QUALCOMM CDMA Technologies

REDEFINING MOBILITY

PM8921™ New Peripheral SMBC and BMS Overview

80-N6817-1 A

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Revision History

Version	Date	Description
A	Jul 2011	Initial release

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- PM8921 Switch Mode Battery Charger (SMBC)
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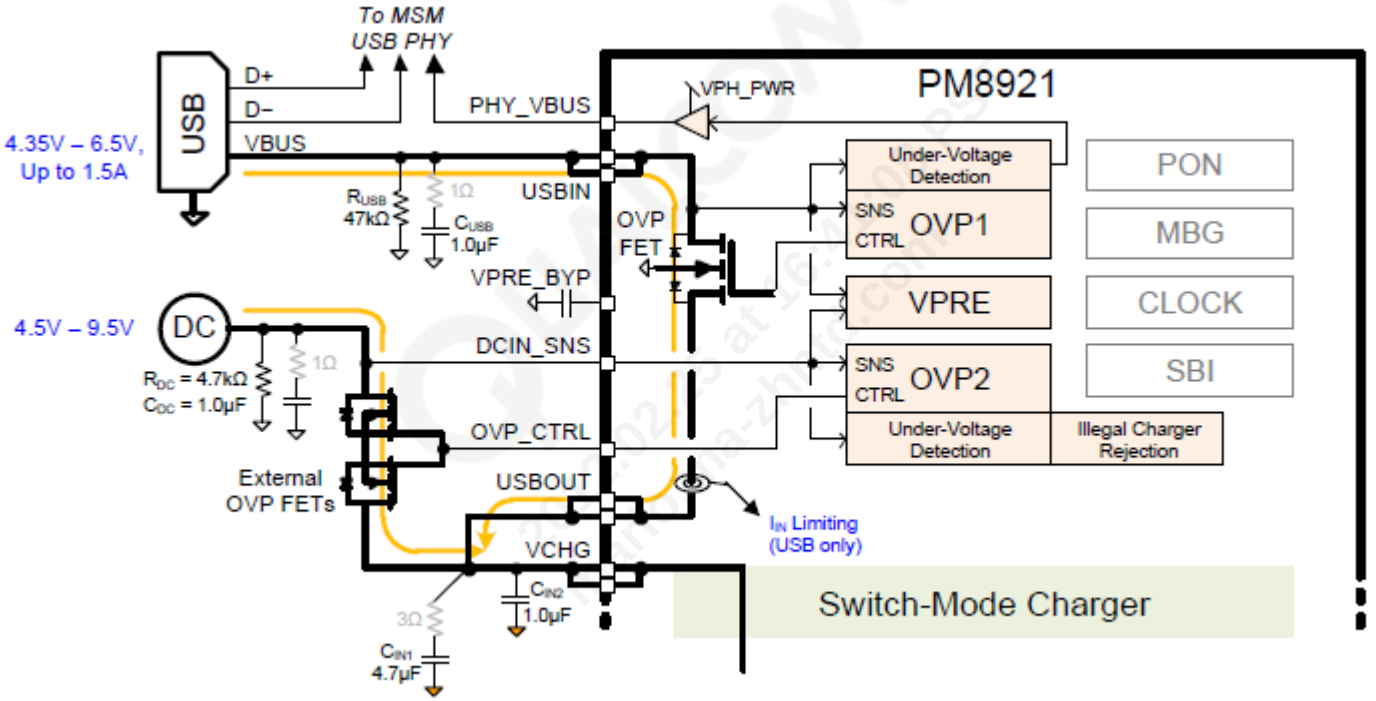
PM8921 Switch Mode Battery Charger (SMBC)

SMBC Features

- Supports single-cell Li-Ion batteries
- Supports dual charging paths
  - Primary USBIN path optimized for USB charging
  - Secondary DCIN path capable of accepting up to 10 VDC input
  - Automatic charging path selection with software priority configurability
  - +30 V Over-Voltage Protection (OVP) with fully integrated OVP FET and OVP sense/control
- Integrated switch FETs
  - Delivering up to 2A with greater than 85% efficiency
  - 1.6 MHz to 3.2 MHz programmable switching frequency

SMBC Adapter Interface Block Diagram



SMBC Features

- A couple of control loops to regulate the battery voltage/current
- Charger FSM autonomously manages the charging after software initialization
  - Trickle → Fast → Termination → Recharge
  - Allows hardware-controlled Auto Trickle Charge (ATC) for dead battery recovery
- SMBC supports the adaptive boot

