Moxa Industrial Linux 1 (Debian 9) Manual for Arm-based Computers

Version 5.3, August 2025

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Moxa Industrial Linux 1 (Debian 9) Manual for Arm-based Computers

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1. Introduction

This user manual is applicable to Moxa's Arm-based computers listed below and covers the complete set of instructions applicable to all the supported models. Detailed instructions on configuring advanced settings are covered in Chapter 3 and Chapter 4 of the manual. Before referring to sections in these chapters, confirm that the hardware specification of your computer model supports the functions/settings covered therein.

Moxa's Arm-based Computing Platforms

- UC-2100 Series
- UC-2100-W Series
- UC-3100 Series
- UC-5100 Series
- UC-8100 Series (firmware V3.0.0 and higher)
- UC-8100-ME-T Series
- UC-8100A-ME-T Series
- UC-8200 Series
- UC-8410A Series
- UC-8540 Series
- UC-8580 Series

Moxa Industrial Linux

Moxa Industrial Linux (MIL) is the optimized Linux distribution for Industrial applications and users, which is released and maintained by Moxa.

The MIL is based on Debian and integrated with several feature sets designed for strengthening and accelerating user's application development as well as ensuring the reliability of system deployment.

Furthermore, the major versions of MIL comply with Moxa's Superior long-term support (SLTS) policy. Moxa will maintain each version of the MIL for 10 years from its launch date. The extended support (ES) may also be purchased by request for additional maintenance. This makes MIL an optimal choice as a Linux operating system for industrial applications.

2. Getting Started

In this chapter, we describe how to configure the basic settings Moxa's Arm-based computers.

Connecting to Your Arm-based Computer

You will need another computer to connect to the Arm-based computer and log on to the command line interface. There are two ways to connect: through serial console cable or through Ethernet cable. Refer to the Hardware Manual to see how to set up the physical connections.

The default login username and password are:

Username: **moxa**
Password: **moxa**

The username and password are the same for all serial console and SSH remote log in actions. Root account login is disabled until you manually create a password for the account. The user **moxa** is in the **sudo** group so you can operate system level commands with this user using the **sudo** command. For additional details, see the *Sudo Mechanism* section in Chapter 5.

ATTENTION

For security reasons, we recommend that you disable the default user account and create your own user accounts.

Connecting via the Serial Console

This method is particularly useful when using the computer for the first time. The signal is transmitted over a direct serial connection, so you do not need to know either of its two IP addresses in order to connect to the Arm-based computer. To connect through the serial console, configure your PC's terminal software using the following settings.

Serial Console Port Settings	
Baudrate	115200 bps
Parity	None
Data bits	8
Stop bits	1
Flow Control	None
Terminal	VT100

Below we show how to use the terminal software to connect to the Arm-based computer in a Linux environment and in a Windows environment.

Linux Users

> **NOTE**
>
> These steps apply to the Linux PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps to connect to the Arm-based computer from your Linux PC.

1. Install **minicom** from the package repository of your operating system.

   For Centos and Fedora:

   ```
   user@PC1:~# yum -y install minicom
   ```

   For Ubuntu and Debian:

   ```
   user@PC2:~# apt-get install minicom
   ```

2. Use the **`minicom -s`** command to enter the configuration menu and set up the serial port settings.

   ```
   user@PC1:~# minicom -s
   ```

3. Select **Serial port setup**.

   ```
   +-----[configuration]------+
   | Filenames and paths      |
   | File transfer protocols  |
   | Serial port setup        |
   | Modem and dialing        |
   | Screen and keyboard      |
   | Save setup as dfl        |
   | Save setup as..          |
   | Exit                     |
   | Exit from Minicom        |
   +--------------------------+
   ```

4. Select **A** to change the serial device. Note that you need to know which device node is connected to the Arm-based computer.

   ```
   +-----------------------------------------------------------------------+
   | A -    Serial Device      : /dev/tty8                                 |
   | B - Lockfile Location     : /var/lock                                 |
   | C -   Callin Program      :                                           |
   | D -  Callout Program      :                                           |
   | E -    Bps/Par/Bits       : 115200 8N1                                |
   | F - Hardware Flow Control : No                                        |
   | G - Software Flow Control : No                                        |
   |                                                                       |
   |    Change which setting?                                              |
   +-----------------------------------------------------------------------+
           | Screen and keyboard      |
           | Save setup as dfl        |
           | Save setup as..          |
           | Exit                     |
           | Exit from Minicom        |
           +--------------------------+
   ```

5. Select **E** to configure the port settings according to the **Serial Console Port Settings** table provided.
6. Select **Save setup as dfl** (from the main configuration menu) to use default values.
7. Select **Exit from minicom** (from the configuration menu) to leave the configuration menu.
8. Execute **minicom** after completing the above configurations.

   ```
   user@PC1:~# minicom
   ```

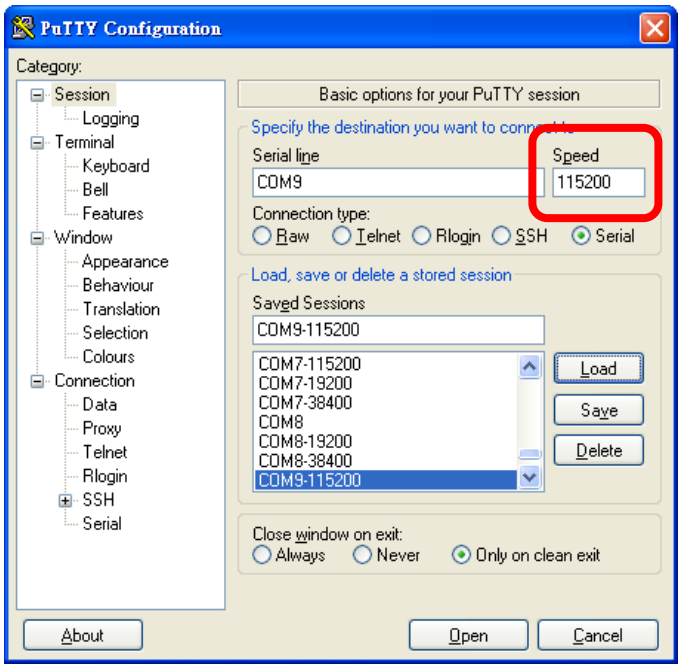
Windows Users

NOTE

These steps apply to the Windows PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps to connect to the Arm-based computer from your Windows PC.

1. Download PuTTY http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html to set up a serial connection with the Arm-based computer in a Windows environment. The figure below shows a simple example of the configuration that is required.



2. Select the **Serial** connection type and choose settings that are similar to the Minicom settings.

Connecting via the SSH Console

The Arm-based computer supports SSH connections over an Ethernet network. Use the following default IP addresses to connect to the Arm-based computer.

Port	Default IP
LAN 1	192.168.3.127
LAN 2	192.168.4.127

Linux Users

NOTE

These steps apply to the Linux PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself. Before you run the **`ssh`** command, be sure to configure the IP address of your notebook/PC's Ethernet interface in the range of 192.168.3.0/24 for LAN1 and 192.168.4.0/24 for LAN2.

Use the **ssh** command from a Linux computer to access the computer's LAN1 port.

```
user@PC1:~ ssh moxa@192.168.3.127
```

Type **yes** to complete the connection.

```
The authenticity of host '192.168.3.127' can't be established.
RSA key fingerprint is 8b:ee:ff:84:41:25:fc:cd:2a:f2:92:8f:cb:1f:6b:2f.
Are you sure you want to continue connection (yes/no)? yes_
```

ATTENTION

Rekey SSH regularly

In order to secure your system, we suggest doing a regular SSH-rekey, as shown in the following steps:

When prompted for a passphrase, leave the passphrase empty and press enter.

```
moxa@Moxa:~$ cd /etc/ssh
moxa@Moxa:~$ sudo rm -rf
ssh_host_ed25519_key2      ssh_host_ecdsa_key     ssh_host_rsa_key
ssh_host_ed25519_key.pub   ssh_host_ecdsa_key.pub   ssh_host_rsa_key.pub

moxa@Moxa:~$ sudo ssh-keygen -t rsa -f /etc/ssh/ssh_host_rsa_key
moxa@Moxa:~$ sudo ssh-keygen -t dsa -f /etc/ssh/ssh_host_dsa_key
moxa@Moxa:~$ sudo ssh-keygen -t ecdsa -f /etc/ssh/ssh_host_ecdsa_key
moxa@Moxa:~$ sudo /etc/init.d/ssh restart
```

For more information about SSH, refer to the following link.

https://wiki.debian.org/SSH

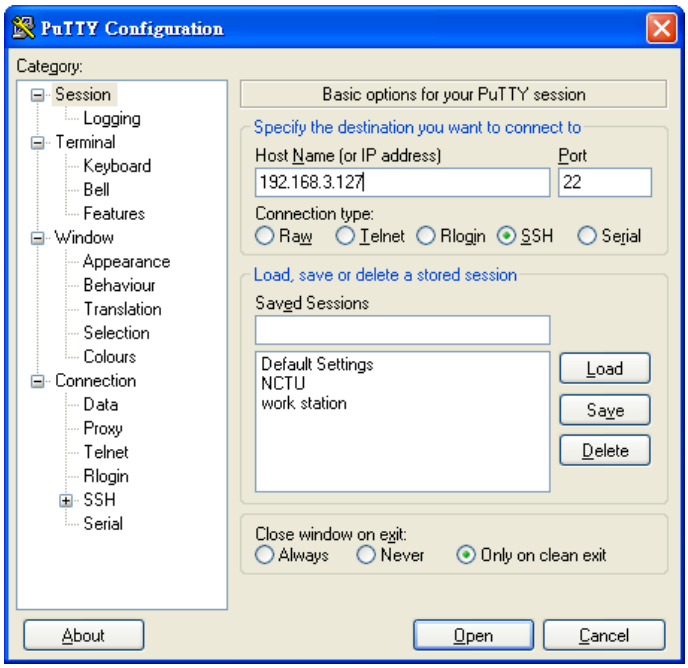
Windows Users

NOTE

These steps apply to the Windows PC you are using to connect to the Arm-based computer. Do NOT apply these steps to the Arm-based computer itself.

Take the following steps from your Windows PC.

Click on the link http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html to download PuTTY (free software) to set up an SSH console for the Arm-based computer in a Windows environment. The following figure shows a simple example of the configuration that is required.



Managing User Accounts

Default User Account and Password Policy

The default login username and password of Moxa Industrial Linux are both **moxa** for first-time login. You will be prompted to set a new password before you can continue to login.

- Default Username: **moxa**
- Default Password: **moxa**

Password Strength Requirements:

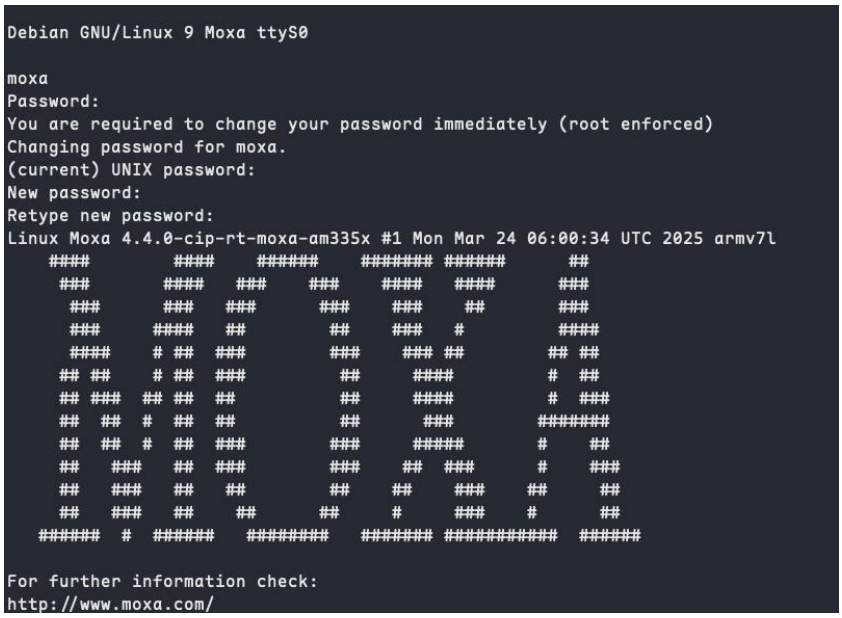
- At least 8 characters in length
- Dictionary checking is enabled to prevent the use of common passwords

To modify the password strength policy, edit the **/etc/security/pwquality.conf.d/99-moxa-pwquality.conf** file to configure the policy. This configuration file will be available with the firmware version with RED adoption. See Security Hardening Guide for details.

NOTE

Click the following link for more information on the password strength configuration.

https://manpages.debian.org/bullseye/libpwquality-common/pwquality.conf.5.en.html


Debian GNU/Linux 9 Moxa ttyS0
moxa
Password:
You are required to change your password immediately (root enforced)
Changing password for moxa.
(current) UNIX password:
New password:
Retype new password:
Linux Moxa 4.4.0-cip-rt-moxa-am335x #1 Mon Mar 24 06:00:34 UTC 2025 armv7l
For further information check:
http://www.moxa.com/

Switching to the Root Account

You can switch to root account using the **sudo -i** (or **sudo su**) command. For security reasons, we do not recommend using **all** commands from the **root** account.

NOTE

Click the following link for more information on the **sudo** command.

https://wiki.debian.org/sudo

ATTENTION

You might get the **permission denied** message when using pipe or redirect behavior with a non-root account.

You must use '**sudo su -c**' to run the command instead of using >, <, >>, <<, etc.

Note: The single quotes enclosing the full command are required.

Creating and Deleting User Accounts

You can use the **useradd** and **userdel** commands to create and delete user accounts. Be sure to reference the main page of these commands to set relevant access privileges for the account. The following example shows how to create a **test1** user in the **sudo** group whose default login shell is **bash** and has home directory at **/home/test1**:

```
moxa@Moxa:~# sudo useradd -m -G sudo -s /bin/bash test1
```

To change the password for test1, use the **passwd** option along with the new password. Retype the password to confirm the change.

```
moxa@Moxa:~# sudo passwd test1
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
```

To delete the user **test1**, use the **userdel** command.

```
moxa@Moxa:# sudo userdel test1
```

Disabling the Default User Account

ATTENTION

You should first create a user account before you disable the default account.

Use the **passwd** command to lock the default user account so that the **moxa** user cannot log in.

```
root@Moxa:# passwd -l moxa
```

To unlock the user moxa:

```
root@Moxa:# passwd -u moxa
```

Configuring Network Settings

Configuring Ethernet Interfaces

After the first login, you can configure the Arm-based computer's network settings to fit your application better. Note that it is more convenient to manipulate the network interface settings from the serial console than from an SSH login because an SSH connection can disconnect when there are network issues, and the connection must be reestablished.

Modifying Network Settings via the Serial Console

In this section, we use the serial console to configure the Arm-based computer's network settings. Follow the instructions in the *Connecting to the Arm-based Computer* section under *Getting Started*, to access the Console Utility of the target computer via the serial Console port, and then type **`cd /etc/network`** to change directories.

```
moxa@Moxa:~$ cd /etc/network/
moxa@Moxa:/etc/network/~$
```

Type **`sudo vi interfaces`** to edit the network configuration file in the **vi** editor. You can configure the Arm-based computer's Ethernet ports to use either **static** or **dynamic** (DHCP) IP addresses.

Setting a Static IP address

To set a static IP address for the Arm-based computer, use the **`iface`** command to modify the default gateway, address, network, netmask, and broadcast parameters of the Ethernet interface.

```
# interfaces(5) file used by ifup(8) and ifdown(8)
auto eth0 eth1 lo
iface lo inet loopback

# embedded ethernet LAN1
#iface eth0 inet dhcp
iface eth0 inet static
        address 192.168.3.127
        network 192.168.3.0
        netmask 255.255.255.0
        broadcast 192.168.3.255

# embedded ethernet LAN2
iface eth1 inet static
        address 192.168.4.127
        network 192.168.4.0
        netmask 255.255.255.0
        broadcast 192.168.4.255~
```

Setting Dynamic IP Addresses

To configure one or both LAN ports to request an IP address dynamically use the **`dhcp`** option in place of the **`static`** in the **`iface`** command as follows**:**

Default Setting for LAN1	Dynamic Setting using DHCP
iface eth0 inet static address 192.168.3.127 network: 192.168.3.0 netmask 255.255.255.0 broadcast 192.168.3.255	iface eth0 inet dhcp

```
# embedded ethernet LAN1
iface eth0 inet dhcp
```

System Administration

Querying the System Image Version

Use the **mx-ver** command to check the system **image version** of your Arm-based computer.

```
moxa@moxa-tbzkb1090923:# mx-ver
UC-3111-LX version 1.6 Build 22042718
```

```
moxa@moxa-tbzkb1090923:# mx-ver -h

Usage: mx-ver [OPTION]
       -a: show product information inline
       -b: show the build time
       -m: show the model name
       -v: show the image version
       -A: show all information
       -M: show the MIL version
       -o: show the image option code
       -h: show the help menu
```

mx-ver may not be available in older version of system image. If it is not available, you can use the **kversion** command.

To check the Arm-based computer's firmware version, type:

```
moxa@Moxa:~$ kversion
UC-3111-LX version 1.6
```

Add the **-a** option to create a full build version:

```
moxa@Moxa:~$ kversion -a
UC-3111-LX version 1.6 Build 22042718
```

Adjusting the Time

The Arm-based computer has two time settings. One is the system time, and the other is the RTC (Real Time Clock) time kept by the Arm-based computer's hardware. Use the **date** command to query the current system time or set a new system time. Use the **hwclock** command to query the current RTC time or set a new RTC time.

Use the **date** ***MMDDhhmmYYYY*** command to set the system time:

MM = Month
DD = Date
hhmm = Hour and minute
YYYY =Year

```
moxa@Moxa:~$ sudo date 071123192014
Mon Jul 11 23:19:00 UTC 2014
```

Use the following command to set the RTC time based on system time:

```
moxa@Moxa:~$ sudo hwclock -w
moxa@Moxa:~$ sudo hwclock
2018-07-31 02:09:00.628145+0000
```

NOTE

Click the following links for more information on date and time:

https://www.debian.org/doc/manuals/system-administrator/ch-sysadmin-time.html

https://wiki.debian.org/DateTime

Setting the Time Zone

There are two ways to configure the Moxa embedded computer's time zone. One is using the **TZ** variable. The other is using the **/etc/localtime** file.

