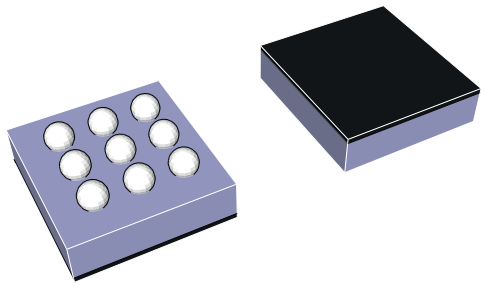
STC3117

Gas gauge IC with battery charger control for handheld applications

Datasheet - production data



CSP (1.49 x 1.594 mm)

Description

The STC3117 includes the STMicroelectronics OptimGauge™ algorithm. It provides accurate battery state-of-charge (SOC) monitoring, tracks battery parameter changes with operation conditions, temperature, and aging, and allows the application to get a battery state-of-health (SOH) indication.

An alarm output signals low SOC or low voltage conditions and also indicates fault conditions like a missing or swapped battery.

Features

- Patented OptimGauge™ algorithm for accurate battery capacity calculation
- Robust initial open-circuit-voltage (OCV) measurement at power up
- Programmable low battery alarm
- Missing/swapped battery detection
- Average current internal calculation
- End-of-charge detection
- Internal temperature sensor
- Battery swap detection with protection against false battery insertion
- Low power: 40 µA in voltage-only mode, 2 µA max in standby mode
- 1.49 x 1.594 mm 9-bump CSP package

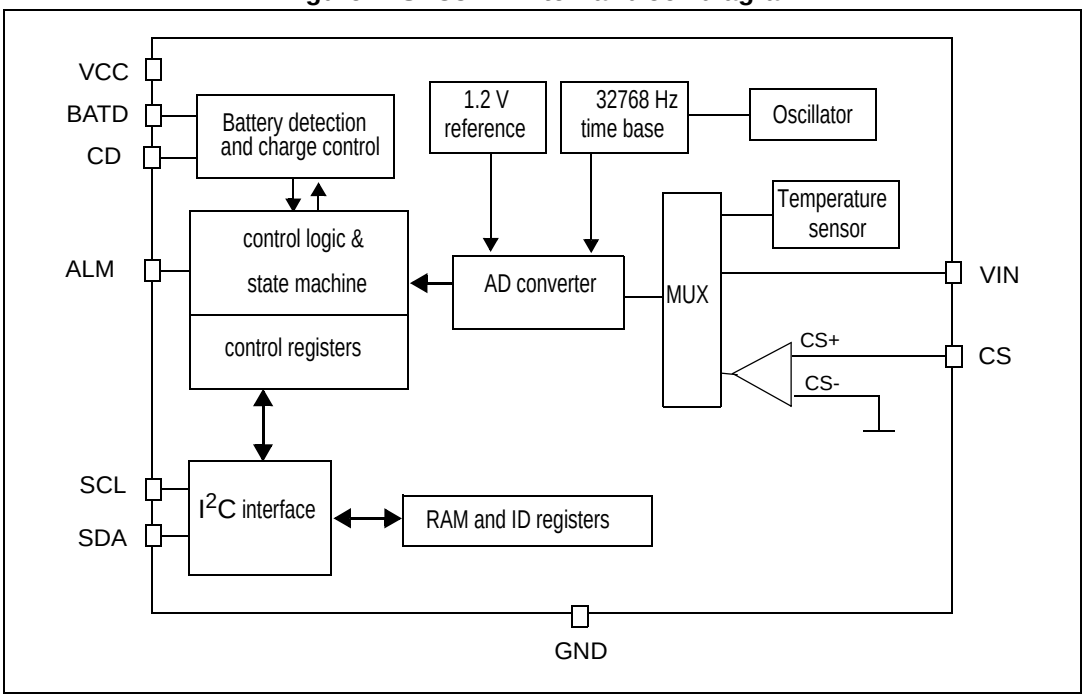
Applications

- Mobile phones, multimedia players, digital cameras
- Portable medical equipment

Contents

1 Block diagram

Figure 1. STC3117 internal block diagram



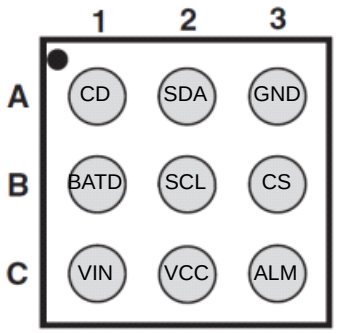
2 Pin assignment

Table 1. STC3117 pin description

CSP bump pin no.	Pin name	Type(1)	Function
C3	ALM	O/OD	Alarm signal output, open drain, external pull-up with resistor
A2	SDA	I/OD	I^2C serial data
B2	SCL	I_D	I^2C serial clock
A3	GND	Ground	Analog and digital ground
B3	CS	I_A	Current sensing input
B1	BATD	I/OA	Battery detection input
A1	CD	O/OD	Battery charge inhibit (active high output)
C2	VCC	Supply	Power supply
C1	VIN	I_A	Battery voltage sensing input

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

Figure 2. STC3117 pin connections (top view)



CSP (1.49 x 1.594 mm)
Top view (balls are underneath)

3 Absolute maximum ratings and operating conditions

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CCMAX}	Maximum voltage on VCC 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)(1)	2	kV
	Electrostatic discharge (MM: machine model)(2)	150	V

1. Tested in compliance with MIL-883-H, AEC-Q100-002D and JEDEC JESD22-A114F
2. Tested in compliance with MIL-883-H, AEC-Q100-003E and JEDEC JESD22-A115A

Table 3. 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 4. 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 voltage mode		40		µA
		Average value over 4 s in mixed mode		80		
I_{STBY}	Current consumption in standby	Standby mode, inputs = 0 V BATD_PU bit = 0			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				500	nA
ADC_res	AD converter granularity			5.88		µV
ADC_offset	AD converter offset	CS = 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
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

