

Test Procedure for the LC709203F-01 Evaluation Board

Scope

The LC709203F measures the remaining power of a 1-cell lithium-ion battery. This product uses a unique correction technology to make battery temperature and voltage measurements. With this technology high precision measurement can be made without the need for an external sense resistor. The following is a manual that describes how to use the Fuel Gauge Interactive Software.

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1. Overview

The LC709203F is an IC that measures the remaining power of a 1-cell lithium-ion battery and displays the Relative State of Charge (RSOC). This product reduces fuel gauge errors with a unique correction technology during measurement of battery temperature and voltage. The LC709203F has the option of four possible battery profiles to select from for best precise RSOC readings. This technology has inherent high precision without the need for an external sense resistor.

2. Evaluation Kit

2.1 Evaluation Board for LC709203F Fuel Gauge

Evaluation Board Part Numbers:

1) LC709203FQH-01-GEVB for VDFN8 Package

2) LC709203FXE-01-GEVB for WLCSP9 Package



-Easy to use: Minimal Connections required



2.2 Fuel Gauge Interactive Software

Co v li → Lib	raries 🕨	Documents 🕨 Fuel Ga	uge FGICTOOL.zip					•	Sear	rch FGICTOOL.zip	× Q
Organize 👻 Extr	act all fil	es									0
☆ Favorites	-	Name	Туре		Compressed size	Password	Size		Ratio	Date modified	
📃 Desktop	=	FGICTool_ver008.0	exe Application		862 KB	No		2,217 KB	62%	8/1/2014 4:43 PM	
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Documents	-			-			_		-		

-Supported Platforms: Windows XP and Windows 7

<u>Fuel Gauge software</u> can be found on the ON Semiconductor Website at onsemi.com and searching part #LC709203F.

2.3 Evaluation Board Block Diagram







3. Connection Instructions

3.1 Connecting of Evaluation Board

-Connect

Evaluation Board Positive Connector + $\rightarrow \rightarrow$ Battery Pack +

Evaluation Board Negative Connector - \rightarrow \rightarrow Battery Pack –







4. Evaluation Procedures

4.1 Software Start-Up

-Start program FIGICTool_ver008.exe

etting	Sub communication	Flash Write	
Communicate	Command(Hex 00-FF) Data(Hex 0000-FFFF) Read word Write word	Open file Flash write	File type No Data Process result
urrent value	Data measured		
RSOC %			
oll temperature			
Cell temperature			
Cell temperature			



4.2 Communication Type Selection

-Select communication type: I^2C

	Communicate 2
Communicate	Period of measure 2 s (1s-300s) s Communication Type
	Communication type 12C (12C or OWSI) 12C dock frequency (100kHz or 400kHz) 100 kHz
	OK Cancel

-Select desired time interval and frequency:

Communicate	-	
Period of measure ((1s-300s)	2	0.
Communication Type		
Communication type (I2C or OWSI)	[12C	•
I2C dock frequency (100kHz or 400kHz)	100	▼ kHz
11.00		

-



4.3 Changing IC Power Mode

-Change mode of Fuel Gauge to 'Operational Mode' Do the following in the *Write Word Sub Communication* window Input [15] in Command box Input [0001] in Data box

	Sub communication Command Read word Write word	d(Hex 00-FF) Data(Hex 0000-FFF	F)	
Command Code	Slave Functions	Status	Range	Unit	Initial Value
0x15	IC Power Mode	R/W	0x0000 to 0x0002	0x0000: Testing Mode 0x0001 Operational Mode 0x0002: Sleep Mode	

Press [Write Word] to complete writing register 0x15 (Twice)

It is recommended to do this task twice, once for a 'wake up' and second to set Fuel Gauge in to 'Operational Mode'.



*While powering on Fuel Gauge, IC starts up in sleep mode. It is essential to ensure IC is set to 'Operational Mode' for accurate measurement.



