MPF42793

2 to 16 Stacked Lithium Iron Phosphate Cells Battery Pack Fuel Gauge with Level LEDs

DESCRIPTION

The MPF42793 is a drop-in solution to provide comprehensive status information on lithium iron phosphate (LFP or $LiFePO_4$) battery strings with up to 16 series cells. The MPF42793 estimates the internal state-of-charge (SOC) and state-of-health (SOH) for each cell, as well as the full pack. The MPF42793 also determines the impedance, remaining runtime, charge time, and instantaneous available power. Onboard memory enables the lifetime logging of key parameters.

The MPF42793 is simple to use and supports a variety of cell sizes. A few basic configurations allow for quick set-up, and advanced configuration capabilities can fine-tune the device for specific applications.

The MPF42793 can be paired with any analog front-end (AFE) or battery stack monitors. The 400kHz I^2C interface provides standard, robust communication. The 5-level LED drivers provide a simple, cost-effective charge level indicator for the device.

The MPF42793 is available in a TQFN-32 (4mmx4mm) package.

MINIMUM SYSTEM REQUIREMENTS

- Battery Monitor System (BMS) Analog Front-End (AFE) Providing Individual Cell Voltages, Pack Currents, and Temperatures
- M0 System MCU with I^2C and Interrupt, 48kB of Flash and 4kB of RAM

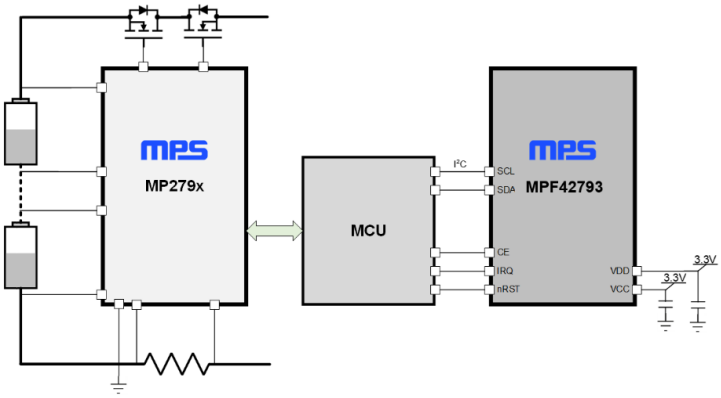
FEATURES

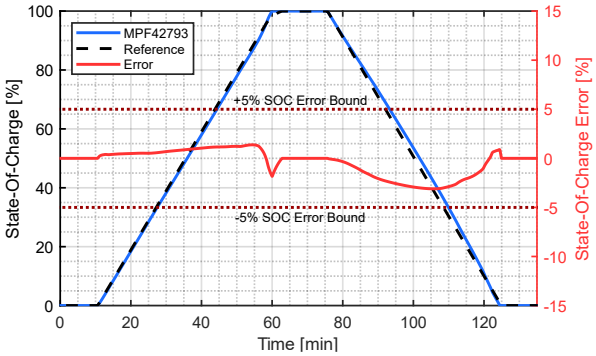
- Compatible with Commonly used Battery Monitors for up to 16 Series Cells
  - ±5% State-of-Charge (SOC) Accuracy when Paired with MP279x Battery Monitors
- Provides Critical Battery Information:
  - Pack and Cell SOC
  - Pack and Cell State-of-Health (SOH)
  - Remaining Runtime and Charge Time
  - Instantaneous Available Power
- Optimized for Lithium Iron Phosphate (LFP) Batteries
- Adaptive Learning can be Enabled to:
  - Refine Initial Charge Settings
  - Refine Initial Discharge Settings
  - Update Individual Cells' SOH to Track Degradation
  - Update Equivalent Series Resistance (ESR) to Track Degradation
- Provides Lifetime Logging
- Supports 5-Level LED SOC Indicator with Push-Button Trigger
- 2.5V Minimum Supply Voltage
- Low Current Consumption: 6µA in Disabled Mode and 135µA (Average) in Operating Mode during Rest
- Supports Up to 400kHz I^2C with Cyclic Redundancy Check (CRC) for Robust Communication
- Available in a Compact TQFN-32 (4mmx4mm) Package
- Available in Turnkey MPS BMS Module:
  - MBM16S-P50-C

APPLICATIONS

- Light Electric Vehicles (EVs): Scooters, Bikes, and Golf Carts
- Energy Storage: Uninterruptable Power Supplies (UPS) and Renewable Energy
- Industrial Robots, Floor Cleaners, and Forklifts
- Cordless Tools and Gardening Equipment

TYPICAL APPLICATION





ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MPF42793DRT-0B-yyyy**	TQFN-32 (4mmx4mm)	*See Below*	3
EVKT-MBM16S-P50-C	Evaluation kit	-	-

* For Tape & Reel, add suffix -Z (e.g. MPF42793DRT-0B-yyyy-Z).

** “yyyy” refers to the default configuration identifier (“0000” by default), where each “y” is a hexadecimal value between 0 and F. Work with an MPS FAE to obtain a customized default configuration.

TOP MARKING

MPSYWW
M4279X
LLLLLL

MPF4279x Family Generic Version

MPS: MPS prefix
Y: Year code
WW: Week code
M4279X: Family part number*
LLLLLL: Lot number

* The specific part number is in the IC_VER register.

EVALUATION KIT EVKT-MBM1XS-P50-C (MP279x BMS)

EVKT-MBM16S-P50-C kit contents (items below can be ordered separately):

#	Part Number	Item	Quantity
1	MBM16S-P50-C	MPF42793DRT-0B-0000 and MP2797DFP-0000 reference design and evaluation board	1
2	EVKT-USB-MBMFG	USB-to-UART/I^{2}C adapter	1
3	Online resources	Include datasheet, user guide, product brief, and GUI	1

Order directly from MonolithicPower.com or our distributors.

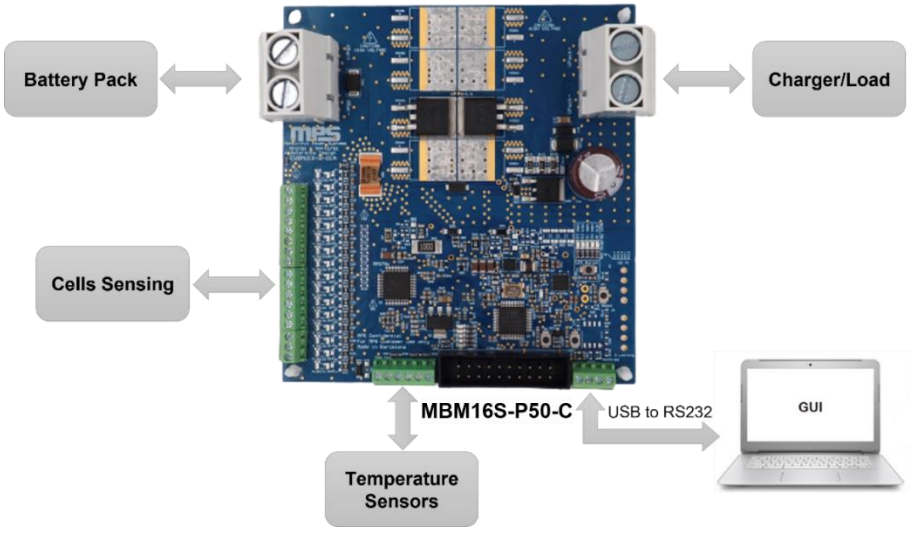
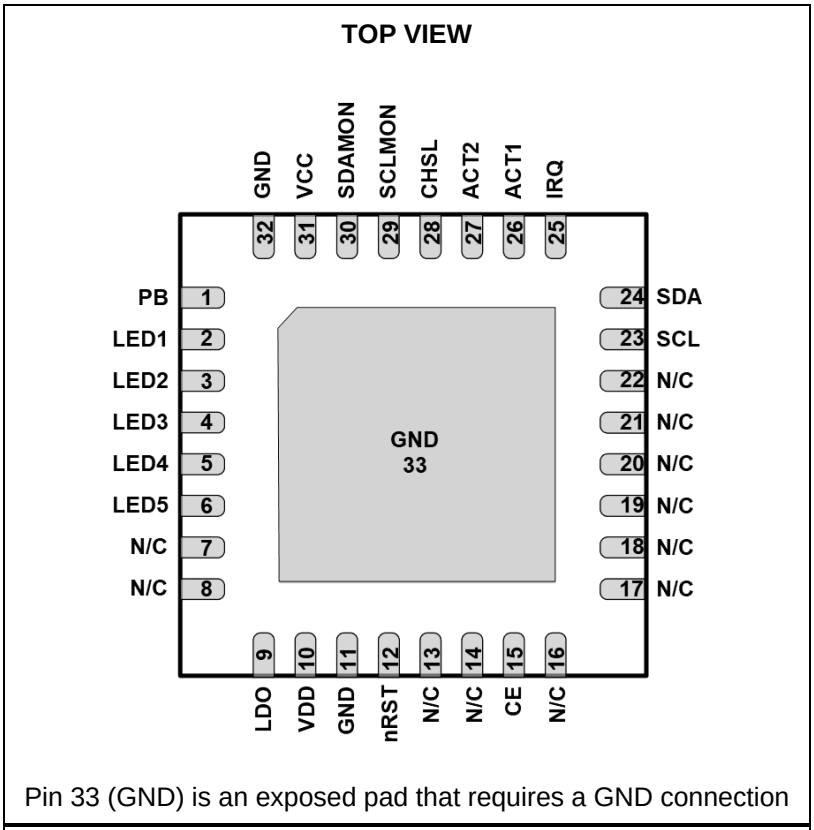


Figure 1: MBM16S-P50-C Evaluation Kit Set-Up

PACKAGE REFERENCE



TQFN-32 (4mmx4mm)

PIN FUNCTIONS

Pin #	Name	I/O	Description
1	PB	I	**Push-button.** Triggers the state-of-charge (SOC) LED indicator.
2	LED1	O	**LED 1 driver.** The LED1 pin reports the SOC with a 330Ω resistor in series.
3	LED2	O	**LED 2 driver.** The LED2 pin reports the SOC with a 330Ω resistor in series.
4	LED3	O	**LED 3 driver.** The LED3 pin reports the SOC with a 330Ω resistor in series.
5	LED4	O	**LED 4 driver.** The LED4 pin reports the SOC with a 330Ω resistor in series.
6	LED5	O	**LED 5 driver.** The LED5 pin reports the SOC with a 330Ω resistor in series.
7	NC	-	**No connection.**
8	NC	-	**No connection.**
9	LDO	Power	**Internal LDO.** Bypass the LDO pin with a 2.2μF + 100nF ceramic capacitor connected to ground.
10	VDD	Power	**Power supply input.** Bypass the VDD pin with a 2.2μF ceramic capacitor connected to ground.
11	GND	Power	**Ground pin.**
12	nRST	I	**IC reset control.**
13	NC	-	**No connection.**
14	NC	-	**No connection.**
15	CE	I	**Chip enable.** Set the CE pin high to enable the communication interface and IC operation. When CE is low, the fuel gauge stops, the communication interface is disabled, and current consumption is heavily reduced.
16	NC	-	**No connection.**
17	NC	-	**No connection.**
18	NC	-	**No connection.**
19	NC	-	**No connection.**
20	NC	-	**No connection.**
21	NC	-	**No connection.**
22	NC	-	**No connection.**
23	SCL	I/O	**I²C interface clock.** Connect the SCL pin to the logic rail through a 10kΩ resistor.
24	SDA	I/O	**I²C interface data.** Connect the SDA pin to the logic rail through a 10kΩ resistor.
25	IRQ	O	**Interrupt request pin.** The IRQ pin is the interrupt going to the host system(s).
26	ACT1	I	**Active pin 1.** Alternative pin to force the IC to go into active mode from standby mode. Only used when SDA_TO_ACTIVE is set to 0.
27	ACT2	I	**Active pin 2.** Alternative pin to force the IC to go into active mode from standby mode. Only used when SDA_TO_ACTIVE is set to 0.
28	CHSL	I	**Channel selection.** The CHSL pin selects which I²C channel is capable of writing data into the fuel gauge memory. Pull CHSL high to write data using the secondary I²C.
29	SCLMON	I/O	**Secondary I²C interface clock.** Connect the SCLMON pin to the logic rail through a 10kΩ resistor.
30	SDAMON	I/O	**Secondary I²C interface data.** Connect the SDAMON pin to the logic rail through a 10kΩ resistor.
31	VCC	Power	**3V to 3.3V power supply input.** Bypass the VCC pin with a 2.2μF ceramic capacitor connected to ground.
32	GND	Power	**Ground pin.**
33	GND	Power	**Ground pin.**

ABSOLUTE MAXIMUM RATINGS (1)

VCC supply voltage (V_{CC}) 3.6V
VDD supply voltage (V_{DD}) 3.6V
nRST pin.....-0.3V to +3.6V
All other pins .....-0.3V to V_{CC} + 0.3V
Total power dissipation (T_A = 25°C) (2) ... 500mW
Storage temperature ..... -55°C to +150°C
Junction temperature (T_J) ..... -55°C to +150°C

ESD Ratings

Human body model (HBM) ..... ±4000V

Recommended Operating Conditions (3)

Supply voltage (V_{DD}) .....3V to 3.6V
All other pins .....-0.3V to V_{CC} + 0.3V
Operating junction temp (T_J)..... -40°C to +85°C

Thermal Resistance (4) θ_{JA} θ_{JC}

TQFN-32 (4mmx4mm).....47…...4.5…°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature, T_J (MAX), the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_{JA}. Exceeding the maximum allowable power dissipation can produce an excessive die temperature, and the regulator may go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on a JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS (5)

V_{CC} = 3.3V, T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
State-of-Charge (SOC) Performance						
Pack SOC peak error	θ_{ERR}	MPS's MP279x AFE family, 0°C ≤ T_A ≤ 60°C, I_{CHG} ≤ 1C, I_{DIS} ≤ 1C	-5		+5	%
Power Supply						
VDD operating voltage range	V_{DD}		2.5	3.3	3.6	V
VCC operating voltage range	V_{CC}		2.5	3.3	3.6	V
Total active current	I_{DD_ACTIVE}	V_{DD} = 3.3V, LEDs off, fuel gauge updating		4.3		mA
Total standby current	$I_{DD\_STANDBY}$	V_{DD} = 3.3V, LEDs off, fuel gauge idle		50		µA
Average operating current during CHG or DSG	$I_{DD\_CHG/DSG}$	V_{DD} = 3.3V, LEDs off, EXE_TIME = 4s, NCELLS_SER = 10, with I^2C traffic		476		µA
Average operating current during rest	I_{DD_REST}	V_{DD} = 3.3V, LEDs off, NCELLS_SER = 10, EXE_TIME = 4s, WEXE_TIME_REST = 4, with I^2C traffic		192		µA
Total disabled current	I_{DD_DIS}	V_{DD} = 3.3V		6		µA
Power-On Reset (POR)						
Release threshold of POR	V_{ROT}	V_{DD} rising	1.66	1.79	1.9	V
nRST Pin						
nRST pin threshold voltage	V_{RST}		0.2 x V_{DD}		0.9 x V_{DD}	V
Minimum pulse width on nRST pin	t_{RST}	V_{DD} = 3.3V		700		ns
Timeout after reset	t_{TOUT}			64	128	ms
CE						
Low input voltage	V_{OL_CE}	I_{OL} = 5mA	-0.3		0.35 x V_{DD}	V
High input voltage	V_{OH_CE}		0.65 x V_{DD}		0.3V + V_{DD}	V
Low leakage current	$I_{CE\_LKG\_LOW}$	V_{CE} = 3.3V			3	µA
High leakage current	$I_{CE\_LKG\_HIGH}$	V_{CE} = 3.3V			3	µA
IRQ						
Low output voltage	V_{IRQL}	Sink = 4mA			0.4	V
High output voltage	V_{IRQH}	Source = 4mA	V_{DD} - 0.4			V
PB						
Low input voltage	V_{PBL}		-0.3		0.35 x V_{DD}	V
High input voltage	V_{PBH}		0.65 x V_{DD}		0.3V + V_{DD}	V
CHSL						
Low input voltage	V_{PBL}		-0.3		0.35 x V_{DD}	V
High input voltage	V_{PBH}		0.65 x V_{DD}		0.3V + V_{DD}	V

ELECTRICAL CHARACTERISTICS *(continued)*

V_{DD} = 3.3V, T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
LEDs						
High-level output voltage	V_{OH_LED}	Output current = 4mA	V_{DD} - 0.4V			V
High-level output current	I_{OH_LED}	V_{LEDx} = V_{DD} - 0.4V	4			mA
I²C DC Characteristics						
High input voltage	V_{IH}	SCL, SDA	0.7 x V_{DD}		0.3V + V_{DD}	V
Low input voltage	V_{IL}	SCL, SDA	-0.5		0.3 x V_{DD}	V
Low output voltage	V_{OL}	SDA, sink current = 3mA			0.4	V
I²C Timing Characteristics						
Spikes suppressed by input filter	t_{SP}		0		50	ns
Operating frequency range	f_{SCL}				400	kHz
SCL clock low period	t_{LOW}		1.125			µs
SCL clock high period	t_{HIGH}		1.125			µs
SCL and SDA falling time	t_{FALL}				0.34	µs
SCL and SDA rising time	t_{RISE}				0.34	µs
Data hold time	t_{HD_DAT}		0			ns
Data set-up time	t_{SU_DAT}		125			ns
Data valid time	t_{V_DAT}		475			ns
Set-up time for a repeated start command	t_{SU_STA}		125			ns
Hold time for a repeated start command	t_{HD_STA}		0			ns
Set-up time for a stop command	t_{SU_STO}		125			ns

Note:

5) Validated on a 10S1P Lithium Werks ANR26650-M1B pack (see the Typical Performance Characteristics section starting on page 9 for more details). Comparable results can be achieved with other cell/pack types after characterization.

TYPICAL PERFORMANCE CHARACTERISTICS

The MPF42793 fuel gauge performance depends on multiple factors, such as the accuracy of the measurements, the correctness of the configuration, and the fidelity of the cell mathematical model. This means that fuel gauge performance may vary depending on the battery operating conditions.

This section shows examples of the MPS MPF42793 fuel gauge pack's SOC performance when paired with MPS's MP279x AFE family.

Constant-Current/Constant-Voltage (CC/CV) Charge and Constant-Current Discharge Cycle

The next scenarios consist of charging a 10S1P (6) battery using the typical CC/CV method, followed by a constant-current discharge at different ambient temperatures. The charge constant current rate is 1C, while the charge termination current in this example is 0.1C. The discharge constant-current rate is 1C. Figure 2 shows the current profile of the complete cycle at 25°C.

