LC709203F

CMOS LSI

Battery Monitor IC
for 1-Cell Lithium-ion (Li+)

ON Semiconductor®

http://onsemi.com

Overview

The LC709203F is an IC that measures the remaining power level of 1-cell lithium-ion (Li+) batteries used for portable equipment etc.

This product reduces fuel gauge errors with a unique correction technology during measurement of battery temperature and voltage.

This technology has inherent high precision without the need for an external sense resistor.

Applications

- Wireless Handsets
- Smartphones / PDA devices
- MP3 players
- Digital cameras
- Portable Game Players
- USB-related devices

Features

- High accuracy of remaining battery power measurements
- Precision Voltage Measurement
- No external sense resistor
- Alert function
- Interface
  - I^2C Interface (up to 400 kHz supported)
- Low power consumption
- Corresponding battery models for various battery electrode materials
- Ports
  - I^2C communication pin   : 2 (SDA, SCL)
  - Battery temperature reading control pin   : 1 (TSW)
  - Analog voltage input pin for battery temperature   : 1 (TSENSE)
  - External alarm / Interrupt for Low-Battery warning   : 1 (ALARMB)
  - Power supply pin   : 2 (V_{SS}, V_{DD})
- Package form
  - VDFN8 3×4, 0.65P : Lead-free type
  - WLCSP9, 1.60×1.76 : Lead-free type
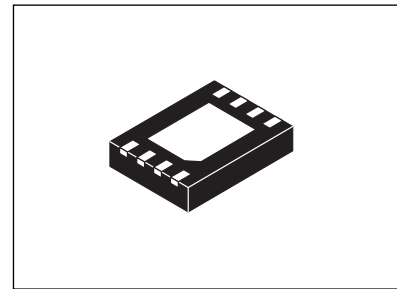
VDFN8 3x4, 0.65P
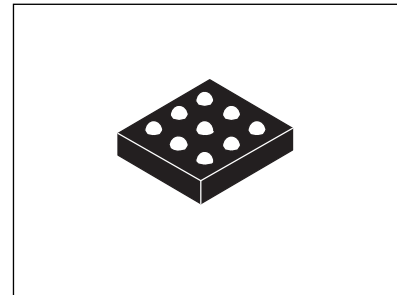
WLCSP9, 1.60x1.76

* I^2C Bus is a trademark of Philips Corporation.

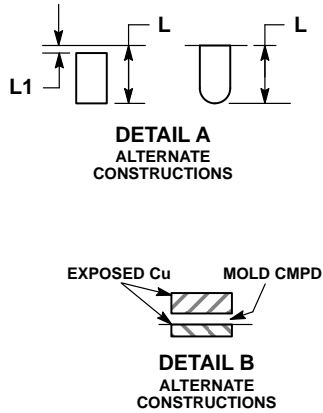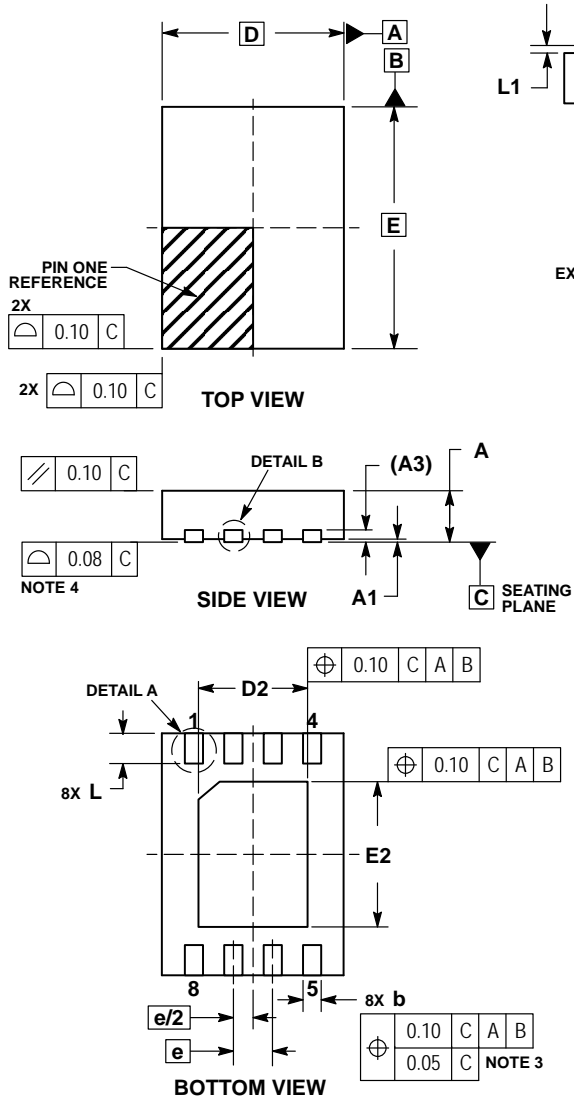## ORDERING INFORMATION

