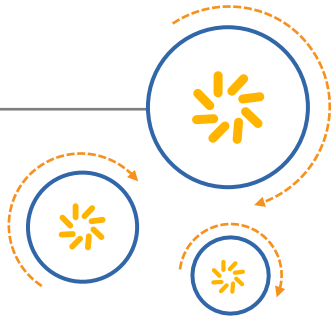
Qualcomm Technologies, Inc.



UEFI PMIC Software

User Guide

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Qualcomm Technologies, Inc.
5775 Morehouse Drive
San Diego, CA 92121
U.S.A.

Revision history

Revision	Date	Description
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1 Introduction

1.1 Purpose

This document provides an overview of unified extensible firmware interface (UEFI) PMIC software drivers, battery management application, and battery charging configuration.

1.2 Conventions

Function declarations, function names, type declarations, attributes, and code samples appear in a different font, for example, `#include`.

Button and key names appear in bold font, for example, click **Save** or press **Enter**.

1.3 Technical assistance

For assistance or clarification on information in this document, submit a case to Qualcomm Technologies, Inc. (QTI) at https://createpoint.qti.qualcomm.com/.

If you do not have access to the CDMATech Support website, register for access or send email to support.cdmatech@qti.qualcomm.com.

2 Overview

The UEFI specification defines a set of platform-independent APIs to enable the following:

- Interaction between the platform firmware and the operating system/OS loader
- Loading, installing, and executing drivers in a pre-OS environment
- Cross-platform portability for UEFI applications

2.1 Protocol

Protocol is a set of software interfaces used for communication between two binary modules.

NOTE: Each protocol must have a specification that includes the protocol GUID and its interface structure.

Driver dependencies

- Defined in the driver INF file
- Loaded and processed during system initialization

Protocol usage

- To use the interfaces from other modules, the module must locate the protocols through GUIDs during module initialization
- To expose the interface for other modules, the module must install the protocol during module initialization

2.1.1 Example – Locate a protocol

The following example demonstrates how to locate the protocol.

```
/* Interface for the protocol to access the RTC */
EFI_QCOM_PMIC_PWRON_PROTOCOL  *pmic_pwron;
…
Status = gBS->LocateProtocol(&gQcomPmicPwrOnProtocolGuid, NULL, (VOID**)
&pmic_pwron);
```

2.1.2 Example – Use the located protocol

The following example demonstrates how to use the interface after the protocol is located.

```
EFI_STATUS Status;
…
Status = pmic_pwron->GetPonPblStatus (0,
EFI_PM_PWRON_PON_PBL_STATUS_XVDD_RB_OCCURRED,&pmicWasBatteryRemoved);
```

2.2 INF file setting

The INF file is used to specify the sources and dependencies for a module.

2.2.1 Example – RealTimeClockLib.inf

For any module requiring a PMIC resource, the related protocol GUID must be included in the INF file.

```
…
[Protocols]
     gQcomPmicRtcProtocolGuid
     gQcomPmicPwrOnProtocolGuid
…
```

2.2.2 Example – PmicDxe.inf

INF enables linking a module to the library.

```
…
[LibraryClasses]
  BaseMemoryLib
  PmicLib
…
```

3 UEFI PMIC software drivers

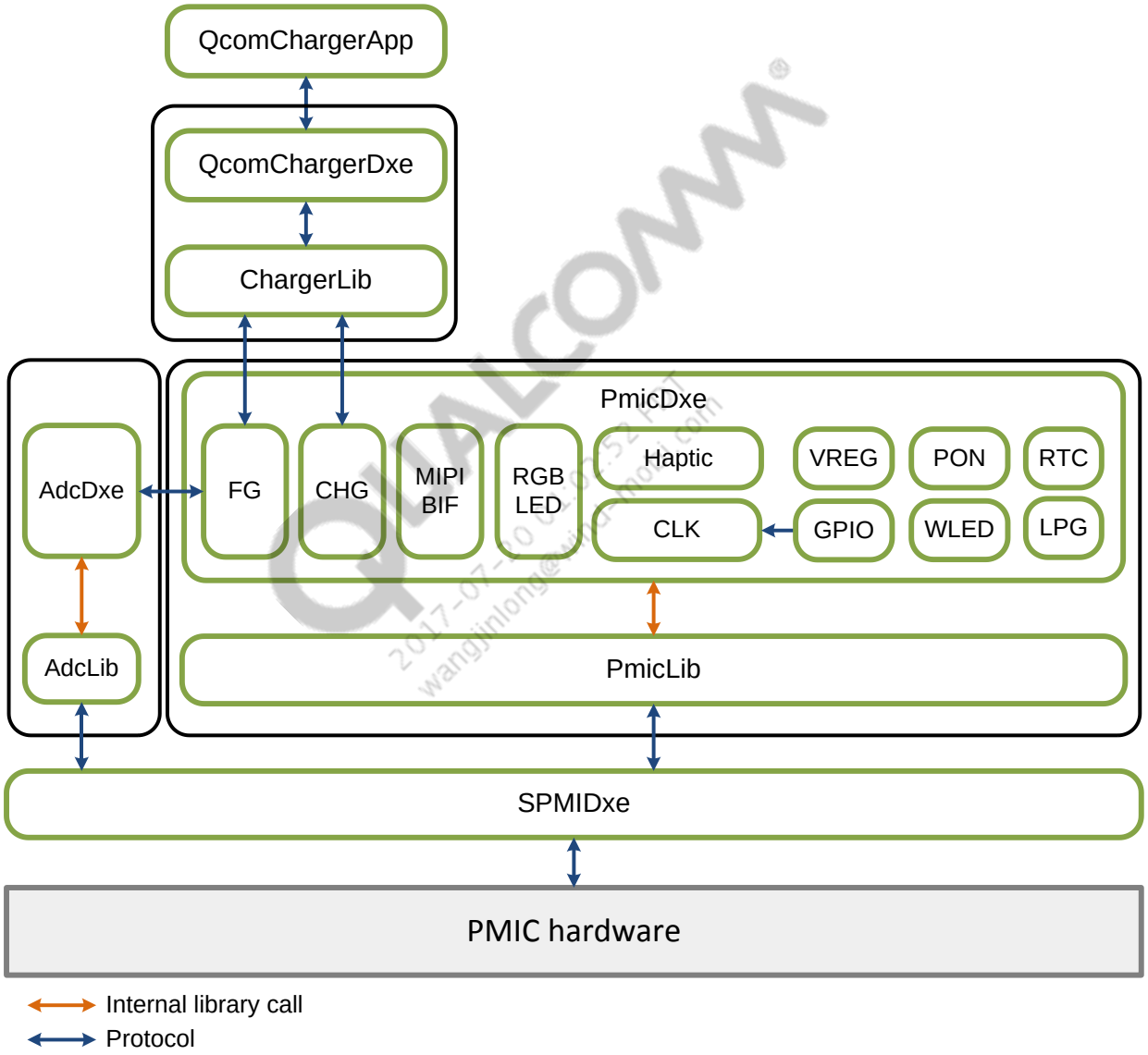


Figure 3-1 PMIC software stack

Table 3-1 UEFI PMIC drivers

Driver	Source path	Functionality
AdcDxe	<src root> \uefi\edk2\QcomPkg\ Drivers\AdcDxe	▪ Provides abstraction of ADC functionality through protocols ▪ Not platform-specific
AdcLib	<src root> \uefi\edk2\QcomPkg\ Library\AdcLibB	▪ Implements register-level access of ADC functionalities ▪ Platform-specific
QcomChargerDxe	<src root> \uefi\edk2\QcomPkg\ Drivers\QcomChargerDxe	▪ Provides abstraction of charging and gauge functionality of the system ▪ Interface between Microsoft® UEFI charger applications or other high-level UEFI applications (such as FLASH) ▪ Battery management customization
PmicShutdownLib	<src root> \uefi\edk2\QcomPkg\ Library\PmicShutdownLib	▪ Implementation of boot time and runtime shutdown/reset functionality
PmicDxe	<src root> \uefi\edk2\QcomPkg\ Drivers\PmicDxe	▪ Provides abstraction of most PMIC functionalities through protocols (see Section 3.3.1) ▪ Not platform-specific
PmicLib	<src root> \uefi\edk2\QcomPkg\ Library\PmicLib	▪ Implements register-level access of PMIC functionality ▪ Platform-specific
SPMIDxe	<src root> \uefi\edk2\QcomPkg\ Drivers\SPMIDxe	▪ Implementation of SPMI communication with PMIC

