LC709203F

智能电量计
电池电量计LSI
(适用于单节锂离子电池(Li+))

概述

LC709203F是一款适用于单节锂离子电池的电量计。它是我们的*智能电量计*系列成员，采用了我们独家的算方(**HG−CVR**)来测量电池的RSOC (相对荷电状态)。通过**HG−CVR**算法，无需使用检测电阻即可提供提供准确的RSOC信息，即使是在不稳定的条件下(例如电池发送变化、温度、负载、老化和自放电)。精确的RSOC信息有助于改善便携式设备的运行时间。

LC709203F采用两种小型封装，以业界最小的PCB占位面积实现了完善的解决方案。用户只需设置非常少的参数就可以简单、快速地进行设置和操作。

产品特性

- **HG−CVR**算法技术
  - 无需外部检测电阻
  - 2.8%的RSOC精度
  - 即使老电池也可提供准确的RSOC
  - 自动误差收敛
  - 可调整电池附近的寄生阻抗
  - 设置简单、快速
- 低功耗
  - 3 μA工作模式
- 精确的电压检测
  - ±7.5 mV
- 精密的计时器
  - ±3.5%
- 低RSOC和/或低电压提醒
- 温度补偿
  - 检测热敏电阻输入
  - 通过I^2C输入
- 检测电池的插入
- I^2C接口(最高支持400 kHz)
- 此类器件无铅、无卤/无BFR，且符合RoHS。

应用

- 无线手持设备
- 智能手机/PDA设备
- MP3播放器
- 数码相机
- 便携式游戏机
- USB设备

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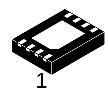
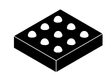


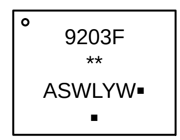
WDFN8
CASE 509AF



WLCSP9
CASE 567JH

MARKING DIAGRAMS

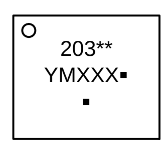
WDFN8



9203F**	=	Specific Device Code
**	=	01 (LC709203FQH−01TWG)
		02 (LC709203FQH−02TWG)
		03 (LC709203FQH−03TWG)
		04 (LC709203FQH−04TWG)
AS	=	Assembly Location
WL	=	Lot Number
YW	=	Work Week
▪	=	Pb−Free Package

(Note: Microdot may be in either location)

WLCSP9



203**	=	Specific Device Code
**	=	01 (LC709203FXE−01MH)
		02 (LC709203FXE−02MH)
		03 (LC709203FXE−03MH)
		04 (LC709203FXE−04MH)
Y	=	Year
M	=	Month Code
XXX	=	Lot Number
▪	=	Pb−Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information on page 19 of this data sheet.

August, 2017 − Rev. 12
Publication Order Number:
LC709203FCN/D

应用电路示例

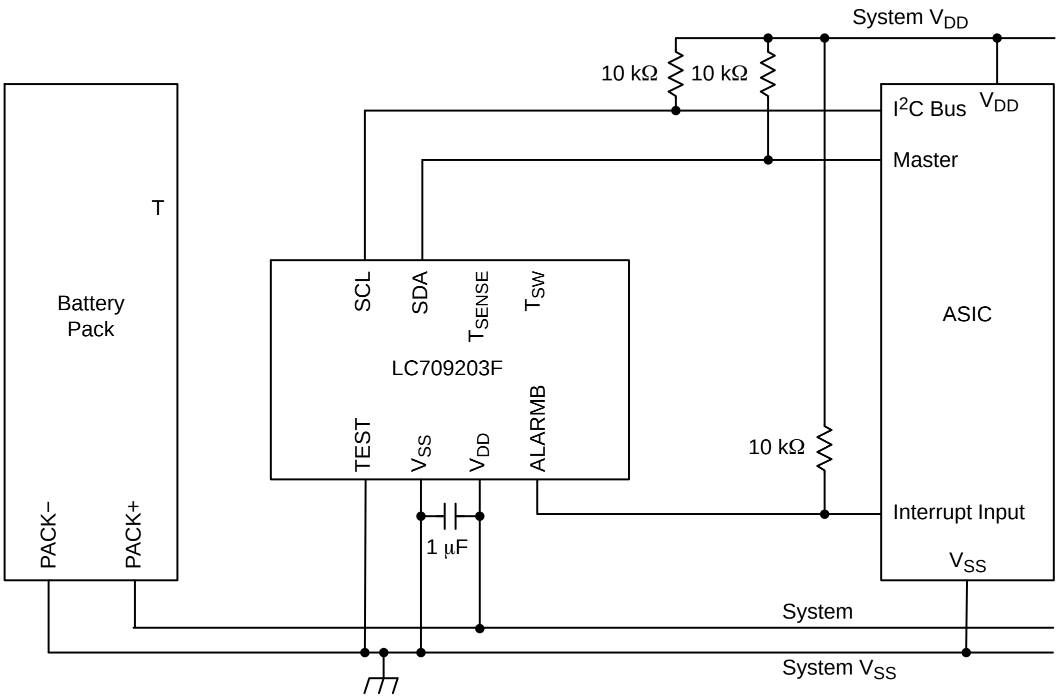


Figure 1. Example of an Application Schematic using LC709203F (Temperature Input via I^2C)

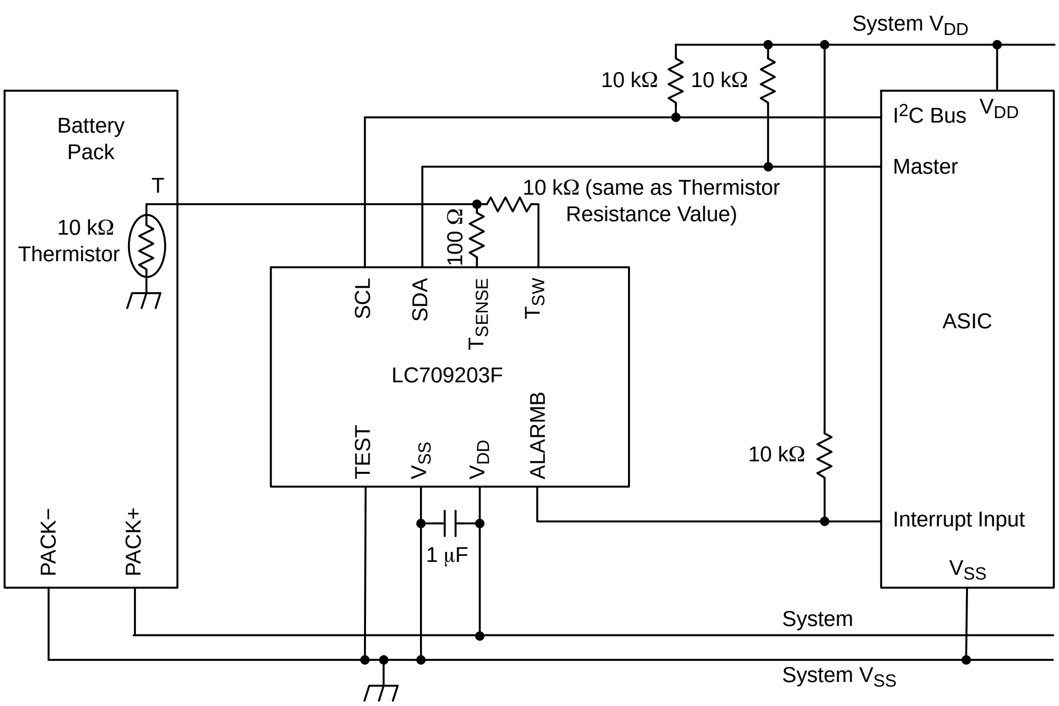


Figure 2. Example of an Application Schematic using LC709203F (The Temperature is Measured Directly by a Thermistor)