See detailed ordering and shipping information on page 12 of this data sheet.

Package Dimensions

unit : mm

VDFN8 3x4, 0.65P
CASE 509AF
ISSUE B

TOP VIEW

PIN ONE REFERENCE

2X △ 0.10 C

2X △ 0.10 C

DETAIL A
ALTERNATE CONSTRUCTIONS

L1 L L

SIDE VIEW

// 0.10 C

△ 0.08 C
NOTE 4

DETAIL B

(A3)

A

A1

C SEATING PLANE

DETAIL B
ALTERNATE CONSTRUCTIONS

EXPOSED Cu   MOLD CMPD

BOTTOM VIEW

DETAIL A

⊕ 0.10 C A B

D2

1   4

8X L

E2

8   5

8X b

e/2

e

⊕ 0.10 C A B
  0.05 C NOTE 3

⊕ 0.10 C A B

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM THE TERMINAL TIP.
4. PROFILE TOLERANCE APPLIES TO THE EXPOSED PAD AS WELL AS THE LEADS.

| DIM	MILLIMETERS	
	MIN	MAX
A	---	0.80
A1	0.00	0.05
A3	0.20 REF	
b	0.20	0.30
D	3.00 BSC	
D2	1.70	1.90
E	4.00 BSC	
E2	2.30	2.50
e	0.65 BSC	
L	0.45	0.55
L1	---	0.10

GENERIC MARKING DIAGRAM*

XXXXX
XXXXX
AYWW■
■
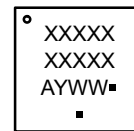
A   = Assembly Location
Y   = Year
WW = Work Week
■   = Pb−Free Package
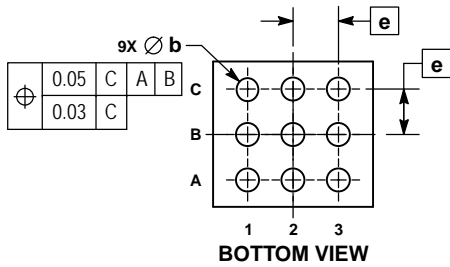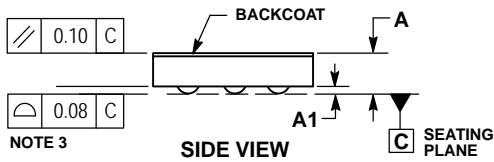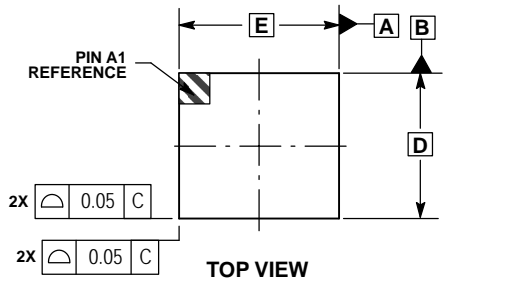(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot " ■ ", may or may not be present.

RECOMMENDED SOLDERING FOOTPRINT*
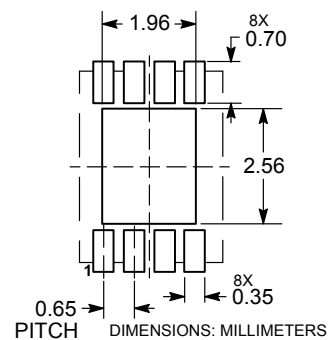
1.96

8X 0.70

2.56

1

8X 0.35

0.65
PITCH   DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

WLCSP9, 1.60x1.76
CASE 567JH
ISSUE B

TOP VIEW

PIN A1
REFERENCE

2X ⌒ 0.05 C

2X ⌒ 0.05 C

SIDE VIEW

BACKCOAT

// 0.10 C

⌒ 0.08 C

NOTE 3

A1

C SEATING PLANE

BOTTOM VIEW

9X ⌀ b

⊕ 0.05 C A B
0.03 C

e

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO THE SPHERICAL CROWNS OF THE SOLDER BALLS.

