MTK Battery Management
- Gauge Master 3

Revision History

Revision	Data (mm/dd/yyyy)	Author	Note
V1.0	07/21/2016	Ricky Wu	1st version for customer
V1.1	01/24/2017	Zhangshuai	Add GM3.0 Mix mode
V1.2	08/07/2017	Zhongneng	Add Auto Calibration
V1.3	04/23/2020	Mark Wang	Add more about mix mode introduction

DCC Online Gauge data

- Web side path：
  - DCC ->Smartphone ->HW Common Design Notes ->PMU ->Fuel Gauge

Introduction：

《Gauge Master 3 0 Introduce》

FG_Customization parameter design guide_V1.0_SS

Implement flow：

《Fuel Gauge Application Notes_V1.0_English_Version.pptx》

《Fuel Gauge Battery ZCV Table Test SOP》

《DTSI TOOL2.0 User Manuel》

GMAT Tool：http://online.mediatek.inc/Tool
《GM3.0_dtsi_CFG_file.rar》
《GM3.0_ZCV_Table_Template》

Preface

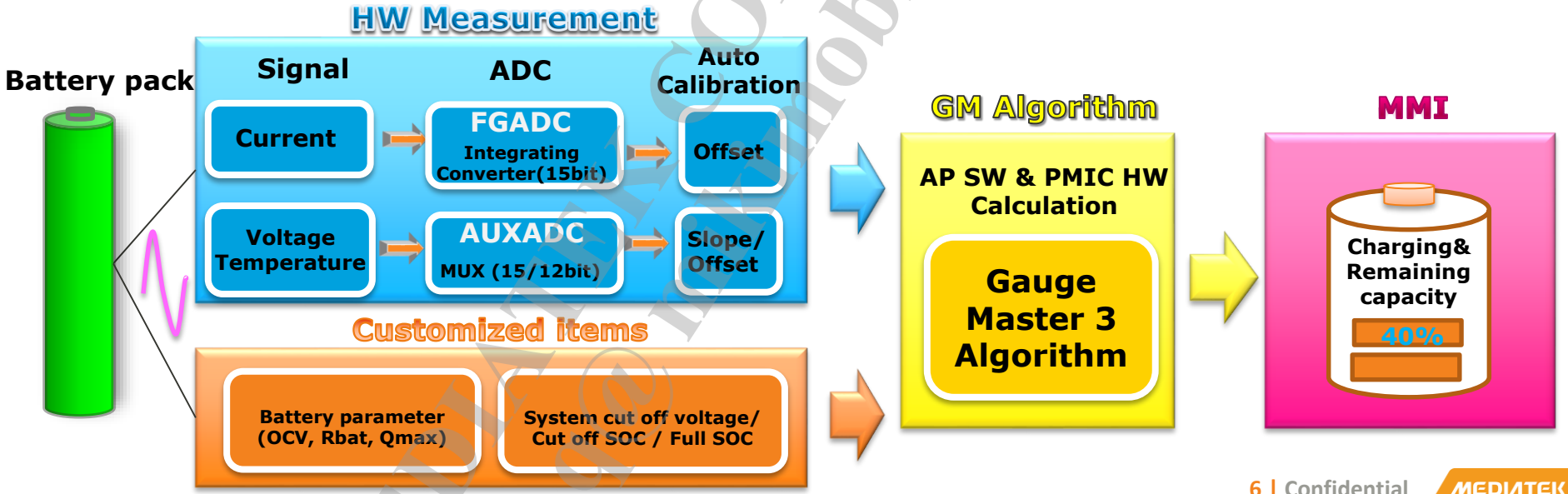
- **SOC** – Status of charge
- **DOD** – Depth of discharge, 100%-DOD=SOC
- **D0** – DOD0, initial depth of discharge
- **OCV/ZCV** – Open circuit voltage / Zero current voltage
- **Qmax** – Maximum available capacity of battery
- **Rbat** – Internal impedance of battery package

