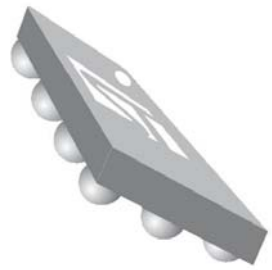
GG25L

Gas gauge IC with alarm output

Datasheet - production data



CSP (1.4 x 2.0 mm)

Features

- OptimGauge™ algorithm
- 0.25% accuracy battery voltage monitoring
- Coulomb counter and voltage-mode gas gauge operations
- Robust initial open-circuit-voltage (OCV) measurement at power up with debounce delay
- Low battery level alarm output with programmable thresholds
- Internal temperature sensor
- Battery swap detection
- Low power: 45 µA in power-saving mode, 2 µA max in standby mode
- 1.4 x 2.0 mm 10-bump CSP package

Applications

- Wearable
- Fitness and healthcare
- Portable medical equipment

Description

The GG25L includes the hardware functions required to implement a low-cost gas gauge for battery monitoring. The GG25L uses current sensing, Coulomb counting and accurate measurements of the battery voltage to estimate the state-of-charge (SOC) of the battery. An internal temperature sensor simplifies implementation of temperature compensation.

An alarm output signals a low SOC condition and can also indicate low battery voltage. The alarm threshold levels are programmable.

The GG25L offers advanced features to ensure high performance gas gauging in all application conditions.

Table 1. Device summary

Order code	Temperature range	Package	Packing	Marking
GG25LJ (1)	-40 °C to +85 °C	CSP-12	Tape and reel	O22
GG25LAJ (2)				O23

1. 4.35 V battery option
2. 4.20 V battery option

This is information on a product in full production. www.st.com

Contents

1 Block diagram . . . 3

2 Pin assignment . . . 4

3 Absolute maximum ratings and operating conditions . . . 4

4 Electrical characteristics . . . 5

5 Application information . . . 8

6 Functional description . . . 10

6.1 Battery monitoring functions . . . 10

6.1.1 Operating modes . . . 10

6.1.2 Battery voltage monitoring . . . 10

6.1.3 Internal temperature monitoring . . . 11

6.1.4 Current sensing . . . 11

6.2 GG25L gas gauge architecture . . . 12

6.2.1 Coulomb counter . . . 12

6.2.2 Voltage gas gauge algorithm . . . 13

6.2.3 Mixed mode gas gauge system . . . 14

6.3 Low battery alarm . . . 15

6.4 Power-up and battery swap detection . . . 16

6.5 Improving accuracy of the initial OCV measurement with the advanced functions of BATD/CD and RSTIO pins . . . 17

6.5.1 BATD and RSTIO pins . . . 17

7 I²C interface . . . 19

7.1 Read and write operations . . . 19

7.2 Register map . . . 21

7.2.1 Register map . . . 21

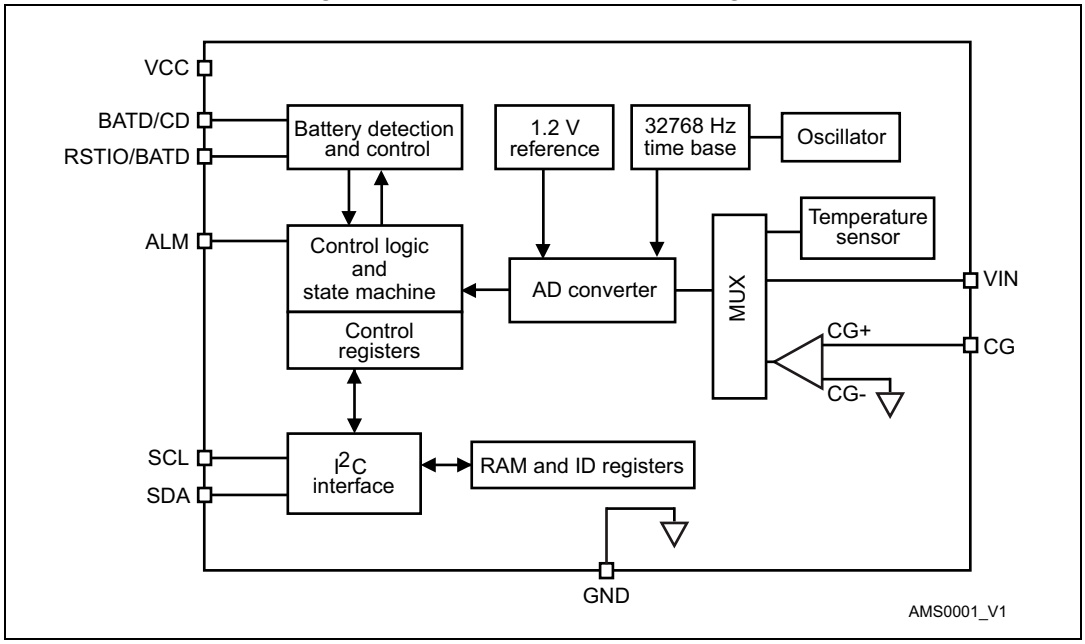
7.2.2 Register description . . . 23

8 Package information . . . 25

9 Revision history . . . 27

1 Block diagram

Figure 1. GG25L internal block diagram



2 Pin assignment

Table 2. GG25L pin description

Pin n°	CSP bump	Pin name	Type(1)	Function
1	A1	ALM	I/OD	Alarm signal output, open drain, external pull-up with resistor
2	B1	SDA	I/OD	I²C serial data
3	C1	SCL	I_D	I²C serial clock
4	D1	GND	Ground	Analog and digital ground
5	D2	NC	-	NC
6	D3	CG	I_A	Current sensing input
7	C3	RSTIO	I/OD	Reset sense input & reset control output (open drain)
8	B2	BATD/CD	I/OA	Battery charge inhibit (active high output) Battery detection (input)
9	B3	VCC	Supply	Power supply
10	A3	VIN	I_A	Battery voltage sensing input

1. I = input, 0 = output, OD = open drain, A = analog, D = digital, NC = not connected

3 Absolute maximum ratings and operating conditions

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CCMAX}	Maximum voltage on V_{CC} pin	6	V
V_{IO}	Voltage on I/O pins	-0.3 to 6	
T_{STG}	Storage temperature	-55 to 150	°C
T_J	Maximum junction temperature	150	
ESD	Electrostatic discharge (HBM: human body model)	2	kV

Table 4. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Operating supply voltage on V_{CC}	2.7 to 4.5	V
V_{MIN}	Minimum voltage on V_{CC} for RAM content retention	2.0	
T_{OPER}	Operating free air temperature range	-40 to 85	°C
T_{PERF}		-20 to 70	

4 Electrical characteristics

Table 5. Electrical characteristics (2.7 V < V_{CC} < 4.5 V, -20 °C to 70 °C)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Supply						
I_{CC}	Operating current consumption	Average value over 4 s in power-saving voltage mode		45	60	µA
		Average value over 4 s in mixed mode			100	
I_{STBY}	Current consumption in standby	Standby mode, inputs = 0 V			2	
I_{PDN}	Current consumption in power-down	V_{CC} < $UVLO_{TH}$, inputs = 0 V			1	
$UVLO_{TH}$	Undervoltage threshold	(V_{CC} decreasing)	2.5	2.6	2.7	V
$UVLO_{HYST}$	Undervoltage threshold hysteresis			100		mV
POR	Power-on reset threshold	(V_{CC} decreasing)		2.0		V
Current sensing						
Vin_gg	Input voltage range		-40		+40	mV
I_{IN}	Input current for CG pin				500	nA
ADC_res	AD converter granularity			5.88		µV
ADC_offset	AD converter offset	CG = 0 V	-3		3	LSB
ADC_time	AD conversion time			500		ms
ADC_acc	AD converter gain accuracy at full scale (using external sense resistor)	25 °C		0.5		%
		Over temperature range			1	
F_{OSC}	Internal time base frequency			32768		Hz
Osc_acc	Internal time base accuracy	25 °C, V_{CC} = 3.6 V		2		%
		Over temperature and voltage ranges			2.5	
Cur_res	Current register LSB value			5.88		µV

