AMEBA
MP Flow
Version 0.2

No. 2, Innovation Road II, Hsinchu Science Park,
Hsinchu 300, Taiwan
www.realtek.com

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Revision History

Revision	Date	Changes	Author
Ver 0.1	2014/9/12	Draft Release	Ed/Ben
Ver 0.2	2016/11/18	add Ameba-Z	Jue/Serena

1. Overview

This document is used to introduce Mass Production Flow for Ameba series chip. Customers can build up their own MP software easily with just following step-by-step guidance of this document. Realtek also cooperates with instrument vendors during chip development stage, so customers can inquire MP software support from instrument vendors.

Ameba-1 series chip includes following IC part numbers and here lists its relative connectivity interface and its memory type,

1. RTL8195AM: Support high speed USB and SDIO connectivity interface with 2MB SDRAM
2. RTL8711AM: Support basic peripheral interface with 2MB SDRAM
3. RTL8711AF: Support basic peripheral interface with embedded flash only

Ameba-Z series chip includes following IC part numbers and here lists its relative connectivity interface and its memory type,

1. RTL8710B: Support basic peripheral interface with external flash.

In order to correctly design your hardware and properly apply Ameba series chip on your platform, please do provide following information to your Realtek local sales and Technical Support Team,

1. Memory requirements, such SDRAM or flash size is required.
2. Connectivity interface requirement, such as USB/SDIO interface.
3. Special GPIO requirement, such as wake trigger pin from deep sleep state, ADC, etc.
4. Antenna configuration, such as one or two antenna and diversity required or not.

Realtek Technical Support Team will depend on above information, and then provide following document or design kit to assist customers on hardware design,

1. IC Datasheet
2. Hard Design Kit (HDK) or suitable recommendation
3. Calibration Data Content (flash/ non-volatile memory) Specification
4. Calibration Data Content (flash/ non-volatile memory) MAP file
5. MP API (customer can use this API to develop their own software tool for mass production)
6. MP calibration Flow

Emphasize again, different hardware configurations have to match up different MAP file, so customers do have to contact Realtek Technical Support team to obtain correct MAP file to match up your hardware design.

2. Test Platform

The calibration flow described in following section is based on WiFi one-box tester, such as Agilent N4010A or LitePoint IQFlex, etc.

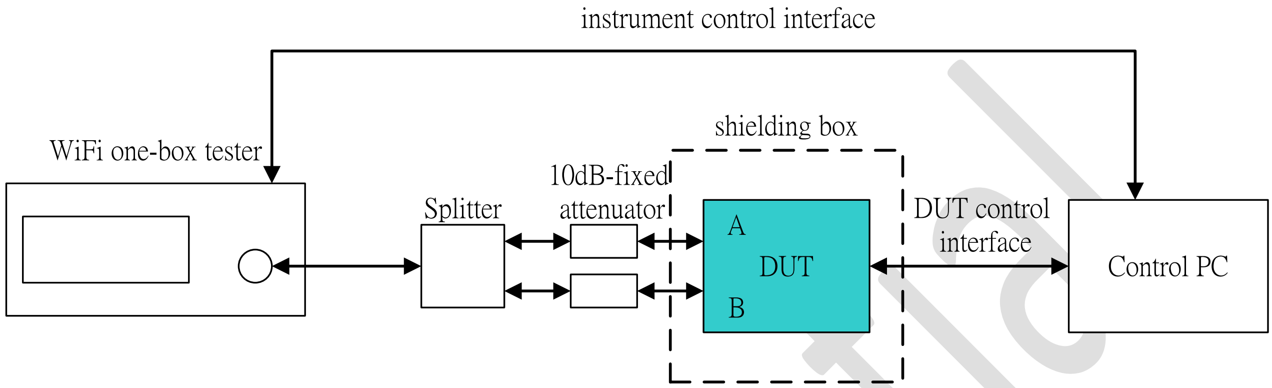

Figure 1: Brief diagram about test environment setup of DUT

Note the 10dB-fixed attenuator has to set as close as possible to DUT since it will reduce the mismatch effect between DUT and the environment.