4.4 Impedance Path Assignment

Account for impedance from battery up too Fuel Gauge Do the following in the *Write Word Sub Communication* window

Input [0B] in Command box

Input [XXXX] in Data box

	Sub communication Command(Hex 00-FF) Data(Hex 0000-FFFF) Read word					
	Write word	0B		XX		
Command Code	Slave Functions	Status		Range	Unit	Initial Value
OxOB	Adjustment Pack Application	R/W	0x0	0000 to 0xFFFF	Value	

Press [Write Word] to complete writing register 0x0B

1			
(Write word	08	XXXX
	\smile		

* This register accounts for the impedance track from the battery to Fuel Gauge. This impedance path can include: Protection IC's, long leads, and internal resistance.



4.5 Battery Profile Assignment

Assign correct batter profile, for best accurate measurements. Do the following in the *Write Word Sub Communication* window Input [12] in Command box

Input [000X] in Data box

	Sub communication Comm Read word	nand(Hex 00-FF)	Data(He	× 0000-FFFF)		
	Write word	12		000×		
Command Code	Slave Functions	Status		Range	Unit	Initial Value
0x12	Default or Alternative Type Select	R/W	Ox	0000 or 0x0001	Please Refer to Table 1	0x0000

Press [Write Word] to complete writing register 0x12



The LC709203F has the option of having either battery profile 301 or 504 pre-loaded. Each battery profile has two optional battery types to select from. Selecting the correct battery profile and type is crucial for accurate results. Please review Table 1 in order to select correct battery profile and type.

ІС-Туре	Nominal/Rated Voltage	Charging Voltage	Battery Type	Battery Profile
	3.7 V 4.2V		Type 01	
LC709203F-01	3.8V	4.35V	Type 03	201
	Δου Τ	N/DO	Re-Scaling	501
	Ally I	уре	Required	
	Use only for UR-186	50ZY (Panasonic)	Type 04	
LC709203F-04	Use only for ICR186	50-26H (Samsung)	Type 05	E04
	Δον Τ	VDO	Re-Scaling	- 504
	Ally I	yhe	Required	





For best results initialize battery capacity.

Do the following in the *Write Word Sub Communication* window

Input [07] in Command box

Input [AA55] in Data box

	Sub communication				
	Read word	nd(Hex UU-FF)	Data(Hex UUUU-FFFF		
	Write word	07	AA55	1	
Command Code	Slave Functions	Status	Range	Unit	Initial Value
0x07	Initial RSOC	w	0xAA55	Value	

Press [Write Word] to complete writing register 0x07

Write word	07	AA55

*This will assign the most accurate Relative State of Charge (RSOC) of the battery being monitored



4.7 Thermistor Mode

The LC709203F has the <u>option</u> of using a thermistor for cell temperature measurements. The following steps show how to enable the thermistor. *Upon start up LC709203F has default setting with thermistor mode disabled.*

Do the follwing in Sub Communication window

Input [16] in Command box

linput [0001] in Data box

	Sub communication Comman Read word	d(Hex 00-FF)	Data(Hex 0000-FFFF)		
	Write word	16	0001		
Command Code	Slave Functions	Status	Range	Unit	Initial Value
0x16	Status Bit	R/W	bit 0: Thermistor Mode bit 1~15 : Reserved (fix 0)	O: disable 1: enable	0x0000

Press [Write Word] to enable Thermistor

(Write word	16	0001



4.8 Thermistor β Assignment

Assign correct β value of thermistor being used.

Ex.

