Ordering number : ENA2173

# LC709202F

**CMOS LSI**

## 1-Cell Li+ (lithium-ion)

# Battery Monitor IC

ON Semiconductor®

http://onsemi.com

## Overview

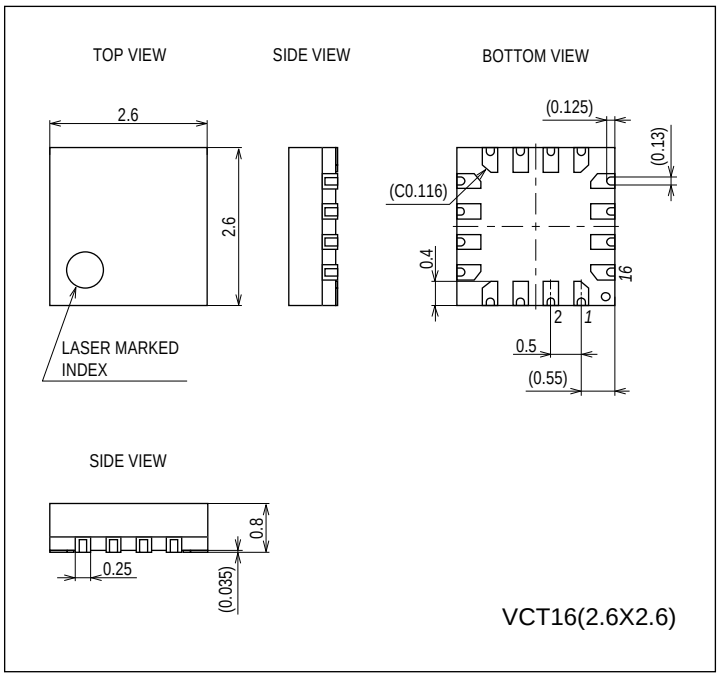
The LC709202F is an IC that measures the remaining power level of 1-cell lithium-ion (Li+) batteries used for a portable equipment etc.
This product is able to reduce a fuel gauge errors by implementing its unique correction technology for measurement value of battery temperature and voltage.
It is possible for this to realize high precision for measurement in battery power measurement IC that does not need a current sensing resistor. (±3% under certain conditions)

## Applications

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

## Package Dimensions

unit : mm (typ)
3318




VCT16(2.6X2.6)

## Features

■ Accuracy of remaining battery power level measurement
- ±3% (at an ambient operating temperature of 0°C to 50°C)
  Note: The accuracy above is the value of an experiment using the evaluation board.

■ Precision ±7.5mV/Cell Voltage Measurement

■ A current sensing resistor is unnecessary.

■ Alert function

■ Interface
- $I^2C$ Interface (up to 400 kHz supported)

■ Low power consumption
- Normal Mode : 15μA
- Sleep Mode : 0.1μA

■ Corresponding battery
- Model to be used depending on the material of the electrode of the battery pack + is different.
  LC709202F-01: ternary system
  LC709202F-02: nickelic acid

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

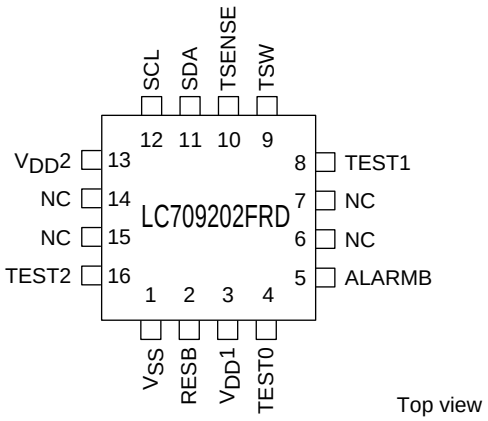
■ Ports

| | |
|---|---|
| • $I^2C$ 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) |
| • Reset pin | 1 (RESB) |
| • TEST pin | 3 (TEST0, TEST1, TEST2) |
| • Power supply pin | 3 ($V_{SS}$, $V_{DD}1$, $V_{DD}2$) |