3. DUT MP Flow

Below diagram shows a global view of mass production flow, please refer to following sub-section to get detailed description for each step.

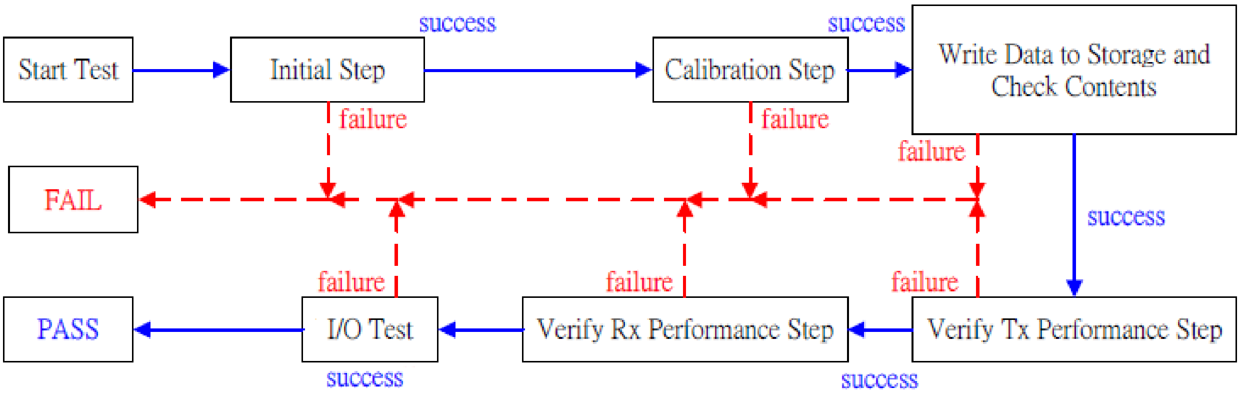

Figure 2: Brief diagram about MP flow

3.1. Initial Step

3.1.1. WiFi Initial Step

The relative control commands about initializing WiFi DUT is in the released UI sample code.

The AT command “ATWP=1” can enable WiFi, and use “ATWP=0” to disable.

Please check the following message. The message “The driver is for MP” indicates this is a MP driver. MP driver is used to calibrate WiFi data.

```
#ATWP=1
[ATWP]: _AT_WLAN_POWER_[ON]

Initializing WIFI ...
RTL8195A[Driver]: The driver is for MP

WIFI initialized

[MEM] After do cmd, available heap 25968
```

3.2. I/O Test Step

Ameba MP API supports IO connection tests for module fabrication. All the peripheral functions are well tested in Realtek mass production testing procedure.

If customers have specified test requirement for GPIO function used for your module or system design, please contact Realtek Support Team.

3.2.1. ADC Test

For the Ameba-1 module, the ADC_CH2 and ADC_CH1 are fed with 0 ~ 3.3V voltage level and read the sample value. The sample value should be within tolerated error.

For the Ameba-Z module, the ADC_CH1, ADC_CH2 and ADC_CH3 are fed with 0 ~ 3.3V voltage level and read the sample value. The sample value should be within tolerated error.

The AT command “ATSA=1” can read ADC_CH1 value, use “ATSA=2” to read ADC_CH2, and use “ATSA=3” to read ADC_CH3.

The following output is the ADC value.

```
#ATSA=1

[ATSA]: _AT_SYSTEM_ADC_TEST_
[ATSA] A1 = 0x0827
[MEM] After do cmd, available heap 37432
```

```
#ATSA=2

[ATSA]: _AT_SYSTEM_ADC_TEST_
[ATSA] A2 = 0x0827
[MEM] After do cmd, available heap 37432
```

Note:

For RTL8195AM module, test the ADC_CH1 and ADC_CH2.

For RTL8711AM, test ADC_CH2 only.