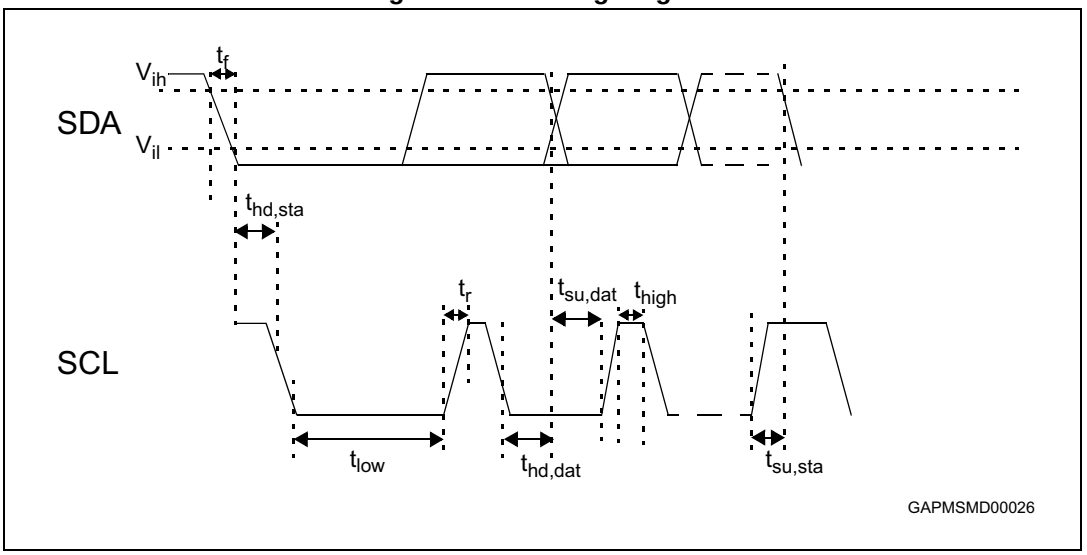
Table 4. Electrical characteristics (2.7 V < V_{CC} < 4.5 V, -20 °C to 70 °C) (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Digital I/O pins (SCL, SDA, ALM)						
Vih	Input logic high		1.2			V
Vil	Input logic low				0.35	
Vol	Output logic low (SDA, ALM)	Iol = 4 mA			0.4	
Analog I/O pins (BATD, CD)						
Vith	BATD input threshold voltage		1.46	1.61	1.76	V
Vihyst	BATD input voltage hysteresis			0.1		
Ru	BATD internal pull-up resistor			1		MΩ
Vcdoh	CD output logic high	Ioh = 3 mA			VCC - 0.4	V
Vinmin_cd	Minimum Vin voltage for CD operation	0°C to 50°C	3.6	3.75	3.9	

Table 5. I^2C 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			
$t_{su,sta}$	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	
t_f	Fall time of both SDA and SCL signals	20+ 0.1C_b		300	
$t_{su,sto}$	Setup time for STOP condition	0.6			µs
t_{buf}	Bus free time between a STOP and START condition	1.3			
C_b	Capacitive load for each bus line			400	pF

Figure 3. I^2C timing diagram



5 Application information

Figure 4. Example of an application schematic

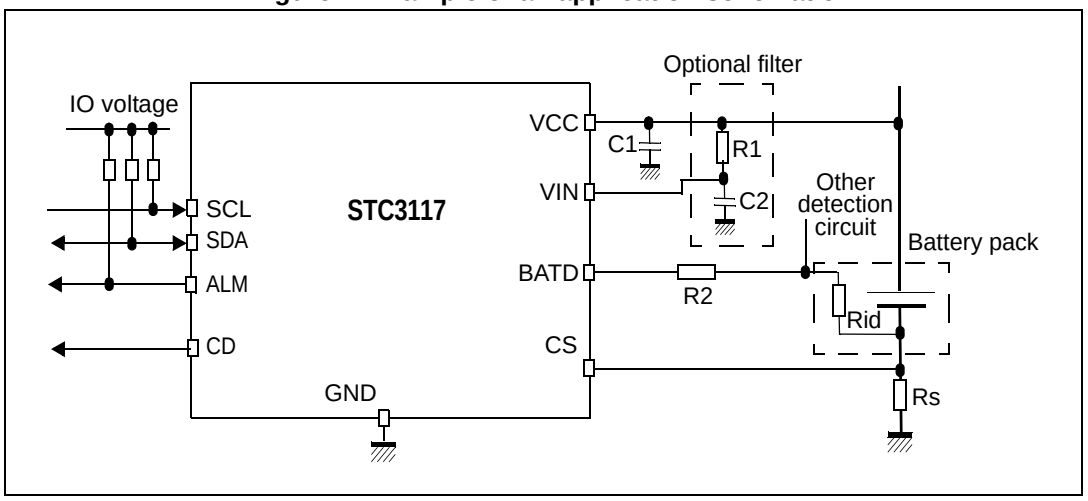


Table 6. External component list

Name	Value	Tolerance	Comments
Rs	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		
R2			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 STC3117 can operate in two different modes with different power consumption (see *Table 7*. Mode selection is made by the VMODE bit in register 0 (refer to *Table 12* for register 0 definition).

Table 7. STC3117 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 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 11*).

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 11*).

6.1.4 Current sensing in mixed mode

Current sensing is available only in mixed mode (VMODE=0).

The voltage drop across the sense resistor is integrated during a conversion period and is 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 after each conversion (that is: once per 500-ms measurement cycle). The result is stored in the REG_CURRENT register (see *Table 11*).

Average current register

In mixed mode, an average value of the current measurement is calculated after each current measurement with a time constant of 2 s.

The register REG_AVG_CURRENT (2 bytes) holds the average current when VMODE=0.

The LSB of REG_AVG_CURRENT is 1/4 the LSB of REG_CURRENT, that is 1.47 µV.

6.1.5 SOC change rate in voltage mode

Current sensing is not available in voltage mode (VMODE=1). Instead, an estimation of the SOC change rate is provided in the REG_AVG_CURRENT register.

The SOC change rate is updated after each SOC calculation (that is: once per 4-s measurement cycle) and is averaged with a time constant of 64 seconds. It is possible to write an initial estimation into the REG_AVG_CURRENT register to speed-up the SOC change rate settling time.

The REG_AVG_CURRENT register (2 bytes) holds the SOC change rate when VMODE=1.

The LSB of REG_AVG_CURRENT is 0.008789 C (by definition, 1 C means 100% SOC change in 1 h).

