

# Battery Sensing Solutions with NGK for 1-Cell Rechargeable Li-ion/LiPo Battery

## Oct. 2022

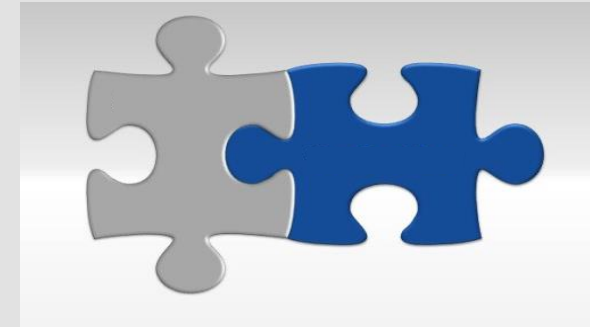
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# Support from NGK INSULATORS & onsemi

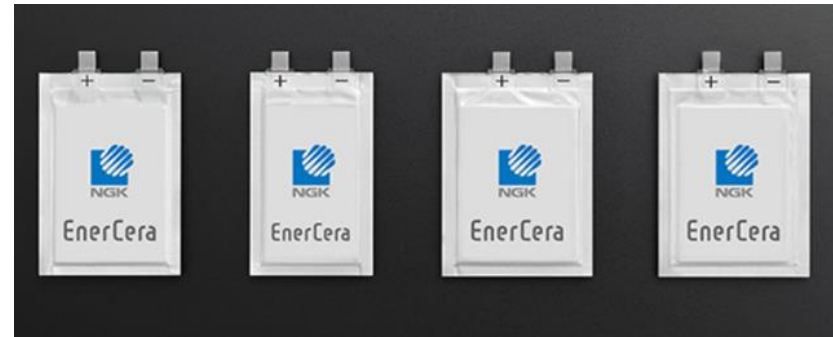
“Solutions from NGK & onsemi”

Provide qualified parameter/data in advance

- 1) Save time for qualifications
- 2) Reduce risks for replacement



+



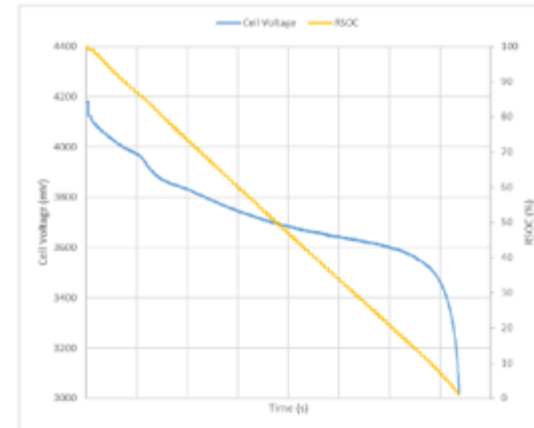
\* EnerCera is a products of NGK Insulators, Ltd. \*NGK EnerCera Lithium-ion battery image (used with permission from NGK Insulators, Ltd.)

# Support from NGK INSULATORS & onsemi

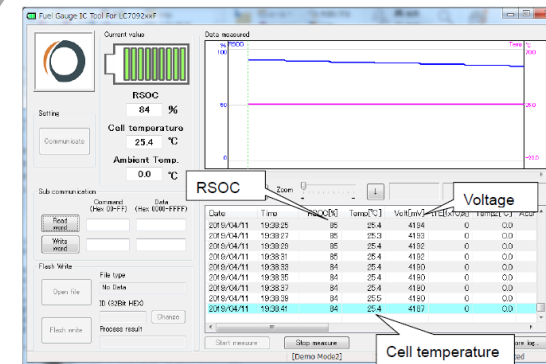
## Support for Customers

- Provide matching data with \*NGK EnerCera battery & onsemi Fuel Gauge IC which reduces qualification process
  - Tool can make it easier to qualify low power operation
  - \*NGK EnerCera & onsemi solutions contribute physically small size system
- \* EnerCera is a product of NGK Insulators, Ltd.