For Ameba-Z QFN68 module, test the ADC_CH1, ADC_CH2 and ADC_CH3.

For Ameba-Z QFN48, test the ADC_CH1 and ADC_CH3.

For Ameba-Z QFN32, test ADC_CH2 only.

3.2.2. GPIO Test

For the RTK module Ameba-1, module pin #36 ~ pin #43 are fed with 0V and 3.3V from the testing equipment. These GPIOs are configured as input mode and read the input value. Check the input logic values are same as the equipment output levels.

For the RTK module Ameba-Z, module pin PA0 ~ PA5, PA12~PA31 and PB0~PB7 are fed with 0V and 3.3V from the testing equipment. These GPIOs are configured as input mode and read the input value. Check the input logic values are same as the equipment output levels.

The AT command “ATSG=xy” can read the number y of GPIO port x.

For example, the command “ATSG=C1” can read GPIOC_1, and use “ATSG=B2” to read GPIOB_2.

The following output is the testing equipment voltage level.

```
#ATSG=C1

[ATSG]: _AT_SYSTEM_GPIO_TEST_
[ATSG] C1 = 1
[MEM] After do cmd, available heap 37432
```

```
# ATSG=B2

[ATSG]: _AT_SYSTEM_GPIO_TEST_
[ATSG] B2 = 0
[MEM] After do cmd, available heap 37432
```

Note:

For Ameba-Z module, PA_6~PA_11 are not allowed to be tested when code running on flash.

3.3. Calibration Step

This step includes 2 sub-steps as shown in Figure 3:

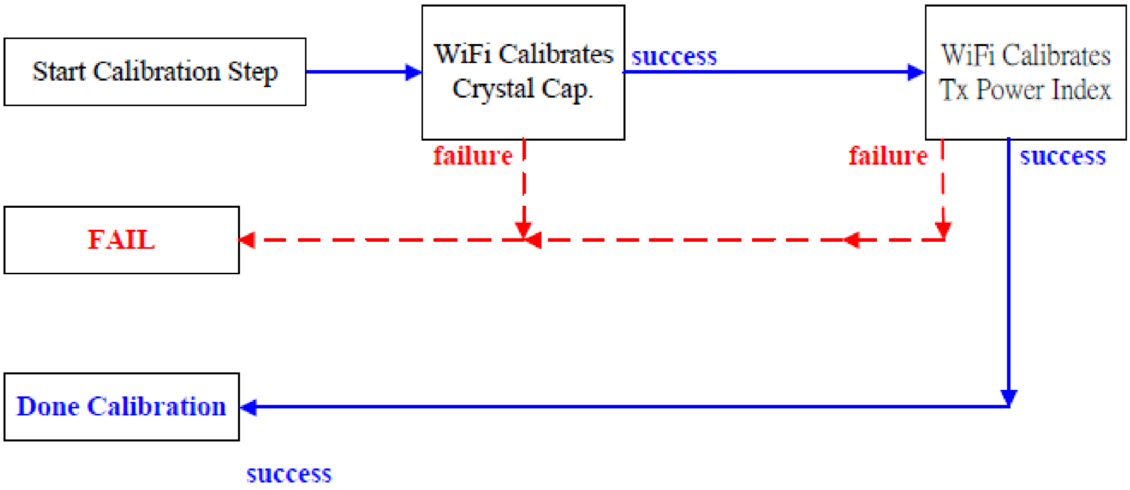

Figure 3: Brief diagram about calibration step

3.3.1. WiFi Calibrates Crystal Cap

3.3.1.1. calibration data definition about Crystal Cap.

First, take a look at calibration data content about setting of Crystal Cap. Normal driver will load this value in initial step. So this value must be well-calibrated and filled on correct calibration data location.

