SX-NEWAH-**EVK** Start-UP Guide

<div align="center">INDEX</div>

Introduction

This document is a startup guide that describes how to use the evaluation board "SX-NEWAH-EVK". Follow the instructions below to correctly use SX-NEWAH-EVK.

NOTE: The contents included in this document are subject to change without a prior-notice.

The other documents of SX-NEWAH can be downloaded from our website below.

www.silextechnology.com.

⚠

Safety Instructions

・When using and storing this product, be careful not to give a shock, vibration, load or liquid. Also, avoid a dusty place, and environment where condensation may occur due to temperature changes.

・If this product is malfunctioned due to improper use of the customer (including electrostatic discharge damage), the repair fee will not be free even if the warranty period is valid.

・The warranty policy of this product can be found on the website below.

https://www.silextechnology.com/support/warranty-and-return-policy

For questions regarding this product, please contact our technical support.
support@silexamerica.com (North America)
support@silexeurope.com (Europe)

When it **Absolutely Must** Connect

1. Outline

SX-NEWAH is a wireless LAN module that complies with the 915MHz band standard IEEE 802.11ah. Transmission of over 1 Mbps of 1km wireless distance (*).

By connecting this product to Raspberry Pi, the functions of SX-NEWAH can be used.

(*) The wireless distance and throughput vary depending on your environment.

2. Feature

- ✓ IEEE 802.11ah support
- ✓ NEWRACOM' NRC7292 chipset
- ✓ 1/2/4MHz bandwidth
- ✓ MCS0-7, MCS10 transfer rate (MCS10 can be used only when the bandwidth is 1MHz.)
- ✓ WPA3(SAE/OWE)
- ✓ The wireless setting can be retrieved and configured using a special utility.
- ✓ MHF1 connector installed for external antennas
- ✓ SPI host interface support

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3. Notifications

- ✓ This equipment uses 915MHz band radio.
- ✓ As this product communicates by radio wave, it is strongly recommended to use some security system to prevent unexpected information leakage to others.
- ✓ This product will effect to some other device or be affected by the some other device using the same frequency band. Please investigate the environment to use this product beforehand.
- ✓ Disassembling or modifying the radio module leads to punishment based on radio law.
- ✓ This equipment t has the exposed connectors or some devices. Please be careful for electro static, condensing, and other dusts.
- ✓ In the case using the other wireless devices using same frequency band around this product, please take care below.(See IEEE802.11-2012)
- ✓ The module is possibly interfered when strong signal is input. The other wireless system should be enough far from this product.
- ✓ Input level from the opponent device must be -10dBm or less with including antenna gain.
- ✓ Firmware of this product shall be updated without the advance notice.

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4. Specifications

Evaluation KIT	
Model number	SX-NEWAH-EVK
Wireless module	SX-NEWAH
Operating voltage	5.0V
Dimensions	90mm×80mm×25mm

Wireless LAN Module		
Chipset	NRC7292	
Wireless LAN standard	IEEE 802.11ah	
Wireless mode	AP, STA	
Frequency (*1)	1MHz	903.5, 904.5, 905.5, 906.5, 907.5, 908.5, 909.5, 910.5, 911.5, 912.5, 913.5, 914.5, 915.5, 916.5, 917.5, 918.5, 919.5, 920.5, 921.5, 922.5, 923.5, 924.5, 925.5(*2), 926.5(*2)
	2MHz	905, 907, 909, 911, 913, 915, 917, 919, 921, 923, 925
	4Mhz	910, 914, 918, 922
Modulation	OFDM	
Transmission rate (MCS)	MCS0-7, MCS10 (MCS10 can be used **only when the bandwidth is 1MHz**.)	
Transmission rate (Kbps)	150Kbps - 15Mbps	
Encryption method	WPA2-PSK, WPA3 (SAE/OWE)	
Antenna connector	MHF1 connector x 1	
Host interface	SPI	
Operating voltage	VDD33: 3.3V VDDFEM: 3.3V or 4.0V	
Consumption current (peak value)	Transmission: VDD33 98mA, VDDFEM 570mA Reception: VDD33 55mA, VDDFEM 28mA	
Operating conditions	Temperature: -40°C to 85°C Humidity: 15 to 95%RH (no condensing)	
Storage conditions	Temperature: -40°C to 85°C Humidity: 15 to 95%RH (no condensing)	
Dimensions	20.5mm×27.0mm×3.1mm	
Weight	3.0g	
Connector type	68 pin Surface mount	
Certification standard	US(FCC), Canada (IC)	

*1 This product can be used in US and Canada only.

*2 When AP mode, STA can connect to AP about 60 seconds after AP starts.

When it **Absolutely Must** Connect

5. Before You Begin

5.1. SX-NEWAH-EVK Package Contents

☐SX-NEWAH-EVK (SX-NEWAH (IEEE 802.11ah wireless module) is installed）

☐Antenna for SX-NEWAH

☐AC adaptor for SX-NEWAH-EVK

☐Raspberry Pi 3 Model B (hereinafter, "Raspberry Pi")

☐AC adaptor for Raspberry Pi (5V/3A or higher)

　- Recommended for the radio to operate properly in accordance to the module specification

☐Micro SD card (8GB or higher・UHS-I / Class 10 or higher)

5.2. Necessary Items

The following items are necessary to use SX-NEWAH-EVK:

Hardware:

☐PC (Windows 10 or higher is recommended)

　(Optional. Please prepare as necessary.)

☐Ethernet cable

☐HDMI compatible monitor

☐HDMI cable

☐USB keyboard／mouse

☐micro SD card reader/writer

Software:

☐Terminal software (e.g. Tera Term, etc.)

➢ In this document, Tera Term (Version 4.102) is used.

☐Software to write an SD card image (e.g. Win32 Disk Imager, etc.)

➢ In this document, Win32 Disk Imager (Version 1.0) is used.

(Refer to 7.2.2 for how to write an image using this software.)

* To use Raspberry Pi with other devices (e.g. sensor, etc.), prepare the necessary items for it.

* This product uses the 920MHz. Recommend that prepare two of EVK in total for AP and STA mode.