■ Package form

• VCT16 (2.6×2.6) : Lead-free type

## Pin Assignment



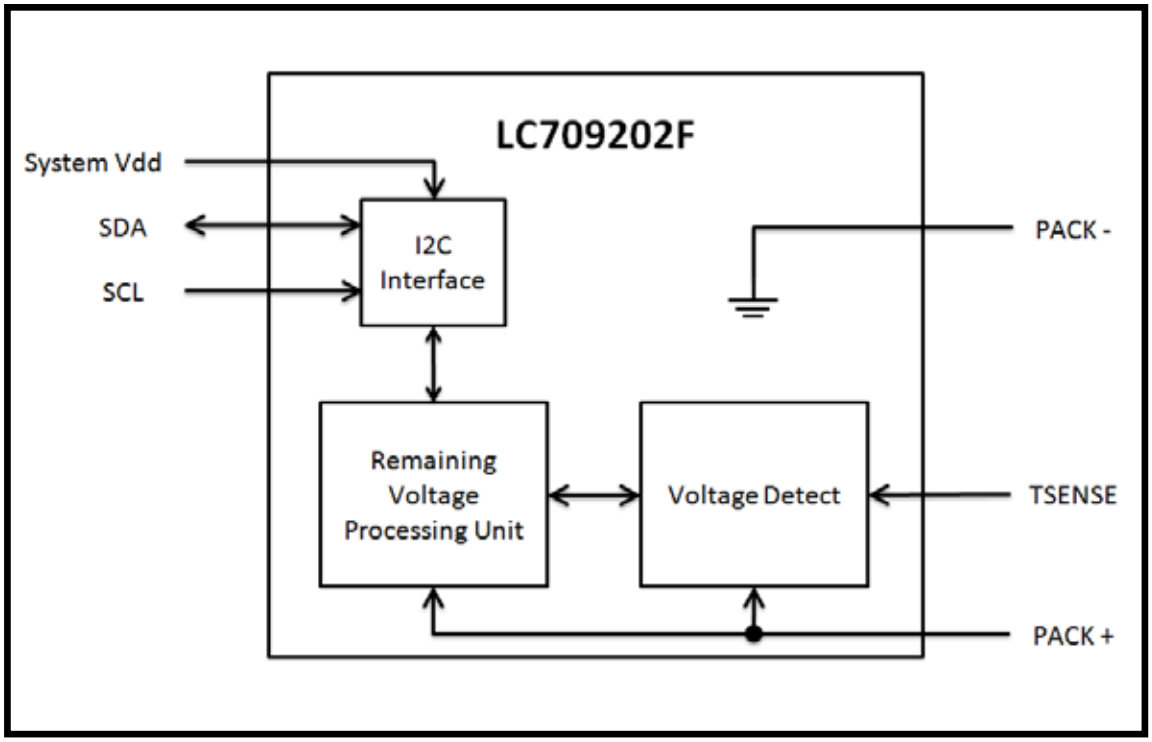

Top view

VCT16 (2.6×2.6) “Lead-free Type”

## Pin Function

| VCT16 | Pin Name | I/O | Description |
|---|---|---|---|
| 1 | $V_{SS}$ | - | Connect to the - terminal of the battery. |
| 2 | RESB | I | Reset pin |
| 3 | $V_{DD}1$ | - | Connect to the + terminal of the battery. |
| 4 | TEST0 | I | Test pin<br>*Connect to $V_{SS}$. |
| 5 | ALARMB | O | Alert indication. An active low output used to indicate specified condition thresholds have been met.<br>*When you do not use an alert function, please connect with $V_{SS}$. |
| 8 | TEST1 | O | Set “OPEN” |
| 9 | TSW | O | Battery temperature reading control pin<br>*Set high when reading in the temperature, held low at other times. |
| 10 | TSENSE | I | Battery temperature analog voltage input pin |
| 11 | SDA | I/O | $I^2C$ data pin |
| 12 | SCL | I/O | $I^2C$ clock pin |
| 13 | $V_{DD}2$ | - | + power pin for $I^2C$-Bus communication pin(SDA,SCL) |
| 16 | TEST2 | O | Set “OPEN” |