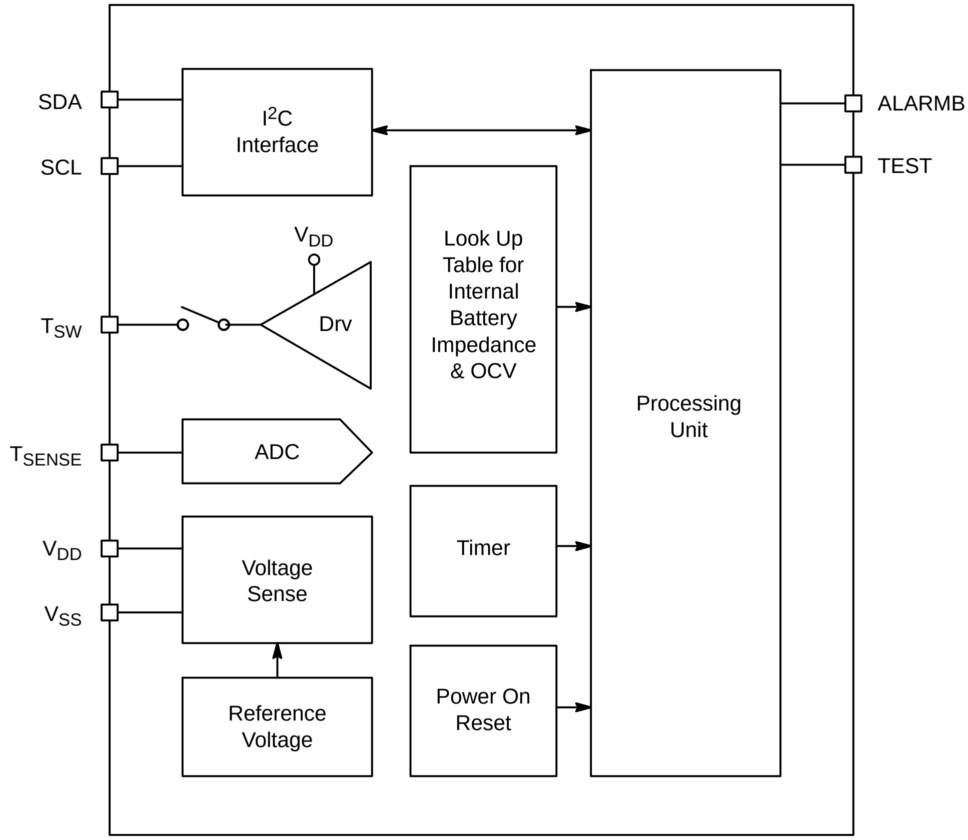


Figure 3. Simplified Block Diagram

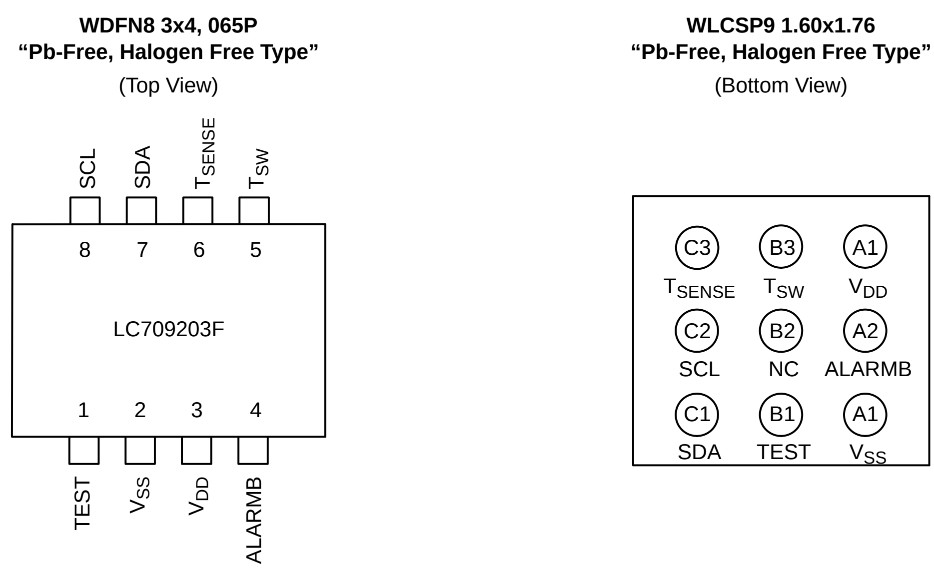


Figure 4. Pin Assignment

Table 1. PIN FUNCTION

WDFN8	WLP9	Pin Name	I/O	Description
1	1B	TEST	I	Connect this pin to V_{SS}.
2	1A	V_{SS}	–	Connect this pin to the battery's negative (–) pin.
3	3A	V_{DD}	–	Connect this pin to the battery's positive (+) pin.
4	2A	ALARMB	O	This pin indicates alarm by low output(open drain). Pull-up must be done externally. Alarm conditions are specified by registers (0x13 or 0x14). Connect this pin to V_{SS} when not in use.
5	3B	T_{SW}	O	Power supply output for thermistor. This pin goes HIGH during temperature read operation. Resistance value of TSW (for thermistor pull-up) must be the same value as the thermistor. (Note 1)
6	3C	T_{SENSE}	I	Thermistor sense input. If you connect this pin to thermistor, insert 100 Ω resistance between them for ESD. (Note 1)
7	1C	SDA	I/O	I[2]C Data pin (open drain). Pull-up must be done externally.
8	2C	SCL	I/O	I[2]C Clock pin (open drain). Pull-up must be done externally.
–	2B	NC	–	Don't care.

1. T_{SW} and T_{SENSE} must be disconnected as Figure 1 when not in use.

Table 2. ABSOLUTE MAXIMUM RATINGS (T_A = 25°C, V_{SS} = 0 V)

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD} (V)	Specification			Unit
					Min	Typ	Max	
Maximum Supply Voltage	V_{DD} max	V_{DD}		–	–0.3	–	+6.5	V
Input Voltage	V_I (1)	T_{SENSE}		–	–0.3	–	V_{DD} + 0.3	
Output Voltage	V_O (1)	T_{SW}		–	–0.3	–	V_{DD} + 0.3	
	V_O (2)	ALARMB		–	–0.3	–		
Input/Output Voltage	V_{IO} (1)	SDA, SCL		–	–0.3	–	+5.5	
Allowable Power Dissipation	$P_{d\ max}$	WDFN8	T_A = –40 to +85°C	–	–	–	480	mW
		WLP9		–	–	–	210	
Operating Ambient Temperature	T_{opr}			–	–40	–	+85	°C
Storage Ambient Temperature	T_{stg}			–	–55	–	+125	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.
(参考譯文)
如果电压超过最大额定值表中列出的值范围，器件可能会损坏。如果超过任何这些限值，将无法保证器件功能，可能会导致器件损坏，影响可靠性。

Table 3. ALLOWABLE OPERATING CONDITIONS (T_A = −40 to +85°C, V_{SS} = 0 V)

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD} (V)	Specification			Unit
					Min	Typ	Max	
Operating Supply Voltage	V_{DD} (1)	V_{DD}		–	2.5	–	4.5	V
High Level Input Voltage	V_{IH} (1)	T_{SENSE}		2.5 to 4.5	0.7 V_{DD}	–	V_{DD}	
	V_{IH} (2)	ALARMB, SDA, SCL		2.5 to 4.5	1.4	–	–	
Low Level Input Voltage	V_{IL} (1)	T_{SENSE}		2.5 to 4.5	V_{SS}	–	0.25 V_{DD}	
	V_{IL} (2)	ALARMB, SDA, SCL		2.5 to 4.5	–	–	0.5	

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.
推薦的工作範圍：
高于推荐工作范围表格中所列电压时，不保证能够正常运行。长时间在推荐工作范围表格中规定范围以外的电压下运行，可能会影响器件的可靠性。

Table 4. ELECTRICAL CHARACTERISTICS (T_A = −40 to +85°C, V_{SS} = 0 V)

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD} (V)	Specification			Unit
					Min	Typ	Max	
High Level Input Current	I_{IH} (1)	SDA, SCL	$V_{IN} = V_{DD}$ (including output transistor off leakage current)	2.5 to 4.5	–	–	1	μA
Low Level Input Current	I_{IL} (1)	SDA, SCL	$V_{IN} = V_{SS}$ (including output transistor off leakage current)	2.5 to 4.5	–1	–	–	
High Level Output Voltage	V_{OH} (1)	T_{SW}	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)	T_{SW}, 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)	SDA, SCL		2.5 to 4.5	–	0.1 V_{DD}	–	
Pin Capacitance	CP	All pins	Pins other than the pin under test $V_{IN} = V_{SS}$ T_A = 25°C	2.5 to 4.5	–	10	–	pF
Reset Release Voltage (Note 2)	V_{RR}	V_{DD}			–	–	2.4	V
Initialization Time after Reset Release (Note 2)	T_{INIT}			2.4 to 4.5	–	–	90	ms
Auto Sleep Set Time	T_{ATS}			2.4 to 4.5	–	1	1.2	s
Time Measurement Accuracy	T_{ME}		T_A = –20°C to +70°C	2.5 to 4.5	–3.5	–	+3.5	%
Consumption Current (Note 3)	I_{DD} (1)	V_{DD}	Operational mode	2.5 to 4.5	–	3	4.5	μA
	I_{DD} (2)		Sleep mode	2.5 to 4.5	–	1	2	
Voltage Measurement Accuracy	V_{ME} (1)	V_{DD}	T_A = +25°C	3.6	–7.5	–	+7.5	mV/cell
	V_{ME} (2)		T_A = –20°C to +70°C	2.5 to 4.5	–20	–	+20	

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
(参考譯文)
除非另有说明，“电气特性”表格中列出的是所列测试条件下的产品性能参数。如果在不同条件下运行，产品性能可能与“电气特性”表格中所列性能参数不一致。

2. Once V_{DD} voltage exceeds over the V_{RR}, this LSI will release RESET status. And the LSI goes into Sleep mode T_{INIT} after it.
3. Consumption current is a value in the range of –20°C to +70°C.

Table 5. I^{2}C SLAVE CHARACTERISTICS (T_A = −40 to +85°C, V_{SS} = 0 V)

Parameter	Symbol	Pin/Remarks	Conditions	V_{DD} (V)	Specification Min	Specification Max	Unit
Clock Frequency	T_{SCL}	SCL		2.5 to 4.5	−	400	kHz
Bus Free Time between STOP condition and START condition	T_{BUF}	SCL, SDA	(See Figure 5)		1.3	−	μs
Hold Time (repeated) START condition. First clock pulse is generated after this interval	$T_{HD:STA}$	SCL, SDA	(See Figure 5)		0.6	−	μs
Repeated START Condition Setup Time	$T_{SU:STA}$	SCL, SDA	(See Figure 5)		0.6	−	μs
STOP Condition Setup Time	$T_{SU:STO}$	SCL, SDA	(See Figure 5)		0.6	−	μs
Data Hold Time	$T_{HD:DAT}$	SCL, SDA	(See Figure 5)		0	0.9	μs
Data Setup Time	$T_{SU:DAT}$	SCL, SDA	(See Figure 5)		100	−	ns
Clock Low Period	T_{LOW}	SCL	(See Figure 5)		1.3	−	μs
Clock High Period	T_{HIGH}	SCL	(See Figure 5)		0.6	−	μs
Clock/Data Fall Time	T_F	SCL, SDA			20 + 0.1C_B	300	ns
Clock/Data Rise Time	T_R	SCL, SDA			20 + 0.1C_B	300	ns
Wake Up Time from Sleep Mode	T_{WU}	SDA	(See Figure 6)		−	400	μs
SDA Low Pulse Width to Wake Up	T_{SP}	SDA	(See Figure 6)		0.6	−	μs
Wake Up Retention Time from the Falling Edge of SDA	T_{WR1}	SDA	(See Figure 6)		500	−	ms
Wake Up Retention Time from STOP Condition	T_{WR2}	SCL, SDA	(See Figure 6)		500	−	ms