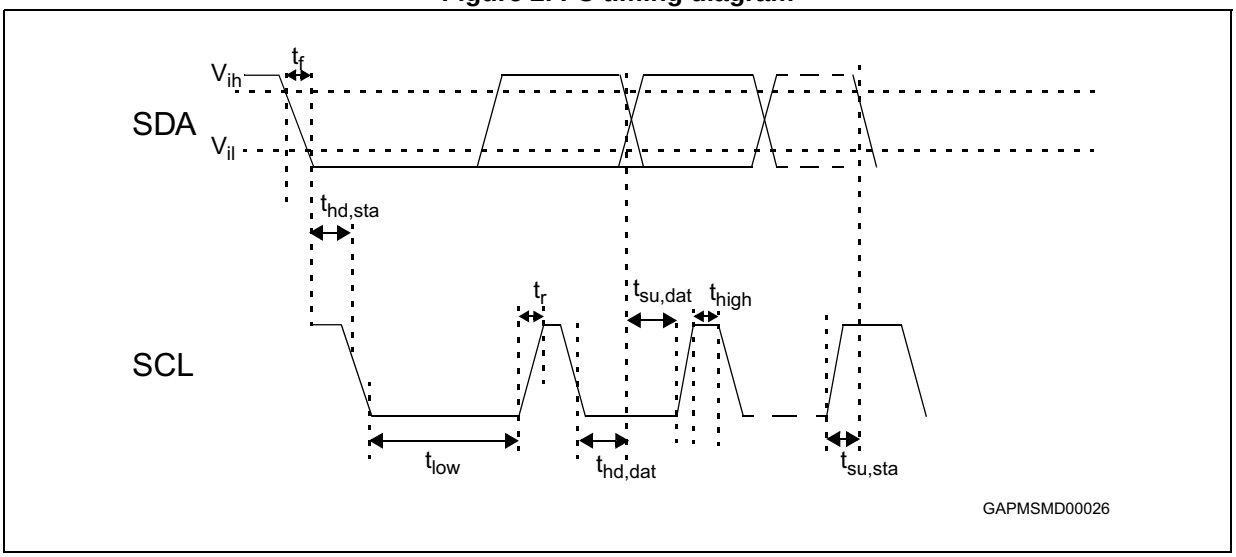
Table 5. Electrical characteristics (2.7 V < V_{CC} < 4.5 V, -20 °C to 70 °C) (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Battery voltage and temperature measurement						
Vin_adc	Input voltage range	V_{CC} = 4.5 V	0		4.5	V
LSB	LSB value	Voltage measurement		2.20		mV
		Temperature measurement		1		°C
ADC_time	AD conversion time			250		ms
Volt_acc	Battery voltage measurement accuracy	2.7 V < Vin < 4.5 V, V_{CC} = Vin 25 °C	-0.25		+0.25	%
		Over temperature range	-0.5		+0.5	
Temp_acc	Internal temperature sensor accuracy		-3		3	°C
Digital I/O pins (SCL, SDA, ALM, RSTIO)						
Vih	Input logic high		1.2			V
Vil	Input logic low				0.35	
Vol	Output logic low (SDA, ALM, RSTIO)	Iol = 4 mA			0.4	
BATD/CD pin						
Vith	Input threshold voltage		1.46	1.61	1.76	V
Vihyst	Input voltage hysteresis			0.1		
Voh	Output logic high (charge inhibit mode enable)	Ioh = 3 mA			Vbat-0.4	

Table 6. I²C timing - V_{IO}= 2.8 V, T_{amb} = -20 °C to 70 °C (unless otherwise specified)

Symbol	Parameter	Min	Typ	Max	Unit
F_{scl}	SCL clock frequency	0	-	400	kHz
$t_{hd,sta}$	Hold time (repeated) START condition	0.6			µs
t_{low}	LOW period of the SCL clock	1.3			
t_{high}	HIGH period of the SCL clock	0.6			
$t_{su,dat}$	Setup time for repeated START condition	0.6			
$t_{hd,dat}$	Data hold time	0		0.9	
$t_{su,dat}$	Data setup time	100			ns
t_r	Rise time of both SDA and SCL signals	20+ 0.1C_b		300	ns
t_f	Fall time of both SDA and SCL signals	20+ 0.1C_b		300	ns
$t_{su,sto}$	Setup time for STOP condition	0.6			µs
t_{buf}	Bus free time between a STOP and START condition	1.3			µs
C_b	Capacitive load for each bus line			400	pF

Figure 2. I²C timing diagram



5 Application information

Figure 3. Example of an application schematic using the GG25L in mixed mode

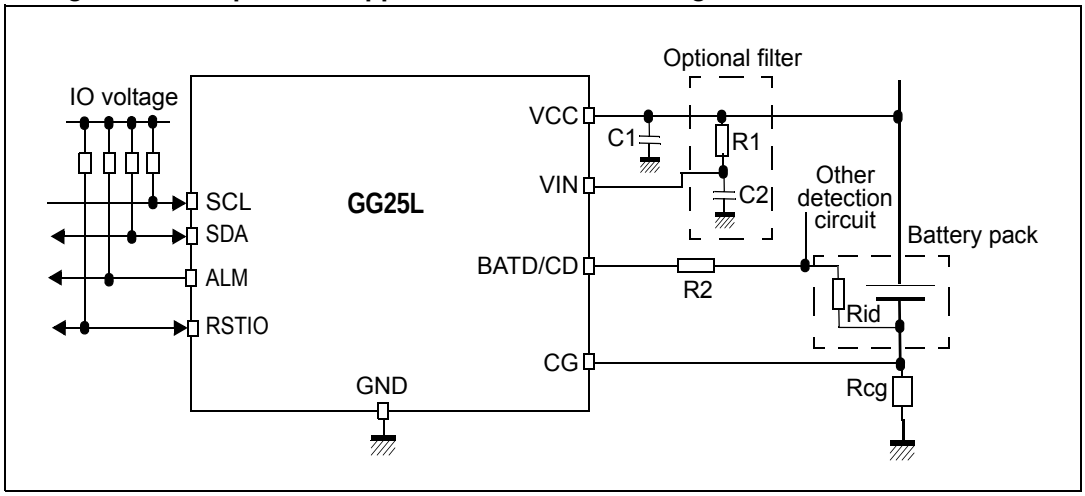


Table 7. External component list

Name	Value	Tolerance	Comments
Rcg	5 to 50 mΩ	1% to 5%	Current sense resistor (2% or better recommended)
C1	1 µF		Supply decoupling capacitor
C2	220 nF		Battery voltage input filter (optional)
R1	1 kΩ		Battery voltage input filter (optional)
R2	1 kΩ		Battery detection function

Figure 4. Example of an application schematic using the GG25L without current sensing

