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nPM1100

Product Specification

v1.3

NORDIC® SEMICONDUCTOR

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nPM1100

nPM1100 is an integrated Power Management IC (PMIC) with a linear-mode lithium-ion/lithium-polymer battery charger in a compact 2.1x2.1 mm WLCSP or 4.0x4.0 mm QFN package. It has a highly efficient DC/DC buck regulator with configurable dual mode output.

nPM1100 is an extremely compact PMIC device, created for space constrained applications that have a small lithium-ion or lithium-polymer battery. It is compatible with all nRF52 and nRF53 Series SoCs, supports charging batteries at up to 400 mA through USB, and delivers up to 150 mA of current to power external components with regulated voltage.

A minimum of five passive components are required for operation. It is the perfect companion for nRF52 and nRF53 multiprotocol SoCs in battery powered designs and the device functions without a control interface. Low quiescent current (IQ) extends battery life for shipping and storage with Ship mode, or in operation using auto-controlled hysteretic buck mode for high efficiency down to 1 µA loads. Charge and error indication LED drivers are built in. Charge profile limits are configurable and VBUS current limits can be fixed or auto-controlled with on-chip USB port detection.

- Ultra-high efficiency prolongs battery life or allows for use of smaller and less costly batteries
- Small solution size leaves space for additional features without increasing product size
- No software control
- Automatic USB port detection minimizes development time

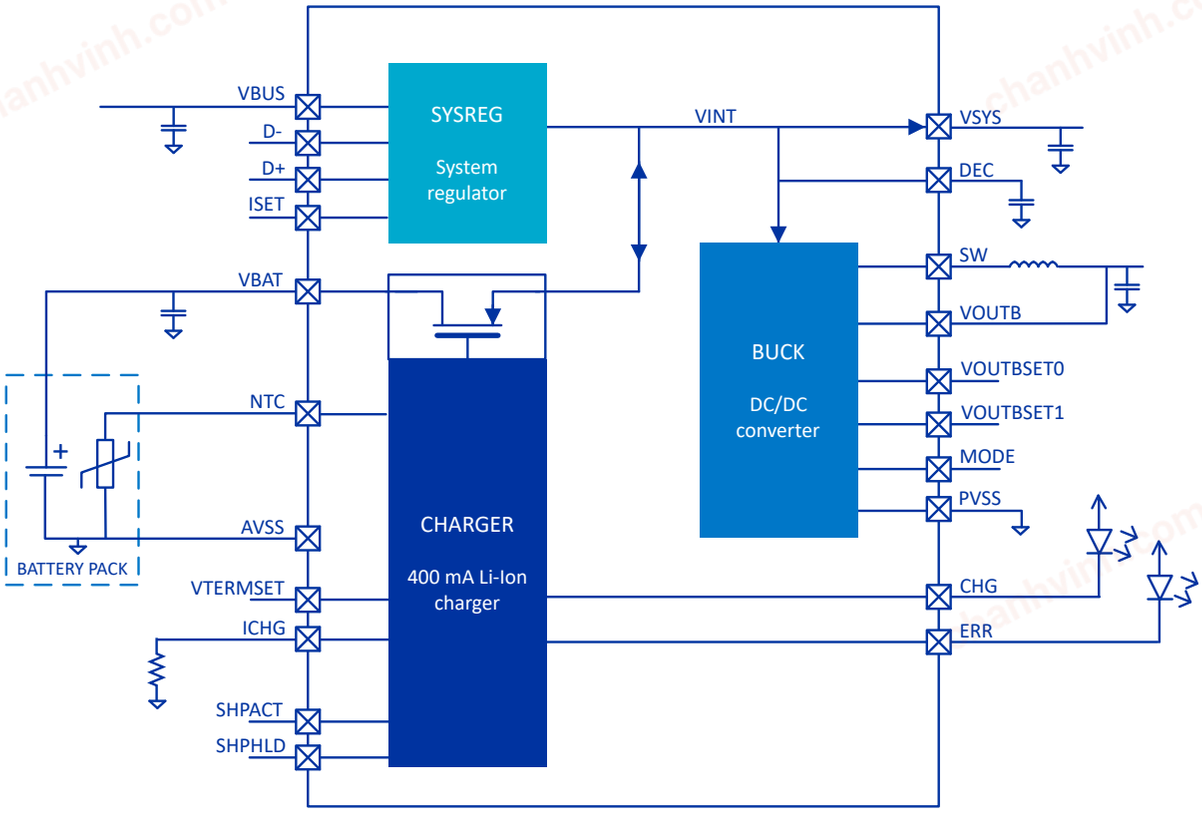


Figure 1: nPM1100 block diagram

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Feature list

Features:

