ON Semiconductor®

# 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.

## Contents

# 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.

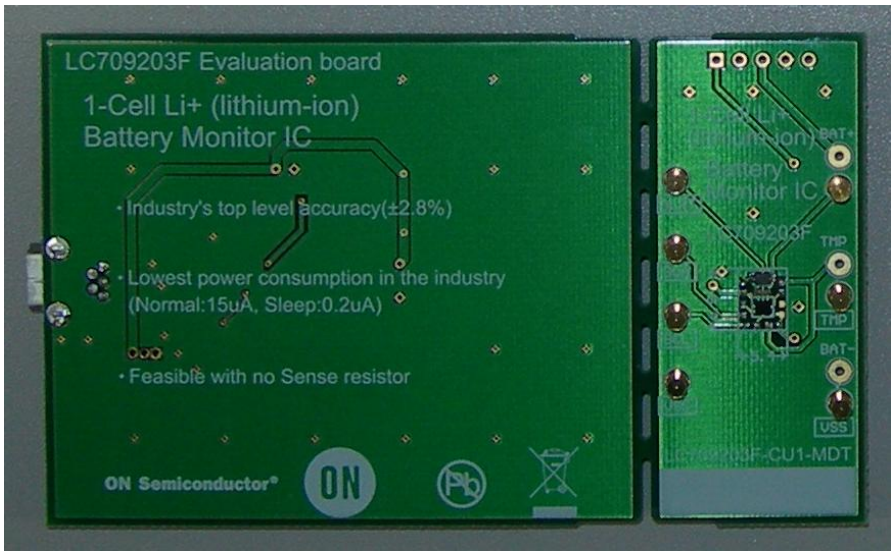
# 2. Evaluation Kit

## 2.1 Evaluation Board for LC709203F Fuel Gauge

## Evaluation Board Part Numbers:

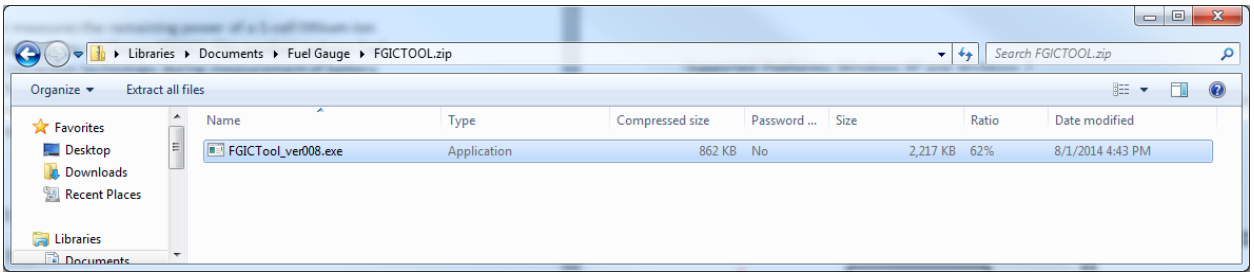
1) LC709203FQH-01-GEVB for VDFN8 Package