6. EVK Composition

● Outline
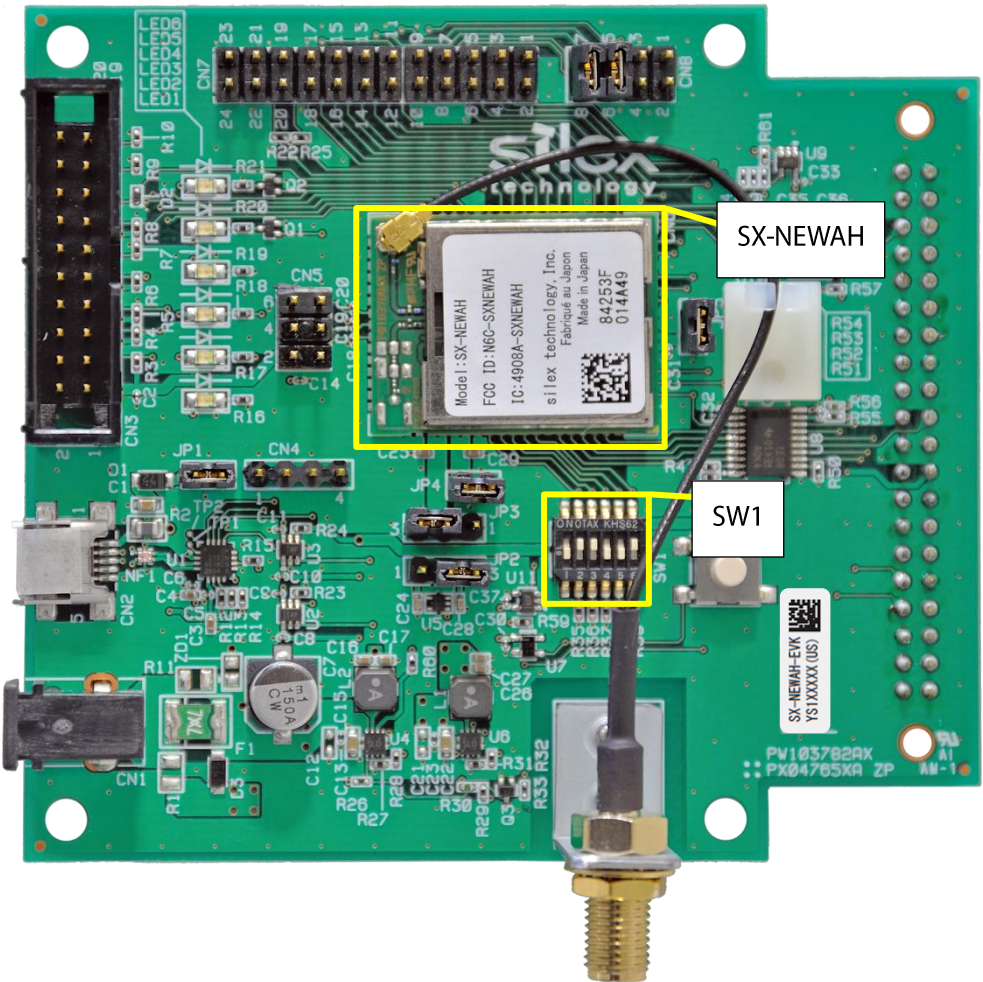
Name	Description
SX-NEWAH	Wireless module
SW1	DIP Switch for mode change

When it **Absolutely Must** Connect

7. Environment Setup

7.1. Hardware

7.1.1. DIP Switch Setting

● Before turning on SX-NEWAH-EVK, turn on/off the SW1 according to the below image.

1	2	3	4	5	6
OFF	ON	OFF	OFF	OFF	ON

7.1.2. How to Connect SX-NEWAH-EVK and Raspberry Pi

(1) Connect SX-NEWAH-EVK and Raspberry Pi according to the image below.

(2) Connect the antenna of SX-NEWAH to the SMA connector.

(3) Connect the AC adaptor of SX-NEWAH-EVK to the power connector.

(4) Connect the AC adaptor of Raspberry Pi.
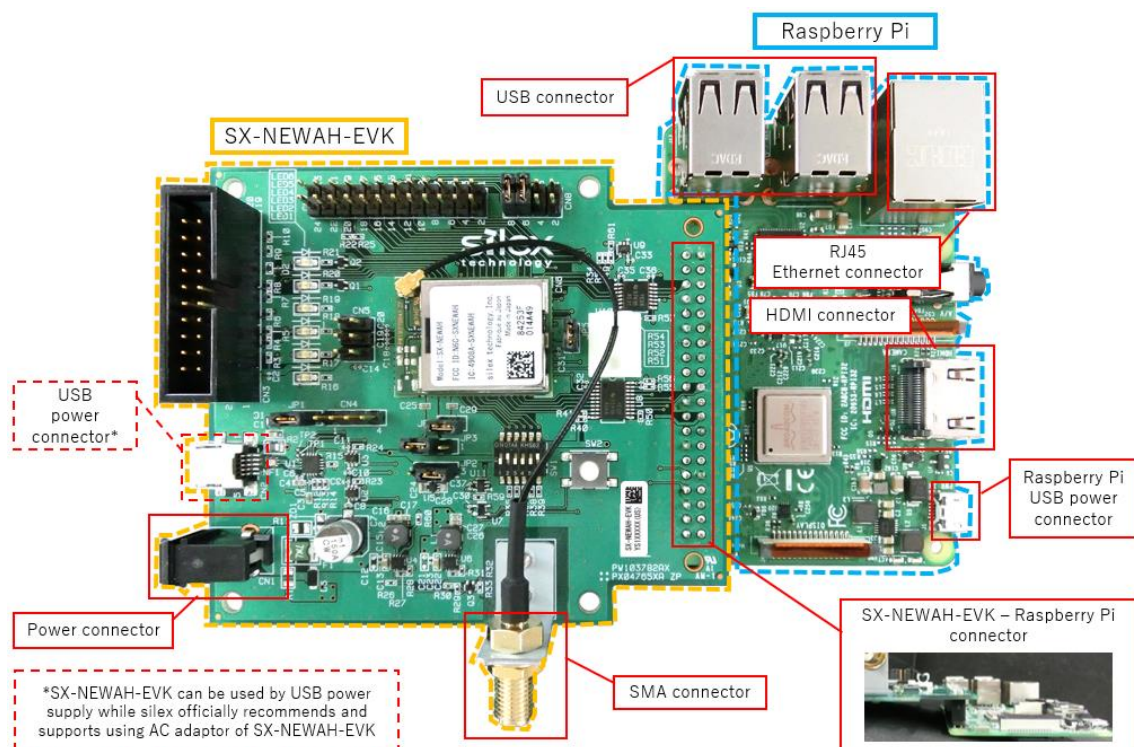
7.2. Software

7.2.1. Getting Started

Before turning on SX-NEWAH-EVK, prepare a micro SD card to which an OS image is written.

To use SX-NEWAH-EVK via SSH, install the terminal software on your PC.

In this document, Tera Term is used as an example.

7.2.2. How to Write an Image to Micro SD Card

Following explains how to write an image using Win32 Disk Imager to the Windows environment.

Download Win32 Disk Imager from the URL below.

https://sourceforge.net/projects/win32diskimager/

Execute the installer you have downloaded, and install it according to the instructions.

When the installation is completed, insert the micro SD card into your PC (when your PC does not support direct connection of a micro SD card, use a micro SD card reader).

