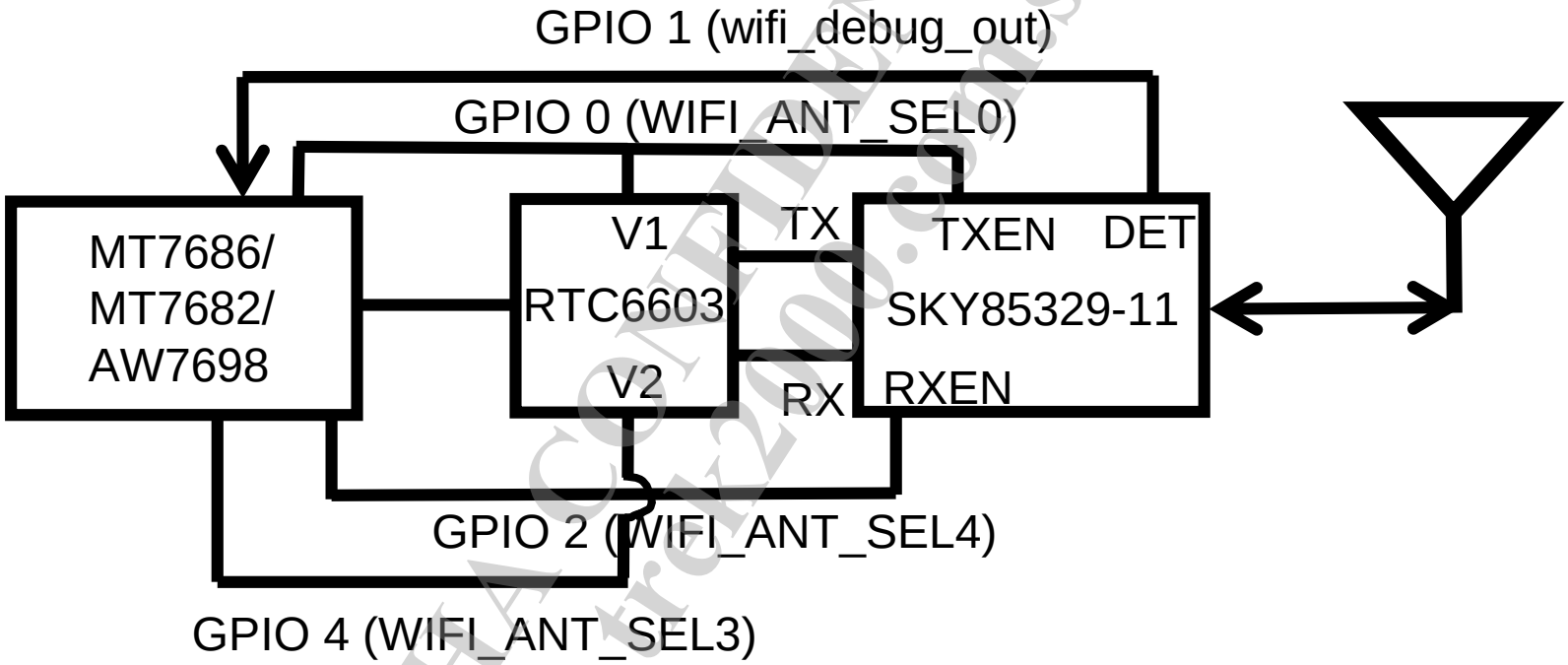
MT768X_eFEM Design guide _V05

Design guide

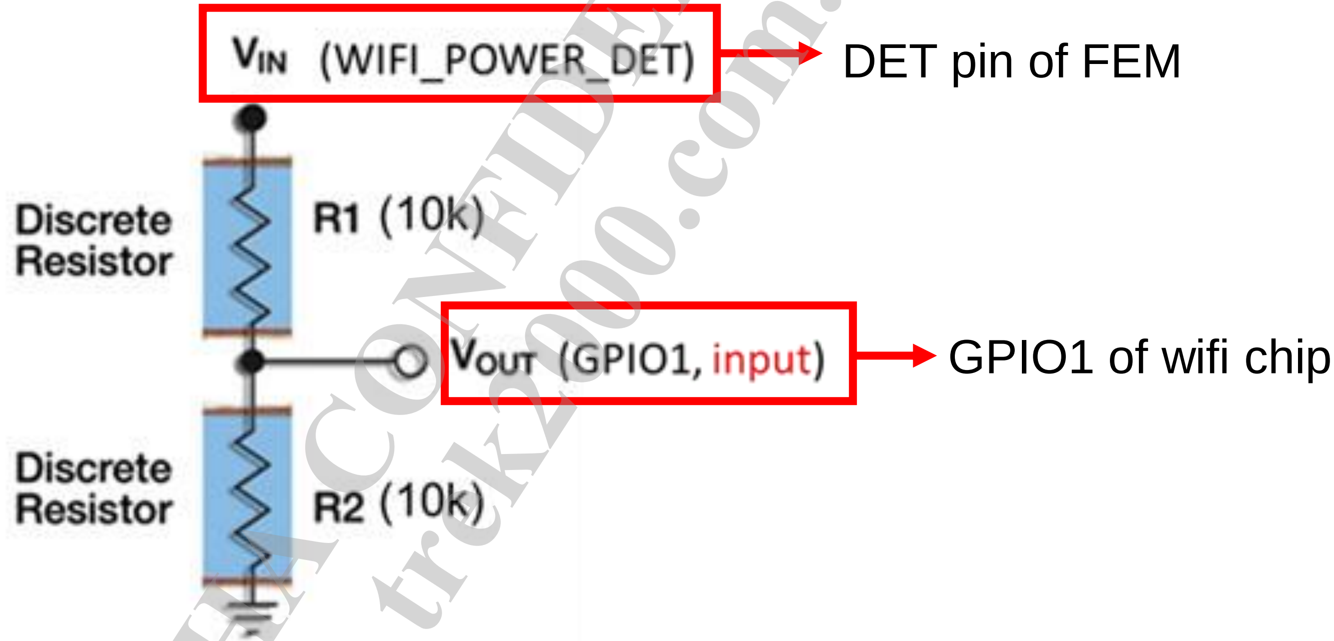
- eFEM control
  - **SKY85329-11**
- Efuse table for eFEM
  - **efuse table for eFEM**
  - **How to write parameter into efuse**
- TX
  - **eFEM TSSI slope and offset tuning**
- HQA test item (define by customer)
  - **TX**
  - **RX**