Crystal Calibration	0xC9[7:0]

Table 1: Crystal calibration offset in calibration data

3.3.1.2. Calibrated Crystal Cap. Flow

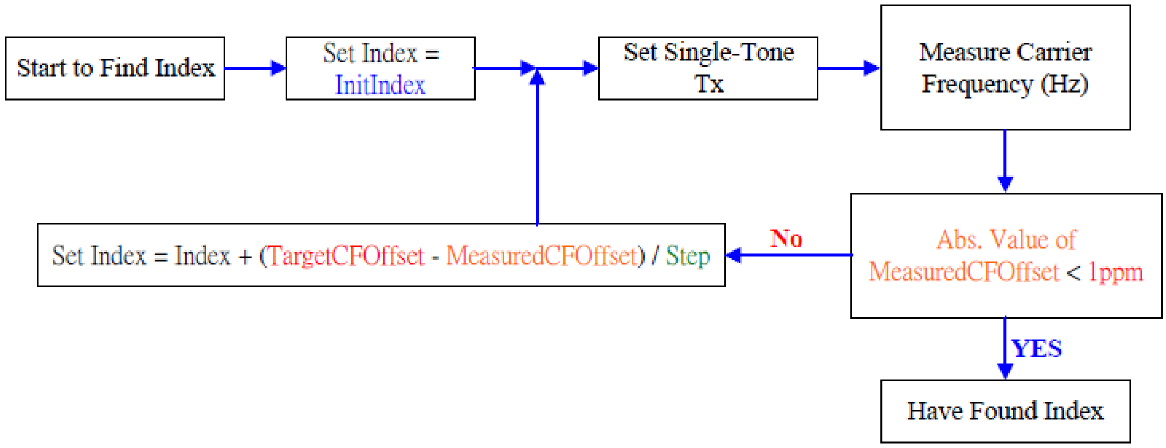

Figure 4: Finding Crystal Cap. Index Flow

Measurement environment : room temperature 25 degree

InitIndex: the default value is 0x20. Index range is 0x0 to 0x3F.

MeasuredCFOffset: Carrier frequency measured by instrument - Ideal Carrier Frequency
Target range Abs. Value of 1ppm in 2.4GHz band is about 5KHz(±2.5KHz).

**TargetCFOffset*: generally is 0~-5ppm ppm , The reason for minus ppm was the frequency deviation could be under 15ppm at high temperature 80 degree environment(reference fig4a).

Step: This value is dependent of different module dominated by external capacitor beside the crystal, so it needs to modify easily in initial file of test program. Usually, the value is about -2 ~ -3KHz by experience. The minus symbol means that the crystal cap. index and carrier frequency is negative-dependent (The larger index is relative to minor carrier frequency).

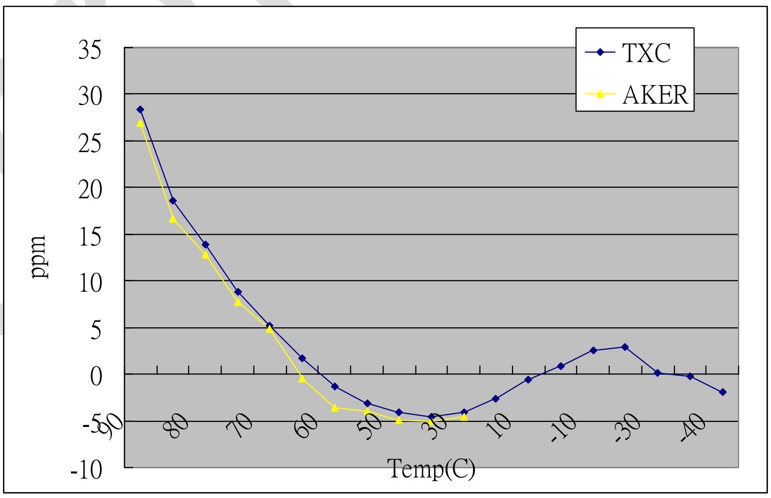

Fig4a the Xtal (size 3225) freq deviation vs temperature (PCB size 36x11mm)

3.3.2. WiFi Calibrates Tx Power Index

3.3.2.1. Calibration data definition about Tx power index and thermal meter

First, take a look at calibration data content about setting of RF Tx gain index. Normal driver will load bellow Tx gain setting for each channel group or each PHY data rate. So these Tx gain setting must be well-calibrated and filled on correct calibration data location.