(1) When the Win32 Disk Imager is started, the below window will appear.
Click the pull-down menu to select the drive to write the image into.
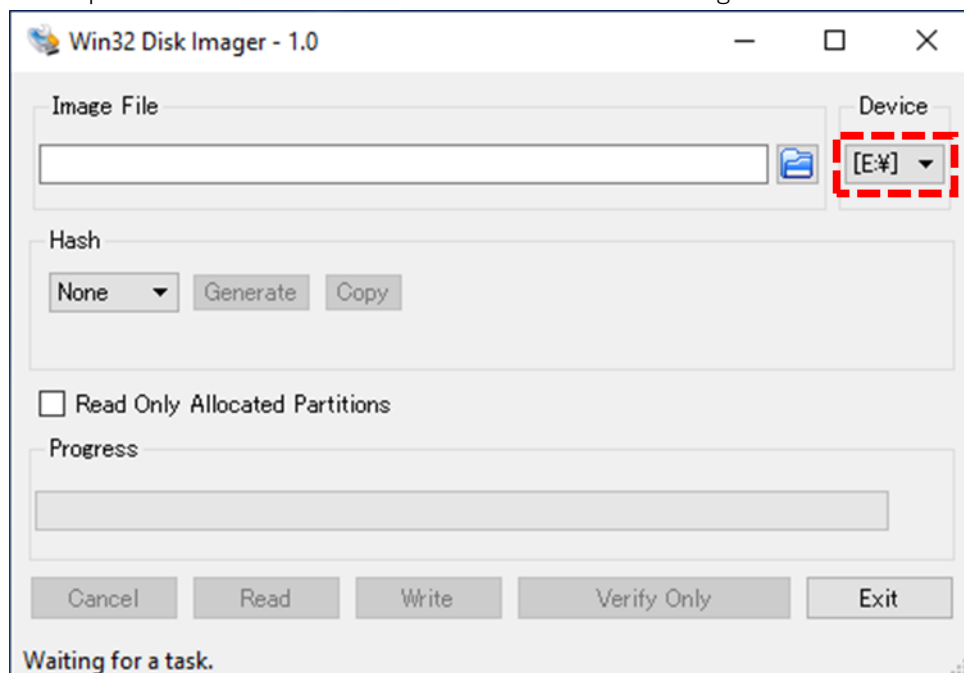
(2) Click the button to show the file selection window.
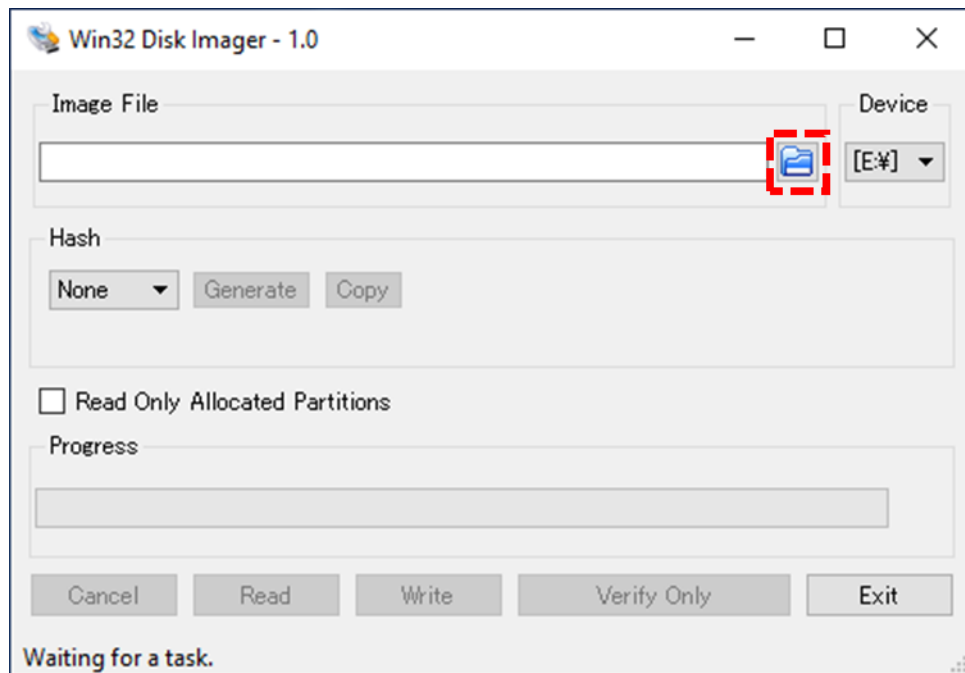
(3) Select the image file to write.