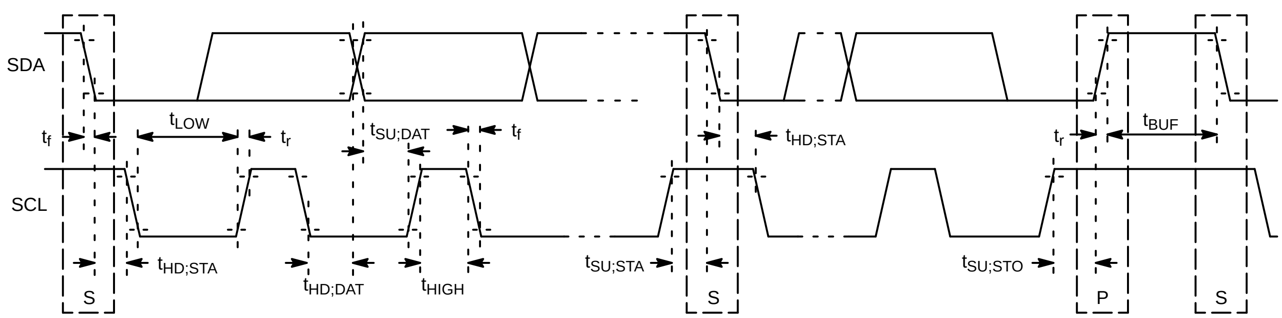


Figure 5. I^{2}C Timing Diagram

I²C通信协议

Communication protocol type: I²C

Frequency: Supported up to 400 kHz

IC address [Slave Address]: 0x16 (It becomes "0001011X" when you write a binary, because the slave address is 7 bits. [X] = Rd/Wr.)

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.3778 mV : 0x16, 0x09, 0x17, 0xC2, 0x0E g 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

* When you do not read CRC−8, there is not the reliability of data. CRC−8−ATM ex: (5 bytes) 0x16, 0x09, 0x17, 0xC2, 0x0E → 0x86

Write Word Protocol

S	Slave Address	Wr	A	Command Code	A	…

Data Byte Low	A	Data Byte High	A	CRC−8	A	P

* When you do not add CRC−8, the Written data (Data byte Low/High) become invalid.
CRC−8−ATM ex: (4 bytes) 0x16, 0x09, 0x55, 0xAA → 0x3B

从睡眠模式唤醒

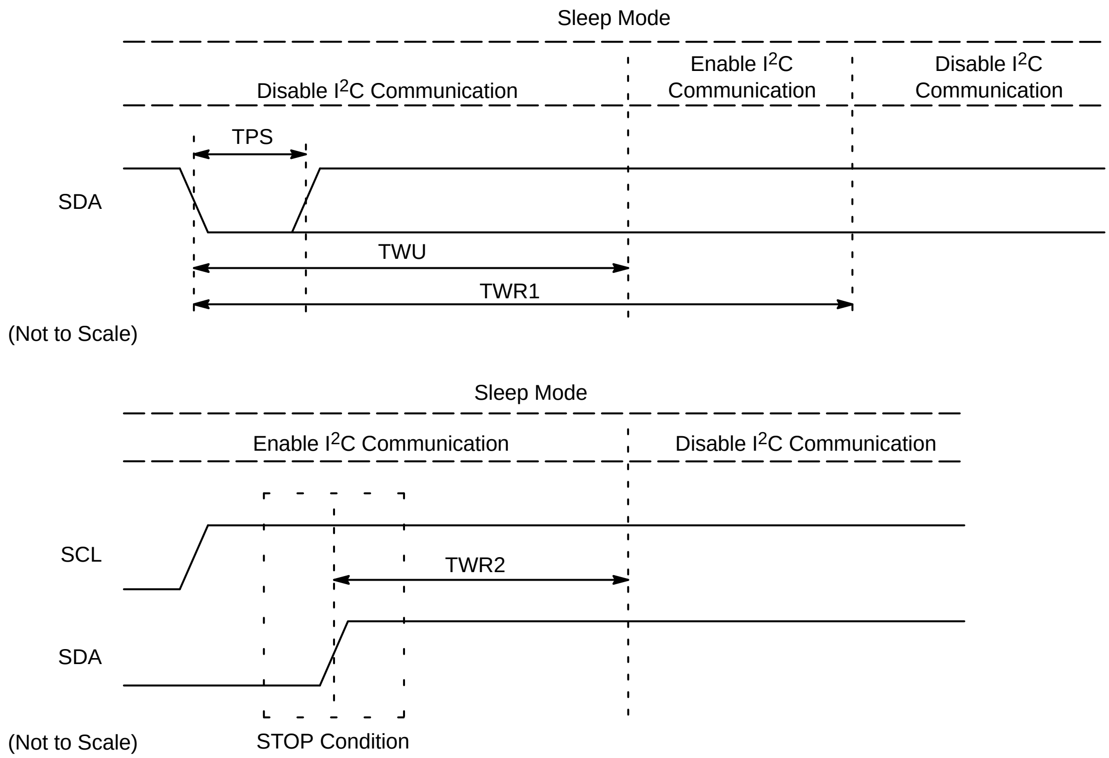


Figure 6. I^{2}C Wake up Timing Diagram

要从睡眠模式唤醒，并启动I^{2}C通信，主机端必须将SDA设置为低，再进行I^{2}C通信。电量计LSI在TWU阶段之后启用I^{2}C通信，该阶段从DA的下降边缘开始测量，如上方时序图所示。对于以下两种情况，此“唤醒条件” 无效。

1. TWR1计时后(从SDA下降边缘之后开始计时)，电量计LSI “唤醒条件”进入自动禁用状态。一旦I^{2}C开始通信，将不会进入禁用状态，直至达到停止条件后TWR2计时结束(下述情况)。
2. TWR2计时后(从达到I^{2}C Bus停止条件后开始计时)电量计LSI“唤醒条件”进入自动禁用状 态。

如果“唤醒条件”进入禁用状态，将SDA设为低，再次从睡眠模式唤醒，然后再进行I^{2}C通信。如果设置了工作模式，则可启动I^{2}C通信，而无需此“唤醒操作”。

与其他器件共用I^{2}C通信的注意事项

与其他器件共用I^{2}C总线(电量计LSI连接在此总线上)时，在其他器件开始I^{2}C通信之前，电量计LSI必须处于工作模式。

Table 6. FUNCTION OF REGISTERS

Command Code	Register Name	R/W	Range	Unit	Description	Initial Value
0x04	Before RSOC	W	0xAA55: Initialize RSOC	Executes RSOC initialization with sampled maximum voltage when 0xAA55 is set.		−
0x06	Thermistor B	R/W	0x0000 to 0xFFFF	1K	Sets B−constant of the thermistor to be measured.	0x0D34
0x07	Initial RSOC	W	0xAA55: Initialize RSOC	Executes RSOC initialization when 0xAA55 is set.		−
0x08	Cell Temperature	R	0x0000 to 0xFFFF	0.1K (0.0°C = 0x0AAC)	Displays Cell Temperature	0x0BA6 (25°C)
		W	0x09E4 to 0x0D04 (I^2C mode)		Sets Cell Temperature in I^2C mode	
0x09	Cell Voltage	R	0x0000 to 0xFFFF	1 mV	Displays Cell Voltage	−
0x0A	Current Direction	R/W	0x0000: Auto mode 0x0001: Charge mode 0xFFFF: Discharge mode	Selects Auto/Charge/Discharge mode		0x0000
0x0B	APA (Adjustment Pack Application)	R/W	0x0000 to 0x00FF	1 mΩ	Sets Parasitic impedance	−
0x0C	APT (Adjustment Pack Thermistor)	R/W	0x0000 to 0xFFFF	Sets a value to adjust temperature measurement delay timing		0x001E
0x0D	RSOC	R	0x0000 to 0x0064	1%	Displays RSOC value based on a 0−100 scale	−
0x0F	ITE (Indicator to Empty)	R	0x0000 to 0x03E8	0.1%	Displays RSOC value based on a 0−1000 scale	−
0x11	IC Version	R	0x0000 to 0xFFFF	Displays an ID number of an IC		−
0x12	Change Of The Parameter	R/W	0x0000 or 0x0001	Selects a battery profile		0x0000
0x13	Alarm Low RSOC	R/W	0x0000: Disable 0x0001to0x0064: Threshold	1%	Sets RSOC threshold to generate Alarm signal	0x0008
0x14	Alarm Low Cell Voltage	R/W	0x0000: Disable 0x0001to0xFFFF: Threshold	1 mV	Sets Voltage threshold to generate Alarm signal	0x0000
0x15	IC Power Mode	R/W	0x0001: Operational mode 0x0002: Sleep mode	Selects Power mode		(Note 4)
0x16	Status Bit	R/W	0x0000: I^2C mode 0x0001: Thermistor mode	Selects Temperature obtaining method		0x0000
0x1A	Number of The Parameter	R	0x0301 or 0x0504	Displays Battery profile code		−

NOTE: 0xXXXX = Hexadecimal notation
4. See “Power-on Reset/Battery Insertion Detection” and Figure 16.