Content

- Architecture
- Compensation introduction
- UISOC optimization

MTK Gauge Master 3 System Architecture

- System-side Li-Ion battery fuel gauge SOC
  - Precise Battery Fuel Gauge
  - Battery current measurement
  - Temperature Reporting



Feature List and Comparison MTK Gauge Masters

GM 1.0

- Voltage Based
- +-10% SOC Error
- Dynamic self-adjusting SOC error
- User Experience Enhancement Package

GM 2.0

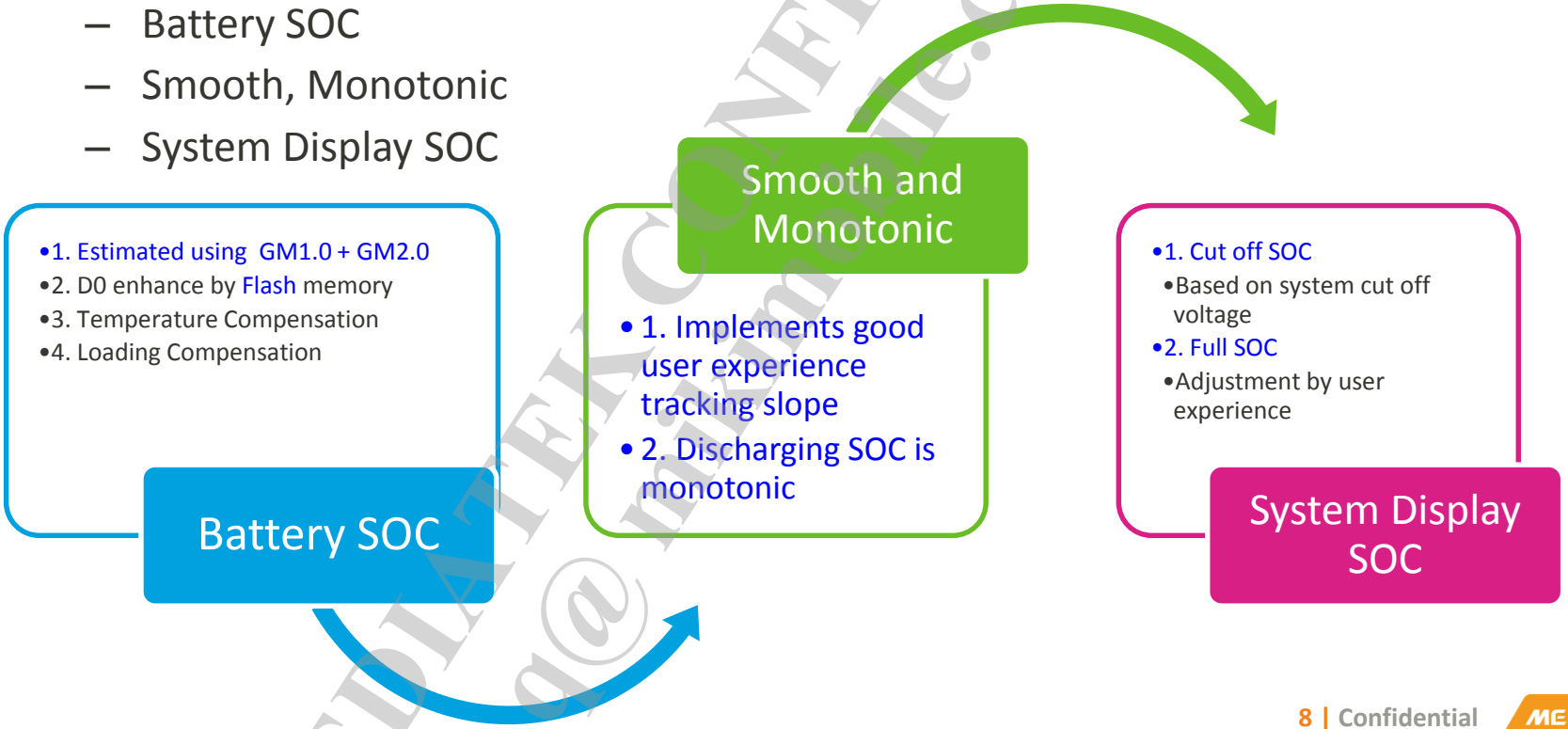
- Coulomb Counter Based
- +-3% SOC Error
- Static self-adjusting SOC error
- User Experience Enhancement Package