- 400 mA linear battery charger
  - Linear charger for lithium-ion/lithium-polymer batteries
  - Adjustable charge current from 20 mA to 400 mA
  - Selectable termination voltage
    - 4.1 V or 4.2 V on the standard V_{TERM} device
    - 4.25 V or 4.35 V on the high V_{TERM} device
  - Automatic trickle, constant current, and constant voltage charging
  - Battery thermal protection
  - Discharge current limitation
  - JEITA compliant
- Li-ion/Li-polymer USB battery charger with a high efficiency buck regulator
- 800 nA - Typical quiescent current
- 460 nA - Shipping mode quiescent current
- Thermal protection
- Input regulator
  - USB compatible current limit of 100 mA and 500 mA
  - 4.1 V to 6.7 V input voltage range for normal operation
  - 20 V overvoltage protection
  - Reverse current protection
  - 3.0 V to 5.5 V system voltage output
  - USB port detection supporting the following types:
    - SDP
    - CDP/DCP
- 1.8 V to 3.0 V, 150 mA step-down buck regulator
  - Step-down buck regulator with up to 92% efficiency
  - Automatic transition between hysteretic and pulse width modulation (PWM) modes
  - Forced PWM mode for clean power operation
  - Pin-selectable output voltage (1.8 V, 2.1 V, 2.7 V, 3.0 V)
  - Soft start-up
- LED drivers for charger state indication
  - 5 mA low side LED driver for charging indication
  - 5 mA low side LED driver for error indication
- 2.3 V to 4.35 V battery operating input range
- Package options suitable for two layer PCB:
  - 2.1x2.1 mm WLCSP package
  - 4.0x4.0 mm QFN package

Applications:

- Advanced wearables
  - Health/fitness sensor and monitor devices
- Advanced computer peripherals and I/O devices
  - Mouse
  - Keyboard
  - Multi-touch trackpad
- Interactive entertainment devices
  - Remote controls
  - Gaming controllers

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1 Revision history

Date	Version	Description

February 2023	1.3	The following has been added or updated:
		• Added QFN package variant information to the following chapters:
		  • Pin assignments on page 45
		  • Mechanical specifications on page 49
		  • Ordering information on page 57
		• CHARGER - added high V_{TERM} option
		• Editorial

October 2022	1.2	The following has been added or updated:
		• Capacitor on VBAT in the following chapters:
		  • Block diagram on page 8
		  • Schematic on page 42
		  • Reference circuitry on page 50
		• Absolute Maximum Ratings – MSL value
		• Editorial

June 2022	1.1	The following has been added or updated: • Ordering code for latest revision in Product options on page 60, build code C00 no longer supported • Editorial
May 2021	1.0	First release

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2 About this document

This document is organized into chapters that are based on the modules available in the IC.

2.1 Document status

The document status reflects the level of maturity of the document.

Document name	Description
Objective Product Specification (OPS)	Applies to document versions up to 1.0. This document contains target specifications for product development.
Product Specification (PS)	Applies to document versions 1.0 and higher. This document contains final product specifications. Nordic Semiconductor ASA reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

Table 1: Defined document names

2.2 Core component chapters

Every core component has a unique capitalized name or an abbreviation of its name, e.g. LED, used for identification and reference. This name is used in chapter headings and references, and it will appear in the C-code header file to identify the component.

The core component instance name, which is different from the core component name, is constructed using the core component name followed by a numbered postfix, starting with 0, for example, LED0. A postfix is normally only used if a core component can be instantiated more than once. The core component instance name is also used in the C-code header file to identify the core component instance.

The chapters describing core components may include the following information:

- A detailed functional description of the core component
- Register configuration for the core component
- Electrical specification tables, containing performance data which apply for the operating conditions described in Recommended operating conditions on page 15.

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3 Product overview

This chapter contains an overview of the main features found in nPM1100.

3.1 Block diagram

The block diagram illustrates the overall system.