Using the TZ Variable

The format of the TZ environment variable looks like this:

TZ=*<Value>HH[:MM[:SS]][daylight[HH[:MM[:SS]]][,start date[/starttime], enddate[/endtime]]]*

Here are some possible settings for the North American Eastern time zone:

1. **TZ=EST5EDT**
2. **TZ=EST0EDT**
3. **TZ=EST0**

In the first case, the reference time is GMT and the stored time values are correct worldwide. A simple change of the TZ variable can print the local time correctly in any time zone.

In the second case, the reference time is Eastern Standard Time and the only conversion performed is for Daylight Saving Time. Therefore, there is no need to adjust the hardware clock for Daylight Saving Time twice per year.

In the third case, the reference time is always the time reported. You can use this option if the hardware clock on your machine automatically adjusts for Daylight Saving Time, or you would like to manually adjust the hardware time twice a year.

```
moxa@Moxa:~$ TZ=EST5EDT
moxa@Moxa:~$ export TZ
```

You must include the TZ setting in the **/etc/rc.local** file. The time zone setting will be activated when you restart the computer.

The following table lists other possible values for the TZ environment variable:

Hours From Greenwich Mean Time (GMT)	Value	Description
0	GMT	Greenwich Mean Time
+1	ECT	European Central Time
+2	EET	European Eastern Time
+2	ART	
+3	EAT	Saudi Arabia
+3.5	MET	Iran
+4	NET	
+5	PLT	West Asia
+5.5	IST	India
+6	BST	Central Asia
+7	VST	Bangkok
+8	CTT	China
+9	JST	Japan
+9.5	ACT	Central Australia
+10	AET	Eastern Australia
+11	SST	Central Pacific
+12	NST	New Zealand
-11	MIT	Samoa
-10	HST	Hawaii
-9	AST	Alaska
-8	PST	Pacific Standard Time
-7	PNT	Arizona
-7	MST	Mountain Standard Time
-6	CST	Central Standard Time
-5	EST	Eastern Standard Time
-5	IET	Indiana East
-4	PRT	Atlantic Standard Time

Hours From Greenwich Mean Time (GMT)	Value	Description
-3.5	CNT	Newfoundland
-3	AGT	Eastern South America
-3	BET	Eastern South America
-1	CAT	Azores

Using the localtime File

The local time zone is stored in the **/etc/localtime** and is used by GNU Library for C (glibc) if no value has been set for the TZ environment variable. This file is either a copy of the **/usr/share/zoneinfo/** file or a symbolic link to it. The Arm-based computer does not provide **/usr/share/zoneinfo/** files. You should find a suitable time zone information file and write over the original local time file in the Arm-based computer.

Determining Available Drive Space

To determine the amount of available drive space, use the **df** command with the **–h** option. The system will return the amount of drive space broken down by file system. Here is an example:

```
moxa@Moxa:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs          803M  238M  524M  32% /
/dev/root       803M  238M  524M  32% /
tmpfs            25M  188K   25M   1% /run
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs            10M     0   10M   0% /dev
tmpfs            50M     0   50M   0% /run/shm
```

Configuring the Bootloader

Accessing the Bootloader Menu

To access Bootloader menu of, first connect to Moxa Arm-based computer via serial console port. After powering on the Arm-based computer, press **Ctrl + Backspace** or **DEL** to enter the Bootloader configuration menu

NOTE

If you cannot enter the bootloader menu by pressing <DEL>, replace the PuTTy tool with the Tera Term terminal console tool (detailed information is available at: https://ttssh2.osdn.jp/index.html.en.)

```
--------------------------------------------------------------------------------
Model: UC-3111-T-AP-LX
 Boot Loader Version: 1.5.0S03          CPU TYPE: 1GHz
 Build date: Apr 26 2022 - 11:53:22     Serial Number: IMOXA1234567
 LAN1 MAC: 00:90:e8:00:00:41            LAN2 MAC: 00:90:e8:00:00:42
--------------------------------------------------------------------------------
 (0) Boot Management                    (1) Update Firmware
 (2) Advance Setting                    (3) Go to Linux
--------------------------------------------------------------------------------
```

Managing System Bootup

Setting Boot Options

By default, Moxa Arm-based computers boot up from the embedded eMMC flash. Some models also provide an option to boot up from an external SD or USB.

The following is an example of changing first boot priority to SD card and embedded storage is secondary boot option in case booting from SD card fails:

1. Select **(0) Boot Management** > **(1) Boot Option**
2. Choose to boot from external storage first.
3. Choose to disable embedded storage or not. If embedded storage is disabled, Moxa Arm-based computers will only attempt to boot from SD card. If embedded storage is set to eMMC, Moxa Arm-based computers will try to boot from eMMC if they fail to boot from SD card.
4. Set External Storage to SD card

```
--------------------------------------------------------------------------------
 Model: UC-3111-T-AP-LX
 Boot Loader Version: 1.5.0S03          CPU TYPE: 1GHz
 Build date: Apr 26 2022 - 11:53:22    Serial Number: IMOXA1234567
 LAN1 MAC: 00:90:e8:00:00:41            LAN2 MAC: 00:90:e8:00:00:42
--------------------------------------------------------------------------------
 (0) Set to Default                     (1) Boot Option
 (2) Advance Boot Option                (3) View Current Setting
--------------------------------------------------------------------------------
Command>>1
Boot Management : Default
Boot Order : Embedded First
Embedded Storage : eMMC
External Storage : Disabled

Would you like to configure the Boot Option?
0 - No, 1 - Yes (0-1, Enter to abort): 1
Set Boot Order:
 0 - Embedded First, 1 - External First (0-1, Enter to abort): 1
Set Embedded Storage:
 0 - Disabled, 1 - eMMC (0-1, Enter to abort): 1
Set External Storage:
 0 - Disabled ,1 - SD (0-1, Enter to abort): 1
```

Below is table to describe the possible combinations of boot options configuration and the corresponding boot action

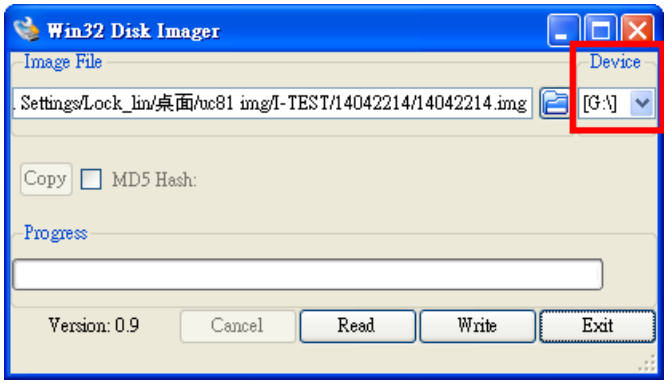
Set Boot Order	Set Embedded Storage	Set External Storage	Boot Action
0 – Embedded First	1 – eMMC	0 – Disabled	Boot from the eMMC
1 – External First	0 – Disabled	1 – SD or 2 – USB	Boot from the external storage
0 – Embedded First	1 – eMMC	1 – SD or 2 – USB	First boot from the eMMC; if it fails, try to boot from the external storage
1 – External First	1 – eMMC	1 – SD or 2 – USB	Boot from the external storage; if this fails, try to boot from eMMC

Preparing a Bootable SD Card

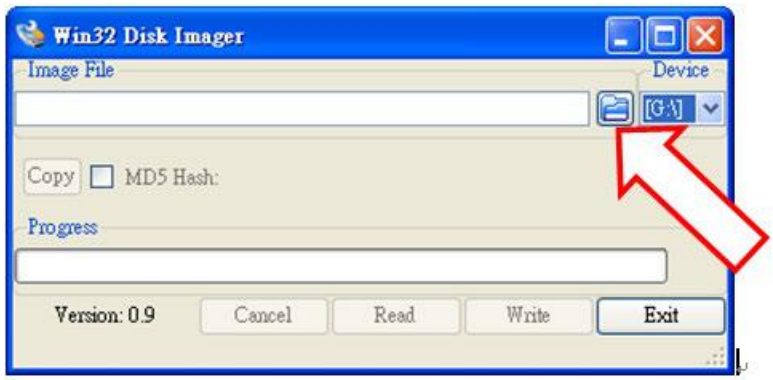
Windows System

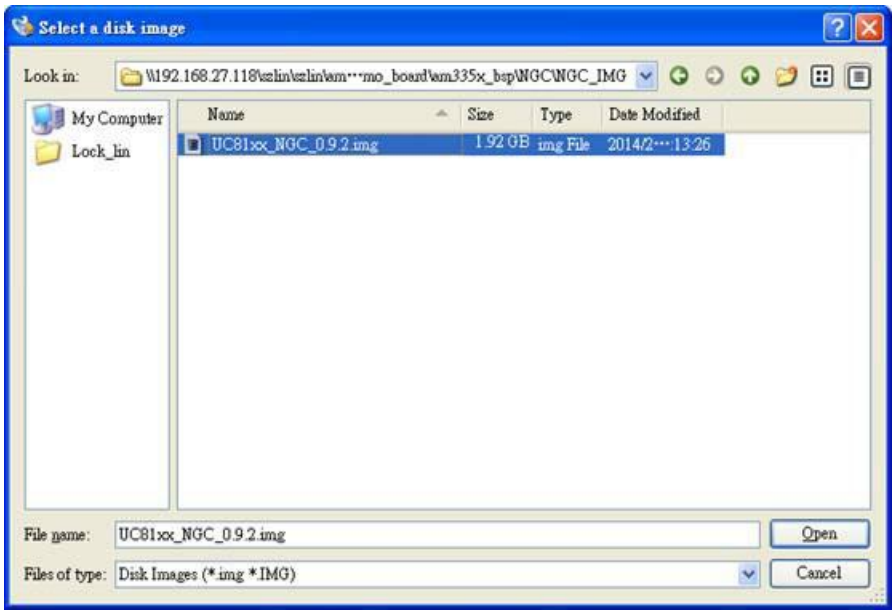
1. Unlock the SD card's write protection switch.

2. Insert the SD card into the corresponding slot on your Windows system.
3. Download **win32diskimager** from following link.
   http://sourceforge.net/projects/win32diskimager/
4. Install and run the **win32diskimager**.
5. Confirm that the device name matches the USB device.

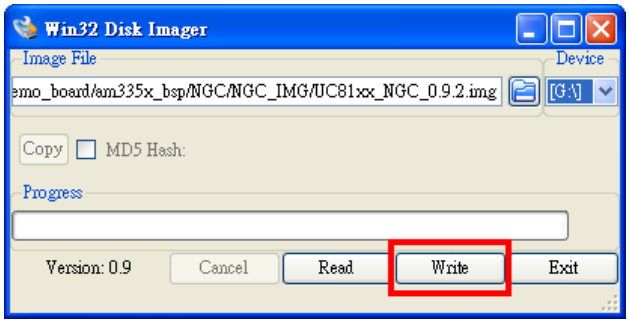


6. Select the image file.

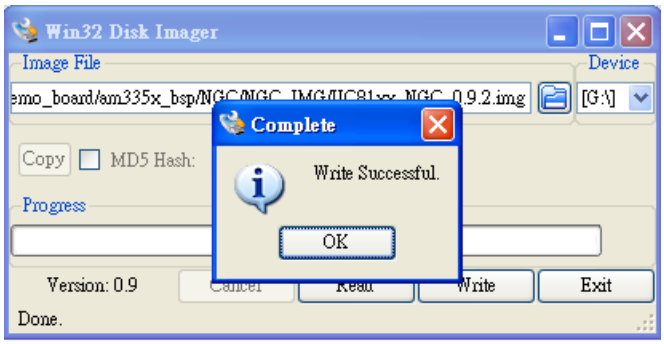




7. Confirm that you have selected the correct image file and click **Write**.



8. When finished, click **OK**.



Linux System

1. Unlock the SD card's write protection switch.

2. Insert the SD card into the corresponding slot on you Linux system.
3. Use the **dmesg** command to determine the device node.

```
scsi 25:0:0:0: Direct-Access     TS-RDF5  SD  Transcend    TS35 PQ: 0 ANSI: 6
sd 25:0:0:0: Attached scsi generic sg3 type 0
sd 25:0:0:0: [sdd] 31260672 512-byte logical blocks: (16.0 GB/14.9 GiB)
sd 25:0:0:0: [sdd] Write Protect is off
sd 25:0:0:0: [sdd] Mode Sense: 23 00 00 00
sd 25:0:0:0: [sdd] Write cache: disabled, read cache: enabled, doesn't support DPO or FUA
 sdd: unknown partition table
sd 25:0:0:0: [sdd] Attached SCSI removable disk
```

4. Use the **dd** command to configure the image on the SD card.

```
moxa@Moxa:/home/work# sudo dd if=./140
42420.img of=/dev/sdd
bs=512k
1954+0 records in
1954+0 records out
1024458752 bytes (1.0 GB) copied, 119.572 s, 8.6 MB/s
```

NOTE

For additional information on the **dd** command, click the following link.

http://www.gnu.org/software/coreutils/manual/html_node/dd-invocation.html

Configuring Advanced Boot Options

Allow advanced users to edit the **bootargs** and **bootcmd** parameters to customize the boot process.

- **bootargs**: Used to tell the kernel how to configure various device drivers and where to find the root filesystem.
- **bootcmd**: Bootloader will execute the commands listed sequentially. Commands should be separated by semicolons.

Installing a System Image

Install the System Image From TFTP

1. Prepare a TFTP server
2. Set up a TFTP server.
3. Make sure the image (*.img) file is in your TFTP server directory.

ATTENTION

If the file size is larger than the file size limit of TFTP (4 GB), we suggest using a specific TFTP server to accommodate a larger file size. Here is an example of one that you can try:
https://www.solarwinds.com/free-tools/free-tftp-server

4. Select **(1) Install System Image** > **(3) TFTP Settings** to configure following:
   a. The LAN port to be used for TFTP transfer.
   b. Local IP address of LAN port
   c. TFTP server IP
5. Press **ESC** to exist and select **(0) Install System Image from TFTP**.
   If you want to change the TFTP IP address, enter 1 to set the local LAN port IP address and the TFTP server IP address, and choose an image (*.img) file

```
Current IP Address

Local IP Address : 192.168.1.2
Server IP Address : 192.168.2.3
Using LAN2 to download data.
Do you want to change the ip address?
0 - No, 1 - Yes(0-1, Enter to abort):1
Local IP Address : 192.168.31.134
Server IP Address : 192.168.31.132
Saving Environment to SPI Flash...
Erasing SPI flash...Writing to SPI flash...done
Valid environment: 2
System Image File Name (system image.img): IMG_UC-3100 v2.0.img
```

6. After the system image installation process is complete, unplug the power supply and reboot the system.
7. After rebooting the system, you can use the following command to check if the system image is up to date.

```
moxa@moxa-tbzkb1090923:# sudo mx-ver
UC-3111-T-AP-LX version 2.0
```

Updating the System Image From an SD or USB Device

The system image of Moxa Arm-based computers can be installed through an external SD or USB disk. Prepare a USB or SD disk in FAT32 or ext4 format with the system image and plug it into USB or SD port of the computer.

1. **Select (1) Install System Image > (1) Install System Image from SD or (2) Install System Image from USB**
2. Type in the system image file name. The system will start the installation process.

```
--------------------------------------------------------------------------------
Model: UC-3111-T-AP-LX
Boot Loader Version: 1.5.0S03         CPU TYPE: 1GHz
Build date: Apr 26 2022 - 11:53:22    Serial Number: IMOXA1234567
LAN1 MAC: 00:90:e8:00:00:41           LAN2 MAC: 00:90:e8:00:00:42
--------------------------------------------------------------------------------
(0) Update Firmware from TFTP         (1) Update Firmware from SD
(2) Update Firmware from USB          (3) TFTP Settings
--------------------------------------------------------------------------------
Command>> Command>>2

System Image File Name (system image.img): IMG_UC-3100 v2.0.img
```

3. After the system image installation process is complete, unplug the power and reboot the system.
4. After rebooting the system, you can use the following command to check if the system image is up to date.

```
moxa@moxa-tbzkb1090923:# sudo mx-ver
UC-3111-T-AP-LX version 2.0
```

NOTE

Update firmware from USB and SD may not be available in older version of bootloader.

ATTENTION

In the case of the UC-8410A Series, the system may fail to boot from an SD card if a USB storage device is also plugged in. Remove all plugged-in USB storage devices before booting the system from an SD card.

Configuring Advanced Bootup Settings

Enabling/Disabling Admin Password

By default, the bootloader menu is not protected by password. To enhance the security of your Moxa Arm-based computer, we strongly recommended you to setup an administrator password if there is a threat of unauthorized physical access. To set up an administrator password, do the following:

1. Select **(2) Advance Setting** > **(0) Enable/Disable Admin Password**
2. Select **1** to set up an administrator password.

   If you select the option **2** (disable), the current password will be cleared.
3. Enter the new password twice.

   Keep the following password strength requirement for the password.
   - 6 to 16 characters in length
   - At least one number: 0 to 9
   - At least one mixed set of upper and lower letters: A to Z, a to z
   - At least one special character: ~!@#$%^&*- |;:,.<>[]{}()

```
--------------------------------------------------------------------------------
 Model: UC-3111-T-AP-LX
 Boot Loader Version: 1.5.0S03         CPU TYPE: 1GHz
 Build date: Apr 26 2022 - 11:53:22    Serial Number: IMOXA1234567
 LAN1 MAC: 00:90:e8:00:00:41           LAN2 MAC: 00:90:e8:00:00:42
--------------------------------------------------------------------------------
 (0) Enable/Disable Admin Password     (1) Configure Admin Password
 (2) Clear TPM
--------------------------------------------------------------------------------
Command>>0
Current Mode: Disabled

0 - Disable, 1 - Enable (0-1, Enter to abort): 1

The current password is empty, please set one.

Note: Password strength should be minimum length (6-16)
and with at least one number: 0 to 9,
mixed upper and lower letters: A to Z, a to z,
and at least one special character: ~!@#$%^&*-_|;:,.<>[]{}()

Enter new password: *************
Retype password: *************
Password set successfully

Password status : Enabled.
```

After the Administrator password is set, password authentication is required when accessing the bootloader menu.

```
DRAM:  1 GiB
MMC:   OMAP SD/MMC: 0, OMAP SD/MMC: 1, OMAP SD/MMC: 2
Net:   cpsw0, cpsw1
Non-security model.
Model: 0x02
2.0 TPM (device-id 0x15D1, rev-id 16)
TPM2 Init OK!
TPM2 Startup (1) OK!

Press <DEL> To Enter BIOS configuration Setting

Please enter your password!
Enter current password: *************
```

WARNING

It is important to save the password in a secure location. If the password is lost and access to bootloader menu is needed, you will have to contact Moxa technical support to send your Arm-based computer to Moxa for a password reset.

Configuring the Admin Password

To change the Administrator password, select **(2) Advance Setting** > **(1) Configure Admin Password** and follow the on-screen instructions.