Each header file listed in Table 3-2 is located in the following path:

< src root>\uefi\edk2 \QcomPkg\Include\Protocol\

Table 3-2 UEFI PMIC protocols

PMIC protocols	Header file	Usage
PMIC_CLKBUFF_PROTOCOL	EFIPmicClkBuff.h	Protocol for the PMIC CLK buffer
PMIC_GPIO_PROTOCOL	EFIPmicGpio.h	Protocol for PMIC GPIO
PMIC_IBB_PROTOCOL	EFIPmicIbb.h	Protocol for PMIC IBB
PMIC_LAB_PROTOCOL	EFIPmicLab.h	Protocol for PMIC LAB
PMIC_LPG_PROTOCOL	EFIPmicLpg.h	Protocol for PMIC LPG
PMIC_MIPIBIF_PROTOCOL	EFIPmicMipiBif.h	Protocol for PMIC MipiBif
PMIC_MPP_PROTOCOL	EFIPmicMpp.h	Protocol for PMIC MPP
PMIC_PWM_PROTOCOL	EFIPmicPwm.h	Protocol for PMIC PWM
PMIC_PWRON_PROTOCOL	EFIPmicPwrOn.h	Protocol for PMIC PON
PMIC_RGB_LED_PROTOCOL	EFIPmicRgbLed.h	Protocol for PMIC RGB
PMIC_RTC_PROTOCOL	EFIPmicRTC.h	Protocol for PMIC RTC
PMIC_SCHG_PROTOCOL	EFIPmicSchg.h	Protocol for PMIC SCHG
PMIC_FG_PROTOCOL	EFIPmicFg.h	Protocol for PMIC FG
PMIC_VIB_PROTOCOL	EFIPmicVib.h	Protocol for PMIC VIB
PMIC_VREG_PROTOCOL	EFIPmicVreg.h	Protocol for PMIC LPG
PMIC_PWM_PROTOCOL	EFIPmicPwm.h	Protocol for PMIC VREG
PMIC_WLED_PROTOCOL	EFIPmicWled.h	Protocol for PMIC WLED

Sample code – UEFI PMIC driver call flow

@RealTimeLib

```
EFI_QCOM_PMIC_PWRON_PROTOCOL  *pmic_pwron;
Status = gBS->LocateProtocol(&gQcomPmicPwrOnProtocolGuid, NULL, (VOID**)
                  &pmic_pwron;
Status = pmic_pwron->GetPonPblStatus (
           RTCInternal.nPmicIndex,
           EFI_PM_PWRON_PON_PBL_STATUS_XVDD_RB_OCCURRED,
           &pmicWasBatteryRemoved);
```

@PmicDxe

```
EFI_QCOM_PMIC_PWRON_PROTOCOL
PmicPwronProtocolImplementation =
{
  PMIC_PWRON_REVISION,
  …
  EFI_PmicPwronGetPonPblStatus,
};

struct _EFI_QCOM_PMIC_PWRON_PROTOCOL {
  UINT32                Revision;
  …
  EFI_PM_PWRON_GET_PON_PBL_STATUS     GetPonPblStatus;
};

EFI_STATUS  EFIAPI  EFI_PmicPwronGetPonPblStatus
(
  IN  UINT32 PmicDeviceIndex,
  IN  EFI_PM_PWRON_PON_PBL_STATUS_TYPE PblStatusType,
  OUT BOOLEAN *Status
)
{
  …
  errFlag = pm_pon_pbl_status_get(PmicDeviceIndex,
(pm_pwron_pon_pbl_status_type)PblStatusType, Status);
  …
  return EFI_SUCCESS;
}
```

@PmicLib

```
pm_err_flag_type pm_pon_pbl_status_get(unsigned pmic_device_index,
pm_pwron_pon_pbl_status_type pbl_status_type, boolean *status)
{
  …
  return ((pm_pwron_data_type*)mappedResource)->ipwron_get_pon_pbl_status(
      mappedResource,
      pbl_status_type, status,
      (uint8)resourceIndex);
  …
}

pmiC_PmicResource* pm_pwron_driver_init( pmiC_PmicDevice  *device )
{
  ...
            pmiC_PmicResource_Init(pwron, PWRON_ModuleType, device);
            …
            ((pm_pwron_data_type*)pwron)->ipwron_get_pon_pbl_status
              = pm_pwron_get_pon_pbl_status_alg;
  ...
}
```

3.1 Core

No OS-level interrupt support

- UEFI is a single thread OS
- Cannot register the Interrupt service routine for PMIC interrupt
- PMIC interrupt can be enabled to detect an event through the latched status bit
- Interrupts enabled in UEFI must be disabled before booting to HLOS to prevent unknown wakeup activities in the HLOS
- Timer or timer-callback can be used as alternatives

No XO shutdown or deep sleep

- Not supported due to framework limitation
- Improves power efficiency during UEFI charging
- Low Power mode is supported by reducing the CPU clock speed and number of active cores
- Display is on for a limited amount of time during boot and can be turned on when the user presses the power and volume keys during UEFI low battery charging

VREG is controlled via NPA/RPM instead of direct register access

- Do not use the following functions to set the VREG register (these functions cause a device crash if misused):
  - PmicVRegProtocol->VregSetLevel
  - PmicVRegProtocol->VregControl
- TZ PMIC SPMI permissions become active when the time device boots up to UEFI

3.2 User interface

Figure 3-2 shows the PMIC drivers used to configure IBB, LAB, and WLED for the display.