GM 3.0

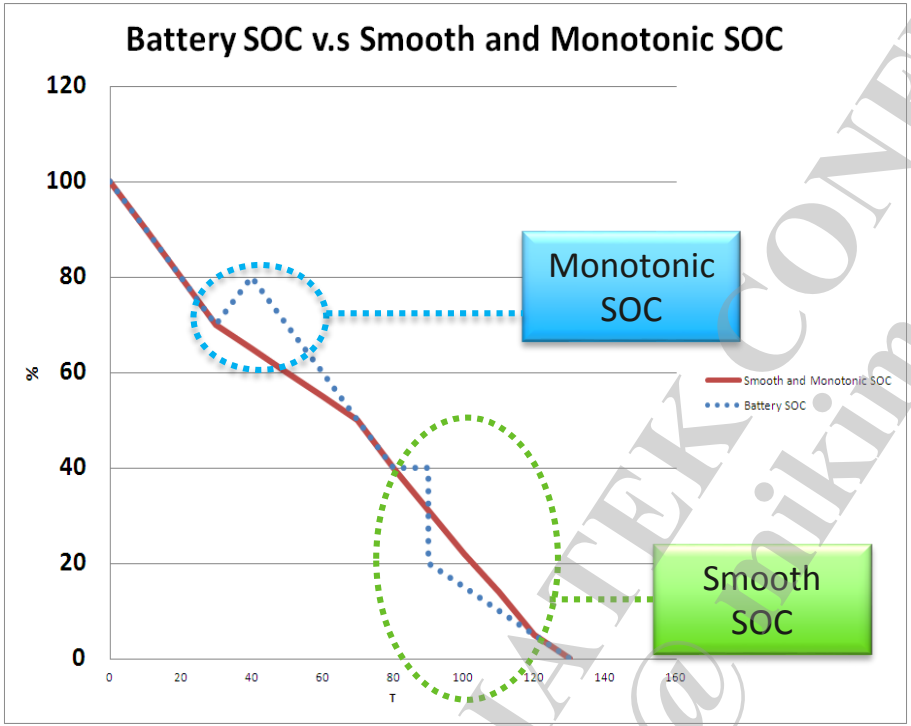
- Coulomb Counter Based+ Voltage Based
- +-1% SOC Error
- Lower power
- Factory Calibration PCB and Rsense
- Limitation Enhancement

MTK Gauge Master 3 Algorithm Overview

- **GM3 Algorithm** are three different layers of SOC
  - Battery SOC
  - Smooth, Monotonic
  - System Display SOC



Smooth and Monotonic SOC



Monotonic SOC

- Decrease only during battery discharge
- Increase only during battery charge

Smooth SOC

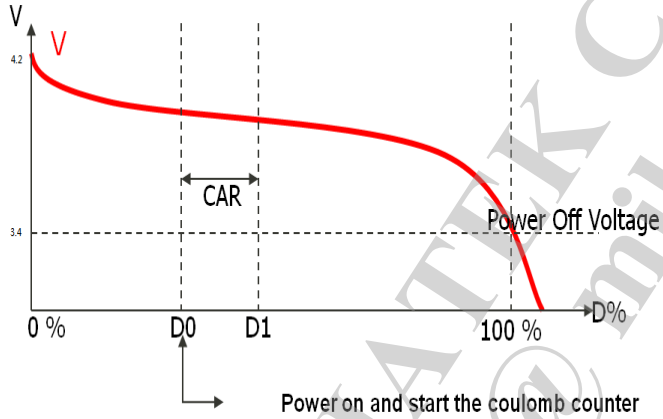
- Smooth tracking SOC depend on Loading, Qmax, SOC, Temp
- Good user experience slope

Basic Theory

- How to estimate DOD?