Clearing the TPM Module

Clearing the TPM will erase all information stored on the module. **You will lose all created keys and access to data encrypted by these keys.**

To clear the TPM, select **(2) Advance Setting** > **(2) Clear TPM** and follow the on-screen instructions.

Shutting Down the Device

To shut down the device, disconnect the power source to the computer. When the computer is powered off, main components such as the CPU, RAM, and storage devices are powered off, although an internal clock may retain battery power.

You can use the **shutdown** command to close all software running on the device and halt the system. However, main components such as the CPU, RAM, and storage devices will continue to be powered after you run this command.

```
moxa@Moxa:~$ sudo shutdown -h now
```

3. Advanced Configuration of Peripherals

In this chapter, we include more information on the Arm-based computer's peripherals, such as the serial interface, storage, diagnostic LEDs, and the cellular module. The instructions in this chapter cover all functions supported in Moxa's Arm-based computers. Before referring to the sections in this chapter, make sure that they are applicable to and are supported by the hardware specification of your Arm-based computer.

Serial Ports

The serial ports support RS-232, RS-422, and RS-485 2-wire operation modes with flexible baudrate settings. The default operation mode is RS-232; use the **`mx-uart-ctl`** command to change the operation mode.

Usage: mx-uart-ctl -p <#port_number> -m <#uart_mode>
Port number: n = 0,1,2,...
uart mode: As in the following table

Interface-No.	Operation Mode
None	Display current setting
0	RS-232
1	RS-485 2-wire
2	RS-422 / RS-485 4-wire

For example, to set Port 0 to the RS-485 4-wire mode, use the following command:

```
root@Moxa:/home/moxa# mx-uart-ctl -p 0
Current uart mode is RS232 interface.
root@Moxa:/home/moxa# mx-uart-ctl -p 0 -m 2
Set OK.
Current uart mode is RS422/RS485-4W interface.
```

Changing the Serial Terminal Settings

The **`stty`** command is used to view and modify the serial terminal settings. The details are given below.

Displaying All Settings

Use the following command to display all serial terminal settings.

```
moxa@Moxa:~$ sudo stty -a -F /dev/ttyM0
speed 9600 baud; rows 0; columns 0; line = 0;
intr = ^C; quit = ^\; erase = ^?; kill = ^U; eof = ^D; eol = <undef>;
eol2 = <undef>; swtch = <undef>; start = ^Q; stop = ^S; susp = ^Z; rprnt = ^R;
werase = ^W; lnext = ^V; flush = ^O; min = 1; time = 0;
-parenb -parodd cs8 hupcl -cstopb cread clocal -crtscts
-ignbrk -brkint -ignpar -parmrk -inpck -istrip -inlcr -igncr icrnl ixon -ixoff
-iuclc -ixany -imaxbel -iutf8
opost -olcuc -ocrnl onlcr -onocr -onlret -ofill -ofdel nl0 cr0 tab0 bs0 vt0 ff0
isig icanon iexten echo echoe echok -echonl -noflsh -xcase -tostop -echoprt
echoctl echoke
```

Configuring Serial Settings

The following example changes the baudrate to 115200.

```
moxa@Moxa:~$ sudo stty 115200 -F /dev/ttyM0
```

Check the settings to confirm that the baudrate has changed to 115200.

```
moxa@Moxa:~$ sudo stty -a -F /dev/ttyM0
speed 115200 baud; rows 0; columns 0; line = 0;
intr = ^C; quit = ^\; erase = ^?; kill = ^U; eof = ^D; eol = <undef>;
eol2 = <undef>; swtch = <undef>; start = ^Q; stop = ^S; susp = ^Z; rprnt = ^R;
werase = ^W; lnext = ^V; flush = ^O; min = 1; time = 0;
-parenb -parodd cs8 hupcl -cstopb cread clocal -crtscts
-ignbrk -brkint -ignpar -parmrk -inpck -istrip -inlcr -igncr icrnl ixon -ixoff
-iuclc -ixany -imaxbel -iutf8
opost -olcuc -ocrnl onlcr -onocr -onlret -ofill -ofdel nl0 cr0 tab0 bs0 vt0 ff0
isig icanon iexten echo echoe echok -echonl -noflsh -xcase -tostop -echoprt
echoctl echoke
```

NOTE

Detailed information on the **stty** utility is available at the following link:
http://www.gnu.org/software/coreutils/manual/coreutils.html

USB and SD Ports

The Arm-based computers are provided with a USB port for storage expansion.

Automounting USB and SD Drives

The Arm-based computers support hot plug function for connecting USB and SD mass storage devices. However, the automount service is disabled by default for better security practice.

Use the **moxa-auto-mountd.service** command to enable automounting:

Command	Description
systemctl enable moxa-auto-mountd.service	Start the automount service at each boot.
systemctl disable moxa-auto-mountd.service	Disable the automount service so it doesn't start at each boot
systemctl start moxa-auto-mountd.service	Start the automount service immediately for the current session.
systemctl stop moxa-auto-mountd.service	Stop the automount service immediately for the current session.

NOTE

The older imager version may not have automount service preloaded. You can use **apt-get install moxa-auto-mountd** command to install the package.

Use the **mount** command to view details about all partitions.

```
moxa@Moxa:~$ mount | grep media
```

ATTENTION

Remember to type the **sync** command before you disconnect the USB mass storage device to prevent loss of data.

Exit from the /media/* directory when you disconnect the storage device. If you stay in /media/[the mounted device folder], the auto unmount process will fail. If that happens, type **#umount /media/[the mounted device folder]**, to unmount the device manually.

CAN Bus Interface

The CAN ports on Moxa's Arm-based computers support CAN 2.0A/B standard.

Configuring the Socket CAN Interface

The CAN ports are initialized by default. If any additional configuration is needed, use the **ip link** command to check the CAN device.

To check the CAN device status, use the **ip link** command.

```
# ip link
can0: <NOARP,UP,LOWER_UP,ECHO> mtu 16 qdisc pfifo_fast state UNKNOWN mode
DEFAULT group default qlen 10 link/can
```

To configure the CAN device, use **# ip link set can0 down** to turn off the device first

```
# ip link set can0 down
# ip link
can0: <NOARP,ECHO> mtu 16 qdisc pfifo_fast state DOWN mode DEFAULT group
default qlen 10 link/can
```

Here's an example with bitrate 12500:

```
# ip link set can0 up type can bitrate 12500
```

CAN Bus Programming Guide

The following code is an example of the SocketCAN API, which sends packets using the raw interface.

CAN Write

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <net/if.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <sys/ioctl.h>
#include <linux/can.h>
#include <linux/can/raw.h>
int main(void)
{
    int s;
    int nbytes;
    struct sockaddr_can addr;
    struct can_frame frame;
    struct ifreq ifr;
    char *ifname = "can1";
    if((s = socket(PF_CAN, SOCK_RAW, CAN_RAW)) < 0) {
        perror("Error while opening socket");
```

```
        return -1;
    }
    strcpy(ifr.ifr_name, ifname);
    ioctl(s, SIOCGIFINDEX, &ifr);
    addr.can_family = AF_CAN;
    addr.can_ifindex = ifr.ifr_ifindex;
    printf("%s at index %d\n", ifname, ifr.ifr_ifindex);
    if(bind(s, (struct sockaddr *)&addr, sizeof(addr)) < 0) {
        perror("Error in socket bind");
        return -2;
    }
    frame.can_id = 0x123;
    frame.can_dlc = 2;
    frame.data[0] = 0x11;
    frame.data[1] = 0x22;
    nbytes = write(s, &frame, sizeof(struct can_frame));
    printf("Wrote %d bytes\n", nbytes);
    return 0;
}
```

CAN Read

The following sample code illustrates how to read the data.

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <net/if.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <sys/ioctl.h>
#include <linux/can.h>
#include <linux/can/raw.h>
Int main(void)
{
    int i;
    int s;
    int nbytes;
    struct sockaddr_can addr;
    struct can_frame frame;
    struct ifreq ifr;
    char *ifname = "can0";
    if((s = socket(PF_CAN, SOCK_RAW, CAN_RAW)) < 0) {
        perror("Error while opening socket");
        return -1;
    }
    strcpy(ifr.ifr_name, ifname);
    ioctl(s, SIOCGIFINDEX, &ifr);
    addr.can_family = AF_CAN;
    addr.can_ifindex = ifr.ifr_ifindex;
    printf("%s at index %d\n", ifname, ifr.ifr_ifindex);
    if(bind(s, (struct sockaddr *)&addr, sizeof(addr)) < 0) {
        perror("Error in socket bind");
        return -2;
    }
    nbytes = read(s, &frame, sizeof(struct can_frame));
    if (nbytes < 0) {
        perror("Error in can raw socket read");
        return 1;
    }
    if (nbytes < sizeof(struct can_frame)) {
        fprintf(stderr, "read: incomplete CAN frame\n");
```

```
        return 1;
    }
    printf(" %5s %03x [%d] ", ifname, frame.can_id, frame.can_dlc);
    for (i = 0; i < frame.can_dlc; i++)
        printf(" %02x", frame.data[i]);
    printf("\n");
    return 0;
}
```

After you use the SocketCAN API, the SocketCAN information is written to the paths: **/proc/sys/net/ipv4/conf/can*** and **/proc/sys/net/ipv4/neigh/can***

Configuring the Real COM Mode

IMPORTANT

The UC-8100, UC-8100-ME-T, and UC-8100A-ME-T Series do not support the Real COM mode.

You can use Moxa's NPort Series serial device drivers to extend the number of serial interfaces (ports) on your Arm-based Moxa computer. The NPort comes equipped with COM drivers that work with Windows systems and TTY drivers for Linux systems. The driver establishes a transparent connection between the host and serial device by mapping the IP Port of the NPort's serial port to a local COM/TTY port on the host computer.

Real COM Mode also supports up to 4 simultaneous connections, so that multiple hosts can collect data from the same serial device at the same time.

One of the major conveniences of using Real COM Mode is that Real COM Mode allows users to continue using RS-232/422/485 serial communications software that was written for pure serial communications applications. The driver intercepts data sent to the host's COM port, packs it into a TCP/IP packet, and then redirects it through the host's Ethernet card. At the other end of the connection, the NPort accepts the Ethernet frame, unpacks the TCP/IP packet, and then sends it transparently to the appropriate serial device attached to one of the NPort's serial ports.

The Real COM driver is installed on the Arm-based computer by default. You will be able to view the driver related files in the **/usr/lib/npreal2/driver** folder.

> mxaddsvr (Add Server, mapping tty port) > mxdelsvr (Delete Server, unmapping tty port)

> mxloadsvr (Reload Server) > mxmknod (Create device node/tty port)

> mxrmnod (Remove device node/tty port)

> mxuninst (Remove tty port and driver files)

At this point, you will be ready to map the NPort serial port to the system **tty** port. For a list of supported NPort devices and their revision history, click https://www.moxa.com/en/support/search?psid=50278.

Mapping TTY Ports

Make sure that you set the operation mode of the desired NPort serial port to Real COM mode. After logging in as a super user, enter the directory /usr/lib/npreal2/driver and then execute mxaddsvr to map the target NPort serial port to the host tty ports. The syntax of **mxaddsvr** command is as follows:

mxaddsvr [NPort IP Address] [Total Ports] ([Data port] [Cmd port])

The **mxaddsvr** command performs the following actions:

1. Modifies the npreal2d.cf.
2. Creates tty ports in the /dev directory with major & minor number configured in npreal2d.cf.
3. Restarts the driver.

NOTE

To keep the connection between your UC and NPort devices secure, make sure to place the NPort devices in a trusted zone. This helps protect them from malicious attacks that might come from untrusted zones, such as the Internet.

Mapping TTY Ports (automatic)

To map tty ports automatically, execute the **mxaddsvr** command with just the IP address and the number of ports, as shown in the following example:

```
# cd /usr/lib/npreal2/driver
# ./mxaddsvr 192.168.3.4 16
```

In this example, 16 tty ports will be added, all with IP 192.168.3.4 consisting of data ports from 950 to 965 and command ports from 966 to 981.

ATTENTION

You must reboot the system after mapping tty ports with **mxaddsvr**

Mapping TTY Ports (manual)

To map tty ports manually, execute the **mxaddsvr** command and specify the data and command ports as shown in the following example:

```
# cd /usr/lib/npreal2/driver
# ./mxaddsvr 192.168.3.4 16 4001 966
```

In this example, 16 tty ports will be added, all with IP 192.168.3.4, with data ports from 4001 to 4016 and command ports from 966 to 981.

ATTENTION

You must reboot the system after mapping tty ports with **mxaddsvr**

Removing Mapped TTY Ports

After logging in as root, enter the directory /usr/lib/npreal2/driver and then execute the **mxdelsvr** command to delete a server. The syntax of **mxdelsvr** is:

mxdelsvr [IP Address]

Example:

```
# cd /usr/lib/npreal2/driver
# ./mxdelsvr 192.168.3.4
```

The following actions are performed when the **mxdelsvr** command is executed:

1. Modify npreal2d.cf.
2. Remove the relevant tty ports from the /dev directory.
3. Restart the driver.

If the IP address is not provided in the command line, the program will list the installed servers and total ports on the screen. You will need to choose a server from the list for deletion.

4. Configuring Wireless Connectivity

The instructions in this chapter cover all wireless functions supported in Moxa's Arm-based computers. Before referring to the sections in this chapter, make sure that they are applicable to and are supported by the hardware specification of your Arm-based computer platform.

Configuring the Cellular Connection

Using Cell_mgmt

The cell_mgmt utility is used to manage the cellular module in the computer. To run the **cell_mgmt** command, you must use **sudo** or run the command with root permission. The utility does not support SMS and MMS communication.

Manual Page

```
NAME
    cell_mgmt

USAGE
    cell_mgmt [-i <module id>] [options]

OPTIONS
       -i <module id>
                Module identifier, start from 0 and default to 0.
       -s <slot id>
                Slot identifier, start from 1 and default value depends
                on module interface.
                example: module 0 may in slot 2
       modules
                Shows module numbers supported.
       slot
                Shows module slot id
       interface [interface id]
                Switching and checking module interface(s)
       start [OPTIONS]
                Start network.

                OPTIONS:
                PIN - PIN code
                Phone - Phone number (especially for AT based modules)
                Auth - Authentication type(CHAP|PAP|BOTH), default=NONE.
                Username
                Password

                example:
                    cell_mgmt start
                    cell_mgmt start PIN=0000
                    cell_mgmt start PIN=0000 Phone=*99#
                    cell_mgmt start PIN=0000 Phone=*99# \
                            Auth=BOTH Username=moxa Password=moxamoxa
       stop
                network.
       power_on
                Power ON.
```

```
        power_off
                Power OFF.
        power_cycle
                Power cycle the module slot.
        switch_sim <1|2>
                Switch SIM slot.
        gps_on
                GPS ON.
        gps_off
                GPS OFF.
        attach_status
                Query network registration status.
        status
                Query network connection status.
        signal
                Get signal strength.
        at <'AT_COMMAND'>
                Input AT Command.
                Must use SINGLE QUOTATION to enclose AT Command.
        sim_status
                Query sim card status.
        unlock_pin <PIN>
                Unlock PIN code and save to configuration file.
        pin_retries
                Get PIN code retry remain times.
        pin_protection <enable|disable> <current PIN>
                Set PIN protection in the UIM.
        set_flight_mode <0|1>
                Set module into flight mode (1) or online mode (0).
        set_apn <APN>
                Set APN to configuration file.
        check_carrier
                Check current carrier.
        switch_carrier <Verizon|ATT|Sprint|Generic>
                Switching between US carrier frequency bands.
        m_info
                Module/SIM information.
        module_info
                Module information.
        module_ids
                Get device IDs (ex: IMEI and/or ESN).
        iccid
                Get SIM card ID
        imsi
                Get IMSI (International Mobile Subscriber Identity).
        location_info
                Get cell location information.
        operator
                Telecommunication operator.
        vzwauto
                Verizon Private Network auto dialup.
        version
                Cellular management version.
```

Dial-up Process

Before dialing, ensure that the APN (Access Point Name) is set correctly and the cellular module has attached with the base station.

1. Unlock the PIN code (if the SIM is locked using a PIN code).
   Use the **`cell_mgmt sim_status`** command to check the SIM card status and the **`cell_mgmt unlock_pin`** *<PIN>* command to unlock the SIM card if a SIM PIN is set.

   ```
   moxa@Moxa:/home/moxa$ sudo cell_mgmt sim_status
   +CPIN: READY
   ```

2. Use the **`cell_mgmt set_apn`** *<APN>* command to set the name of the access point that will be used to connect to the carrier.

   ```
   moxa@Moxa:/home/moxa$ sudo cell_mgmt set_apn internet
   old APN=test, new APN=internet
   ```

3. Check if the service attaches with the correct APN.

   ```
   moxa@Moxa:/home/moxa$ sudo cell_mgmt attach_status
   CS: attached
   PS: attached
   ```

   PS (packet-switched) should be **attached** to establish a network connection.

4. Dial up using the **`cell_mgmt start`** command.

   ```
   moxa@Moxa:/home/moxa$ sudo cell_mgmt start
   PIN code: Disabled or verified
   Starting network with '_qmicli --wds-start-network=apn=internet,ip-type=4 --
   client-no-release-cid --device-open-net=net-802-3|net-no-qos-header'...
   Saving state... (CID: 8)
   Saving state... (PDH: 1205935456)
   Network started successfully
   ```

   The dial-up function in the **`cell_mgmt`** utility will automatically set the DNS and default gateway of the computer, if they have not been set.

Dial-up Commands

cell_mgmt start

To start a network connection, use the default cellular module of the computer (If the computer supports multiple modules, use the **`cell_mgmt interface`** command to verify the default module that is selected).

If you run the **`cell_mgmt start`** command with the Username, Password, and PIN, all the configurations will be written into the configuration file **`/etc/moxa-cellular-utils/moxa-cellular-utils.conf`**.

This information is then used when you run the command without specifying the options.

Usage: **`cell_mgmt start Username=[user] Password=[pass] PIN=[pin_code]`**

cell_mgmt stop

Stops/disables the network connection on the cellular module of the computer

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt stop
Killed old client process
Stopping network with '_qmicli --wds-stop-network=1205933264 --client-cid=8'...
Network stopped successfully
Clearing state...
```

cell_mgmt status

Provides information on the status of the network connection.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt status
Status: connected
```

cell_mgmt signal

Provides the cellular signal strength.

