[Application Note]
MT7986 Thermal protection

Thermal Protection Service Introduction

illustration and command notice (Duty Control)

1. Command example for 2.4G

Step A: Setup Lv0~Lv3 duty value

```
iwpriv ra0 set thermal_protect_duty_cfg=0:0:100
iwpriv ra0 set thermal_protect_duty_cfg=0:1:60
iwpriv ra0 set thermal_protect_duty_cfg=0:2:40
iwpriv ra0 set thermal_protect_duty_cfg=0:3:20
```

Step B: enable and setup thermal protection parameters

```
iwpriv ra0 set thermal_protect_enable=0:1:1:120:114:0005
// disable and setup new thermal protection parameters for fine tune
iwpriv ra0 set thermal_protect_disable=0:1:1
iwpriv ra0 set thermal_protect_enable=0:1:1:xxx:xxx:xxxx
```

2. Command example for 5G

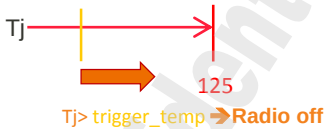
Step A: Setup Lv0~Lv3 duty value

```
iwpriv rax0 set thermal_protect_duty_cfg=1:0:100
iwpriv rax0 set thermal_protect_duty_cfg=1:1:60
iwpriv rax0 set thermal_protect_duty_cfg=1:2:40
iwpriv rax0 set thermal_protect_duty_cfg=1:3:20
```

Step B: enable and setup thermal protection parameters

```
iwpriv rax0 set thermal_protect_enable=1:1:1:120:114:0005

// disable and setup new thermal protection parameters for fine tune
iwpriv rax0 set thermal_protect_disable=1:1:1
iwpriv rax0 set thermal_protect_enable=1:1:1:xxx:xxx:xxxx
```

illustration and command notice (Radio off)



- **Command Example:**
  - **iwpriv ra0 set thermal_protect_enable=0:2:1:125:000:0005 //2.4G, Radio off Tiger_T=125, 5 sec recheck time**
  - **iwpriv rax0 set thermal_protect_enable=1:2:1:125:000:0005 //5G, Radio off Tiger_T=125, 5 sec recheck time**

Note: DUT should be reboot once Radio off has been triggered.

Thermal Protection Command Introduction

Thermal protection command format (Enable)

- **WIFI command format**

iwpriv ra0/rax0 set thermal_protect_enable=Param1:Param2:1:Param4:Param5:Param6

Parameters

Param1: band_idx, (1-symbol format) band index (0: band0, 1: band1), (0:2.4G/5G)

Param2: protection_type, (1-symbol format) thermal protection type (1: duty protection, 2: radio off protection)

Param3: always=1

Param4: trigger_temp, (3-symbol format) thermal protection state transition trigger temperature threshold (in unit of Celcius)

Param5: restore_temp, (3-symbol format) thermal protection state restore temperature threshold (in unit of Celcius)

Param6: recheck_time, (4-symbol format) state sustain time for level transition (in unit of sec).

Note that *trigger_temp > restore_temp* condition must be satisfied.

- **Command Example:**

[TX Duty Control Enable]

- **iwpriv ra0 set thermal_protect_enable=0:1:1:120:114:0005 //2.4G, Tiger_T=120, Restore_T=114, 5 sec recheck**
- **iwpriv rax0 set thermal_protect_enable=1:1:1:120:114:0005 //5G, Tiger_T=120, Restore_T=114, 5 sec recheck**

[Radio off Enable]

- **iwpriv ra0 set thermal_protect_enable=0:2:1:124:000:0005 //2.4G, Radio off Tiger_T=124, 5 sec recheck time**
- **iwpriv rax0 set thermal_protect_enable=1:2:1:124:000:0005 //5G, Radio off Tiger_T=124, 5 sec recheck time**

Note: DUT should be reboot once Radio off has been triggered.