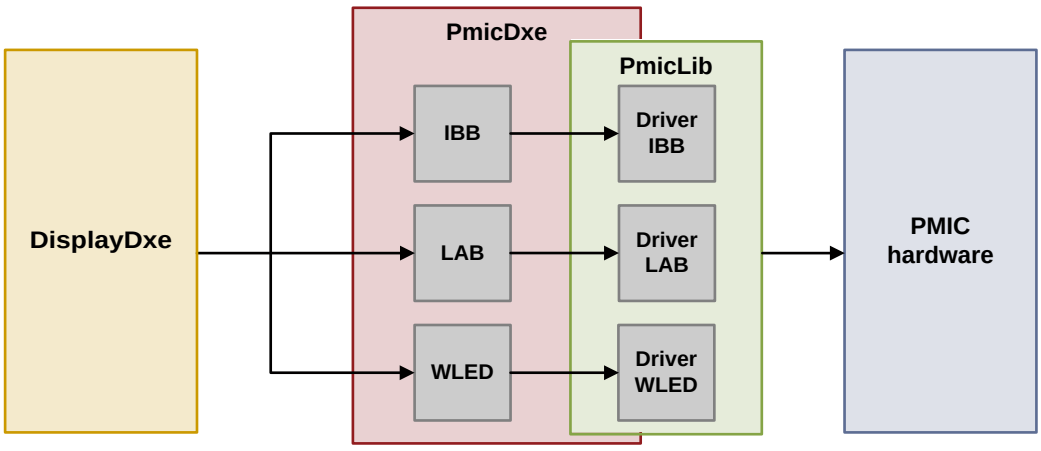


Figure 3-2 Display driver and PMIC driver flow

3.3 UEFI charger app

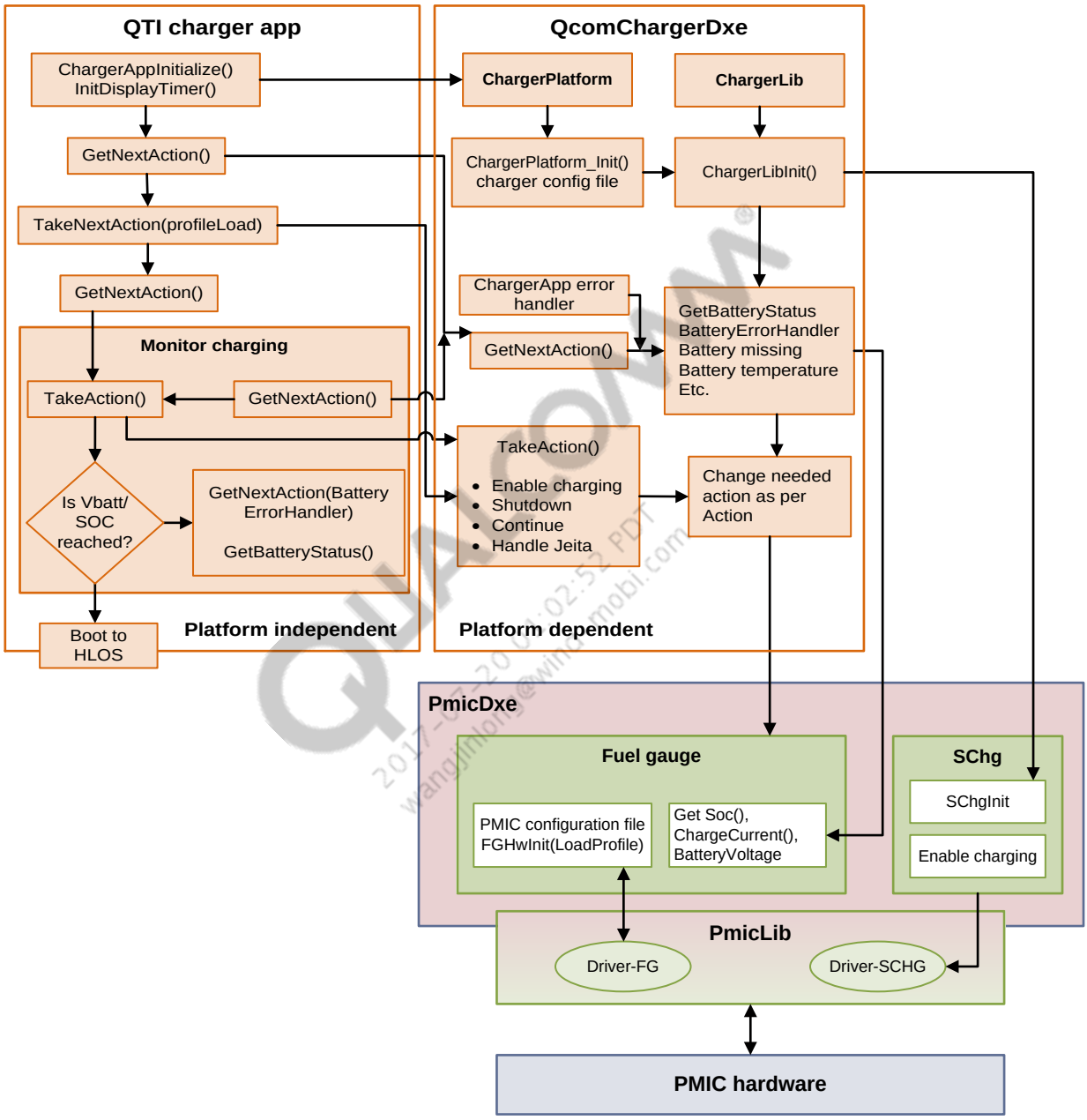


Figure 3-3 UEFI charger app design

3.3.1 PmicDxe

The PmicDxe driver implements functions to program the charger/FG hardware. It also implements functions such as parsing/load battery profile, FG boot sequence, AICL rerun etc.

3.3.2 ChargerLib

The platform-dependent ChargerLib provides the following functions:

- Enable charging, disable charging
- Set charger maximum battery current
- Float voltage (FV)
- Check charger source
- Get battery SOC, voltage, and current
- Battery error handling and software Jeita

3.3.3 QTI charger app

The QTI charger app supports voltage-based and SOC-based threshold charging. The QTI charger app calls ChargerLib to determine if it is OK to boot to HLOS or whether to stay in UEFI charging until the threshold is reached. The QTI charger app has one main loop that keeps the application running, checking if it is OK to exit.

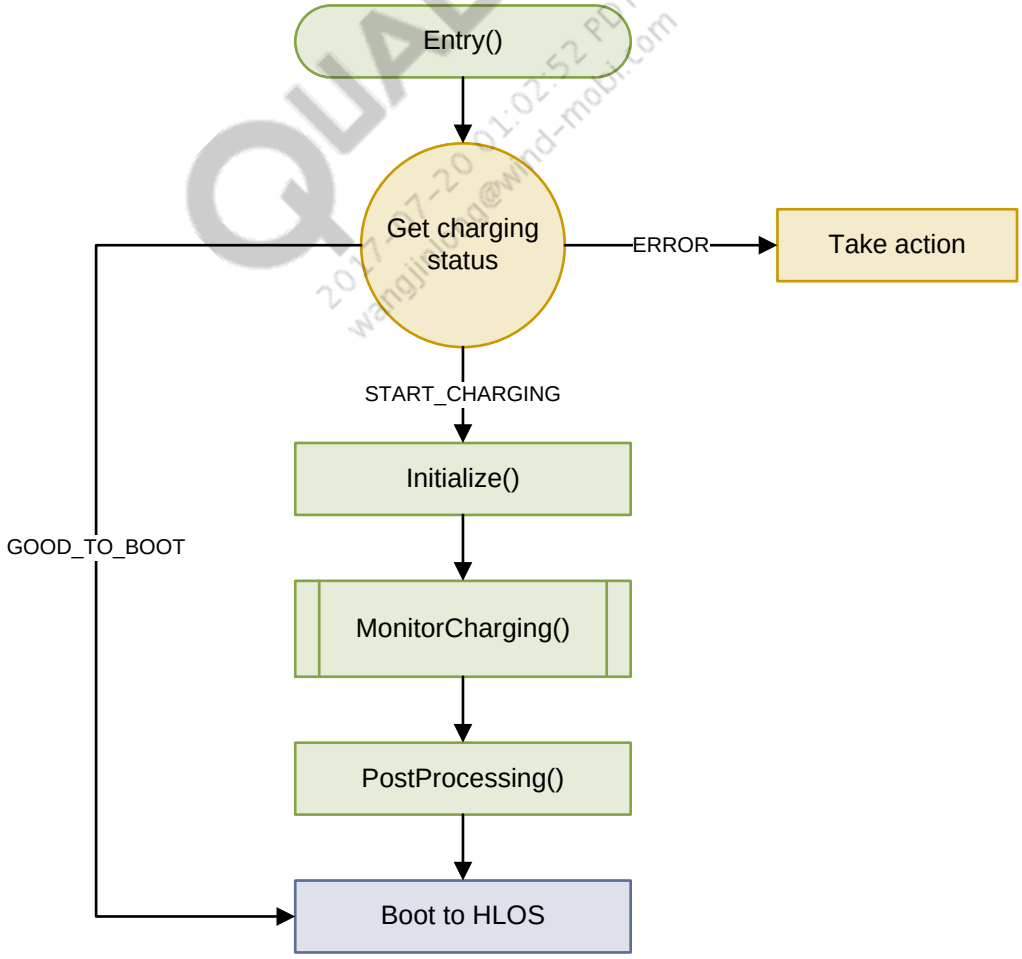


Figure 3-4 QTI charger app call flow

The charger has a timer for the following tasks:

- Turn the display On or Off
- Display the charging/battery icon
- Run the following in a loop every 3 sec until threshold is reached
  - Check battery status
  - Manage charging
  - Error handling

Additional support includes safety features such as thermal mitigation, WiPower, etc.