Graph the .csv file.



This graph shows association between time and cell voltage and RSOC in constant current discharging.

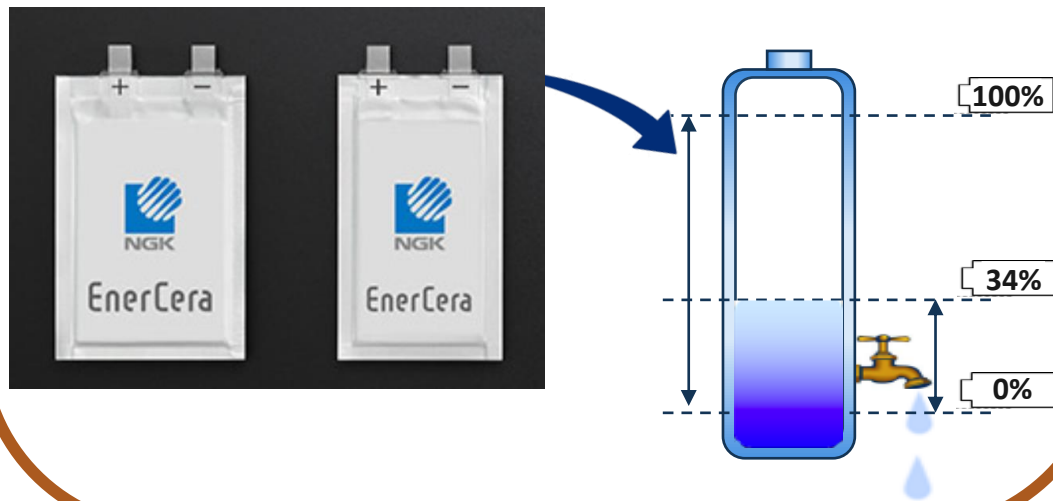


# Requirements and Role of Battery sensing solutions

## Requirements from power system

- High safety
- Long operating time

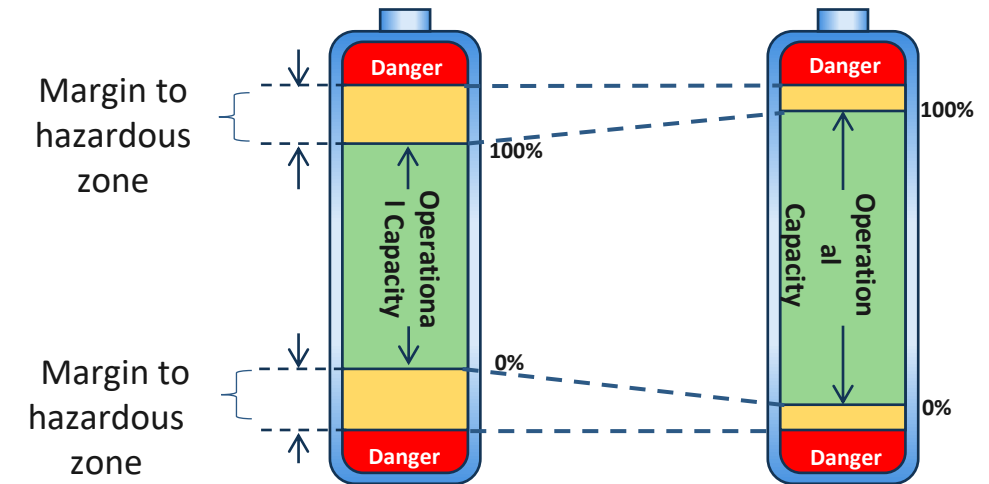
\*NGK EnerCera Lithium-ion battery image  
(used with permission from NGK Insulators, Ltd.)



