Tektronix AH Performance Test Method

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Test Methods for TCC AH Performance

Revision Record

Date	Version	Description Description	Revised by
2023-9-3	V2.1	Add the method description of the actual measurement of each channel;	WY
2023-6-12	V2.0	Addition of instrument-based test items;	WY
2022-7-24	V1.2.2	Modify the pen error;	WY
2022-2-18	V1.2.1	Modify the logo;	XYJ
2021-7-22	V1.2	Add sensitivity test description;	WY
2021-7-3	V1.1	Add instructions for test pattern pair testing; Add description of board bottom noise test;	WY
2020-11-10	V1.0	Initial version;	WY

Catalog

1 Overview This document describes how to test the AH module on the solution board with or without test instrument.

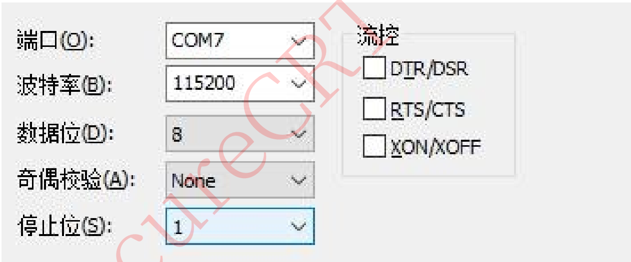
This document describes how to test the Tx/Rx performance of the AH module on the solution board with or without a test instrument. The results of the test can be used as a basis for improving the performance of the solution board.

2 Test Preparation

2.1 Serial Port Configuration

Serial port configuration is performed according to the following figure.

Figure 2-1 Serial Port Parameter Configuration



In addition, please note that the new line mode is checked, take SecureCRT as an example:

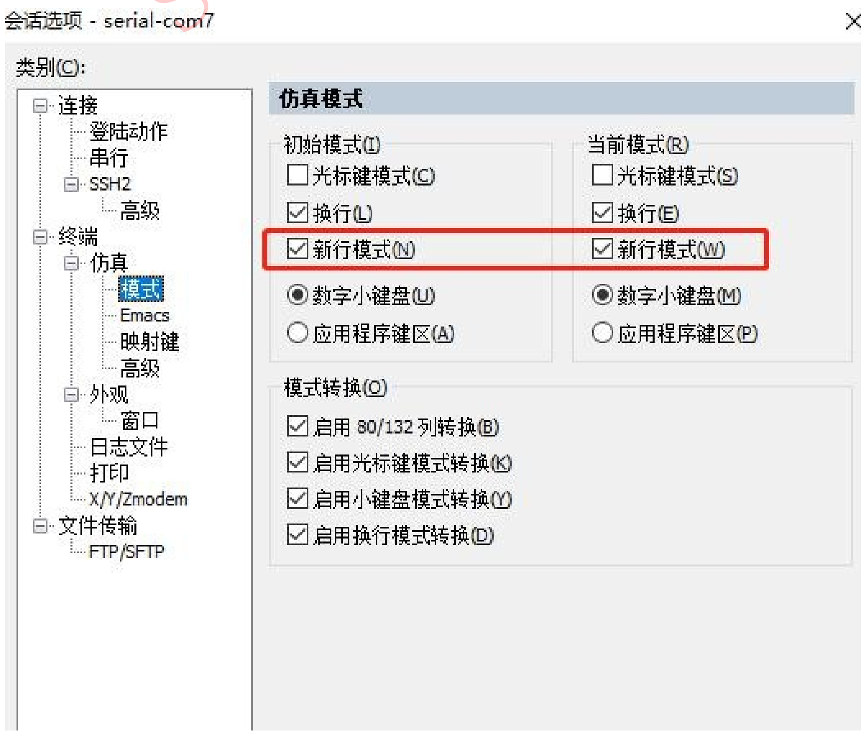


Figure 2-2 Check New Line Mode

To test if the serial port is working properly, enter AT+, and the following figure will be printed:

