

User Manual

DA16200 Mass Production

UM-WI-011

Abstract

This User Manual is intended to help customers setup the hardware development environment, install the required software, and download and run an example application on the DA16200 Development Kit development platform.

Contents

Abstract 1

Contents 2

Figures..... 3

Tables 3

1 Terms and Definitions..... 4

2 References 4

3 Overview..... 5

 3.1 Production Process 5

4 Firmware Download 6

 4.1 OTP Protection..... 6

 4.2 Download via UART 7

 4.3 UART Multi Downloader..... 7

 4.4 NVRAM Initialization 7

 4.5 S/W Version Verification 8

 4.6 Download the Manufacturer and General Images 9

5 XTAL Calibration 10

 5.1 Frequency Calibration 10

6 Wi-Fi RF Test..... 12

 6.1 Test Parameter 12

 6.2 Test Channel..... 12

 6.3 Test Mode 12

 6.4 Test Command..... 13

 6.4.1 Start 13

 6.4.2 TX Test 13

 6.4.2.1 11 B Mode 13

 6.4.2.2 11 G Mode 13

 6.4.2.3 11 N Mode 14

 6.4.3 RX Test..... 14

7 Writing MAC Address 15

 7.1 AT GUI Tool 15

 7.2 Checking MAC 16

8 Wi-Fi Function Test..... 17

9 Standby Current Measurement..... 17

10 Factory Reset..... 18

 10.1 Console Command 18

 10.2 AT Command 18

11 Change Boot Index..... 19

 11.1 Console Command 19

Revision History 20

Figures

Figure 1: UART Multi Downloader..... 7
 Figure 2: Version Verification Using the AT Command..... 8
 Figure 3: Calibration Procedure 10
 Figure 4: Certification Mode Screen in AT GUI Tool..... 12
 Figure 5: OTP Mode Screen in AT GUI Tool..... 15
 Figure 6: Network Mode Screen in AT GUI Tool..... 17

Tables

Table 1: AT Command to Check Version..... 8
 Table 2: XTAL Offset OTP Address 11
 Table 3: RF Test Parameters 12
 Table 4: RF AT Command..... 13
 Table 5: 11B_1Mbps 13
 Table 6: 11G_54Mbps 13
 Table 7: 11N_MCS7 14
 Table 8: RX Test..... 14
 Table 9: AT Command for Writing/Reading MAC Address 15
 Table 10: AT Command for Factory Reset..... 18

1 Terms and Definitions

GUI	Graphical User Interface
UART	Universal Asynchronous Receiver/Transmitter
SPI	Serial Peripheral Interface
RF	Radio Frequency
OTP	One-Time Password

2 References

- [1] DA16200, Datasheet, Dialog Semiconductor
- [2] UM-WI-023 DA16200 EVK User Manual, Dialog Semiconductor
- [3] UM-WI-004 DA16200_DA16600 AT GUI Tool, Dialog Semiconductor
- [4] UM-WI-039 DA16200_DA16600 Multi Downloader User Manual, Dialog Semiconductor
- [5] UM-WI-035 DA16200 SDK Memory Map User Manual, Dialog Semiconductor
- [6] UM-WI-003 DA16200 AT-Command User Manual, Dialog Semiconductor

3 Overview

This document explains the production process for the DA16200 and what options and limitations the customer needs to consider in the production process. Any procedure or the order introduced here can be omitted or changed according to customer's production environment.

The following serial interfaces are used in the production process:

- UART0: Debug console and firmware download
 - Some RF test functions of AT commands can be implemented
 - Available to download the firmware up to max 16 devices via Multi downloader
- UART1: AT command

The DA16200 provides firmware download tools that use UART0 or SPI, and the AT GUI tool that uses AT commands for RF testing, Wi-Fi function testing, OTP writing, and so forth. If necessary, AT-Command can be implemented in UART0 as well, and the part with RF TEST and OTP write (Contact the technical support team more information on this). It is possible to use these tools in the production process or look at the sample application source codes to make a customer's production application.