## Role of the Battery sensing solution

- Keep **system safety**
- Support **efficient energy use**

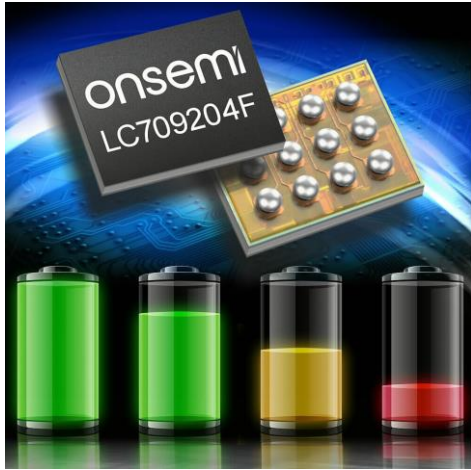
onsemi  
Battery  
sensing



## The function of Battery sensing

- Fuel gauge supports base report as RSOC
- Indicates status of battery voltage, temperature, and health

# onsemi Battery Sensing solution features



## Accurate Gauging

### Robust gauging under unstable conditions

Unique gauging methodology based on battery profile which is supported by chemical physics of composition in battery

## Very Low Power Consumption

### Extremely Low power consumption

Extremely low operational power consumption with optimized interval using “Dual Clock Architecture”

## No-current Sense Resistor

### Reduced BoM Count

No need for external current sensing resistor algorithm. Smaller footprint on PCB increases product designability and enhances cost benefits.

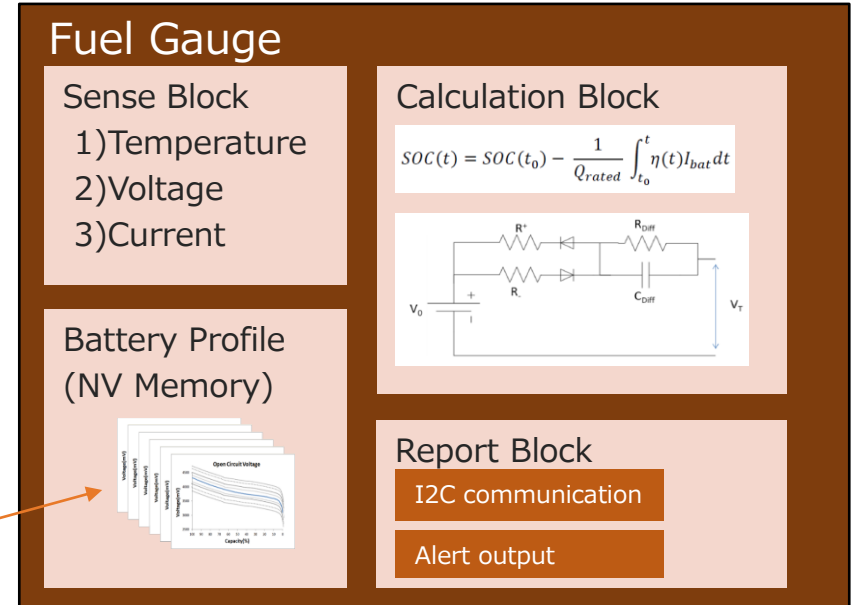
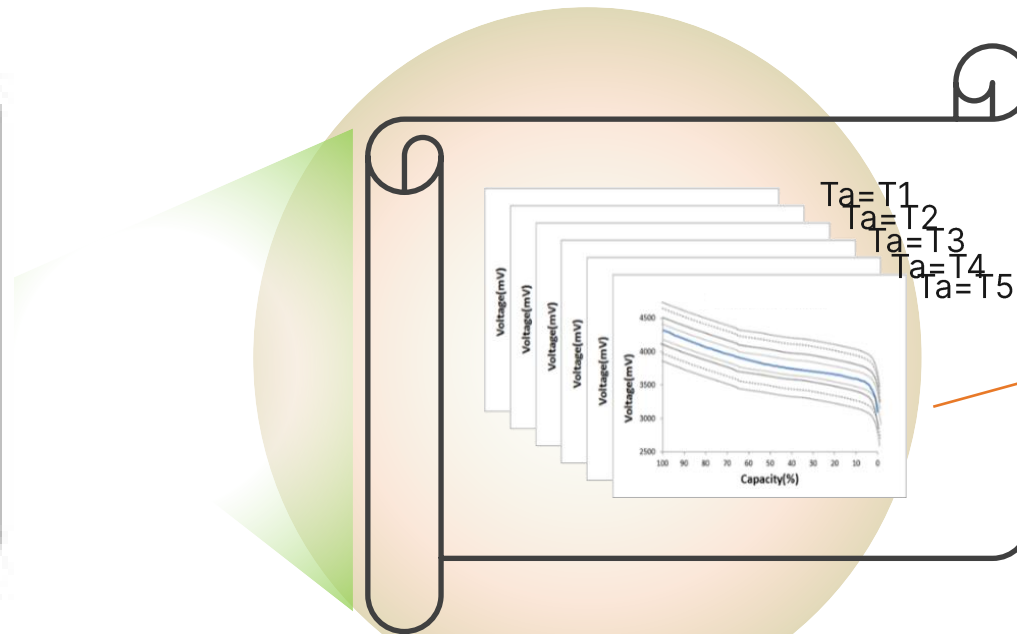
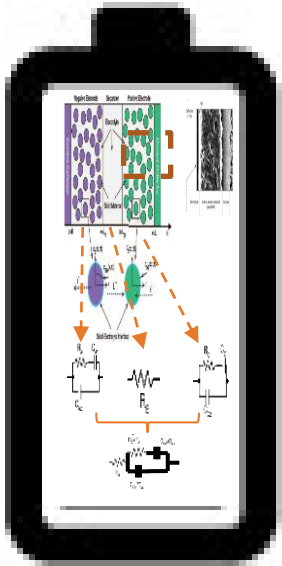
# Accurate Gauging