For moxa-cellular-utils version 2.0.0 and later, cellular signal strength is indicated using levels.

```
root@Moxa:/home/moxa$ sudo cell_mgmt signal
4G Level 4 (Good)
```

Level	Description
5	Excellent
4	Good
3	Fair
2	Poor
1	Very Poor
0	No Signal

For moxa-cellular-utils versions prior to version 2.0.0, the cellular signal strength is measured using Reference Signal Received Power (RSRP). The following table lists the signal strength for RSRP ranges.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt signal
umts -77 dbm
```

RSRP	Signal Strength
<-115 dBm	No signal
-105 to -115 dBm	Poor
-95 to -105 dBm	Fair
-85 to -95 dBm	Good
>-85 dBm	Excellent

cell_mgmt operator

Provides information on the cellular service provider.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt operator
Chunghwa
```

Cellular Module

cell_mgmt module_info

Provides information of the cellular module (AT port, GPS port, QMI port, and module name, etc.).

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt module_info
SLOT: 1
Module: MC7354
WWAN_node: wwan0
AT_port: /dev/ttyUSB2
GPS_port: /dev/ttyUSB1
QMI_port: /dev/cdc-wdm0
Modem_port: NotSupport
```

cell_mgmt interface [id]

Used to view the supported modules and default module on the computer with their IDs. Change the default module by specifying the ID.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt interface
[0] wwan0    <Current>
```

cell_mgmt power_cycle

Use the **cell_mgmt power_cycle** command to power cycle the cellular module in the computer. You may see a kernel message that the module has been reloaded.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt power_cycle
Network already stopped
Clearing state...
[232733.202208] usb 1-1: USB disconnect, device number 2
[232733.217132] qcserial ttyUSB0: Qualcomm USB modem converter now disconnected
from ttyUSB0
[232733.225616] qcserial 1-1:1.0: device disconnected
[232733.256738] qcserial ttyUSB1: Qualcomm USB modem converter now disconnected
from ttyUSB1
[232733.265214] qcserial 1-1:1.2: device disconnected
[232733.281566] qcserial ttyUSB2: Qualcomm USB modem converter now disconnected
from ttyUSB2
[232733.290006] qcserial 1-1:1.3: device disconnected
[232733.313572] qmi_wwan 1-1:1.8 wwan0: unregister 'qmi_wwan' usb-musb-
hdrc.0.auto-1, WWAN/QMI device
[232746.879873] usb 1-1: new high-speed USB device number 3 using musb-hdrc
[232747.020358] usb 1-1: config 1 has an invalid interface number: 8 but max is
3
[232747.027639] usb 1-1: config 1 has no interface number 1
[232747.036212] usb 1-1: New USB device found, idVendor=1199, idProduct=68c0
[232747.043185] usb 1-1: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
[232747.050473] usb 1-1: Product: MC7354
[232747.054151] usb 1-1: Manufacturer: Sierra Wireless, Incorporated
[232747.068022] qcserial 1-1:1.0: Qualcomm USB modem converter detected
[232747.079525] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB0
[232747.089754] qcserial 1-1:1.2: Qualcomm USB modem converter detected
[232747.099156] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB1
[232747.109317] qcserial 1-1:1.3: Qualcomm USB modem converter detected
[232747.118581] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB2
[232747.130890] qmi_wwan 1-1:1.8: cdc-wdm0: USB WDM device
[232747.137174] qmi_wwan 1-1:1.8 wwan0: register 'qmi_wwan' at usb-musb-
hdrc.0.auto-1, WWAN/QMI device, 0a:ba:e1:d6:ed:4a
```

cell_mgmt check_carrier

The **cell_mgmt check_carrier** command helps to check if the current carrier matches with the service (SIM card) provider.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt check_carrier
----------Carrier Info----------
preferred firmware=05.05.58.01
preferred carrier name=ATT
preferred carrier config=ATT_005.026_000
firmware=05.05.58.01
carrier name=ATT
carrier config=ATT_005.026_000
--------------------------------
```

cell_mgmt switch_carrier

Some modules provide multiple carrier support. Use the **`cell_mgmt switch_carrier`** command to switch between carriers. It may take some time (depending on the module's mechanism) to switch between carriers.

For the UC-2114 and UC-2116 computers, refer to the following table for a list of the cellular carriers supported.

MNO Profile (UC-2114 & UC-2116)	System Selection (Primary/Secondary)	LTE Bands Supported	UBANDMASK Support
Default	M1/NB1	2, 3, 4, 5, 8, 12, 13, 18, 19, 20, and 25 (M1 only)	No
AT&T	M1 only	2, 4, 5, and 12	No
China Telecom	M1/NB1	3, 5, and 8	Yes
Deutsche Telekom	M1/NB1	3, 8, and 20	Yes
Sprint	M1 only	2, 4, 12, and 25	Yes
Standard Europe	M1/NB1	3, 8, and 20	Yes
Telstra	M1 only	3, 5, 8, and 28	No
T-Mobile USA	NB1 only	2, 4, 5, and 12	Yes
TELUS	M1 only	2, 4, 5, and 12	No
Verizon	M1 only	13	No
Vodafone	NB1/M1	3, 8, and 20	Yes

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt switch_carrier
----------------------
Usage:
       switch_carrier <Verizon|ATT|Sprint|Generic>
moxa@Moxa:/home/moxa$ sudo cell_mgmt switch_carrier Verizon
----------switch_carrier------------
cmd=AT!GOBIIMPREF="05.05.58.01","VZW","VZW_005.029_001"

OK

OK


wait for power cycle...
Network already stopped
Clearing state...
[236362.468977] usb 1-1: USB disconnect, device number 3
[236362.482562] qcserial ttyUSB0: Qualcomm USB modem converter now disconnected
from ttyUSB0
[236362.491019] qcserial 1-1:1.0: device disconnected
[236362.521065] qcserial ttyUSB1: Qualcomm USB modem converter now disconnected
from ttyUSB1
[236362.529430] qcserial 1-1:1.2: device disconnected
[236362.544653] qcserial ttyUSB2: Qualcomm USB modem converter now disconnected
from ttyUSB2
[236362.553133] qcserial 1-1:1.3: device disconnected
[236362.558283] qmi_wwan 1-1:1.8 wwan0: unregister 'qmi_wwan' usb-musb-
hdrc.0.auto-1, WWAN/QMI device
[236376.209868] usb 1-1: new high-speed USB device number 4 using musb-hdrc
[236376.350358] usb 1-1: config 1 has an invalid interface number: 8 but max is
3
[236376.357639] usb 1-1: config 1 has no interface number 1
[236376.364991] usb 1-1: New USB device found, idVendor=1199, idProduct=68c0
[236376.371925] usb 1-1: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
[236376.379217] usb 1-1: Product: MC7354
[236376.382924] usb 1-1: Manufacturer: Sierra Wireless, Incorporated
```

```
[236376.400588] qcserial 1-1:1.0: Qualcomm USB modem converter detected
[236376.412010] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB0
[236376.422273] qcserial 1-1:1.2: Qualcomm USB modem converter detected
[236376.429958] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB1
[236376.441031] qcserial 1-1:1.3: Qualcomm USB modem converter detected
[236376.448337] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB2
[236376.461514] qmi_wwan 1-1:1.8: cdc-wdm0: USB WDM device
[236376.467762] qmi_wwan 1-1:1.8 wwan0: register 'qmi_wwan' at usb-musb-
hdrc.0.auto-1, WWAN/QMI device, 0a:ba:e1:d6:ed:4a
[236411.387228] usb 1-1: USB disconnect, device number 4
[236411.393963] qcserial ttyUSB0: Qualcomm USB modem converter now disconnected
from ttyUSB0
[236411.402361] qcserial 1-1:1.0: device disconnected
[236411.422719] qcserial ttyUSB1: Qualcomm USB modem converter now disconnected
[236411.431186] qcserial 1-1:1.2: device disconnected
[236411.446102] qcserial ttyUSB2: Qualcomm USB modem converter now disconnected
from ttyUSB2
[236411.454583] qcserial 1-1:1.3: device disconnected
[236411.459687] qmi_wwan 1-1:1.8 wwan0: unregister 'qmi_wwan' usb-musb-
hdrc.0.auto-1, WWAN/QMI device
[236423.109879] usb 1-1: new high-speed USB device number 5 using musb-hdrc
[236423.250364] usb 1-1: config 1 has an invalid interface number: 8 but max is
3
[236423.257649] usb 1-1: config 1 has no interface number 1
[236423.266064] usb 1-1: New USB device found, idVendor=1199, idProduct=68c0
[236423.273024] usb 1-1: New USB device strings: Mfr=1, Product=2,
SerialNumber=3
[236423.280331] usb 1-1: Product: MC7354
[236423.284011] usb 1-1: Manufacturer: Sierra Wireless, Incorporated
[236423.298320] qcserial 1-1:1.0: Qualcomm USB modem converter detected
[236423.310356] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB0
[236423.318614] qcserial 1-1:1.2: Qualcomm USB modem converter detected
[236423.328841] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB1
[236423.338942] qcserial 1-1:1.3: Qualcomm USB modem converter detected
[236423.348418] usb 1-1: Qualcomm USB modem converter now attached to ttyUSB2
[236423.360733] qmi_wwan 1-1:1.8: cdc-wdm0: USB WDM device
[236423.366960] qmi_wwan 1-1:1.8 wwan0: register 'qmi_wwan' at usb-musb-
hdrc.0.auto-1, WWAN/QMI device, 0a:ba:e1:d6:ed:4a
moxa@Moxa:/home/moxa$ sudo cell_mgmt check_carrier
----------Carrier Info----------
preferred firmware=05.05.58.01
preferred carrier name=VZW
preferred carrier config=VZW_005.029_001
firmware=05.05.58.01
carrier name=VZW
carrier config=VZW_005.029_001
--------------------------------
```

cell_mgmt at AT_COMMAND

The **AT** command is used to provide inputs. For example, use the **AT** command, **AT+CSQ** as follows:

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt at 'AT+CSQ'

+CSQ: 18,99

OK
```

Configuring a NB-IoT/Cat. M1 Connection (UC-2114 and UC-2116 only)

You can change the RAT (radio access technology) type of the NB-IoT module in UC-2114 and UC-2116 using the following AT commands:

Switching to the Cat. M1 Mode

```
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+COPS=2'
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+URAT=7'
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+COPS=0'
```

Switching to the NB-IoT Mode

```
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+COPS=2'
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+URAT=8'
moxa@Moxa:/home/moxa$ cell_mgmt at 'AT+COPS=0'
```

NOTE

- The APN name 'internet.iot' is set by the user. For information on the APN settings, contact your mobile network operator.
- A PPP dial-up connection that uses Cat. M1 and CAT. NB1 may sometimes take a couple of minutes to establish a connection if the signal is weak.
- Power saving mode (PSM) is not supported in the UC-2114 and UC-2116 computers.

You can also use an **AT** command to read the mode:

```
cell_mgmt at AT+URAT?

root@Moxa:/home/moxa# cell_mgmt at AT+URAT?

+URAT: 7,8

OK

7: CAT-M1
8: NB-IOT
```

GPS

UC-8112-ME-T-US-LTE Model

To view the GPS information for the UC-8112-ME-T-US-LTE model, do the following:

1. Power on the GPS module using the command:

   ```
   root@Moxa:/home/moxa# cell_mgmt gps_on
   ```

2. Check the GPS port using the **cell_mgmt** command.
   In the following example, the GPS port is at **/dev/ttyUSB1**.

   ```
   root@Moxa:/home/moxa# cell_mgmt module_info
   SLOT: 1
   Module: MC7354
   WWAN_node: wwan1
   AT_port: /dev/ttyUSB2
   GPS_port: /dev/ttyUSB1
   QMI_port: /dev/cdc-wdm1
   Modem_port: NotSupport
   AT_port (reserved): NotSupport
   ```

3. Type the following command to get the GPS location information from the GPS port.

   ```
   root@Moxa:/home/moxa# cat /dev/ttyUSB1
   ```

For Other Models

Use **cell_mgmt module_info** to get information of the cellular module including the GPS port information.

```
moxa@Moxa:/home/moxa$ sudo cell_mgmt module_info
SLOT: 1
Module: MC7354
WWAN_node: wwan0
AT_port: /dev/ttyUSB2
GPS_port: /dev/ttyUSB1
QMI_port: /dev/cdc-wdm0
Modem_port: NotSupport
```

Type the following command to get the GPS location information from the GPS port.

```
root@Moxa:/home/moxa# cat /dev/ttyUSB1
```

Configuring the Wi-Fi Connection

You can configure the Wi-Fi connection for your Arm-based computer using a configuration file or the **wifi_mgmt** utility provided by Moxa. For advanced settings, you can use the **`wpa_supplicant`** command.

Configuring WPA2

Moxa's Arm-based computers support WPA2 security using the **/sbin/wpa_supplicant** program. Refer to the following table for the configuration options. The **Key required before joining network?** column specifies whether an encryption and/or authentication key must be configured before associating with a network.

Infrastructure mode	Authentication mode	Encryption status	Manual Key required?	IEEE 802.1X enabled?	Key required before joining network?
ESS	Open	None	No	No	No
ESS	Open	WEP	Optional	Optional	Yes
ESS	Shared	None	Yes	No	Yes
ESS	Shared	WEP	Optional	Optional	Yes
ESS	WPA	WEP	No	Yes	No
ESS	WPA	TKIP	No	Yes	No
ESS	WPA2	AES	No	Yes	No
ESS	WPA-PSK	WEP	Yes	Yes	No
ESS	WPA-PSK	TKIP	Yes	Yes	No
ESS	WPA2-PSK	AES	Yes	Yes	No

Using wifi_mgmt

Manual Page

The **wifi_mgmt** utility manages the behavior of the Wi-Fi module.

```
moxa@Moxa:~$ sudo wifi_mgmt help
[sudo] password for moxa:
Usage:
/usr/sbin/wifi_mgmt [-i <interface id>] [-s <slot id>] [OPTIONS]
OPTIONS
start Type=[type] SSID=[ssid] Password=[password]
Insert an AP information to the managed AP list and then connect to the AP.
[type] open/wep/wpa/wpa2
[ssid] access point's SSID
[password] access point's password
example:
wifi_mgmt start Type=wpa SSID=moxa_ap Password=moxa
wifi_mgmt start Type=open SSID=moxa_ap
```

```
start [num]
Connect to AP by the managed AP list number.
start
Connect to the last time AP that was used.
scan -d
Scan all the access points information and show the detail message.
scan
Scan all the access points information.
signal
Show the AP's signal.
list
Show the managed AP list.
insert Type=[type] SSID=[ssid] Password=[password]
Insert a new AP information to the managed AP list.
[type] open/wep/wpa/wpa2
[ssid] access point's SSID
[password] access point's password
example:
wifi_mgmt insert Type=wpa SSID=moxa_ap Password=moxa
select [num]
Select an AP num to connect which is in the managed AP list.
stop
Stop network.
status
Query network connection status.
interface [num]
Switch to another wlan[num] interface.
[num] interface number
example:
wifi_mgmt interface 0
interface
Get the current setting interface.
reconnect
Reconnect to the access point.
restart
Stop wpa_supplicant then start it again.
version
Wifi management version.
```

Connecting to an AP

You can connect your computer to an AP using the following three commands. The DNS and default gateway will be configured automatically. If you want to use the wireless interface's gateway, you must clean up your computer's default gateway configuration.

wifi_mgmt start Type=[type] SSID=[ssid] Password=[password]

Insert the AP information in the managed AP list and then connect to the AP.

```
root@Moxa:~# wifi_mgmt start Type=wpa SSID=moxa_ap Password=moxa
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

wifi_mgmt start [num]

Connect to the AP using the managed AP list number. If you have inserted the AP information before, the information may still be in the managed AP list. Check the managed AP list using the **`wifi_mgmt list`** command.

```
root@Moxa:~# wifi_mgmt list
network id / ssid / bssid / flags
0 MOXA_AP1 any [LAST USED]
1 MOXA_AP2 any [DISABLED]
2 MOXA_AP3 any [DISABLED]
```

Choose an AP number to start.

```
root@Moxa:~# wifi_mgmt start 1
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

wifi_mgmt start

Connect to the previous AP that was used.

```
root@Moxa:~# wifi_mgmt list
network id / ssid / bssid / flags
0 MOXA_AP1 any [LAST USED]
1 MOXA_AP2 any [DISABLED]
2 MOXA_AP3 any [DISABLED]
```

Use the **wifi_mgmt** command to connect to the AP "MOXA_AP1" that was used previously as follows:

```
root@Moxa:~# wifi_mgmt start
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

Stop or Restart a Network Connection

wifi_mgmt stop

```
root@Moxa:~# wifi_mgmt stop
Stopped.
```

wifi_mgmt restart

```
root@Moxa:~# wifi_mgmt restart
wpa_supplicant is closed!!
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

Inserting an AP or Choosing Another AP to Connect To

If you want to insert an AP use the **wifi_mgmt insert** command.

```
root@Moxa:~# wifi_mgmt insert Type=wpa2 SSID=MOXA_AP3 Password=moxa
root@Moxa:~# wifi_mgmt list
network id / ssid / bssid / flags
0 MOXA_AP1 any [CURRENT]
1 MOXA_AP2 any [DISABLED]
2 MOXA_AP3 any [DISABLED]
```

If you want to use another AP to connect, use the **wifi_mgmt select** command to switch to the AP.

```
root@Moxa:~# wifi_mgmt list
network id / ssid / bssid / flags
0 MOXA_AP1 any [DISABLED]
1 MOXA_AP2 any [CURRENT]
2 MOXA_AP3 any [DISABLED]
root@Moxa:~# wifi_mgmt select 2
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

Other Functions

wifi_mgmt scan

Scan all of the access point information.

```
root@Moxa:~# wifi_mgmt scan
bssid / frequency / signal level / flags / ssid
b0:b2:dc:dd:c9:e4 2462 -57 [WPA-PSK-TKIP][ESS] WES_AP
fc:f5:28:cb:8c:23 2412 -57 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fe:f0:28:cb:8c:23 2412 -59 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fc:f5:28:cb:39:08 2437 -79 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fe:f0:28:cb:39:08 2437 -81 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fc:f5:28:cb:5d:a8 2462 -83 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
2c:54:cf:fd:5a:cf 2437 -83 [WPA-PSK-TKIP][ESS] 5566fans
fe:f0:28:cb:5d:a8 2462 -87 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fe:f0:28:cb:5d:78 2462 -89 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fe:f0:28:cb:39:11 2437 -89 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fc:f5:28:cb:39:11 2437 -91 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fe:f0:28:cb:39:0b 2412 -91 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
02:1a:11:f1:dc:a1 2462 -91 [WPA2-PSK-CCMP][ESS] M9 Davidoff
fc:f5:28:cb:5d:78 2462 -93 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fe:f0:28:cb:5d:b7 2462 -93 [WPA2-EAP-CCMP-preauth][ESS] MHQ-Mobile
fc:f5:28:cb:39:0b 2412 -93 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fc:f5:28:cb:5d:b7 2462 -95 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
fc:f5:28:cb:5d:93 2462 -97 [WPA2-EAP-CCMP-preauth][ESS] MHQ-NB
```

wifi_mgmt scan -d

Scan all of the access point information and show a detailed message.