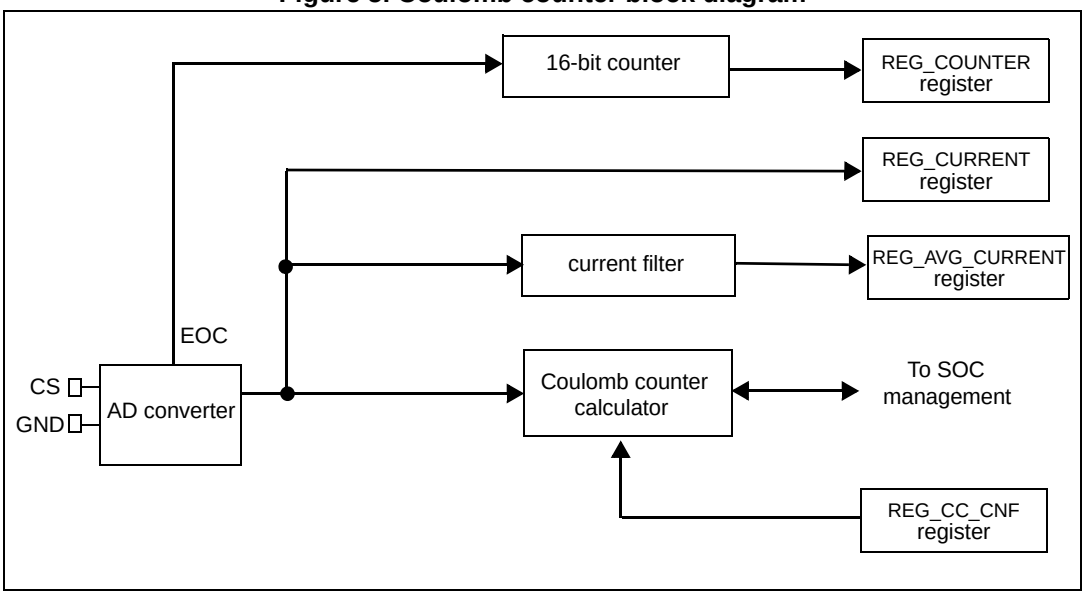
6.2 STC3117 gas gauge architecture

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 I^2C 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 CC_CNF that is calculated as shown in *Equation 1*:

Equation 1

$$CC\_CNF = Rsense \times Cnom / 49.556$$

Rsense is in mΩ and Cnom is in mAh.

Example: Rsense =10 mΩ, Cnom = 1500 mAh, CC_CNF = 303

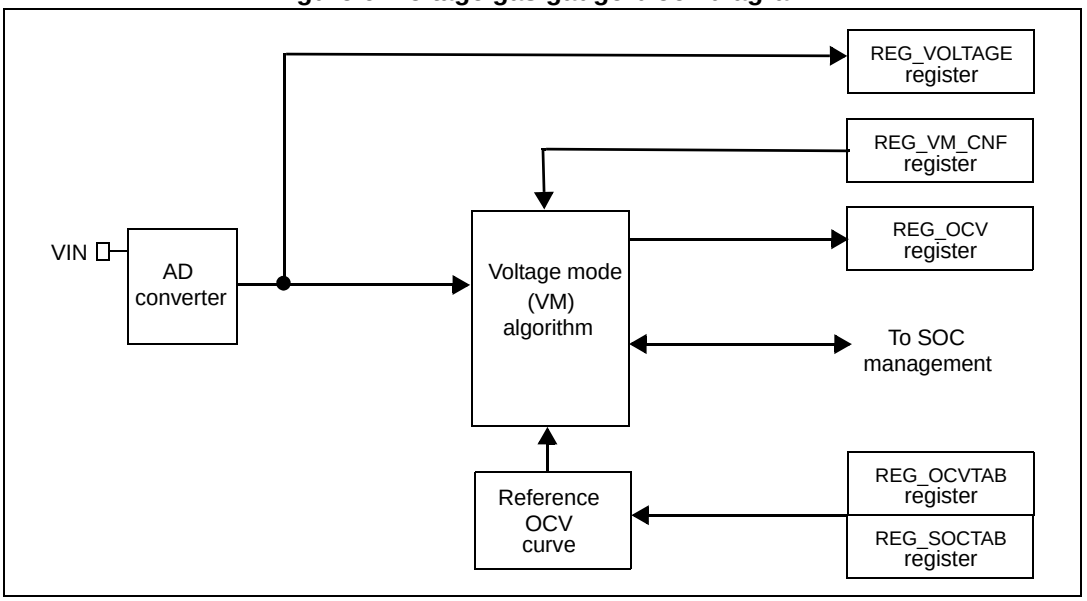
6.2.2 Voltage gas gauge algorithm

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 STC3117.

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 (corresponding to 160 mΩ internal battery impedance and 1957 mAh Cnom battery capacity).

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

The REG_OCVTAB and REG_SOCTAB registers define the OCV curve for a given battery type; the default power-up values can be updated at software initialization.

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

$$VM\_CNF = Ri \times Cnom / 977.78$$

Ri is in mΩ and Cnom is in mAh.

Example: Ri = 250 mΩ, Cnom =1500 mAh, VM_CNF= 384

6.2.3 Mixed mode gas gauge system

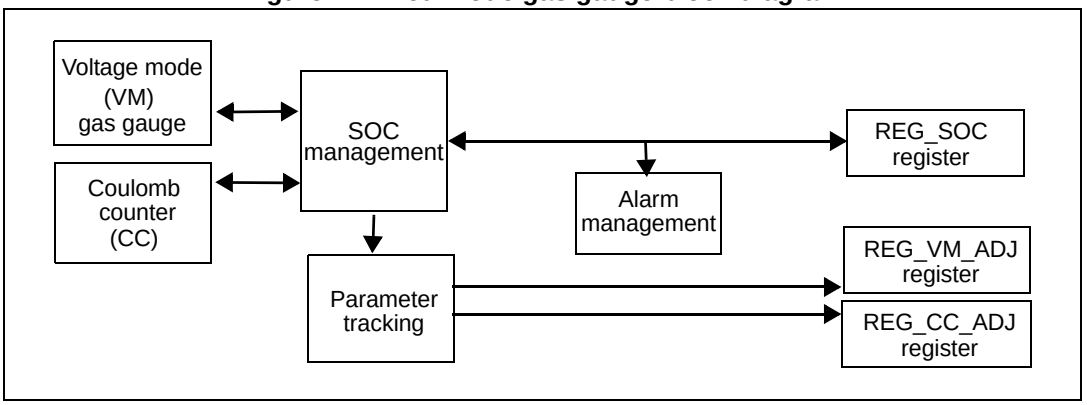
The STC3117 implements a mixed mode gas gauge (OptimGauge^{TM} 1) that uses both the Coulomb counter (CC) and the voltage mode (VM) algorithm to track the battery SOC in all application conditions and automatically provide the optimum SOC information. The VM algorithm cancels any long-term errors and prevents the SOC drift problem that is commonly found in CC-only solutions.

The STC3117 automatically selects the best method based on the relaxation timer (see *Section 6.4: Current monitoring*) as follows: when a low-power application state is detected by the relaxation timer, the SOC reported by the STC3117 is the VM SOC, otherwise the CC SOC is reported. The STC3117 manages the transitions between the VM and CC modes without discontinuity by adjusting the VM and the CC SOC to ensure smooth SOC variations without jumps in any application conditions.

The current mixed mode state is indicated by the GG_VM bit in the REG_CTRL register: GG_VM=1 means the reported SOC is the VM SOC, otherwise the SOC is the CC SOC.

Note: When the application enters standby mode, the STC3117 can be put into power-saving mode by setting the VMODE bit to 1 in the REG_MODE register. Only the VM gas gauge stays active, the CC is stopped, and the power consumption is reduced.

