UI USP 13S2P BMS FW Functionalities (10/21)

1. Power Modes

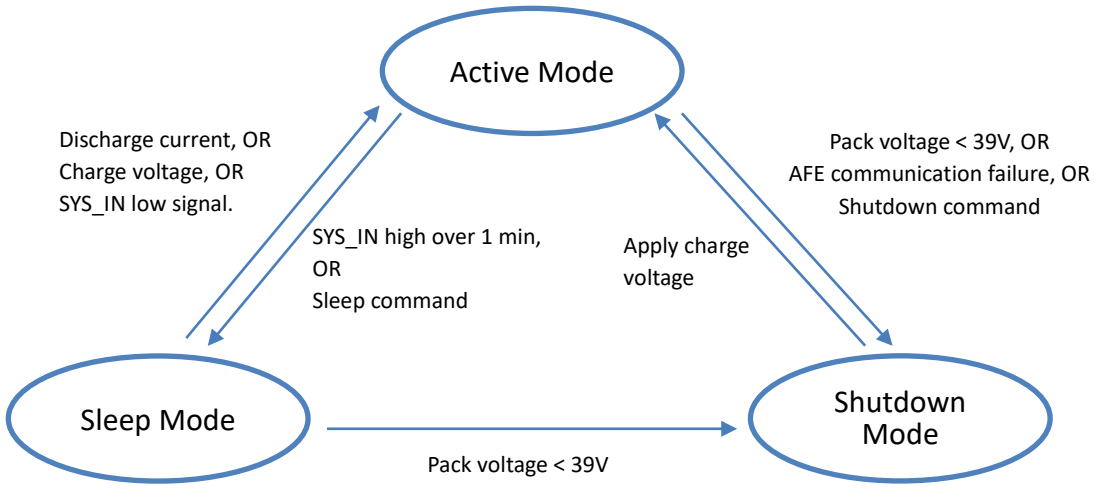
1.1. **Active Mode:** BMS is fully functional, monitor battery voltage, current, temperature and cell voltages, calculates RSOC, check protections to enable/disable MOSFET, controls charge process and handles host I2C commands.

1.2. **Sleep Mode:** BMS sleeps and wakes up periodically to reads pack voltage, current and input voltage. Host I2C communication will be disabled under sleep mode.

- **Two situations of entering sleep mode:**
  - **I.** SYS_IN is high for over 1 min, BMS will enter sleep mode automatically and turn off charging/discharging MOS, can only wake up BMS by pull low SYS_IN signal.
  - **II.** If sleep command is received when SYS_IN is low, BMS will enter sleep mode instantly and keep charging/discharging MOS on, if charging/discharging current > 100mA is detected with SYS_IN kept low, BMS will wake up. But if SYS_IN state changes to high under sleep mode, charging/discharging MOS will be turned off, then BMS can only be woken up by pull low SYS_IN.

1.3. **Shutdown Mode:** BMS shuts down AFE and disable self VCC to achieve lowest power consumption

- **Enter:** Pack voltage is lower than 39V, AFE communication failure, or by Shutdown command.
- **Exit:** Apply charge voltage.



2. Protections and Alarms

Item	Trigger	Release
Charge OCP	Charging current > 2A, stop charge.	After 30 secs.
Discharge OCP	Discharging current > 15A, stop discharge	After 30 secs.
Battery OVP	Pack voltage≧ 54.8V, stop charge.	Pack voltage < 54.3V
Battery UVP	Pack voltage≦ 39V, stop discharge.	Pack voltage > 39V
Battery OVA	Pack voltage≧ 22V	Pack voltage < 22V
Safety Under Voltage	Pack Voltage < 26V	None, cannot charge or discharge.
Charge OCA	Charge current≧ 2A	Charge current < 2A
Discharge OCA	Discharge current≧ 15A	Discharge current < 15A
Charge OTA	Charging temperature≧ 50℃	Temperature < 50℃
Discharge OTA	Discharging temperature≧ 60℃	Temperature < 60℃
UTA	Temperature≦ 0℃	Temperature > 0℃

3. I2C Communication

3.1. I2C 7-bits slave address: 0x0B, frequency up to 100kHz.

3.2. User can read an additional byte of CRC8 with all read commands, and all write commands need CRC8 byte at the end of packet to verify the transaction.

- CRC byte calculation: from address byte to last data byte.