DIM	MILLIMETERS	
	MIN	MAX
A	---	0.51
A1	0.09	0.19
b	0.20	0.30
D	1.60 BSC	
E	1.76 BSC	
e	0.50 BSC	

**RECOMMENDED
SOLDERING FOOTPRINT***

A1

PACKAGE OUTLINE

0.50 PITCH

9X ⌀ 0.25

0.50 PITCH

DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.
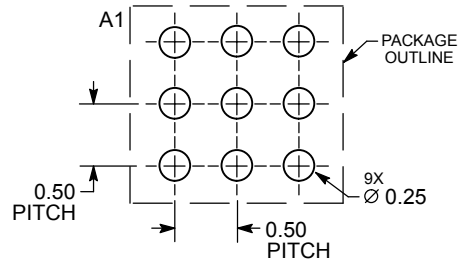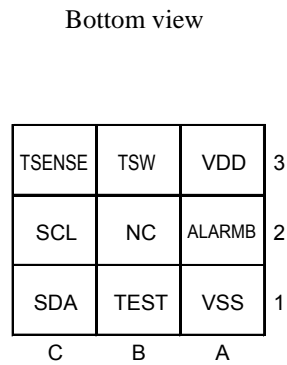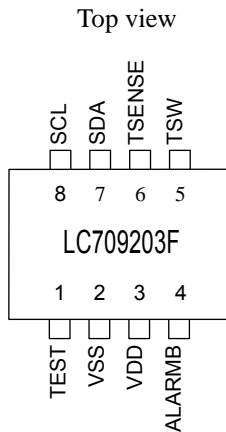
Pin Assignment

VDFN8 3x4, 0.65P "Lead-free Type"

WLCSP9, 1.60x1.76 "Lead-free Type"

Top view

Bottom view

Pin Function

VDFN8	WLP9	Pin Name	I/O	Description
1	1B	TEST	I	Factory Test pin *Connect to V_{SS}.
2	1A	V_{SS}	-	Connect to the - terminal of the battery.
3	3A	V_{DD}	-	Connect to the + terminal of the battery.
4	2A	ALARMB	O	Alert indication. An active low output used to indicate specified condition thresholds have been met. *When you do not use an alert function, please connect with V_{SS}. (Note 3)
5	3B	TSW	O	Battery temperature reading control pin (Note.1)
6	3C	TSENSE	I	Battery temperature analog voltage input pin (Note.2)
7	1C	SDA	I/O	I^2C data pin
8	2C	SCL	I/O	I^2C clock pin
-	2B	NC	-	Not used pin. *Recommend to connect to V_{SS}.
	-	EP	-	Exposed Pad, must not be connected.

(Note 1)
This pin provides power for the thermistor and goes high during a temperature read operation from Command code x08.

(Note 2)
If TSENSE is not used leave leads TSW and TSENSE disconnected, as in figure 4 and set bit 0 of command code register x16 low.
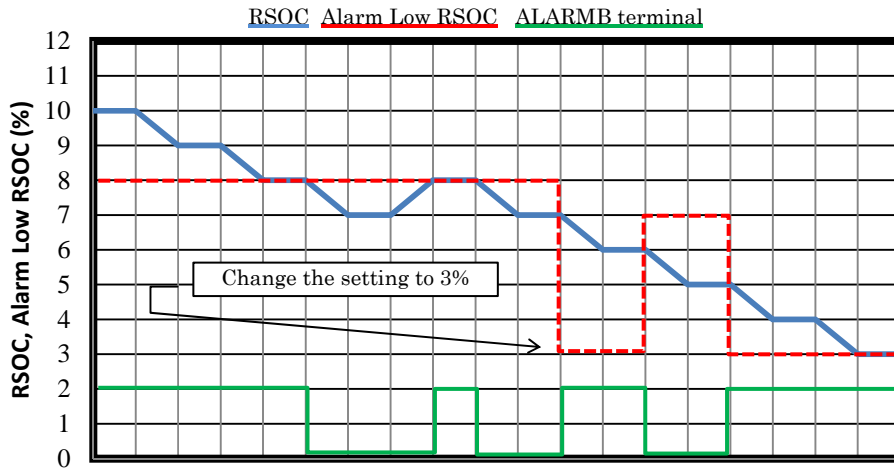 If TSENSE is utilized connect as in figure 5 with resistor network and set bit 0 of command code register x16 high.