FEM control: circuit example for SKY85329-11



1. Please configure "**WIFI_ANT_SEL**" interface, see pin-mux table on datasheet page 51.
2. Configure GPIO1 as Aux function2- **WIFI_DEBUG_OUT.**

FEM control: GPIO1 for power detecting



1. It’s necessary for doing voltage dividing on power detect pin since max. voltage input is 0.75V on GPIO1 as power detect, and max voltage output is 1V on DET pin of FEM (SKY85329).
2. Please refer the figure here for schematic design.

FEM control:
efem.ini setting in QAtool folder

```
[pin_mux]
# Configure the pin mux including the mode, direction and the data
# Format : GPIOx=mode,direction,data
# Pleae confirm the configuration with HW owner to make sure the configuration is correct
GPIO0=8,1,1
GPIO1=2,0,1
GPIO2=10,1,1
GPIO4=9,1,1

[ant_select_mode]
# Configure the antenna selection mode
ant_select_index0=2
ant_select_index3=3
ant_select_index4=6
```

1.

2.

1. GPIO configuration for mode, direction, data.

Ball Name	Aux Func.0	Aux Func.1	Aux Func.2	Aux Func.3	Aux Func.4	Aux Func.5	Aux Func.6	Aux Func.7	Aux Func.8	Aux Func.9	Aux Func.10
GPIO_0	GPIO0	EINT0		U1RTS	SCL1	I2S_RX	JTDI		WIFI_ANT_SEL0	BT_PRI1	PWM0
GPIO_1	GPIO1	EINT1	wifi_debug	U1CTS	SDA1	I2S_TX	JTMS		WIFI_ANT_SEL1	BT_PRI3	PWM1
GPIO_2	GPIO2	EINT2		URXD0	PWM0	I2S_WS	JTCK	CLKO0		BT_PRI0	WIFI_ANT_SEL4
GPIO_3	GPIO3	EINT3		UTXD0	PWM1	I2S_CK	JTRST_B			WIFI_ANT_SEL2	I2S_CK
GPIO_4	GPIO4	SPISLV_A_SIO2	SPIMST_A_SIO2	EINT4		I2S_MCLK	JTDO			WIFI_ANT_SEL3	I2S_MCLK
GPIO_5	GPIO5	SPISLV_A_SIO3	SPIMST_A_SIO3	EINT5	URXD1	WIFI_ANT_SEL0	TDM_RX			SCL0	PMU_RGU_RSTB

FEM control:
efem.ini setting in QAtool folder

```
[pin_mux]
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# Format : GPIOx=mode,direction,data
# Pleae confirm the configuration with HW owner to make sure the configuration is correct
GPIO0=8,1,1
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[ant_select_mode]
# Configure the antenna selection mode
ant_select_index0=2
ant_select_index3=3
ant_select_index4=6
```

1.

2.

2. Antenna select mode configuration

ant_sel_mode	value
0	1'b0
1	1'b1
2	phy_rf_sw_t
3	phy_rf_sw_r
4	~phy_rf_sw_t
5	~phy_rf_sw_r
6	phy_rf_ext_lna
7	phy_rf_paon
8	~phy_rf_ext_lna
9	~phy_rf_paon
10	bt_tr

Efuse table for eFEM SKY85329-11

Eeprom.bin for SKY85329-11:
WIFI_EFUSE0 = 0x00403608
WIFI_EFUSE1 = 0x8200009C
WIFI_EFUSE2 = 0xB1810E3F
WIFI_EFUSE3 = 0x00000000
WIFI_EFUSE4 = 0x800000E0
WIFI_EFUSE5 = 0xCDF02600
WIFI_EFUSE6 = 0x0000FF00