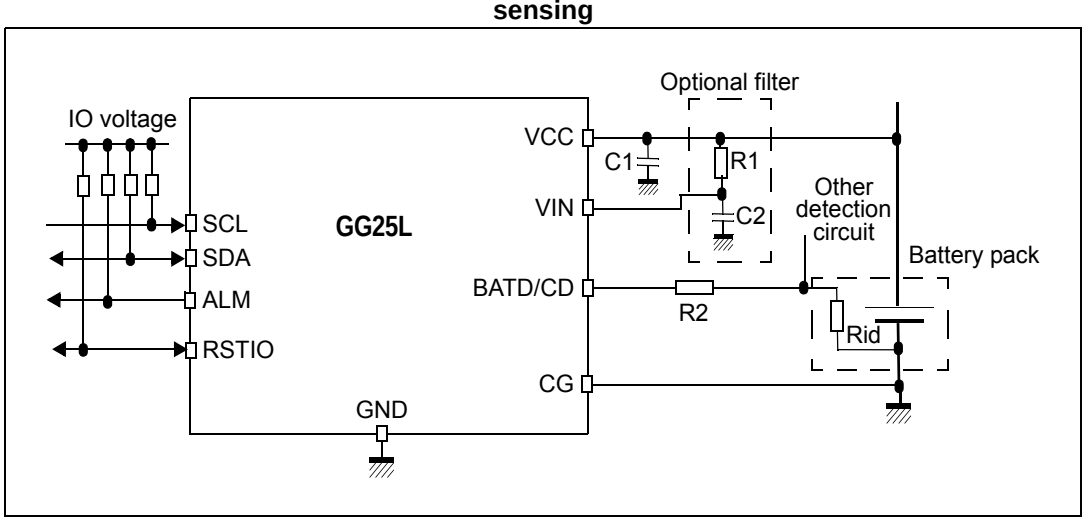


Table 8. External component list

Name	Value	Comments
C1	1 µF	Supply decoupling capacitor
C2	220 nF	Battery voltage input filter (optional)
R1	1 kΩ	
R2	1 kΩ	Battery detection function

6 Functional description

6.1 Battery monitoring functions

6.1.1 Operating modes

The monitoring functions include the measurement of battery voltage, current, and temperature. A Coulomb counter is available to track the SOC when the battery is charging or discharging at a high rate. A sigma-delta A/D converter is used to measure the voltage, current, and temperature.

The GG25L can operate in two different modes with different power consumption (see *Table 9*. Mode selection is made by the VMODE bit in register 0 (refer to *Table 14* for register 0 definition).

Table 9. GG25L operating modes

VMODE	Description
0	Mixed mode, Coulomb counter is active, voltage gas gauge runs in parallel
1	Voltage gas gauge with power saving Coulomb counter is not used. No current sensing.

In mixed mode, current is measured continuously (except for a conversion cycle every 4 s and every 16 s seconds for measuring voltage and temperature respectively). This provides the highest accuracy from the gas gauge.

In voltage mode with no current sensing, a voltage conversion is made every 4 s and a temperature conversion every 16 s. This mode provides the lowest power consumption.

It is possible to switch between the two operating modes to get the best accuracy during active periods, and to save power during standby periods while still keeping track of the SOC information.

6.1.2 Battery voltage monitoring

Battery voltage is measured by using one conversion cycle of the A/D converter every 4 s.

The conversion cycle takes 2^{13} = 8192 clock cycles. Using the 32768 Hz internal clock, the conversion cycle time is 250 ms.

The voltage range is 0 to 4.5 V and resolution is 2.20 mV. Accuracy of the voltage measurement is ±0.5% over the temperature range. This allows accurate SOC information from the battery open-circuit voltage.

The result is stored in the REG_VOLTAGE register (see *Table 13*).

6.1.3 Internal temperature monitoring

The chip temperature (close to the battery temperature) is measured using one conversion cycle of the A/D converter every 16 s.

The conversion cycle takes 2^{13} = 8192 clock cycles. Using the 32768 Hz internal clock, the conversion cycle time is 250 ms. Resolution is 1° C and range is -40 to +125 °C.

The result is stored in the REG_TEMPERATURE register (see *Table 13*).

6.1.4 Current sensing

Voltage drop across the sense resistor is integrated during a conversion period and input to the 14-bit sigma-delta A/D converter.

Using the 32768 Hz internal clock, the conversion cycle time is 500 ms for a 14-bit resolution. The LSB value is 5.88 µV. The A/D converter output is in two's complement format.

When a conversion cycle is completed, the result is added to the Coulomb counter accumulator and the number of conversions is incremented in a 16-bit counter.

The current register is updated only after the conversion closest to the voltage conversion (that is: once per 4-s measurement cycle). The result is stored in the REG_CURRENT register (see *Table 13*).

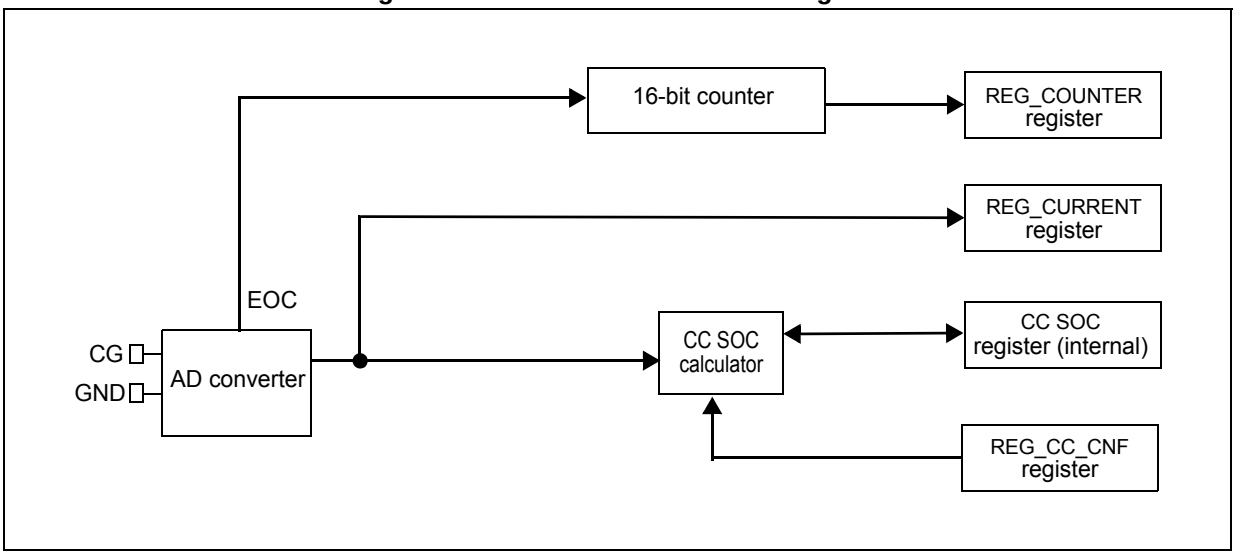
6.2 GG25L gas gauge architecture

6.2.1 Coulomb counter

The Coulomb counter is used to track the SOC of the battery when the battery is charging or discharging at a high rate. Each current conversion result is accumulated (Coulomb counting) for the calculation of the relative SOC value based on the configuration register.

The system controller can control the Coulomb counter and set and read the SOC register through the I²C control registers.

Figure 5. Coulomb counter block diagram



The REG_CC_CNF value depends on battery capacity and the current sense resistor. It scales the charge integrated by the sigma delta converter into a percentage value of the battery capacity. The default value is 395 (corresponding to a 10 mΩ sense resistor and 1957 mAh battery capacity).

The Coulomb counter is inactive if the VMODE bit is set, this is the default state at power-on-reset (POR) or reset (VMODE bit = 1).

Writing a value to the register REG_SOC (mixed mode SOC) forces the Coulomb counter gas gauge algorithm to restart from this new SOC value.