(Note 3)
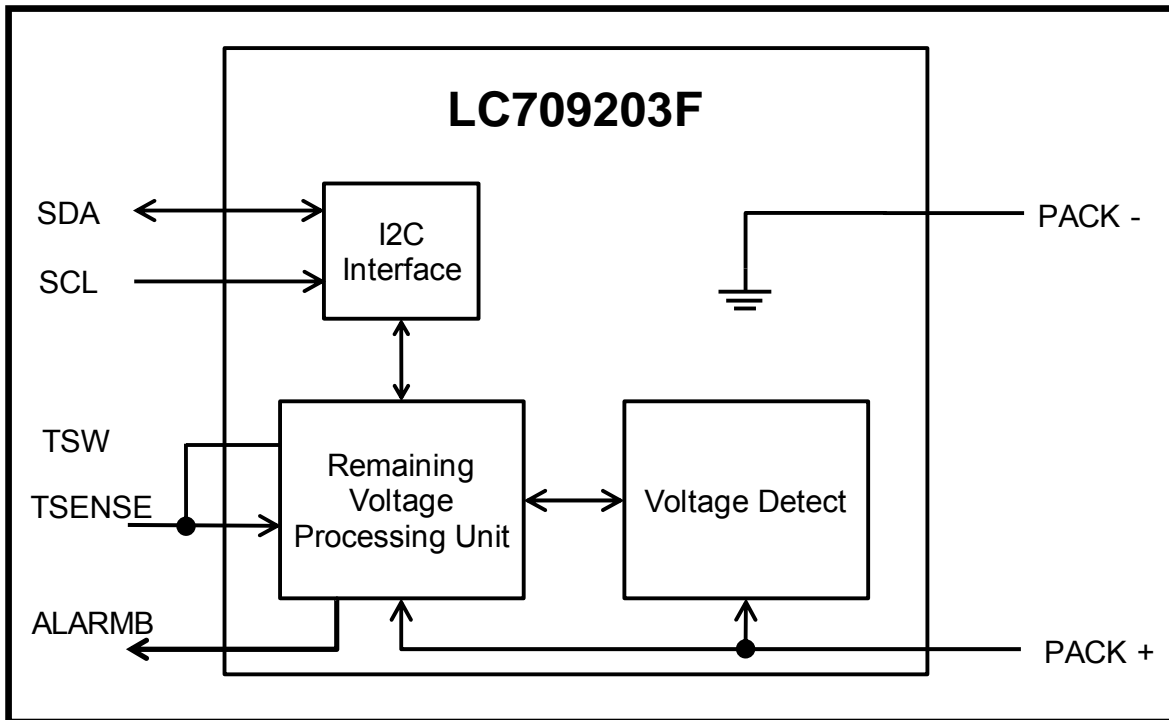ALARMB indicates a low RSOC, or an under voltage battery.

Alert Function

  ■ Configurable Alert Indicator
- Low RSOC
- Battery Under Voltage

Alarm RSOC Function

RSOC   Alarm Low RSOC   ALARMB terminal

Change the setting to 3%

Block Diagram

LC709203F

Absolute Maximum Ratings at Ta = 25°C, V_{SS} = 0V

Parameter	Symbol	Pin/Remarks	Conditions		Specification			Unit
				V_{DD} [V]	min	typ	max	
Maximum supply voltage	V_{DD} max	V_{DD}			−0.3		+6.5	V
Input voltage	V_I (1)	TSENSE			−0.3		V_{DD} +0.3	
Output voltage	V_O (1)	TSW			−0.3		V_{DD} +0.3	
	V_O (2)	ALARMB			−0.3			
Input/output voltage	V_{IO} (1)	SDA, SCL			−0.3		+5.5	
Allowable power dissipation	Pd max	VDFN8	Ta = −40 to +85°C				480	mW
		WLP9					210	
Operating ambient temperature	Topr				−40		+85	°C
Storage ambient temperature	Tstg				−55		+125	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Allowable Operating Conditions at Ta = −40 to +85°C, V_{SS} = 0V