Table 3-3 QTI charger app functions

Source file	Function	Description
QcomChargerApp.c	Entry()	Initializes the QTI charger app, starts the charging loop, and cleans up after exiting the charging loop.
	Initialize()	Sets the charging parameters and starts the display timer.
	MonitorCharging()	Charging loop that monitors battery charging status until battery status is at a good enough charge to boot to HLOS.
	PostProcessing()	Called after exiting the charging loop, this function closes all the events and timers, and decides whether to boot to HLOS, stay in UEFI, or shut down.
	DeInitialize()	Performs required exit actions before leaving the app.
QcomChargerApp-EventHandler.c	KeyPressEventHandler()	Turns on the display, starts the display timer, and exits LPM mode when the volume up/down, power key, or home key is pressed.
	KeyPressControl()	Registers or unregisters volume up, volume down, and home key press event callback with the keypad driver.
	HandleLPMClock()	Signals the Clock driver to enter or exit LPM.
	HandleLPMDisplay()	Signals the Display driver to enter or exit LPM to turn the display ON or OFF.
	EnterLPM()	Called when the display is turned off, this function sends an enter LPM signal to Clock and Display drivers.
	ExitLPM()	Called when the display is turned on by key press, this function sends an exit LPM signal to the Clock and Display drivers.
	AnimImgTimer()	Animates image display during charging (display ON).
	DisplayTimerEvent()	Displays the battery image during charging (display ON).

See Chapter 4 for QTI charger app configuration details.

4 UEFI QTI charger app LA configuration

The UEFI QTI charger app handles the following:

- Charges the battery to a specified level
- Determines if the battery is OK to boot to HLOS without UEFI charging

See Section 3.3.3 for an overview of the QTI charger app.

4.1 QTI charger app configuration file

The QTI charger app includes a build-time configuration file with parameters for charger/fuel gauge (FG) management.

Refer to Section 4.12 for a QTI charger app LA example file.

The QcomChargerConfig_VbattTh_8998.cfg file is located in the following boot build folder:

/QcomPkg/Drivers/QcomChargerDxe/

NOTE: The configuration file must be renamed *QcomChargerCfg.cfg* to be used.

4.2 Debug overwrite feature

The debug overwrite feature enables debug logs and overwrites UEFI configuration at runtime. Overwriting configuration at runtime makes it unnecessary to rebuild the core. On debug builds, the UEFI QTI charger app is built during initialization.

NOTE: This feature only works on debug builds.

Flash tools FV and enable the debug overwrite feature

The QComChargerCfg.cfg file can be copied via mass storage application from the UEFI BDS menu to mount the LogFS drive on which to copy the file. The FV tool must be flashed to enable the UEFI BDS menu.

The tools.fv file is located in the following metabuild folder:

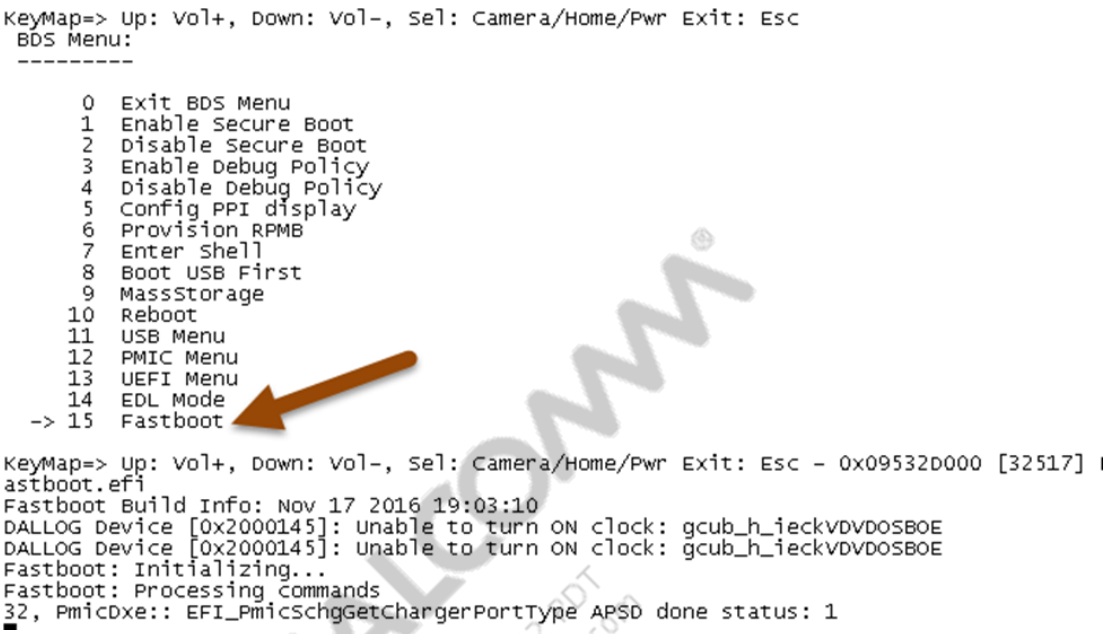
..\boot_images\QcomPkg\QcomToolsPkg\Bin\QcomTools\DEBUG

1. Type the following command:

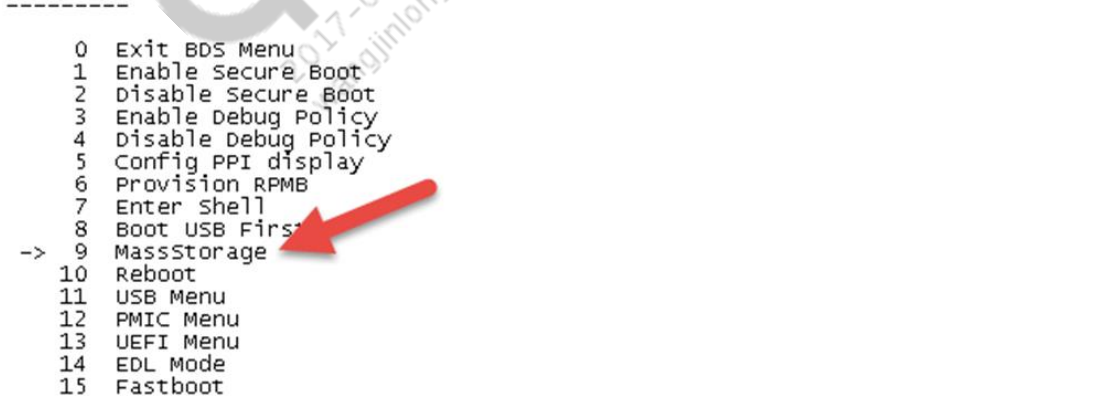
   ```
   fastboot flash toolsfv ..\boot_images\QcomPkg\QcomToolsPkg\Bin\QcomTools
   \DEBUG\tools.fv
   ```

2. During boot, hold down the volume key to display the boot device selection (BDS) menu.

3. Use the volume down key to scroll down the menu, and press the Home/Power key to select Fastboot.



4. Reboot the device, press and hold down the volume key to open the UEFI BDS menu, and press volume down to select MassStorage.



