



NRC7292 Evaluation Kit

User Guide

(OpenWrt)

Ultra-low power & Long-range Wi-Fi

Ver1.2
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NEWTRACOM, Inc.

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

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Office

Newracom, Inc.

25361 Commercentre Drive, Lake Forest, CA 92630 USA

<http://www.newracom.com>

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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.

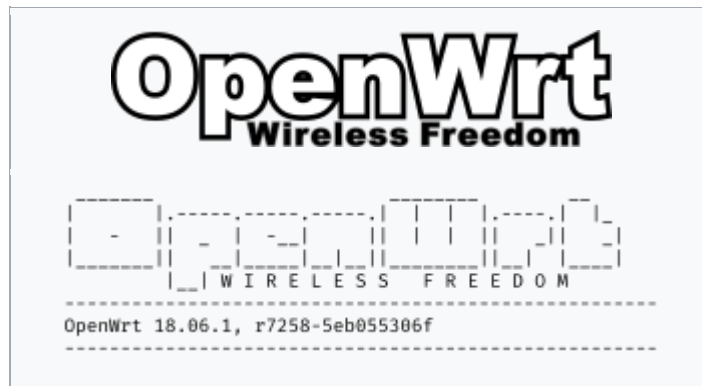


Figure 1.1 OpenWrt login screen

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 HLLLLH.

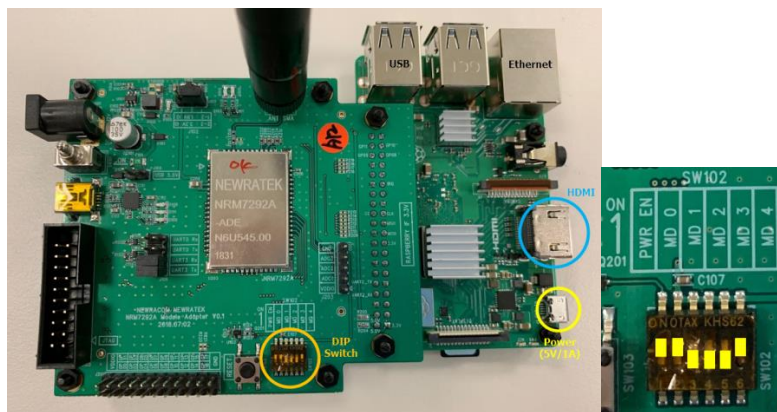


Figure 1.2 OpenWrt Device and DIP Switch Configuration

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 check 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
```

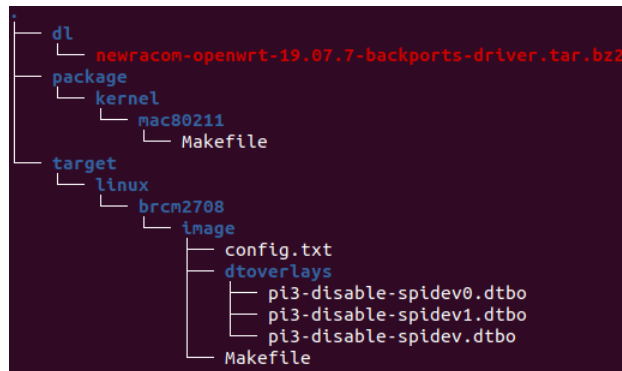


Figure 2.3 Patch file lists

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