Parameter	Symbol	Pin/Remarks	Conditions		Specification			unit
				V_{DD} [V]	min	typ	max	
Operating supply voltage	V_{DD} (1)	V_{DD}			2.5		4.5	V
High level input voltage	V_{IH} (1)	TSENSE		2.5 to 4.5	$0.7V_{DD}$		V_{DD}	
	V_{IH} (2)	ALARMB, SDA, SCL		2.5 to 4.5	1.4			
Low level input voltage	V_{IL} (1)	TSENSE		2.5 to 4.5	V_{SS}		$0.25V_{DD}$	
	V_{IL} (2)	ALARMB, SDA, SCL		2.5 to 4.5			0.5	

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Electrical Characteristics at Ta = −40 to +85°C, V_{SS} = 0V

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD}[V]	Specification min	Specification typ	Specification max	Unit
High level input current	I_{IH} (1)	SDA, SCL	$V_{IN} = V_{DD}$ (including output transistor off leakage current)	2.5 to 4.5			1	μA
Low level input current	I_{IL} (1)	SDA, SCL	$V_{IN} = V_{SS}$ (including output transistor off leakage current)	2.5 to 4.5	−1			
High level output voltage	V_{OH} (1)	TSW	I_{OH} = −0.4 mA	3.0 to 4.5	V_{DD}−0.4			V
	V_{OH} (2)		I_{OH} = −0.2 mA	2.5 to 4.5	V_{DD}−0.4			
Low level output voltage	V_{OL} (1)	TSW, ALARMB, SDA, SCL	I_{OL} = 3.0 mA	3.0 to 4.5			0.4	
	V_{OL} (2)		I_{OL} = 1.3 mA	2.5 to 4.5			0.4	
Hysteresis voltage	VHYS(1)	SDA, SCL		2.5 to 4.5		0.1V_{DD}		
Pin capacitance	CP	All pins	Pins other than the pin under test VIN = VSS Ta = 25°C	2.5 to 4.5		10		pF
Consumption current (Note 1)	I_{DD} (1)	V_{DD}	Normal Mode	2.5 to 4.5		15	26	μA
	I_{DD} (2)		Accurate ECO Mode	2.5 to 4.5		2	4.5	
	I_{DD} (3)		Sleep Mode	2.5 to 4.5		0.2	4	
Voltage measurement accuracy	V_{ME} (1)	V_{DD}	Ta = +25°C	3.6	−7.5		+7.5	mV/cell
	V_{ME} (2)		Ta = −20°C to +70°C	2.5 to 4.5	−20		+20	