REG_CC_CNF register is a 16-bit integer value and is calculated as shown in *Equation 1*:

Equation 1

$$REG_CC_CNF = Rsense \times Cnom / 49.556$$

Rsense is in mΩ and Cnom is in mAh.

Example: Rsense =10 mΩ, Cnom = 1650 mAh, REG_CC_CNF = 333

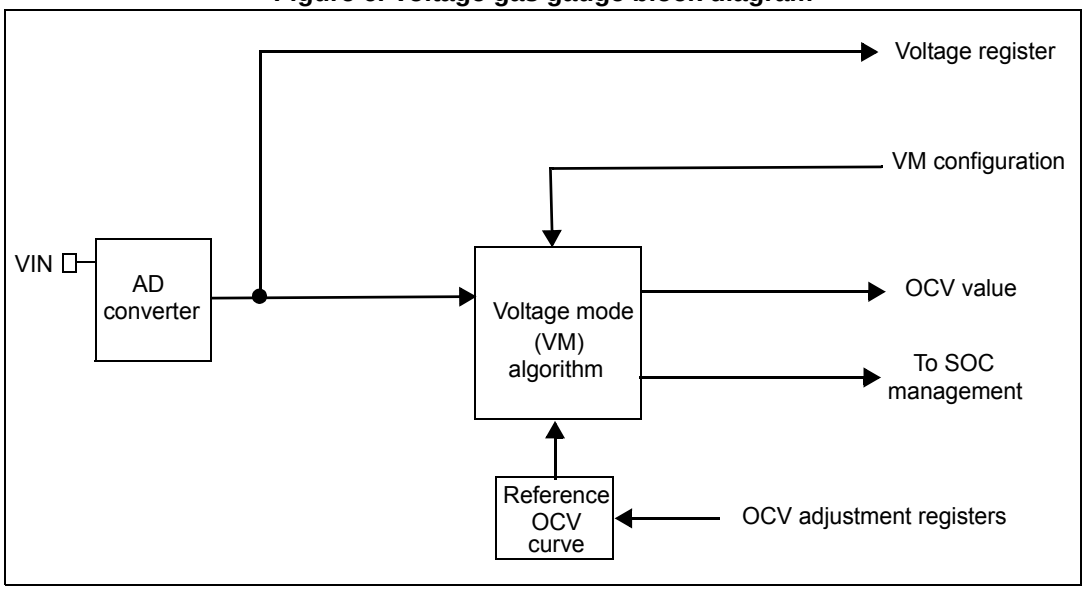
6.2.2 Voltage gas gauge algorithm

No current sensing is needed for the voltage gas gauge. An internal algorithm precisely simulates the dynamic behavior of the battery and provides an estimation of the OCV. The battery SOC is related to the OCV by means of a high-precision reference OCV curve built into the GG25L.

Any change in battery voltage causes the algorithm to track both the OCV and SOC values, taking into account the non-linear characteristics and time constants related to the chemical nature of the Li-Ion and Li-Po batteries.

A single parameter fits the algorithm to a specific battery. The default value provides good results for most battery chemistries used in hand-held applications.

Figure 6. Voltage gas gauge block diagram



Voltage gas gauge algorithm registers

The REG_VM_CNF configuration register is used to configure the parameter used by the algorithm based on battery characteristic. The default value is 321.

The REG_OCV register holds the estimated OCV value corresponding to the present battery state.

The REG_OCVTAB registers are used to adjust the internal OCV table to a given battery type.

The REG_VM_CNF register is a 12-bit integer value and is calculated from the averaged internal resistance and nominal capacity of the battery as shown in *Equation 2*:

Equation 2

$$REG_VM_CNF = Ri \times Cnom / 977.78$$

Ri is in mΩ and Cnom is in mAh.

Example: Ri = 190 mΩ, Cnom =1650 mAh, REG_VM_CNF = 321

6.2.3 Mixed mode gas gauge system

The GG25L provides a mixed mode gas gauge using both a Coulomb counter (CC) and a voltage-mode (VM) algorithm to track the SOC of the battery in all conditions with optimum accuracy. The GG25L directly provides the SOC information.

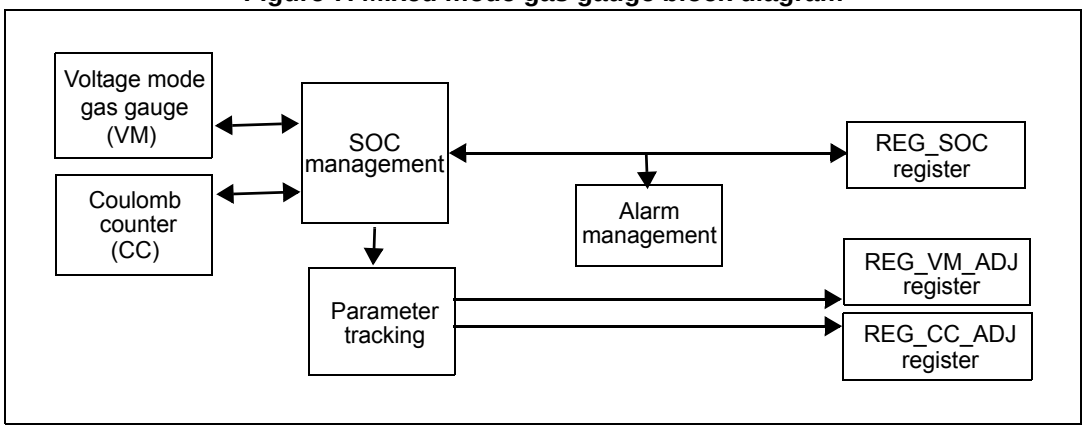
The Coulomb counter is mainly used when the battery is charging or discharging at a high rate. Each current conversion result is accumulated (Coulomb counting) for the calculation of the relative SOC value based on a configuration register.

The voltage-mode algorithm is used when the application is in low power consumption state.

The GG25L automatically uses the best method in any given application condition.

However, when the application enters standby mode, the GG25L can be put in power-saving mode: only the voltage-mode gas gauge stays active, the Coulomb counter is stopped and power consumption is reduced.

Figure 7. Mixed mode gas gauge block diagram



The combination of the CC and VM algorithms provides optimum accuracy under all application conditions. The voltage gas gauge cancels any long-term errors and prevents the SOC drift problem that is commonly found in Coulomb counter only solutions.

Furthermore, the results of the two algorithms are continuously compared and adjustment factors are calculated. This enables the application to track the CC and VM algorithm parameters for long-term accuracy, automatically compensating for battery aging, application condition changes, and temperature effects. Five registers are dedicated to this monitoring:

- REG_CC_ADJ and REG_VM_ADJ are continuously updated. They are signed, 16-bit, user-adjusted registers with LSB = 1/512 %.
- ACC_CC_ADJ and ACC_VM_ADJ are updated only when a method switch occurs. They are signed, 16-bit user adjusted accumulators with LSB = 1/512%
- RST_ACC_CC_ADJ and RST_ACC_VM_ADJ bits in the REG_MODE register are used to clear the associated counter.

6.3 Low battery alarm

The ALM pin provides an alarm signal in case of a low battery condition. The output is an open drain and an external pull-up resistor is needed in the application. Writing the IO0DATA bit to 0 forces the ALM output low; writing the IO0DATA bit to 1 lets the ALM output reflect the battery condition. Reading the IO0DATA bit gives the state of the ALM pin.

When the IO0DATA bit is 1, the ALM pin is driven low if either of the following two conditions is met:

- The battery SOC estimation from the mixed algorithm is less than the programmed threshold (if the alarm function is enabled by the ALM_ENA bit).
- The battery voltage is less than the programmed low voltage level (if the ALM_ENA bit is set).