## onsemi solution uses:

- Battery profile consists of unique look-up tables with parameters based on actual measurement and battery chemistry
- Internal battery resistance to enable stable gauging accuracy under various conditions

## onsemi battery gauging is robust against:

- Battery aging from charge/discharge cycles
- Temperature fluctuation
- Charging voltage changes



Battery Profile Table supports  
 Several parameters  
 -Charge current, -Discharge current  
 -Temperature, -Voltage shift from OCV

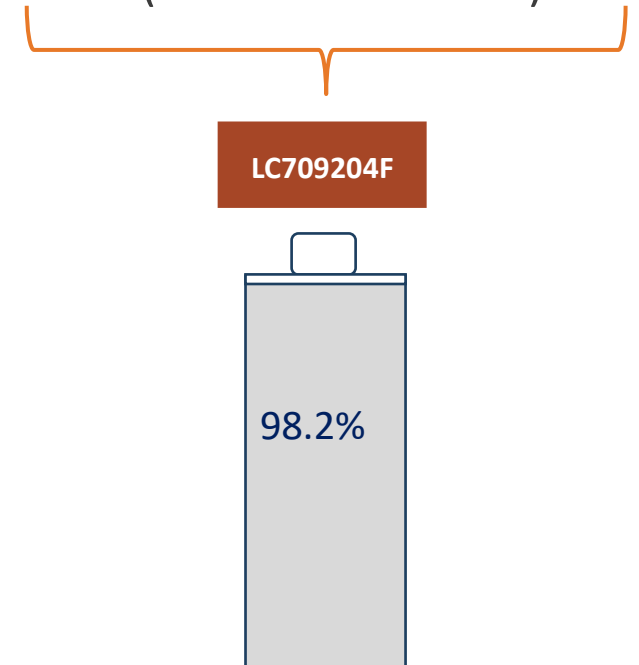
# Extremely Low Power Consumption

## Power Consumption

LC709204F	
Gauging Methodology	onsemi Technology
Supply Current (operation mode)	<u>2</u> $\mu$ A