Origin eeprom.bin w/o eFEM:
WIFI_EFUSE0 = 0x00403608
WIFI_EFUSE1 = 0x8300009C
WIFI_EFUSE2 = 0x00000000
WIFI_EFUSE3 = 0x00000000
WIFI_EFUSE4 = 0x800000E1
WIFI_EFUSE5 = 0x8CB04080
WIFI_EFUSE6 = 0x0000FF00

1. **Do not change value of efuse1/2 again because Airoha** had fine tuned the best results;
2. Follow this guide to **fine tune efuse4/5 on your PCB;**
3. **Eeprom.bin must be modified in WIFI_EFUSE1/2/4/5 before DUT connect to QA tool;**
4. **Efuse should be modified in WIFI_EFUSE1/2/4/5 before normal using.**

Note:
SKY85329-11 is the only QVL part of MT768x, if you want to select another component, please contact Airoha HW support team for help

Efuse table for eFEM SKY85329-11

Eeprom.bin for SKY85329-11:
WIFI_EFUSE0 = 0x00403608
WIFI_EFUSE1 = 0x8200009C
WIFI_EFUSE2 = 0xB1810E3F
WIFI_EFUSE3 = 0x00000000
WIFI_EFUSE4 = 0x800000E0
WIFI_EFUSE5 = 0xCDF02600
WIFI_EFUSE6 = 0x0000FF00

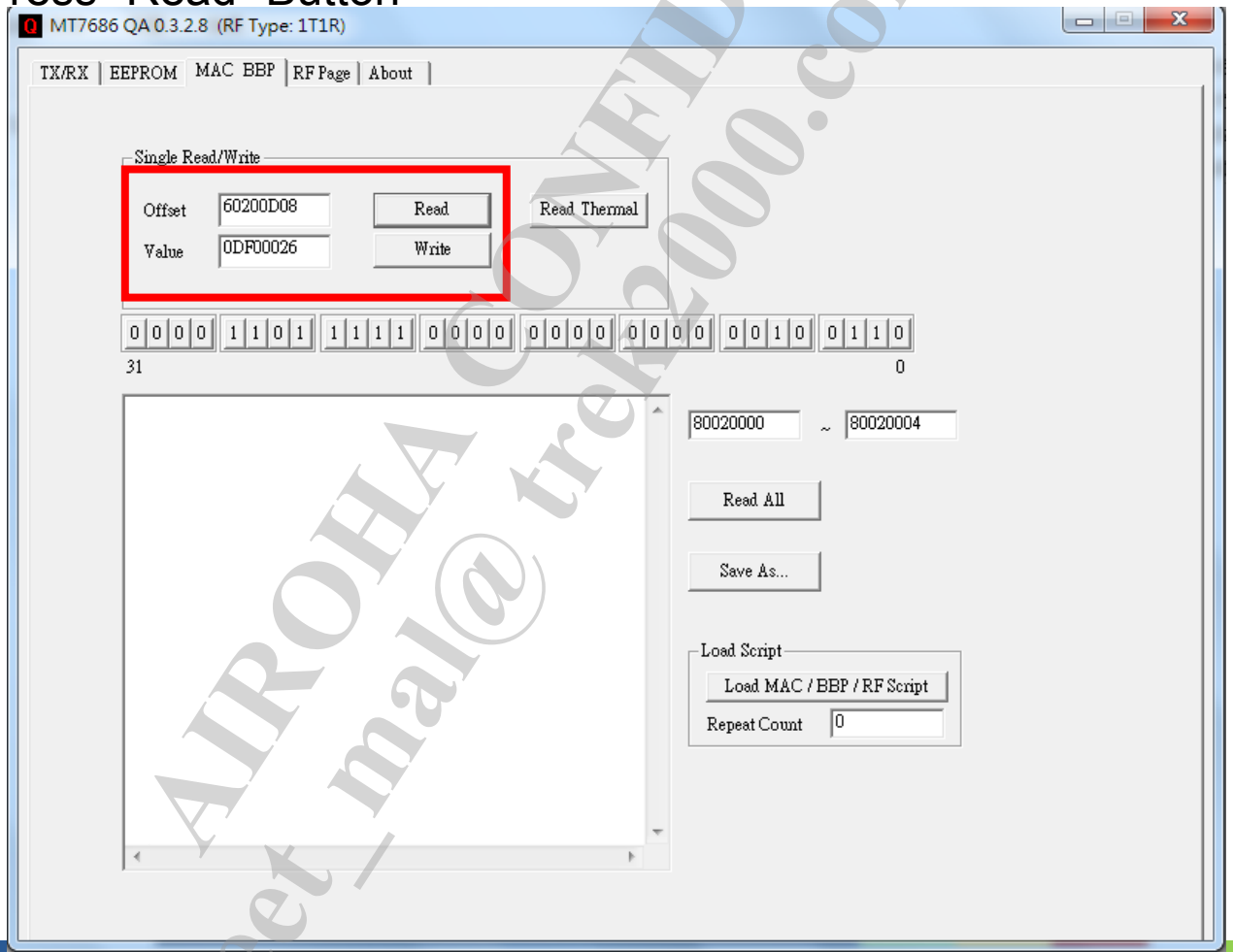
1. **Efuse2 should be modified if you want to select another FEM component, please refer below table:**

