Stop

Click on "**BLE Transmit_stop**" to stop the BLE transmission.

Note: This has to be done before Tx Start is initiated again

4.4.2 BLE_RX_PER

Then figure below shows the BLE Receive Test page

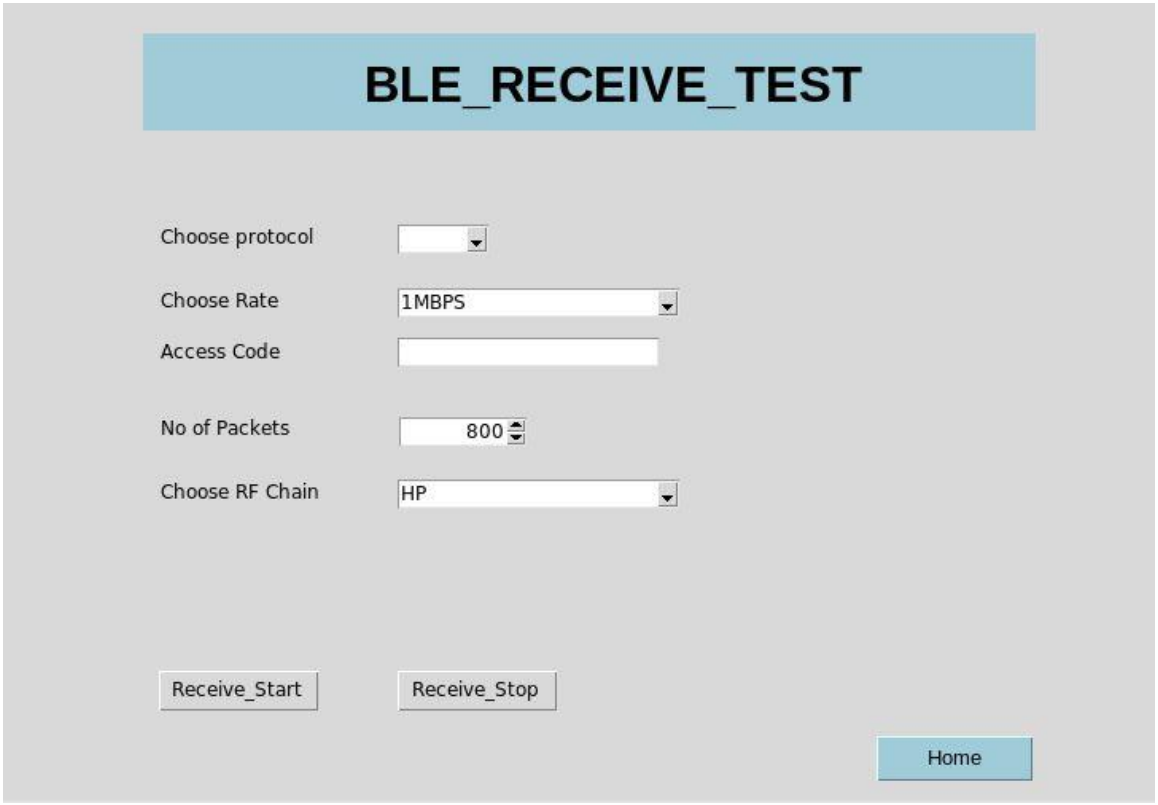


Figure 12: BLE_RECEIVE_TEST Page

In the BLE_RECEIVE_TEST page we can select following options

1. **Choose protocol:** Select the protocol as BT for the list of channels available as specified by Bluetooth standard
   a) BLE: Bluetooth v5.0. Channels available are 0-39
2. **Choose Rate:** Select the rate of the packet to be received
   a) 1MBPS: LE-1Mbps
   b) 2MBPS: LE-2Mbps
   c) 125_500_KBPS: LR
3. **Access Code:** Provide the 32-bit Access Code in hexadecimal format

Note: The standard Access Code for LE Reference packet is "**71764129**". This is used in Direct Test Mode of Bluetooth 5.0 Standard.

4. **No of Packets:** Indicates the number of expected packets per second

Note: This is needed to provide the accurate PER in the Statistics

5. **Choose RF Chain:** Select receive chain.

a) HP: Uses HP Chain for reception
b) LP: Uses LP Chain for reception

4.4.2.1 Rx Start

Once the Receive settings are configured as above, click on "**Receive_start**" to start the BLE reception.

4.4.2.2 Rx Stop

Click on "**Receive_stop**" to stop the BLE reception.

Note: This has to be done before Rx Start is initiated again

5 Appendix A: SDIO Header Pin Description

The following figure describes the pins of SDIO header.

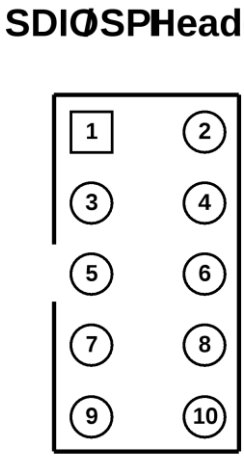


Figure 13: SDIO Header PIN Orientation

SDIO Header Pin Description

The following table describes the pins of SDIO header.