ATC

- ATC is a hardware-controlled charging that is necessary when:
  - Battery voltage is too low for system boot
  - System cannot do Fast Low-Current Boot (FLCB) because of:
    - No BAT FET

      or
    - System boot current exceeds the charging source limit – USB 100 mA

Boot Timer and Adaptive Boot

- During boot, the power source may not be able to provide sufficient power for phone to complete boot
- SMBC FSM features a boot timer, which is stared when phone starts to boot
- If boot timer is not stopped before it expires, the SMBC FSM will assume the boot failed, and automatically starts the adaptive boot feature
- For adaptive boot, FSM shuts down VPH_PWR and goes to ATC if a valid charging source is present

System Features

- Enhanced battery charging safety features
  - Maximum charging timers
  - Watchdog timer
  - One-time write registers
  - Battery Over-Voltage Detection (OVD)

Hardware Watchdog

- SMBC features a hardware watchdog timer to ensure the charging control software remains alive.
- When the watchdog timer times out, it will:
  1. First generate an interrupt “bark”
  2. Then stop charging “bite” after a programmable delay (5 sec default)

Write-Once Registers (for Charging Safety)

1. The SMBC features two write-once registers:
   - CHG_VDD_SAFE – Limit the maximum voltage
   - CHG_IBAT_SAFE – Limit the maximum current
2. Any VDD_MAX or IBAT_MAX value larger than VDD_SAFE or IBAT_SAFE is ignored.
3. VBAT_SAFE and IBAT_SAFE can be written only once after PMIC power-on reset.
4. Identify the battery type before configuring the write-once registers because multiple battery types may have different chemistries (such as 4.2 V normal voltage and 4.35 V high voltage).
5. If no battery is present, it is still better to write some conservative values to the write-once registers, such as 4.2 V and 1.0 A.