```
root@Moxa:~# wifi_mgmt scan -d
wlan0 Scan completed :
Cell 01 - Address: FC:F5:28:CB:8C:23
Channel:1
Frequency:2.412 GHz (Channel 1)
Quality=51/70 Signal level=-59 dBm
Encryption key:on
ESSID:"MHQ-NB"
9 Mb/s; 12 Mb/s; 18 Mb/s
Mode:Master
Group Cipher : CCMP
Pairwise Ciphers (1) : CCMP
Authentication Suites (1) : 802.1x
Preauthentication Supported
Cell 02 - Address: FE:F0:28:CB:5D:A8
Channel:11
Frequency:2.462 GHz (Channel 11)
Quality=25/70 Signal level=-85 dBm
Encryption key:on
ESSID:"MHQ-Mobile"
9 Mb/s; 12 Mb/s; 18 Mb/s
Mode:Master
Group Cipher : CCMP
Pairwise Ciphers (1) : CCMP
Authentication Suites (1) : 802.1x
Preauthentication Supported
More.. .. ..
```

wifi_mgmt signal

Show the AP's signal.

```
root@Moxa:~# wifi_mgmt signal
level=-59 dBm
```

wifi_mgmt delete

```
root@Moxa:~# wifi_mgmt list
network id / ssid / bssid / flags
0 MOXA_AP1 any [CURRENT]
1 MOXA_AP1 any [DISABLED]
2 MOXA_AP3 any [DISABLED]
root@Moxa:~# wifi_mgmt delete 2
***** WARNING *****
Are you sure that you want to delete network id 2 (y/n)y
network id / ssid / bssid / flags
0 MOXA_AP1 any
1 MOXA_AP2 any [DISABLED]
```

wifi_mgmt status

```
root@Moxa:~# wifi_mgmt status
bssid=b0:b2:dc:dd:c9:e4
ssid=MOXA_AP1
id=0
mode=station
pairwise_cipher=TKIP
group_cipher=TKIP
key_mgmt=WPA-PSK
wpa_state=COMPLETED
ip_address=192.168.1.36
address=00:0e:8e:4c:13:5e
```

wifi_mgmt interface [num]

If there is more than one Wi-Fi interface, you can change the interface.

```
root@Moxa:~# wifi_mgmt interface
There is(are) 2 interface(s):
wlan0 [Current]
wlan1
root@Moxa:~# wifi_mgmt interface 1
Now is setting the interface as wlan1.
```

wifi_mgmt reconnect

```
root@Moxa:~# wifi_mgmt reconnect
wpa_state=SCANNING
wpa_state=SCANNING
wpa_state=COMPLETED
*** Get DHCP IP address from AP ***
*** Get DHCP IP from AP! ***
```

wifi_mgmt version

```
root@Moxa:~# wifi_mgmt version
wifi_mgmt version 1.0 Build 15050223
```

Configuring the Wireless LAN Using the Configuration File

You can edit the **/etc/wpa_supplicant/wpa_supplicant.conf** file to configure a Wi-Fi connection. The following is an example of the configuration file for an OPEN/WEP/WPA/WPA2 access point.

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=wheel
update_config=1
### Open system ###
#network={
# ssid="Open"
# key_mgmt=NONE
#}
####################
##### WEP #####
```

```
#network={
# ssid="WEP-ssid"
# bssid=XX:XX:XX:XX:XX:XX
# key_mgmt=NONE
# wep_key0=KEY
#}
###############
##### WPA/WPA2 PSK #####
#network={
# ssid="WPA-ssid"
# proto=WPA WPA2 RSN
# key_mgmt=WPA-PSK
# pairwise=TKIP CCMP
# group=TKIP CCMP
# psk="KEY"
#}
######################
```

The basic command to connect to a WPA-supplicant is:

```
root@Moxa:~# wpa_supplicant -i <interface> -c <configuration file> -B
```

The **-B** option should be included because it forces the supplicant to run in the background.

1. Connect with the following command after editing the **wpa_supplicant.conf** file:

   ```
   root@Moxa:~# wpa_supplicant -i wlan0 -c
   /etc/wpa_supplicant/wpa_supplicant.conf -B
   ```

2. Use the **#sudo apt-get install wireless-tools** command to install the Wi-Fi utility.

   You can use the **iwconfig** command to check the connection status. The response you receive should be similar to the following:

   ```
   wlan0 IEEE 802.11abgn ESSID:"MOXA_AP"
   Mode:Managed Frequency:2.462 GHz Access Point: 00:1F:1F:8C:0F:64
   Bit Rate=36 Mb/s Tx-Power=27 dBm
   Retry min limit:7 RTS thr:off Fragment thr:off
   Encryption key:1234-5678-90 Security mode:open
   Power Management:off
   Link Quality=37/70 Signal level=-73 dBm
   Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
   Tx excessive retries:0 Invalid misc:0 Missed beacon:0
   ```

WARNING

Moxa strongly advises against using the WEP and WPA encryption standards. Both are now officially deprecated by the Wi-Fi Alliance, and are considered insecure. To guarantee good Wi-Fi encryption and security, use WPA2 with the AES encryption algorithm.

Configuring the Bluetooth Connection

Bluetooth connectivity is supported in the following computer models.

Computer Model	Bluetooth Version	Accessory Required
UC-3111-T-US-LX	5.0	None. Bluetooth module is built-in
UC-3121-T-US-LX	5.0	None. Bluetooth module is built-in
UC-3111-T-EU-LX	5.0	None. Bluetooth module is built-in
UC-3121-T-EU-LX	5.0	None. Bluetooth module is built-in
UC-3111-T-AP-LX	5.0	None. Bluetooth module is built-in
UC-3121-T-AP-LX	5.0	None. Bluetooth module is built-in
UC-8220-T-LX	4.2	Yes, UC-8200-WLAN22-AC (SparkLan WPEQ261ACNI (BT))
UC-8220-T-LX-US-S	4.2	Yes, UC-8200-WLAN22-AC (SparkLan WPEQ261ACNI (BT))
UC-8220-T-LX-EU-S	4.2	Yes, UC-8200-WLAN22-AC (SparkLan WPEQ261ACNI (BT))
UC-8220-T-LX-AP-S	4.2	Yes, UC-8200-WLAN22-AC (SparkLan WPEQ261ACNI (BT))

To be able to send data via Bluetooth between devices, you must first "pair" and "connect" the devices.

In Bluetooth terminology, "pairing" is the process of making two devices known to each other. Pairing remote devices can be done in two ways because the process can be initiated from either device. In the following sections, we provide examples on how to pair and connect devices for Bluetooth.

NOTE

All tools used in the following example can be found in the **bluez** package available on the computer. Use the **`#sudo apt-get install wireless-tools`** command to install the Wi-Fi utility. You can install the bluez package using the command **`# apt-get install bluez`**.

Paring Devices

In this example, we describe how to pair two UC-3111-T-US-LX devices (Device A and Device B) for Bluetooth connectivity.

Step 1:

Run the **`bluetoothctl`** command on both Device A and Device B.

Device A

```
root@Moxa:/home/moxa# bluetoothctl
[NEW] Controller 0C:1C:57:B7:B7:7B Moxa [default]
[bluetooth]#
```

Device B

```
root@Moxa:/home/moxa# bluetoothctl
[NEW] Controller C8:DF:84:4A:67:3F Moxa [default]
[bluetooth]#
```

We can see from the console output that the MAC address of Device A is **0C:1C:57:B7:B7:7B** and the MAC address of Device B is **C8:DF:84:4A:67:3F**.

Step 2:

Set Device A to **`discoverable`** and initiate scanning on Device B to find Device A.

NOTE

- You can use the **system-alias** command to assign a name to a device so it can be identified easily when it is discovered by other device.
- You can set the **discoverable** status to **off** or scan status to **off** at any time.

Device A

```
[bluetooth]# system-alias Device A
Changing Device A succeeded
[CHG] Controller 0C:1C:57:B7:B7:7B Alias: Device A
[bluetooth]# discoverable on
Changing discoverable on succeeded
[CHG] Controller 0C:1C:57:B7:B7:7B Discoverable: yes
```

Device B

```
[bluetooth]# system-alias Device B
Changing Device B succeeded
[CHG] Controller C8:DF:84:4A:67:3F Alias: Device B
[bluetooth]# scan on
Discovery started
[CHG] Controller C8:DF:84:4A:67:3F Discovering: yes
[NEW] Device 0C:1C:57:B7:B7:7B Device A
```

Device A is discovered by Device B.

Step 3:

Use the **pair** command to pair the two devices.

Device A

```
[NEW] Device C8:DF:84:4A:67:3F Device B
[CHG] Device C8:DF:84:4A:67:3F Modalias: usb:v1D6Bp0246d052B
[CHG] Device C8:DF:84:4A:67:3F UUIDs: 0000110c-0000-1000-8000-00805f9b34fb
[CHG] Device C8:DF:84:4A:67:3F UUIDs: 0000110e-0000-1000-8000-00805f9b34fb
[CHG] Device C8:DF:84:4A:67:3F UUIDs: 00001200-0000-1000-8000-00805f9b34fb
[CHG] Device C8:DF:84:4A:67:3F UUIDs: 00001800-0000-1000-8000-00805f9b34fb
[CHG] Device C8:DF:84:4A:67:3F UUIDs: 00001801-0000-1000-8000-00805f9b34fb
[CHG] Device C8:DF:84:4A:67:3F ServicesResolved: yes
[CHG] Device C8:DF:84:4A:67:3F Paired: yes
[CHG] Device C8:DF:84:4A:67:3F ServicesResolved: no
[CHG] Device C8:DF:84:4A:67:3F Connected: no
[bluetooth]# quit
[DEL] Controller 0C:1C:57:B7:B7:7B Device A [default]
```

Device B

```
[bluetooth]# pair 0C:1C:57:B7:B7:7B
Attempting to pair with 0C:1C:57:B7:B7:7B
[CHG] Device 0C:1C:57:B7:B7:7B Connected: yes
[CHG] Device 0C:1C:57:B7:B7:7B UUIDs: 0000110c-0000-1000-8000-00805f9b34fb
[CHG] Device 0C:1C:57:B7:B7:7B UUIDs: 0000110e-0000-1000-8000-00805f9b34fb
[CHG] Device 0C:1C:57:B7:B7:7B UUIDs: 00001200-0000-1000-8000-00805f9b34fb
[CHG] Device 0C:1C:57:B7:B7:7B UUIDs: 00001800-0000-1000-8000-00805f9b34fb
[CHG] Device 0C:1C:57:B7:B7:7B UUIDs: 00001801-0000-1000-8000-00805f9b34fb
[CHG] Device 0C:1C:57:B7:B7:7B ServicesResolved: yes
[CHG] Device 0C:1C:57:B7:B7:7B Paired: yes
Pairing successful
[CHG] Device 0C:1C:57:B7:B7:7B ServicesResolved: no
[CHG] Device 0C:1C:57:B7:B7:7B Connected: no
[bluetooth]# quit
[DEL] Controller C8:DF:84:4A:67:3F Device B [default]
```

After the two devices are paired successfully, use the **quit** command to exit the bluetoothctl program.

Connecting Devices

After the two devices are paired, the next step is to connect them for Bluetooth.

Step 1:

Use the **hciconfig** command to check device names.

Device A

```
root@Moxa:/home/moxa# hciconfig
hci0:   Type: Primary  Bus: UART
BD Address: 0C:1C:57:B7:B7:7B  ACL MTU: 1021:6  SCO MTU: 180:4
UP RUNNING PSCAN
RX bytes:2166 acl:16 sco:0 events:91 errors:0
TX bytes:3781 acl:16 sco:0 commands:61 errors:0
```

Device B

```
root@Moxa:/home/moxa# hciconfig
hci0:   Type: Primary  Bus: UART
BD Address: C8:DF:84:4A:67:3F  ACL MTU: 1021:6  SCO MTU: 180:4
UP RUNNING PSCAN
RX bytes:8521 acl:16 sco:0 events:509 errors:0
TX bytes:6186 acl:16 sco:0 commands:350 errors:0
```

The Bluetooth device name for both Device A and Device is **hci0**.

Step 2:

Connect the two devices using the **rfcomm** tool.

1. Set Device A to "listen state" so that Device B can connect.
2. From Device B, connect to the MAC address of Device A.

Device A

```
root@Moxa:/home/moxa# rfcomm -i hci0 listen /dev/rfcomm0
Waiting for connection on channel 1
Connection from C8:DF:84:4A:67:3F to /dev/rfcomm0
Press CTRL-C for hangup
```

Device B

```
root@Moxa:/home/moxa# rfcomm -i hci0 connect /dev/rfcomm0 0C:1C:57:B7:B7:7B
Connected /dev/rfcomm0 to 0C:1C:57:B7:B7:7B on channel 1
Press CTRL-C for hangup
```

The devices can now communicate over the **/dev/rfcomm0** interface.

Step 3:

Test the connection between the devices over the **/dev/rfcomm0** interface.

Device A

```
root@Moxa:/home/moxa# echo "123" > /dev/rfcomm0
```

Device B

```
root@Moxa:/home/moxa# cat /dev/rfcomm0
123
```

Additional References

- BlueZ
- bluetoothctl man page
- rfcomm man page

5. Security

Moxa's Arm-based computers offer better security by introducing Moxa's innovative Secure Boot feature, and the integration of a Trusted Platform Module gives the user more solid protection for the platform.

Sudo Mechanism

In Moxa Arm-based computers, the root account is disabled in favor of better security. Sudo is a program designed to let system administrators allow permitted users to execute some commands as the root user or another user. The basic philosophy is to give as few privileges as possible but still allow people to get their work done. Using sudo is better (safer) than opening a session as root for a number of reasons, including:

- Nobody needs to know the root password (sudo prompts for the current user's password). Extra privileges can be granted to individual users temporarily, and then taken away without the need for a password change.
- It is easy to run only the commands that require special privileges via sudo; the rest of the time, you work as an unprivileged user, which reduces the damage caused by mistakes.
- Some system-level commands are not available to the user moxa directly, as shown in the sample output below:

```
moxa@Moxa:~$ /sbin/hwclock
hwclock: Cannot access the Hardware Clock via any known method.
hwclock: Use the --debug option to see the details of our search for an
access method.

moxa@Moxa:/etc$ sudo /sbin/hwclock
2022-10-15 16:28:35.332239+0000
```

Service and Ports

Only activate services that are require to use the system. A list of the services enabled by default and the port numbers they use for external interfaces is given in the table below. Refer to the Firewall section to modify the list of allowed ports if additional ports are required.

Service	Protocol	Transport layer	Port Number
SSH	SSH	TCP	22
SFTP server	SSH	TCP	22
SCP server	SSH	TCP	22
APT client	HTTPS	TCP	n/a

Disabling Unnecessary Protocols, Services, and Ports

You can use **#ss** to list all the processes currently running in the system with the associated service, protocol, and network port.

```
moxa@moxa-tbbbb1182827:~$ sudo ss -tulpn
Netid       State        Recv-Q       Send-Q             Local Address:Port
Peer Address:Port       Process
tcp         LISTEN       0            128                      0.0.0.0:22
0.0.0.0:*           users:(("sshd",pid=974,fd=3))
tcp         LISTEN       0            128                         [::]:22
[::]:*           users:(("sshd",pid=974,fd=4))
```

You can disable a daemon or service using the **kill** command with the process ID (PID) directly. For example:

```
moxa@moxa-tbbbb1182827:~$ sudo kill 974
```

Or just stop and disable the service using the **#systemctl** command. For example:

```
moxa@moxa-tbbbb1182827:~$ sudo systemctl stop sshd
moxa@moxa-tbbbb1182827:~$ sudo systemctl disable sshd
```

Restricting Unnecessary Protocols, Services, and Ports

Protocols

Use **nfables** to match the kind of TCP traffic with the packet meta information. Refer to iptable wiki for details.

Services

Use **# systemctl list-unit-files** command to find unused services and disable them using **systemctl disable** <*service*> command.

Ports

Use the **iptable** command to add accepted ports to the whitelist. Refer to iptable wiki for details.

6. System Boot Up, Recovery, and Update

Set-to-default Function

Press and hold the reset button between 7 to 9 seconds to reset the computer to the factory default settings. When the reset button is held down, the LED will blink once every second. The LED will become steady when you hold the button continuously for 7 to 9 seconds. Release the button immediately when the LED becomes steady to start loading the factory default settings. For additional details on the LEDs, refer to the quick installation guide or the user's manual for your Arm-based computer.

ATTENTION

Reset-to-default will erase all the data stored on the boot storage

Please back up your files before resetting the system to factory defaults. All the data stored in the Arm-based computer's boot storage will be destroyed after resetting to factory defaults.

You can also use the **`mx-set-def`** command to restore the computer to factory default:

```
moxa@Moxa:~$ sudo mx-set-def
```

Firmware Update Using a TFTP Server

To update the firmware packages, follow the instructions at:
Installing the System Image from TFTP

NOTE

Download the firmware from the Moxa website. Before updating your UC Series device, make sure the image checksum matches the one provided on the Moxa website to ensure the firmware file is correct and safe to use. Visit the Moxa website: https://www.moxa.com/en/products/industrial-computing/arm-based-computers.

Firmware Update via APT

To update the firmware packages, follow the instructions at:
Keeping IIoT Gateway Software Up-to-date and Free of Vulnerabilities

Creating a Customized Firmware Image

To create a customized firmware image for your computer, follow the instructions at:
https://github.com/Moxa-Linux/resize-image

Boot-up Option

To change the boot-up option, follow the instructions at:
Setting Boot Options

To prepare a bootable SD card, follow the instructions at:
Preparing a Bootable SD Card

7. Security Hardening Guide

In this chapter, we will provide guidance on how to deploy Moxa's Arm-based computers in a secure manner

RED Compliance Requirement

To comply with the EU Radio Equipment Directive (RED) Article 3.3(d) on cybersecurity, this gateway implements measures to protect network integrity and prevent misuse of network resources. The RED requirement includes secure boot up, encrypted communications, strong authentication, and regular security updates to safeguard against unauthorized access and cyberthreats.