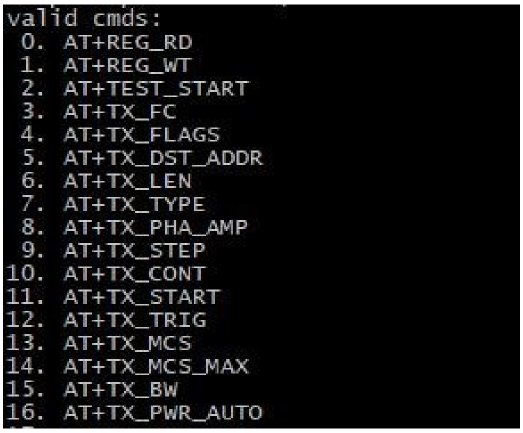

```
valid cmds:
 0. AT+REG_RD
 1. AT+REG_WT
 2. AT+TEST_START
 3. AT+TX_FC
 4. AT+TX_FLAGS
 5. AT+TX_DST_ADDR
 6. AT+TX_LEN
 7. AT+TX_TYPE
 8. AT+TX_PHA_AMP
 9. AT+TX_STEP
10. AT+TX_CONT
11. AT+TX_START
12. AT+TX_TRIG
13. AT+TX_MCS
14. AT+TX_MCS_MAX
15. AT+TX_BW
16. AT+TX_PWR_AUTO
```

Figure 2-3 Display of AT+ input

If there is no such printout, it means the serial port input is not correct, you need to contact our FAE.

2.2 Serial Port Commands

(1) Enter/Exit Test Mode

at+test_start=1 or 0

After entering the test mode, the default is to do rx mode; this command is not saved when power down;

(2) Set the center frequency point

at+lo_freq=908000

The unit is Khz, 908000 means 908M, 921500 means 921.5M; this command is not saved when power off;

(3) Setting bandwidth

at+bss_bw=8 or 4 or 2 or 1

The 4 kinds of bandwidths that can be supported are 8M, 4M, 2M and 1M, and it is recommended to set the values consistent with the actual situation of the program; this command is saved when power is turned off, and it should be noted that it should be restored after modification;

(4) Setting enter/exit Tx mode

at+tx_start=1 or 0

This command is not saved when power off;

(5) Set MAC address

at+mac_addr=0

Set mac_addr to 0 to enter test mode for Rx test; this command is not saved when power off;

(6) at+tx_mcs=255 or any value from 0~7

By default, tx_mcs=255, which means switching the mcs automatically according to the channel condition; set it to any value from 0 to 7 to fix the mcs; and set it to any

value from 0 to 7 to fix the mcs.

to any value from 0 to 7 means that the mcs is fixed;

In test mode, 255 will be sent by mcs7, when doing Tx/Rx test, it is recommended to set mcs=1, i.e., fixed to 1, to avoid mcs7 can not be solved when Rx performance is not good, resulting in incorrect test results;

This command will be saved after power down, note that mcs will be restored to 255 after the test is completed to avoid fixing it to mcs1 in actual use, which will affect the actual use;

(7) Setting Channel list at+chan_list=9080, 9160, 9240

This command is to set the channel list to be used, the unit is 100Khz, 9080 means 908M; according to the actual situation of the program;

The configuration result of this command will be saved after power down, note that it will be restored to the original value after testing;

(8) Start background noise scanning

at+acs_start=1

This command starts the automatic background noise scanning, and you can see the minimum value (min), average value (avg) and maximum value (max) of the background noise (bgr, backgroundrssi) of each channel;

This command is not saved when power off;

3 Test Item

3.1 Instrument-based test items

3.1.1 Tx Cable Single Tone Test

1. At+test_start=1 At+test_start=1 //Enter test mode
2. At+lo_freq=915000 //Take 915M as an example, it is recommended to cover the upper and lower limits of the working band.
3. At+tx_start=1 //Enable tx
4. at+tx_type=S //S means single tone, default should send out -500kHz signal, N means Normal (modulated signal)
5. at+tx_cont=1 //Continuous transmission, note that if you want to modify the parameters of Tx, you need to exit continuous transmission first.

