MPF42795

2 to 10 Stacked Cells Battery Pack Fuel Gauge with Level Leds

PRELIMINARY SPECIFICATIONS SUBJECT TO CHANGE

DESCRIPTION

The MPF42795 is a battery fuel gauge drop in solution that provides accurate and robust internal state estimates of batteries ranging from 2 up to 10 stacked lithium cells, resulting in nominal battery pack voltages ranging from 7.4V up to 37V.

The MPF42795 supports a wide variety of lithium cell chemistries with distinct properties. Despite of the fuel gauge algorithm complexity, the MPF42795 is engineered to be easy to use by only requiring a few basic key configuration settings to work. Additionally, advanced configuration settings that allow further tuning are also available to meet application-specific design needs.

The MPF42795 is also highly flexible, capable of working with any Analog Front End (AFE) on the market because battery readings are provided by the system's MCU. To ensure the exchanged data integrity, the device possesses I2C interface with CRC support.

APPLICATIONS

- E-Bike and E-Mobility
- Energy Storage and UPS Applications
- Battery Powered Cleaning Robots
- Battery Powered Medical Devices

FEATURES

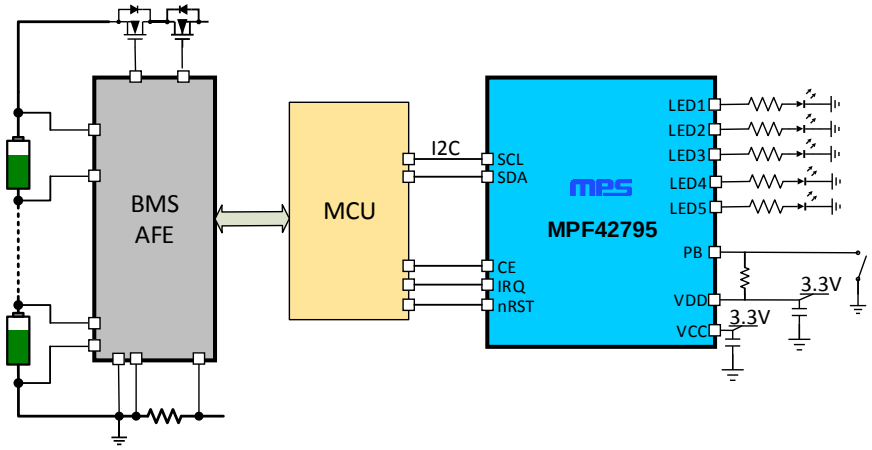
- Supports a wide variety of lithium cells up to 65.5Ah (with standard configuration)
- Supports from 2 up to 10 series cells
- Supports high degree of configurability (with current settings up to 131A)
- Provides key battery information such as:
  - Pack and cells state-of-charge
  - Remaining runtime and charge time
  - Instantaneous available power
  - Pack and cells state-of-health
- Provides lifetime logging
- Compatible with any AFE on the market
- Supports 5-level LED state-of-charge indicator with pushbutton trigger
- Low current consumption: 6 µA in Disable Mode and 135 µA (average) in Operating Mode during Rest
- Supports up to 400kHz I2C with CRC for robust communication
- Compact package: 32-pin QFN 4mm x 4mm

MINIMUM SYSTEM REQUIREMENTS

- BMS AFE providing individual cell voltages, pack current and temperature
- M0 system MCU with I2C and interrupt; 48 Kbyte of flash and 4Kbyte of RAM

All MPS parts are lead-free, halogen-free, and adhere to the RoHS directive. For MPS green status, please visit the MPS website under Quality Assurance. "MPS", the MPS logo, and "Simple, Easy Solutions" are trademarks of Monolithic Power Systems, Inc. or its subsidiaries.

TYPICAL APPLICATION



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ORDERING INFORMATION

Part Number*	Package	Top Marking	MSL Rating
MPF42795DRT-0B-yyyy**	QFN-32 (4mmx4mm)	*See Below*	3
EVKT-MPF42795	Evaluation kit		
EVKT-BMU10S	Evaluation kit		

* For Tape & Reel, add suffix –Z (e.g., MPF42795DRT-0B-yyyy–Z).

** “yyyy” refers to the default configuration identifier (“0000” by default) where each “y” is a hexadecimal value between 0 and F. Please work with the MPS FAE to get your customized default configuration.

TOP MARKING

MPSYWW
M4279X
LLLLLL

MPF4279X Family generic version

MPS: MPS prefix
Y: Year code
WW: Week code
4279X: part number
LLLLLL: Lot number

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EVALUATION KIT EVKT-MPF42795 (3RD PARTY BMS)

EVKT-MPF42795 kit contents:

#	Part Number	Item	Quantity
1	EVF42795-R-01A	MPF42795DRT-0B-yyyy Reference Design Evaluation Board	1
2	EVKT-USB_RS232/I2C-01	USB to RS232/I2C adapter	1
3	Tdrive-xxxx	USB Flash drive with GUI installation files and additional documents	1

Order directly from MonolithicPower.com or our distributors.

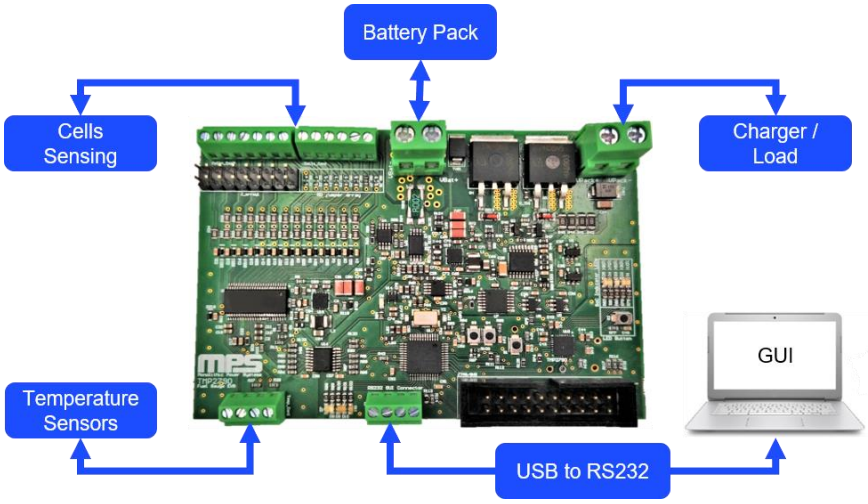


Figure 1: EVKT-MPF42795 Evaluation Kit Set-Up

EVALUATION KIT EVKT-BMU10S (MP2791 BMS)

EVKT-BMU10S kit contents:

#	Part Number	Item	Quantity
1	EVBMU10S-R-00A	MPF42795DRT-0B-yyyy and MP2791 Reference Design Evaluation Board	1
2	EVKT-USB_RS232/I2C-01	USB to RS232/I2C adapter	1
3	Tdrive-xxxx	USB Flash drive with GUI installation files and additional documents	1

Order directly from MonolithicPower.com or our distributors.

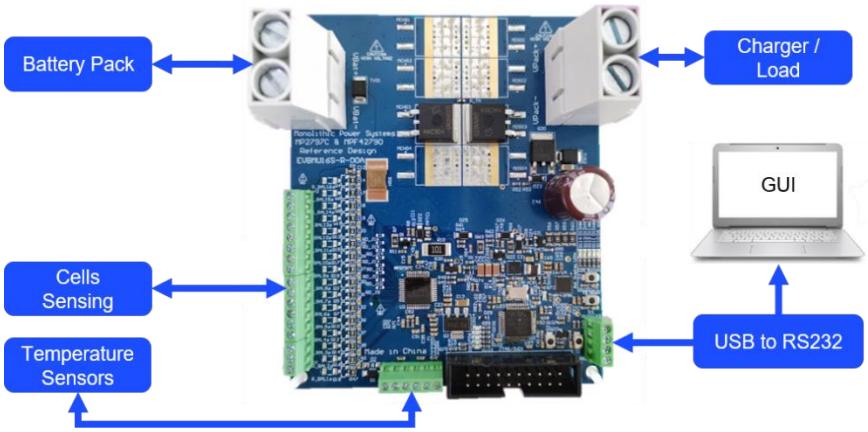
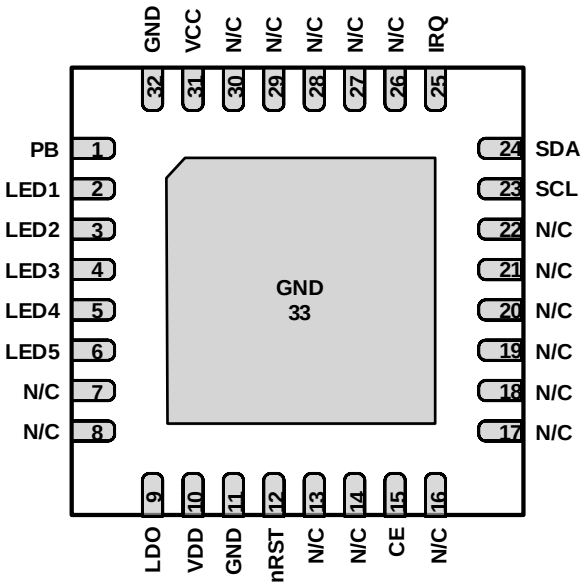


Figure 2: EVBMU10S-R-00A Evaluation Kit Set-Up

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PACKAGE REFERENCE

TOP VIEW



Note: GND 33 is an exposed PAD that needs a GND connection

QFN-32 (4mmx4mm)

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PIN FUNCTIONS

Pin #	Name	I/O	Description
1	PB	I	**Push-Button.** Triggers state-of-charge LED indicator.
2	LED1	O	**LED1 Driver.** Reports state of charge with a 330 Ω resistor in series.
3	LED2	O	**LED2 Driver.** Reports state of charge with a 330 Ω resistor in series.
4	LED3	O	**LED3 Driver.** Reports state of charge with a 330 Ω resistor in series.
5	LED4	O	**LED4 Driver.** Reports state of charge with a 330 Ω resistor in series.
6	LED5	O	**LED5 Driver.** Reports state of charge with a 330 Ω resistor in series.
7	N/C		
8	N/C		
9	LDO	Power	**Internal LDO.** Bypass with 2.2µF + 100nF ceramic capacitor to ground.
10	VDD	Power	**Power supply input.** Bypass with 2.2µF ceramic capacitor to ground.
11	GND	Power	**Ground Pin.**
12	nRST	I	**IC Reset Control.**
13	N/C		
14	N/C		
15	CE	I	**Chip Enable**. Setting this low stops the Fuel Gauge updates and disables the communication interface to minimize current consumption.
16	N/C		
17	N/C		
18	N/C		
19	N/C		
20	N/C		
21	N/C		
22	N/C		
23	SCL	I / O	**I2C Interface Clock.** Connect SCL to the logic rail through a 10kΩ resistor.
24	SDA	I / O	**I2C Interface Data.** Connect SDA to the logic rail through a 10kΩ resistor.
25	IRQ	O	**Interrupt Request Pin.** Interrupt going to the Host Systems.
26	N/C		
27	N/C		
28	N/C		
29	N/C		
30	N/C		
31	VCC	Power	**3-3.3V Power supply input.** Bypass with 2.2 µF ceramic capacitor to ground.
32	GND	Power	**Ground Pin.**
33	GND	Power	**Ground Pin.**

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ABSOLUTE MAXIMUM RATINGS (1)

Supply voltage (V_{CC}) 3.6V
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) .. 500 mW
Storage temperature ..... -55°C to +150°C
Junction temperature ..... -55°C to +150°C

ESD Rating

Human-body model (HBM) ..... ±4000V

Recommended Operating Conditions (3)

Supply voltage (V_{DD}) .....3.0V to 3.6V
All other pins .....–0.3V to V_{CC}+0.3V
Operating junction temp. (T_J)..... -40ºC to +85°C

Thermal Resistance (4) θ_{JA} θ_{JC}

QFN-32 (4mm x 4mm) ..... 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 produces an excessive die temperature, causing the regulator to 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 JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

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

Parameters	Symbol	Condition	Min	Typ	Max	Units
Power Supply						
Operating voltage range	V_{DD}			3.3	3.6	V
Operating voltage range	V_{CC}			3.3	3.6	V
Total active current	I_{DD}	V_{DD} = 3.3V, LEDs Off, Fuel Gauge Updating		7.5		mA
Total standby current	I_{DD}	V_{DD} = 3.3V, LEDs Off, Fuel Gauge Idle		50		µA
Average operating current during CHG or DSG	I_{DD_AVG}	V_{DD} = 3.3V, LEDs Off, NCELLS_SER = 10, EXE_TIME = 4s, with I2C traffic		270		µA
Average operating current during Rest	I_{DD_AVG}	V_{DD} = 3.3V, LEDs Off, NCELLS_SER = 10, EXE_TIME = 4s, WEXE_TIME_REST = 4, with I2C traffic		135		µA
Total disabled current	I_{DD}	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}		0.2VDD		0.9VDD	V
Minimum pulse width on nRST pin	t_{RST}	V_{DD} =3.3V		700		ns
Time-out after reset	t_{TOUT}			64	128	ms
CE						
Low input voltage	V_{OL_CE}	I_{OL}=5mA	-0.3		V_{DD} x 0.35	V
High input voltage	V_{OH_CE}		V_{DD} x 0.65V		V_{DD} + 0.3V	V
Low leakage current	I_{CE_LKG}	V_{CE}=3.3V			3	µA
High leakage current	I_{CE_LKG}	V_{CE}=3.3V			3	µA
IRQ						
Low output voltage	V_{IRQH}	Sink = 4 mA			0.4	V
High output voltage	V_{IRQL}	Source = 4 mA	V_{DD} -0.4			V
PB						
Low input voltage	V_{PBL}		-0.3		V_{DD} x 0.35	V
High input voltage	V_{PBH}		V_{DD} x 0.65V		V_{DD} + 0.3V	V
LEDs						
High level output voltage	V_{OH_LED}	Output Current = 4 mA	V_{DD} - 0.4V			V
High level output current	I_{OH_LED}	LEDx = VDD - 0.4V	4			mA
I²C DC Characteristics						
High input voltage	V_{IH}	SCL, SDA	0.7 V_{DD}		V_{DD} +0.3	V
Low input voltage	V_{IL}	SCL, SDA	-0.5		0.3 V_{DD}	V
Low output voltage	V_{OL}	SDA 3mA sink current			0.4	V