```

├── drivers
│   └── net
│       └── wireless
│           ├── Kconfig
│           ├── Makefile
│           └── newracom
│               ├── Kconfig
│               ├── Makefile
│               └── nrc7292
│                   ├── compat.h
│                   ├── fastboot-cm0.h
│                   └── firmware
│                       ├── nrc7292_bd.dat
│                       └── nrc7292_cspi.bin
│                   ├── hif.c
│                   ├── Kconfig
│                   ├── mac80211-ext.c
│                   ├── mac80211-ext.h
│                   ├── Makefile
│                   ├── nrc-bd.c
│                   ├── nrc-bd.h
│                   ├── nrc-build-config.h
│                   ├── nrc-debug.c
│                   ├── nrc-debug.h
│                   ├── nrc-dump.c
│                   ├── nrc-dump.h
│                   ├── nrc-fw.c
│                   ├── nrc-fw.h
│                   ├── nrc.h
│                   ├── nrc-hif-cspi.c
│                   ├── nrc-hif-cspi.h
│                   ├── nrc-hif.h
│                   ├── nrc-init.c
│                   ├── nrc-init.h
│                   ├── nrc.lds
│                   ├── nrc-mac80211.c
│                   ├── nrc-mac80211.h
│                   ├── nrc-netlink.c
│                   ├── nrc-netlink.h
│                   ├── nrc-pm.c
│                   ├── nrc-recovery.c
│                   ├── nrc-recovery.h
│                   ├── nrc-stats.c
│                   ├── nrc-stats.h
│                   ├── nrc-trx.c
│                   ├── nrc-vendor.h
│                   ├── nrc-wim-types.h
│                   ├── wim.c
│                   └── wim.h

```

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 "package/kernel/mac80211/Makefile" file.

The original files in the Backports package are modified 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 \  
83
```

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/overlays 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+)

```
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))

```
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 lperf for performance measurment

```
$ make menuconfig
```

(Kernel modules -> Wireless Drivers)

```

< > kmod-ath9k-htc..... Atheros 802.11n USB device support
< > kmod-brcmfmac..... Broadcom IEEE802.11n USB FullMAC WLAN driver
< > kmod-brcmutil..... Broadcom IEEE802.11n common driver parts
< > kmod-carl9170..... Driver for Atheros AR9170 USB sticks
-* kmod-cfg80211..... cfg80211 - wireless configuration API
< > kmod-lib80211..... 802.11 Networking stack
< > kmod-libertas-sdio..... Marvell 88W8686 Wireless Driver
< > kmod-libertas-spi..... Marvell 88W8686 SPI Wireless Driver
< > kmod-libertas-usb..... Marvell 88W8015 Wireless Driver
-* kmod-mac80211..... Linux 802.11 Wireless Networking Stack
< > kmod-mac80211-hwsim..... mac80211 HW simulation device
< > kmod-mt7601u..... MT7601U-based USB dongles Wireless Driver
< > kmod-mt76x0u..... MediaTek MT76x0U wireless driver
< > kmod-mt76x2u..... MediaTek MT76x2U wireless driver
< > kmod-mwifiex-sdio
< > kmod-net-rtl8192su..... RTL8192SU support (staging)
< * > kmod-nrc7292..... Newracom 802.11ah Wi-Fi halow driver
< > kmod-p54-common..... Prism54 Drivers (COMMON)

```

(LuCI -> 1. Collections)

```

< * > luci..... LuCI interface with Uhttpd as Webserver (default)
< > luci-nginx..... LuCI interface with Nginx as Webserver
< > luci-ssl..... LuCI with HTTPS support (mbedTLS as SSL backend)
< > luci-ssl-nginx. LuCI with HTTPS support on Nginx (OpenSSL as SSL backend)
< > luci-ssl-openssl..... LuCI with HTTPS support (OpenSSL as SSL backend)

```

(Network)

```

< * > iperf..... Internet Protocol bandwidth measuring tool
< * > iperf3..... Internet Protocol bandwidth measuring tool

```

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

```
— config.buildinfo
— feeds.buildinfo
— openwrt-brcm2708-bcm2710-device-rpi-3.manifest
— openwrt-brcm2708-bcm2710-rpi-3-ext4-factory.img.gz
— openwrt-brcm2708-bcm2710-rpi-3-ext4-sysupgrade.img.gz
— openwrt-brcm2708-bcm2710-rpi-3-squashfs-factory.img.gz
— openwrt-brcm2708-bcm2710-rpi-3-squashfs-sysupgrade.img.gz
— packages
— sha256sums
— version.buildinfo
```

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.

