Wi-Fi® Link Controller Linux® User Guide

Introduction

This user guide describes how to run Wi-Fi on the ATWILC1000 SD card or the ATWILC3000 Shield board on the SAMA5D4 Xplained Ultra running with the Linux® kernel 5.4.

Notes: All references to the ATWILC module includes all the devices listed below unless otherwise noted:

- ATWILC1000
- ATWILC3000

The source codes are maintained on GitHub. For latest source codes, see GitHub Linux for ATWILC at github.com/linux4sam/linux-at91/tree/master/drivers/staging/wilc1000.

Figure 1. ATWILC1000 SD Card and ATWILC3000 Shield Board

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1. Prerequisites

The build prerequisite for Linux is a host PC with Linux operating system. The hardware prerequisites are the following:

- Linux
  - SAMA5D4 Xplained Ultra
  - ATWILC1000 SD Pro card
  - ATWILC3000 Shield board
  - USB to Serial adapter (for DEBUG port)
- Common
  - Micro-USB cable (Micro-A/Micro-B)

Depending on the WILC board used, the `chip_en` pin can either be tied high, as in the case of SD card boards, or connected to the host as in case of the ATWILC3000 shield board. For the latter case, the GPIO connected to ATWILC3000 shield board will be low by default, or configured as an input GPIO, preventing the kernel from loading the ATWILC driver as the ATWILC SDIO controller cannot be detected. To change the `chip_en`, refer the following steps:

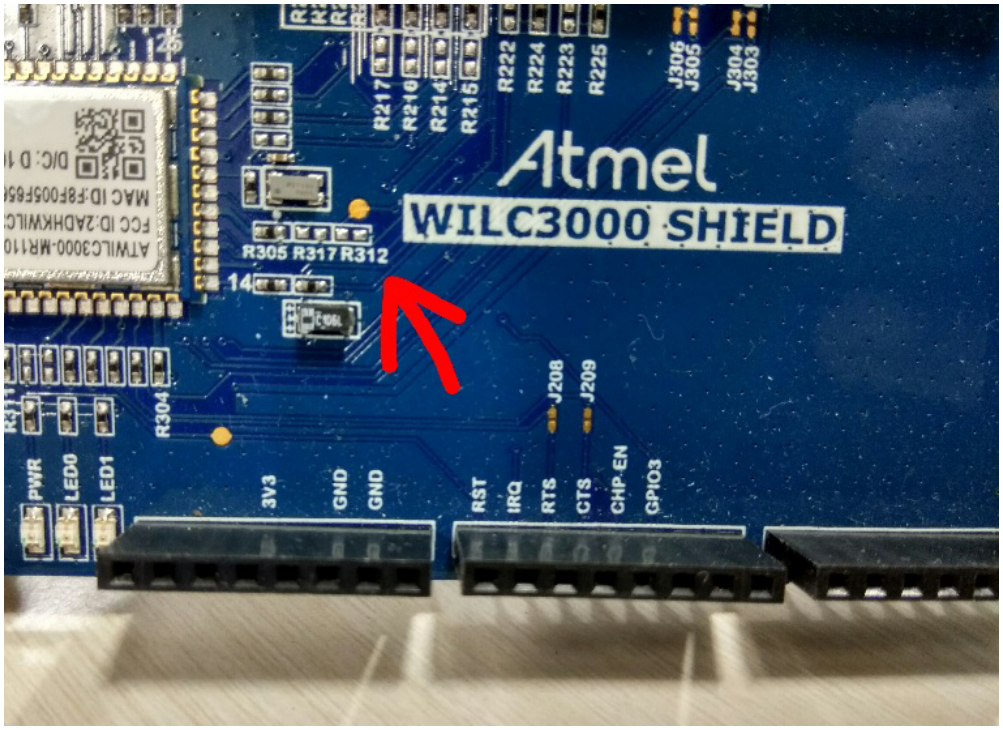
- Command line: Use the command line to assert the `chip_en` every time the host is power cycled.

```
$ echo "94" > /sys/class/gpio/export
$ echo "out" > /sys/class/gpio/pioC30/device/gpio/pioC30/direction
$ echo "1" > /sys/class/gpio/pioC30/device/gpio/pioC30/value
```

  Note: "94" is the GPIO NUM, and pioC0 is the pin number of the host GPIO connected to WILC3000 `chip_en` pin.

- Adding Pullup resistor: Mount a pullup resistor to the `chip_en` pin. For ATWILC3000 shield board, the resistor R312 can be mounted with 120k Ohm resistor in the location as shown in the figure.

Figure 1-1. ATWILC3000 Shield Board



2. Building Linux for SAMA5D4 Xplained Ultra Board

This section describes how to build the root file system and kernel image to use for ATWILC devices demo.

This user guide describes general information on the AT91Bootstrap and U-Boot information. For more details on the AT91Bootstrap and U-Boot, see U-Boot of Linux & Open Source related information for AT91 Smart ARM Microcontrollers.

2.1 Cloning a Kernel Source and Root File System

The demo uses buildroot and buildroot-external to get the suitable toolchain, root file system, and Linux kernel.

To get the source code & build, you have to clone the buildroot-at91 and buildroot-external-microchip repositories under the same parent directory.

The buildroot is cloned from linux4sam github at the following address:

```
$ git clone https://github.com/linux4sam/buildroot-at91.git
```

The buildroot is cloned at the following path in the current directory:

```
\buildroot-at91
```

The buildroot-external is cloned from linux4sam github at the following address:

```
$ git clone https://github.com/linux4sam/buildroot-external-microchip.git
```

The buildroot-external is cloned at the following path in the current directory:

```
\buildroot-external-microchip
```

The source code has been taken from the **master** branch which is pointing to the latest version of buildroot-at91 and buildroot-external-microchip. We advise you to use linux4sam tags to be sure that there is no mismatch between the versions of these two repositories.

For example, the tag linux4sam-2020.04 used to switch to the WILC Linux 15.4 release source
You can list them and use one of them by doing this:

```
$ cd buildroot-external-microchip
$ git tag | grep linux4sam
linux4sam-2020.04
linux4sam-2020.04-rc1
linux4sam-2020.04-rc2
linux4sam_5.8
linux4sam_5.8-rc1
...
$ git checkout linux4sam-2020.04 -b buildroot-external-microchip-linux4sam-2020.04
Switched to a new branch 'buildroot-external-microchip-linux4sam-2020.04'

$ cd ../buildroot-at91/
$ git tag | grep linux4sam
linux4sam-2020.04
linux4sam-2020.04-rc1
linux4sam_5.8
linux4sam_5.8-rc1
...
$ git checkout linux4sam-2020.04 -b buildroot-at91-linux4sam-2020.04
Switched to a new branch 'buildroot-at91-linux4sam-2020.04'
```

2.2 Loading SAMA5D4 Configuration File

Use the predefined `defconfig` file to create the required `.config` configuration file. This `defconfig` file is available in `configs` folder of the buildroot-external-microchip folder `linux4sam`.

For SAMA5D4, the `sama5d4_xplained_headless_wilc_defconfig` defconfig file is used.

To build the root file system for SAMA5D4 with Linux kernel 5.4 for the ATWILC board, browse to the directory buildroot-at91 where the files are buildroot repository is extracted and create the .config file, using the following commands:

```
$ BR2_EXTERNAL=../buildroot-external-microchip/ make sama5d4_xplained_headless_wilc_defconfig
```

Modify linux kernel configuration to compile 'cfg80211 - wireless configuration API' as built-in module

```
$ cd buildroot-at91
$ make linux-menuconfig
```

From kernel config GUI → Select 'Networking Support' → 'Wireless --> '

Include the cfg80211 module as an inbuilt module to kernel, from the GUI selection window:

1. Go to **Networking support** > **wireless**.
2. Press * to include the cfg80211 – wireless configuration API module to kernel.
3. Save the configuration.

2.3 Buildroot File System and Linux Kernel

Start the build operation using `$ make` command from the `buildroot-at91` directory.

This `$ make` command displays the build status on the terminal.
Note: Ensure that the host PC is connected to the internet before starting the build operation and do not use any build options.

The following files gets generated in the `buildroot-at91/output/images` directory when the build operation is completed.

File Name	Description
sama5d4_xplained.itb	Image Tree Blob - contains zImage, base device tree along with dt-overlays
rootfs.ubi	The root file system includes the WILC modules by default
at91-sama5d4_xplained.dtb	Device tree Blob file for SAMA5d4_xplanined board
u-boot.bin	U-boot for Microchip SoC (aka AT91)
uboot-env.bin	U-boot environment
sama5d4_xplained_wilc_sdio.dtso	WILC SDIO dt-overlay
sama5d4_xplained_wilc_spi.dtso	WILC SPI dt-overlay
sama5d4_xplained-nandflashboot-uboot-3.8.8.bin	AT91Bootstrap binary and is 2nd level bootloader for Atmel AT91 SoC

The driver source files are located at: `github.com/linux4sam/linux-at91/tree/linux-5.4-at91/drivers/staging/wilc1000` in the `linux-at91` kernel.
Note: The driver directory name is wilc1000 for legacy reasons only. The driver supports both ATWILC1000 and ATWILC3000.

The AT91 Device Tree Overlays and FIT image descriptors repository is located at: github.com/linux4sam/dt-overlay-at91.git
To clone the dt-overlay-at91 repository, use the below commands.

```
$ git clone https://github.com/linux4sam/dt-overlay-at91.git
$ git tag | grep linux4sam
linux4sam-2020.04
linux4sam-2020.04-rc1
linux4sam-2020.04-rc2
linux4sam-2020.04-rc3
linux4sam-2020.04-rc4
...
```

```
$ git checkout linux4sam-2020.04 -b dt-overlay-at91-linux4sam-2020.04
Switched to a new branch 'dt-overlay-at91-linux4sam-2020.04'
```

2.4 Building Linux Kernel Individually

Buildroot downloads the Linux kernel as per the buildroot configuration file from GitHub. The downloaded kernel must be available in the `buildroot-at91/output/build/linux-xxxx` path, and is built automatically during the buildroot build operation.

However, if the kernel is modified after building the buildroot, the user must rebuild the kernel. The following is the procedure to build the Linux kernel against the toolchain and ARM architecture:

1. Change the directory to the Linux kernel source folder, using the following command:

   ```
   $ cd output/build/linux-xx
   ```

2. Create the kernel with the help of `sama5_defconfig` defconfig file, using the following command:

   ```
   $ make ARCH=arm sama5_defconfig
   ```

3. Perform the required changes using the menuconfig tool, using the following command:

   ```
   $ make ARCH=arm menuconfig
   ```

4. Build the Linux kernel against the toolchain and ARM architecture, using the following commands:

   ```
   $ make ARCH=arm CROSS_COMPILE=../../../output/host/bin/arm-linux-
   $ make ARCH=arm CROSS_COMPILE=../../../output/host/bin/arm-linux- zImage
   $ make ARCH=arm CROSS_COMPILE=../../../output/host/bin/arm-linux- dtbs
   ```

3. Building and Flashing the System Image into the SAMA5D2 Xplained Ultra Board

This section describes the steps to prepare the Board Support Package for SAMA5D2 Xpalined Ultra Board. The package includes Bootstrap, u-boot, env file, Root File System (RFS), device tree blob (dtb) and kernel image with WILC driver support to interface WILC devices to SAMA5D2 Xplained Ultra Board.

SAMA5D2 Xplained Ultra Board have 1 SD card slot. By making the board boot from embedded Multi-Media Controller (eMMC), we will interface the WILC SD card device into the available SD card slot.

3.1 Build Binaries form Source code

This section describes, downloading the sources for Bootstrap, u-boot, kernel and RFS and configuring them to boot from eMMC.

3.1.1 AT91Bootstrap

Perform the following steps to build the AT91Bootstrap.

1. Setup ARM Cross Compiler:
   - In Ubuntu, install the ARM Cross Compiler by using the following command:

     ```
     $ sudo apt-get install gcc-arm-gnueabi
     ```

   - Export the cross compiler path to terminal by using the following command:

     ```
     $ export CROSS_COMPILER=arm-linux-gnueabi-
     ```

2. To get the source code, clone the repository by using the following command:

   ```
   $ git clone git://github.com/linux4sam/at91bootstrap.git
   ```

3. After downloading the at91bootstrap move to the cloned directory by using the following command:

   ```
   $ cd at91bootstrap/
   ```

4. After moving into the AT91Bootstrap root directory, you will find a `board/sama5d2_xplained` folder which contains several default configurations files. To make the bootstrap to load the u-boot from the eMMC, configure the bootstrap with the `sama5d2_xplainedemmc_uboot_defconfig` file.

   ```
   make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- sama5d2_xplainedemmc_uboot_defconfig
   ```

   After successful completion of the configuration process the `.config` file is available in AT91Bootstrap root directory.

5. Build the Bootstrap binary by executing the following code:

   ```
   $ make
   ```

   This generates the `sama5d2_xplained-sdcardboot-uboot-3.9.1.bin` file in the binaries directory.

6. For the boot ROM code to recognize the valid boot code in the SD card or eMMC, rename the `sama5d2_xplained-sdcardboot-uboot-3.9.1.bin` AT91bootstrap file to `BOOT.BIN`

3.1.2 Build U-Boot from Sources

Perform the following steps to build the u-boot.

Note: Make sure to install the mkenvimage tool on the Linux machine.

1. Export the cross compiler toolchain path, using the following command:

   ```
   export CROSS_COMPILER=arm-linux-gnueabi-
   ```

2. Clone the Linux4sam GitHub U-Boot repository, enter in to the cloned directory using the following command:

   ```
   $ git clone git://github.com/linux4sam/u-boot-at91.git
   ```

3. Move to the u-boot-at91 directory, using the following command:

```
$ cd u-boot-at91
```

4. Switch to a new branch `u-boot-2018.07-at91`, using the following commands:

```
$ git branch -r
$ git checkout origin/u-boot-2018.07-at91 -b u-boot-2018.07-at91
```

5. The configs/ directory lists many defconfig files. Use the `sama5d2_xplained_mmc_defconfig` file to configure the u-boot by using the following command:

```
$make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- sama5d2_xplained_mmc_defconfig
```

6. Open the `u-boot-at91/include/configs/sama5d2_xplained.h` file and modify the definitions for `FAT_ENV_DEVICE_AND_PART` and `CONFIG_BOOTCOMMAND`, using the following commands:

```
/*bootstrap + u-boot + env in sd card */
#undef FAT_ENV_DEVICE_AND_PART
#undef CONFIG_BOOTCOMMAND
#define FAT_ENV_DEVICE_AND_PART    "0"
#define CONFIG_BOOTCOMMAND         "fatload mmc 0:1 0x21000000 at91-sama5d2_xplained.dtb; " \
                                   "fatload mmc 0:1 0x22000000 zImage; " \
                                   "bootz 0x22000000 - 0x21000000"
#undef CONFIG_BOOTARGS
#define CONFIG_BOOTARGS            "console=ttyS0,115200 earlyprintk root=/dev/mmcblk0p2 rw rootwait"
#elif CONFIG_SPI_BOOT
```

7. Build the u-boot binary, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi-
```

   – The result of these operations is a fresh U-Boot binary called `u-boot.bin` corresponding to the binary ELF file `u-boot`.
     - `u-boot.bin` file will be created in `u-boot-at91` directory.
     - `u-boot` is the ELF format binary file can be used to debug U-Boot through a JTag link.

8. Create a text file named `u-boot-env.txt` in any directory with the u-boot environment variables mentioned below:

```
bootargs=console=ttyS0,115200 root=/dev/mmcblk0p2 rw rootfstype=ext4 rootwait
bootcmd=fatload mmc 0:1 0x21000000 at91-sama5d2_xplained.dtb; fatload mmc 0:1 0x22000000
zImage; bootz 0x22000000 - 0x21000000
bootdelay=1
ethact=gmac0
stderr=serial
stdin=serial
stdout=serial
```

9. Move to the direcrory and enter the following command to generate `uboot.env` file from the previously created `u-boot-env.txt` file.

```
$ mkenvimage -s 0x2000 -o uboot.env u-boot-env.txt
```

3.1.3 Building Kernel Image

Perform the following steps to build the kernel.

1. Clone the Linux4sam GitHub linux-at91 kernel repository by using the following command:

```
$ git clone https://github.com/linux4sam/linux-at91.git
```

2. Move to the kernel directory and export the toolchain path by using the following command:

```
export CROSS_COMPILE=arm-linux-gnueabi-
```

3. Configure the kernel by using the following commands:

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- sama5_defconfig
```

4. Modify the default kernel configuration using the menuconfig. Use the following command to execute:

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabihf- menuconfig
```

5. Select the ATWILC driver module, from the GUI selection window:
   5.1. Go to **Device Drivers** > **Staging driver**
   5.2. Press '**M**' to modularize **WILC SDIO** to include the module during run time.
   5.3. Save the configuration.
6. Include the cfg80211 module as an inbuilt module to kernel, from the GUI selection window:
   6.1. Go to **Networking support** > **wireless**.
   6.2. Press ***** to include the **cfg80211 – wireless configuration API module** to kernel.
   6.3. Save the configuration.
7. Build the kernel, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- zImage
```

   zImage is available in `arch/arm/boot` directory.
8. Build the modules, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- modules
```

   The file `wilc-sdio.ko` will be available in `driver/staging/wilc1000` directory.
9. Build the `.dtb` file, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- at91-sama5d2_xplained.dtb
```

   The `at91-sama5d2_xplained.dtb` file is available in `arch/arm/boot/dts` folder.

3.1.4 Building Root File System

In this section use the buildroot as the build system to build the rootfs. By considering its simplicity, efficiency and easiness to generate embedded linux systems through cross-compilation the user can opt for buildroot framework. Microchip's linux4sam website provide the source code for the buildroot and another external microchip repository which contain necessary defconfig file through which the user is benefited in configuring the buildroot to meet the requirement.