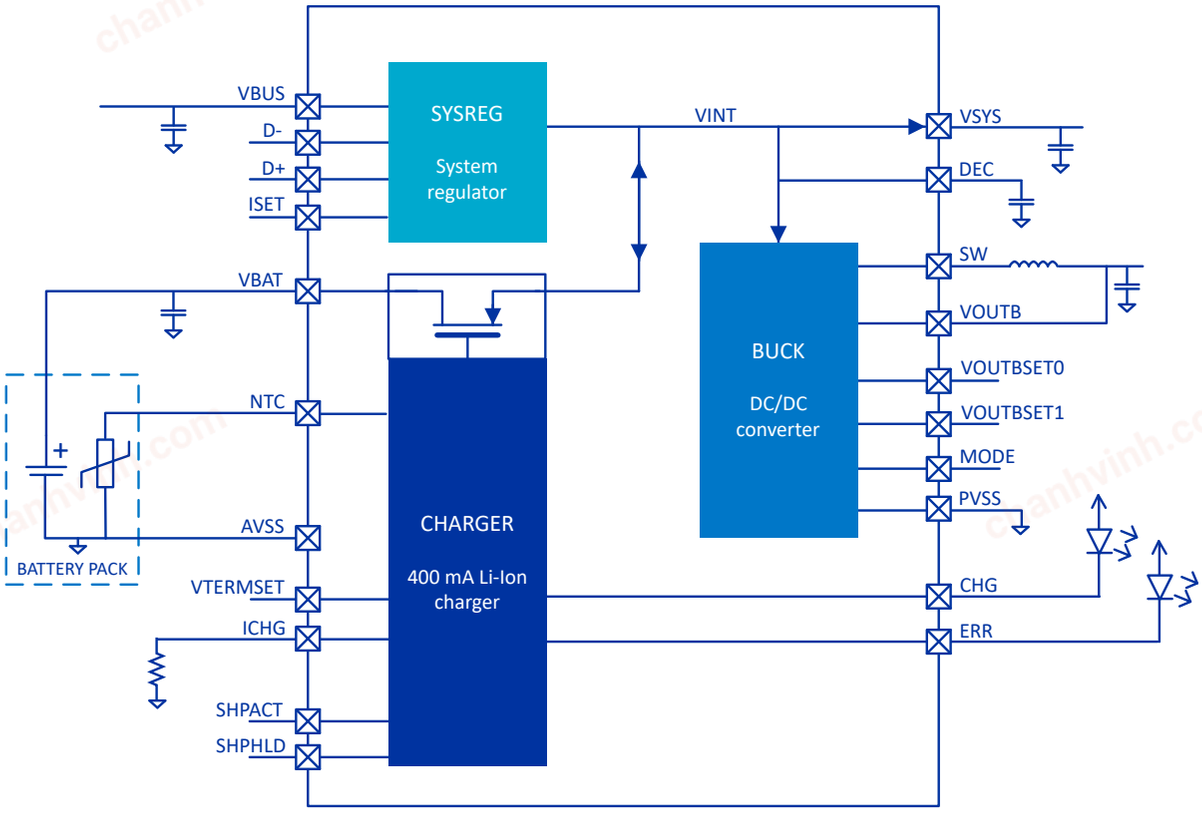


Figure 2: Block diagram

3.1.1 In circuit configurations

The device is configurable for different applications and battery characteristics through input pins.

Static input pins must be configured before power-on reset. Dynamic input pins may be modified during operation under conditions described in references. For the full list of pins, see Pin assignments on page 45.

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Pin	Function	Input type	Usage reference
VTERMSET	Sets termination voltage Battery dependent	Static (H/L)	Termination voltage (VTERMSET) on page 22
ICHG	Charge current limit	Static (resistor)	Charge current limit (ICHG) on page 23
ISET	**VBUS** current limit	Dynamic (H/L)	VBUS current limit ISET
MODE	BUCK PWM mode override	Dynamic (H/L)	BUCK mode selection (MODE) on page 32
VOUTBSET[n]	Two pin **VOUTB** voltage configuration	Static (H/L)	Output voltage selection (VOUTBSET0, VOUTBSET1) on page 31
SHPACT	Enables Ship mode	Dynamic (H/L)[1]	Using Ship mode on page 10
SHPHLD	Disables Ship mode	Dynamic (H/L)[1]	Using Ship mode on page 10

Table 2: In circuit configurations

[1]These pins are level and hold-time controlled.

3.2 System description

The device has the following core components that are described in detail in the respective chapters.

- SYSREG — System regulator on page 17
- CHARGER — Battery charger on page 21
- BUCK — Buck regulator on page 31

The system regulator (SYSREG) is a 5 V LDO supplied by **VBUS**. It generates VINT when enabled. VINT is the internal supply for the device and available on an external pin, **VSYS**. SYSREG supports a wide operating voltage range on **VBUS**, tolerates transient voltages up to 20 V, and implements overvoltage protection. SYSREG also implements configurable current limiting from **VBUS**, and USB port detection. When **VBUS** is disconnected, SYSREG ensures the device enters Ultra-Low Power mode to minimize quiescent current. Reverse current protection is enabled when VBUS<VBAT. See SYSREG — System regulator on page 17 for more information and electrical parameters.