2) LC709203FXE-01-GEVB for WLCSP9 Package




-Easy to use: Minimal Connections required

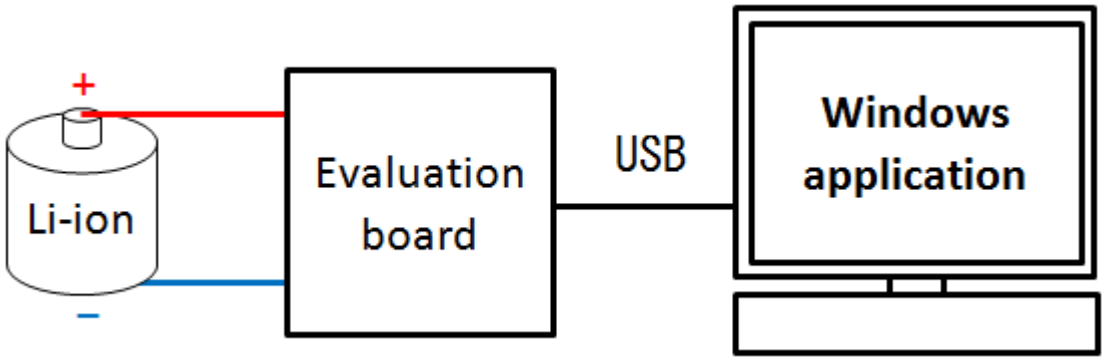
## 2.2 Fuel Gauge Interactive Software




-Supported Platforms: Windows XP and Windows 7

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

## 2.3 Evaluation Board Block Diagram



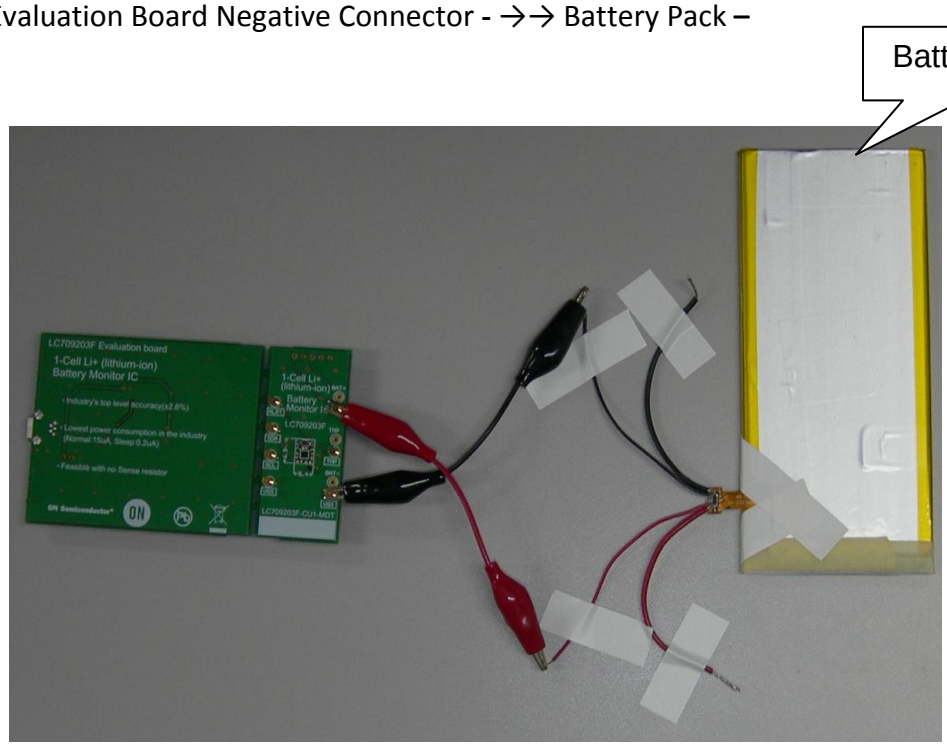
# 3. Connection Instructions

## 3.1 Connecting of Evaluation Board

-Connect

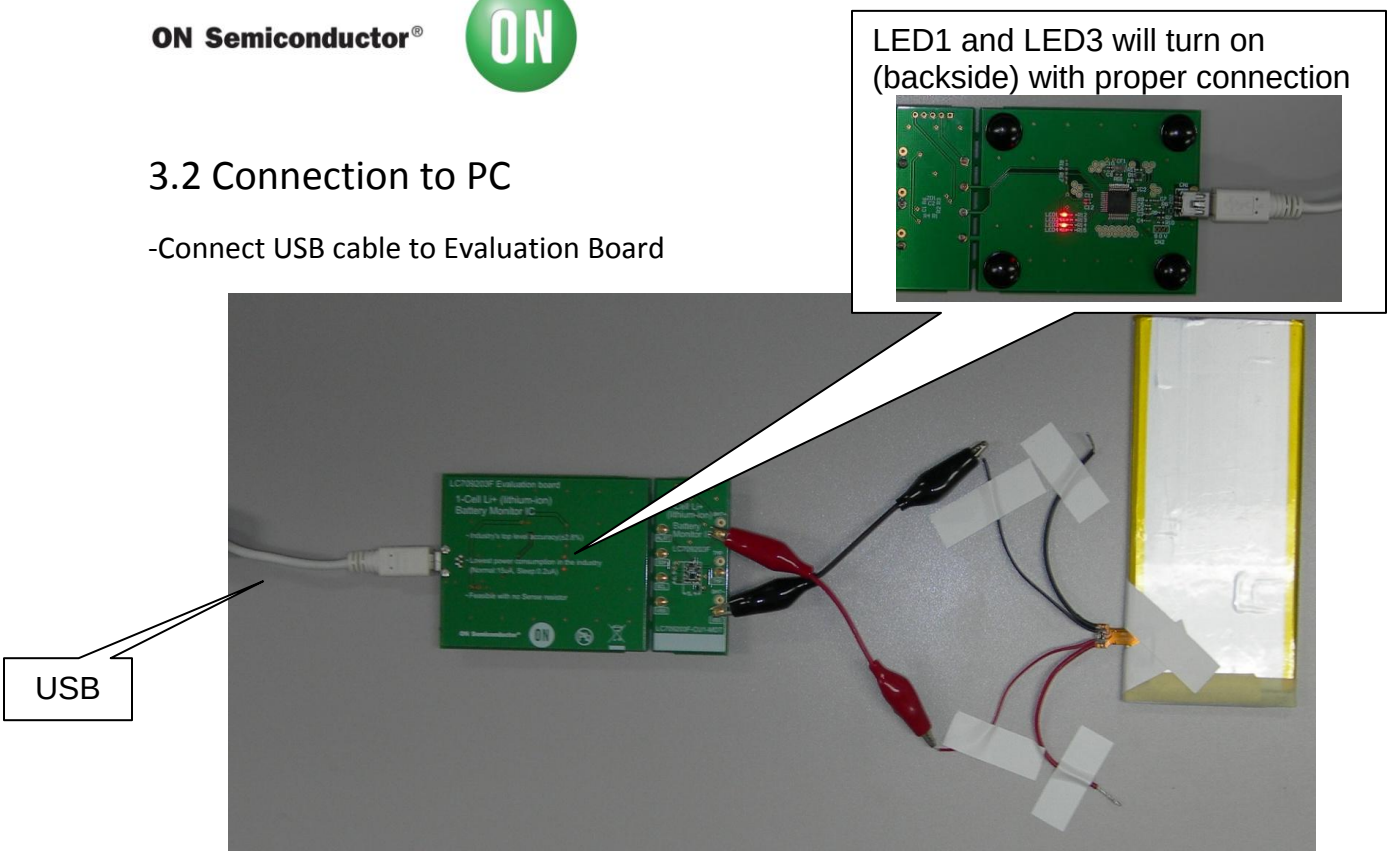
Evaluation Board Positive Connector **+** →→ Battery Pack **+**