The 0x1B default value was 0x02 for all channel. But the customer also can measured OFDM&HT20 to calculate diff value on CH7(recommend).

AUX Antenna	CH01 - CH02	CH03 - CH05	CH6 - CH8	CH9 – CH11	CH12 – CH14
MCS07 HT40-A (Absolute)	0x26[7:0] (HT40_A_L)	0x27[7:0] (HT40_A_LM)	0x28[7:0] (HT40_A_M)	0x29[7:0] (HT40_A_MH)	0x2A[7:0] (HT40_A_H)
MCS07 HT20-A (Relative to HT40_1S)	0x2B[7:4] (HT20_DIFF_A)				
OFDM54M-A (Relative to HT40_1S)	0x2B[3:0] (OFDM_DIFF_A)				

AUX Antenna	CH1 - CH2	CH3 - CH5	CH6 - CH8	CH9 – CH11	CH12 – CH13	CH14
CCK-A (Absolute)	0x20[7:0] (CCK_A_L)	0x21[7:0] (CCK_A_LM)	0x22[7:0] (CCK_A_M)	0x23[7:0] (CCK_A_MH)	0x24[7:0] (CCK_A_H)	0x25[7:0] (CCK_A_14)

Thermal meter	0xCA[7:0]

Table 2: Tx gain index and thermal meter offset in calibration data

Describe label definition of above table:

HT40_A_L: HT40 lower channel index in antenna A for channel 1~2 (calibration data offset 0x26[7:0])

HT40_A_LM: HT40 middle channel index in antenna A for channel 3~5 (calibration data offset 0x27[7:0])

HT40_A_M: HT40 high channel index in antenna A for channel 6~8 (calibration data offset 0x28[7:0])

HT40_A_MH: HT40 high channel index in antenna A for channel 9~11 (calibration data offset 0x29[7:0])

HT40_A_H : HT40 high channel index in antenna A for channel 12~14 (calibration data offset 0x2A[7:0])

HT20_A_L: HT20 lower channel index in antenna A for channel 1~2 (Note1)
HT20_A_LM: HT20 lower channel index in antenna A for channel 3~5(Note1)
HT20_A_M: HT20 middle channel index in antenna A for channel 6~8 (Note1)
HT20_A_MH: HT20 lower channel index in antenna A for channel 9~11 (Note1)
HT20_A_H: HT20 high channel index in antenna A for channel 12~14 (Note1)

HT20_DIFF_A: Difference between HT20 and HT40 in antenna A for channel 1~2 (calibration data offset 0x2B[7:4])
HT20_DIFF_A: Difference between HT20 and HT40 in antenna A for channel 3~5 (calibration data offset 0x2B[7:4])
HT20_DIFF_A: Difference between HT20 and HT40 in antenna A for channel 6~8 (calibration data offset 0x2B[7:4])
HT20_DIFF_A: Difference between HT20 and HT40 in antenna A for channel 9~11 (calibration data offset 0x2B[7:4])
HT20_DIFF_A: Difference between HT20 and HT40 in antenna A for channel 12~14 (calibration data offset 0x2B[7:4])

OFDM_A_L: OFDM lower channel index in antenna A for channel 1~2 (Note1)
OFDM_A_LM: OFDM lower channel index in antenna A for channel 3~5 (Note1)
OFDM_A_M: OFDM middle channel index in antenna A for channel 6~8 (Note1)
OFDM_A_MH: OFDM middle channel index in antenna A for channel 9~11 (Note1)
OFDM_A_H: OFDM high channel index in antenna A for channel 12~14 (Note1)