## Block Diagram



## 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 | $V_{DD}1$, $V_{DD}2$ | | | -0.3 | | +6.5 | V |
| Input voltage | $V_I$ (1) | RESB, TSENSE | | | -0.3 | | $V_{DD}1$ +0.3 | |
| Output voltage | $V_O$ (1) | TSW | | | -0.3 | | $V_{DD}1$ +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 | VCT16 | Ta=-40 to+85°C | | | | 55 | mW |
| Operating ambient temperature | Topr | | | | -40 | | +85 | °C |
| Storage ambient temperature | Tstg | | | | -55 | | +125 | |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

## 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) | $V_{DD}1$ | | | 2.5 | | 4.5 | V |
| High level input voltage | $V_{IH}$ (1) | TSENSE | | 2.5 to 4.5 | 0.70$V_{DD}1$ | | $V_{DD}1$ | |
| | $V_{IH}$ (2) | RESB | | 2.5 to 4.5 | 0.75$V_{DD}1$ | | $V_{DD}1$ | |
| | $V_{IH}$ (3) | SDA, SCL | $V_{DD}2$=1.6V to 5.5V | 2.5 to 4.5 | 0.70$V_{DD}2$ | | $V_{DD}2$ | |
| Low level input voltage | $V_{IL}$ (1) | TSENSE | | 2.5 to 4.5 | $V_{SS}$ | | 0.25$V_{DD}1$ | |
| | $V_{IL}$ (2) | RESB | | 2.5 to 4.5 | $V_{SS}$ | | 0.25$V_{DD}1$ | |
| | $V_{IL}$ (3) | SDA, SCL | $V_{DD}2$=1.6V to 5.5V | 2.5 to 4.5 | $V_{SS}$ | | 0.30$V_{DD}2$ | |

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

| Parameter | Symbol | Pin/Remarks | Conditions | | Specification | | | Unit |
|---|---|---|---|---|---|---|---|---|
| | | | | $V_{DD}$[V] | min | typ | max | |
| High level input current | $I_{IH}$ (1) | RESB | $V_{IN}$=$V_{DD}$1 (including output transistor off leakage current) | 2.5 to 4.5 | | | 1 | μA |
| | $I_{IH}$ (2) | SDA, SCL | $V_{IN}$=$V_{DD}$2 $V_{DD}$2=1.6V to 5.5V (including output transistor off leakage current) | 2.5 to 4.5 | | | 1 | |
| Low level input current | $I_{IL}$ (1) | RESB | $V_{IN}$=$V_{SS}$ (including output transistor off leakage current) | 2.5 to 4.5 | -1 | | | |
| | $I_{IL}$ (2) | SDA, SCL | $V_{IN}$=$V_{SS}$ $V_{DD}$2=1.6V to 5.5V (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) | RESB | | 2.5 to 4.5 | | 0.1$V_{DD}$1 | | |
| | VHYS(2) | SDA, SCL | | 2.5 to 4.5 | | 0.1$V_{DD}$2 | | |
| Pin capacitance | CP | All pins | Pins other than the pin under test $V_{IN}$=$V_{SS}$ Ta=25°C | 2.5 to 4.5 | | 10 | | pF |
| Consumption current (Note 1) | $I_{DD}$ (1) | $V_{DD}$1 | Normal Mode | 2.5 to 4.5 | | 15 | 26 | μA |
| | $I_{DD}$ (2) | | Auto Mode | 2.5 to 4.5 | | 2 to 15 | 4 to 26 | |
| | $I_{DD}$ (3) | | Sleep Mode | 2.5 to 4.5 | | 0.1 | 5 | |
| Voltage measurement accuracy | $V_{ME}$ (1) | $V_{DD}$1 | 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

**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<br>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. | 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 + 0.1$C_B$ | 300 | ns |
| Clock/data rise time | TR | SCL, SDA | | 20 + 0.1$C_B$ | 300 | ns |