3.1.2 Tx Cable Modulation Signal Test

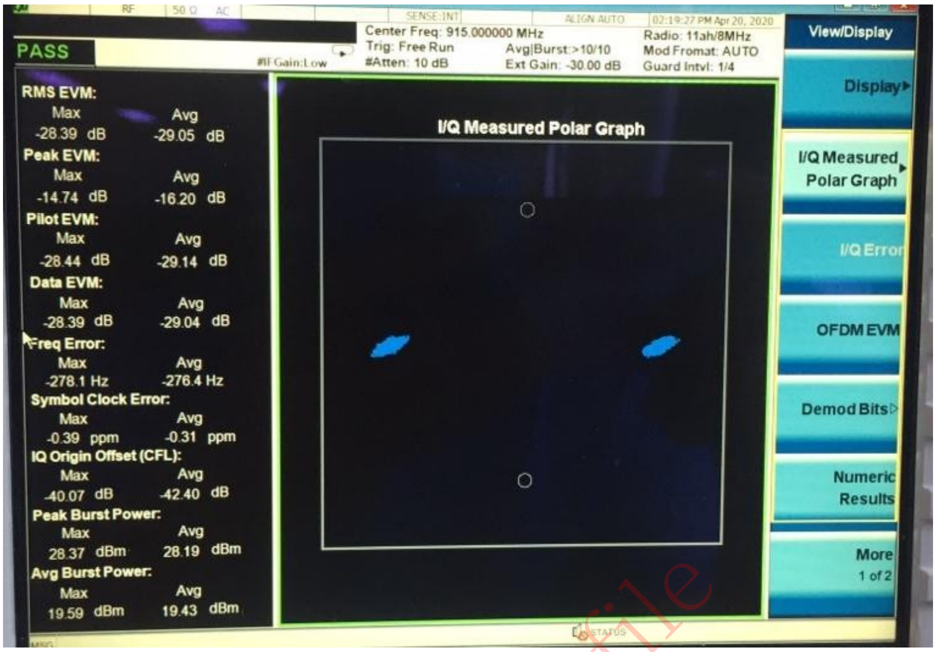


Figure 3-1 Modulation Model Test (Spectrometer is N9020 with AH license)

Test command:

1. At+test_start=1
2. At+bss_bw=8 //Set bss_bw, default is 8M, can be changed to 2/4M;
3. At+lo_freq=915000 //Here take 915M as an example, it is recommended to cover the upper and lower limits of the working frequency band
4. At+tx_pwr_super=1 //Enable superpwr to output 25dbm at mcs0 and 20dbm at mcs7.
5. At+tx_mcs=0 //Configure tx-mcs to test mcs0 and mcs7.
6. At+tx_start=1 //Enable tx

Spectrometer Operation

1. Press mode to select wlan
2. Press input to compensate for -31db (because of 30db attenuator, and about 1db line loss)
3. Press mode setup to select 11ah sub-mode
4. Modify freq center to match lo_freq of DUT.
5. Select the test item as modulation analysis, and set it in measure setup/advance.

The search time is 50ms (the default value is too small, it can't be locked and the constellation map will flash).

1. The spectrum analyzer must be connected to the attenuator (30db), otherwise it will burn out the instrument.
2. Observe the printout to see if the chip temperature is high, if it is high, it means the heat dissipation is poor;

3.1.3 Rx Cable Sensitivity Test

Test command

1. At+test_start=1 //Enter test mode

2. At+bss_bw=8 //set bss_bw, default is 8M, can also be changed to 2/4M;
3. At+lo_freq=908000 //Here take 908M as an example, can't just test one point, need to cover all channels in the working band.
4. At+tx_start=0 At+tx_start=0 //Turn off the tx test mode, the default

is to turn off the operation of the signal source (the signal source is E4438C with AH license).

1. PC connect to the signal source through network cable, check the IP address of the signal source in the utility option of the signal source, and connect to the signal source through wlan software;
2. Load the configuration file of AH, you can get it by contacting FAE of TCC;
3. Modify the packet sending interval not less than 1ms, set the frequency, transmit power (-40dbm first), bw, mcs and other parameters, and then download to the signal source;
4. After observing that the DUT receives packets successfully, record the current number of packets received as the number of packets sent by the signal source in each cycle;
5. Press the local button to release the remote mode of the signal source, debug the output power, check to what extent the output power is small, the packets received will be reduced to 90% of the number of packets sent by the signal source (due to errors and missed packets), and observe the rssi and evm; usually the sensitivity of the 8M mcs7 is around -81dbm, and the sensitivity of the 8M mcs0 can be up to -95dbm; if the real power is not available, the sensitivity of the signal source will be up to -95dbm.

   -If the measured value differs greatly from the expected value, it is necessary to investigate the reason;

6. Modify the test frequency to cover all channels in the working frequency band;

3.1.4 Rx lip-sensitivity test

Put the DUT (with antenna) into the shielding box, the signal source is also connected to another antenna built into the shielding box through the cable, and use the sensitivity test method to see if there is any abnormality in the sensitivity of each frequency point of the working band. Note that the antenna of the DUT should be consistent with the actual use situation, so that the test result is closer to the normal use situation.