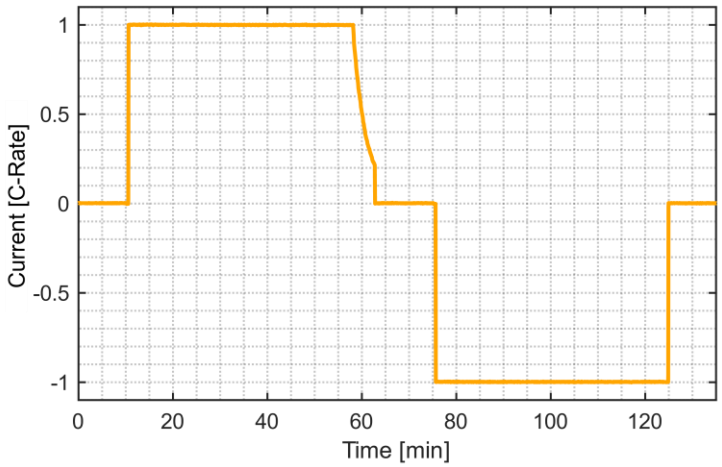


Figure 2: CC/CV Charge and CC Discharge Current Profile

Figure 3 shows the MPF42793's performance for the CC/CV charge and CC discharge cycle at an ambient temperature of 25°C. During charge, the root-mean-squared (7) and maximum pack SOC error are 0.89% and 1.84%, respectively. During discharge, the root-mean-squared and pack SOC error are 2.12% and 3.11%, respectively.

Notes:

6) 10S1P refers to the battery configuration. There are 10 groups of 1 parallel cell connected in series.

7) The RMS error is equal to $\sqrt{\frac{\sum_{n=1}^{N}(\theta_n-\hat{\theta}_n)^2}{N}}$, where θ is the actual SOC, $\hat{\theta}$ is the estimated SOC, and *N* is the number of samples.

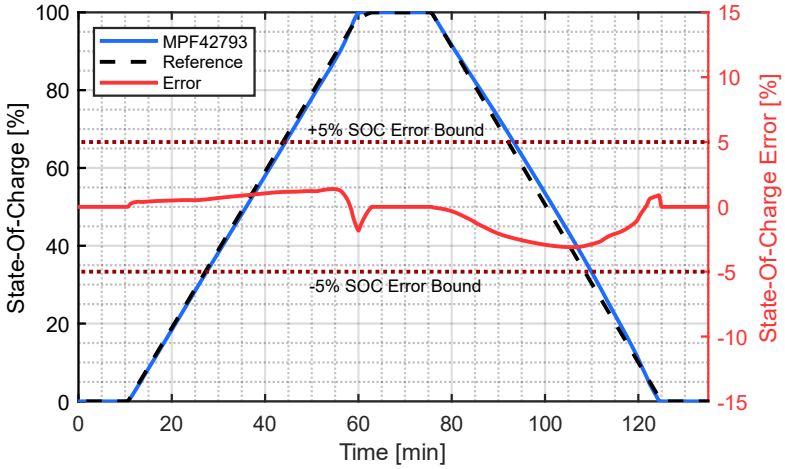


Figure 3: MPF42793 Performance for a CC/CV Charge and CC Discharge (Ambient Temperature = 25°C)

Figure 4 shows the MPF42793's performance for the CC/CV charge and CC discharge cycle at an ambient temperature of 40°C. During charge, the root-mean-squared and maximum pack SOC error are 2.81% and 4.22%, respectively. During discharge, the root-mean-squared and pack SOC error are 0.61% and 1.30%, respectively.

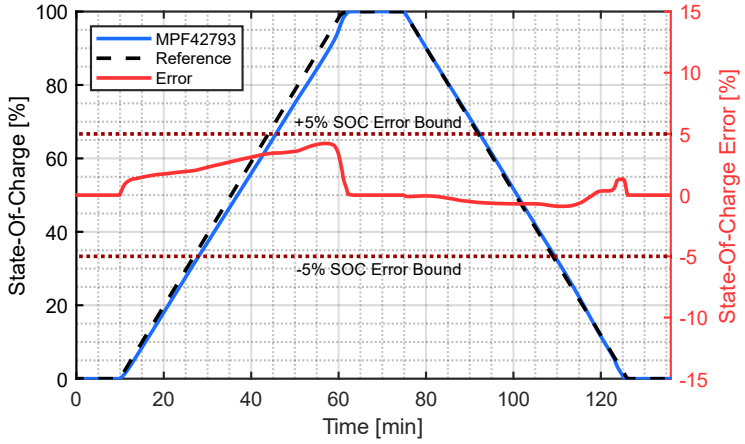


Figure 4: MPF42793 Performance for a CC/CV Charge and Dynamic Discharge (Ambient Temperature = 40°C)

Figure 5 shows the MPF42793's performance for the CC/CV charge and CC discharge cycle at an ambient temperature of 10°C. During charge, the root-mean-squared and maximum pack SOC error are 2.39% and 4.20%, respectively. During discharge, the root-mean-squared and pack SOC error are 2.62% and 3.97%, respectively.

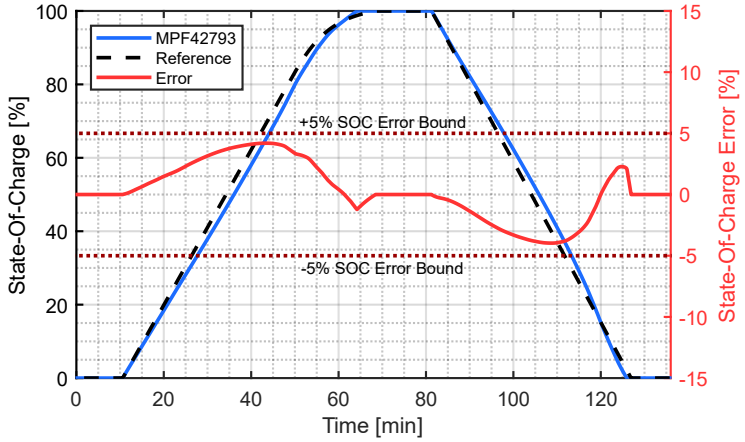


Figure 5: MPF42793 Performance for a CC/CV Charge and Dynamic Discharge (Ambient Temperature = 10°C)

Performance Summary

This section provides a summary of the MPF42793's real-world performance. Table 1 shows a summary of the pack SOC performance metrics for a 10S1P battery.

Table 1: MPF42793 SOC Root-Mean-Squared (and Maximum) Error

Test Case	10°C	25°C	40°C
CC/CV charge	2.39% (4.20%)	0.89% (1.84%)	2.81% (4.22%)
CC discharge	2.62% (3.97%)	2.12% (3.11%)	0.61% (1.30%)

OPERATION

The MPF42793 relies on a host microcontroller (MCU) to periodically update the fuel gauge's required inputs. This includes the cell voltages (via the VRDG_CELLx registers), current (via the IRDG_CELLx registers), and temperature (via the TRDG_TSx registers).

The host MCU is responsible for synchronizing the input data to the fuel gauge's execution time (EXE_TIME). The host MCU sends the EXE_CMD command to trigger the fuel gauge execution and waits until the iteration is completed (FG_EXE_FLAG = 0). Then the host MCU can read back the fuel gauge's output registers, such as the pack state-of-charge (SOC). The interrupt request (IRQ) pin can be configured to notify the MCU of several events, such as a completed iteration or other conditions (see the xx_INTR_EN registers for details).

Operating Modes

Active

In active mode, the fuel gauge is either updating the battery's internal states or communicating via the I^2C bus.

Standby

In standby mode, the fuel gauge is idle, which means that all triggered updates have been completed and the fuel gauge is waiting for activity on the SDA line to transition to active mode. See the I^2C Communication Interface section on page 12 for more details.

Disabled

In disabled mode, the chip enable (CE) pin is low. I^2C communication is not available. The fuel gauge achieves minimal current consumption but still retains all internal state variables in its memory.

Configuration and Data Exchange

Configuration Mode

In configuration mode, the MPF42793 is set to receive parameter configurations, though the device stops operating. This mode is enabled by sending the CONFIG_MODE_CMD command, and it can be confirmed by reading the CONFIG_MODE_FLAG register. After the fuel gauge configurations are successfully updated, the host system must send the CONFIG_EXIT_CMD command to save the configuration into the non-volatile memory (NVM). This ensures that the configuration remains after a hardware reset (cycling the device's power or cycling power on the nRST pin).

Editing Mode

As an alternative to configuration mode, editing mode allows for partial configuration changes. In this mode, the fuel gauge settings can be updated, but the fuel gauge cell model cannot be changed. Configuration mode is required to change the fuel gauge cell model.

In editing mode, the fuel gauge does not stop operating, which allows for on-the-fly configurations. This mode is enabled by sending the EDIT_CONFIG_CMD command and can be confirmed by reading EDIT_SETTINGS_FLAG. The host system can exit this mode by sending the END_EDIT_CONFIG_CMD or CONFIG_EXIT_CMD command, which store the updated configuration in the MPF42793's NVM.

LED Control

The MPF42793 can drive five external LEDs that report the pack's state-of-charge (SOC). There are 2 methods to control the LEDs: direct control or manual control, which can be configured via the LEDS_ON_MAN register.

The LED settings can be written at any time during active or standby operating modes without having to enter configuration or editing mode.

Direct LED Control

With direct LED control, the fuel gauge directly controls the LEDs based on the pack SOC (see Table 2 on page 12). When the PB pin is pulled low (if the LEDS_ON_BTN register is enabled), or when the battery pack is charging (if LEDS_ON_CHG is enabled), the LEDs display the pack SOC. The deglitch time between charge and discharge can be configured via the LED_TRANS register. The LED turn-on time can be configured via the LEDS_ON_TIME register.

Table 2: LED State-of-Charge Indicator Map

Pack SOC	LED Status				
	1	2	4	4	5
SOC > 90%	On	On	On	On	On
90% ≥ SOC > 70%	On	On	On	On	Off
70% ≥ SOC > 50%	On	On	On	Off	Off
50% ≥ SOC > 30%	On	On	Off	Off	Off
30% ≥ SOC > 10%	On	Off	Off	Off	Off
10% ≥ SOC	Off	Off	Off	Off	Off

Manual LED Control

With manual LED control, the host manually controls each LED via the corresponding LEDx_ON register.

I²C Communication Interface

The MPF42793 has two I²C-compatible interfaces. The primary I²C channel communicates with the host MCU, which extracts the data from the analog front-end (AFE). The secondary I²C channel is designed to monitor the fuel gauge status in real time and configure the fuel gauge using the MPF4279x graphic user interface (GUI). Note that write operations are only accepted from one channel at a time (the primary channel by default). To write to the fuel gauge using the secondary I²C channel, the CHSL pin must be pulled high; otherwise, write operations from this channel are ignored.

The I²C is a bidirectional, two-wire serial interface. Only two bus lines are required: a serial data line (SDA) and a serial clock line (SCL). The device can be considered a master or a slave when performing data transfers. A device that initiates a data transfer on the bus and generates the clock signals to permit the transfer is considered a master. Any device that the master addresses is considered a slave.

Both MPF42793 I²C interfaces operate as slave devices with a configurable address (0x08 by default). They receive control inputs from the master device and ignore general call addresses.

The two I²C interfaces support standard mode (up to 100kbps), and fast mode (up to 400kbps). The SDA and SCL lines are bidirectional with open-drain outputs that should be connected to the positive supply voltage via a current source or pull-up resistor. When the bus is free, both lines are high.

The data on the SDA line must be stable during the high period of the clock. The high or low state of the data line can only change when the clock signal on the SCL line is low. A single clock pulse is generated for each data bit transferred (see Figure 6).

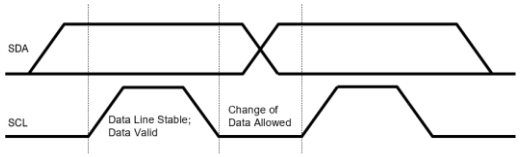


Figure 6: Bit Transfer on the I²C Bus

All transactions must begin with a start (S) command and can be terminated with a stop (P) command. Start and stop commands are always generated by the master. A start command is defined by a high-to-low transition on the SDA line while SCL is high (see Figure 7). A stop command is defined by a low-to-high transition on the SDA line while the SCL is high (see Figure 7). The bus is considered busy after a start command and free after a stop command.

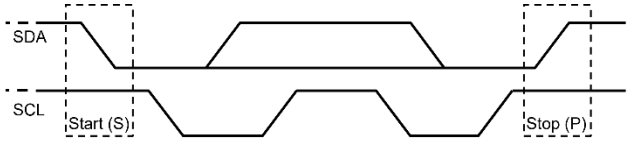


Figure 7: I²C Start (S) and Stop (P) Commands

Every byte on the SDA line must be 8 bits long and must be followed by an acknowledge bit (ACK). Note that data is transferred with the most significant bit (MSB) first.

A slave cannot receive or transmit a complete byte of data while performing other tasks, but it can hold the SCL line low to force the master into a wait state (clock stretching). Then, when the slave is ready, data transfer continues, and the clock line (SCL) is released. Figure 8 on page 13 shows a complete data transfer.

The acknowledgement takes place after every byte and allows the receiver to signal to the transmitter that the byte was successfully received. All clock pulses are generated by the master, including the 9th clock pulse (ACK).

The transmitter releases the SDA line during the ACK clock pulse so that the receiver pulls the SDA line low. If the SDA line remains high during the acknowledge clock pulse, it is not acknowledged (NACK). Then the master can generate a stop command to abort the transfer, or it can generate a repeated start (Sr) command to start a new transfer.

After the start command, a 7-bit slave address is sent, followed by the read/write (R/W) bit. A 0 represents a write transmission (W), while a 1 indicates a read request (R). Figure 8 shows a complete data transfer.

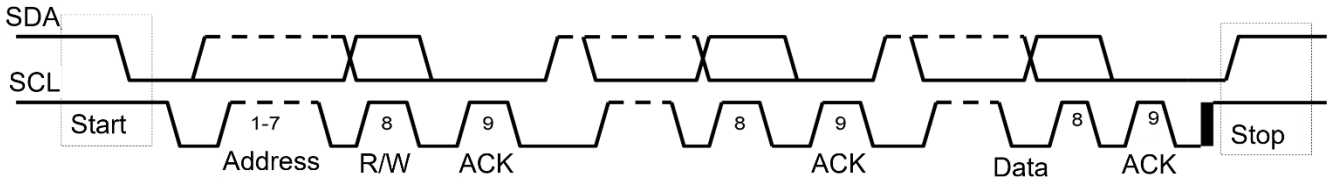


Figure 8: Complete Data Transfer

Active Mode

The MPF42793 must be in active mode to communicate (see the Operating Modes section on page 11 for more details). The value of SDA_TO_ACTIVE determines which pins are dedicated to force the IC into active mode. If SDA_TO_ACTIVE is set to 1 (default), the SDA lines are used for this purpose, which prevents the need for an additional pin. When SDA_TO_ACTIVE is set to 0, the ACTx pins force the device to active mode. This means that there can be more than one I²C slave without forcing the MPF42793 into active mode, in the event that there is I²C activity on the line aimed at another device.

To transition to active mode, the SDA line or an ACTx pin must be pulled low. There is a 20ms timeout to starting operation before the device transitions back to standby mode. After the operations are completed (e.g. I²C communication or fuel gauge updates), there is a 5ms timeout before the IC goes to standby mode.

A low 5ms pulse on the SDA line or ACTx pin is recommended to transition to active mode. It may take a few additional milliseconds for the MPF42793 to enter active mode and for the I²C to be ready. To verify that the MPF42793 is ready for communication, an I²C header with the start command, device address, and R/W bit can be sent. The device responds with an ACK signal if it is ready for communication.

Protocol Layer

The MPF42793 uses a protocol where 2 bytes are used for the register and command addresses. A length field is also provided to declare the number of bytes in each read or write transaction. The maximum allowed transaction length is 82 bytes of data (not including the register address, length byte, or CRC bytes).

A cyclic redundancy check (CRC) can be used to ensure the transaction's integrity. When enabled, the last 4 bytes of the transaction correspond to the CRC. Figure 9 and Figure 10 show an example of write and read transactions with CRC, respectively.

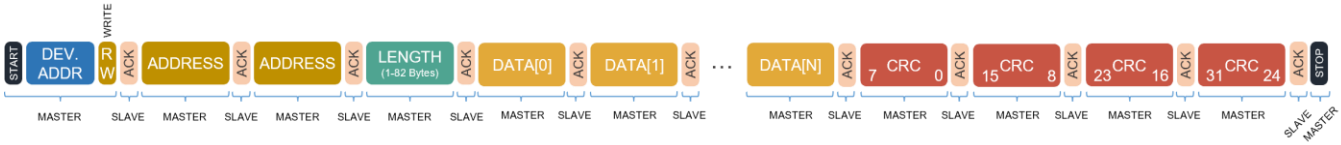


Figure 9: I²C Write Transaction with CRC

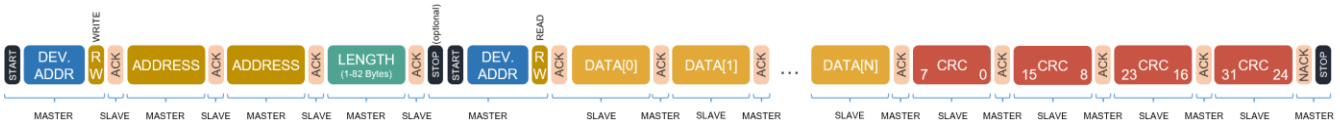


Figure 10: I²C Read Transaction with CRC

If CRC is disabled, a write transaction can optionally include the correct CRC bytes to be accepted. During a read, the MPF42793 does not include the CRC, so the NACK signal and stop command from the master come after DATA[x].

I²C operations using any address outside of the register map are invalid, even if they are partially valid addresses. An invalid read operation returns a 0 as the data and correct CRC (if enabled), and an invalid write operation is ignored.

Cyclic Redundancy Check (CRC)

The CRC spans the register address, length, and data payload. It is generated in blocks of 4 bytes. If the number of bytes is not a multiple of 4, the block is padded with 0x00. The algorithm to generate the CRC is listed below.

To disable the CRC and configure the slave address as 0x08, send the following message: {0x00, 0x54, 0x01, 0x08, 0xBA, 0x82, 0x67, 0x4D} (Address = 0x5400, Length = 0x01, Data = 0x08, CRC = 0x4D67 82BA).

```
unsigned long crc32 (unsigned short Reg_Address, unsigned
char len, unsigned char *data){
    short i;
    unsigned long crc = 0xffffffff;
    unsigned char dataTemp[4];

    for (i=-1; i<len; i++) {
        if(i==-1) {
             dataTemp[0]=len;
             dataTemp[1]=Reg_Address&0x00FF;
             dataTemp[2]=(Reg_Address&0xFF00)>>8;
             dataTemp[3]=0;
        }
        else dataTemp[i%4]=data[i];
        if((i%4)==3 || i == len-1 || i == -1) {
             for (char j=0; j<4; j++) {
                  crc ^= dataTemp[3-j] << 24;
                  for (char k = 0; k < 8; ++k) {
                         if ((crc & 0x80000000) != 0)
                              crc = (crc << 1) ^ 0x04C11DB7;
                         else
                              crc <<= 1;
                         }}
             dataTemp[0]=0;
             dataTemp[1]=0;
             dataTemp[2]=0;
             dataTemp[3]=0;
        }}
    return crc;
}
```

APPLICATION INFORMATION

CORE ALGORITHM

The fuel gauge core algorithm accurately estimates core cell-level and pack-level parameters. These core parameters can be found in the Fuel Gauge Output Register Map section starting on page 30.

