



**SANYO Semiconductors**

# DATA SHEET

An ON Semiconductor Company

## LC709201F — CMOS IC Battery Monitor IC

### Overview

The LC709201F is an IC that measures the remaining power level of 1-cell lithium-ion secondary batteries by monitoring the battery voltage without an external sense resistor, and detects the remaining battery power level by current prediction. It monitors the battery voltage and realizes a function that precisely measures the remaining battery charge. In addition, the IC realizes the function for calculating the remaining battery power level even more accurately by utilizing a temperature correction function that makes use of the temperature input from a thermistor.

### Features

- Accuracy of remaining battery power level measurement
  - Accuracy of  $\pm 5\%$  during discharging from 100% to 0% (at an ambient operating temperature of 0°C to 50°C)
- Measurement of remaining battery power level
  - The remaining power level is measured four times a second and calculated with each measurement undertaken.
- Interface
  - I<sup>2</sup>Cbus, communication in slave mode up to 100kHz supported
- Ports
 

|  |              |
|--|--------------|
| • I <sup>2</sup> C-bus communication pin           | 2 (SDA, SCL) |
| • Battery temperature reading control pin          | 1 (TSW)      |
| • Analog voltage input pin for battery temperature | 1 (TSENSE)   |
| • Reset pin  | 1 (RESB)     |
| • TEST pin   | 1 (TEST)     |
| • Power supply pin                                 | 2 (VSS, VDD) |
- Package form
  - MFP10S (225 mil): LC709201FM-01/02/03
  - VCT16 (2.6×2.6): LC709201FRD-01/02/03

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# LC709201F

## Applications

- Cell phones, PDA devices, MP3 players, cordless phones, digital cameras, USB-related devices, etc.

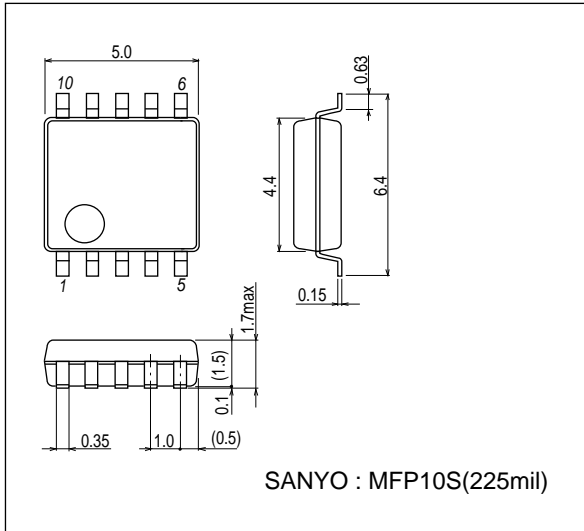
(Note) Depending on the kinds of battery, applicable model differs (LC709201F-01/02/03).

Please contact us for more detail information.

## Package Dimensions

unit : mm (typ)