$$DOD1 = DOD0 + (\Delta\ car / Qmax)$$

$$SOC = 100 - D1$$

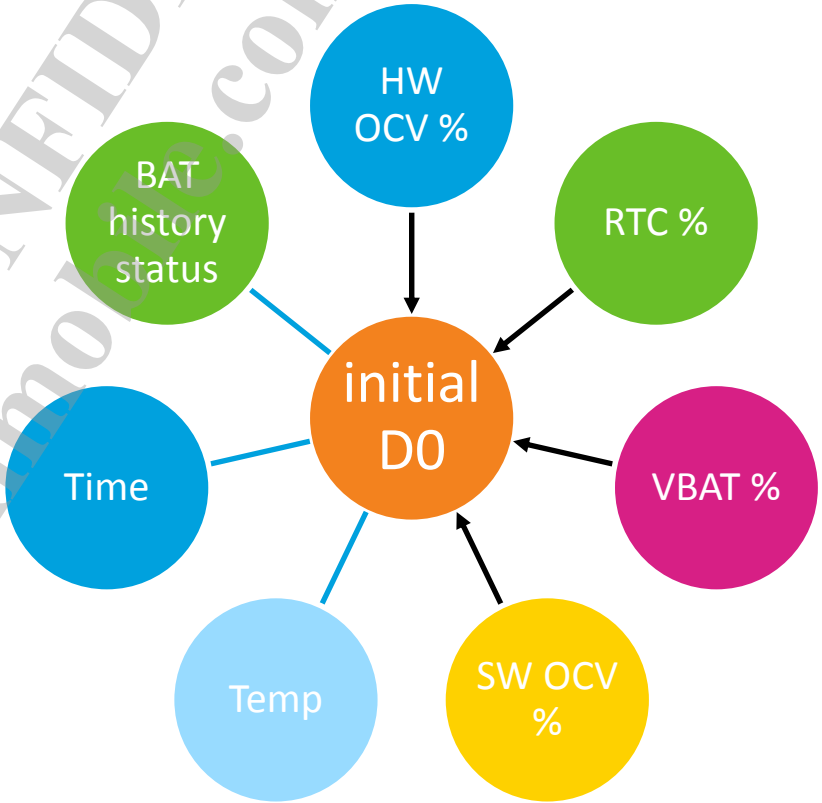


DOD0 = initial battery percentage
CAR = read from coulomb register(HW)
Qmax = battery capacity in SPEC (ex. 2000mAh)

Note 1 :
If discharging,
CAR is +, D1>D0,
% ↓ 。
If charging,
CAR is -, D1<D0,
% ↑ 。

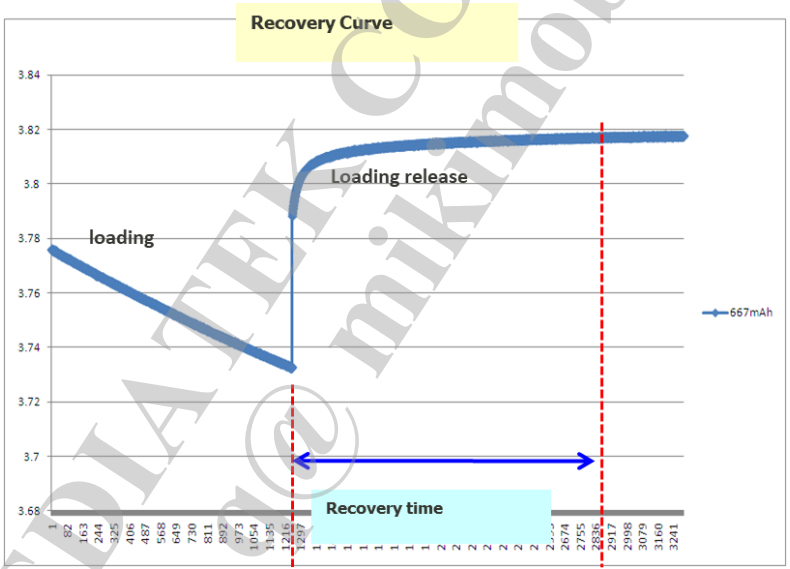
Power on off initial D0

- Initial D0 is determined by the following parameter
  - HW OCV
  - SW OCV
  - RTC Record
- Analyzing Initial D0 results by the following factors
  - HW OCV
  - SW OCV
  - RTC Record
  - Temp
  - Time
  - BAT history status