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ELECTRICAL CHARACTERISTICS

VDD = 3.3V, T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
I2C Timing Characteristics						
Spikes suppressed by input filter	t_{SP}		0		50	ns
Operating frequency range	f_{SCL}		10		400	kHz
Low period of SCL clock	t_{LOW}		1.125			µs
High period of SCL clock	t_{HIGH}		1.125			µs
SCL and SDA fall time	t_{FALL}				0.34	µs
SCL and SDA fall time	t_{RISE}				0.34	µs
Data hold time	$t_{HD:DAT}$		0			ns
Data setup time	$t_{SU:DAT}$		125			ns
Data valid Time	$T_{v:DAT}$		475			ns
Setup time for repeated start condition	$t_{SU:STA}$		125			ns
Hold time (repeated) start condition	$t_{HD:STA}$		0			ns
Setup time for stop condition	$t_{SU:STO}$		125			ns

Note: Sampled during initial release to ensure compliance, not subject to production testing.

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OPERATION

The host MCU periodically updates the fuel gauge required inputs such as cells voltage (“VRDG_CELLxx” registers), current (“IRDG_CELLxx” registers) and temperature (“TRDG_TSx” registers). The host MCU is responsible of synchronizing the input data refresh with the fuel gauge execution time (EXE_TIME). Then, the host MCU sends the EXE_CMD command to trigger the fuel gauge execution and waits to receive the IRQ notification, which indicates the fuel gauge has completed the calculations. At that point, the host MCU can read back the fuel gauge output registers such as pack state-of-charge.

OPERATING MODES

Active

In active mode, the fuel gauge is either updating the battery internal states or communicating through the I2C bus.

Standby

In standby mode, the fuel gauge is idle, which means all triggered updates have been completed and the fuel gauge is waiting for activity on the SDA line to transition to active mode (see I^2C Communication Interface section).

Disabled

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

FUEL GAUGE DESCRIPTION

CORE ALGORITHM

The fuel gauge core algorithm is responsible for accurately estimating cell-level internal variables and pack-level quantities.

Cell Mathematical Model

Cell dynamics are influenced by multiple factors such as chemistry, state-of-charge, current and temperature among others. Thus, a mathematical model that captures the cell most important dynamics is required for accurate internal variable estimation.

Cell mathematical models are provided by MPS, either from a database or as a result of a cell characterization routine.

Cell State-of-Charge

Cell state-of-charge refers to the cell capacity that is currently available as a function of the rated capacity. State-of-charge is an unknown internal variable that cannot be directly measured and therefore, needs to be estimated using available measurements. Our fuel gauge uses voltage, current and temperature measurements observed over time to produce accurate state-of-charge estimates over a wide range of operating conditions.

Empty State-of-Charge

Empty state-of-charge refers to the state-of-charge level at which the battery pack is unable to discharge further without breaching the voltage cutoff limits. Thus, the empty state-of-charge prediction relies on the operating condition of the different cells as well as the discharge current supplied to the load, which is application specific.

In addition, our fuel gauge is able to predict if the battery pack discharge will be limited by the pack or one of the cells (cell ID also provided). This is extremely important for accurate empty state-of-charge estimation in unbalanced packs since the fuel gauge must track the condition that will actually limit the battery pack discharge.

Full State-of-Charge

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

In addition, our fuel gauge is able to predict if the battery pack charge will be limited by the pack or one of the cells (cell ID also provided). This is extremely important for accurate full state-of-charge estimation in unbalanced packs since the fuel gauge must track the condition that will actually limit the battery pack charge.

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Pack State-of-Charge

Pack state-of-charge provides the capacity that is currently available as a function of the available capacity given the actual pack operating conditions. It relies on cell-level quantities and tracks the remaining capacity the battery can charge or discharge without breaching the cutoff limits.
This is perhaps the most important estimate because of the information it contains and it is usually the value exposed to the application user.

Pack Unavailable State-of-Charge

Pack unavailable state-of-charge refers to the capacity that is not available due to the actual pack operating conditions, including cells mismatch and battery pack configuration. In other words, pack unavailable state-of-charge provides the amount of capacity the battery is not able to use without violating the safe operating region.

INDICATORS

Fuel gauge indicators are based on internal battery estimates and provide useful information to customers.

Remaining Time-to-Empty

Remaining time-to-empty refers to how much time is left until the battery pack reaches the empty state assuming the application-specific discharge current. In other words, the remaining time-to-empty estimate informs the user the remaining run time until the pack reaches 0% state-of-charge.

Remaining Time-to-Full

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

Max. Discharge Power

Maximum discharge power refers to how much power the pack can deliver to the load without breaching the pack empty levels and the safe operating region.
Furthermore, our fuel gauge is able to predict if the limiting factor under maximum discharge power will be caused by the pack or one of the cells (cell ID also provided).

Max. Charge Power

Maximum charge power refers to how much power the pack can accept for charging without breaching the cutoff limits.
Furthermore, our fuel gauge is able to predict if the limiting factor under maximum charge power will be caused by the pack or one of the cells (cell ID also provided).

LEARNINGS

Fuel gauge learnings are responsible for automatically fine tune the algorithm and track ageing to keep the estimates accurate over its lifetime.

Charge Constant-Current

The charge constant-current learning feature is able to refine the initial charge constant-current value defined by the user. This smart adjustment allows to compensate for constant charge current deviating from its nominal settings, which happens frequently, for example due to production tolerances of the charging system. This charge constant-current learning minimizes the need for tuning while keeping optimal state-of-charge accuracy. The learning can be completed and leveraged within the same charge cycle.

Charge Termination-Current

The charge termination-current learning feature is able to refine the initial charge termination-current value defined by the user. This smart adjustment allows to compensate for charge termination current deviating from its nominal settings, which happens frequently, for example due to production tolerances of the charging system. Charge termination-current smart adjustments are applied in subsequent charge cycles following the one where the learning has happened.

Charge Constant-Voltage

The charge constant-voltage learning feature is able to refine the initial charge constant-voltage value defined by the user. This smart adjustment allows to compensate for charge constant-voltage deviating from its nominal settings, which happens frequently, for example due to production tolerances of the charging system.

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Charge constant-voltage smart adjustments are applied in subsequent charge cycles following the one where the learning has happened.

Discharge Average-Current

The discharge average-current learning feature calculates the load average discharge current in order to accurately provide the time-to-empty estimate.

Discharge Termination-Current

The discharge termination-current learning feature is able to refine the initial discharge termination-current value defined by the user. Hence, the discharge termination-current value will adapt to load dynamics and keep the state-of-charge accurate with minimum user tuning required.

Moreover, the discharge termination-current learning feature includes two different modes of operation depending on the application requirements: continuous and past-cycle learning. In the continuous learning mode, the discharge termination current will update continuously while the pack discharges in order to accurately determine the empty state-of-charge whereas the past-cycle learning will use the previous discharge cycle data to learn. The former is recommended for unpredictable discharge termination currents whereas the latter is recommended for consistent discharge termination currents.

State-of-Health

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

Our fuel gauge incorporates a state-of-health learning feature that is able to track individual cell capacities with respect to their nominal capacity. This feature might as well be used for identification of weak cells that are affecting the overall pack performance.

LIFETIME LOG

Important events and certain conditions are reported in the lifetime log in order to gain insight on how the battery pack has been operated. The fuel gauge backs this information up to its non-volatile memory every time the MPF42795 goes to disabled mode or every elapsed hour.

Count Log

The number of times the pack has been charged from below 15% to above 85% state-of-charge and the number of times the pack has been charged by at least 10% state-of-charge are reported in the lifetime log as well as the number of shutdowns. Note that both powerdown and entering disabled mode are considered as shutdowns.

Current Log

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

Voltage Log

The maximum and minimum voltage for each cell (or group of parallel cells) 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 maximum and minimum temperature the pack has sensed is reported in the lifetime log.

Moreover, the maximum temperature difference between two sensors is also reported as well as their corresponding temperature sensor ID.

Furthermore, the lifetime log also details how much time the pack has operated under different temperature ranges.

Balancing Log

The amount of time each cell has been balanced is reported in the lifetime log.

CONFIGURATION

Configuration Mode

The host system can send the CONFIG_MODE_CMD command to enable full configuration changes. However, the fuel gauge operation will stop. The register CONFIG_MODE_FLAG indicates whether or not the fuel gauge has entered this mode. After the fuel gauge configuration has been successfully updated, the host system must send the CONFIG_EXIT_CMD command. Then, the updated configuration will be stored in the MPF42795 non-volatile memory and therefore,

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configuration will be preserved even after a hardware reset (power cycle or nRST pin cycle). Note that LED configuration can be changed when not in configuration mode. However, the LED configuration will be only stored in the non-volatile memory after sending the "Exit Configuration Mode" and therefore, configuration will be preserved even after a hardware reset.

Editing Mode

Alternatively, the host system can send the EDIT_CONFIG_CMD command to enable partial configuration changes. In this case, the fuel gauge operation will not stop, allowing on the fly configuration edits. The register EDIT_SETTINGS_FLAG indicates whether or not the fuel gauge has entered this mode. The host system can exit this mode by sending the END_EDIT_CONFIG_CMD or the CONFIG_EXIT_CMD command, which will store the updated configuration in the MPF42795 non-volatile memory.

Note that LED configuration can be changed when not in editing mode. However, the LED configuration will be only stored in the non-volatile memory after sending the "Exit Configuration Mode" and therefore, configuration will be preserved even after a hardware reset.

LEDS CONTROL

The MPF42795 can drive 5 external LEDs that report the pack state-of-charge. This section explains the LEDs direct and manual control modes, which can be selected by the LEDS_ON_MAN register.

DIRECT CONTROL

The fuel gauge directly controls and indicates the pack state-of-charge in the 5 LEDs (see Table 1). The LEDs display pack state-of-charge when triggered by a pulldown applied to the PB pin (if LEDS_ON_BTN register is enabled), or when battery pack is charging (if LEDS_ON_CHG is enabled). Deglitch time between charge and discharge can be configured by the LED_TRANS register.

Table 1 LEDs State-of-Charge Indicator Map

Pack State of Charge	LEDs 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

Note that LEDs turn on time can be configured by the LEDS_ON_TIME register.

MANUAL CONTROL

The host manually controls each LED by the corresponding LEDx_ON register.

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FUEL GAUGE PERFORMANCE

The 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. Hence, fuel gauge performance might vary depending on the battery operating conditions.
This section shows examples of MPF42795 pack state-of-charge performance of a battery pack built from Samsung INR18650 25R cylindrical cells.

CONSTANT CURRENT DISCHARGE TEST

This scenario consists of discharging a battery at a constant current. Note that fuel gauge performance will depend on the specific test operating conditions such as current rate and temperature.
Figure 3 shows an example of MPF42795 performance for a 1C constant current discharge at 15ºC ambient temperature. In this case, the root-mean-squared and maximum pack state-of-charge error are 0.68% and 1.38% respectively.

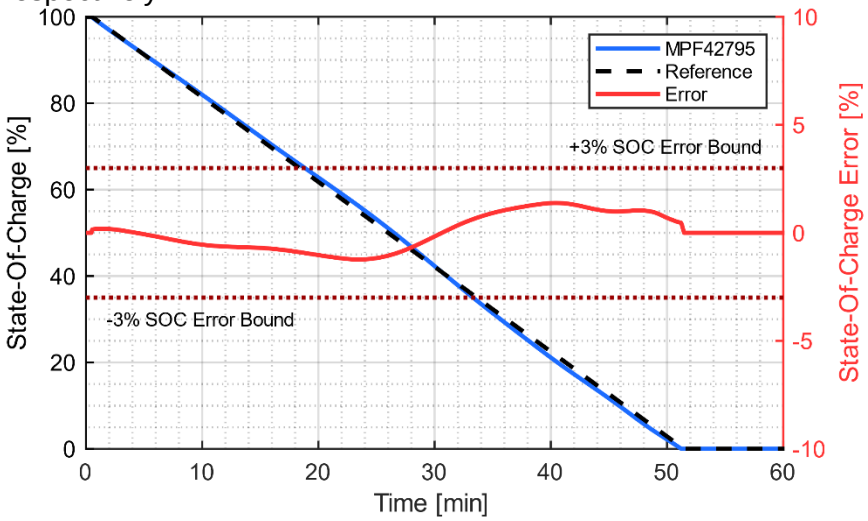


Figure 3: MPF42795's Performance for a 1C Discharge at 15ºC Ambient Temperature

Table 2 shows MPF42795 performance metrics for other constant current discharge tests under different operation conditions.