Thermal protection command format (Set Duty)

- **WIFI 2.4G/5G command format**

  iwpriv ra0/rax0 set thermal_protect_duty_cfg=Param1:Param2:Param3

- **Parameters**

  Param1: band_idx, *(1-symbol format)* band index (0: band0, 1: band1), For (0:2.4G/5G)

  Param2: level_idx , *(1-symbol format)* level index for duty cycle control, valid range is 0, 1, 2 ,3

  Level need to follow condition *Duty level 0 ≥ Duty level 1 ≥ Duty level 2 ≥ Duty level 3*

  Param3: duty, *(3-symbol format)* percentage of duty cycle, valid range is 0~100

- **Command Example:**
  - iwpriv ra0 set thermal_protect_duty_cfg=0:0:80 //Fix Lv0 duty cycle =80% for 2.4G all rate
  - iwpriv rax0 set thermal_protect_duty_cfg=1:0:50 //Fix Lv0 duty cycle =50% for 5G all rate

Thermal protection command format (Force Level)

- **WIFI 2.4G/5G command format**
  - **iwpriv ra0/rax0 set thermal_protect_state_act =Param1:Param2:Param3:Param4**

Parameters

Param1: band_idx, (1-symbol format) band index (0: band0, 1: band1), (0:2.4G/5G)

Param2: protection_type, (1-symbol format) thermal protection type (1: duty protection, 2: radio off protection)

Param3: always=1

Param4: level_idx , *(1-symbol format)* level index for duty cycle control, valid range is 0, 1, 2 ,3

Level need to follow condition *Duty level 0 ≥ Duty level 1 ≥ Duty level 2 ≥ Duty level 3*

- **AX1800 Command Example:**
  - iwpriv ra0 set thermal_protect_state_act=0:1:1:3 //Force to Lv3 for 2.4G all rate
  - iwpriv rax0 set thermal_protect_state_act=1:1:1:3 //Force to Lv3 for 5G all rate

Thermal protection command format (Status Check)

- **Command format**

  iwpriv ra0/rax0 set thermal_protect_info=x //x=0:2G, x=1:5G , check enable/disable/temp/recheck time status
  iwpriv ra0/rax0 set thermal_protect_duty_info=x //x=0:2G, x=1:5G, check duty setting for current Lv0~Lv3

- **Command Example:**

  iwpriv ra0 set thermal_protect_info=0 // check 2G enable/disable/temp/recheck time status
  iwpriv rax0 set thermal_protect_duty_info=1 //check 5G, check duty setting for current Lv0~Lv3