3.1 Production Process

Production will be done in the following sequence:

1. Firmware download.
2. XTAL calibration.
3. Wi-Fi RF test.
4. Writing MAC address.
5. Wi-Fi function test.
6. Standby current measurement.
7. Factory reset.

4 Firmware Download

The first step is to write the initial images to an empty serial flash IC. The DA16200 supports UART and SPI to download firmware and provides a GUI tool and the sample source codes.

The download of firmware is done with an MROM prompt (boot mode).

See Ref. [5] for the download addresses of each firmware image.

4.1 OTP Protection

Before writing the RTOS image, do OTP lock checking to protect OTP area and download firmware safely:

- Providing macro script file via UART firmware update
- Basically, UART Multi downloader supports OTP Protection function

Following is a macro script for protection.

```
sendln "reset"
mpause 700

; otp init (it is already init status in MROM prompt)
; read lock status
sendln 'lwr 40120000 38000000'
wait '[BOOT]' '[MROM]'

:RETRY
sendln 'lrd 40103ffc'
wait '[0x40103FFC] : '
recvln
;strtrim inputstr '[0x40103FFC] :'
;messagebox inputstr "str"
;strtrim inputstr '[0x40103FFC] : 0x0000000'
strcpy inputstr 25 1 substr
;messagebox substr "str"
strcmpare substr '1'
; if locked do nothing
if result=0 then
    goto END
; if not lock the 0bit
else
    messagebox 'secure regien lock' "confirm"
    sendln 'lwr 40120000 34000000'
    wait '[BOOT]' '[MROM]'
    sendln 'lwr 40103ffc 04000000'
    wait '[BOOT]' '[MROM]'
    sendln 'lwr 40120000 38000000'
    wait '[BOOT]' '[MROM]'
    goto RETRY
goto END
```

```
endif
:END
;MessageBox 'end' 'unlock'
;end

sendln "boot"
```

4.2 Download via UART

There are three images (BOOT, SLIB and RTOS) to be downloaded via UART0 with the `ymodem` protocol. See section Firmware Update in Ref. [2] about firmware download commands.

There are two types of OS for the DA16200, and in the case of FreeRTOS, just write `boot` and `RTOS` image.

Dialog Semiconductor provides a GUI to use a download tool. For details, see Ref. [2].

4.3 UART Multi Downloader

The Multi-Downloader is used to write the DA16200 images to the flash IC through the UART interface of the RS232 port between the DA16200 and PC. And it can download the images to multiple devices at the same time.

See Ref. [4] for firmware download via UART Multi Downloader user guide.