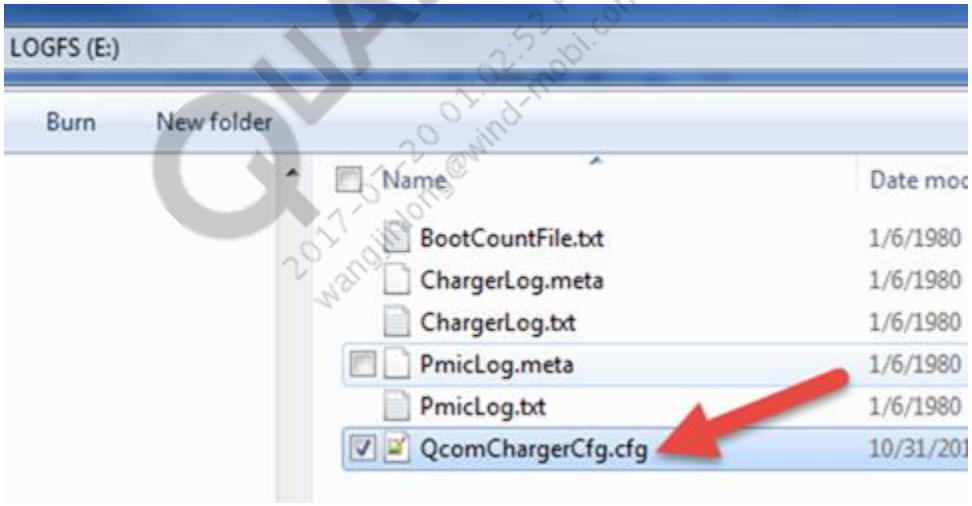
5. Press the Home/Power key to launch the UEFI MassStorage app.

6. Mount the LogFS partition.

```
     54      limits  (4)
     55      toolsfv  (1024)
 ->**56      logfs  (8192)
     57      sti  (2048)
     58      devcfg  (128)
     59      storsec  (128)
     60      storsecbak  (128)
     61  UFS-LUN 5  (1572864)
     62      modemst1  (2048)
     63      modemst2  (2048)
     64      fsc  (4)
     67  RPMB  (16384)

     68  <Mount Partitions>
KeyAction: Mounting Drives...
Unmount error: Not Found
MountSelection: Mounting logfs on Lun 0
MountSelection:  Press Any Key To Unmount
```

7. Copy the QcomChargerCfg.cfg file to the LogFS partition root level with the modified configuration.



8. Remove LogFS from the task bar.
9. Reboot the device.

   The new configuration takes effect and the modified configuration is listed in the LogFS configuration file, e.g., the configuration file changes to enable the charger.

4.3 Configuration quick reference

Refer to Section 4.12 for a QTI charger app LA example file.

Table 4-1 Configuration quick reference

Entry	Description	Default	Dependency	Data Format
Threshold charging				
SocOrVoltageBaseBoot	Sets the thresholds in QTI charger app to allow boot when the configured threshold is met.	FALSE	LoadBatteryProfile	Boolean
LoadBatteryProfile	Loads the battery profile for battery state of charge (SOC) accuracy.	TRUE	DispSignOfLifeMaxThresholdMv	Boolean
DispSignOfLifeMaxThresholdMv	Displays the sign of life during battery profile load, providing a user indication for cold boot.	3700 mV	LoadBatteryProfile	mV
FgCondRestart	Decides if the fuel gauge must be restarted to allow battery accuracy.	TRUE	LoadBatteryProfile	Boolean
ChargerLedConfig	Configures the charger LED status.	1	None	Decimal
Debug				
PrintChargerAppDbgMsg	If TRUE, enables QTI charger app logs and respective pmic.dxe charger logs and displays them on UART.	FALSE	None	Boolean
PrintChargerAppDbgMsgToFile	If TRUE, enables the QTI charger app file logs and respective pmic.dxe charger logs and saves them to a file.	FALSE	LogFS partition availability	Boolean
EnableChargerFGDump	Enables PMIC Charger and Fuel Gauge peripheral dumps (if TRUE).	FALSE	PrintChargerAppDbgMsg PrintChargerAppDbgMsgToFile	Boolean

Entry	Description	Default	Dependency	Data Format
FG and FG debug				
BatteryIdTolerance	Reads the battery ID to load the battery profile and set a tolerance limit.	8%	LoadBatteryProfile	8% +/- on current battery ID reading
DumpSram	Enables QTI charger app Fuel Gauge SRAM dumps.	FALSE	PrintChargerAppDbgMsg PrintChargerAppDbgMsgToFile	Boolean
DumpSramStartAddr	SRAM dump start address (values in decimal).	0	DumpSram	Decimal
DumpSramEndAddr	SRAM dump end address (values in decimal).	124	DumpSram	Decimal
DumpSramDuration	Dump SRAM contents timer duration in seconds.	90 s	DumpSram	Seconds
Required initially				
BootToHLOSThresholdInMv	Configures the QTI charger app threshold to allow boot.	3600 mV	None	mV
OsStandardBootSocThreshold	Configures the QTI charger app minimum threshold to allow boot.	7	LoadBatteryProfile	1-100% SOC
BattVoltLimHighDelta	Enables delta float voltage (FV) and current limit to charge the battery.	30 mV	None	mV
ChgFvMax	Enables battery FV.	4350 mV	None	mV
ChgFccMax	Enables fast charging current.	2000 mA	None	mA
ChargingTermCurrent	Enables charger termination current to declare 100% SOC.	200 mA	None	mA
ConservChgFvDelta	Enables maximum charger delta FV maximum for unknown battery configurations.	200 mV	None	mV
BATT_THERM coefficients	Enables battery thermal coefficients to read the battery temperature accuracy.	See Section 4.7.8	ProgramBattThermCoeffs=TRUE	Hexadecimal

Entry	Description	Default	Dependency	Data Format
AUX_THERM coefficients	Enables auxiliary thermal coefficients to adjust voltage to the temperature mapping.	See Section 4.7.9	ProgramAuxThermCoeffs=TRUE	Hexadecimal
Device skin and charger hot thresholds	Enables configuring device skin and charger hot thresholds.	See Section 4.7.10	ProgramSkinAndChargerHot Threshold = TRUE	Hexadecimal
EmergencyShutdownVbatt	Configures the device emergency shutdown limit.	3200 mV	None	mV
EnableChargerWdog	Enables the charger watchdog to safeguard unintentional charging if the software gets stuck.	TRUE	None	Boolean
VBtEmpty threshold	Configures the low battery voltage threshold for the SOC empty interrupt.	2800 mV	None	mV
VBattEstDiffThreshold	Configures the estimated voltage difference threshold to restart the FG if the threshold difference is higher.	30 mV	FgCondRestart	mV
Battery error handling				
DebugBoardBatteryIdMin and DebugBoardBatteryIdMax	Specifies the debug board battery ID range.	2000-14000	DebugBoardBehavior	Ohms
SmartBatteryIdMin and SmartBatteryIdMax	Specifies the smart battery ID range.	240000-450000	None	Ohms
RegularBatteryIdMin and RegularBatteryIdMax	Specifies the regular battery ID range.	15000-137000	None	Ohms
UnknownBatteryBehavior	Defines unknown battery behavior. Detects if the battery ID is within the specified range.	BattID < 2000 and ID > 450000	Battery error handling configuration	Ohms
DebugBoardBehavior	Defines debug board battery behavior.	2	Battery error handling configuration	Decimal
BattMissingCfg	Configures the battery missing detection behavior.	0	None	Decimal