Figure 7. Mixed mode gas gauge block diagram



Adjustment registers

The registers REG_CC_ADJ and REG_VM_ADJ are signed 16-bit registers. They accumulate the adjustment quantities made to the SOC values by the embedded mixed mode algorithm:

- REG_CC_ADJ = REG_SOC – (unadjusted CC SOC)
- REG_VM_ADJ = REG_SOC – (unadjusted VM SOC)

These registers can be used by the system application to implement more sophisticated algorithms for improved performance and accuracy.

Writing to the REG_SOC or REG_OCV initializes the two VM and CC algorithms to the corresponding SOC value and clears REG_VM_ADJ and REG_CC_ADJ. It is possible to write to the REG_SOC, REG_OCV, REG_VM_CNF and REG_CC_CNF registers when the STC3117 is running without disturbing SOC management.

Note: When writing to the REG_SOC or REG_OCV registers, the resulting SOC value is rounded to the nearest 1/64 % value (the least three bits of REG_SOC are zero).

6.3 Alarm output

The ALM pin provides an alarm signal in case of low battery or fault 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 any of the following conditions are 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)
- the BATFAIL bit is set (if the ALM_ENA bit is set)

Low-voltage or low-SOC alarms

When a low-voltage or low-SOC condition is triggered, the STC3117 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 true 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. The other 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 STC3117 is reset, the SOC and voltage alarms are enabled (ALM_ENA bit = 1). The ALM pin is in high-impedance directly after a POR and is driven low if the SOC and/or the voltage is below the default thresholds (1% SOC, 3.00 V), 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. Default value is 170 (i.e. 3.00 V).

BATFAIL alarm

The BATFAIL bit in REG_CTRL reflects the battery swap event: BATFAIL bit is set when the BATD signal rises above the BATD threshold (1.61 V typ) for more than 0.5 s. and is reset by writing 0 to the BATFAIL bit if the BATD signal is below the BATD threshold (if BATD is still above 1.61 V, then BATFAIL bit can not be cleared).

The STC3117 drives the ALM pin low when the BATFAIL bit is set and releases the ALM pin when the BATFAIL bit is cleared.

6.4 Current monitoring

The battery average current is monitored and is used in conjunction with a timer to implement a battery relaxation timer.

Battery relaxation timer

The battery relaxation timer is used to detect a light-load, low-power condition.

The REG_CMONIT_COUNT register is an 8-bit, read-only counter that is incremented every 4 s when the average current is inside a window defined by positive and negative thresholds set by the REG_CURRENT_THRES register, and decremented every 500 ms when the current is outside the thresholds.

When the counter reaches its maximum value set by the REG_CMONIT_MAX register, a low-power condition is reported to the mixed mode algorithm causing VM mode to be used. When the counter reaches its minimum value (0), a high-power condition is reported and CC mode is used.

The REG_CMONIT_MAX register sets the maximum value of the counter. With the default value (120 dec), the counter provides an 8-minute delay when switching from CC to VM mode and a 1-minute delay when switching from VM to CC mode.

The REG_CURRENT_THRES register is an 8-bit R/W register set by the gas gauge firmware from the I^2C. It holds the threshold amplitude in bits 0 to 6 (unsigned value applicable for both positive and negative thresholds). Bit 7 of REG_CURRENT_THRES is reserved and must be set to zero for operation of the current monitoring counter as a relaxation timer. The LSB value of the REG_CURRENT_THRES is 47.04 µV and provides a range of 0 to 6 mV.

It is possible to set the counter to zero or the maximum value using the FORCE_CC and FORCE_VM bits in the REG_MODE register. These bits are self-clearing.

6.5 Power-up and battery swap detection

When the STC3117 is powered up at first battery insertion (power-on reset) or after a soft reset condition (PORDET bit set by host), an automatic battery voltage, current and temperature measurement cycle is made immediately after startup and debounce delay.

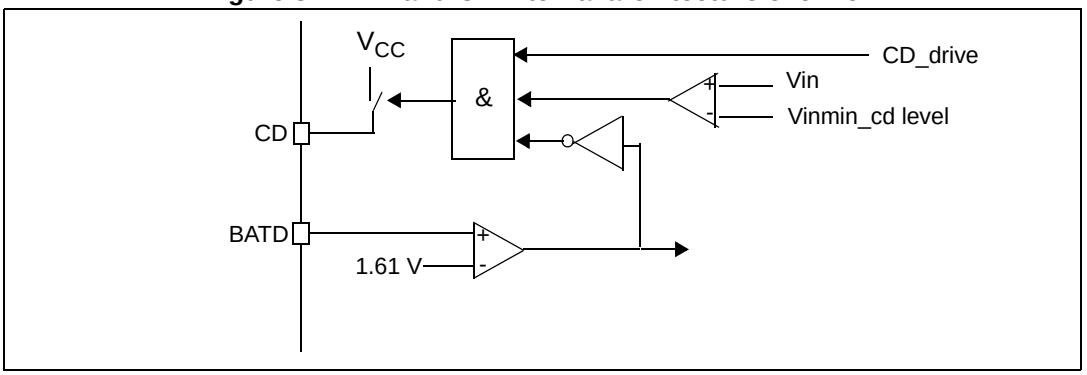
This feature enables the system controller to get the SOC of a newly inserted battery based on the OCV.

The CD pin controls the battery charger to inhibit the charge during the initial OCV measurement. The CD output is validated during the power-up/restart sequence but is actually driven high only if the battery is present (BATD < 1.61V) and the battery voltage is higher than a threshold (Vin > Vinmin_cd) at the beginning of the restart sequence.

The CD pin can be driven high under software control by using the bit FORCE_CD in the REG_MODE register.

The BATD pin senses the presence of the battery independently of the battery voltage.