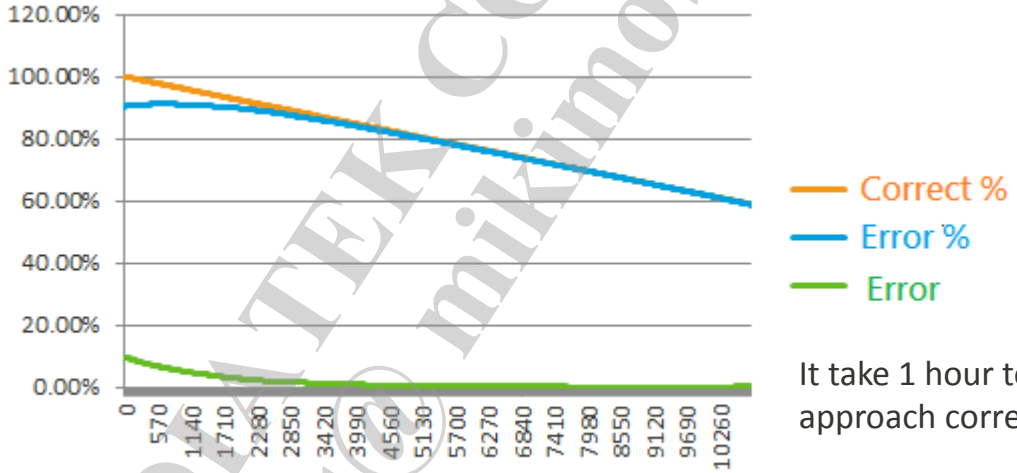
CSOC

- DOD1 = DOD0 + (△ car / Quse)
- △ car use real current measured from HW
- Disadvantage: DOD0 error (Need to wait battery stable)



VSOC

- DOD1 = DOD0 + (Δ car / Quse)
- Detect ΔV to calculate Δ car
- Advantage: auto tracking SOC error (like D0 error)



It take 1 hour to be approach correct answer

SOC and UISOC

- SOC based on CSOC and VSOC diff.

  Log: soc:9966 fg_c_soc:9966 fg_v_soc:10000 ui_soc:9995 vc_diff:-34

- UISOC based on three factors：
  - UISOC and SOC relationship
  - Qremain and discharge capacity
  - UI monotonic parameters optimization

Example:
If SOC=CSOC=VSOC=50%,UISOC=80%, Qmax=1000mAh ➔ Qremain=500mAh
Next UISOC and SOC update rate will be:
UISOC 1% decrease rate ➔ 500mAh/80%=6.25mAh
SOC 1% decrease rate ➔ 500mAh/50%=10mAh