Note 1 : Consumption current is a value in the range of −20°C to +70°C

LC709203F

I²C Slave Characteristics at Ta = −40 to +85°C, V_{SS} = 0V

| Parameter	Symbol	Pin/Remarks	Conditions	Specification			unit
				V_{DD}[V]	min	Max	
Clock frequency	TSCL	SCL				400	kHz
Bus free time between STOP condition and START condition	TBUF	SCL, SDA	See Fig. 1.		1.3		μs
Hold time (repeated) START condition First clock pulse is generated after this interval	THD:STA	SCL, SDA	See Fig. 1.		0.6		μs
Repeated START condition setup time	TSU:STA	SCL, SDA	See Fig. 1.	2.5 to 4.5	0.6		μs
STOP condition setup time	TSU:STO	SCL, SDA	See Fig. 1.		0.6		μs
Data hold time	THD:DAT	SCL, SDA	See Fig. 1.		0	0.9	μs
Data setup time	TSU:DAT	SCL, SDA	See Fig. 1.		100		ns
Clock low period	TLOW	SCL			1.3		μs
Clock high period	THIGH	SCL			0.6		μs
Clock/data fall time	TF	SCL, SDA			$20 + 0.1C_B$	300	ns
Clock/data rise time	TR	SCL, SDA			$20 + 0.1C_B$	300	ns
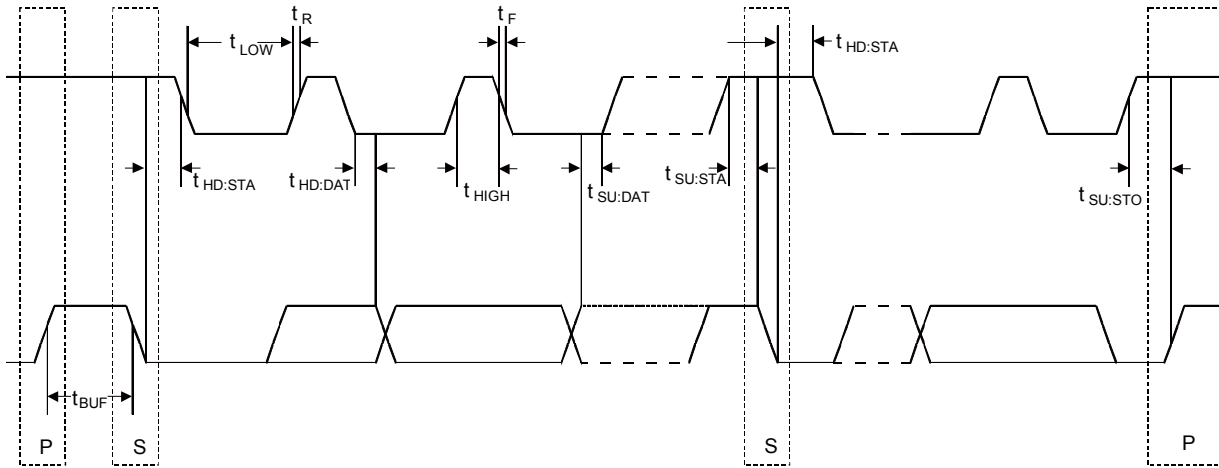
Figure 1 I²C Timing