RED Adoption Firmware Versions for UC Series Devices:

Series	Firmware
UC-2100	V1.15
UC-3100	V1.9
UC-5100	V1.7
UC-8100-ME	V3.4
UC-8100	V3.8
UC-8200 (MIL1)	V1.9
UC-8410A	V4.4.2
DA-662C (GLB)	V1.1.4

If your UC Series has a version older than the RED-adoption firmware version above, run the command below to migrate the system settings for RED compliance.

```
root@moxa-imoxa0920007:/# mx-red-migrate
```

The tool **mx-red-migrate** includes the following changes:

No.	Items	Description
1	Add the password quality configure file	Modify the configuration file located at **/etc/security/pwquality.conf.d/99-moxa-pwquality.conf** The following parameters have been updated: • dcredit=0 • dictcheck=1 • lcredit=0 • minlen=8 • ocredit=0 • ucredit=0 These settings ensure stronger password requirements for enhanced security.
2	Modify the SSH configuration	Update the configuration file at **/etc/ssh/sshd_config** with the following additions: **Ciphers and keying** • Ciphers chacha20-poly1305@openssh.com,aes128-ctr,aes192-ctr,aes256-ctr,aes128-gcm@openssh.com,aes256-gcm@openssh.com • KexAlgorithms curve25519-sha256,curve25519-sha256@libssh.org,ecdh-sha2-nistp256,ecdh-sha2-nistp384,ecdh-sha2-nistp521,diffie-hellman-group-exchange-sha256,diffie-hellman-group16-sha512,diffie-hellman-group18-sha512,diffie-hellman-group14-sha256 • MACs hmac-sha2-256-etm@openssh.com,hmac-sha2-512-etm@openssh.com,hmac-sha2-256,hmac-sha2-512 **Authentication:** • LoginGraceTime 60 • MaxAuthTries 5 These updates strengthen SSH security with approved ciphers and authentication limits.

No.	Items	Description
4	Add fail2ban support	Enable **fail2ban** support to protect against brute-force attacks by automatically blocking suspicious IP addresses. (Note: Additional configuration may be required for full functionality.)
5	Force password change on first login	Require a password change when you log in for the first time. This applies only to initial setups and not to existing devices upgraded to the RED adoption version.
6	Regenerate the SSH key on first login	Generate a new SSH key during your first login to ensure secure authentication and communication.
7	Adopt **pam_tally2** mechanism	Implement the **pam_tally2** mechanism, which locks the account for 300 seconds if login fails five times. This adds an extra layer of security against unauthorized access.

Defense-in-depth Strategy

Security Layer	Security Measures	Threat mitigated/handled	Responsibility
Policy and procedure	Establish policies and procedures to guide employees on their role and responsibilities to for safe use of security sensitive assets.	Vulnerabilities created due to employee lack of security policies and procedures awareness	Asset owner (Essential)
		Malicious code attack that could create or exploit system vulnerabilities (Threat ID #6)	
Perimeter Security	Use LTE service provides with Carrier Grade NAT (CGNAT) and firewall	Unauthorized and malicious communications from untrusted network	Asset owner (Essential)
	Perimeter firewall	Unauthorized and malicious communications from untrusted network	Asset owner (Essential)
	Physical security (Refers to section Physical Installation)	Physical modification, manipulation, theft, removal, or destruction of asset	
Network Security	Network IDS/IPS	Network attacks from various sources such as port scanning, DDOS, etc.	Asset owner (Recommended)
	VPN	Man-in-the-middle attacks that allow hackers to intercept and manipulate network traffic (Threat ID #4)	
Endpoint Security	End point Firewall (iptable)	Unauthorized and malicious communications from untrusted network (Threat ID #2, Threat ID #5)	Asset owner / Provided by Moxa Arm-based Computer
	Brute-force attacks IPS (fail2ban)	Trial and error attack attempting to crack login credentials (Threat ID #3)	
	Extend the perimeter of physical security to reduce the impact from radio jamming attack	Radio jamming attack (Threat ID #1)	
	Firmware Update via APT	Vulnerabilities from outdated software could expose the system to security breaches.	

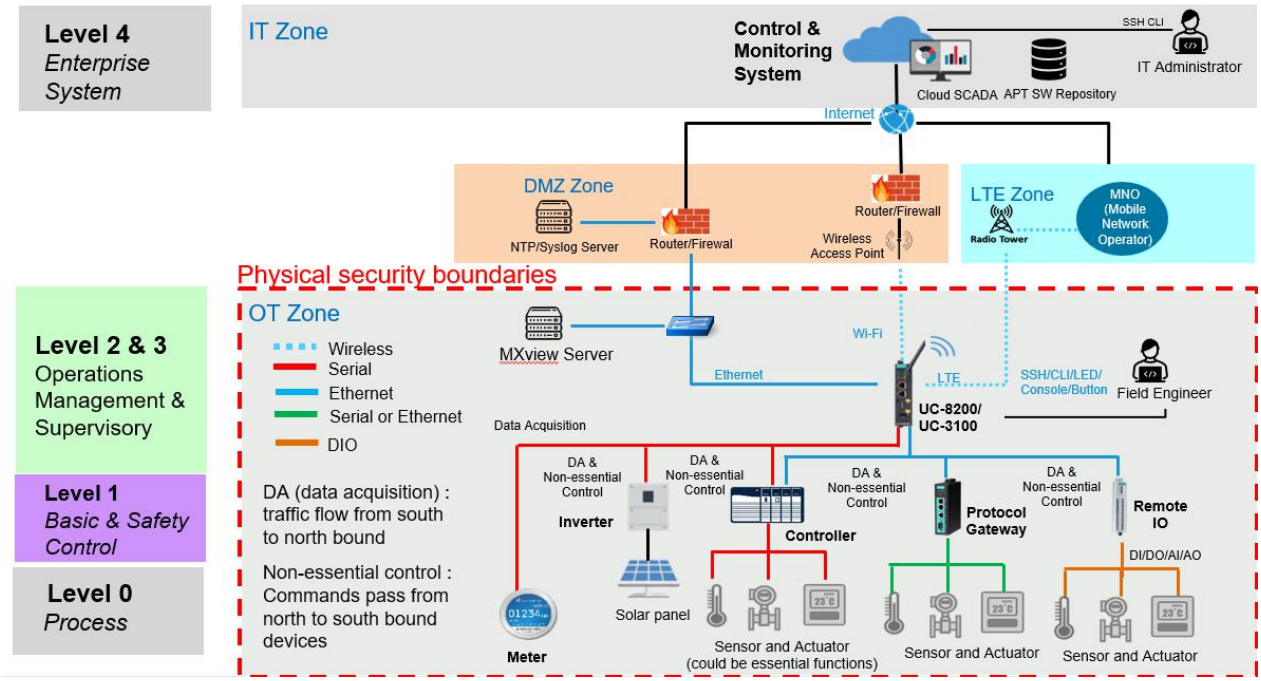
Security Layer	Security Measures	Threat mitigated/handled	Responsibility
	Secure transmission protocol (SSH, SecureAPT)	Man-in-the-middle attacks that allow hackers to intercept and manipulate network traffic (Threat ID #4)	Asset owner / Moxa Arm-based Computer (Essential)
Security Layer	Security Measures	Threat mitigated/handled	Responsibility
Application Security	Secure design, implementation, validation, and defect management process	Potential vulnerabilities generated from the development and testing process that doesn't follow the security best practices.	Provided by Moxa Arm-based Compute
Data Security	Access control and login policy including limit invalid login attempts, automatic session termination and login banner	Unauthorized operation to Moxa Arm-based computer that could lead to system confidentiality and integrity breach or availability attack.	Provided by Moxa Arm-based Computer
	Secure Boot	Tampering of bootloader, OS kernel and rootFS.	

Table 7.1 – Defense-in-Depth Strategy

*Essential: Security measures that must be taken by asset owners to ensure secure use of Moxa Arm-based computers.
*Recommended: Security measures that need to be taken by the asset owner if the threats apply.

Potential Threats and Corresponding Security Measures

The role and position of the UC-8200 and UC-3100 Series is shown in the following diagram along with a list of potential security threats and the corresponding security measures that need to be taken by the asset owner if the threats apply.



Threat ID	Threat mitigated/handled	Security Measures
1	Radio jamming attack resulting in Wi-Fi and cellular connection DOS	Extend the perimeter of physical security to reduce the impact from radio jamming attack
2	Network data flow through Ethernet, Wi-Fi, cellular interface could be potentially interrupted, crashed or stopped by DOS attack	Configure rate limiting to limit the network traffic
3	SSH server could be potentially interrupted, crashed or stopped by DOS attack	1. Following parameters are set in SSH server configuration file by Moxa as countermeasure. ➢ MaxSessions: set to 6 to protect a system from denial of service due to a large number of concurrent sessions ➢ MaxStartups: set to 6:30:60 to protect a system from denial of service due to a large number of ending authentication connection attempts 2. Fail2ban is preinstalled and running in Moxa Arm-based computer to automatically ban malicious IP
4	Data flowing across Ethernet may be sniffed by an attacker	1. Make sure a secure protocol with encryption and authentication are used for data transmission (e.g., SSHv2 and SNMPv3) 2. Install and use VPN for secure data transmission
5	DOS attack from untrusted NTP server when Moxa Arm-based computer attempt to synchronize time	If a public NTP server without NTS support is used, it is vulnerable to an NTP amplification attack in which the attacker could exploit public NTP servers to overwhelm Moxa Arm- based computer with UDP traffic.
6	Data read from USB or SD card could be spoofed	1. Use sha256 or other checksums tools to check the integrity of the file before installing or transferring it to device. If the file is Debian package (.deb), refers to "How to manually check for package's integrity" to validate. 2. Scan the file with Clamav before installing or transferring it to the device 3. Use OpenSSL to verify the signature of the file before installing or transferring to the device.
7	If the Ethernet connection between the NPort device and the Moxa computer crosses an internet boundary without proper security measures, data transmission is vulnerable to interception, tampering, or unauthorized access. This risk is heightened if the NPort 5000 series is used, as it does not support SSL-enabled RealTTY, leaving communication unencrypted.	For the NPort 5000 series, implement a site-to-site VPN connection or a private network to encrypt data and protect it from interception, tampering, and unauthorized access.
8	If the Ethernet connection between the ioLogik and the Moxa computer crosses an internet boundary without adequate security measures, the data transmitted is at risk of being intercepted, tampered with, or accessed by unauthorized parties, potentially leading to data breaches or system compromises.	Implement a site-to-site VPN connection or a private network to encrypt the data and safeguard it against interception, tampering, and unauthorized access, ensuring secure communication between the ioLogik and the Moxa computer.

Installation

Physical Installation

1. Moxa Arm-based computers MUST be protected by physical security that can include CCTV surveillance, security guards, protective barriers, locks, access control, perimeter intrusion detection, etc. The proper form of physical security should apply depending on the environment and the physical attack risk level.
2. Moxa Arm-based computer MUST not be used to **control** the operation of mission-critical IACS component, where failure to maintain control of such device could result in threats to human and environmental safety, or could lead to massive financial loss.

Environment Requirement

1. If Moxa Arm-based computer connects to an untrusted network (e.g., Internet) via Ethernet or Wi-Fi, it MUST NOT directly connect to an untrusted network, which means a firewall must be set up between Ethernet and Wi-Fi connection from Moxa Arm-based computer and the untrusted network.
2. For security-critical applications, we strongly recommend using a private APN for cellular networks.

Access Control

1. The default user account **Moxa** of Linux belongs to the sudo group. Before deploying Moxa Arm-based computer after development, you must disable this default account and create new account(s) following the least privilege principle, granting only the necessary access right and permission for the intended operation.
2. Each account should be assigned the correct privileges. Moxa Industrial Linux uses Discretionary Access Control (DAC) based on Access Control Lists (ACLs) to manage permissions and privileges. Refers to Permissions and Privileges Control for details.
3. The default password policy requires the password to be at least 8 characters in length. We strongly recommend keeping the default setting, or you can reduce the password length by adding additional complexity rules to the password, such as special character or numeric character enforcement. Refers to instructions to configure the policy for Linux and Bootloader, respectively.
4. Update user passwords on a timely manner. For administrator, we recommend refreshing password at least every 3 months.
5. Bootloader configuration menu comes with a single administrator account shared by all users. Asset owner MUST have access and identity records of the personnel who accessed the bootloader to ensure non-repudiation in case of security breach incidents.
6. Below is a list of all services in Moxa Arm-based computer uses to connect with external processes and components.

Service	Default Status	Protocol	Port
SSH server	Enabled	SSH	TCP 22
SFTP server	Enabled	SSH	TCP 22
SCP server	Enabled	SSH	TCP 22
Serial Getty service	Disabled	RS-232	N/A
APT client	Disabled	HTTPS	TCP 443
NTP client	Disabled	TLS/SSL, NTP	UDP 123

Operations

Administrator

1. **Disable default account**

   Use the **passwd** command to lock the default user account so that the **moxa** user cannot log in. Make sure to create a new account before disable the default account.

   ```
   moxa@moxa-tbzkb1090923:# sudo passwd -l moxa
   ```

2. **Disabled interfaces that are not in use**

   The interfaces that are not in use should be deactivated. Please refer to Disabled Unused Interface for detailed instructions.

3. **Ensure NPort connection in the trusted zone**

   To keep your NPort devices secure, make sure the connection between your Moxa Arm-based computer and NPort devices is set up within the trusted zone.

4. **Trusted administrator**

   Make sure only trusted and reliable people are registered in the sudo groups for root privilege.

5. **Only use secure cryptographic**

   Moxa Industrial Linux on Moxa Arm-based computer only uses secure cryptographic that are commonly accepted industry best practices and recommendations as defined in NIST SP 800-57.

6. **Malicious code protection**

   - Downloading files from untrusted sources is not recommended. If you still want to do it, make sure to verify the file using following recommendation:
     - Use sha512 or stronger algorithms checksums tools to check the integrity of the file before installing or transferring to device
     - If the file is Debian package (.deb), follow "How to manually check for package's integrity" for the instruction.
     - Use OpenSSL to verify the signature of the file before installing or transferring to the device.

Administrator and User

1. **Periodically refresh password**

   Update user passwords on a timely manner. For administrator, we recommend refreshing password at least every 3 months

2. **Encrypt confidential file**

   Use GPG to encrypt confidential files or directory with a password in Linux. You can reference How To Encrypt And Decrypt Files With A Password for quick instructions.

Maintenance

1. **Perform Update Frequently**

   Perform Firmware Update via APT frequently to enhance features, deploy security patches, and fix bugs.

2. **Flushing the OS image in a trust environment**

   To safely flash the OS image, ensure that the TFTP server is located within the trusted network. This helps protect your device from malicious attacks. Report the vulnerability to Moxa.

   To report vulnerabilities of Moxa products, please submit your findings on the following web page: https://www.moxa.com/en/support/product-support/security-advisory/report-a-vulnerability.

8. Programmer's Guide

Building an Application

Introduction

Moxa's Arm-based computers support both native and cross-compiling of code. Native compiling is more straightforward since all the coding and compiling can be done directly on the device. However, Arm architecture is less powerful and hence the compiling speed is slower. To overcome this, you can cross compile your code on a Linux machine using a toolchain; the compiling speed is much faster.

Native Compilation

Follow these steps to update the package menu:

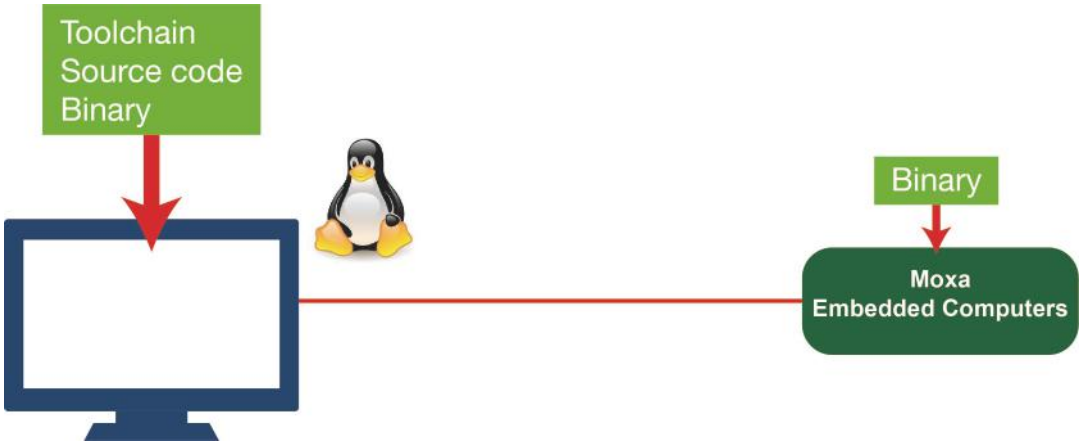
1. Make sure a network connection is available.
2. Use the **apt-get update** command to update the Debian package list.

```
moxa@Moxa:~$ sudo apt-get update
```

3. Install the native compiler and necessary packages.

```
moxa@Moxa:~$ sudo apt-get install gcc build-essential flex bison automake
```

Cross Compilation



Moxa Industrial Linux (MIL) in Moxa's Arm-based computers is based on Debian. So, we recommend setting up a Debian environment on the host device to ensure best compatibility during cross compilation.

The toolchain will need about 300 MB of hard disk space on your PC.

To cross compile your code, do the following:

1. Set up a Debian 9 environment using a VM or Docker.
2. Add the Moxa Debian repository to the apt source list.

   Open **moxa.source.list** in the vi editor.

```
user@Linux:~$ sudo vi /etc/apt/sources.list.d/moxa.sources.list
```

   Add the following line to **moxa.source.list**:

   deb http://debian.moxa.com/debian stretch main contrib non-free

3. Update the apt information.

```
user@Linux:~$ apt-get update
```

4. (Optional) During the update process, if you don't want to see messages related to "server certificate verification failed", you can install Moxa apt **keyring**. These messages, however, will not affect the operation.

```
user@Linux:~$ apt-get install moxa-archive-keyring
```

5. In order to install non-amd64 packages, such as armhf and u386, add the external architecture. In the example, we are adding the armhf architecture.

```
user@Linux:~$ dpkg --add-architecture armhf
```

6. Update the apt information again.

```
user@Linux:~$ apt-get update
```

7. Download the toolchain file from apt server (all Moxa UC series computers use the official Debian toolchain).

```
user@Linux:~$ apt-get install crossbuild-essential-armhf
```

8. Install **dev** or **lib** packages depending on whether Debian or Moxa packages are applicable for the procedure.

   Example for installing a Moxa package:

```
user@Linux:~$ apt-get install libmoxa-uart-control-dev:armhf
```

   Example for installing a Debian official package:

```
user@Linux:~$ apt-get install libssl-dev:armhf
```

You can now start compiling programs using the toolchain.