Evaluation Board Negative Connector **-** →→ Battery Pack **–**



## 3.2 Connection to PC

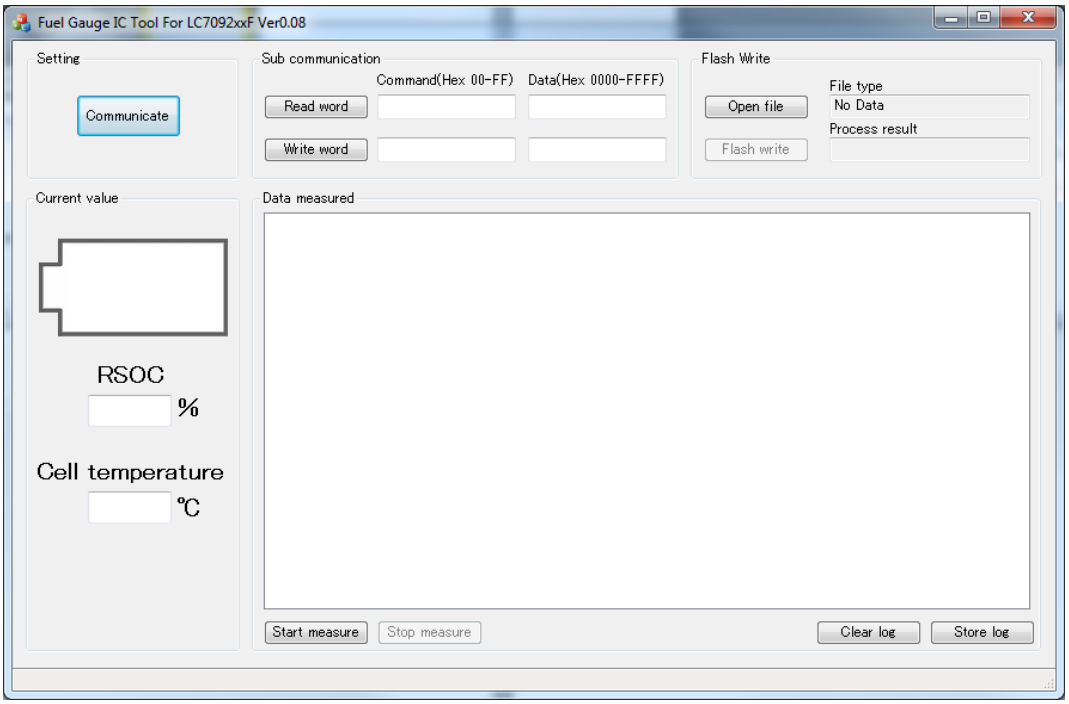
-Connect USB cable to Evaluation Board



# 4. Evaluation Procedures

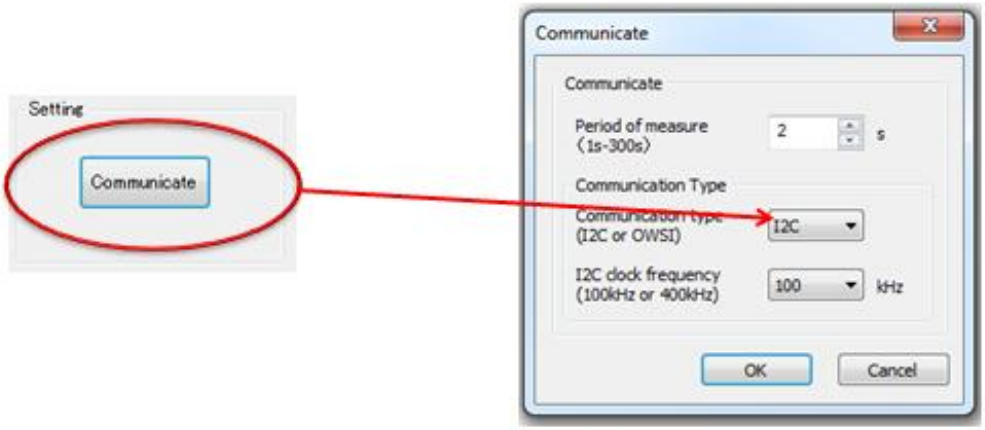
## 4.1 Software Start-Up

-Start program *FIGICTool_ver008.exe*



## 4.2 Communication Type Selection

-Select communication type: $I^2C$




-Select desired time interval and frequency:

## 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


| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x15 | IC Power Mode | R/W | 0x0000 to 0x0002 | 0x0000: Testing Mode<br>0x0001 Operational Mode<br>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

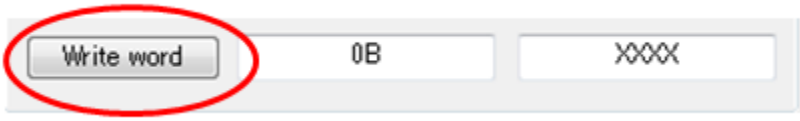
Do the following in the *Write Word Sub Communication* window

Input [0B] in Command box

Input [XXXX] in Data box


| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x0B | Adjustment Pack Application | R/W | 0x0000 to 0xFFFF | Value | --- |

Press [Write Word] to complete writing register 0x0B

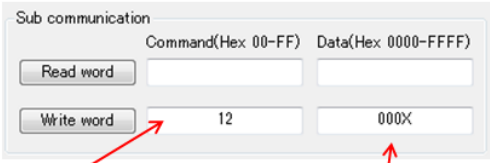



* This register accounts for the impedance track from the battery to Fuel Gauge. This impedance path can include: Protection IC's, long leads, and internal resistance.

## 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




| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x12 | Default or Alternative Type Select | R/W | 0x0000 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.