[7:0]	WIFI_EFUSE2	External LNA gain for 2G[2:0]			ePA gain[4:0] for 2G	
[15:8]		External bypass gain for 2G[1:0]		External LNA P1dB for 2G[3:0]		External LNA gain for 2G[4:3]
[23:16]		External bypass P1dB for 2G [4:0]				External bypass gain for 2G[4:2]
[31:24]		Valid		ePA enable	eLNA enable	iPA/ePA Gband FE loss between Ant and Chip out

AIROHA

Use QAtool to fine tune TSSI buffer -- MAC BBP

1. Move to MAC BBP page; (this page can read and write the buffer value of relative efuse, affecting the test results directly.)
2. Key in address “60200D08” (detail information in following page)
3. Press “Read” Button



Use QAtool to fine tune TSSI buffer -- detail information

- Example in Sky85329-11

BBPCR	value	
60200D08	0DF00026	TSSI slope and offset
60200D18	001F00F0	check the TSSI work
60200D00	824041C0	Check TSSI enable

1. 0x60200D08 = 0x0DF00026 // [27:20]: TSSI curve offset, [6:0] TSSI curve slope
2. 0x60200D00[31] = 1'b1 // TSSI enable
3. TSSI will be enabled and tracked the power level, check if value of 60200D18[21:16] is variety with time

Use QAtool for fine tune TSSI —Fine Tune Flow using eeprom.bin

1. Modify EEPROM.bin according to Page 4;
2. Connect DUT to QA tool and check CR in MAC BBP Page : 0x60200D08 = 0x0DF00026 // [27:20]: TSSI curve offset, [6:0] TSSI curve slope; 0x60200D00[31] = 1'b1 // TSSI enable
3. In TX/RX page, un-check TSSI and start TX, tune TX power column to meet the target power;
4. Check TSSI and re-start TX, tune the offset in MAC BBP to meet the target power;
5. Restart TX and tune TX power column to check the power variation slope; tune the slope in MAC BBP to make it better.

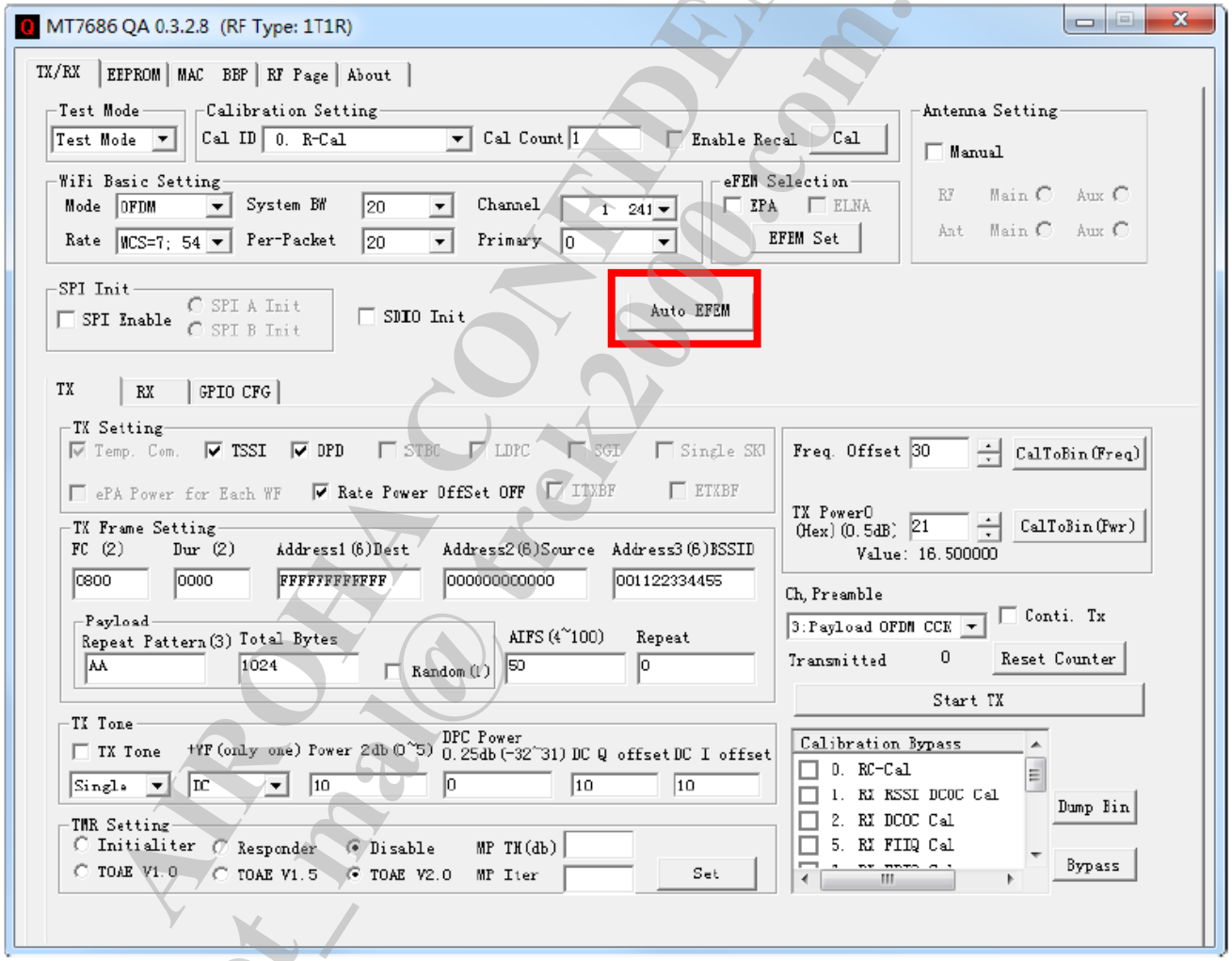
Note：

The value of 60200D18[21:16] is variety with time once TSSI enabled and tracked the power level.

