PCA9420

Power management IC for low-power microcontroller applications

Rev. 1.1 — 24 October 2019 Product data sheet

1 General description

The PCA9420 is a highly-integrated Power Management IC (PMIC), targeted to provide a full power management solution for low power microcontroller applications or other similar applications.

The device consists of a linear battery charger capable of charging up to 315mA current. It has an I^2C programmable Constant Current (CC) and Constant Voltage (CV) values for flexible configuration. Various built-in protection features such as input overvoltage protection, overcurrent protection, thermal protection, etc. are also provided for safe battery charging. It also features JEITA compliant charging.

The device also integrates two step-down (buck) DC/DC converters which have I^2C programmable output voltage. Both buck regulators have integrated high-side and low-side switches and related control circuitry, to minimize the external component counts; a Pulse-Frequency Modulation (PFM) approach is utilized to achieve better efficiency under light load condition. Other protection features such as overcurrent protection, under-voltage lockout (UVLO), etc. are also provided. By default, the input for these regulators is powered by either VIN or VBAT, whichever is greater.

In addition, two on-chip LDO regulators are provided to power up various voltage rails in the system.

Other features such as FM+ I^2C-bus interface, chip enable, interrupt signal, etc. are also provided.

The chip is offered in 2.09mm x 2.09mm, 5 x 5 bump, 0.4mm pitch WLCSP package; and 3mm x 3mm, 24-pin QFN package.

2 Features and Benefits

- Linear battery charger for charging single cell li-ion battery
  - 20V tolerance on VIN pin
  - Programmable input OVP (5.5V or 6V)
  - Programmable constant current (up to 315 mA) and pre-charge low voltage current threshold
  - Programmable constant voltage regulation
  - Programmable automatic recharge voltage and termination current threshold
  - Built-in protection features such as input OVP, battery SCP, thermal protection
  - JEITA compliant
  - Battery attached detection
  - Over-temperature protection
- Two step-down DC/DC converters
  - Very low quiescent current
  - Programmable output voltage

  - SW1: core buck converter, 0.5V~1.5V output, 25mV/step, and a fixed 1.8V, up to 250mA
  - SW2: system buck converter, 1.5V~2.1V/2.7V~3.3V output, 25mV/step, up to 500mA
  - Low power mode for extra power saving
- Two LDOs
  - Programmable output voltage regulation
  - LDO1: always-on LDO, 1.70V~1.90V output, 25mV/step, up to 1mA
  - LDO2: system LDO, 1.5V~2.1V/2.7V~3.3V output, 25mV/step, up to 250mA
- 1 MHz I^2C-bus slave interface
- -40°C ~ +85°C ambient temperature range
- Offered in 5 x 5 bump-array WLCSP and 24-pin QFN package

3 Applications

- Low power microcontroller application

4 Ordering information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Version
PCA9420BS	420	HVQFN24	plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 3 x 3 x 0.85 mm	SOT905-1
PCA9420UK	9420	WLCSP25	wafer level chip-scale package; 25 bumps; 0.4 mm pitch, 2.09 mm x 2.09 mm x 0.525 mm body	SOT1397-7

4.1 Ordering options

Table 2. Ordering options

Type number	Orderable part number	Package	Packing method	Minimum order quantity	Temperature range
PCA9420BS	PCA9420BSAZ	HVQFN24	REEL 7" Q2 NDP	1400	-40°C to +85°C
PCA9420UK	PCA9420UKZ	WLCSP25	REEL 7" Q1 DP CHIPS	3000	-40°C to +85°C

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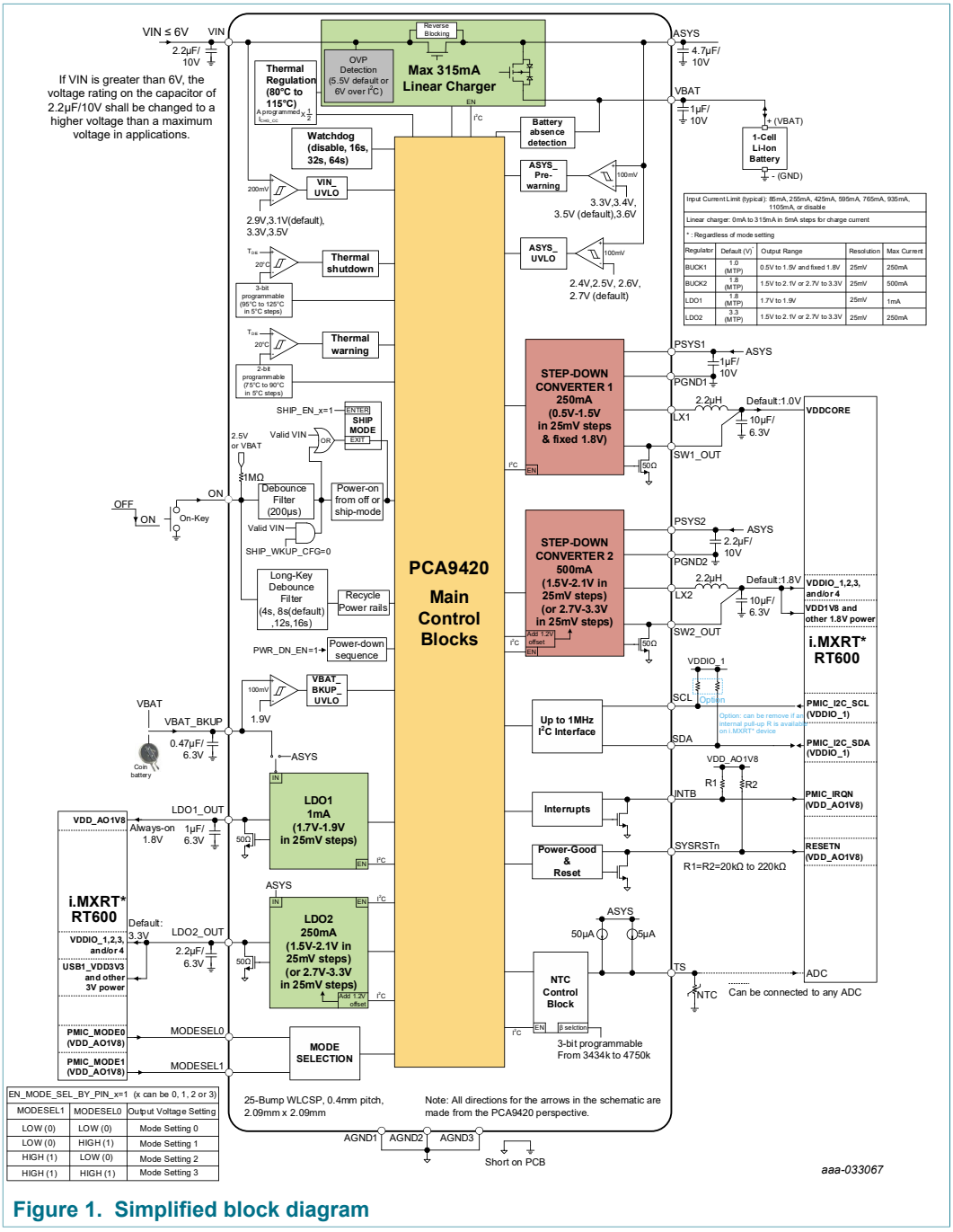
5 Simplified block diagram



EN_MODE_SEL_BY_PIN_x=1 (x can be 0, 1, 2 or 3)		
MODESEL1	MODESEL0	Output Voltage Setting
LOW (0)	LOW (0)	Mode Setting 0
LOW (0)	HIGH (1)	Mode Setting 1
HIGH (1)	LOW (0)	Mode Setting 2
HIGH (1)	HIGH (1)	Mode Setting 3

Regulator	Default (V)	Output Range	Resolution	Max Current
BUCK1	1.0 (MTP)	0.5V to 1.5V and fixed 1.8V	25mV	250mA
BUCK2	1.8 (MTP)	1.5V to 2.1V or 2.7V to 3.3V	25mV	500mA
LDO1	1.8 (MTP)	1.7V to 1.9V	25mV	1mA
LDO2	3.3 (MTP)	1.5V to 2.1V or 2.7V to 3.3V	25mV	250mA

Figure 1. Simplified block diagram

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6 Pinning information

6.1 Pinning

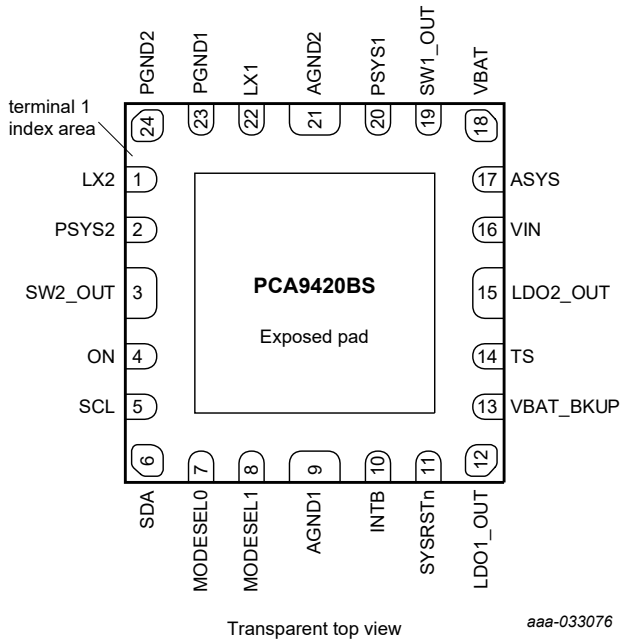

Figure 2. PCA9420BS pinout (HVQFN24) – top view

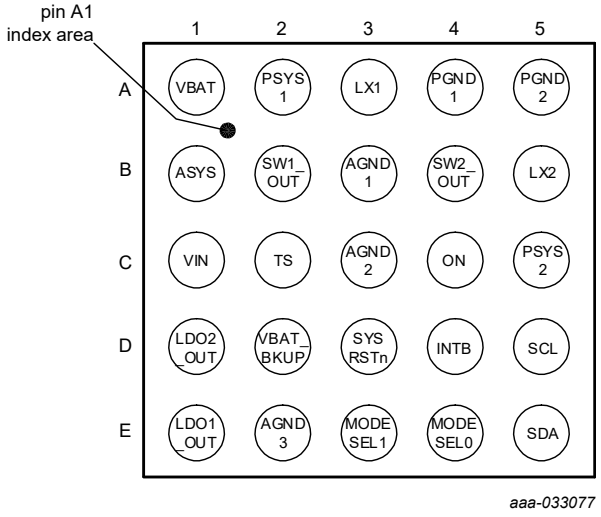

Figure 3. PCA9420UK pinout (WLCSP25) – top view

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6.2 Pin description

Table 3. Pin Description

Symbol	Pin		Pin Type	Description
	HVQFN24	WLCSP25		
INPUT SUPPLY				
VIN	16	C1	P	Input supply voltage. Bypass with a 2.2µF/10V ceramic capacitor. If VIN is greater than 6V, the voltage rating shall be changed to a higher voltage than the maximum voltage in applications.
ASYS	17	B1	P	Bypass output of VIN and input supply voltage for LDO2, connect with a typical 4.7µF or 10µF/10V decoupling capacitor.
VBAT_BKUP	13	D2	P	Backup battery input voltage. LDO1 is powered by the greater of ASYS or VAT_BKUP. If a back-up battery with a coin cell is not connected, connect the pin to VBAT power domain. Connect with a typical 0.47µF/6.3V decoupling capacitor.
LINEAR CHARGER				
VBAT	18	A1	P	Battery (+) connection point. A typical 1µF/10V decoupling capacitor should be connected between VBAT to system ground.
TS	14	C2	I	Battery temperature sensing pin. An external thermistor is connected between TS pin and system ground.
BUCK1 STEP_DOWN CONVERTER (SW1)				
PSYS1	20	A2	P	Input supply for SW1. Bypass with a typical 1µF/10V ceramic capacitor. Connect to ASYS power domain as short as possible in the system.
LX1	22	A3	P	Switching node for SW1. Connect to a 2.2µH inductor.
SW1_OUT	19	B2	I	Feedback pin. Bypass with a 10µF/6.3V ceramic capacitor.
PGND1	23	A4	P	Power ground for buck 1 (SW1). Connect ground nodes of two bypass capacitors for PSYS1 and SW1_OUT as close to PGND1 pin as possible in the system.
BUCK2 STEP_DOWN CONVERTER (SW2)				
PSYS2	2	C5	P	Input supply for SW2. Bypass with a typical 2.2µF/10V ceramic capacitor. Connect to ASYS power domain as short as possible in the system.
LX2	1	B5	P	Switching node for SW2. Connect to a 2.2µH inductor.
SW2_OUT	3	B4	I	Feedback pin. Bypass with a 10µF/6.3V ceramic capacitor.
PGND2	24	A5	P	Power ground for buck 2 (SW2). Connect ground nodes of two bypass capacitors for PSYS2 and SW2_OUT as close to PGND2 pin as possible in the system.
LOW_DROPOUT REGULATORS (LDO1 and LDO2)				
LDO1_OUT	12	E1	P	LDO1 output. It is always-ON supply. The input supply is a higher voltage between ASYS and VBAT_BKUP. Bypass with a 1µF/6.3V ceramic capacitor.

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Symbol	Pin		Pin Type	Description
	HVQFN24	WLCSP25		
LDO2_OUT	15	D1	P	LDO2 output. The input supply is ASYS. Bypass with a 2.2µF/6.3V ceramic capacitor.
LOGIC INPUTS				
ON	4	C4	I	ON Pin with an internal pull-up resistor, 1MΩ typ, to either 2.5V or VBAT. Refer to Section 8.3 for more details.
MODESEL0	7	E4	I	Mode selection input pin #1
MODESEL1	8	E3	I	Mode selection input pin #2
LOGIC OUTPUTS				
INTB	10	D4	O	Interrupt output, Open-drain type. Place a pull-up resistor from 20kΩ to 220kΩ to a system I/O supply rail.
SYSRSTn	11	D3	O	Reset output for external MCU, Open-drain type. Place a pull-up resistor from 20kΩ to 220kΩ to a system I/O supply rail.
SERIAL I^2C INTERFACE				
SCL	5	D5	I	I^2C Interface clock pin. Place a pull-up resistor between 2.2kΩ and 10kΩ to a system I/O supply rail.
SDA	6	E5	I/O	I^2C Interface data pin. Place a pull-up resistor between 2.2kΩ and 10kΩ to a system I/O supply rail.
DEVICE GROUND				
AGND1	9	B3	P	Analog ground. It shall be connected to system ground through a via. Do not connect AGND1 and AGND2 to PGND1 or PGND2 on the top PCB layer in the system.
AGND2	21	C3	P	
AGND3		E2	P	
	Exposed Pad			Exposed pad. Connect to system ground

P = Power, I = Input, I/O = input/output

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7 System configuration diagram

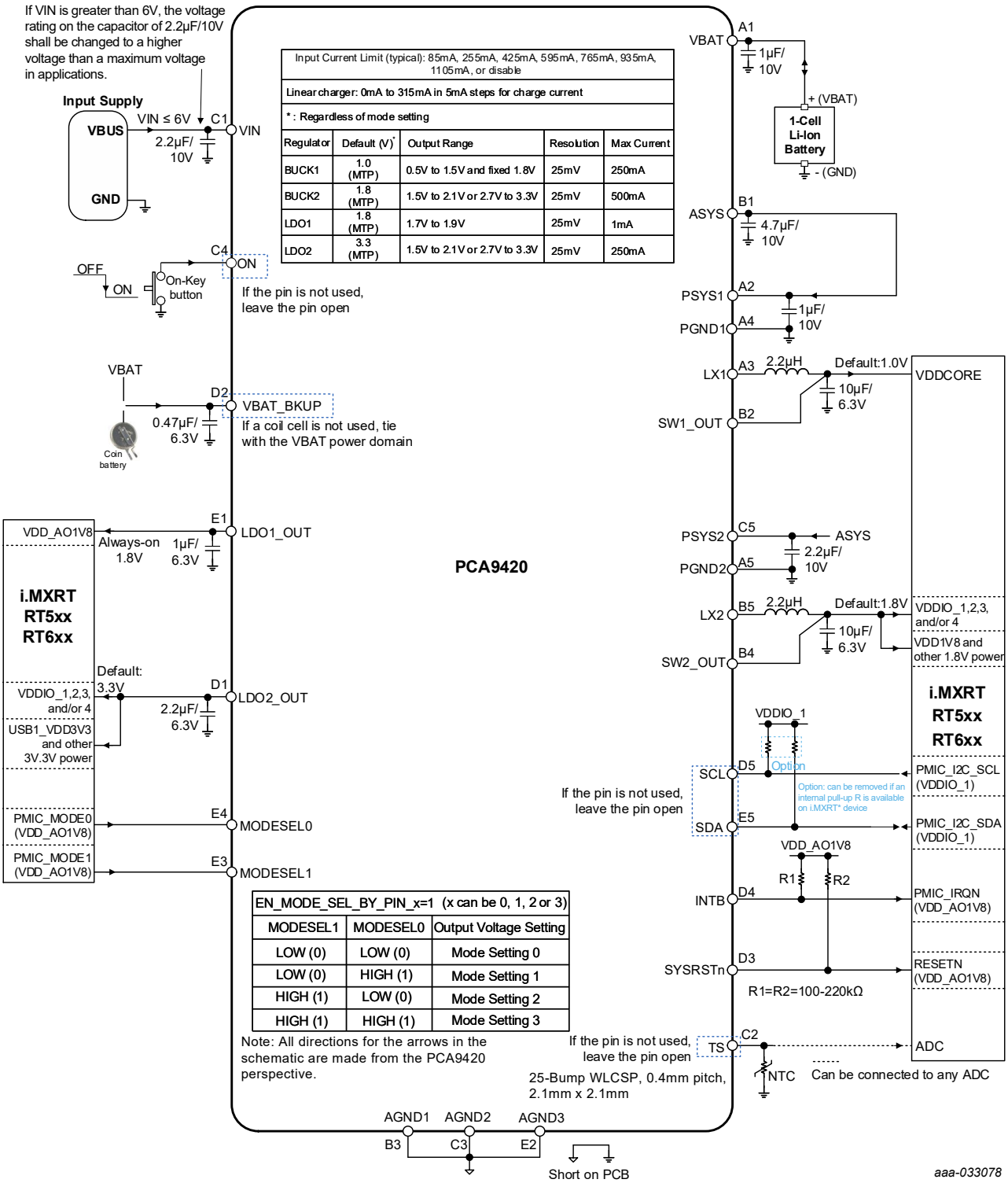

Figure 4. System configuration diagram; i.MXRT series

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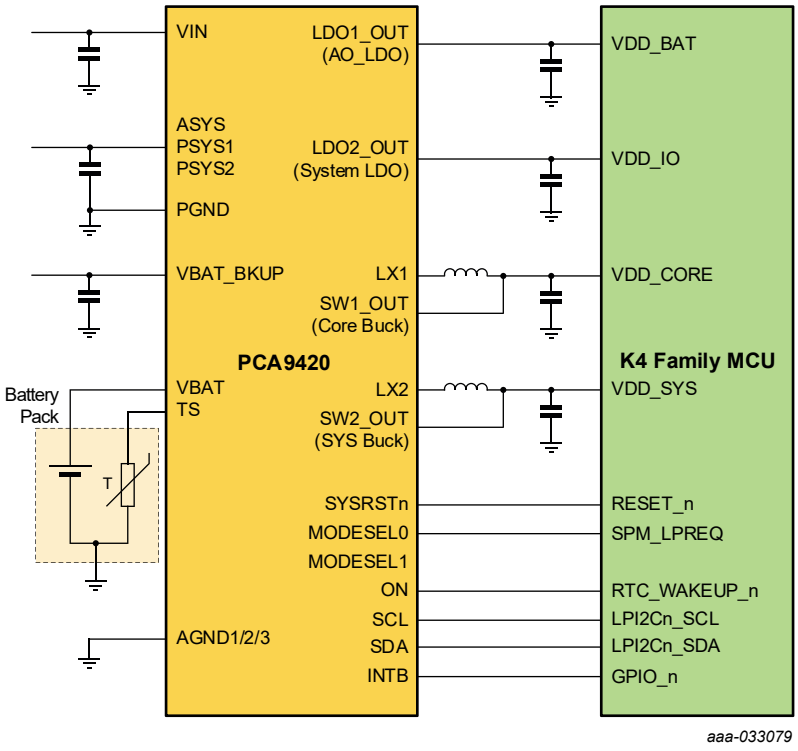

Figure 5. System configuration diagram; K4-family MCU

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8 Functional description

8.1 ASYS

The ASYS pin serves as the input power pin for SW1, SW2 and LDO2. Internally by default it's powered by either VIN or VBAT, whichever is greater. The internal ASYS input selection circuit ensures a seamless transition when its input source changes from VIN to VBAT, or vice versa.