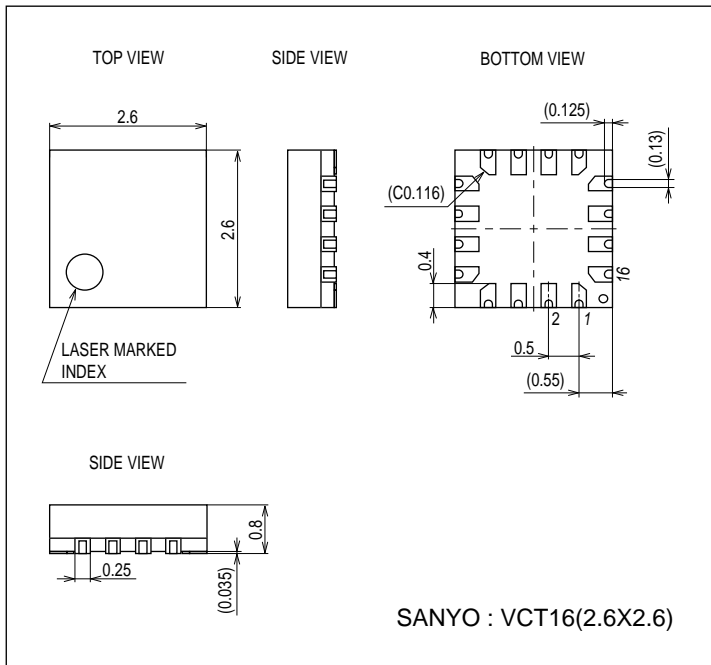
3086B



## Package Dimensions

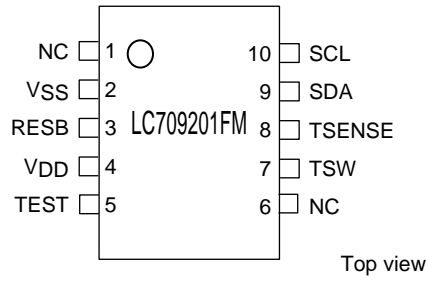
unit : mm (typ)

3318

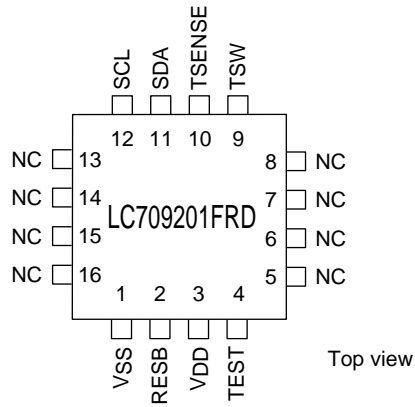


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## Pin Assignment

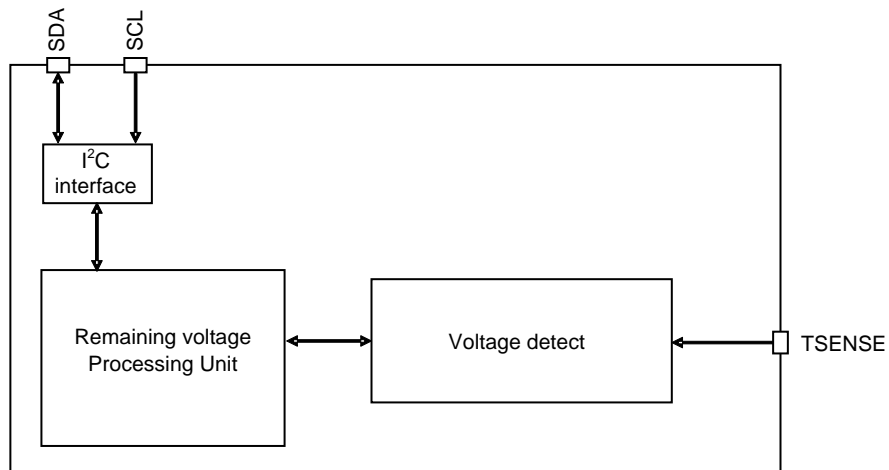


SANYO: MFP10S (225mil) "Lead-free Type"



SANYO: VCT16 (2.6x2.6) "Lead-free Type"

Block Diagram



Pin Function

| Pin Name        | I/O | Description  |
|-----------------|-----|--|
| V <sub>SS</sub> | -   | - power pin  |
| V <sub>DD</sub> | -   | + power pin  |
| RESB            | I   | Reset pin  |
| TEST            | I/O | Test pin<br>*Connect an external 100kΩ pull-down resistor.   |
| SDA             | I/O | I <sup>2</sup> C data pin  |
| SCL             | I/O | I <sup>2</sup> C clock pin   |
| TSW             | O   | Battery temperature reading control pin<br>*Set high when reading in the temperature, held low at other times. |
| TSENSE          | I   | Battery temperature analog voltage input pin   |