When a low-voltage or low-SOC condition is triggered, the GG25L drives the ALM pin low and sets the ALM_VOLT or ALM_SOC bit in REG_CTRL.

The ALM pin remains low (even if the conditions disappear) until the software writes the ALM_VOLT and ALM_SOC bits to 0 to clear the interrupt.

Clearing the ALM_VOLT or ALM_SOC while the corresponding low-voltage or low-SOC condition is still in progress does not generate another interrupt; this condition must disappear first and must be detected again before another interrupt (ALM pin driven low) is generated for this alarm. Another alarm condition, if not yet triggered, can still generate an interrupt.

Usually, the low-SOC alarm occurs first to warn the application of a low battery condition, then if no action is taken and the battery discharges further, the low-voltage alarm signals a nearly-empty battery condition.

At power-up, or when the GG25L is reset, the SOC and voltage alarms are enabled (ALM_ENA bit = 1). The ALM pin is high-impedance directly after POR and is driven low if the SOC and/or the voltage is below the default thresholds (1% SOC, 3.00 V voltage), after the first OCV measurement and SOC estimation.

The REG_SOC_ALM register holds the relative SOC alarm level in 0.5 % units (0 to 100 %). Default value is 2 (i.e. 1% SOC).

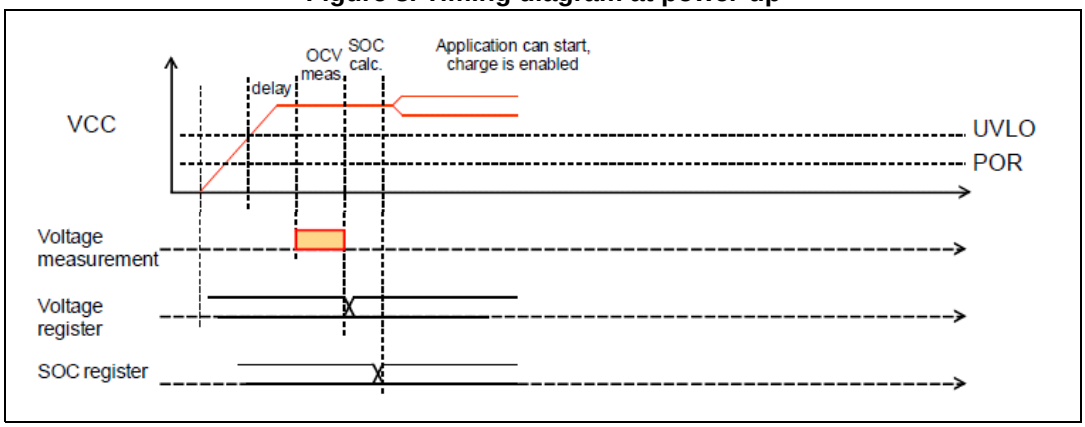
The REG_ALARM_VOLTAGE holds the low voltage threshold and can be programmed over the full scale voltage range with 17.60 (2.20 * 8) mV steps. The default value is 170 (3.00 V).

6.4 Power-up and battery swap detection

When the GG25L is powered up at first battery insertion, an automatic battery voltage measurement cycle is made immediately after startup and debounce delay.

This feature enables the system controller to get the SOC of a newly inserted battery based on the OCV measured just before the system actually starts.

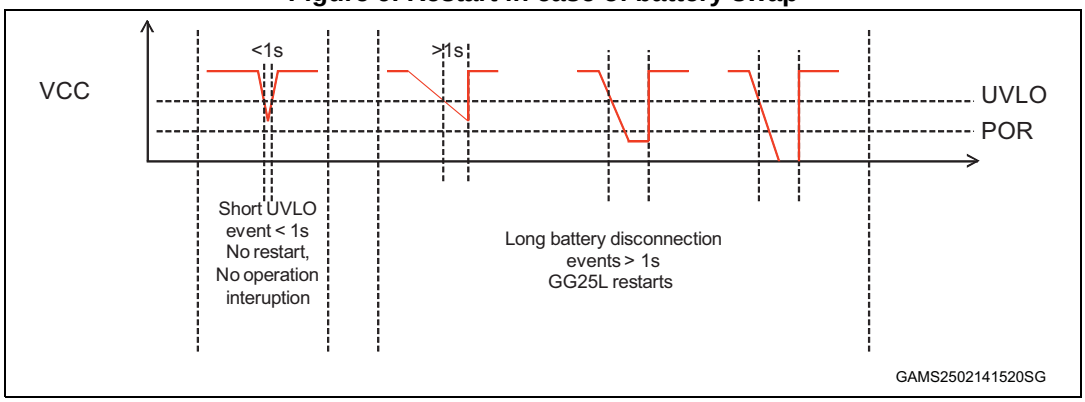
Figure 8. Timing diagram at power-up



A battery swap is detected when the battery voltage drops below the undervoltage lockout (UVLO) for more than 1 s. The GG25L restarts when the voltage goes back above UVLO, in the same way as for a power-up sequence.

Such filtering provides robust battery swap detection and prevents restarting in case of short voltage drops. This feature protects the application against high surge currents at low temperatures.

Figure 9. Restart in case of battery swap



Example: When BATD/CD is high (voltage above the 1.61 V threshold) for more than 1 s, a battery swap is detected. The GG25L restarts when the BATD/CD level returns below the threshold, in the same way as for a power-up sequence.

Using the 1-s filter prevents false battery swap detection if short contact bouncing occurs at the battery terminals due to mechanical vibrations or shocks.

6.5 Improving accuracy of the initial OCV measurement with the advanced functions of BATD/CD and RSTIO pins

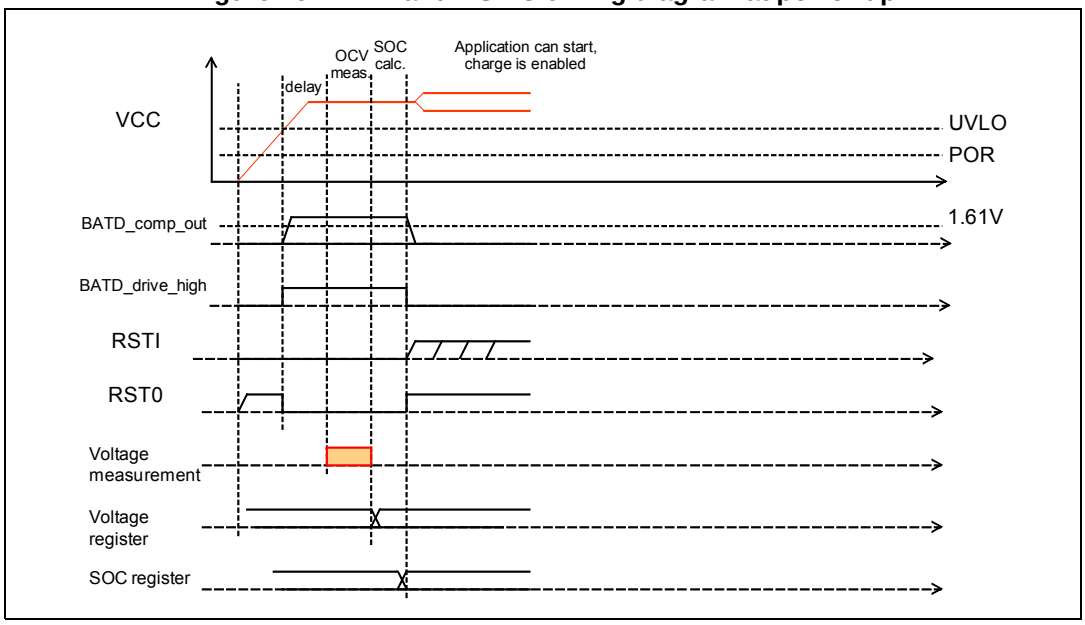
The advanced functions of the BATD/CD and RSTIO pins provide a way to ensure that the OCV measurement at power-up is not affected by the application startup or by the charger operation. This occurs as follows:

- The BATD/CD pin is driven high to V_{CC} voltage which inhibits the charge function (assuming that the BATD/CD signal is connected to disable input of the charger circuit).
- The RSTIO pin senses the system reset state and if the system reset is active (that is RSTIO is low), the RSTIO is kept low until the end of the OCV measurement.