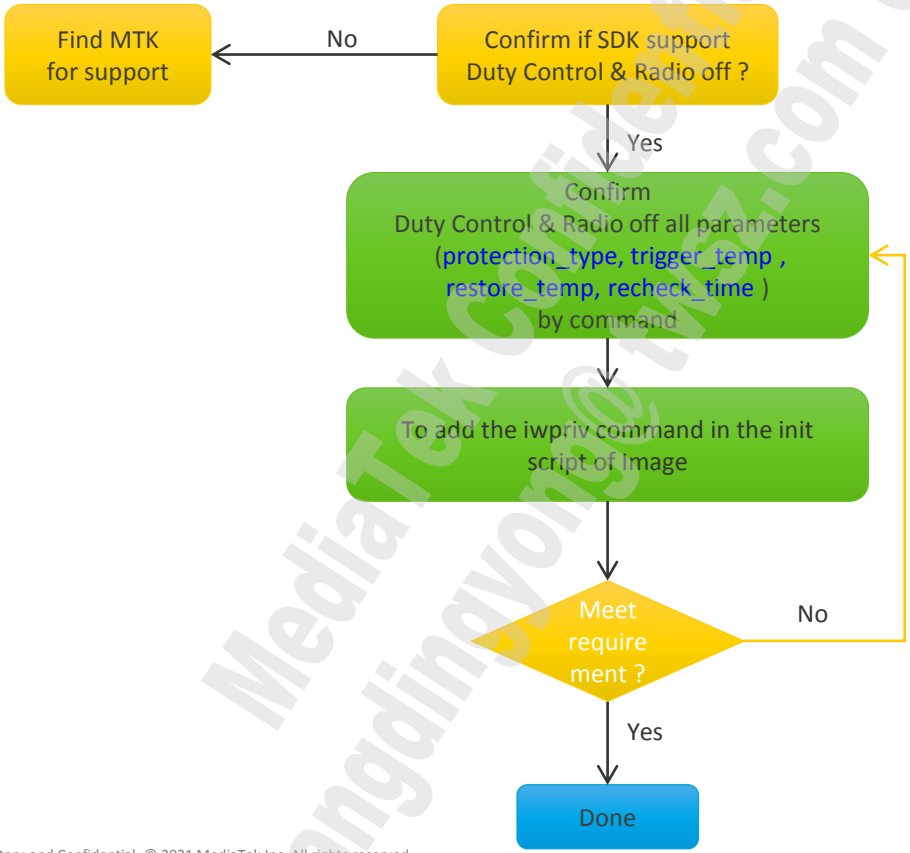
```
root@LEDE:/# iwpriv ra0 set thermal_protect_info=0
[  735.609275] SetThermalProtectInfo(): band_idx: 0
[  735.613916] MtCmdThermalProtectInfo: band_idx: 0
root@LEDE:/# [  735.620789] band_idx: 0
[  735.623249] prot_type: 0, trig_type: 1
[  735.626991] state: 0, enable: 0
[  735.630137] trigger_temp: 0, restore_temp: 0
[  735.634402] recheck_time: 0
[  735.637197] ------------------------
[  735.640960] prot_type: 1, trig_type: 1
[  735.644708] state: 3, enable: 1          Duty Control enabled
[  735.647843] trigger_temp: 50, restore_temp: 30
[  735.652287] recheck_time: 9999
[  735.655336] ------------------------
[  735.659086] prot_type: 2, trig_type: 1
[  735.662829] state: 0, enable: 0          Radion off protect disabled
[  735.665965] trigger_temp: 0, restore_temp: 0
[  735.670234] recheck_time: 0
[  735.673023] ------------------------
```

```
iwpriv rax0 set thermal_protect_duty_cfg=1:0:100
iwpriv rax0 set thermal_protect_duty_cfg=1:1:60
iwpriv rax0 set thermal_protect_duty_cfg=1:2:40
iwpriv rax0 set thermal_protect_duty_cfg=1:3:20
.....

root@LEDE:/# iwpriv rax0 set thermal_protect_duty_info=1
[ 2205.377169] SetThermalProtectDutyInfo(): band_idx: 1
[ 2205.384551] MtCmdThermalProtectDutyInfo: band_idx: 1
[ 2205.395314] EventThermalProtDutyInfo
[ 2205.398935] band_idx: 1
[ 2205.401399] duty0: 100, duty1: 60, duty2: 40, duty3: 20
```

Example

Manual TX Duty Control & Radio OFF with temperature threshold

Duty Control & Radio off implement flow



Popular command for TX duty control

```
//2.4G TX Duty Control
iwpriv ra0 set thermal_protect_duty_cfg=0:0:100
iwpriv ra0 set thermal_protect_duty_cfg=0:1:60
iwpriv ra0 set thermal_protect_duty_cfg=0:2:50
iwpriv ra0 set thermal_protect_duty_cfg=0:3:20
iwpriv ra0 set thermal_protect_duty_info=0
iwpriv ra0 set thermal_protect_enable=0:1:1:120:114:0005
iwpriv ra0 set thermal_protect_info=0
iwpriv ra0 set thermal_protect_disable=0:1:1

//5G TX Duty Control
iwpriv rax0 set thermal_protect_duty_cfg=1:0:100
iwpriv rax0 set thermal_protect_duty_cfg=1:1:60
iwpriv rax0 set thermal_protect_duty_cfg=1:2:40
iwpriv rax0 set thermal_protect_duty_cfg=1:3:20
iwpriv rax0 set thermal_protect_duty_info=1
iwpriv rax0 set thermal_protect_enable=1:1:1:120:114:0005
iwpriv rax0 set thermal_protect_info=1
iwpriv rax0 set thermal_protect_disable=1:1:1
```