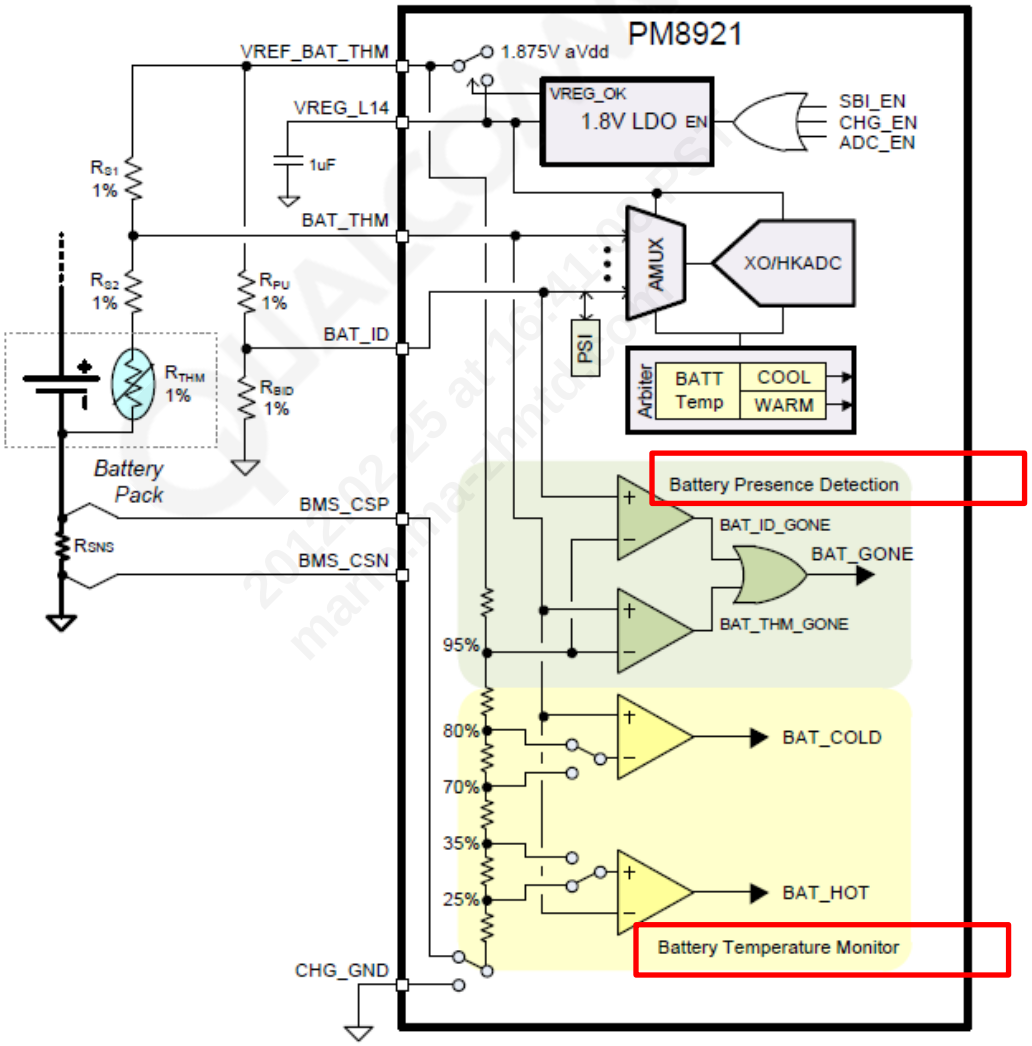
OVD

- For OVD, the VBAT_DET comparator can be used during Constant Voltage (CV) charging to detect battery over-voltage condition.
- To do OVD:
  1. Increase the VBAT_DET comparator threshold to 4.3 V when the SMBC is in CV charging and enable the VBAT_OV_IRQ.
  2. Upon VBAT_OV_IRQ, the software may generate a warning, or even reduce CHG_VDD_MAX.
  3. The VBAT_DET threshold shall be reduced to 4.1 V when the SMBC is not in CV charging, i.e., when either FAST_CHG_ON_IRQ or BUCK_VDD_LOOP_IRQ is low.

SMBC Features

- JEITA-compliant Battery Temperature Monitoring (BTM)
- Battery presence detection using battery thermistor or ID resistor
- Shared battery current-sensing resistor with battery monitoring system (fuel gauging)

SMBC Battery Interface Block Diagram

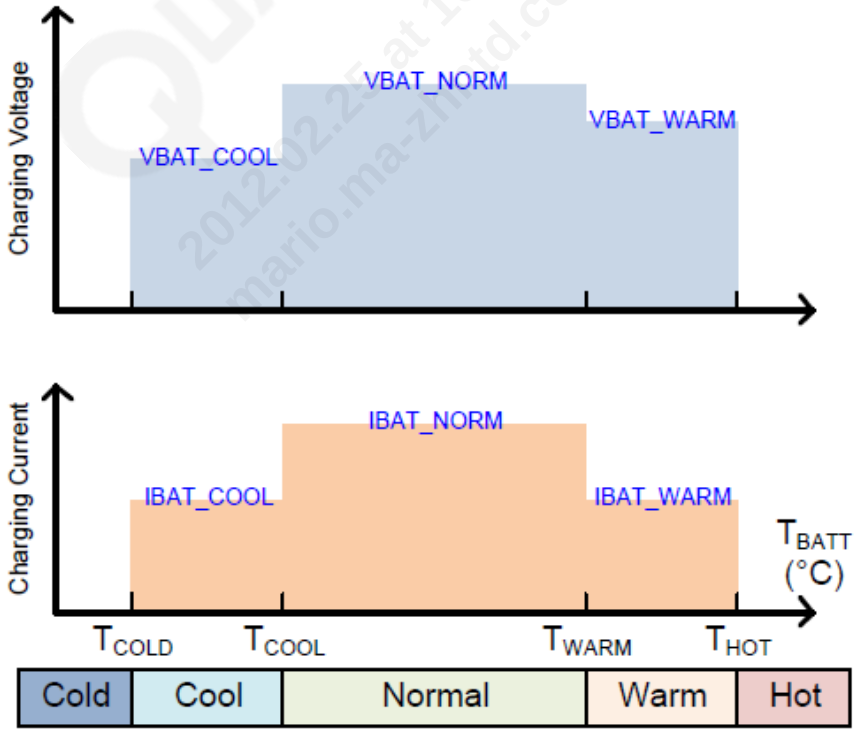


BTM

1. Charger software needs to configure the BTM parameters before enabling the hardware-managed autonomous charging.
2. SMBC BTM is enabled by setting CHG_BATT_TEMP_DIS = “0”.
3. The analog comparators continuously monitor battery thermistor voltage.
4. Charging is paused when battery is too cold or too hot.
5. Interrupts are generated to allow charger software to pause the software timers, if there are any.
6. Once BTM is configured and enabled, BTM will be active as long as the coin cell voltage, VCOIN, is above 2 V.

BTM (cont.)