Entry	Description	Default	Dependency	Data Format
Jeita				
Jeita zones	Enables specified Jeita zones.	See Section 4.9	None	Celsius
JeitaCcCompCfg	Enables configuring Jeita charge current compensation when the device is within the battery temperature soft-limit for hardware Jeita.	1000 mA	None	mA
JeitaFvCompCfg	Enables configuring Jeita charge voltage compensation when in device is in battery temperature soft-limit for hardware Jeita.	105 mV	None	mV
NoChargeAndWait	Configures device behavior for temperatures outside of the charging range but within the operating range.	TRUE	None	Boolean
WiPower				
WiPowerSupported	Enables configuring WiPower support for the QTI charger app charging device.	TRUE	None	Boolean
DCInBootToHLOSThresholdInMv	Enables configuring the WiPower threshold for QTI charger app charging.	3600 mV	None	mV
SuspendDCIn	Enables configuring suspended DCIN behavior when WiPower is enabled.	FALSE	None	Boolean
Thermal				
SWThermalMitigationEnable	Configures thermal safety mitigation in the QTI charger app charging device.	FALSE	None	Boolean
TsensTimeoutMins	Configures a thermal safety timer when the device is in the thermal zone and not in charger wait state.	30 min	None	Minutes
Tsens limits or zone	Configures thermal safety zones or limits.	See Section 4.11.3	None	Celsius

4.4 Threshold charging configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.4.1 SocOrVoltageBaseBoot

Sets the thresholds in QTI charger app to allow boot when the configured threshold is met. The threshold can be voltage or SOC-based.

Default value – FALSE (indicates the voltage-based thresholds charging).

NOTE: To allow accurate SOC estimates during charging, this parameter must be to set to the LoadBatteryProfile configuration.

4.4.2 LoadBatteryProfile

Loads the battery profile for battery state of charge (SOC) accuracy. If enabled, QTI charger app loads profile data to the fuel gauge first.

Default value – TRUE (indicates voltage-based thresholds charging).

NOTE: This configuration might add a delay of ~1.5 sec to boot while the profile loads and the SOC estimate is calculated. DispSignOfLifeMaxThresholdMv configuration shows sign of life while loading battery profile. This delay/wait only applies to cold boot or battery removal.

The FG SRAM profile integrity status dedicated register contains the profile load and FG restart status.

4.4.3 DispSignOfLifeMaxThresholdMv

Displays the sign of life during battery profile load, providing a user indication for cold boot. If the LoadBatteryProfile parameter is enabled, QTI charger app shows sign of life and loads the profile first.

Default value – 3700 mV (used to decide on displaying image)

Dependency – LoadBatteryProfile must be set for an accurate SOC estimate during charging.

4.4.4 FgCondRestart

Decides if the fuel gauge must be restarted to allow battery accuracy for the following condition:

```
If abs(Vbatt_Estimate_diff ) > Vbatt_Estimate_diff_threshold
```

Default value – TRUE

Dependency – LoadBatteryProfile must be set.

4.4.5 ChargerLedConfig

Configures the charger LED status.

Supported values:

0 = Disable

1 (default) = Solid during charging

2 = LED blinks during charging

NOTE: If enabled, the LED turns off after threshold charging is complete, i.e., when the device boots to HLOS.

4.5 Debug configuration

Debug configuration only works on non-production builds. Refer to Section 4.12 for a QTI charger app LA example file.

4.5.1 PrintChargerAppDbgMsg

If TRUE, enables QTI charger app logs and respective pmic.dxe charger logs and displays them on UART.

Default value – FALSE (excludes extensive charging logs and only displays battery status information on UART for general users).

Example charger log

```
 ------------------------------
 - 0x09C0AD000 [16004] QcomChargerApp.efi
QcomChargerApp:: QcomChargerApp_MonitorCharging
TimeStamp,StateOfCharge,Voltage,ChargeCurrent,Temp
16, ChargerApp:: Battery Status 1,3536,206,25
Waiting for 3 sec
0x2B, ChargerApp: Battery Status 17,3732,-1072,24
Waiting for 3 sec
```

4.5.2 PrintChargerAppDbgMsgToFile

If TRUE, enables QTI charger app file logs and respective pmic.dxe charger logs and saves them to a file.

Default value – FALSE (indicates excludes extensive charging logs and only displays battery status information on UART for general users).

If file log configuration is enabled, the chargerlog.txt and pmiclog.txt files are generated in the debug LogFS 8 MB partition.

When the file size reaches its limit, this configuration acts as a circular buffer and starts overwriting old logs.

The chargerlog.txt file has the charger and boot configuration. The pmiclog.txt file has fuel gauge and charger-related information, e.g., SRAM dumps.

4.5.3 EnableChargerFGDump

Enables PMIC charger and FG peripheral dumps (if TRUE). Dumps also occur during the Charger app initialization and exit. Dumps are initiated if any key is pressed while charging.

Default value – FALSE

Dependency – PrintChargerAppDbgMsg charger logs must be enabled.

4.6 FG and FG debug configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.6.1 BatteryIdTolerance

Battery ID tolerance limit to load the battery profile against the battery ID reading.

If the battery ID falls into tolerance range, only the respective profile with that battery ID is flashed to the fuel gauge. Otherwise, the default profile is loaded from the battery profile file, which is the first profile. QTI charger app includes eight profile supports.

Default value – 8%

4.6.2 DumpSram

Enables QTI charger app Fuel Gauge SRAM dumps. If enabled (TRUE), QTI charger app periodically dumps SRAM to get debug information from hardware FG algorithms.

Default value – FALSE

Dependency – PrintChargerAppDbgMsg charger logs must be enabled.

4.6.3 DumpSramStartAddr

SRAM dump start address (values in decimal).

4.6.4 DumpSramEndAddr

SRAM dump end address (values in decimal).

4.6.5 DumpSramDuration

Dump SRAM contents timer duration in seconds.

Default value – 90 sec

4.7 Initial required charger configuration

See Section 4.12 for a QTI charger app LA example file.

4.7.1 BootToHLOSThresholdInMv

Configures the QTI charger app threshold to allow boot. This threshold is also used for unsupported batteries or battery emulators.

Default value – 3600 in MV

4.7.2 OsStandardBootSocThreshold

Configures the QTI charger app minimum threshold to allow boot. This threshold is not used in unsupported batteries or battery emulators.

Default value – 7 % SOC

Dependencies:

- SocOrVoltageBaseBoot = TRUE
- LoadBatteryProfile = TRUE

4.7.3 BattVoltLimHighDelta

Enables delta float voltage (FV) to charge the battery.

Default value – 30 mV

4.7.4 ChgFvMax

Enables battery FV.

Default value – 4350 mV

4.7.5 ChgFccMax

Enables fast charging current.

Default value – 2000 mA

4.7.6 ChargingTermCurrent

Enables charger termination current to declare 100% SOC.

Default value – 200 mA

4.7.7 ConservChgFvDelta

Enables maximum charger delta FV maximum for unknown battery configurations.

Default value – 200 mV

4.7.8 BATT_THERM coefficients

Enables battery thermal coefficients to read the battery temperature accurately. Picked up as per ThermBias value per device/battery and initial values given are formatted with half-float encoding. Contact systems if these values must be updated. Refer to the BATT_THERM master beta coefficient table in *Understanding PMI8998 Fuel Gauge* (80-VT310-138).

Default values:

BattThermC1 = A1

BattThermC2 = 50

BattThermC3 = FF

Values are based on the following ThermBias and pull up resistor value:

```
BattThermHalfRangeInC = 25
```

Dependency – ProgramBattThermCoeffs = TRUE

4.7.9 AUX_THERM coefficients

Enables auxiliary thermal coefficients to adjust voltage to the temperature mapping. Temperature mapping is based on the beta 3435 of the thermistor in use and the associated temperature to 50% ratio (dependent on the pull up value). Refer to the AUX_THERM master beta coefficient table in *Understanding PMI8998 Fuel Gauge* (80-VT310-138).