Table 1: Table of Battery Profiles and Types

| IC-Type | Nominal/Rated Voltage | Charging Voltage | Battery Type | Battery Profile |
|---|---|---|---|---|
| LC709203F-01 | 3.7 V | 4.2V | Type 01 | 301 |
| | 3.8V | 4.35V | Type 03 | |
| | Any Type | | Re-Scaling Required | |
| LC709203F-04 | Use only for UR-18650ZY (Panasonic) | | Type 04 | 504 |
| | Use only for ICR18650-26H (Samsung) | | Type 05 | |
| | Any Type | | Re-Scaling Required | |

## 4.6 Intialization of Battery Capacity

For best results initialize battery capacity.

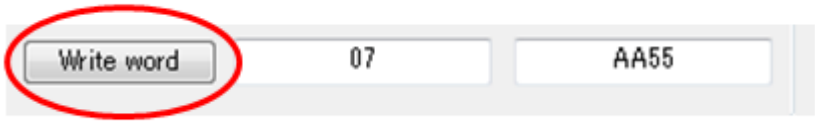
Do the following in the *Write Word Sub Communication* window

Input [07] in Command box

Input [AA55] in Data box


| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x07 | Initial RSOC | W | 0xAA55 | Value | --- |

Press [Write Word] to complete writing register 0x07




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

## 4.7 Thermistor Mode

The LC709203F has the option 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.*

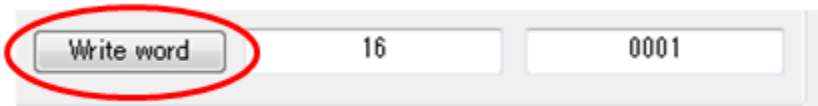
Do the follwing in Sub Communication window

Input [16] in Command box

Iinput [0001] in Data box


| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x16 | Status Bit | R/W | bit 0: Thermistor Mode<br>bit 1~15 : Reserved (fix 0) | O: disable<br>1: enable | 0x0000 |

Press [Write Word] to enable Thermistor



## 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 |

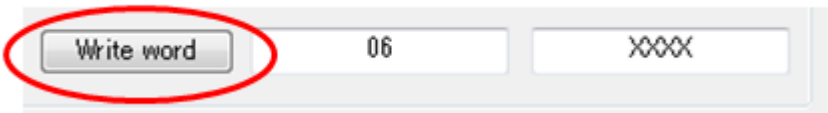
Do the follwing in Sub Communication window

Input [06] in Command box

Input [XXXX] in Data box

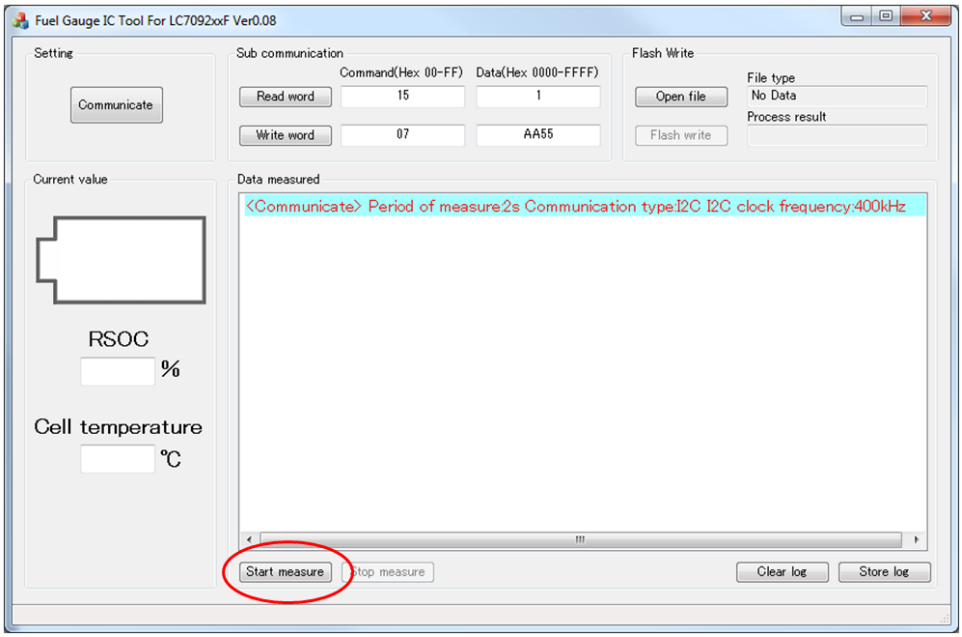

| Command Code | Slave Functions | Status | Range | Unit | Initial Value |
|---|---|---|---|---|---|
| 0x06 | Thermistor β | R/W | 0x0000 or 0xFFFF | β | 0x0D34 |