Cell Mathematical Model

Cell dynamics are influenced by multiple factors, such as chemistry, SOC, current, and temperature. A mathematical model that captures the cell's most important dynamics is required to accurately measure internal variables.

Cell mathematical models are provided by MPS. These mathematical models are either from a database or they are a result of the cell characterization routine.

The cell mathematical model registers in this document are only informative. Use the Battery Pack Complete Solution GUI to load the complete cell mathematical model into the MPF42793, or contact MPS for an alternative methods.

Cell State-of-Charge (SOC)

Cell SOC (SOC_ABS_CELLx) refers to the cell capacity that is currently available, as a function of the rated capacity. SOC is an unknown, internal variable that cannot be directly measured, meaning it must be estimated using available measurements. The MPF42793 uses voltage, current, and temperature measurements observed over time to produce accurate SOC estimates across a wide range of operating conditions.

Empty State-of-Charge (SOC)

Empty SOC (EMTY_SOC_CELLx) refers to the SOC level at which the battery pack is unable to discharge further without reaching the voltage cutoff limits defined in VPACK_EMTY. The empty SOC prediction relies on the operating conditions of the different cells, as well as the discharge current supplied to the load, which is specific to each application.

In addition, the MPF42793 can predict whether the battery pack discharge is limited by the pack or one of the cells (the cell ID is provided). This is extremely important for accurate empty SOC estimation in unbalanced packs, since the fuel gauge must track the condition that limits the battery pack discharge.

Full State-of-Charge (SOC)

Full SOC (FULL_SOC_CELLx) refers to the SOC level at which the battery pack is unable to charge further without leaving the safe operating area (SOA). The full SOC prediction relies on the operating conditions of the different cells, as well as the constant-current/constant-voltage (CC/CV) charging sequence, which is specific to each application.

The MPF42793 can predict whether the battery pack charge is limited by the pack or one of the cells (the cell ID is provided). This is extremely important for accurate full SOC estimation in unbalanced packs, since the fuel gauge must track the condition that limits the battery pack charge.

Thermal Modeling

The MPF42793 incorporates battery thermal modeling, which is extremely important to account for battery self-heating.

The internal resistance of each cell causes the cell's temperature to rise during charge and discharge due to the Joule heating effect. As the temperature of the cell(s) increases, the internal resistance decreases; this can dramatically impact performance, especially at low temperatures.

The ability to predict this temperature rise allows the fuel gauge to determine SOC more accurately.

Pack State-of-Charge (SOC)

Pack SOC (SOC_PACK) provides the capacity, which is a function of the available capacity given the actual pack operating conditions. Pack SOC relies on cell-level quantities and tracks the remaining capacity that the battery can charge or discharge without reaching the cutoff limits.

Pack SOC can be considered the most vital estimate since it is typically the value shown to the application end user.

Pack Unavailable State-of-Charge (SOC)

Pack unavailable SOC (SOC_PACK_UNAVBL) refers to the capacity that is not available due to

the actual pack operating conditions (e.g. mismatched cells and battery pack configurations). The pack unavailable SOC provides the capacity that the battery cannot use without violating the defined SOA.

INDICATORS

In addition to the core parameters, an extensive set of fuel gauge indicators are provided, based on the internal battery estimates. These indicators can be found in the Fuel Gauge Output Register Map section starting on page 30.

Remaining Time-to-Empty

Remaining time-to-empty (EMTY_RTIME) refers to how much time is left until the battery pack reaches the empty state while assuming the application-specific discharge current. This estimate informs the user of the remaining runtime until the pack reaches 0% SOC.

Remaining Time-to-Full

Remaining time-to-full (FULL_RTIME) refers to how much time is left until the battery pack reaches the cutoff limits using the application-specific charge parameters (i.e. the CC and CV levels). This estimate informs the user of the remaining charge time until the pack reaches 100% SOC.

Max. Discharge Power

The maximum discharge power (P_{DIS}) refers to how much power the pack can deliver to the load without reaching the pack's empty levels and leaving the SOA.

The MPF42793 can predict whether the limiting factor under P_{DIS} is caused by the pack or one of the cells (the cell ID is provided).

Maximum Charge Power

The maximum charge power (P_{CHG}) refers to how much power the pack can accept for charging without breaching the cutoff limits.

The MPF42793 can predict whether the limiting factor under P_{CHG} is caused by the pack or one of the cells (the cell ID is provided).

LEARNINGS

The MPF42793 includes the ability to learn and adjust key fuel gauge parameters, allowing for autonomous fine-tuning of the algorithm. This also provides a method to account for aging to keep estimates accurate across the device's lifetime.

Charge Constant Current (CC)

The charge CC learning feature (ICHG_CC_LRN) refines the initial charge CC value defined by the user. This smart adjustment compensates for when the charge CC deviates from its nominal settings, such as when there are production tolerances to the charging system. This feature minimizes the need for tuning while maintaining optimal SOC accuracy. The learning can be completed and leveraged within the same charge cycle.

Charge Termination Current

The charge termination current learning (ICHG_END_LRN) feature refines the initial charge termination current value defined by the user. This smart adjustment compensates for when the charge termination current deviates from its nominal settings, such as when there are production tolerances to the charging system.

Charge termination current smart adjustments are applied in subsequent charge cycles following the cycle in which the learning occurred.

Charge Constant Voltage (CV)

The charge CV learning feature (VCHG_CV_LRN) refines the initial charge CV value defined by the user. This smart adjustment compensates for when the charge CV deviates from its nominal settings, such as production tolerances to the charging system. Charge CV smart adjustments are applied in subsequent charge cycles following the cycle in which the learning occurred.

Discharge Average Current

The discharge average current learning (IDIS_AVG_LRN) feature calculates the load average discharge current to accurately provide the time-to-empty estimate.

Discharge Termination Current

The discharge termination current learning (IDIS_END_LRN) feature refines the initial discharge termination current value defined by the user. This value adapts to load dynamics and keeps the SOC accurate with minimal user tuning.

In addition, this feature includes two different operation modes depending on the application requirements: continuous and past-cycle learning. In continuous learning mode, the discharge termination current updates continuously while the pack discharges to accurately determine the empty SOC. Past-cycle learning uses the previous discharge cycle data to learn. Continuous learning is recommended for unpredictable discharge termination currents, whereas past-cycle learning is recommended for consistent discharge termination currents.

State-of-Health (SOH)

As battery cells age, their total capacity decreases due to unwanted side reactions and structural deterioration (often referred to as capacity fading). Up-to-date SOH information is important since it has a major impact on the battery pack's available energy.

The MPF42793 incorporates an SOH learning (SOH_LRN) feature that can track individual cells' capacities (SOH_CELLx) with respect to their nominal capacity. This feature can identify cells that are negatively impacting the overall pack performance.

Equivalent Series Resistance (ESR)

As battery cells age, their equivalent series resistance (ESR) increases due to unwanted side reactions and structural deterioration (often referred to as power fading). Up-to-date ESR information is important since it has a major impact on the battery pack's available power and SOC estimates.

The MPF42793 incorporates an ESR learning (RESR_LRN) feature that tracks individual cells' ESR (RESR_CELL_DIS_x) with respect to their characterized value. This feature can identify cells that are negatively impacting the overall pack performance.

Heat Transfer Coefficient

Heat is generated in a battery pack when charging and discharging due to the Joule heating effect. The ability to dissipate the heat generated to the environment will determine the temperature increase in the battery pack. A precise heat transfer coefficient is important to accurately predict the temperature rise during charge and discharge since the temperature rise has a major impact on performance, especially at low temperatures.

The MPF42793 incorporates a heat transfer coefficient learning feature that can refine the initial heat transfer coefficient defined by the user.

LIFETIME LOG

Notable events and certain conditions are reported in the lifetime log to gain insight on how the battery pack has been operating. The MPF42793 backs the relevant registers up to its non-volatile memory (NVM) every time the part enters disabled mode (or for each elapsed hour).

Count Log

The count log is the number of times the pack has been charged from below 15% to above 85%. The number of times the pack has been charged by 10% and the number of shutdowns are also reported in the lifetime log. Full shutdowns and entering disabled mode are considered shutdowns that increase the counter.

Current Log

The current log is the maximum charge and discharge current that has been applied to the pack. It is reported in the lifetime log.

Voltage Log

The voltage log tracks the maximum and minimum voltage for each cell. This is reported in the lifetime log. In addition, the maximum cell voltage difference between two cells is also reported, as well as their corresponding cell IDs.

Temperature Log

The temperature log tracks the maximum and minimum temperature sensed on the pack. It also reports the maximum temperature difference between two sensors, and their corresponding temperature sensor IDs.

The lifetime log details how much time the pack has operated under different temperature ranges.

Balancing Log

The balancing log tracks the number of times each cell has been balanced.

TYPICAL APPLICATION CIRCUIT

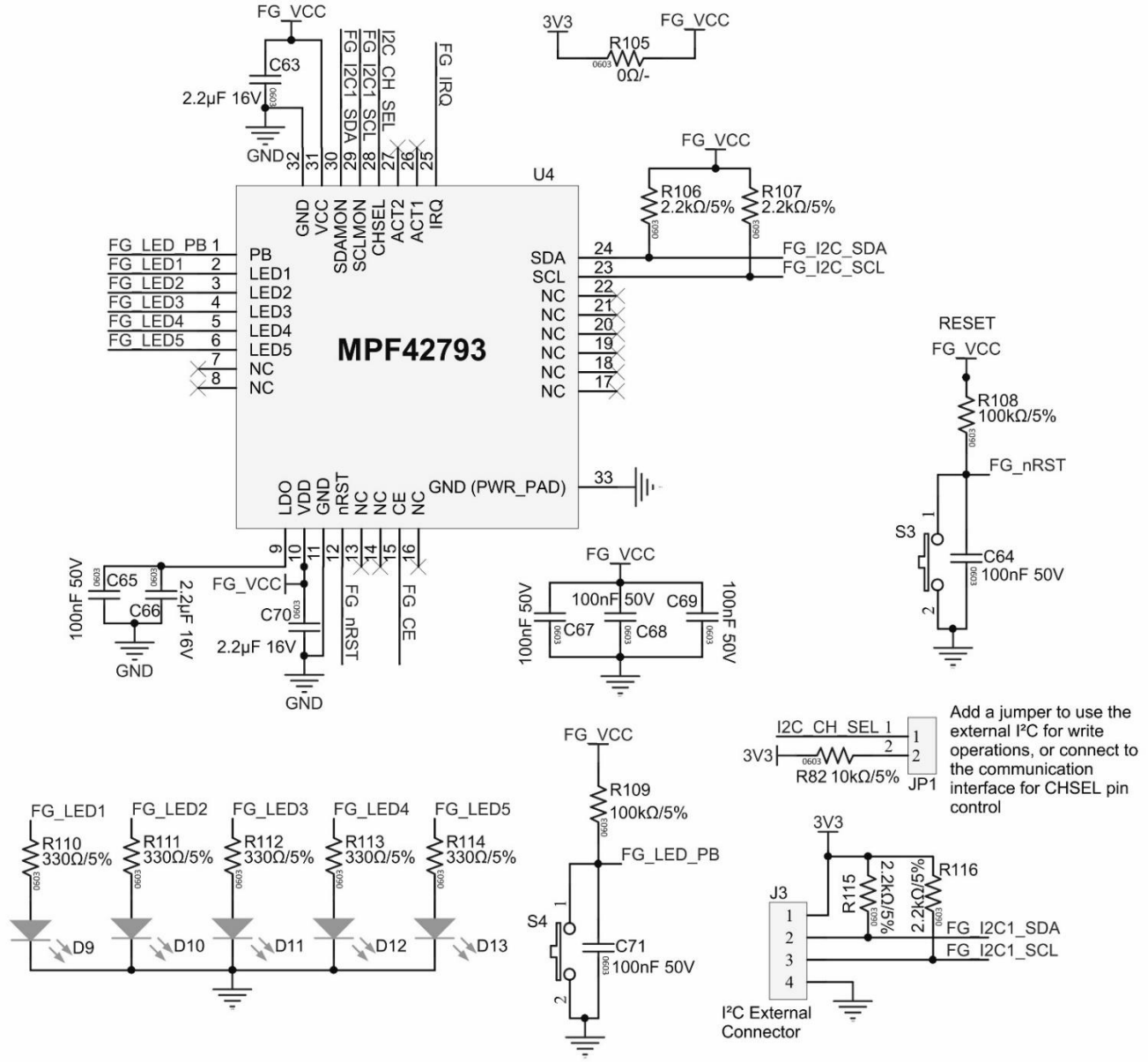


Figure 11: Typical Application Circuit

FUEL GAUGE INPUT REGISTER MAP

VRDG_CELL1 (0000h)

Format: 16-bit unsigned integer

The VRDG_CELL1 command inputs cell 1's voltage reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VRDG_CELL1	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_CELLx (0000h + (*x* - 1) x 0002h)

Format: 16-bit unsigned integer

The VRDG_CELLx command inputs cell *x*'s (where *x* = 2–15) voltage reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VRDG_CELLx	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_CELL16 (001Eh)

Format: 16-bit unsigned integer

The VRDG_CELL16 command inputs cell 16's voltage reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VRDG_CELL16	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_PACK (0020h)

Format: 16-bit unsigned integer

The VRDG_PACK command inputs the pack voltage reading if VRDG_PACK_EN is enabled.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VRDG_PACK	0mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

IRDG_CELL1 (0022h)

Format: 32-bit signed, 2-comp integer

The IRDG_CELL1 command inputs cell 1's current reading if IRDG_CELLS_EN is enabled.

Bits	Access	Bit Name	Default	Description
31:0	R/W	IRDG_CELL1	0mA	The resolution is 1mA, and the range is between -524288mA and +524287mA.

IRDG_CELLx (0022h + (*x* - 1) x 0004h)

Format: 32-bit signed, 2-comp integer

The IRDG_CELLx command inputs cell *x*'s (where *x* = 2–15) current reading if IRDG_CELLS_EN is enabled.

Bits	Access	Bit Name	Default	Description
31:0	R/W	IRDG_CELLx	0mA	The resolution is 1mA, and the range is between -524288mA and +524287mA.

IRDG_CELL16 (005Eh)

Format: 32-bit signed, 2-comp integer

The IRDG_CELL16 command inputs cell 16's current reading if IRDG_CELLS_EN is enabled.

Bits	Access	Bit Name	Default	Description
31:0	R/W	IRDG_CELL16	0mA	The resolution is 1mA, and the range is between -524288mA and +524287mA.

IRDG_PACK (0062h)

Format: 32-bit signed, 2-comp integer

The IRDG_PACK command inputs the pack current reading if IRDG_PACK_EN is enabled.

Bits	Access	Bit Name	Default	Description
31:0	R/W	IRDG_PACK	0mA	The resolution is 1mA, and the range is between -524288mA and +524287mA.

CCRDG (0066h)

Format: 32-bit signed, 2-comp integer

The CCRDG command inputs the Coulomb count reading if CCRDG_EN is enabled.

Bits	Access	Bit Name	Default	Description
31:0	R/W	CCRDG	0mAs	The resolution is 0.0005mAs, and the range is between -1073741.832mAs to +1073741.832mAs.

TRDG_AMB (006Ah)

Format: 16-bit signed, 2-comp integer

The TRDG_AMB command inputs the ambient temperature reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	TRDG_AMB	0°C	The resolution is 0.01°C, and the range is between -273.15°C and +327.67°C.

TRDG_TS1 (006Ch)

Format: 16-bit signed, 2-comp integer

The TRDG_TS1 command inputs temperature sensor 1's reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	TRDG_TS1	0°C	The resolution is 0.01°C, and the range is between -273.15°C and +327.67°C.

TRDG_TS2 (006Eh)

Format: 16-bit signed 2-comp integer

The TRDG_TS2 command inputs temperature sensor 2's reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	TRDG_TS2	0°C	The resolution is 0.01°C, and the range is between -273.15°C and +327.67°C.

TRDG_TS3 (0070h)

Format: 16-bit signed, 2-comp integer

The TRDG_TS3 command inputs temperature sensor 3's reading.

Bits	Access	Bit Name	Default	Description
15:0	R/W	TRDG_TS3	0°C	The resolution is 0.01°C, and the range is between -273.15°C and +327.67°C.

TRDG_TS4 (0072h)

Format: 16-bit signed, 2-comp integer

The TRDG_TS4 command inputs temperature sensor 4's reading..

Bits	Access	Bit Name	Default	Description
15:0	R/W	TRDG_TS4	0°C	The resolution is 0.01°C, and the range is between -273.15°C and +327.67°C.

BAL_CELL1TO8 (0076h)

Format: Boolean true/false

The BAL_CELL1TO8 command inputs the balancing status for cells 1 through 8.

Bits	Access	Bit Name	Default	Description
7	R/W	BAL_CELL8	0	Ranges from 0 to 1. 1: Active 0: Inactive
6	R/W	BAL_CELL7	0	Ranges from 0 to 1. 1: Active 0: Inactive
5	R/W	BAL_CELL6	0	Ranges from 0 to 1. 1: Active 0: Inactive
4	R/W	BAL_CELL5	0	Ranges from 0 to 1. 1: Active 0: Inactive
3	R/W	BAL_CELL4	0	Ranges from 0 to 1. 1: Active 0: Inactive
2	R/W	BAL_CELL3	0	Ranges from 0 to 1. 1: Active 0: Inactive
1	R/W	BAL_CELL2	0	Ranges from 0 to 1. 1: Active 0: Inactive
0	R/W	BAL_CELL1	0	Ranges from 0 to 1. 1: Active 0: Inactive

BAL_CELL9TO16 (0077h)

Format: Boolean true/false

The BAL_CELL9TO16 command inputs the balancing status for cells 9 through 16.

Bits	Access	Bit Name	Default	Description
7	R/W	BAL_CELL16	0	Ranges from 0 to 1. 1: Active 0: Inactive
6	R/W	BAL_CELL15	0	Ranges from 0 to 1. 1: Active 0: Inactive
5	R/W	BAL_CELL14	0	Ranges from 0 to 1. 1: Active 0: Inactive
4	R/W	BAL_CELL13	0	Ranges from 0 to 1. 1: Active 0: Inactive
3	R/W	BAL_CELL12	0	Ranges from 0 to 1. 1: Active 0: Inactive
2	R/W	BAL_CELL11	0	Ranges from 0 to 1. 1: Active 0: Inactive
1	R/W	BAL_CELL10	0	Ranges from 0 to 1. 1: Active 0: Inactive
0	R/W	BAL_CELL9	0	Ranges from 0 to 1. 1: Active 0: Inactive

RST_CMD1TO8 (0078h)

Format: Boolean true/false

The RST_CMD1TO8 command resets the fuel gauge functions.

Bits	Access	Bit Name	Default	Description
7	R/W	SOC_RST	0	Resets the state-of-charge (SOC). Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
6	R	RESERVED	N/A	Reserved.
5	R/W	SOH_RST	0	Resets the state-of-health (SOH). Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
4	R/W	STATUS_RST	0	Resets the pack status. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action

3	R/W	WKUP	0	Wakes up the fuel gauge. Ranges from 0 to 1. 1: Wake up (self-clears) 0: No action
2	R/W	LOG_RST	0	Resets the lifetime log. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
1	R/W	FG_RST	0	Reinitializes certain estimations. Ranges from 0 to 1. Setting this bit to 1 is equivalent to setting STATUS_RST = SOC_RST = FULL_RST = EMTY_RST = 1. This is a self-clearing register that returns to 0 automatically.
0	R/W	HARD_RST	0	Resets all fuel gauge functions, such as learnings and lifetime log. Ranges from 0 to 1. Setting this bit to 1 is equivalent to setting all other reset bits to 1. This is a self-clearing register that returns to 0 automatically.