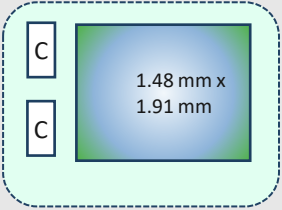
- LC709204F only consumes 2  $\mu$ A of operating current, noticeably lower
- Power consumptions at operational mode is extremely low

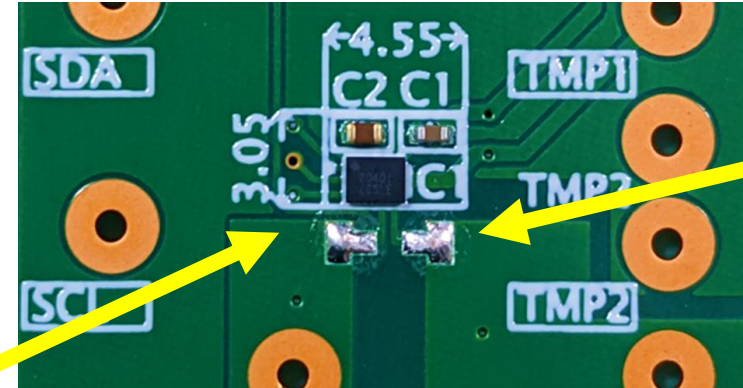
Remaining Battery, when an end-product is stored in a warehouse for 30 days (calculated values)



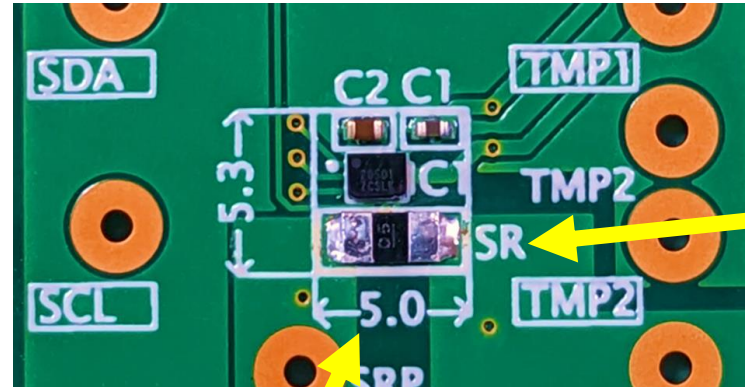
(80 mAh Battery)

# No-current Sense Resistor

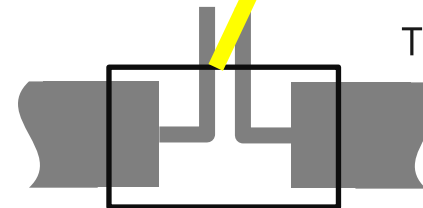
	<b>onsemi</b> <b>LC709204F</b>
Current Sensing Resistor	Not Required
External Part Count	Sense Resistor : 0 Resistor : 0 Capacitor : 2
Footprint Image	



No sense resistor



With sense resistor



Typical Current Sense Resistor (5 mΩ, 1%) :  
 PCB footprint: connection pattern

## Customer Benefits:

- No sense R becomes increasing important for wearables and small form factor applications.
- Its not just the sense R dimensions, the pcb footprint for the sense R is bigger than the sense R physical package dimensions.