3.1.5 Test with test box instead of instrument

If you don't have an instrument, you can use AH test box to replace the instrument to test the performance of cable or air port, please refer to the instruction of the test box, and the first few items of instrument-based test;

You can also use the test box as a golden device and operate it directly through the serial port for Tx-Rx pair testing (described in the following sections).

Note that the test box adds about 48db of attenuation inside the test box (the documentation and the labeling on the box may not be consistent, but it's actually about

48db).

3.2 Non-Instrument Based Test Items

3.2.1 Tx-Rx Pair Test

In the absence of AH-specific test instruments, in order to facilitate the testing of the solution boards and troubleshoot the poor performance of the Tx and Rx, you can consider using the Tx-Rx pair test of the two solution boards.

It is recommended to make sure the Rx side is OK when testing the Tx side and vice versa.

If the Tx-Rx side is connected by RF cable, it is recommended to string an attenuator around 50db in the middle, if no attenuator is connected, the received energy will be too large, which will lead to inaccurate test; if the Tx-Rx side is connected to an antenna, it is recommended that the two prototypes are separated by more than 1 meter, so as to avoid too much received energy in too close proximity.

The Tx test command sequence is as follows:

a) at+test_start=1 //Enter test mode

b) at+lo_freq=908000 //Here take 908M as an example, subject to the supported frequency of the actual AH module.

c) at+bss_bw=8 //Here the bandwidth is 8M, the actual bandwidth of the program shall prevail.

d) at+mac_addr=0 // Clear the mac address to 0

e) at+tx_start=1 //Enable tx, enter tx mode.

f) at+tx_mcs=1 //Set mcs=1

The Rx side test command sequence is as follows:

a) at+test_start=1 //Enter test mode

b) at+lo_freq=908000 //Here take 908M as an example, subject to the actual module's support frequency.

c) at+bss_bw=8 //Take 8M bandwidth as an example, subject to the actual bandwidth of the program.

d) at+mac_addr=0 // Clear the mac address to 0.

The result is analyzed:

(1) If the reception and transmission of both Tx-Rx are normal, the printout is shown in Figure 3-2a and 3-2b.

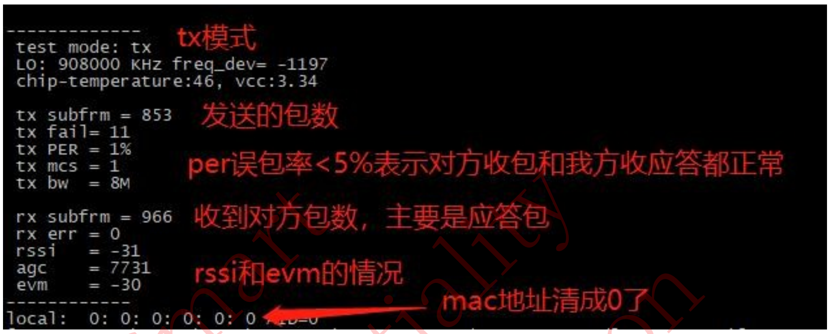


Figure 3-2a Printing of the Tx side when both Tx-Rx are normal

Figure 3-2b Printing on the Rx side when both Tx-Rx are normal

(2) If the number of packets received on the Rx side is low, the Tx side may not be sending properly;

(3) If the packets received by the Rx side are normal, but the Tx side receives very few answer packets, the Rx side may have a problem with the transmission;

(4) If the transmission of one party can be confirmed to be OK, but the rssi and evm of the other party are not good, it may be that the reception performance of this party has a problem;

(5) This is a simple way to test the receiver's sensitivity (with the help of a test box, a variable attenuator and a shielding box, or by pulling the transmitter away from the receiver to see how the receiver's signal rssi and evm are related); to test the sensitivity, let the Rx side's RSSI be around -40dbm, and then record the number of packets received for one print cycle (normally all should be correct), and then increase the attenuator to see how low the RSSI gets. Then increase the attenuator to see how small the RSSI is, and the number of packets received correctly (received packets - wrong packets) is reduced to 90% of the number of packets received just now when the signal was large, and observe the rssi and evm; Figure 3-3 shows the cable sensitivity test values of the AH module. The empty port condition will usually deteriorate by a few db, and if it deteriorates too much, it is recommended to optimize the hardware design.