Part Number	Resistance (25°C) (ohm)	B-Constant (25-50°C) (K)	B-Constant (25-80°C) Reference Value) (K)	B-Constant (25-85°C) (Reference Value) (K)	B-Constant (25-100°C) (Reference Value) (K)	Permissive Operating Current (25°C) (mA)	Rated Electric Power (25°C) (mW)	Typical Dissipation Constant (25°C) (mW/°C)
NCP21XM221J03RA	220 ±5%	3500 ±3%	3539	3545	3560	3.00	200	2
NCP21XQ471J03RA	470 ±5%	3650 ±3%	3688	3693	3706	2.00	200	2
NCP21XQ102J03RA	1.0k ±5%	3650 ±3%	3688	3693	3706	1.40	200	2
NCP21XW222J03RA	2.2k ±5%	3950 ±3%	3982	3987	3998	0.90	200	2
NCP21XM472J03RA	4.7k ±5%	3500 ±3%	3539	3545	3560	0.65	200	2
NCP21XV103J03RA	10k ±5%	3900 ±3%	3930	3934	3944	0.44	200	2
NCP21XW153J03RA	15k ±5%	3950 ±3%	3982	3987	3998	0.36	200	2
NCP21XW223J03RA	22k ±5%	3950 ±3%	3982	3987	3998	0.30	200	2
NCP21WB333J03RA	33k ±5%	4050 ±3%	4101	4108	4131	0.24	200	2
NCP21WB473J03RA	47k ±5%	4050 ±3%	4101	4108	4131	0.20	200	2
NCP21WF104J03RA	100k ±5%	4250 ±3%	4303	4311	4334	0.14	200	2

Do the follwing in Sub Communication window

Input [06] in Command box

Input [XXXX] in Data box

	Sub communication Comman Read word	d(Hex OO-FF) D	Data(Hex 0000-FFFF)		
	Write word	06	XXXXX		
Command Code	Slave Functions	Status	Range	Unit	Initial Value
0x06	Thermistor β	R/W	0x0000 or 0xFFFF	β	0x0D34

Press [Write Word] to assign Thermistor β constant





4.9 Start of Measurements

Press [Start Measure] to begin measurements

ietting	Sub communication	n		Flash Write	
		Command(Hex 00-FF)	Data(Hex 0000-FFFF)		File type
Communicate	Read word	15	1	Open file	No Data
	Write word	07	AA55	Flash write	Tioceas result
Current value	Data measured				
	Communica	ate> Period of mea	sure:2s Communicat	tion type:I2C I2C	clock frequency:400kHz
DCOO					
RSOC					
RSOC %					
RSOC %					
RSOC %					
RSOC %					
RSOC %					
RSOC %					
RSOC %	·		m		

4.10 Sample Measurements

Setting	Sub communication			Flash Write		
	Com	mand(Hex 00-FF)	Data(Hex 0000-FFFF)		File type	
Communicate	Read word	15	1	Open file	No Data	
Communicate					Process result	
	Write word	07	AA55	Flash write		
Current value	Data measured					-
	<communicate></communicate>	Period of mea	sure:2s Communica	tion VO	ltage	400kHz
000000000	2014/08/18 13:0	2:28, 87, 25.0, 4	4175	/m	~~~~	
	2014/08/18 13:0	2:30, 87, 25.0, 4	4175	(I	nv)	
	2014/08/18 13:0	2:32, 87, 25.0, •	4175			
	2014/08/18 13:0	2:34, 87, 25.0, 4	4175			
	2014/08/18 13:0	2:36, 87, 25.0, 4	4175			
RSOC	2014/08/18 13:0	2:38, 87, 25.0, 4	4175			
07 0/	2014/08/18 13:0	2:40, 87, 25.0,	4175			
8/ %	2014/08/18 13:0	2:42, 87, 25.0,	4175			
	2014/08/18 13:0	2:44, 87, 25.0,	4175			
Cell temperature						
05.0 %0						
25.0 °C		/	\mathcal{N}			
			$ \rightarrow $			
	Start measure Start	op measure		<u> </u>	Clear log	Store log
<				Coll tomo	oroturo	
				Jen remb	eralure	

With a successful connection you will see screen as above



5 Graphical Analysis

The LC709203F software has the option to save all measurements via a text file. Measured data can be converted in to excel format. Once in excel format, data can be plotted for analysis. A graph can give a great visual to see how the LC709203F tracks voltage and RSOC over time.