You just need to tune the tx power of 54M (the TX powers of other date rate are set in txpower.bin)

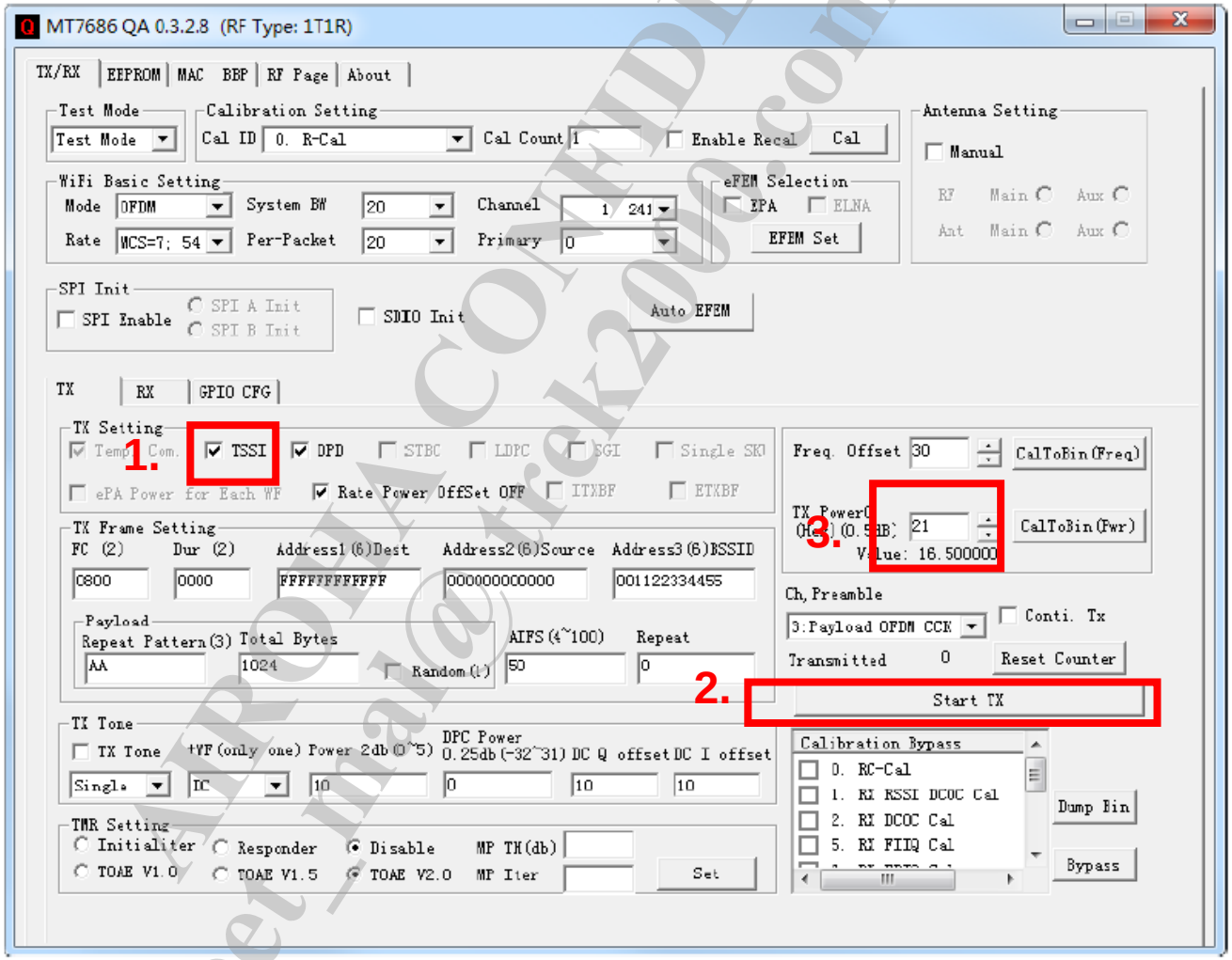
Use QAtool for fine tune TSSI（1）

1. Open QAtool
2. Press “Auto FEM” Button