Figure 3-3 AH Module Sensitivity Test Values

测试频点 900MHz

BW MCS	1M	2M	4M	8M
0	-106	-103	-99	-96
1	-103	-100	-97	-94
2	-102	-99	-96	-93
3	-99	-96	-93	-90
4	-96	-93	-90	-87
5	-94	-90	-87	-83
6	-93	-89	-86	-82
7	-91	-87	-84	-81
10	-108	-	-	-

3.2.2 Background Noise Scan

The background noise bgr brought by emi can be scanned by at+acs_start=1 command.

Usually, the antenna is connected to scan the bgr, because the antenna can receive the emi noise from the solution board, and the RF cable will block the emi noise, resulting in a lower result than the bgr.

The RF cable will shield the emi noise, resulting in a much better result than the antenna.

When testing, try to stay away from off-board interference sources, such as interference from the base station, and interference from other boards, it is better if there is a shielding box.

Input at+acs_start=1, you can see the serial port display as shown in Figure 2-5.

All the frequencies in the channel list will be scanned, the number of times each frequency is determined by the bandwidth, for example, 8 MHz bandwidth will be scanned 8 times, 4 MHz bandwidth will be scanned 8 times.

For example, 8M bandwidth will be scanned 8 times, 4M bandwidth will be scanned 4M and so on;

Bgr scan result can be seen in min / avg / max columns, it is recommended to focus on avg, followed by max;

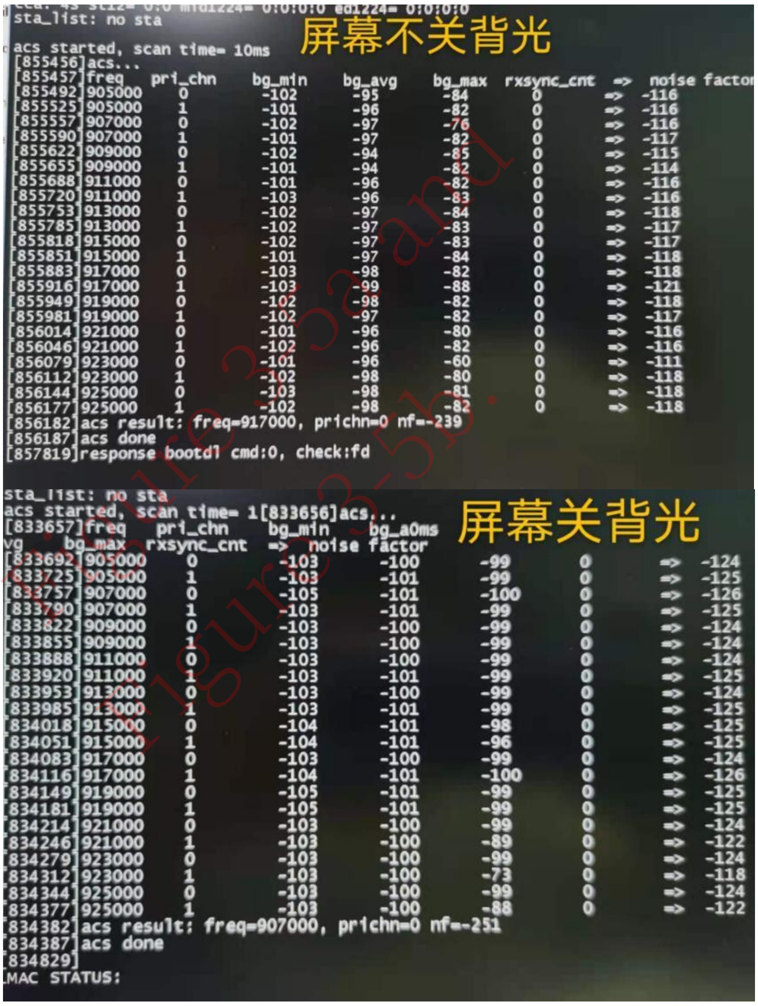
通常 8M 带宽下，bgr-avg 在<-90 算是比较 ok，如果>-90 建议考虑整改硬件的 EMI；4M的情况要在 8M 上-3db 来看，即 bgr-avg 在<-93 算是比较 ok，如果>-93 建议考虑整改；2M的情况要在 8M 上-6db 来看，即 bgr- avg at <-96 is considered ok, if >-96 it is recommended to consider rectification; 1M case should be viewed at -9db on 8M, i.e. bgr-avg at <-99 is considered ok, if >-99 it is recommended to consider rectification.

```
acs started, scan time= 10ms
[26549]acs...
[26550]freq   pri_chn   bg_min   bg_avg   bg_max  rxsync_cnt  =>  noise factor
[26583]908000   0    -100    -97    -92    0    =>  -120
[26613]908000   1    -100    -95    -60    0    =>  -110
[26643]908000   2    -100    -97    -92    0    =>  -120
[26673]908000   3    -100    -93    -59    0    =>  -107
[26703]908000   4    -100    -96    -60    0    =>  -111
[26734]908000   5    -100    -97    -94    0    =>  -120
[26764]908000   6    -100    -91    -60    0    =>  -106
[26794]908000   7    -101    -96    -60    0    =>  -111
[26824]916000   0    -100    -97    -91    0    =>  -119
[26854]916000   1    -100    -96    -60    0    =>  -111
[26885]916000   2    -100    -97    -94    0    =>  -120
[26915]916000   3    -100    -97    -94    0    =>  -120
[26945]916000   4    -100    -95    -60    0    =>  -110
[26975]916000   5    -100    -94    -60    0    =>  -109
[27006]916000   6    -100    -97    -94    0    =>  -120
[27036]916000   7    -100    -97    -93    0    =>  -120
[27066]924000   0    -103    -98    -60    0    =>  -113
[27096]924000   1    -103    -99    -94    0    =>  -122
[27126]924000   2    -103    -97    -60    0    =>  -112
[27157]924000   3    -104    -98    -60    0    =>  -113
[27187]924000   4    -105    -96    -60    0    =>  -111
[27217]924000   5    -103    -99    -95    0    =>  -122
[27247]924000   6    -103    -99    -94    0    =>  -122
[27278]924000   7    -105    -97    -60    0    =>  -112
[27283]acs result: freq=916000, prichn=1 nf=-929
[27288]notify freq: 916000
[27290]acs done
```