> **NOTE**
>
> For all available libraries and headers offered by Debian, visit: https://packages.debian.org/index

Example Program—hello

In this section, we use the standard "hello" example program to illustrate how to develop a program for Moxa computers. All example codes can be downloaded from Moxa's website. The "hello" example code is available in the **hello** folder; hello/hello.c:

```
#include <stdio.h>

int main(int argc, char *argv[])
{
    printf("Hello World\n");
    return 0;
}
```

Native Compilation

1. Compile the hello.c code.

```
moxa@Moxa:~$ gcc -o hello hello.c
moxa@Moxa:~$ strip -s hello
```

   or
   use Makefile as follows:

```
moxa@Moxa:~$ make
```

2. Run the program.

```
moxa@Moxa:~$ ./hello
Hello World
```

Cross Compiling

1. Compile the hello.c code.

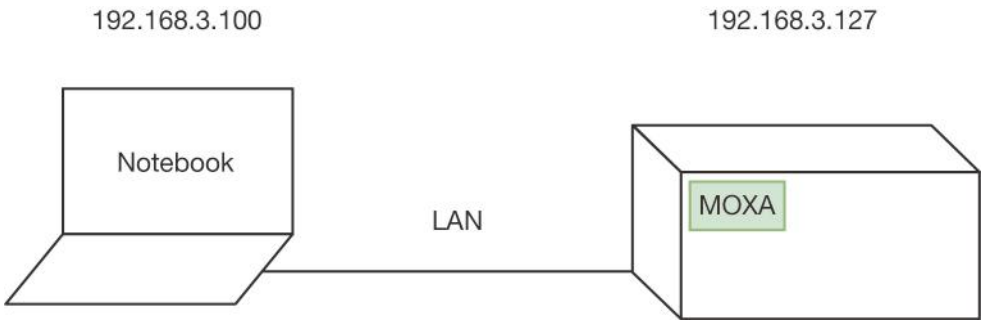
```
user@Linux:~$ arm-linux-gnueabihf-gcc -o hello \
 hello.c
user@Linux:~$ arm-linux-gnueabihf-strip -s hello
```

or
use Makefile as follows:

```
user@Linux:~$ make CC=arm-linux-gnueabihf-gcc \
 STRIP=arm-linux-gnueabihf-strip
```

2. Copy the program to a Moxa computer:

   For example, if the IP address of your device used for cross compiling the code is "192.168.3.100" and the IP address of the Moxa computer is "192.168.3.127", use the following command:




```
user@Linux:~$ scp hello moxa@192.168.3.127:~
```

3. Run the hello.c program on the Moxa computer.

```
moxa@Moxa:~$ ./hello
Hello World
```

Makefile Example

You can create a Makefile for the “hello" example program using the following code. By default, the Makefile is set for native compiling.

"hello/Makefile":

```
CC:=gcc
STRIP:=strip

all:
    $(CC) -o hello hello.c
    $(STRIP) -s hello

.PHONY: clean
clean:
    rm -f hello
```

To set the hello.c program for cross compilation, modify the toolchain settings as follows:

```
CC:=arm-linux-gnueabihf-gcc
STRIP:=arm-linux-gnueabihf-strip
```

Standard APIs

This section shows how to use some standard APIs on Moxa computers.

Cryptodev

The purpose of cryptographic hardware accelerator is to load off the intensive encryption/decryption and compression/decompression tasks from CPU.

Cryptodev-linux is a device that allows access to Linux kernel cryptographic drivers, allowing the userspace applications to take advantage of hardware accelerators. Cryptodev-linux uses "**/dev/crypto**" interface to let kernel space hardware accelerator drivers become accessible from typical userspace programs and libraries.

Example Code

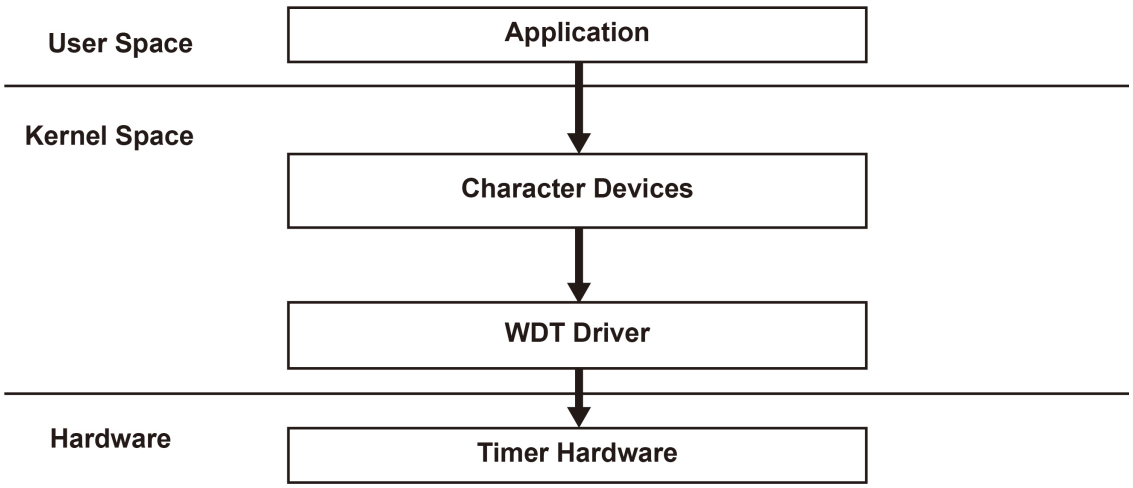
The cryptodev example code is available in the **cryptodev** folder.

Cryptodev-linux APIs are defined in **crypto/cryptodev.h**.

> **NOTE**
>
> Need to install Linux kernel header.
>
> More information is available at Cryptodev-linux document:
> http://cryptodev-linux.org/documentation.html

Watchdog Timer (WDT)

The WDT works like a watchdog function that can be enabled or disabled. When the WDT is enabled, but the application does not acknowledge it, the system will reboot. You can set the ack time from a minimum of 1 sec to a maximum of 1 day; the default is 60 seconds. The NO WAY OUT option is disabled by default; once the option is enabled, you will not be able to disable the watchdog. For this reason, if the watchdog daemon crashes, the system will reboot after the timeout interval has passed.



Config

You need to know which driver you're using first. Assume that the watchdog driver's name is "ds1374_wdt", then you can use the **modinfo** command to check the information as follows:

```
moxa@Moxa:~$ sudo modinfo ds1374_wdt
filename:       /lib/modules/4.4.0-cip-
uc5100+/kernel/drivers/watchdog/ds1374_wdt.ko
license:        GPL
description:    Maxim/Dallas DS1374 WDT Driver
author:         Scott Wood <scottwood@freescale.com>
depends:
intree:         Y
vermagic:       4.4.0-cip-uc5100+ mod_unload ARMv7 p2v8
parm:           nowayout:Watchdog cannot be stopped once started, default=0
(bool)
parm:           timer_margin:Watchdog timeout in seconds (default 60s) (int)
```

The parameter's name is "nowayout" for NO WAY OUT and "timer_margin" for timeout setting. To change the setting, you can add a conf file under the directory "/etc/modprobe.d/". For example, add a file "/etc/modprobe.d/watchdog.conf" with the following content:

```
options ds1374_wdt nowayout=1 timer_margin=60
```

This changes the setting for "ds1374_wdt" driver with nowayout=1 and timeout=60 seconds.

Example Code

The example code is available in the **watchdog** folder.

WDT driver APIs are used via "ioctl" through a file descriptor. The methods are defined in **linux/watchdog.h**.

The watchdog device node locate at "/dev/watchdog".

```
int fd = open("/dev/watchdog", O_WRONLY);
if (fd < 0) {
    perror("open watchdog failed");
    exit(EXIT_FAILURE);
}
```

API List

IOCTL Function	WDIOC_KEEPALIVE
Description	Writes to the watchdog device to keep the watchdog alive
Example	`ioctl(fd, WDIOC_KEEPALIVE, 0);`

IOCTL Function	WDIOC_GETTIMEOUT
Description	Queries the current timeout
Example	`int timeout;` `ioctl(fd, WDIOC_GETTIMEOUT, &timeout);`

IOCTL Function	WDIOC_SETTIMEOUT
Description	Modifies the watchdog timeout Default: 60 seconds
Example	`int timeout = 60;` `ioctl(fd, WDIOC_SETTIMEOUT, &timeout);`

IOCTL Function	WDIOC_GETSTATUS
Description	Asks for the current status
Example	`int flags;` `ioctl(fd, WDIOC_GETSTATUS, &flags);`

IOCTL Function	WDIOC_SETOPTIONS
Description	Control the following aspects of the card's operation • WDIOS_DISABLECARD: Turn off the watchdog timer • WDIOS_ENABLECARD: Turn on the watchdog timer • WDIOS_TEMPPANIC: Kernel panic on temperature trip Note: In some older versions of OS, the watchdog driver may return an ERROR for WDIOS_DISABLECARD and WDIOS_ENABLECARD. However, the settings still work as expected.
Example	`int options = WDIOS_DISABLECARD;` `ioctl(fd, WDIOC_SETOPTIONS, &options);`

IOCTL Function	WDIOC_GETSUPPORT
Description	Asks what the device can do
Example	`struct watchdog_info ident;` `ioctl(fd, WDIOC_GETSUPPORT, &ident);`

NOTE

More information is available at Linux kernel document:
https://www.kernel.org/doc/Documentation/watchdog/watchdog-api.txt

Real-time Clock (RTC)

The Real-time Clock is a computer clock that keeps track of the current time. RTC can be used to complete time critical tasks. Using RTC can benefit from its lower power consumption and higher accuracy.

Example Code

The RTC example code is available in the **rtc** folder.

RTC APIs are used via "ioctl" through a file descriptor. The methods are defined in <linux/rtc.h>.

The rtc device node locate at "/dev/rtc0".

The APIs that read time from RTC and set RTC time are using a structure "struct rtc_time". It is defined in <linux/rtc.h>:

```
struct rtc_time {
     int tm_sec;
     int tm_min;
     int tm_hour;
     int tm_mday;
     int tm_mon;
     int tm_year;
     int tm_wday;
     int tm_yday;
     int tm_isdst;
};
```

Note that variable "tm_mon" starts with 0 and variable "tm_year" represents the number of years since 1900.

API List

IOCTL Function	RTC_RD_TIME
Description	Reads time information from the RTC; returns the value of argument 3
Example	`struct rtc_time rtc_tm;` `ioctl(fd, RTC_RD_TIME, &rtc_tm);`

IOCTL Function	RTC_SET_TIME
Description	Sets the RTC time. Argument 3 will be passed to the RTC.
Example	`struct rtc_time rtc_tm;` `ioctl(fd, RTC_SET_TIME, &rtc_tm);`

NOTE

More information is available at Linux kernel document:
https://www.kernel.org/doc/Documentation/rtc.txt

Modbus

The Modbus protocol is a messaging structure used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open, and the most widely used network protocol in industrial manufacturing environments. It has been implemented by hundreds of vendors on thousands of different devices to transfer discrete/analog I/O and register data between control devices.

Example Code

We use "libmodbus" with current stable version v3.0.6 as our Modbus package, which is available at:
http://libmodbus.org/releases/libmodbus-3.0.6.tar.gz

To run the test program, we first need to build the "libmodbus" library. We can build it simply by running the following commands:

```
$ cd modbus/libmodbus-3.0.6/
$ ./configure && make install
```

After build completes, the test program can be found at "tests" directory. The test program provides 3 types of protocols (tcp/ tcppi/ rtu) which can be set by passing command line arguments.

The test program is client-server modeled. We should run the server program first, and then run the client program from another terminal.

```
$ cd modbus/libmodbus-3.0.6/tests/
$ ./unit-test-server tcp
```

```
$ cd modbus/libmodbus-3.0.6/tests/
$ ./unit-test-client tcp
```

NOTE

More information is available at libmodbus document: http://libmodbus.org/documentation/

Eco-friendly Modes for Power Conservation

Moxa UC-3100 Series offers 3 operating modes: Active mode, Conservation mode, Scheduled Awakening mode. These modes can be used to optimize power consumption, especially in remote deployments that lack a stable power source. This section explains the procedure to set up the **mx-power-mgmt** utility to enable the ECO mode.

NOTE

ECO Mode is only available in UC-3100 Series hardware v.1.0.0 and higher with firmware v1.2 and above required.

Using mx-power-mgmt

To be able to run the **mx-power-mgmt** command, you must use **sudo** or run the command with the root permission. Use the **# sudo mx-power-mgmt help** command to display the menu page.

```
moxa@Moxa:~$ sudo mx-power-mgmt help
Usage:
        mx-power-mgmt [Command]...
Command:
        scheduled-awakening [time]
                Set system to scheduled-awakening mode.
                [time]: a number in range 30 ~ 864000
        conservation [time]
                [time]: a number in range 30 ~ 864000
        red-led [on|off|blink]
                Set MCU red led
        green-led [on|off]
                Set MCU green led
        wake-up
                Wake up from conservation mode
        mcu-upgrade
                Upgrade MCU firmware
        check-mode
                Check MCU current mode
        help
                Show the usage manual
        version
                Show MCU firmware and utility version
moxa@Moxa:~$
```

Scheduled Awakening Mode

If this mode is enabled, the power input to the CPU and cellular module is temporarily cut off until the scheduled wake-up duration (in seconds).

 # sudo mx-power-mgmt scheduled-awakening 30

```
moxa@Moxa:~$ sudo mx-power-mgmt scheduled-awakening 30
[sudo] password for moxa:
Execute user scheduled-awakening preinstall configuration (Command: /etc/power-
management-utils/config/scheduled_awakening_preinst)
Execute scheduled-awakening function configuration (Command: /etc/power-
management-utils/executable/scheduled_awakening)
```

Conservation Mode

If this mode is enabled, the CPU frequency is reduced to 300 MHz and all I/Os are turned Off except CAN port for UC-3121. But users can still turn on each I/O individually. The SYS LED will continue to blink as an indication that the computer is under conservation mode.

The computer can be awakened from conservation mode according to the time you set. If you set the timer to 0, the system will remain in the conservation mode until it is woken up by a **Wake-up** Command.

 # sudo mx-power-mgmt conservation 30

```
moxa@Moxa:~$ sudo mx-power-mgmt conservation 30
[sudo] password for moxa:
Execute user conservation preinstall configuration (Command: /etc/power-
management-utils/config/conservation_preinst)
Execute conservation function configuration (Command: /etc/power-management-
utils/executable/conservation)
Network already stopped
Clearing state...
moxa@Moxa:~$
```

 # sudo mx-power-mgmt conservation 0

```
moxa@Moxa:~$ sudo mx-power-mgmt conservation 0
Execute user conservation preinstall configuration (Command: /etc/power-
management-utils/config/conservation_preinst)
Execute conservation function configuration (Command: /etc/power-management-
utils/executable/conservation)
WARNING: If you set timer as 0, it will not wake up automatically
You need to use '# mx-power-mgmt wake-up' command to wake up system by yourself
Do you want to continue? (N/y)
y
Enter into conservation mode
```

Setting the SYS LEDs Using mx-power-mgmt

The SYS LEDs on the UC-3100 computer are connected both to the system and the power management MCU. Hence, you can control the MCU to set the SYS LED through the **mx-power-mgmt** utility. There are two SYS LEDs on the MCU: Green and Red. Before turning on/off the LEDs using the **mx-power-mgmt** utility, ensure that the SYS LEDs are turned off on the system side using the command **# mx-led-ctl -p 1 -i 1 off**. You can then use the following **mx-power-mgmt** commands to control the SYS LEDs.

Command	Description
# sudo mx-power-mgmt green-led on	Turn on the SYS Green LED
# sudo mx-power-mgmt green-led off	Turn off the SYS Green LED
# sudo mx-power-mgmt red-led on	Turn on the SYS Red LED
# sudo mx-power-mgmt red-led off	Turn off the SYS Red LED
# sudo mx-power-mgmt red-led blink	Set the SYS Red LED to the blinking mode

Wake-up From Conservation Mode

The computer can be awakened from the Conservation mode according to a time interval that you set. If you set the timer interval to 0, the computer will stay in this mode until it is woken up using the **# sudo mx-power-mgmt wake-up** command.

```
moxa@Moxa:~$ sudo mx-power-mgmt wake-up
Execute conservation wake up function configuration (Command: /etc/power-
management-utils/executable/conservation_wake_up)
Execute user conservation wake up postinst configuration (Command: /etc/power-
management-utils/config/conservation_wake_up_postinst)
moxa@Moxa:~$
```

MCU Firmware Upgrade

If there is a new version of the MCU firmware, the system will automatically update the MCU after a reboot following the update of the system using the **apt-get dist-upgrade** and **apt-get upgrade** commands. You can also manually update the MCU firmware with the following command:

 # sudo mx-power-mgmt mcu-upgrade

```
moxa@Moxa:~$ sudo mx-power-mgmt mcu-upgrade
Start to upgrade MCU firmware
MCU enter into BSL mode.
Reset MCU
MCU firmware upgrade completed
moxa@Moxa:~$
```

Checking the MCU mode

MCU has four modes: power on, active, scheduled awakening, and conservation. In general, the power on mode is equivalent to active mode. The difference is that active means that your system is awakened from conservation or scheduled awakening.

 # sudo mx-power-mgmt check-mode

```
moxa@Moxa:~$ sudo mx-power-mgmt check-mode
active mode
moxa@Moxa:~$
```

Viewing the Utility and MCU Firmware Version

 # sudo mx-power-mgmt version

```
moxa@Moxa:~$ sudo mx-power-mgmt version
MCU firmware version 1.0.0S04
mx-power-mgmt version 1.0.0
moxa@Moxa:~$
```

User-defined Actions

The **mx-power-mgmt** utility allows customers to specify the I/O peripherals that they want to turn off in the conservation mode (this will affect the power consumption). The utility also supports the execution of user programs before entering the Conservation and Scheduled Awakening modes or start a service to keep a program running after wake-up.

To specify the I/O peripheral that you want to turn off in the conservation mode, modify the following file:

 # vi /etc/power-management-utils/config/conservation_config

```
# System Leds
CONFIG_TURN_OFF_LED=y
# System Loading
CONFIG_STOP_WIFI_SIGNALD_SERVICE=y
CONFIG_STOP_CELLULAR_SIGNALD_SERVICE=y
CONFIG_STOP_PUSH_BUTTON_SERVICE=y
CONFIG_LOW_CPU_FREQUENCY=y
# Ethernet
CONFIG_POWER_OFF_ETHERNET_ETH0=y
CONFIG_POWER_OFF_ETHERNET_ETH1=y
# Cellular Wireless
CONFIG_TURN_OFF_CELLULAR_USB=y
CONFIG_POWER_OFF_CELLULAR=y
# Others
CONFIG_TURN_OFF_USB_BUS=y
CONFIG_PULL_DOWN_GPIO=y
```

```
# Wake Up Time
CONFIG_DEFAULT_WAKE_UP_TIME=30

# WiFi Wireless (For UC-3111-LX and UC-3121-LX series model)
CONFIG_POWER_SAVE_WIFI=y
```

To run your own program to back up or shut down your service(s) before entering the Conservation or Scheduled Awakening, edit the following files.