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## Absolute Maximum Ratings at Ta=25°C, VSS=0V

| Parameter                     | Symbol              | Pin/Remarks     | Conditions      | Specification       |      |     | Unit                 |     |
|-------------------------------|---------------------|-----------------|-----------------|---------------------|------|-----|----------------------|-----|
|                               |                     |                 |                 | V <sub>DD</sub> [V] | min  | typ |                      | max |
| Maximum supply voltage        | V <sub>DD</sub> max | V <sub>DD</sub> |                 |                     | -0.3 |     | +6.5                 | V   |
| Input voltage                 | V <sub>I</sub> (1)  | RESB, TSENSE    |                 |                     | -0.3 |     | V <sub>DD</sub> +0.3 |     |
| Output voltage                | V <sub>O</sub> (1)  | TSW             |                 |                     | -0.3 |     | V <sub>DD</sub> +0.3 |     |
| Input/output voltage          | V <sub>IO</sub> (1) | SDA, SCL, TEST  |                 |                     | -0.3 |     | V <sub>DD</sub> +0.3 |     |
| Allowable power dissipation   | Pd max              | MFP10S          | Ta=-40 to +85°C |                     |      |     | 110                  | mW  |
|                               |                     | VCT16           |                 |                     |      |     | 55                   |     |
| Operating ambient temperature | Topr                |                 |                 |                     | -40  |     | +85                  | °C  |
| Storage ambient temperature   | Tstg                |                 |                 |                     | -55  |     | -125                 |     |

## Allowable Operating Conditions at Ta=-40 to +85°C, VSS=0V

| Parameter                | Symbol              | Pin/Remarks     | Conditions | Specification       |                         |     | unit                    |     |
|--------------------------|---------------------|-----------------|------------|---------------------|-------------------------|-----|-------------------------|-----|
|                          |                     |                 |            | V <sub>DD</sub> [V] | min                     | typ |                         | max |
| Operating supply voltage | V <sub>DD</sub> (1) | V <sub>DD</sub> |            |                     | 2.25                    |     | 5.5                     | V   |
| High level input voltage | V <sub>IH</sub> (1) | SDA, SCL        |            | 2.25 to 5.5         | 0.3V <sub>DD</sub> +0.7 |     | V <sub>DD</sub>         |     |
| Low level input voltage  | V <sub>IL</sub> (1) | SDA, SCL        |            | 4.0 to 5.5          | V <sub>SS</sub>         |     | 0.1V <sub>DD</sub> +0.4 |     |
|                          | V <sub>IL</sub> (2) |                 |            | 2.25 to 4.0         | V <sub>SS</sub>         |     | 0.2V <sub>DD</sub>      |     |

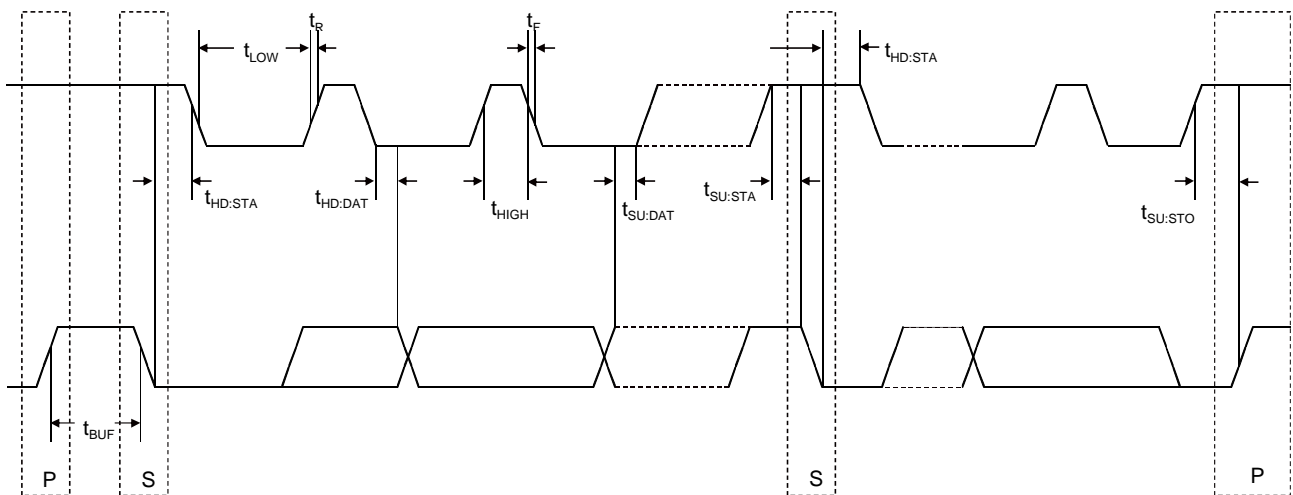
## Electrical Characteristics at Ta=-40 to +85°C, VSS=0V