RSOC (0x04)前

上电复位10毫秒后，此LSI将获取开路电压(OCV)读数，以初始化RSOC (参见图7)。

或者，可通过发送“RSOC前”命令(0×04 = AA55)或“初始化RSOC”命令(0×07 = AA55)，强制LSI初始化RSOC。需要获取电池最低负载或电量和OCV读数，才能确保初始化的准确性(误差小于0.025C)。(即对于设计容量3000 mAh的电池，误差需小于75 mA)。

写入“RSOC前”命令时，LSI将使用从上电复位后初始化到设置命令期间的最大电压，初始化RSOC。(参见图8)。

热敏电阻B (0x06)

设置待测热敏电阻的常数B。关于要使用的设置值，请参阅热敏电阻规格表。

初始RSOC (0x07)

可通过发送RSOC前命令(0×04 = AA55)或初始化RSOC命令(0×07 = AA55)，强制LSI初始化RSOC。

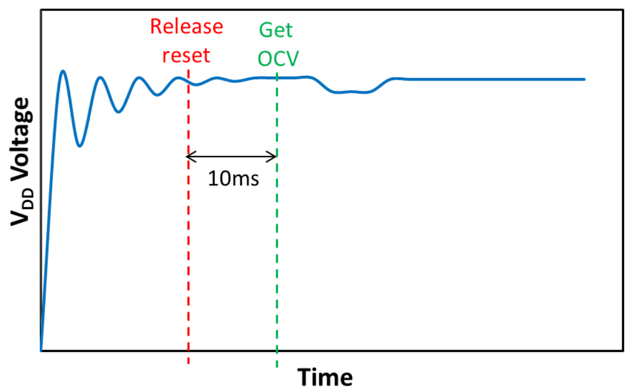


Figure 7. RSOC Automatic Initialization

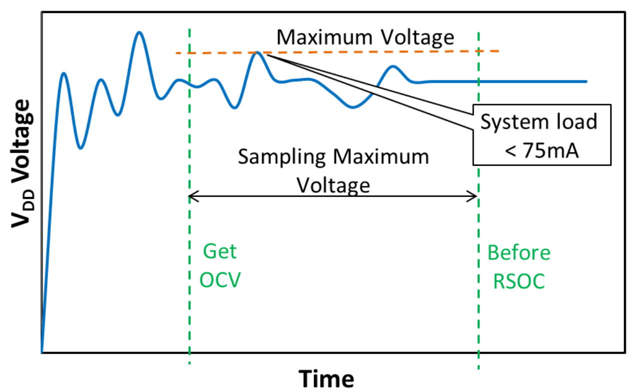


Figure 8. Before RSOC Command

LSI通过写入初始RSOC命令时测得的电压来初始化RSOC。(参见图9)。写入命令后初始化RSOC的最大时间为1.5 ms。

电池温度(0x08)

此寄存器包含从−20°C (0×09E4)到+60°C (0×0D04)的电池温度，测量单位为0.1°C。

在热敏电阻模式(0×16 = 01)中，LSI测量所连接的热敏电阻，并将温度加载至电池温度寄存器。在热敏电阻模式中，热敏电阻应如图2所示连接至LSI。通过使TSW引脚向热敏电阻供电并使TSENSE引脚检测热敏电阻的输出电压，来测量温度。温度测量计时由LSI控制，出于测量温度之外的其他原因，不对热敏电阻供电。

在I2C模式(0×16 = 00)中，由主机处理器提供温度数据。在放电/充电期间，温度变化超过1°C时，应当更新寄存器

电池电压(0x09)

此寄存器包含V_{DD}电压(单位为1 mV)。

电流方向(0x0A)

此寄存器用于控制RSOC的报告。在自动模式中，将在RSOC升高或降低时报告。在充电模式中，RSOC不得降低。在放电模式中，RSOC得升高。

考虑到容量受温度影响，我们建议以自动模式运行，因为电池温度会影响RSCO。热电池比冷电池的容量更大。在放电模式中切勿充电，在充电模式中切勿放电；否则会发生错误。

RSOC报告示例如图10和图11所示。

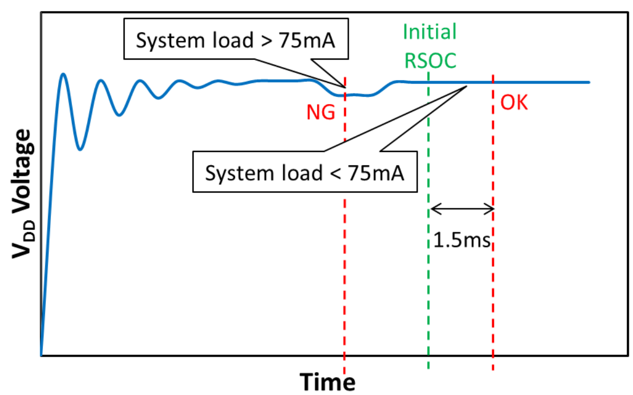


Figure 9. Initial RSOC Command

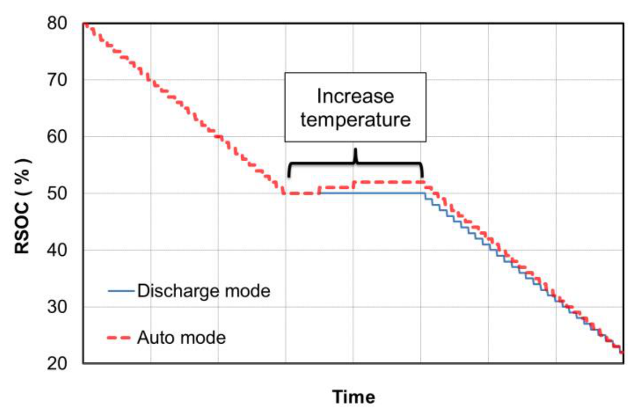


Figure 10. Discharge Mode
(An example with increasing in temperature. A warm cell has more capacity than a cold cell. Therefore RSOC increases without charging in Auto mode)

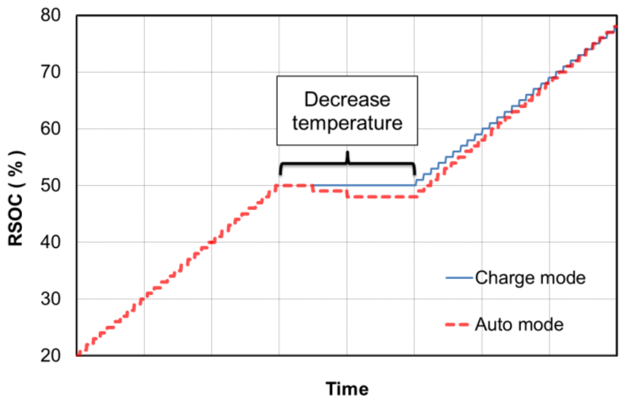


Figure 11. Charge Mode (An example with decreasing in temperature. A cold cell has less capacity than a warm cell. Therefore RSOC decreases without discharging in Auto mode)

调整包应用(0x0B)

此寄存器包含针对电池类型的调整值，用以改善RSOC的精确度。图12和表7显示了依设计容量而定的APA典型值(每种电池类型1节电池)。当有若干电池并联时，每节电池的设计容量如下表所示。04类型和05类型的APA值适用于表8中指定的电池类型。如果您对RSOC精确度不满意，请联系安森美半导体。深入调整APA可改善精确度。

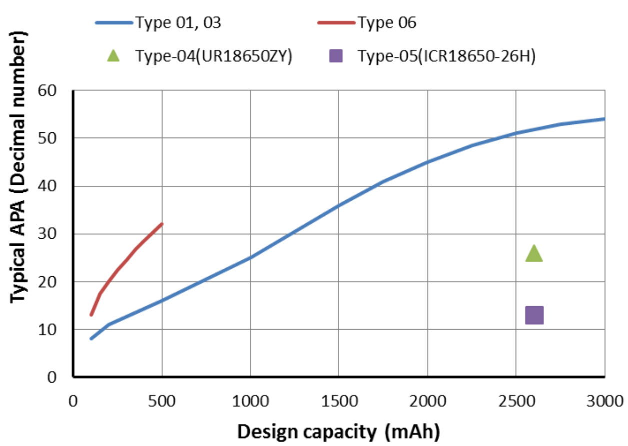


Figure 12. Typical APA

调整包热敏电阻(0x0C)

用于补偿因热敏电阻电容而导致的热敏电阻测量延迟。默认值适用于大多数如图13所示未放置电容的电路。

如果要采用特殊的电路，请联系安森美半导体。

Table 7. TYPICAL APA

Design Capacity of Battery	APA(0x0B)			
	Type−01, Type−03	Type−06	Type−04	Type−05
100 mAh	0x08	0x0D	−	−
200 mAh	0x0B	0x15	−	−
500 mAh	0x10	0x20	−	−
1000 mAh	0x19	−	−	−
2000 mAh	0x2D	−	−	−
3000 mAh	0x36	−	−	−
2600 mAh	−	−	0x1A	0x0D

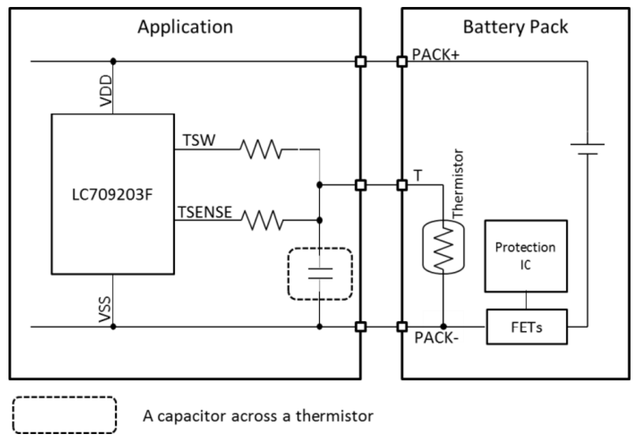


Figure 13. An Example fo a Capacitor Across the Thermistor

RSOC (0x0D)

以1%为单位在0%至100%范围内报告RSOC。

无电指示器(0x0F)

这与RSOC相同，分辨率为0.1%，范围为0.0%至100.0%。

IC版本(0x11)

这是LSI的ID号码。

参数变化(0x12)

LSI包含由两个电池配置文件组成的数据文件。此寄存器用于选择要使用的电池配置文件。参见表8。参数(0x1A)的寄存器包含数据文件识别信息。

根据所订购的器件编号，在最终测试时加载数据文件。

一般使用电池标称/额定电压或充电电压值确定应使用哪个配置文件数据。如果您无法确定要选择哪个配置文件，请联系安森美半导体。

低RSOC警报(0x13)