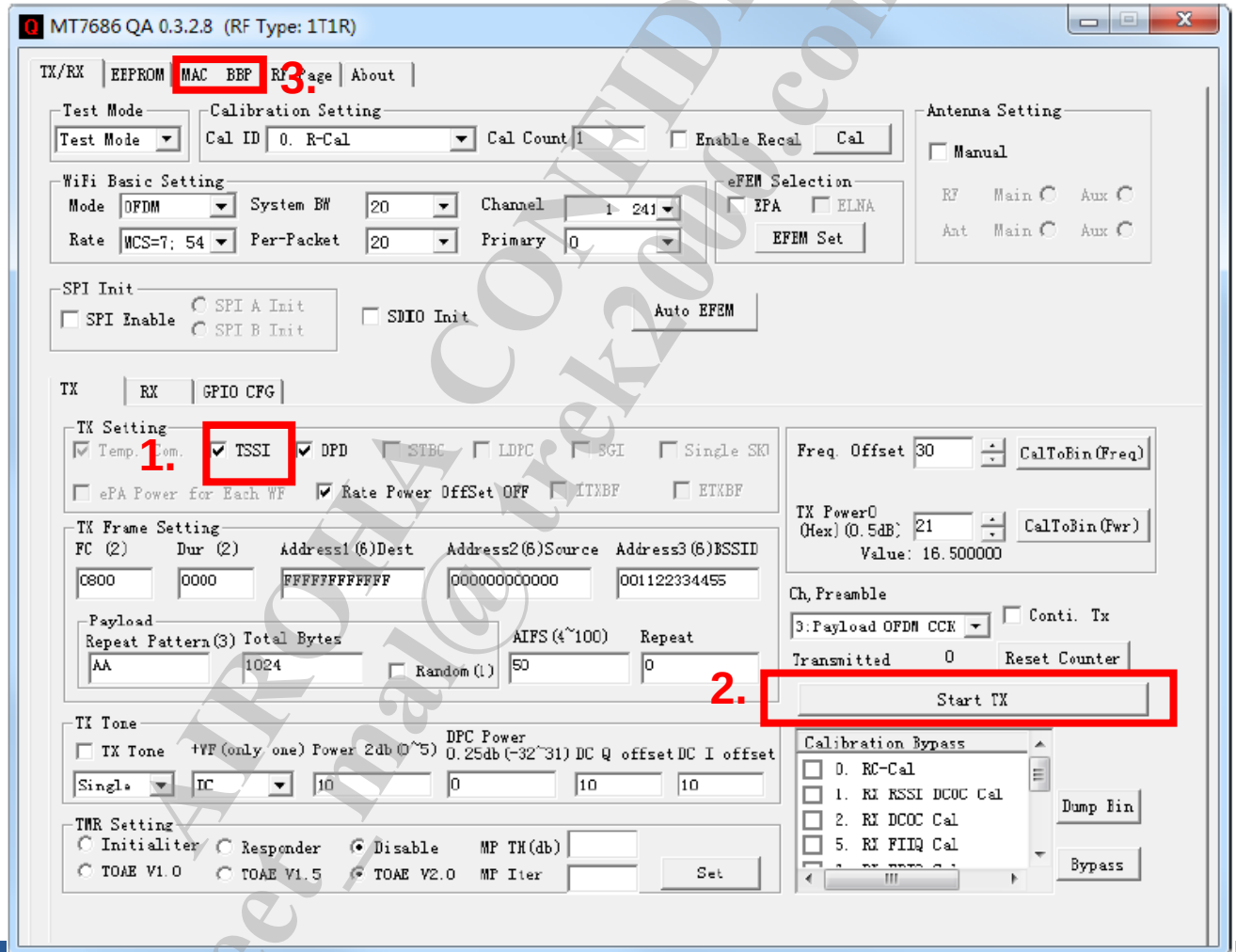
Use QAtool for fine tune TSSI（2）

1. Select ch6, OFDM-54M, **Un-check TSSI**
2. Start Tx and measure the power by WiFi tester
3. Tuning Tx power column to meet your target (ex. 20dBm)