3.1.4.1 Get Sources

To get the source code, clone the buildroot-at91 and buildroot-external-microchip repositories using the following steps:

1. Clone the buildroot-at91 repository by using the following command:

```
$ git clone https://github.com/linux4sam/buildroot-at91.git
```

2. Clone the buildroot-external-microchip repository by using the following command:

```
$ git clone https://github.com/linux4sam/buildroot-external-microchip.git
```

Notes:

- The source code is taken from the `master` branch which is pointing to the latest version of buildroot-at91 and buildroot-external-microchip. The advice is to use linux4sam tags to make sure there is no mismatch between the versions of the two repositories.
- The buildroot tag used for testing in this document is `linux4sam_6.2`

```
$ cd buildroot-external-microchip
$ git tag | grep linux4sam
linux4sam_5.8
linux4sam_5.8-rc1
linux4sam_5.8-rc2
linux4sam_6.0
linux4sam_6.0-rc1
[…..]
linux4sam_6.1
linux4sam_6.1-rc1
linux4sam_6.1-rc2
linux4sam_6.1-rc3
linux4sam_6.1-rc4
linux4sam_6.1-rc5
linux4sam_6.2
$ git checkout linux4sam_6.2 -b buildroot-external-microchip- linux4sam_6.2
Switched to a new branch 'buildroot-external-microchip-linux4sam_6.2
$ cd ../buildroot-at91/
$ git tag | grep linux4sam
linux4sam_5.8
linux4sam_5.8-rc1
linux4sam_6.0
linux4sam_6.0-rc1
linux4sam_6.0-rc2
linux4sam_6.0-rc3
linux4sam_6.1
linux4sam_6.1-rc1
linux4sam_6.2
linux4sam_6.2-icp
linux4sam_6.2-icp-rc1
linux4sam_6.2-rc1
$ git checkout linux4sam_6.2 -b buildroot-at91-linux4sam_6.2
Switched to a new branch 'buildroot-at91-linux4sam_6.2'
```

3.1.4.2 Configuring the Buildroot

In Buildroot root directory, there is `configs` directory which containing several default configurations. The buildroot-external-microchip repository provides extra defconfigs in its own `configs` directory. Use `BR2_EXTERNAL` file to configure the buildroot with the defconfig file available in the externel tree.

Use the following command to configure the buildroot and generate a `.config file`.

```
$ BR2_EXTERNAL=../buildroot-external-microchip/ make sama5d2_xplained_graphics_defconfig
```

3.1.4.3 Customize Buildroot by Adding Additional Modules

To modify the buildroot configuration or to add additional modules into the buildroot, use the menuconfig command. The menuconfig is a Graphical User Interface utility through which the user can modify the buildroot configuration.

Use the following command to modify the buildroot configuration:

```
$ BR2_EXTERNAL=../buildroot-external-microchip/ make menuconfig
```

3.1.4.4 Including wpa_cli for Station Connectivity

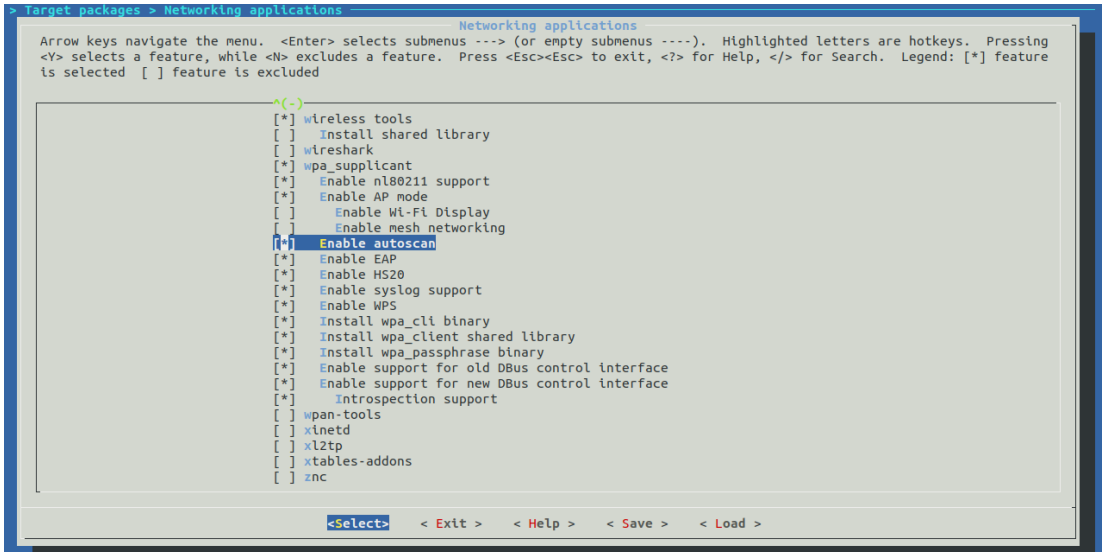
To include the wpa-cli into the buildroot package, include the modules by selecting 'Y' in the following location:

Target packages > Networking applications.

- Enable autoscan
- Enable EAP
- Enable HS20
- Enable syslog support
- Enable WPS

- Install wpa_cli binary
- Install wpa-client shared library
- Install wpa_passphrase binary
- Enable support for old DBus control interface
- Enable support for new DBus control interface
- Introspection support

Figure 3-1. Networking Application Modules



3.1.4.5 Initiate the Build

After adding all the necessary modules into the buildroot, initiate the build. Execute `make` command in the buildroot-at91 and it will generate the `rootfs.tar` file with all the modules included, refer the following steps:

1. Open the terminal and move to **Buildroot_6.2** > **buildroot-at91** directory
2. Execute `make` command in the buildroot-at91.
3. Make sure the Linux host machine is connected to internet before the build is initiated. The build will take quite few hours to complete.
4. After the build is complete, it will generate the `rootfs.tar` file in the directory with all the modules included. **Buildroot_6.2 > buildroot-at91 > output >image**

3.1.4.6 Saving the Changes

Once all the necessary modules are added into the buildroot, save the changes in order to add the modules into the package. Refer the following steps:

1. To save the changes, navigate and select the save option and press OK
2. Click on Exit.

3.2 Creating an Image for SAMA5D2_Xplained to Boot using eMMC

A single bootable image is required to write on eMMC of the SAMA5D2 Xplained target. This image must contain all the previous images (AT91bootstrap, u-boot, env file, device tree blob(dtb), kernel and rootfs). To create the image, perform the following steps.

1. Create a directory called test under home directory. Create a dummy image file `sdcard.img`, using the following command:

```
$sudo dd if=/dev/zero of=<path>/test/sdcard.img bs=2G count=1
$ls -al
```

2. Move to the `test` directory and partition the image file with two partitions, using the following commands:

```
$sudo fdisk sdcard.img
Welcome to fdisk(util-linux 2.27.1).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Device does not contain a recognized partition table.
Created a new DOS disklabel with disk identifier 0x24d68b30.

Command (m for help): n
Partion type
 p primary (0 primary, 0 extended, 4 free)
 e extended (container for logical partions)
Select (default p): p
Partition number (1-4, default 1):
First sector (2048-4194295, default 2048):
Last sector, +sectors or +size{K,M,G,T,P} (2048-4194295, default 4194295):+64M

Created a new partition 1 of type 'Linux' and of size 64 MiB.
Command (m for help): t
Selected partion 1
Hex code (type L to list all codes): b
Changed type of partition 'Linux' to 'W95 FAT32'.


Command (m for help): n
Partion type
 p primary (1 primary, 0 extended, 3 free)
 e extended (container for logical partitions)
Select (default p):


Using default response p.
Partition number (2-4, default 2):
First sector (133120-4194295, default 133120):
Last sector, +sectors or +size{K,M,G,T,P} (133120-4194295, default4194295):

Created a new partition 2 of type 'Linux' and of size 2 GiB.

Command (m for help): w
The partition table has been altered.
Syncing disks.
```

Two partitions in `sdcard.img` file are created successfully.

3. Mount the two partitions on two loop devices, using the following commands:

```
$sudo losetup /dev/loop20 sdcard.img -o 1048576
$sudo losetup /dev/loop21 sdcard.img -o 68157440
```

Notes:

- The numbers 1048576 and 68157440 are the offsets of the partitions.
- Before using the loop device kindly check whether the loop device is already assigned. If the loop device is already taken the following error is displayed:

```
losetup: sdcard.img: failed to set up loop device: Device or resource busy
```

4. To resolve the error, use the following command to check the loop device is already in use or not:

```
$ losetup -a
```

5. If the loop device is already in use, unmount it by using `umount` command or use a different loop device. The partition can be verified by using the following command:

```
fdisk -l sdcard.img
Disk sdcard.img: 2 GiB, 2147479552 bytes, 4194296 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x7d182fdd

Device                                Boot   Start   End Sectors  Size  Id  Type
```

```
sdcard.img1                             2048   133119  131072       64M   b   W95 FAT
sdcard.img2                             133120 4194295 4061176      2G    83  Linux
```

Here, the first partition starts at "2048" location and its physical location is (512 bytes * 2048) 1048576.

Similarly, the second partition starts at "133120" location and its physical location is (512 bytes * 133120) 68157440.

6. Format the partitions that are mounted on the loop devices, using the following commands:

```
$sudo mkfs.vfat /dev/loop20
$sudo mkfs.ext4 /dev/loop21
```

7. Create two temporary folders and mount each partition (FAT32 and EXT4) on the folders, using the following commands:

```
$ mkdir emmcmntp1
$ mkdir emmcmntp2
$ sudo mount -o loop,offset=1048576 sdcard.img emmcmntp1
$ sudo mount -o loop,offset=68157440 sdcard.img emmcmntp2
```

Note: If the loop device is wrongly chosen, the following error will be displayed during mounting the loop device.

```
mount: emmcmntp1: overlapping loop device exists for /<path>/sdcard.img
```

If we proceed further without fixing the cause, even after copying the FAT partition modules, in the final image FAT partition will be still empty. The solution for this issue is to select the proper loop device.

8. In the first partition (FAT32), copy the AT91bootstrap, u-boot, uboot.env, kernel and dtb files, using the following commands:

```
$ cd emmcmntp1
$ sudo cp <path>at91bootstrap/binaries/BOOT.bin .
$ sudo cp <path>u-boot-at91/u-boot.bin .
$ sudo cp <path>uboot.env .
$ sudo cp <path>linux-at91/arch/arm/boot/zImage .
$ sudo cp <path>linux-at91/arch/arm/boot/dts/at91-sama5d2_xplained.dtb .
```

9. In the second partition (EXT4), copy the rootfs already built in 3.1.4 Building Root File System, using the following commands:

```
$ cd ../emmcmntp2
$ sudo tar -xvf <path>rootfs.tar .
```

10. Unmount the temporary mount points emmcmntp1, emmcmntp2, and loop device using the following commands:

```
$ cd ..
$ sudo umount emmcmntp1 emmcmntp2
$ sudo losetup -d/dev/loop20
$ sudo losetup -d/dev/loop21
```

3.3 Install the Demo Image on the SAMA5D2 Xplained eMMC

Prerequisite:

- Power up the SAMA5D2 Xplained Ultra board by connecting a micro USB cable at J23.
- Connect the FTDI cable to the Debug connector (J1).
  Note: Do not use J14 connector to receive debug messages.
- Download the SAM-BA® 3.2.1 for Linux software from github.com/atmelcorp/sam-ba/releases/tag/v3.2.0.
- Close the jumper JP9, press the **Reset** button and open the jumper.
- Create a `emmc-usb.qml` file and add the following:

```
import SAMBA 3.2
import SAMBA.Connection.Serial 3.2
import SAMBA.Device.SAMA5D2 3.2

SerialConnection {
device: SAMA5D2Xplained {
```

```
}

onConnectionOpened: {
// initialize SD/MMC applet
initializeApplet("sdmmc")

// write file
applet.write(0, "sdcard.img", false)

// initialize boot config applet
initializeApplet("bootconfig")

// Use BUREG0 as boot configuration word
applet.writeBootCfg(BootCfg.BSCR, BSCR.fromText("VALID,BUREG0"))

// Enable external boot only on SDMMC0
applet.writeBootCfg(BootCfg.BUREG0,
BCW.fromText("EXT_MEM_BOOT,UART1_IOSET1,JTAG_IOSET1," +
"SDMMC0,SDMMC1_DISABLED,NFC_DISABLED," +
"SPI1_DISABLED,SPI0_DISABLED," + "QSPI1_DISABLED,QSPI0_DISABLED"))
}
}
```

- Place the `emmc-usb.qml` file in the same directory as the `sdcard.img` is located. Run the `emmc-usb.qml` script, using the following command:

```
$sudo su
$ <path>sam-ba -x emmc-usb.qml
```

Note: This process takes several minutes to complete. The `sdcard.img` is installed on the SAMA5D2 Xplained eMMC and after the flashing is complete, debug messages are sent via J1 port through FTDI cable.

3.4 Initializing the WILC Device

- Insert the WILC1000 sd card device into the SD Card slot.
- Copy the wilc-sdio.ko (drivers/staging/wilc) to the rootfile system using USB mass storage drive using the following commands:

```
$ mount /dev/sda1 /mnt
$ cp /mnt/wilc-sdio.ko .
```

- Initialize the WILC device by inserting the `wilc-sdio.ko` module using the following command:

```
$ insmod wilc-sdio.ko
```

After successful completion of the process, wlan0 interface is up and running.

4. Building and Flashing the System Image into the SAMA5D3 Xplained Board

This section describes the steps to interface WILC1000 device with SAMA5D3 Xplained Board. Interfacing steps mentioned here are applicable for WILC3000 device as well.

SAMA5D3 Xplained has one SD card slot available on the board. This SD card slot can be used to interface the WILC SD card device while making the board boot from the NAND Flash. Start with preparing the board support package by building necessary components required to boot the board from NAND Flash and include WILC driver support.

4.1 Download the Demo Package

The demo package contains all the prebuild components required to boot up the board. The demo package includes Bootstrap, u-boot, u-boot env file, itb (zImage & dtb) and other files required to flash the package to board.

The support for the WILC device is not added to the default demo package. To include the WILC driver support or to make the board boot from the desired kernel version, build a new kernel image (with WILC driver support included), device tree blob(dtb) file and replace it with the existing files in demo package. The demo package contains the `sama5d3_xplained.itb` file, which is the combination of zImage and dtb file.

Download the Yocto Project/ Poky based demo package for NAND Flash from the demo archive section in www.linux4sam.org/bin/view/Linux4SAM/Sama5d3XplainedMainPage

Note: The demo package version used during the preparation of this document is `linux4sam-poky-sama5d3_xplained-headless-6.2.zip`.

4.2 Building the component

The demo package is built for booting from NAND Flash memory. The bootstrap and u-boot available in the demo package are configured to boot from the NAND Flash. To add the WILC support, a new kernel image need to be built by including WILC driver support and WILC module (`.ko`) file needs to be generated. In the demo package, the kernel image is present in the Image Tree Blob (`.itb`) format is the combination of zImage and dtb file

4.2.1 Getting DT-Overlay Sources

- Clone the Linux4sam GitHub DT Overlay repository by using the following command:

```
$ git clone git://github.com/linux4sam/dt-overlay-at91.git
```

- To build the overlays for a board make sure the following steps are followed:
  - The environment variables `ARCH` and `CROSS_COMPILE` are set correctly.
  - The environment variable present in the Makefile: `KERNEL_DIR` should point to Linux kernel. For this to happen, first clone the kernel and build the zImage and dtb file by including the WILC Driver support and during the DT-Overlay build, provide the path to the kernel and it uses this newly build zImage and dtb file to create the Image Tree Blob (`.itb`) file.

4.2.2 Adding WILC Driver Support to Kernel

- Clone the Linux4sam GitHub linux-at91 kernel repository by using the following command:

```
$ git clone https://github.com/linux4sam/linux-at91.git
```

- Move to the kernel directory and export the toolchain path by using the following command:

```
export CROSS_COMPILE=arm-linux-gnueabi-
```

- Configure the kernel by using the following command:

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- sama5_defconfig
```

- Modify the default kernel configuration using the following menuconfig command:

```
make ARCH=arm CROSS_COMPILE=arm-linux-gnueabihf- menuconfig
```

- Select the ATWILC driver module, from the GUI selection window:
  5.1. Navigate to **Device Drivers** > **Staging driver**.
  5.2. Press **M** to modularize **WILC SDIO** to include the module during runtime.
  5.3. Save the configuration.
- Include the cfg80211 as an inbuild module to kernel, from the GUI selection window by performing the following steps:
  6.1. Navigate to **Networking support** > **wireless**.
  6.2. Press ***** to include the **cfg80211 – wireless configuration API module** to kernel.
  6.3. Save the configuration.
- Build the kernel, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- zImage
```

  Note: zImage is available in *arch/arm/boot directory*.
- Build the modules, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- modules
```

  Note: `wilc-sdio.ko` file is available in *driver/staging/wilc1000 directory*.
- Build the `.dtb` file, using the following command:

```
$ make ARCH=arm CROSS_COMPILE=arm-linux-gnueabi- at91-sama5d3_xplained.dtb
```

  Note: The `at91-sama5d3_xplained.dtb` file is available in *arch/arm/boot/dts directory*.

4.2.3 Build DT- Overlay

By default, `KERNEL_DIR` in the Makefile is set to a `linux` directory that would be under the parent directory in the directory tree that is `../linux`. Change it and provide the path to the newly build kernel to this variable `KERNEL_DIR`. Our newly build zImage and dtb file are available in this kernel.

This is needed because the DT Overlay repository uses the Device Tree Compiler (DTC) from the kernel source tree.

Build the Image Tree Blob (`.itb`) file using the following commands:

```
$ make sama5d3_xplained_dtbos
$ make sama5d3_xplained.itb
```

The process will generate `sama5d3_xplained.itb` file and is available in the dt-overlay-at91 directory.

4.3 Flashing the Package to SAMA5D3 Board

Replace the existing `sama5d3_xplained.itb` file in the downloaded demo package with the newly build Image Tree Blob (`.itb`) file. This newly build Image Tree Blob (`.itb`) file have the support for the WILC devices. Refer to the following steps:

1. Download the SAM-BA Flashing tool from: https://github.com/atmelcorp/sam-ba/releases
2. Open the `demo_linux_nandflash.sh` file and provide the SAM-BA path in this file for flashing.
3. Connect a USB Cable to the J6 port.
4. Open JP5 to disable NAND Flash memory access.
5. Press **BP2 reset** button to boot from on-chip Boot ROM.
6. Close JP5 to enable NAND Flash memory access.
7. Run the `demo_linux_nandflash.sh` file by using the following command:

```
sudo sh demo_linux_nandflash.sh
```

8. This script runs SAM-BA 3 and the associated QML sam-ba script (`demo_linux_nandflash_usb.qml`) with proper parameters.

9. At the end of the flashing process, the following message is displayed:

```
-I- === Done. ===
Connection closed.
```

Note: The process will take a few minutes to finish.

10. To see the terminal logs, connect a FTDI cable to the DEBUG J23 port. *A /dev/ttyUSB0* node has been created.
11. Open the favorite terminal emulator with appropriate settings.

4.4 Booting the SAMA5D3 Xplained Board

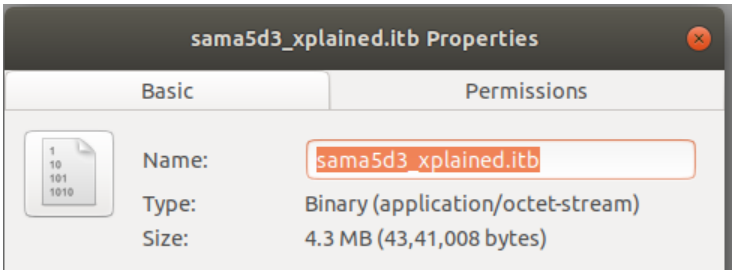
4.4.1 Change the Kernel Size in U-Boot

The size of the newly build kernel will be different from the kernel size set in the u-boot environment variable and without changing the kernel size, the booting process will look for kernel image in wrong location and will fail to fetch the kernel image.

Update the new kernel image size in the u-boot environment variable bootcmd. Refer the following steps:

- Right click the Image Tree Blob (`.itb`) file and select properties to see the size, refer the following image for details:

Figure 4-1. SAMA5D3 Xplained Properties



- Convert the bytes to Hexadecimal number.
  For Example: Hexadecimal value: 423D10
- Interrupt the booting process at u-boot and edit the bootcmd variable and change the kernel image size by using the following command:

```
=> edit bootcmd
```

  Update the size mentioned in the `bootcmd` variable with the previously converted size:

```
edit: nand read 0x24000000 0x00180000 0x423D10; bootm 0x24000000#kernel_dt
```

- Save the changes by using the following command:

```
=> saveenv
```

  The following is the reply displayed after executing `=> saveenv` command:

```
Saving Environment to NAND
Erasing NAND
Erasing at 0x140000 -- 100% complete.
Writing to NAND OK
OK
```

- Boot the board by using the following command:

```
=> boot
```

4.5 Initializing the WILC Device

- Insert the WILC1000 SD Card device into the SD Card slot.
- Copy the `wilc-sdio.ko` (*drivers/staging/wilc*) to the rootfile system using USB mass storage drive by using the following commands:

```
$ mount /dev/sda1 /mnt
$ cp /mnt/wilc-sdio.ko .
```

- Initialize the WILC device by inserting the `wilc-sdio.ko` module using the following command:

```
$insmod wilc-sdio.ko
```

Note: After successful completion of the process the wlan0 interface is up and starts running.

5. Building and Flashing the System Image into the SAMA5D27-SOM1-EK1

This section provides the instructions to build the components for running Linux on the SAMA5D27-SOM1-EK1 board. This setup is configured to boot from the micro-SD card slot which leaves the standard SD card slot open for the ATWILC1000 SDIO board.

In this section the buildroot is used as the build system to build the SD Card image. By considering its simplicity, efficiency and easiness to generate embedded linux systems through cross-compilation is then reason for the selection of buildroot framework. Microchip's linux4sam website provide the source code for the buildroot and another external microchip repository which contain necessary defconfig file through which we can benefit in configuring our buildroot to meet our requirement

5.1 Buildroot

5.1.1 Get Sources

To get the source code, clone the buildroot-at91 and buildroot-external-microchip repositories. Refer the following steps for details:

- Clone the buildroot-at91 repository by using the following commands:

```
$ git clone https://github.com/linux4sam/buildroot-at91.git
```

- Clone the buildroot-external-microchip repository by using the following command:

```
$ git clone https://github.com/linux4sam/buildroot-external-microchip.git
```

- The source code is taken from the `master` branch which is pointing to the latest version of buildroot-at91 and buildroot-external-microchip. Use linux4sam tags to make sure that there is no mismatch between the versions of the two repositories.
  Note: The buildroot tag used for testing in this document is `linux4sam_6.2`

```
$ cd buildroot-external-microchip
$ git tag | grep linux4sam
linux4sam_5.8
linux4sam_5.8-rc1
linux4sam_5.8-rc2
linux4sam_6.0
linux4sam_6.0-rc1
[…..]
linux4sam_6.1
linux4sam_6.1-rc1
linux4sam_6.1-rc2
linux4sam_6.1-rc3
linux4sam_6.1-rc4
linux4sam_6.1-rc5
linux4sam_6.2
$ git checkout linux4sam_6.2 -b buildroot-external-microchip- linux4sam_6.2
Switched to a new branch 'buildroot-external-microchip-linux4sam_6.2
$ cd ../buildroot-at91/
$ git tag | grep linux4sam
linux4sam_5.8
linux4sam_5.8-rc1
linux4sam_6.0
linux4sam_6.0-rc1
linux4sam_6.0-rc2
linux4sam_6.0-rc3
linux4sam_6.1
linux4sam_6.1-rc1
linux4sam_6.2
linux4sam_6.2-icp
linux4sam_6.2-icp-rc1
linux4sam_6.2-rc1
$ git checkout linux4sam_6.2 -b buildroot-at91-linux4sam_6.2
Switched to a new branch 'buildroot-at91-linux4sam_6.2'
```

5.2 Configuring the Buildroot

In Buildroot root directory, there is `configs` directory containing several default configurations. The buildroot-external-microchip repository provides extra defconfigs in its own `configs` directory. All these defconfigs target the SD card as boot media.

Configure the buildroot with the defconfig file present in the external tree using BR2_EXTERNAL. Refer the following command for details:

```
$ BR2_EXTERNAL=../buildroot-external-microchip/ make sama5d27_som1_ek_graphics_defconfig
```

By configuring the buildroot with `sama5d27_som1_ek_graphics_defconfig` file, the WILC support will be included into the package. WILC driver support will be added to the kernel present at `buildroot-at91/output/build/linux-linux4sam_6.2/`.

The command will configure the buildroot and generate a `.config` file.

Additional modules to be added to the buildroot apart from what is included in the defconfig file use the following command and add necessary components into buildroot.

5.3 Customize Buildroot by Adding Additional Modules

To modify the buildroot configuration or to add additional modules into the buildroot, use the `menuconfig` command. The menuconfig is a GUI utility through which the user can modify the buildroot configuration. Refer the following command for details:

```
$ BR2_EXTERNAL=../buildroot-external-microchip/ make menuconfig
```

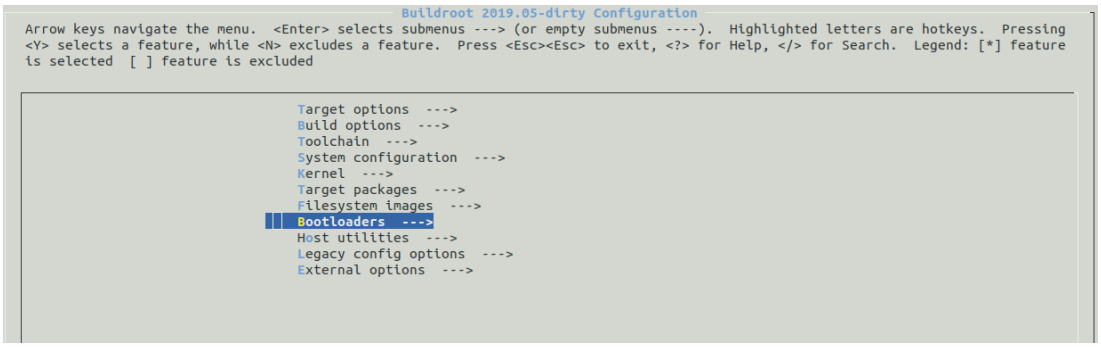
5.3.1 Configuration to Booting from Micro SD Card

To make the board boot from the Micro SD Card slot, the bootloaders like, bootstrap and u-boot need to be configured to make it boot from the mmc1 slot. Based on the configuration, the resultant `boot.bin` and `u-boot.bin` files will get configured to get it boot from the micro sd card slot. To achieve this, user needs to modify the default configurations like, version and defconfig file name.

5.3.1.1 Configuring Bootstrap

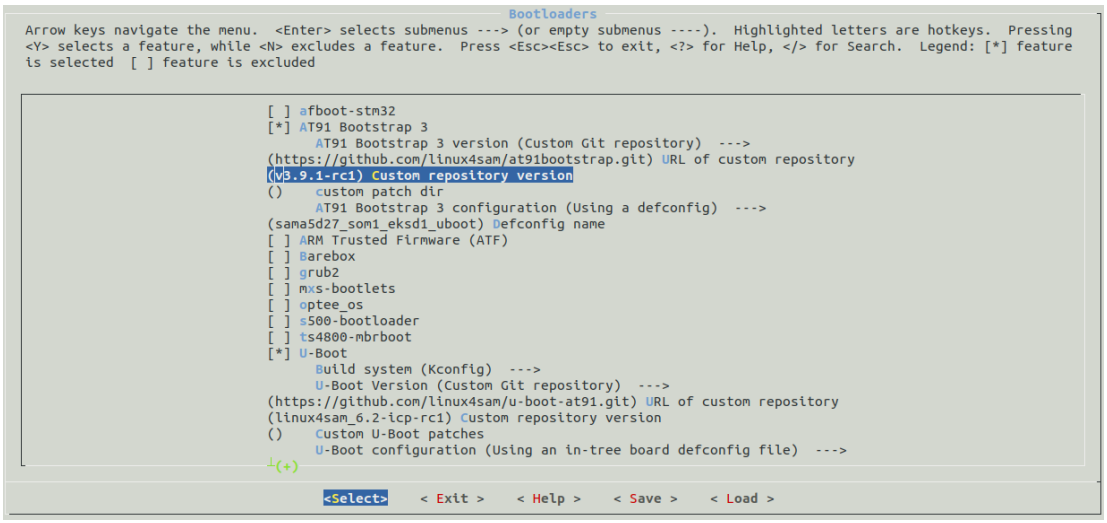
- Open Bootloaders session from the menuconfig, see the following image:

  Figure 5-1. Bootloaders



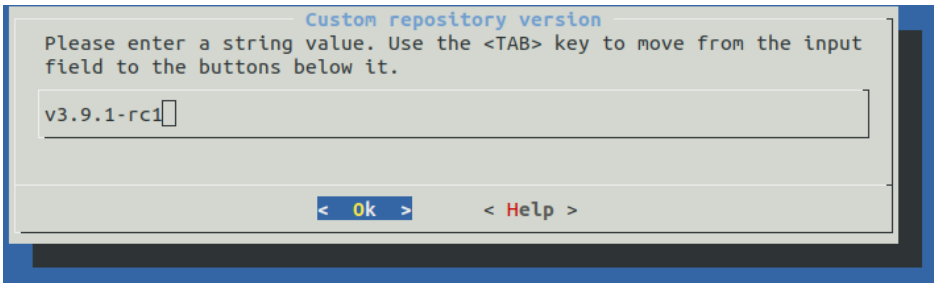
- Select the Bootstrap repository version.

Figure 5-2. Bootstrap Repository Version



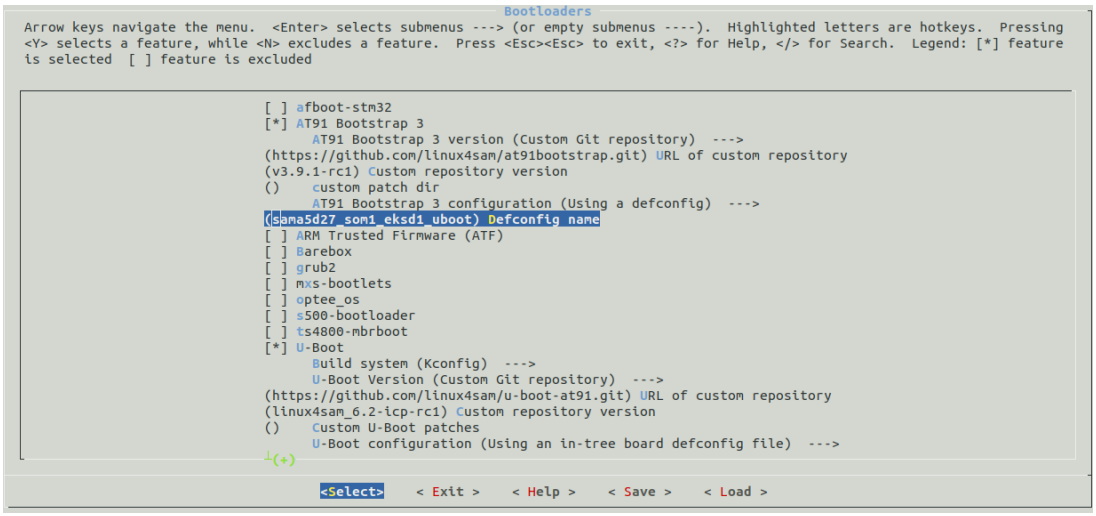
- Update the repository tag name to `v3.9.1-rc1`.

Figure 5-3. Custom Repository Version



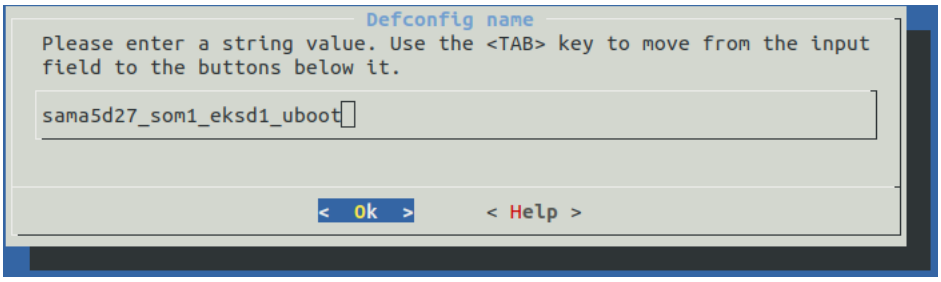
- Select the Bootstrap defconfig file name.

Figure 5-4. Bootstrap Defconfig File Name



- Update the Bootstrap defconfig file name to `sama5d27_som1_eksd1_uboot`.

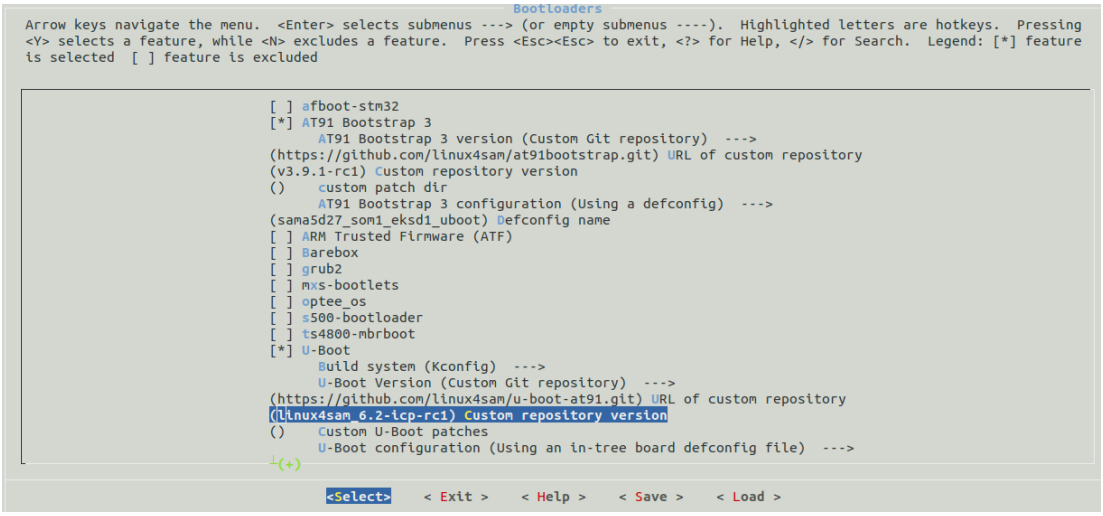
Figure 5-5. Update Bootstrap Defconfig File Name



5.3.1.2 Configuring U-Boot

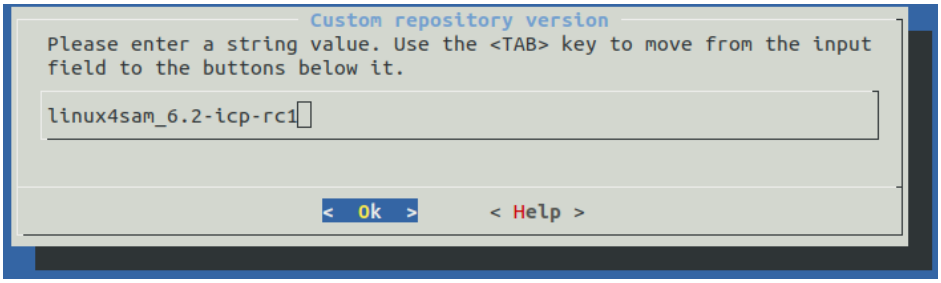
- Select the U-boot repository version.

Figure 5-6. U-boot Repository Version



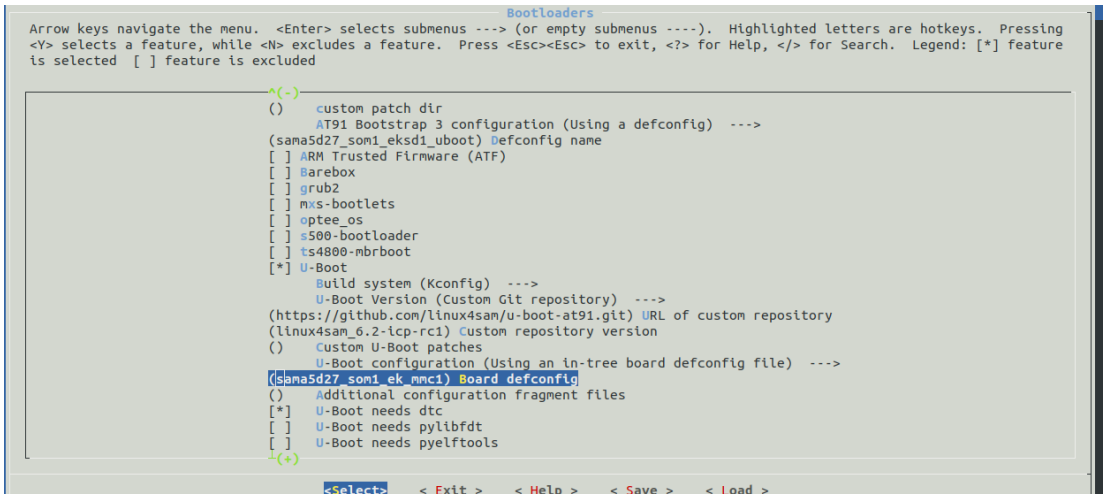
- Update the U-boot repository tag to `linux4sam_6.2-icp-rc1`.

Figure 5-7. Update U-boot Repository Version



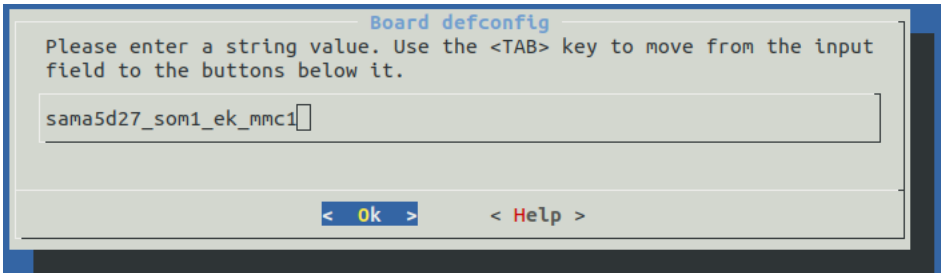
- Select the U-Boot defconfig configuration

Figure 5-8. U-Boot defconfig



- Update the u-boot defconfig file name to `sama5d27_som1_ek_mmc1`.

Figure 5-9. Update the U-boot Defconfig File Name



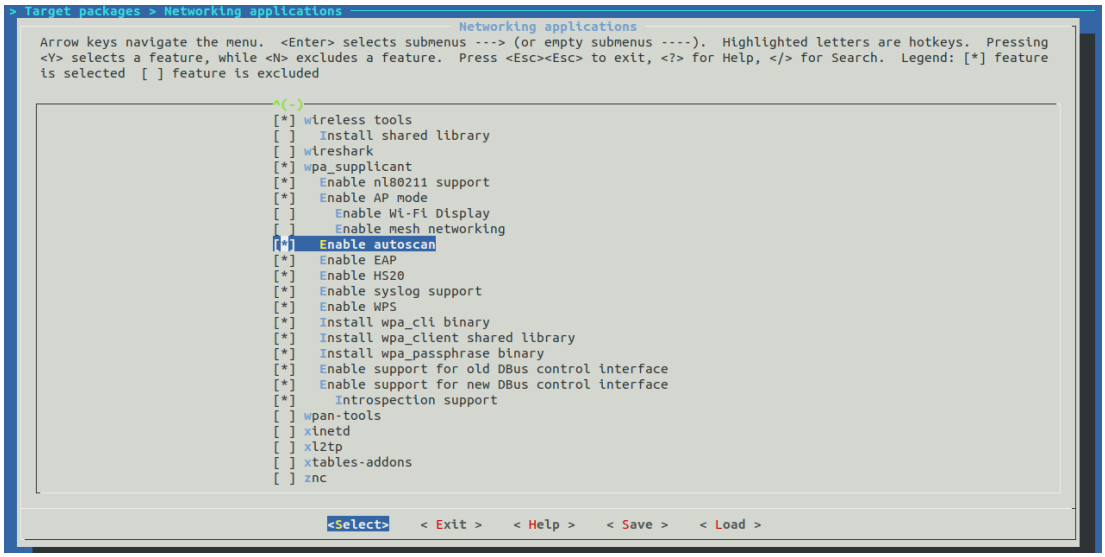
5.3.1.3 Including wpa_cli for Station Connectivity

To include the wpa-cli into the buildroot package, include the below modules by selecting Y in the location:

Target packages > Networking applications

- Enable autoscan
- Enable EAP
- Enable HS20
- Enable syslog support
- Enable WPS
- Install wpa_cli binary
- Install wpa-client shared library
- Install wpa_passphrase binary
- Enable support for old DBus control interface
- Enable support for new DBus control interface
- Introspection support

Figure 5-10. Networking Application Modules



5.3.1.4 Saving the Changes

Once all the necessary modules are added into the buildroot, save the changes in order to get the modules added into the package. Refer the following steps for details:

- To save the changes, navigate and select the save option and press OK.
- Exit after the save.

5.4 Building SD Card Image

After adding all the necessary modules into the buildroot, it is now time to build the SD Card image.

- Open the terminal and move to **Buildroot_6.2 à buildroot-at91** directory.
- Run `make` command in the buildroot-at91, generating the SD Card image with all the modules included.
- Make sure the Linux host machine is connected to internet before we initiate the build.
  Note: The build will take quite few hours to complete.
- After the build is complete, it will generate SD Card image(`sdcard.img`) in the directory `Buildroot_6.2 > buildroot-at91 > output > image`.

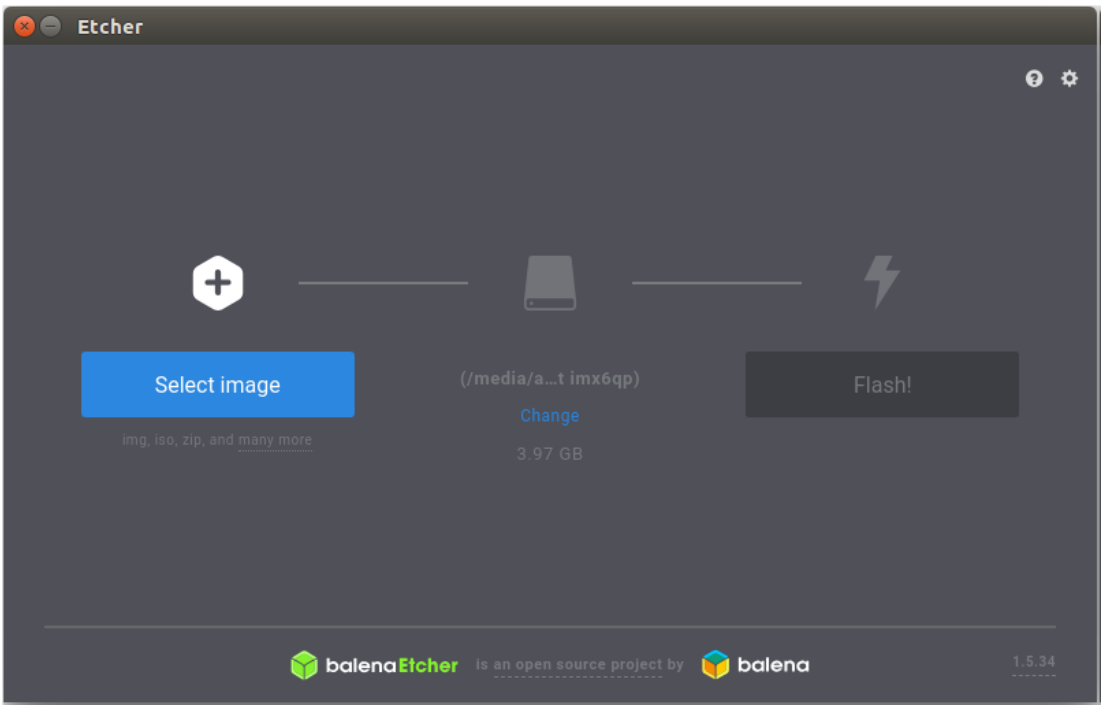
5.5 Flashing the SD Card Image Using Etcher

The SD card image (`.sdcard`) contains all the necessary modules required to boot up the board. The image can be flashed into the SD card using the Etcher application.

Download and install the Etcher application in the Linux host machine. The Etcher application is quite easy to use and Flashing using the Etcher requires the 2 following simple steps:

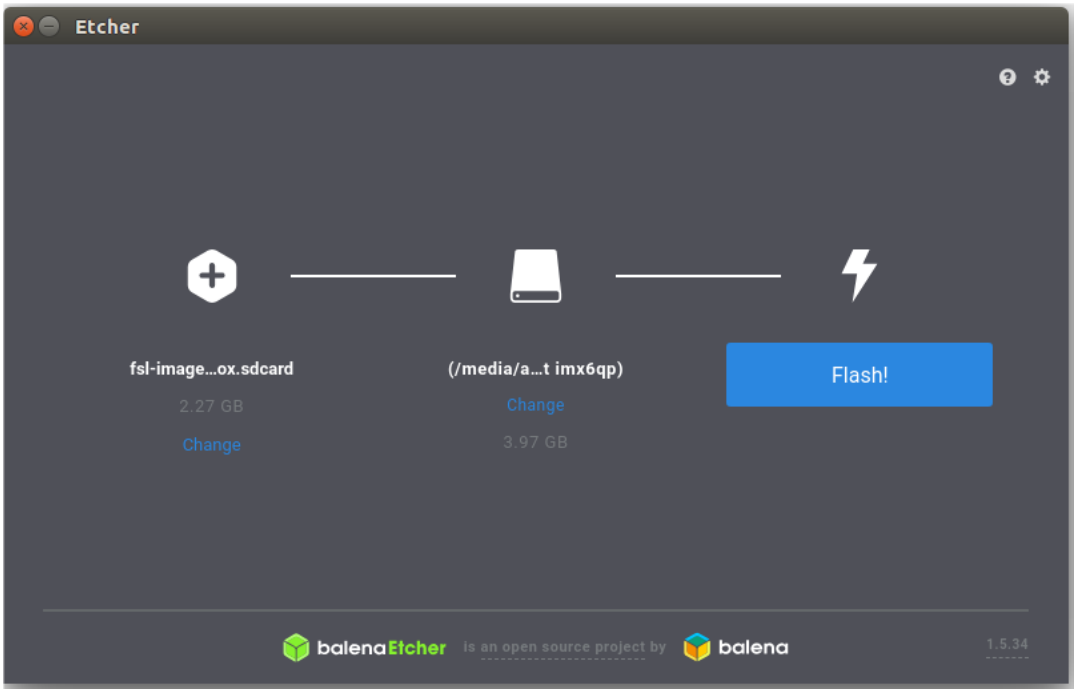
- Select the SD card image to Flash.

Figure 5-11. Image Selection



- Select Flash to download the image into SD card and select Flash option.

Figure 5-12. Flash Selection



5.6 Booting Up the Board

- After flashing, insert the SD Card into the micro sd cards slot.
- Connect micro usb cable to the j10 port. In the linux host machine, it will enumerate as /dev/ttyACM0.
- Open minicom and set up the settings.
- Press the **Reset** button on board.
- This time board will start to bootup. Interrupt at the u-boot timeout to make changes to the u-boot environment variables.
- Modify the two variables as shown:
  - bootargs: Change the `mmcblk0p2` to `mmcblk1p2` by using the following command:

    ```
    => edit bootargs
    ```

    Edit the response and change `mmcblk0p2` to `mmcblk1p2` by using the following command:

    ```
    edit: console=ttyS0,115200 root=/dev/mmcblk1p2 rw rootwait rootfstype=ext4
    atmel.pm_modes=standby,ulp1
    ```

  - bootcmd_boot: Change `mmc 0:1` to `mmc 1:1` by using the following command:

    ```
    => edit bootcmd_boot
    ```

    Edit the response and change `mmc 0:1` to `mmc 1:1` by using the following command:

    ```
    edit: fatload mmc 1:1 ${loadaddr} ${board_name}.itb; bootm ${loadaddr}#kernel_dtb$
    {at91_overlays_config};
    ```

  - Save environment by using the following command:

    ```
    => saveenv
    ```

    The following is the reply displayed after executing `=> saveenv` command:

    ```
    Saving Environment to FAT... OK boot
    ```

  - Boot the board by using the following command:

    ```
    => boot
    ```

    Note: For reference see the following image:

    ```
    => edit bootargs
    edit: console=ttyS0,115200 root=/dev/mmcblk1p2 rw rootwait rootfstype=ext4 atmel.pm_modes=standby,ulp1
    => edit bootcmd_boot
    edit: fatload mmc 1:1 ${loadaddr} ${board_name}.itb; bootm ${loadaddr}#kernel_dtb${at91_overlays_config};
    => saveenv
    Saving Environment to FAT... OK
    => boot
    ```

5.7 Initializing the WILC Device

- Insert the WILC1000 sd card device into the SD Card slot.
- Initialize the WILC device by inserting the `wilc-sdio.ko` module by using the following command:

  ```
  $ modprobe wilc-sdio.ko
  ```

- After successful completion, wlan0 interface is up and running.

5.8 WILC Support for Desired Kernel Version

By configuring the buildroot with `sama5d27_som1_ek_graphics_defconfig` file, WILC Driver support will be be added to the kernel image that generate along with the buildroot build and is available at `buildroot-at91/`

`output/build/linux-linux4sam_6.2/`. If the user needs control on the kernel version, then user should download the new kernel and build a new Image Tree Blob (`.itb`) file and replace the file present in the micro SD Card.

The procedure to build the Image Tree Blob (`.itb`) file with WILC driver support is previously discussed in the section 4.2 Building the component, the same procedure is applicable here as well.

6. Updating Binary and System Image into the Target Board

This section describes how to update or flash the system image. The pre-build images include pre-build driver and firmware binaries, which are available at GitHub.

The SAM-BA® tool is used to flash the binaries into the target board.
Note: Ensure that the SAM-BA tool is installed in the host machine before updating the system image. The scripts in the demo package use 3.2.x when user selects in step 5 of the following procedure.

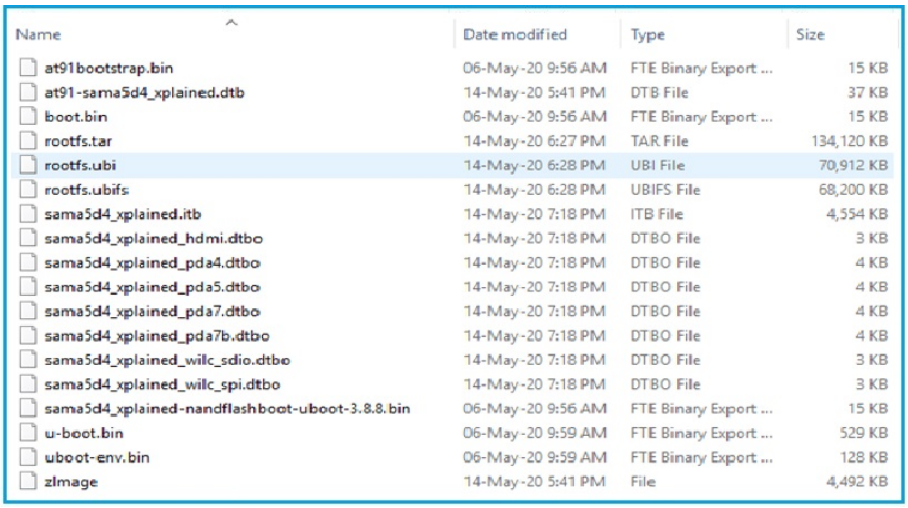
For additional information, refer to the following:

- Software Tools
- SAMA5D4 Xplained Board
- ATSAMA5D44 Microprocessor

To start flashing, perform the following steps:

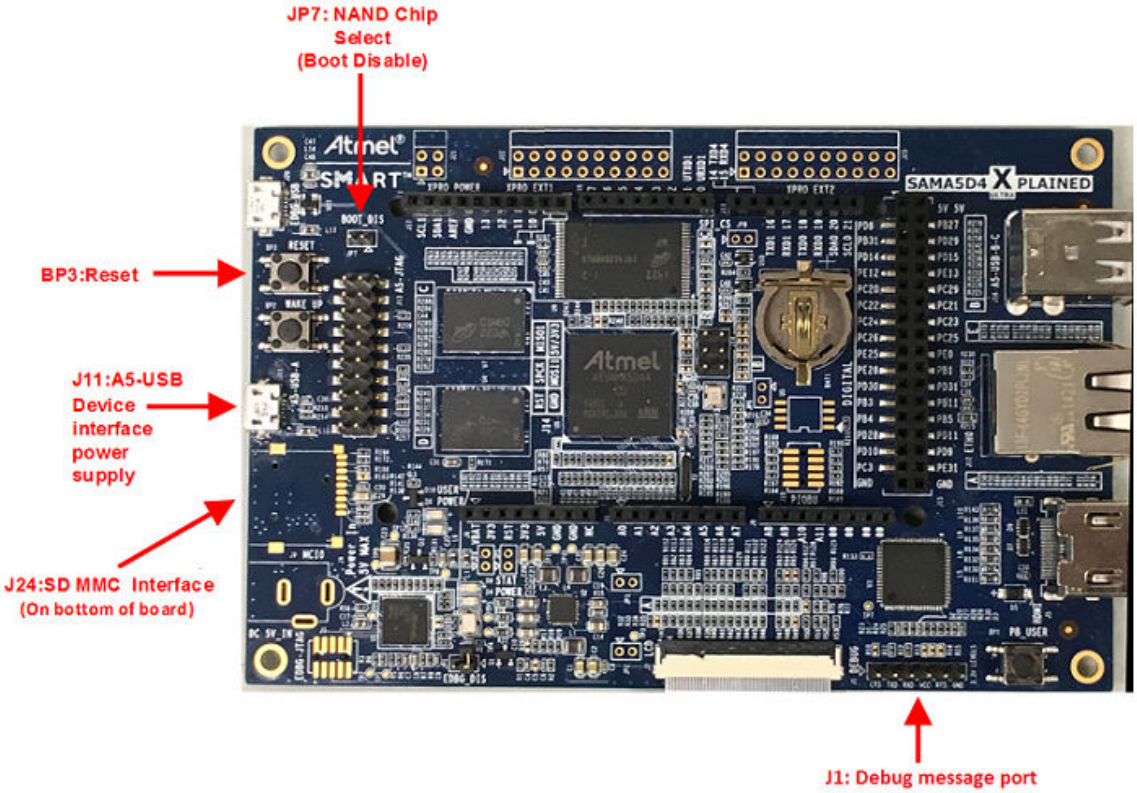
1. Download the pre-built images from github.com/linux4wilc/wilc_demo.
2. Unzip the downloaded file.
3. Once the new image is built as described in Chapter 2, Building Linux for SAMA5D4 Xplained Ultra Board, these files must be copied from the `buildroot-at91\output\images` directory to the directory where the `demo_linux_nandflash_usb.qml` file is available.

   Figure 6-1. List of Files in buildroot\output\images Location



4. Add the jumper at JP7 and connect to the host PC via the USB port at J11. Ensure that the host machine completes the USB serial port connection and then remove the jumper at JP7. The following figure shows the SAMA5D4 adapter connections.

Figure 6-2. SAMA5D4 Adapter Connections



5. Execute the `demo_linux_nandflash.bat` (for Windows®) file or the `demo_linux_nandflash.sh` (for Linux) file.
   Notes:
   - By default, the `demo_linux_nandflash.sh` file has `sam-ba` binary for 32-bit operating system. For 64-bit operating system, change the `sam-ba` to `sam-ba_64` in the same file.
   - Execute the script in the super user mode. If sam-ba 3.2 is installed, use `demo_linux_nandflash_3_2.bat` or `demo_linux_nandflash_3_2.sh` instead.

   The output log can be viewed via J1 serial port.
   Open the serial terminal on PC via the COM port, with the following configurations:
   - 115200 baud rate
   - 8-bit data
   - No parity
   - One stop bit
   - No flow control
6. Successful download of the system image into the board is indicated by a log file, which opens automatically. This log file contains all the download process history.

7. Updating ATWILC Firmware

This chapter describes how to update the ATWILC firmware or driver on the demo image.

7.1 ATWILC1000 and ATWILC3000 Driver Modules

After the system boots, add the ATWILC driver modules `wilc-sdio.ko`, or `wilc-spi.ko` to `/lib/modules/<kernel_release>/kernel/drivers/staging/wilc1000/` directory or copy to any location on the file system.

7.2 ATWILC1000 and ATWILC3000 Firmware Binaries

1. Add the ATWILC1000 firmware `wilc1000_wifi_firmware.bin` to the `/lib/firmware/mchp/` directory.
2. Add the ATWILC3000 Wi-Fi firmware, `wilc3000_wifi_firmware.bin` to the`/lib/firmware/mchp/` directory.
3. Add the ATWILC3000 Bluetooth® firmware, `wilc3000_ble_firmware.bin` to the `/lib/firmware/mchp/` directory.

Note: The firmware is available at https://github.com/linux4wilc/firmware.

The files can be transferred into the SAMA5D4 platform using any of the following methods:

- Ethernet
- ZMODEM

7.2.1 Adding Files Using Ethernet

The Local Area Network (LAN)/ Wide Area Network (WAN) can be used to transfer the file from one machine to another machine, using the following command:

```
$ scp [path of file to send] root@[receiver's IP]:[target directory]
```

For example, the following command sends the `wilc1000_wifi_firmware.bin` file from the binary directory to the `/lib/firmware/mchp` directory of the device using the internal IP address `192.168.0.11`.