Figure 8. BATD and CD internal architecture overview

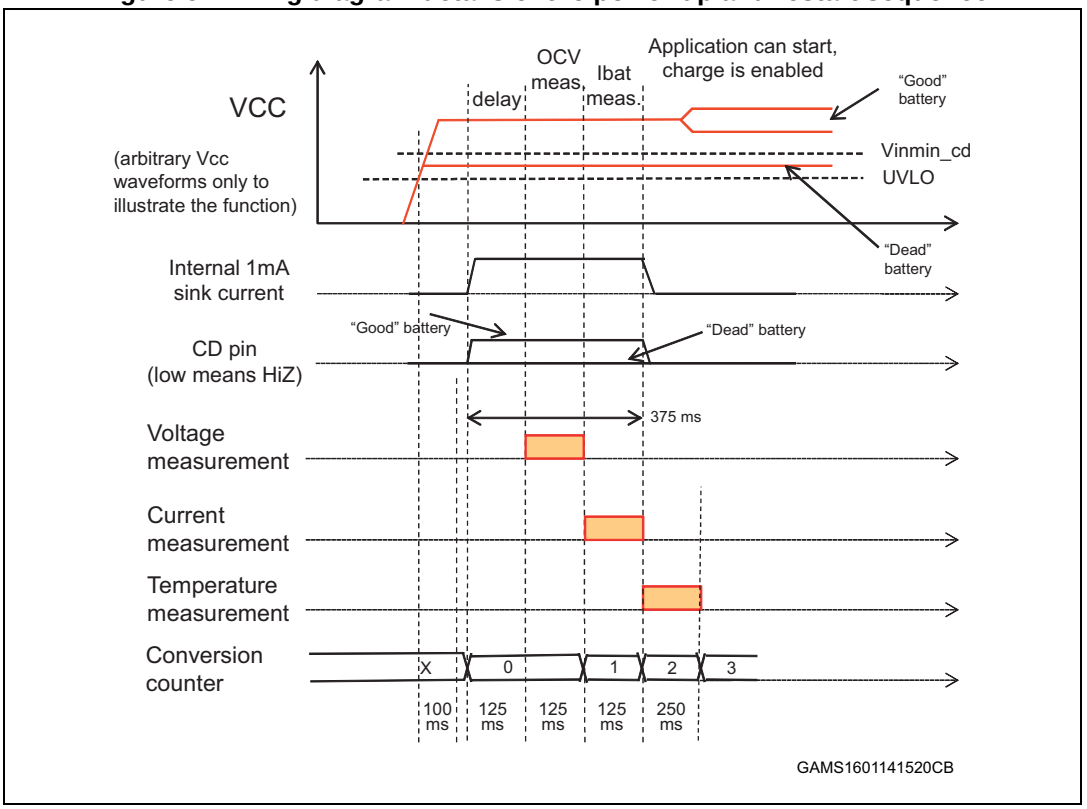


The BATD pin is an analog I/O. The input detection threshold is typically 1.61 V.

The CD pin is an output connected to the V_{CC} level when active. Otherwise, it is high impedance.

The BATD pin can be connected to the NTC sensor or to the identification resistor of the battery pack. By default, the STC3117 provides an internal pull-up resistor for the detection of battery removal. The internal resistor can be disabled by clearing the bit BATD_PU in the REG_MODE register. When disabled, an external pull-up resistor or another device has to pull the BATD pin high.

Figure 9. Timing diagram details of the power-up and restart sequence



Battery swap detection

A battery swap can be detected in two ways:

- the battery voltage drops below the undervoltage lockout (UVLO) for more than tdel
- the BATD signal rises above the BATD threshold (1.61 V typ) for more than tdel

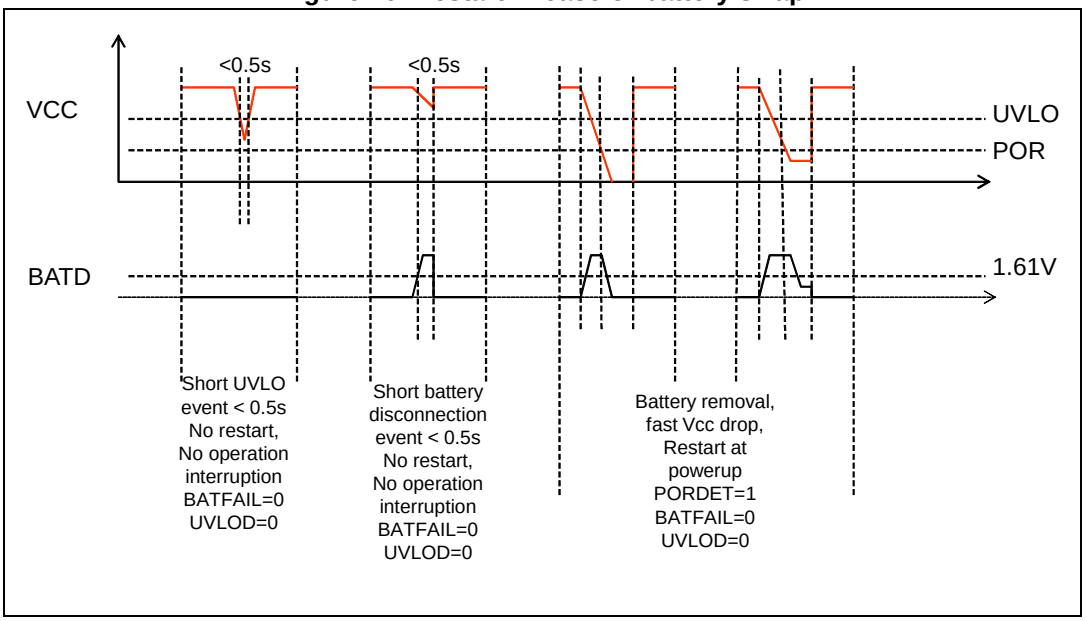
The tdel delay is 0.5 s.

Using the 0.5 s filter provides robust battery swap detection and prevents false battery swap detection if short contact bouncing occurs at the battery terminals due to mechanical vibrations or shocks. This also prevents false detections in case of short battery voltage drops and protects the application against high surge currents at low temperatures.

Following a battery swap detection and after the battery voltage goes back above UVLO and the BATD level returns to low level, the STC3117 is on hold with new voltage and current measurements in the corresponding registers. The system has to restart the STC3117 by doing a device soft reset i.e. by setting the PORDET bit to 1 in the REG_CTRL register and restoring the parameters (if needed). To recover the event, either use the measured voltage and current to define a new OCV voltage, or restore a previous SOC state.

The occurrence of the battery swap event is indicated by the BATFAIL and UVLOD bits in the REG_CTRL register.

Figure 10. Restart in case of battery swap



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. The default device address value is 1110 000. The STC3117 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 final acknowledge.