当RSOC值降至该值以下时，ALARMB引脚将被设为低电平，当RSOC值高于该值时，引脚将会从低电平释放。设为零时即可禁用。图14。

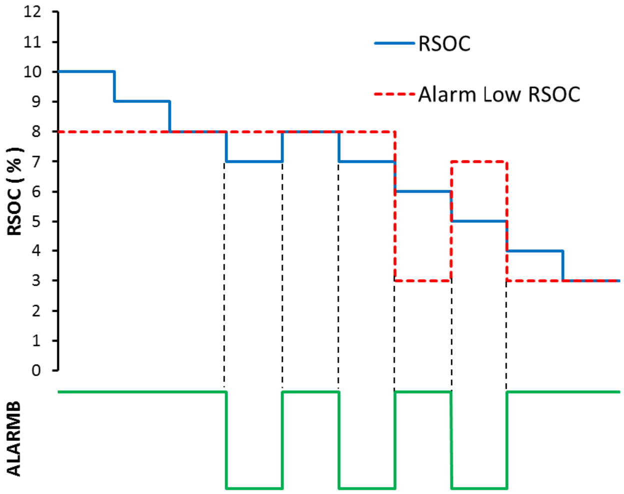


Figure 14. Alarm Low RSOC

低电池电压警报(0x14)

如果VDD值降至该值以下，ALARMB引脚将被设为低电平，如果VDD值高于该值，引脚将会从低电平释放。 设为零时即可禁用。图15。

IC电源模式(0x15)

LSI具有两种电源模式。睡眠模式(0x15 = 02)或工作模式(0x15 = 01)。在睡眠模式中，仅具有I²C通信功能运行。在工作模式中，所有功能均运行，并在充电和放电期间全面计算和跟踪RSOC。

在睡眠模式中，如果电池快速充电或放电，RSOC会不准确。将持续对电量变动情况进行计数，以在工作模式中测量RSOC。如果在睡眠模式中电池放电或充电，计数将中断。

从睡眠模式切换至工作模式时，使用之前工作模式中测量的数据继续计算RSOC。

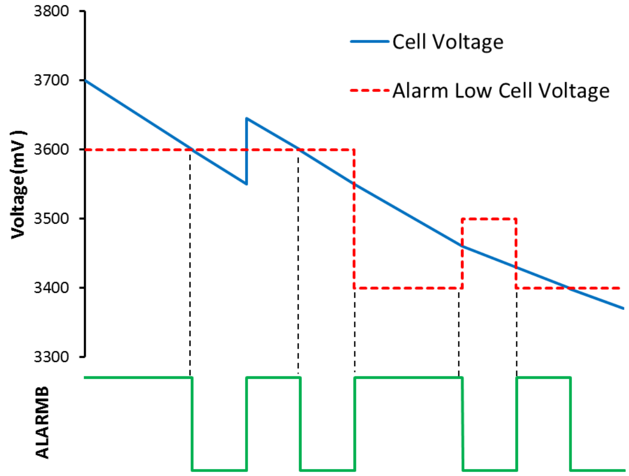


Figure 15. Alarm Low Cell Voltage

状态位(0x16)

用于选择热敏电阻模式。在热敏电阻模式(0x16=01)中，LSI测量所连接的热敏电阻，并将温度加载至电池温度寄存器。

在I²C模式(0x16=00)中，由主机处理器提供温度数据。

参数编号(0x1A)

LSI包含由两个电池配置文件组成的数据文件。此寄存器包含数据文件识别信息。关于如何选择要使用的电池配置文件，请参见寄存器*参数变化(0x12)*参见表8。

根据所订购的器件编号，在最终测试时加载数据文件。如果需要，可在现场加载此文件。

如果您无法确定要选择哪个配置文件，请联系安森美半导体。

Table 8. BATTERY PROFILE VS. REGISTER

IC Type	Battery Type	Nominal/Rated Voltage	Charging Voltage	Design Capacity	Number of the Parameter (0x1A)	Change of the Parameter (0x12)
LC709203Fxx−01xx	03	3.8 V	4.35 V	≥ 500 mAh	0x0301	0x0000
	01	3.7 V	4.2 V	–		0x0001
LC709203Fxx−03xx	06	3.8 V	4.35 V	< 500 mAh	0x0601	0x0000
	01	3.7 V	4.2 V	–		0x0001
LC709203Fxx−04xx	05	ICR18650−26H (SAMSUNG)			0x0504	0x0000
	04	UR18650ZY (Panasonic)				0x0001

HG−CVR

基于内部电阻跟踪电流−电压的混合计量法

HG−CVR是安森美半导体开发的一种独特方法，用于计算准确的RSOC。**HG−CVR**首先测量电池电压和温度。精确的参考电压对于准确测量电压至关重要。LC709203F带有精确的内部参考电压电路，几乎不受温度影响。

此外，它还使用所测得的电池电压、内部阻抗以及电池的开路电压(OCV)来测量电流。OCV是无负载电流的电池电压。测得的电池电压依负载电流分为OCV和可变电压。可变电压是负载电流和内部阻抗的产物。然后，再使用以下方程确定电流。

$$V(VARIED) = V(MEASURED) - OCV \qquad (eq. 1)$$

$$I = \frac{V(VARIED)}{R(INTERNAL)} \qquad (eq. 2)$$

式中，*V(可变)*是依负载电流分类的可变电压，*V(测得)*是测得的电压，*R(内部)*是电池的内部阻抗。LSI内装载了内阻抗和OCV的详细信息。内部阻抗受剩余容量、负载电流、温度等的影响。LSI将以查询表的形式提供信息。**HG−CVR**使用电流和稳定阶段(使用高精度内部计时器确定)信息累计电池电量(库仑)。然后再使用所累计的电量计算电池的剩余容量。

如何识别老化

通过重复放电/充电，电池内部阻抗逐渐增大，满充容量(FCC)将会减小。在库仑计数法中，通常使用FCC和剩余电容(RM)计算RSOC。

$$RSOC = \frac{RM}{FCC} \times 100\% \qquad (eq. 3)$$

库仑计数法必须通过学习周期预先测量减小的FCC。但**HG−CVR**无需学习周期即可测量老化电池的RSOC。**HG−CVR**用于计算电流的电池内阻抗与FCC高度相关。这种相关性取决于电池的化学成分。此LSI使用相关性报告的RSOC不受老化影响。

图23−25显示了电池的RSOC测量结果以及因老化而减小的FCC。所示RSOC基于减小的FCC (即使电池在执行300次放电/充电后，仍具有80%的FCC)。

自动误差收敛

库仑计数法的一个问题是误差随时间而累积，此误差必须要进行校正。采用库仑计数法的普通电量计必须要找机会校正此误差。

而采用**HG−CVR**的LSI则具有RSOC误差自动收敛功能，无需寻找机会校准。误差将在从开路电压的估测中不断收敛。图26显示初始误差的收敛特性。

此外，库仑计数法无法检测准确的剩余变化，因为自放电的电流量太小，但**HG−CVR**能够使用电压信息准确检测。

设置简单、快速

一般而言，对电量计来说，必须要获取多个参数，这通常耗费大量资源和额外的开发时间。LC709203F的一个独特功能是电池测量开始时要准备的参数量非常少—用户可采用的最少参数量是一个参数，因为调整包应用寄存器必须有一个参数。通过将多种配置文件数据内置于LSI中，实现了简单、快速的启动，以支持各种类型的电池。请联系您当地的销售办事处，详细了解如何测量无法使用内置配置文件数据的电池。

低功耗

在工作模式中，能够实现3 μA的低功耗。此LSI监控电池的充电/放电情况，并根据其电流变化更改采样率。利用此方法，可降低功耗，而不会影响RSOC的准确性。

上电复位/电池插入检测

当此LSI检测到电池插入时，会自动开始上电复位。一旦电池电压超过V_{RR}，将会释放复位状态，并在T_{INIT}内完成LSI初始化，以进入工作模式。上电复位后即会初始化所有寄存器。然后即可启动I^2C通信。

从初始化结束起，经过T_{ATS}之后，LC709203FXE−0xMH会自动进入睡眠模式。因此，在其进入睡眠模式后，需手动切换到工作模式。LC709203FQH−0xTWG不会自动进入睡眠模式。图16。

如果工作期间，电池电压远低于V_{RR}，此LSI也会自动执行系统复位。此外，输入参数变化(0x12)命令后，将会执行LSI初始化，如电池插入时。图17。

寄生电阻

LSI使用电池内部阻抗来测量RSOC。因此，在电池与电池组之间V_{DD}/V_{SS}线上存在的对LSI的寄生电阻可能会成为误差因子。但LSI未连接的线路电阻不包含在内。图18。