```
$ scp binary/wilc1000_wifi_firmware.bin root@192.168.0.11:/lib/firmware/mchp
```

7.2.2 Adding Files using ZMODEM

The ZMODEM file transfer protocol also can be used to transfer the files.

In Teraterm, change the target location directory using the following command:

```
$ cd Target_location
```

Execute the ZMODEM command using the following command:

```
$ rz
```

In Teraterm, from the `File` menu, choose `Transfer` > `Send`, then browse and select the desired file.

8. Running ATWILC

This chapter describes how to use the ATWILC1000 and ATWILC3000 on the SAMA5D4 Xplained Board or any similar Linux platform.

8.1 Accessing the Console

The user can access the serial console through the on board serial-to-USB converter. In fact, the Embedded Debugger (EDBG) chip on the evaluation kit acts as a serial-to-USB converter and is loaded with a firmware that can communicate via USB-CDC protocol.

To enable EDBG, open JP1 and connect the USB cable to the board (J20 EDBG-USB).

8.1.1 For Microsoft Windows Users

Install USB drivers for Atmel and Segger tools. Then, identify the USB connection that is established. The user can verify this by checking if the EDBG virtual COM port appears in the Device Manager. The COMxx number is used to configure the terminal emulator.

8.1.2 For Linux Users

Identify the USB connection by monitoring the last lines of `dmesg` command. The `/dev/ttyACMx` number is used to configure the terminal emulator.

The following is the USB debug port connection:

```
[172677.700868] usb 2-1.4.4: new full-speed USB device number 31 using ehci-pci
[172677.792677] usb 2-1.4.4: not running at top speed; connect to a high speed hub
[172677.793418] usb 2-1.4.4: New USB device found, idVendor=03eb, idProduct=6124
[172677.793424] usb 2-1.4.4: New USB device strings: Mfr=0, Product=0, SerialNumber=0
[172677.793897] cdc_acm 2-1.4.4:1.0: This device cannot do calls on its own. It is not a
modem.
[172677.793924] cdc_acm 2-1.4.4:1.0: ttyACM0: USB ACM device
```

The identifiers **idVendor=03eb**, and **idProduct=6124** indicate the device as the evaluation kit board with USB connection.

Now, use the terminal emulator with appropriate terminal settings (see Table 8-1) to communicate with the SAMA5D4 adapter.

8.1.3 Serial Communication Parameters

The serial communication parameters are as follows:

Table 8-1. Serial Port Settings

Function	Settings
Baud rate	115200
Data	8-bit
Parity	None
Stop	1-bit
Flow control	None

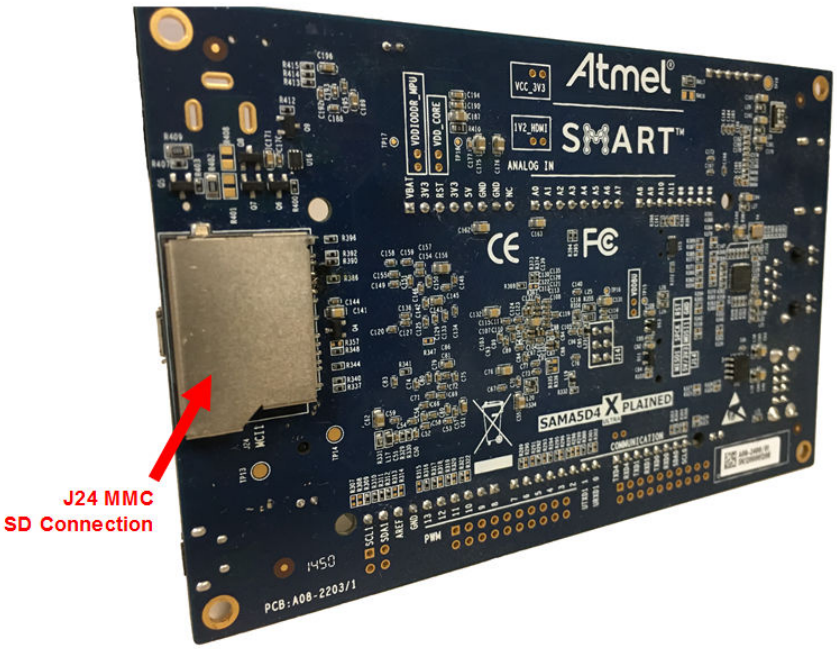
8.2 Recognizing ATWILC1000

The following section describes the SD express board and Serial Peripheral Interface (SPI) board connections.

8.2.1 SD Express Board

Before performing the boot-up operation, ensure that the ATWILC1000 SD Express board is connected in the SD slot (J24) of the SAMA5D4 Xplained board (see following figure).

Figure 8-1. SAMA5D4 SD Connection



The Secure Digital Input/Output (SDIO) Express card is recognized during boot-up with the following lines.

```
mmc0: new high speed SDIO card at address 0001
```

Use the following commands to load the ATWILC1000 module SDIO driver.

```
Welcome to Buildroot
buildroot login: root
[root@buildroot ~]# insmod wilc.ko
wilc: module is from the staging directory, the quality is unknown, you have been warned.
[root@buildroot ~]# insmod wilc-sdio.ko
wilc_sdio: module is from the staging directory, the quality is unknown, you have been
warned.
linux_sdio_probe init_power =0
wilc_sdio mmc0:0001:1:Driver Initializing success
```

Note: Do not panic upon receiving the following message while loading the module:
`wilc: module is from the staging directory, the quality is unknown, you have been warned`

This is the default message for all the drivers in kernel staging directory.

8.2.2 Serial Peripheral Interface Board

The ATWILC1000 Serial Peripheral Interface (SPI) board must be connected to SPI1 interface at J17 as shown in the following figure.

Figure 8-2. SAMA5D4 SPI Connection

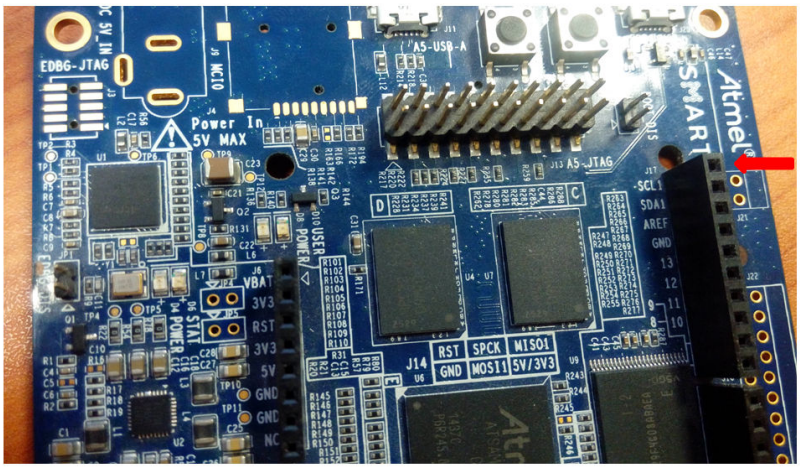


Table 8-2. SPI Pin Descriptions

SPI Pins	Header J17 Pins	XPRO EXT1 Pins
MOSI	PIN11	PIN16
CLK	PIN13	PIN18 (SPCK)
MISO	PIN12	PIN17
CS	PIN10	PIN15
IRQ	PIN8	PIN9

Note: VEXT pin in the SPI card can be connected to 3V3 pin in the header J6. Alternatively, WINC1500/WINC3400 Xplained Pro boards can be directly connected to XPRO EXT1 header, which exposes the same SPI1 peripheral exposed on J17. In this case, the IRQ GPIO has to be changed to PB26, which is pin9 of XPRO EXT1.

8.3 Recognizing ATWILC3000

The following section describes the SDIO shield board and SPI shield board connections.

8.3.1 SDIO Shield Board

Before performing the bootup operation, ensure that the ATWILC3000 Shield board is connected to the Shield Arduino Shield Stacking Connector of the SAMA5D4 Xplained adapter.

Load the Wi-Fi SDIO driver module using the following command:

```
# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been warned.
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [wilc_wfi_cfg_alloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [wilc_wfi_cfg_alloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
wilc_sdio mmc0:0001:1: WILC got 60 for gpio_reset
wilc_sdio mmc0:0001:1: WILC got 94 for gpio_chip_en
wilc_sdio mmc0:0001:1: WILC got 91 for gpio_irq
wifi_pm : 0
wifi_pm : 1
wilc_sdio mmc0:0001:1: Driver Initializing success
# wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_netdev_cleanup]Unregistering netdev d4643800
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_netdev_cleanup]Freeing Wiphy...
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_free_wiphy]Unregistering wiphy
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_free_wiphy]Freeing wiphy
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_netdev_cleanup]Freeing netdev...
```

```
wilc_sdio mmc0:0001:1 p2p0: INFO [wilc_netdev_cleanup]Unregistering netdev d46ba800
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_netdev_cleanup]Freeing Wiphy...
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_free_wiphy]Unregistering wiphy
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_free_wiphy]Freeing wiphy
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_netdev_cleanup]Freeing netdev...
Module_exit Done.
at_pwr_dev: deinit
at_pwr_dev: unregistered
mmc0: card 0001 removed
mmc0: new high speed SDIO card at address 0001
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [wilc_wfi_cfg_alloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [wilc_wfi_cfg_alloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
wilc_sdio mmc0:0001:1: WILC got 60 for gpio_reset
wilc_sdio mmc0:0001:1: WILC got 94 for gpio_chip_en
wilc_sdio mmc0:0001:1: WILC got 91 for gpio_irq
wilc_sdio mmc0:0001:1: Driver Initializing success
```

Note: Do not panic upon receiving the following message while loading the module:
`wilc: module is from the staging directory, the quality is unknown, you have been warned`

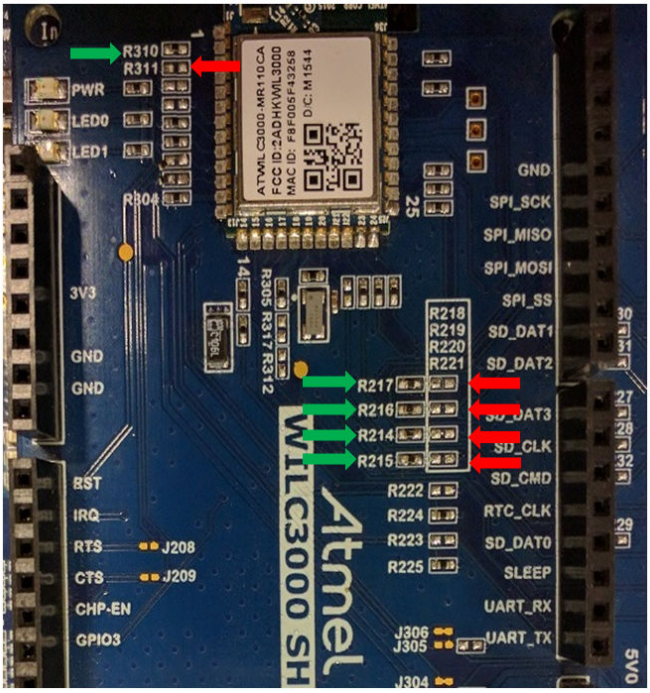
This is the default message for all the drivers in kernel staging directory.

8.3.2 Serial Peripheral Interface Shield Board

The ATWILC3000 Shield boards can operate using both SDIO and SPI, and are configured by installing or removing 0 Ohm resistors. By default, the boards are preconfigured for SDIO mode.

To switch to the SPI mode, the user must change the following resistors as shown in the following illustration.

Figure 8-3. ATWILC3000 Shield Board Configured for SPI



The resistors marked in green arrows must be connected and those marked in red arrows must be removed.

Table 8-3. SPI Resistor Configuration

Resistors to be Removed	Resistors to be Connected
R311	R310
R218	R214
R219	R215
R220	R216
R221	R217

1. Load the Wi-Fi SDIO driver module, using the following command:

```
# modprobe wilc-spi
wilc_spi: module is from the staging directory, the quality is unknown, you have been
warned.
WILC_SPI spi32765.0: spiModalias: wilc_spi, spiMax-Speed: 48000000
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
WILC_SPI spi32765.0: WILC got 60 for gpio_reset
WILC_SPI spi32765.0: WILC got 94 for gpio_chip_en
WILC_SPI spi32765.0: WILC got 91 for gpio_irq
wifi_pm : 0
wifi_pm : 1
WILC_SPI spi32765.0: WILC SPI probe success
# ifconfig wlan0 up
WILC_SPI spi32765.0 wlan0: INFO [wilc_mac_open]MAC OPEN[d477d800] wlan0
WILC POWER UP
WILC_SPI spi32765.0 wlan0: INFO [wilc_init_host_int]Host[d477d800][d477cc00]
WILC_SPI spi32765.0 wlan0: INFO [wilc_mac_open]*** re-init ***
WILC_SPI spi32765.0 wlan0: INFO [wlan_init_locks]Initializing Locks ...
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_init]Initializing WILC_Wlan ...
WILC_SPI spi32765.0 wlan0: INFO [init_chip]Bootrom sts = c
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_initialize]WILC Initialization done
WILC_SPI spi32765.0 wlan0: INFO [init_irq]IRQ request succeeded IRQ-NUM= 137 on GPIO: 91
WILC_SPI spi32765.0 wlan0: INFO [wlan_initialize_threads]Initializing Threads ...
WILC_SPI spi32765.0 wlan0: INFO [wlan_initialize_threads]Creating kthread for
transmission
WILC_SPI spi32765.0 wlan0: INFO [wlan_initialize_threads]Creating kthread for Debugging
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_get_firmware]Detect chip WILC3000
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_get_firmware]loading firmware mchp/
wilc3000_wifi_firmware.bin
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_get_firmware]WLAN firmware: mchp/
wilc3000_wifi_firmware.bin
WILC_SPI spi32765.0 wlan0: INFO [wilc_firmware_download]Downloading Firmware ...
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_firmware_download]Downloading firmware size =
137172
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_firmware_download]Offset = 120228
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_firmware_download]Offset = 137172
WILC_SPI spi32765.0 wlan0: INFO [wilc_firmware_download]Download Succeeded
WILC_SPI spi32765.0 wlan0: INFO [linux_wlan_start_firmware]Starting Firmware ...
WILC_SPI spi32765.0 wlan0: INFO [linux_wlan_start_firmware]Waiting for Firmware to get
ready ...
WILC_SPI spi32765.0 wlan0: INFO [linux_wlan_start_firmware]Firmware successfully started
WILC_SPI spi32765.0 wlan0: INFO [wilc_wlan_initialize]WILC Firmware Ver =
WILC_WIFI_FW_REL_15_00_RC4 Build: 9153
[root@buildroot ~]#
```

8.4 Modifying Configuration Files

To use the Wi-Fi module, the user must load a set of default configuration files on the prebuilt image. These files can be modified as per the requirement described in the following section.

8.4.1 Wi-Fi Protected Access Supplicant

The reference configuration files for Wi-Fi Protected Access (WPA) supplicant are available in: `/etc/` directory. The configuration files for both Station and Access Point modes are available in the demo prebuilt image.

8.4.1.1 Station Mode

The configuration file for Station mode `wilc_wpa_supplicant.conf` contains the following lines.

```
ctrl_interface=/var/run/wpa_supplicant
update_config=1
```

8.4.1.2 Access Point Open Security Mode

The Access Point (AP) mode configuration file with open security `wilc_hostapd_open.conf` contains the following lines.

```
interface=wlan0
driver=nl80211
ctrl_interface=/var/run/hostapd
ssid=wilc1000_SoftAP
dtim_period=2
beacon_int=100
channel=7
hw_mode=g
max_num_sta=8
ap_max_inactivity=300
```

8.4.1.3 Access Point Wired Equivalent Privacy Security Mode

The AP mode configuration file for Wired Equivalent Privacy (WEP) Security `wilc_hostapd_wep.conf` contains the following lines.

```
interface=wlan0
driver=nl80211
ctrl_interface=/var/run/hostapd
ssid=wilc1000_SoftAP
dtim_period=2
beacon_int=100
channel=7
hw_mode=g
max_num_sta=8
ap_max_inactivity=300
ieee80211n=1
auth_algs=1

#########    WEP  ############
wep_default_key=0
wep_key0=1234567890
wep_key1="vwxyz"
wep_key2=0102030405060708090a0b0c0d
wep_key3=".2.4.6.8.0.23"
wep_key_len_broadcast=5
wep_key_len_unicast=5
wep_rekey_period=300
```

8.4.1.4 WPA Security Mode

The AP mode configuration file with WPA security `wilc_hostapd_wpa.conf` contains the following lines.

```
interface=wlan0
driver=nl80211
ctrl_interface=/var/run/hostapd
ssid=wilc1000_SoftAP
dtim_period=2
beacon_int=100
channel=7
hw_mode=g
max_num_sta=8
ap_max_inactivity=300
ieee80211n=1
auth_algs=1
```

```
#########    WPA/WPA2  ############
wpa=3
wpa_passphrase=12345678
wpa_key_mgmt=WPA-PSK
wpa_pairwise=TKIP CCMP
rsn_pairwise=CCMP
```

8.4.2 Dynamic Host Configuration Protocol

The reference configuration file for the Dynamic Host Configuration Protocol (DHCP) server is available in the `/etc/dhcp/dhcpd.conf` file.