CONSTANT CURRENT CHARGE TEST

This scenario consists of charging a battery following the typical constant-current constant-voltage (CC-CV) method. Note that fuel gauge performance will depend on the specific test operating conditions such as current rate and temperature.
Figure 4Figure 3 shows an example of MPF42795 performance for a complete 1C constant-current and constant-voltage (CC-CV) charge at 15ºC ambient temperature, which terminates when charge current drops to 0.1C. In this case, the root-mean-squared and maximum pack state-of-charge error are 0.50% and 1.22% respectively.

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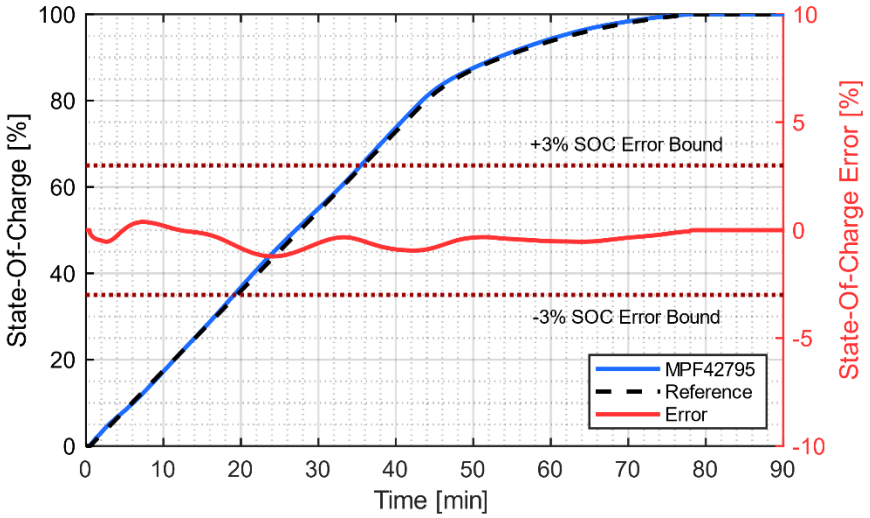


Figure 4: MPF42795's Performance for a 1C Charge at 15ºC Ambient Temperature

Table 2 shows MPF42795 performance metrics for other constant-current constant-voltage (CC-CV) charge tests under different operation conditions.

E-BIKE DISCHARGE TEST

This scenario consists of discharging a battery following a typical application current profile such as an e-bike load profile. Figure 5Figure 3 shows a real, pre-recorded e-bike current profile with a 0.5C average current.

Note that fuel gauge performance will depend on the specific test operating conditions such as maximum and average current rate and temperature.

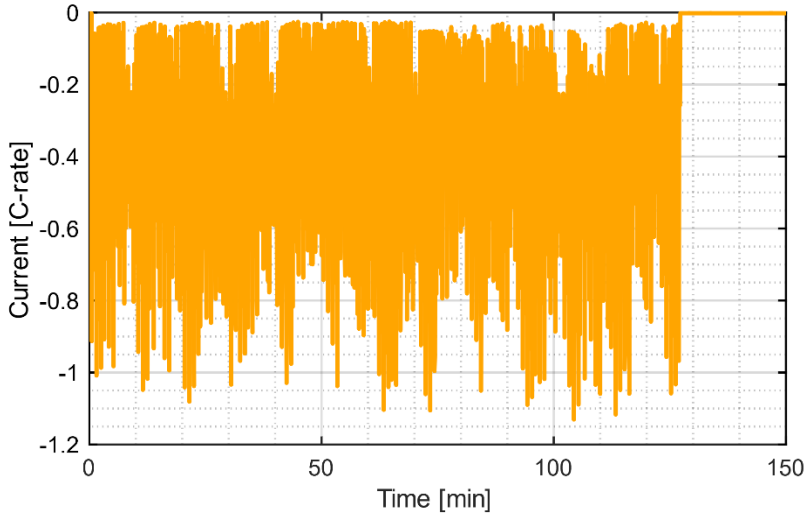


Figure 5: Typical E-bike Discharge Current Profile

Figure 6Figure 3 shows an example of MPF42795 performance for the e-bike profile discharge at 15ºC ambient temperature. In this case, the root-mean-squared and maximum pack state-of-charge error are 1.02% and 2.49% respectively.

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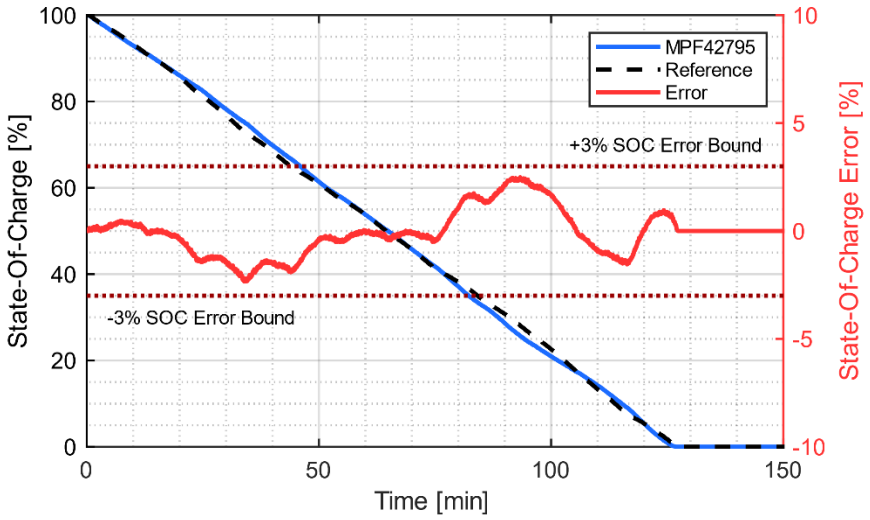


Figure 6: MPF42795's Performance for a Typical E-Bike Discharge at 15ºC Ambient Temperature

Table 2 shows MPF42795 performance metrics for other e-bike discharge tests under different operation conditions.

PERFORMANCE SUMMARY

This section aims to provide a summary of achievable real world MPF42795 performance. Table 2 shows pack state-of-charge performance metrics for multiple test cases.

Table 2: MPF42795 State-of-Charge Root-Mean-Squared (and Maximum) Error

Test Case	15°C	25°C	35°C
0.5C charge	0.80% (1.79%)	0.87% (1.78%)	0.98% (1.60%)
1C charge	0.50% (1.22%)	0.74% (1.72%)	0.60% (1.31%)
0.5C discharge	0.41% (0.88%)	0.39% (1.12%)	0.35% (1.39%)
1C discharge	0.68% (1.38%)	0.66% (1.26%)	0.40% (1.05%)
2C discharge	0.75% (1.99%)	0.99% (1.61%)	0.52% (1.71%)
e-bike profile	1.02% (2.49%)	1.25% (2.58%)	0.80% (2.07%)

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I²C COMMUNICATION INTERFACE

The MPF42795 uses an I2C compatible interface for flexible parameters setting and instantaneous device status reporting. I2C™ is a bidirectional 2-wire serial interface developed by Philips Semiconductor (now NXP Semiconductors). 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 master is the device which initiates a data transfer on the bus and generates the clock signals to permit the transfer. At that time, any device addressed is considered as a slave. MPF42795 operates as a slave device with a configurable address (0x08 by default), receiving control inputs from the master device. MPF42795 will ignore general call addresses.

The I²C interface supports both standard mode (up to 100kbits), and fast mode (up to 400kbits). Both SDA and SCL are bi-direction lines, connecting to the positive supply voltage via a current source or pull-up resistor. When the bus is free, both lines are HIGH. The SDA and SCL pins are open drain.

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. Note that a single clock pulse is generated for each data bit transferred (see Figure 7).

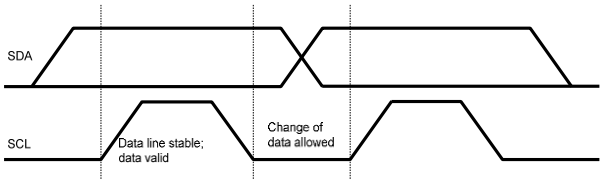


Figure 7: Bit Transfer on the I²C Bus

All transactions must begin with a START (S) and can be terminated with a STOP (P). START and STOP conditions are always generated by the master. A START is defined by a HIGH to LOW transition on the SDA line while SCL is HIGH (see Figure 9). A STOP is defined by a LOW to HIGH transition on the SDA line while the SCL is HIGH (see Figure 9). The bus is considered busy after the START condition, and free after the STOP condition.

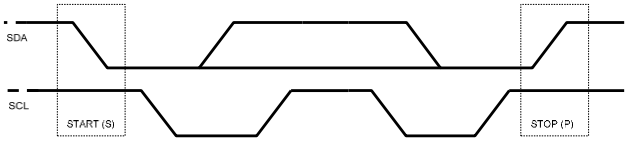


Figure 9: I²C START and STOP Conditions

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 (see Figure 8).

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

The transmitter releases the SDA line during the acknowledge clock pulse for the receiver to pull the SDA line LOW. If the SDA line remains HIGH during the acknowledge clock pulse, it will not be acknowledged (NACK). In this case, the master can generate a STOP to abort the transfer or a repeated START to start a new transfer.

After the START, a slave address is sent, which is 7 bits long, followed by the data R/W bit. A transmission or WRITE (W) is indicated by a zero whereas a request or READ (R) is indicated by a one. Figure 8 shows a complete data transfer.

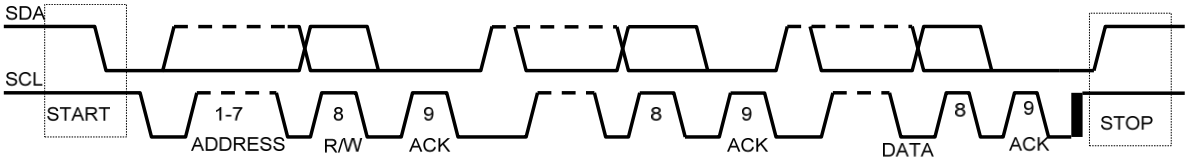


Figure 8: Complete Data Transfer

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ACTIVE MODE

MPF42795 must be in active mode to communicate. To transition to active mode, the SDA line must be set low. Then, there is a 20ms timeout to start operation or it will transition back to standby mode. After operations are completed such as I²C communication, fuel gauge updates or non-volatile memory writes, there is a 5ms timeout.

A low 5ms pulse on the SDA line is recommended to transition to active mode. To verify the MPF42795 is ready for communications, an I²C header with the START condition, the device address and the R/W bit can be sent. Then, the device will respond with an ACK if it is ready for communications.

PROTOCOL LAYER

The MPF42795 uses a protocol where 2 bytes are used for register and command addresses. A length field is also provided to declare the number of bytes in each read or write transaction. Cyclic redundancy check (CRC) can be used to ensure the integrity of the transaction. The last 4 bytes of the transaction correspond to the CRC when enabled. Figure 10 and Figure 11 show an example of write and read transactions with CRC respectively.

However, if CRC is disabled, the transaction can either include the correct CRC bytes or not include the CRC bytes and therefore, the NACK and STOP from the master should go after DATA[n].

Cyclic Redundancy Check (CRC)

The CRC spans the register address, length and data payload and 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:

```
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;
}
```

To disable CRC and configure the slave address as 0x08 the following message can be sent: {0x00, 0x41, 0x01, 0x08, 0x94, 0xA0, 0xDE, 0xDD} (Address = 0x4100, Length = 0x01, Data = 0x08, CRC = 0xDDDE A094).