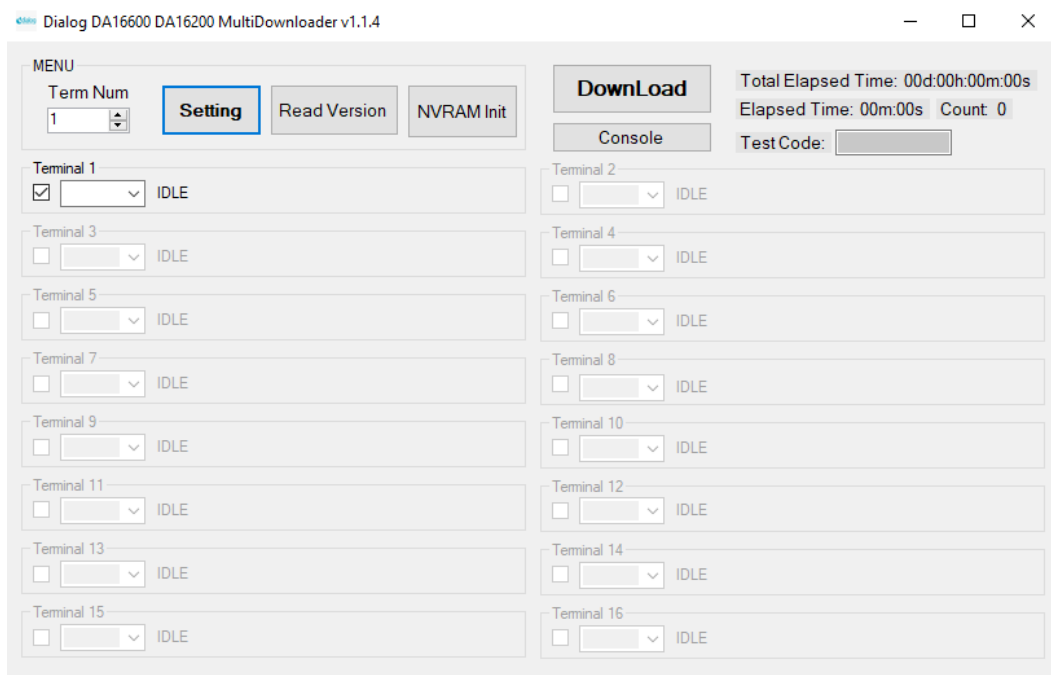


Figure 1: UART Multi Downloader

4.4 NVRAM Initialization

Normally, the flash memory is empty before downloading firmware, so the `NVRAM` region should be initialized. The console command in the DA16200 prompt and the `NVRAM` region can be initialized with the following commands after the first firmware download.

DA16200 Mass Production

```
[/DA16200] # nvram
[/DA16200/NVRAM] nvedit erase sflash
[/DA16200/NVRAM] nvedit clear
[/DA16200/NVRAM] nvcfg update sflash
update, sflash completed
[/DA16200/NVRAM] nvedit load sflash
nvedit, load completed
```

4.5 S/W Version Verification

Run the following console command or AT command to find out what the written firmware’s versions are.

- UART0 Console command `ver`

```
[/DA16200] # ver
*****
*
*          DA16200 SDK Information
* -----
*
* - CPU Type: Cortex-M4 (80 MHz)
* - OS Type: ThreadX 5.7
* - Serial Flash: 16 Mbits (2 MBytes)
* - SDK Type: Generic v1.0.0
* - F/W Version: RTOS-GEN01-01-7140-000000
*
*          : SLIB-GEN01-01-7089-000000
* - F/W Build Time: Jul  5 2019 17:35:59
* - Boot Index: 0
*
*****
[/DA16200] #
```

- UART1 AT command `AT+VER`

Table 1: AT Command to Check Version

Command	Parameters	Description
AT+VER	(none)	Get version info. Response: +VER:<RTOS version>,<SLIB version>

```
AT+VER
+VER:RTOS-GEN01-01-7140-000000,SLIB-GEN01-01-7089-000000
OK
```

Figure 2: Version Verification Using the AT Command

DA16200 Mass Production

4.6 Download the Manufacturer and General Images

A manufacturer's image set may be needed for calibration and an RF test during the production process. There is an effective way to download the General Image set and the Test Image set to reduce production time.

The DA16200 provides two image areas (boot_idx 0 and boot_idx 1) for OTA update. It is possible to use these regions for each image set and change the index of the boot image set. The default value of the boot index points to #0, so it will work as a manufacturer's image on first boot.

1. Go to MROM prompt and download the secondary bootloader.
2. Download the manufacturer's image to the RTOS # 0 and SLIB # 0 region.
3. Download the general image to the RTOS # 1 and SLIB # 1 regions.
4. Boot - the default boot index is #0.
5. Initialize the NVRAM.
6. Execute the test process.

5 XTAL Calibration

The DA16200 has several OTP slots for TX power, temperature, and XTAL frequency calibration. The AT GUI tool provides menus for each calibration. This section explains only XTAL frequency calibration. TX power and temperature frequency calibration is done during the ATE test.

5.1 Frequency Calibration

This section describes how to do the frequency calibration.

Figure 3 gives an example flowchart of the procedure.