Through I^2C register setting selection (SYS_INPUT_SEL [1:0]), the user also has the option to choose the ASYS input source. However, upon power cycling and/or chip reset, the ASYS input source goes back to the default setting (option 1 below).

SYS_INPUT_SEL [1:0]

1. 2b'00: From either VBAT or VIN, whichever is greater (default setting);
2. 2b'01: From VBAT only;
3. 2b'10: From VIN only;
4. 2b'11: Disconnect from VBAT or VIN (not a normal operation condition, for test purposes only).

An I^2C programmable pre-warning ASYS voltage threshold (ASYS_PRE_WARNING [1:0]) can also be used to indicate when ASYS voltage drops below the ASYS pre-warning threshold voltage, which triggers an interrupt event.

If any peripheral regulators are connected to ASYS node, the ASYS node follows a VIN voltage up to a programmed OVP threshold (either 5.5V or 6V) with a various voltage difference depending on a load current.

8.2 VBAT_BKUP (back-up battery input)

Internally, the input power source for LDO1 is provided by either VBAT_BKUP or ASYS, whichever is greater. When a coin cell battery (or similar battery) is used in the system as a backup battery, it can be connected to VBAT_BKUP; thus the LDO1 is powered by either ASYS or the backup battery. When no such backup battery is used, the VBAT_BKUP pin should always be connected to VBAT.

8.3 ON

The ON pin has the following functions implemented:

1. ON pin has internal 1MΩ pull-up resistor to either 2.5V or VBAT depending on VBAT voltage. If VBAT is less than 3V, ON is pulled up to 2.5V and if VBAT is greater than 3V, it is pulled to VBAT.
   Falling edge (filtered after deglitching time, 200µs typ), active-low signal enables the chip. If the chip stays in ship mode before applying ON falling edge, upon the filtered falling edge of the ON pin, the chip exits ship mode to start up into Mode Setting 0.

If the device is already in the middle of power-up or power-down sequence, the falling edge applied on the ON pin is ignored by the chip.

1. Long press (duration time, 4s, 8s, 12s or 16s, is programmable via I^2C, ON_GLT_LONG [1:0]). If the logic low signal is applied continuously over a programmed duration, the chip gets reset and recycles all power rails to their default values

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2. Also, in mode setting 0, 1, 2, or 3, an I^2C bit “ON_CFG_x“ (x=0, 1, 2, or 3) is reserved; by setting its value to either 0 or 1, the user can configure whether a mode setting switches back to Mode Setting 0 or not, upon a valid falling edge detected from “ON” pin. Refer to ON_CFG_x bit description in the relation registers for more details.
3. The filtered falling edge on the ON pin resets the bit of EN_MODE_SEL_BY_PIN_A to the default value, 0, at 22h register.

8.4 TS

With the temperature sensing pin, the external thermistor (NTC) is connected between the TS pin and ground. The thermistor may be included in the battery pack to monitor the battery pack temperature, or it may be an additional component user chooses to have on the board level to monitor the temperature at a chosen area.

The voltage at TS pin is monitored, and the user can enable the feature through I^2C-bus interface (NTC_EN) to implement JEITA compliant charging at a safe temperature. Per JEITA standard, there are four temperature threshold settings:

1. Cold threshold (T1, 0°C as example)
2. Cool threshold (T2, 10°C as example)
3. Warm threshold (T3, 45°C as example)
4. Hot threshold (T4, 60°C as example)

Each of the above temperature thresholds represents a voltage threshold. When the monitored temperature, T, falls into a different temperature zone, the charger should adjust the charging method accordingly:

1. T > T4 or T < T1, i.e., when the temperature is in a “cold” or “hot” zone, charging is suspended, as well as the safety timer;
2. T1 < T < T2, charging current is reduced by 50% of the programmed current level;
3. T2 < T < T3, normal charging;
4. T3 < T < T4, the CV mode regulating voltage should be set as VBAT_REG [5:0] – ΔVBAT_REG(HOT), 140mV typical

To disable this function, set NTC_EN to “0”.

8.5 Mode setting

When the MCU operates in different modes such as overdrive run mode or low power mode, it may require the power supply to operate in different settings accordingly (for example, enable/disable of each rail, output voltage of each rail, etc.) to achieve a better performance and efficiency.

On the PCA9420, there are four modes of registers representing Mode Setting A/B/C/D to accommodate such requirements from MCU, where Mode Setting A is the default mode setting (i.e., the initial mode setting upon initial power up). Depending on the user’s preference, switching among different mode settings can be controlled by either the external signal (ON pin), external pins (MODESEL0/1) or I^2C.

Within each mode setting, the user can program the follow parameters providing great flexibility to accommodate different MCU operation modes:

1. Enable/disable of the four output voltage rails
2. Voltage setting of the four output voltage rails
3. Ship mode enable/disable
4. Watchdog timer setting

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5. Mode control selection (EN_MODE_SEL_BY_PIN_x, x=0, 1, 2, or 3)

EN_MODE_SEL_BY_PIN_x = 0: under current mode setting, mode setting switch is controlled by internal I^2C register bits MODE0_I2C and/or MODE1_I2C only; signal applied on external MODESEL0/MODESEL1 pins is ignored.

EN_MODE_SEL_BY_PIN_x = 1: under current mode setting, mode setting switch is controlled by signal applied on external MODESEL0 and/or MODESEL1 pins only, not by internal I^2C register bits MODE0_I2C and MODE1_I2C.

1. Mode setting switches back to Mode Setting A triggered by ON pin falling edge. Refer to register description for “ON_CFG_x” bit for more details.

In the event of switching from one mode setting (initial mode setting) to another mode setting (target mode setting):

1. If one output rail remains enabled in both initial mode setting and target mode setting but with different output voltage in each setting, such voltage transition should happen when the mode setting switch command (from either internal I^2C setting or external signal) is received;
2. If there are output rails which may be enabled or disabled from initial mode setting to target mode setting, then always make sure these rails which change from disabled to enabled take higher priority over rails which change from enabled to disabled, i.e., make sure all the rails change from disabled status to enabled status (reaches 90% of its target value) first, and then start to disable these rails, changing from enable status to disable status.

8.6 Mode selection by external pins (MODESEL0, MODESEL1)

Up on initial power-up, PCA9420 enters its default setting (Mode Setting 0). While operating under Mode Setting 0, by default the I^2C register bit, EN_MODE_SEL_BY_PINEN_MODE_SEL_BY_PIN_0, is set to “0”, and the external signal applied on the MODESEL0 and MODESEL1 pins are ignored. Only when the user sets EN_MODE_SEL_BY_PINEN_MODE_SEL_BY_PIN_0 to “1”, can the mode control on the chip be programmed via MODESEL0 and MODESEL1 pin signal settings.

Table 4. Mode Selection by external pins (MODESEL0, MODESEL1)

MODESEL1 pin voltage level	MODESEL0 pin voltage level	All Settings from
LOW (0)	LOW (0)	Mode Setting 0
LOW (0)	HIGH (1)	Mode Setting 1
HIGH (1)	LOW (0)	Mode Setting 2
HIGH (1)	HIGH (1)	Mode Setting 3

8.7 SYSRSTn

The SYSRSTn is implemented as an open-drain output signal. It is used as an output of “power-good” indication as well as to reset the microcontroller system.

The SYSRSTn signal is held from high to low under one of following conditions:

1. When any of the ***enabled*** voltage rail output voltage drops below 90% (typ) of its target value.
2. When any of the ***enabled*** voltage rail output voltage goes above 110% (typ) of its target value

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If any of the voltage rail is disabled by the user (by setting the corresponding enable bit in I^2C register in each mode setting, i.e., LDO1_EN_x, LDO2_EN_x, SW1_EN_x, SW2_EN_x), the SYSRSTn signal should NOT assert (stays high) under such scenario.

This also applies during the power-up/power-down sequence events, i.e., during power-up or power-down event, the SYSRSTn signal should assert when any of the enabled rail has not reaches the 90% ~ 110% of its target value. In other words, the SYSRSTn = 0 (low) needs to remain at such state until all enabled rails reach 90% of the target values.

1. When a programmed watchdog timer expires (only when watchdog timer is enabled)

Once the condition that caused the SYSRSTn signal to go low is removed, then the SYSRSTn should refresh accordingly.

Meanwhile, during the voltage change on-the-fly, this could be caused by:

1. Mode setting remains the same, but the user chooses to change one or some of the enabled output rail voltage by programming its output voltage I^2C register setting
2. Mode setting changes by setting different values on MODESEL0/MODESEL1 pins or MODE0_I2C/MODE1_I2C bits, and it causes one or some of the output rail voltage change

In such case, the SYSRSTn signal does NOT assert when any of the ***enabled*** voltage rail output voltage is in the middle of the transition from initial output voltage level to target level.

8.8 SHIP mode

PCA9420 features a “SHIP mode”, in which the chip provides the lowest quiescent consumption.

To enter the SHIP mode, set the bit of SHIP_EN_x (x can be 0, 1, 2 or 3) in each Mode register to 1. Once the bit is set to 1, the ship mode immediately takes place regardless of any operation under any mode setting. It means that the SHIP mode has a higher priority over any conditions and operations.

Upon request to enter the ship mode while the device is running in active mode, a power-down sequence should take place first and then enter the ship mode. **Once the device enters ship mode, all the I^2C register values are reset to their default setting.**

To exit ship mode, one of the following conditions must be satisfied:

1. ON pin falling edge (filtered) applied, less than the long-press duration of time
2. A valid VIN attached. For the VIN attached plugin event, depending on OPERATION_SEL_FROM_SHIPMODE bit setting, there are two possible operations as described below:
   a. OPERATION_SEL_FROM_SHIPMODE=0, upon VIN attached, the chip enables the charging process, as well as start the power-up sequence for LDO1/LDO2/SW1/SW2 per the setting
   b. OPERATION_SEL_FROM_SHIPMODE=1, upon VIN attached, the chip enables the charging process, LDO1/LDO2/SW1/SW2 remains in shutdown mode and the chip will only enable the power-up sequence upon ON pin falling edge signal.

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8.9 Watchdog timer

PCA9420 provides an on-chip watchdog timer, the duration of this watchdog can be programmed via I^2C register setting (WD_TIMER_x [1:0] in each mode configuration registers), or disabled if needed in each mode setting.

Upon initial enable, the watchdog timer starts counting. If the watchdog timer expires before reset, an interrupt signal is issued (WD_TIMER). Depending on the I^2C register setting (nEN_CHG_IN_WATCHDOG), the following action is also taken:

1. nEN_CHG_IN_WATCHDOG = 0: when the watchdog timer expires, the following operations are expected.
   - The SYSRSTn signal asserted (high to low)
   - Charging is continued based on battery condition
   - All settings for LDO1/LDO2/SW1/SW2 set to Mode 0 settings
2. nEN_CHG_IN_WATCHDOG=1: when the watchdog timer expires, the following operations are expected.
   - The SYSRSTn signal asserted (high to low)
   - Charging is suspended
   - All settings for LDO1/LDO2/SW1/SW2 set to Mode 0 settings

The following events reset the watchdog timer:

1. When WD_TIMER_CLR bit is set to 3b'001 at 0Dh register
2. When the device changes the mode settings

8.10 Regulators

There are four regulators on PCA9420, which include two buck regulators and two LDOs. Table 5 shows the outline for each regulator:

Table 5. Regulator summary

Regulator name	Output regulation voltage range	Adjustable resolution	Max output current
SW1 (Core Buck)	0.5V ~ 1.5V and a fixed 1.8V	25mV/step	Up to 250mA
SW2 (System Buck)	1.5V ~ 2.1V or 2.7V~3.3V	25mV/step	Up to 500mA
LDO1 (Always-on LDO)	1.7V ~ 1.9V	25mV/step	Up to 1mA
LDO2 (System LDO)	1.5V ~ 2.1V or 2.7V~3.3V	25mV/step	Up to 250mA

For each rail, its output target voltage can be set independently in mode setting 0, 1, 2 or 3. User can also choose to switch among any of the mode settings.

8.10.1 Enable/disable and active discharge

Enable/disable: Each rail can be enabled/disabled via I^2C register setting independently in each mode setting.

Active discharge: Additionally, there is an active discharge resistor on each rail, and the user can choose to enable/disable such feature through I^2C register setting, so that when the output rail is disabled, it can quickly discharge the output voltage to ground. In addition, the active discharge is also enabled during voltage step down. This can be disabled by MTP bit.

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8.10.2 Power-good indication

There is an output voltage comparator for each rail, comparing the actual output voltage against 90% and 110% of its target value; when the actual voltage is between 90% and 110% of its target value, the read-only related bits in I^2C register, Regulator Status_1 (address: 20h) are updated accordingly to report the output voltage status (Power-good Indication). These comparators can be enabled/disabled by setting I^2C register bit, PG_EN. A corresponding interrupt is triggered if unmasked. During steady state, only 90% threshold is monitored.

The power-good indication is shown as “not good”, and refreshes upon the completion of any of the following events:

1. During the power-up sequence stage
2. During power-down sequence stage
3. During the on-the-fly change of output voltage

8.10.3 Power-up/down sequence and on-the-fly voltage change

Power-up sequence

The device initiates the default power-up sequence in three different conditions.

Condition 1) The device is off with no any power supply (No valid VIN and No battery with 2.7V or above attached). In this condition, two signals below are able to start the default power-up sequence.

- A valid VIN supply on VIN pin
- A voltage on ASYS higher than ASYS_UVLO, a 2.8V typical

Condition 2) The device stays off by enabling SHIPMODE or in SHIP mode with a battery ≥ 2.8V attached. In this condition, two signals are able to start the default power-up sequence.

- A valid VIN supply on VIN pin
- A falling edge on ON key over a 200µs

Condition 3) The device stays off by enabling PWR_DN_EN bit setting to 1 with a battery ≥ 2.8V attached. In this condition, only one signal is able to start the default power-up sequence.

- A falling edge on ON key over a 200µs

Condition 4) The device stays at VIN OVP condition with no any valid supply attached at VBAT. In result, all enabled power rails have been off. The following condition re-initiates the power-up sequence.

- The VIN goes below its VIN OVP hysteresis (typ 100mV)

The power-up sequence by ON key=Low over the debounce time is described as shown in Figure 6.

For the power-up sequence, the chip can set the default sequence per the customer requirement at factory setting (i.e. MTP option), from one of the 64 options. Once the chip enters the power-down stage, the power-down sequence is implemented as the reverse of the power-up sequence (i.e., first up, last down).

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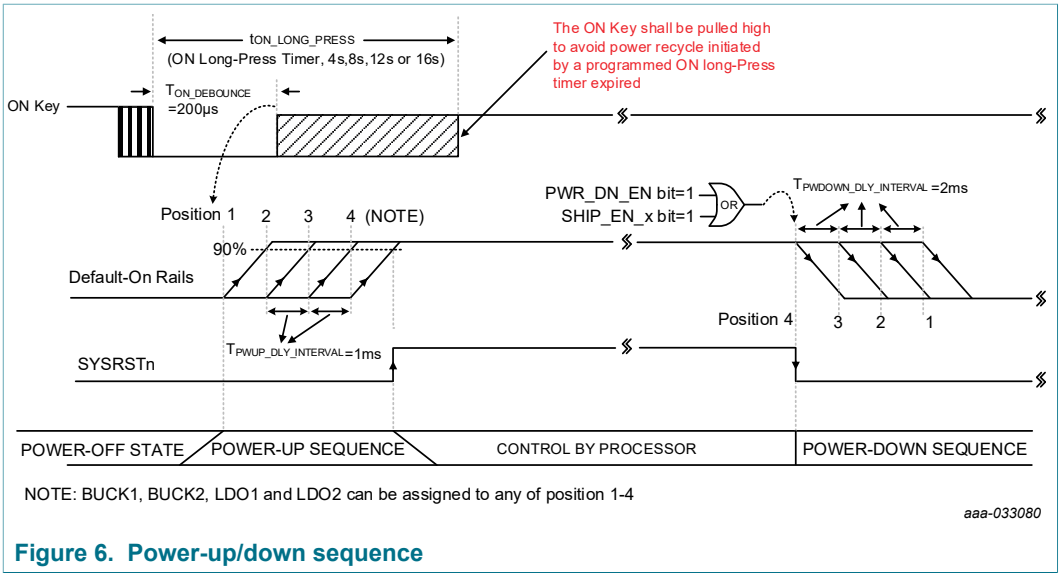

Figure 6. Power-up/down sequence

On-the-fly output voltage change sequence

On-the-fly output voltage change is defined as the following: for any output rail, its output voltage changes from one level (initial level) to another level (target level). Note this assumes the output rail is always enabled before and after the on-the-fly change transition. It does not include the case when any output rail is changed from disabled state to enabled state, or vice versa.

If a user prefers to change any rail voltage on-the-fly, depending on the scenarios listed below, the chip behavior is described as the following:

1. While the chip remains in its current operation mode, and the user programs the output voltage setting I^2C register value or enables/disables any or some of output voltage rail(s), the chip simply executes the I^2C command
2. While the user chooses to switch modes, i.e. change mode between any of the two mode settings among Mode 0/1/2/3, and if this involves on-the-fly voltage change for one or some output rails, such change should occur simultaneously when the chip switches from initial mode to the target mode.

CAUTION: The user should not send an I^2C command related to changing the setting of the output rails during the power up/down or mode setting change process.

8.10.4 BUCK1 (SW1, core buck regulator)

The SW1 supplies the core power.

Its output voltage can be programmed via I^2C from 0.5V to 1.5V at 25mV step and a fixed 1.8V, which is capable of providing up to 250mA loading. The application circuit uses typical 2.2µH inductor and 10µF/6.3V output capacitor.

8.10.5 BUCK2 (SW2, system buck regulator)

The SW2 output voltage can be programmed via I^2C register from 1.5V to 2.1V, or from 2.7V to 3.3V in both at 25mV/step and is capable of providing up to 500mA loading. The application circuit uses a 2.2µH inductor and 10µF output capacitor.

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In SW2, a pass-through mode is implemented. When its input (ASYS) is close to the output voltage (within typical 200mV), the SW2 enters the pass-through mode operation; the high-side switch is fully turned on and the low-side switch is turned off, and the output voltage can be calculated as input voltage – (RDSON*I_{LOAD}), where RDSON is the on-resistance of the high-side switch, and the I_{LOAD} refers to the load current. When the input voltage rises again, so that the voltage different between input and output crosses the typical 250mV threshold, the SW2 exits the pass-through mode and re- enters the normal switching mode operation.

While SW2 operates in pass-through mode, protection features such as over-current protection are also implemented as well.

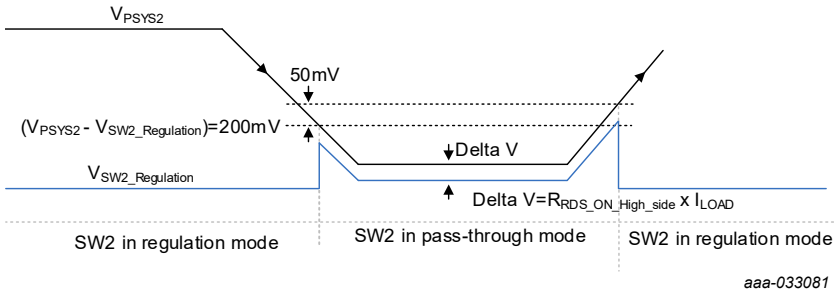

Figure 7. Pass-Through mode of BUCK2 (SW2)

8.10.6 LDO1 (always-on LDO)

The LDO1 (Always-on LDO) output can be programmed from 1.7V to 1.9V at 25mV step, depending on the system requirements (selectable through I^2C register). Typically, a 1µF/6.3V MLCC output capacitor providing at least 1mA loading capability is needed.