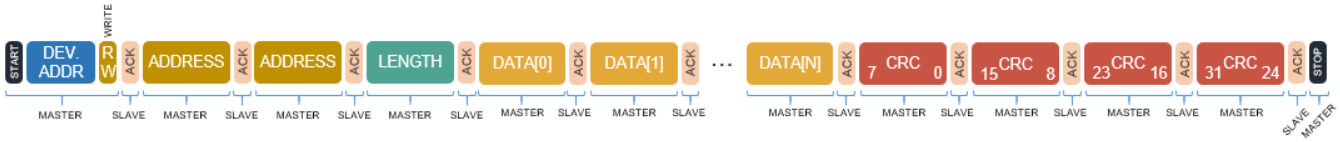


Figure 10: I2C Write Transaction with CRC

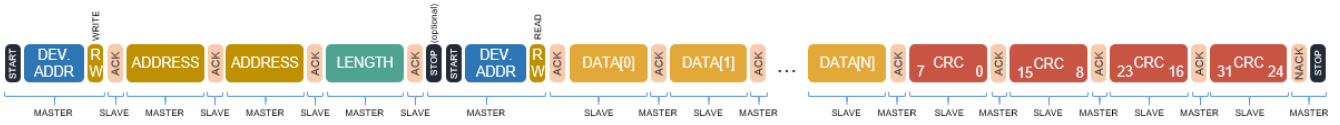


Figure 11: I2C Read Transaction with CRC

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I²C REGISTER MAP

Fuel Gauge Input

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
VRDG_CELL1, 0x0000	*— Cell 1 Voltage Reading —* Inputs cell 1 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL2, 0x0002	*— Cell 2 Voltage Reading —* Inputs cell 2 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL3, 0x0004	*— Cell 3 Voltage Reading —* Inputs cell 3 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL4, 0x0006	*— Cell 4 Voltage Reading —* Inputs cell 4 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL5, 0x0008	*— Cell 5 Voltage Reading —* Inputs cell 5 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL6, 0x000A	*— Cell 6 Voltage Reading —* Inputs cell 6 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL7, 0x000C	*— Cell 7 Voltage Reading —* Inputs cell 7 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL8, 0x000E	*— Cell 8 Voltage Reading —* Inputs cell 8 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL9, 0x0010	*— Cell 9 Voltage Reading —* Inputs cell 9 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_CELL10, 0x0012	*— Cell 10 Voltage Reading —* Inputs cell 10 voltage reading.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_PACK, 0x0020	*— Pack Voltage Reading —* Inputs pack voltage reading if VRDG_PACK_EN is enabled.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mV	0	0 to 131070 mV
IRDG_CELL1, 0x0022	*— Cell 1 Current Reading —* Inputs cell 1 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL2, 0x0026	*— Cell 2 Current Reading —* Inputs cell 2 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL3, 0x002A	*— Cell 3 Current Reading —* Inputs cell 3 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL4, 0x002E	*— Cell 4 Current Reading —* Inputs cell 4 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL5, 0x0032	*— Cell 5 Current Reading —* Inputs cell 5 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL6, 0x0036	*— Cell 6 Current Reading —* Inputs cell 6 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA

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IRDG_CELL7, 0x003A	*— Cell 7 Current Reading —* Inputs cell 7 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL8, 0x003E	*— Cell 8 Current Reading —* Inputs cell 8 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL9, 0x0042	*— Cell 9 Current Reading —* Inputs cell 9 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_CELL10, 0x0046	*— Cell 10 Current Reading —* Inputs cell 10 current reading if IRDG_CELLS_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
IRDG_PACK, 0x0062	*— Pack Current Reading —* Inputs pack current reading if IRDG_PACK_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 1 mA	0	-524288 to 524287 mA
CCRDG, 0x0066	*— Coulomb Count Reading —* Inputs Coulomb count reading if CCRDG_EN is enabled.	32, [31:0]	R/W	32 bit signed 2-comp integer LSB = 0.0005 mAs	0	-1073741.832 to 1073741.832 mAs
TRDG_TS1, 0x006A	*— Temperature Sensor 1 Reading —* Inputs temperature sensor 1 reading.	16, [15:0]	R/W	16 bit signed 2-comp integer LSB = 0.01 ºC	0	-273.15 to 327.67 ºC
TRDG_TS2, 0x006C	*— Temperature Sensor 2 Reading —* Inputs temperature sensor 2 reading.	16, [15:0]	R/W	16 bit signed 2-comp integer LSB = 0.01 ºC	0	-273.15 to 327.67 ºC
TRDG_TS3, 0x006E	*— Temperature Sensor 3 Reading —* Inputs temperature sensor 3 reading.	16, [15:0]	R/W	16 bit signed 2-comp integer LSB = 0.01 ºC	0	-273.15 to 327.67 ºC
TRDG_TS4, 0x0070	*— Temperature Sensor 4 Reading —* Inputs temperature sensor 4 reading.	16, [15:0]	R/W	16 bit signed 2-comp integer LSB = 0.01 ºC	0	-273.15 to 327.67 ºC
TRDG_DIE, 0x0072	*— Die Temperature Reading —* Inputs die temperature reading.	16, [15:0]	R/W	16 bit signed 2-comp integer LSB = 0.01 ºC		-273.15 to 327.67 ºC
BAL_CELL1, 0x0074	*— Cell 1 Balancing —* Inputs cell 1 balancing status: 1 = active, 0 = inactive.	1, [0]	R/W	Boolean True/False	0	0 to 1
BAL_CELL2, 0x0074	*— Cell 2 Balancing —* Inputs cell 2 balancing status: 1 = active, 0 = inactive.	1, [1]	R/W	Boolean True/False	0	0 to 1
BAL_CELL3, 0x0074	*— Cell 3 Balancing —* Inputs cell 3 balancing status: 1 = active, 0 = inactive.	1, [2]	R/W	Boolean True/False	0	0 to 1
BAL_CELL4, 0x0074	*— Cell 4 Balancing —* Inputs cell 4 balancing status: 1 = active, 0 = inactive.	1, [3]	R/W	Boolean True/False	0	0 to 1

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BAL_CELL5, 0x0074	— *Cell 5 Balancing* — Inputs cell 5 balancing status: 1 = active, 0 = inactive.	1, [4]	R/W	Boolean True/False	0	0 to 1
BAL_CELL6, 0x0074	— *Cell 6 Balancing* — Inputs cell 6 balancing status: 1 = active, 0 = inactive.	1, [5]	R/W	Boolean True/False	0	0 to 1
BAL_CELL7, 0x0074	— *Cell 7 Balancing* — Inputs cell 7 balancing status: 1 = active, 0 = inactive.	1, [6]	R/W	Boolean True/False	0	0 to 1
BAL_CELL8, 0x0074	— *Cell 8 Balancing* — Inputs cell 8 balancing status: 1 = active, 0 = inactive.	1, [7]	R/W	Boolean True/False	0	0 to 1
BAL_CELL9, 0x0074	— *Cell 9 Balancing* — Inputs cell 9 balancing status: 1 = active, 0 = inactive.	1, [8]	R/W	Boolean True/False	0	0 to 1
BAL_CELL10, 0x0074	— *Cell 10 Balancing* — Inputs cell 10 balancing status: 1 = active, 0 = inactive.	1, [9]	R/W	Boolean True/False	0	0 to 1
HARD_RST, 0x0076	— *Hard Reset* — Resets fuel gauge and lifetime log if HARD_RST = 1 (i.e., FG_RST = LOG_RST = 1). Note: This is a self-clearing register and will return to 0 automatically.	1, [0]	R/W	Boolean True/False	0	0 to 1
FG_RST, 0x0076	— *Fuel Gauge Reset* — Resets fuel gauge if FG_RST = 1 (i.e., STATUS_RST = SOH_RST = SOC_RST = FULL_RST = EMTY_RST = IR_RST = ETAC_RST = IDIS_AVG_RST = IDIS_END_RST = ICHG_END_RST = ICHG_CC_RST = VCHG_CV_RST = 1). Note: This is a self-clearing register and will return to 0 automatically.	1, [1]	R/W	Boolean True/False	0	0 to 1
LOG_RST, 0x0076	— *Lifetime Log Reset* — Resets lifetime log: 1 = reset (self-clears), 0 = no action.	1, [2]	R/W	Boolean True/False	0	0 to 1
WKUP, 0x0076	— *Wakeup* — Wakes up fuel gauge: 1 = wake up (self-clears), 0 = no action.	1, [3]	R/W	Boolean True/False	0	0 to 1
STATUS_RST, 0x0076	— *Status Reset* — Resets pack status: 1 = reset (self-clears), 0 = no action.	1, [4]	R/W	Boolean True/False	0	0 to 1
SOH_RST, 0x0076	— *SOH Reset* — Resets state-of-health: 1 = reset (self-clears), 0 = no action.	1, [5]	R/W	Boolean True/False	0	0 to 1

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SOC_RST, 0x0076	*— SOC Reset —* Resets state-of-charge: 1 = reset (self-clears), 0 = no action.	1, [7]	R/W	Boolean True/False	0	0 to 1
FULL_RST, 0x0076	*— Pack Full Reset —* Resets pack full: 1 = reset (self-clears), 0 = no action.	1, [8]	R/W	Boolean True/False	0	0 to 1
EMTY_RST, 0x0076	*— Pack Empty Reset —* Resets pack empty: 1 = reset (self-clears), 0 = no action.	1, [9]	R/W	Boolean True/False	0	0 to 1
IDIS_AVG_RST, 0x0076	*— Discharge Average Current Reset —* Resets discharge average current: 1 = reset (self-clears), 0 = no action.	1, [10]	R/W	Boolean True/False	0	0 to 1
IDIS_END_RST, 0x0076	*— Discharge Termination Current Reset —* Resets discharge termination current: 1 = reset (self-clears), 0 = no action.	1, [11]	R/W	Boolean True/False	0	0 to 1
ICHG_END_RST, 0x0076	*— Charge Termination Current Reset —* Resets charge termination current: 1 = reset (self-clears), 0 = no action.	1, [12]	R/W	Boolean True/False	0	0 to 1
ICHG_CC_RST, 0x0076	*— Charge Constant Current Reset —* Resets charge constant current: 1 = reset (self-clears), 0 = no action.	1, [13]	R/W	Boolean True/False	0	0 to 1
VCHG_CV_RST, 0x0076	*— Charge Constant Voltage Reset —* Resets charge constant voltage: 1 = reset (self-clears), 0 = no action.	1, [14]	R/W	Boolean True/False	0	0 to 1
PCHG_SHW, 0x0078	*— Max. Charge Power Shown —* Shows maximum charge power in PCHG, limiting cell ID in PCHG_ID and limiting factor in PCHG_LIM (PCHG_SHW_EN by default): 1 = show, 0 = not show.	1, [0]	R/W	Control Enable(=1)/Disable(=0)	PCHG_SHW_EN	0 to 1
PDIS_SHW, 0x0078	*— Max. Discharge Power Shown —* Shows maximum discharge power (PDIS_SHW_EN by default): 1 = show, 0 = not show.	1, [1]	R/W	Control Enable(=1)/Disable(=0)	PDIS_SHW_EN	0 to 1

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Fuel Gauge Backup

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
SOH_CELL1_BKUP, 0x0200	*— Cell 1 State-of-Health Backup Register —* Backup Register for Cell 1 State of Health. This address is a R/W alias for the SOH_CELL1 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL2_BKUP, 0x0204	*— Cell 2 State-of-Health Backup Register —* Backup Register for Cell 2 State of Health. This address is a R/W alias for the SOH_CELL2 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL3_BKUP, 0x0208	*— Cell 3 State-of-Health Backup Register —* Backup Register for Cell 3 State of Health. This address is a R/W alias for the SOH_CELL3 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL4_BKUP, 0x020C	*— Cell 4 State-of-Health Backup Register —* Backup Register for Cell 4 State of Health. This address is a R/W alias for the SOH_CELL4 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %

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SOH_CELL5_BKUP, 0x0210	*— Cell 5 State-of-Health Backup Register —* Backup Register for Cell 5 State of Health. This address is a R/W alias for the SOH_CELL5 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL6_BKUP, 0x0214	*— Cell 6 State-of-Health Backup Register —* Backup Register for Cell 6 State of Health. This address is a R/W alias for the SOH_CELL6 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL7_BKUP, 0x0218	*— Cell 7 State-of-Health Backup Register —* Backup Register for Cell 7 State of Health. This address is a R/W alias for the SOH_CELL7 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL8_BKUP, 0x021C	*— Cell 8 State-of-Health Backup Register —* Backup Register for Cell 8 State of Health. This address is a R/W alias for the SOH_CELL8 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %

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SOH_CELL9_BKUP, 0x0220	*— Cell 9 State-of-Health Backup Register —* Backup Register for Cell 9 State of Health. This address is a R/W alias for the SOH_CELL9 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL10_BKUP, 0x0224	*— Cell 10 State-of-Health Backup Register —* Backup Register for Cell 10 State of Health. This address is a R/W alias for the SOH_CELL10 register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this or any other of the Cell SoH Backup Registers will prepare the FG to use the values written in these registers as starting point for the SoH learning.	32, [31:0]	R/W	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
IDIS_AVG_BKUP, 0x0280	*— Discharge Average Current Backup Register —* Backup Register for Average Discharge Current. This address is a R/W alias for the IDIS_AVG register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this Backup Registers will prepare the FG to use the values written in this register as starting point for this learning.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
IDIS_END_BKUP, 0x0290	*— Discharge Termination Current Backup Register —* Backup Register for Discharge End Current. This address is a R/W alias for the IDIS_END register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this Backup Registers will prepare the FG to use the values written in this register as starting point for this learning.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA

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ICHG_CC_BKUP, 0x02A0	*— Charge Constant Current Backup Register —* Backup Register for Charge CC Current. This address is a R/W alias for the ICHG_CC register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this Backup Registers will prepare the FG to use the values written in this register as starting point for this learning.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
ICHG_END_BKUP, 0x02B0	*— Charge Termination Current Backup Register —* Backup Register for Charge Termination Current. This address is a R/W alias for the ICHG_END register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this Backup Registers will prepare the FG to use the values written in this register as starting point for this learning.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
VCHG_CV_BKUP, 0x02C0	*— Charge Constant Voltage Backup Register —* Backup Register for Charge CV Voltage. This address is a R/W alias for the VCHG_CV register. FG has to be in Learning Backup Mode for this register to be written (see FG_BKUP_ENABLE and FG_BKUP_FLAG) once writting to this Backup Registers will prepare the FG to use the values written in this register as starting point for this learning.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mV		0 to 131070 mV
FG_BKUP_ENABLE, 0x0300	*— Learnings Backup Enable Backup Register —* This Control Enables and Disables the Learning Backup Mode. See FG_BKUP_FLAG. Learning Backup Mode must be enabled in order to enable write operations to Learning Backup Registers.	1, [0]	Write Only	Control Enable(=1)/Disable(=0)	0	0 to 1

