NRC7292 Evaluation Kit User Guide

(OpenWrt)

Ultra-low power & Long-range Wi-Fi

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NEWRACOM, Inc.

NRC7292 Evaluation Kit User Guide (OpenWrt)
Ultra-low power & Long-range Wi-Fi

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1 Overview

1.1 Introduction

OpenWrt (OPEN Wireless RouTer) is an open source project for embedded operating systems based on Linux, primarily used on embedded devices to route network traffic. All components have been optimized to be small enough to fit into the limited storage and memory available in home routers.

OpenWrt is configured using a command-line interface (ash shell), or a web interface (LuCI). There are about 3500 optional software packages available for installation via the opkg package management system.

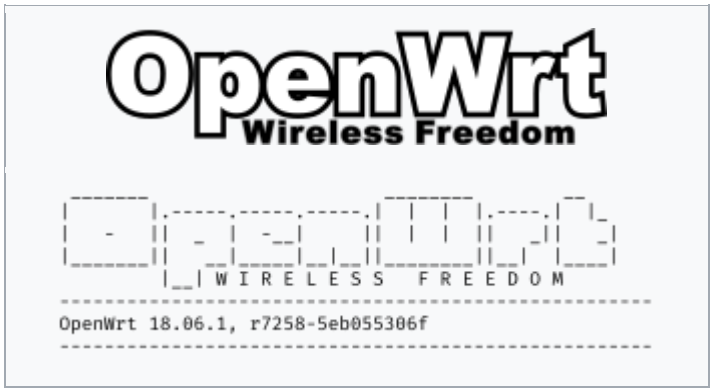


Figure 1.1 OpenWrt login screen

1.2 Device configuration

An RPi3 host is required to run OpenWrt on an NRC7292 module. The DIP switch on the module must be set to HHLLLH.

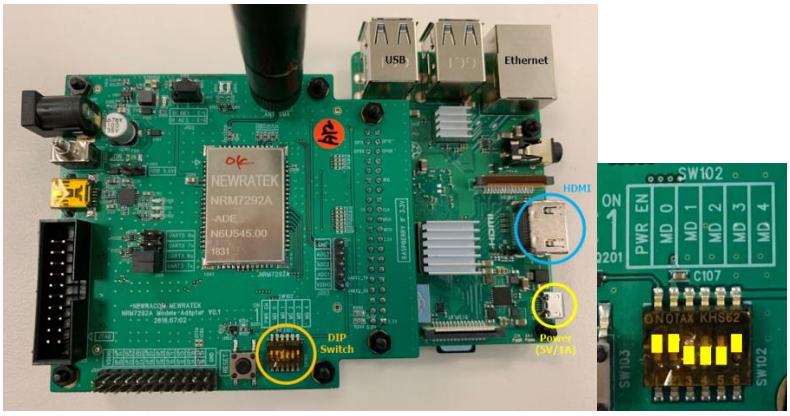


Figure 1.2 OpenWrt Device and DIP Switch Configuration

2 Start Guide for Image Building

2.1 Dependencies

Make sure all the required dependencies are installed (on Debian/Ubuntu):

```
$ sudo apt-get update
$ sudo apt-get install subversion g++ zlib1g-dev build-essential git python
python3 python3-distutils libncurses5-dev gawk gettext unzip file libssl-dev
wget libelf-dev ecj fastjar java-propose-classpath
```

For Ubuntu 18.04 or later:

```
$ sudo apt-get install build-essential libncursesw5-dev python unzip gawk
```

2.2 Get the OpenWrt source code

Clone the OpenWrt repository and ckeck out the release version.

For OpenWRT 19.07.7

```
$ cd ~
$ git clone https://git.openwrt.org/openwrt/openwrt.git
$ cd openwrt
$ git tag
$ git checkout -b tag-v19.07.7 v19.07.7
```

For OpenWRT 21.02.1

```
$ cd ~
$ git clone https://git.openwrt.org/openwrt/openwrt.git
$ cd openwrt
$ git tag
$ git checkout -b tag-v21.02.1 v21.02.1
```

2.3 Patch

Apply the Newracom patch files. The file “openwrt-19.07.7-patches.tar.bz2” (for 19.07.7) and “openwrt-21.02.1-patches.tar.bz2” (for 21.02.1) are located in “NRC7292_SW_PKG/nrc7292_openwrt” folder.