RST_CMD9TO16 (0079h)

Format: Boolean true/false

The RST_CMD9TO16 command resets the fuel gauge functions.

Bits	Access	Bit Name	Default	Description
7	R/W	RESR_RST	0	Resets the equivalent-series resistance estimate. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
6	R/W	VCHG_CV_RST	0	Resets the charge constant voltage. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
5	R/W	ICHG_CC_RST	0	Resets the charge constant current. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
4	R/W	ICHG_END_RST	0	Resets the charge termination current. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
3	R/W	IDIS_END_RST	0	Resets the discharge termination current. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
2	R/W	IDIS_AVG_RST	0	Resets the discharge average current. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
1	R/W	EMTY_RST	0	Resets the pack empty estimate. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
0	R/W	FULL_RST	0	Resets the pack full estimate. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action

RST_CMD17TO24 (007Ah)

Format: Boolean true/false

The RST_CMD17TO24 command resets the fuel gauge functions.

Bits	Access	Bit Name	Default	Description
7:3	R	RESERVED	N/A	Reserved.
2	R/W	RCXN_RST	0	Resets the cell connection resistance. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action
1	R	RESERVED	N/A	Reserved.
0	R/W	HCONV_RST	0	Resets the heat transfer coefficient. Ranges from 0 to 1. 1: Reset (self-clears) 0: No action

SHW_CMD (007Bh)

Format: Control enable (=1)/disable (=0)

The SHW_CMD command shows the fuel gauge charge and discharge power estimation.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1	R/W	PDIS_SHW	PDIS_ SHW_EN	Shows the maximum discharge power (PDIS_SHW_EN by default). Ranges from 0 to 1. 1: Show 0: Do not show
0	R/W	PCHG_SHW	PCHG_ SHW_EN	Shows the maximum charge power in PCHG, the limiting cell ID in PCHG_ID, and the limiting factor in PCHG_LIM (PCHG_SHW_EN by default). Ranges from 0 to 1. 1: Show 0: Do not show

FUEL GAUGE BACKUP REGISTER MAP

RESR_CELL_DIS_1_BKUP (0200h)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_1_BKUP command backs up cell 1's discharge equivalent series resistance (ESR) state. This address is an R/W alias for the RESR_CELL_DIS_1 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_DIS_1_BKUP	0%	Stores cell 1's discharge ESR backup.

RESR_CELL_DIS_x_BKUP (0200h + (*x* - 1) x 0004h)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_x_BKUP command backs up cell *x*'s (where *x* = 2–15) discharge ESR state. This address is an R/W alias for the RESR_CELL_DIS_x register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_DIS_x_BKUP	0%	Stores cell *x*'s discharge ESR backup.

RESR_CELL_DIS_16_BKUP (023Ch)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_16_BKUP command backs up cell 16's discharge ESR state. This address is an R/W alias for the RESR_CELL_DIS_16 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_DIS_16_BKUP	0%	Stores cell 16's discharge ESR backup.

RESR_CELL_CHG_1_BKUP (0240h)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_1_BKUP command backs up cell 1's charge ESR state. This address is an R/W alias for the RESR_CELL_CHG_1 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_CHG_1_BKUP	0%	Stores cell 1's charge ESR backup.

RESR_CELL_CHG_x_BKUP (0240h + (x - 1) x 0004h)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_x_BKUP command backs up the cell *x*'s (where *x* = 2–15) charge ESR state. This address is an R/W alias for the RESR_CELL_CHG_x register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_CHG_x_BKUP	0%	Stores cell *x*'s charge ESR backup.

RESR_CELL_CHG_16_BKUP (027Ch)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_16_BKUP command backs up the cell 16 charge ESR state. This address is an R/W alias for the RESR_CELL_CHG_16 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this register or any other of the cell ESR backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the ESR learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	RESR_CELL_CHG_16_BKUP	0%	Stores cell 16's charge ESR backup.

SOH_CELL1_BKUP (02A0h)

Format: 32-bit unsigned integer

The SOH_CELL1_BKUP command backs up cell 1's SOH. This address is an R/W alias for the SOH_CELL1 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell SOH backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the SOH learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	SOH_CELL1_BKUP	0%	The resolution is 0.0000001%, and the range is between 0% and 255%.

SOH_CELLx_BKUP (02A0h + (x - 1) x 0004h)

Format: 32-bit unsigned integer

The SOH_CELLx_BKUP command backs up the cell *x*'s (where *x* = 2–15) SOH. This address is an R/W alias for the SOH_CELLx register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell SOH backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the SOH learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	SOH_CELLx_BKUP	0%	The resolution is 0.0000001%, and the range is between 0% and 255%.

SOH_CELL16_BKUP (02DCh)

Format: 32-bit unsigned integer

The SOH_CELL16_BKUP command backs up cell 16's SOH. This address is an R/W alias for the SOH_CELL16 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell SOH backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the SOH learning.

Bits	Access	Bit Name	Default	Description
31:0	R/W	SOH_CELL16_BKUP	0%	The resolution is 0.0000001%, and the range is between 0% and 255%.

IDIS_AVG_BKUP (0360h)

Format: 16-bit unsigned integer

The IDIS_AVG_BKUP command backs up the average discharge current. This address is an R/W alias for the IDIS_AVG register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	IDIS_AVG_BKUP	0 C-Rate	The resolution is 0.001 C-rate, and the range is between 0 C-rate to 65.535 C-rate.

IDIS_END_BKUP (0370h)

Format: 16-bit unsigned integer

The IDIS_END_BKUP command backs up the discharge end current. This address is an R/W alias for the IDIS_END register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	IDIS_END_BKUP	0 C-Rate	The resolution is 0.001 C-rate, and the range is between 0 C-rate to 65.535 C-rate.

ICHG_CC_BKUP (0380h)

Format: 16-bit unsigned integer

The ICHG_CC_BKUP command backs up the charge CC current. This address is an R/W alias for the ICHG_CC register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	ICHG_CC_BKUP	0 C-Rate	The resolution is 0.001 C-rate, and the range is between 0 C-rate to 65.535 C-rate.

ICHG_END_BKUP (0390h)

Format: 16-bit unsigned integer

The ICHG_END_BKUP command backs up the charge termination current. This address is an R/W alias for the ICHG_END register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	ICHG_END_BKUP	0 C-Rate	The resolution is 0.001 C-rate, and the range is between 0 C-rate to 65.535 C-rate.

VCHG_CV_BKUP (03A0h)

Format: 16-bit unsigned integer

The VCHG_CV_BKUP command backs up the charge CV voltage. This address is an R/W alias for the VCHG_CV register.

The fuel gauge must be in learning backup mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VCHG_CV_BKUP	0mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

HCONV_BKUP (03B0h)

Format: 16-bit unsigned integer

The HCONV_BKUP command backs up the heat transfer coefficient. This address is an R/W alias for the HCONV register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this backup register prepares the fuel gauge to use the values written in this register as a starting point for this learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	HCONV_BKUP	0W/(m^{2}K)	The resolution is 0.01W/(m^{2}K), and the range is between 0W/(m^{2}K) and 655.35W/(m^{2}K).

RCXN_CELL1_BKUP (03C0h)

Format: 16-bit unsigned integer

The RCXN_CELL1_BKUP command backs up cell 1’s connection resistance. This address is an R/W alias for the RCXN_CELL1 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell RCXN backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the RCXN learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELL1_BKUP	0mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_CELLx_BKUP (03C0h + (x - 1) x 0002h)

Format: 16-bit unsigned integer

The RCXN_CELLx_BKUP command backs up the cell *x*'s (where *x* = 2–15) connection resistance. This address is an R/W alias for the RCXN_CELLx register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell RCXN backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the RCXN learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELLx_BKUP	0mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_CELL16_BKUP (03DEh)

Format: 16-bit unsigned integer

The RCXN_CELL16_BKUP command backs up cell 16's connection resistance. This address is an R/W alias for the RCXN_CELL16 register.

The fuel gauge must be in learning backup mode for this register to be written (by setting FG_BKUP_ENABLE and FG_BKUP_FLAG). Writing to this or any other of the cell RCXN backup registers prepares the fuel gauge to use the values written in these registers as a starting point for the RCXN learning.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELL16_BKUP	0mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

FG_BKUP_ENABLE (03F0h)

Format: Control enable (=1)/disable (=0)

The FG_BKUP_ENABLE command enables learning backup mode. See the FG_BKUP_FLAG section on page 55 for more details.

Bits	Access	Bit Name	Default	Description
7:1	R	RESERVED	N/A	Reserved.
0	Write-only	FG_BKUP_ENABLE	0	Ranges from 0 to 1 .

FUEL GAUGE OUTPUT REGISTER MAP

INTR_STS (0400h)

Format: Boolean true/false

The INTR_STS command returns the fuel gauge interrupt bits.

Bits	Access	Bit Name	Default	Description
23:18	R	RESERVED	N/A	Reserved.
17	W1C/ RO	PCHG_LIM_INTR	0	Signals a change in the PCHG_LIM register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
16	W1C/ RO	PDIS_LIM_INTR	0	Signals a change in the PDIS_LIM register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
15	R	RESERVED	N/A	Reserved.
14	W1C/ RO	SOH_CELLS_INTR	0	Signals a change in the SOH_LRN_CELLx or the SOH_RSLT_CELLx registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
13	W1C/ RO	HCONV_INTR	0	Signals a change in the HCONV_LRN or the HCONV_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
12	W1C/ RO	RCXN_CELLS_INTR	0	Signals a change in the RCXN_LRN_CELLx or the RCXN_RSLT_CELLx registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
11	W1C/ RO	SORESR_CELLS_ INTR	0	Signals a change in the RESR_LRN_CELLx or the RESR_RSLT_CELLx registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
10	W1C/ RO	VCHG_CV_INTR	0	Signals a change in the VCHG_CV_LRN or the VCHG_CV_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
9	W1C/ RO	ICHG_END_INTR	0	Signals a change in the ICHG_END_LRN or the ICHG_END_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
8	W1C/ RO	ICHG_CC_INTR	0	Signals a change in the ICHG_CC_LRN or the ICHG_CC_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
7	W1C/ RO	IDIS_END_INTR	0	Signals a change in the IDIS_END_LRN or the IDIS_END_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
6	W1C/ RO	IDIS_AVG_INTR	0	Signals a change in the IDIS_AVG_LRN or the IDIS_AVG_RSLT registers. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
5	W1C /RO	OT_WARN_INTR	0	Signals that an over-temperature condition is projected; check OT_ID, WARN_OTDIS, WARN_OTCHG_CC, and WARN_OTCHG_END for more details. Writing this bit to 1 will clear the interrupt.
4	W1C/ RO	SOC_PACK_RSLT_ INTR	0	Signals a change in the SOC_PACK_RSLT register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
3	W1C/ RO	FULL_LIM_INTR	0	Signals a change in the FULL_LIM register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
2	W1C/ RO	EMTY_LIM_INTR	0	Signals a change in the EMTY_LIM register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.

1	W1C/ RO	STATUS_INTR	0	Signals a change in the STATUS register. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.
0	W1C/ RO	IT_DONE_INTR	0	Signals an iteration has been completed. This interrupt bit automatically clears when a new iteration is requested. Ranges from 0 to 1. Writing 1 to this bit clears the interrupt.

STATUS (0403h)

Format: 8-bit unsigned integer

The STATUS command returns the pack status.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	STATUS	0	The resolution is 1, and the range is from 0 to 2. 0: Charge 1: Discharge 2: Rest

SOC_ABS_CELL1 (0524h)

Format: 8-bit unsigned integer

The SOC_ABS_CELL1 command returns cell 1's absolute SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	SOC_ABS_CELL1	0%	The resolution is 0.4%, and the range is between 0% and 100%.

SOC_ABS_CELLx (0524h + (*x* – 1) x 0001h)

Format: 8-bit unsigned integer

The SOC_ABS_CELLx command returns cell *x*'s (where *x* = 2–15) absolute SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	SOC_ABS_CELLx	0%	The resolution is 0.4%, and the range is between 0% and 100%.

SOC_ABS_CELL16 (0533h)

Format: 8-bit unsigned integer

The SOC_ABS_CELL16 command returns cell 16's absolute SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	SOC_ABS_CELL16	0%	The resolution is 0.4%, and the range is between 0% and 100%.

EMTY_SOC_CELL1 (0578h)

Format: 8-bit unsigned integer

The EMTY_SOC_CELL1 command returns cell 1's SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	EMTY_SOC_CELL1	0%	The resolution is 0.4%, and the range is between 0% and 100%.

EMTY_SOC_CELLx (0578h +(*x* – 1) x 0001h)

Format: 8-bit unsigned integer

The EMTY_SOC_CELLx command returns cell *x*'s (where *x* = 2–15) empty SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	EMTY_SOC_CELLx	0%	The resolution is 0.4%, and the range is between 0% and 100%.

EMTY_SOC_CELL16 (0587h)

Format: 8-bit unsigned integer

The EMTY_SOC_CELL16 command returns cell 16's empty SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	EMTY_SOC_CELL16	0%	The resolution is 0.4%, and the range is between 0% and 100%.

EMTY_ID (0588h)

Format: 8-bit unsigned integer

The EMTY_ID command returns the empty pack's limiting cell ID.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	EMTY_ID	0 Cell ID	The resolution is 1 cell ID. It ranges from 1 cell ID to 16 cell ID.

EMTY_RTIME (0589h)

Format: 16-bit unsigned integer

The EMTY_RTIME command returns the remaining time to reach an empty pack.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	EMTY_RTIME	0s	The resolution is 1s, and the range is between 0s and 65535s.

EMTY_DTEMP (058Bh)

Format: 16-bit signed, 2-comp integer

The EMTY_DTEMP command returns the predicted temperature to reach an empty pack.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	EMTY_DTEMP	0°C	The resolution is 0.01°C, and the range is between -327.68°C and +327.67°C.

EMTY_LIM (058Dh)

Format: Non-standard

The EMTY_LIM command returns the empty pack's limiting factor:

Bits	Access	Bit Name	Default	Description
7:0	Read-only	EMTY_LIM	0	The resolution is 1, and it ranges from 0 to 1. 0: Cell 1: Pack

FULL_SOC_CELL1 (0592h)

Format: 8-bit unsigned integer

The FULL_SOC_CELL1 returns cell 1's full SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read Only	FULL_SOC_CELL1	100%	The resolution is 0.4%, and the range is between 0% and 100%.

FULL_SOC_CELLx (0592h +(*x* – 1) x 0001h)

Format: 8-bit unsigned integer

The FULL_SOC_CELLx command returns the cell *x*'s (where *x* = 2–15) full SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	FULL_SOC_CELLx	100%	The resolution is 0.4%, and the range is between 0% and 100%.

FULL_SOC_CELL16 (05A1h)

Format: 8-bit unsigned integer

The FULL_SOC_CELL16 command returns cell 16's full SOC.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	FULL_SOC_CELL16	100%	The resolution is 0.4%, and the range is between 0% and 100%.

FULL_ID (05A2h)

Format: 8-bit unsigned integer

The FULL_ID command returns the empty pack's limiting cell ID.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	FULL_ID	0 Cell ID	The resolution is 1 cell ID. It ranges from 1 cell ID to 16 cell ID.

FULL_RTIME (05A3h)

Format: 16-bit unsigned integer

The FULL_RTIME command returns the remaining time to reach a full pack.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	FULL_RTIME	0s	The resolution is 1s, and the range is between 0s and 65535s.

FULL_RTIME_CC (05A5h)

Format: 16-bit unsigned integer

The FULL_RTIME_CC command returns the remaining time to reach the end of the charge constant-current region.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	FULL_RTIME_CC	0s	The resolution is 1s, and the range is between 0s and 65535s.

FULL_DTEMP (05A7h)

Format: 16-bit signed, 2-comp integer

The FULL_DTEMP command returns the predicted temperature rise to reach a full pack.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	FULL_DTEMP	0°C	The resolution is 0.01°C, and the range is between -327.28°C and +327.27°C.

FULL_DTEMP_CC (05A9h)

Format: 16-bit signed, 2-comp integer

The FULL_DTEMP command returns the predicted temperature rise at the end of the charge CC region.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	FULL_DTEMP_CC	0°C	The resolution is 0.01°C, and the range is between -327.28°C and +327.27°C.

FULL_LIM (05ABh)

Format: Non-standard

The FULL_LIM command returns the full pack's limiting factor.

Bits	Access	Bit Name	Default	Description
7:3	R	RESERVED	N/A	Reserved.
2:0	Read-only	FULL_LIM	0	The resolution is 1, and it ranges from 0 to 4. 0: Cell 1: Pack 2: Charger 3: Smartcharger cell 4: Smartcharger pack

SOC_PACK (05ACh)

Format: 16-bit unsigned integer

The SOC_PACK command returns the pack SOC.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	SOC_PACK	0%	The resolution is 0.002%, and the range is between 0% and 100%.

SOC_PACK_UNAVBL (05AFh)

Format: 16-bit unsigned integer

The SOC_PACK_UNAVBL command returns the unavailable pack SOC due to empty/full conditions and a mismatch between the cells. Returns the quantity of the pack's unusable capacity.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	SOC_PACK_UNAVBL	0%	The resolution is 0.002%, and the range is between 0% and 100%.

IDIS_AVG (05B1h)

Format: 16-bit unsigned integer

The IDIS_AVG command returns the learned value for the typical load current drained from the battery during its use.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	IDIS_AVG	0 C-Rate	The resolution is 0.001 C-rate. It ranges between 0 C-rate and 65.535 C-rate.

IDIS_AVG_LRN (05B3h)

Format: 8-bit unsigned integer

The IDIS_AVG_LRN command returns the state of the discharge average current learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	IDIS_AVG_LRN	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

IDIS_AVG_RSLT (05B4h)

Format: 8-bit unsigned integer

The IDIS_AVG_RSLT command returns the result of the detected discharge average current value.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	IDIS_AVG_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

IDIS_END (05B5h)

Format: 16-bit unsigned integer

The IDIS_END command returns the learned value for the typical end of discharge current.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	IDIS_END	0 C-Rate	The resolution is 0.001 C-rate. It ranges between 0 C-rate and 65.535 C-rate.

IDIS_END_LRN (05B7h)

Format: 8-bit unsigned integer

The IDIS_END_LRN command returns the state of the end discharge current learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	IDIS_END_LRN	0	The resolution is 1, and it ranges from 0 to 2. 0: Disable 1: Paused 2: Ongoing

IDIS_END_RSLT (05B8h)

Format: 8-bit unsigned integer

The IDIS_END_RSLT command returns the result of the detected discharge end current value.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	IDIS_END_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

ICHG_CC (05B9h)

Format: 16-bit unsigned integer

The ICHG_CC command returns the learned charge current of the charger in the CC region performed by the algorithm.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	ICHG_CC	0 C-Rate	The resolution is 0.001 C-rate. It ranges between 0 C-rate and 65.535 C-rate.