8.10.7 LDO2 (system LDO)

The LDO2 (system LDO) output can be programmed via the I^2C register from 1.5V to 2.1V, or 2.7V to 3.3V at 25mV/step. Typically, a 2.2µF/6.3V MLCC output capacitor providing at least 250mA loading current is needed.

8.11 Linear battery charger

The battery charger is a linear charger. Its charging is done through a linear switch with the following output protections:

- Reverse current protection
  - (triggers when VIN < VBAT+ VIN2BAT_HEADROOM*)
- Charging current limiting
  - (a function of programmed threshold and battery temperature)
- VBAT short circuit protection
  - short circuit output voltage threshold: (typ 0.8V with 80mV hysteresis)
  - Maximum output sourcing current during “short circuit” detection ~ 13mA (VIN2BAT_HEADROOM = 100mV, typical)

If the battery voltage is below the V_{BAT_LOW} threshold, the battery is considered discharged and a preconditioning cycle begins. The amount of pre-charge current (ICHG_LOW) can be programmed through I^2C register setting. This feature is useful when there is a load connected directly across the battery (at VBAT pin) “stealing” the

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battery current. The pre-charge current can be set higher to account for the system loading while allowing the battery to be properly conditioned. Once the battery voltage has charged to the V_{BAT_LOW} threshold, fast charge is initiated and a programmed fast charge current (I_{CHG_CC}) is applied. The fast charge constant current is programmed using I^2C register. The constant current provides the bulk of the charge. Power dissipation in the device is greatest in fast charge with a lower battery voltage.

If the device reaches a programmed thermal regulation threshold temperature from 85°C to 115°C in 5°C steps, the device enters thermal regulation. Thermal regulation increases the safe-charging-timer period by 2x and reduces the charge current in half (if the initial current is 5mA, it will remain unchanged) to keep the temperature from rising any further when battery charger works in constant current charging mode, or at a reduced regulated voltage when battery charger works in constant voltage charging mode.

Figure 8 shows the charging profile with a dead battery condition. Once the cell has charged to the regulation voltage (V_{BAT_REG}) the voltage loop takes control and holds the battery at the regulation voltage until the current tapers to the termination threshold (I_{CHG_TOPOFF}).

8.11.1 Battery charging management

Battery charging management supports typical constant current/constant voltage charging profile for single cell Li-Ion battery, as well as pre-qualification (dead battery, low battery), top-off mode, etc.; JEITA and thermal regulation compliant.

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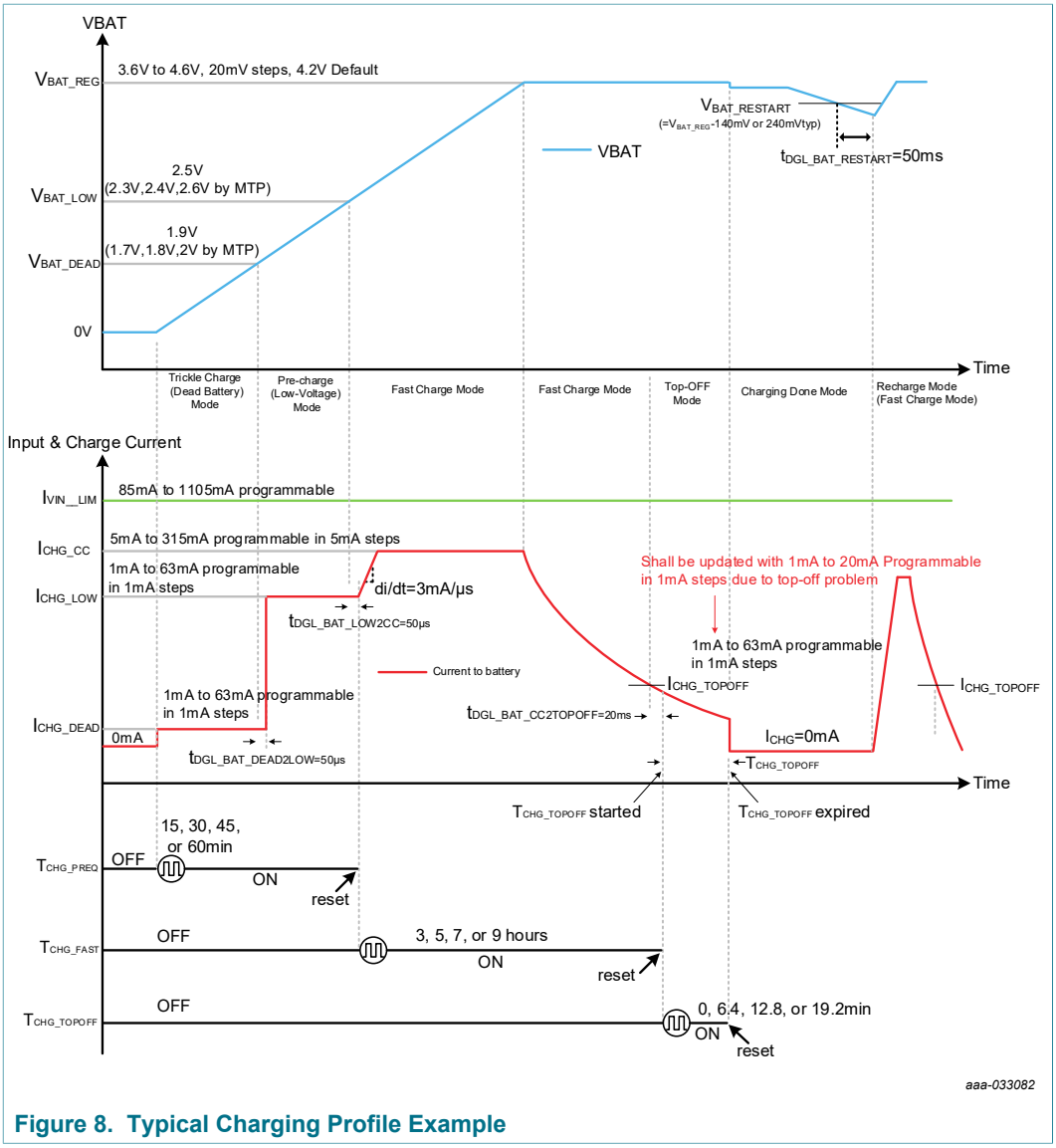

Figure 8. Typical Charging Profile Example

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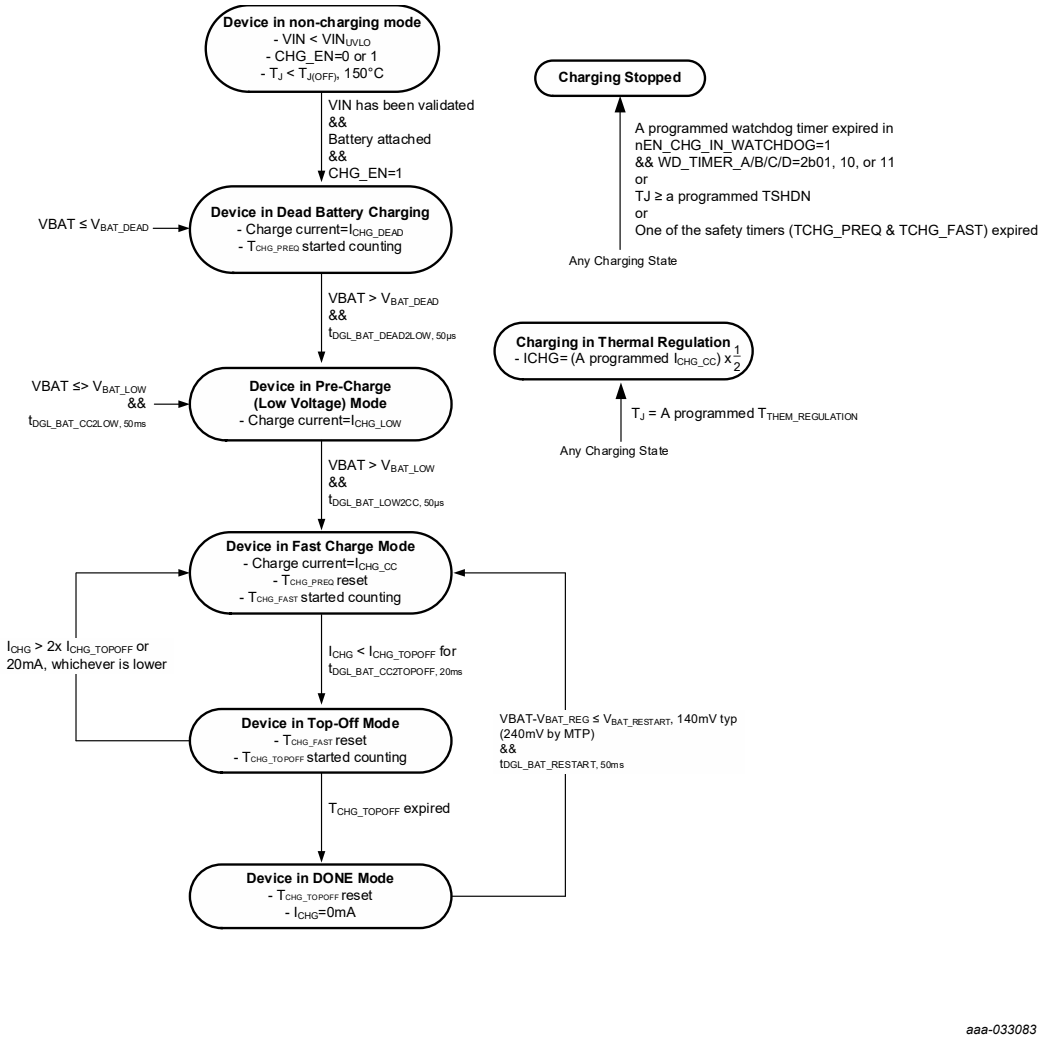

Figure 9. Charger State Diagram

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8.11.2 Battery temperature sensing and JEITA-compliant charging profile

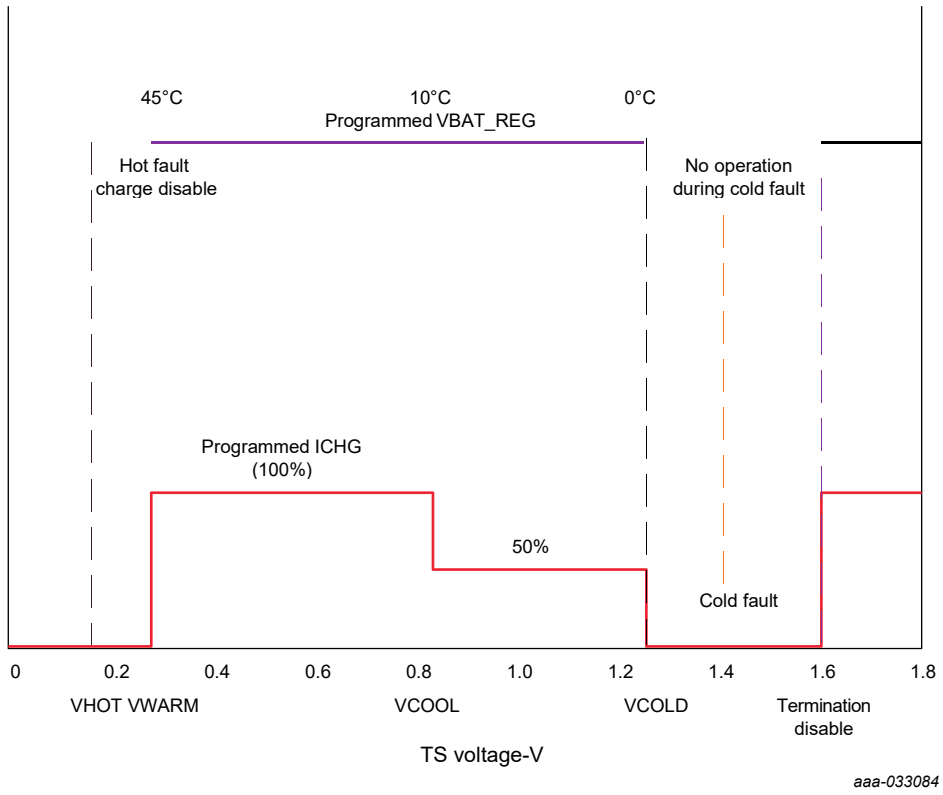

Figure 10. Operation over TS bias voltage for JEITA

8.11.3 Low-battery/dead-battery (pre-qualification) charging

If the battery is detected and VBAT < VBAT_LOW, the charger initiates pre-charging using a predefined (I^2C register) current.

When it is under the dead-battery condition, the charging current I_{CHG_DEAD} is programmed by ICHG_DEAD [5:0]; and when it is under the low-battery condition, the charging current I_{CHG_LOW} is programmed by ICHG_LOW [5:0]. When $V_{BAT} \geq V_{BAT_LOW}$, the charger moves to the next state, fast charging mode.

8.11.4 Constant current charging/constant voltage charging (fast charging) and termination

When $V_{BAT} \geq V_{BAT_LOW}$, the charger enters Fast Charge Mode (Constant Current). In this state, the battery voltage VBAT continues to rise, while the battery is being charged with the current set by ICHG_CC [5:0], until VBAT reaches the maximum allowable voltage set by VBAT_REG [5:0].

At this time, the charger enters the Constant Voltage (CV) mode. While operating in the CV mode, the voltage is still regulated at the level set by VBAT_REG [5:0], and the charging current continues to decrease.

When the charging current drops below the top-off current threshold, set by ICHG_TOPOFF [5:0], the charger enters TOPOFF mode, and upon expiration of TOPOFF timer (set by T_TOPOFF [1:0]), the charger enters DONE mode.

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8.11.5 Charger safety timers

Two sets of charging safety timers are implemented on PCA9420. These timers ensure the charging is terminated if the charging time is longer than its predefined limit (programmed via I^2C registers) at given states:

- Pre-qualification timer, set by ICHG_PREQ_TIMER [1:0], 15min ~ 60min
- Fast charge timer, set by ICHG_FAST_TIMER [1:0], 3hr ~ 9hr

8.11.6 Recharging

While in DONE mode, if the voltage of VBAT stays below (a programmed VBAT_REG – 140mV or 240mV) over the deglitch time ($t_{DGL_BAT_RESTART}$), 50ms the battery charger resumes back to Constant Current (CC) Mode.

8.11.7 Starting a new charge cycle

When a VIN plug in, VBAT attached, or CHG_EN are set to “1”, the device initializes a new charging process.

8.11.8 Battery attach detection

The device has a unique battery detection scheme with two comparators, 1.9V and 3.4V. when the detection scheme is executed, a 5mA current sink is activated to determine battery presence by detection the fall threshold, $V_{BAT_DET_LOW}$, 1.9V typ. In addition, a 5mA current source is used to detect battery voltage whether it stays above the threshold, $V_{BAT_DET_UP}$, 3.4V. if both conditions are met, absence of battery is declared.

8.12 Hardware and software reset

Please refer to description for ON pin for the hardware reset function by a long time ON key pressed. The "software reset” is achieved by setting “1” to SW_RST bit in I^2C register. If the user writes a “1” to this bit, it resets all other I^2C register bits to their default setting; this bit is cleared and reset back to “0” as well.

9 I^2C-bus interface and register

The PCA9420 implements an I^2C-bus slave interface to communicate with the host system. The interface supports Fast Mode plus Fm+ with up to 1 Mbit/s. A detailed description of the I^2C-bus specification is given in UM10204, Rev. 06, 4 April 2014 ,“ I^2C-bus specification and user manual”.

Features such as clock-stretching and 10-bit slave address are not supported; general call is supported by default but can be disabled via metal option. Auto increment with address wrap-around is supported as well.

9.1 I^2C slave address

Following a START condition, the bus master must send the target slave address followed by a read or write operation. The slave address of the PCA9420 is shown below:

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Table 6. I^2C Slave Address

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	0	0	0	0	1	0/1
Fixed	Fixed	Fixed	MTP option	Fixed	Fixed	Fixed	R/W

Bit 4 should be reserved as MTP option, with its default value set as “0” but can be trimmed to “1” when needed.

9.2 General call and device ID addresses

The device implements two different addresses for general call and device ID.

9.3 Register type

There are four register types used on the device:

- Read and Write (R/W)
- Read Only (R)
- Write Only (W)
- Write and Clear (W/C)

For Write and Clear (W/C), a write to a register with a bit-mask specifies which interrupts to clear.

For example, if the status register shows 8’b0000_1001 as an interrupt status (i.e. interrupt [0] and interrupt [3] are both set), user may write 8’b0000_1000, meaning the intent is to only clear interrupt [3] (but interrupt [0] should NOT be “cleared”). If the intent is to clear both interrupts, then the user could write back 8’b0000_1001.