Press [Write Word] to assign Thermistor β constant

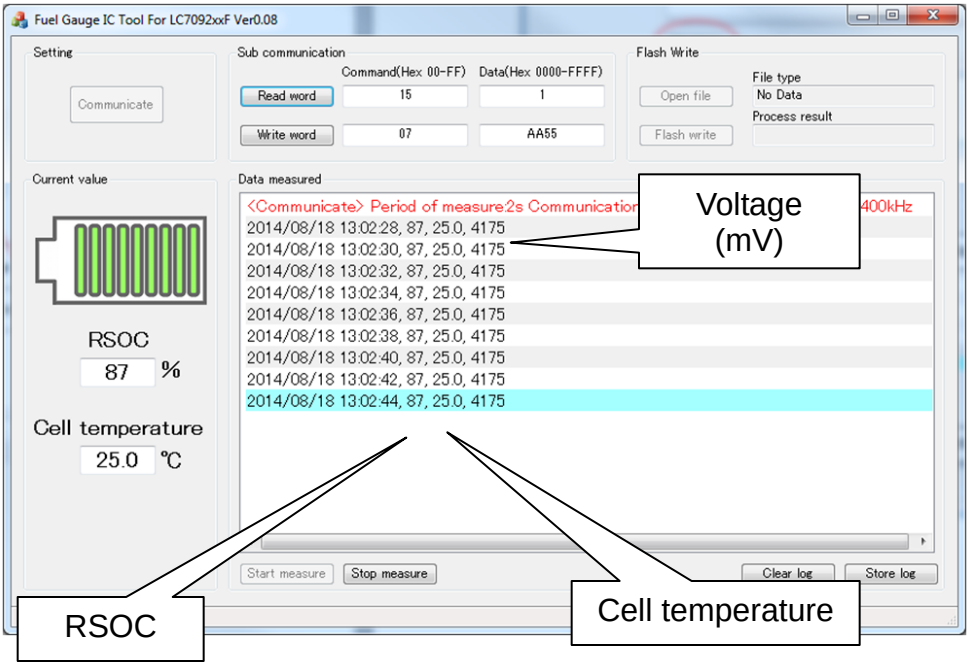


## 4.9 Start of Measurements

Press [Start Measure] to begin measurements




## 4.10 Sample Measurements




With a successful connection you will see screen as above

# 5 Graphical Analysis

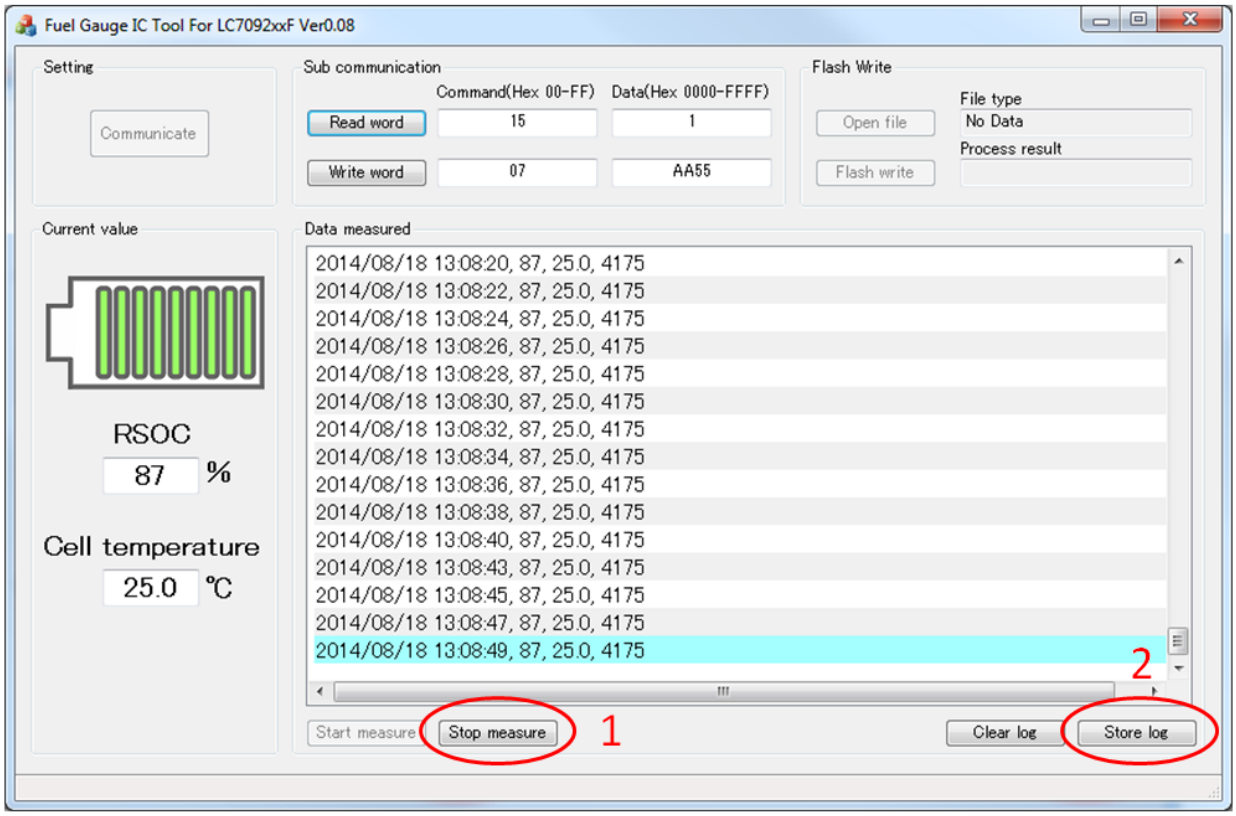
The LC709203F software has the option to save all measurements via a text file. Measured data can be converted in to excel format. Once in excel format, data can be plotted for analysis. A graph can give a great visual to see how the LC709203F tracks voltage and RSOC over time.