2.5 to 4.5

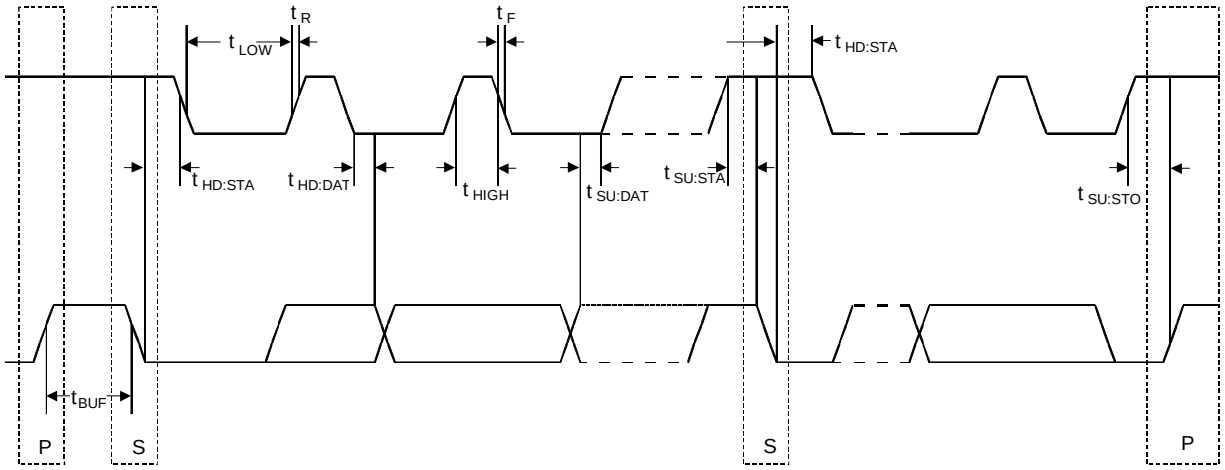



Figure 1 I²C Timing

## Discharge Characteristics

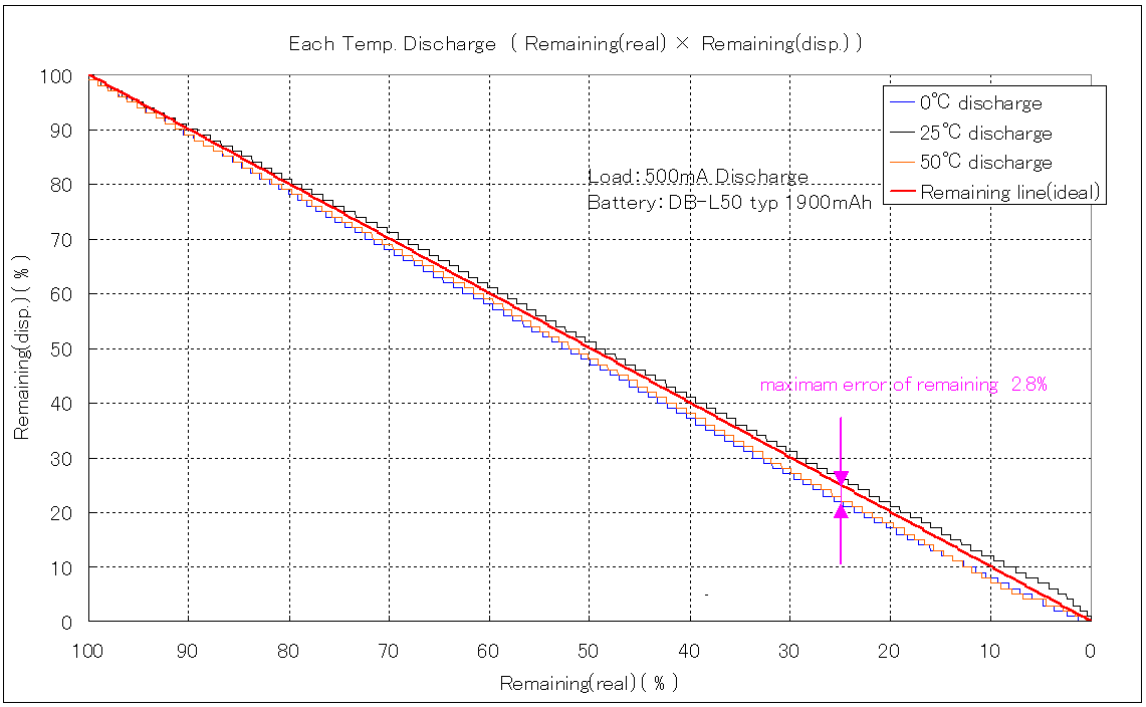



Figure 2 Discharge Characteristics by Temperature Change

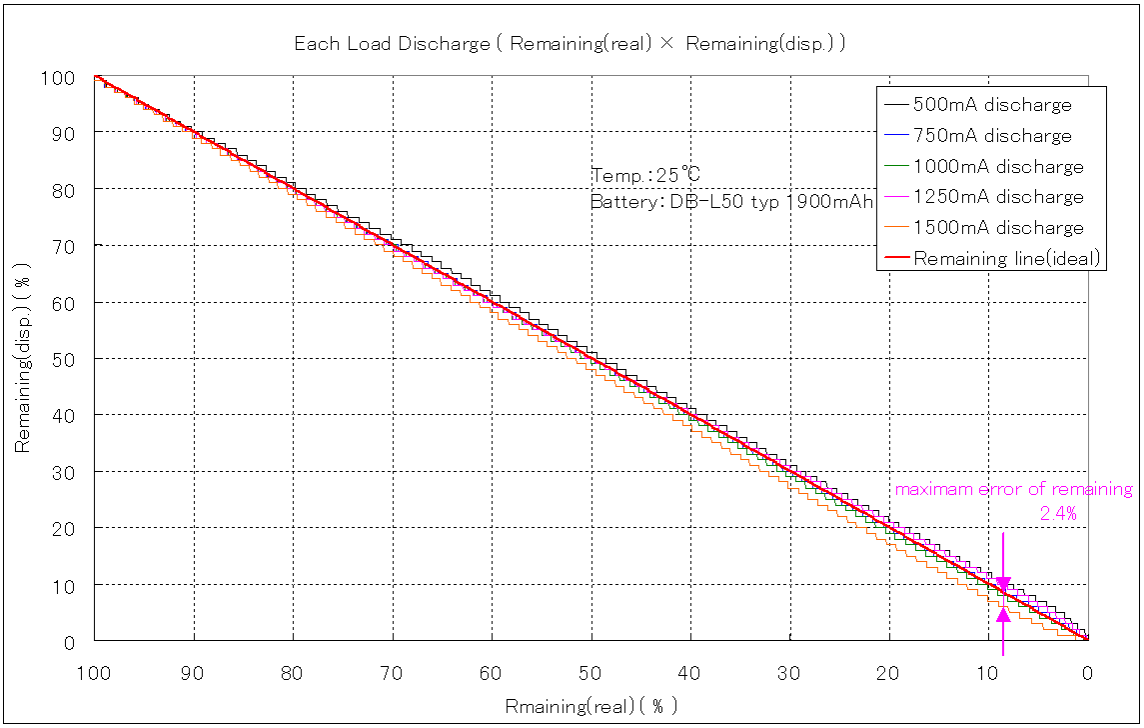



Figure 3 Discharge Characteristics by Load Change

## Communication Protocol

Communication protocol type: $I^2C$
Frequency: 400 kHz
Address: 0x16

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 | | | |

Write Word Protocol

| | | | | | | |
|---|---|---|---|---|---|---|
| S | Slave Address | Wr | A | Command Code | A | … |
| Data Byte Low | A | Data Byte High | A | CRC-8 | A | P |