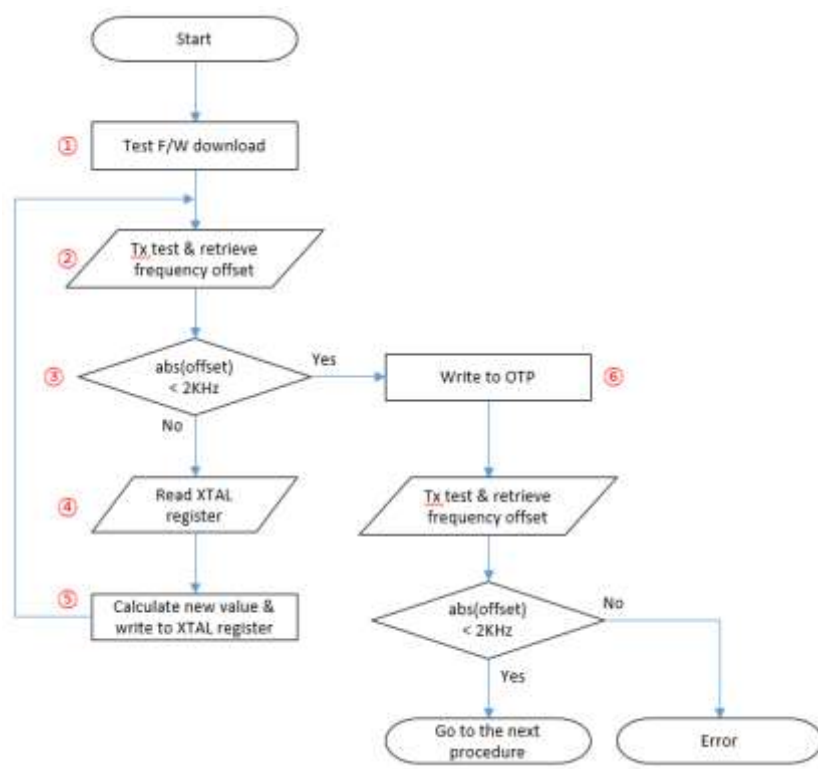


Figure 3: Calibration Procedure

1. Download the test firmware.
This firmware can be the final image.
2. On the DA16200, run the TX test mode and read the frequency offset with the use of measuring equipment.
3. If the offset is below 2 kHz, then the value is within the margin.
If not, then do the steps 4 and 5 to change the XTAL register value.
4. Read the XTAL register value with command `AT+XTALRD`.
The example shows the AT command to read the current value of the XTAL register. The result is 0x29 in this example.

```
AT+XTALRD
0x29
```

5. Calculate a new value for the XTAL register and write the XTAL register.
The example code shows how to calculate a new XTAL value.

```
if (abs(offset) < 2000) {
    // Go to write OTP
```

DA16200 Mass Production

```

} else {
    newXtalValue = currentXtalValue - (offset / 4000);
    if (offset % 4000 > 0) newXtalValue--;
    else if (offset % 4000 < 0) newXtalValue++;
    // Go to write the XTAL register
}

```

6. Use the AT command `AT+XTALWR=<newValue>` to write a new value for the XTAL register.

```

AT+XTALWR=<newValue>
OK

```

7. Write the final value with command `AT+UOTPWRASC=0428,1,<newValue>` to OTP and go to the next step to confirm if the result is good.

```

AT+UOTPWRASC=0428,1,<newValue>
OK

```

8. The DA16200 has two slots to store the XTAL offset in the OTP memory. See [Table 2](#). To use AT command to write value at OTP address, address x 4 should be taken because address is 4-byte aligned address. For more details, see section OTP Commands in Ref. [\[6\]](#).

Table 2: XTAL Offset OTP Address

Slot	OTP Address	Address for AT command	Size (Bytes)
XTAL Offset #0	0x10A	428	2
XTAL Offset #1	0x10B	42c	2

6 Wi-Fi RF Test

You can test TX/RX performance of the DA16200 in the Certification Mode menu of the AT GUI tool. See [Figure 4](#). For more information about AT commands, see section RF Test Function Commands in Ref. [\[3\]](#).