Discharge Characteristics
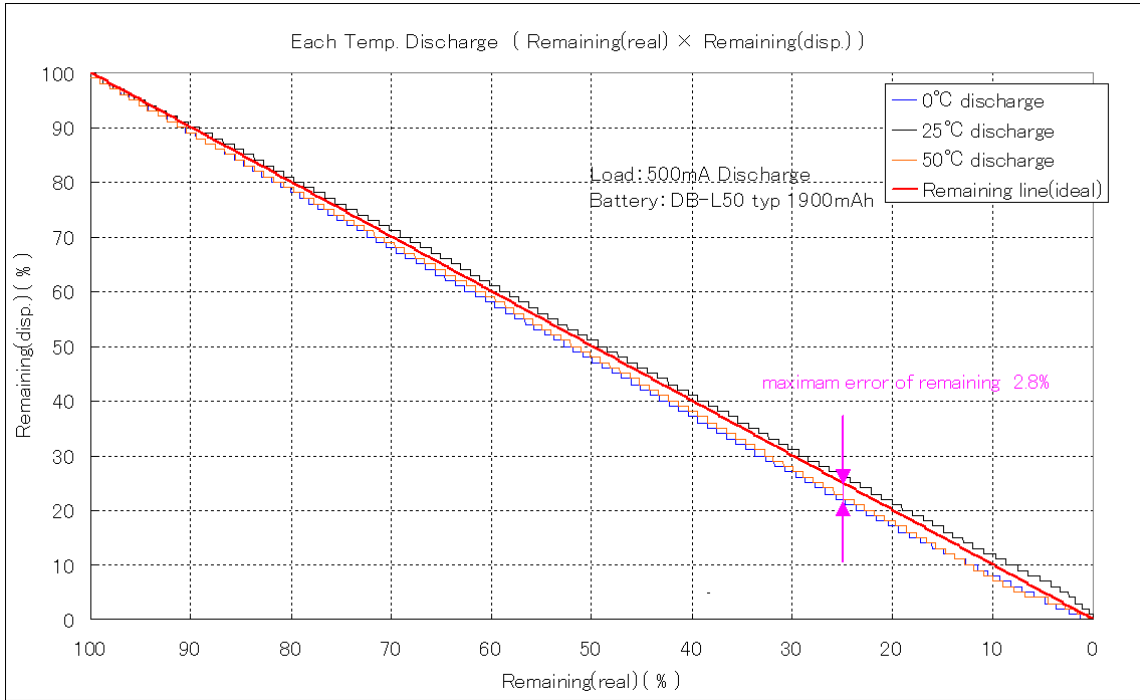
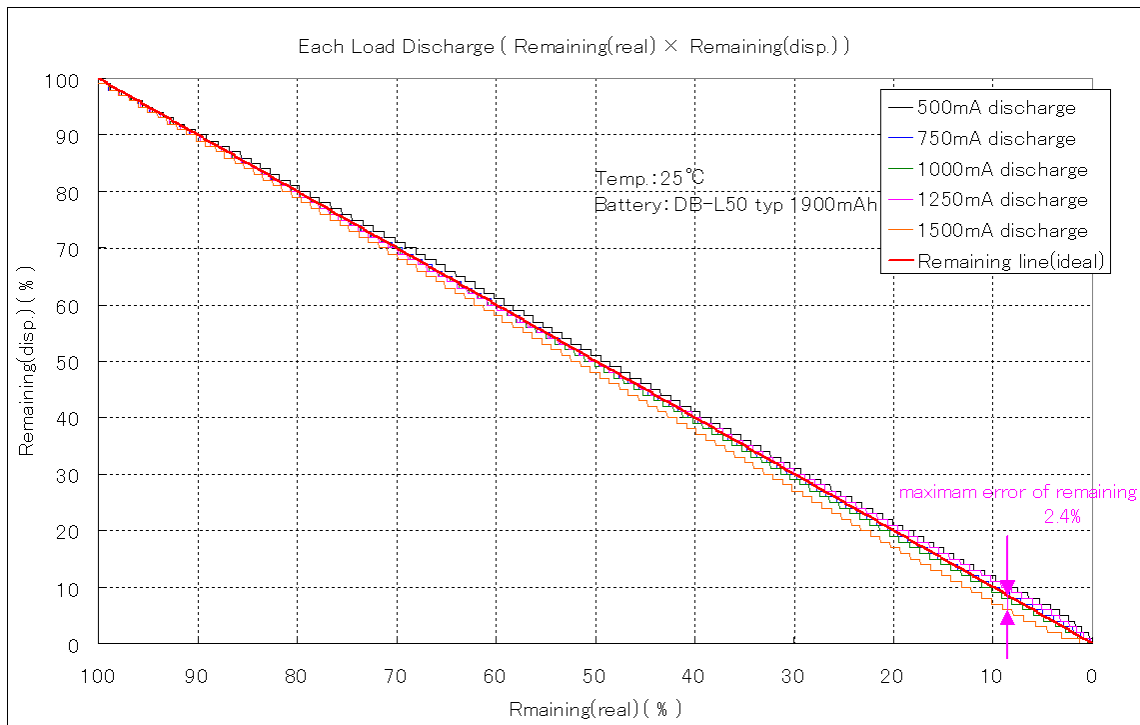

Figure 2 Discharge Characteristics by Temperature Change

Figure 3 Discharge Characteristics by Load Change

Communication Protocol

Communication protocol type : I2C

Frequency : to 400kHz

IC address : 0x16 (It becomes "0001011X" w hen you w rite a binary, because the slave address is 7 bits. [X]=Rd/Wr.)

Bus Protocols

S	:	Start Condition
Sr	:	Repeated Start Condition
Rd	:	Read (bit value of 1)
Wr	:	Write (bit value of 0)
A	:	ACK (bit value of 0)
N	:	NACK (bit value of 1)
P	:	Stop Condition
CRC-8	:	Slave Address to Last Data (CRC-8-ATM : ex.3778mV : 0x16,0x09,0x17,0xC2,0x0E → 0x86)
	:	Master-to-Slave
	:	Slave-to-Master
…	:	Continuation of protocol

Read Word Protocol

S	Slave Address	Wr	A	Command Code	A	…
Sr	Slave Address	Rd	A	Data Byte Low	A	Data Byte High	…
A	CRC-8	N	P
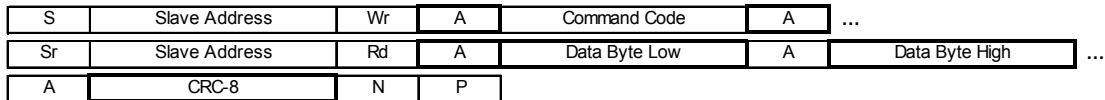
*When you do not read CRC -8, there is not the reliability of data. CRC-8-ATM ex : (5 bytes) 0x16,0x09,0x17,0xC2,0x0E → 0x86

Write Word Protocol

S	Slave Address	Wr	A	Command Code	A	…
Data Byte Low	A	Data Byte High	A	CRC-8	A	P
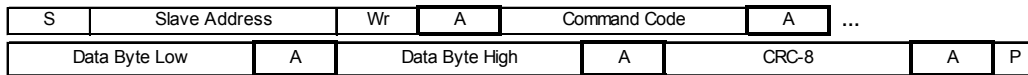
*When you do not add CRC -8, the Written data (Data byte Low /High) become invalid.