ICHG_CC_LRN (05BBh)

Format: 8-bit unsigned integer

The ICHG_CC_LRN command returns the state of the CC charge current learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	ICHG_CC_LRN	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

ICHG_CC_RSLT (05BCh)

Format: 8-bit unsigned integer

The ICHG_CC_RSLT command returns the result of the detected CC charge current value:

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	ICHG_CC_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

ICHG_END (05BDh)

Format: 16-bit unsigned integer

The ICHG_END command returns the learned value for the typical end of discharge current.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	ICHG_END	0 C-Rate	The resolution is 0.001 C-rate. It ranges between 0 C-rate and 131070 C-rate.

ICHG_END_LRN (05CFh)

Format: 8-bit unsigned integer

The ICHG_END_LRN command returns the state of the end discharge current learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	ICHG_END_LRN	0	The resolution is 1. Range is from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

ICHG_END_RSLT (05C0h)

Format: 8-bit unsigned integer

The ICHG_END_RSLT command returns the result of the detected discharge end current value.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	ICHG_END_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

VCHG_CV (05C1h)

Format: 16-bit unsigned integer

The VCHG_CV command returns the learned value for the typical charge CV voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VCHG_CV	0mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

VCHG_CV_LRN (05C3h)

Format: 8-bit unsigned integer

The VCHG_CV_LRN command returns the state of the CV charge voltage learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	VCHG_CV_LRN	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

VCHG_CV_RSLT (05C4h)

Format: 8-bit unsigned integer

The VCHG_CV_RSLT command returns the state of the detected charge CV voltage result:

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.

1:0	Read-only	VCHG_CV_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RESR_CELL_DIS_1 (05C5h)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_1 command returns cell 1's equivalent-series resistance (ESR) state compared to the beginning of life (BOL) for discharge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_DIS_1	100%	Returns the state of cell 1's discharge ESR.

RESR_CELL_DIS_x (05C5h + (*x* - 1) x 0004h)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_x returns cell *x*'s (where *x* = 2–15) ESR state compared to the BOL for discharge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_DIS_2	100%	Returns the state of cell *x*'s discharge ESR.

RESR_CELL_DIS_16 (0601h)

Format: 32-bit floating point (single)

The RESR_CELL_DIS_16 command returns cell 16's ESR state compared to the BOL for discharge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_DIS_16	100%	Returns the state of cell 16's discharge ESR.

RESR_CELL_CHG_1 (0605h)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_1 command returns cell 1's ESR state compared to the BOL for charge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_CHG_1	100%	Returns the state of cell 1's charge ESR.

RESR_CELL_CHG_x (0605h + (*x* - 1) x 0004h)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_x command returns cell *x*'s (where *x* = 2–15) ESR state compared to the BOL in charge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_CHG_x	100%	Returns the state of cell *x*'s charge ESR.

RESR_CELL_CHG_16 (0641h)

Format: 32-bit floating point (single)

The RESR_CELL_CHG_16 command returns cell 16's ESR state compared to the beginning of life (BOL) in charge.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	RESR_CELL_CHG_16	100%	Returns the state of cell 16's charge ESR.

RESR_LRN_CELL1 (0645h)

Format: 8-bit unsigned integer

The RESR_LRN_CELL1 command returns the state of cell 1's ESR learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RESR_LRN_CELL1	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RESR_LRN_CELLx (0645h + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The RESR_LRN_CELLx command returns the state of cell *x*'s (where *x* = 2–15) ESR learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RESR_LRN_CELLx	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RESR_LRN_CELL16 (0654h)

Format: 8-bit unsigned integer

The RESR_LRN_CELL16 command returns the state of cell 16's ESR learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RESR_LRN_CELL16	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RESR_RSLT_CELL1 (0655h)

Format: 8-bit unsigned integer

The RESR_RSLT_CELL1 command returns the state of cell 1's ESR result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.

1:0	Read-only	RESR_RSLT_CELL1	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RESR_RSLT_CELLx (0655h + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The RESR_RSLT_CELLx command returns the state of cell *x*'s (where *x* = 2–15) ESR result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RESR_RSLT_CELLx	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RESR_RSLT_CELL16 (0664h)

Format: 8-bit unsigned integer

The RESR_RSLT_CELL16 command returns the state of cell 16's ESR result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RESR_RSLT_CELL16	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RCXN_CELL1 (0665h)

Format: 16-bit unsigned integer

The RCXN_CELL1 command returns cell 1's connection resistance learning value.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	RCXN_CELL1	0mΩ	The resolution is 0.1mΩ, and it ranges between 0Ω and 6553.5mΩ.

RCXN_CELLx (0665h + (*x* - 1) x 0002h)

Format: 16-bit unsigned integer

The RCXN_CELLx command returns the cell *x*'s (where *x* = 2–15) connection resistance learning value.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	RCXN_CELLx	0mΩ	The resolution is 0.1mΩ, and it ranges between 0Ω and 6553.5mΩ.

RCXN_CELL16 (0683h)

Format: 16-bit unsigned integer

The RCXN_CELL16 command returns cell 16's connection resistance learning value.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	RCXN_CELL16	0mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_LRN_CELL1 (0685h)

Format: 8-bit unsigned integer

The RCXN_LRN_CELL1 command returns the state of cell 1's connection resistance learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RCXN_LRN_CELL1	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RCXN_LRN_CELLx (0685h + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The RCXN_LRN_CELLx command returns the state of cell *x*'s (where *x* = 2–15) connection resistance learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RCXN_LRN_CELLx	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RCXN_LRN_CELL16 (0694h)

Format: 8-bit unsigned integer

The RCXN_LRN_CELL16 command returns the state of cell 16's connection resistance learning.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RCXN_LRN_CELL16	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

RCXN_RSLT_CELL1 (0695h)

Format: 8-bit unsigned integer

The RCXN_RSLT_CELL1 command returns the state of cell 1's connection resistance result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.

1:0	Read-only	RCXN_RSLT_CELL1	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RCXN_RSLT_CELLx (0695h + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The RCXN_RSLT_CELLx command returns the state of cell *x*'s (where *x* = 2–15) connection resistance result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RCXN_RSLT_CELLx	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

RCXN_RSLT_CELL16 (06A4h)

Format: 8-bit unsigned integer

The RCXN_RSLT_CELL16 command returns the state of cell 16's connection resistance result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	RCXN_RSLT_CELL16	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

HCONV (06A5h)

Format: 16-bit unsigned integer

The HCONV command returns the heat transfer coefficient.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	HCONV	23W/(m^2K)	The resolution is 0.01W/(m^2K). It ranges between 0W/(m^2K) and 655.35W/(m^2K).

HCONV_LRN (06A7h)

Format: 8-bit unsigned integer

The HCONV_LRN command returns the state of the heat transfer coefficient learning:

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	HCONV_LRN	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

HCONV_RSLT (06A8h)

Format: 8-bit unsigned integer

The HCONV_RSLT command returns the state of the heat transfer coefficient result:

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	HCONV_RSLT	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

SOH_PACK (06A9h)

Format: 32-bit unsigned integer

The SOH_PACK command returns the pack's SOH.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	SOH_PACK	0%	The resolution is 0.0000001%, and the range is between 0% and 100%.

SOH_CELL1 (06ADh)

Format: 32-bit unsigned integer

The SOH_CELL1 command returns cell 1's SOH.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	SOH_CELL1	0%	The resolution is 0.0000001%, and the range is between 0% and 100%.

SOH_CELLx (06ADh + (*x* - 1) x 0004h)

Format: 32-bit unsigned integer

The SOH_CELLx command returns cell *x*'s (where *x* = 2–15) SOH.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	SOH_CELLx	0%	The resolution is 0.0000001%, and the range is between 0% and 100%.

SOH_CELL16 (06E9h)

Format: 32-bit unsigned integer

The SOH_CELL16 command returns cell 16's SOH.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	SOH_CELL16	0%	The resolution is 0.0000001%, and the range is between 0% and 100%.

SOH_LRN_CELL1 (06EDh)

Format: 8-bit unsigned integer

The SOH_LRN_CELL1 command returns cell 1's SOH learning status.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.

1:0	Read-only	SOH_LRN_CELL1	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

SOH_LRN_CELLx (06EDh + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The SOH_LRN_CELLx command returns cell *x*'s (where *x* = 2–15) SOH learning status.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_LRN_CELLx	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

SOH_LRN_CELL16 (06FCh)

Format: 8-bit unsigned integer

The SOH_LRN_CELL16 command returns cell 16's SOH learning status.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_LRN_CELL16	0	The resolution is 1, and it ranges from 0 to 2. 0: Disabled 1: Paused 2: Ongoing

SOH_RSLT_CELL1 (06FDh)

Format: 8-bit unsigned integer

The SOH_RSLT_CELL1 command returns cell 1's SOH result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_RSLT_CELL1	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

SOH_RSLT_CELLx (06FDh + (*x* - 1) x 0001h)

Format: 8-bit unsigned integer

The SOH_RSLT_CELLx command returns cell *x*'s (where *x* = 2–15) SOH result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_RSLT_CELLx	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

SOH_RSLT_CELL16 (070Ch)

Format: 8-bit unsigned integer

The SOH_RSLT_CELL16 command returns cell 16's SOH result.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_RSLT_CELL16	0	The resolution is 1, and it ranges from 0 to 3. 0: Default 1: Updated 2: Updated to max 3: Updated to min

SOH_ETIME_CELL1 (070Dh)

Format: 16-bit unsigned integer

The SOH_ETIME_CELL1 command returns the time since cell 1's SOH was last updated.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_ETIME_CELL1	0	The resolution is 1min, and the range is between 0min to 65535min.

SOH_ETIME_CELLx (070Dh + (*x* - 1) x 0001h)

Format: 16-bit unsigned integer

The SOH_ETIME_CELLx command returns the time since cell *x*'s (where *x* = 2–15) SOH was last updated.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_ETIME_CELLx	0	The resolution is 1min, and the range is between 0min to 65535min.

SOH_ETIME_CELL16 (072Bh)

Format: 16-bit unsigned integer

The SOH_ETIME_CELL16 command returns the time since cell 16's SOH was last updated.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1:0	Read-only	SOH_ETIME_CELL16	0	The resolution is 1min, and the range is between 0min to 65535min.

PRDG (07ADh)

Format: 32-bit unsigned integer

The PRDG command returns the battery pack's actual power.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	PRDG	0mW	The resolution is 0.1mW, and the range is between 0mW and 429496729.5mW.

PDIS_MAX (07B1h)

Format: 32-bit unsigned integer

The PDIS_MAX command returns the maximum possible applicable discharge power.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	PDIS	0mW	The resolution is 0.1mW, and the range is between 0mW and 429496729.5mW.

PDIS_ID (07B5h)

Format: 8-bit unsigned integer

The PDIS_ID command returns the ID of the cell that is limiting the maximum discharge power estimate the most.

Bits	Access	Bit Name	Default	Description
7:5	R	RESERVED	N/A	Reserved.
4:0	Read-only	PDIS_ID	1 Cell ID	The resolution is 1 cell ID, and it ranges from 1 cell ID to 16 cell ID.

PDIS_LIM (07B6h)

Format: 8-bit unsigned integer

The PDIS_LIM command returns the limiting factor of the maximum discharge power estimate.

Bits	Access	Bit Name	Default	Description
7:1	R	RESERVED	N/A	Reserved.
0	Read-only	PDIS_LIM	0	Ranges from 0 to 1. 0: A cell is limiting the maximum discharge power estimate 1: The pack is limiting the maximum discharge power estimate

PCHG_MAX (07B7h)

Format: 32-bit unsigned integer

The PCHG_MAX command returns the maximum possible applicable charge power.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	PCHG	0mW	The resolution is 0.1mW, and the range is between 0mW and 429496729.5mW.

PCHG_ID (07BBh)

Format: 8-bit unsigned integer

The PCHG_ID command returns the ID of the cell that is limiting the maximum charge power estimate the most.

Bits	Access	Bit Name	Default	Description
7:5	R	RESERVED	N/A	Reserved.
4:0	Read-only	PCHG_ID	1 Cell ID	The resolution is 1 cell ID, and it ranges from 1 cell ID to 16 cell ID.

PCHG_LIM (07BCh)

Format: 8-bit unsigned integer

The PCHG_LIM command returns the limiting factor of the maximum charge power estimate.

Bits	Access	Bit Name	Default	Description
7:1	R	RESERVED	N/A	Reserved.
0	Read-only	PCHG_LIM	0	Ranges from 0 to 1. 0: A cell is limiting the maximum charge power estimate 1: The pack is limiting the maximum charge power estimate

OT_ID (07BDh)

Format: 8-bit unsigned integer

The OT_ID command returns the ID of the cell temperature sensor with the highest temperature.

Bits	Access	Bit Name	Default	Description
7:3	R	RESERVED	N/A	Reserved.
2:0	Read-only	OT_ID	1 Cell ID	The resolution is 1 cell ID, and it ranges from 1 cell ID to 4 cell ID.

WARN_OT (07BEh)

Format: Boolean true/false

The WARN_OT command returns the fuel gauge warning bits that indicate potential over-temperature conditions.

Bits	Access	Bit Name	Default	Description
7:3	R	RESERVED	N/A	Reserved.
2	Read-only	WARN_OTDIS	0	Ranges from 0 to 1.
1	Read-only	WARN_OTCHG_END	0	Ranges from 0 to 1.
0	Read-only	WARN_OTCHG_CC	0	Ranges from 0 to 1.

FG_ITER (07BFh)

Format: 32-bit unsigned integer

The FG_ITER command returns the number of iterations executed by the fuel gauges.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	FG_ITER	0	The resolution is 1, and the range is between 0 and 4294967295.

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VRDG_MIN_CELL1 (0C00h)

Format: 16-bit unsigned integer

The VRDG_MIN_CELL1 command returns cell 1's minimum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MIN_CELL1	5000mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_MIN_CELLx (0C00h + (x - 1) x 0002h)

Format: 16-bit unsigned integer

The VRDG_MIN_CELLx command returns cell *x*'s (where *x* = 2–15) minimum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MIN_CELLx	5000mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_MIN_CELL16 (0C1Eh)

Format: 16-bit unsigned integer

The VRDG_MIN_CELL16 command returns cell 16's minimum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MIN_CELL16	5000mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_MAX_CELL1 (0C20h)

Format: 16-bit unsigned integer

The VRDG_MAX_CELL1 command returns cell 1's maximum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MAX_CELL1	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_MAX_CELLx (0C20h + (x - 1) x 0002h)

Format: 16-bit unsigned integer

The VRDG_MAX_CELLx command returns cell *x*'s (where *x* = 2–15) maximum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MAX_CELLx	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_MAX_CELL16 (0C3Eh)

Format: 16-bit unsigned integer

The VRDG_MAX_CELL16 command returns cell 16's maximum measured voltage.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	VRDG_MAX_CELL16	0mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VRDG_DMAX (0C40h)

Format: 8-bit unsigned integer

The VRDG_DMAX command returns the maximum voltage imbalance between cells.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	VRDG_DMAX	0mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

VRDG_DMAX_IDMAX_IDMIN (0C41h)

Format: Non-Standard

The VRDG_DMAX_IDMAX_IDMIN command returns the identifiers for the cells between which the maximum voltage imbalance (VRDG_DMAX) has been detected. VRDG_DMAX_IDMIN shows the identifier for the cell with the lower voltage, and VRDG_DMAX_IDMAX shows the identifier for the cell with the higher voltage.

Bits	Access	Bit Name	Default	Description
7:4	Read-only	VRDG_DMAX_IDMIN	1 Cell ID	The resolution is 1 cell ID, the offset is 1 cell ID, and it ranges from 1 cell ID to 16 cell ID.
3:0	Read-only	VRDG_DMAX_IDMAX	1 Cell ID	The resolution is 1 cell ID, the offset is 1 cell ID, and it ranges from 1 cell ID to 16 cell ID.

BAL_ETIME_CELL1 (0C42h)

Format: 16-bit unsigned integer

The BAL_ETIME_CELL1 command returns the total amount of time during which cell 1 has been balanced.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	BAL_ETIME_CELL1	0min	The resolution is 1min, and it ranges between 0min and 65535min.

BAL_ETIME_CELLx (0C42h + (x - 1) x 0002h)

Format: 16-bit unsigned integer

The BAL_ETIME_CELLx command returns the total amount of time during which cell *x* (where *x* = 2–15) has been balanced.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	BAL_ETIME_CELLx	0min	The resolution is 1min, and it ranges between 0min and 65535min.

BAL_ETIME_CELL16 (0C60h)

Format: 16-bit unsigned integer

The BAL_ETIME_CELL16 command returns the total amount of time during which cell 16 has been balanced.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	BAL_ETIME_CELL16	0min	The resolution is 1min, and it ranges between 0min and 65535min.

TRDG_MIN_TS1 (0C62h)

Format: 8-bit unsigned integer

The TRDG_MIN_TS1 command returns the minimum temperature measured with temperature sensor 1.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MIN_TS1	97.5°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MIN_TS2 (0C63h)

Format: 8-bit unsigned integer

The TRDG_MIN_TS2 command returns the minimum temperature measured with temperature sensor 2.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MIN_TS2	97.5°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MIN_TS3 (0C64h)

Format: 8-bit unsigned integer

The TRDG_MIN_TS3 command returns the minimum temperature measured with temperature sensor 3.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MIN_TS3	97.5°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MIN_TS4 (0C65h)

Format: 8-bit unsigned integer

The TRDG_MIN_TS4 command returns the minimum temperature measured with temperature sensor 4.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MIN_TS4	97.5°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MAX_TS1 (0C66h)

Format: 8-bit unsigned integer

The TRDG_MAX_TS1 command returns the maximum temperature measured with temperature sensor 1.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MAX_TS1	97.5°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MAX_TS2 (0C67h)

Format: 8-bit unsigned integer

The TRDG_MAX_TS2 command returns the maximum temperature measured with temperature sensor 2.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MAX_TS2	-30°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MAX_TS3 (0C68h)

Format: 8-bit unsigned integer

The TRDG_MAX_TS3 command returns the maximum temperature measured with temperature sensor 3.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MAX_TS3	-30°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_MAX_TS4 (0C69h)

Format: 8-bit unsigned integer

The TRDG_MAX_TS4 command returns the maximum temperature measured with temperature sensor 4.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_MAX_TS4	-30°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TRDG_DMAX (0C6Ah)

Format: 8-bit unsigned integer

The TRDG_DMAX command returns the maximum temperature delta between sensors.

Bits	Access	Bit Name	Default	Description
7:0	Read-only	TRDG_DMAX	0°C	The resolution is 0.5°C, and the range is between 0°C and 127.5°C.

TRDG_DMAX_IDMAX_IDMIN (0C6Bh)

Format: Non-standard

The TRDG_DMAX_IDMAX_IDMIN command returns the identifiers for the temperature sensors between which the maximum temperature delta (TRDG_DMAX) has been detected. TRDG_DMAX_IDMIN shows the identifier for the sensor reporting the lower temperature, and TRDG_DMAX_IDMAX shows the identifier for the sensor reporting the higher voltage.