* The file name will vary depending on the version.
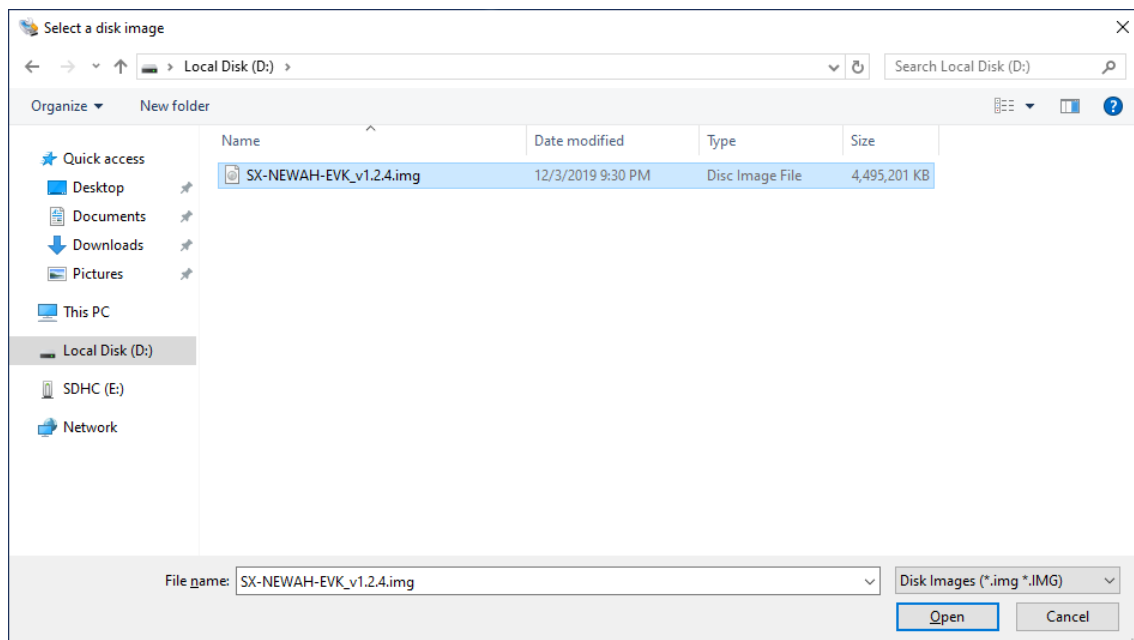
(4) Select the image to write and then click "Write".
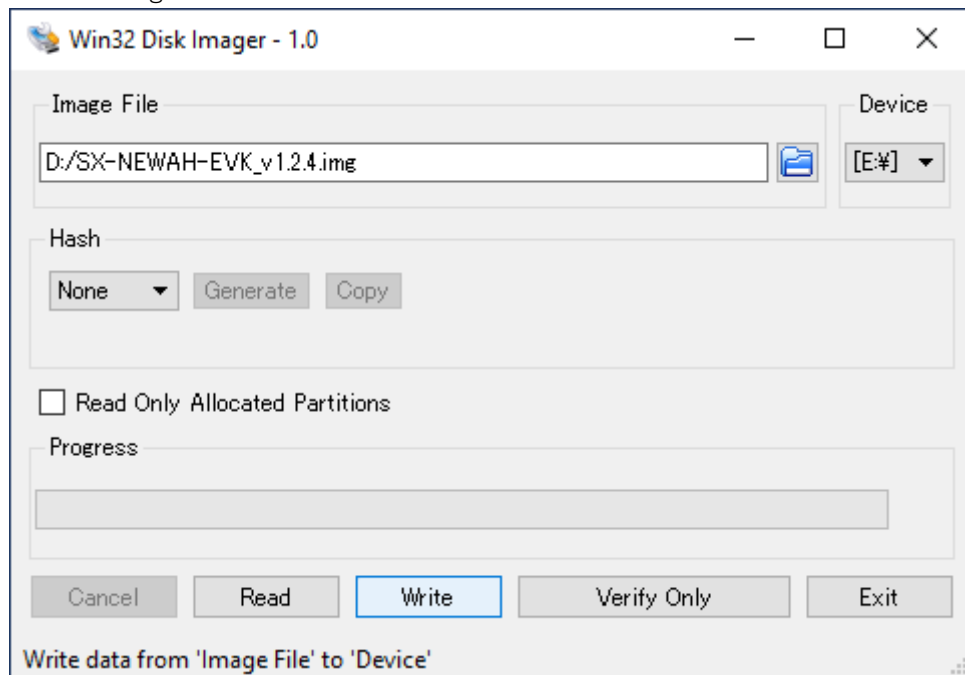
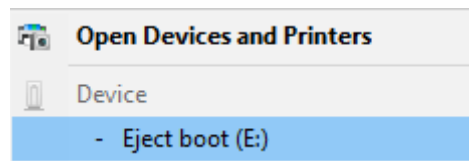(5) When the confirmation message appears, check the drive and click "Yes".
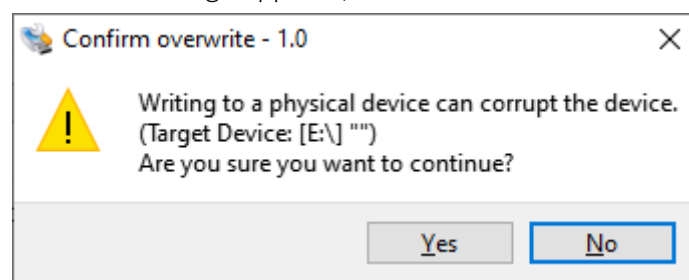
(6) When the write process is completed successfully, the message below appears. Click "OK".
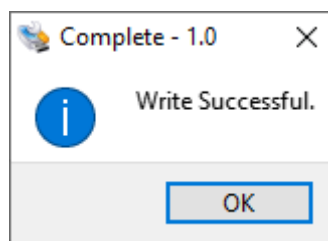
(7) Click "Exit".
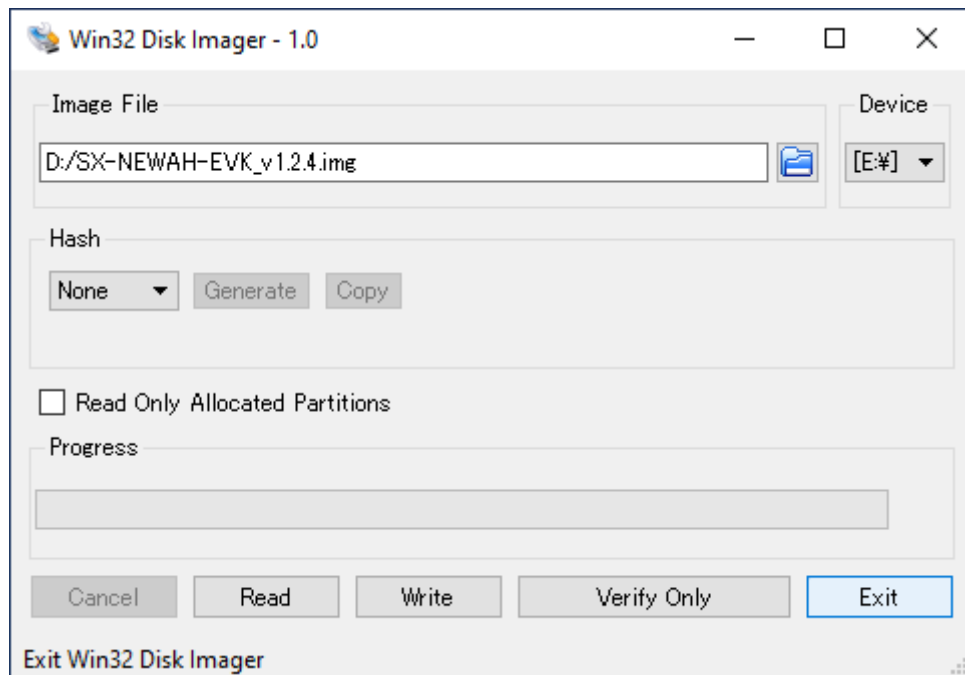
(8) Remove a micro SD card from the PC.
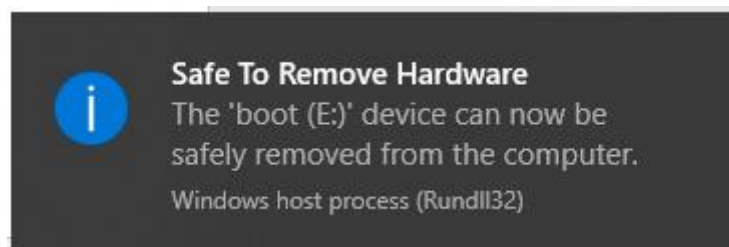

(9) Insert the micro SD card to Raspberry Pi.

When it **Absolutely Must** Connect

8. Device Connection

There are two methods for console connection; one is the connection using HDMI(GUI) of Raspberry Pi, and the other is the connection using a network access (SSH) from a PC.

8.1. When GUI is Used

Connect a monitor, mouse and keyboard to Raspberry Pi.
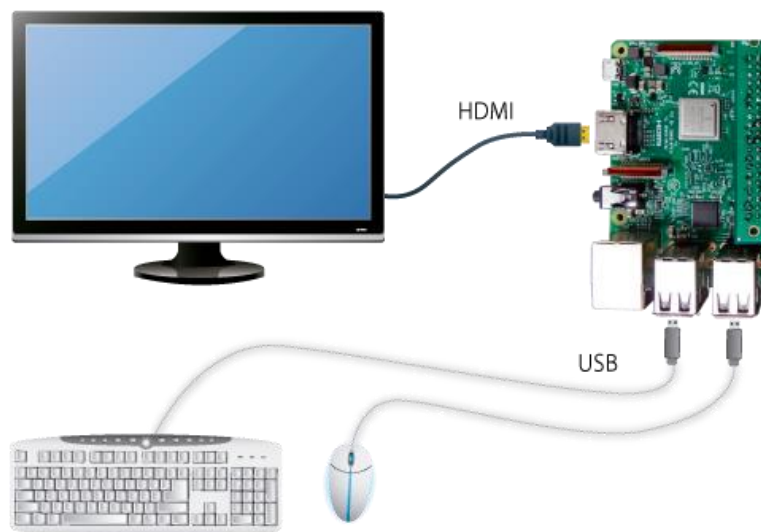
(1) When Raspberry Pi is turned on, the login performs automatically and the desktop screen appears.