Figure 3-4 Scanning results of acs

To illustrate an example of EMI leading to a bad program board situation: the screen machine when the screen is lit and when the screen is off the frequency sweep results are very different, as shown in Figure 3-5a and Figure 3-5b.

Figure 3-5a Frequency Sweep with Screen On



```
sta_list: no sta
acs started, scan time= 10ms
[855456]acs...
[855457]freq   pri_chn   bg_min   bg_avg   bg_max  rxsync_cnt  =>  noise factor
[855492]905000   0    -102    -95    -84    0    =>  -116
[855525]905000   1    -101    -96    -82    0    =>  -116
[855557]907000   0    -102    -97    -76    0    =>  -116
[855590]907000   1    -101    -97    -82    0    =>  -117
[855622]909000   0    -102    -94    -85    0    =>  -115
[855655]909000   1    -101    -94    -82    0    =>  -114
[855688]911000   0    -101    -96    -82    0    =>  -116
[855720]911000   1    -103    -96    -83    0    =>  -116
[855753]913000   0    -102    -97    -84    0    =>  -118
[855785]913000   1    -102    -97    -83    0    =>  -117
[855818]915000   0    -102    -97    -83    0    =>  -117
[855851]915000   1    -101    -97    -84    0    =>  -118
[855883]917000   0    -103    -98    -82    0    =>  -118
[855916]917000   1    -103    -99    -88    0    =>  -121
[855949]919000   0    -102    -98    -82    0    =>  -118
[855981]919000   1    -102    -97    -82    0    =>  -117
[856014]921000   0    -101    -96    -80    0    =>  -116
[856046]921000   1    -102    -96    -82    0    =>  -116
[856079]923000   0    -101    -96    -60    0    =>  -111
[856112]923000   1    -102    -98    -80    0    =>  -118
[856144]925000   0    -103    -98    -81    0    =>  -118
[856177]925000   1    -102    -98    -82    0    =>  -118
[856182]acs result: freq=917000, prichn=0 nf=-239
[856187]acs done
[857819]response bootdl cmd:0, check:fd

sta_list: no sta
acs started, scan time= 1[833656]acs...
[833657]freq   pri_chn   bg_min   bg_a0ms
vg   bg_max  rxsync_cnt  =>  noise factor
[833692]905000   0    -103    -100    -99    0    =>  -124
[833725]905000   1    -103    -101    -99    0    =>  -125
[833757]907000   0    -105    -101    -100   0    =>  -126
[833790]907000   1    -103    -101    -99    0    =>  -125
[833822]909000   0    -103    -100    -99    0    =>  -124
[833855]909000   1    -103    -100    -99    0    =>  -124
[833888]911000   0    -103    -100    -99    0    =>  -124
[833920]911000   1    -103    -101    -99    0    =>  -125
[833953]913000   0    -103    -100    -99    0    =>  -124
[833985]913000   1    -103    -101    -99    0    =>  -125
[834018]915000   0    -104    -101    -98    0    =>  -125
[834051]915000   1    -104    -101    -96    0    =>  -125
[834083]917000   0    -103    -100    -99    0    =>  -124
[834116]917000   1    -104    -101    -100   0    =>  -126
[834149]919000   0    -105    -101    -99    0    =>  -125
[834181]919000   1    -105    -101    -99    0    =>  -125
[834214]921000   0    -103    -100    -99    0    =>  -124
[834246]921000   1    -103    -100    -89    0    =>  -122
[834279]923000   0    -103    -100    -99    0    =>  -124
[834312]923000   1    -103    -100    -73    0    =>  -118
[834344]925000   0    -103    -100    -99    0    =>  -124
[834377]925000   1    -103    -100    -88    0    =>  -122
[834382]acs result: freq=907000, prichn=0 nf=-251
[834387]acs done
[834829]
MAC STATUS:
```