OFDM_DIFF_A: Difference between OFDM and HT40 in antenna A for channel 1~2 (calibration data offset 0x2B[3:0])
OFDM_DIFF_A: Difference between OFDM and HT40 in antenna A for channel 3~5 (calibration data offset 0x2B[3:0])
OFDM_DIFF_A: Difference between OFDM and HT40 in antenna A for channel 6~8 (calibration data offset 0x2B[3:0])
OFDM_DIFF_A: Difference between OFDM and HT40 in antenna A for channel 9~11 (calibration data offset 0x2B[3:0])
OFDM_DIFF_A: Difference between OFDM and HT40 in antenna A for channel 12~14 (calibration data offset 0x2B[3:0])

CCK_A_L: CCK lower channel index in antenna A for channel 1~2 (calibration data offset 0x20[7:0])

CCK_A_LM: CCK lower channel index in antenna A for channel 3~5 (calibration data offset 0x21[7:0])

CCK_A_M: CCK lower channel index in antenna A for channel 6~8 (calibration data offset 0x22[7:0])

CCK_A_MH: CCK lower channel index in antenna A for channel 9~11 (calibration data offset 0x23[7:0])

CCK_A_H: CCK lower channel index in antenna A for channel 12~13 (calibration data offset 0x24[7:0])

CCK_A_14: CCK lower channel index in antenna A for channel 14 (calibration data offset 0x25[7:0])

Note1: These variables described above labeled by note1 are not stored in (or Efuse instead if needed), they are just only used for assistant on explanation about Tx power index relationship as below:

HT20_DIFF_A = *HT20_A_L* - *HT40_A_L;*
HT20_DIFF_A = *HT20_A_LM* - *HT40_A_LM;*
HT20_DIFF_A = *HT20_A_M* - *HT40_A_M;*
HT20_DIFF_A = *HT20_A_MH* - *HT40_A_MH;*
HT20_DIFF_A = *HT20_A_H* - *HT40_A_H;*

OFDM_DIFF_A = *OFDM_A_L* - *HT40_A_L;*
OFDM_DIFF_A = *OFDM_A_LM* - *HT40_A_LM;*
OFDM_DIFF_A = *OFDM_A_M* - *HT40_A_M;*
OFDM_DIFF_A = *OFDM_A_MH* - *HT40_A_MH;*
OFDM_DIFF_A = *OFDM_A_H* - *HT40_A_H;*

3.3.2.2. Define target power

According to

(1) EMI/EMC regulatory
(2) IEEE TX EVM / Spectrum Mask requirement
(3) The method was interpolation power index for un-calibration channel group.

Then you can define your target power for each channel group and also each PHY data rate. The recommended target power is listed below and assumes all channel have the same target power for each PHY data rate.

Data Rate	MCS07 HT40	MCS07 HT20	OFDM54M	CCK
Target Power	13dBm	13dBm	14dBm	16dBm

Table 3: The recommended target power

3.3.2.3. Tx calibration flow

Only use MCS07 HT40 to do all Tx calibration. The flow is shown as below:

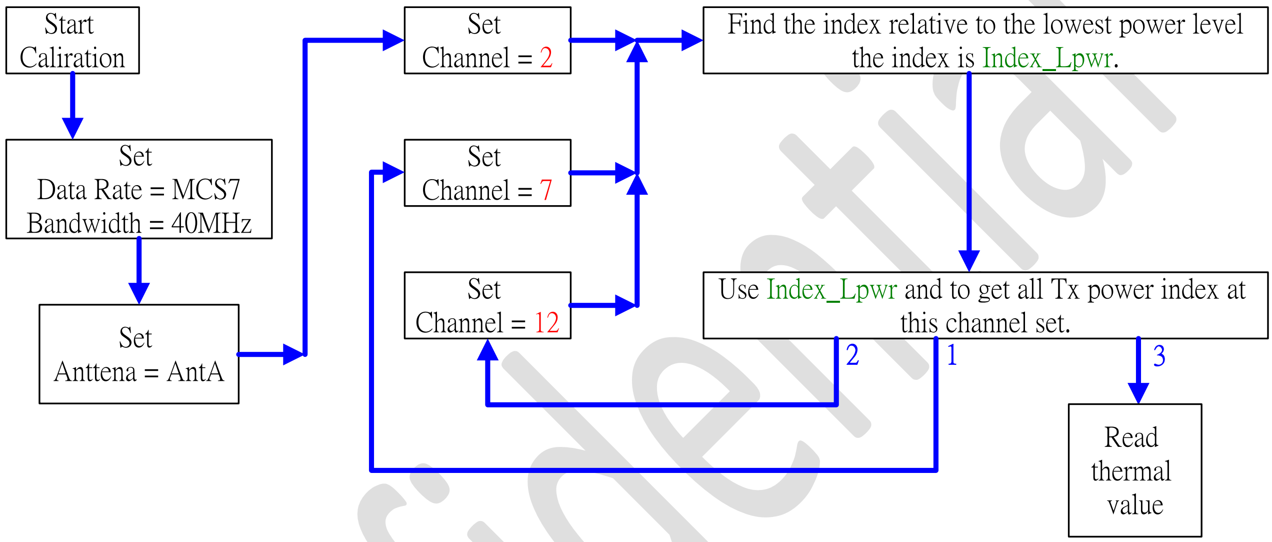

Figure 5: Tx calibration flow

Describe label definition of above Figure:

Index_Lpwr: the found index relative to the lowest power level that is usually MCS07 HT40 target power level.

Each finding index flow is shown as below:

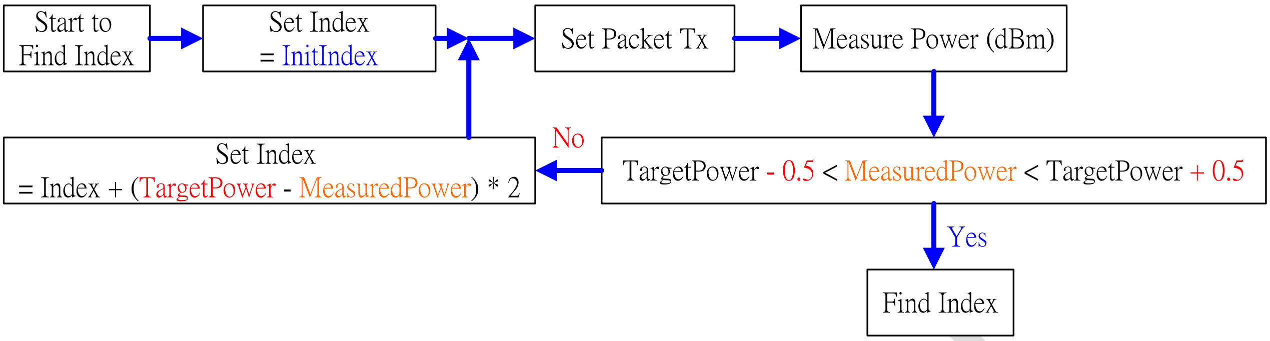

Figure 6: Finding index flow

When finding *Index_Lpwr*, the *InitIndex* is defined by user or programmer and Target power is usually MCS7B40M target power level.

After Finding *Index_Lpwr*, use this value to get all Tx gain index in each channel set by below equations.

$$\mathrm{HT40\_Index} = \mathrm{Index\_Lpwr} \qquad (1)$$

$$\mathrm{CCK\_Index} = \mathrm{Index\_Lpwr} + (\mathrm{CCKTargerPwr} - \mathrm{HT40\_TargetPwr}) \times 2 + \mathrm{CCK\_Offset} \qquad (2)$$

CCK_Offset is defined by user. The recommend default value is -2.

$$\mathrm{HT20\_DIFF} = (\mathrm{HT20\_TargetPwr} - \mathrm{HT40\_TargetPwr}) \times 2 \qquad (3)$$

$$\mathrm{OFDM\_DIFF} = (\mathrm{OFDM\_TargetPwr} - \mathrm{HT40\_TargetPwr}) \times 2 \qquad (4)$$

LMeasuredPwr means the measured power using *Index_Lpwr*.