For OpenWRT 19.07.7,

```
$ cp openwrt-19.07.7-patches.tar.bz2 ~/
$ cd ~/
$ tar -xjvf openwrt-19.07.7-patches.tar.bz2
$ cp -a openwrt-19.07.7-patches/* ~/openwrt
$ cd ~/openwrt
```

For OpenWRT 21.02.1,

```
$ cp openwrt-21.02.1-patches.tar.bz2 ~/
$ cd ~/
$ tar -xjvf openwrt-21.02.1-patches.tar.bz2
$ cp -a openwrt-21.02.1-patches/* ~/openwrt
$ cd ~/openwrt
```

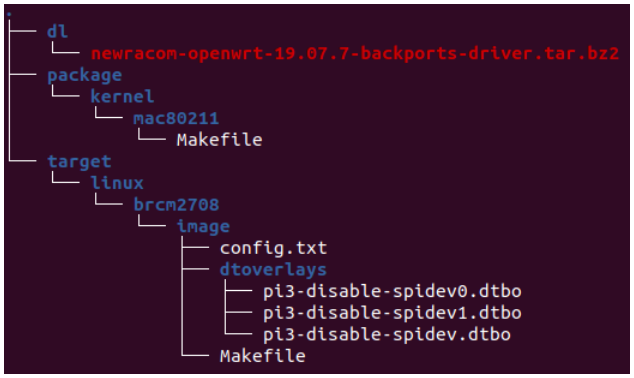
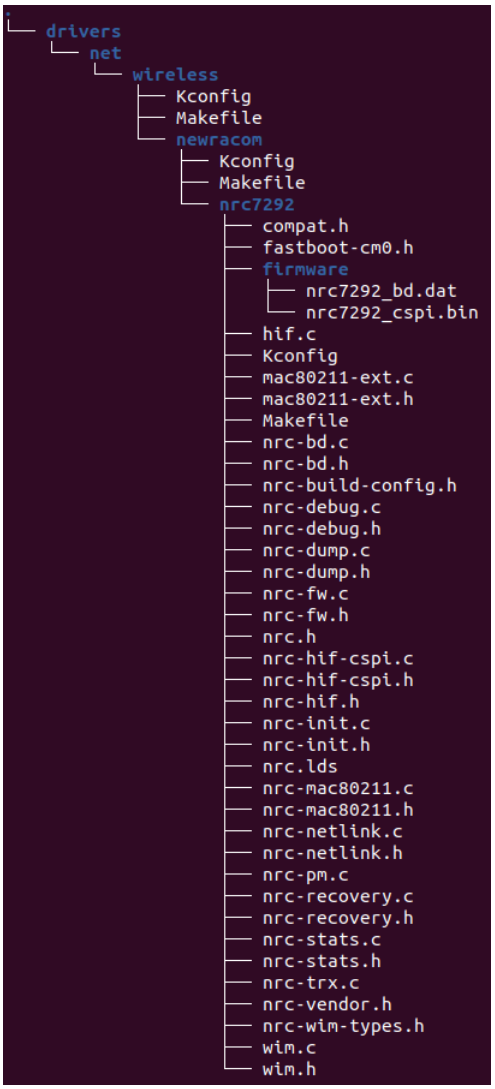


Figure 2.3 Patch file lists

- **dl/newracom-openwrt-19.07.7-backports-driver.tar.bz2**



NRC7292 host driver sources for the Backports package.
This file is extracted into ”build_dir/target-aarch64_cortex-a53_musl/linux-brcm2708_bcm2710/backports-4.19.98-1” directory by ”pacakge/kernel/mac80211/Makefile” file.

The original files in the Backports pacakge are modifiled to build the NRC7292 host driver.

drivers/net/wireless/Kconfig

```
41 source "drivers/net/wireless/mediatek/Kconfig"
42 source "drivers/net/wireless/newracom/Kconfig"
43 source "drivers/net/wireless/ralink/Kconfig"
```

drivers/net/wireless/Makefile

```
14 obj-$(CPTCFG_WLAN_VENDOR_MEDIATEK) += mediatek/
15 obj-$(CPTCFG_WLAN_VENDOR_NEWRACOM) += newracom/
16 obj-$(CPTCFG_WLAN_VENDOR_RALINK) += ralink/
```

- **package/kernel/mac80211/Makefile**

The original file in the OpenWRT is modified to build the NRC7292 host driver.

Line 35

```
24 PKG_DRIVERS = \
25     adm8211 \
26     airo \
27     hermes hermes-pci hermes-pcmcia hermes-plx\
28     lib80211 \
29     mac80211-hwsim \
30     mt7601u \
31     p54-common p54-pci p54-usb \
32     rsi91x rsi91x-usb rsi91x-sdio\
33     wlcore wl12xx wl18xx \
34     zd1211rw \
35     nrc7292
```

Line 82

```
58 config-y:= \
59     WLAN \
60     NL80211_TESTMODE \
61     CFG80211_WEXT \
62     CFG80211_CERTIFICATION_ONUS \
63     MAC80211_RC_MINSTREL \
64     MAC80211_RC_MINSTREL_HT \
65     MAC80211_RC_MINSTREL_VHT \
66     MAC80211_RC_DEFAULT_MINSTREL \
67     WLAN_VENDOR_ADMTEK \
68     WLAN_VENDOR_ATH \
69     WLAN_VENDOR_ATMEL \
70     WLAN_VENDOR_BROADCOM \
71     WLAN_VENDOR_CISCO \
72     WLAN_VENDOR_INTEL \
73     WLAN_VENDOR_INTERSIL \
74     WLAN_VENDOR_MARVELL \
75     WLAN_VENDOR_MEDIATEK \
76     WLAN_VENDOR_RALINK \
77     WLAN_VENDOR_REALTEK \
78     WLAN_VENDOR_RSI \
79     WLAN_VENDOR_ST \
80     WLAN_VENDOR_TI \
81     WLAN_VENDOR_ZYDAS \
82     WLAN_VENDOR_NEWRACOM \
```