| Parameter                 | Symbol              | Pin/Remarks     | Conditions   | Specification       |                      |                    | Unit |     |
|---------------------------|---------------------|-----------------|--|---------------------|----------------------|--------------------|------|-----|
|                           |                     |                 |  | V <sub>DD</sub> [V] | min                  | typ                |      | max |
| High level input current  | I <sub>IH</sub> (1) | RESB, SDA, SCL  | V <sub>IN</sub> =V <sub>DD</sub><br>(including output transistor off leakage current)        | 2.25 to 5.5         |                      |                    | 1    | μA  |
| Low level input current   | I <sub>IL</sub> (1) | RESB, SDA, SCL  | V <sub>IN</sub> =V <sub>SS</sub><br>(including output transistor off leakage current)        | 2.25 to 5.5         | -1                   |                    |      |     |
| High level output voltage | V <sub>OH</sub> (1) | TSW             | I <sub>OH</sub> =-0.4mA  | 3.0 to 5.5          | V <sub>DD</sub> -0.4 |                    |      | V   |
|                           | V <sub>OH</sub> (2) |                 | I <sub>OH</sub> =-0.2mA  | 2.25 to 5.5         | V <sub>DD</sub> -0.4 |                    |      |     |
| Low level output voltage  | V <sub>OL</sub> (1) | TSW, SDA, SCL   | I <sub>OL</sub> =3.0mA   | 3.0 to 5.5          |                      |                    | 0.4  |     |
|                           | V <sub>OL</sub> (2) |                 | I <sub>OL</sub> =1.3mA   | 2.25 to 5.5         |                      |                    | 0.4  |     |
| Hysteresis voltage        | VHYS                | RESB, SDA, SCL  |  | 2.25 to 5.5         |                      | 0.1V <sub>DD</sub> |      |     |
| Pin capacitance           | CP                  | All pins        | Pins other than the pin under test<br>V <sub>IN</sub> =V <sub>SS</sub><br>f=1 MHz<br>Ta=25°C | 2.25 to 5.5         |                      | 10                 |      | pF  |
| Consumption current       | I <sub>DD</sub> (1) | V <sub>DD</sub> | When detecting remaining capacity  | 2.25 to 5.5         |                      | 8                  | 16   | μA  |
|                           | I <sub>DD</sub> (2) |                 | When not detecting remaining capacity  | 2.25 to 5.5         |                      | 5                  | 12   |     |

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## I<sup>2</sup>C Slave Characteristics at Ta=-40 to+85°C, V<sub>SS</sub>=0V