```
ddns-update-style none;
default-lease-time 600;
max-lease-time 7200;

option subnet-mask 255.255.255.0;
option domain-name-servers 168.126.63.1, 164.124.101.2; # DNS Server IP
option domain-name “sample.example”;                    # domain name

subnet 192.168.0.0 netmask 255.255.255.0 {
   range 192.168.0.100 192.168.0.110;                   # range ip
   option broadcast-address 192.168.0.255;
   option routers 192.168.0.1;                          # gateway ip
}
Log-facility local7;
```

Note: Each value must be modified as per the test environment.

The location of the dhcpd.conf file should match the location defined in `/etc/init.d/S80dhcp-server` under: `test -f /etc/dhcp/dhcpd.conf || exit 0`.

8.4.3 radvd

For IPv6, the radvd configuration file is required. The reference file on the demo image is available in the `/etc/radvd.conf` directory.

```
interface wlan0
{
    AdvSendAdvert on;
    prefix 2001:db8:0:2::/64
    {
    };
};
```

8.5 Running in the ATWILC Station Mode

The following example shows how to run the ATWILC device in Station mode, and connect to an AP.

1. Initialize the ATWILC1000 and ATWILC3000 driver module, using the following command:

```
Welcome to Buildroot
buildroot login: root
root@buildroot ~]# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been
warned.
linux_sdio_probe init_power =0
wilc_sdio mmc0:0001:1: Driver Initializing success
```

2. Start the WPA supplicant service and execute `wpa_supplicant`, using the following command:

```
# wpa_supplicant -iwlan0 -Dnl80211 -c /etc/wilc_wpa_supplicant.conf &
# Successfully initialized wpa_supplicant
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mgmt_frame_register]Frame registering Frame
Type: d0: Boolean: 1
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mgmt_frame_register]Return since mac is closed
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]MAC OPEN[d464f800] wlan0
WILC POWER UP
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_init_host_int]Host[d464f800][d463b000]
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]*** re-init ***
```

```
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_init_locks]Initializing Locks ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_init]Initializing WILC_Wlan
wilc_sdio mmc0:0001:1: SDIO speed: 50000000
wilc_sdio mmc0:0001:1: chipid 001003a0
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_initialize]WILC Initialization done
wilc_sdio mmc0:0001:1 wlan0: INFO [init_irq]IRQ request succeeded IRQ-NUM= 137 on GPIO:
91
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Initializing Threads ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Creating kthread for
transmission
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Creating kthread for Debugging
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]Detect chip WILC1000
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]loading firmware mchp/
wilc1000_wifi_firmware.bin
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]WLAN firmware: mchp/
wilc1000_wifi_firmware.bin
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_firmware_download]Downloading Firmware ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Downloading firmware size
= 134964
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Offset = 119660
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Offset = 134964
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_firmware_download]Download Succeeded
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Starting Firmware ...
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Waiting for FW to get
ready ...
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Firmware successfully
started
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_initialize]WILC Firmware Ver =
WILC_WIFI_FW_REL_15_01_RC3 Build: 9792
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_init_test_config]Start configuring Firmware
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]Mac address: fa:f0:05:f1:3d:64
```

3. Connect to the Access Point:

3.1. To connect to an unsecured AP:
Use the following commands to scan and connect to the AP.

```
# wpa_cli -p/var/run/wpa_supplicant ap_scan 1
# wpa_cli -p/var/run/wpa_supplicant add_network
# wpa_cli -p/var/run/wpa_supplicant set_network 0 ssid '"User_AP"'
# wpa_cli -p/var/run/wpa_supplicant set_network 0 key_mgmt NONE
# wpa_cli -p/var/run/wpa_supplicant select_network 0
```

Note: Change the **User_AP** with the Service Set Identifier (SSID) of the desired AP.

3.2. To connect to the WPA secured Access Point:
Use the following commands to scan and connect to a WPA or WPA2 and Temporal Key Integrity Protocol (TKIP) or Advanced Encryption Standard (AES) protected AP.

```
# wpa_cli -p/var/run/wpa_supplicant ap_scan 1
# wpa_cli -p/var/run/wpa_supplicant add_network
# wpa_cli -p/var/run/wpa_supplicant set_network 0 ssid '"User_AP"'
# wpa_cli -p/var/run/wpa_supplicant set_network 0 key_mgmt WPA-PSK
# wpa_cli -p/var/run/wpa_supplicant set_network 0 psk '"12345678"'
# wpa_cli -p/var/run/wpa_supplicant select_network 0
```

Note: Change the **User_AP** and **12345678** with the SSID and password of desired AP.

3.3. To connect to the WEP secured Access Point:
Use the following commands to scan and connect to a WEP shared key protected AP.

```
#wpa_cli -p/var/run/wpa_supplicant ap_scan 1
#wpa_cli -p/var/run/wpa_supplicant add_network
#wpa_cli -p/var/run/wpa_supplicant set_network 0 ssid '"User_AP"'
#wpa_cli -p/var/run/wpa_supplicant set_network 0 key_mgmt NONE
#wpa_cli -iwlan0 -p/var/run/wpa_supplicant set_network 0 wep_key0 1234567890
#wpa_cli -p/var/run/wpa_supplicant set_network 0 wep_tx_keyidx 0
#wpa_cli -p/var/run/wpa_supplicant set_network 0 auth_alg SHARED
#wpa_cli -p/var/run/wpa_supplicant select_network 0
```

Note: Change the **User_AP** and **12345** with the Service Set Identifier (SSID) and ASCII (or Hex) of desired AP.

3.4. Connect to the WPS secured Access Point Trigger WPS Push-Button mode, using the following command:

```
wpa_cli wps_pbc
```

(or) to connect using PIN method, use the following command:

```
sudo wpa_cli wps_pin any <the pin>
```

4. Run the DHCP service.
If the IP address can be allocated from the AP automatically, start the DHCP client, using the following command:

```
#dhcpcd wlan0 &
```

Note: If the AP does not support the DHCP service, manually set the static IP address value using the `ifconfig wlan0 xxx,xxx.xxx.xxx` command.

5. Check and validate the connection status, using the following commands:

```
# wpa_cli status

bssid=88:9b:39:f3:d0:4d
ssid=User_AP
id=0
mode=station
pairwise_cipher=NONE
group_cipher=NONE
key_mgmt=NONE
wpa_state=COMPLETED
ip_address=192.168.43.2
address=00:80:c2:b3:d7:4d
```

The user can save and use the network information to automatically connect to the network using the `wpa_cli save` command in Linux.

8.6 Running in the ATWILC AP Mode

This section describes how to connect a device to the ATWILC1000 Access Point.

1. Initialize the ATWILC1000 or ATWILC3000 driver module, using the following command:

```
[root@buildroot ~]# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been
warned.
linux_sdio_probe init_power =0
wilc_sdio mmc0:0001:1: Driver Initializing success
```

2. Run hostapd as user configuration, using the following command:

```
# hostapd /etc/wilc_hostapd_open.conf -B &
# Configuration file: /etc/wilc_hostapd_open.conf
wilc_sdio mmc0:0001:1 wlan0: INFO [change_virtual_intf]In Change virtual interface
function
wilc_sdio mmc0:0001:1 wlan0: INFO [change_virtual_intf]Wireless interface name =wlan0
wilc_sdio mmc0:0001:1 wlan0: INFO [change_virtual_intf]Changing virtual interface,
enable scan
wilc_sdio mmc0:0001:1 wlan0: INFO [change_virtual_intf]Interface type = NL80211_IFTYPE_AP
wilc_sdio mmc0:0001:1 wlan0: INFO [add_virtual_intf]Adding monitor interface[d4789800]
wilc_sdio mmc0:0001:1 wlan0: INFO [add_virtual_intf]Initializing mon ifc virtual device
driver
wilc_sdio mmc0:0001:1 wlan0: INFO [add_virtual_intf]Adding monitor interface[d4789800]
wilc_sdio mmc0:0001:1 wlan0: INFO [add_virtual_intf]Setting monitor flag in private
structure
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]MAC OPEN[d4789800] wlan0
WILC POWER UP
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_init_host_int]Host[d4789800][d45dd000]
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]*** re-init ***
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_init_locks]Initializing Locks ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_init]Initializing WILC_Wlan
wilc_sdio mmc0:0001:1: SDIO speed: 50000000
wilc_sdio mmc0:0001:1: chipid 001003a0
```

```
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_initialize]WILC Initialization done
wilc_sdio mmc0:0001:1 wlan0: INFO [init_irq]IRQ request succeeded IRQ-NUM= 137 on GPIO:
91
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Initializing Threads ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Creating kthread for
transmission
wilc_sdio mmc0:0001:1 wlan0: INFO [wlan_initialize_threads]Creating kthread for Debugging
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]Detect chip WILC1000
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]loading firmware mchp/
wilc1000_wifi_firmware.bin
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_get_firmware]WLAN firmware: mchp/
wilc1000_wifi_firmware.bin
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_firmware_download]Downloading Firmware ...
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Downloading firmware size
= 134964
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Offset = 119660
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_firmware_download]Offset = 134964
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_firmware_download]Download Succeeded
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Starting Firmware ...
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Waiting for FW to get
ready ...
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_start_firmware]Firmware successfully
started
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_initialize]WILC Firmware Ver =
WILC_WIFI_FW_REL_15_01_RC3 Build: 9792
wilc_sdio mmc0:0001:1 wlan0: INFO [linux_wlan_init_test_config]Start configuring Firmware
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_mac_open]Mac address: fa:f0:05:f1:3d:64

wilc_sdio mmc0:0001:1 wlan0: INFO [del_station]Deleting station
wilc_sdio mmc0:0001:1 wlan0: INFO [del_station]All associated stations
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_del_allstation]NO ASSOCIATED STAS
Using interface wlan0 with hwaddr fa:f0:05:f1:3d:64 and ssid "wilc1000_SoftAP"
wilc_sdio mmc0:0001:1 wlan0: INFO [start_ap]Starting ap
wilc_sdio mmc0:0001:1 wlan0: INFO [start_ap]Interval= 100
 DTIM period= 2
 Head length= 66 Tail length= 9
wilc_sdio mmc0:0001:1 wlan0: INFO [set_channel]Setting channel 7 with frequency 2442
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_set_bssid]set bssid on[d4789800]
wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_wlan_set_bssid]set bssid [fa][f0][5]
wilc_sdio mmc0:0001:1 wlan0: INFO [change_bss]Changing Bss parametrs
wlan0: interface state UNINITIALIZED->ENABLED
wlan0: AP-ENABLED
```

Note: See the `wilc_hostapd_open.conf` file for unencrypted AP settings, `wilc_hostapd_wep.conf` file for WEP AP settings and `wilc_hostapd_wpa.conf` file for WPA/WPA2 AP settings.

3. Run DHCP server to allocate IP to client. Set the IP address to the gateway using the `#ifconfig wlan0 192.168.0.1` command.
   Note: The gateway IP address is defined in the `dhcpd.conf` file.

   Start the DHCP server using the `#/etc/init.d/S80dhcp-server start` command.

   The user can now connect the PC or smartphone to the ATWILC1000 access point.

   To configure AP in the WPS mode, use the same steps for WPA/WPA2 settings, then use the following command to configure to the Push-Button mode:

   ```
   hostapd_cli wps_pbc
   ```

   (or) to configure for the Pin mode, use the following command:

   ```
   hostapd_cli wps_pin any <pin>
   ```

8.7 Running in the ATWILC P2P Mode

A P2P group includes two devices: One device acts as a P2P Group Owner (GO) and the other device acts as a P2P Client. The ATWILC devices support both P2P GO and P2P Client modes. The following is the procedure to test P2P mode on ATWILC.

There are two scenarios in which the P2P mode can be tested. The following section describes each scenario:

Scenario 1 - WILC device as a group owner and mobile phone as a P2P client

Configuring the WILC device as a group owner:

1. Load both the WILC modules, using the following command:

```
modprobe wilc-sdio
echo <mode> > /sys/wilc/p2p_mode
```

   where, mode = 1 for P2P GO and mode = 0 for P2P Client.
2. Add the p2p0 virtual interface:

```
iw phy0 interface add p2p0 type station
```

3. Start the WPA supplicant service and open the P2P device, using the following command:

```
wpa_supplicant -Dnl80211 -ip2p0 -c/etc/wilc_p2p_supplicant.conf &
```

4. Configure the IP address of the P2P GO and start the DHCP server, using the following command:

```
ifconfig p2p0 192.168.0.1
/etc/init.d/S80dhcp-server start
```

5. On the terminal, enter into wpa_cli interactive mode, using the following command:

```
wpa_cli -ip2p0
```

6. Scan for neighbouring P2P devices for specified duration, using the following command:

```
p2p_find <scan_duration_in_seconds>
```

7. After scan is complete, list the available P2P peers using the following command:

```
p2p_peers
```

   This command lists the BSSID of the P2P peer.
8. Connect to the P2P Client using the BSSID of the P2P peer, using the following command:

```
p2p_connect <MAC_ADDRESS> pbc
```

Configuring a mobile phone as a P2P client:

In the Wi-Fi settings menu on the phone, enter into Wi-Fi Direct® mode and perform the following to establish the connection.

- Trigger connection from WILC:
  1. Enter `p2p_find` command without timeout value on the WILC.
     The SSID of the P2P peer appears on the phone.
  2. Enter the `p2p_connect` command as shown above in the WILC. A pop-up window appears on the phone.
  3. Click the Accept button or prompt to connect.
- Trigger connection from phone:
  1. Click the SSID displayed on the phone and send a P2P invite.
  2. Enter the `p2p_connect <MAC_ADDRESS> pbc` command in the WILC to form a P2P group.

Scenario 2 - WILC device as a P2P client and mobile phone as a group owner

Configuring WILC device as a P2P client:

1. Load both the WILC modules, using the following command:

```
modprobe wilc-sdio
```

2. Add the p2p0 virtual interface:

```
iw phy0 interface add p2p0 type station
```

3. Start the WPA supplicant service and open the P2P device, using the following command:

```
wpa_supplicant -Dnl80211 -ip2p0 -c/etc/wilc_p2p_supplicant.conf &
```

4. On the terminal, enter into wpa_cli interactive mode, using the following command:
   ```
   wpa_cli -ip2p0
   ```
5. Scan for neighbouring P2P devices for specified duration, using the following command:
   ```
   p2p_find <scan_duration_in_seconds>
   ```
6. After the scan is complete, list the available P2P peers, using the following command:
   ```
   p2p_peers
   ```
   This command lists the BSSID of the P2P peer.
7. Connect to the P2P Go using the BSSID of the P2P peer, using the following command:
   ```
   p2p_connect <MAC_ADDRESS> pbc go_intent=1
   ```
8. Press Ctrl+c to exit the interactive mode.
9. Run the DHCP client on the WILC to obtain IP address.
   ```
   dhcpcd p2p0 &
   ```

Configuring a mobile phone as a group owner:

In the Wi-Fi settings menu on the phone, enter into Wi-Fi Direct mode and perform the following to establish the connection.

- Trigger connection from WILC:
  1. Enter the `p2p_find` command without time-out value on the WILC.
     The SSID of the P2P peer appears on the phone.
  2. Enter the `p2p_connect` command as shown above in the WILC. A pop-up window appears on the phone.
  3. Click the Accept button or prompt to connect.
- Trigger connection from phone:
  1. Click the SSID displayed on the phone and send a P2P invite.
  2. Enter the `p2p_connect <MAC_ADDRESS> pbc` command in the WILC to form a P2P group.

8.8 Supported Modes with Concurrency

The ATWILC devices support the following modes to execute concurrently.

- STA - STA (see *Running in the ATWILC Station Mode* section)
- STA - P2P Client (see *Running in the ATWILC Station Mode* and *Configuring WILC device as a P2P client* sections)
- STA - P2P GO (see *Running in the ATWILC Station Mode* and *Configuring WILC device as a group owner* sections)
- AP - P2P Client (see *Running in the ATWILC AP Mode* and *Configuring WILC device as a P2P client* sections)
- STA - AP (see *Running the ATWILC Device in Station and AP Modes Concurrently* section)
  Note: Use Wlan0 and p2p0 interfaces to run the ATWILC device concurrently.

By default, wlan0 virtual interface is automatically created when the WILC driver is initialized. To use concurrency, the user has to add a new virtual interface before using it with the following command:

```
iw phy0 interface add p2p0 type station
```

Note: phy0 device might differ according to the available phy devices on the user's host. To get a list of available phy device, use :

```
iw dev
```

Note: hostapd removes the virtual interface it was using when it's killed, which means that to restart hostapd, the user has to re-add the virtual interface, whether it was p2p0 or wlan0. Similar behavior doesn't happen when killing the wpa_supplicant.

8.8.1 Running the ATWILC Device in Station and AP Modes Concurrently

The following section describes the configuration steps to run the ATWILC device in Station (STA) and AP modes, concurrently.

1. Initialize the ATWILC1000 and ATWILC3000 driver module, using the following command:

```
Welcome to Buildroot
buildroot login: root
[root@buildroot ~]# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been
warned.
linux_sdio_probe init_power =0
wilc_sdio mmc0:0001:1: Driver Initializing success
```

2. Start the WPA Supplicant service and execute `wpa_supplicant`, using the following command:

```
# wpa_supplicant -Dnl80211 -iwlan0 -c/etc/wilc_wpa_supplicant.conf &
Successfully initialized wpa_supplicant
rfkill: Cannot open RFKILL control dev
wilc_sdio mmc0:0001:1 wlan0: Detect chip WILC3000
wilc_sdio mmc0:0001:1 wlan0: loading firmware wilc3000_wifi_firmware.bin
wilc_gnrl_async_info_received
wilc_sdio mmc0:0001:1 wlan0: WILC Firmware Ver = WILC_WIFI_FW_REL_15_00 Build: 8719
```

3. Connect to the Access Point, using the following command:

```
#wpa_cli -p/var/run/wpa_supplicant ap_scan 1
#wpa_cli -p/var/run/wpa_supplicant add_network
#wpa_cli -p/var/run/wpa_supplicant set_network 0 ssid '"User_AP"'
#wpa_cli -p/var/run/wpa_supplicant set_network 0 key_mgmt NONE
#wpa_cli -p/var/run/wpa_supplicant set_network 0 psk '"12345"'
#wpa_cli -p/var/run/wpa_supplicant set_network 0 wep_tx_keyidx 0
#wpa_cli -p/var/run/wpa_supplicant set_network 0 auth_alg SHARED
#wpa_cli -p/var/run/wpa_supplicant select_network 0
```

4. Run the DHCP service.
   If the IP address can be allocated from the AP automatically, start the DHCP client using the following command:

```
#dhcpcd wlan0 &
```

5. Ping the **User AP** to check the connection, using the following command:

```
# ping 192.168.0.1
```

6. Add the p2p0 virtual interface:

```
iw phy0 interface add p2p0 type station
```

7. Run the hostapd as user's configuration, making sure that the .conf file uses the p2p0 interface

```
# hostapd /etc/wilc_hostapd_open.conf -B &

Configuration file: /etc/wilc_hostapd_open.conf
rfkill: Cannot open RFKILL control device
wilc_sdio mmc0:0001:1 wlan0: Detect chip WILC3000
wilc_sdio mmc0:0001:1 wlan0: loading firmware wilc3000_wifi_firmware.bin
wilc_gnrl_async_info_received
wilc_sdio mmc0:0001:1 wlan0: WILC Firmware Ver = WILC_WIFI_FW_REL_15_00 Build: 8719
Using interface wlan0 with hwaddr fa:f0:05:f6:56:6a and ssid "wilc_SoftAP"
wilc_gnrl_async_info_received
wilc_sdio mmc0:0001:1 wlan0: there is no current Connect Request
wlan0: interface state UNINITIALIZED->ENABLED
wlan0: AP-ENABLED
```

8. Run the DHCP Server to allocate IP to client.
   - Set the IP of AP; `#ifconfig p2p0 192.168.0.1`
   - Start the DHCP server; `#/etc/init.d/S80dhcp-server start`
     The user can connect the PC or smartphone to the ATWILC1000 AP.

8.9 Powersave

8.9.1 Wi-Fi Powersave

Wi-Fi Powersave state can be controlled by the kernel or the command line. To change the default Powersave state, `CONFIG_CFG80211_DEFAULT_PS` can be defined to enable Powersave while the WLAN interface is being initialized, or undefined to disable Powersave at initialization. To control Powersave manually after the WLAN interface is initialized, use the iw tool.