The battery charger (CHARGER) is a JEITA compatible linear battery charger for Li-ion/Li-poly batteries. CHARGER controls the charge cycle using a standard Li-ion charge profile. CHARGER implements dynamic power-path management regulating current in and out of the battery, depending on system requirements. Charge current and charge termination voltage can be set with the **ICHG** and **VTERMSET** pins respectively. LED drivers for charging indication and charging error indication are implemented in CHARGER. See CHARGER — Battery charger on page 21 for more information and electrical parameters.

The buck regulator (BUCK) is a step-down DC/DC regulator with PWM and Hysteretic modes with automatic control for optimum efficiency and manual enable of PWM mode to reduce voltage ripple and inductive interference if needed. The output voltage is pin configurable (through **VOUTSET0** and **VOUTSET1**) for different application circuit requirements. BUCK is supplied by VINT (from SYSREG or the battery). See BUCK — Buck regulator on page 31 for more information and electrical parameters.

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The device also features Ship mode, the lowest quiescent current state. It disconnects the battery from the system and reduces the quiescent current of the device to extend battery life when products are in storage. See Using Ship mode on page 10 and Charging and error LED drivers on page 11 for more information.

3.3 Power-on reset (POR) and brownout reset (BOR)

When one of the following conditions are met, a power-on reset (POR) occurs.

- **VBUS** voltage rises above $VBUS_{POR}$
- **VBAT** voltage rises above $VBAT_{POR}$

When both of the following conditions are met, a brownout reset (BOR) occurs.

- **VBUS** voltage falls below $VBUS_{BOR}$
- **VBAT** voltage falls below $VBAT_{BOR}$

BOR may occur if both supply voltages are below the maximum of the parameter range. BOR occurs if both supply voltages are below the minimum of the parameter range.

The device is held in reset, or System OFF, when both supply voltages **VBAT** and **VBUS** are below minimum thresholds.

3.4 DPPM — Dynamic power-path management

Dynamic power-path management (DPPM) is a feature that regulates internal voltage (VINT) as system load (I_{SYS}) changes to maintain supply to the application circuit (supplied by the **VSYS** and **VOUTB** pins).

CHARGER applies DPPM during charging, after charging completes, or when the **VBUS** pin is disconnected, to dynamically control current in and out of the battery. See DPPM — Dynamic power-path management on page 25.

3.5 Using Ship mode

Ship mode isolates the battery, reducing quiescent current.

To enter Ship mode, **SHPACT** must be set high for a minimum period of $t_{activeToShip}$ when **VBUS** is disconnected and **SHPHLD** held high (V_{IH}). **SHPACT** has an internal pull-down resistor. **SHIPACT** can be connected to a microcontroller GPIO (using logic levels in the range V_{IL} and V_{IH}) or to a PCB test pin for activation at the end of production.

> **Note:** **VBUS** must be discharged to below minimum level $VBUS_{MIN}$ which may require waiting for any capacitive discharge before activating **SHPACT**.

There are two ways to exit Ship mode. Either connect the USB (**VBUS**) or set **SHPHLD** low for a minimum period of $t_{shipToActive}$. The battery supply (**VBAT**) is used to hold **SHPHLD** high through a weak pull-up resistor when Ship mode is enabled. A circuit to pull down **SHPHLD** is optional (see the Button switch shown in the following figure). If no pull-down circuit is present, Ship mode is exited when **VBUS** is connected.

If Ship mode is not required, then **SHPACT** and **SHPHLD** pins may be tied to **AVSS**.

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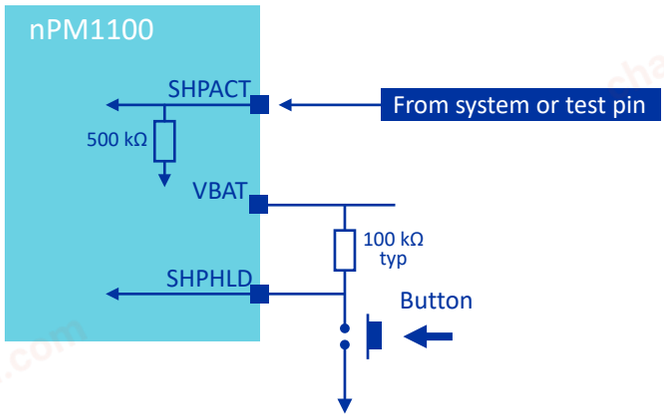


Figure 3: A typical configuration for Ship mode

3.6 Thermal protection

The device implements thermal regulation based on battery temperature, see Battery thermal protection using NTC thermistor (NTC) on page 23 and Charger thermal regulation on page 24.