When it **Absolutely Must** Connect
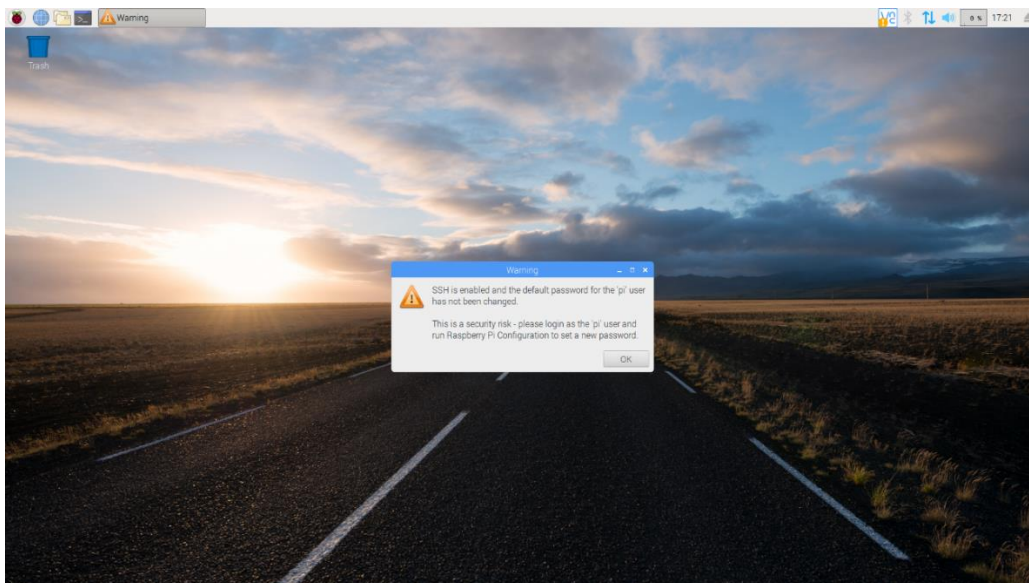
(2) Start Terminal (LXTerminal) from the menu.

When it **Absolutely Must** Connect
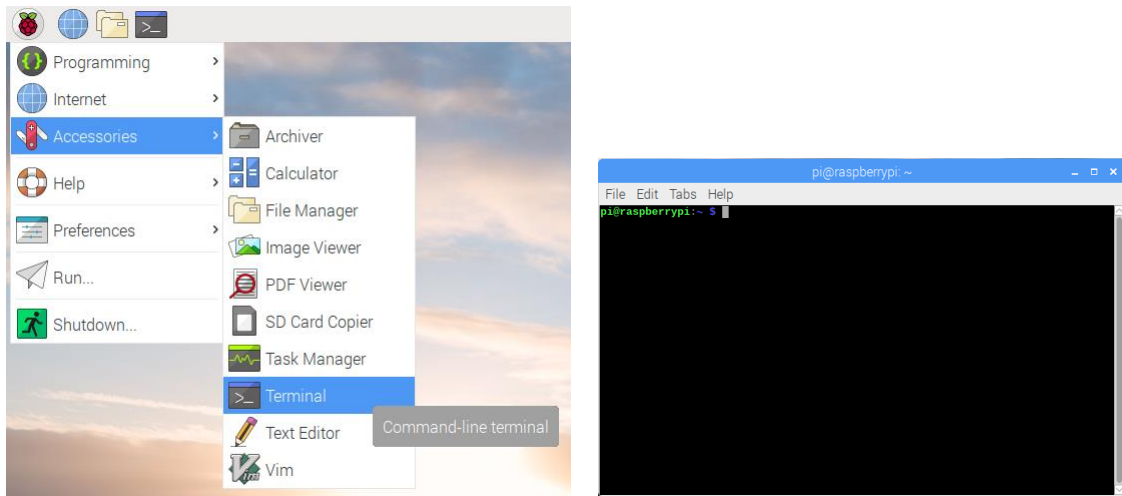
8.2. When SSH is Used

* It is necessary to set the static IP address of the wired LAN adaptor of the PC to the same segment as the Raspberry Pi.

Setting example:

        IP address: 192.168.0.1

        Subnet mask: 255.255.255.0

Connect a PC and Raspberry Pi using an Ethernet cable.
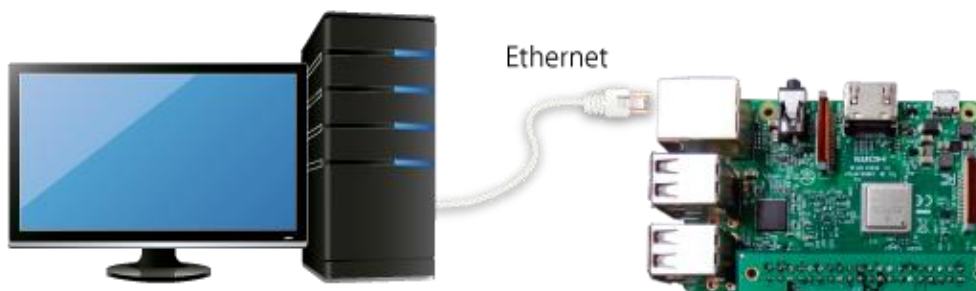
(1) Start the terminal software.

(2) Enter "192.168.0.10" for the host and "22" for the TCP port#.

(3) Select "SSH" for Service, and click "OK".