3.3.2.4. Read Thermal Meter

Normal driver will load thermal meter to do power tracking. So this value must be filled on correct calibration data location.

The below MP command “iwpriv mp_ther” is used to get thermal meter value:

```
#iwpriv mp_ther

Private Message: 24
[MEM] After do cmd, available heap 25968
```

3.4. Write Data to Storage and Check Contents

3.4.1. Write WiFi Calibration data

Allocate 512 bytes of memory space on your local PC and then load default map file to this memory space. (UCHAR calibration_data[512]) Write board-dependent information into respective calibration data offset, this information include MAC address, calibrated Tx index, Thermal Meter, and so on.

Use the MP command:

> "iwpriv config_set wmap,offset,data"
>
> Note: Please reference document AN0004 Realtek mp user guide.pdf

to send 16 bytes calibration data content to on-chip Calibration data area, therefore 512 bytes contents need to do above command 512/16=32 times. If you want rewrite new contents, you can use above command again.

After above step, you should use below MP command to read partial contents,

> "iwpriv config_get rmap,offset,count"

or use below MP command to get full contents

> "iwpriv config_get realmap"
>
> Note: Please reference document AN0004 Realtek mp user guide.pdf

to check the written contents are all correct or not.

3.5. Verify Tx Performance Step

3.5.1. WiFi Verify Tx Performance

Use the calibrated index in previous step and measure Tx power, EVM, frequency offset and LO leakage to check Tx performance is ok or not. The recommended test items are listed below:

Rx Test	Data Rate	Antenna	Channel	Criteria	
Test Item 1	MCS07 HT40	AUX	CH6	Power	Typical: 13dBm Acceptable Range: 11.5~14dBm
				EVM	<-28dB
				Freq. Err.	±15ppm
				Leakage	< -20dBtotal
Test Item 2	MCS07 HT20	AUX	CH1	Power	Typical: 13dBm Acceptable Range: 11.5~14dBm
				EVM	<-28dB
				Freq. Err.	±15ppm
				Leakage	< -15dBtotal
Test Item 3	OFDM54M	AUX	CH7	Power	Typical: 14dBm Acceptable Range: 12.5~15dBm
				EVM	<-25dB
				Freq. Err.	±15ppm
				Leakage	< -15dBtotal
Test Item 4	CCK2M	AUX	CH13	Power	Typical: 16dBm Acceptable Range: 14.5~17dBm
				EVM	<10% rms
				Freq. Err.	±15ppm

Table 4: The recommended test items of WiFi Tx

3.6. Verify Rx Performance Step

This step includes 1 sub-step as shown in Figure 7:

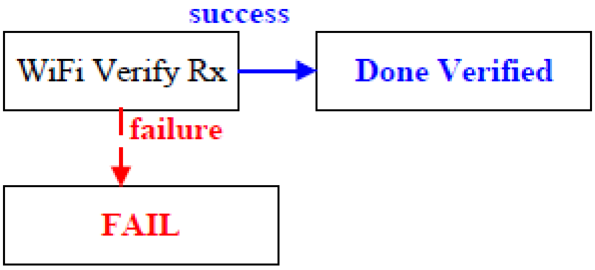

Figure 7: Verify Rx Performance Flow

3.6.1. WiFi Verify Rx Performance

Measure the DUT Rx sensitivity to check Rx performance is ok or not. The recommended test items are listed below:

Rx Test	Data Rate	Channel	Sensitivity Criteria
Test Item 1	MCS7 HT40	CH6	-64dBm
Test Item 2	MCS7 HT20	CH1	-67dBm
Test Item 3	OFDM54M	CH7	-71dBm
Test Item 4	CCK11M	CH13	-82dBm

Table 5: The recommended test items of WiFi Rx