| Access | Slave Functions | Command Code | Range | | Unit |
|---|---|---|---|---|---|
| Read | Cell Temperature | 0x08 | 0 to 65535 | | 0.1°K (0.0°C= 2732) |
| | Cell Voltage | 0x09 | 0 to 65535 | | mV |
| | Current | 0x0A | -32768 to 32767 | | mA |
| | Adjustment Pack 8 | 0x0B | 0 to 255 | | Value |
| | Relative State Of Charge | 0x0D | 0 to 100 | | % |
| | Remaining Capacity | 0x0F | 0 to 1000 | | mAh |
| | Full Charge Capacity | 0x10 | 1000 | | mAh |
| | IC Version | 0x11 | 0 to 65535 | | Version |
| | Adjustment Thermistor | 0x12 | 0 to 255 | | Value |
| | Hot Start | 0x13 | bit 0 | | disable: 0 or enable: 1 |
| | Sleep Mode | | bit 1 | | |
| | Auto Mode | | bit 2 | | |
| | Alarm Low Battery | 0x14 | High : | 0 to 250 | 20mV |
| | | | Low : | 0 to 100 | % |
| | Adjustment B | 0x15 | 0 to 65535 | | B |
| | System Mode | 0x16 | bit 0to3 : | data 0 | Nomal Mode |
| | | | | data 1 | Sleep Mode |
| | | | | data 2 | Auto Mode |
| | | | bit 4to7 : data 0 to 6 | | Auto deep |
| Write | Adjustment Pack 0 | 0x00 | 0 to 32767 | | Value |
| | Adjustment Pack 1 | 0x01 | 0 to 32767 | | Value |
| | Adjustment Pack 2 | 0x02 | 0 to 32767 | | Value |
| | Adjustment Pack 3 | 0x03 | 0 to 32767 | | Value |
| | Adjustment Pack 4 | 0x04 | 0 to 32767 | | Value |
| | Adjustment Pack 5 | 0x05 | 0 to 32767 | | Value |
| | Set Relative State Of Charge | 0x08 | High : | 0xA5 | - |
| | | | Low : | 0 to 100 | % |
| | Adjustment Pack 8 | | High : | 0x5A | - |
| | | | Low : | 0 to 255 | Value |
| | Adjustment Thermistor | | High : | 0xAA | - |
| | | | Low : | 0 to 255 | Value |
| | Hot Start | | High : 0x55 | Low : bit 0 | disable: 0 or enable: 1 |
| | Sleep Mode | | | Low : bit 1 | |
| | Auto Mode | | | Low : bit 2 | |
| | Initial Relative State Of Charge | 0x09 | 0xAA55 | | - |
| | Alarm Low Battery | 0x0A | High : | 0 to 250 | 20mV(activate under) |
| | | | Low : | 0 to 100 | % (activate under) |
| | Adjustment B | 0x0B | 0 to 65535 | | B |
| | Cell Temperature | 0x0C | 2532 to 3332 (I2C Write Mode) | | 0.1°K (0.0°C= 2732) |
| | | | 0xAA55 (Thermistor Mode) | | - |

## Application Circuit Example

Figure 4 Example of an application schematic using LC709202F
(not use temperature detection function)