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- UISOC optimization

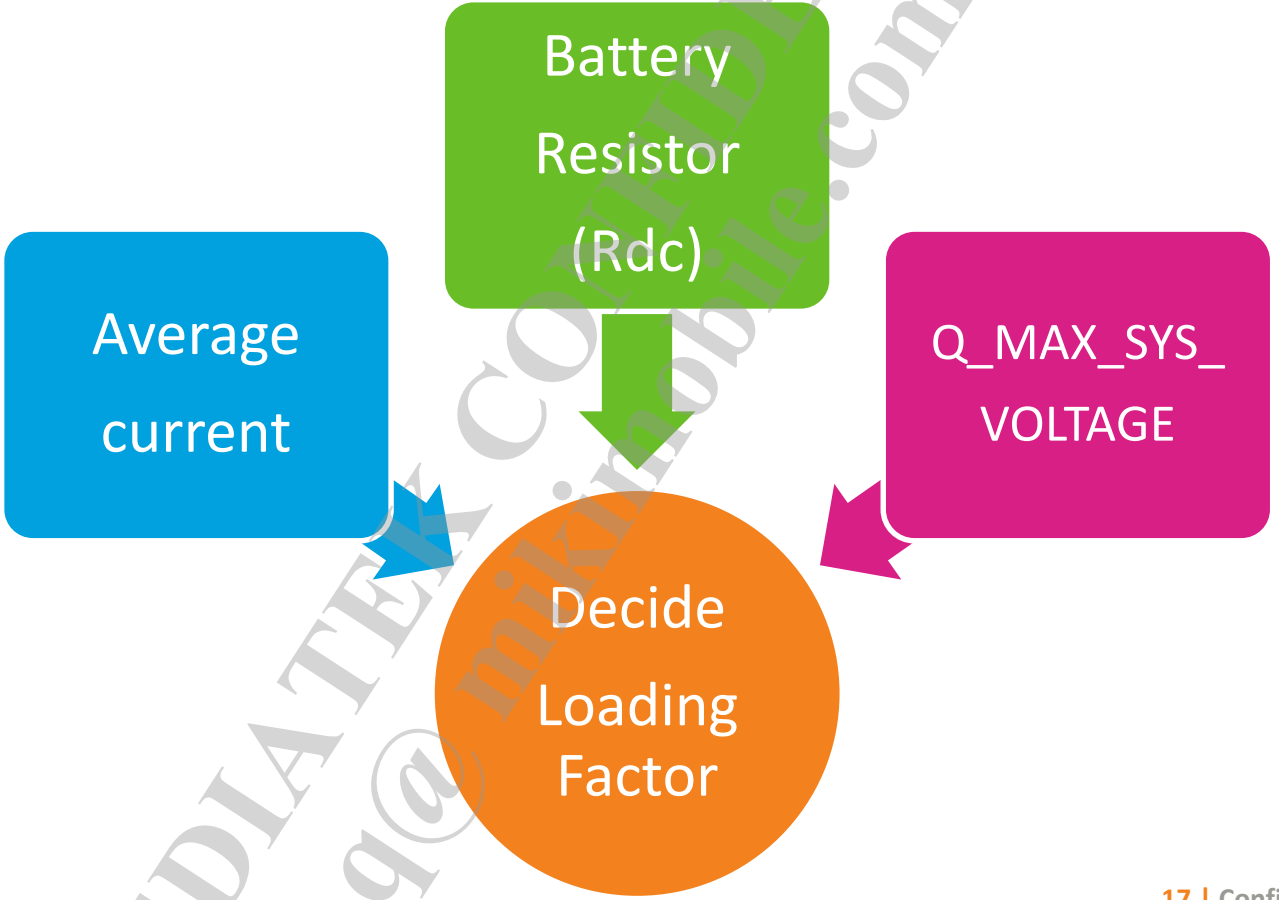
Temperature Compensation

- Based on -10 Degrees, 0 degrees, 10 degrees, 25 degrees, 50 degrees battery parameters, using interpolation to sort out the other temperature battery parameters
- Each temperature changes, algorithm dynamic sorting battery parameters for the new temperature of the battery
  - ZCV, DOD, Rbat, Qmax

For example: QMAX change by different temp.