电阻越小，RSOC精确度可能越高。请参阅LC709203F应用指南，了解有关V_{DD}/V_{SS}线路布局方法的信息，以降低电阻值。

测量启动流程

复位释放后，用户可按照图19−20所示流程，将适当的值写入寄存器，启动电池测量。各寄存器的详细信息，请参阅“寄存器功能”部分。

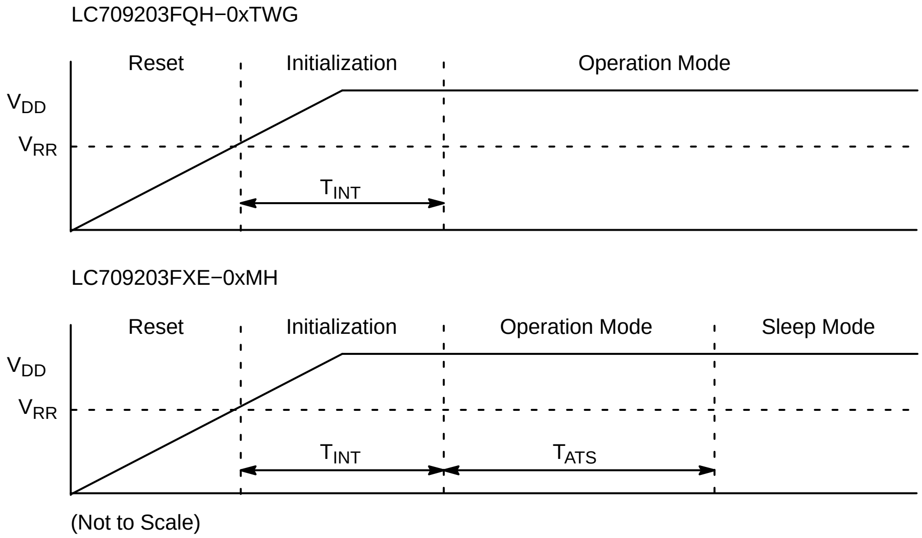


Figure 16. Power On Timing Diagram

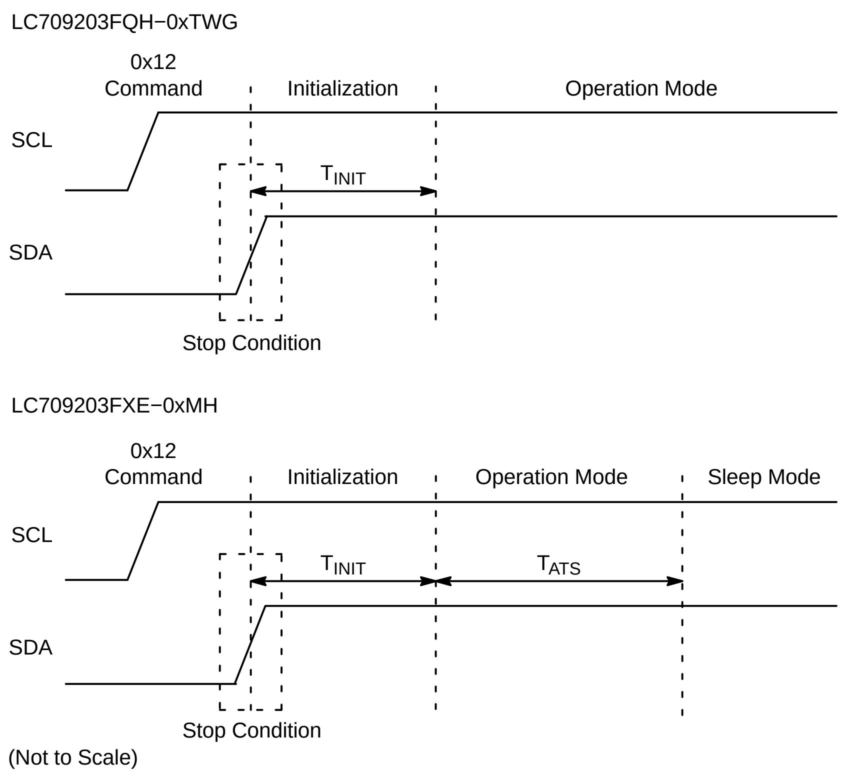


Figure 17. Timing Diagram after 0x12 Command

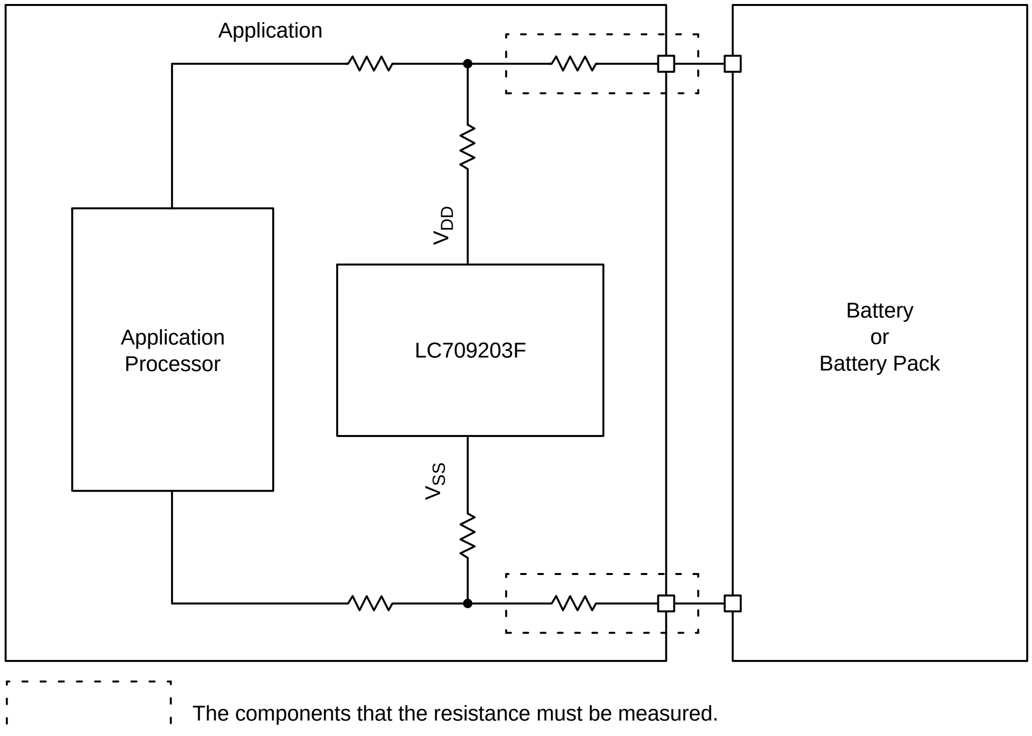


Figure 18. An Example fo Parasitic Resistance

启动流程

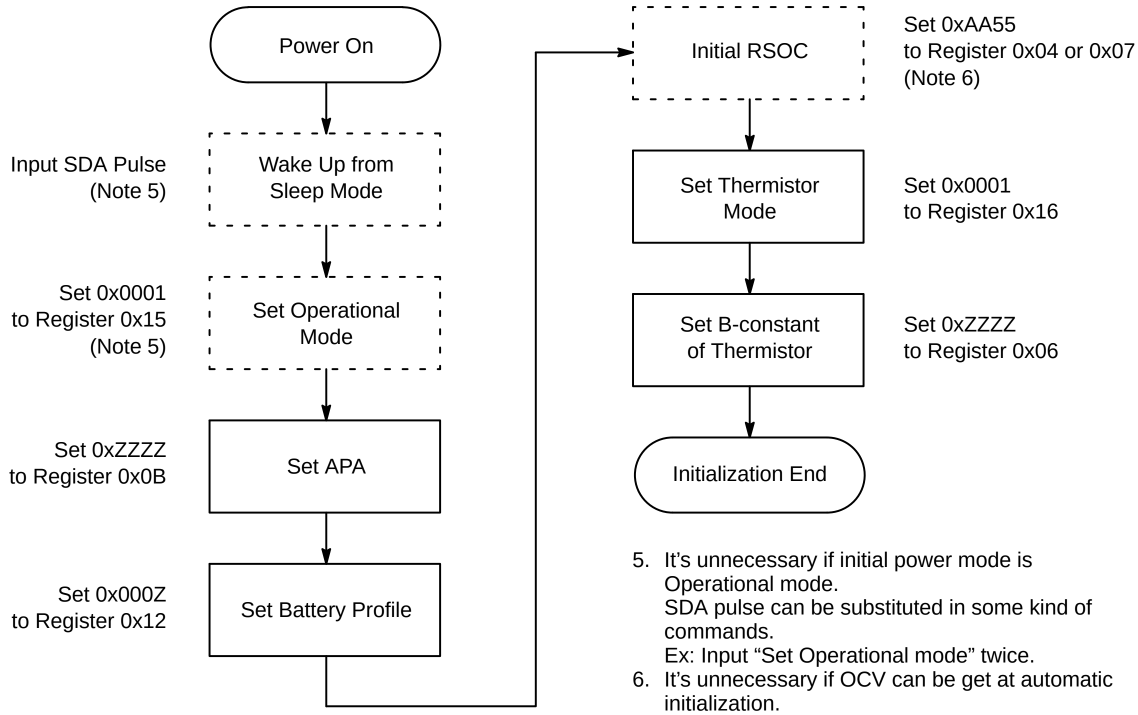


Figure 19. Starting Flow at Thermistor Mode

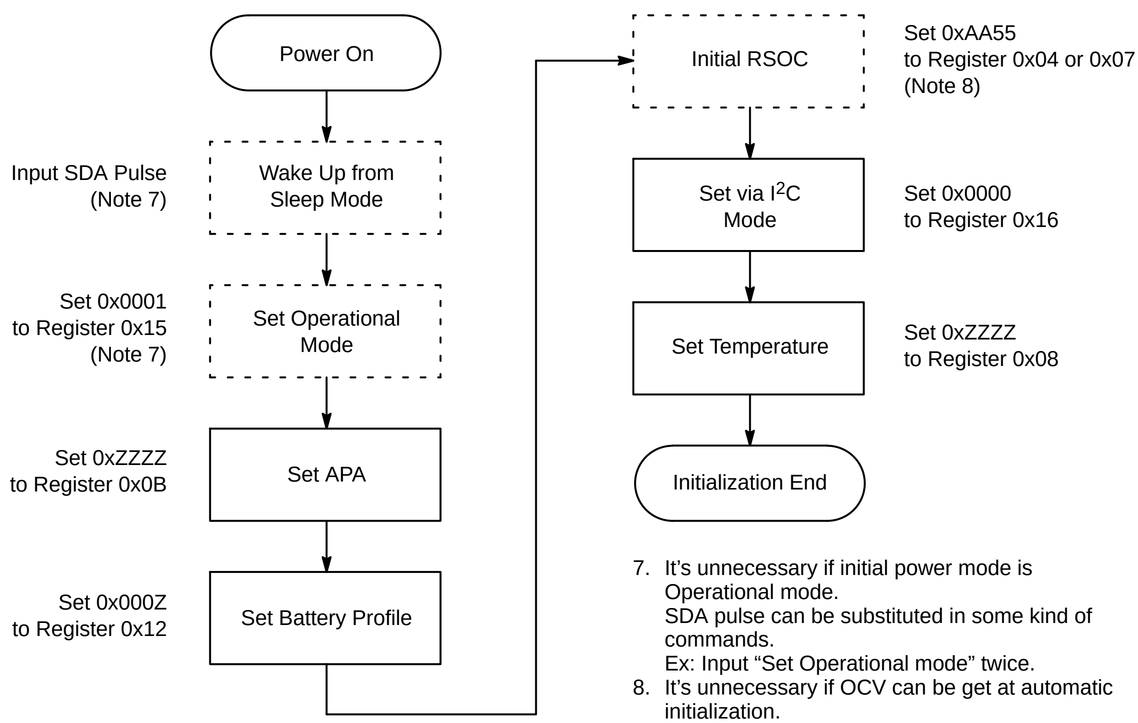


Figure 20. Starting Flow at I²C Mode

典型特性

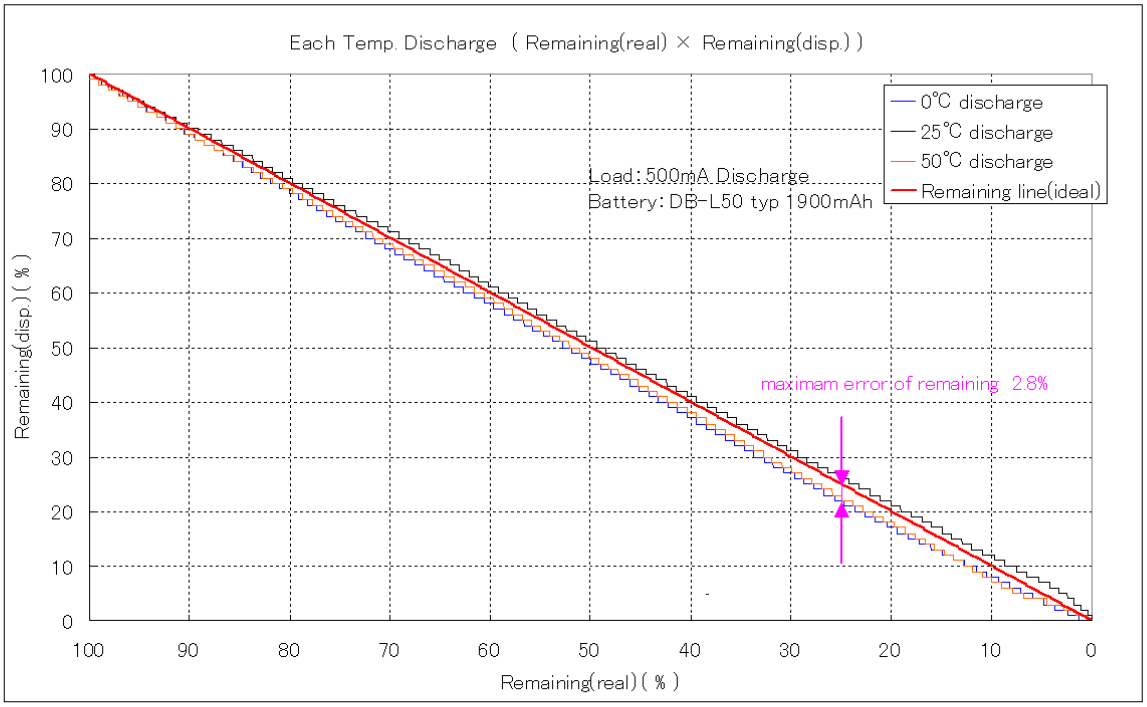


Figure 21. Discharge Characteristics by Temperature Change

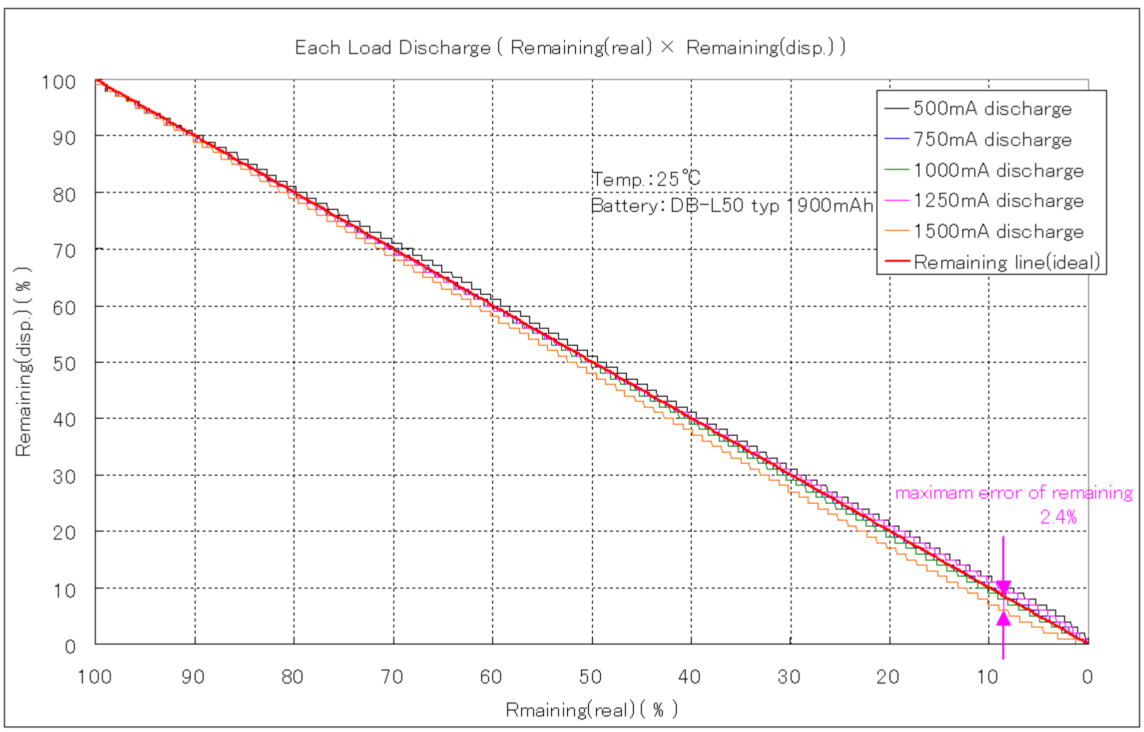


Figure 22. Discharge Characteristics by Load Change

典型特性

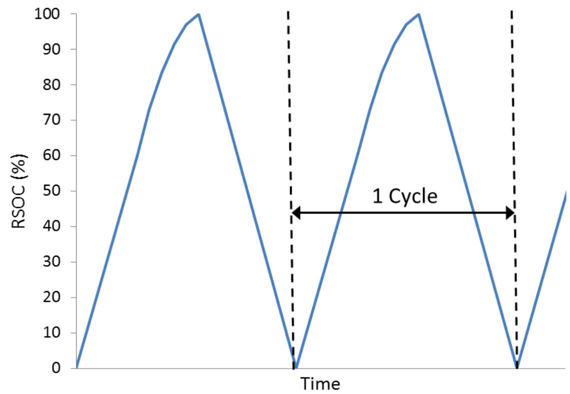


Figure 23. Discharge/Charge Cycle

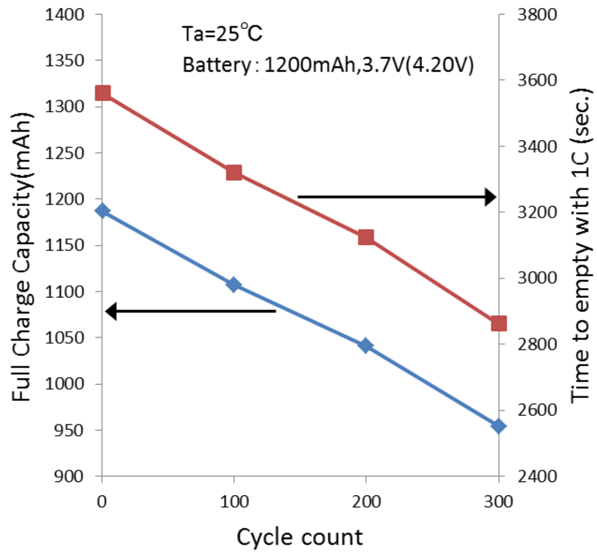


Figure 24. Battery Capacity Deterioration

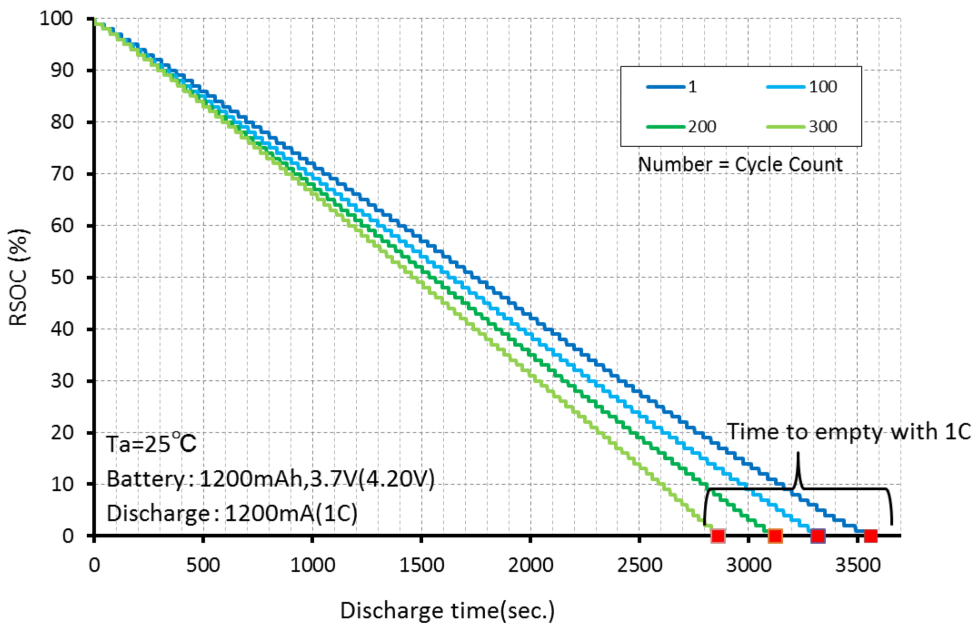


Figure 25. Discharge Characteristics of Deterioration Battery