| Parameter  | Symbol               | Pin/Remarks | Conditions  | Specification       |     |     | unit |      |    |
|--|----------------------|-------------|-------------|---------------------|-----|-----|------|------|----|
|  |                      |             |             | V <sub>DD</sub> [V] | min | typ |      | max  |    |
| Clock frequency  | T_SCL                | SCL         |             | 2.25 to 5.5         |     |     | 100  | kHz  |    |
| Bus free time between STOP condition and START condition                                   | T <sub>BUF</sub>     | SCL, SDA    | See Fig. 1. |                     | 4.7 |     |      |      | μs |
| Hold time (repeated) START condition<br>First clock pulse is generated after this interval | T <sub>HD: STA</sub> | SCL, SDA    | See Fig. 1. |                     | 4.0 |     |      |      | μs |
| Repeated START condition setup time  | T <sub>SU: STA</sub> | SCL, SDA    | See Fig. 1. |                     | 4.7 |     |      |      | μs |
| STOP condition setup time  | T <sub>SU: STO</sub> | SCL, SDA    | See Fig. 1. |                     | 4.0 |     |      |      | μs |
| Data hold time   | T <sub>HD: DAT</sub> | SCL, SDA    | See Fig. 1. |                     | 300 |     |      |      | ns |
| Data setup time  | T <sub>SU: DAT</sub> | SCL, SDA    | See Fig. 1. |                     | 250 |     |      |      | ns |
| Clock low period   | T <sub>LOW</sub>     | SCL         |             |                     | 4.7 |     |      |      | μs |
| Clock high period  | T <sub>HIGH</sub>    | SCL         |             |                     | 4.0 |     |      |      | μs |
| Clock/data fall time   | T <sub>F</sub>       | SCL, SDA    |             |                     |     |     |      | 300  | ns |
| Clock/data rise time   | T <sub>R</sub>       | SCL, SDA    |             |                     |     |     |      | 1000 | ns |