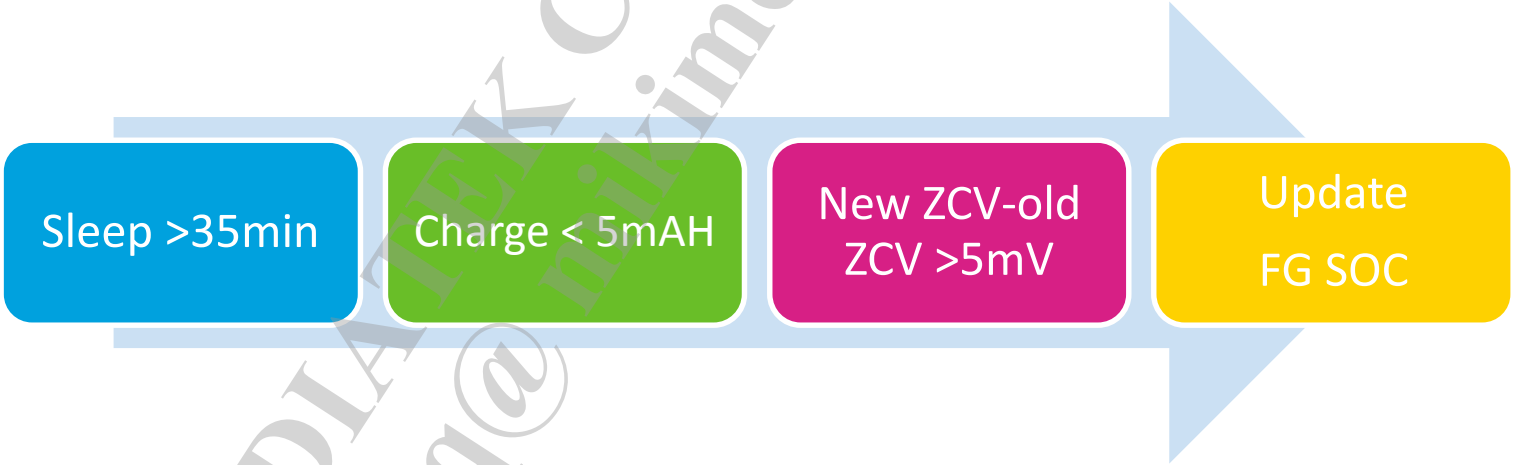
Temp (℃)	Usable Capacity (mAH)	Use Capacity (mAH)	Rest Percentage(%)
40	1020	500	(1020-500)/1020=50.9
25	1000	500	(1000-500)/1000=50
0	700	500	(700-500)/700=28.5
-10	500	500	(500-500)/500=0

Loading Compensation



Error Compensation when System Sleep

- When AP sleep more than 35 minutes, and charge consumption <5mAH, If the new battery ZCV and old battery ZCV gap> 5mV, readjust FG SOC percentage



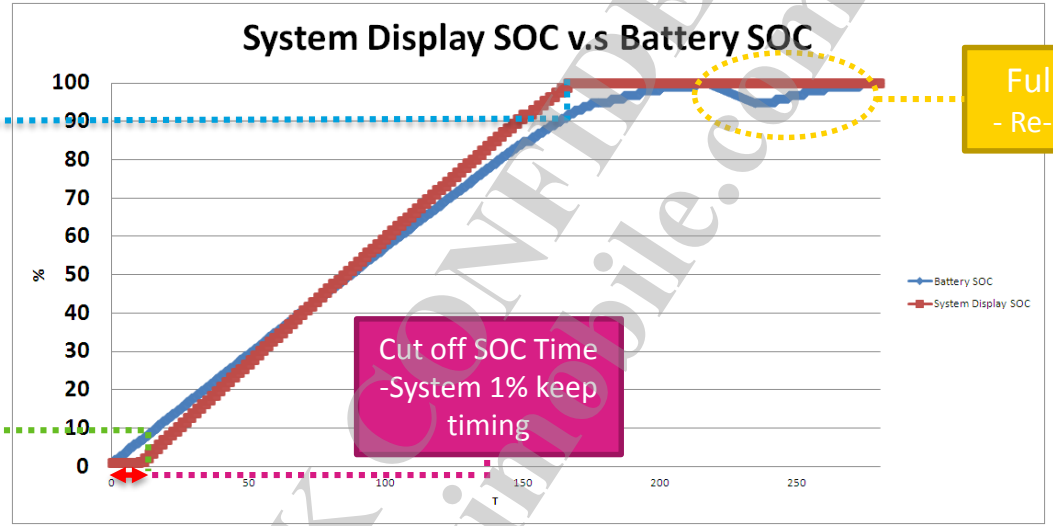
Content

- Architecture
- Compensation introduction
- System Display SOC (UISOC) optimization