CRC-8-ATM ex : (4 bytes) 0x16, 0x09, 0x55, 0xAA → 0x3B

Command Code	Slave Functions	Stats	Range	Unit	Initial Value
0x06	Thermistor B	R/W	0x0000 to 0xFFFF	B	0x0D34
0x07	Initial RSOC	W	0xAA55	Value	-
0x08	Cell Temperature	R	0x0000 to 0xFFFF (Thermistor Mode)	0.1°K (0.0°C = 0x0AAC)	0x0BA6 (25°C)
		W	0x09E4 to 0x0D04 (Via I2C)		
0x09	Cell Voltage	R	0x0000 to 0xFFFF	mV	-
0x0A	Current Direction	R/W	0x0000 or 0x0001 or 0xFFFF	0x0001 : Charge Mode 0x0000 : Auto Mode 0xFFFF : Discharge Mode	0x0000
0x0B	Adjustment Pack Appli	R/W	0x0000 to 0xFFFF	Value	-
0x0C	Adjustment Pack Thermistor	R/W	0x0000 to 0xFFFF	Value	0x001E
0x0D	RSOC	R	0x0000 to 0x0064	%	-
	Set RSOC	W			
0x0F	Indicator To Empty	R	0x0000 to 0x03E8	Value	-
0x11	IC Version	R	0x0000 to 0xFFFF	Version	-
0x12	Change Of The Parameter	R/W	0x0000 or 0x0001	Please refer to a low er list	0x0000
0x13	Alarm Low RSOC	R/W	0x0000 to 0x0064	% (activate under)	0x0008
0x14	Alarm Low Cell Voltage	R/W	0x0000 to 0xFFFF	mV (activate under)	0x0000
0x15	IC Pow er Mode	R/W	0x0000 to 0x0002	0x0000 : Nomal Mode 0x0001 : Accurate ECO 0x0002 : Sleep Mode	-
0x16	Status Bit	R/W	bit 0 : Thermistor Mode	0 : disable 1 : enable	0x0000
			bit 1 to 15 : Reserved (fix 0)		
0x1A	Number Of The Parameter	R	0x0301 or 0x0504	Please refer to a low er list	-

	Type Of The Battery	Number Of The Parameter	Change Of The Parameter
LC709203F-01	Normal Voltage3.8V, Charge Voltage 4.35V	0x0301	0x0000
	Normal Voltage3.7V, Charge Voltage 4.2V		0x0001
LC709203F-04	ICR18650-26H (SAMSUNG)	0x0504	0x0000
	UR18650ZY (Panasonic)		0x0001

RSOC = Relative State Of Charge

0xXXXX = Hexadecimal notation

(Note)

Initialization from Host :

- The IC w ill initialize reading the battery temperature until Initialization sequence w ith serial port is executed. (Please see EVB manual for sequences.)

Control from Host :

- The Remaining State of Charge (RSOC) is normally read periodically.

- To read temperature the part w ill need a sequence of instructions and then returned to RSOC reading.

Application Circuit Example

Figure 4 Example of an application schematic using LC709203F
(not use temperature detection function)

Figure 5 Example of an application schematic using LC709203F
(use temperature detection function)

ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
LC709203FQH-01TWG	VDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2000 / Tape & Reel
LC709203FQH-02TWG	VDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2000 / Tape & Reel
LC709203FQH-03TWG	VDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2000 / Tape & Reel
LC709203FQH-04TWG	VDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2000 / Tape & Reel
LC709203FXE-01MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5000 / Tape & Reel
LC709203FXE-02MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5000 / Tape & Reel
LC709203FXE-03MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5000 / Tape & Reel
LC709203FXE-04MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5000 / Tape & Reel

(Note)
The type of battery affects the performance to some degree. Contact your sales team for assistance in choosing the correct model.