When it **Absolutely Must** Connect
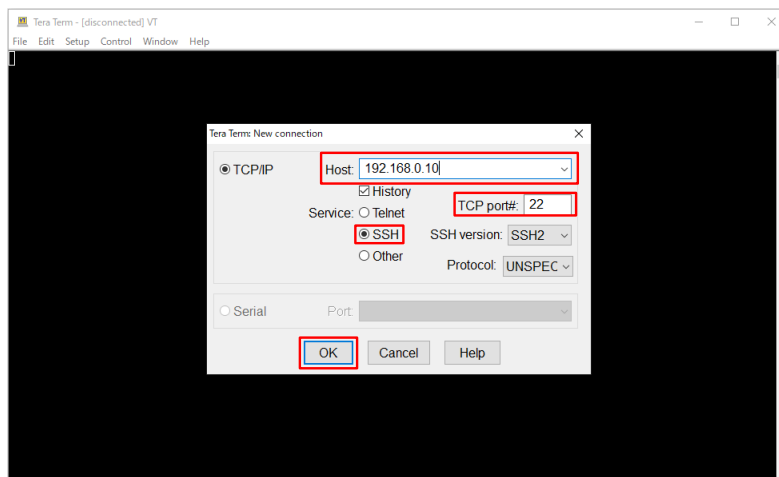
(4) If the below window is displayed, click "Continue"
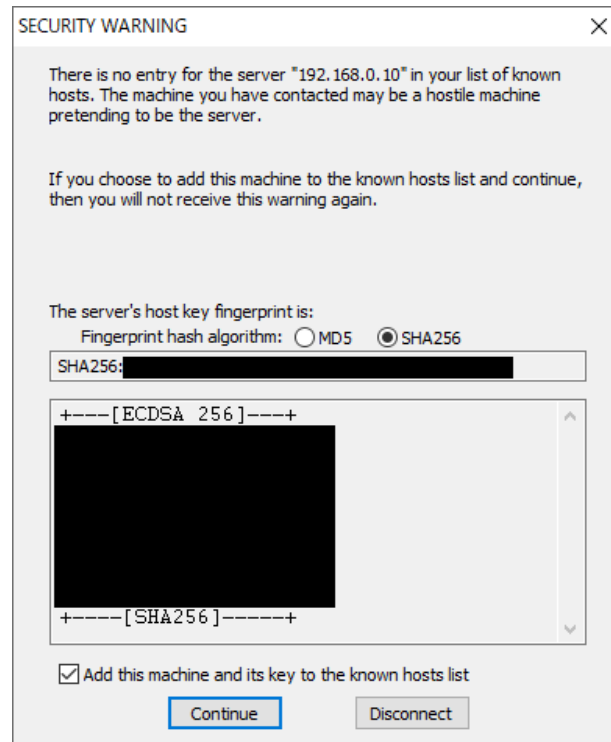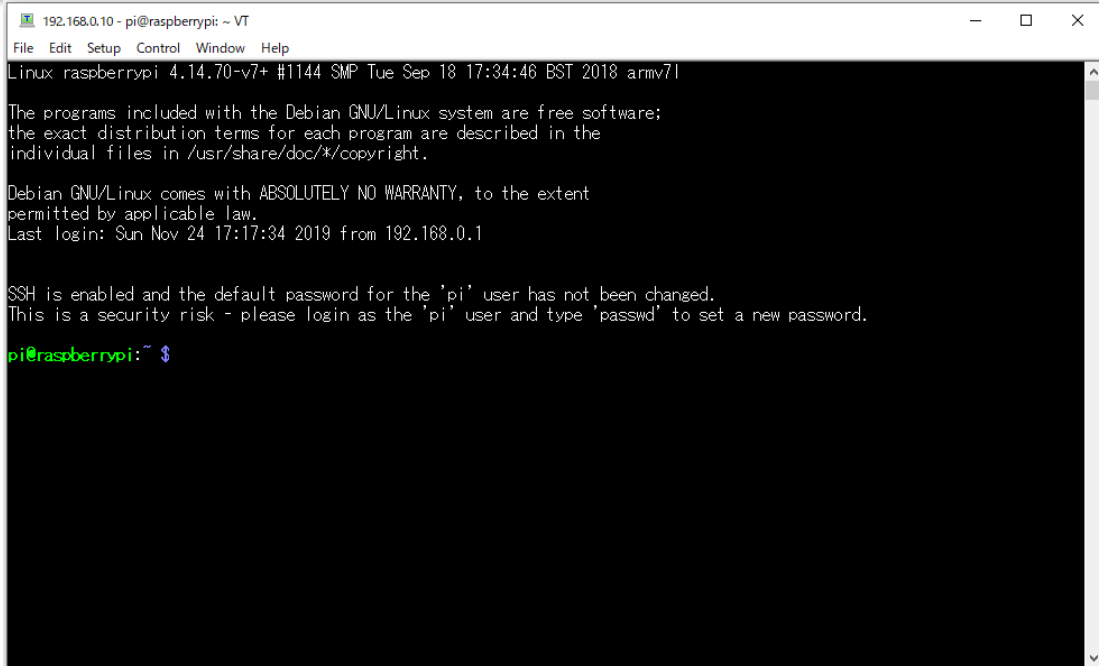
(5) Enter "User name" and "Passphrase" and click "OK".

➢ User name   : pi

➢ Passphrase   : raspberry
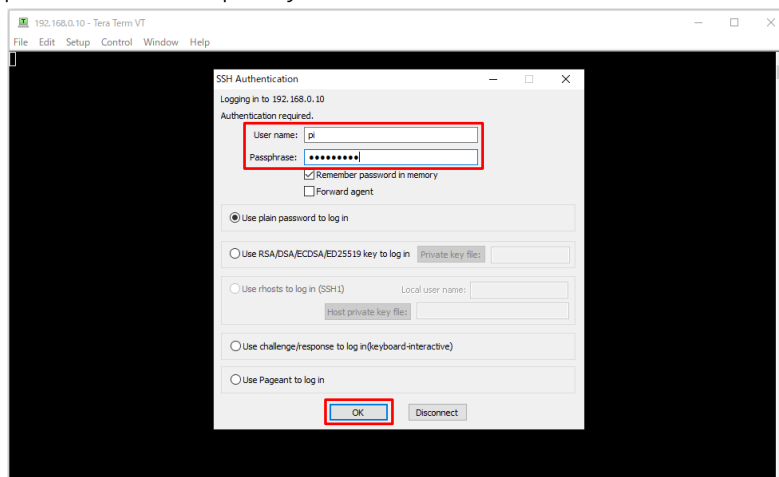
(6) When the below screen appears, the login is completed.

```
192.168.0.10 - pi@raspberrypi: ~ VT                                    —    □    ×
File  Edit  Setup  Control  Window  Help
Linux raspberrypi 4.14.70-v7+ #1144 SMP Tue Sep 18 17:34:46 BST 2018 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sun Nov 24 17:17:34 2019 from 192.168.0.1


SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $
```
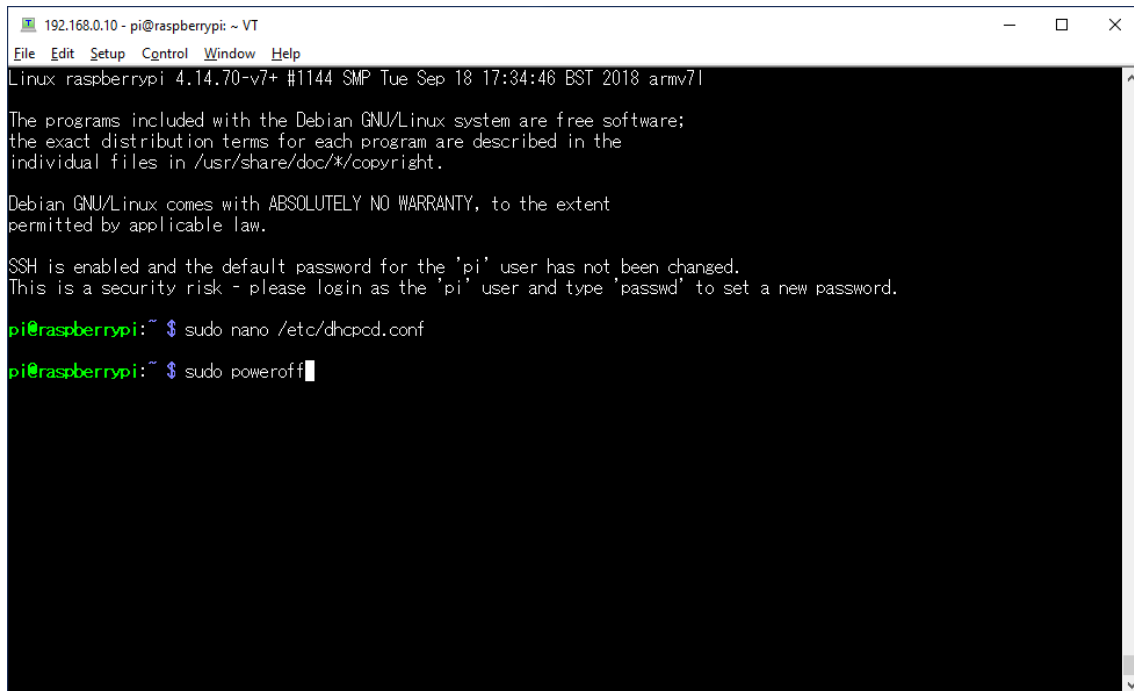
9. Wireless Communication Check

Following explains how to check IP communication for a wireless connection after SX-NEWAH-EVK is turned on in AP/STA mode.

* Before using this product, make sure that a specific low-power radio station is not operating nearby. If a specific low-power radio station is operated, interference may occur.