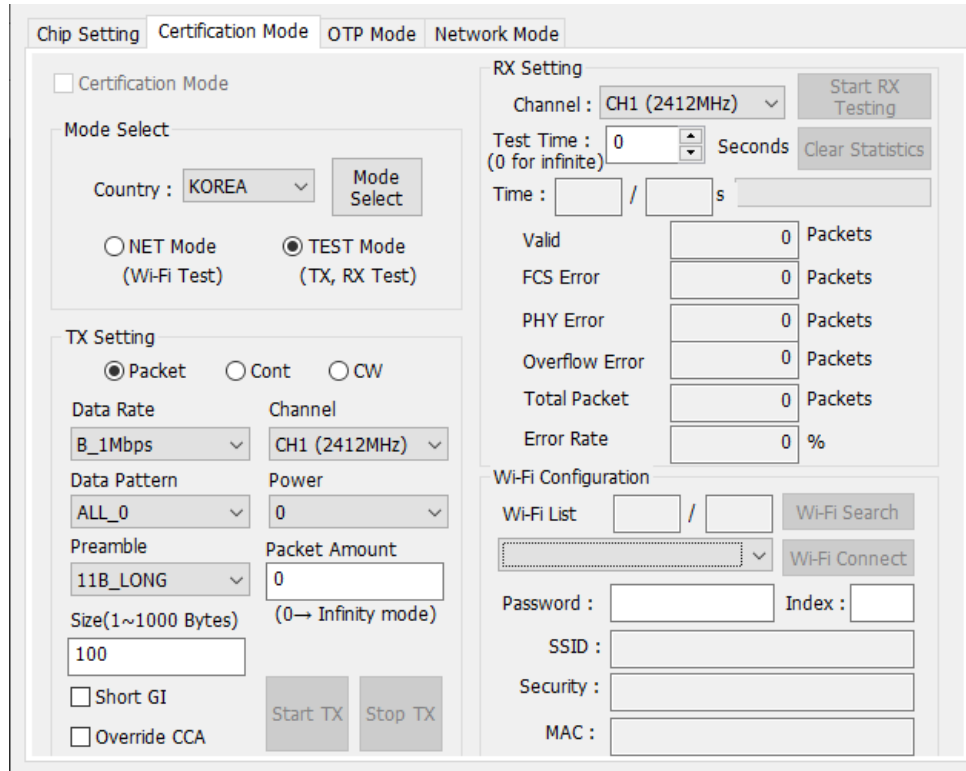


Figure 4: Certification Mode Screen in AT GUI Tool

6.1 Test Parameter

Basic Wi-Fi RF test parameters are listed in [Table 3](#).

6.2 Test Channel

The DA16200 supports up to 14 channels, but it is highly recommended to check what the performance is at CH1 (2,412 MHz), CH7 (2,442 MHz), and CH13 (2,472 MHz).

6.3 Test Mode

To confirm the best performance of the product, the recommendation is to check the test parameter of the Receiver and Transmitter mentioned in [Table 3](#).

Table 3: RF Test Parameters

Test Parameter	802.11 B	802.11 G	802.11 N (HT20)
Tx	EVM	EVM	EVM
	Frequency Tolerance	Frequency Tolerance	Frequency Tolerance
	Output Power	Output Power	Output Power
	Data rate	Data rate	Data rate

DA16200 Mass Production

Test Parameter	802.11 B	802.11 G	802.11 N (HT20)
	Symbol Clock Tolerance	Symbol Clock Tolerance	Symbol Clock Tolerance
	Tx Carrier Leakage	Tx Carrier Leakage	Tx Carrier Leakage
	Spectrum Emission Mask	Spectrum Emission Mask	Spectrum Emission Mask
Rx	Sensitivity	Sensitivity	Sensitivity

6.4 Test Command

See Ref. [6] for RF test using DA16200 AT Command [4] in detail.

6.4.1 Start

Table 4: RF AT Command

Command	Parameters	Description
AT+TMRFNINIT=1	<0,1>	Set boot mode. 0 (normal boot), 1 (RF test mode boot)
AT+RESTART	(none)	If set the boot mode as RF test mode (AT+TMRFNINIT=1), Restart the DA16200 (AT+RESTART)
AT+RFTESTSTART	(none)	Start RF test mode.
AT+RFTESTSTOP	(none)	Stop RF test mode.