Fuel Gauge Output

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
EMTY_SOC_CELL1, 0x0564	*— Cell 1 Empty SOC —* Outputs cell 1 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL2, 0x0565	*— Cell 2 Empty SOC —* Outputs cell 2 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %

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EMTY_SOC_CELL3, 0x0566	— *Cell 3 Empty SOC* — Outputs cell 3 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL4, 0x0567	— *Cell 4 Empty SOC* — Outputs cell 4 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL5, 0x0568	— *Cell 5 Empty SOC* — Outputs cell 5 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL6, 0x0569	— *Cell 6 Empty SOC* — Outputs cell 6 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL7, 0x056A	— *Cell 7 Empty SOC* — Outputs cell 7 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL8, 0x056B	— *Cell 8 Empty SOC* — Outputs cell 8 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL9, 0x056C	— *Cell 9 Empty SOC* — Outputs cell 9 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_SOC_CELL10, 0x056D	— *Cell 10 Empty SOC* — Outputs cell 10 empty state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
EMTY_ID, 0x0574	— *Empty Limiting Cell ID* — Outputs pack empty limiting cell ID.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 1 Cell_ID	0	1 to 10 Cell_ID
EMTY_RTIME, 0x0575	— *Remaining Time-to-Empty* — Outputs remaining time to reach pack empty. Smoother changes on the remaining time estimate can be achieved by increasing EMTY_RTIME_FILTER at the price of increased phase delay.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 s	0	0 to 65535 s
EMTY_LIM, 0x0577	— *Empty Limiting Factor* — Outputs pack empty limiting factor: 0 = Cell, 1 = Pack.	8, [7:0]	Read Only	Non-Standard LSB = 1	0	0 to 1
FULL_SOC_CELL1, 0x057C	— *Cell 1 Full SOC* — Outputs cell 1 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL2, 0x057D	— *Cell 2 Full SOC* — Outputs cell 2 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL3, 0x057E	— *Cell 3 Full SOC* — Outputs cell 3 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL4, 0x057F	— *Cell 4 Full SOC* — Outputs cell 4 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL5, 0x0580	— *Cell 5 Full SOC* — Outputs cell 5 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL6, 0x0581	— *Cell 6 Full SOC* — Outputs cell 6 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %

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FULL_SOC_CELL7, 0x0582	— *Cell 7 Full SOC* — Outputs cell 7 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL8, 0x0583	— *Cell 8 Full SOC* — Outputs cell 8 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL9, 0x0584	— *Cell 9 Full SOC* — Outputs cell 9 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_SOC_CELL10, 0x0585	— *Cell 10 Full SOC* — Outputs cell 10 full state-of-charge.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	250	0 to 100 %
FULL_ID, 0x058C	— *Full Limiting Cell ID* — Outputs pack empty limiting cell ID.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 1 Cell_ID	0	1 to 10 Cell_ID
FULL_RTIME, 0x058D	— *Remaining Time-to-Full* — Outputs remaining time to reach pack full.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 s	0	0 to 65535 s
FULL_LIM, 0x058F	— *Full Limiting Factor* — Outputs pack full limiting factor: 0 = Cell, 1 = Pack.	1, [0]	Read Only	Non-Standard	0	0 to 1
IDIS_AVG, 0x0590	— *Discharge Average Current* — Learned value for the typical load current drained from the battery during its use	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
IDIS_END, 0x0593	— *Discharge Termination Current* — Learned value for the typical end of discharge current	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
ICHG_CC, 0x0597	— *Charge Constant Current* — Learned charge current of the charger in the CC region performed by the algorithm	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
ICHG_END, 0x059B	— *Charge Termination Current* — Learned value for the typical end of discharge current	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA		0 to 131070 mA
VCHG_CV, 0x059F	— *Charge Constant Voltage* — Learned value for the typical charge CV Voltage	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mV		0 to 131070 mV
SOC_PACK_UNAVBL, 0x05A3	— *Pack Unavailable State-of-Charge* — Pack Unavailable SoC due to empty and full conditions and mismatch between cells. Reflects the quantity of unusable capacity of the Pack	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.002 %	0	0 to 100 %
SOC_PACK, 0x05A5	— *Pack State-of-Charge* — Pack State of Charge	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.002 %	0	0 to 100 %
SOC_ABS_CELL1, 0x05A8	— *Cell 1 Absolute State-of-Charge* — Cell 1 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL2, 0x05A9	— *Cell 2 Absolute State-of-Charge* — Cell 2 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %

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SOC_ABS_CELL3, 0x05AA	*— Cell 3 Absolute State-of-Charge —* Cell 3 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL4, 0x05AB	*— Cell 4 Absolute State-of-Charge —* Cell 4 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL5, 0x05AC	*— Cell 5 Absolute State-of-Charge —* Cell 5 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL6, 0x05AD	*— Cell 6 Absolute State-of-Charge —* Cell 6 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL7, 0x05AE	*— Cell 7 Absolute State-of-Charge —* Cell 7 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL8, 0x05AF	*— Cell 8 Absolute State-of-Charge —* Cell 8 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL9, 0x05B0	*— Cell 9 Absolute State-of-Charge —* Cell 9 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOC_ABS_CELL10, 0x05B1	*— Cell 10 Absolute State-of-Charge —* Cell 10 Absolute State of Charge; Show as reserved to customers	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.4 %	0	0 to 100 %
SOH_PACK, 0x0608	*— Pack State-of-Health —* Pack State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL1, 0x060C	*— Cell 1 State-of-Health —* Cell 1 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL2, 0x0610	*— Cell 2 State-of-Health —* Cell 2 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL3, 0x0614	*— Cell 3 State-of-Health —* Cell 3 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL4, 0x0618	*— Cell 4 State-of-Health —* Cell 4 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL5, 0x061C	*— Cell 5 State-of-Health —* Cell 5 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL6, 0x0620	*— Cell 6 State-of-Health —* Cell 6 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %

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SOH_CELL7, 0x0624	*— Cell 7 State-of-Health —* Cell 7 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL8, 0x0628	*— Cell 8 State-of-Health —* Cell 8 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL9, 0x062C	*— Cell 9 State-of-Health —* Cell 9 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
SOH_CELL10, 0x0630	*— Cell 10 State-of-Health —* Cell 10 State of Health	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.0000001 %	0	0 to 255 %
PRDG, 0x070C	*— Power Reading —* Power state of the battery pack; Pack Current * Battery Pack Voltage	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.1 mW	0	0 to 429496729.5 mW
PDIS, 0x0710	*— Maximum Discharge Power —* Maximum possible applicable discharge power	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.1 mW	0	0 to 429496729.5 mW
PDIS_ID, 0x0714	*— Maximum Discharge Power Limiting Cell ID —* ID of the cell that is more limiting in the Maximum Discharge power estimate	5, [4:0]	Read Only	8 bit unsigned integer LSB = 1 Cell_ID	0	1 to 10 Cell_ID
PDIS_LIM, 0x0715	*— Maximum Discharge Power Limiting Factor —* Limiter factor in the Maximum Discharge power estimate0: Cell is limiting1: Pack is limiting	1, [0]	Read Only	Non-Standard	0	0 to 1
PCHG, 0x0716	*— Maximum Charge Power —* Maximum possible applicable charge power	32, [31:0]	Read Only	32 bit unsigned integer LSB = 0.1 mW	0	0 to 429496729.5 mW
PCHG_ID, 0x071A	*— Maximum Charge Power Limiting Cell ID —* ID of the cell that is more limiting in the Maximum Charge power estimate	5, [4:0]	Read Only	8 bit unsigned integer LSB = 1 Cell_ID	0	1 to 10 Cell_ID
PCHG_LIM, 0x071B	*— Maximum Charge Power Limiting Factor —* Limiter factor in the Maximum Charge power estimate 0: Cell is limiting 1: Pack is limiting	1, [0]	Read Only	8 bit unsigned integer	0	0 to 1
STATUS, 0x071C	*— Battery Status —* Pack Current Status: 0 = Charge 1 = Discharge 2 = Rest	2, [1:0]	Read Only	8 bit unsigned integer LSB = 1	0	0 to 2
FG_ITER, 0x071D	*— Fuel Gauge Iteration Counter —* Counts the number of iterations done by the FG. Counts the number of iterations done by the FG.	32, [31:0]	Read Only	32 bit unsigned integer LSB = 1	0	0 to 4294967295

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Fuel Gauge Lifetime Log

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
VRDG_MIN_CELL1, 0x0C00	*— Cell 1 Minimum Measured Voltage —* Minimum Voltage measured for cell 1	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL2, 0x0C02	*— Cell 2 Minimum Measured Voltage —* Minimum Voltage measured for cell 2	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL3, 0x0C04	*— Cell 3 Minimum Measured Voltage —* Minimum Voltage measured for cell 3	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL4, 0x0C06	*— Cell 4 Minimum Measured Voltage —* Minimum Voltage measured for cell 4	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL5, 0x0C08	*— Cell 5 Minimum Measured Voltage —* Minimum Voltage measured for cell 5	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL6, 0x0C0A	*— Cell 6 Minimum Measured Voltage —* Minimum Voltage measured for cell 6	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL7, 0x0C0C	*— Cell 7 Minimum Measured Voltage —* Minimum Voltage measured for cell 7	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL8, 0x0C0E	*— Cell 8 Minimum Measured Voltage —* Minimum Voltage measured for cell 8	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL9, 0x0C10	*— Cell 9 Minimum Measured Voltage —* Minimum Voltage measured for cell 9	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MIN_CELL10, 0x0C12	*— Cell 10 Minimum Measured Voltage —* Minimum Voltage measured for cell 10	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	50000	0 to 6553.5 mV
VRDG_MAX_CELL1, 0x0C20	*— Cell 1 Maximum Measured Voltage —* Maximum Voltage measured for cell 1	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL2, 0x0C22	*— Cell 2 Maximum Measured Voltage —* Maximum Voltage measured for cell 2	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL3, 0x0C24	*— Cell 3 Maximum Measured Voltage —* Maximum Voltage measured for cell 3	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV

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VRDG_MAX_CELL4, 0x0C26	*— Cell 4 Maximum Measured Voltage —* Maximum Voltage measured for cell 4	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL5, 0x0C28	*— Cell 5 Maximum Measured Voltage —* Maximum Voltage measured for cell 5	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL6, 0x0C2A	*— Cell 6 Maximum Measured Voltage —* Maximum Voltage measured for cell 6	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL7, 0x0C2C	*— Cell 7 Maximum Measured Voltage —* Maximum Voltage measured for cell 7	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL8, 0x0C2E	*— Cell 8 Maximum Measured Voltage —* Maximum Voltage measured for cell 8	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL9, 0x0C30	*— Cell 9 Maximum Measured Voltage —* Maximum Voltage measured for cell 9	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_MAX_CELL10, 0x0C32	*— Cell 10 Maximum Measured Voltage —* Maximum Voltage measured for cell 10	16, [15:0]	Read Only	16 bit unsigned integer LSB = 0.1 mV	0	0 to 6553.5 mV
VRDG_DMAX, 0x0C40	*— Maximum Measured Cell Voltage Difference —* Maximum voltage imbalance between cells	8, [7:0]	Read Only	8 bit unsigned integer LSB = 2 mV	0	0 to 512 mV
VRDG_DMAX_IDMAX, 0x0C41	*— Maximum Measured Cell Voltage Difference Cell ID Max —* Identifier of the cell with highest voltage between which the maximum voltage difference is detected.	4, [3:0]	Read Only	Non-Standard LSB = 1 Cell_ID Offset = 1 Cell_ID	1	1 to 10 Cell_ID
VRDG_DMAX_IDMIN, 0x0C41	*— Maximum Measured Cell Voltage Difference Cell ID Min —* Identifier of the cell with lowest voltage between which the maximum voltage difference is detected.	4, [7:4]	Read Only	Non-Standard LSB = 1 Cell_ID Offset = 1 Cell_ID	1	1 to 10 Cell_ID
BAL_ETIME_CELL1, 0x0C42	*— Cell 1 Elapsed Time Balancing —* Total amount of time cell 1 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL2, 0x0C44	*— Cell 2 Elapsed Time Balancing —* Total amount of time cell 2 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL3, 0x0C46	*— Cell 3 Elapsed Time Balancing —* Total amount of time cell 3 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL4, 0x0C48	*— Cell 4 Elapsed Time Balancing —* Total amount of time cell 4 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min