9.4 Register map

Table 7. Register map

Address (Hex)	Register Name	Description	Type	Reset Value (Binary)
System Control Registers				
00	Device Information, DEV_INFO	Device ID, revision	R	0000 0000
01	Top Level Interrupt Status, TOP_INT	Top level interrupt event status	R/C	0000 0000
02	Sub Level Interrupt_0, SUB_INT0	Sub-level interrupt indication_0	W/C	0000 0000
03	Sub Level Interrupt_0 Mask, SUB_INT0_MASK	Sub-level interrupt mask for SUB_INT0	R/W	0001 1111
04	Sub Level Interrupt_1, SUB_INT1	Sub-level interrupt indication_1	W/C	0000 0000
05	Sub Level Interrupt_1 Mask, SUB_INT1_MASK	Sub-level interrupt mask for SUB_INT1	R/W	0111 1111
06	Sub Level Interrupt_2, SUB_INT2	Sub-level interrupt indication_2	W/C	0000 0000
07	Sub Level Interrupt_2 Mask, SUB_INT2_MASK	Sub-level interrupt mask for SUB_INT2	R/W	1111 1111
08	RSVD	Reserved	R/W	0000 0000
09	Top Level Control_0, TOP_CNTL0	Top level system control_0	R/W	0100 0001

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Address (Hex)	Register Name	Description	Type	Reset Value (Binary)
0A	Top Level Control_1, TOP_CNTL1	Top level system control_1	R/W	1000 1001
0B	Top Level Control_2, TOP_CNTL2	Top level system control_2	R/W	1100 1110
0C	Top Level Control_3, TOP_CNTL3	Top level system control_3	R/W	0000 0001
0D	Top Level Control_4, TOP_CNTL4	Top level system control_4	W	0000 0000
0E – 0F	RSVD	Reserved		
Battery Charger Control				
10	Battery Charger Control_0, CHG_CNTL0	Battery charger control register_0	R/W	0000 0011
11	Battery Charger Control_1, CHG_CNTL1	Battery charger control register_1	R/W	0000 1000
12	Battery Charger Control_2, CHG_CNTL2	Battery charger control register_2	R/W	0000 0100
13	Battery Charger Control_3, CHG_CNTL3	Battery charger control register_3	R/W	0000 0100
14	Battery Charger Control_4, CHG_CNTL4	Battery charger control register_4	R/W	0000 0100
15	Battery Charger Control_5, CHG_CNTL5	Battery charger control register_5	R/W	0001 1110
16	Battery Charger Control_6, CHG_CNTL6	Battery charger control register_6	R/W	1001 0101
17	Battery Charger Control_7, CHG_CNTL7	Battery charger control register_7	R/W	0010 0100
18	Battery Charger Status_0, CHG_STATUS_0	Battery charger status indication_0	R	0001 0000
19	Battery Charger Status_1, CHG_STATUS_1	Battery charger status indication_1	R	0000 0000
1A	Battery Charger Status_2, CHG_STATUS_2	Battery charger status indication_2	R	0111 1000
1B	Battery Charger Status_3, CHG_STATUS_3	Battery charger status indication_3	R	0000 0000
1C – 1F	RSVD	Reserved		
Regulator Control				
20	Regulator Status, REG_STATUS	Regulators status indication	R	0000 0000
21	Active Discharge Control, ACT_DISCHARGE_CNTL_1	Active Discharge control register	R/W	0000 0000
22	Mode Configuration Mode Setting 0_0, MODECFG_0_0	Mode configuration settings for Mode 0_0	R/W	0001 0100
23	Mode Configuration Mode Setting 0_1, MODECFG_0_1	Mode configuration settings for Mode 0_1	R/W	0100 1100
24	Mode Configuration Mode Setting 0_2, MODECFG_0_2	Mode configuration settings for Mode 0_2	R/W	0100 1111

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Address (Hex)	Register Name	Description	Type	Reset Value (Binary)
25	Mode Configuration Mode Setting 0_3, MODECFG_0_3	Mode configuration settings for Mode 0_3	R/W	0011 1001
26	Mode Configuration Mode Setting 1_0, MODECFG_1_0	Mode configuration settings for Mode 1_0	R/W	0001 1100
27	Mode Configuration Mode Setting 1_1, MODECFG_1_1	Mode configuration settings for Mode 1_1	R/W	0100 1100
28	Mode Configuration Mode Setting 1_2, MODECFG_1_2	Mode configuration settings for Mode 1_2	R/W	0100 1111
29	Mode Configuration Mode Setting 1_3, MODECFG_1_3	Mode configuration settings for Mode 1_3	R/W	0000 1100
2A	Mode Configuration Mode Setting 2_0, MODECFG_2_0	Mode configuration settings for Mode 2_0	R/W	0001 1100
2B	Mode Configuration Mode Setting 2_1, MODECFG_2_1	Mode configuration settings for Mode 2_1	R/W	0100 1100
2C	Mode Configuration Mode Setting 2_2, MODECFG_2_2	Mode configuration settings for Mode 2_2	R/W	0100 1111
2D	Mode Configuration Mode Setting 2_3, MODECFG_2_3	Mode configuration settings for Mode 2_3	R/W	0000 1100
2E	Mode Configuration Mode Setting 3_0, MODECFG_3_0	Mode configuration settings for Mode 3_0	R/W	0001 1100
2F	Mode Configuration Mode Setting 3_1, MODECFG_3_1	Mode configuration settings for Mode 3_1	R/W	0100 1100
30	Mode Configuration Mode Setting 3_2, MODECFG_3_2	Mode configuration settings for Mode 3_2	R/W	0100 1111
31	Mode Configuration Mode Setting 3_3, MODECFG_3_3	Mode configuration settings for Mode 3_3	R/W	0000 1100

9.5 Register description

9.5.1 Device information (DEV_INFO, address 00h)

The device identification code stores a unique identifier for each version and/or revision of device, so that the connected MCU recognizes it automatically.

This is a READ ONLY register.

Table 8. DEV_INFO register bit description

Bit	Symbol	Default value	Type	Function
7	DEV_ID [4]	0	R	Device ID
6	DEV_ID [3]	0	R	
5	DEV_ID [2]	0	R	
4	DEV_ID [1]	0	R	
3	DEV_ID [0]	0	R	

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Bit	Symbol	Default value	Type	Function
2	DEV_REV [2]	0	R	Device revision
1	DEV_REV [1]	0	R	
0	DEV_REV [0]	0	R	

9.5.2 Top level interrupt status (TOP_INT, address 01h)

The top-level interrupt register contains flags indicating various top level interrupt events as indicated below. An event will be latched and only its first occurrence triggers the interrupt signal INTB (if it is not being masked). Reoccurring events will not change the flag's status or trigger an additional interrupt. If multiple interrupt events happen, its corresponding interrupt bits in the related registers will be “triggered”, however, the INTB signal will be only triggered upon the first interrupt event.

The interrupt event reporting on the device is structured in a two-layer configuration. The interrupt events are grouped as (1) system level; (2) charger block; (3) buck regulator block; (4) LDO block. When any interrupt event is triggered, based on which mode it falls into, the related bit for that mode in TOP_INT flags “1”. Any of the related bits in TOP_INT will only change back to 0 when all the interrupt events in its affiliated mode have been cleared.

This is READ Only register.

Table 9. TOP_INT register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R	Reserved bit
6	RSVD	0	R	Reserved bit
5	RSVD	0	R	Reserved bit
4	RSVD	0	R	Reserved bit
3	SYS_INT	0	R	System level interrupt event trigger indication 0: no system level interrupt event triggered 1: system level interrupt event triggered
2	CHG_INT	0	R	Linear battery charger block interrupt event trigger indication 0: no linear battery charger block interrupt event triggered 1: linear battery charger block interrupt event triggered
1	SW_INT	0	R	Buck regulator blocks (SW1, SW2) interrupt event trigger indication 0: no interrupt event on SW1 and/or SW2 blocks triggered 1: interrupt event on SW1 and/or SW2 blocks triggered
0	LDO_INT	0	R	LDO block (LDO1, LDO2) interrupt event trigger indication 0: no interrupt event on LDO1 and/or LDO2 blocks triggered 1: interrupt event on LDO1 and/or LDO2 blocks triggered

9.5.3 Sub level interrupt_0 (SUB_INT0, address 02h)

The sub-level interrupt register contains flags indicating the second-tier interrupt event. For this register, it contains system level related interrupt events.

This is WRITE AND CLEAR register.

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Table 10. Sub_INT0 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	W/C	Reserved bit
6	RSVD	0	W/C	Reserved bit
5	ON_PUSH_INT	0	W/C	ON falling edge longer than 5ms happened
4	TEMP_ PREWARNING	0	W/C	Die temperature pre-warning interrupt 1: die temp ≥ TWARNING; 0: die temp < TWARNING TWARNING threshold is configured by T_WARNING [1:0]
3	THEM_SHDN	0	W/C	Thermal shutdown interrupt 0: thermal shutdown is not triggered 1: die temp ≥ TSHDN (set in THEM_SHDN [2:0], thermal shutdown is triggered
2	ASYS_ PREWARNING	0	W/C	ASYS Pre-Warning Voltage Interrupt: 0: ASYS voltage does NOT fall below the threshold set in ASYS_ PREWARNING [1:0] 1: ASYS voltage falls below the threshold set in ASYS_PREWARNING [1:0]
1	WD_TIMER	0	W/C	Watchdog Timer Expiration Interrupt: 0: The watchdog timer expiration has not happened since the last time this bit was cleared. 1: The watchdog timer expiration has happened since the last time this bit was cleared.
0	VIN	0	W/C	Input Voltage Interrupt 0: The VIN_OK bit has not changed since the last time this bit was cleared. 1: The VIN _OK bit has changed since the last time this bit was cleared.

9.5.4 Sub level interrupt_0 mask (Sub_INT0_Mask, address 03h)

This is a READ AND WRITE register.

Table 11. Sub_INT0_Mask bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit
5	ON_PUSH_INT_MASK	0	R/W	ON Key falling interrupt mask bit 0: Not Masked 1: Masked
4	TEMP_PREWARNING_MASK	1	R/W	Die temp pre-warning interrupt mask bit 0: Not Masked 1: Masked
3	THEM_SHDN_MASK	1	R/W	Thermal shutdown interrupt mask bit 0: Not Masked 1: Masked

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Bit	Symbol	Default value	Type	Function
2	ASYS_PREWARNING_MASK	1	R/W	ASYS Pre-Warning Voltage Interrupt Mask bit 0: Not Masked 1: Masked
1	WD_TIMER_MASK	1	R/W	Watchdog Timer Expiration Interrupt Mask bit 0: Not Masked 1: Masked
0	VIN_MASK	1	R/W	Input Voltage Interrupt Mask bit 0: Not Masked 1: Masked

9.5.5 Sub level interrupt_1 (Sub_INT1, address 04h)

The sub-level interrupt register contains flags indicating the second-tier interrupt event. For this register, it contains battery charger related interrupt events.

This is WRITE AND CLEAR register.

Table 12. Sub_INT1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	W/C	Reserved bit
6	RSVD	0	W/C	Reserved bit
5	VIN_ILIM	0	W/C	Input Current Limit Interrupt: 0: no Input current limit has been triggered since the last time this bit is cleared; 1: input current limit event is triggered since last time this bit is cleared.
4	ICHG_FAST_TIMER	0	W/C	Fast Charging Timer Expiration Interrupt: 0: The fast charging timer expiration has not happened since the last time this bit was cleared. 1: The fast charging timer expiration has happened since the last time this bit was cleared.
3	ICHG_PREQ_TIMER	0	W/C	Pre-qualification Charging Timer Expiration Interrupt: 0: The pre-qual charging timer expiration has not happened since the last time this bit was cleared. 1: The pre-qual charging timer expiration has happened since the last time this bit was cleared.
2	BATTERY_DETECTION	0	W/C	Battery presence Interrupt 0: The VBAT_DET_OK bit has not changed since the last time this bit was cleared. 1: The VBAT_DET_OK bit has changed since the last time this bit was cleared.
1	VBAT	0	W/C	Battery Interrupt 0: The VBAT_OK bit has not changed since the last time this bit was cleared. 1: The VBAT_OK bit has changed since the last time this bit was cleared.

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Bit	Symbol	Default value	Type	Function
0	CHG_OK	0	W/C	Charger Status Interrupt 0: The CHG_OK bit has not changed since the last time this bit was cleared. 1: The CHG_OK bit has changed since the last time this bit was cleared

9.5.6 Sub level interrupt_1 mask (Sub_INT1_Mask, address 05h)

This is a READ AND WRITE register.

Table 13. Sub_INT1_Mask register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	1	R/W	Reserved bit
5	VIN_ILIM_MASK	1	R/W	Input Current Limit Interrupt Mask bit 0: Not Masked 1: Masked
4	ICHG_FAST_TIMER_MASK	1	R/W	Fast Charging Timer Expiration Interrupt Mask bit 0: Not Masked 1: Masked
3	ICHG_PREQ_TIMER_MASK	1	R/W	Pre-qual Charging Timer Expiration Interrupt Mask bit 0: Not Masked 1: Masked
2	BATTERY_DETECTION_MASK	1	R/W	Battery presence Interrupt Mask bit 0: Not Masked 1: Masked
1	VBAT_MASK	1	R/W	Battery Interrupt Mask bit 0: Not Masked 1: Masked
0	CHG_OK_MASK	1	R/W	Charger Interrupt Mask bit 0: Not Masked 1: Masked

9.5.7 Sub level interrupt_2 (Sub_INT2, address 06h)

The sub-level interrupt register contains flags indicating the second-tier interrupt event. For this register, it contains LDO1/LDO2, SW1/SW2 related interrupt events.

This is WRITE AND CLEAR register.

Table 14. Sub_INT2 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	W/C	Reserved bit
6	RSVD	0	W/C	Reserved bit
5	RSVD	0	W/C	Reserved bit

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Bit	Symbol	Default value	Type	Function
4	RSVD	0	W/C	Reserved bit
3	VOUTSW1	0	W/C	SW1 Output Voltage Interrupt 0: The VOUTSW1_OK bit has not changed since the last time this bit was cleared. 1: The VOUTSW1_OK bit has changed since the last time this bit was cleared.
2	VOUTSW2	0	W/C	SW2 Output Voltage Interrupt 0: The VOUTSW2_OK bit has not changed since the last time this bit was cleared. 1: The VOUTSW2_OK bit has changed since the last time this bit was cleared.
1	VOUTLDO1	0	W/C	LDO1 Output Voltage Interrupt 0: The VOUTLDO1_OK bit has not changed since the last time this bit was cleared. 1: The VOUTLDO1_OK bit has changed since the last time this bit was cleared.
0	VOUTLDO2	0	W/C	LDO2 Output Voltage Interrupt 0: The VOUTLDO2_OK bit has not changed since the last time this bit was cleared. 1: The VOUTLDO2_OK bit has changed since the last time this bit was cleared.

9.5.8 Sub level interrupt_2 mask (Sub_INT2_Mask, address 07h)

This is a READ AND WRITE register.

Table 15. Sub_INT2_Mask register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	1	R/W	Reserved bit
6	RSVD	1	R/W	Reserved bit
5	RSVD	1	R/W	Reserved bit
4	RSVD	1	R/W	Reserved bit
3	VOUTSW1 _MASK	1	R/W	VOUTSW1 Voltage Interrupt Mask bit 0: Not Masked 1: Masked
2	VOUTSW2 _MASK	1	R/W	VOUTSW2 Voltage Interrupt Mask bit 0: Not Masked 1: Masked
1	VOUTLDO1 _MASK	1	R/W	VOUTLDO1 Voltage Interrupt Mask bit 0: Not Masked 1: Masked
0	VOUTLDO2_MASK	1	R/W	VOUTLDO2 Voltage Interrupt Mask bit 0: Not Masked 1: Masked

08h register: Reserved

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9.5.9 Top level control_0 (TOP_CTL0, address 09h)

This register contains various configuration bits for top level related functions, part 0. This is a READ AND WRITE register.

Table 16. TOP_CNTL0 register bit description

Bit	Symbol	Default value	Type	Function
7 6 5	VIN_ILIM_SEL [2:0]	010	R/W	VIN input current limit selection: (min/typ/max) 000: 74mA/85mA/98mA, (another default setting by MTP) 001: 222mA/255mA/293mA 010: 370mA/425mA/489mA (default setting) 011: 517mA/595mA/684mA 100: 665mA/765mA/880mA 101: 813mA/935mA/1075mA 110: 961mA/1105mA/1271mA 111: Input current limit disabled [Note] 1-bit MTP, VIN_ILIM_SEL [1], should be reserved to change the default value for this function
4	OPERATION_SEL_ FROM_SHIPMODE	0	R/W	Ship mode wakeup configuration setting 0: upon VIN plug in, the chip will enable the battery charging process, AND start the power-up sequence for LDO1/LDO2/ SW1/SW2 per the setting 1: upon VIN plug in, the chip will enable the charging process, LDO1/LDO2/SW1/SW2 remain in shutdown mode and the chip will only enable the power-up sequence upon ON pin falling edge [Note] 1-bit MTP should be reserved to change the default value for this function
3	PWR_DN_EN[1]	0	R/W	Power-down Sequence Enable 0: Do not start power-down sequence 1: Start power-down sequence
2	nEN_CHG_IN_ WATCHDOG	0	R/W	Configure operations in a programmed watchdog timer expired 0: When the programmed watchdog timer expires, the following operations take place. • SYSRSTn signal asserts (high to low) • Charging is continued • LDO1/LDO2/SW1/SW2 enters the mode 0 setting (the default factory setting for the initial power up) 1: When the programmed watchdog timer expires, the following operations take place. • SYSRSTn signal asserts (high to low) • Charging is disabled • LDO1/LDO2/SW1/SW2 enters the mode 0 setting (the default factory setting for the initial power up)
1	RSVD	0	R/W	Reserved bit
0	PGood_EN	1	R/W	LDO1, LDO2, SW1, SW2 Output Voltage Status Indication 0: Output voltage power-good comparators are disabled. This will also set “VOUTSW1 _OK”, “VOUTSW2 _OK”, “VOUTLDO1_OK” and “VOUTLDO2 _OK” bits to 0 1: Output voltage power-good comparators are enabled

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[1] A valid VIN does not generate the initial power-up sequence if all power rails have been turned off by setting PWR_DN_EN to 1. The use of PWR_DN_EN bit is prohibited to be used in any application that requires power-up sequence by both VIN and ON key.
The use of SHIP_EN_x (x can be 0, 1, 2 &3) is recommended for the application.

9.5.10 Top level control_1 (TOP_CTL1, address 0Ah)

This register contains various configuration bits for top level related functions, part 1. This is a READ AND WRITE register.

Table 17. TOP_CNTL1 register bit description

Bit	Symbol	Default value	Type	Function
7 6	ASYS_PREWARNING [1:0]	10	R/W	ASYS Program a pre-warning voltage threshold on ASYS 00: 3.3V 01: 3.4V 10: 3.5V 11: 3.6V
5 4	ASYS_INPUT_SEL [1:0]	00	R/W	ASYS input source selection 00: ASYS is power by either VBAT or VIN (VIN has higher priority over VBAT if both are presented) 01: ASYS is powered by VBAT only 10: ASYS is powered by VIN only 11: ASYS is disconnected to either VBAT or VIN (for internal testing purpose only)
3	RSVD	1	R/W	Reserved bit
2	VIN_OVP_SEL	0	R/W	VIN over-voltage protection threshold (rising) selection 0: 5.50V 1: 6.0V **Note: The current default value for VIN_OVP_SEL is set at 5.5V, but it should be MTP programmable**
1 0	VIN_UVLO_SEL [1:0]	01	R/W	Program an under-voltage lockout threshold (falling) on VIN 00: 2.9V 01: 3.1V 10: 3.3V 11: 3.5V

9.5.11 Top level control_2 (TOP_CTL2, address 0Bh)

This register contains various configuration bits for top level related functions, part 2. This is a READ AND WRITE register.

Table 18. TOP_CNTL2 register bit description

Bit	Symbol	Default value	Type	Function
7 6	ASYS_UVLO_SEL [1:0]	11	R/W	Program a UVLO threshold on ASYS 00: 2.4V 01: 2.5V 10: 2.6V 11: 2.7V

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Bit	Symbol	Default value	Type	Function
5	TERM_DIS	0	R/W	Enable/Disable the charge termination control. In this mode, the fast charge timer is reset. 0: Enable charge termination mode 1: Disable charge termination mode
4 3 2	THEM_SHDN [2:0]	011	R/W	Program a thermal shutdown threshold, TSHDN, in rising(hysteresis with 20°C) 000: 95°C 001: 100°C 010: 105°C 011: 110°C 100: 115°C 101: 120°C 110: 125°C 111: reserved
1 0	DIE_TEMP_WARNING [1:0]	10	R/W	Program a Die temperature warning threshold 00: 75°C 01: 80°C 10: 85°C 11: 90°C

9.5.12 Top level control_3 (TOP_CTL3, address 0Ch)

This register contains various configuration bits for top level related functions, part 3. This is a READ AND WRITE register.

Table 19. TOP_CNTL3 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit
5	RSVD	0	R/W	Reserved bit
4	MODE1_I2C	0	R/W	Depending on EN_MODE_SEL_BY_PIN_x (x="0", or "1", or "2", or "3") bit setting, the chip mode control is set by either the I^2C bit MODE1_I2C/ MODE0_I2C value, or the signal applied on external MODESEL1/ MODESEL1 pins. Refer to EN_MODE_SEL_BY_PIN description for more details. With EN_MODE_SEL_BY_PIN=0, the mode selection is determined by the following: [MODE1_I2C: MODE0_I2C] = 00, mode 0 setting [MODE1_I2C: MODE0_I2C] = 01, mode 1 setting [MODE1_I2C: MODE0_I2C] = 10, mode 2 setting [MODE1_I2C: MODE0_I2C] = 11, mode 3 setting
3	MODE0_I2C	0	R/W	
2	SW_RST	0	W/C	Chip software reset bit. If user write "1" to this bit, it will reset all other I^2C register bit to its default setting and cycle the regulator outputs, and meanwhile, this bit will be clear and reset back to "0" as well.

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Bit	Symbol	Default value	Type	Function
1 0	ON_GLT_LONG [1:0]	01	R/W	Program a long glitch timer on ON key 00: 4s 01: 8s 10: 12s 11: 16s **Note: 2-bit MTP should be reserved to change the default setting**

9.5.13 Top level control_4 (TOP_CTL4, address 0Dh)

This register contains various configuration bits for top level related functions, part 4. This is a WRITE ONLY register.