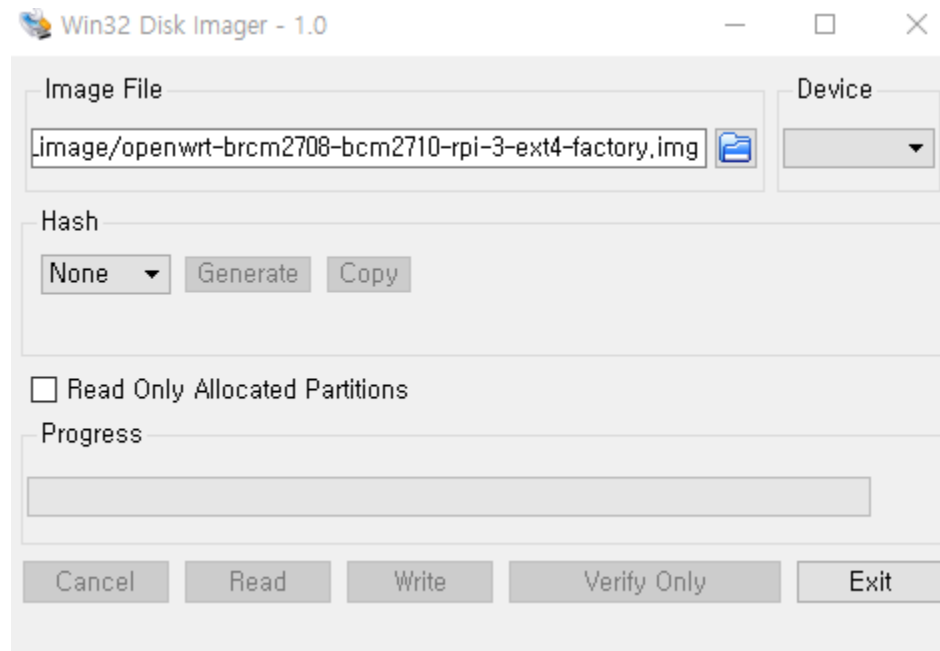


Figure 2.5 Cloning the image

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

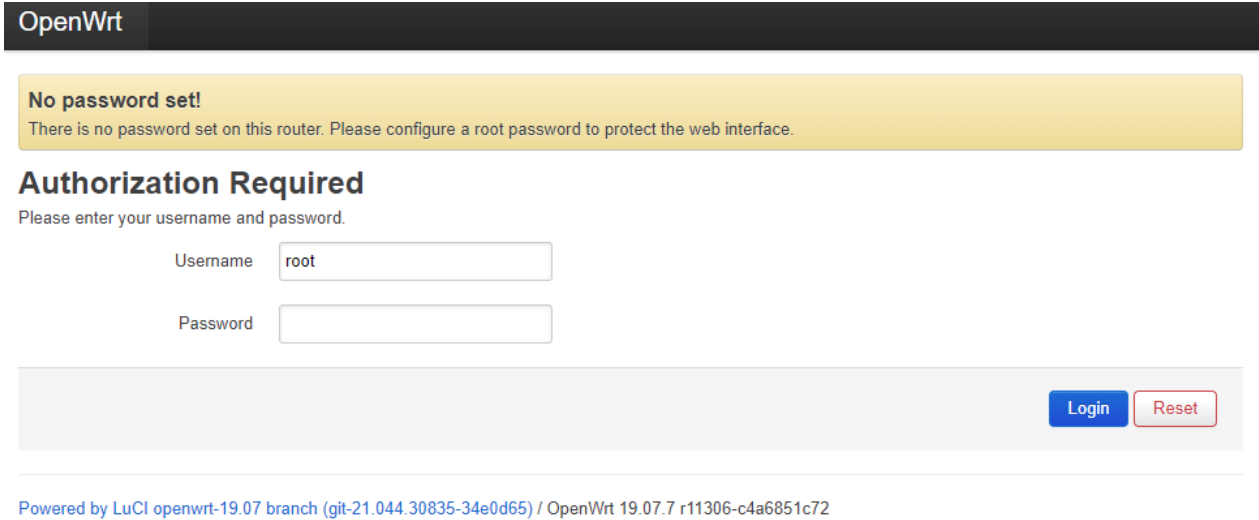
Default IP of the bridge network is 192.168.1.1