Necessary Items

Prepare two SX-NEWAH-EVK units to which the configuration has been made according to Chapter 7. For the IP address of eth0 (Ethernet I/F) of Raspberry Pi, configure the appropriate one.

* For the IP address configuration method, refer to "11.2 How to Change IP Address of Raspberry Pi's eth0 (Ethernet I/F)".

9.1. Sample Connection

Ethernet

PC
Tera Term
192.168.0.1

SX-NEWAH-EVK
(STA mode)
eth0:192.168.0.20
wlan0:192.168.200.2

SX-NEWAH-EVK
(AP mode)
eth0:192.168.0.10
wlan0:192.168.200.1
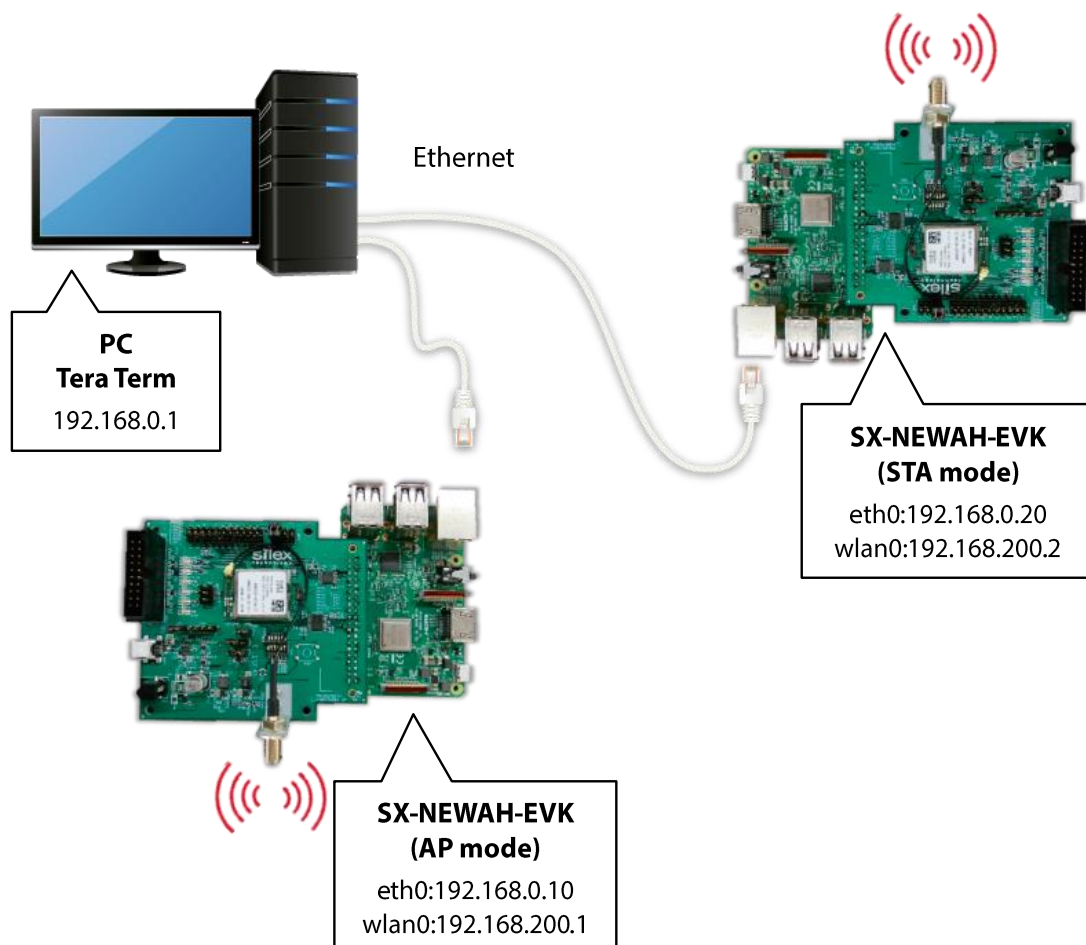
9.2.   How to Start in AP Mode

● Sample command to start in AP mode

①	sudo insmod /lib/modules/$(uname -r)/nrc.ko fw_name=nrc7292_cspi.bin hifspeed=16000000
②	sudo ifconfig wlan0 up
③	cli_app set txpwr 23
④	cli_app set maxagg 1 8
⑤	cli_app set gi short
⑥	sudo hostapd -B ~/sx-newah/conf/US/ap_halow_sae.conf
⑦	sudo ifconfig wlan0 192.168.200.1

● Explanations of commands and parameters above

(For details, refer to "Driver Load Parameter" and "Command List" of the specification document[SC111270].)

① Driver load

* Be sure to wait for 5 or more seconds before starting ② after finishing ①.

② Active a wireless interface

③ Tx power setting

Command	txpwr <value>	
Command sample	set txpwr 23	
Command argument	value	1-30(1dB step)
Default value	10	

④ Maximum aggregation size

Command	maxagg <ac> <max num> {size}	
Command sample	set maxagg 0 8	
Command argument	ac	Access Category 0:BK, 1:BE, 2:VI, 3:VO
	max_num (*)	1-13: Aggregation size 0: Aggregation disabled
	Size	Data size threshold for aggregation (option) (*) 0 is set when not specified. (*) The data frame is aggregated when the total size of the MAC layer is larger than the threshold. When 0 is set, all data frames are aggregated.
Default value	Aggregation is disabled for all access categories.	
Note	* Set the aggregation size 8 or lower, or otherwise, the communication becomes unstable.	

⑤ Guard interval

Command	gi <short|long|auto>	
Command sample	set gi short	
Command argument	short	Fixed to Short Guard Interval
	long	Fixed to Long Guard Interval
	auto	Short/Long Guard Interval switches automatically according to the wireless environment. * This setting is valid only when the station mode is on.
Default value	long	

When it **Absolutely Must** Connect

⑥ Hostapd start

⑦ IP address configuration for a wireless interface

9.3. How to Start in STA Mode

● Sample Command to Start in STA Mode

①	sudo insmod /lib/modules/$(uname -r)/nrc.ko fw_name=nrc7292_cspi.bin hifspeed=16000000
②	sudo ifconfig wlan0 up
③	cli_app set txpwr 23s
④	cli_app set maxagg 1 8
⑤	cli_app set gi short
⑥	sudo wpa_supplicant -i wlan0 -D nl80211 -B -c ~/sx-newah/conf/US/sta_halow_sae.conf
⑦	sudo ifconfig wlan0 192.168.200.2

● Explanations of commands and parameters above

(For details, refer to "Driver Load Parameter" and "Command List" of the specification document[SC111270].)

① Driver load

* Be sure to wait for 5 or more seconds before starting ② after finishing ①.

② Active a wireless interface

③ Tx power setting (The configuration method and the specification are the same as AP mode.)

④ Maximum Aggregation size (The configuration method and the specification are the same as AP mode.)

⑤ Guard interval (The configuration method and the specification are the same as AP mode.)

⑥ wpa_supplicant start

* When "wpa_state=COMPLETED" is displayed after "sudo wpa_cli -i wlan0 status" is executed, AP connection is completed.

⑦ IP address configuration for a wireless interface

When it **Absolutely Must** Connect

9.4. Communication Check Using Ping Command

For a wireless connection between the units operating in AP/STA mode, communication can be checked using the ping command.