Bits	Access	Bit Name	Default	Description
7:4	Read-only	TRDG_DMAX_IDMIN	1 Sensor ID	The resolution is 1 sensor ID, the offset is 1 sensor ID, and it ranges from 1 sensor ID to 4 sensor ID.
3:0	Read-only	TRDG_DMAX_IDMAX	1 Sensor ID	The resolution is 1 sensor ID, the offset is 1 sensor ID, and it ranges from 1 sensor ID to 4 sensor ID.

TRDG_ETIME_UND0 (0C6Ch)

Format: 16-bit unsigned integer

The TRDG_ETIME_UND0 command returns the amount of time during which the battery's average temperature has been below 0°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_UND0	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_0TO5 (0C6Eh)

Format: 16-bit unsigned integer

The TRDG_ETIME_0TO5 command returns the amount of time during which the battery's average temperature is between 0°C and 5°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_0TO5	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_5TO10 (0C70h)

Format: 16-bit unsigned integer

The TRDG_ETIME_5TO10 command returns the amount of time during which the battery's average temperature is between 5°C and 10°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_5TO10	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_10TO15 (0C72h)

Format: 16-bit unsigned integer

The TRDG_ETIME_10TO15 command returns the amount of time during which the battery's average temperature is between 10°C and 15°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_10TO15	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_15TO20 (0C74h)

Format: 16-bit unsigned integer

The TRDG_ETIME_15TO20 command returns the amount of time during which the battery's average temperature is between 15°C and 20°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_15TO20	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_20TO25 (0C76h)

Format: 16-bit unsigned integer

The TRDG_ETIME_20TO25 command returns the amount of time during which the battery's average temperature is between 20°C and 25°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_20TO25	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_25TO30 (0C78h)

Format: 16-bit unsigned integer

The TRDG_ETIME_25TO30 command returns the amount of time during which the battery's average temperature is between 25°C and 30°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_25TO30	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_30TO35 (0C7Ah)

Format: 16-bit unsigned integer

The TRDG_ETIME_30TO35 command returns the amount of time during which the battery's average temperature is between 30°C and 35°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_30TO35	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_35TO40 (0C7Ch)

Format: 16-bit unsigned integer

The TRDG_ETIME_35TO40 command returns the amount of time during which the battery's average temperature is between 35°C and 40°C.

Bits	Access	Bit Name	Default	Description
15:0	Read Only	TRDG_ETIME_35TO40	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_40TO45 (0C7Eh)

Format: 16-bit unsigned integer

The TRDG_ETIME_40TO45 command returns the amount of time during which the battery's average temperature is between 40°C and 45°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_40TO45	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_45TO50 (0C80h)

Format: 16-bit unsigned integer

The TRDG_ETIME_45TO50 command returns the amount of time during which the battery's average temperature is between 45°C and 50°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_45TO50	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_50TO55 (0C82h)

Format: 16-bit unsigned integer

The TRDG_ETIME_50TO55 command returns the amount of time during which the battery's average temperature is between 50°C and 55°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_50TO55	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_55TO60 (0C84h)

Format: 16-bit unsigned integer

The TRDG_ETIME_55TO60 command returns the amount of time during which the battery's average temperature is between 55°C and 60°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_55TO60	0h	The resolution is 1h, and the range is between 0h and 65535h.

TRDG_ETIME_ABV60 (0C86h)

Format: 16-bit unsigned integer

The TRDG_ETIME_ABV60 command returns the amount of time during which the battery's average temperature exceeds 60°C.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	TRDG_ETIME_ABV60	0h	The resolution is 1h, and the range is between 0h and 65535h.

IRDG_MAX_CHG (0C8Ah)

Format: 16-bit unsigned integer

The IRDG_MAX_CHG command returns the maximum measured charge current.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	IRDG_MAX_CHG	0mA	The resolution is 2mA, and the range is between 0mA and 131070mA.

IRDG_MAX_DIS (0C8Ch)

Format: 16-bit unsigned integer

The IRDG_MAX_DIS command returns the maximum measured discharge current.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	IRDG_MAX_DIS	0mA	The resolution is 2mA, and the range is between 0mA and 131070mA.

NCHG_CYC (0C8Eh)

Format: 16-bit unsigned integer

The NCHG_CYC command returns the number of times for which the battery has been charged from a pack SOC below 15% to above 85%.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	NCHG_CYC	0 Event(s)	The resolution is 1 event(s). It ranges between from 0 events to 65535 events.

NCHG_10SOC (0C90h)

Format: 16-bit unsigned integer

The NCHG_10SOC command returns the number of times the pack has been charged by 10%

Bits	Access	Bit Name	Default	Description
15:0	Read-only	NCHG_10SOC	0 Event(s)	The resolution is 1 event(s). It ranges between from 0 events to 65535 events.

NSHDN (0C92h)

Format: 16-bit unsigned integer

The NSHDN command returns the number of times the fuel gauge has woken up after sleep mode, a hard reset, or shutdown.

Bits	Access	Bit Name	Default	Description
15:0	Read-only	NSHDN	0 Event(s)	The resolution is 1 event(s). It ranges between from 0 events to 65535 events.

FUEL GAUGE FLAGS REGISTER MAP

FG_FLAGS (0F00h)

Format: Non-standard

The FG_FLAGS command returns the fuel gauge algorithm flags.

Bits	Access	Bit Name	Default	Description
15	Read-only	LEDS_CHG_FLAG	0	Ranges from 0 to 1. 1: The LED controller considers the fuel gauge is in a charge state 0: The LED controller does not consider the fuel gauge is in a charge state.
14	Read-only	LEDS_ON_CHG_FLAG	0	Ranges from 0 to 1. 1: The LEDs are on due to a detected charge current 0: The LEDs are not on due to a detected charge current
13	Read-only	LEDS_ON_BTN_FLAG	0	Ranges from 0 to 1. 1: The LEDs are on due to the PB pin 0: The LEDs are not on due to the PB pin
12	Read-only	FG_BKUP_FLAG	0	Ranges from 0 to 1. To enter/exit this mode, use FG_BKUP_ENABLE. 1: The fuel gauge is in learning backup mode 0: The fuel gauge is not in learning backup mode
11	Read-only	CUST_BLOCK_LOCKED_FLAG	0	Ranges from 0 to 1. 1: The customer block feature is locked and will remain locked until a hardware reset is performed 0: The customer block feature is not locked
10:9	Read-only	CUST_BLOCK_FAIL_CNTR_FLAG	0	The resolution is 1. Ranges from 0 to 3. A counter containing the number of failed attempts at writing the password. 4 failed attempts set the CUST_BLOCK_LOCKED_FLAG and the customer block feature is locked until a hardware reset is performed.
8	Read-only	CUST_BLOCK_FLAG	0	Ranges from 0 to 1. 1: The customer block is active 0: The customer block is not active
7	Read-only	LOG_RST_PNDG_FLAG	0	Ranges from 0 to 1. 1: There is a pending reset to the lifetime log registers 0: No pending reset to the lifetime log registers
6	Read-only	LOG_RST_FLAG	0	Ranges from 0 to 1. 1: The lifetime log registers are being reset in the current fuel gauge iteration 0: The lifetime log registers are not being reset
5	Read-only	FG_RST_FLAG	0	Ranges from 0 to 1. 1: There is a pending reset for the fuel gauge algorithm 0: There is no pending reset for the fuel gauge algorithm
4	R	RESERVED	N/A	Reserved.
3	Read-only	CONFIG_EXIT_FLAG	0	Ranges from 0 to 1. 1: Pending exit from configuration mode 0: Not pending exit from configuration mode

2	Read-only	CONFIG_MODE_FLAG	0	Ranges from 0 to 1. 1: The fuel gauge is in configuration mode 0: The fuel gauge is in running mode
1	Read-only	EDIT_SETTINGS_FLAG	0	Ranges from 0 to 1. 1: The fuel gauge settings can be edited on the fly 0: The fuel gauge settings cannot be edited on the fly
0	Read-only	FG_EXE_FLAG	0	Ranges from 0 to 1. 1: The fuel gauge calculations are ongoing 0: The fuel gauge calculations are completed

FUEL GAUGE SETTINGS REGISTER MAP

EXE_TIME (1000h)

Format: 8-bit unsigned integer

The EXE_TIME command sets the fuel gauge's execution time interval.

Bits	Access	Bit Name	Default	Description
7:0	R/W	EXE_TIME	4s	The resolution is 0.1s, and the range is between 0.5s and 16s.

WEXE_TIME_REST (1001h)

Format: 8-bit unsigned integer

The WEXE_TIME_REST command sets the weight for the fuel gauge's execution time interval during rest. When the fuel gauge is in rest mode, it updates the most time-consuming functions each (WEXE_TIME_REST x EXE_TIME) instead of each EXE_TIME. The maximum allowed value for the execution period of this functions is 32s; if the fuel gauge is set such that (WEXE_TIME_REST x EXE_TIME) is longer than 32s, the used period is the multiple of EXE_TIME that is closer to, but below, 32s.

Bits	Access	Bit Name	Default	Description
7:5	R	RESERVED	N/A	Reserved.
4:0	R/W	WEXE_TIME_REST	4	The resolution is 1, and the range is between 1 and 16.

DIS_ITH (1002h)

Format: 16-bit unsigned integer

The DIS_ITH command sets the discharge status current threshold.

Bits	Access	Bit Name	Default	Description
15:0	R/W	DIS_ITH	25mA	The resolution is 1mA, and the range is between 0mA and 65535mA.

CHG_ITH (1004h)

Format: 16-bit unsigned integer

The CHG_ITH command sets the charge status current threshold.

Bits	Access	Bit Name	Default	Description
15:0	R/W	CHG_ITH	25mA	The resolution is 1mA, and the range is between 0mA and 65535mA.

SOC_DMAX (1006h)

Format: 16-bit unsigned integer

The SOC_DMAX command sets the maximum SOC steepness for the charge and discharge status.

Bits	Access	Bit Name	Default	Description
15:0	R/W	SOC_DMAX	0.07%/s	The resolution is 0.00005%/s, and the range is between 0.00005%/s and 2%/s.

SOC_DMAX_REST (1008h)

Format: 16-bit unsigned integer

The SOC_DMAX_REST command sets the maximum SOC steepness for the rest status.

Bits	Access	Bit Name	Default	Description
15:0	R/W	SOC_DMAX_REST	0.001%/s	The resolution is 0.00005%/s, and the range is between 0%/s and 2%/s.

SET_EN1TO8 (1040h)

Format: Control enable (=1)/disable (=0)

The SET_EN1TO8 command enables certain features.

Bits	Access	Bit Name	Default	Description
7:5	R	RESERVED	N/A	Reserved.
4	R/W	TRDG_AMB_EN	0	Ranges from 0 to 1. Enables the TRDG_AMB input.
3	R/W	CCRDG_EN	0	Ranges from 0 to 1. Enables the CCRDG input.
2	R/W	IRDG_CELLS_EN	0	Ranges from 0 to 1. Enables the IRDG_CELLX inputs.
1	R/W	IRDG_PACK_EN	1	Ranges from 0 to 1. Enables the IRDG_PACK input.
0	R/W	VRDG_PACK_EN	1	Ranges from 0 to 1. Enables the VRDG_PACK input.

SET_EN9TO16 (1041h)

Format: Control enable (=1)/disable (=0)

The SET_EN9TO16 command enables certain features.

Bits	Access	Bit Name	Default	Description
7	R/W	IDIS_AVG_LRN_EN	1	Ranges from 0 to 1. Enables discharge average current learning.
6	R/W	VCHG_CV_LRN_EN	1	Ranges from 0 to 1. Enables charge constant-voltage learning.
5	R/W	ICHG_END_LRN_EN	1	Ranges from 0 to 1. Enables charge termination current learning.
4	R/W	ICHG_CC_LRN_EN	1	Ranges from 0 to 1. Enables charge constant-current learning.
3	R/W	RCXN_CELLS_LRN_EN	0	Ranges from 0 to 1. Enables cells' connection resistance learning.
2	R/W	RESR_LRN_EN	1	Ranges from 0 to 1. Enables equivalent series resistance learning.
1	R	RESERVED	N/A	Reserved.
0	R/W	SOH_LRN_EN	1	Ranges from 0 to 1. Enables state-of-health learning.

SET_EN17TO24 (1042h)

Format: Control enable (=1)/disable (=0)

The SET_EN17TO24 command enables certain features.

Bits	Access	Bit Name	Default	Description
7	R/W	PCHG_SHW_EN	1	Ranges from 0 to 1. Sets the PCHG_SHW default value.
6:5	R	RESERVED	N/A	Reserved.

4	R/W	HCONV_LRN_CONT_EN	0	Ranges from 0 to 1. Activates continuous discharge termination current learning.
3	R/W	HCONV_LRN_EN	1	Ranges from 0 to 1. Activates continuous discharge termination current learning.
2	R/W	THRM_MDL_EN	1	Ranges from 0 to 1. Activates continuous discharge termination current learning.
1	R/W	IDIS_END_LRN_CONT_EN	1	Ranges from 0 to 1. Activates continuous discharge termination current learning.
0	R/W	IDIS_END_LRN_EN	1	Ranges from 0 to 1. Enables discharge termination current learning.

SET_EN25TO32 (1043h)

Format: Control enable (=1)/disable (=0)

The SET_EN25TO32 command enables certain features.

Bits	Access	Bit Name	Default	Description
7:1	R	RESERVED	N/A	Reserved.
0	R/W	PDIS_SHW_EN	1	Ranges from 0 to 1. Sets the PDIS_SHW default value.

SET_INTR_EN (1080h)

Format: Control enable (=1)/disable (=0)

The SET_INTR_EN command sets the fuel gauge's interrupt registers.

Bits	Access	Bit Name	Default	Description
24:18	R	RESERVED	N/A	Reserved.
17	R/W	PCHG_LIM_INTR_EN	0	Ranges from 0 to 1. Enables the PCHG_LIM_INTR interrupt.
16	R/W	PDIS_LIM_INTR_EN	0	Ranges from 0 to 1. Enables the PDIS_LIM_INTR interrupt.
15	R	RESERVED	N/A	Reserved.
14	R/W	SOH_CELLS_INTR_EN	0	Ranges from 0 to 1. Enables the SOH_CELLS_INTR interrupt.
13	R/W	HCONV_INTR_EN	0	Ranges from 0 to 1. Enables the HCONV_INTR interrupt.
12	R/W	RCXN_CELLS_INTR_EN	0	Ranges from 0 to 1. Enables the RCXN_CELLS_INTR interrupt.
11	R/W	SORESR_CELLS_INTR_EN	0	Ranges from 0 to 1. Enables the SORESR_CELLS_INTR interrupt.
10	R/W	VCHG_CV_INTR_EN	0	Ranges from 0 to 1. Enables the VCHG_CV_INTR interrupt.
9	R/W	ICHG_END_INTR_EN	0	Ranges from 0 to 1. Enables the ICHG_END_INTR interrupt.
8	R/W	ICHG_CC_INTR_EN	0	Ranges from 0 to 1. Enables the ICHG_CC_INTR interrupt.
7	R/W	IDIS_END_INTR_EN	0	Ranges from 0 to 1. Enables the IDIS_END_INTR interrupt.
6	R/W	IDIS_AVG_INTR_EN	0	Ranges from 0 to 1. Enables the IDIS_AVG_INTR interrupt.
5	R/W	OT_WARN_INTR_EN	0	Ranges from 0 to 1. Enables the OT_WARN_INTR interrupt.
4	R/W	SOC_PACK_RSLT_INTR_EN	0	Ranges from 0 to 1. Enables the SOC_PACK_RSLT_INTR interrupt.
3	R/W	FULL_LIM_INTR_EN	0	Ranges from 0 to 1. Enables the FULL_LIM_INTR interrupt.
2	R/W	EMTY_LIM_INTR_EN	0	Ranges from 0 to 1. Enables the EMTY_LIM_INTR interrupt.

1	R/W	STATUS_INTR_EN	0	Ranges from 0 to 1. Enables the STATUS_INTR interrupt.
0	R/W	IT_DONE_INTR_EN	1	Ranges from 0 to 1. Enables IT_DONE_INTR interrupt.

VCELL_MAX (10C0h)

Format: 16-bit unsigned integer

The VCELL_MAX command sets the maximum voltage accepted at the cell level.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VCELL_MAX	3600mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VCELL_MAX_MRGN (10C2h)

Format: 8-bit unsigned integer

The VCELL_MAX_MRGN command sets the maximum cell voltage margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCELL_MAX_MRGN	5mV	The resolution is 0.5mV, and the range is between 0mV and 127.5mV.

VCELL_MIN (10C3h)

Format: 16-bit unsigned integer

The VCELL_MIN command sets the minimum voltage accepted at the cell level.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VCELL_MIN	2500mV	The resolution is 0.1mV, and the range is between 0mV and 6553.5mV.

VCELL_MIN_MRGN (10C5h)

Format: 8-bit unsigned integer

The VCELL_MIN_MRGN command sets the minimum cell voltage margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCELL_MIN_MRGN	5mV	The resolution is 0.5mV, and the range is between 0mV and 127.5mV.

VPACK_MAX (10C6h)

Format: 16-bit unsigned integer

The VPACK_MAX command sets the maximum pack voltage that the pack can accept; this can be used for the charge power estimate.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VPACK_MAX	57200mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

VPACK_MAX_MRGN (10C8h)

Format: 8-bit unsigned integer

The VPACK MAX_MRGN command sets the pack’s maximum voltage margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VPACK_MAX_MRGN	48mV	The resolution is 4mV, and the range is between 0mV and 1020mV.

VPACK_MIN (10C9h)

Format: 16-bit unsigned integer

The VPACK_MIN command sets the pack's empty voltage that represents the lowest usable pack voltage.

Bits	Access	Bit Name	Default	Description
15:0	R/W	VPACK_MIN	41500mV	The resolution is 2mV, and the range is between 0mV to 131070mV.

VPACK_MIN_MRGN (10CBh)

Format: 8-bit unsigned integer

The VPACK_MIN_MRGN command sets the margin for the pack empty voltage.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VPACK_MIN_MRGN	48mV	The resolution is 4mV, and the range is between 0mV and 1020mV.

ICHG_MAX (1100h)

Format: 16-bit unsigned integer

The ICHG_MAX command sets the maximum charge current that the pack can accept.

Bits	Access	Bit Name	Default	Description
15:0	R/W	ICHG_MAX	1 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

ICHG_MAX_MRGN (1102h)

Format: 8-bit unsigned integer

The ICHG_MAX_MRGN command sets the maximum charge current margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_MAX_MRGN	0.02 C-Rate	The resolution is 0.002 C-rate, and the range is between 0 C-rate and 0.51 C-rate.

IDIS_MAX (1103h)

Format: 16-bit unsigned integer

The IDIS_MAX command sets the maximum discharge current that the pack can accept.

Bits	Access	Bit Name	Default	Description
15:0	R/W	IDIS_MAX	2 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

IDIS_MAX_MRGN (1105h)

Format: 8-bit unsigned integer

The IDIS_MAX_MRGN command sets the maximum discharge current margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_MAX_MRGN	0.02 C-Rate	The resolution is 0.002 C-rate, and the range is between 0 C-rate and 0.51 C-rate.