Line 383 .. 389

```
383 define KernelPackage/nrc7292
384   $(call KernelPackage/mac80211/Default)
385   TITLE:=Newracom 802.11ah Wi-Fi halow driver
386   DEPENDS+= @TARGET_brcm2708 +kmod-mac80211 +kmod-spi-bcm2835 +@DRIVER_11N_SUPPORT
387   FILES:=$(PKG_BUILD_DIR)/drivers/net/wireless/newracom/nrc7292/nrc7292.ko
388   AUTOLOAD:=$(call AutoProbe,nrc7292)
389 endef
```

Line 460

```
457     $(TAR) -C $(PKG_BUILD_DIR) -xzf $(DL_DIR)/$(IPW2100_NAME)-$(IPW2100_VERSION).tgz
458     $(TAR) -C $(PKG_BUILD_DIR) -xzf $(DL_DIR)/$(IPW2200_NAME)-$(IPW2200_VERSION).tgz
459     $(TAR) -C $(PKG_BUILD_DIR) -xjf $(DL_DIR)/$(ZD1211FW_NAME)-$(ZD1211FW_VERSION).tar.bz2
460     $(TAR) -C $(PKG_BUILD_DIR) --overwrite -xjf $(DL_DIR)/newracom-openwrt-19.07.2-backports-driver.tar.bz2
```

Line 571 .. 574

```
571 define KernelPackage/nrc7292/install
572     $(INSTALL_DIR) $(1)/lib/firmware
573     $(INSTALL_DATA) $(PKG_BUILD_DIR)/drivers/net/wireless/newracom/nrc7292/firmware/* $(1)/lib/firmware
574 endef
```

- **target/linux/brcm2708/image/config.txt**

  The original file in the OpenWRT is modified to disable Broadcom Wi-Fi/BT driver and User mode SPI driver.

```
963 #
964 # newracom
965 #
966 dtoverlay=pi3-disable-bt
967 dtoverlay=pi3-disable-wifi
968 dtoverlay=pi3-disable-spidev
```

- **target/linux/brcm2708/image/dtoverlays**

  Device Tree Blob Overlay files

- **target/linux/brcm2708/image/Makefile**

  The original file in the OpenWRT is modified to copy the Device Tree Blob Overlay files to /boot/overalys directory in Root File system.

```
39      $(foreach dts,$(shell echo $(DEVICE_DTS)),mcopy -i $@.boot $(DTS_DIR)/$(dts).dtb ::;)
40      mmd -i $@.boot ::/overlays
41      mcopy -i $@.boot $(DTS_DIR)/overlays/*.dtbo ::/overlays/
42      mcopy -i $@.boot $(DTS_DIR)/overlays/README ::/overlays/
43      mcopy -i $@.boot ./dtoverlays/* ::/overlays/
```

2.4 Update

Update and install package information.

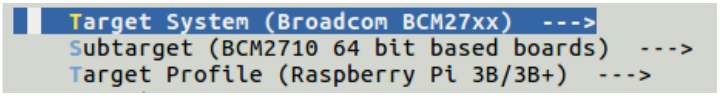
```
$ ./scripts/feeds update -a
$ ./scripts/feeds install -a
```

2.5 Configuration

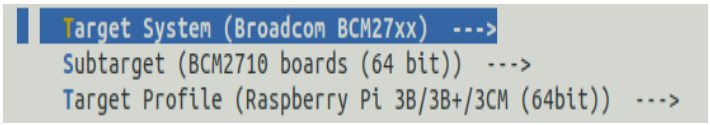
Configure the target system.

```
$ make menuconfig
```

For Openwrt 19.07.7,
(Target System -> Broadcom BCM27xx)
(Subtarget -> BCM2710 64 bit based boards)
(Target Profile -> Raspberry pi 3B/3B+)



For Openwrt 21.02.1,
(Target System -> Broadcom BCM27xx)
(Subtarget -> BCM2710 boards (64 bit))
(Target Profile -> Raspberry pi 3B/3B+/3CM (64bit))



Create a ".config" file with default options from the ARCH supplied defconfig.