```
$ iw dev wlan0 set power_save on
```

Note: The Powersave mode is disabled by default for AP and P2P mode.

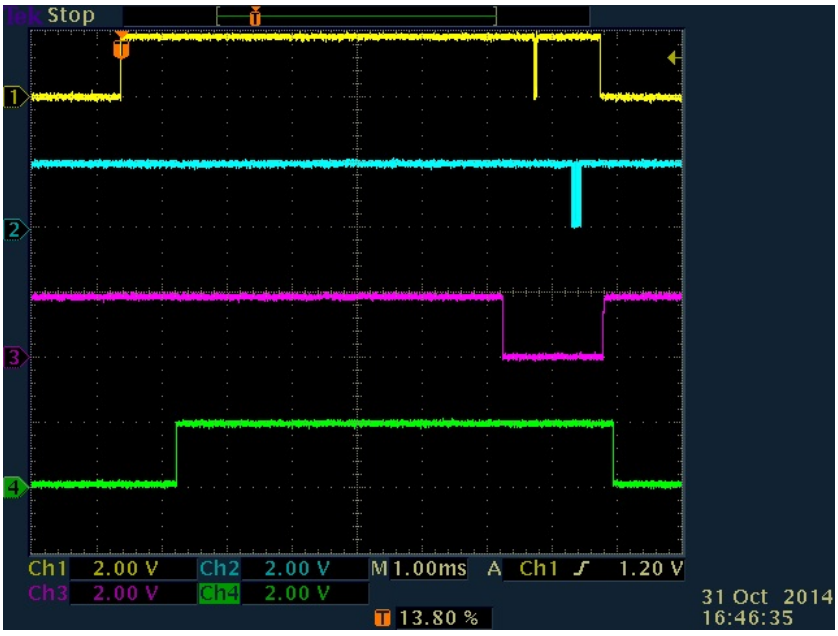
8.9.2 BLE Powersave

To use BLE powersave, UART flow control should be enabled, to hold the host back from sending new commands to the ATWILC3000 BLE controller when it is in Sleep mode.

This can be done using the Update UART Parameters vendor specific HCI command to enable flow control on ATWILC3000, then update the host's UART configuration to enable flow control. Also, the host application should allow the ATWILC3000 BLE controller to enter powersave, by setting the host's UART Tx line low, entering a Break mode. Before starting any HCI communication, the application should get the host's UART out of the Break mode, then proceed with sending the HCI commands to the ATWILC3000.

When ATWILC3000 is in Powersave mode, it will set the UART RTS line high to hold back the host from sending any additional HCI commands. Once the host UART Tx line is back high, ATWILC3000 will go out of Powersave mode, but will not be fully active instantly. After ATWILC3000 is up and ready to receive more HCI commands, it will set the UART RTS line low, and the host will be able to send more HCI commands.

This is illustrated in the following figure:



1. Yellow: UART Rx (ATWILC3000 perspective) 2. Blue: UART Tx 3. Purple: UART RTS 4. Green: ATWILC3000 Ready

To control the Break mode, IOCTL can be used as follows:

```
int main(int argc,char *argv[])
{
    int fd, serial;

    fd = open("/dev/ttyS1", O_RDWR);
    if(atoi(argv[1])==1) {
```

```
        printf("assert on %d\n",fd);
        ioctl(fd, TIOCCBRK, 0);
    } else if(atoi(argv[1])==0) {
        printf("deassert on %d\n",fd);
        ioctl(fd, TIOCSBRK, 0);
    }
     close(fd);
}
```

An example of such application is available on the reference image under `etc/uart_brk_ioctl`. To enable powersave, the following commands can be used:

```
# modprobe wilc-sdio.ko
# echo BT_POWER_UP > /dev/wilc_bt
# echo BT_DOWNLOAD_FW > /dev/wilc_bt
# hciattach ttyS1 any 115200 noflow
# hciconfig hci0 up
# hcitool cmd 0x3F 0x0053 00 C2 01 00 01
# stty -F /dev/ttyS1 crtscts
# /etc/etc/uart_brk_ioctl 1
```

To disable Break mode and wake up ATWILC3000, use the following command:

```
# /etc/etc/uart_brk_ioctl 0
```

8.10 Antenna Switching

The ATWILC devices support antenna diversity where dual antennas are connected to the chip using an external antenna switch.

Antenna switches are controlled using two input signals to select which antenna is in operation, and the user uses two different configurations with respect to the control GPIOs:

1. Dual GPIO – two different ATWILC device GPIOs are used to control each of the antenna switch's control lines.
2. Single GPIO – a single ATWILC device GPIO is used to control one of the switch's control lines, and its inverse is connected to the other control line. This configuration requires an external inverter. The antenna selection algorithm evaluates the average RSSI every second, and based on that, it determines if it needs to switch the antenna.

The average RSSI is calculated based on the RSSI read while receiving each packet. If the average RSSI is below threshold, it switches to the other antenna and sets a new threshold to the average RSSI of the abandoned antenna. To avoid unnecessary switching, the antenna switching happens only when the RSSI is below -30dBm, and has a margin of 1dBm to avoid hysteresis.

Sysfs entries can be used to configure the ATWILC device driver for the Antenna Diversity mode, and the GPIOs that are used to control the antenna switch at run time.

8.10.1 Antenna Switch GPIO Control

Sysfs entry `/sys/wilc/ant_swtch_mode` can be used as follows to configure the GPIOs used to control the antenna switch:

```
# echo mode > /sys/wilc/ant_swtch_mode
```

where, mode = 1 for Single Antenna , mode = 2 for Dual Antenna and 0 - to Disable diversity.

For WILC1000 valid GPIOs are 0, 1, 3, 4 and 6, and for WILC3000 valid GPIOs are 0, 3, 4, 6, 17, 18, 19 and 20.

8.10.2 GPIOs

To configure the GPIOs that are connected to the antenna switch, sysfs entry `/sys/wilc/antenna1` and `/sys/wilc/antenna2` can be used as follows.

```
# echo GPIO_NUM > /sys/wilc/antenna1 ( for single antenna switch)
# echo GPIO_NUM > /sys/wilc/antenna2 ( for dual antenna switch)
```

where, GPIO_NUM is any valid GPIO for antenna diversity.

Valid GPIOs for the ATWILC1000 are 0, 1, 4 and 6.

Valid GPIOs for the ATWILC3000 are 3, 4, 17, 18, 19 and 20.

8.10.3 Antenna Selection

The antenna used can be selected using the iw tool to either select Fixed Manual mode (antenna1 or antenna2) or automatic switching according to the antenna performance as follows:

- Set the Antenna 1, using the following command:

```
iw phy phy0 set antenna 1 1
```

- Set the Antenna 2, using the following command:

```
iw phy phy0 set antenna 2 2
```

- Enable Automatic switching, using the following command:

```
iw phy phy0 set antenna 3 3
```

Notes:

- Since WILC exposes two phy devices, both devices can be used to set the antenna selection, but the same antenna selection is applied to both the devices. Also, before setting the antenna selection, the antenna switch control GPIOs should be configured.
- Appropriate phy device value can be verified from the following command:

```
iw dev
```

In Manual modes, the GPIOs is set according to the following tables.

Table 8-4. Single Mode

Antenna Selected	GPIO1 Value
Antenna 1	1
Antenna 2	0

Table 8-5. Dual Mode

Antenna Selected	GPIO1 Value	GPIO2 Value
Antenna 1	1	0
Antenna 2	0	1

8.11 Debug Logs

The ATWILC driver inherits the debug logs levels from Linux. To change the system's debug level, use one of the following methods:

```
#echo "7" > /proc/sys/kernel/printk
```

where "7" is the highest desired log level

or

```
# dmesg -n 7
```

To change the default level while building the kernel, change the following line in `kernel_src/include/linux/printk.h`

```
#define CONSOLE_LOGLEVEL_DEFAULT 7
```

ATWILC driver also uses debugfs to allow the user to control which code regions to enable or disable logs for.

To change it, the user has to first mount the debugfs:

```
# mount -t debugfs nodev /sys/kernel/debug
```

Then echo a number that represents a bit field of the regions that the user wants to enable logs from. The bit field is defined as follows:

```
BIT 0: GENERIC
BIT 1: HOSTAPD
BIT 2: HOSTINF
BIT 3: CORECONFIG
BIT 4: CFG80211
BIT 5: INT
BIT 6: TX
BIT 7: RX
BIT 8: TCP
BIT 9: INIT
BIT 10: PWRDEV
```

8.12 Monitor Mode

The Monitor mode can be enabled on Linux using the following commands:

```
# modeprobe wilc-sdio.ko
# ifconfig wlan0 up
# iw dev wlan0 set type monitor
# iw dev wlan0 set freq <freq> // eg. 2437 for channel 6
```

A capturing tool can then be used with the interface to dump the received packets. In the following example, `tcpdump` is used as follows:

```
# tcpdump -i wlan0 -n -w packets_dump.cap
```

Note: To use `tcpdump`, it must be enabled in buildroot's menuconfig under *Target Packages*> *Network*.

8.13 Miscellaneous Linux Topics

This section provides additional information on Linux topics.

8.13.1 Host Suspend/Resume Mechanism

Upon suspending, Linux disconnects the Access Point. To maintain the connection after suspending, modify the Linux code by removing the following code from the `\net\wireless\sysfs.c` file.

```
//Prevent disconnecting from connected AP's on suspension
        //if (!rdev->wiphy.wowlan_config)
            //cfg80211_leave_all(rdev);
```

The following is the sample of the `\net\wireless\sysfs.c` file:

```
static int wiphy_suspend(struct device *dev, pm_message_t state)
{
    struct cfg80211_registered_device *rdev = dev_to_rdev(dev);
    int ret = 0;

    rdev->suspend_at = get_seconds();
rtnl_lock();
    if (rdev->wiphy.registered) {
        //Prevent disconnecting from connected AP's on suspension
        //if (!rdev->wiphy.wowlan_config)
            //cfg80211_leave_all(rdev);
        if (rdev->ops->suspend)
            ret = rdev_suspend(rdev, rdev->wiphy.wowlan_config);
        if (ret == 1) {
            /* Driver refuse to configure wowlan */
            cfg80211_leave_all(rdev);
            ret = rdev_suspend(rdev, NULL);
```

```
        }
    }
    rtnl_unlock();
return ret;
}
```

The user can configure Linux in Suspend mode, using mem string in the `/sys/power/state` path. For more information, see https://www.kernel.org/doc/Documentation/power/interface.txt.

The controller then wakes up the host on certain wake-up on wireless LAN triggers that can be configured using the iw tool. The controller then asserts a wake-up signal on a dedicated wake-up General Purpose Input/output (GPIO) pin on the host board which is connected to the IRQ pin on ATWILC device board.

The ATWILC only supports the ANY option in the Wake on Wireless (WoW) mode from the set of allowed wake-up triggers. The host wakes up the ATWILC device upon receiving any type of packets from the connected access point if the triggers are set by the user. If it is not set by the user, the controller must not wake up the host.

To configure the host wake-up triggers as ANY, use the following any command argument:

```
#iw phy0 wowlan enable any
```

Where `phy0` resembles wireless hardware interface name, and any is the required trigger.

To disable all the triggers, use the `disable` argument as shown in the following command:

```
#iw phy0 wowlan disable
```

To show the configured triggers, use the `show` argument as shown in the following command:

```
#iw phy0 wowlan show
```

To configure the host into Suspend mode, use the following command:

```
#echo mem > /sys/power/state
```

8.13.2 Set Transmit Power

The user can control the Tx power of ATWILC1000 or ATWILC3000 using the iw tool with the following command line arguments.

```
$ iw dev wlan0 set txpower fixed x
```

Where `x` is the desired Tx level in mBm (1dBm = 100mBm).

The supported levels are 0, 300, 600, 900, 1200, 1500, and 1800.

Note: If the input Tx power value is other than the mentioned supported levels, the `x` value is automatically set to the first greater value.

8.13.3 Scan

To scan for the available APs, use the `$ wpa_cli scan` command.

8.13.4 Get Scan Results

To get a list of identified APs with associated attributes such as bssid, frequency, Received Signal Strength Indicator (RSSI), encryption and Service Set Identifier (SSID), use the following command:

```
$ wpa_cli scan_results
Selected interface 'wlan0'
bssid / frequency / signal level / flags / ssid
02:1a:11:f5:56:81       2437    -54     [ESS]   AndroidAP
68:7f:74:c7:4e:d9       2462    -54     [WPA2-PSK-CCMP][WPS][ESS]       IOT_58
d8:fe:e3:03:4e:30       2422    -54     [WPA-PSK-CCMP+TKIP][WPA2-PSK-CCMP+TKIP][ESS]    dlink-
enterprise
00:0c:43:44:0a:b4       2437    -51     [ESS]   RT2880_AP
```

8.13.5 Save Network Information

To avoid the loss of network information after reboot, use the `$ wpa_cli save_config` command.

8.13.6 Load Network Information

To get the saved network information after reboot, use the `$ wpa_cli list_networks` command.

8.13.7 Get Current Network Information

To get the connected interface information of the network, which includes RSSI, channel, encryption, and so on, use the following command:

```
$ iwconfig wlan0
DBG [WILC_WFI_get_tx_power: 3418]Got tx power 18
wlan0     IEEE 802.11bgn  ESSID:"AndroidAP"
          Mode:Managed  Frequency:2.437 GHz  Access Point: 02:1A:11:F5:56:81
          Bit Rate=0 kb/s   Tx-Power=18 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Encryption key:off
          Power Management:on
          Link Quality=49/70  Signal level=-61 dBm
          Rx invalid nwid:0  Rx invalid crypt:0  Rx invalid frag:0
          Tx excessive retries:0  Invalid misc:0   Missed beacon:0
```

8.13.8 Change Regulatory Domain Settings

Kernel's Central Regulatory Domain Agent (CRDA) acts as the udev helper for the communication between the kernel and for regulatory compliance. CRDA is enabled by default on the reference platform. To enable it for other platforms, it must be selected on buildroot's package using the menuconfig:

Target Packages>Networking applications>crda

CRDA uses a database that specifies the channels which are to be used at each country, with a restricting "World Regulatory Domain". This database is defined in `db.txt` file in the `wireless-regdb` package. World Regulatory Domain helps to apply some restrictions according to the country and the device is configured to operate, even if the user used it in a country that does not have these restrictions. For more details, see wireless.wiki.kernel.org/en/developers/Regulatory/CRDA#Using_iw_to_change_regulatory_domains.

Linux allows changing of the regulatory domains in compliance with worldwide regulatory restrictions, including the US FCC. In order to achieve this, this device always respects its programmed regulatory domain and a country code selection will enhance regulatory restrictions. This is in accordance with the FCC part 15 country code selection knowledge base publication number 594280. For example, if the device is programmed for operation in the US which allows operation on channels 1-11 on the 2.4 GHz band, and the user visits Japan which allows operation on channels 1-14 and the user changes the regulatory domain to JP, then the channel 12, 13 or 14 (CCK) cannot be used. However, if a device is programmed for operation in Japan and visits the US, selecting US as the regulatory domain will have channel 12-14 disabled.

The default database restricts channels 12 to 14 as listen only; therefore, use these channels for the AP mode. For example, the flag NO-IR must be removed.

1. This is the world regulatory domain country 00: (2402 - 2472 @ 40), (20)
2. Channel 12 - 13. (2457 - 2482 @ 20), (20), AUTO-BW
3. Channel 14. Only JP enables this and for 802.11b only (2474 - 2494 @ 20), (20), NO-OFDM
4. Channel 36 - 48 (5170 - 5250 @ 80), (20), NO-IR, AUTO-BW
5. Channel 52 - 64 (5250 - 5330 @ 80), (20), NO-IR, DFS, AUTO-BW
6. Channel 100 - 144 (5490 - 5730 @ 160), (20), NO-IR, DFS
7. Channel 149 - 165 (5735 - 5835 @ 80), (20), NO-IR
8. IEEE 802.11ad (60GHz), channels 1..3 (57240 - 63720 @ 2160), (0)

Generating a New Regulatory Database Binary

The regulatory domain database binary is digitally signed to guarantee integrity; therefore, to generate a new database binary, the key must also be used while compiling CRDA, and also be copied to the target. To create a new regulatory file perform the following steps:

1. Open an already built buildroot.
2. Go to `output/build/wireless-regdb-2017.03.07/`.
3. Change `db.tx`.
4. Build regdb using `make` command.
   This creates a new public key, and can be used to generate and sign a new `regulartory.bin` file. The user must install m2crypto Python® package to build `regdb # sudo apt-get install python-m2crypto`.
5. Copy the file to `output/build/crda-3.18/pubkeys/`.
6. Modify wireless-regdb package to install the new key to the target as:
   – Go to `wireless-regdb.mk`.
   – Edit `WIRELESS_REGDB_INSTALL_TARGET_CMDS` to copy the new key to the target folder.
7. Force rebuild and installation to target for both crda and wireless-regdb by removing `.stamp_target_installed`, `.stamp_built from output/build/crda-3.18` and `wireless-regdb-2017.03.07`.
8. Rebuild buildroot.

To verify the process, use regdbdump to make sure the new `regulatory.bin` can be verified.