Discharge Characteristics

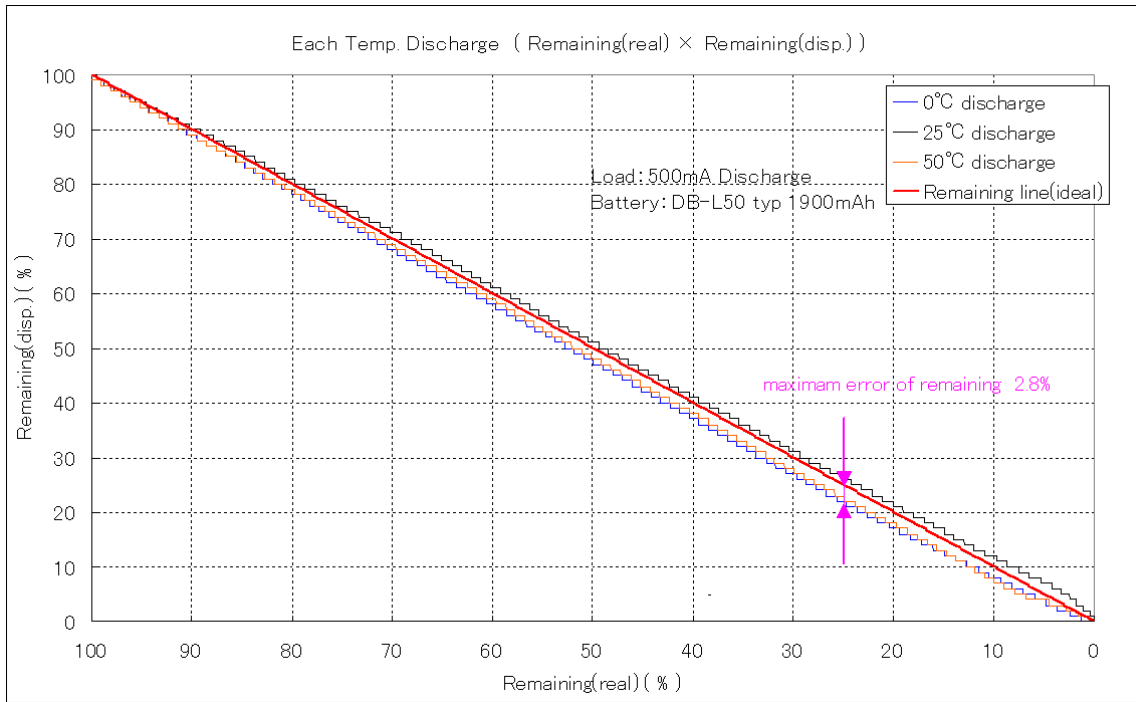


Figure2 Discharge Characteristics by Temperature Change

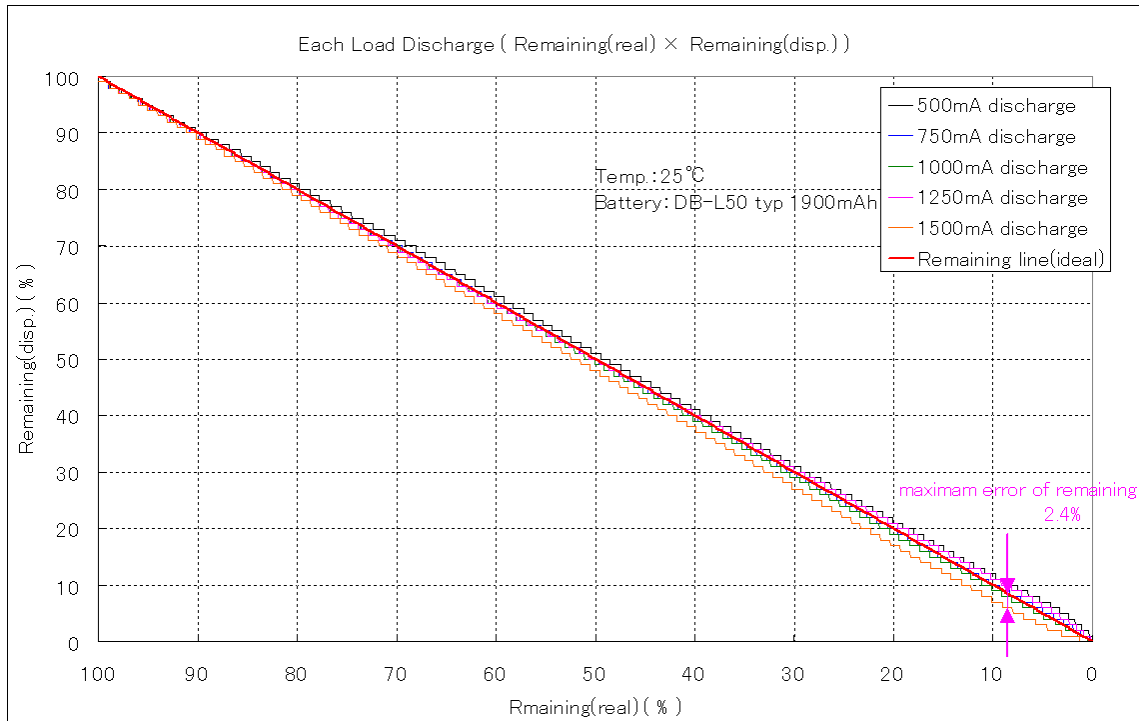


Figure 3 Discharge Characteristics by Load Change

**Communication Protocol**

Communication protocol type: I<sup>2</sup>C  
 Frequency: 100kHz  
 Address: 0x16

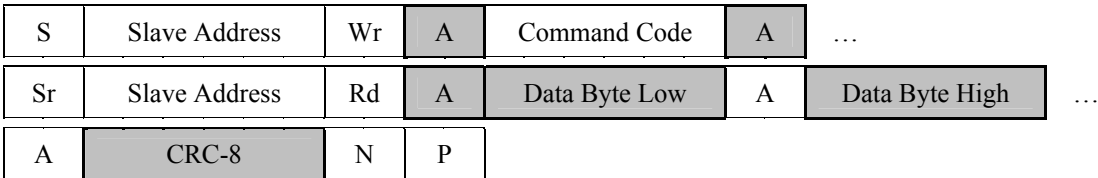
**Bus Protocols**

- 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 (ex.3778mV: 0x16, 0x09, 0x17, 0xC2, 0x0E → 0x86)
- |  |
|--|
|  |
|--|