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BAL_ETIME_CELL5, 0x0C4A	*— Cell 5 Elapsed Time Balancing —* Total amount of time cell 5 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL6, 0x0C4C	*— Cell 6 Elapsed Time Balancing —* Total amount of time cell 6 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL7, 0x0C4E	*— Cell 7 Elapsed Time Balancing —* Total amount of time cell 7 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL8, 0x0C50	*— Cell 8 Elapsed Time Balancing —* Total amount of time cell 8 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL9, 0x0C52	*— Cell 9 Elapsed Time Balancing —* Total amount of time cell 9 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
BAL_ETIME_CELL10, 0x0C54	*— Cell 10 Elapsed Time Balancing —* Total amount of time cell 10 has been balanced	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 min	0	0 to 65535 min
TRDG_MIN_TS1, 0x0C62	*— Sensor 1 Minimum Measured Temperature —* Minimum temperature measured with the Temperature sensor 1	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	200	-30 to 97.5 ºC
TRDG_MIN_TS2, 0x0C63	*— Sensor 2 Minimum Measured Temperature —* Minimum temperature measured with the Temperature sensor 2	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	200	-30 to 97.5 ºC
TRDG_MIN_TS3, 0x0C64	*— Sensor 3 Minimum Measured Temperature —* Minimum temperature measured with the Temperature sensor 3	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	200	-30 to 97.5 ºC
TRDG_MIN_TS4, 0x0C65	*— Sensor 4 Minimum Measured Temperature —* Minimum temperature measured with the Temperature sensor 4	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	200	-30 to 97.5 ºC
TRDG_MAX_TS1, 0x0C66	*— Sensor 1 Maximum Measured Temperature —* Maximum temperature measured with the Temperature sensor 1	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
TRDG_MAX_TS2, 0x0C67	*— Sensor 2 Maximum Measured Temperature —* Maximum temperature measured with the Temperature sensor 2	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
TRDG_MAX_TS3, 0x0C68	*— Sensor 3 Maximum Measured Temperature —* Maximum temperature measured with the Temperature sensor 3	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
TRDG_MAX_TS4, 0x0C69	*— Sensor 4 Maximum Measured Temperature —* Maximum temperature measured with the Temperature sensor 4	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
TRDG_DMAX, 0x0C6A	*— Maximum Measured Cell Temperature Difference —* Maximum temperature delta between sensors.	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	0 to 127.5 ºC

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TRDG_DMAX_IDMAX, 0x0C6B	*— Maximum Measured Cell Temperature Difference Cell ID max —* Identifier of the cell with highest temperature between which the maximum temperature difference is detected.	4, [3:0]	Read Only	Non-Standard LSB = 1 Cell_ID Offset = 1 Cell_ID	1	1 to 4 Cell_ID
TRDG_DMAX_IDMIN, 0x0C6B	*— Maximum Measured Cell Temperature Difference Cell ID Min —* Identifier of the cell with lowest temperature between which the maximum temperature difference is detected.	4, [7:4]	Read Only	Non-Standard LSB = 1 Cell_ID Offset = 1 Cell_ID	1	1 to 4 Cell_ID
TRDG_ETIME_UND0, 0x0C6C	*— Elapsed Time Under 0ºC —* Amount of time the battery average temperature has been under 0ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_0TO5, 0x0C6E	*— Elapsed Time Between 0ºC To 5ºC —* Amount of time the battery average temperature has been between 0ºC and 5ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_5TO10, 0x0C70	*— Elapsed Time Between 5ºC To 10ºC —* Amount of time the battery average temperature has been between 5ºC and 10ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_10TO15, 0x0C72	*— Elapsed Time Between 10ºC To 15ºC —* Amount of time the battery average temperature has been between 10ºC and 15ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_15TO20, 0x0C74	*— Elapsed Time Between 15ºC To 20ºC —* Amount of time the battery average temperature has been between 15ºC and 20ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_20TO25, 0x0C76	*— Elapsed Time Between 20ºC To 25ºC —* Amount of time the battery average temperature has been between 20ºC and 25ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_25TO30, 0x0C78	*— Elapsed Time Between 25ºC To 30ºC —* Amount of time the battery average temperature has been between 25ºC and 30ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_30TO35, 0x0C7A	*— Elapsed Time Between 30ºC To 35ºC —* Amount of time the battery average temperature has been between 30ºC and 35ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_35TO40, 0x0C7C	*— Elapsed Time Between 35ºC To 40ºC —* Amount of time the battery average temperature has been between 35ºC and 40ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h

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TRDG_ETIME_40TO45, 0x0C7E	*— Elapsed Time Between 40ºC To 45ºC —* Amount of time the battery average temperature has been between 40ºC and 45ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_45TO50, 0x0C80	*— Elapsed Time Between 45ºC To 50ºC —* Amount of time the battery average temperature has been between 45ºC and 50ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_50TO55, 0x0C82	*— Elapsed Time Between 50ºC To 55ºC —* Amount of time the battery average temperature has been between 50ºC and 55ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_55TO60, 0x0C84	*— Elapsed Time Between 55ºC To 60ºC —* Amount of time the battery average temperature has been between 55ºC and 60ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_ETIME_ABV60, 0x0C86	*— Elapsed Time Above 60ºC —* Amount of time the battery average temperature has been above 60ºC.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 h	0	0 to 65535 h
TRDG_MIN_DIE, 0x0C88	*— Die Minimum Measured Temperature —* Maximum temperature measured on the die	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
TRDG_MAX_DIE, 0x0C89	*— Die Maximum Measured Temperature —* Minimum temperature measured on the die	8, [7:0]	Read Only	8 bit unsigned integer LSB = 0.5 ºC	0	-30 to 97.5 ºC
IRDG_MAX_CHG, 0x0C8A	*— Charge Measured Peak Current —* Maximum measured charge current.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA	0	0 to 131070 mA
IRDG_MAX_DIS, 0x0C8C	*— Measured Discharge Peak Current —* Maximum measured discharge current.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 2 mA	0	0 to 131070 mA
NCHG_CYC, 0x0C8E	*— Number Of Complete Charge Cycles —* Number of times the battery has been charged from a Pack SoC below 15% to above 85%.	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 Event	0	0 to 65535 Event
NCHG_10SOC, 0x0C90	*— Number Of 10% State-Of-Charge Charges —* Number of times the pack has been charged by 10%	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 Event	0	0 to 65535 Event
NSHDN, 0x0C92	*— Number Of Shutdowns —* .Number of times the FG has woke up after sleep mode, hard reset or power down	16, [15:0]	Read Only	16 bit unsigned integer LSB = 1 event	0	0 to 65535 event

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Fuel Gauge Flags

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
FG_EXE_FLAG, 0x0F00	*— Fuel Gauge updates —* 1 = Fuel Gauge calculations are ongoing, 0 = Fuel Gauge calculations completed.	1, [0]	Read Only	Non-Standard	0	0 to 1
EDIT_SETTINGS_FLAG, 0x0F00	*— Fuel Gauge Edit Config —* 1 = Fuel Gauge Settings can be edited on the fly, 0 = Fuel Gauge Settings can not be edited on the fly.	1, [1]	Read Only	Non-Standard	0	0 to 1
CONFIG_MODE_FLAG, 0x0F00	*— Fuel Gauge config mode —* 1 = Fuel Gauge in Configuration mode, 0 = Fuel Gauge in running mode.	1, [2]	Read Only	Non-Standard	0	0 to 1
CONFIG_EXIT_FLAG, 0x0F00	*— Configuration Mode exit status —* 1 = Pending exit from Configuration Mode, 0 = No pending exit from Configuration Mode.	1, [3]	Read Only	Non-Standard	0	0 to 1
CONFIG_RST_FLAG, 0x0F00	*— Configurations reset status —* 1 = Pending reset configurations to default values, 0 = No pending reset configurations to default values.	1, [4]	Read Only	Non-Standard	0	0 to 1
FG_RST_FLAG, 0x0F00	*— Fuel Gauge algorithm reset status —* 1 = No pending reset of the Fuel Gauge algorithm, 0 = Pending reset of the Fuel Gauge algorithm.	1, [5]	Read Only	Non-Standard	0	0 to 1
LOG_RST_FLAG, 0x0F00	*— Lifetime log registers reset status —* 1 = Lifetime log registers are being reset in the current FG iteration, 0 = Lifetime log registers are not being reset..	1, [6]	Read Only	Non-Standard	0	0 to 1
LOG_RST_PNDG_FLAG, 0x0F00	*— Lifetime log registers reset pending —* 1 = Pending reset to lifetime log registers, 0 = No pending reset to lifetime log registers.	1, [7]	Read Only	Non-Standard	0	0 to 1
LEDS_ON_BTN_FLAG, 0x0F00	*— LED on Push Button —* 1 = LEDs are on due to PB, 0 = LEDs are not on due to PB.	1, [8]	Read Only	Non-Standard	0	0 to 1
LEDS_ON_CHG_FLAG, 0x0F00	*— LED on charging —* 1 = LEDs are on due to charge current detected, 0 = LEDs are not on due to charge current detected.	1, [9]	Read Only	Non-Standard	0	0 to 1
LEDS_CHG_FLAG, 0x0F00	*— LED controler charge status —* 1 = LED controller considers FG is in charge state, 0 = LED controller does not consider charge state.	1, [10]	Read Only	Non-Standard	0	0 to 1

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FG_BKUP_FLAG, 0x0F00	— *Learning Backup Mode* — 1 = FG is in Learning Backup Mode, 0 = FG is not in Learning Backup Mode. Learning Backup Mode must be enabled in order to enable write operations to Learning Backup Registers. To Enter/Exit this mode use: FG_BKUP_ENABLE.	1, [11]	Read Only	Non-Standard	0	0 to 1

Fuel Gauge Settings

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
EXE_TIME, 0x1000	— *Execution Period* — Sets the fuel gauge execution time interval.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.1 second	4	0.5 to 16 second
WEXE_TIME_REST, 0x1001	— *Rest Execution Period Multiplier* — When the FG is at REST it will update the most time consuming functions each WEXE_TIME_REST*EXE_TIME instead of each EXE_TIME. The maximum allowed value for the execution period of this functions is 32 s so if the FG is set in a way that WEXE_TIME_REST*EXE_TIME is greater than 32 s the used period will be the multiple of EXE_TIME closer to, but below, 32 s.	5, [4:0]	R/W	8 bit unsigned integer LSB = 1	4	1 to 16
DIS_ITH, 0x1002	— *Discharge Current Threshold* — Sets discharge STATUS current threshold.	16, [15:0]	R/W	16 bit unsigned integer LSB = 1 mA	25	0 to 65535 mA
CHG_ITH, 0x1004	— *Charge Current Threshold* — Sets charge STATUS current threshold.	16, [15:0]	R/W	16 bit unsigned integer LSB = 1 mA	25	0 to 65535 mA
SOC_DMAX, 0x1006	— *Max. SOC Slope* — Sets maximum state-of-charge steepness for charge and discharge STATUS.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.00005 %/s	0.07	0.00005 to 2 %/s
SOC_DMAX_REST, 0x1008	— *Max. Rest SOC Slope* — Sets maximum state-of-charge steepness for rest STATUS.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.00005 %/s	0.001	0 to 2 %/s
VRDG_PACK_EN, 0x1100	— *Enable Pack Voltage Reading* — Enables VRDG_PACK input.	1, [0]	R/W	Control Enable(=1)/Disable(=0)	0	0 to 1
IRDG_PACK_EN, 0x1100	— *Enable Pack Current Reading* — Enables IRDG_PACK input.	1, [1]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
IRDG_CELLS_EN, 0x1100	— *Enable Cells Current Reading* — Enables IRDG_CELLX inputs.	1, [2]	R/W	Control Enable(=1)/Disable(=0)	0	0 to 1
CCRDG_EN, 0x1100	— *Enable Coulomb Count* — Enables CCRDG input.	1, [3]	R/W	Control Enable(=1)/Disable(=0)	0	0 to 1

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SOH_LRN_EN, 0x1100	— *Enable SOH Learning* — Enables state-of-health learning.	1, [7]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
ICHG_CC_LRN_EN, 0x1100	— *Enable Charge CC Current Learning* — Enables charge-constant-current learning.	1, [10]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
ICHG_END_LRN_EN, 0x1100	— *Enable Charge End Current Learning* — Enables charge-termination-current learning.	1, [11]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
VCHG_CV_LRN_EN, 0x1100	— *Enable Charge CV Voltage Learning* — Enables charge-constant-voltage learning.	1, [12]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
IDIS_AVG_LRN_EN, 0x1100	— *Enable Discharge Average Current* — Enables discharge-average-current learning.	1, [13]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
IDIS_END_LRN_EN, 0x1100	— *Enable Discharge End Current* — Enables discharge-termination-current learning.	1, [14]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
IDIS_END_LRN_CONT_EN, 0x1100	— *Continuous Discharge End Current* — Activates continuous discharge-termination-current learning.	1, [15]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
PCHG_SHW_EN, 0x1100	— *Show Max. Charge Power* — Sets PCHG_SHW default value.	1, [18]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
PDIS_SHW_EN, 0x1100	— *Show Max. Disharge Power* — Sets PDIS_SHW default value.	1, [19]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
TSS_CELL1, 0x1200	— *Cell 1 Temperature Sensor Source* — Sets cell 1 temperature sensor source.	2, [1:0]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL2, 0x1200	— *Cell 2 Temperature Sensor Source* — Sets cell 2 temperature sensor source.	2, [3:2]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL3, 0x1200	— *Cell 3 Temperature Sensor Source* — Sets cell 3 temperature sensor source.	2, [5:4]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL4, 0x1200	— *Cell 4 Temperature Sensor Source* — Sets cell 4 temperature sensor source.	2, [7:6]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL5, 0x1201	— *Cell 5 Temperature Sensor Source* — Sets cell 5 temperature sensor source.	2, [1:0]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL6, 0x1201	— *Cell 6 Temperature Sensor Source* — Sets cell 6 temperature sensor source.	2, [3:2]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4