Figure 10 describes the BATD/CD and RSTIO operation at power-up. Please refer to the block diagram of *Figure 11* for the RSTI, RSTO, BATD_comp_out, and BATD_drive_high signals.

At the end of the OCV measurement, the BATD/CD and RSTIO pin are released (high impedance), the application can start and the charger is enabled.

Figure 10. BATD and RSTIO timing diagram at power-up



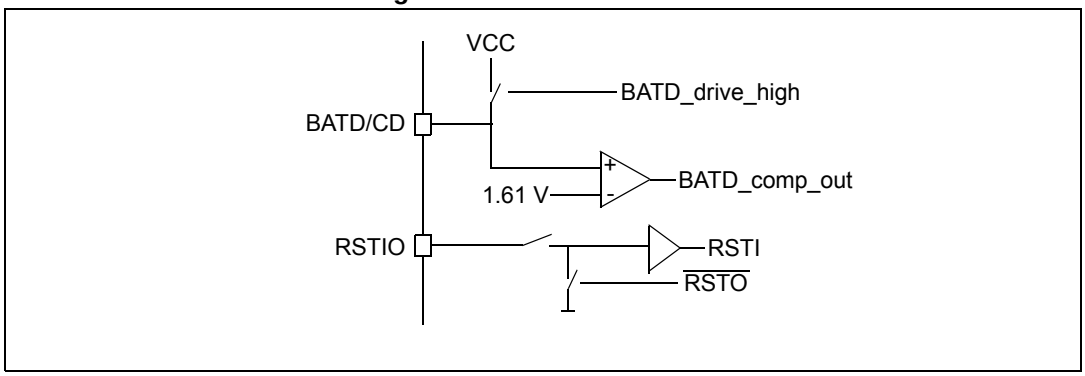
6.5.1 BATD and RSTIO pins

The GG25L provides platform synchronization signals to provide reliable SOC information in different cases.

The BATD/CD pin senses the presence of the battery independently of the battery voltage and it controls the battery charger to inhibit the charge during the initial OCV measurement.

The RSTIO pin can be used to delay the platform startup during the first OCV measurement at battery insertion.

Figure 11. BATD and RSTIO



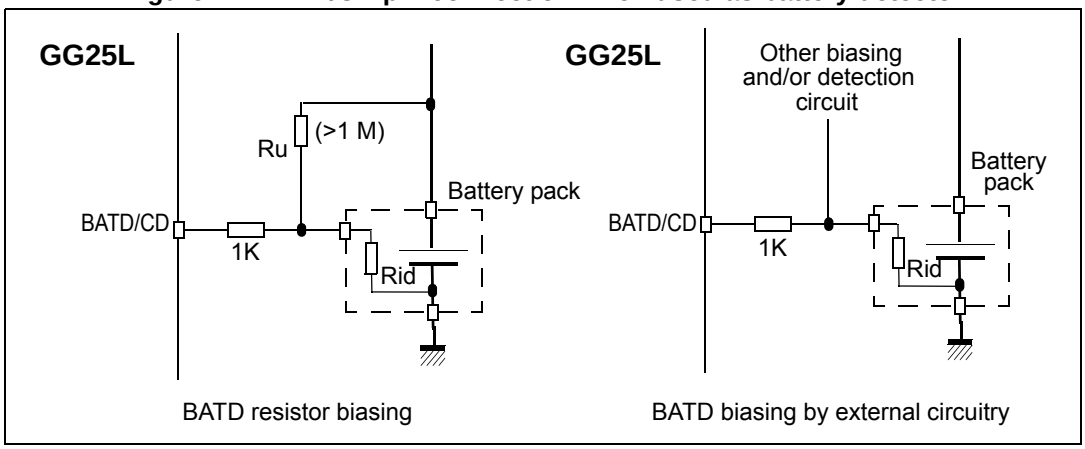
The BATD/CD pin used as a battery detector is an analog I/O.The input detection threshold is typically 1.61 V.

BATD/CD is also an output connected to V_{CC} level when active. Otherwise, it is high impedance.

The RSTIO signal is used to control the application system reset during the initial OCV measurement. The RSTIO pin is a standard I/O pin with open drain output.

BATD/CD can be connected to the NTC sensor or to the identification resistor of the battery pack. The GG25L does not provide any biasing voltage or current for the battery detection. An external pull-up resistor or another device has to pull the BATD/CD pin high when the battery is removed.

Figure 12. BATD/CD pin connection when used as battery detector



7 I²C interface

7.1 Read and write operations

The I²C interface is used to control and read the current accumulator and registers. It is compatible with the Philips I²C Bus® (version 2.1). It is a slave serial interface with a serial data line (SDA) and a serial clock line (SCL).

- SCL: input clock used to shift data
- SDA: input/output bidirectional data transfers

A filter rejects the potential spikes on the bus data line to preserve data integrity.

The bidirectional data line supports transfers up to 400 Kbit/s (fast mode). The data are shifted to and from the chip on the SDA line, MSB first.

The first bit must be high (START) followed by the 7-bit device address and the read/write control bit. Bits DevADDR0 to DevADDR2 are factory-programmable, the default device address value being 1110 000 (AddrID0 = AddrID1 = AddrID2 = 0). The GG25L then sends an acknowledge at the end of an 8-bit long sequence. The next eight bits correspond to the register address followed by another acknowledge.

The data field is the last 8-bit long sequence sent, followed by a last acknowledge.

Table 10. Device address format

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
1	1	1	0	DevADDR2	DevADDR1	DevADDR0	R/W

Table 11. Register address format

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
RegADDR7	RegADDR6	RegADDR5	RegADDR4	RegADDR3	RegADDR2	RegADDR1	RegADDR0