In addition to battery thermal protection and charger thermal regulation, a global thermal shutdown based on die temperature is implemented when die temperature exceeds the operating temperature range, see TSD. All device functions are disabled in thermal shutdown. The device functions are re-enabled when the temperature is sufficiently reduced according to a hysteresis TSD_{HYST}.

3.7 Battery considerations

The charger can only be used with Li-ion/Li-poly rechargeable batteries.

Battery packs connected to the **VBAT** pin must contain the following protection circuitry:

- Overcharge protection
- Undervoltage protection
- Overcurrent discharge fuse
- Thermal fuse to protect from overtemperature (if NTC thermistor is not present)

3.8 Charging and error LED drivers

CHARGER controls the **CHG** and **ERR** pins, which are used to drive LEDs and signal status to an external circuit.

See Charging indication (CHG) and charging error indication (ERR) on page 25 for more information.

3.9 System electrical parameters

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Symbol	Description	Min.	Typ.	Max.	Unit
IQ_{SHIP}	Ship mode quiescent current	-	460	-	nA
IQ_{BAT}	Quiescent current, battery operation, no load, **MODE** = LOW, **VBUS** disconnected	-	800	-	nA
TSD	Thermal shutdown threshold	-	120	-	°C
TSD_{HYST}	Thermal shutdown hysteresis	-	10	-	°C
V_{IH}	Input HIGH	1.1	-	VINT	V
V_{IL}	Input LOW	0	-	0.4	V
R_{SHPACT}	Internal resistance between **SHPACT** and **AVSS**		500		kΩ
$t_{activeToShip}$	Duration **SHPACT** must be held high to enable Ship mode	200			ms
$t_{shipToActive}$	Duration **SHPHLD** must be held low to disable Ship mode	200			ms

Table 3: System electrical parameters

3.10 System efficiency

Described here is the characterization of the power path from the battery supply (**VBAT**) to the BUCK output (**VOUTB**) under different battery voltages, output voltages, and load current conditions.

In the following figure, the load current is swept from 1 µA to 150 mA and back to capture mode change hysteresis.

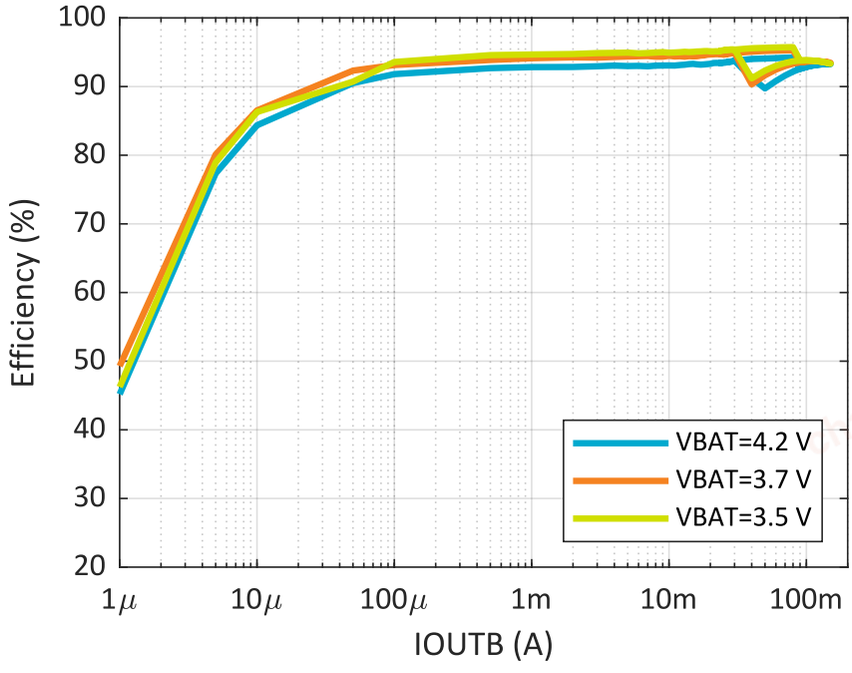


Figure 4: VOUTB = 3.0 V system efficiency, MODE=AUTO

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4 Absolute maximum ratings

Maximum ratings are the extreme limits to which the chip can be exposed for a limited amount of time without permanently damaging it. Exposure to absolute maximum ratings for prolonged periods of time may affect the reliability of the device.