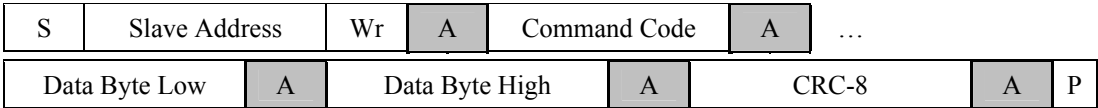
 : Master-to-Slave
- |  |
|--|
|  |
|--|

 : Slave-to-Master
- ... : Continuation of protocol

**Read Word Protocol**



**Write Word Protocol**



| Slave Functions                  | Command Code | Range             | Access | Unit           |
|----------------------------------|--------------|-------------------|--------|----------------|
| Cell Temperature                 | 0x08         | 0 to 65535        | R      | 0.1°K          |
| Cell Voltage                     | 0x09         | 0 to 65535        | R      | mV             |
| Current                          | 0x0A         | -32768 to 32767   | R      | mA             |
| Adjustment Pack                  | 0x0B         | 0 to 255          | R      | Value          |
| Relative State Of Charge         | 0x0D         | 0 to 100          | R      | %              |
| Remaining Capacity               | 0x0F         | 0 to 65535        | R      | mAh            |
| Full Charge Capacity             | 0x10         | 0 to 65535        | R      | mAh            |
| IC Version                       | 0x11         | 0 to 65535        | R      | Version        |
| Adjustment Thermistor            | 0x12         | 0 to 255          | R      | Value          |
| Set Relative State Of Charge     | 0x08         | 0xA500 + 0 to 100 | W      | 0xA500 + %     |
| Adjustment Pack                  | 0x08         | 0x5A00 + 0 to 255 | W      | 0x5A00 + Value |
| Adjustment Thermistor            | 0x08         | 0xAA00 + 0 to 255 | W      | 0xAA00 + Value |
| Initial Relative State Of Charge | 0x09         | 0xAA55            | W      | -              |