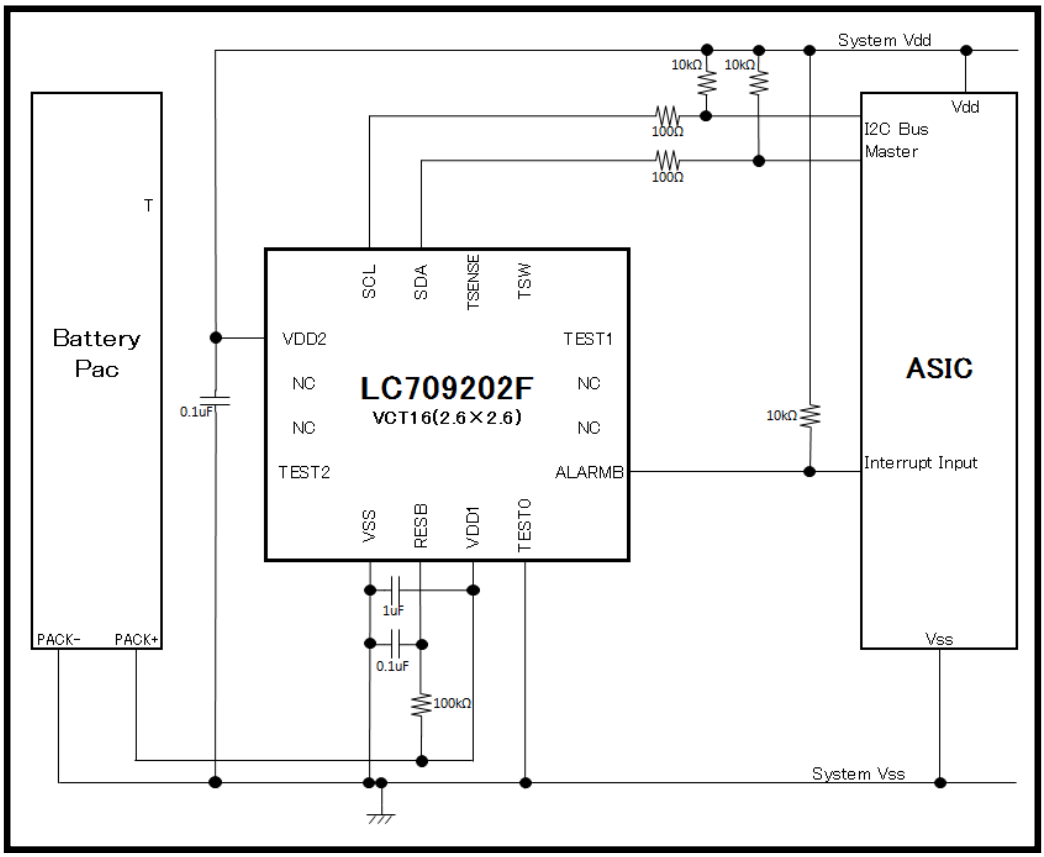
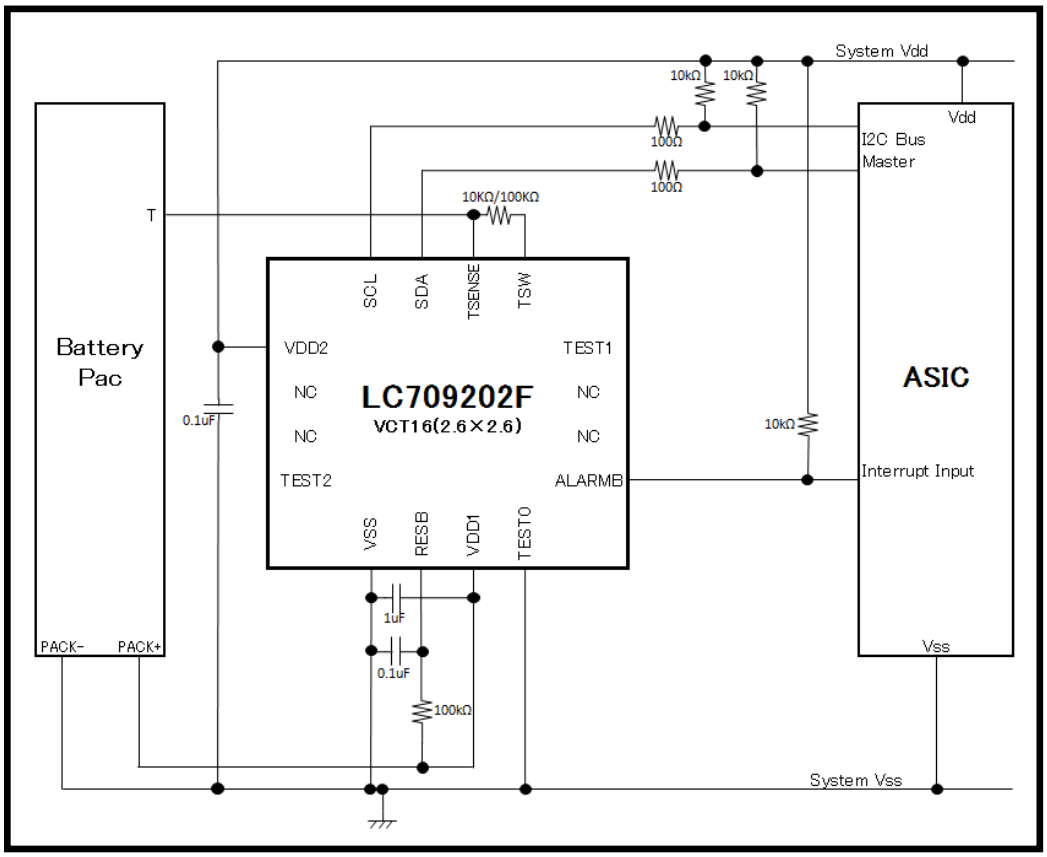



Figure 5 Example of an application schematic using LC709202F
(use temperature detection function)



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