# onsemi Battery Sensing base model LC709204F

onsemi  
LC709204  
F

## LC709204F

The standard model with the low power consumption and the small size in the industry, for safety and flexible size design, supports extensive enhanced alert functions

- External parts : 2pcs
- Lower Power : 2uA

## Enhanced battery monitor report

IC	LC709204F
Advanced	Rescaled RSOC
	Time to Empty
	Time to Full
Alarm	Ambient Temperature
	High/Low Voltage
	Low RSOC
	High/Low Temperature
Battery Lifetime	Estimated SOH
	Cycle Count
	Max/Min Cell Voltage
	Max/Min Cell Temperature
	Total Runtime
	Accumulated Temperature
	Accumulated RSOC

# Key Take Away

## onsemi Battery Sensing(Fuel Gauging) Solutions

**Accurate Gauging  
Robust Gauging under Unstable Battery Conditions**

**Extremely Low Power Consumption, Monitoring the Status of Operations**

**No-current Sense Resistor, Reduced BoM Count**

# Support and Collateral

Data Sheet  
[Click Here](#)

**Battery Fuel Gauge LSI [Smart LiB Gauge] for 1-Cell Lithium-ion/ Polymer (Li+) with Low Power 2  $\mu$ A Operation**

**ON Semiconductor**  
[www.onsemi.com](http://www.onsemi.com)

**LC709204F**

**Overview**

LC709204F is a Fuel Gauge for 1-Cell Lithium-ion/Polymer batteries. It is part of our Smart LiB Gauge family of Fuel Gauges which measure the battery RSOC (Relative State Of Charge) using its unique algorithm called HG-CVR2. The HG-CVR2 algorithm provides accurate RSOC information even under unstable conditions (e.g. changes of battery; temperature, loading, aging and self-discharge). An accurate RSOC contributes to the operating time of portable devices. The Fuel Gauge (in other words, Gas Gauge, Battery Monitor or Battery Gauge) feature of HG-CVR2 algorithm makes LSI highly applicable in various applications. The LSI can immediately start battery measurement by setting a few parameters after battery insertion. Learning cycles that make complicated manufacturing process of applications can be avoided.

The LSI also supports battery safety by alarm functions and SOH (State of Health) reporting to the application processor. The operating consumption current is very low 2  $\mu$ A and it is suitable for applications such as wearables and 1 series N parallel batteries.

**Features**

- HG-CVR2 Algorithm Technology
  - Small Footprint: No Need for Current Sensing Resistor
  - Accurate RSOC of Aging Battery
  - Stable Gauging by Automatic Convergence of Error
  - Immediate Accurate Gauging after Battery Insertion
  - Eliminates Learning Cycle
- Low Power Consumption
  - 2  $\mu$ A Operational Mode Current
- Improvement of the Battery Safety by Alarm Function
  - RSOC / Voltage / Temperature
- Battery Lifetime Measurement
  - SOH / Cycle Count / Operating Time
- Remaining Time Estimation
  - Time to Full / Time to Empty
- Three Temperature Inputs
  - Inputs to sense two NTC Thermistors
  - Via I<sup>2</sup>C
- Detection of Battery Operating Conditions
  - Charging / Discharging
- Detection of Battery Insertion
  - I<sup>2</sup>C Interface (supported up to 400 kHz)
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

**Applications**

- Wearables / IoT Devices
- Smartphones/PDA Devices
- Digital Cameras
- Portable Game Players
- USB-related Devices

**MARKING DIAGRAM**

204\*\* = 20401 (LC709204FXE-01TBG)  
 A = Assembly Site  
 WL = Wafer Lot Number  
 YW = Assembly Start Week

**ORDERING INFORMATION**

See detailed ordering and shipping information on page 20 of this data sheet.

**Applications**

- Wearables / IoT Devices
- Smartphones/PDA Devices
- Digital Cameras
- Portable Game Players
- USB-related Devices

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 September, 2019 - Rev. 0  
 Publication Order Number: LC709204F-D

App Note  
[Click Here](#)

**Battery Fuel Gauge [Smart LiB Gauge] for 1-Cell Lithium-ion/Polymer with LC709204F**

**ON Semiconductor**  
[www.onsemi.com](http://www.onsemi.com)

**AND9985/D**

**APPLICATION NOTE**

LC709204F is a Fuel Gauge for 1-Cell Lithium-ion/Polymer batteries. It is a part of our Smart LiB Gauge family of Fuel Gauges which measure the battery RSOC (Relative State Of Charge) using its unique algorithm called HG-CVR2. The HG-CVR2 algorithm provides accurate RSOC information even under unstable conditions (e.g. changes of battery; temperature, loading, aging and self-discharge).