- Battery temperature is automatically measured by the ADC arbiter periodically.
- Interrupts are generated if either COOL or WARM threshold is exceeded.
- Charger software needs to adjust the VBAT_MAX and IBAT_MAX accordingly.



Batter Presence Detection (BPD)

- Battery presence is detected by sensing the presence of battery thermistor or ID resistor.
- Two dedicated BPD comparators monitor the BAT_THM and BAT_ID voltage level.
- The battery is considered as gone if either one is above the 95% threshold.
- Interrupts are generated when detecting battery insertion or removal.

Battery Identification

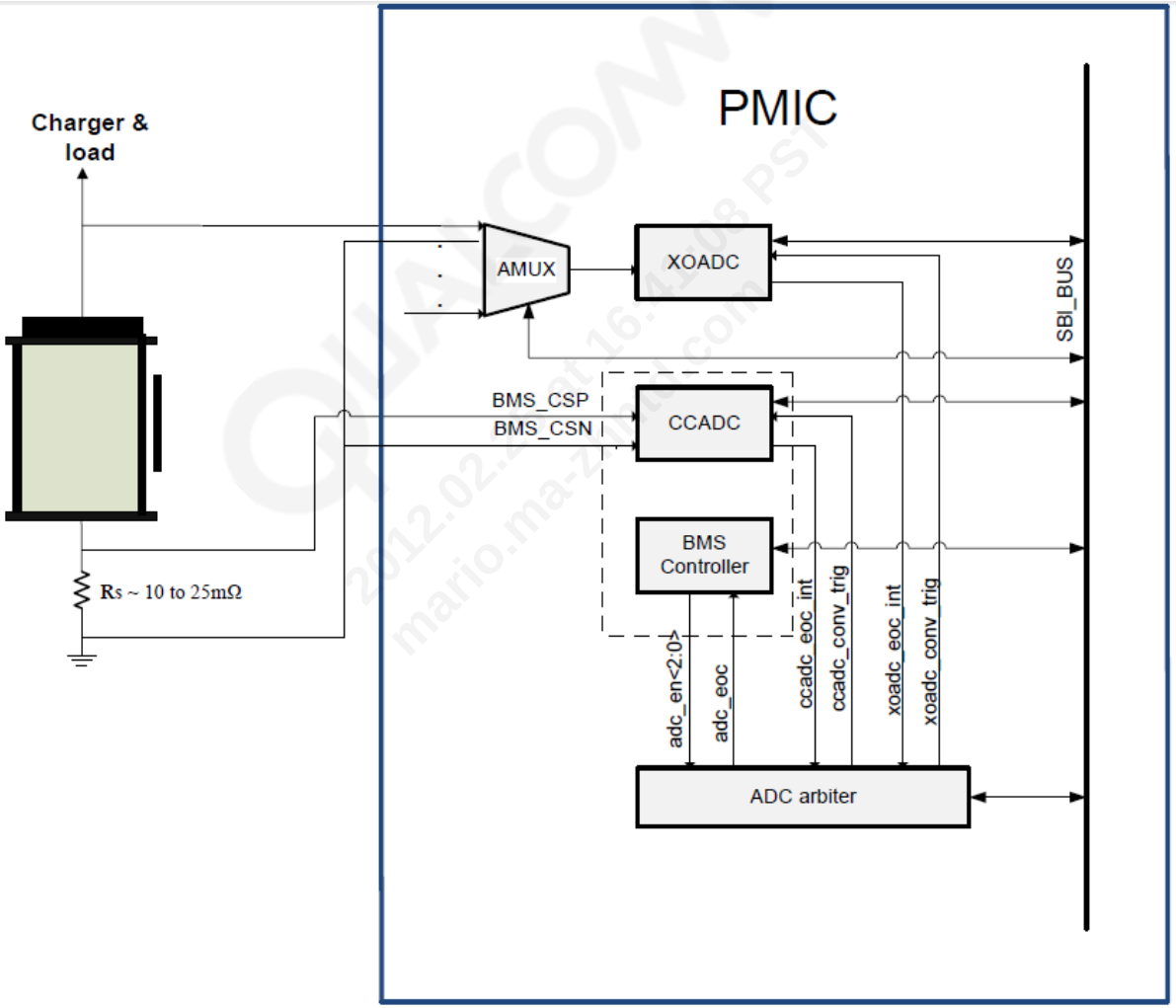
- Identifying different battery models supported by the phone is done by putting different values of resistor in different batteries.
- Software can read the ID resistor value by measuring the BAT_ID voltage using PMIC AMUX and ADC, and comparing with the pull-up resistor.
- Software can further find out the battery type by checking the prestored licensee-configurable RBAT_ID battery type look-up table.