典型特性

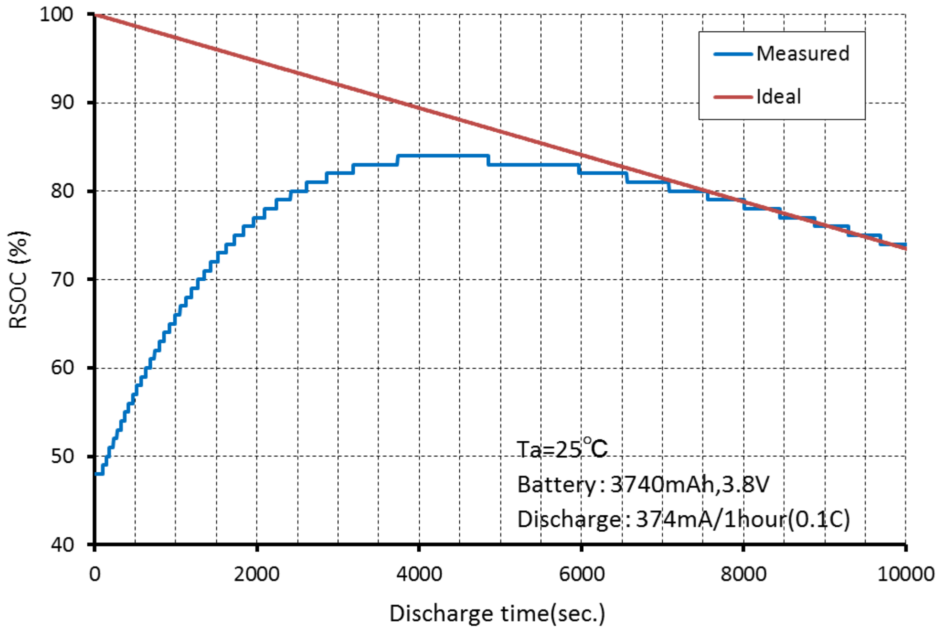


Figure 26. Convergent Characteristic from the Initialize Error
This Graph is the Example for Starting Point 48% (Includes 52% Error Case) Instead of 100% (No Error)

Table 9. ORDERING INFORMATION

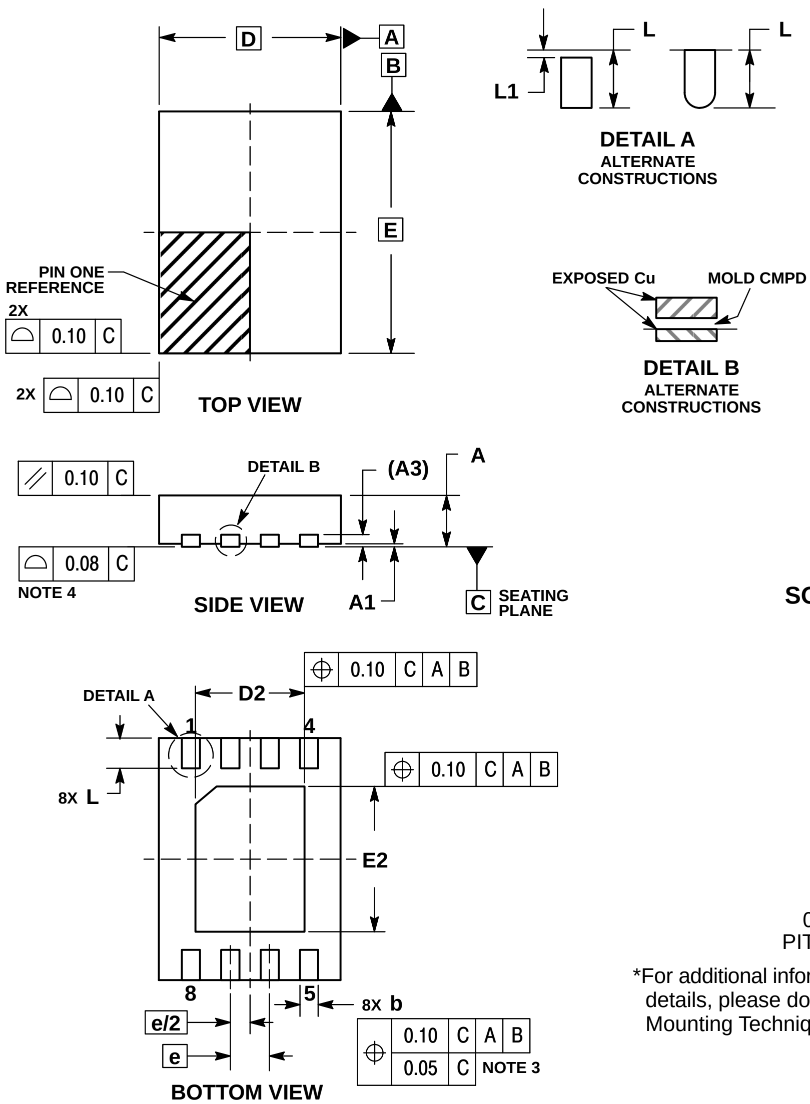
Device	Package	Shipping†
LC709203FQH−01TWG	WDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2,000 / Tape & Reel
LC709203FQH−02TWG	WDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2,000 / Tape & Reel
LC709203FQH−03TWG	WDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2,000 / Tape & Reel
LC709203FQH−04TWG	WDFN8 3x4, 0.65P (Pb-Free / Halogen Free)	2,000 / Tape & Reel
LC709203FXE-01MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5,000 / Tape & Reel
LC709203FXE-02MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5,000 / Tape & Reel
LC709203FXE-03MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5,000 / Tape & Reel
LC709203FXE-04MH	WLCSP9, 1.60x1.76 (Pb-Free / Halogen Free)	5,000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