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TSS_CELL7, 0x1201	*— Cell 7 Temperature Sensor Source —* Sets cell 7 temperature sensor source.	2, [5:4]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL8, 0x1201	*— Cell 8 Temperature Sensor Source —* Sets cell 8 temperature sensor source.	2, [7:6]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL9, 0x1202	*— Cell 9 Temperature Sensor Source —* Sets cell 9 temperature sensor source.	2, [1:0]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
TSS_CELL10, 0x1202	*— Cell 10 Temperature Sensor Source —* Sets cell 10 temperature sensor source.	2, [3:2]	R/W	Non-Standard LSB = 1 Offset = 1	1	1 to 4
NCELLS_SER, 0x1204	*— Number of Series Cells —* Sets number of series connected cells in battery pack.	5, [4:0]	R/W	8 bit unsigned integer LSB = 1	10	2 to 10
NCELLS_PAR, 0x1205	*— Number of Parallel Cells —* Sets number of parallel connected cells in battery pack.	8, [7:0]	R/W	8 bit unsigned integer LSB = 1	1	1 to 255
NTSS, 0x1206	*— Number of Temperature Sensors —* Sets number of temperature sensors in battery pack.	3, [2:0]	R/W	8 bit unsigned integer LSB = 1	1	1 to 4
RCXN_PACK, 0x1207	*— Pack Connection Resistance —* Sets connection resistance between the battery and the battery-management-system terminals.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	10	0 to 6553.5 mOhm
RBMS_HSIDE, 0x1209	*— BMS High Side Resistance —* Sets battery-management-system high-side resistance.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	4	0 to 6553.5 mOhm
RBMS_LSIDE, 0x120B	*— BMS Low Side Resistance —* Sets battery-management-system low-side resistance.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	2	0 to 6553.5 mOhm
RCXN_CELL1, 0x120D	*— Cell 1 Connection Resistance —* Sets connection resistance between cell 1 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL2, 0x120F	*— Cell 2 Connection Resistance —* Sets connection resistance between cell 2 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL3, 0x1211	*— Cell 3 Connection Resistance —* Sets connection resistance between cell 3 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL4, 0x1213	*— Cell 4 Connection Resistance —* Sets connection resistance between cell 4 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm

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RCXN_CELL5, 0x1215	*— Cell 5 Connection Resistance —* Sets connection resistance between cell 5 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL6, 0x1217	*— Cell 6 Connection Resistance —* Sets connection resistance between cell 6 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL7, 0x1219	*— Cell 7 Connection Resistance —* Sets connection resistance between cell 7 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL8, 0x121B	*— Cell 8 Connection Resistance —* Sets connection resistance between cell 8 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL9, 0x121D	*— Cell 9 Connection Resistance —* Sets connection resistance between cell 9 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
RCXN_CELL10, 0x121F	*— Cell 10 Connection Resistance —* Sets connection resistance between cell 10 terminals and its corresponding voltage-sensing probes.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mOhm	1	0 to 6553.5 mOhm
ICHG_MAX, 0x122D	*— Max. Charge Current —* Maximum charge current the pack can accept.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	4000	0 to 131070 mA
ICHG_MAX_MRGN, 0x122F	*— Max. Charge Current Margin —* Maximum charge current margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 4 mA	120	0 to 1020 mA
IDIS_MAX, 0x1230	*— Max. Discharge Current —* Maximum discharge current the pack can accept.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	20000	0 to 131070 mA
IDIS_MAX_MRGN, 0x1232	*— Max. Discharge Current Margin —* Maximum discharge current margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 4 mA	500	0 to 1020 mA
VCELL_MAX, 0x1233	*— Max. Cell Voltage —* Maximum voltage accepted at cell level.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	4200	0 to 6553.5 mV
VCELL_MAX_MRGN, 0x1235	*— Max. Cell Voltage Margin —* Maximum cell voltage margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.5 mV	5	0 to 127.5 mV
VCELL_MIN, 0x1236	*— Min. Cell Voltage —* Minimum voltage accepted at cell level.	16, [15:0]	R/W	16 bit unsigned integer LSB = 0.1 mV	3000	0 to 6553.5 mV
VCELL_MIN_MRGN, 0x1238	*— Min. Cell Voltage Margin —* Minimum cell voltage margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.5 mV	5	0 to 127.5 mV

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VPACK_MAX, 0x1239	*— Max. Pack Voltage —* Maximum pack voltage the pack can accept; used for charge power estimate. Pack Float Voltage represents the maximum voltage the battery pack can reach in a charging scenario and it is used. It should be set the same or higher compared to the Constant Voltage (CV) of the charging system.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mV	41750	0 to 131070 mV
VPACK_MAX_MRGN, 0x123B	*— Max. Pack Voltage Margin —* Maximum pack voltage margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 4 mV	48	0 to 1020 mV
VPACK_EMTY, 0x123C	*— Pack Empty Voltage —* Pack Empty Voltage represents the lowest usable pack voltage. This would be the voltage for which the application would consider a battery pack as completely discharged and stop operation.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mV	30500	0 to 131070 mV
VPACK_EMTY_MRGN, 0x123E	*— Pack Empty Voltage Margin —* Margin the power learning algorithm will apply to Pack Empty Voltage	8, [7:0]	R/W	8 bit unsigned integer LSB = 4 mV	48	0 to 1020 mV
IDIS_AVG_SET, 0x1400	*— Nominal Discharge Average Current —* Sets nominal average discharge current (i.e., IDIS_AVG).	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	2500	2 to 131070 mA
IDIS_END_SET, 0x1402	*— Nominal Discharge Termination Current —* Sets nominal discharge termination current (i.e., IDIS_END).	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	2500	2 to 131070 mA
EMTY_RTIME_FILTER, 0x1406	*— Remaining Time-to-Empty Filter Time Constant —* Sets filter time constant of remaining time-to-empty (i.e., EMTY_RTIME). Increasing EMTY_RTIME_FILTER results in smoother estimate at the price of increased phase delay.	8, [7:0]	R/W	8 bit unsigned integer LSB = 1 second	60	0 to 255 second
ICHG_CC_SET, 0x1500	*— Nominal Charge Constant Current —* Sets nominal charge constant current (i.e., ICHG_CC). Should be set to the nominal current applied by the external charger the battery pack while in constant current charge region.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	2500	2 to 131070 mA
ICHG_END_SET, 0x1502	*— Nominal Charge Termination Current —* Sets nominal charge termination current (i.e., ICHG_END). Should be set to the nominal current used to detect the end of charge while in constant voltage charge region.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	250	2 to 131070 mA
VCHG_CV_SET, 0x1504	*— Nominal Charge Constant Voltage —* Sets nominal charge constant voltage (i.e., VCHG_CV). Should be set to the nominal voltage applied to the battery pack by the external charger during constant voltage charge.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mV	41500	0 to 131070 mV

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VCHG_CV_MRGN, 0x1506	*— Charge Constant Voltage Margin —* Sets charge constant voltage (i.e., VCHG_CV) margin.	8, [7:0]	R/W	8 bit unsigned integer LSB = 2 mV	50	0 to 510 mV
FULL_RTIME_FILTER, 0x150A	*— Remaining Time-to-Full Filter Time Constant —* Sets filter time constant of remaining time-to-full (i.e., FULL_RTIME).	8, [7:0]	R/W	8 bit unsigned integer LSB = 1 s	10	0 to 255 s
ICHG_CC_LRN_RNG, 0x1600	*— Charge Constant Current Learning Range —* Sets charge-constant-current (i.e., ICHG_CC) learning range if ICHG_CC_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	10	0 to 100 %
ICHG_END_LRN_RNG, 0x1601	*— Charge Termination Current Learning Range —* Sets charge-termination-current (i.e., ICHG_END) learning range if ICHG_END_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	10	0 to 100 %
VCHG_CV_LRN_RNG, 0x1602	*— Charge Constant Voltage Learning Range —* Sets charge-constant-voltage (i.e., VCHG_CV) learning range if VCHG_CV_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	3	0 to 100 %
ICHG_LRN_ITH, 0x1603	*— Charge Current Learning Threshold —* Sets charge-current threshold for learnings, ICHG_END, VCHG_CV.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.01 C-Rate	0.01	0 to 2.55 C-Rate
ICHG_LRN_DITH, 0x1604	*— Charge Current Derivative Learning Threshold —* Sets charge-current-derivative threshold for learnings, ICHG_CC.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.01 mA/s	0.1	0 to 2.55 mA/s
VCHG_LRN_DVTH, 0x1605	*— Charge Voltage Derivative Learning Threshold —* Sets charge-voltage-derivative threshold for learnings, ICHG_END, VCHG_CV.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.01 mV/s	0.1	0 to 2.55 mV/s
IDIS_END_LRN_RNG, 0x1700	*— Discharge Termination Current Learning Range —* Sets discharge-termination-current (i.e., IDIS_END) learning range if IDIS_END_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	10	0 to 100 %
IDIS_END_LRN_SOCTH, 0x1701	*— Discharge Termination Current Learning SOC Threshold —* Sets discharge-termination-current (i.e., IDIS_END) state-of-charge learning threshold if IDIS_END_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	50	0 to 100 %
IDIS_END_LRN_KPEAK, 0x1702	*— Discharge Termination Peak Current Learning Gain —* Sets discharge-termination-current (i.e., IDIS_END) learning peak current gain if IDIS_END_LRN_EN enabled.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1 %	70	0 to 100 %
IDIS_LRN_ITH, 0x1703	*— Discharge Current Learning Threshold —* Sets discharge-current threshold for learnings, IDIS_AVG, IDIS_END.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.01 C-Rate	0.05	0 to 2.55 C-Rate

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IDIS_LRN_FILTER, 0x1704	*— Discharge Current Filter Time Constant —* Sets filter time constant of discharge-current learnings, IDIS_AVG, IDIS_END.	8, [7:0]	R/W	8 bit unsigned integer LSB = 1 second	10	0 to 255 second
SOH_LRN_K, 0x1800	*— SOH Learning Gain —* Sets state-of-health learning gain if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.001	0.1	0 to 0.255
SOH_LRN_DMAX, 0x1801	*— SOH Learning Max. Increase —* Sets maximum increase of state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.1 %	1	0 to 25.5 %
SOH_LRN_DMIN, 0x1802	*— SOH Learning Max. Decrease —* Sets maximum decrease of state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit unsigned integer LSB = 0.1 %	1	0 to 25.5 %
SOH_LRN_MAX, 0x1803	*— SOH Learning Max. Range —* Sets maximum value of state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit unsigned integer LSB = 1 %	110	100 to 255 %
SOH_LRN_MIN, 0x1804	*— SOH Learning Min. Range —* Sets minimum value of state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit unsigned integer LSB = 1 %	80	0 to 100 %
SOH_LRN_TMAX, 0x1805	*— SOH Learning Max. Temperature —* Sets maximum temperature for state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit signed 2-comp integer LSB = 1 ºC	30	-128 to 127 ºC
SOH_LRN_TMIN, 0x1806	*— SOH Learning Min. Temperature —* Sets minimum temperature for state-of-health learning if SOH_LRN_EN enabled.	8, [7:0]	R/W	8 bit signed 2-comp integer LSB = 1 ºC	10	-128 to 127 ºC

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Fuel Gauge Model

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
CELL_MFR, 0x2000	*— Cell Manufacturer —* Manufacturer of the Cell	128, [127:0]	R/W	ASCII character(s)	Default	to
CELL_TYPE, 0x2010	*— Cell Type —* Cell type/model	128, [127:0]	R/W	ASCII character(s)	Default	to
MDL_QNOM, 0x2036	*— Nominal Capacity —* Nominal Capacity of the cell reported by the manufacturer, for example in the datasheet.	16, [15:0]	R/W	16 bit unsigned integer LSB = 1 mAh	2500	1 to 65535 mAh
MDL_QMEAS, 0x2038	*— Measured Capacity —* Capacity measured in the cell characterization test	16, [15:0]	R/W	16 bit unsigned integer LSB = 1 mAh	2437	1 to 65535 mAh
CELL_ICHG_MAX, 0x203E	*— Maximum Cell Charge Current —* Maximum Charge Current that the cell can handle according to the manufacturer.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	4000	0 to 131070 mA
CELL_IDIS_MAX, 0x2040	*— Maximum Cell Discharge Current —* Maximum Disharge Current that the cell can handle according to the manufacturer.	16, [15:0]	R/W	16 bit unsigned integer LSB = 2 mA	20000	0 to 131070 mA
CELL_TMIN, 0x2042	*— Minimum Cell Temperature —* Minimum temperature that the cell can handle according to the manufacturer	8, [7:0]	R/W	8 bit signed 2-comp integer LSB = 1 ºC	0	-128 to 127 ºC
CELL_TMAX, 0x2043	*— Maximum Cell Temperature —* Maximum temperature that the cell can handle according to the manufacturer	8, [7:0]	R/W	8 bit signed 2-comp integer LSB = 1 ºC	50	-128 to 127 ºC