This application note will explain how to initialize various parameters for the selected battery to start a higher accuracy gauging. Users can see various registers based on their application requirement using the notes, guidelines and examples given in this note. Sample program codes explained at the end of the note will provide various guidelines on how this device communicates with the host side application processors.

**Figure 1. An Example of an Application Schematic using LC709204F**

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 April, 2021 - Rev. 1  
 Publication Order Number: AND9985/D

Evaluation Board  
[Click Here](#)



LC709204FXE-N01-GEVB

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Test Procedure for LC709204FXE-N01-GEVB

## 1 Evaluation Kit

### 1.1 How to select Evaluation board

Select a suitable Evaluation board according to target device and your battery.

Evaluation board	Target device	Battery Type	Related documents
LC709204FXE-N01-GEVB	LC709204FXE-01TBG	EC01	LC709204FXE-01-GEVB_SCHEMATIC.pdf
		EC02	LC709204FXE-01-GEVB_GERBER.zip
		EC03	LC709204FXE-01-GEVB_BOM.pdf
		EC04	

# onsemi<sup>TM</sup>

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# Appendix

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# LC709204F Product Overview

## Battery Fuel Gauge with Low-Power 2 $\mu$ A Operation

Unique Features	Benefits
HG-CVR2: Unique gauging methodology based on battery's chemical composition	Highly accurate and robust RSOC gauging
2 $\mu$ A ultra low operating current	Energy efficient
Battery lifetime report	Provides system safety
Multi NTC thermistor sensing inputs	Monitors system/battery temperature
One-chip sensing without sensing resistor	PCB footprint area

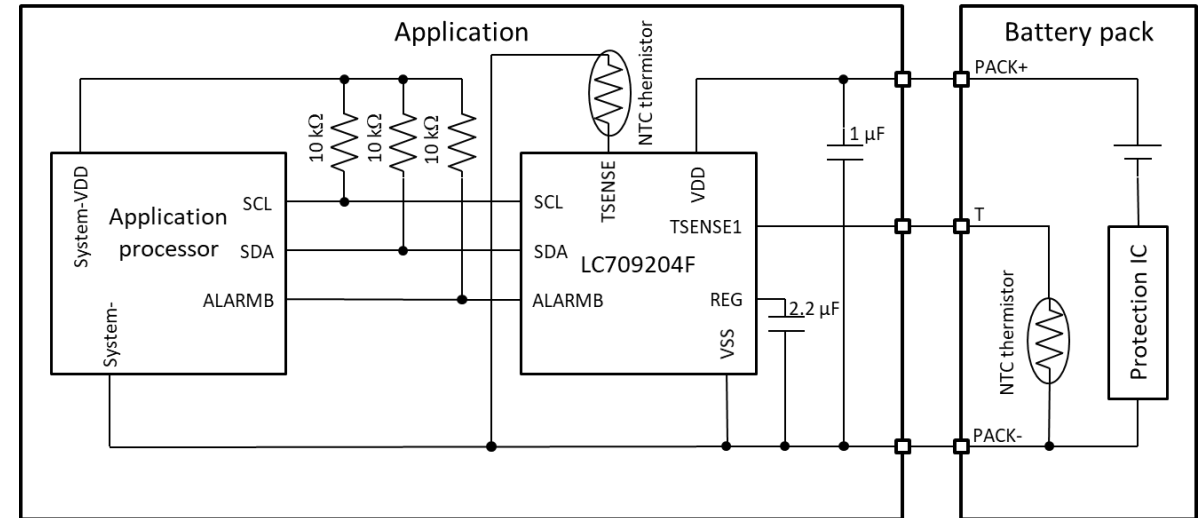
### Other Features

- Target battery type: 1-Cell Lithium-ion/Polymer. Pouch and Prism, Cylinder type
- Battery capacity range: Up to 6,500 mAh x Parallel cell number
- Alarms for high and low voltage, current, temperature, RSOC to the host using dedicated output
- Auto empty adjustment to protect the system from voltage drop of aged battery
- The maximum and minimum condition records for failure analysis
- I<sup>2</sup>C Interface (supported up to 400 kHz )
- 32 bits non volatile memory to be usable for any usage