Table 20. TOP_CNTL4 register bit description

Bit	Symbol	Default value	Type	Function
7 6 5 4 3	RSVD	00000	W	Reserved bit
2 1 0	WD_TIMER_CLR [2:0]	000	W	Watchdog Timer Reset. 001: When written 001 to WD_TIMER_CLR [2:0], the watchdog timer is reset. All other values: when written to WD_TIMER_CLR [2:0], watchdog timer remains unaffected.

9.5.14 Battery charger control_0 (CHG_CTL0, address 10h)

This register stores the linear battery charge related control registers, part 0. This is a READ AND WRITE register.

Table 21. CHG_CNTL0 register bit description

Bit	Symbol	Default value	Type	Function
7 6 5 4 3	CHG_LOCK [4:0]	00000	R/W	Critical charger related setting lock. CHG_LOCK [4:0] = 10101, these registers which are labeled as “locked by CHG_LOCK” can be accessed to perform I^2C “write” command. CHGN_LOCK [4:0] ≠ 10101, these registers which are labeled as “locked by CHG_LOCK” can NOT be accessed to perform I^2C “write” command. In such case when “write” command is performed on these locked registers, it will keep the present register value.
2	NTC_EN	0	R/W	Enable TS pin external thermistor (NTC) control in charger 0: Disable Thermistor (NTC) control in charger 1: Enable Thermistor (NTC) control in charger
1	CHG_TIMER_EN	1	R/W	Enable the fast charge timer and pre-qual timer 0: Disable both fast charge timer and pre-qual timer 1: Enable both fast charge timer and pre-qual timer

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Bit	Symbol	Default value	Type	Function
0	CHG_EN	1	R/W	Enable the linear battery charger 0: Disable charger 1: Enable charger **Note: The default value for this bit should be MTP programmable**

9.5.15 Battery charger control_1 (CHG_CTL1, address 11h)

This register stores the linear battery charge related control registers, part 1.

This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

Table 22. CHG_CNTL1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit
5	ICHG_CC [5:0]	001000	R/W	Program a fast charge current **Note: The current default value for ICHG_CC [5:0] is set at 40mA, but it should be MTP programmable.**
4				
3				
2				
1				
0				

Table 23. Linear battery charger constant current (CC) setting

00h: 0mA	10h: 80mA	20h: 160mA	30h: 240mA
01h: 5mA	11h: 85mA	21h: 165mA	31h: 245mA
02h: 10mA	12h: 90mA	22h: 170mA	32h: 250mA
03h: 15mA	13h: 95mA	23h: 175mA	33h: 255mA
04h: 20mA	14h: 100mA	24h: 180mA	34h: 260mA
05h: 25mA	15h: 105mA	25h: 185mA	35h: 265mA
06h: 30mA	16h: 110mA	26h: 190mA	36h: 270mA
07h: 35mA	17h: 115mA	27h: 195mA	37h: 275mA
08h: 40mA (default)	18h: 120mA	28h: 200mA	38h: 280mA
09h: 45mA	19h: 125mA	29h: 205mA	39h: 285mA
0Ah: 50mA	1Ah: 130mA	2Ah: 210mA	3Ah: 290mA
0Bh: 55mA	1Bh: 135mA	2Bh: 215mA	3Bh: 295mA
0Ch: 60mA	1Ch: 140mA	2Ch: 220mA	3Ch: 300mA
0Dh: 65mA	1Dh: 145mA	2Dh: 225mA	3Dh: 305mA
0Eh: 70mA	1Eh: 150mA	2Eh: 230mA	3Eh: 310mA
0Fh: 75mA	1Fh: 155mA	2Fh: 235mA	3Fh: 315mA

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9.5.16 Battery charger control_2 (CHG_CTL2, address 12h)

This register stores the present status of chip, part 2, linear battery charger related status. This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

Table 24. CHG_CNTL2 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit
5	ICHG_TOPOFF [5:0]	000100b	R/W	Program a top-off current **Note: The current default value for ICHG_TOPOFF [5:0] is set at 4mA, but it should be MTP programmable.**
4				
3				
2				
1				
0				

Table 25. Linear battery charger top-off charge current setting

00h: 0mA	10h: 16mA	20h: 32mA	30h: 48mA
01h: 1mA	11h: 17mA	21h: 33mA	31h: 49mA
02h: 2mA	12h: 18mA	22h: 34mA	32h: 50mA
03h: 3mA	13h: 19mA	23h: 35mA	33h: 51mA
04h: 4mA (default)	14h: 20mA	24h: 36mA	34h: 52mA
05h: 5mA	15h: 21mA	25h: 37mA	35h: 53mA
06h: 6mA	16h: 22mA	26h: 38mA	36h: 54mA
07h: 7mA	17h: 23mA	27h: 39mA	37h: 55mA
08h: 8mA	18h: 24mA	28h: 40mA	38h: 56mA
09h: 9mA	19h: 25mA	29h: 41mA	39h: 57mA
0Ah: 10mA	1Ah: 26mA	2Ah: 42mA	3Ah: 58mA
0Bh: 11mA	1Bh: 27mA	2Bh: 43mA	3Bh: 59mA
0Ch: 12mA	1Ch: 28mA	2Ch: 44mA	3Ch: 60mA
0Dh: 13mA	1Dh: 29mA	2Dh: 45mA	3Dh: 61mA
0Eh: 14mA	1Eh: 30mA	2Eh: 46mA	3Eh: 62mA
0Fh: 15mA	1Fh: 31mA	2Fh: 47mA	3Fh: 63mA

9.5.17 Battery charger control_3 (CHG_CTL3, address 13h)

This register stores the present status of chip, part 3, linear battery charger related status. This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

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Table 26. CHG_CNTL3 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit
5	ICHG_LOW [5:0]	000100	R/W	Program a pre-charge (Low battery charge current) Note: Current value set in ICHG_LOW [5:0] should NOT be higher than the value set in ICHG_LOW [5:0]. **Note: The current default value for ICHG_LOW [5:0] is set at 8mA, ICHG_LOW [4:3] should be MTP programmable.**
4				
3				
2				
1				
0				

Table 27. Low battery charge current setting

00h: 0mA	10h: 16mA	20h: 32mA	30h: 48mA
01h: 1mA	11h: 17mA	21h: 33mA	31h: 49mA
02h: 2mA	12h: 18mA	22h: 34mA	32h: 50mA
03h: 3mA	13h: 19mA	23h: 35mA	33h: 51mA
04h: 4mA	14h: 20mA	24h: 36mA	34h: 52mA
05h: 5mA	15h: 21mA	25h: 37mA	35h: 53mA
06h: 6mA	16h: 22mA	26h: 38mA	36h: 54mA
07h: 7mA	17h: 23mA	27h: 39mA	37h: 55mA
08h: 8mA (default)	18h: 24mA	28h: 40mA	38h: 56mA
09h: 9mA	19h: 25mA	29h: 41mA	39h: 57mA
0Ah: 10mA	1Ah: 26mA	2Ah: 42mA	3Ah: 58mA
0Bh: 11mA	1Bh: 27mA	2Bh: 43mA	3Bh: 59mA
0Ch: 12mA	1Ch: 28mA	2Ch: 44mA	3Ch: 60mA
0Dh: 13mA	1Dh: 29mA	2Dh: 45mA	3Dh: 61mA
0Eh: 14mA	1Eh: 30mA	2Eh: 46mA	3Eh: 62mA
0Fh: 15mA	1Fh: 31mA	2Fh: 47mA	3Fh: 63mA

9.5.18 Battery charger control_4 (CHG_CTL4, address 14h)

This register stores the present status of chip, part 4, linear battery charger related status. This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

Table 28. CHG_CNTL4 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit

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Bit	Symbol	Default value	Type	Function
5	ICHG_DEAD [5:0]	000100	R/W	Program a Dead battery charge current Note: Current value set in ICHG_DEAD [5:0] should **NOT** be greater than the value set in ICHG_LOW [5:0]. **Note: The current default value for ICHG_DEAD [5:0] is set at 4mA, ICHG_DEAD [2] and ICHG_DEAD [4] should be MTP programmable.**
4				
3				
2				
1				
0				

Table 29. Dead battery charge current setting

00h: 0mA	10h: 16mA	20h: 32mA	30h: 48mA
01h: 1mA	11h: 17mA	21h: 33mA	31h: 49mA
02h: 2mA	12h: 18mA	22h: 34mA	32h: 50mA
03h: 3mA	13h: 19mA	23h: 35mA	33h: 51mA
04h: 4mA (default)	14h: 20mA	24h: 36mA	34h: 52mA
05h: 5mA	15h: 21mA	25h: 37mA	35h: 53mA
06h: 6mA	16h: 22mA	26h: 38mA	36h: 54mA
07h: 7mA	17h: 23mA	27h: 39mA	37h: 55mA
08h: 8mA	18h: 24mA	28h: 40mA	38h: 56mA
09h: 9mA	19h: 25mA	29h: 41mA	39h: 57mA
0Ah: 10mA	1Ah: 26mA	2Ah: 42mA	3Ah: 58mA
0Bh: 11mA	1Bh: 27mA	2Bh: 43mA	3Bh: 59mA
0Ch: 12mA	1Ch: 28mA	2Ch: 44mA	3Ch: 60mA
0Dh: 13mA	1Dh: 29mA	2Dh: 45mA	3Dh: 61mA
0Eh: 14mA	1Eh: 30mA	2Eh: 46mA	3Eh: 62mA
0Fh: 15mA	1Fh: 31mA	2Fh: 47mA	3Fh: 63mA

9.5.19 Battery charger control_5 (CHG_CTL5, address 15h)

This register stores the present status of chip, part 5, linear battery charger related status. This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

Table 30. CHG_CNTL5 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	VBAT_RESTART	0	R/W	Program a threshold for recharge 0: 140mV below a programmed V_{BAT_REG} 1: 240mV below a programmed V_{BAT_REG} **Note: The default value should be 1-bit MTP programmable.**

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Bit	Symbol	Default value	Type	Function
5	VBAT_REG [5:0]	011110	R/W	Program a battery regulation voltage, V_{BAT_REG} **Note: The current default value for VBAT_REG [5:0] is set at 4.20V, but it should be MTP programmable.**
4				
3				
2				
1				
0				

Table 31. VBATREG, linear battery charger regulated battery voltage setting

00h: 3.60V	10h: 3.92V	20h: 4.24V	30h: 4.56V
01h: 3.62V	11h: 3.94V	21h: 4.26V	31h: 4.58V
02h: 3.64V	12h: 3.96V	22h: 4.28V	32h: 4.60V
03h: 3.66V	13h: 3.98V	23h: 4.30V	33~3Fh: 4.60V
04h: 3.68V	14h: 4.00V	24h: 4.32V	
05h: 3.70V	15h: 4.02V	25h: 4.34V	
06h: 3.72V	16h: 4.04V	26h: 4.36V	
07h: 3.74V	17h: 4.06V	27h: 4.38V	
08h: 3.76V	18h: 4.08V	28h: 4.40V	
09h: 3.78V	19h: 4.10V	29h: 4.42V	
0Ah: 3.80V	1Ah: 4.12V	2Ah: 4.44V	
0Bh: 3.82V	1Bh: 4.14V	2Bh: 4.46V	
0Ch: 3.84V	1Ch: 4.16V	2Ch: 4.48V	
0Dh: 3.86V	1Dh: 4.18V	2Dh: 4.50V	
0Eh: 3.88V	1Eh: 4.20V	2Eh: 4.52V	
0Fh: 3.90V	1Fh: 4.22V	2Fh: 4.54V	

9.5.20 Battery charger control_6 (CHG_CTL6, address 16h)

This register stores the present status of chip, part 7, linear battery charger related status. This is a READ AND WRITE register, **and this register is locked by CHG_LOCK**.

Table 32. CHG_CNTL6 register bit description

Bit	Symbol	Default value	Type	Function
7	NTC_RES_SEL	1	R/W	External thermistor typical resistance selection: 0: 100kΩ 1: 10kΩ
6	TIMER_2X	0	R/W	Charging Safety Timer Extension: 0: Both pre-qual and fast charge timer duration keeps as the values set in ICHG_PREQ_TIMER [1:0] and ICHG_FAST_TIMER [1:0] 1: Both pre-qual and fast charge timer duration is extended to 2x of the values set in ICHG_PREQ_TIMER [1:0] and ICHG_FAST_TIMER [1:0]

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Bit	Symbol	Default value	Type	Function
5 4	ICHG_FAST_ TIMER [1:0]	01	R/W	Linear battery charger fast charge timer setting: 00: 3hr; 01: 5hr; 10: 7hr; 11: 9hr
3 2	ICHG_PREQ_ TIMER [1:0]	01	R/W	Linear battery charger pre-qualification charge timer setting: 00: 15 min; 01: 30 min; 10: 45 min; 11: 60 min
1 0	T_TOPOFF [1:0]	01	R/W	TOPOFF Timer setting: 00: 0min; 01: 6.4min; 10: 12.8min; 11: 19.2min

9.5.21 Battery charger control_7 (CHG_CTL7, address 17h)

This register stores the present status of chip, part 7, linear battery charger related status. This is a READ AND WRITE register.

Table 33. CHG_CNTL7 register bit description

Bit	Symbol	Default value	Type	Function
7:5	NTC_BETA_SEL [2:0]	001	R/W	Set the thermistor beta value selection (see below)
4	RSVD	0	R/W	Reserved bit
3	RSVD	0	R/W	Reserved bit
2 1 0	THM_REG [2:0]	100	R/W	Thermal regulation threshold setting (see below)

Table 34. Set the thermistor beta value selection

000: 3434k	010: 3934k	100: 4100k	110: 4543k
001: 3610k	011: 3950k	101: 4311k	111: 4750k

Table 35. Thermal regulation threshold setting

000: 80°C	010: 90°C	100: 100°C	110: 110°C
001: 85°C	011: 95°C	101: 105°C	111: 115°C

9.5.22 Battery charger status_0 (CHG_STATUS_0, address 18h)

This register stores the present status of the linear battery charger, part 0. This is a READ ONLY register.

Table 36. CHG_STATUS_0 register bit description

Bit	Symbol	Default value	Type	Function
7	VBAT_DET_OK	0	R	VBAT Detection Status: 0: No valid battery attachment detected. 1: Battery attachment detected.

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Bit	Symbol	Default value	Type	Function
6	VBAT_OK	0	R	(Only valid with VBAT_DET_OK = 1) VBAT status, refer to BAT_DETAIL_STATUS [2:0] for more details 0: the battery is invalid/missing, or charger reset is active, i.e. BAT_DETAIL_STATUS [2:0] = 0b000, 0b111 1: the battery is OK. i.e. BAT_DETAIL_STATUS [2:0] = 0b001, 0b010, 0b011, 0b100, 0b101
5	VIN_OK	0	R	VIN status, refer to VIN_STATUS [1:0] for more details 0: VIN voltage is invalid. i.e. VIN_STATUS [1:0] ≠ 0b11 1: VIN voltage is invalid. i.e. VIN_STATUS [1:0] = 0b11
4	CHG_OK	1	R	Charger status 0: The charger has suspended due to the following conditions: TS_DETAIL_STATUS [2:0] = 001'b or 100'b; or SFTY_TIMER_STATUS [1:0] ≠ 00'b 1: The charger is OK
3	RSVD	0	R	Reserved bit
2	RSVD	0	R	Reserved bit
1	RSVD	0	R	Reserved bit
0	RSVD	0	R	Reserved bit

9.5.23 Battery charger status_1 (CHG_STATUS_1, address 19h)

This register stores the present status of the linear battery charger, part 1. This is a READ ONLY register.

Table 37. CHG_STATUS_1 register bit description

Bit	Symbol	Default value	Type	Function
7 6	VIN_STATUS	00	R	VIN Status 00: VIN is invalid. VIN<VIN_UVLO 01: VIN is invalid. VIN< VBAT+VIN_HEADROOM and VIN>VIN_UVLO 10: VIN is invalid. VIN>VIN_OVP 11: VIN is valid. VIN>VIN_UVLO, VIN>VBAT+VIN2BAT_HEADROOM, VIN<VIN_OVP
1	RSVD	0	R	Reserved bit
4	TREG_STATUS	0	R	Temperature Regulation Loop Status 0: Die junction temperature is less than the threshold set by THM_REG and the full charge current limit is available. 1: Die junction temperature is greater than the threshold set by THEM_REG, and the charge current limit may be folding back to reduce power dissipation.
3	RSVD	0	R	Reserved bit
2	RSVD	0	R	Reserved bit
1	RSVD	0	R	Reserved bit
0	RSVD	0	R	Reserved bit

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9.5.24 Battery charger status_2 (CHG_STATUS_2, address 1Ah)

This register stores the present status of the linear battery charger, part 2.

This is a READ ONLY register. The status of this register is only valid when VIN_OK = 1

Table 38. CHG_STATUS_2 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R	Reserved bit
6 5 4	BAT_DETAIL_STATUS [2:0]	111	R	Battery conditions in details 000: Battery missing, not attached 001: Battery detection in-progress 010: VBAT < V_{BAT_DEAD} 011: V_{BAT_DEAD} < VBAT < V_{BAT_LOW} 100: V_{BAT_LOW} < VBAT < (V_{BAT_REG} – $V_{BAT_RESTART}$) 101: VBAT > (V_{BAT_REG} – $V_{BAT_RESTART}$) 110: reserved 111: battery charger is in reset
3	RSVD	0	R	Reserved bit
2 1 0	BAT_CHG_STATUS [2:0]	000	R	Charge conditions in details: 000: Charger in Idle State 001: Charger in Dead-Battery State 010: Charger in Low-Battery State 011-100: Charger in Fast Charging state in either CC or CV 101: Charger in Top-off State 110: Charger in Done State 111: Reserved

9.5.25 Battery charger status_3 (CHG_STATUS_3, address 1Bh)

This register stores the present status of the linear battery charger, part 3. This is a READ ONLY register.

Table 39. CHG_STATUS_3 register bit description

Bit	Symbol	Default value	Type	Function
7	TS_STATUS	0	R	0: TS_DETAIL_STATUS [2:0] = 000. Battery temp is normal, no impact on normal charging. 1: TS_DETAIL_STATUS [2:0] ≠ 000.
6 5 4	TS_DETAIL_STATUS [2:0]	000	R	000: Battery Temperature Nominal, T2 ≤ T ≤ T3 001: Battery Temperature is Cold, T < T1 010: Battery Temperature is Cool, T1 ≤ T < T2 011: Battery Temperature is Warm, T3 < T ≤ T4 100: Battery Temperature is Hot, T > T4
3	RSVD	0	R	Reserved bit
2	CHIP_TEMP_STATUS	0	R	Chip Temp Status: 0: Thermal regulation not activated 1: Thermal regulation activated

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Bit	Symbol	Default value	Type	Function
1 0	SFTY_TIMER_STATUS [1:0]	00	R	00: Safety Timers having No Effect on Battery Charging 01: Pre-qual Timer expires, battery charging suspended 10: Fast Timer expires, battery Charging suspended 11: Battery short test fails, battery charging suspended

1Ch ~ 1Fh registers: Reserved

9.5.26 Regulator status (REG_STATUS, address 20h)

This register stores the present status of the SW1, SW2, LDO1, LDO2. This is a READ ONLY register.