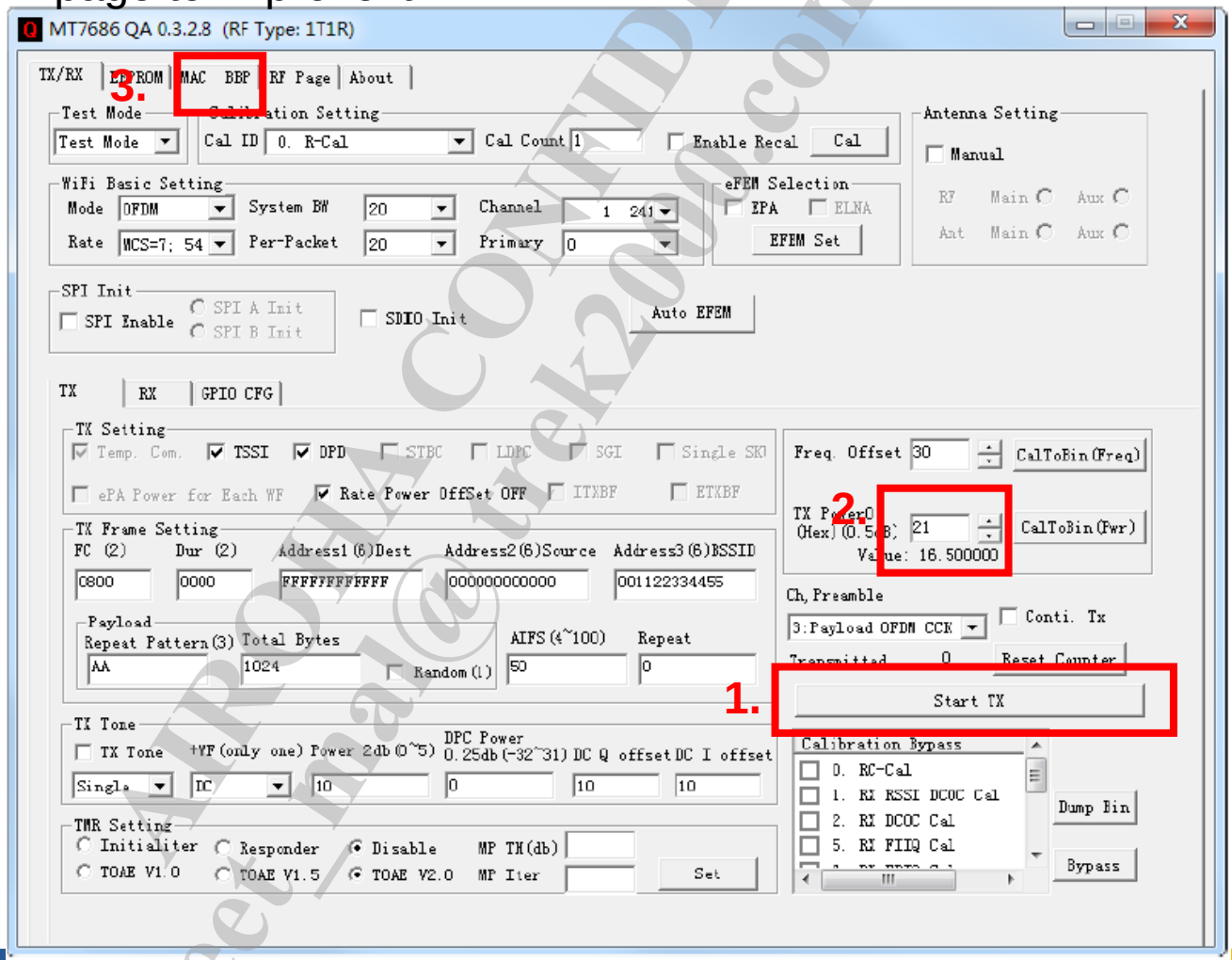
Use QAtool for fine tune TSSI（3）

1. **check TSSI**
2. Re-start Tx and measure the power by WiFi tester
3. If power does not meet your target power, fine tune TSSI offset value on MAC BBP page to achieve it.



Use QAtool for fine tune TSSI（4）

1. Re-start Tx
2. Tune Tx power column to check the power variation slope；
3. If step variation of slope is too large, fine tune TSSI slope value on MAC BBP page to improve it.



Use QAtool for fine tune TSSI（5）

Example: Tuning Offset to meet target power within ±0.25dB variation

DAC	TSSI Offset	Measured power	Target power	variation
16	0xDF	19.6	20	-0.4

DAC	TSSI Offset	Measured power	Target power	variation
16	0xE0	19.9	20	-0.1

Use QAtool for fine tune TSSI（6）

Example: Tuning slope to make the whole variation smaller as possible

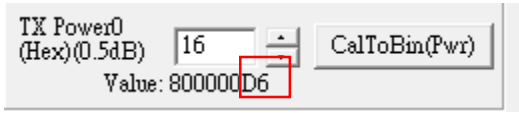
(DAC means the value of Tx power column)

DAC	Slope	Measured power	ideal power	variation
1B		22.9	22.5	-0.4
1A		22.3	22	-0.3
19		21.7	21.5	-0.2
18		21.2	21	-0.2
17		20.6	20.5	-0.1
16		19.9	20	-0.1
15		19.2	19.5	0.3
14	0x26	18.7	19	0.3
13		18.1	18.5	0.4
12		17.7	18	0.3
11		17.0	17.5	0.5
10		16.4	17	0.6
0F		16.0	16.5	0.5
0E		15.4	16	0.6
0D		15.0	15.5	0.5

DAC	Slope	Measured power	ideal power	variation
1B		22.7	22.5	-0.2
1A		22.2	22	-0.2
19		21.6	21.5	-0.1
18		21.1	21	-0.1
17		20.6	20.5	-0.1
16		19.9	20	0.1
15		19.3	19.5	0.2
14	0x25	18.8	19	0.2
13		18.4	18.5	0.1
12		18	18	0
11		17.4	17.5	0.1
10		16.9	17	0.1
0F		16.4	16.5	0.1
0E		15.7	16	0.3
0D		15.2	15.5	0.3