Table 8. Device address format

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

Table 9. Register address format

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

Table 10. Register data format

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

Figure 11. Read operation

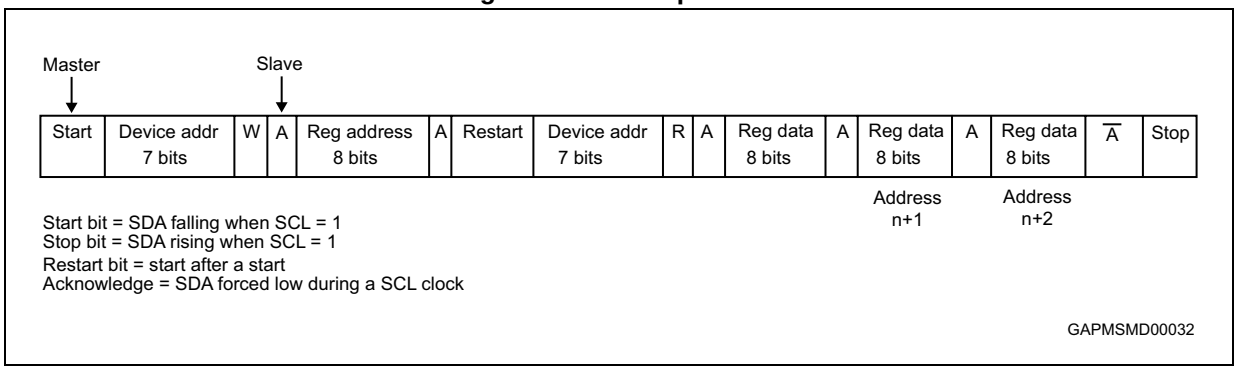
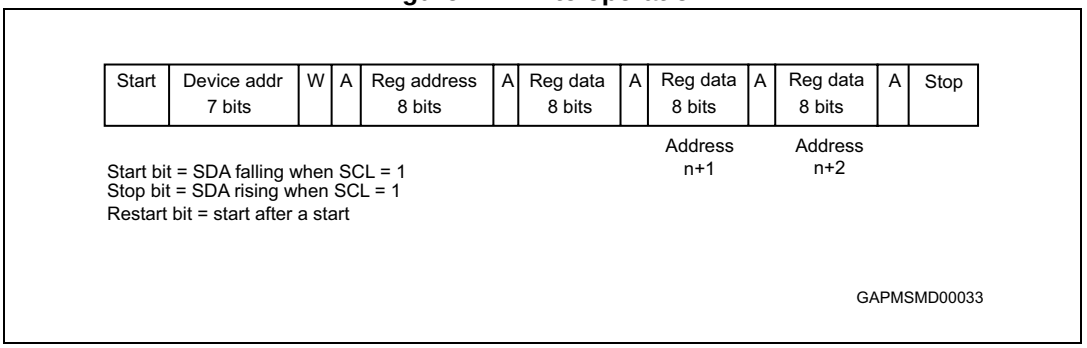


Figure 12. Write operation



7.2 Register map and description

7.2.1 Register map

The register space provides 31 control registers, 16 read/write RAM working registers reserved for the gas gauge algorithm, and 48 OCV table registers. Mapping of all registers is shown in *Table 11*. Detailed descriptions of registers 0 (REG_MODE) and 1 (REG_CTRL) are shown in *Table 12* and *Table 13*. 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 14* gives a detailed description of the internal OCV table registers.

Table 11. Register map

Name	Address (decimal)	Type	POR	Soft POR	Description	LSB
Control registers	0 to 30					
REG_MODE	0	R/W			Mode register	
REG_CTRL	1	R/W			Control and status register	
REG_SOC (L-H)	2-3	R/W			Battery SOC (2 bytes)	1/512 %
REG_COUNTER (L-H)	4-5	R	0x00	0x00	Number of conversions (2 bytes)	
REG_CURRENT (L-H)	6-7	R	0x00	0x00	Battery current (2 bytes)	5.88 µV
REG_VOLTAGE (L-H)	8-9	R	0x00	0x00	Battery voltage (2 bytes)	2.2 mV
REG_TEMPERATURE	10	R	0x00	0x00	Temperature	1 °C
REG_AVG_CURRENT (L-H)	11-12	R/W	0x00	0x00	Battery average current or SOC change rate (2 bytes)	1.47 µV or 0.008789 C
REG_OCV (L-H)	13-14	R/W	0x00	0x00	OCV register (2 bytes)	0.55 mV
REG_CC_CNF (L-H)	15-16	R/W	395	395	Coulomb counter gas gauge configuration (2 bytes)	
REG_VM_CNF (L-H)	17-18	R/W	321	321	Voltage gas gauge algorithm parameter(2 bytes)	
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 current monitoring (bits 6-0)	47.04 µV
REG_CMONIT_COUNT	22	R	0x78	0x78	Current monitoring counter	
REG_CMONIT_MAX	23	R/W	0x78	0x78	Maximum counter value for current monitoring	
REG_ID	24	R	0x16	0x16	Part type ID = 16h	
REG_CC_ADJ (L-H)	27-28	R	0x00	0x00	Coulomb counter adjustment register (2 bytes)	1/512 %
REG_VM_ADJ (L-H)	29-30	R	0x00	0x00	Voltage mode adjustment register (2 bytes)	

Table 11. Register map (continued)

Name	Address (decimal)	Type	POR	Soft POR	Description	LSB
RAM registers	32 to 47					
REG_RAM0	32	R/W	0x00	0x00	Working register 0 for gas gauge	
...	...				...	
REG_RAM15	47	R/W	0x00	0x00	Working register 15 for gas gauge	
OCV table registers	48 to 95					
REG_OCVTAB0 (L-H) to REG_OCVTAB15 (L-H)	48-49 to 78-79	R/W	See table 14	See table 14	OCV points, 2 bytes per point (32 registers)	0.55 mV
REG_SOCTAB0 to REG_SOCTAB15	80 to 95	R/W	See table 14	See table 14	SOC points, 1 byte per point (16 registers)	1/2 %

7.2.2 Register description

Values held in consecutive registers (such as the SOC value in the REG_SOC register pair) are stored with low bits in the low-address register (L) and high bits in the high-address register (H). 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.

7.2.3 REG_MODE and REG_CTRL register description

Table 12. 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
BATD_PU	1	R/W	1	BATD internal pull-up enable 0: internal pull-up disconnected 1: internal pull-up connected
FORCE_CD	2	R/W	0	0: CD driven by internal logic (refer to *Section 6.5*) 1: CD output is forced high
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 relaxation timer to switch to the Coulomb counter (CC) state. Write 1, self clear to 0 Relaxation counter = 0
FORCE_VM	6	R/W	0	Forces the relaxation timer to switch to voltage mode (VM) state. Write 1, self clear to 0 Relaxation counter = Relax_max
	7			Unused

Table 13. 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 (BATD high). Write 0 to clear (effective only if BATD low) (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.
UVLOD	7	R/W	0	UVLO event detection. Cleared by writing 0.