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
```

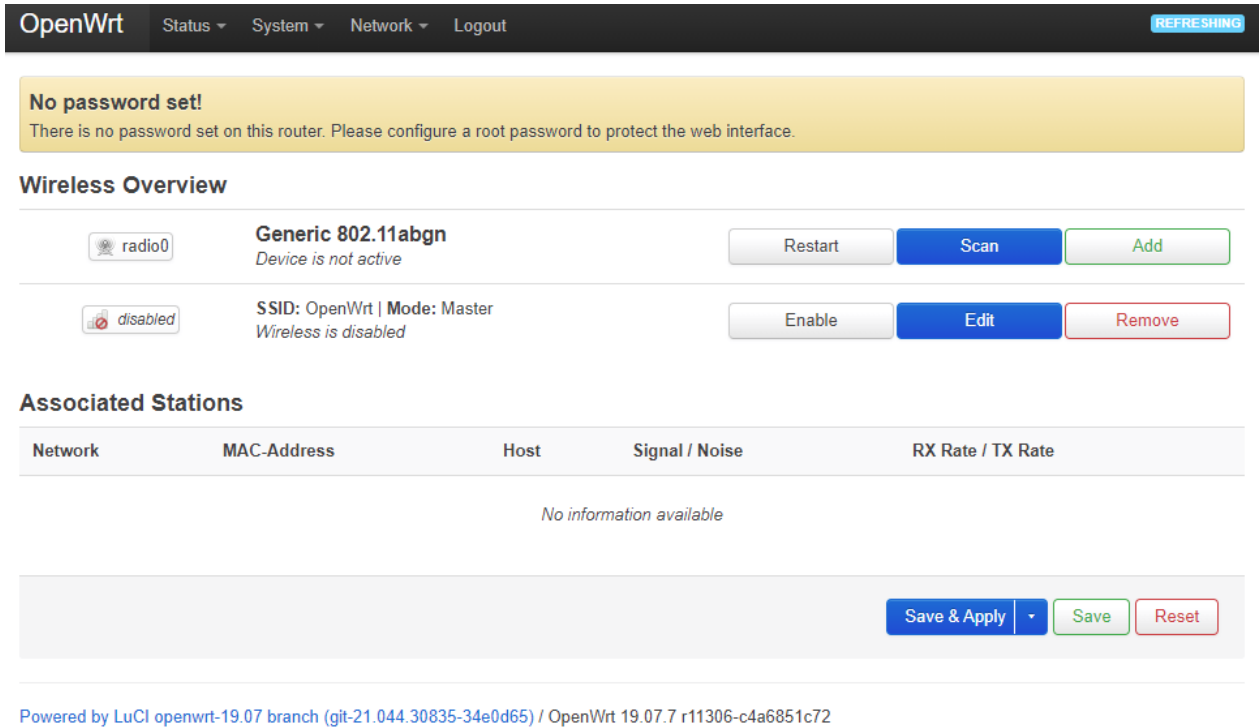

2.9 Configuration via Web UI

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.



The screenshot shows the OpenWrt web interface. At the top, there is a black header with the text "OpenWrt". Below the header is a yellow warning box that says "No password set!" and "There is no password set on this router. Please configure a root password to protect the web interface." Underneath is a section titled "Authorization Required" with the instruction "Please enter your username and password." There are two input fields: "Username" with the value "root" and "Password" which is empty. To the right of the password field are two buttons: "Login" (blue) and "Reset" (red). At the bottom of the page, there is a footer that reads "Powered by LuCI openwrt-19.07 branch (git-21.044.30835-34e0d65) / OpenWrt 19.07.7 r11306-c4a6851c72".

Move the "Network -> Wireless" page.



The screenshot shows the OpenWrt web interface on the "Wireless Overview" page. The top navigation bar includes "OpenWrt", "Status", "System", "Network", and "Logout", along with a "REFRESHING" button. A yellow warning box at the top states "No password set!". The main content area is titled "Wireless Overview" and contains two entries for wireless interfaces. The first entry is for "radio0" (Generic 802.11abgn), which is "Device is not active" and has buttons for "Restart", "Scan", and "Add". The second entry is for a disabled interface, showing "SSID: OpenWrt | Mode: Master" and "Wireless is disabled", with buttons for "Enable", "Edit", and "Remove". Below this is a section titled "Associated Stations" with a table that has columns for "Network", "MAC-Address", "Host", "Signal / Noise", and "RX Rate / TX Rate". The table is currently empty, with the text "No information available" centered below it. At the bottom of the page, there are buttons for "Save & Apply", "Save", and "Reset". The footer at the bottom reads "Powered by LuCI openwrt-19.07 branch (git-21.044.30835-34e0d65) / OpenWrt 19.07.7 r11306-c4a6851c72".

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

The screenshot shows the OpenWrt web interface. At the top, there is a navigation bar with 'OpenWrt', 'Status', 'System', 'Network', and 'Logout' menus, and a 'REFRESHING' button. A yellow warning box states 'No password set!' with the message: 'There is no password set on this router. Please configure a root password to protect the web interface.'

Wireless Overview

radio0	Generic 802.11abgn Channel: 36 (5.180 GHz) Bitrate: ? Mbit/s	Restart	Scan	Add