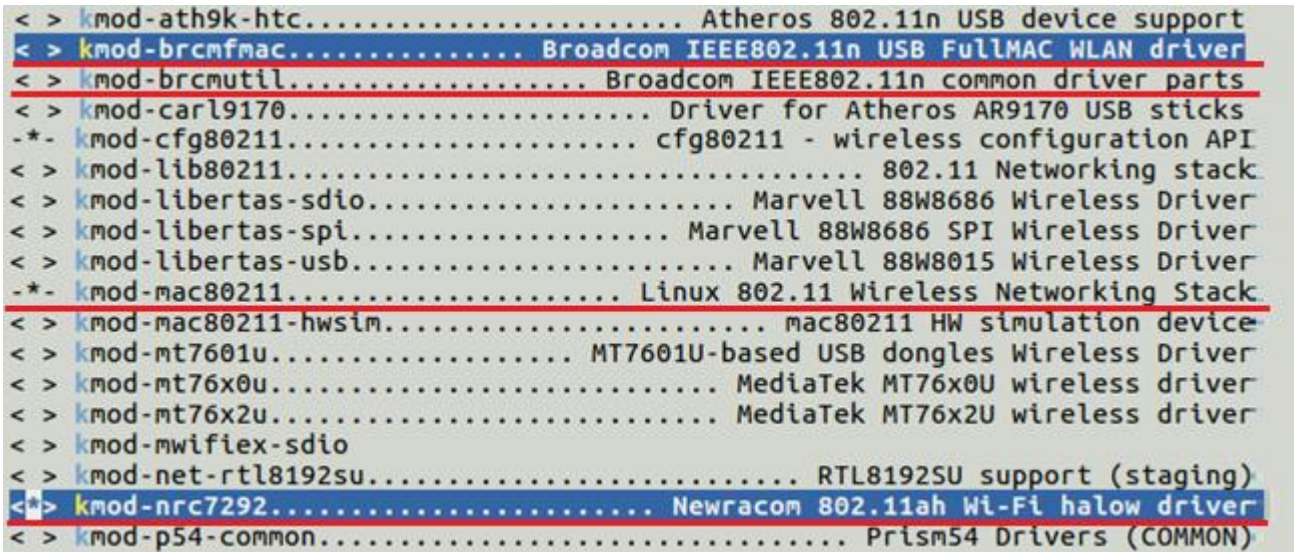
```
$ make defconfig
```

Additional setup:

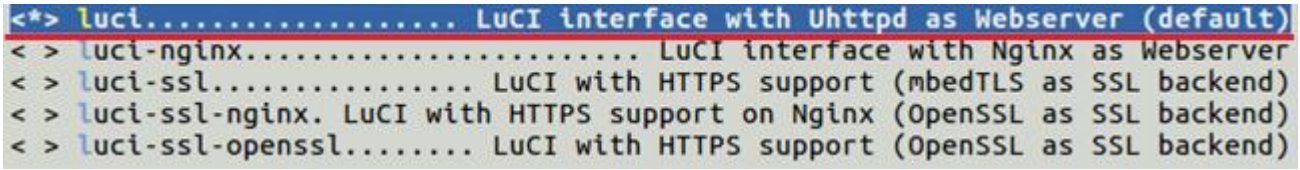
- Disable Broadcom Wi-Fi driver module
- Enable Newracom Wi-Fi Halow driver module
- Enable LuCI for WebUI
- Enable Iperf for perfomance measurment

```
$ make menuconfig
```

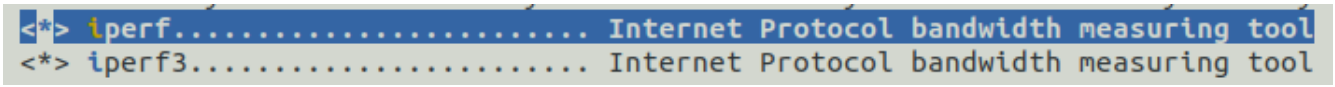
(Kernel modules -> Wireless Drivers)



(LuCI -> 1. Collections)



(Network)



2.6 Build

```
$ make download
$ make
```

Package and patch files are saved in 'dl' directory
Build image path: bin/targets/brcm2708/bcm2710 (for 19.07.7)
Build image path: bin/targets/bcm27xx/bcm2710 (for 21.02.1)
Name: openwrt-brcm2708-bcm2710-rpi-3-ext4-factory.img.gz

Figure 2.4 Build images

2.7 Cloning the SD card

Launch Win32DiskImager and provide the path to the image file.
Click the "Write" button to start writing the image to the SD card.