6.4.2 TX Test

6.4.2.1 11 B Mode

Table 5: 11B_1Mbps

Command	Description
AT+RFTX 2412,0,0,200,b1,0	11 B 1 Mbps/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX 2442,0,0,200,b1,0	11 B 1 Mbps/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX 2472,0,0,200,b1,0	11 B 1 Mbps/Channel 13
AT+RFTXSTOP	Stop Tx

6.4.2.2 11 G Mode

Table 6: 11G_54Mbps

Command	Description
AT+RFTX 2412,0,0,1000,g54,0	11 G 54 Mbps/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX 2442,0,0,1000,g54,0	11 G 54 Mbps/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX 2472,0,0,1000,g54,0	11 G 54 Mbps/Channel 13

Command	Description
AT+RFTXSTOP	Stop Tx

6.4.2.3 11 N Mode

Table 7: 11N_MCS7

Command	Description
AT+RFTX 2412,0,0,1000,n65,0	11N MCS7/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX 2442,0,0,1000,n65,0	11N MCS7/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX 2472,0,0,1000,n65,0	11N MCS7/Channel 13
AT+RFTXSTOP	Stop Tx

6.4.3 RX Test

For accurate RX measurement, measurement must be performed under lossless (Shield room or Anechoic chamber) conditions and without external signal influence.

- **Channel:** Support CH1 ~ CH13
- **Test Time:** Maximum 3600s (Duration is 1 second fixed)
- **RX Packet Rate:** FCS + PHY + Overflow packet / Total packet = Error rate
- **The error rate** must not be greater than 10 %

Table 8: RX Test

Command	Description
AT+RFCHANNEL 2412	Change RF channel to 1.
AT+RFPERRESET	Reset PER count.
AT+RFPER	Display PER state.
AT+RFCHANNEL 2442	Change RF channel to 7.
AT+RFPERRESET	Reset PER count.
AT+RFPER	Display PER state.
AT+RFCHANNEL 2472	Change RF channel to 13.
AT+RFPERRESET	Reset PER count.
AT+RFPER	Display PER state.

7 Writing MAC Address

The MAC address written in the OTP memory is used for the WLAN0 interface (Station) MAC address and the next number is automatically designated as the WLAN1 (Soft-AP) MAC address. For example, if AA:BB:11:22:33:44 is written in the OTP memory, then WLAN0 has AA:BB:11:22:33:44 and WLAN1 has AA:BB:11:22:33:45.

As each DA16200 chip consumes two MAC addresses, when you write a mac address to a DA16200 chip, the last byte of the mac address should be bigger by two than that of the previous DA16200 chip in the production line. For example, AA:BB:11:22:33:44, AA:BB:11:22:33:46, AA:BB:11:22:33:48 and so on. The last digit of the WLAN0 MAC address should be an even number.

7.1 AT GUI Tool

You can write MAC addresses in OTP Mode menu in the AT GUI tool. The DA16200 provides 4 slots to store MAC addresses in the OTP memory. When a new MAC address is written, the previous slot should be invalidated. See Ref. [3].