- Sample Ping command (when the ping command is executed from the AP-mode unit to the STA-mode unit)

①	ping 192.168.200.2 -c 100 -i 0.2 -s 100

Explanations of parameters in the above sample command

Parameters	Meaning
192.168.200.2	Specify the destination IP address to communicate with. In the sample command, the destination is set to 192.168.200.2.
-c 100	Specify the number of ping communications. In the sample command, it is set to 100 times.
-i 0.2	Specify the interval of ping communication (second). In the sample command, it is set to 0.2 sec.
-s 100	Specify the ping data size (byte). In the sample command, it is set to 100Byte.

When the result of packet loss is 0% as shown below after the ping command is executed, the communication is successfully completed.

9.5. Speed Check Using iperf Command

For a wireless connection between the units operating in AP/STA mode, communication speed can be checked using the iperf command.

- Sample iperf command (UDP communication)
  - Start the AP-mode unit as a server of iperf

①	iperf -s -u -i 10

Explanations of parameters in the above sample command

Parameters	Meaning
-s	Start iperf as a server. In the sample command, the AP mode unit is used as a server.
-u	Specify that the iperf communication runs in UDP.
-i 10	Specify the interval to display the result of iperf throughput (seconds). In the sample command, the interval is set to 10 sec.

  - Start the STA-mode unit as a client of iperf (do it after the server is started)

①	iperf -c 192.168.200.1 -u -b 50M -i 10 -t 60

Explanations of parameters in the above sample command

Parameters	Meaning
-c 192.168.200.1	Start iperf as a client and specify the IP address of the server. In the sample command, "192.168.200.1" is set for the server.
-u	Specify that the iperf communication runs in UDP.
-b 50M	Specify the bandwidth for data transmission (bps). In the sample command, it is set to 50Mbps.
-i 10	Specify the interval to display the result of iperf throughput (seconds). In the sample command, the interval is set to 10 sec.
-t 60	Specify the data transmission period (seconds). In the sample command, the data transmission period is set to 60 sec.

The communication performs correctly if the result of the command is output from the server as shown below, after the client unit is turned on and the specified period (the period specified by 't' option) has elapsed.

```
pi@raspberrypi:~$ iperf -c 192.168.200.1 -u -b 50M -i 10 -t 60
------------------------------------------------------------
Client connecting to 192.168.200.1, UDP port 5001
Sending 1470 byte datagrams, IPG target: 235.20 us (kalman adjust)
UDP buffer size:  160 KByte (default)
------------------------------------------------------------
[  3] local 192.168.200.2 port 56398 connected with 192.168.200.1 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec  10.9 MBytes  9.16 Mbits/sec
[  3] 10.0-20.0 sec  11.2 MBytes  9.43 Mbits/sec
[  3] 20.0-30.0 sec  11.2 MBytes  9.41 Mbits/sec
[  3] 30.0-40.0 sec  11.2 MBytes  9.37 Mbits/sec
[  3] 40.0-50.0 sec  11.3 MBytes  9.51 Mbits/sec
[  3] 50.0-60.0 sec  11.0 MBytes  9.23 Mbits/sec
[  3]  0.0-60.0 sec  66.9 MBytes  9.35 Mbits/sec
[  3] Sent 47712 datagrams
[  3] Server Report:
[  3]  0.0-60.1 sec  66.9 MBytes  9.34 Mbits/sec   3.933 ms    0/47712 (0%)
pi@raspberrypi:~$
```

- NOTE

    Make sure that the AP-mode unit and STA-mode unit are not placed too close together. Wireless communication may not be stable in an environment where signal strength is strong as the distance is too short.

    It is recommended to keep the devices at least 3 m apart.

txpwr=17

AP ⟺ STA

3m
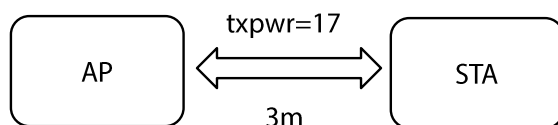
10. Troubleshooting

- SSH login fails
  - ➢ Make sure that the PC and Raspberry Pi are correctly connected using an Ethernet cable.
  - ➢ Connect to Raspberry Pi as explained at 8.1 and check the IP address of the Ethernet I/F(eth0) using the ifconfig command.

- Even if a wireless driver is loaded, the wireless interface (wlan0) is not generated.
  - ➢ Check the DIPSW setting of SX-NEWAH-EVK (7.1.1 DIP Switch Setting).
  - ➢ Check the connection between Raspberry Pi and SX-NEWAH-EVK.
  - ➢ Restart SX-NEWAH-EVK and try again.

- Wireless connection between AP and STA is not established.
  - ➢ Check that the settings described in the configuration files are correct for both AP' and STA' (ap_halow_*.conf or sta_halow_*.conf).
    - ✧ When WPA2-PSK, WPA3-SAE/OWE is used:
      Check that the settings (e.g. wpa_passphrase, IEEE 802.11w, etc.) are identical between the AP's and STA's configuration files (ap_halow_*.conf or sta_halow_*.conf).

- iperf throughput is low
  - ➢ The reception strength may be too strong as the units are too close. Keep more distance between the units or change the Tx power for both AP/STA units using the txpwr command.
  - ➢ Check the connection between antenna and the antenna cable.

When it **Absolutely Must** Connect

11. Appendix

11.1. Sample Image Files

File or Folder	Path	Description
ap_halow_open.conf	[SX_PKG]/conf/US	AP configuration file (open mode)
ap_halow_wpa2.conf	[SX_PKG]/conf/US	AP configuration file (WPA2-PSK)
ap_halow_owe.conf	[SX_PKG]/conf/US	AP configuration file (WPA3-OWE)
ap_halow_sae.conf	[SX_PKG]/conf/US	AP configuration file (WPA3-SAE)
sta_halow_open.conf	[SX_PKG]/conf/US	STA configuration file (open mode)
sta_halow_wpa2.conf	[SX_PKG]/conf/US	STA configuration file (WPA2-PSK)
sta_halow_owe.conf	[SX_PKG]/conf/US	STA configuration file (WPA3-OWE)
sta_halow_sae.conf	[SX_PKG]/conf/US	STA configuration file (WPA3-SAE)
nrc.ko	/lib/modules/4.14.70-v7+	SX-NEWAH Host driver
nrc7292_cspi.bin	/lib/firmware	SX-NEWAH firmware

* [SX_PKG] = /home/pi/sx-newah

* Please refer to "hostapd.conf" and "wpa_supplicant.conf" of the specification document(SC111270) for the contents of "ap_halow_*.conf" and "sta_halow_*.conf".

11.2. How to Change IP Address of Raspberry Pi's eth0 (Ethernet I/F)

Following explains how to change the IP address of Raspberry Pi's eth0 (Ethernet I/F).

● Login according to "8.2 When SSH is Used".

● On the SSH console, execute "sudo nano /etc/dhcpcd.conf".

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● Change the below IP address to a desired one.

● Press Ctrl + O.

● Press the Enter key and press Ctrl + X.

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- Execute "sudo poweroff".

- Restart Raspberry Pi.

* When Raspberry Pi is started next time, the specified value is used as an IP address of eth0.

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Revision History

25th May, 2020	First edition
29th May, 2020	Updated to reflect EVK kit composition for STAE.

When it Absolutely Must Connect