Pin	Note	Min.	Max.	Unit
VBUS	Power	-0.3	20	V
VBAT	Power	-0.3	5.5	V
VSYS, **DEC**, **SW**		-0.3	5.5	V
AVSS, **PVSS**	Power		0	V
$VANA_{I/O}$	Analog I/O **D-** , **D+**, **NTC**, **ICHG**, **VOUTB**	-0.3	VINT + 0.3	V
$VDIG_{I/O}$	Digital I/O **VOUTBSET0**, **VOUTBSET1**, **VTERMSET**, **SHPHLD**, **SHPACT**, **ISET**, **ERR**, **CHG**, **MODE**	-0.3	VINT + 0.3	V

Table 4: Pin voltage

	Note	Min.	Max.	Unit
Storage temperature		-40	+125	°C
MSL	Moisture Sensitivity Level		1	
ESD HBM	Human Body Model Class 2		2	kV
ESD CDM	Charged Device Model		500	V

Table 5: Environmental (WLCSP package)

	Note	Min.	Max.	Unit
Storage temperature		-40	+125	°C
MSL	Moisture Sensitivity Level		2	
ESD HBM	Human Body Model Class 2		2	kV
ESD CDM	Charged Device Model		500	V

Table 6: Environmental (QFN package)

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5 Recommended operating conditions

The operating conditions are the physical parameters that the chip can operate within.

Symbol	Parameter	Notes	Min.	Nom.	Max.	Unit
$VBUS_{OP}$	Supply voltage		4.1	5	6.7	V
$VBAT_{OP}$	Battery voltage		2.30		4.35	V
T_J	Junction temperature		-40		+125	°C
T_O	Operating temperature	Ambient	-40		+85	°C

Table 7: Recommended operating conditions

5.1 Dissipation ratings

Thermal resistances and thermal characterization parameters as defined by JESD51-7 are shown in the following table.

Symbol	Parameter	WLCSP 25 pins	Units
$R_{\Theta JA}$	Junction-to-ambient thermal resistance	50.7	°C/W
$R_{\Theta JC(top)}$	Junction-to-case (top) thermal resistance	9.2	°C/W
$R_{\Theta JB}$	Junction-to-board thermal resistance	22.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	1.05	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	23	°C/W

Table 8: Recommended operating conditions

Symbol	Parameter	QFN 24 pins	Units
$R_{\Theta JA}$	Junction-to-ambient thermal resistance	33.5	°C/W
$R_{\Theta JC(top)}$	Junction-to-case (top) thermal resistance	16.1	°C/W
$R_{\Theta JB}$	Junction-to-board thermal resistance	14.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.25	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	14.1	°C/W

Table 9: Recommended operating conditions

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5.2 WLCSP light sensitivity

WLCSP package is sensitive to visible and near infrared light, which means that a final product design must shield the chip properly.

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6 Core components

6.1 SYSREG — System regulator

VBUS supplies the input voltage to the system voltage regulator (SYSREG) . **VBUS** voltage is supplied by AC wall adapters or USB ports.

SYSREG is a linear voltage regulator (LDO) that supplies VINT when the device is in normal state.

Features of SYSREG are the following:

- 5 V linear voltage regulator (LDO) supplying VINT when **VBUS** is connected
- Operating voltage up to 6.7 V
- Overvoltage protection to 20 V
- USB port detection and control pin for setting the current limit on **VBUS**

Note: The **VSYS** and **DEC** pins must not be externally supplied.

6.1.1 USB port detection and VBUS current limiting

The device supports automatic detection of USB port type in line with the *Battery Charging Specification* v1.2 found on usb.org.

Primary detection is performed for Standard Downstream Port (SDP), Dedicated Charging Port (DCP), and Charging Downstream Port (CDP) USB ports. The detection sequence starts once **VBUS** is connected, and completes after T_{CONN0} .

If SDP is detected, the **VBUS** current limit is set to 100 mA. An external microcontroller with a USB interface can negotiate a 500 mA limit with the USB host. It then raises the **VBUS** current limit using a GPIO to control **ISET**. This is referred to as USB port negotiation.

If DCP/CDP is detected, the **VBUS** current limit is set to 500 mA. In this case, **ISET** configuration is ignored.

It is possible to configure the device to set the **VBUS** current limit to either 100 mA or 500 mA using **ISET** and disabling USB port detection.

The following table describes **ISET**, **D+**, and **D−** configurations to fix **VBUS** current limit or set **VBUS** current limit based on either USB port detection or USB port negotiation.

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Limit set method	Pin configuration	VBUS current limit
Fixed 100 mA	**ISET** = **D−** = **AVSS** **D+** = NC	100 mA
Fixed 500 mA	**ISET** = **VSYS** **D−** = **AVSS** **D+** = NC	500 mA
USB port detection	**ISET** = **AVSS** **D+** and **D−** are connected to host	100 mA if SDP detected 500 mA if DCP/CDP detected
USB port detection and negotiation (requires a USB enabled microcontroller)	**ISET** = microcontroller GPIO **D+** and **D−** connected to USB host	100 mA if SDP detected, **ISET** = LOW 500 mA if SDP detected, **ISET** = HIGH 500 mA if DCP/CDP

*Table 10: Pin configuration for **VBUS** current limit*

When a microcontroller uses GPIO to control **ISET** for USB port negotiation, **ISET** must be set LOW on reset and when USB is disconnected. **ISET** is only set HIGH when the USB port is SDP and negotiation for a higher current limit is complete.