 # vi /etc/power-management-utils/config/conservation_preinst
 # vi /etc/power-management-utils/config/scheduled_awakening_preinst

To start a service to keep your program running after the system wake-up from Conservation or Scheduled Awakening mode, edit the following files:

e.g., # vi /etc/power-management-utils/config/conservation_wake_up_postinst
e.g., # vi /etc/power-management-utils/config/scheduled_awakening_wake_up_postinst

Moxa Platform Libraries

Moxa provides several libraries for developing customized applications. In this section, we will show how to utilize these libraries.

Example codes are available at: https://github.com/Moxa-Linux

Error Numbers

Moxa defines exclusive error numbers for Moxa libraries. It works with other Moxa library codes and is useful for checking the result of executing an API.

If you call an API, you can check the return value to take particular action in response.

```
int num_of_interfaces;
ret = mx_get_number_of_interfaces(&num_of_interfaces);
if (ret == E_SYSFUNCERR){
    // do something...
}
```

Usage

- Install the package "libmoxa-errno-dev"
- Include header <moxa/mx_errno.h>

Error Code List

Error Code	Value	Description
E_SUCCESS	0	Exit successfully
E_SYSFUNCERR	-1	Error occurs in system functions (e.g., open)
E_INVAL	-2	Invalid input
E_LIBNOTINIT	-3	Library is not initialized
E_UNSUPCONFVER	-4	Config version is not supported for the library
E_CONFERR	-5	Error in config file
E_GPIO_NOTEXP	-20	The GPIO is not exported
E_GPIO_UNKDIR	-21	Unknown GPIO direction get
E_GPIO_UNKVAL	-22	Unknown GPIO value get
E_BUZZER_PLAYING	-30	The buzzer is already playing
E_UART_NOTOPEN	-50	The UART port is not opened
E_UART_GPIOIOCTLINCOMP	-51	GPIO and IOCTL are incompatible for UART
E_UART_UNKMODE	-52	Unknown UART mode get
E_UART_EXTBAUDUNSUP	-53	Extended baudrate is not supported
E_PBTN_NOTOPEN	-70	The push button is not opened

Platform Information

Moxa platform info library is used to get information of interfaces on the device, which is useful to know the device's capability before developing applications.

Usage

- Install the package "libmoxa-platform-info-dev"

  ("libjson-c-dev" package will be installed automatically when install "libmoxa-platform-info-dev")

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-platform-info-dev
```

- Include header <moxa/mx_platform_info.h> and <json-c/json.h>
- Link the libraries "-ljson-c" and "-lmx_platform_info" while compiling

API List

Function Prototype	int mx_get_number_of_interfaces(int *num_of_interfaces);
Description	Get the number of interfaces supported on the device
Parameters	• num_of_interfaces: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int num_of_interfaces;` `mx_get_number_of_interfaces(&num_of_interfaces);`

Function Prototype	int mx_get_platform_interface(char ***profiles);
Description	Get the interfaces supported on the device
Parameters	• profiles: a pointer which points to a place for storing output value ➢ the list of platform interfaces, in "char **" format. e.g. { "led-control", … }
Return Value	• 0 on success • negative integers as error number
Example	`char **profiles;` `mx_get_platform_interface(&profiles);`

Function Prototype	int mx_free_platform_interface(char **profiles);
Description	Free the memory space of profiles allocated by "mx_free_platform_interface" API
Parameters	• profiles: profiles from "mx_free_platform_interface" API
Return Value	• 0 on success • negative integers as error number
Example	`mx_free_platform_interface(profiles);`

Function Prototype	int mx_get_profile(const char *interface, struct json_object **profile);
Description	Get the profile of target interface
Parameters	• interface: the name of the target interface ➢ "buzzer-control" ➢ "dio-control" ➢ "uart-control" ➢ "led-control" ➢ "push-button" • profile: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`struct json_object *profile;` `mx_get_profile("led-control", &profile);`

Buzzer

Moxa buzzer control library can be used to control the buzzer on the device. We provide interfaces for controlling the buzzer to beep for a certain period or keep beeping till it is switched off.

NOTE

- The Moxa buzzer control library is supported only in the UC-8100A-ME-T Series.
- Use the Moxa buzzer control library with caution and stop the buzzer before the process ends; otherwise, it might beep without control.

Usage

- Need package "libmoxa-buzzer-control-dev"

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-buzzer-control-dev
```

- Include header <moxa/mx_buzzer.h>
- Link library "-lmx_buzzer_ctl" while compiling

API List

Function Prototype	int mx_buzzer_init(void);
Description	Initialize Moxa buzzer control library
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_buzzer_init();`

Function Prototype	int mx_buzzer_play_sound(unsigned long duration);
Description	Play the buzzer
Parameters	• duration: the duration time in seconds ➢ range: 1 to 60 ➢ 0 for keep beeping
Return Value	• 0 on success • negative integers as error number
Example	`mx_buzzer_play_sound(3);`

Function Prototype	int mx_buzzer_stop_sound(void);
Description	Stop the buzzer
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_buzzer_stop_sound();`

Digital I/O

Moxa DIO control library can be used to control digital I/O interface. Including getting states from Direct Input and Output ports, setting state of Direct Output ports.

Usage

- Need package "libmoxa-dio-control-dev"

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-dio-control-dev
```

- Include header <moxa/mx_dio.h>
- Link library "-lmx_dio_ctl" while compiling
- Need to call "mx_dio_init" before using other APIs

API List

Function Prototype	int mx_dio_init(void);
Description	Initialize Moxa DIO control library
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_dio_init();`

Function Prototype	int mx_dout_set_state(int doport, int state);
Description	Set state for target Direct Output port
Parameters	• doport: target DOUT port number • state: ➢ DIO_STATE_LOW: low ➢ DIO_STATE_HIGH: high
Return Value	• 0 on success • negative integers as error number
Example	`mx_dout_set_state(0, DIO_STATE_HIGH);`

Function Prototype	int mx_dout_get_state(int doport, int *state);
Description	Get state from target Direct Output port
Parameters	• doport: target DOUT port number • state: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int state;` `mx_dout_get_state(0, &state);`

Function Prototype	int mx_din_get_state(int diport, int *state);
Description	Get state from target Direct Input port
Parameters	• diport: target DIN port number • state: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int state;` `mx_din_get_state(0, &state);`

Function Prototype	int mx_din_set_event(int diport, void (*func)(int diport), int mode, unsigned long duration);
Description	Set an action for an event occurred of target Direct Input port
Parameters	• diport: target DIN port number • func: a function pointer which will be invoked on DIN event detected • mode: DIN event mode ➢ DIN_EVENT_CLEAR ➢ DIN_EVENT_LOW_TO_HIGH ➢ DIN_EVENT_HIGH_TO_LOW ➢ DIN_EVENT_STATE_CHANGE • duration: The during time that the event occurred to trigger action ➢ range: 40 to 3600000 (ms) ➢ 0 means no duration
Return Value	• 0 on success • negative integers as error number
Example	`void (*fp)(int );` `mx_din_set_event(0, fp, DIN_EVENT_STATE_CHANGE, 100);`

Function Prototype	int mx_din_get_event(int diport, int *mode, unsigned long *duration);
Description	Get event setting of target Direct Input port
Parameters	• diport: target DIN port number • mode: a pointer which points to a place for storing output value • duration: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number

Example	`int mode;`
	`unsigned long duration;`
	`mx_din_get_event(0, &mode, &duration);`

UART

Moxa UART can be used to set the mode of UART ports and transmit data via UART ports.

Usage

- Install the package "libmoxa-uart-control-dev"

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-uart-control-dev
```

- Include header <moxa/mx_uart.h>
- Link library "-lmx_uart_ctl" while compiling
- Need to call "mx_uart_init" before using other APIs

API List

Function Prototype	int mx_uart_init(void);
Description	Initialize Moxa UART control library
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_init();`

Function Prototype	int mx_uart_set_mode(int port, int mode);
Description	Set mode of target UART port
Parameters	• port: target UART port • mode: ➢ UART_MODE_RS232 ➢ UART_MODE_RS485_2W ➢ UART_MODE_RS422_RS485_4W
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_set_mode(0, UART_MODE_RS232);`

Function Prototype	int mx_uart_get_mode(int port, int *mode);
Description	Get mode of target UART port
Parameters	• port: target UART port • mode: a pointer for storing output
Return Value	• 0 on success • negative integers as error number
Example	`int mode;` `mx_uart_get_mode(0, &mode);`

Function Prototype	int mx_uart_open(int port);
Description	Open target UART port
Parameters	• port: target UART port
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_open(0);`

Function Prototype	int mx_uart_close(int port);
Description	Close target UART port
Parameters	• port: target UART port
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_close(0);`

Function Prototype	int mx_uart_read(int port, char *data, size_t count);
Description	Read data from target UART port
Parameters	• port: target UART port • data: memory location of data to be stored • count: read size
Return Value	• positive integers means size of data read • negative integers as error number
Example	`char data[256];` `mx_uart_read(0, data, 256);`

Function Prototype	int mx_uart_write(int port, char *data, size_t count);
Description	Write data from target UART port
Parameters	• port: target UART port • data: memory location of data to be written • count: write size
Return Value	• positive integers indicate the size of data read • negative integers as error number
Example	`char data[256];` `mx_uart_read(0, data, 256);`

Function Prototype	int mx_uart_set_baudrate(int port, int baudrate);
Description	Set the baudrate of target UART port
Parameters	• port: target UART port • baudrate: The baudrate
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_set_baudrate(0, 115200);`

Function Prototype	int mx_uart_get_baudrate(int port, int *baudrate);
Description	Get the baudrate of target UART port
Parameters	• port: target UART port • baudrate: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int baudrate;` `mx_uart_get_baudrate(0, &baudrate);`

Function Prototype	int mx_uart_set_databits(int port, int bits);
Description	Set the data bits of target UART port
Parameters	• port: target UART port • bits: The data bits
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_set_databits(0, 8);`

Function Prototype	int mx_uart_get_databits(int port, int *bits);
Description	Get the data bits of target UART port
Parameters	• port: target UART port • bits: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int bits;` `mx_uart_get_databits(0, &bits);`

Function Prototype	int mx_uart_set_stopbits(int port, int bits);
Description	Set the stop bits of target UART port
Parameters	• port: target UART port • bits: The stop bits
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_set_stopbits(0, 1);`

Function Prototype	int mx_uart_get_stopbits(int port, int *bits);
Description	Get the stop bits of target UART port
Parameters	• port: target UART port • bits: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int bits;` `mx_uart_get_stopbits(0, &bits);`

Function Prototype	int mx_uart_set_parity(int port, int parity);
Description	Set the parity of target UART port
Parameters	• port: target UART port • parity: The parity
Return Value	• 0 on success • negative integers as error number
Example	`mx_uart_set_parity(0, 0);`

Function Prototype	int mx_uart_get_parity(int port, int *parity);
Description	Get the parity of target UART port
Parameters	• port: target UART port • parity: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int parity;` `mx_uart_get_parity(0, &parity);`

LED

LED APIs can control the LEDs on the device, which can be ON, OFF, or BLINK. LEDs on a device are separated to types and groups. There are 2 types of LED: Signal LED and Programmable LED. Each type may contain several groups, and each group may contain several LEDs.

Usage

- Install package "libmoxa-led-control-dev"

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-led-control-dev
```

- Include the header <mx_led.h>
- Link the library "-lmx_led_ctl" while compiling
- Call "mx_led_init" before using other APIs

API List

Function Prototype	int mx_led_init(void);
Description	Initialize Moxa LED control library
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_led_init();`

Function Prototype	int mx_led_get_num_of_groups(int led_type, int *num_of_groups);
Description	Get the number of groups of a LED type
Parameters	• led_type: ➢ LED_TYPE_SIGNAL or LED_TYPE_PROGRAMMABLE • num_of_groups: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int num_of_groups;` `mx_led_get_num_of_groups(LED_TYPE_SIGNAL, &num_of_groups);`

Function Prototype	int mx_led_get_num_of_leds_per_group(int led_type, int *num_of_leds_per_group);
Description	Get the number of LEDs per group of a LED type
Parameters	• led_type: ➢ LED_TYPE_SIGNAL or LED_TYPE_PROGRAMMABLE • num_of_leds_per_group: a pointer which points to a place for storing output value
Return Value	• 0 on success • negative integers as error number
Example	`int num_of_leds_per_group;` `mx_led_get_num_of_leds_per_group(LED_TYPE_SIGNAL, &num_of_leds_per_group);`

Function Prototype	int mx_led_set_brightness(int led_type, int group, int index, int state);
Description	Set LED state on, off, blink
Parameters	• led_type: ➢ LED_TYPE_SIGNAL or LED_TYPE_PROGRAMMABLE • group: group number • index: LED index • state: ➢ LED_STATE_OFF or LED_STATE_ON or LED_STATE_BLINK
Return Value	• 0 on success • negative integers as error number
Example	`mx_led_set_brightness(LED_TYPE_PROGRAMMABLE, 1, 1, LED_STATE_ON);`

Function Prototype	int mx_led_set_all_off(void);
Description	Set all LED off
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_led_set_all_off();`

Function Prototype	int mx_led_set_all_on(void);
Description	Set all LED on
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_led_set_all_on();`

Push Button

Push button APIs.

Usage

- Install package "libmoxa-push-button-dev"

```
moxa@Moxa:~$ sudo apt-get install \
  libmoxa-push-button-dev
```

- Include header <moxa/mx_pbtn.h>
- Link library "-lmx_push_btn" while compiling
- Needs to call "mx_pbtn_init" before using other APIs

NOTE

Remember to terminate the push button daemon that run by the system. Or you might accidentally trigger some system functions which defined in the daemon when testing the button.

The push button daemon is called **moxa-pbtnd**. You can terminate the process by using the **`systemctl stop moxa-push-button`** command.

API List

Function Prototype	int mx_pbtn_init(void);
Description	Initialize Moxa push button library
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_pbtn_init();`

Function Prototype	int mx_pbtn_open(int type, int index);
Description	Open a push button by button type and index
Parameters	• type: ➢ BUTTON_TYPE_SYSTEM or BUTTON_TYPE_USER • index: button index
Return Value	• negative integers as error number • 0 or positive integer: button ID for manipulate the button by other APIs
Example	`int btn_id;` `btn_id = mx_pbtn_open(BUTTON_TYPE_USER, 1);`

Function Prototype	int mx_pbtn_close(int btn_id);
Description	Close a push button
Parameters	• btn_id: button ID returned by "mx_pbtn_open"
Return Value	• 0 on success • negative integers as error number
Example	`mx_pbtn_close(0);`

Function Prototype	int mx_pbtn_wait(void);
Description	Check if there is any button being listened on, if so, hang the process. This API can be used for daemon.
Parameters	N/A
Return Value	• 0 on success • negative integers as error number
Example	`mx_pbtn_wait();`

Function Prototype	int mx_pbtn_is_pressed(int btn_id);
Description	Get the state of a button
Parameters	• btn_id: button ID returned by "mx_pbtn_open"

Function Prototype	int mx_pbtn_is_pressed(int btn_id);
Return Value	• negative integers as error number • 0 if the button is released • 1 if the button is pressed
Example	`mx_pbtn_is_pressed(0);`

Function Prototype	int mx_pbtn_pressed_event(int btn_id, void (*func)(int));
Description	Register action on button pressed
Parameters	• btn_id: button ID returned by "mx_pbtn_open" • func: a function pointer which will be invoked on button pressed
Return Value	• 0 on success • negative integers as error number
Example	`void (*fp)(int );` `mx_pbtn_pressed_event(0, fp);`

Function Prototype	int mx_pbtn_released_event(int btn_id, void (*func)(int));
Description	Register action on button released
Parameters	• btn_id: button ID returned by "mx_pbtn_open" • func: a function pointer which will be invoked on button released
Return Value	• 0 on success • negative integers as error number
Example	`void (*fp)(int );` `mx_pbtn_released_event(0, fp);`

Function Prototype	int mx_pbtn_hold_event(int btn_id, void (*func)(int), unsigned long duration);
Description	Register action on button hold
Parameters	• btn_id: button ID returned by "mx_pbtn_open" • func: a function pointer which will be invoked on button hold • duration: Time for which the button is held to trigger an action (in seconds) ➢ range: 1 to 3600 ➢ 0 for keep triggering every second
Return Value	• 0 on success • negative integers as error number
Example	`void (*fp)(int );` `mx_pbtn_hold_event(0, fp, 60);`

Power Ignition Function (UC-8540 only)

The Power Ignition function controls the computer's power behavior. This function detects the ignition signal status and allows users to control the on/off delay time setting through Moxa's Power Ignition Software Utility.

The default setting of power ignition function is disabled. You could use the Moxa power ignition utility to enable the function.

Use the **mx_igt –h** command for help instructions

```
# mx_igt -h
Moxa power ignition utility

Usage:
      /sbin/mx_igt [Options]

Options:
-l              , list power ignition configuration
-s [on|off]     , setting power on/off function
-t <time>       , setting delay time(seconds) of power on/off
-e              , enable power ignition
-d              , disable power ignition

Example:
mx_igt -l, power ignition configuration state
mx_igt -s on -t 10, set 10 seconds delay time for power on
mx_igt -d, disable power ignition function
```

To enable the power ignition function, use the following command:

```
# mx_igt -e
Ignition function is ENABLE
```

To list the configurations of current power ignition setting, use the following command:

```
# mx_igt -l
Power ignition configuration:
---------------------------------------------
Status : Disable (val=0x00)
Signal : OFF (val=0x00)
Delay time of power on : 3 (sec)
Delay time of power off : 3 (sec)
```

For example, to set 10 seconds delay time for power on

```
# mx_igt -s on -t 10
```

You will see the delay time of power on is set to 10 seconds:

```
# mx_igt -l
Power ignition configuration:
---------------------------------------------
Status : Disable (val=0x00)
Signal : OFF (val=0x00)
Delay time of power on : 10 (sec)
Delay time of power off : 3 (sec)
```

To disable the power ignition function, use the following command:

```
# mx_igt -d
Ignition function is DISABLE
```

To utilize the power ignition function, you need to use the following command to activate service first

```
# systemctl unmask mx_igt
# reboot
```

After reboot, use the following command to enable ignition function.

```
# mx_igt -e
Ignition function is ENABLE
```