Table 12. Register data format

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0

Figure 13. Read operation

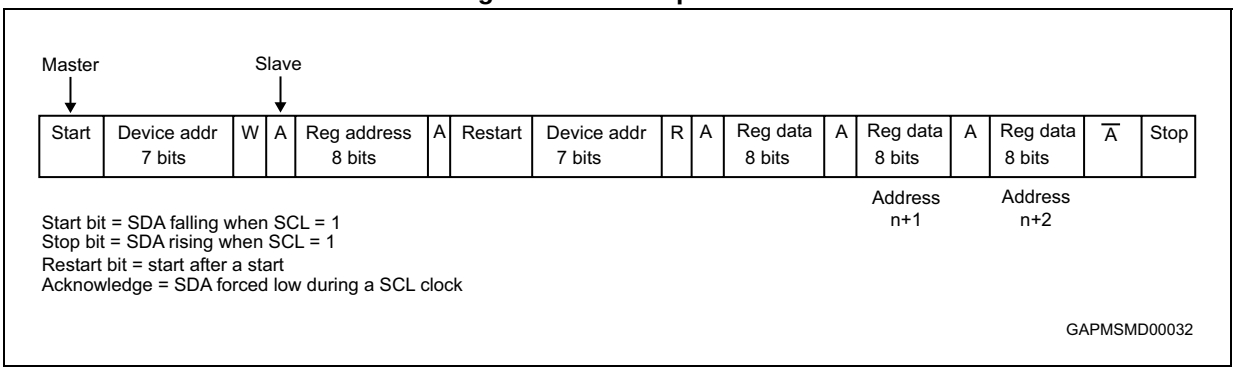
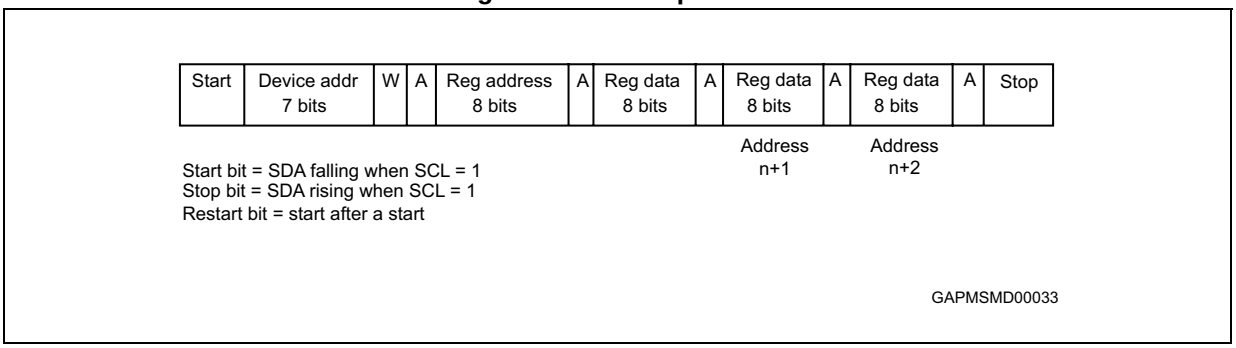


Figure 14. Write operation



7.2 Register map

7.2.1 Register map

The register space provides 28 control registers, 1 read-only register for device ID, 16 read/write RAM working registers reserved for the gas gauge algorithm, and 16 OCV adjustment registers. Mapping of all registers is shown in *Table 13*. Detailed descriptions of registers 0 (REG_MODE) and 1 (REG_CTRL) are shown in *Table 14* and *Table 15*. All registers are reset to default values at power-on or reset, and the PORDET bit in register REG_CTRL is used to indicate the occurrence of a power-on reset.

Table 13. Register map

Name	Address (decimal)	Type	POR	Soft POR	Description	LSB
Control registers	0 to 23					
REG_MODE	0	R/W			Mode register	
REG_CTRL	1	R/W			Control and status register	
REG_SOC	2-3	R/W			Gas gauge relative SOC	1/512%
REG_COUNTER	4-5	R	0x00	0x00	Number of conversions (2 bytes)	
REG_CURRENT	6-7	R	0x00	0x00	Battery current value (2 bytes)	5.88 µV
REG_VOLTAGE	8-9	R	0x00	0x00	Battery voltage value (2 bytes)	2.2 mV
REG_TEMPERATURE	10	R	0x00	0x00	Temperature data	1 °C
REG_CC_ADJ_HIGH	11	R/W	0x00	0x00	Coulomb counter adjustment factor	1/2%
REG_VM_ADJ_HIGH	12	R/W	0x00	0x00	Voltage mode adjustment factor	
REG_OCV	13-14	R/W	0x00	0x00	OCV register (2 bytes)	0.55 mV
REG_CC_CNF	15-16	R/W	395	395	Coulomb counter gas gauge configuration	
REG_VM_CNF	17-18	R/W	321	321	Voltage gas gauge algorithm parameter	
REG_ALARM_SOC	19	R/W	0x02	0x02	SOC alarm level (default = 1%)	1/2%
REG_ALARM_VOLTAGE	20	R/W	0xAA	0xAA	Battery low voltage alarm level (default is 3 V)	17.6 mV
REG_CURRENT_THRES	21	R/W	0x0A	0x0A	Current threshold for the relaxation counter	47.04 µV
REG_RELAX_COUNT	22	R	0x78	0x78	Relaxation counter	
REG_RELAX_MAX	23	R/W	0x78	0x78	Relaxation counter max value	
REG_ID	24	R	0x14	0x14	Part type ID = 14h	

Table 13. Register map (continued)

Name	Address (decimal)	Type	POR	Soft POR	Description	LSB
REG_CC_ADJ_LOW	25	R/W	0x00	0x00	Coulomb counter adjustment factor	1/512%
REG_VM_ADJ_LOW	26	R/W	0x00	0x00	Voltage mode adjustment factor	
ACC_CC_ADJ	27-28	R/W	0x00	0x00	Coulomb Counter correction accumulator	
ACC_VM_ADJ	29-30	R/W	0x00	0x00	Voltage mode correction accumulator	
RAM registers	32 to 47					
REG_RAM0	32	R/W	Random	Unchanged	Working register 0 for gas gauge	
...	...				...	
REG_RAM15	47	R/W	Random	Unchanged	Working register 15 for gas gauge	
OCV adjustment registers						
REG_OCVTAB	48 to 63	R/W	0x00	0x00	OCV adjustment table (16 registers)	0.55 mV

7.2.2 Register description

Values held in consecutive registers (such as the charge value in the REG_SOC register pair) are stored with high bits in the first register and low bits in the second register. The registers must be read with a single I²C access to ensure data integrity. It is possible to read multiple values in one I²C access. All values must be consistent.

The SOC data are coded in binary format and the LSB of the low byte is 1/512 %. The battery current is coded in 2's complement format and the LSB value is 5.88 µV. The battery voltage is coded in 2's complement format and the LSB value is 2.20 mV. The temperature is coded in 2's complement format and the LSB value is 1°C.

Table 14. REG_MODE - address 0

Name	Position	Type	Def.	Description
VMODE	0	R/W	1	0: Mixed mode (Coulomb counter active) 1: Power saving voltage mode
CLR_VM_ADJ	1	R/W	0	Write 1 to clear ACC_VM_ADJ and REG_VM_ADJ. Auto clear bit if GG_RUN = 1
CLR_CC_ADJ	2	R/W	0	Write 1 to clear ACC_CC_ADJ and REG_CC_ADJ Auto clear bit if GG_RUN = 1
ALM_ENA	3	R/W	1	Alarm function 0: Disabled 1: Enabled
GG_RUN	4	R/W	0	0: Standby mode. Accumulator and counter registers are frozen, gas gauge and battery monitor functions are in standby. 1: Operating mode.
FORCE_CC	5	R/W	0	Forces the mixed mode relaxation timer to switch to the Coulomb counter mode. Write 1, self clear to 0 Relaxation counter = 0
FORCE_VM	6	R/W	0	Forces the mixed mode relaxation timer to switch to voltage gas gauge mode. Write 1, self clear to 0 Relaxation counter = Relax_max
	7			Unused