See the circuit schematics in the Reference circuitry on page 50 for designs illustrating these configurations.

6.1.2 SYSREG resistance and output voltage

SYSREG regulates the VINT voltage to $VINT_{REG}$. When the **VBUS** pin voltage is below $VINT_{REG}$, there is typically RON_{REG} resistance between **VBUS** and VINT.

6.1.3 VBUS overvoltage and undervoltage protection

The overvoltage threshold for **VBUS** is $VBUS_{OVP}$. The undervoltage threshold for **VBUS** is $VBUS_{MIN}$.

SYSREG is disabled when **VBUS** voltage is above the overvoltage threshold $VBUS_{OVP}$, or below the undervoltage threshold $VBUS_{MIN}$. This isolates **VBUS** and prevents current flowing from VINT to **VBUS**.

6.1.4 VBUS disconnect

SYSREG isolates **VBUS** from VINT when **VBUS** is disconnected and the voltage drops below $VBUS_{MIN}$.

When **VBUS** reaches $VBUS_{ULP}$, the device enters an ultra-low power (ULP) operation mode. This takes $T_{DISCONN}$, dependent on capacitive load on **VBUS**. The device stays in a ULP mode while **VBUS** is under $VBUS_{ULP}$.

6.1.5 Electrical specification

Symbol	Description	Min.	Typ.	Max.	Units
$IBUS_{LIM1}$	Max **VBUS** input current, **CDP**/**DCP** USB or **ISET** = HIGH	450	-	500	mA

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Symbol	Description	Min.	Typ.	Max.	Units
$IBUS_{LIM0}$	Max **VBUS** input current, SDP USB and **ISET** = LOW, 25°C	90	-	100	mA
$VINT_{REG}$	Regulated VINT voltage from SYSREG, **VBUS** = 6 V		5.2		V
RON_{REG}	SYSREG on resistance, ISET = HIGH	-	440	720	mΩ
$VBUS_{OVP}$	Overvoltage protection threshold		6.9		V
$VBUS_{MIN}$	Undervoltage threshold		3.9		V
$VBUS_{ULP}$	Threshold for entering ULP mode		1.8		V
$VBUS_{POR}$	Power-on reset release voltage for **VBUS**		3.9		V
$VBUS_{BOR}$	Brownout reset trigger voltage for **VBUS**[1]		3.8		V
T_{CONN0}	Time for USB detection, ISET = LOW		-	700	ms
T_{CONN1}	Time for VINT to settle after **VBUS** connection, **ISET** = HIGH, no load	-	1.2		ms
$T_{DISCONN}$	Time for system to reach ULP mode after **VBUS** disconnect, C_{VBUS} = 10 µF	-	110		ms

Table 11: SYSREG electrical specification

[1]Device enters BOR only if (V(**VBUS**) < $VBUS_{BOR}$) AND (V(**VBAT**) < $VBAT_{BOR}$).

6.1.6 Electrical characteristics

The following graphs show SYSREG electrical characteristics.