LEDs Settings

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
LEDS_ON_MAN, 0x4000	*— Manual LED Control —* 1 = LEDs are controlled manually using the dedicated register bits, 0 = LEDs controlled directly to report State of Charge	1, [0]	R/W	Control Enable(=1)/Disable(=0)	0	0 to 1
LEDS_ON_CHG, 0x4000	*— LEDs On while charging —* 1 = LEDs will display the pack SoC while charging if Manual LEDs Control =0; 0 = LEDs will not display the pack SoC while charging and manual LEDs Control = 0;	1, [1]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1
LEDS_ON_BTN, 0x4000	*— LEDs On Button —* 1 = LEDs will display the pack SoC after the LEDs PB is pressed if Manual LEDs Control =0; 0 = LEDs will not display the pack SoC after the LEDs PB is pressed and Manual LEDs Control =0	1, [2]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1

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LED1_ON, 0x4000	*— LED 1 On —* 1 = If Manual LED Control = 1 the LED will turn ON; 0 = If Manual LED Control = 1 the LED will turn OFF	1, [3]	R/W	Control On(=1)/Off(=0)	0	0 to 1
LED2_ON, 0x4000	*— LED 2 On —* 1 = If Manual LED Control = 1 the LED will turn ON; 0 = If Manual LED Control = 1 the LED will turn OFF	1, [4]	R/W	Control On(=1)/Off(=0)	0	0 to 1
LED3_ON, 0x4000	*— LED 3 On —* 1 = If Manual LED Control = 1 the LED will turn ON; 0 = If Manual LED Control = 1 the LED will turn OFF	1, [5]	R/W	Control On(=1)/Off(=0)	0	0 to 1
LED4_ON, 0x4000	*— LED 4 On —* 1 = If Manual LED Control = 1 the LED will turn ON; 0 = If Manual LED Control = 1 the LED will turn OFF	1, [6]	R/W	Control On(=1)/Off(=0)	0	0 to 1
LED5_ON, 0x4000	*— LED 5 On —* 1 = If Manual LED Control = 1 the LED will turn ON; 0 = If Manual LED Control = 1 the LED will turn OFF	1, [7]	R/W	Control On(=1)/Off(=0)	0	0 to 1
LED_TRANS, 0x4001	*— LED Transition —* Deglitch time to control LED turn on and off upon transitioning between charge and discharge	7, [6:0]	R/W	8 bit unsigned integer LSB = 0.1 s	4	0 to 12.7 s
LEDS_ON_TIME, 0x4002	*— LEDs ON Time —* Time the LEDs will be on after pressing the LEDs PB.	4, [3:0]	R/W	8 bit unsigned integer LSB = 1 s Offset = 1 s	5	1 to 16 s

I2C Settings

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
I2C_ADDRESS, 0x4100	*— I2C Address —* Use this register to select the slave I2C address of the device. Use this register to select the slave I2C address of the device.	7, [6:0]	R/W	8 bit unsigned integer LSB = 1	8	0 to 127
I2C_CRC_EN, 0x4100	*— CRC Enable —* 1 = CRC on I2C communication is Enabled; 0 = CRC on I2C communication is Disabled; 1 = CRC on I2C communication is Enabled, only Write commands with correct CRC will be accepted, the response after a read command will include the 4 CRC bytes at the end; 0 = CRC on I2C communication is Disabled, Write commands with no CRC bytes or with correct CRC will be accepted, the response after a read command will not include the 4 CRC bytes.	1, [7]	R/W	Control Enable(=1)/Disable(=0)	1	0 to 1

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Commands

Name, Address	Description	Bit Length, Position	Type	Encoding	Decoded Default Value	Range
RST_CMD, 0x7FFF	*— Reset Command —* Send to reset FG calculations 0x01 = Reset the FG. Self-Clearing.	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
EXE_CMD, 0x7FFE	*— Trigger FG calculations —* The System MCU is responsible for periodically writing this register to trigger an update of the State of Charge. Should be triggered after providing all the updated voltage and current reading that should be used to the produce the updated SoC estimate. 0x01 = Send to Trigger a Fuel Gauge update refresh	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
EDIT_CONFIG_CMD, 0x7FFD	*— Edit Configuration Command —* 0x01 = FG settings can be edited	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
END_EDIT_CONFIG_CMD, 0x7FFC	*— Stop Edit Configuration Command —* 0x01 = FG settings can not be edited	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
CONFIG_MODE_CMD, 0x7FFB	*— Enter Configuration Mode —* FG enters in Configuration Mode (Cell Profile, Battery Pack and Algorithm tuning). 0x01 = Enters in Configuration mode	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
CONFIG_EXIT_CMD, 0x7FFA	*— Exit Configuration Mode —* If FG is in configuration mode, it will exit this mode (saves configuration values to flash) and reset. If not it will simply store the FG and LED settings from the volatile to the non-volatile memory. 0x01 = Exits configuration mode. New Configuration is stored in non-volatile memory	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
CONFIG_RST_CMD, 0x7FF9	*— Reset Configuration —* The configuration values are re-initialized to the default values and the FG calculations are reset. 0x01 = Reset configuration and Fuel Gauge. Self Clearing.	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255
LOG_RST_CMD, 0x7FF8	*— Reset lifetime log registers —* Re-initialize the lifetime logging. 0x01 = Re-initialize the lifetime log registers. Self-Clearing.	8, [7:0]	Write Only	Active High Command (1=Do) LSB = 1	0	0 to 255

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PCB LAYOUT GUIDELINE

Place the bypass capacitor between each pair of VDD-GND pins as close as possible to the pin.

TYPICAL APPLICATION CIRCUIT

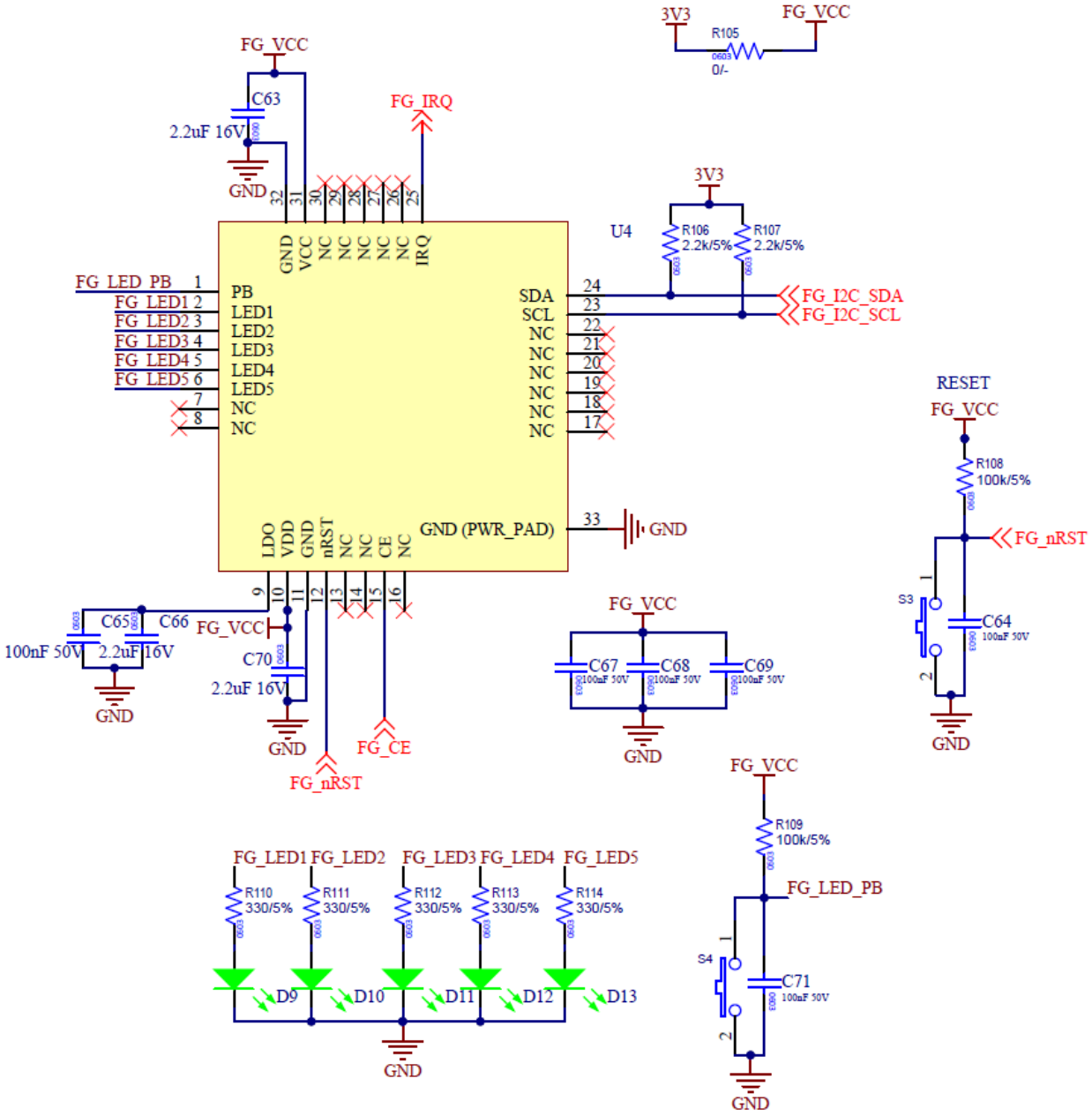
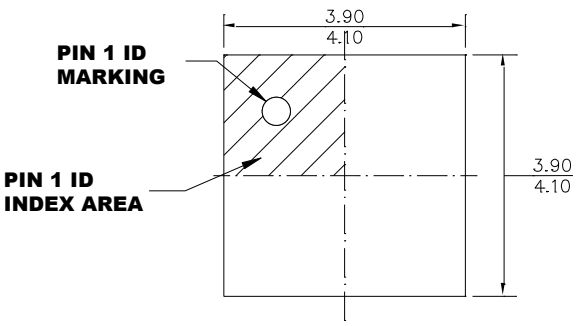


Figure 12: Application Circuit

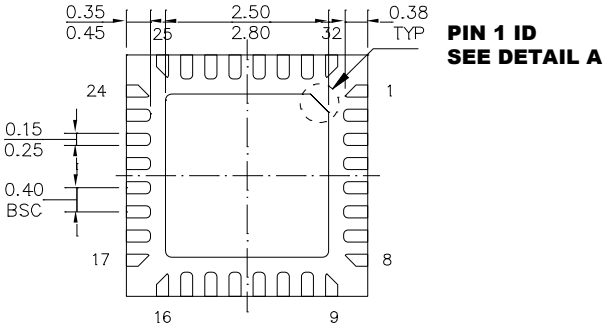
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PACKAGE INFORMATION

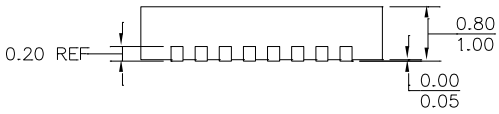
QFN-32 (4mmx4mm)



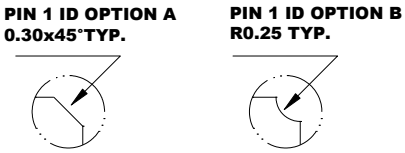
TOP VIEW



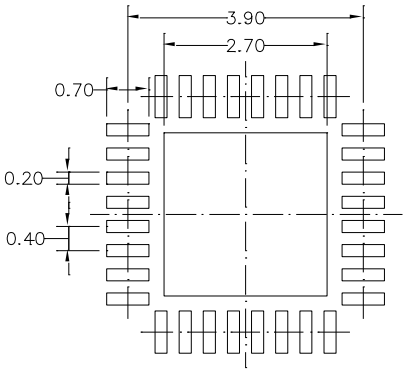
BOTTOM VIEW



SIDE VIEW



DETAIL A



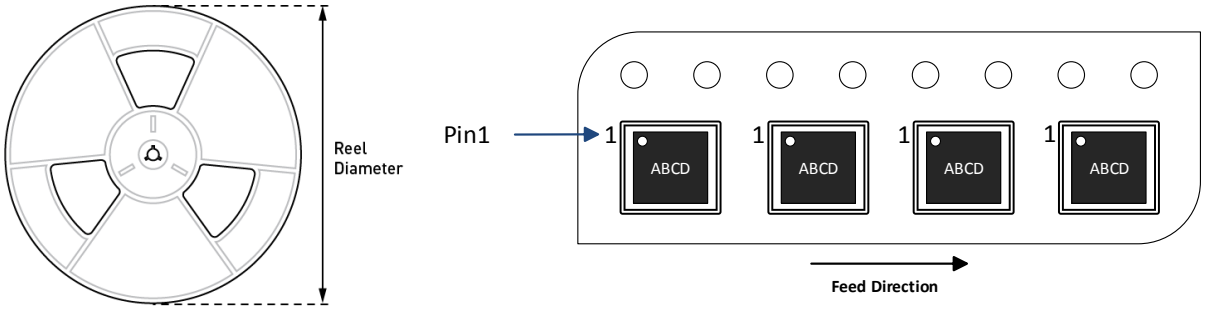
RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETERS MAX.
4) JEDEC REFERENCE IS MO-220.
5) DRAWING IS NOT TO SCALE.

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CARRIER INFORMATION



Part Number	Package Description	Quantity/ Reel	Quantity/ Tube	Quantiy/ Tray	Reel Diameter	Carrier Tape Width	Carrier Tape Pitch
MPF42795DRT-0B-yyyy	QFN-32 (4mmx4mm)	5000	N/A	N/A	13 in.	12 mm	8 mm

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