Default values:

AuxThermC1 = BF

AuxThermC2 = 36

AuxThermC3 = FF

Values are based on the following ThermBias and pull up resistor value:

```
AuxThermHalfRangeInC = 25
```

Dependency – ProgramAuxThermCoeffs = TRUE

4.7.10 Device skin and charger hot thresholds

Enables configuring device skin and charger hot thresholds. Device skin temperature is usually on device display. Charger hot thresholds are used for thermal mitigation via intelligent negotiation for optimum voltage (INOV).

Default values:

DeviceSkinHotInC = 70

DeviceSkinTooHotInC = 80

ChargerHotInC = 80

ChargerTooHotInC = 90

Dependency – ProgramSkinAndChargerHotThreshold must be TRUE.

4.7.11 EmergencyShutdownVbatt

Configures the device emergency shutdown limit. QTI charger app monitors charge current (less than 0 mA) and battery voltage (less than 3.2) for three consecutive reads before initiating emergency shutdown to safeguard the battery.

Default value – 3200 mV

4.7.12 EnableChargerWdog

Enables the charger watchdog to safeguard unintentional charging if the software gets stuck. Charging becomes disabled if the watchdog is configured. Software must pet the watchdog based on its set expiration limit.

Supported values:

0 – Do not enable the charger watchdog.

1 (default) – Enable the charger watchdog during charging and disable before exiting.

2 – Enable the charger watchdog during charging and leave enabled when exiting.

4.7.13 VBtEmpty threshold

Configures the low battery voltage threshold for the SOC empty interrupt.

Default value – 2800 mV

```
VBtEmpty = 2800
```

4.7.14 VBattEstDiffThreshold

Configures the estimated voltage difference threshold to restart the FG if the threshold difference is higher.

Default value – 30 mV (Vbatt_Estimate_diff_threshold)

Dependency – FgCondRestart

4.8 Battery error handling configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.8.1 DebugBoardBatteryIdMin and DebugBoardBatteryIdMax

Specifies the debug board battery ID range. If the voltage associated with the battery ID falls below the range, QTI charger app handles the battery as a debug board based on Vbatt > boot threshold (3.6 V) allow boot to HLOS. Otherwise, shut down.

Default value – 2000-14000

Dependency – DebugBoardBehavior

See also BootToHLOSThresholdInMv

4.8.2 SmartBatteryIdMin and SmartBatteryIdMax

Specifies the smart battery ID range. QTI charger app handles the battery as a smart battery based on Vbatt > 3.6 V allow boot to HLOS. Otherwise, continue charging until the configured threshold is reached.

Default value – 240000-450000 Ohms smart battery ID range.

See also BootToHLOSThresholdInMv

4.8.3 RegularBatteryIdMin and RegularBatteryIdMax

Specifies the regular battery ID range. QTI charger app handles the battery as a regular board based on Vbatt > 3.6 V and allows boot to HLOS. Otherwise continue charging until the configured threshold is reached.

Default value – 15000-137000 regular battery ID range, value in Ohms

4.8.4 UnknownBatteryBehavior

Defines unknown battery behavior. Detects if the battery ID is within the specified range.

Supported values:

- 0 – Shuts down the device
- 1 – Boot to HLOS if battery more than threshold else shutdown
- 2 – Conservative charging
- 3 (default) – Regular charging

4.8.5 DebugBoardBehavior

Defines debug board battery behavior.

Supported values:

- 0 – Show low battery icon, disable PON1/USBIN trigger to prevent reboot and shutdown
- 1 (default) – Show low battery icon and stay on until device is turned off by user
- 2 – Boot to HLOS

4.8.6 BattMissingCfg

Configures the battery missing detection behavior.

Supported values:

- 0 (default) – Use battery ID
- 1 – Use battery thermistor
- 2 – Use battery thermistor and ID

4.9 Jeita configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.9.1 Jeita zones

Enables specified Jeita zones. For negative values, use the negative symbol, e.g., -30.

Default values:

JeitaCriticalTempLowLimit	-20
JeitaHardColdLimit	0
JeitaSoftColdLimit	10
JeitaSoftHotLimit	45
JeitaHardHotLimit	60
JeitaCriticalTempHighLimit	70

4.9.2 JeitaCcCompCfg

Enables configuring Jeita charge current compensation when the device is within the battery temperature soft-limit for the hardware Jeita.

The Jeita compensation values are as follows:

- Minimum value – 0 mA
- Maximum value – 1575 mA
- Step size – 25 mA

Default value – 1000 mA

4.9.3 JeitaFvCompCfg

Enables configuring Jeita charge voltage compensation when in device is in battery temperature soft-limit for hardware Jeita.

The Jeita compensation values are as follows:

- Minimum value – 0 mV
- Maximum value – 472.5 mV
- Step size – 7.5 mV

Default value – 105 mV

4.9.4 NoChargeAndWait

Configures device behavior for temperatures outside of the charging range but within the operating range.

Supported values:

TRUE (default) – Disable charging and wait

FALSE – Shutdown the device if the temperature is outside of the charging range

4.10 WiPower configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.10.1 WiPowerSupported

Enables configuring WiPower support for the QTI charger app charging device.

Default value – TRUE

4.10.2 DCInBootToHLOSThresholdInMv

Enables configuring the WiPower threshold for QTI charger app charging.

Default value – 3600 mV

4.10.3 SuspendDCIn

Enables configuring suspended DCIN behavior when WiPower is enabled in QTI charger app charging.

Default value – FALSE

4.11 Thermal configuration

Refer to Section 4.12 for a QTI charger app LA example file.

4.11.1 SWThermalMitigationEnable

Enables configuring thermal safety mitigation in the QTI charger app charging device.

Mitigation is based on the MSM Tsens maximum average temperature reading.

Default value – FALSE

4.11.2 TsensTimeoutMins

Enables configuring a thermal safety timer when the device is in the thermal zone and not in charger wait state. The device waits for the configured wait time and initiates shutdown if thermal conditions do not normalize.

Default value – 30 min (give up time in thermal wait for battery disconnect – Max 60 min)

4.11.3 Tsens limits or zone

Enables configuring thermal safety zones or limits. If the temperature is above the extreme temperature limit, the device performs automatic fault protection (AFP).

If the Tsens temperature limit is within the specified wait range (e.g., 75-90 min), the QTI charger app waits 30 min (polling every 3 sec) to allow the device to cool down. The device performs AFP after the 30 min expiration.

Default values:

Parameter	Temp (°C)	Description
TsensHighTemp	85	High temperature limit for thermal wait
TsensExtremeTemp	90	High temperature limit for battery and device safety on battery disconnect
TsensLowTemp	75	Low Temperature limit for end of thermal wait