MTK Gauge Master 3 Algorithm

		GM 2.0	GM 3.0
System Display SOC	Full SOC - System 100%	Yes (Customized)	Yes (Customized)
	UI 100% Prolong	NO	Yes (Customized)
	Cut off SOC - System 1%	Yes (Need adjustment)	Yes (Auto calculated)
	Cut off SOC Time -System 1% keep timing	Yes (Customized)	Yes (Customized)
	Full SOC - Re-Charge	Keep 100% when FG SOC > CV-10%	Keep 100% when FG SOC > CV-10%

System Display SOC



Full SOC
- System 100%

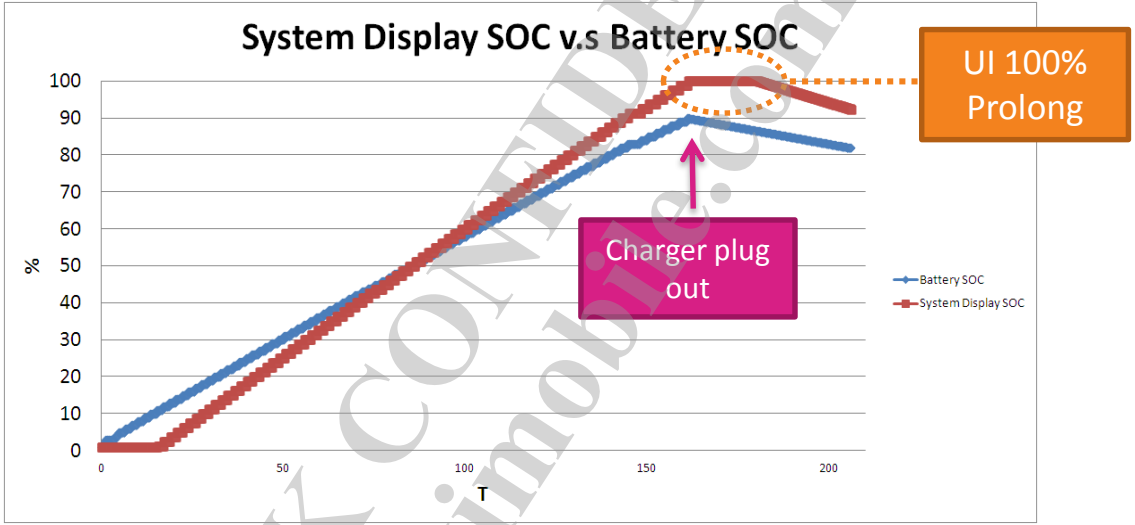
Full SOC
- Re-Charge

Cut off SOC
- System 1%

Cut off SOC Time
-System 1% keep timing

Full SOC - System 100%	Cut off SOC - System 1%	Cut off SOC Time -System 1% keep timing	Full SOC - Re-Charge
• Customized Feature • Enhance User experience for CV stage	• Enhance User experience for Heavy Loading • Auto calculated	• Customized Feature • Enhance User experience for Light Loading	• Enhance User experience for Re-Charge stage

System Display SOC



UI 100% Prolong

- Customized Feature
- Enhance User experience for Charger plug out immediately at the moment UI turns 100% in charging cycle.

Shutdown condition

Shutdown event	Shutdown condition	SWITCH	Parameters
overheat	Battery temp>=60degC	Turn on	
soc_zero_percent	Vbat < 3.4v && soc <0	SHUTDOWN_GAUGE0	SHUTDOWN_GAUGE0_VOLTAGE
uisoc_one_percent	UISOC == 1% keep xx mins	SHUTDOWN_GAUGE1_XMINS	SHUTDOWN_1_TIME
Gauge1%	UISOC < 1% && Vbat<3.4V	SHUTDOWN_GAUGE1_VBAT_EN	SHUTDOWN_GAUGE1_VBAT
dlpt_shutdown	VBAT < 3.2V around xx sec	Turn on	
under_shutdown_voltage	VBAT < 3.45V	Turn on	VBAT2_DET_VOLTAGE1

Appendix

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