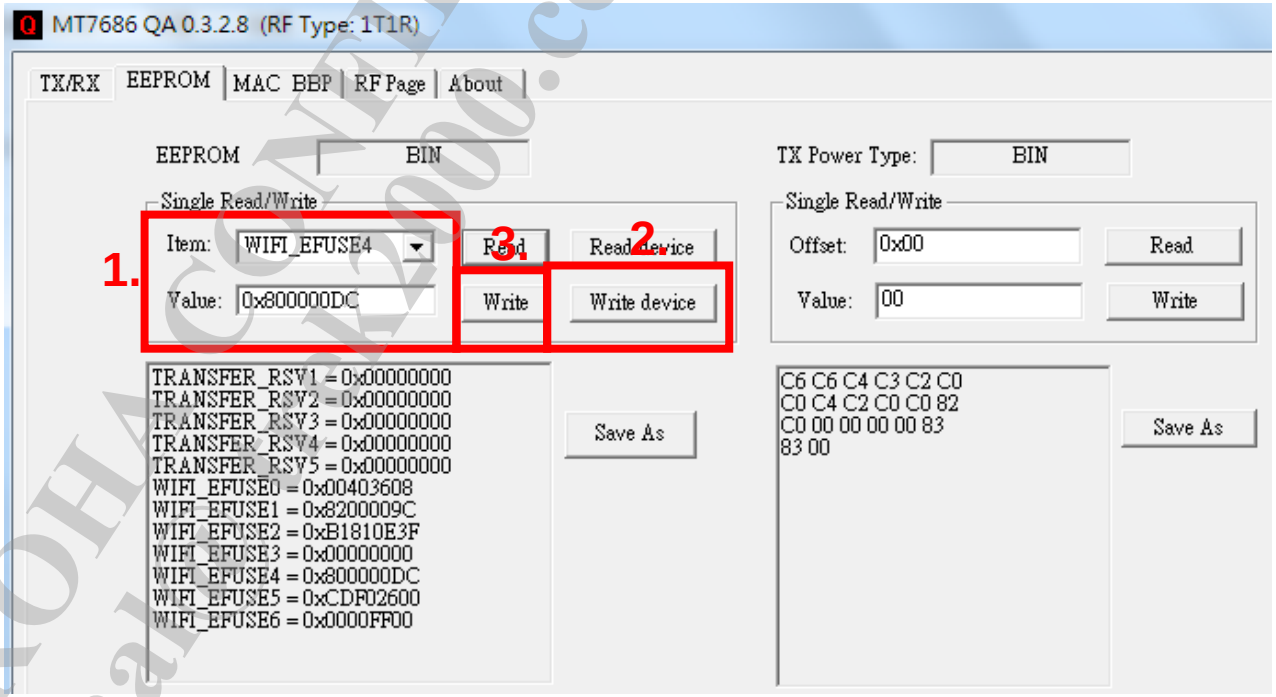
Use QAtool to write efuse

1. Write WIFI_EFUSE1/2/4/5 to efuse after fine tuning;
2. “Write Device ” means writing value to the efuse of DUT;
3. “Write” means writing value to eeprom.bin of tool; so you can use eeprom.bin to varify first and write to DUT efuse at last.



Efuse4 target power

Note:
Change the name of eeprom.bin in tool, then the tool will apply the efuse in DUT.



HQA test item (define by customer)

- TX
  - **Transmit spectrum mask**
  - **Transmit power**
  - **Transmit spectrum flatness**
  - **Transmit EVM**
  - **Transmit center frequency tolerance**
  - **LO leakage**
  - **Ramp up and Ramp down time**
  - **FCC/CE pre-test**
- RX
  - **Sensitivity**
  - **Maximum input level**
  - **Adjacent channel rejection**

Note:

Ensure your eFEM parameter is set to your eeprom.bin or efuse before you start HQA test;

For normal using, efuse must be set.

Appendix

Efuse table for eFEM

[7:0]	WIFI_EFUSE1	7	6	5	4	3	2	1	0
		RG_WF0_DIVLDO_VS[3:0]				RG_WF0_TRXLDO_VS[3:0]			
[15:8]		15	14	13	12	11	10	9	8
		Valid							
[23:16]		23	22	21	20	19	18	17	16
		2G TX DPD Calibration (G0 offset[3:0])				Thermal slope of gain drop,bit3~0: FPA, 0.25dB/step			
[31:24]		31	30	29	28	27	26	25	24
		Valid			TX shpaing type	TX PA config, bit[1:0]		TSSI enable/disable bit	2G TX DPD Calibration (enable/disable bit)

[7:0]	WIFI_EFUSE2	External LNA gain for 2G[2:0]		ePA gain[4:0] for 2G		
[15:8]		External bypass gain for 2G[1:0]	External LNA P1dB for 2G[3:0]			External LNA gain for 2G[4:3]
[23:16]		External bypass P1dB for 2G [4:0]				External bypass gain for 2G[4:2]
[31:24]		Valid		ePA enable	eLNA enable	iPA/ePA Gband FE loss between Ant and Chip out

[7:0]	WIFI_EFUSE5	TX0 2.4G TX power offset high(CH11~14)(delta,dB)			
[15:8]		~~TX0 2.4G PA TSSI_VLD~~	TX0 2.4G PA TSSI slope		
[23:16]		TX0 2.4G PA TSSI offset[7:0]			
[31:24]		Valid	WIFI_EFUSE5_PA_TSSI_VALID		TX0 2.4G PA TSSI offset[11:8]

Airoha Technology Corp.