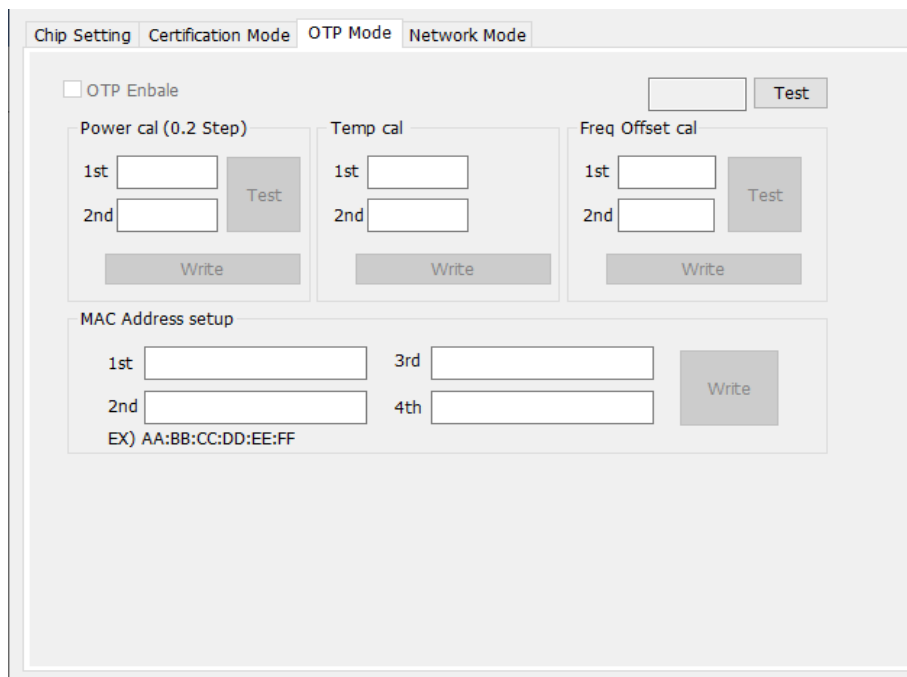


Figure 5: OTP Mode Screen in AT GUI Tool

Table 9: AT Command for Writing/Reading MAC Address

Command	Parameters	Description
AT+WFOTP	<mac>	Write MAC address in the OTP memory. An old MAC address in the OTP will be invalidated if one exists. There are four mac address slots available in OTP, so only a maximum of four MAC addresses are written in total at production. Response: OK or ERROR For example: AT+WFOTP=EC:9F:0D:90:00:48 The last hex of <mac> should be an even number.

DA16200 Mass Production

Command	Parameters	Description
		The MAC address written in the OTP is used as WLAN0 MAC address and then WLAN's MAC+1 will be used as WLAN1 MAC address.
AT+WEMAC	(none)	Get the current MAC address of the activated WLAN interface. DA16200 provides three types of MAC addresses (OTP MAC address, user MAC address and spoofing MAC address). The priority is OTP < User < Spoofing. Response: +WEMAC:<mac>

7.2 Checking MAC

- Write the new MAC address to an empty slot using command `setotpmac` as shown in the example code.
This command invalidates the previous slot and validates the new slot.

```
[/DA16200] # setotpmac AA:BB:11:22:33:44
```

- Check what the new MAC address is using command `getwlanmac`.

```
[/DA16200] # getwlanmac
MAC TYPE: OTP MAC
WLAN0 - AA:BB:11:22:33:44
WLAN1 - AA:BB:11:22:33:45
```


DA16200 Mass Production

8 Wi-Fi Function Test

To test the basic Wi-Fi function (station and soft-AP), use the **Network Mode** menu in the AT GUI tool. See Ref. [4] and for related commands, see section **Network Function Commands** in Ref. [6].