5.1 Storing Measured Data

To save data to a text file, do the following:

Press [Stop measure]

Press [Store log]

Fuel Gauge IC Tool For LC7092xx	F Ver0.08	
Setting	Sub communication Flash Write	
Communicate	Command(Hex UU-FF) Data(Hex UUU-FFF) File type Read word 15 1 Open file No Data	
	Write word 07 AA55 Flash write	esult
Current value	Data measured	
	2014/08/18 13:08:20, 87, 25:0, 4175	•
00000000	2014/08/18 13:08:22, 87, 25:0, 4175	
	2014/08/18 13:08:24, 87, 25:0, 4175	
	2014/08/18 13:08:26, 87, 25:0, 4175	
	2014/08/18 13:08:28, 87, 25:0, 4175	
	2014/08/18 13:08:30, 87, 25:0, 4175	
RSOC	2014/08/18 13:08:32, 87, 25:0, 4175	
07 0/	2014/08/18 13:08:34, 87, 25:0, 4175	
8/ 70	2014/08/18 13:08:36, 87, 25:0, 4175	
	2014/08/18 13:08:38, 87, 25:0, 4175	
Cell temperature	2014/08/18 13:08:40, 87, 25:0, 4175	
05.0 %	2014/08/18 13:08:43, 87, 25:0, 4175	
23.0 0	2014/08/18 13:08:45, 87, 25:0, 4175	
	2014/08/18 13:08:47, 87, 25:0, 4175	2
	2014/08/18 13:08:49, 87, 25:0, 4175	2 🗧
	< III	
	Start measure Stop measure 1 Clear lo	e Store log
		\sim

Measured Data becomes a txt file

Save Fuel Gauge Data Example.txt



5.2 Converting Fuel Gauge Data

Convert .txt file to .csv in order to create a graph

FullDischargeTest.txt - Notepad	
File Edit Format View Help	
Ccommunicates Period of measure:2s Communication type:I2C I2C clock frequency:400kHz 2014/06/10 11:48:03, 96, 25.0, 4144 2014/06/10 11:48:07, 96, 25.0, 4144 2014/06/10 11:48:09, 96, 25.0, 4144 2014/06/10 11:48:13, 96, 25.0, 4144 2014/06/10 11:48:15, 96, 25.0, 4144 2014/06/10 11:48:17, 96, 25.0, 4144 2014/06/10 11:48:13, 96, 25.0, 4144 2014/06/10 11:48:13, 96, 25.0, 4144 2014/06/10 11:48:23, 96, 25.0, 4144 2014/06/10 11:48:33, 96, 25.0, 4144 2014/06/10 11:48:33, 96, 25.0, 4144 2014/06/10 11:48:33, 96, 25.0, 4144 2014/06/10 11:48:41, 96, 25.0, 4144 2014/06/10 11:48:41, 96, 25.0, 4144 2014/06/10 11:48:41, 96, 25.0, 4144 2014/06/10 11:48:43, 96, 25.0, 4144 2014/06/10 11:48:45, 96, 25.0, 4144 2014/06/10 11:48:51, 96, 25.0, 4144 2014/06/10 11:49:03, 96, 25.0, 4144 2014/06/10 11:49:03, 96, 25.0, 4144 2014/06/10 11:49:03, 96, 25.0, 4144	
1	