Figure 3-5a Sweep with Screen On Figure 3-5b Sweep with Screen Off

In this case, the difference of bgr-avg when the screen is on/off is not too big, but the difference of bgr-max is very big, close to 15db, and the actual Rx sensitivity of the board is also 15db, which is basically the same as the difference of bgr-max.

So this case should be suggested to find the source of EMI when lighting up the screen and how to avoid it.

3.2.3 Various channels measured

In the shielded box to test the background noise, is to utilize the AH test mode. Test mode may not be close enough to the program's real background noise, because the interface with the master control is not completely moved, the master control side may also have some EMI will only come out in the real program operation, so you can consider the actual program, traversing the various channels to test, to see whether the operation of each channel is normal. As this test is not good in the shielded environment test, to first confirm that the environment does not have significant interference.

The general idea of the test is to pull a program required distance, you do not have to be particularly extreme, but far enough away, the signal is not strong, such as rssi-70dbm or so, to see the communication of each channel, you can use the smoothness of the screen, or the application layer statistics of the packet loss rate, to assess whether each channel can work properly. If you find that some channels are normal and some channels are obviously stuck, you can do further analysis to determine whether it is caused by external environmental noise interference or board-level noise EMI. If it is caused by board-level EMI, you can see whether it is good to eliminate. If it is good, try to eliminate as much as possible, so that there are as many channels available as possible; if it is not good, you can consider deleting this channel from the chan_list (note that the chan_list of AP and STA should be consistent, and synchronously delete the bad channel).

The following describes the method of manually cutting channels in the normal scheme to realize traversing channel test. Through the following two AT+ commands: 1, AT+CS_NUM=xxx: manually set the frequency point for frequency cutting, with 700M as the base point, if you want to set the frequency point to 906, it is =206, if you set 996, it is =206.

If you want to set the frequency point as 906, it is =206, if you set 922, it is =222; the step is 1Mhz (because the bit number defined in the protocol is only 8bit, so it can only represent 1M step); after setting CS_NUM, the AP will communicate with the STA and cut the frequency point corresponding to CS_NUM after CS_CNT;

2, AT+CS_CNT=10: manually set the number of countdown beacon cycles for frequency cutting (default is 10), set the number of countdown beacon cycles after 10 beacon cycles.

AT+CS_CNT=10: manually set the number of countdown beacon periods for frequency cut (default 10 is OK), after 10 beacon periods, AP and STA will synchronize to execute frequency cut, and can keep the connection;

These two commands are set at the AP side; after they are set, you can see that the frequency cutting is successful after a while, and then observe whether the image is stuck or not.