Table 1: SDIO Header Pins

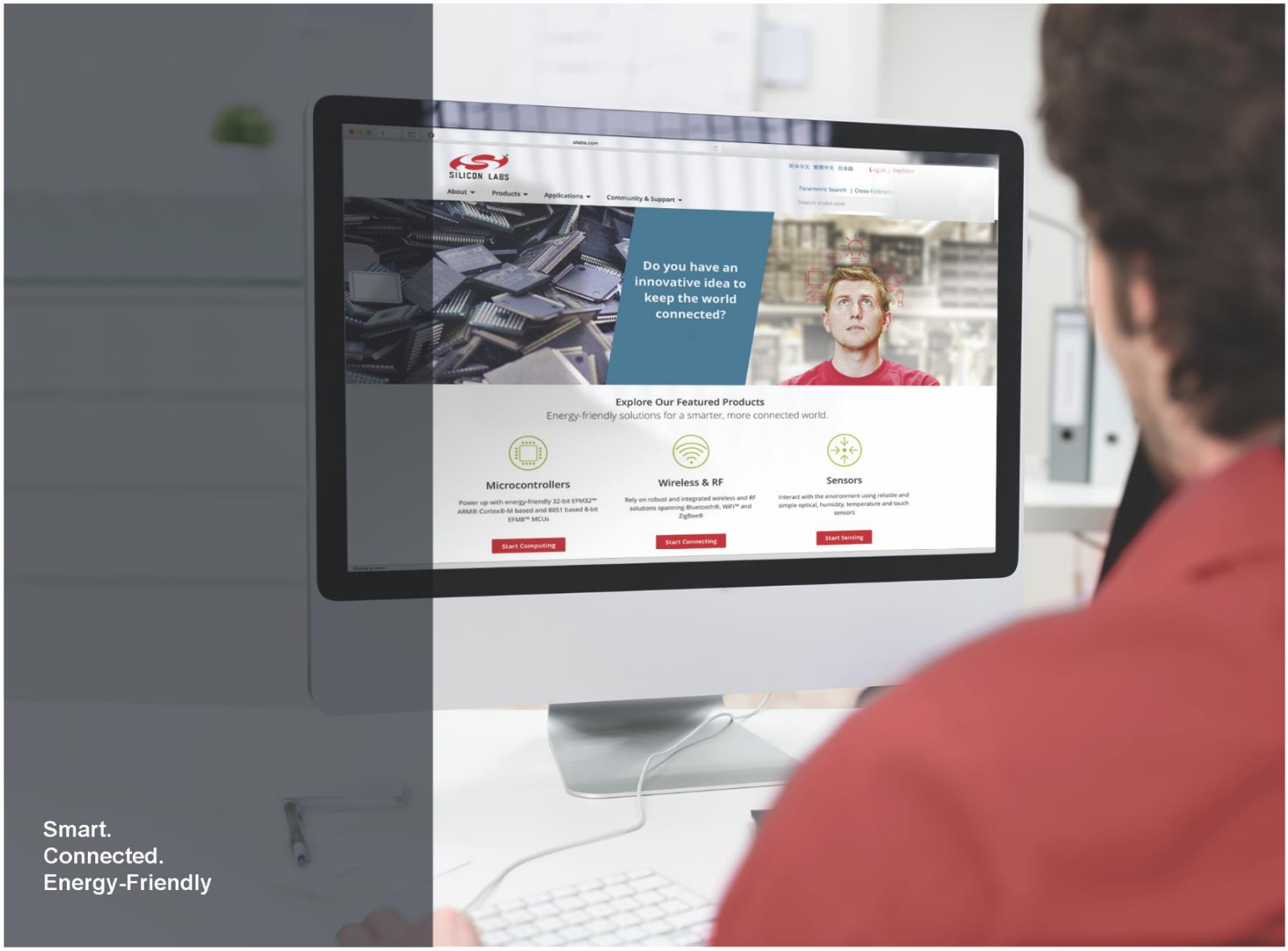
Pin No.	Pin Name	Direction	Description
1	SDIO_DATA3	Input/Output	Data3 of SDIO interface.
2	SDIO_CMD	Input/Output	SDIO Mode: SDIO interface command signal.
3	GND	-	Ground
4	VDD	-	Supply voltage.
5	SDIO_CLK	Input	This signal is SDIO clock.
6	GND	-	Ground
7	SDIO_DATA0	Input/Output	Data0 of SDIO interface.
8	SDIO_DATA1	Input/Output	Data1 of SDIO interface.
9	SDIO_DATA2	Input/Output	Data2 of SDIO interface.
10	NC	-	No Connect

Reset - When the EVB is powered through the USB on "Power" port or through the power on any interface (UART, USB, USB-CDC, SDIO/SPI) than it gets the Power on Reset.
To control the reset there are two methods:
1. Reset Button on baseboard.
2. Host can control the Reset by controlling the pin #2 (RST_PS) on header J9 via GPIO.

Note: Signal Integrity Guidelines for SPI/SDIO interface: Glitches in the SPI/SDIO clock can potentially take the SPI/SDIO interface out of synchronization. The quality and integrity of the clock line needs to be maintained. In case a cable is used for board to board connection, the following steps are recommended (please note that this is not an exhaustive list of guidelines and depending on individual cases additional steps may be needed.):
1. Minimize the length of the SPI/SDIO bus cable to as small as possible, preferably to within an inch or two.
2. Increase the number of ground connections between the EVB and the Host processor PCB.

6 Revision History

Revision No.	Version No.	Date	Changes
1	1.0	Nov 2019	Initial Version
2	1.1	May 2020	Updated with improvements



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