PM8921 Battery Monitoring System

PM8921 BMS

- It is comprised of hardware and software components
- Hardware provides necessary functions to monitor the battery capacity
- Algorithm utilized in BMS is designed to work autonomously
- Software provides the ability to:
  - Configure the BMS hardware
  - Collect necessary data
  - Calculate the battery State of Charge (SoC)
  - SoC is a percentage of the remaining usable capacity on a scale from 100% to 0%.

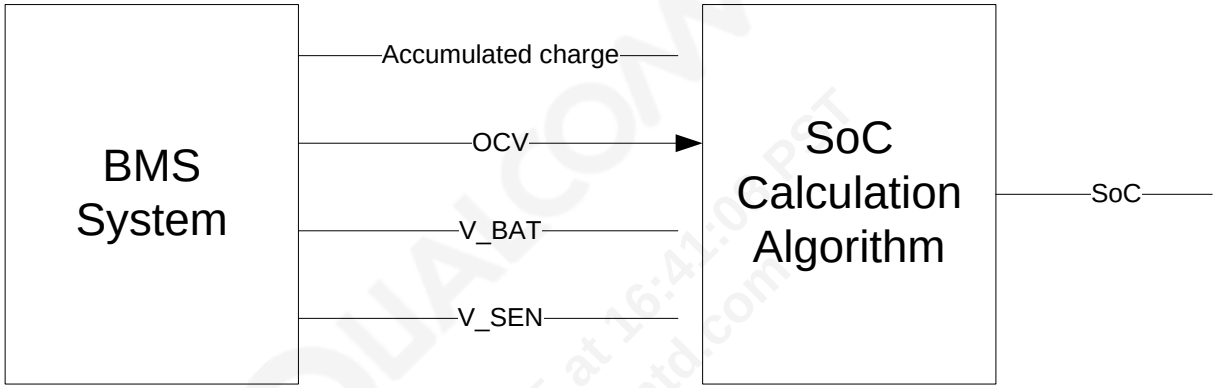
BMS Architecture



BMS Components

- CCADC – Coulomb Counter (counting accumulated charge) Analog-to-Digital Converter
  - Produces digitized Vsense
- XOADC – Crystal oscillator ADC
  - Produces digitized Vbatt
- BMS controller
  - Controls the turn-on and turn-off of the analog front end
  - Determines what data (Vsense, Vbatt) is necessary at what time for accurate SoC
  - SoC approximation software is located on a processor

BMS System Outputs



Features of BMS Module

- Automated Coulomb counting
- Coulomb counter updates from battery Open Circuit Voltage (OCV) to reduce integrated error
- User-programmability with separate settings for Active and Standby modes
- Measurement frequency – 0 ms delay to 16.5 sec delay
- Samples per averaged measurement – 1 to 512 samples
- Conditions for state changes – Thresholds and durations
- Fully internal FSM

Advantages of BMS Module

- The raw data necessary for SoC calculation is continuously provided to software.
  - No need for additional software interaction
- The end-of-line SoC software only needs to poll the outputs of the BMS controller when an update is requested from the client.
  - No other hardware-software interaction is required.