Table 40. REG_STATUS register bit description

Bit	Symbol	Default value	Type	Function
7	VOUTSW1 _OK	0	R	SW1 VOUT “Power-good” Status 0: VOUT_SW1 is not OK, i.e., VOUTSW1 / VOUTSW1(nominal) ≤ 90% or VOUTSW1 / VOUTSW1(nominal) ≥ 110% 1: VOUT_SW1 is OK, i.e., 110% > VOUTSW1 / VOUTSW1(nominal) > 90%
6	VOUTSW2 _OK	0	R	SW2 VOUT “Power-good” Status 0: VOUT_SW2 is not OK, i.e., VOUTSW2 / VOUTSW2(nominal) ≤ 90% or VOUTSW2 / VOUTSW2(nominal) ≥ 110% 1: VOUT_SW2 is OK, i.e., 110% > VOUTSW2 / VOUTSW2(nominal) > 90%
5	VOUTLDO1 _OK	0	R	LDO1VOUT “Power-good” Status 0: VOUTLDO1 is not OK, i.e., VOUTLDO1 / VOUTLDO1 (nominal) ≤ 90% or VOUT LDO1 / VOUT LDO1 (nominal) ≥ 110% 1: VOUTLDO1 is OK, i.e., 110% > VOUTLDO1 / VOUTLDO1 (nominal) > 90%
4	VOUTLDO2_OK	0	R	LDO2VOUT “Power-good” Status 0: VOUTLDO2 is not OK, i.e., VOUTLDO2 / VOUTLDO2 (nominal) ≤ 90% or VOUTLDO2 / VOUTLDO2 (nominal) ≥ 110% 1: VOUTLDO2 is OK, i.e., 110% > VOUTLDO2 / VOUTLDO2 (nominal) > 90%
3	RSVD	0	R	Reserved bit
2	RSVD	0	R	Reserved bit
1	RSVD	0	R	Reserved bit
0	RSVD	0	R	Reserved bit

9.5.27 Active Discharge Regulator control (ACT_DISCHARGE_CNTL, address 21h)

This register stores the control functions of the SW1, SW2, LDO1, LDO2. This is a READ AND WRITE register.

Table 41. ACT_DISCHARGE_CNTL register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	RSVD	0	R/W	Reserved bit

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Bit	Symbol	Default value	Type	Function
5	RSVD	0	R/W	Reserved bit
4	RSVD	0	R/W	Reserved bit
3	nEN_SW1_BLEED	0	R/W	SW1 Output Active Discharge Turn-on Control in the regulator disabled 0: Enable output discharge bleeding resistor disabled 1: Disable Output discharge bleeding resistor
2	nEN_SW2_BLEED	0	R/W	SW2 Output Active Discharge Turn-on Control in the regulator disabled 0: Enable output discharge bleeding resistor disabled 1: Disable Output discharge bleeding resistor
1	nEN_LDO1_ BLEED	0	R/W	LDO1 Output Active Discharge Turn-on Control in the regulator disabled 0: Enable output discharge bleeding resistor disabled 1: Disable Output discharge bleeding resistor
0	nEN_LDO2_ BLEED	0	R/W	LDO2 Output Active Discharge Turn-on Control in the regulator disabled 0: Enable output discharge bleeding resistor disabled 1: Disable Output discharge bleeding resistor

9.5.28 Mode configuration mode setting 0_0 (MODECFG_0_0, address 22h)

This register contains mode setting 0, part 0 configuration register. This is a READ AND WRITE register.

Table 42. MODECFG_0_0 register bit description

Bit	Symbol	Default value	Type	Function
7	SHIP_EN_0	0	R/W	Ship mode enable/disable in mode setting 0 0: Device is NOT set in ship mode 1: Device is set in ship mode
6	EN_MODE_ SEL_BY_PIN_0	0	R/W	MODESEL0/MODESEL1 Control Selection in mode setting 0: 0: mode control by internal I^2C register bits, MODE0_I2C and/or MODE1_I2C only; signal applied on external MODESEL0/MODESEL1 pins is ignored. 1: mode control by signal applied on external MODESEL0 and/or MODESEL1 pins only, not by internal I^2C register bits, MODE0_I2C and MODE1_I2C **[1-bit MTP to set default value]**
5	SW1_OUT_0 [5:0]	010100	R/W	SW1 output voltage for mode setting 0 (see below). **[Note: The default value for SW1 _OUT_0[5:0] is set at 1.00V, but it should be MTP programmable.]**
4				
3				
2				
1				
0				

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Table 43. SW1 output voltage for Mode Setting 0

000000=0.500V	001110=0.850V	011100=1.200V
000001=0.525V	001111=0.875V	011101=1.225V
000010=0.550V	010000=0.900V	011110=1.250V
000011=0.575V	010001=0.925V	011111=1.275V
000100=0.600V	010010=0.950V	100000=1.300V
000101=0.625V	010011=0.975V	100001=1.325V
000110=0.650V	010100=1.000V	100010=1.350V
000111=0.675V	010101=1.025V	100011=1.375V
001000=0.700V	010110=1.050V	100100=1.400V
001001=0.725V	010111=1.075V	100101=1.425V
001010=0.750V	011000=1.100V	100110=1.450V
001011=0.775V	011001=1.125V	100111=1.475V
001100=0.800V	011010=1.150V	101000=1.500V
001101=0.825V	011011=1.175V	101001~111110=1.5V
		111111 = 1.8V

9.5.29 Mode configuration mode setting 0_1 (MODECFG_0_1, address 23h)

This register contains mode setting A, part 1 configuration register. This is a READ AND WRITE register.

Table 44. MODECFG_0_1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	ON_CFG_0	1	R/W	Mode configuration upon falling edge applied on “ON” pin in Mode Setting 0: 0: upon valid falling edge applied on “ON” pin, the device will switch back to mode 0 setting (if the device is currently operating in mode 0 setting, then no mode switch) 1: upon valid falling edge applied on “ON” pin, no mode switch, the device stays in its current mode setting operation **[1-bit MTP to set default value]**
5	SW2_OUT_0_OFFSET	0	R/W	SW2 output voltage offset selection in mode setting 0 0: SW2 Output Voltage = SW2_OUT_0_LSB [4:0] + 0V 1: SW2 Output Voltage = SW2_OUT_0_LSB [4:0] + 1.2V
4	SW2_OUT_0_LSB [4:0]	01100	R/W	SW2 default output voltage for mode setting 0 (see below). **Note: The default value for SW2_OUT_A_LSB [4:0] is set at 1.8V, but it should be MTP programmable.**
3				
2				
1				
0				

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Table 45. SW2 default output voltage for mode setting 0

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.30 Mode configuration mode setting 0_2 (MODECFG_0_2, address 24h)

This register contains mode setting 0, part 2 configuration register. This is a READ AND WRITE register.

Table 46. MODECFG_0_2 register bit description

Bit	Symbol	Default value	Type	Function
7	LDO1_ OUT_0 [3:0]	0100	R/W	LDO1 default output voltage for mode setting 0 (see below). **Note: The default value for LDO1_OUT_0 [3:0] is set at 1.8V, but it should be MTP programmable.**
6				
5				
4				
3	SW1_EN_0	1	R/W	SW1 Enable Control in mode setting 0: 0: SW1 disabled 1: SW1 enabled **[Note] reserve 1-bit MTP to set its default value**
2	SW2_EN_0	1	R/W	SW2 Enable Control in mode setting 0: 0: SW2 disabled 1: SW2 enabled **[Note] reserve 1-bit MTP to set its default value**
1	LDO1_EN_0	1	R/W	LDO1 Enable Control in mode setting 0: 0: LDO1 disabled 1: LDO1 enabled **[Note] reserve 1-bit MTP to set its default value**
0	LDO2_EN_0	1	R/W	LDO2 Enable Control in mode setting 0: 0: LDO2 disabled 1: LDO2 enabled **[Note] reserve 1-bit MTP to set its default value**

Table 47. LDO1 default output voltage for mode setting 0

0000: 1.700V	0011: 1.775V	0110: 1.850V	1001~1111:1.9V
0001: 1.725V	0100: 1.800V	0111: 1.875V	
0010: 1.750V	0101: 1.825V	1000: 1.900V	

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9.5.31 Mode configuration mode setting 0_3 (MODECFG_0_3, address 25h)

This register contains mode setting 0, part 3 configuration register. This is a READ AND WRITE register.

Table 48. MODECFG_0_3 register bit description

Bit	Symbol	Default value	Type	Function
7 6	WD_TIMER_0 [1:0]	00	R/W	Watchdog timer setting in mode setting 0: 00: Watchdog Timer Disabled 01: Watchdog Timer = 16s 10: Watchdog Timer = 32s 11: Watchdog Timer = 64s **[2-bit MTP to set default value]**
5	LDO2_OUT_0_ OFFSET	1	R/W	LDO2 output voltage offset selection in mode setting 0: 0: LDO2 Output Voltage = LDO2_OUT_0_LSB[4:0] + 0V 1: LDO2 Output Voltage = LDO2_OUT_0_LSB[4:0] + 1.2V **[1-bit MTP to set default value]**
4 3 2 1 0	LDO2_OUT_0_ LSB [4:0]	11001	R/W	LDO2 default output voltage for mode setting 0 (see below). **Note: The default value for LDO2_OUT_0_LSB [4:0] is set at 3.3V, but it should be MTP programmable.**

Table 49. LDO2 default output voltage for mode setting 0

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.32 Mode configuration mode setting 1_0 (MODECFG_1_0, address 26h)

This register contains mode setting 1, part 0 configuration register. This is a READ AND WRITE register.

Table 50. MODECFG_1_0 register bit description

Bit	Symbol	Default value	Type	Function
7	SHIP_EN_1	0	R/W	Ship mode enable/disable in mode setting 1 0: Device is NOT set in ship mode 1: Device is set in ship mode

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Bit	Symbol	Default value	Type	Function
6	EN_MODE_ SEL_BY_PIN_1	0	R/W	MODESEL0/MODESEL1 Control Selection in mode setting 1: 0: mode control by internal I^2C register bits, MODE0_I2C and/or MODE1_I2C only; signal applied on external MODESEL0/MODESEL1 pins is ignored. 1: mode control by signal applied on external MODESEL0 and/or MODESEL1 pins only, not by internal I^2C register bits, MODE0_I2C and MODE1_I2C
5	SW1_OUT_1 [5:0]	011100	R/W	SW1 output voltage for mode setting 1 (see below).
4				
3				
2				
1				
0				

Table 51. SW1 output voltage for Mode Setting 1

000000=0.500V	001110=0.850V	011100=1.200V
000001=0.525V	001111=0.875V	011101=1.225V
000010=0.550V	010000=0.900V	011110=1.250V
000011=0.575V	010001=0.925V	011111=1.275V
000100=0.600V	010010=0.950V	100000=1.300V
000101=0.625V	010011=0.975V	100001=1.325V
000110=0.650V	010100=1.000V	100010=1.350V
000111=0.675V	010101=1.025V	100011=1.375V
001000=0.700V	010110=1.050V	100100=1.400V
001001=0.725V	010111=1.075V	100101=1.425V
001010=0.750V	011000=1.100V	100110=1.450V
001011=0.775V	011001=1.125V	100111=1.475V
001100=0.800V	011010=1.150V	101000=1.500V
001101=0.825V	011011=1.175V	101001~111110=1.5V
		111111 = 1.8V

9.5.33 Mode configuration mode setting 1_1 (MODECFG_1_1, address 27h)

This register contains mode setting 1, part 1 configuration register. This is a READ AND WRITE register.

Table 52. MODECFG_1_1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit

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Bit	Symbol	Default value	Type	Function
6	ON_CFG_1	1	R/W	Mode configuration upon falling edge applied on “ON” pin in Mode Setting B: 0: upon valid falling edge applied on “ON” pin, the device will switch back to mode 0 setting (if the device is currently operating in mode 0 setting, then no mode switch) 1: upon valid falling edge applied on “ON” pin, no mode switch, the device stays in its current mode setting operation
5	SW2_OUT_1_ OFFSET	0	R/W	SW2 output voltage offset selection in mode setting 1 0: SW2 Output Voltage = SW2_OUT_1_LSB[4:0] + 0V 1: SW2 Output Voltage = SW2_OUT_1_LSB[4:0] + 1.2V
4	SW2_OUT_1_ LSB [4:0]	01100	R/W	SW2 default output voltage for mode setting 1 (see below).
3				
2				
1				
0				

Table 53. SW2 default output voltage for mode setting 1

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.34 Mode configuration mode setting 1_2 (MODECFG_1_2, address 28h)

This register contains mode setting 1, part 2 configuration register. This is a READ AND WRITE register.

Table 54. MODECFG_1_2 register bit description

Bit	Symbol	Default value	Type	Function
7	LDO1_ OUT_1 [3:0]	0100	R/W	LDO1 default output voltage for mode setting 1 (see below).
6				
5				
4				
3	SW1_EN_1	1	R/W	SW1 Enable Control in mode setting 1: 0: SW1 disabled 1: SW1 enabled

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Bit	Symbol	Default value	Type	Function
2	SW2_EN_1	1	R/W	SW2 Enable Control in mode setting 1: 0: SW2 disabled 1: SW2 enabled
1	LDO1_EN_1	1	R/W	LDO1 Enable Control in mode setting 1: 0: LDO1 disabled 1: LDO1 enabled
0	LDO2_EN_1	1	R/W	LDO2 Enable Control in mode setting 1: 0: LDO2 disabled 1: LDO2 enabled

Table 55. LDO1 default output voltage for mode setting 1

0000: 1.700V	0011: 1.775V	0110: 1.850V	1001~1111:1.9V
0001: 1.725V	0100: 1.800V	0111: 1.875V	
0010: 1.750V	0101: 1.825V	1000: 1.900V	

9.5.35 Mode configuration mode setting 1_3 (MODECFG_1_3, address 29h)

This register contains mode setting 1, part 3 configuration register. This is a READ AND WRITE register.

Table 56. MODECFG_1_3 register bit description

Bit	Symbol	Default value	Type	Function
7 6	WD_TIMER_1 [1:0]	00	R/W	Watchdog timer setting in mode setting 1: 00: Watchdog Timer Disabled 01: Watchdog Timer = 16s 10: Watchdog Timer = 32s 11: Watchdog Timer = 64s
5	LDO2_OUT_1_OFFSET	0	R/W	LDO2 output voltage offset selection in mode setting 1: 0: LDO2 Output Voltage = LDO2_OUT_1_LSB[4:0] + 0V 1: LDO2 Output Voltage = LDO2_OUT_1_LSB[4:0] + 1.2V
4 3 2 1 0	LDO2_OUT_1_LSB [4:0]	01100	R/W	LDO2 default output voltage for mode setting 1 (see below)

Table 57. LDO2 default output voltage for mode setting 1

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V

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00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.36 Mode configuration mode setting 2_0 (MODECFG_2_0, address 2Ah)

This register contains mode setting 2, part 0 configuration register. This is a READ AND WRITE register.

Table 58. MODECFG_2_0 register bit description

Bit	Symbol	Default value	Type	Function
7	SHIP_EN_2	0	R/W	Ship mode enable/disable in mode setting 2 0: Device is NOT set in ship mode 1: Device is set in ship mode
6	EN_MODE_SEL_BY_PIN_2	0	R/W	MODESEL0/MODESEL1 Control Selection in mode setting 2 0: mode control by internal I^2C register bits, MODE0_I2C and/or MODE1_I2C only; signal applied on external MODESEL0/MODESEL1 pins is ignored. 1: mode control by signal applied on external MODESEL0 and/or MODESEL1 pins only, not by internal I^2C register bits, MODE0_I2C and MODE1_I2C
5	SW1_OUT_2[5:0]	011100	R/W	SW1 output voltage for mode setting 2 (see below).
4				
3				
2				
1				
0				

Table 59. SW1 output voltage for Mode Setting 2

000000=0.500V	001110=0.850V	011100=1.200V
000001=0.525V	001111=0.875V	011101=1.225V
000010=0.550V	010000=0.900V	011110=1.250V
000011=0.575V	010001=0.925V	011111=1.275V
000100=0.600V	010010=0.950V	100000=1.300V
000101=0.625V	010011=0.975V	100001=1.325V
000110=0.650V	010100=1.000V	100010=1.350V
000111=0.675V	010101=1.025V	100011=1.375V
001000=0.700V	010110=1.050V	100100=1.400V
001001=0.725V	010111=1.075V	100101=1.425V
001010=0.750V	011000=1.100V	100110=1.450V

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001011=0.775V	011001=1.125V	100111=1.475V
001100=0.800V	011010=1.150V	101000=1.500V
001101=0.825V	011011=1.175V	101001~111110=1.5V
		111111 = 1.8V

9.5.37 Mode configuration mode setting 2_1 (MODECFG_2_1, address 2Bh)

This register contains mode setting 2, part 1 configuration register. This is a READ AND WRITE register.

Table 60. MODECFG_2_1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	ON_CFG_2	1	R/W	Mode configuration upon falling edge applied on “ON” pin in Mode setting 2 0: upon valid falling edge applied on “ON” pin, the device will switch back to mode 0 setting (if the device is currently operating in mode 0 setting, then no mode switch) 1: upon valid falling edge applied on “ON” pin, no mode switch, the device stays in its current mode setting operation
5	SW2_OUT_2_OFFSET	0	R/W	SW2 output voltage offset selection in mode setting 2 0: SW2 Output Voltage = SW2_OUT_2_LSB[4:0] + 0V 1: SW2 Output Voltage = SW2_OUT_2_LSB[4:0] + 1.2V
4	SW2_OUT_2_LSB [4:0]	01100	R/W	SW2 default output voltage for mode setting 2 (see below)
3				
2				
1				
0				

Table 61. SW2 default output voltage for mode setting 2

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

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9.5.38 Mode configuration mode setting 2_2 (MODECFG_2_2, address 2Ch)

This register contains mode setting 2, part 2 configuration register. This is a READ AND WRITE register.

Table 62. MODECFG_2_2 register bit description

Bit	Symbol	Default value	Type	Function
7	LDO1_ OUT_2 [3:0]	0100	R/W	LDO1 default output voltage for mode setting 2 (see below).
6				
5				
4				
3	SW1_EN_2	1	R/W	SW1 Enable Control in mode setting 2 0: SW1 disabled 1: SW1 enabled
2	SW2_EN_2	1	R/W	SW2 Enable Control in mode setting 2 0: SW2 disabled 1: SW2 enabled
1	LDO1_EN_2	1	R/W	LDO1 Enable Control in mode setting 2 0: LDO1 disabled 1: LDO1 enabled
0	LDO2_EN_2	1	R/W	LDO2 Enable Control in mode setting 2 0: LDO2 disabled 1: LDO2 enabled

Table 63. LDO1 default output voltage for mode setting 2

0000: 1.700V	0011: 1.775V	0110: 1.850V	1001~1111:1.9V
0001: 1.725V	0100: 1.800V	0111: 1.875V	
0010: 1.750V	0101: 1.825V	1000: 1.900V	

9.5.39 Mode configuration mode setting 2_3 (MODECFG_2_3, address 2Dh)

This register contains mode setting 2, part 3 configuration register. This is a READ AND WRITE register.

Table 64. MODECFG_2_3 register bit description

Bit	Symbol	Default value	Type	Function
7	WD_TIMER_2 [1:0]	00	R/W	Watchdog timer setting in mode setting 2 00: Watchdog Timer Disabled 01: Watchdog Timer = 16s 10: Watchdog Timer = 32s 11: Watchdog Timer = 64s
6				
5	LDO2_OUT_2_ OFFSET	0	R/W	LDO2 output voltage offset selection in mode setting 2 0: LDO2 Output Voltage = LDO2_OUT_2_LSB[4:0] + 0V 1: LDO2 Output Voltage = LDO2_OUT_2_LSB[4:0] + 1.2V

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Bit	Symbol	Default value	Type	Function
4	LDO2_OUT_2_ LSB [4:0]	01100	R/W	LDO2 default output voltage for mode setting 2 (see below).
3				
2				
1				
0				

Table 65. LDO2 default output voltage for mode setting 2

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.40 Mode configuration mode setting 3_0 (MODECFG_3_0, address 2Eh)

This register contains mode setting 3, part 0 configuration register. This is a READ AND WRITE register.