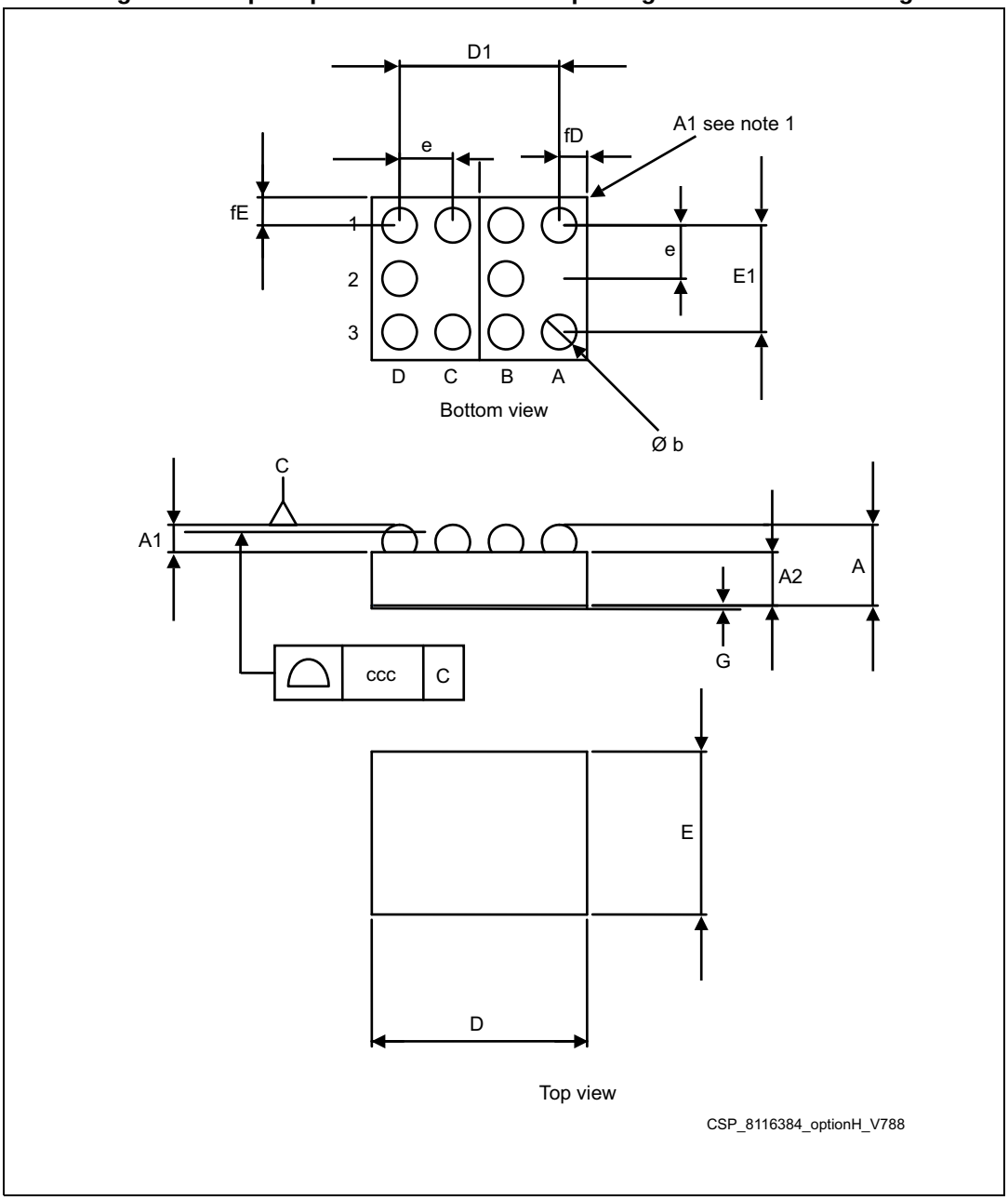
Table 15. REG_CTRL - address 1

Name	Position	Type	Def.	Description
IO0DATA	0	R	X	ALM pin status 0 = ALM input is low 1 = ALM input is high
		W	1	ALM pin output drive 0 = ALM is forced low 1 = ALM is driven by the alarm conditions
GG_RST	1	W	0	0: no effect 1: resets the conversion counter GG_RST is a self-clearing bit.
GG_VM	2	R	0	Voltage mode active 0 = REG_SOC from Coulomb counter mode 1 = REG_SOC from Voltage mode
BATFAIL	3	R/W	0	Battery removal or UVLO detection bit. Write 0 to clear (Write 1 is ignored)
PORDET	4	R	1	Power on reset (POR) detection bit 0 = no POR event occurred 1 = POR event occurred
		W	0	Soft reset 0 = release the soft-reset and clear the POR detection bit, 1 = assert the soft-reset and set the POR detection bit. This bit is self clearing.
ALM_SOC	5	R/W	0	Set with a low-SOC condition. Cleared by writing 0.
ALM_VOLT	6	R/W	0	Set with a low-voltage condition. Cleared by writing 0.
	7			Unused

8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

Figure 15. Flip Chip CSP 1.40 x 2.04 mm package mechanical drawing



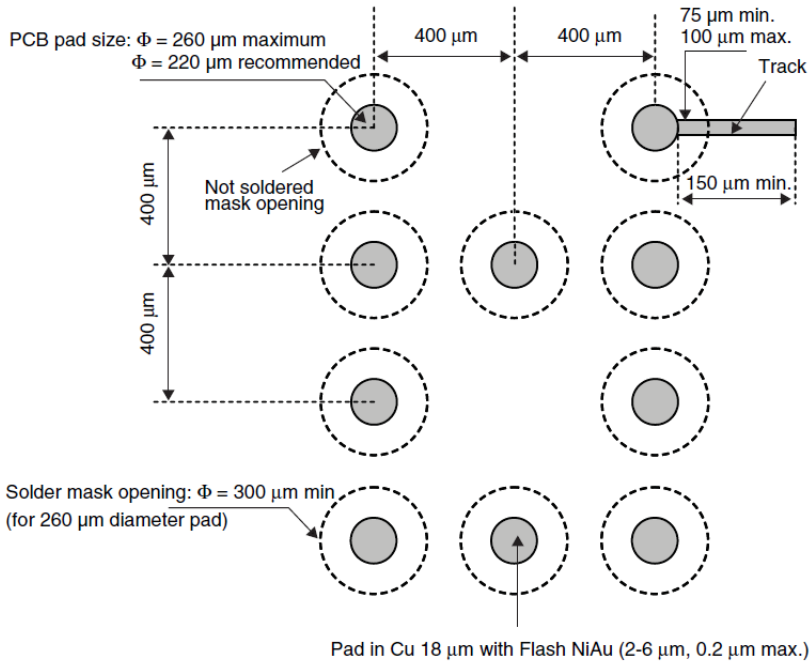
1. The terminal A1 on the bump side is identified by a distinguishing feature - for instance, by a circular “clear area” typically 0.1 mm in diameter and/or a missing bump.
2. The terminal A1, on the back side, is identified by a distinguishing feature - for instance, by a circular “clear

area" typically 0.2 mm in diameter depending on the die size.

Table 16. Flip Chip CSP 1.4 x 2.04 mm package mechanical data

Symbol	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.545	0.600	0.655	0.021	0.024	0.026
A1	0.165	0.200	0.235	0.006	0.008	0.009
A2	0.330	0.350	0.370	0.013	0.014	0.015
b	0.220	0.260	0.300	0.009	0.010	0.012
D	1.98	2.01	2.04	0.078	0.079	0.080
D1		1.20			0.047	
E	1.34	1.37	1.40	0.053	0.054	0.055
E1		0.800			0.031	
e	0.360	0.400	0.440	0.014	0.016	0.017
fD	0.395	0.405	0.415	0.016	0.016	0.016
fE	0.275	0.285	0.295	0.011	0.011	0.012
G		0.050			0.002	
ccc			0.050			0.002

Figure 16. Flip Chip CSP 1.4 x 2.04 mm footprint recommendation



9 Revision history

Table 17. Document revision history

Date	Revision	Changes
28-Feb-2014	1	Initial release

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST’S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER’S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR “AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL” INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.
Information in this document supersedes and replaces all information previously supplied.
The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2014 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com