7.2.4 OCV table register description

Table 14. Default OCV table and OCV table registers

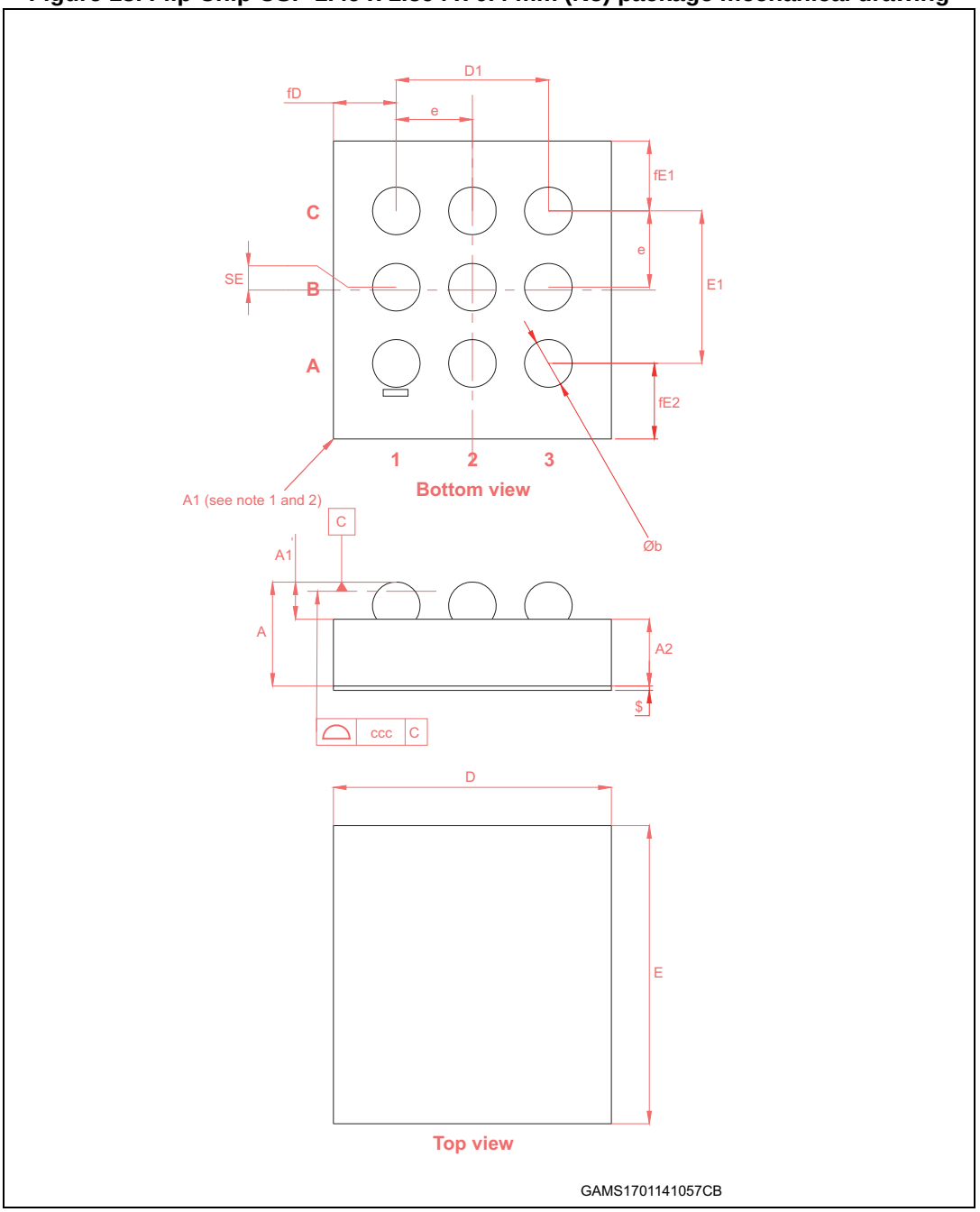
Table entry	Default SOC		Default OCV		SOC register	OCV register
	%	Hex code	mV	Hex code		
0	0	00	3300	1770	REG_SOCTAB0	REG_OCVTAB0
1	3	06	3541	1926	REG_SOCTAB1	REG_OCVTAB1
2	6	0C	3618	19B2	REG_SOCTAB2	REG_OCVTAB2
3	10	14	3658	19FB	REG_SOCTAB3	REG_OCVTAB3
4	15	1E	3695	1A3E	REG_SOCTAB4	REG_OCVTAB4
5	20	28	3721	1A6D	REG_SOCTAB5	REG_OCVTAB5
6	25	32	3747	1A9D	REG_SOCTAB6	REG_OCVTAB6
7	30	3C	3761	1AB6	REG_SOCTAB7	REG_OCVTAB7
8	40	50	3778	1AD5	REG_SOCTAB8	REG_OCVTAB8
9	50	64	3802	1B01	REG_SOCTAB9	REG_OCVTAB9
10	60	78	3863	1B70	REG_SOCTAB10	REG_OCVTAB10
11	65	82	3899	1BB1	REG_SOCTAB11	REG_OCVTAB11
12	70	8C	3929	1BE8	REG_SOCTAB12	REG_OCVTAB12
13	80	A0	3991	1C58	REG_SOCTAB13	REG_OCVTAB13
14	90	B4	4076	1CF3	REG_SOCTAB14	REG_OCVTAB14
15	100	C8	4176	1DA9	REG_SOCTAB15	REG_OCVTAB15

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.

8.1 Flip Chip CSP 1.49 x 1.594 x 0.4 mm (N5) with coating ball printing package information

Figure 13. Flip Chip CSP 1.49 x 1.594 x 0.4 mm (N5) 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 15. Flip Chip CSP 1.49 x 1.594 x 0.4 mm (N5) package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.545	0.60	0.655	0.021	0.024	0.026
A1	0.17	0.20	0.23	0.007	0.008	0.009
A2	0.38	0.4	0.42	0.015	0.016	0.017
b	0.23	0.26	0.29	0.009	0.010	0.011
D	1.43	1.46	1.49	0.056	0.057	0.059
D1		0.8			0.031	
E	1.534	1.564	1.594	0.060	0.062	0.063
E1		0.8			0.031	
e		0.4			0.016	
SE		0.015			0.001	
fD	0.32	0.33	0.34	0.013	0.013	0.013
fE1	0.357	0.367	0.377	0.014	0.014	0.015
fE2	0.387	0.397	0.407	0.015	0.016	0.016
$		0.05			0.002	
ccc			0.05			0.002

Figure 14. Flip Chip CSP 1.49 x 1.594 x 0.4 mm (N5) package footprint recommendation (top view)