### Markets & Applications

- Wearables
- Wireless headsets
- IoT devices
- Smartphones / PDA devices
- Portable game players
- USB-related devices

### Typical Application Schematic



### Ordering & Packaging Information

ONPN	Description	Package
LC709204FXE-01TBG	Battery Fuel Gauge LSI for 1-Cell Lithium-ion/Polymer (Li+) with Low-Power 2 $\mu$ A Operation	WLCSP12, 1.48x1.91x0.51



# onsemi Fuel Gauge Product

<b>Model</b>	<b>LC709204FXE</b>
<b>Algorithm</b>	HG-CVR2 <sup>*1</sup>
<b>Package</b>	WLCSP12
<b>Size</b>	1.48 mm x 1.91 mm x 0.51 mm
<b>Pin Pitch</b>	0.4 mm
<b>Max Voltage</b>	5.0 V
<b>Accuracy</b>	±2.0%
<b>Operating Idd</b>	2.0 µA
<b>Rescaling</b>	√
<b>Alarm</b>	5
<b>Sense Temperature</b>	2xNTC Thermistor , Host Reported
<b>Basic Report <sup>*2</sup></b>	√
<b>Advanced Report <sup>*3</sup></b>	√
<b>Battery Lifetime Report <sup>*4</sup></b>	√
<b>Current Report <sup>*5</sup></b>	Option <sup>*6</sup>
<b>User ID</b>	√
<b>Battery Embedded/Removal</b>	√
<b>Embedded Battery Profile</b>	5

**Notes:**

- \*1: HG-CVR2 - Increased look-up tables to increase the device gauging accuracy  
- Improved sampling timing to reduce the overall power consumption
- \*2: Basic Report - RSOC, Cell Voltage, Cell Temperature
- \*3: Advanced Report - Rescaled RSOC, Time to Empty, Time to Full, Ambient Temperature
- \*4: Battery Lifetime Report - Cycle Count, SOH(State of Health), Total Run Time
- \*5: Current Report - Remaining Capacity, FCC, Average Current, Dynamic Current
- \*6: Contact your onsemi FAE

# Alarms and Battery Lifetime Reporting

- LC709204F sends an alert to a host via an alarm function with little or no delay, when battery operating conditions exceed the parameters set up by the customer
- A record of historical data and stresses applied to the battery are logged in the battery lifetime report

IC	LC709204F
Advanced Reports	<ul style="list-style-type: none"> <li>• Rescaled RSOC</li> <li>• Time to Empty</li> <li>• Time to Full</li> <li>• Ambient Temperature</li> <li>• Battery Status</li> </ul>
Alarm Conditions	<ul style="list-style-type: none"> <li>• High/Low Voltage</li> <li>• Low RSOC</li> <li>• High/Low Temperature</li> <li>• Over-Charge/Discharge Current <sup>*1</sup></li> </ul>
Battery Lifetime Reports	<ul style="list-style-type: none"> <li>• SOH</li> <li>• Cycle Count</li> <li>• Max/Min Cell Voltage</li> <li>• Max/Min Cell Temperature</li> <li>• Total Runtime</li> <li>• Accumulated Temperature</li> <li>• Accumulated RSOC</li> <li>• Ave/Dynamic Cell Current <sup>*1</sup></li> <li>• Full Charge/Remaining Capacity <sup>*1</sup></li> </ul>

\*1. Optional. Please contact your onsemi FAE for details.



Thank you

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