4.12 Example configuration file

QTI charger app configuration file for LA is as follows:

```
#
# Default Charger App Config settings
#
[CHARGER Config]

#
# Version/Information:
# file ChargerApp_VbattTh_8998.cfg
#
# Implements the Qualcomm's Charger application config parameters
#
# Copyright (c) 2016,  Qualcomm Technologies Inc. All rights reserved.
#
#      1 : Initial revision
#      2 : Deleting not needed config params and removing dummy battery2
support
#      3:  Adding Jeita Compensation params
#      4 : Adding parameters for different battery types and QC 3.0 and QC
2.0 chargergers
#      5 : Added parameter to support enabling watchdog when charging is
enabled
#      6 : Adding parameters for Aux Coffes, SkinHot and Charger Hot
settings
#      7 : Update for Battery profile load
#      8 : Added SupportHostMode
#      9 : Adding Thermal configs
#     10 : Adding support for Charger Fg Peripheral dumps
#     11 : Adding HVDCP Enable control
#     12 : Adding WIPOWER configs
#     13 : Removed config item for setting IUSB_MAX in case of SDP
#     14 : Adding Restarting FG flag
#     15 : Adding Charger led indication config, rasing skin hot to 70-80C,
disabling watchdog as default
#     16 : Added changes for supporting different platforms, MTP, QRD, etc.
CfgVersion = 17
```

```
--- Threshold Charging Configurations --
#Use Battery SOC or voltage as threshold charging criteria
#Voltage is default
SocOrVoltageBaseBoot = FALSE

#Load Fuel Gauge Battery Profile profile for SOC estimation and accuracy
LoadBatteryProfile   = FALSE

#Below VBAT threshold is used to decide on showing sign of life first
before FG Module Initialization and continuing with threshold charging
DispSignOfLifeMaxThresholdMv = 3700

# FG Conditional Restart on Device reset
FgCondRestart = TRUE

# Charging status indication via led
# 0 = Disable 1 = solid during charging 2 = led blinks during charging
# if turned on LED will be turned off after threhsold charging is completed
i.e. when device boot to HLOS
ChargerLedConfig = 1

--- Threshold Charging Configurations End --

--- Debug Configurations --

# Print Charger DEBUG Messages
PrintChargerAppDbgMsg = FALSE

#Print Charger DEBUG Messages to ULOG File..Default is false
PrintChargerAppDbgMsgToFile = FALSE

#Enable/disable Charger/FG Dump support
EnableChargerFgDump = FALSE

--- ----Debug FG Configurations ------
#dump SRAM contents Default value – FALSE
DumpSram = FALSE

#dump SRAM Start and End Address in Hex Format
#SRAM Block    SRAM Address
#System        0x00 - 0x17
#Profile       0x18 - 0x3C
#Scratchpad    0x50 - 0x7C
#values in decimal
DumpSramStartAddr = 0
#values in decimal
DumpSramEndAddr   = 124
```

```
#dump SRAM contents timer Duration in s
DumpSramDuration = 90
--- ---- Debug FG Configurations End -----

--- Debug Configurations End --

--- Battery Error Handling Configurations  --
#Battery ID Tolerance Percentage 8%
BatteryIdTolerance = 8

#Debug board ID range, value in Ohms
DebugBoardBatteryIdMin = 0
DebugBoardBatteryIdMax = 14000

#Regular battery ID range, value in Ohms
RegularBatteryIdMin = 15000
RegularBatteryIdMax = 137000

#Smart battery ID range, value in Ohms
SmartBatteryIdMin = 240000
SmartBatteryIdMax = 450000

#Support unknown battery charging behavior
# 0: Shuts down device,    1: Boot to HLOS if battery more than threshold
else shutdown
# 2: Conservative Charging 3: Regular charging
UnknownBatteryBehavior = 3

#Debug board behavior
# 0: Show low battery icon, disable PON1/USBIN trigger to prevent reboot
and shutdown
# 1: Show low battery icon and stay on until device is turned off by user.
# 2: Boot to HLOS
DebugBoardBehavior = 2

#Battery missing config
# 0 = using batt id 1 = using batt therm 2 = both
BattMissingCfg = 0

--- Battery Error Handling Configurations End --
```

```
--- Jeita Configurations --

# Configure limits for Battery Temperature (For negative values, use
negative sign. Ex: -30)
JeitaCriticalTempLowLimit = -20
JeitaHardColdLimit = 0
JeitaSoftColdLimit = 10
JeitaSoftHotLimit  = 45
JeitaHardHotLimit  = 60
JeitaCriticalTempHighLimit = 70

#JEITA Charge Current Compensation when in battery temperature soft-limit
#JEITA CC = min is 0 ma and max is 1575 ma - step size is 25mA
JeitaCcCompCfg = 1000

#JEITA Float Voltage Compensation when in battery temperature soft-limit
#min is 0 and max .4725 V step size is 7.5 mV - unit is in mV
JeitaFvCompCfg = 105

#device behaviour if temp is outside charging range but within operational
range
# 1= Disable charging and wait. 0 = Shutdown device is temp outside
NoChargeAndWait =  TRUE

--- Jeita Configurations End --

--- Initial Configurations  --
#Boot device to HLOS in case of unsupported battery or battery emulator. In
millivolt*/
BootToHLOSThresholdInMv = 3600

#Minimum SOC Threshold before allowing to boot to HLOS
#below param is considered only when SocOrVoltageBaseBoot = TRUE and
LoadBatteryProfile = TRUE
OsStandardBootSocThreshold = 7

# Configure Battery Voltage and Current limit
BattVoltLimHighDelta = 30
# Configure VddMax and IbatMax values
# Set to 0 to configure through API
ChgFvMax  = 4350
ChgFccMax = 2000

#Charging termination current in milliamps
ChargingTermCurrent = 200

# Voltage (in mV) to be reduced from FV_MAX during conservative charging
ConservChgFvDelta  = 200
```

```
#Program THERM coeffs ..
#Picked up as per ThermB value per device/battery and initial values are
given in HALF encoded
ProgramAuxThermCoeffs = TRUE
AuxThermC1           = A0
AuxThermC2           = 4F
AuxThermC3           = CF

#based on ThermB and pull up resistor value
AuxThermHalfRangeInC = 25

#Program device Skin and Charger Hot thresholds
ProgramSkinAndChargerHotThreshold = TRUE
DeviceSkinHotInC    = 50
DeviceSkinTooHotInC = 60
ChargerHotInC       = 80
ChargerTooHotInC    = 90

#Lowest Voltage at which device should shutdown gracefully
#value in mV
EmergencyShutdownVbatt = 3200

#Charger WDOG Support options
# 0: Do not enable Charger WDOG
# 1: Enable Charger WDOG during charging and Disable before exiting
# 2: Enable Charger WDOG during charging and leave enabled when exiting
EnableChargerWdog = 1

#Vbat Empty threshold in mv
VBtEmpty = 2800

--- Initial Configurations  End --

--- Thermal Configurations --
#Enable SW thermal mitigation during charging by default FALSE
# Mitigation is based on MSM Tsens max avg temp reading
SWThermalMitigationEnable = FALSE

## TSENS ##
#High Temperature limit for thermal wait
TsensHighTemp = 85
#High Temperature limit for battey and device safety (battery disconnect)
TsensExtremeTemp = 90
#Low Temperature limit for end of thermal wait
TsensLowTemp = 75
# Give up time in thermal wait for battery disconnect - support up to 60min
TsensTimeoutMins = 30
--- Thermal Configurations End --
```

```
--- WiPower Configurations  --
#support wipower or not
WiPowerSupported = FALSE

#Boot device to HLOS in case of wipower charging. In millivolt
DCInBootToHLOSThresholdInMv = 3600

#suspend DCIn or not after exiting UEFI
SuspendDCIn = TRUE
--- WiPower Configurations End --
#
#  End of config
#  Blank line needed after the last config
#
```

5 QTI charger app WP configuration

TBD

A References

A.1 Related documents

Title	Number
Qualcomm Technologies, Inc.	
Understanding PMI8998 Fuel Gauge	80-VT310-138

A.2 Acronyms and terms

Acronym or term	Definition
AFP	automatic fault protection
BDS	Boot device selection
FG	Fuel gauge
FV	Float voltage
GUID	Globally unique identifier (GUID) 128-bit number used to identify an entity (drivers, protocols, files, etc.) within UEFI.
INF	Make file for a module that specifies the sources and dependencies.
INOV	Intelligent negotiation for optimum voltage
Module	Separate compilable code or prebuilt library consisting of INF and source code (or binary), such as drivers and libraries.
SOC	State of charge
UEFI	Unified extensible firmware interface