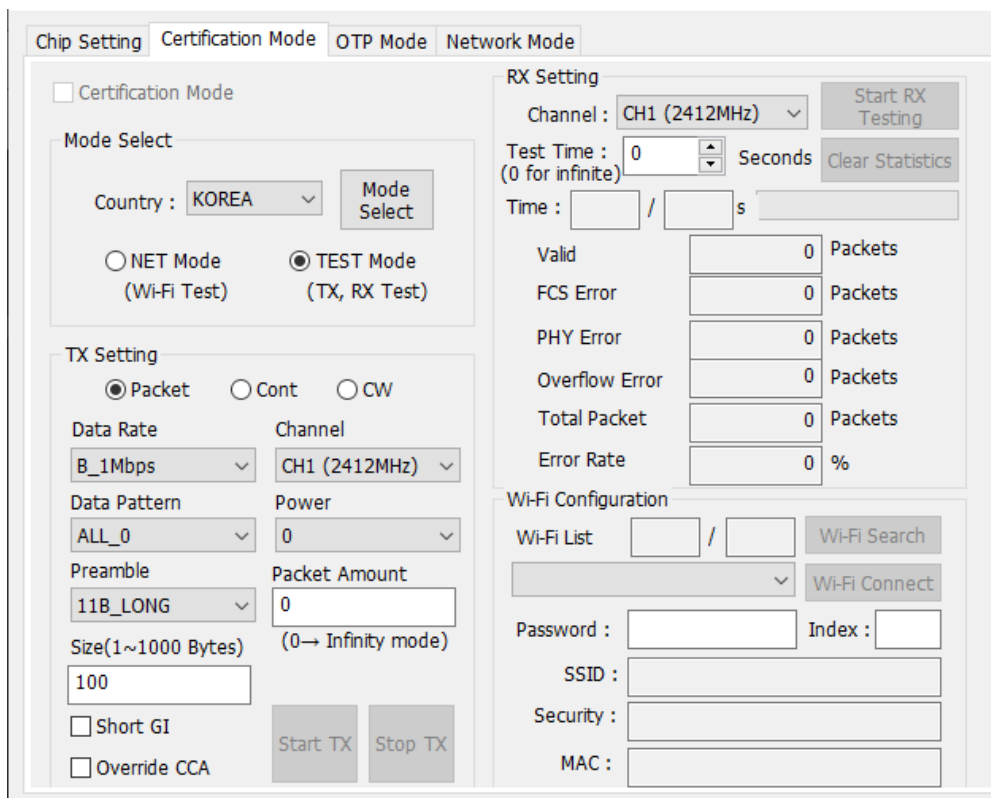


Figure 6: Network Mode Screen in AT GUI Tool

9 Standby Current Measurement

You may need to measure the standby current consumption to detect any current leakage in the DA16200. The following example code makes the DA16200 go to sleep mode.

```
[/DA16200] # sys.hal
[/DA16200/SYS] # sleep [mode] [time]
Mode: sleep mode
2: Sleep mode 2.
3: Sleep mode 3.
Time: DA16200 wakes up after this time passes (second)
```

See section Test Methods in Ref. [2] about measuring current consumption.

10 Factory Reset

Many profiles may be written in the NVRAM during the production process so the DA16200 may need to be initialized to the factory status. The command code example in Section 10.1 or the use of the AT command in Table 10 erases all user NVRAM items.

10.1 Console Command

```
[/DA16200] # factory
FACTORY RESET [N/y/?] y

Start Factory-Reset ...

Rebooting....
```

10.2 AT Command

Table 10: AT Command for Factory Reset

Command	Parameters	Description
ATF	(none)	The DA16200 factory reset.

11 Change Boot Index

To change the manufacturer's image to the General Image, change the boot index, and then reboot. See the example code in Section 11.1. After the reboot is completed, check if the version printed at boot and the boot index values are changed. See Section 4.6.

11.1 Console Command

```
[/DA16200] # boot_idx 1
[/DA16200] # reboot

>>> Network Interface (wlan0): DOWN
[wpasupplicant_event_disassoc] CTRL-EVENT-DISCONNECTED bssid=aa:ab:ac:ad:ae:af
reason=3 locally_generated=1
[wpasupplicant_ev_disassoc_fin] Disconnect event - remove keys
RaLIB is relocated to RETMEM (20f815c0, 564, 12904718, 12904718)
P.TIM is relocated to RETMEM (20f835c0, 3)
dpm_init_retmemory::316 DPM INIT CONFIGURATION(1)

Wakeup source is 0x0

*****
*                DA16200 SDK Information
* -----
*
* - CPU Type: Cortex-M4 (80 MHz)
* - OS Type: ThreadX 5.7
* - Serial Flash: 16 Mbits (2 MBytes)
* - SDK Type: Generic v1.0.0
* - F/W Version: RTOS-GEN01-01-7140-000000
*                : SLIB-GEN01-01-7089-000000
* - F/W Build Time: Jul  5 2019 17:35:59
* - Boot Index: 1
*
*****
```

DA16200 Mass Production

Revision History

Revision	Date	Description
1.5	27-Oct-2021	Updated References Section 4 updated firmware update Section 4.3 Added UART Multi Downloader Section 4.6 updated description Section 6.4 updated
1.4	17-Mar-2021	Add Note 1 at page 4
1.3	21-Nov-2019	Finalized for publication
1.2	18-Nov-2019	Editorial review Add description for OTP write command at page 9
1.1	12-Nov-2019	Add 2.5 Download the Manufacture and General Images Add Section 9 Change Boot Index Error correction on Table 4
1.0	31-Jul-2019	Preliminary DRAFT Release

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Status Definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
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