# LC709201F

## Application Circuit Example

Figure 4 Example of an application schematic using LC709201F

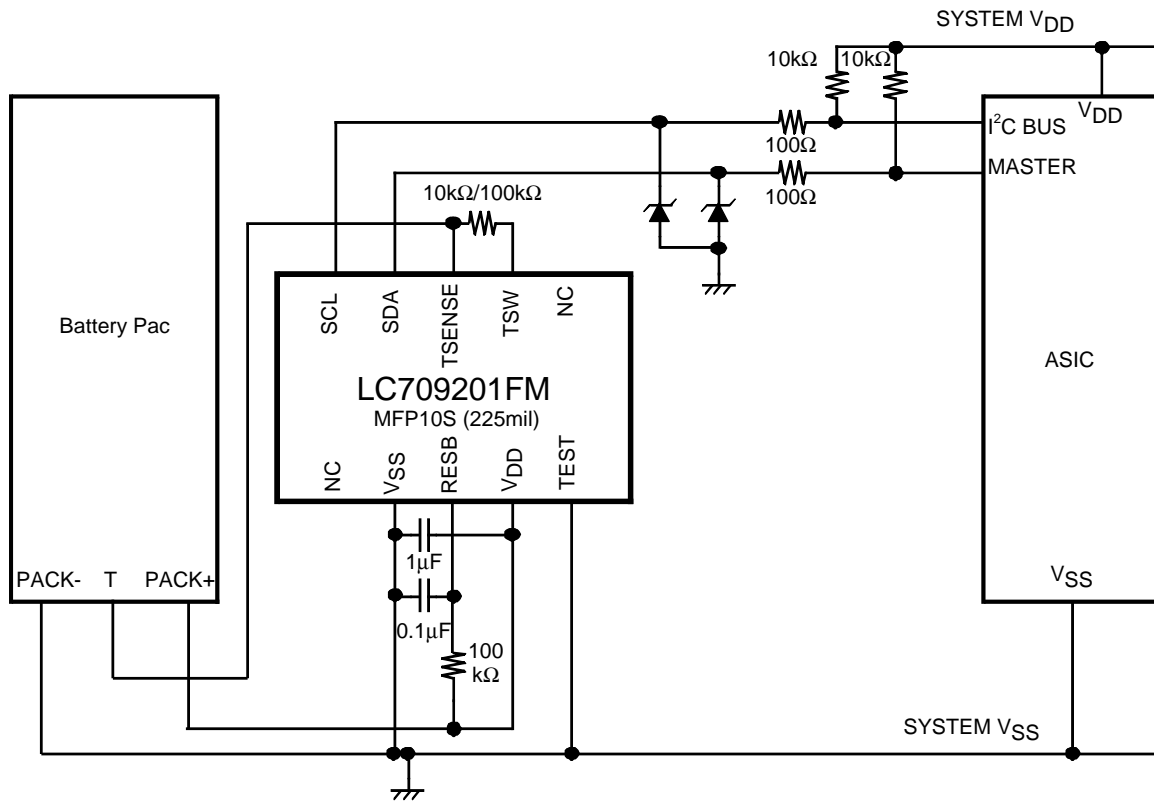
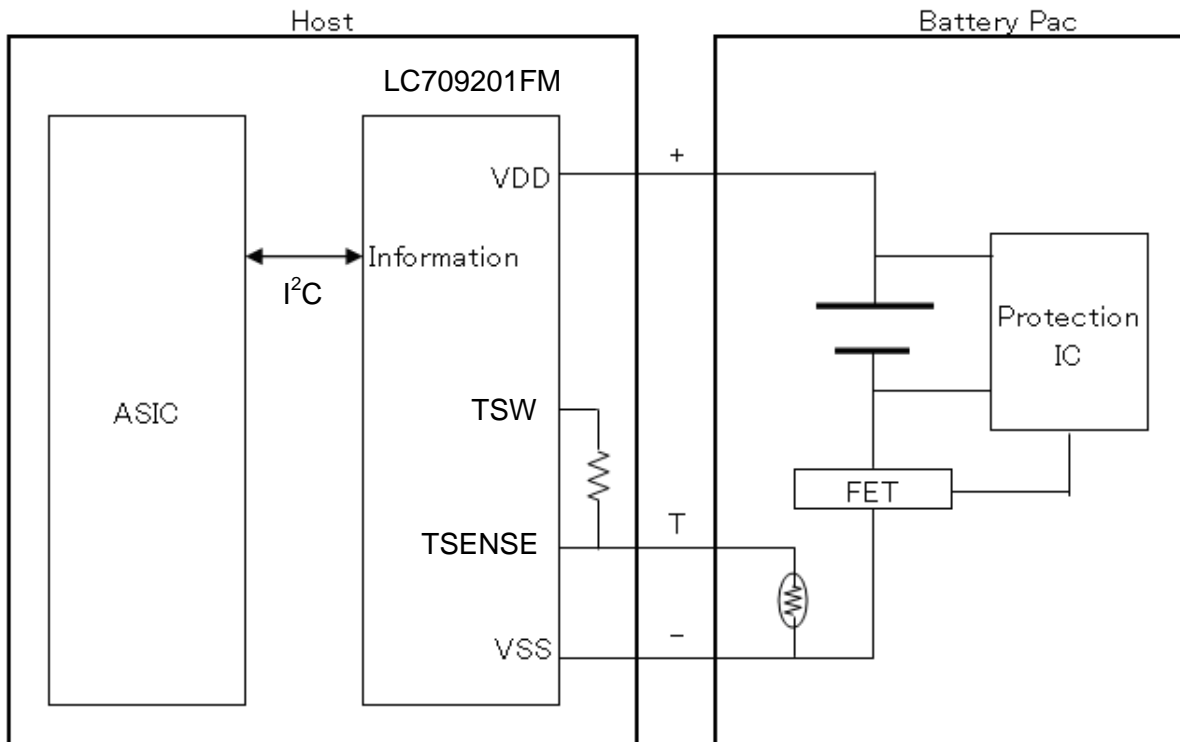


Figure 5 Conceptual diagram using LC709201F



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