BMS Calibration Items

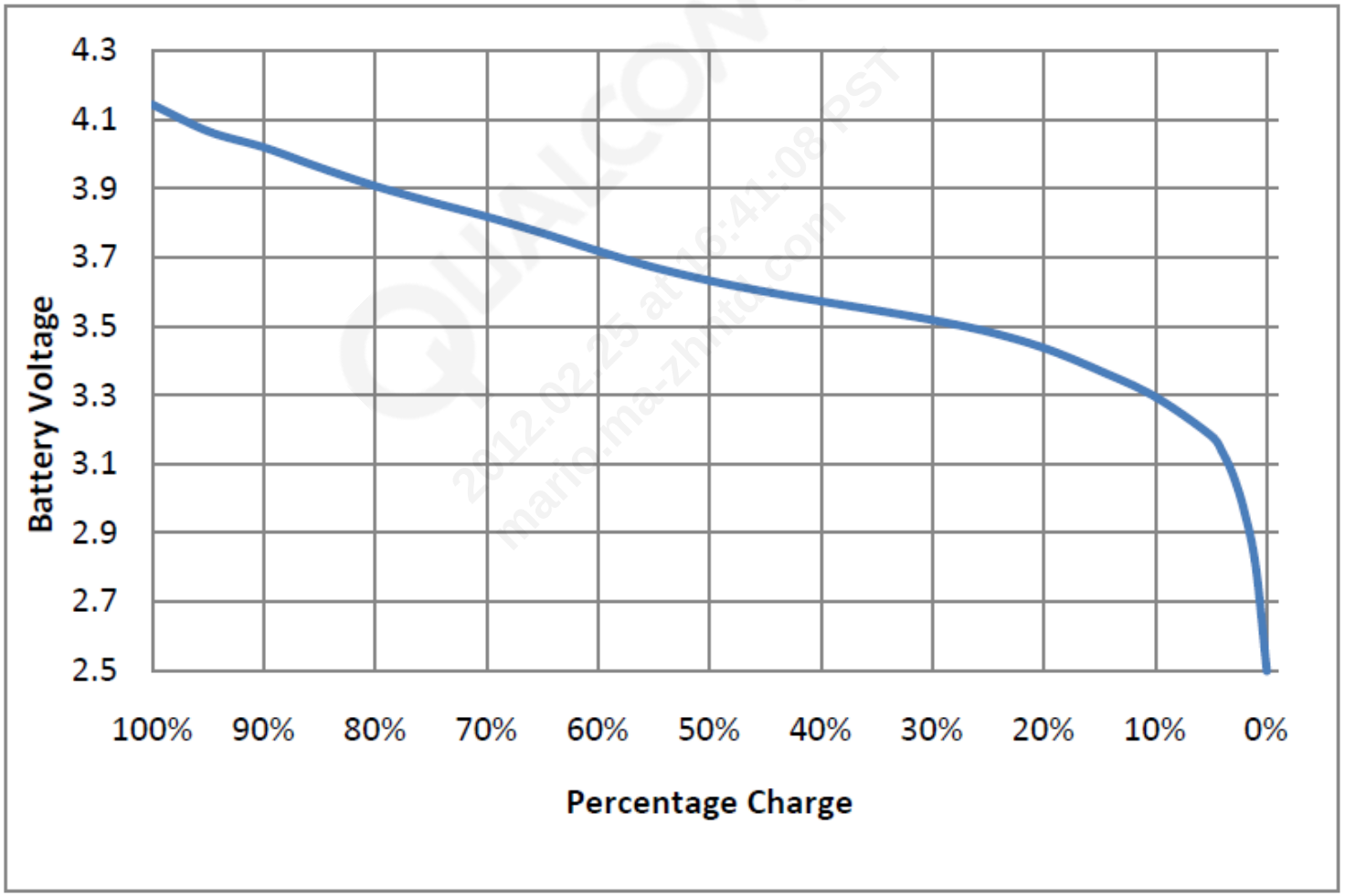
- In order to get the accurate SoC, some items are needed for calibration, such as:
  - Battery discharge profile
  - Full charge capacity
  - Battery resistance

BMS Calibration and Stored Data

- Battery discharge profile
  - Fundamental to determining SoC is the ability to map battery voltage to SoC based on the battery's discharge profile
  - Software loads unique battery discharge profiles in NV memory, and then uses this profile when calculating SoC
  - Customers will have unique discharge profiles and may desire to change the stored profile at any time
  - Profile will be used as a lookup function that returns an approximate Remaining Charge (RC) percentage when provided a voltage
  - RC vs OCV table must be stored − Ideal, temperature will be an input to this table

Diagram of Battery Voltage vs Percentage Charge

- Percentage charge = Lookup (OCV)



BMS Calibration and Stored Data

- Full Charge Capacity (FCC)
  - FCC provides necessary scaling to use Coulomb counting as part of the SoC calculation
  - Customer should provide a starting value for FCC so the BMS can immediately provide accurate SoC values
  - Since the BMS must compensate the SoC solution for temperature variations, preloading an FCC vs temperature will assist in getting accurate SoC calculations
  - If no FCC is provided, then the system will have to go through charge cycles to learn the FCC

BMS Calibration and Stored Data

- Battery resistance
  - The internal resistance of the battery is a key parameter in determining the Unusable Charge (UUC) portion of the FCC.
  - The BMS should be able to obtain a resistance measurement fairly quickly during normal operation.
  - Preloading battery resistance vs temperature will assist in getting accurate SoC calculations to the user.

References

Ref.	Document	
Qualcomm		
Q1	*Application Note: Software Glossary for Customers*	CL93-V3077-1

Questions?

https://support.cdmatech.com