## 5.1 Storing Measured Data

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

Press [Stop measure]

Press [Store log]

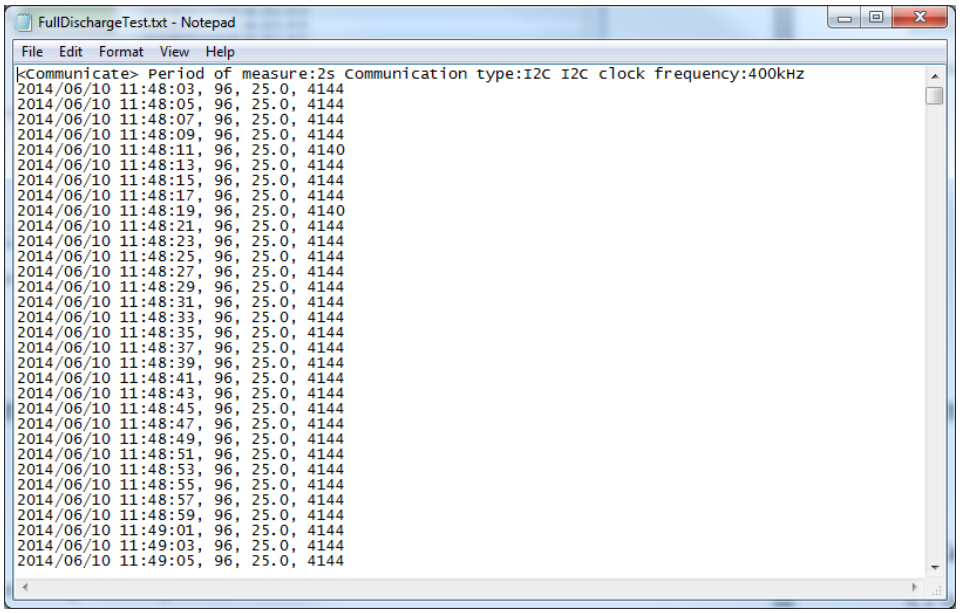



Measured Data becomes a txt file

Save Fuel Gauge Data *Example.txt*

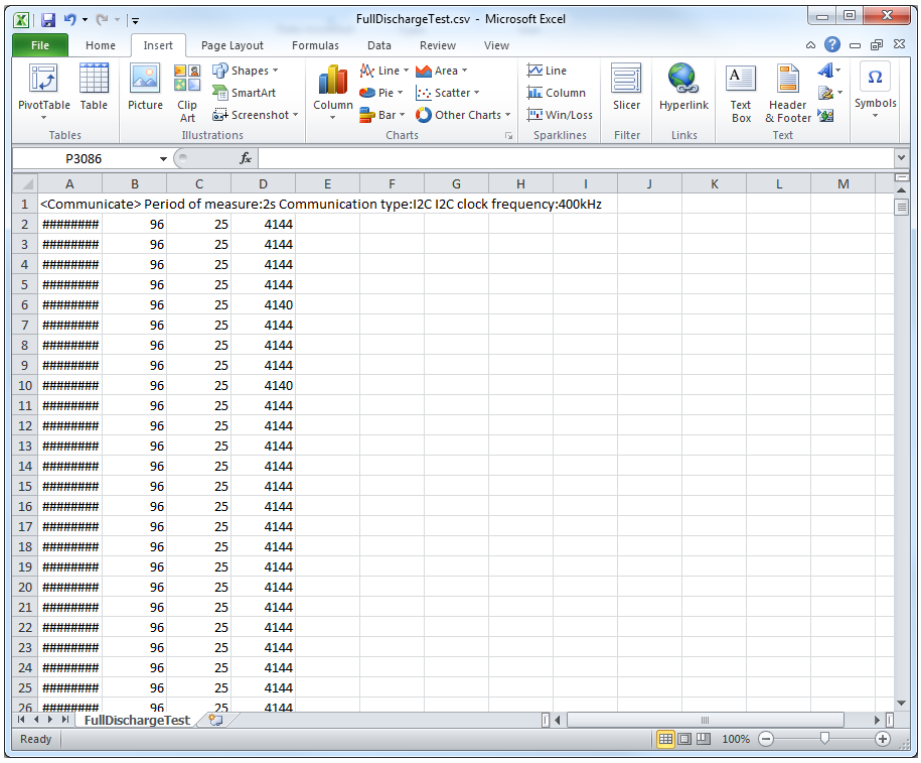
## 5.2 Converting Fuel Gauge Data

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



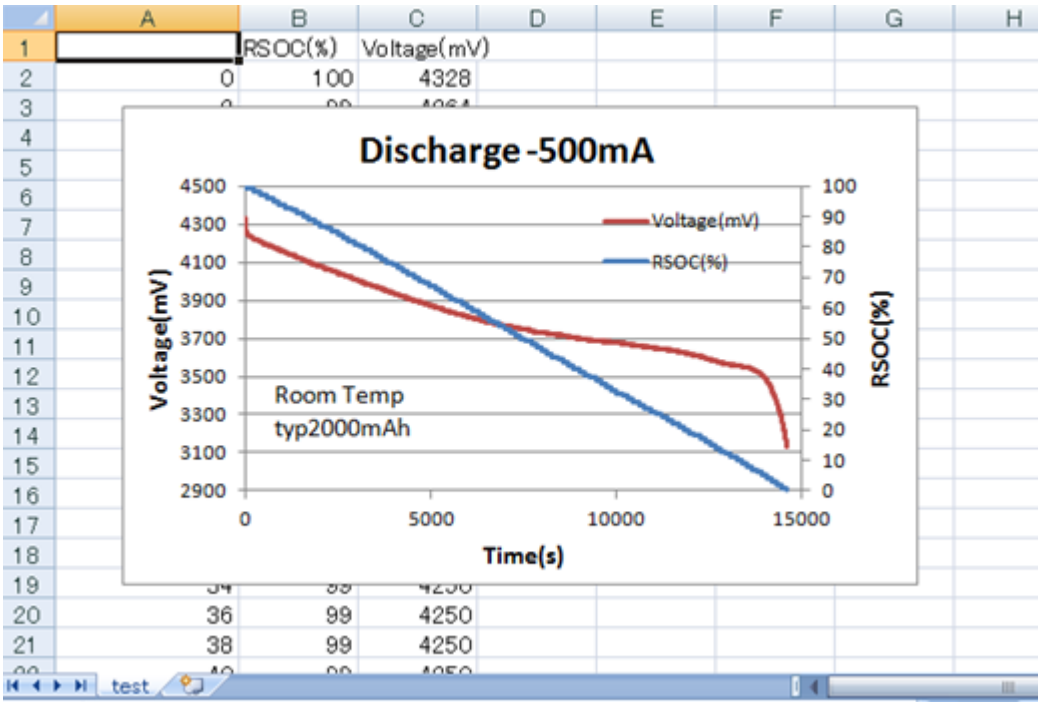

```
<Communicate> Period of measure:2s Communication type:I2C I2C clock frequency:400kHz
2014/06/10 11:48:03, 96, 25.0, 4144
2014/06/10 11:48:05, 96, 25.0, 4144
2014/06/10 11:48:07, 96, 25.0, 4144
2014/06/10 11:48:09, 96, 25.0, 4144
2014/06/10 11:48:11, 96, 25.0, 4140
2014/06/10 11:48:13, 96, 25.0, 4144
2014/06/10 11:48:15, 96, 25.0, 4144
2014/06/10 11:48:17, 96, 25.0, 4144
2014/06/10 11:48:19, 96, 25.0, 4140
2014/06/10 11:48:21, 96, 25.0, 4144
2014/06/10 11:48:23, 96, 25.0, 4144
2014/06/10 11:48:25, 96, 25.0, 4144
2014/06/10 11:48:27, 96, 25.0, 4144
2014/06/10 11:48:29, 96, 25.0, 4144
2014/06/10 11:48:31, 96, 25.0, 4144
2014/06/10 11:48:33, 96, 25.0, 4144
2014/06/10 11:48:35, 96, 25.0, 4144
2014/06/10 11:48:37, 96, 25.0, 4144