(注): IC能可能因所使用的电池类型而异。如需帮助选择正确的型号，请联系您当地的销售办事处。

PACKAGE DIMENSIONS

WDFN8 3x4, 0.65P
CASE 509AF
ISSUE C

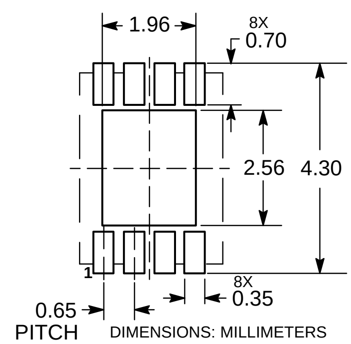


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM THE TERMINAL TIP.
4. PROFILE TOLERANCE APPLIES TO THE EXPOSED PAD AS WELL AS THE LEADS.

	MILLIMETERS	
DIM	MIN	MAX
A	---	0.80
A1	0.00	0.05
A3	0.20 REF	
b	0.20	0.30
D	3.00 BSC	
D2	1.70	1.90
E	4.00 BSC	
E2	2.30	2.50
e	0.65 BSC	
L	0.45	0.55
L1	---	0.10

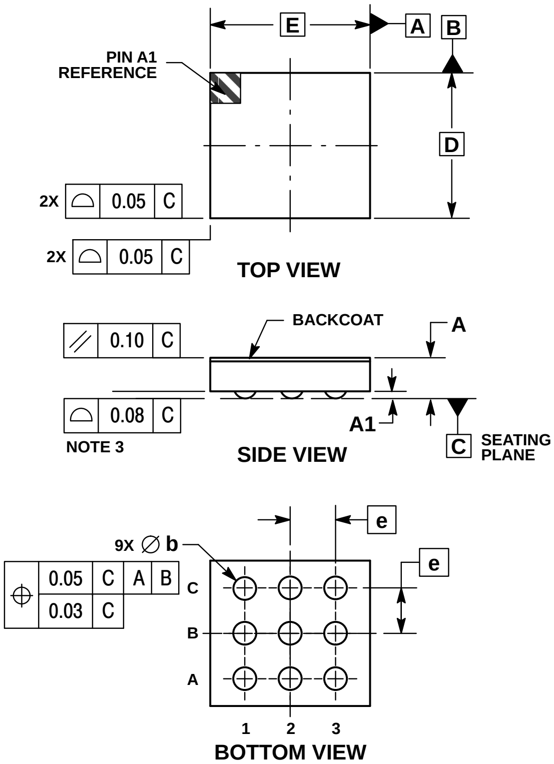
RECOMMENDED SOLDERING FOOTPRINT*



*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

PACKAGE DIMENSIONS

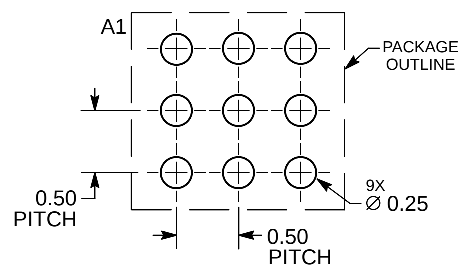
WLCSP9, 1.60x1.76
CASE 567JH
ISSUE B



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO THE SPHERICAL CROWNS OF THE SOLDER BALLS.

	MILLIMETERS	
DIM	**MIN**	**MAX**
A	---	0.51
A1	0.09	0.19
b	0.20	0.30
D	1.60 BSC	
E	1.76 BSC	
e	0.50 BSC	

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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