RCXN_PACK (1140h)

Format: 16-bit unsigned integer

The RCXN_PACK command sets the connection resistance between the battery and the battery management system terminals.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_PACK	10mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RBMS_HSIDE (1142h)

Format: 16-bit unsigned integer

The RBMS_HSIDE command sets the battery management system's high-side resistance.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RBMS_HSIDE	4mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RBMS_LSIDE (1144h)

Format: 16-bit unsigned integer

The RBMS_LSIDE command sets the battery management system's low-side resistance.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RBMS_LSIDE	2mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_CELL1 (1146h)

Format: 16-bit unsigned integer

The RCXN_CELL1 command sets the connection resistance between cell 1's terminals and its corresponding voltage-sensing probes.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELL1	1mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_CELLx (1146h + (x - 1) x 0002h)

Format: 16-bit unsigned integer

The RCXN_CELLx command sets the connection resistance between cell *x*'s (where *x* = 2–15) terminals and its corresponding voltage-sensing probes.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELLx	1mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

RCXN_CELL16 (1164h)

Format: 16-bit unsigned integer

The RCXN_CELL16 command sets the connection resistance between cell 16's terminals and its corresponding voltage-sensing probes.

Bits	Access	Bit Name	Default	Description
15:0	R/W	RCXN_CELL16	1mΩ	The resolution is 0.1mΩ, and the range is between 0Ω and 6553.5mΩ.

TSS_CELL1TO4 (11C0h)

Format: Non-standard

The TSS_CELL1TO4 command sets the temperature sensor source for cells 1–4.

Bits	Access	Bit Name	Default	Description
7:6	R/W	TSS_CELL4	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
5:4	R/W	TSS_CELL3	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
3:2	R/W	TSS_CELL2	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
1:0	R/W	TSS_CELL1	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.

TSS_CELL5TO8 (11C1h)

Format: Non-standard

The TSS_CELL5TO8 command sets the temperature sensor source for cells 5–8.

Bits	Access	Bit Name	Default	Description
7:6	R/W	TSS_CELL8	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
5:4	R/W	TSS_CELL7	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
3:2	R/W	TSS_CELL6	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
1:0	R/W	TSS_CELL5	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.

TSS_CELL9TO12 (11C2h)

Format: Non-standard

The TSS_CELL9TO12 command sets the temperature sensor source for cells 9–12.

Bits	Access	Bit Name	Default	Description
7:6	R/W	TSS_CELL12	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
5:4	R/W	TSS_CELL11	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
3:2	R/W	TSS_CELL10	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
1:0	R/W	TSS_CELL9	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.

TSS_CELL13TO16 (11C3h)

Format: Non-Standard

The TSS_CELL13TO16 command sets the temperature sensor source for cells 13–16.

Bits	Access	Bit Name	Default	Description
7:6	R/W	TSS_CELL16	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
5:4	R/W	TSS_CELL15	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
3:2	R/W	TSS_CELL14	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.
1:0	R/W	TSS_CELL13	1	The resolution is 1, the offset is 1, and it ranges from 1 to 4.

TCHG_MAX (11C4h)

Format: 8-bit unsigned integer

The TCHG_MAX command sets the maximum temperature allows by the application while charging.

Bits	Access	Bit Name	Default	Description
7:0	R/W	TCHG_MAX	50°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

TDIS_MAX (11C5h)

Format: 8-bit unsigned integer

The TDIS_MAX command sets the maximum allowed temperature by the application while discharging.

Bits	Access	Bit Name	Default	Description
7:0	R/W	TDIS_MAX	60°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

HCONV_PACK (11C6h)

Format: 16-bit unsigned integer

The HCONV_PACK command sets the battery pack's heat transfer coefficient.

Bits	Access	Bit Name	Default	Description
15:0	R/W	HCONV_PACK	23W/(m^2K)	The resolution is 0.01W/(m^2K), and the range is between 0.01W/(m^2K) and 655.35W/(m^2K) .

NCELLS_SER (1200h)

Format: 8-bit unsigned integer

The NCELLS_SER command sets the number of series-connected cells in the battery pack.

Bits	Access	Bit Name	Default	Description
7:5	R	RESERVED	N/A	Reserved.
4:0	R/W	NCELLS_SER	16	The resolution is 1, and it ranges from 2 to 16.

NCELLS_PAR (1201h)

Format: 8-bit unsigned integer

The NCELLS_PAR command sets the number of parallel-connected cells in the battery pack.

Bits	Access	Bit Name	Default	Description
7:0	R/W	NCELLS_PAR	1	The resolution is 1, and it ranges from 1 to 255.

NTSS (1202h)

Format: 8-bit unsigned integer

The NTSS command sets the number of temperature sensors in the battery pack.

Bits	Access	Bit Name	Default	Description
7:3	R	RESERVED	N/A	Reserved.
2:0	R/W	NTSS	1	The resolution is 1, and it ranges from 1 to 4.

IDIS_AVG_SET (1280h)

Format: 16-bit unsigned integer

The IDIS_AVG_SET command sets the nominal average discharge current (e.g. IDIS_AVG).

Bits	Access	Bit Name	Default	Description
15:0	R/W	IDIS_AVG_SET	1 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

IDIS_END_SET (1282h)

Format: 16-bit unsigned integer

The IDIS_END_SET command sets the nominal discharge termination current (e.g. IDIS_END).

Bits	Access	Bit Name	Default	Description
15:0	R/W	IDIS_END_SET	1 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

ICHG_CC_SET (12C0h)

Format: 16-bit unsigned integer

The ICHG_CC_SET command sets the nominal charge constant current (e.g. ICHG_CC).

Bits	Access	Bit Name	Default	Description
15:0	R/W	ICHG_CC_SET	0.5 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

ICHG_END_SET (12C2h)

Format: 16-bit unsigned integer

The ICHG_END_SET command sets the nominal charge termination current (e.g. ICHG_END).

Bits	Access	Bit Name	Default	Description
15:0	R/W	ICHG_END_SET	0.1 C-Rate	The resolution is 0.001 C-rate, and the range is between 0.001 C-rate and 65.535 C-rate.

ICHG_END_MRGN (12C4h)

Format: 8-bit unsigned integer

The ICHG_END_MRGN command sets the charge termination current (e.g. ICHG_END_SET) margin.

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_END_MRGN	0.005 C-Rate	The resolution is 0.001 C-rate, and the range is between 0 C-rate and 0.255 C-rate.

VCHG_CV_SET (12C5h)

Format: 16-bit unsigned integer

The VCHG_CV_SET command sets the nominal charge constant voltage (e.g. VCHG_CV).

Bits	Access	Bit Name	Default	Description
15:0	R/W	VCHG_CV_SET	56800mV	The resolution is 2mV, and the range is between 0mV and 131070mV.

EMTY_RTIME_FILTER (1304h)

Format: 8-bit unsigned integer

The EMTY_RTIME_FILTER command sets the filter time constant for the remaining time-to-empty (e.g. EMTY_RTIME).

Bits	Access	Bit Name	Default	Description
7:0	R/W	EMTY_RTIME_FILTER	60s	The resolution is 1s, and the range is between 0s and 255s.

EMTY_DTEMP_FILTER (1305h)

Format: 8-bit unsigned integer

The EMTY_DTEMP_FILTER command sets the filter time constant for the remaining time-to-empty (e.g. EMTY_RTIME).

Bits	Access	Bit Name	Default	Description
7:0	R/W	EMTY_DTEMP_ FILTER	60s	The resolution is 1s, and the range is between 0s and 255s.

FULL_RTIME_FILTER (1345h)

Format: 8-bit unsigned integer

The FULL_RTIME_FILTER command sets the filter time constant for the remaining time-to-full (e.g. FULL_RTIME).

Bits	Access	Bit Name	Default	Description
7:0	R/W	FULL_RTIME_FILTER	60s	The resolution is 1s, and the range is between 0s and 255s.

FULL_DTEMP_FILTER (1346h)

Format: 8-bit unsigned integer

The FULL_DTEMP_FILTER command sets the filter time constant for the predicted temperature-to-full (e.g. FULL_DTEMP).

Bits	Access	Bit Name	Default	Description
7:0	R/W	FULL_DTEMP_ FILTER	60s	The resolution is 1s, and the range is between 0s and 255s.

ICHG_CC_LRN_RNG (1380h)

Format: 8-bit unsigned integer

The ICHG_CC_LRN_RNG command sets the charge constant current (e.g. ICHG_CC) learning range if ICHG_CC_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_CC_LRN_RNG	0.25 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

ICHG_CC_LRN_SOCTH (1381h)

Format: 8-bit unsigned integer

The ICHG_CC_LRN_SOCTH command sets the SOC threshold for charge constant-current learning (ICHG_CC).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_CC_LRN_ SOCTH	80%	The resolution is 0.5%, and the range is between 0% and 100%.

ICHG_CC_LRN_DITH (1382h)

Format: 8-bit unsigned integer

The ICHG_CC_LRN_DITH command sets the charge current derivative threshold for charge constant-current learning (ICHG_CC).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_CC_LRN_DITH	0.1mA/s	The resolution is 0.01mA/s, and the range is between 0mA/s and 2.55mA/s.

ICHG_CC_LRN_CNTRTH (1384h)

Format: 8-bit unsigned integer

The ICHG_CC_LRN_CNTRTH command sets the sample counter threshold for charge constant-current learning (ICHG_CC).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_CC_LRN_ CNTRTH	20 Sample(s)	The resolution is 1 sample, and it ranges from 0 samples to 255 samples.

ICHG_END_LRN_RNG (13C0h)

Format: 8-bit unsigned integer

The ICHG_END_LRN_RNG command sets the charge termination current (e.g. ICHG_END) learning range if ICHG_END_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_END_LRN_ RNG	0.1 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

ICHG_END_LRN_SOCTH (13C1h)

Format: 8-bit unsigned integer

The ICHG_END_LRN_SOCTH command sets the SOC threshold for charge termination current learning (ICHG_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_END_LRN_ SOCTH	80%	The resolution is 0.5%, and the range is between 0% and 100%.

ICHG_END_LRN_ITH (13C2h)

Format: 8-bit unsigned integer

The ICHG_END_LRN_ITH command sets the charge current threshold for charge termination current learning (ICHG_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_END_LRN_ITH	0.01 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

ICHG_END_LRN_DVTH (13C3h)

Format: 8-bit unsigned integer

The ICHG_END_LRN_DVTH command sets the charge voltage derivative threshold for charge termination current learning (ICHG_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	ICHG_END_LRN_ DVTH	0.1mV/s	The resolution is 0.01mV/s, and the range is between 0mV/s and 2.55mV/s.

VCHG_CV_LRN_RNG (1400h)

Format: 8-bit unsigned integer

The VCHG_CV_LRN_RNG command sets the charge constant-voltage (e.g. VCHG_CV) learning range if VCHG_CV_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCHG_CV_LRN_RNG	200mV	The resolution is 20mV, and the range is between 0mV and 5100mV.

VCHG_CV_LRN_SOCTH (1401h)

Format: 8-bit unsigned integer

The VCHG_CV_LRN_SOCTH command sets the SOC threshold for charge constant voltage learning (VCHG_CV).

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCHG_CV_LRN_SOCTH	80%	The resolution is 0.5%, and the range is between 0% and 100%.

VCHG_CV_LRN_ITH (1402h)

Format: 8-bit unsigned integer

The VCHG_CV_LRN_ITH command sets the charge current threshold for charge constant voltage learning (VCHG_CV).

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCHG_CV_LRN_ITH	0.01 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

VCHG_CV_LRN_DVTH (1403h)

Format: 8-bit unsigned integer

The VCHG_CV_LRN_DVTH command sets the charge voltage derivative threshold for charge constant voltage learning (VCHG_CV).

Bits	Access	Bit Name	Default	Description
7:0	R/W	VCHG_CV_LRN_DVTH	0.1mV/s	The resolution is 0.01mV/s, and the range is between 0mV/s and 2.55mV/s.

IDIS_AVG_LRN_RNG (1440h)

Format: 8-bit unsigned integer

The IDIS_AVG_LRN_RNG command sets the discharge termination current (e.g. IDIS_END) learning range if IDIS_END_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_AVG_LRN_RNG	0.5 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

IDIS_AVG_LRN_ITH (1441h)

Format: 8-bit unsigned integer

The IDIS_AVG_LRN_ITH command sets the discharge current threshold for learnings (IDIS_AVG and IDIS_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_AVG_LRN_ITH	0.05 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

IDIS_AVG_LRN_FILTER (1442h)

Format: 8-bit unsigned integer

The IDIS_AVG_LRN_FILTER command sets the filter time constant for discharge current learnings (IDIS_AVG and IDIS_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_AVG_LRN_FILTER	10s	The resolution is 1s, and the range is between 0s and 255s.

IDIS_END_LRN_RNG (1480h)

Format: 8-bit unsigned integer

The IDIS_END_LRN_RNG command sets the discharge termination current (e.g. IDIS_END) learning range if IDIS_END_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_END_LRN_RNG	0.5 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

IDIS_END_LRN_SOCTH (1481h)

Format: 8-bit unsigned integer

The IDIS_END_LRN_SOCTH command sets the discharge termination current (e.g. IDIS_END) SOC learning threshold if IDIS_END_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_END_LRN_ SOCTH	50%	The resolution is 0.5%, and the range is between 0% and 100%.

IDIS_END_LRN_PEAK_GAIN (1482h)

Format: 8-bit unsigned integer

The IDIS_END_LRN_PEAK_GAIN command sets the discharge termination current (e.g. IDIS_END) learning peak current gain if IDIS_END_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_END_LRN_ KPEAK	70%	The resolution is 0.5%, and the range is between 0% and 100%.

IDIS_END_LRN_ITH (1483h)

Format: 8-bit unsigned integer

The IDIS_END_LRN_ITH command sets the discharge current threshold for learnings (IDIS_AVG and IDIS_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_END_LRN_ITH	0.05 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

IDIS_END_LRN_FILTER (1484h)

Format: 8-bit unsigned integer

The IDIS_END_LRN_FILTER command sets the filter time constant for the discharge current learnings (IDIS_AVG and IDIS_END).

Bits	Access	Bit Name	Default	Description
7:0	R/W	IDIS_END_LRN_FILT ER	10s	The resolution is 1s, and the range is between 0s and 255s.

SOH_LRN_K (14C0h)

Format: 8-bit unsigned integer

The SOH_LRN_K command sets the SOH learning gain if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_K	0.1	The resolution is 0.001, and the range is between 0 and 0.255.

SOH_LRN_DMAX (14C1h)

Format: 8-bit unsigned integer

The SOH_LRN_DMAX command sets the maximum increase for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_DMAX	1%	The resolution is 0.1%, and the range is between 0% and 25.5%.

SOH_LRN_DMIN (14C2h)

Format: 8-bit unsigned integer

The SOH_LRN_DMIN command sets the maximum decrease for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_DMIN	1%	The resolution is 0.1%, and the range is between 0% and 25.5%.

SOH_LRN_MAX (14C3h)

Format: 8-bit unsigned integer

The SOH_LRN_MAX command sets the maximum value for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_MAX	110%	The resolution is 1%, and the range is between 100% and 200%.

SOH_LRN_MIN (14C4h)

Format: 8-bit unsigned integer

The SOH_LRN_MIN command sets the minimum value for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_MIN	80%	The resolution is 1%, and the range is between 0% and 100%.

SOH_LRN_TMAX (14C5h)

Format: 8-bit unsigned integer

The SOH_LRN_TMAX command sets the maximum temperature for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_TMAX	30°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

SOH_LRN_TMIN (14C6h)

Format: 8-bit unsigned integer

The SOH_LRN_TMIN command sets the minimum temperature for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_TMIN	10°C	The resolution is 0.5°C, the offset is -30°C, and the range is between -30°C and +97.5°C.

SOH_LRN_IMIN (14C7h)

Format: 8-bit unsigned integer

The SOH_LRN_IMIN command sets the minimum current for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_IMIN	0.1 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

SOH_LRN_IMAX (14C8h)

Format: 8-bit unsigned integer

The SOH_LRN_IMAX command sets the maximum current for SOH learning if SOH_LRN_EN is enabled.

Bits	Access	Bit Name	Default	Description
7:0	R/W	SOH_LRN_IMAX	2 C-Rate	The resolution is 0.01 C-rate, and the range is between 0 C-rate and 2.55 C-rate.

RESR_LRN_DITH (1540h)

Format: 8-bit unsigned integer

The RESR_LRN_DITH command sets the minimum current variation for ESR learning.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RESR_LRN_DITH	0.5 C-Rate/s	The resolution is 0.01 C-rate, and the range is between 0 C-rate/s and 2.55 C-rate/s.

RESR_LRN_DRSTD (1541h)

Format: 8-bit unsigned integer

The RESR_LRN_DRSTD command sets the maximum (standard) resistance variation for ESR learning.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RESR_LRN_DRSTD	2.5%	The resolution is 0.1%, and the range is between 0% and 25.5%.

RESR_LRN_DREXT (1542h)

Format: 8-bit unsigned integer

The RESR_LRN_DREXT command sets the maximum (extended) resistance variation for ESR learning.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RESR_LRN_DREXT	10%	The resolution is 0.1%, and the range is between 0% and 25.5%.

RESR_LRN_NHIT2EXT (1543h)

Format: 8-bit unsigned integer

The RESR_LRN_NHIT2EXT command sets the number of times the standard resistance variation must be reached before using the extended resistance variation for the ESR learning.

Bits	Access	Bit Name	Default	Description
7:4	R	RESERVED	N/A	Reserved.
3:0	R/W	RESR_LRN_ NHIT2EXT	4	The resolution is 1, and it ranges between 0 and 8 .

RCXN_CELLS_LRN_NAVG (1580h)

Format: 8-bit unsigned integer

The RCXN_CELLS_LRN_NAVG command sets the number of events used to estimate the cells' connection resistance.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RCXN_CELLS_LRN_NAVG	100 Event(s)	The resolution is 1 event, and the range is between 1 event and 255 events.

RCXN_CELLS_LRN_DITH (1581h)

Format: 8-bit unsigned integer

The RCXN_CELLS_LRN_DITH command sets the current difference threshold to estimate the cells' connection resistance.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RCXN_CELLS_LRN_DITH	0.5 C-Rate/s	The resolution is 0.01 C-rate/s, and the range is between 0 C-rate/s and 2.55 C-rate/s.

RCXN_CELLS_LRN_RMIN (1582h)

Format: 8-bit unsigned integer

The RCXN_CELLS_LRN_RMIN command sets the minimum cell connection resistance value.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RCXN_CELLS_LRN_RMIN	0mΩ	The resolution is 1mΩ, and the range is between 0mΩ and 255mΩ.

RCXN_CELLS_LRN_RMAX (1583h)

Format: 8-bit unsigned integer

The RCXN_CELLS_LRN_RMAX command sets the maximum cell connection resistance value.

Bits	Access	Bit Name	Default	Description
7:0	R/W	RCXN_CELLS_LRN_RMAX	20mΩ	The resolution is 1mΩ, and the range is between 0mΩ and 255mΩ.

HCONV_LRN_K (15C0h)

Format: 8-bit unsigned integer

The HCONV_LRN_K command sets the heat transfer coefficient learning gain.