2014/06/10 11:48:39, 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 11:48:47, 96, 25.0, 4144
2014/06/10 11:48:49, 96, 25.0, 4144
2014/06/10 11:48:51, 96, 25.0, 4144
2014/06/10 11:48:53, 96, 25.0, 4144
2014/06/10 11:48:55, 96, 25.0, 4144
2014/06/10 11:48:57, 96, 25.0, 4144
2014/06/10 11:48:59, 96, 25.0, 4144
2014/06/10 11:49:01, 96, 25.0, 4144
2014/06/10 11:49:03, 96, 25.0, 4144
2014/06/10 11:49:05, 96, 25.0, 4144
```

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




| | A | B | C | D |
|---|---|---|---|---|
| 1 | <Communicate> Period of measure:2s Communication type:I2C I2C clock frequency:400kHz | | | |
| 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 |
| 21 | ######## | 96 | 25 | 4144 |
| 22 | ######## | 96 | 25 | 4144 |
| 23 | ######## | 96 | 25 | 4144 |
| 24 | ######## | 96 | 25 | 4144 |
| 25 | ######## | 96 | 25 | 4144 |
| 26 | ######## | 96 | 25 | 4144 |

## 5.3 Create a Graph




Graph Displays:

1) RSOC vs. Time

2) Voltage vs. Time

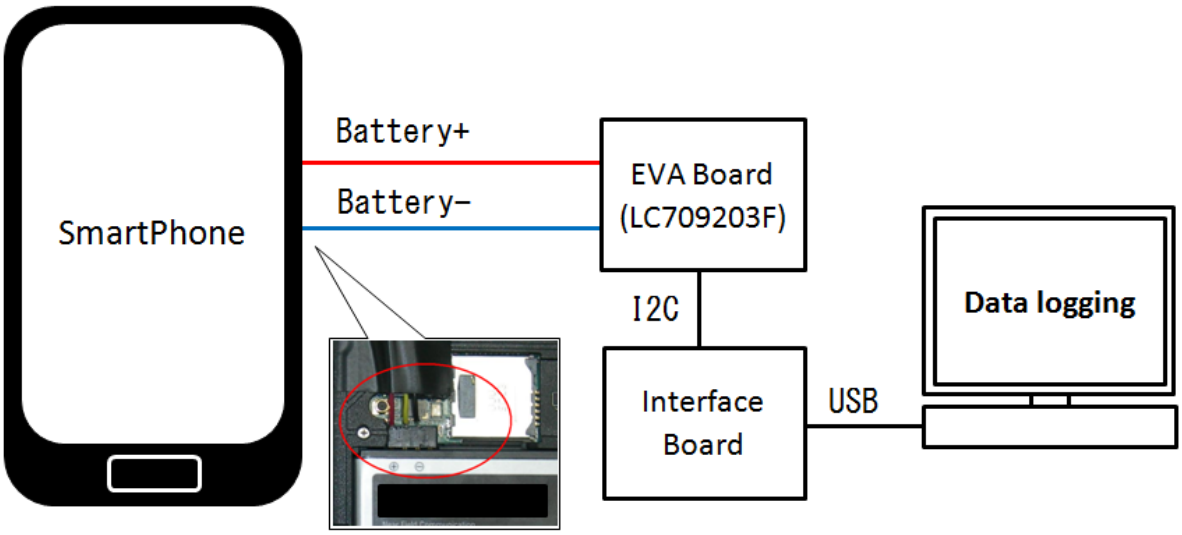
Graph gives a visual representation of how the LC709203F tracks battery voltage while discharging.