Convert file type Example.txt → *Example.csv*

	🚽 🄊 • (° -	- -		_		FullDischa	argeTest.csv ·	Micro	soft Excel						- 6	3 X
F	ile Home	Insert	Page La	ayout F	ormulas	Data	Review	View						c	ລ 🕜 🕯	- # X
Pivo	otTable Table	Picture	Illustration	hapes * martArt creenshot *	Column	A Line ▼ ● Pie ▼ ■ Bar ▼ Char	Area × Scatter × Other Cl ts	narts *	Line	nn .oss es	Slicer Filter	Q Hyperlink Links	A Text Box	Header & Footer Text	- 4 - ≥- * <u>≫</u>	Ω Symbols
	P3086	• (6	f _x												`
	A	В	С	D	E	F	G		н	1	J	K		L	М	5
1	<communica< td=""><td>ate> Perio</td><td>d of meas</td><td>ure:2s Cor</td><td>nmunicat</td><td>tion type</td><td>:12C 12C clos</td><td>k freq</td><td>uency:400</td><td>OkHz</td><td></td><td></td><td></td><td></td><td></td><td></td></communica<>	ate> Perio	d of meas	ure:2s Cor	nmunicat	tion type	:12C 12C clos	k freq	uency:400	OkHz						
2	******	96	25	4144												
3	*****	96	25	4144												
4	*****	96	25	4144												
5	*****	96	25	4144												
6	*****	96	25	4140												
7	*****	96	25	4144												
8	*****	96	25	4144												
9	*****	96	25	4144												
10	*****	96	25	4140												
11	*****	96	25	4144												
12	*****	96	25	4144												
13	*****	96	25	4144												
14	*****	96	25	4144												
15	*****	96	25	4144												
16	*****	96	25	4144												
17	*****	96	25	4144												
18	*****	96	25	4144												
19	########	96	25	4144												
20	*****	96	25	4144												
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22	*****	96	25	4144												
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24	########	96	25	4144												
25	########	96	25	4144												
26		96	25	4144												
Rea	ady	schargere	SL <u>(</u>										100%	Θ	-0	+



5.3 Create a Graph



Graph Displays:

- 1) RSOC vs. Time
- 2) Voltage vs. Time

Graph gives a visual representation of how the LC709203F tracks battery voltage while discharging.

A separate graph to model a charging pattern can be obtained by taking measurements while charging a battery pack using the LC709203F software.

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6. Smartphone Evaluation Example

The LC709203F Evaluation board can be used to analyze applications. Here is an example of an analysis of a smartphone undergoing charging and discharging conditions.

6.1 Block Diagram







6.2 Testing Results #1



6.3 Testing Results #2





<u>Test Results</u>

Test 1: This test shows the use of a smartphone over an 8 hour window. During this 8 hour window the smartphone went through a charge/discharge state. During charge state the phone was being charged via charger and discharged by using features on smartphone. This graph displays how the LC709203F tracks the voltage level and displays a RSOC value.

Test 2: Smartphone starts off 100% charged then discharges due to recording a movie. The battery is then removed, charged, and then put back in to smartphone. The LC709203F tracks the voltage level and displays a RSOC value.



7. FAQ's

Q. How do I know what battery profile to use?

A. Battery characteristics are listed on Table 2. If battery you wish to use is not listed on Table 2, please contact ON Semiconductor.

Q. Why does my Fuel Gauge continue to display same voltage value?

A. Please ensure Fuel Gauge is not in 'Sleep' mode. Following Fuel Gauge Initialization Flow Chart will ensure it reads proper values.

Q. What if I order Fuel Gauge with battery profile 301 but need battery profile 504 instead?

A. Alternative battery profile can be made available, please contact ON Semiconductor for more information.

Q. How do I load a new battery profile to LC709203F?

A. After receiving new battery profile from ON Semiconductor please use software to *Flash* the new profile on to Fuel Gauge.

Q. I tried loading a new battery profile but I am receiving a Flash Write error?

A. Please insure that IC is not in 'Sleep mode, please follow Fuel Gauge initiation to place IC in 'Operational' mode.

8. Related Documents

Supporting information such as: Datasheets, Application Notes, Evaluation Board Documents and Software are available for the LC709203F.To obtain the most updated documentation please visit the ON Semiconductor Web site at <u>www.onsemi.com</u> and search part number: LC709203F.

- 1) LC709203F, Battery Monitor IC for 1-Cell Lithium-ion Li+ Data Sheet (Data Sheet)
- 2) LC709203F, Application Note (App. Note)
- 3) LC709203F, Evaluation Board Documents (Evaluation Board Docs)
- 4) LC709203F, Software FGICTool (Software)



9. Revision History

Version	Date	Details
1.0	08/20/2014	Initial Release