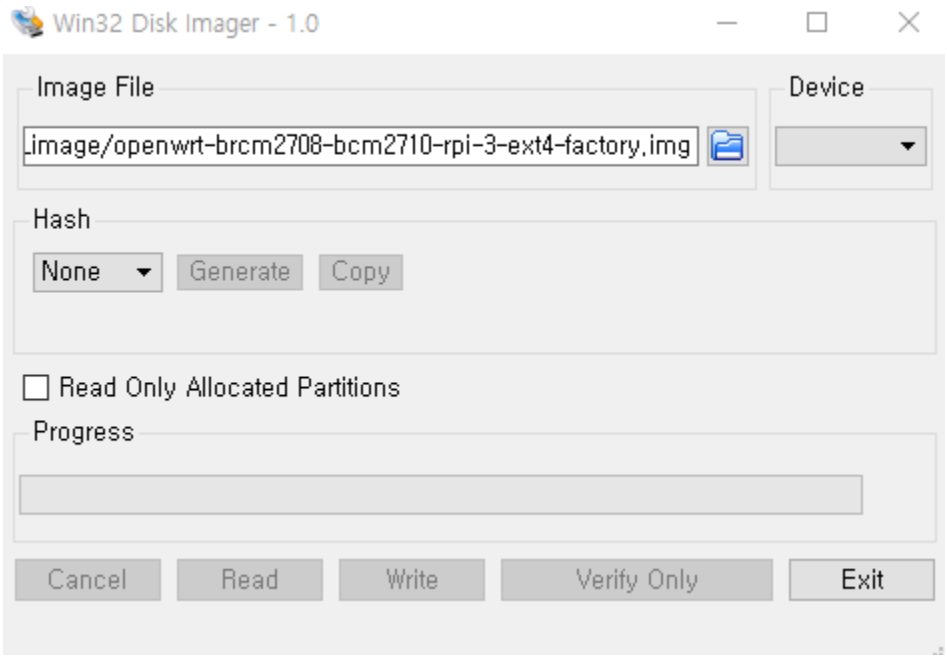


Figure 2.5 Cloning the image

2.8 Run

The Newracom Wi-Fi Halow driver module (wlan0) will be loaded during kernel loading.

```
$ ifconfig -a
```

```
br-lan    Link encap:Ethernet  HWaddr B8:27:EB:EB:60:AA
          inet addr:192.168.123.24  Bcast:192.168.123.255  Mask:255.255.255.0
          inet6 addr: fe80::ba27:ebff:feeb:60aa/64 Scope:Link
          inet6 addr: fd7b:14ab:8b12::1/60 Scope:Global
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:483 errors:0 dropped:0 overruns:0 frame:0
          TX packets:121 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:201230 (196.5 KiB)  TX bytes:31632 (30.8 KiB)

eth0      Link encap:Ethernet  HWaddr B8:27:EB:EB:60:AA
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:494 errors:0 dropped:1 overruns:0 frame:0
          TX packets:137 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:212170 (207.1 KiB)  TX bytes:33712 (32.9 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:88 errors:0 dropped:0 overruns:0 frame:0
          TX packets:88 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6517 (6.3 KiB)  TX bytes:6517 (6.3 KiB)

wlan0     Link encap:Ethernet  HWaddr 02:00:EB:EB:60:AB
          BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Figure 2.6 interface after kernel loading

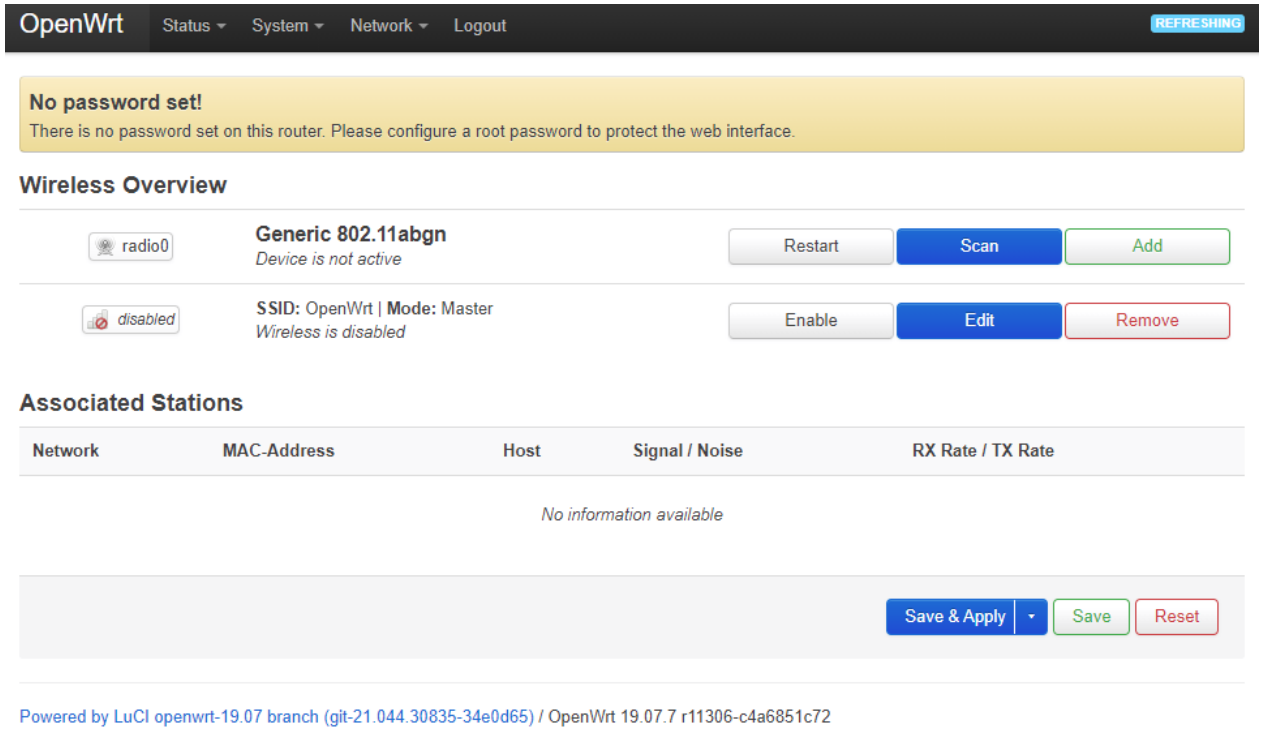
Default IP of the bridge network is 192.168.1.1
A dynamic Ethernet IP can be allocated by enabling the DHCP client:

```
$ uci set network.lan.proto=dhcp
$ uci commit
$ /etc/init.d/network restart
```

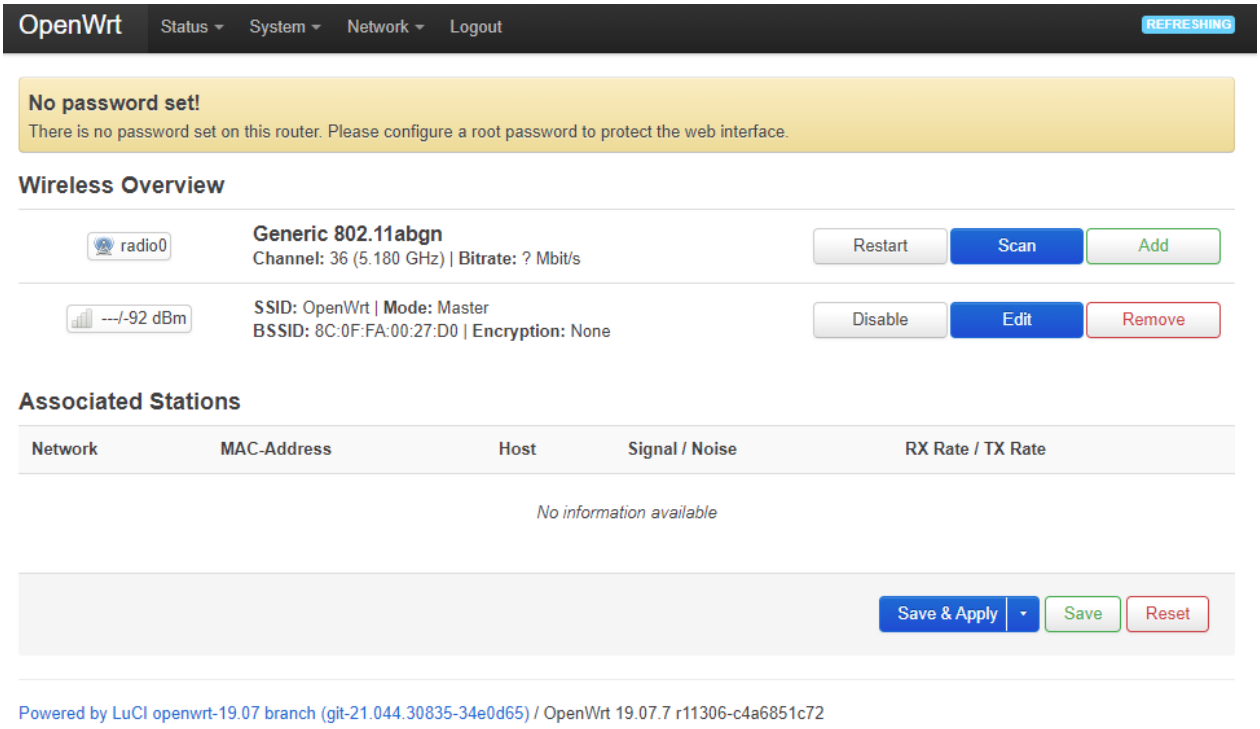
2.9 Configuration via Web UI

Open a browser and navigate to the web server (default address: http://192.168.1.1).
The default Username is ”root”, and the default Password is blank.

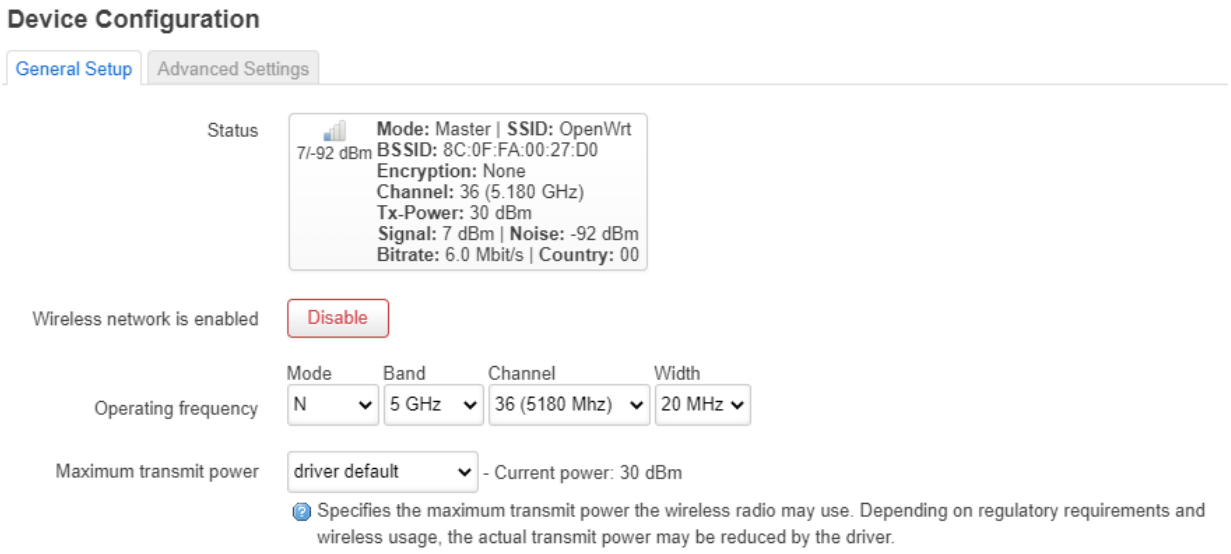
Move the ”Network -> Wireless” page.

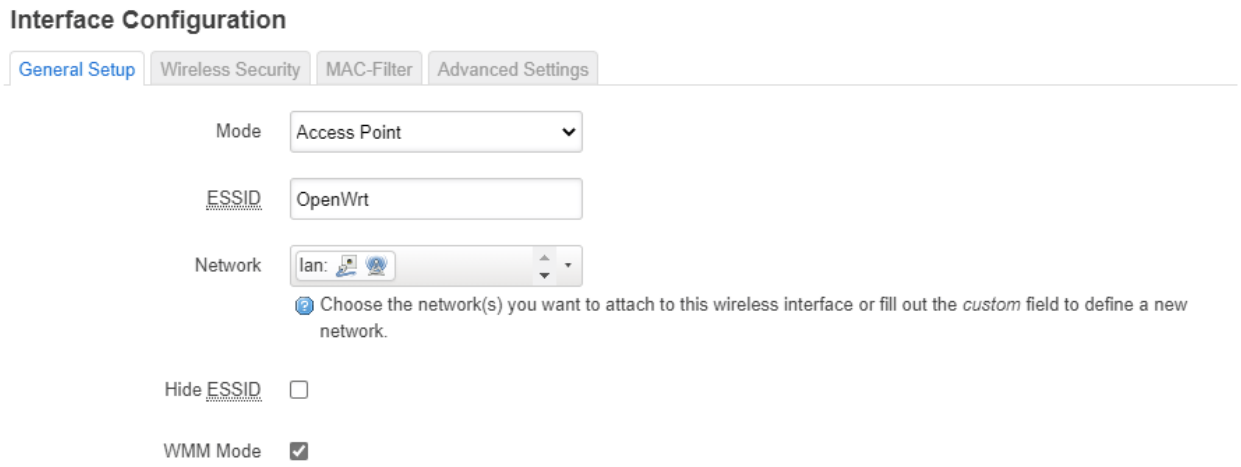


Press the ”Enable” button to enable the wireless network.



On the same page, press the ”Edit” button to configure the wireless network.





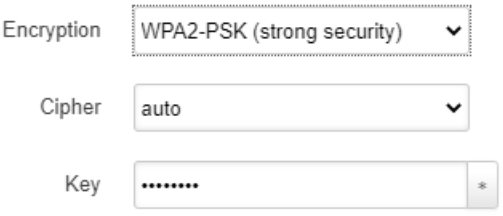
Next, select and configure as follows:

Country Code : Device Configuration -> Advanced Settings

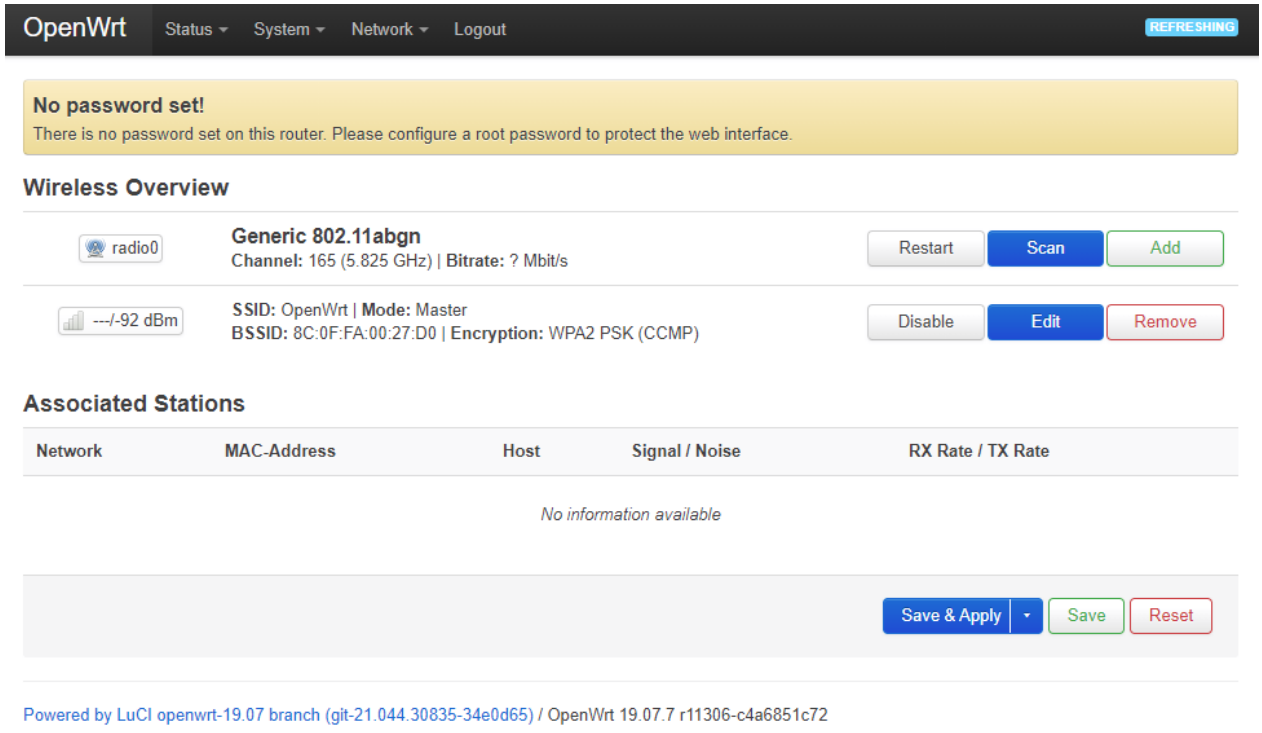
Operation frequency : Device Configuration -> General Setup

ESSID : Interface Configuration -> General Setup