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

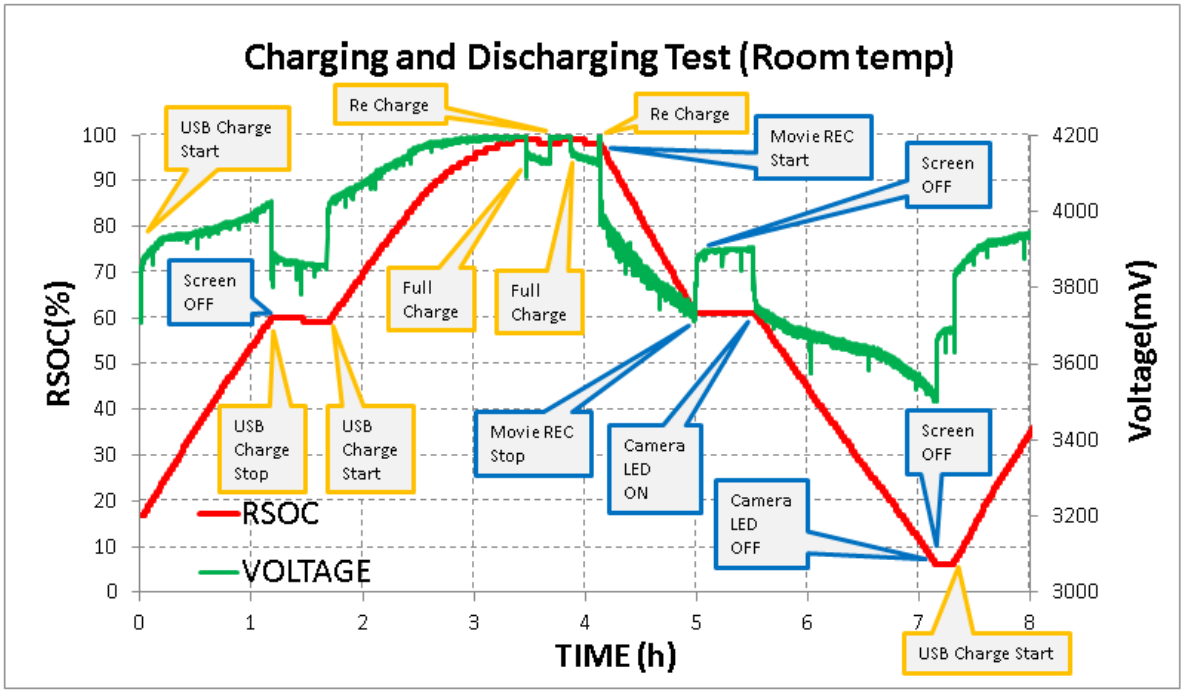
# 6. Smartphone Evaluation Example

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.

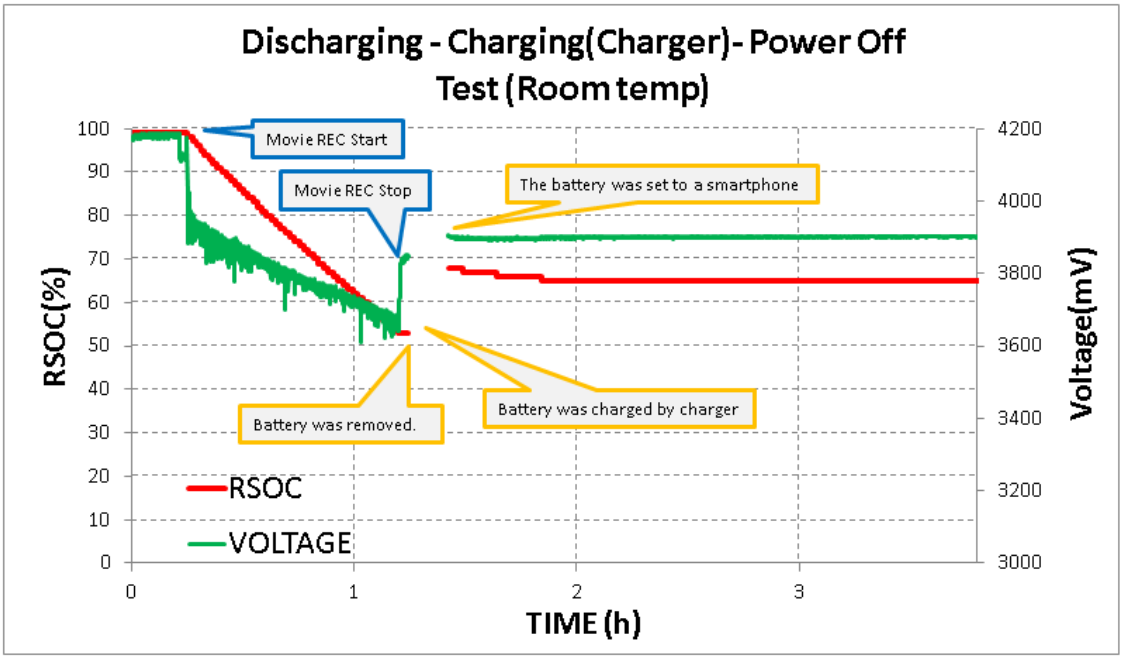
## 6.1 Block Diagram



## 6.2 Testing Results #1




## 6.3 Testing Results #2



Test Results

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 www.onsemi.com 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 |