Set Lv0~Lv3 duty

//Check duty setting

//Enable TX duty control w/ temperature

//Check thermal protect enable/disable status

//Disable TX duty control w/ temperature

Set Lv0~Lv3 duty

//Check duty setting

//Enable TX duty control w/ temperature

//Check thermal protect enable/disable status

//Disable TX duty control w/ temperature

Step A. Check 5G current temp

```
rootled:/# iwpriv rai0 stat

[  826.283393] PhyStatGetRssi: invalid entry. no station link up.
rai0     stat:
CurrentTemperature          = 53
Tx success                  = 0
Tx fail count               = 0, PER=0.0%
Current BW Tx count         = 0
Other BW Tx count           = 0
Rx success                  = 45935
Rx with CRC                 = 4260, PER=8.4%
Rx drop due to out of resource  = 0
Rssi: 0 0 0 0
CN Info:                    = 255
proxy arp enable            = 0
WNMNotify enable            = 1
WNM BSS Transition Management enable = 1
GAS come back delay         = 1
GAS MMPDU size              = 1024
GAS enable                  = 1
```

Step B. set duty % per level

```
root@LEDE:/# iwpriv rai0 set thermal_protect_duty_cfg=0:0:100
[ 1069.376473] SetThermalProtectDutyCfg(): band_idx: 0, level_idx: 0, duty: 90
[ 1069.383462] MtCmdThermalProtectDutyCfg: band_idx: 0, level_idx: 0
[ 1069.389654] MtCmdThermalProtectDutyCfg: duty: 90
root@LEDE:/# iwpriv rai0 set thermal_protect_duty_cfg=0:1:60
[ 1075.164255] SetThermalProtectDutyCfg(): band_idx: 0, level_idx: 1, duty: 60
[ 1075.171236] MtCmdThermalProtectDutyCfg: band_idx: 0, level_idx: 1
[ 1075.177334] MtCmdThermalProtectDutyCfg: duty: 60
root@LEDE:/# iwpriv rai0 set thermal_protect_duty_cfg=0:2:40
[ 1079.797450] SetThermalProtectDutyCfg(): band_idx: 0, level_idx: 2, duty: 40
[ 1079.804547] MtCmdThermalProtectDutyCfg: band_idx: 0, level_idx: 2
[ 1079.810653] MtCmdThermalProtectDutyCfg: duty: 40
root@LEDE:/# iwpriv rai0 set thermal_protect_duty_cfg=0:3:20
[ 1085.117271] SetThermalProtectDutyCfg(): band_idx: 0, level_idx: 3, duty: 20
[ 1085.124312] MtCmdThermalProtectDutyCfg: band_idx: 0, level_idx: 3
[ 1085.130462] MtCmdThermalProtectDutyCfg: duty: 20
[ 1085.130462] iwpriv rai0 set thermal_protect_duty_info=0
[ 2256.443987] SetThermalProtectDutyInfo(): band_idx: 0
[ 2256.449035] MtCmdThermalProtectDutyInfo: band_idx: 0
root@LEDE:/# [ 2256.456173] EventThermalProtDutyInfo
[ 2256.459744] band_idx: 0
[ 2256.462188] duty0: 100, duty1: 60, duty2: 40, duty3: 20
```

Step C. Check thermal protect status before thermal protection enable

```
root@LEDE:/# iwpriv ra0 set thermal_protect_info=0
Interface doesn't accept private ioctl...
set (8BE2): Invalid argument
root@LEDE:/# iwpriv rai0 set thermal_protect_info=0
[ 1486.931490] SetThermalProtectInfo(): band_idx: 0
[ 1486.936194] MtCmdThermalProtectInfo: band_idx: 0
root@LEDE:/# [ 1486.942936] band_idx: 0
[ 1486.945382] prot_type: 0, trig_type: 1
[ 1486.949127] state: 0, enable: 0
[ 1486.952264] trigger_temp: 0, restore_temp: 0
[ 1486.956528] recheck_time: 0
[ 1486.959313] --------------------------
[ 1486.963055] prot_type: 1, trig_type: 1
[ 1486.966799] state: 0, enable: 0
[ 1486.969935] trigger_temp: 0, restore_temp: 0
[ 1486.974199] recheck_time: 0
[ 1486.976986] --------------------------
[ 1486.980729] prot_type: 2, trig_type: 1
[ 1486.984472] state: 0, enable: 0
[ 1486.987604] trigger_temp: 0, restore_temp: 0
[ 1486.991875] recheck_time: 0
[ 1486.994664] --------------------------
```

Duty Control Disabled ➔ Enabled

Thermal protection function work !!