Table 66. MODECFG_3_0 register bit description

Bit	Symbol	Default value	Type	Function
7	SHIP_EN_3	0	R/W	Ship mode enable/disable in mode setting 3 0: Device is NOT set in ship mode 1: Device is set in ship mode
6	EN_MODE_ SEL_BY_PIN_3	0	R/W	MODESEL0/MODESEL1 Control Selection in mode setting 3 0: mode control by internal I^2C register bits, MODE0_I2C and/or MODE1_I2C only; signal applied on external MODESEL0/MODESEL1 pins is ignored. 1: mode control by signal applied on external MODESEL0 and/or MODESEL1 pins only, not by internal I^2C register bits, MODE0_I2C and MODE1_I2C
5	SW1_OUT_3 [5:0]	011100	R/W	SW1 output voltage for mode setting 3 (see below).
4				
3				
2				
1				
0				

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Table 67. SW1 output voltage for mode setting 3

000000=0.500V	001110=0.850V	011100=1.200V
000001=0.525V	001111=0.875V	011101=1.225V
000010=0.550V	010000=0.900V	011110=1.250V
000011=0.575V	010001=0.925V	011111=1.275V
000100=0.600V	010010=0.950V	100000=1.300V
000101=0.625V	010011=0.975V	100001=1.325V
000110=0.650V	010100=1.000V	100010=1.350V
000111=0.675V	010101=1.025V	100011=1.375V
001000=0.700V	010110=1.050V	100100=1.400V
001001=0.725V	010111=1.075V	100101=1.425V
001010=0.750V	011000=1.100V	100110=1.450V
001011=0.775V	011001=1.125V	100111=1.475V
001100=0.800V	011010=1.150V	101000=1.500V
001101=0.825V	011011=1.175V	101001~111110=1.5V
		111111 = 1.8V

9.5.41 Mode configuration mode setting 3_1 (MODECFG_3_1, address 2Fh)

This register contains mode setting 3, part 1 configuration register. This is a READ AND WRITE register.

Table 68. MODECFG_3_1 register bit description

Bit	Symbol	Default value	Type	Function
7	RSVD	0	R/W	Reserved bit
6	ON_CFG_3	1	R/W	Mode configuration upon falling edge applied on “ON” pin in mode setting 3 0: upon valid falling edge applied on “ON” pin, the device will switch back to mode 0 setting (if the device is currently operating in mode 0 setting, then no mode switch) 1: upon valid falling edge applied on “ON” pin, no mode switch, the device stays in its current mode setting operation
5	SW2_OUT_3_OFFSET	0	R/W	SW2 output voltage offset selection in mode setting 3 0: SW2 Output Voltage = SW2_OUT_3_LSB[4:0] + 0V 1: SW2 Output Voltage = SW2_OUT_3_LSB[4:0] + 1.2V
4	SW2_OUT_3_LSB [4:0]	01100	R/W	SW2 default output voltage for mode setting 3 (see below).
3				
2				
1				
0				

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Table 69. SW2 default output voltage for mode setting 3

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

9.5.42 Mode configuration mode setting 3_2 (MODECFG_3_2, address 30h)

This register contains mode setting 3, part 2 configuration register. This is a READ AND WRITE register.

Table 70. MODECFG_3_2 register bit description

Bit	Symbol	Default value	Type	Function
7	LDO1_ OUT_3 [3:0]	0100	R/W	LDO1 default output voltage for mode setting 3 (see below).
6				
5				
4				
3	SW1_EN_3	1	R/W	SW1 Enable Control in mode setting 3 0: SW1 disabled 1: SW1 enabled
2	SW2_EN_3	1	R/W	SW2 Enable Control in mode setting 3 0: SW2 disabled 1: SW2 enabled
1	LDO1_EN_3	1	R/W	LDO1 Enable Control in mode setting 3 0: LDO1 disabled 1: LDO1 enabled
0	LDO2_EN_3	1	R/W	LDO2 Enable Control in mode setting 3 0: LDO2 disabled 1: LDO2 enabled

Table 71. LDO1 default output voltage for mode setting 3

0000: 1.700V	0011: 1.775V	0110: 1.850V	1001~1111:1.9V
0001: 1.725V	0100: 1.800V	0111: 1.875V	
0010: 1.750V	0101: 1.825V	1000: 1.900V	

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9.5.43 Mode configuration mode setting 3_3 (MODECFG_3_3, address 31h)

This register contains mode setting 3, part 3 configuration register. This is a READ AND WRITE register.

Table 72. MODECFG_3_3 register bit description

Bit	Symbol	Default value	Type	Function
7	WD_TIMER_3 [1:0]	00	R/W	Watchdog timer setting in mode setting 3 00: Watchdog Timer Disabled 01: Watchdog Timer = 16s 10: Watchdog Timer = 32s 11: Watchdog Timer = 64s
6				
5	LDO2_OUT_3_OFFSET	0	R/W	LDO2 output voltage offset selection in mode setting D 0: LDO2 Output Voltage = LDO2_OUT_3_LSB[4:0] + 0V 1: LDO2 Output Voltage = LDO2_OUT_3_LSB[4:0] + 1.2V
4	LDO2_OUT_3_LSB [4:0]	01100	R/W	LDO2 default output voltage for mode setting 3 (see below)
3				
2				
1				
0				

Table 73. LDO2 default output voltage for mode setting 3

00000=1.500V	01001=1.725V	10010=1.950V
00001=1.525V	01010=1.750V	10011=1.975V
00010=1.550V	01011=1.775V	10100=2.000V
00011=1.575V	01100=1.800V	10101=2.025V
00100=1.600V	01101=1.825V	10110=2.050V
00101=1.625V	01110=1.850V	10111=2.075V
00110=1.650V	01111=1.875V	11000=2.100V
00111=1.675V	10000=1.900V	11001-11111=2.1V
01000=1.700V	10001=1.925V	

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10 Limiting values

Table 74. Limiting values

Symbol	Parameter	Conditions	Min	Max	Unit
Voltage range (with respect to AGND)	VIN		-0.3	20	V
	ASYS, VBAT, VBAT_BKUP		-0.3	6	V
	LX1, LX2		-2	6	V
	SW1_OUT, SW2_OUT		-0.3	6	V
	LDO1, LDO2		-0.3	6	V
	SDA, SCL, MODESEL0, MODESEL1, ON, TS, SYSRSTn, INTB		-0.3	6	V
	PGND to AGND		-0.3	0.3	V
$I_{O(sink)}$	Output sink current	on pins SYSRSTn, INTB, SDA, SCL		5	mA
T_j	Junction temperature		–40	125	°C

11 ESD ratings

Table 75. Limiting values

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM)	-	2000	V
		Charged device model (CDM)	-	500	V

12 Recommended operating conditions

Table 76. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IN}	Supply Voltage	VIN	3.3	5.5	V
V_{IO}	Input/output voltage	SDA, SCL, MODESEL0, MODESEL1, SYSRSTn	0	3.6	V
T_{amb}	Ambient Temperature		-40	85	°C
T_j	Junction Temperature		-40	125	°C
T_{stg}	Storage Temperature		-55	150	°C

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13 Electrical characteristics

Unless otherwise specified, V_{VIN}=5V, V_{VBAT}=3.8V, LDO1_OUT=1.8V, LDO2_OUT=1.8V. C_{VIN}=2.2µF/10V, C_{ASYS}=4.7µF/10V, C_{VBAT}=1µF/10V, C_{LDO1_OUT}=1µF/6.3V, C_{LDO2_OUT}=2.2µF/6.3V, C_{SW1_OUT}=10µF/6.3V, C_{SW2_OUT}=10µF/6.3V, L_{SW1} =2.2µH, L_{SW2} =2.2µH, T_{amb}= -40°C ~ +85°C, Typical value at T_{amb}=25°C

13.1 Top level parameter

Table 77. EC table for Top level

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VBAT QUIESCENT CURRENT						
$I_{BAT_NOLOAD1}$	VBAT quiescent Current VBAT=4.5V SW1, SW2, LDO1, LDO2 enabled, no load. No switching on SW1, SW2. VIN = open, charger disabled	T_J = 25°C		2.9	4.5	µA
		T_J = 85°C[1]		4.5	8	
$I_{BAT_NOLOAD2}$[1]	VBAT quiescent Current VBAT = 4.5V SW1, SW2, LDO1, LDO2 enabled, no load. Switching on SW1, SW2. VIN = open, charger disabled	T_J = 25°C		3.5	5	µA
		T_J = 85°C		5.5	11	
$I_{BAT_DISABLE}$[1]	VBAT quiescent Current VBAT = 4.5V SW1, SW2, LDO1, LDO2 Disabled VIN = open, charger disabled	T_J = 25°C		750	1200	nA
		T_J = 85°C		1500	3000	
I_{BAT_SHIP}	VBAT quiescent current	VBAT=4.5V VIN =open, Ship Mode activated at T_J = 25°C		100	150	nA
VIN						
VIN_{UVLO}	VIN Under voltage lock-out	I^2C programmable in 200mV steps, VIN Falling	2.9		3.5	V
$VIN_{UVLO\ Accuracy}$			-5		+5	%
VIN_{UVLO_HYS}	Hysteresis on VINUVLO			200		mV
VIN_{OVP}		I^2C programmable at 5.5V or 6V, VIN Rising	5.5		6.0	V
$VIN_{OVP\ Accuracy}$	Input over- voltage protection threshold		-3.5		+3.5	%
$VIN_{OVP\ Hysteresis}$		VIN Falling		100		mV
$t_{DGL(VINOVP)}$	Input over-voltage blanking time	VIN: 5 V → 7V, 1V/µs		20		µs

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VIN Current Limit	Input current limit	VIN_ILIM [2:0] = 000	74	85	98	mA
		VIN_ILIM [2:0] = 010	370	425	489	
ASYS						
$V_{ASYS_UVLO_RISING}$		ASYS in rising		2.8		V
$V_{ASYS_UVLO_FALLING}$		ASYS in falling		2.7		V
		By MTP		2.4		
$\%V_{ASYS_UVLO_FALLING}$	ASYS UVLO Accuracy		-3.5		+3.5	%
$V_{ASYS_UVLO_HYS}$	ASYS UVLO Hysteresis	400mV for 2.4V falling threshold		100 or 400		mV
$T_{ASYS_SW_DELAY}$		Time when ASYS voltage is switched between VIN and VBAT		0.5		ms
$V_{ASYS_PREWARNING}$	ASYS Pre-Warning Threshold Accuracy	ASYS falling, I^2C programmable		3.3 3.4 3.5 3.6		V
$\%V_{ASYS_PREWARNING}$	ASYS Pre-Warning Threshold Accuracy		-4		+4	%
$V_{ASYS_PREWARNING_HYS}$	ASYS Pre-warning Threshold Hysteresis			100		mV
VBAT_BKUP						
VBAT_BKUP UVLO		VBAT_BKUP falling edge		1.9		V
VBAT_BKUP UVLO Accuracy			-5		5	%
VBAT_BKUP UVLO Hysteresis				100		mV
PROTECTION[1]						
$T_{WARNING}$	Pre-warning temperature	2-bit programmable, T_WARNING [1:0]		75 80 85 90		°C
$T_{WARNING_HYS}$	Pre-warning threshold Hysteresis			20		°C
T_{SHDN}	Thermal shutdown	3-bit programmable,THEM_SHDN [2:0], in 5°C steps		95 to 125		°C
T_{SHDN_HYS}	Thermal shutdown Hysteresis			20		°C
WATCHDOG & SAFETY TIMER						

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_{WD_TIMER} Range	Watchdog Timer	When enabled via I^2C Programming	-15%	Disable 16 32 64	+15%	s
T_{CHG_PREQ}	Pre-qualification Charging Safety Timer Range	I^2C Programmable, 15min/step **[Note] When under thermal fold- back status, the timer will extend by 2x automatically**	-15%	15 30 45 60	+15%	min
T_{CHG_FAST}	Fast (CC and CV) Charging Safety Timer Range	I^2C Programmable, 2hr/step **[Note] When under thermal fold- back status, the timer will extend by 2x automatically**	-15%	3 5 7 9	+15%	hrs
POWER UP/DOWN SEQUENCE TIMING[1]						
$T_{PWUP_DLY_INI}$	Power up Initial delay	Time from ON signal asserts to the first output rail reaches 90% of its nominal value		2		ms
$T_{PWDN_DLY_INTERVAL}$	Power down interval delay	Delay between power rail		2		ms
$T_{PWUP_DLY_INTERVAL}$	Power up interval delay	For power-up: this is the time from previous voltage rail reaches 90% of its nominal value to the time when the following voltage rail reaches its 90% nominal value For power-down: this is the time from the previous voltage rail starts falling to the time the following rail starts falling		1		ms

[1] Guaranteed by design and characterization; not tested in production.

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13.2 Battery charger

Table 78. EC table for Linear Charger

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
LINEAR CHARGER						
V_{BAT_REG}	V_{BAT} regulation voltage range	I^2C programmable, 20mV/step	3.60		4.60	V
$\%V_{BAT_REG}$	V_{BAT_REG} Regulation Voltage Accuracy	I_{OUT}=0 mA to 200 mA; VIN= 5V, T_{amb}=25°C	-0.75		0.75	%
		I_{OUT}=0 mA to 200 mA; V_{IN}= 5V, T_{amb}=-40°C~ +85°C	-1		1	%
I_{CHG_CC}	Constant charging current value	I^2C programmable, $V_{BAT_REG} > V_{BAT} > V_{BAT_LOW}$; V_{IN} = 5V	5		315	mA
$\%I_{CHG_CC}$	I_{CHG_CC} Accuracy	$V_{BAT_REG} > V_{BAT} > V_{BAT_LOW}$; V_{IN} = 5V				
		I_{CHG_CC} > 40mA	-6		+6	%
		$I_{CHG_CC} \leq$ 40mA	-12		+12	%
$\Delta V_{BAT_REG\ (HOT)}$	V_{BAT_REG} reduction in warm condition	T3 < V_{TS} < T4 in TS enabled	120	140	160	mV
$R_{DS_ON_VIN_TO_ASYS}$[1]	R_{DS_ON} between VIN and ASYS	VIN = 5V at 50mA		250	360	mΩ
$R_{DS_ON_ASYS_TO_VBAT}$[1]	R_{DS_ON} between ASYS and VBAT	VBAT = 3.8V at 50mA		130	175	mΩ
DEAD BATTERY IN PRECHARGE MODE						
V_{BAT_DEAD}	Dead battery charge to low battery charge transition threshold	[Note: reserve 2-bit MTP for programmability, 1.7V/1.8V/1.9V/2.0V]		1.9		V
$\%V_{BAT_DEAD}$ Accuracy			-4.5		+4.5	%
$t_{DGL_BAT_DEAD2LOW}$	Deglitch time from dead battery charge to low battery charge transition			50		µs
I_{CHG_DEAD}		I^2C programmable,1mA/ step	1		63	mA
$\%I_{CHG_DEAD}$	I_{CHG_DEAD} Accuracy	V_{BAT} =1V, I_{CHG_DEAD} =4mA	-12		+12	%
LOW BATTERY IN PRECHARGE MODE						
V_{BAT_LOW}	Precharge to fast-charge transition threshold	[Note: reserve 2-bit MTP for programmability, 2.3V/2.4V/2.5V/2.6V]		2.5		V
$\%V_{BAT_LOW}$	V_{BAT_LOW} Accuracy		-3.5		+3.5	%
$t_{DGL_BAT_LOW2CC}$	Deglitch time on pre-charge to fast-charge transition			50		µs

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{CHG_LOW}		I^2C programmable,1mA/ step	1		63	mA
$\%I_{CHG_LOW}$	I_{CHG_LOW} Accuracy	V_{BAT} =2V, I_{CHG_DEAD} =8mA	-10		+10	%
$t_{DGL_BAT_CC2LOW}$	Deglitch time from fast-charge to low battery charge transition			50		ms
TOP-OFF MODE						
I_{CHG_TOPOFF}	I_{CHG_TOPOFF} programmed value	I^2C programmable,1mA/ step	1		63	mA
I_{CHG_TOPOFF} Accuracy		I_{CHG_TOPOFF} ≥ 8mA	-15		+15	%
		I_{CHG_TOPOFF} < 8mA, test 4mA only in production	-20		+20	%
$t_{DGL_BAT_CC2TOPOFF}$	I_{CHG_TOPOFF} detection deglitch time on fast charging to top-off charging transition			20		ms
RECHARGE MODE						
$V_{BAT_RESTART}$	Charging restart threshold voltage	When below VBAT_ REG [Note: reserve 1-bit MTP bit to set the typical value, 140mV or 240mV]	95	140	165	mV
			185	240	270	
$t_{DGL_BAT_RESTART}$	Deglitch time, recharge threshold detected			50		ms
BATTERY PRESENCE DETECTION						
$I_{BAT_DET_SINK}$	Sink current during battery detection	V_{IN} = 5V; Battery absent		5		mA
$t_{DGL(BAT_DET_SINK)}$	Deglitch time, for sinking current	V_{IN} = 5V; Battery absent		300		ms
$I_{BAT_DET_SOURCE}$	Source current during battery detection	V_{IN} = 5V; Battery absent		5		mA
$t_{DGL(BAT_DET_SOURCE)}$	Deglitch time, for sourcing current	V_{IN} = 5V; Battery absent		300		ms
$V_{BAT_DET_LOW}$	Battery detection lower threshold	V_{IN} = 5V; Battery absent [Note: reserve 2-bit MTP for programmability, 1.7V/1.8V/1.9V/2.0V]		1.9		V
$V_{BAT_DET_UP}$	Battery detection upper threshold	V_{IN} = 5V; Battery absent [Note: reserve 2-bit MTP for programmability, 3.2V/3.3V/3.4V/3.5V]		3.4		V
BATTERY-PACK NTC MONITOR (TS)						
$I_{NTC-10k}$	NTC thermistor bias current	V_{TS} < ASYS-200mV	44 (-12%)	50	56 (+12%)	µA

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{NTC-DIS-10k}$	10k NTC bias current when charging is disabled	V_{TS} < ASYS-200mV	4.4 (-12%)	5	5.6 (+12%)	µA
$V_{TS(0°C)}$	TS threshold voltage at 0°C	NTC_BETA_SEL [2:0] = 000	1.171	1.372	1.45	V
$V_{TS(0°C)_HYS}$	$V_{TS(0°C)}$ Hysteresis Threshold			110		mV
$V_{TS(10°C)}$	TS threshold voltage at 10°C	NTC_BETA_SEL [2:0] = 000	0.813	0.900	0.999	V
$V_{TS(10°C)_HYS}$	$V_{TS(10°C)}$ Hysteresis Threshold			70		mV
$V_{TS(45°C)}$	TS threshold voltage at 45°C	NTC_BETA_SEL [2:0] = 000	0.205	0.246	0.303	V
$V_{TS(45°C)_HYS}$	$V_{TS(45°C)}$ Hysteresis Threshold			24		mV
$V_{TS(60°C)}$	TS threshold voltage at 60°C	NTC_BETA_SEL [2:0] = 000	0.128	0.151	0.187	V
$V_{TS(60°C)_HYS}$	$V_{TS(60°C)}$ Hysteresis Threshold			20		mV
$T_{DGL\ (TS)}$	Deglitch time for TS pin			50		ms
C_{TS}	Maximum Decoupling Capacitor			10		nF
THERMAL REGULATION[1]						
$T_{THEM_REGULATION}$	Thermal regulation (fold-back) range	I^2C Programmable, 5°C/ step	80		115	°C
$T_{THEM_REGULATION_HYS}$	Thermal regulation (fold-back) Hysteresis			20		°C

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13.3 BUCK1 (SW1)