  (CRC initial value: 0x00, poly: 0x07)

  For example, the CRC byte of packet 16 A1 00 01 82 00 94 4D 82 00 B0 8C 82 00 B0 8C 82 00 99 B4 82 00 B0 8C 82 00 B0 8C 82 00 B0 8C 82 00 99 AF

  is 0x6F

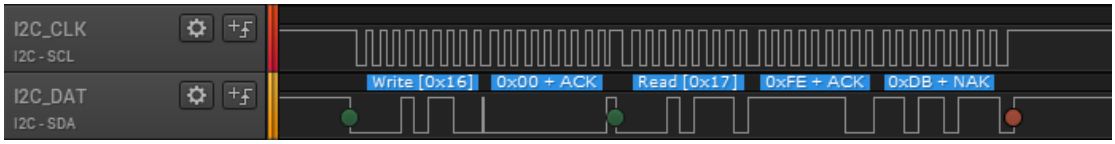
3.3. Command list:

Item	Command	Description	Unit
Temperature	0x08	Read word, unsigned int.	0.1K
Pack voltage	0x09	Read word, unsigned int.	10mV
Current	0x0A	Read word, signed int.	10mA
RSOC	0x0D	Read word, unsigned int.	%

Run Time To Empty	0x11	Read word, unsigned int. Returns 0xFFFF if there's no discharging current.	Minute
Charge Time To Full	0x13	Read word, unsigned int. Returns 0xFFFF if there's no charging current.	Minute
Battery Status	0x16	Read word. **Bit 4:** Fully Discharged **Bit 5:** Fully Charged, will be set after pack voltage > 51V and taper current < 100mA. **Bit 6:** Discharging, assert when discharge current is detected. **Bit 7:** Initialized, assert after confirm AFE communication is normal. **Bit 8:** Under Voltage Alarm **Bit 9:** Over Voltage Alarm **Bit 10:** Charge Over Current Alarm **Bit 11:** Discharge Over Current Alarm **Bit 12:** Under Temperature Alarm **Bit 13:** Over Temperature Alarm	Hex
Cell 1 Voltage	0x31	Read word, unsigned int.	mV
Cell 2 Voltage	0x32	Read word, unsigned int.	mV
Cell 3 Voltage	0x33	Read word, unsigned int.	mV
Cell 4 Voltage	0x34	Read word, unsigned int.	mV
Cell 5 Voltage	0x35	Read word, unsigned int.	mV
Cell 6 Voltage	0x36	Read word, unsigned int.	mV
Cell 7 Voltage	0x37	Read word, unsigned int.	mV
Cell 8 Voltage	0x38	Read word, unsigned int.	mV
Cell 9 Voltage	0x39	Read word, unsigned int.	mV
Cell 10 Voltage	0x3A	Read word, unsigned int.	mV
Cell 11 Voltage	0x3B	Read word, unsigned int.	mV
Cell 12 Voltage	0x3C	Read word, unsigned int.	mV
Cell 13 Voltage	0x3D	Read word, unsigned int.	mV
State of Health	0x4F	Read word, unsigned int.	%
All Cell Voltage	0xF1	Read 26-Bytes, Cell 1 – 13 voltage.	mV
FW Version	0x80	Read 4-Bytes: **Byte 0**: 0x4D('M') means running in main code, 0x42('B') means in BSL. **Byte 1**: Major version **Byte 2**: Minor version **Byte 3**: Test version	Hex
Lifetime Data	0x81	Read 12-bytes. **Byte 1-2:** Max pack voltage	

		Byte 3-4: Min pack voltage **Byte 5-6:** Max charging current **Byte 7-8:** Max discharging current **Byte 9-10:** Max temperature **Byte 11-12:** Min temperature	
FW Update Start	0xA0	Write with first 32-Bytes of FW data.	Hex
FW Packet	0xA1	Write with packet number and 32-Bytes FW data.	Hex
FW Update Finish	0xA2	Write with data 0x00.	Hex
Shutdown	0x00	Write with data 0x10 0x00, need to send twice consecutively within 4 seconds.(1)	Hex
Sleep	0x00	Write with data 0xFE 0x00.(1)	Hex

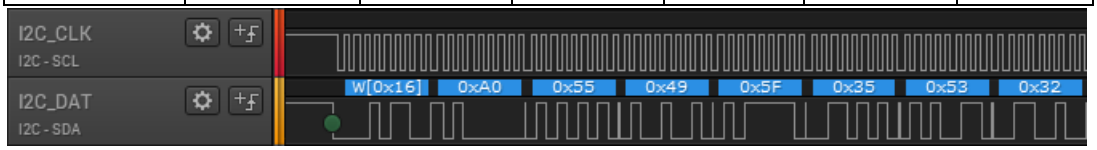
(1)Note: After receiving Shutdown and Sleep command, BMS will delay 5 seconds before entering Shutdown/Sleep, during this period, user can read command 0x00 to verify status, if BMS is entering Shutdown, the first returned byte will be 0x10, and if BMS is entering Sleep, it will return 0xFE. For example:



4. I2C Firmware Update Process

4.1. Read first 32 bytes of FW bin file and send with I2C command 0xA0.

Address(W)	Command	Byte 0	Byte 1	…	Byte 31	CRC Byte
Write[0x16]	0xA0	FW data	FW data	…	FW data	CRC8

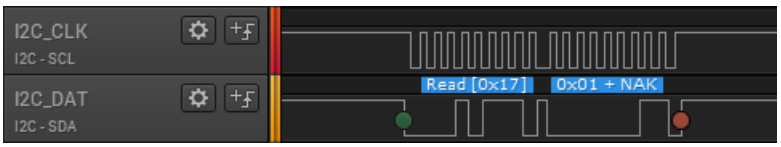


BMS will verify the information and jump to bootloader if this is valid FW bin file.

4.2. Delay around 100ms

4.3. Read 1 byte which indicates status

Address(R)	Data
Read[0x17]	Status byte



0x01: BMS already jumped to BSL, ready for next step

0x00: Command not received.

0xE0: Incorrect bin file.

0xE1: Incorrect MCU type.

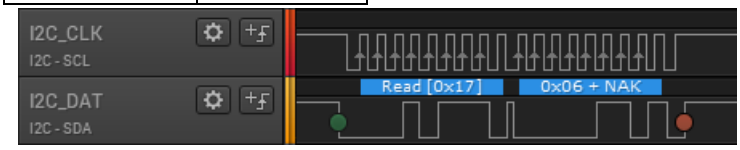
4.4. Read next 32 bytes of bin file and send with command 0xA1 and packet number, start from 0x01.

Address(W)	CMD	Packet Number (high byte)	Packet Number (Low byte)	Byte 0	…	Byte 31	CRC Byte
Write[0x16]	0xA1	0x00	0x01	FW data	…	FW data	CRC8

Packet number: from 0x01 ~ 0x180

4.5. Read status

Address(R)	Data
Read[0x17]	Status byte



0x06: ACK, continue next packet.

0xE2: CRC error

0xE3: Packet number out of range, packet number should be 0x01 to 0x180.

0xE4: Wrong packet number, packet number must be transmitted in order.

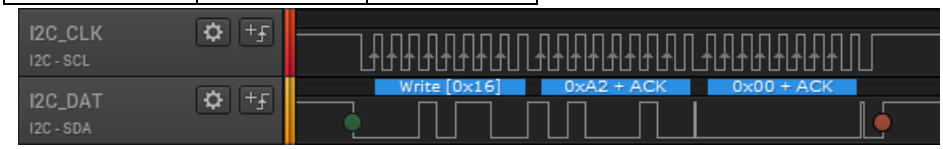
※ <u>If BMS does not return ACK, need to re-start update process from packet 1.</u>

4.6. Continue to send remaining FW data as step 4 and 5 until end of the bin file. Last packet number should be 0x180.

4.7. Send finish command 0xA2 with data 0x00.

Address(W)	Command	Data

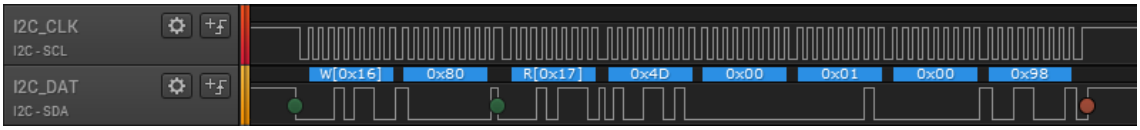
Write[0x16]	0xA2	0x00



4.8. After receiving 0xA2 command, BMS will jump to main code if all packets are received and CRC32 are verified correctly, if verified failed, it will keep running BSL code for correct FW update.

4.9. Command 0x80 can be used to read BMS FW version and check if FW is successfully updated:

Address(W)	Command	Address(R)	Byte 0	Byte 1	Byte 2	Byte 3	CRC
Write[0x16]	0x80	Read[0x17]	0x4D	0x00	0x01	0x00	0x98



Byte 0: 0x4D('M') indicates in main code, 0x42('B') indicates in BSL code.

Byte 1: Major version

Byte 2: Minor version

Byte 3: Test version

CRC byte: Calculate from address(w) byte to byte 3.