Bits	Access	Bit Name	Default	Description
7:0	R/W	HCONV_LRN_K	1W/(mK)^2	The resolution is 0.1W/(mK)^2, and the range is between 0 W/(mK)^2 and 25.5W/(mK)^2.

HCONV_LRN_RNG (15C1h)

Format: 8-bit unsigned integer

The HCONV_LRN_RNG command sets the heat transfer coefficient learning range.

Bits	Access	Bit Name	Default	Description
7:0	R/W	HCONV_LRN_RNG	10W/(m^{2}K)	The resolution is 0.1W/(m^{2}K), and the range is between 0W/(m^{2}K) and 25.5W/(m^{2}K).

HCONV_LRN_DTIMETH (15C2h)

Format: 8-bit unsigned integer

The HCONV_LRN_DTIMETH command sets the heat transfer coefficient learning time difference threshold.

Bits	Access	Bit Name	Default	Description
7:0	R/W	HCONV_LRN_ DTIMETH	10s	The resolution is 1s, and the range is between 0s and 255s.

HCONV_LRN_DTEMPTH (15C3h)

Format: 8-bit unsigned integer

The HCONV_LRN_DTEMPTH command sets the heat transfer coefficient learning temperature difference threshold.

Bits	Access	Bit Name	Default	Description
7:0	R/W	HCONV_LRN_ DTEMPTH	0.2°C	The resolution is 0.01°C, and the range is between 0°C and 2.55°C.

FUEL GAUGE CELL MATHEMATICAL MODEL REGISTER MAP

MDLCELL_ID (2000h)

Format: 32-bit unsigned integer

The MDLCELL_ID command returns the cell mathematical model identifier.

Bits	Access	Bit Name	Default	Description
31:0	R/W	MDLCELL_ID	0	The resolution is 1, and the range is between 0 and 4294967295.

MDLCELL_MFR (2004h)

Format: ASCII character(s)

The MDLCELL_MFR command returns the manufacturer of the cell.

Bits	Access	Bit Name	Default	Description
127:0	R/W	MDLCELL_MFR	Default	Returns the cell manufacturer description.

MDLCELL_TYPE (2014h)

Format: ASCII character(s)

The MDLCELL_TYPE command returns the cell type/model.

Bits	Access	Bit Name	Default	Description
127:0	R/W	MDLCELL_TYPE	Default	Returns the cell model description.

MDLCELL_QNOM (2024h)

Format: 16-bit unsigned integer

The MDLCELL_QNOM command returns the nominal capacity of the cell reported by the manufacturer in the cell datasheet.

Bits	Access	Bit Name	Default	Description
15:0	R/W	MDLCELL_QNOM	2500mAh	The resolution is 5mAh, and the range is between 5mAh and 327675mAh.

MDLCELL_QMEAS (2026h)

Format: 16-bit unsigned integer

The MDLCELL_QMEAS command returns the capacity measured in the cell characterization test.

Bits	Access	Bit Name	Default	Description
15:0	R/W	MDLCELL_QMEAS	2437mAh	The resolution is 5mAh, and the range is between 5mAh and 327675mAh.

MDLCELL_CP (202Ah)

Format: 16-bit unsigned integer

The MDLCELL_CP command returns the cell's specific heat coefficient.

Bits	Access	Bit Name	Default	Description
15:0	R/W	MDLCELL_CP	0.85J/(g^K)	The resolution is 0.001J/(g^K), and the range is between 0.001J/(g^K) and 65.535J/(g^K).

MDLCELL_MASS (202Ch)

Format: 16-bit unsigned integer

The MDLCELL_MASS command returns the cell's mass.

Bits	Access	Bit Name	Default	Description
15:0	R/W	MDLCELL_MASS	45g	The resolution is 0.5g, and the range is between 0.5g and 32767.5g.

MDLCELL_AREA (202Eh)

Format: 16-bit unsigned integer

The MDLCELL_AREA command returns the cell's surface area.

Bits	Access	Bit Name	Default	Description
15:0	R/W	MDLCELL_AREA	4262mm^2	The resolution is 5mm^2, and the range is between 1mm^2 and 327675mm^2.

LEDS SETTINGS REGISTER MAP

LED_CTRL (5300h)

Format: Control enable (=1)/disable (=0)

The LED_CTRL command sets the LED control bits.

Bits	Access	Bit Name	Default	Description
7	R/W	LED5_ON	0	Ranges from 0 to 1. 1: If LEDS_ON_MAN = 1, the fifth LED turns on 0: If LEDS_ON_MAN = 1, the fifth LED turns off
6	R/W	LED4_ON	0	Ranges from 0 to 1. 1: If LEDS_ON_MAN = 1, the fourth LED turns on 0: If LEDS_ON_MAN = 1, the fourth LED turns off
5	R/W	LED3_ON	0	Ranges from 0 to 1. 1: If LEDS_ON_MAN = 1, the third LED turns on 0: If LEDS_ON_MAN = 1, the third LED turns off
4	R/W	LED2_ON	0	Ranges from 0 to 1. 1: If LEDS_ON_MAN = 1, the second LED turns on 0: If LEDS_ON_MAN = 1, the second LED turns off
3	R/W	LED1_ON	0	Ranges from 0 to 1. 1: If LEDS_ON_MAN = 1, the first LED turns on 0: If LEDS_ON_MAN = 1, the first LED turns off
2	R/W	LEDS_ON_BTN	1	Ranges from 0 to 1. Applies only when LEDS_ON_MAN = 0. 1: The LEDs display the pack SOC after a falling edge is detected on the PB pin 0: LEDs do not display the pack SOC after a falling edge is detected on PB pin
1	R/W	LEDS_ON_CHG	1	Ranges from 0 to 1. Applies only when LEDS_ON_MAN = 0. 1: The LEDs display the pack SOC while charging 0: The LEDs do not display the pack SOC while charging
0	R/W	LEDS_ON_MAN	0	Ranges from 0 to 1. 1: The LEDs are controlled manually using the dedicated register bits 0: The LEDs controlled directly to report the SOC

LED_TRANS (5301h)

Format: 8-bit unsigned integer

The LED_TRANS command sets the deglitch time to control the LED turn-on/-off upon transitioning between charge and discharge.

Bits	Access	Bit Name	Default	Description
7	R	RESERVED	N/A	Reserved.
6:0	R/W	LED_TRANS	4s	The resolution is 0.1s, and the range is between 0s and 12.7s.

LEDS_ON_TIME (5302h)

Format: 8-bit unsigned integer

The LEDS_ON_TIME command sets the time after which the LEDs turn on after a falling edge is detected on the LED PB pin.

Bits	Access	Bit Name	Default	Description
7:4	R	RESERVED	N/A	Reserved.
3:0	R/W	LEDS_ON_TIME	5s	The resolution is 1s, the offset is 1s, and the range is between 1s and 16s.

I²C SETTINGS AND INFO REGISTER MAP

I2C_SETTINGS (5400h)

Format: 8-bit unsigned integer

The I2C_SETTINGS command sets the I²C settings.

Bits	Access	Bit Name	Default	Description
7	R/W	I2C_CRC_EN	1	Enables the CRC on I²C communication. Ranges from 0 to 1. 1: Enabled 0: Disabled
6:0	R/W	I2C_ADDRESS	8	The resolution is 1, and the range is between 0 and 127. Use this register to select the device's slave I²C address.

SDA_TO_ACTIVE (5401h)

Format: Control enable (=1)/ disable (=0)

The SDA_TO_ACTIVE command sets the SDA transition to active.

Bits	Access	Bit Name	Default	Description
7:1	R	RESERVED	N/A	Reserved.
0	R/W	SDA_TO_ACTIVE	1	Ranges from 0 to 1 . 1: A low pulse on an SDA pin forces the MPF4279x to transition to active mode when in standby mode 0: A low pulse on an ACT pin forces the MPF4279x to transition to active mode when in standby mode

I2C_CHAN_INFO (5500h)

Format: Boolean true/false

The I2C_CHAN_INFO command sets the I²C channel information.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1	Read-only	I2C_CHAN_SEL	0	Ranges from 0 to 1. This register returns the state of the I2C_SEL pin, which determines the selected I²C channel to accept write operations. 0: The primary I²C channel is selected for write operations. 1: The secondary I²C channel is selected for write operations.
0	Read-only	I2C_CHANNEL	0	Ranges from 0 to 1. This register returns to the master the I²C channel used for the current transaction. 0: The master is connected to the primary I²C channel 1: The master is connected to the secondary I²C channel

CUSTOMER BLOCK REGISTER MAP

CUST_BLOCK_PASSWORD (5800h)

Format: 32-bit unsigned integer

The CUST_BLOCK_PASSWORD command sets the password to allow editing to the custom block feature.

Write a value to this register while in configuration mode when CUST_BLOCK_PASS_EDIT_EN = 1 to set the given value as the new password; after the new password is set, CUST_BLOCK_PASS_EDIT_EN is reset to 0. When writing a new value for the password, only the four password bytes must be written, so the address used must be 5800h, and the data length must be 4. It is required to exit configuration mode for the new password to be stored in the non-volatile memory of the fuel gauge.

To edit the values of CUST_BLOCK_PASS_EDIT_EN and CUST_BLOCK_EN, a write with a length of 5 bytes to address 5800h containing the correct password in the first 4 bytes and the desired values for CUST_BLOCK_PASS_EDIT_EN and CUST_BLOCK_EN in the last is required.

The content of this register can only be read when CUST_BLOCK_FLAG = 0. This register can only be written to when CONFIG_MODE_FLAG = 1 and CUST_BLOCK_ PASS_EDIT_EN =1.

Bits	Access	Bit Name	Default	Description
31:0	R/W	CUST_BLOCK_ PASSWORD	4294967295	The resolution is 1, and the range is between 0 and 4294967295.

CUST_BLOCK_EN_BITS (5804h)

Format: Control enable (=1)/ disable (=0)

The CUST_BLOCK_EN_BITS command enables the customer block. The content of this register can only be read when CUST_BLOCK_FLAG = 0.

This register can only be written to when CONFIG_MODE_FLAG = 1.

Bits	Access	Bit Name	Default	Description
7:2	R	RESERVED	N/A	Reserved.
1	R/W	CUST_BLOCK_ PASS_EDIT_EN	0	Ranges from 0 to 1. This register allows costumer block password editing. To allow/prevent costumer block password editing, send a write command to address 0x5000. This command must have a data length of 5, and it must contain the correct password and the desired value for this register. This register can only be set when CUST_BLOCK_FLAG = 0; otherwise, it stays set at 0.
0	R/W	CUST_BLOCK_EN	0	Ranges from 0 to 1. This register enables the customer block feature. To enable/disable the customer block feature, send a write command to address 0x5000. This command must have a data length of 5, and it must contain the correct password and the desired value for this register. The CUST_BLOCK_FLAG flag shows the same value as this register.

IC VERSION REGISTER MAP

IC_VERSION (6100h)

Format: ASCII character(s)

The IC_VERSION command returns the fuel gauge IC version:

- 42790: Supports 2S to 16S cells and LEDs
- 42791: Supports 2S to 16S cells, LEDs, ESR detection, and a thermal model
- 42792: Supports 2S to 16S cells
- 42793: Supports 2S to 16S cells, LEDs, ESR detection, thermal model, and LFP chemistry
- 42795: Supports 2S to 10S cells and LEDs
- 42797: Supports 2S to 10S cells

Bits	Access	Bit Name	Default	Description
39:0	Read-only	IC_VER	42793	Returns the IC fuel gauge version

SP_CSTR_REQ_VER (6109h)

Format: ASCII character(s)

The SP_CSTR_REQ_VER command returns the optional special request from the customer.

Bits	Access	Bit Name	Default	Description
31:0	Read-only	SP_CSTR_REQ_VER	0000	Returns the optional special request from the customer.

COMMANDS REGISTER MAP

FG_RST (7FFFh)

Format: 8-bit unsigned integer

The FG_RST command resets the fuel gauge calculations.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	RST_CMD	0	The resolution is 1, and the range is between 0 and 255. The RST_CMD command resets the fuel gauge calculations. 0x01: Reset some fuel gauge items by setting FG_RST_FLAG = 1; equivalent to FG_RST. Self-clearing

EXE_FG_CMD (7FFEh)

Format: 8-bit unsigned integer

The EXE_FG_CMD command runs an iteration of the fuel gauge. The system's MCU is responsible for periodically writing to this register to trigger an update of the fuel gauge.

This command should be sent after providing all the updated measurement readings that are needed to produce the updated estimates.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	EXE_CMD	0	The resolution is 1, and the range is between 0 and 255. The EXE_CMD command triggers a fuel gauge update. 0x01: Send to trigger a fuel gauge update refresh

EDIT_CONFIG_CMD (7FFDh)

Format: 8-bit unsigned integer

The EDIT_CONFIG_CMD command is used to enter the edit configuration mode.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	EDIT_CONFIG_CMD	0	The resolution is 1, and the range is between 0 and 255. The EDIT_CONFIG_CMD command enters the edit configuration mode. 0x01: The fuel gauge settings can be edited

END_EDIT_CONFIG_CMD (7FFCh)

Format: 8-bit unsigned integer

The END_EDIT_CONFIG_CMD command is used to exit the edit configuration mode.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	END_EDIT_CONFIG_CMD	0	The resolution is 1, and the range is between 0 and 255. The END_EDIT_CONFIG_CMD command exits the edit configuration mode. 0x01: The fuel gauge settings cannot be edited

ENTER_CONFIG_MODE_CMD (7FFBh)

Format: 8-bit unsigned integer

The ENTER_CONFIG_MODE_CMD command is used to enter configuration mode (cell mathematical model, battery pack, and algorithm tuning).

Once the command is received, the IC needs a few milliseconds (typically 2.2ms) to internally prepare for accepting write operations to the configuration registers. After sending this command, monitor CONFIG_MODE_FLAG; when CONFIG_MODE_FLAG is set to 1, the device has entered configuration mode and can accept modifications to the configuration registers.

Configuration mode cannot be entered while a fuel gauge iteration is running. If this command is sent while an iteration is running, the device does not enter configuration mode until the iteration is finished. This adds a significant delay from when the command is sent to when the fuel gauge enters configuration mode.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	CONFIG_MODE_CMD	0	The resolution is 1, and the range is between 0 and 255. The CONFIG_MODE_CMD command enters configuration mode. 0x01: Enter configuration mode

EXIT_CONFIG_MODE_CMD (7FFAh)

Format: 8-bit unsigned integer

The EXIT_CONFIG_MODE command is used to exit configuration mode. If the fuel gauge is in configuration mode, it exits this mode, saves the configuration values to the NVM, and resets the fuel gauge algorithm. Otherwise, it stores the fuel gauge and LED settings from the volatile memory to the NVM.

Once the command is received, the IC needs some time (typically around 40ms) to store all the configuration values to the NVM. When the command is received, CONFIG_EXIT_FLAG is set, and the configuration registers are stored to the NVM. Once this process is complete, CONFIG_EXIT_FLAG and CONFIG_MODE_FLAG are reset to notify that the fuel gauge has exited configuration mode.

Bits	Access	Bit Name	Default	Description
7:0	Write-only	CONFIG_EXIT_CMD	0	The resolution is 1, and the range is between 0 and 255. The CONFIG_EXIT_CMD command exits configuration mode. 0x01: Exit configuration mode. The new configuration is stored in the NVM

RST_LOG_CMD (7FF8h)

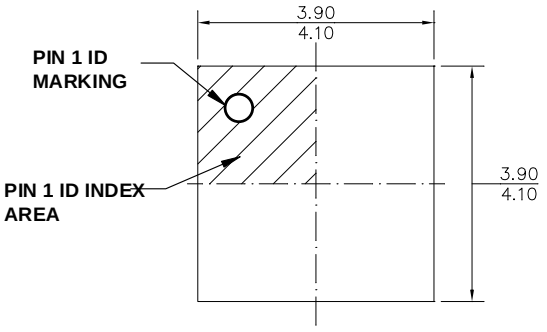
Format: 8-bit unsigned integer

The RST_LOG_CMD command re-initializes the lifetime logging.

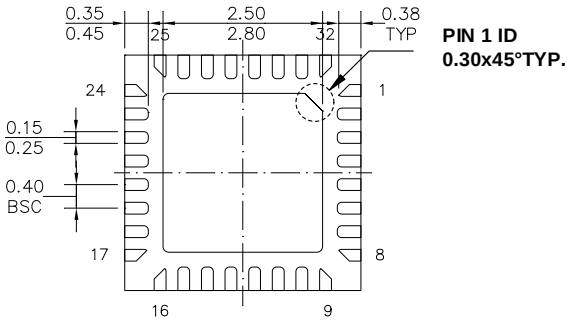
Bits	Access	Bit Name	Default	Description
7:0	Write-only	LOG_RST_CMD	0	The resolution is 1, and the range is between 0 and 255. 0x01: Re-initialize the lifetime log registers. Self-clearing

PACKAGE INFORMATION

TQFN-32 (4mmx4mm)

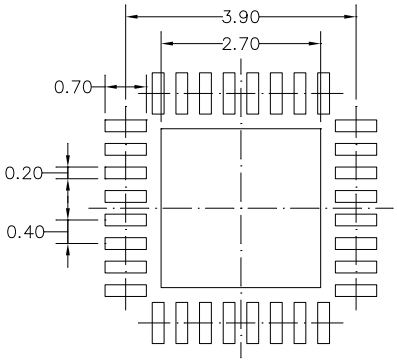


TOP VIEW



BOTTOM VIEW

SIDE VIEW

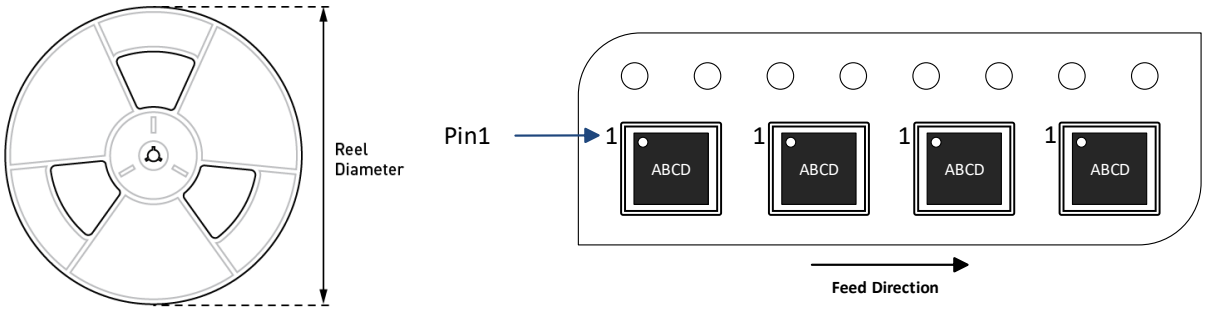


RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.08 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-220.
5) DRAWING IS NOT TO SCALE.

CARRIER INFORMATION



Part Number	Package Description	Quantity/ Reel	Quantity/ Tube	Quantity/ Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MPF42793DRT-0B-yyyy-Z	TQFN-32 (4mmx4mm)	5000	N/A	N/A	13in	12mm	8mm

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	11/5/2024	Initial Release	-