Step D. Enable protection then check status again

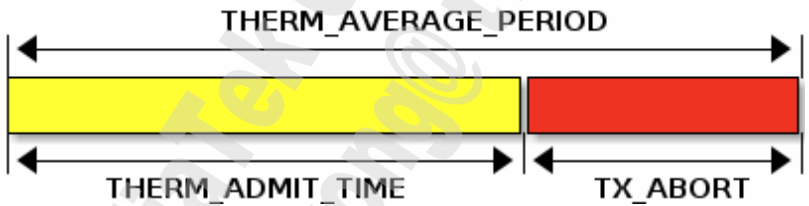
```
root@LEDE:/# iwpriv rai0 set thermal_protect_enable=0:1:1:050:045:0005
[ 2668.881746] SetThermalProtectEnable(): band_idx: 0, protection_type: 1, trigger_type: 1
[ 2668.889921] SetThermalProtectEnable(): trigger_temp: 50, restore_temp: 45, recheck_time: 5
[ 2668.898192] MtCmdThermalProtectEnable: band_idx: 0, protect_type: 1
[ 2668.904508] MtCmdThermalProtectEnable: trigger_type: 1, trigger_temp: 50
[ 2668.911300] MtCmdThermalProtectEnable: restore_temp: 45, recheck_time: 5
root@LEDE:/# [ 2668.920104] (Thermal Protect) Duty Notify.
[ 2668.924199] band_idx: 0, level_idx: 0, duty_percent: 90
[ 2668.929425] (Thermal Protect) Duty Notify.
[ 2668.933516] band_idx: 0, level_idx: 1, duty_percent: 60
[ 2668.938734] Trigger Temp = 50

root@LEDE:/# iwpriv rai0 set thermal_protect_info=0
[ 2788.983655] (Thermal Protect) Duty Notify.
[ 2788.987755] band_idx: 0, level_idx: 3, duty_percent: 20
[ 2788.992978] Trigger Temp = 50

[ 2789.571485] SetThermalProtectInfo(): band_idx: 0
[ 2789.576172] MtCmdThermalProtectInfo: band_idx: 0
root@LEDE:/# [ 2789.582983] band_idx: 0
[ 2789.585429] prot_type: 0, trig_type: 1
[ 2789.589174] state: 0, enable: 0
[ 2789.592310] trigger_temp: 0, restore_temp: 0
[ 2789.596574] recheck_time: 0
[ 2789.599359] --------------------------
[ 2789.603103] prot_type: 1, trig_type: 1
[ 2789.606846] state: 3, enable: 1
[ 2789.609983] trigger_temp: 50, restore_temp: 45
[ 2789.614420] recheck_time: 5
[ 2789.617207] --------------------------
[ 2789.620950] prot_type: 2, trig_type: 1
[ 2789.624694] state: 0, enable: 0
[ 2789.627826] trigger_temp: 0, restore_temp: 0
[ 2789.632090] recheck_time: 0
[ 2789.634874] --------------------------
[ 2793.986830] (Thermal Protect) Duty Notify.
[ 2793.990940] band_idx: 0, level_idx: 3, duty_percent: 20
[ 2793.996156] Trigger Temp = 50
```

How to check the current duty value

Read 0x820E0030 (Band0 – 2.4G)
Read 0x820F0030 (Band1 – 5G)

Bit(s)	Name
31:16	THERMO_ADMIT_TIME
14:8	THERMO_AVERAGE_PERIOD

Bit31:16 means the valid transmission time. (in 32us unit)
Bit14:8 period means the observing period. (in 64us unit)
TxDuty(%) = THERMO_ADMIT_TIME/THERMO_AVERAGE_PERIOD.



For example:
When the value of CR 0x820E0030 is fe7f05.
Valid transmission time [bit 31:16] is fe=254 *32 us = 8ms
Observing time [bit 14:8] is 7f=127 * 64us = 8ms
8ms/8ms = **100%**

fe7f = 100%
7f7f = 50%
657f = 40%
4c7f = 30%
327f = 20%

Thank you

Questions and Discussions