---/-92 dBm	SSID: OpenWrt Mode: Master BSSID: 8C:0F:FA:00:27:D0 Encryption: None	Disable	Edit	Remove

Associated Stations

Network	MAC-Address	Host	Signal / Noise	RX Rate / TX Rate
No information available				

Buttons: Save & Apply, Save, Reset

Powered by LuCI openwrt-19.07 branch (git-21.044.30835-34e0d65) / OpenWrt 19.07.7 r11306-c4a6851c72

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

Device Configuration

General Setup | Advanced Settings

The screenshot shows the 'Device Configuration' page for the wireless network. It has two tabs: 'General Setup' (selected) and 'Advanced Settings'.

Status (7/-92 dBm):
Mode: Master | SSID: OpenWrt
BSSID: 8C:0F:FA:00:27:D0
Encryption: None
Channel: 36 (5.180 GHz)
Tx-Power: 30 dBm
Signal: 7 dBm | Noise: -92 dBm
Bitrate: 6.0 Mbit/s | Country: 00

Wireless network is enabled

Operating frequency:
Mode: N | Band: 5 GHz | Channel: 36 (5180 Mhz) | Width: 20 MHz

Maximum transmit power: driver default - Current power: 30 dBm



Specifies the maximum transmit power the wireless radio may use. Depending on regulatory requirements and wireless usage, the actual transmit power may be reduced by the driver.

Interface Configuration

General Setup | Wireless Security | MAC-Filter | Advanced Settings

Mode: Access Point

ESSID: OpenWrt

Network: lan:  

Choose the network(s) you want to attach to this wireless interface or fill out the *custom* field to define a new network.

Hide ESSID:

WMM Mode:

Next, select and configure as follows:

Country Code : Device Configuration -> Advanced Settings

Country Code: US - United States

Operation frequency : Device Configuration -> General Setup

	Mode	Band	Channel	Width
Operating frequency	N	5 GHz	165 (5825 Mhz)	20 MHz

ESSID : Interface Configuration -> General Setup

ESSID: OpenWrt

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

Encryption: WPA2-PSK (strong security)

Cipher: auto


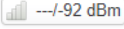
Key:

Save and apply the changes.

OpenWrt Status ▾ System ▾ Network ▾ Logout REFRESHING

No password set!
There is no password set on this router. Please configure a root password to protect the web interface.

Wireless Overview

 radio0	Generic 802.11abgn Channel: 165 (5.825 GHz) Bitrate: ? Mbit/s	Restart Scan Add
 --/-92 dBm	SSID: OpenWrt Mode: Master BSSID: 8C:0F:FA:00:27:D0 Encryption: WPA2 PSK (CCMP)	Disable Edit Remove

Associated Stations

Network	MAC-Address	Host	Signal / Noise	RX Rate / TX Rate
<i>No information available</i>				

Save & Apply ▾ Save Reset

Powered by LuCI openwrt-19.07 branch (git-21.044.30835-34e0d65) / OpenWrt 19.07.7 r11306-c4a6851c72

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