Encryption/Cypher/Key : Interface Configuration -> Wireless Security



Save and apply the changes.



3 Channel Table (US)

The current release supports additional US channels. Table 3.1 lists supported US channels and their corresponding channel indices.

Table 3.1 Available frequency band and corresponding channel for US

Available frequency band index	Bandwidth (MHz)	Sub-1GHz frequency	2.4 / 5G frequency
1	1	902.5	2412
3	1	903.5	2422
5	1	904.5	2432
7	1	905.5	2442
9	1	906.5	2452
11	1	907.5	2462
36	1	908.5	5180
37	1	909.5	5185
38	1	910.5	5190
39	1	911.5	5195
40	1	912.5	5200
41	1	913.5	5205
42	1	914.5	5210
43	1	915.5	5215
44	1	916.5	5220
45	1	917.5	5225
46	1	918.5	5230
47	1	919.5	5235
48	1	920.5	5240
149	1	921.5	5745
150	1	922.5	5750
151	1	923.5	5755
152	1	924.5	5760
100	1	925.5	5500
104	1	926.5	5520
108	1	927.5	5540
2	2	903	2417
6	2	905	2437
10	2	907	2457
153	2	909	5765
154	2	911	5770
155	2	913	5775
156	2	915	5780

157	2	917	5785
158	2	919	5790
159	2	921	5795
160	2	923	5800
161 (Default)	2	925	5805
112	2	927	5560
8	4	906	2447
162	4	910	5810
163	4	914	5815
164	4	918	5820
165	4	922	5825
116	4	926	5580

4 Reference

OpenWRT Build system: https://openwrt.org/docs/guide-developer/build-system/start

- Install: https://openwrt.org/docs/guide-developer/build-system/install-buildsystem
- Usage: https://openwrt.org/docs/guide-developer/build-system/use-buildsystem

OpenWRT Wiki: https://en.wikipedia.org/wiki/OpenWrt

5 Revision history

Revision No	Date	Comments
Ver 1.0	5/1/2020	Initial version for customer release created
Ver 1.1	8/2/2021	OpenWrt version changed (19.07.2 -> 19.07.7)
Ver 1.2	10/29/2021	nrc7292 F/W update to 1.3.4. Added support for OpenWRT version 21.02.1