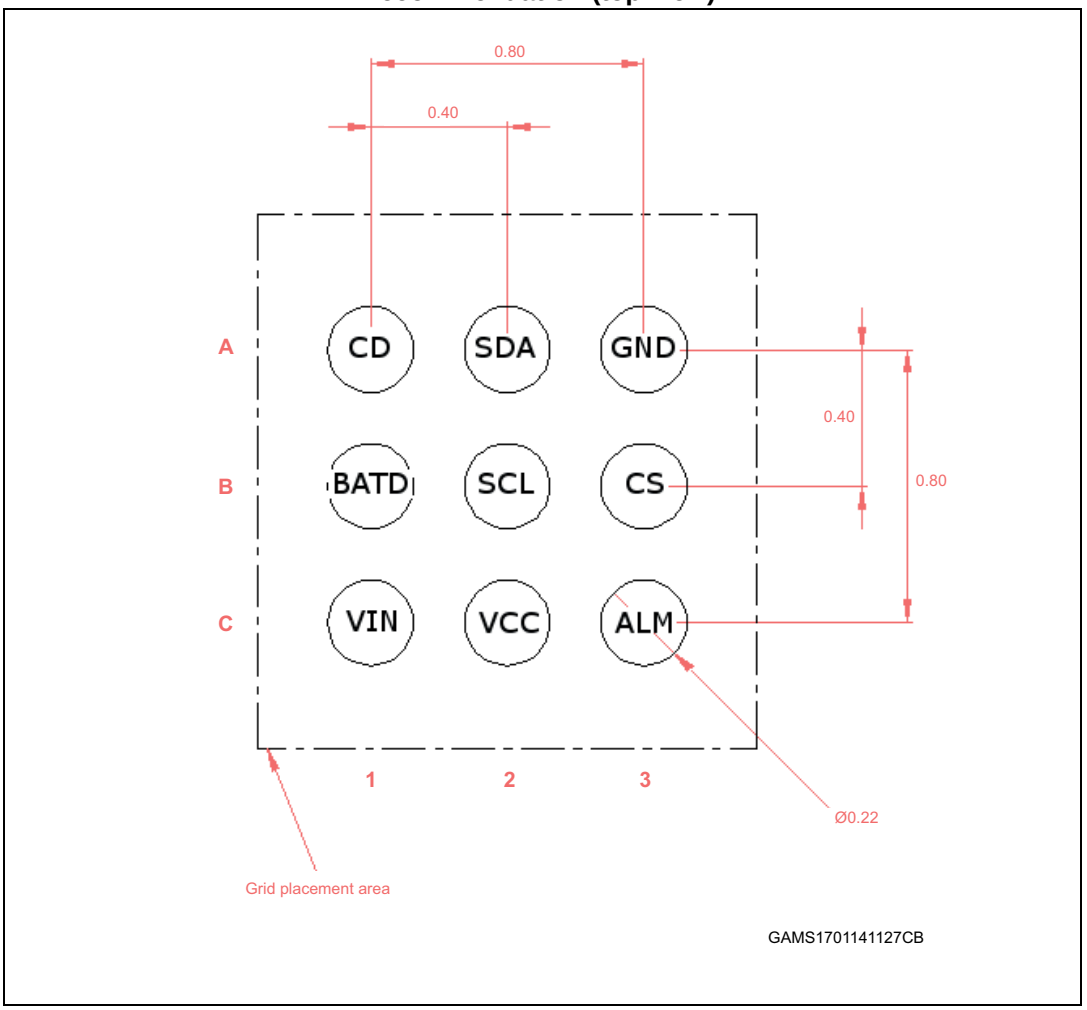
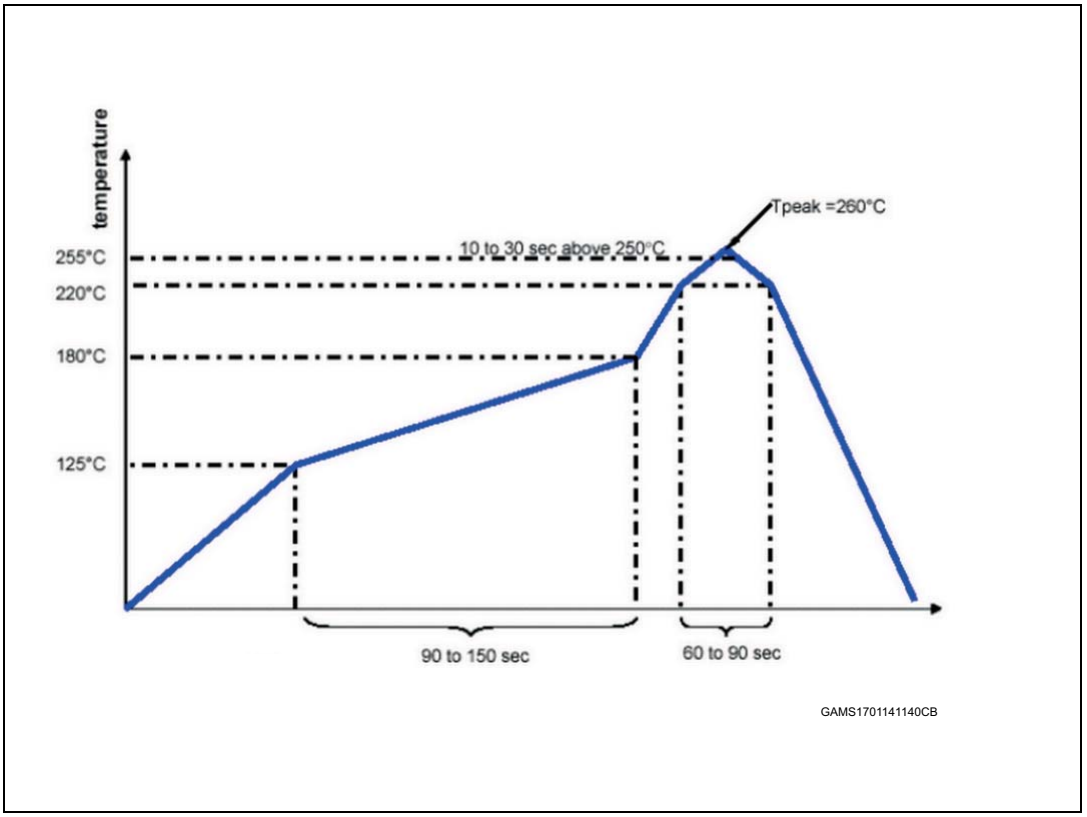


Figure 15. Flip Chip CSP 1.49 x 1.594 x0.4 mm (N5) package reflow profile recommendation



9 Ordering information

Table 16. Order code

Order code	Temperature range	Package	Packing	Marking
STC3117IJT	-40°C to +85°C	CSP 9-bump	Tape and reel	VWV

10 Revision history

Table 17. Document revision history

Date	Revision	Changes
23-Jul-2014	1	Initial release
19-Jan-2015	2	Updated "low power" value in *Features* Updated *Section 6.1.4: Current sensing in mixed mode* Added *Section 6.1.5: SOC change rate in voltage mode* Updated *Figure 5: Coulomb counter block diagram* Updated example of *Equation 2* Re-wrote *Section 6.2.3: Mixed mode gas gauge system* Re-wrote *Section 6.4: Current monitoring* Updated *Section 6.5: Power-up and battery swap detection*. Updated *Table 11: Register map* Updated *Table 12: REG_MODE - address 0* Updated *Table 13: REG_CTRL - address 1*
10-Nov-2017	3	Updated $t_{su,sta}$ symbol in *Table 5: I^2C timing - V_{IO} = 2.8 V, T_{amb} = -20 °C to 70 °C (unless otherwise specified)*.

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