```
# regdbdump /usr/lib/crda/regulatory.bin
```

8.13.9 Get Current Regulatory Domain

To get a list of identified APs with associated attributes such as bssid, frequency, RSSI, encryption, and SSID, use the following command:

```
$ iw reg get
country EG: DFS-UNSET
        (2402 - 2482 @ 40), (N/A, 20)
        (5170 - 5250 @ 80), (N/A, 20)
        (5250 - 5330 @ 80), (N/A, 20), DFSiwconfig wlan0
```

8.13.10 Set Current Regulatory Domain

To get a list of identified APs with associated attributes such as like bssid, frequency, RSSI, encryption and SSID, use the following command:

```
$ iw reg set US
cfg80211: Calling CRDA for country: US
[root@buildroot ~]# cfg80211: Regulatory domain changed to country: US
cfg80211:  DFS Master region: unset
cfg80211:   (start_freq - end_freq @ bandwidth), (max_antenna_gain, max_eirp), (dfs_cac_time)
cfg80211:   (2402000 KHz - 2472000 KHz @ 40000 KHz), (N/A, 3000 mBm), (N/A)
cfg80211:   (5170000 KHz - 5250000 KHz @ 80000 KHz), (N/A, 1700 mBm), (N/A)
cfg80211:   (5250000 KHz - 5330000 KHz @ 80000 KHz), (N/A, 2300 mBm), (0 s)
cfg80211:   (5735000 KHz - 5835000 KHz @ 80000 KHz), (N/A, 3000 mBm), (N/A)
cfg80211:   (57240000 KHz - 63720000 KHz @ 2160000 KHz), (N/A, 4000 mBm), (N/A)
```

To change the default regulatory domain that Linux uses at startup, the user must edit the configuration file that was passed while starting the `wpa_cli` using the vi tool. The configuration is as follows:

```
$ vi /etc/wilc_wpa_supplicant.conf
ctrl_interface=/var/run/wpa_supplicant
update_config=1
country=US

network={
        ssid="AndroidAP"
        key_mgmt=NONE
}
```

8.14 Running ATWILC3000 in Bluetooth Mode

Use the following commands to use BLE after loading the `wilc-sdio.ko` modules.

When WILC3000 initializes, it creates a node at `/dev/wilc_bt`, which can be used to write the following commands:

- BT_POWER_UP
- BT_DOWNLOAD_FW
- BT_FW_CHIP_WAKEUP
- BT_FW_CHIP_ALLOW_SLEEP
- BT_POWER_DOWN

8.14.1 BT_POWER_UP

The following command powers up the chip, and indicates that the BT requires the chip to be ON.

```
$ echo BT_POWER_UP > /dev/wilc_bt
```

8.14.2 BT_DOWNLOAD_FW

The following command downloads the BT firmware using SDIO.

```
$ echo BT_DOWNLOAD_FW > /dev/wilc_bt
```

8.14.3 BT_FW_CHIP_WAKEUP

The following command prevents the chip from sleeping.

```
$ echo BT_FW_CHIP_WAKEUP > /dev/wilc_bt
```

This command is used before downloading the firmware using Universal Asynchronous Receiver/Transmitter (UART). Otherwise, the chip may go to Sleep mode when the stack is downloading the BT firmware.

8.14.4 BT_FW_CHIP_ALLOW_SLEEP

The following command specifies that the `at_pwr_dev` module does not require the chip to be awake. The user must use this command after downloading and starting the BT firmware using UART, allowing the BT and Wi-Fi firmwares to take sleep or wake decisions.

```
$ echo BT_FW_CHIP_ALLOW_SLEEP > /dev/wilc_bt
```

8.14.5 BT_POWER_DOWN

The following command is used to chip down the power when the BT is not in use.

```
$ echo BT_POWER_DOWN > /dev/wilc_bt
```

The chip cannot be powered-down using the BT_POWER_DOWN command, if Wi-Fi is active. However, using BT_POWER_UP and BT_POWER_DOWN in the correct sequence the user can power on and off the chip successfully.

8.14.6 Attaching UART for Bluetooth

The ATWILC3000 Bluetooth driver provides the UART interface and is connected via a Teletypewriter (TTY) device. It is connected to the BlueZ stack.

The following command is used to attach the device. Ensure that the `/dev/ttyS1` folder is available on the target platform. The user must set the Bluetooth firmware baud rate at 115200 and should enable noflow control.

```
$ hciattach ttyS1 any 115200 noflow
```

Ensure that the Host Control Interface (HCI) is created.

```
$ hciconfig -a
hci0:    Type: BR/EDR  Bus: UART
    BD Address: AB:89:67:45:23:01  ACL MTU: 1021:9  SCO MTU: 255:4
    DOWN
    RX bytes:574 acl:0 sco:0 events:27 errors:0
    TX bytes:411 acl:0 sco:0 commands:27 errors:0
    Features: 0xff 0xff 0xcd 0xfe 0xdb 0xff 0x7b 0x87
```

```
    Packet type: DM1 DM3 DM5 DH1 DH3 DH5 HV1 HV2 HV3
    Link policy: RSWITCH HOLD SNIFF PARK
    Link mode: SLAVE ACCEPT
```

8.14.7 Enabling the Bluetooth Interface

Enable the ATWILC3000 Bluetooth HCI interface, using the following command.

```
$ hciconfig hci0 up
```

8.14.8 Run bluetoothd (Bluetooth daemon)

The user must create symbolic link for the bluetoothd as:

```
$ ln -svf /usr/libexec/bluetooth/bluetoothd /usr/sbin
```

Start the Bluetooth daemon in background using the `$ bluetoothd -n &` command.

8.14.9 Scanning for Devices

The user can scan for the neighboring networks using the `$ scan on` command. This command displays a list of networks showing the Bluetooth address (BD_ADDR) and name when the scan is complete.

Start the **bluetoothctl** using the `$ bluetoothctl` command, which can be used to scan and connect.

The following is a sample when the scan is started:

```
$ scan on
Scanning ...
    60:6C:66:A4:29:63    D247-PC
    60:03:08:89:93:E7    damiank-mbp1
    E0:06:E6:BE:A8:FA    APDN194
    78:DD:08:B2:91:C9    ALEX-PC
```

8.14.10 Connecting to a Device

It is recommended to use the DBUS interface to connect to a device that is found during scanning.

Use the `connect` command to connect to the device with the specified Bluetooth address.

For example, to connect to the Bluetooth address 00:02:3C:3A:95:6F, use the following command:

```
$ connect 00:02:3C:3A:95:6F
```

8.14.11 BLE Peripheral Mode Example For BlueZ 5.28 and Earlier

BlueZ can be used to run in BLE Peripheral mode using the Low Energy Advertise command (`leadv`). The Bluetooth Daemon (bluetoothd) is also used to provide time profile using the following commands:

```
# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been warned.
Registering wifi device
Max scan ids= 10,Max scan IE len= 1000,Signal Type= 1,Interface Modes= 844
Initializing Locks ...
wifi_pm : 0
wilc_sdio mmc0:0001:1: succesfully got gpio_reset
wilc_sdio mmc0:0001:1: succesfully got gpio_chip_en
wifi_pm : 1
wilc_sdio mmc0:0001:1: succesfully got gpio_reset
wilc_sdio mmc0:0001:1: succesfully got gpio_chip_en
wilc_sdio mmc0:0001:1: Driver Initializing success
# wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_netdev_cleanup]Unregistering netdev d45a4000
De-Initializing Locks
Freeing wiphy
Module_exit Done.
at_pwr_dev: deinit
at_pwr_dev: unregistered
mmc0: card 0001 removed
mmc0: new high speed SDIO card at address 0001
Registering wifi device
Max scan ids= 10,Max scan IE len= 1000,Signal Type= 1,Interface Modes= 844
```

```
Initializing Locks ...
wilc_sdio mmc0:0001:1: Driver Initializing success

#
# echo BT_POWER_UP > /dev/wilc_bt
at_pwr_dev: open()
AT PWR: bt_power_up
wilc_sdio mmc0:0001:1: SDIO speed: 50000000
wilc_sdio mmc0:0001:1: chipid 003000d0
WILC POWER UP
at_pwr_dev: close()
#
# echo BT_FW_CHIP_WAKEUP > /dev/wilc_bt
at_pwr_dev: open()
at_pwr_dev: close()
#
# echo BT_DOWNLOAD_FW > /dev/wilc_bt
at_pwr_dev: open()
AT PWR: bt_download_fw
Bluetooth firmware: mchp/wilc3000_ble_firmware.bin
Downloading BT firmware size = 58704 ...
Starting BT firmware
BT Start Succeeded
at_pwr_dev: close()
#
# echo BT_FW_CHIP_ALLOW_SLEEP   > /dev/wilc_bt
at_pwr_dev: open()
at_pwr_dev: close()
#
# hciattach ttyS1 any 115200 noflow
atmel_usart fc010000.serial: using dma0chan10 for rx DMA transfers
atmel_usart fc010000.serial: using dma0chan11 for tx DMA transfers
Device setup complete
#
# hciconfig hci0 up
#
# hciconfig -a
hci0:   Type: BR/EDR  Bus: UART
        BD Address: F8:F0:05:F6:53:89  ACL MTU: 27:30  SCO MTU: 0:0
        UP RUNNING
        RX bytes:382 acl:0 sco:0 events:24 errors:0
        TX bytes:128 acl:0 sco:0 commands:24 errors:0
        Features: 0x00 0x00 0x00 0x00 0x60 0x00 0x00 0x00
        Packet type: DM1 DH1 HV1
        Link policy:
        Link mode: SLAVE ACCEPT
Can't read local name on hci0: Input/output error (5)
#
# ln -svf /usr/libexec/bluetooth/bluetoothd /usr/sbin '/usr/sbin/bluetoothd' -> '/usr/libexec/
bluetooth/bluetoothd'
#
# bluetoothd  -p time -n &
# bluetoothd[230]: Bluetooth daemon 5.27
bluetoothd[230]: Starting SDP server
bluetoothd[230]: Ignoring (cli) hostname
bluetoothd[230]: Ignoring (cli) wiimote
bluetoothd[230]: Ignoring (cli) autopair
bluetoothd[230]: Ignoring (cli) policy
bluetoothd[230]: Ignoring (cli) neard
bluetoothd[230]: Ignoring (cli) sap
bluetoothd[230]: Ignoring (cli) a2dp
bluetoothd[230]: Ignoring (cli) avrcp
bluetoothd[230]: Ignoring (cli) network
bluetoothd[230]: Ignoring (cli) input
bluetoothd[230]: Ignoring (cli) hog
bluetoothd[230]: Ignoring (cli) health
bluetoothd[230]: Ignoring (cli) gap
bluetoothd[230]: Ignoring (cli) scanparam
bluetoothd[230]: Ignoring (cli) deviceinfo
bluetoothd[230]: Ignoring (cli) alert
bluetoothd[230]: Ignoring (cli) proximity
bluetoothd[230]: Ignoring (cli) thermometer
bluetoothd[230]: Ignoring (cli) heartrate
bluetoothd[230]: Ignoring (cli) cyclingspeed
bluetoothd[230]: Bluetooth management interface 1.14 initialized
bluetoothd[230]: Failed to set local name: Failed (0x03)
```

```
# hciconfig hci0 leadv
```

8.14.12 BLE Peripheral Mode Example for BlueZ 5.29 and Later

Starting with BlueZ 5.29 and later, the time profile is no longer supported using `bluetoothd`. An alternative approach is to use the btgatt-server example that is automatically built while building the BlueZ package. However, it is important to note that buildroot does not install this example to the target by default, and it should be transferred manually to the host using scp or rz.

To install it automatically, the .mk file for BlueZ in the buildroot system will need to be modified as follows:

1. Edit file `buildroot/package/bluez5_utils/bluez5_utils.mk`.
2. Add the following lines at the end of the file before `$(eval $(autotools-package))`

```
define BLUEZ5_UTILS_INSTALL_GATTEXAMPLE
        $(INSTALL) -D -m 0755 $(@D)/tools/btgatt-server $(TARGET_DIR)/usr/bin/btgatt-
server
endef
BLUEZ5_UTILS_POST_INSTALL_TARGET_HOOKS += BLUEZ5_UTILS_INSTALL_GATTEXAMPLE
```

To run the example, use the following commands:

```
# modprobe wilc-sdio
wilc_sdio: module is from the staging directory, the quality is unknown, you have been warned.
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
wilc_sdio mmc0:0001:1: WILC got 60 for gpio_reset
wilc_sdio mmc0:0001:1: WILC got 94 for gpio_chip_en
wilc_sdio mmc0:0001:1: WILC got 91 for gpio_irq
wifi_pm : 0
wifi_pm : 1
wilc_sdio mmc0:0001:1: Driver Initializing success
# wilc_sdio mmc0:0001:1 wlan0: INFO [wilc_netdev_cleanup]Unregistering netdev d4782000
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_netdev_cleanup]Freeing Wiphy...
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_free_wiphy]Unregistering wiphy
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_free_wiphy]Freeing wiphy
wilc_sdio mmc0:0001:1 wlan0 (unregistered): INFO [wilc_netdev_cleanup]Freeing netdev...
wilc_sdio mmc0:0001:1 p2p0: INFO [wilc_netdev_cleanup]Unregistering netdev d477b000
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_netdev_cleanup]Freeing Wiphy...
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_free_wiphy]Unregistering wiphy
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_free_wiphy]Freeing wiphy
wilc_sdio mmc0:0001:1 p2p0 (unregistered): INFO [wilc_netdev_cleanup]Freeing netdev...
Module_exit Done.
at_pwr_dev: deinit
at_pwr_dev: unregistered
mmc0: card 0001 removed
mmc0: new high speed SDIO card at address 0001
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Registering wifi device
(unnamed net_device) (uninitialized): INFO [WILC_WFI_CfgAlloc]Allocating wireless device
(unnamed net_device) (uninitialized): INFO [wilc_create_wiphy]Successful Registering
wilc_sdio mmc0:0001:1: WILC got 60 for gpio_reset
wilc_sdio mmc0:0001:1: WILC got 94 for gpio_chip_en
wilc_sdio mmc0:0001:1: WILC got 91 for gpio_irq
wilc_sdio mmc0:0001:1: Driver Initializing success

# echo BT_POWER_UP > /dev/wilc_bt
at_pwr_dev: open()
AT PWR: bt_power_up
wilc_sdio mmc0:0001:1: SDIO speed: 50000000
wilc_sdio mmc0:0001:1: chipid 003000d0
WILC POWER UP
at_pwr_dev: close()
#
# echo BT_FW_CHIPaWt_pUwr_dev: open()
 > /at_pwwrc_dtev: close()
#
```

```
# echo BT_DOWNLOAD_FW > /dev/wilc_bt
at_pwr_dev: open()
AT PWR: bt_download_fw
Bluetooth firmware: mchp/wilc3000_ble_firmware.bin
Downloading BT firmware size = 58276 ...
Starting BT firmware
BT Start Succeeded
at_pwr_dev: close()
#
# echo BT_FW_CHIP_ALLOW_SLEEP   > /dev/wilc_bt
at_pwr_dev: open()
at_pwr_dev: close()
#
# hciattach ttyS1 any 115200 noflow
atmel_usart fc010000.serial: using dma0chan10 for rx DMA transfers
atmel_usart fc010000.serial: using dma0chan11 for tx DMA transfers
Device setup complete
#
# hciconfig hci0 up
#
# hciconfig hci0 leadv
#
# btgatt-server -i hci0 -s low -t public -r -v
Started listening on ATT channel. Waiting for connections
Connect from 49:0D:EA:C2:98:66
NET: Registered protocol family 38
Running GATT server
[GATT server]# att: > 0a 10 00                                          ...
[GATT server]# att: ATT PDU received: 0x0a
[GATT server]# server: Read Req - handle: 0x0010
[GATT server]# att: ATT op 0x0b
[GATT server]# att: < 0b 01                                             ..
[GATT server]#
```

8.14.13 Setting Wi-Fi Mac Address

The ATWILC has a nonvolatile memory that is used to keep a unique mac address for each of its Wi-Fi interfaces.

If the ATWILC does not have MAC address in its nonvolatile memory, the host must assign a unique MAC address when the interface is initialized.

Use the following Linux commands to set the MAC address:

```
ifconfig wlan0 up
ifconfig wlan0 hw ether fa:f0:05:f6:53:88
```

(or)

If iproute2 utilities are available, use the following commands:

```
ifconfig wlan0 up
ip link set wlan0 address fa:f0:05:f6:53:88
```

The user can also use the same commands for p2p0 interface.

9. Document Revision History

Revision	Date	Section	Description
E	06/2020	How to Build Linux for SAMA5D4 Xplained	Updated
		Updating Binary and System Image into the Target Board.	Updated
D	03/2020	3. Building and Flashing the System Image into the SAMA5D2 Xplained Ultra Board	Updated
		4. Building and Flashing the System Image into the SAMA5D3 Xplained Board	Updated
		5. Building and Flashing the System Image into the SAMA5D27-SOM1-EK1	Updated
		1. Prerequisites	Updated
		• Running in the ATWILC P2P Mode • Supported Modes with Concurrency • BLE Powersave • Set Transmit Power • BLE Peripheral Mode Example For BlueZ 5.28 and Earlier	• Modified steps to add p2p0 virtual interface before using it • Added note about hostapd removing virtual interface before closing • Add missing parameters to uart_brk_ioctl command • Explain allowed tx power levels and their units • Modify BlueZ's output to match the existing SW
C	02/2019	• Building Linux for SAMA5D2 Xplained Ultra Board • Building and Flashing the System Image into the SAMA5D3 Xplained Board • Building and Flashing the System Image into the SAMA5D27-SOM1-EK1 Board • Serial Peripheral Interface Board • Monitor Mode • Change Regulatory Domain settings • Setting Wi-Fi MAC address	• Added new section • Added new section • Added new section • Added details about XPRO EXT1 Pins for SPI pins • Added new section • Added new section • Added new section
B	06/2018	Document	• Updated procedure for building Linux for SAMA5D4 Xplained Ultra Board • Updated the procedure for updating ATWILC Firmware • Added information about Powersave, Antenna Switching, and Debug Logs • Added details about BLE Peripheral Mode example for BlueZ 5.28 and Earlier, and BlueZ 5.29 and Later

.....continued

Revision	Date	Section	Description
A	08/2017	Document	Initial Release

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