Table 79. EC table for BUCK1 (SW1)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IN(SW1)}$	Input voltage range for CORE BUCK	Input is PSYS1, guaranteed by design	2.5		5.5	V
$I_{OUT(SW1)\ MAX}$	Max Output Current	Over V_{PSYS1}, guaranteed by design	250			mA
V_{SW1} Range	Output range for CORE BUCK	I^2C programmable from 0.5V to 1.5V in 25mV/step, a fixed 1.8V	0.5		1.5	V
V_{SW1_OUT} Accuracy	CORE BUCK DC Output Accuracy	Over full V_{PSYS1}, $I_{OUT(SW1)}$, -40°C ≤ T_{amb} ≤ +85°C, for all V_{SW1_OUT} except for 500mV and 1.8V	-3		+3	%
		Over full V_{PSYS1}, $I_{OUT(SW1)}$, -40°C ≤ T_{amb} ≤ +85°C, for only V_{SW1_OUT} =1.8V	-3.5		+3.5	
		Over full V_{PSYS1}, $I_{OUT(SW1)}$, -40°C ≤ T_{amb} ≤ +85°C, for only V_{SW1_OUT} =0.5V	-4		+4	
ΔV_{SW1} / ΔV_{PSYS1}	DC Line regulation	$V_{SW1(NOM)}$+0.5V < V_{PSYS1} < 5.5V, $I_{OUT(SW1)}$ = 250mA		0.15		%/V
ΔV_{SW1} / $\Delta I_{OUT(SW1)}$	DC Load regulation	0 mA < $I_{OUT(SW1)}$ < 250mA		0.008		%/mA
$T_{ON\ (SW1)}$		-40°C ≤ T_{amb} ≤ +85°C[1]	110	240	350	ns
$I_{IN(SW1)}$[1]	Quiescent current	SW1 enabled, $I_{OUT(SW1)}$ = 0, no switching		700		nA
Inductor value	L			2.2		µH
$R_{DSON(SW1)}$[1]	High Side P-FET R_{DSON}	V_{PSYS1}=5V		500	900	mΩ
	Low Side N-FET R_{DSON}	V_{PSYS1}=5V		250	450	
$R_{STDN(SW1)}$	SW1 Output Active Discharge Resistance			50		Ω
$I_{LIM(SW1)}$	Internal Peak Current Limit	Cycle by cycle peak current limit	700	950	1200	mA
$t_{ONMIN(SW1)}$	Minimum On-Time			50		ns
$t_{OFFMIN(SW1)}$	Minimum-Off Time			10		ns
$t_{SSTART(SW1)}$	Soft-start time	V_{SW1OUT}=1.2V		1.2		ms
Efficiency[1]	V_{PSYS1}=5V, V_{SW1OUT}=1.5V	@I_{OUT}=10µA		> 76		%
		@I_{OUT}=100µA		> 84		%
		@I_{OUT}=65mA		> 86		%
		@I_{OUT}=125mA		> 86		%

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		@I_{OUT}=250mA		> 84		%

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13.4 BUCK2 (SW2)

Table 80. EC table for BUCK2 (SW2)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{IN(SW2)}$	Input voltage range for SW2	Input is V_{PSYS2}	2.5		5.5	V
$I_{OUT(SW2)MAX}$	Maximum Output Current	Over V_{PSYS2}	500			mA
V_{SW2_RANGE}	Output range for SW2	I^2C programmable, 25mV/step	1.5		2.1	V
			2.7		3.3	
$V_{SW2_Accuracy}$	SW2 DC Output Accuracy	Over full V_{PSYS2}, $I_{OUT(SW2)}$, T_{amb}=room temp	-2		2	%
		Over full V_{PSYS2}, $I_{OUT(SW2)}$, temperature range	-3		3	%
ΔV_{SW2} / ΔV_{PSYS2}	DC Line regulation	$V_{SW2OUT(NOM)}$+0.5V < V_{PSYS2} < 5.5V, $I_{OUT(SW1)}$ = 500 mA		0.15		%/V
ΔV_{SW2} / $\Delta I_{OUT(SW2)}$	DC Load regulation	0 mA < $I_{OUT(SW1)}$ < 500 mA		0.008		%/mA
$T_{ON\ (SW2)}$			250	360	490	ns
IIN(SW2)[1]	Quiescent current	SW2 enabled, $I_{OUT(SW2)}$ =0, no switching		700		nA
Inductor value	L			2.2		µH
$R_{DSON(SW2)}$[1]	High Side P-FET RDSON	V_{PSYS2}=5V		250	450	mΩ
	Low Side N-FET RDSON	V_{PSYS2}=5V		125	250	
$R_{STDN(SW2)}$	SW2 Output Active Discharge Resistance			50		Ω
$I_{LIM(SW2)}$	Peak Current Limit	Cycle by cycle peak current limit	900	1300	1800	mA
$t_{ONMIN(SW2)}$	Min. On Time			50		ns
$t_{OFFMIN(SW2)}$	Max On Time			10		ns
$t_{SSTART(SW2)}$	Softstart time	V_{SW2OUT}=1.8V		1.8		ms
Efficiency[1]	V_{PSYS2}5V V_{SW2OUT}=1.8V	@I_{OUT}=10µA		> 78		%
		@I_{OUT}=100µA		> 87		
		@I_{OUT}=125mA		> 88		
		@I_{OUT}=250mA		> 88		
		@I_{OUT}=500mA		> 86		

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13.5 LDO1 (Always-On LDO)

Table 81. EC table for LDO1

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN_LDO1}	Input voltage range for Always-On LDO	Whichever is higher between VBAT_BKUP and ASYS	2.0		5.5	V
$I_{OUT_LDO1_MAX}$	Maximum Output DC Current		1			mA
$I_{OUT_LDO1_LIMIT}$	Internal Current Limit	LDO1_OUT = GND	1.4	3.3	7.0	mA
V_{LDO1_OUT} Range	LDO1 nominal output voltage	I^2C Programmable, 25mV/step	1.700		1.900	V
V_{LDO1_OUT} Accuracy	LDO1 Output Voltage Accuracy	Over V_{IN_LDO1}, I_{OUT}= 0~1mA	-3		+3	%
ΔV_{LDO1_OUT} / ($V_{LDO1_OUT(NOM)}$ x ΔV_{IN_LDO1})	DC Line regulation	$V_{LDO1_OUT(NOM)}$+0.5V < V_{IN_LDO1} < 5V, I_{OUT}= 1mA		1		%/V
ΔV_{LDO1_OUT} / ($V_{LDO1_OUT(NOM)}$ x ΔV x ΔI_{OUT})	DC Load regulation	0 mA < I_{OUT} < 1 mA		1		%/mA
Power Supply Rejection Ratio (PSRR)[1]				40		dB
$I_{IN(LDO1)}$	Quiescent current	I_{OUT} =0mA		94		nA
$V_{DROPOUT(LDO1)}$[1][2]	Dropout Voltage	I_{OUT}=1mA			200	mV
$R_{STDN(LDO1)}$	LDO1 Output Active Discharge Resistance			50		Ω

[1] Guaranteed by design and characterization; not tested in production.
[2] Dropout voltage is defined as the input-to-output difference in the predefined load when the output is below 100mV to the nominal regulation voltage.

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13.6 LDO2 (System LDO)

Table 82. EC table for LDO2

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN_LDO2}	Input voltage range	ASYS	2.5		5.5	V
$I_{OUT_LDO2_MAX}$	Maximum Output Current		250			mA
$I_{OUT_LDO2_LIMIT}$[1]	Internal Current Limit	LDO2_OUT = GND	300	450	600	mA
V_{LDO2_OUT} Range	LDO2 output voltage range	programmable 25mV steps	1.5		2.1	V
			2.7		3.3	
V_{LDO2_OUT} Accuracy	LDO2 Output Accuracy	Over V_{IN_LDO2}, I_{OUT}, temperature	-3.5		3.5	%
ΔV_{LDO2_OUT} / ($V_{LDO2_OUT(NOM)}$ x ΔV_{IN_LDO2})	DC Line regulation	$V_{LDO2_OUT(NOM)}$+0.5V < V_{IN_LDO2} < 5.5V, I_{OUT} = 250 mA		0.35		%/V
ΔV_{LDO2_OUT} / ($V_{LDO2_OUT(NOM)}$ x ΔI_{OUT})	DC Load regulation	0 mA < I_{OUT} < 250 mA		0.0065		%/mA
PSRR[1]	Power Supply Rejection Ratio			40		dB
$I_{IN(LDO2)}$	Quiescent current	I_{OUT} =0mA		450		nA
$V_{DROPOUT(LDO2)}$[2]	Dropout Voltage	I_{OUT}=100mA			150	mV
$R_{STDN(LDO2)}$	LDO2 Output Active Discharge Resistance			150		Ω

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[2] Dropout voltage is defined as the input-to-output difference in the predefined load when the output is below 100mV to the nominal regulation voltage.

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13.7 I²C Interface and Logic I/O

Table 83. EC table for I²C and Logic

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
SERIAL INTERFACE (SCL & SDA)						
V_{PULLUP} Range[1]	Pullup Voltage Range		1.5		3.6	V
F_{I2C}	I²C Clock frequency	On SCL	0		1000	kHz
V_{IH}	High-level Input voltage		1.5			V
V_{IL}	Low-level Input voltage				0.5	V
V_{hys}	Hysteresis of Schmitt trigger inputs		0.01			V
V_{OL}	Low-level output voltage at 3mA sink current		0		0.4	V
I_{OL}	Low-level output current	V_{OL} =0.4 V; Standard and Fast modes	3			mA
		V_{OL} =0.6 V; Fast mode	6			mA
I_{IL}	Low-level input current	Pin voltage: 0.1xVpullup to 0.9x Vpullup max	-10		10	µA
C_I	Capacitance of IO pin				10	pF
$t_{HD,STA}$	Hold time (repeated) START condition	Fast mode plus; After this period, the first clock pulse is generated	0.26			µs
t_{LOW}	LOW period of I²C clock	Fast mode plus	0.5			µs
t_{HIGH}	HIGH period of I²C clock	Fast mode plus	0.26			µs
$t_{SU,STA}$	Setup time (repeated) START condition	Fast mode plus	0.26			µs
$t_{HD,DAT}$	Data Hold time	Fast mode plus	0			µs
$t_{SU,DAT}$	Data Setup time	Fast mode plus	50			ns
t_r	Rise time of I2C_SCL and I2C_SDA signals	Fast mode plus			120	ns
t_f	Fall time of I2C_SCL and I2C_SDA signals	Fast mode plus			120	ns
$t_{SU,STO}$	Setup time for STOP condition	Fast mode plus	0.26			µs
t_{BUF}	Bus free time between STOP and START condition	Fast mode plus	0.5			µs
$t_{VD,DAT}$	Data valid time	Fast mode plus			0.45	µs
$t_{VD,ACK}$	Data valid acknowledge time	Fast mode plus			0.45	µs
t_{SP}	Pulse width of spikes that must be suppressed by input filter		0		50	ns

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
MODESEL0/MODESEL1						
V_{IH1}	Logic Input High Threshold		1.5			V
V_{IL1}	Logic Input Low Threshold				0.4	V
I_{LK1}	Logic Pin Leakage Current	Pulled up to 5.0V		0.1	1	µA
$t_{debounce_1}$	Debounce time for MODESEL0, MODESEL1			1		µs
ON						
V_{IH2}	Logic Input High Threshold	Note: ON pin internally pulled up, no external pull-up voltage needed.	70% * VBAT			V
V_{IL2}	Logic Input Low Threshold				0.4	V
$t_{debounce}$	Debounce time for ON	To initiate the default power-up sequence		200		µs
SYSRSTn, INTB						
V_{OL1}	Low-level output voltage at 1mA sink current				0.5	V
I_{LK2}	Logic Pin Leakage Current	Pulled up to 5.0V		0.01	0.1	µA
$V_{PULLUP1}$	Minimum Supply Voltage for valid Open-drain signal		1.5			V

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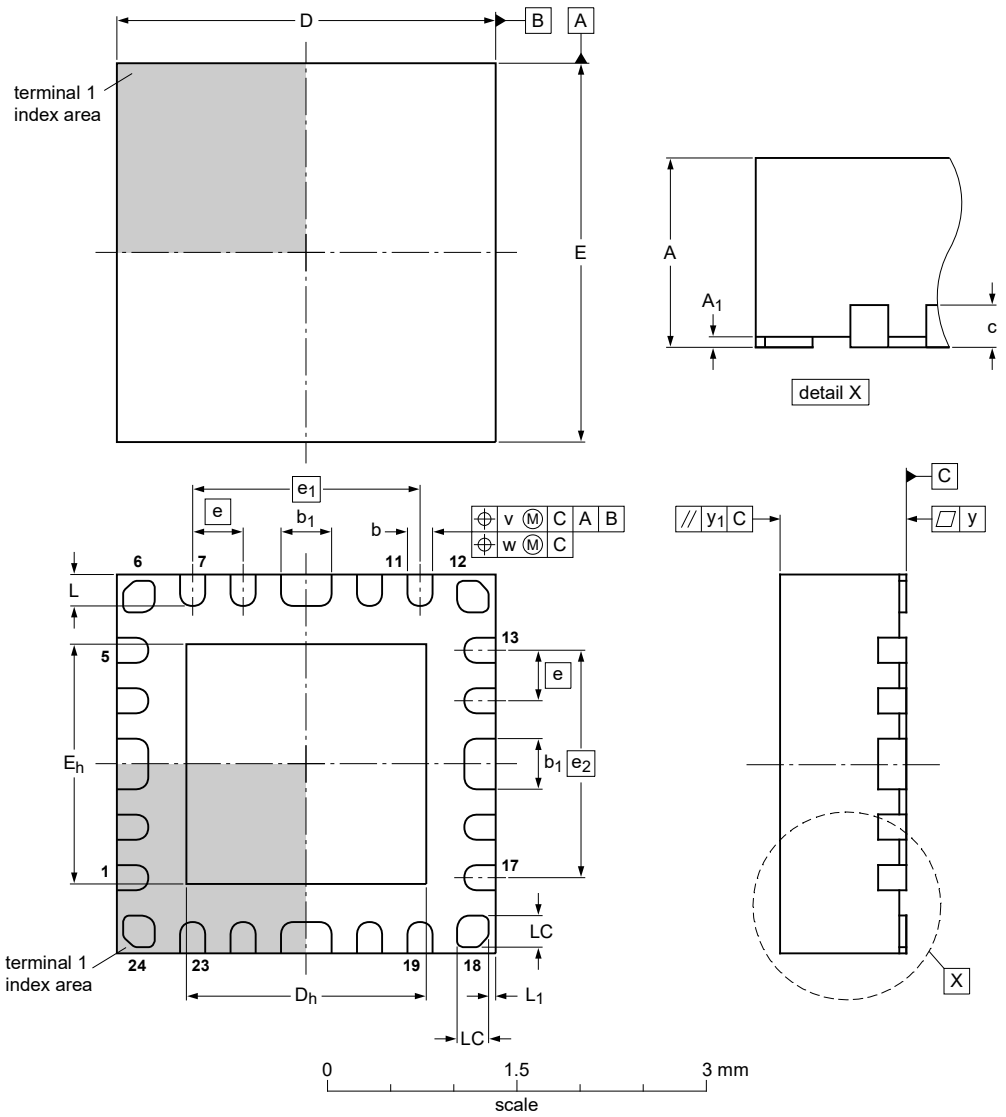
14 Package outline

HVQFN24: plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 3 x 3 x 0.85 mm **SOT905-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max	A1	b	b1	c	D(1)	Dh	E(1)	Eh	e	e1	e2	L	L1	LC	v	w	y	y1
mm	1	0.05 0.00	0.25 0.15	0.45 0.35	0.2	3.1 2.9	2.05 1.75	3.1 2.9	2.05 1.75	0.4	1.8	1.8	0.35 0.15	0.1 0.0	0.3 0.2	0.1	0.05	0.05	0.1

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT905-1	- - -	- - -	- - -			~~06-03-13~~ 06-03-31

Figure 11. Package outline SOT905-1 (HVQFN24)

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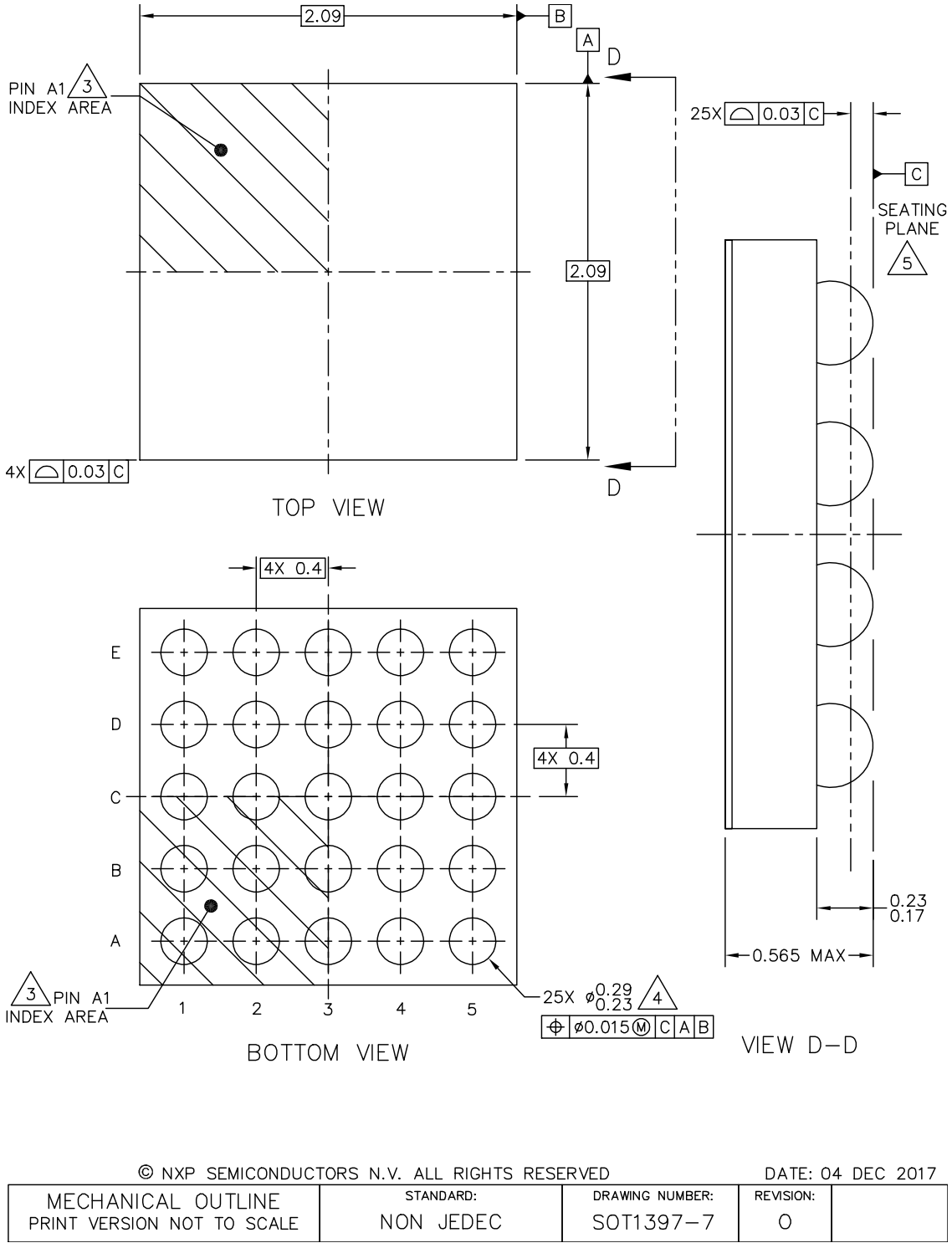

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DATE: 04 DEC 2017

MECHANICAL OUTLINE PRINT VERSION NOT TO SCALE	STANDARD: NON JEDEC	DRAWING NUMBER: SOT1397-7	REVISION: 0	

Figure 12. Package outline SOT1397-7 (WLCSP25) (1 of 2)

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NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
3. PIN A1 FEATURE SHAPE, SIZE AND LOCATION MAY VARY.
4. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM C.
5. DATUM C, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
6. THIS PACKAGE HAS A BACK SIDE COATING THICKNESS OF 0.025.

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MECHANICAL OUTLINE PRINT VERSION NOT TO SCALE	STANDARD: NON JEDEC	DRAWING NUMBER: SOT1397–7	REVISION: O	

Figure 13. Package outline SOT1397-7 (WLCSP25) (2 of 2)

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15 Revision history

Table 84. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
PCA9420 v.1.1	20191024	Product data sheet	-	PCA9420 v.1.0
Modifications:	• Table 10 and Table 11: Bit 5 updated from "reserved" to "ON_PUSH_INT". • Changed orderable part number, packing method and minimum order quantity for PCA9420BS.			
PCA9420 v.1.0	20190601	Product data sheet	-	-

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16 Legal information

16.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.
[2] The term 'short data sheet' is explained in section "Definitions".
[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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Date of release: 24 October 2019
Document identifier: PCA9420