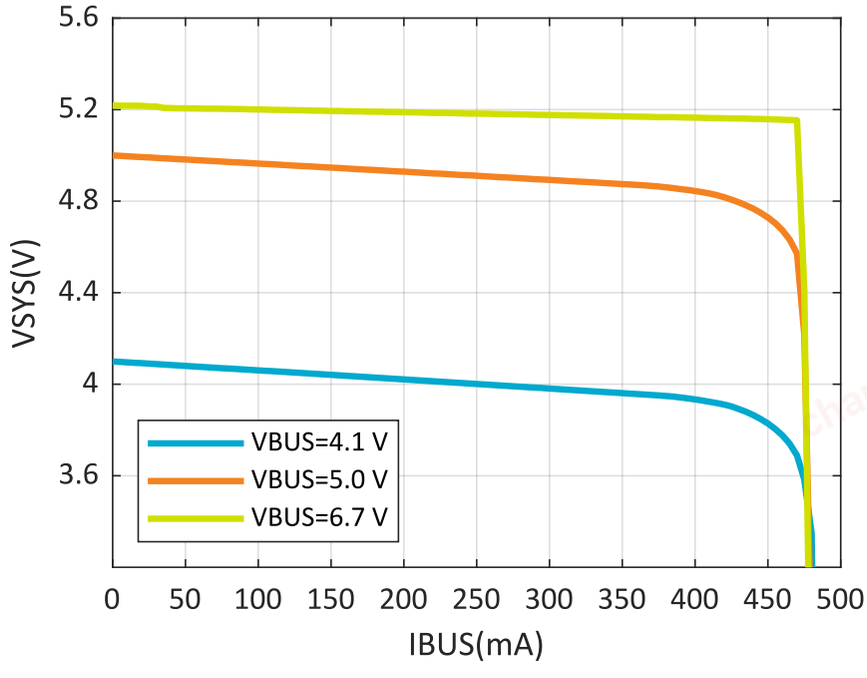


Figure 5: VSYS voltage vs. VBUS current, ILIM=500 mA

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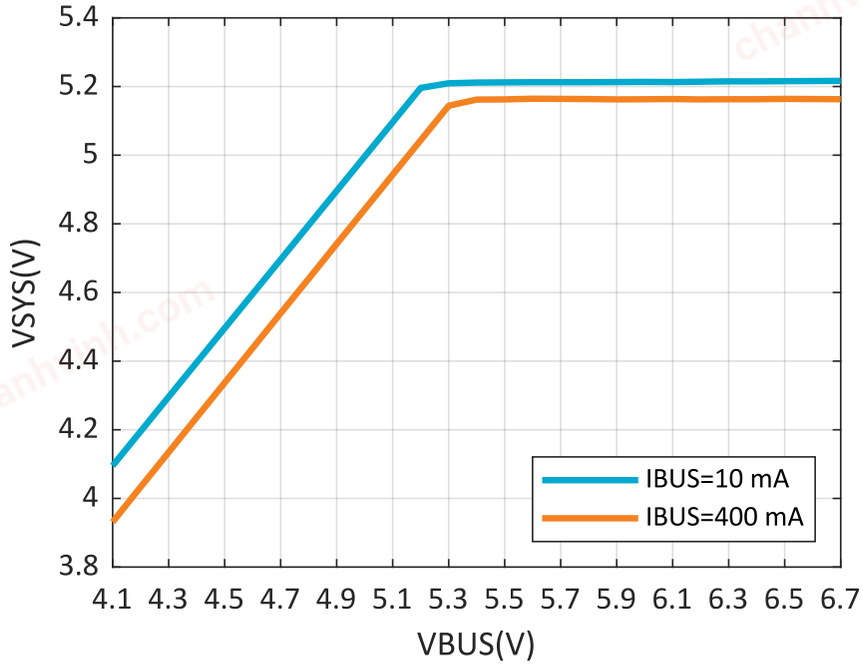


Figure 6: VSYS voltage vs. VBUS voltage, ILIM=500 mA

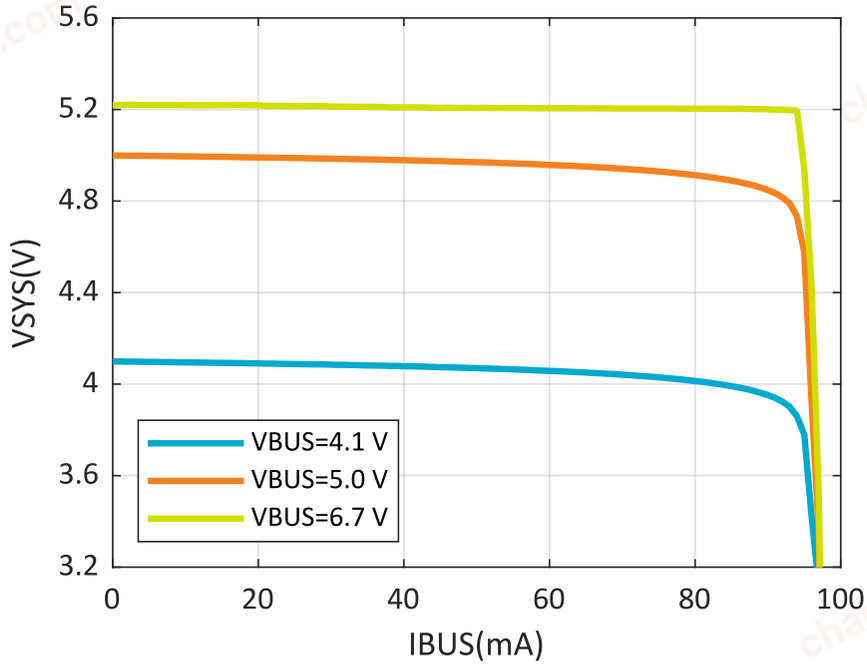


Figure 7: VSYS voltage vs. VBUS current, ILIM=100 mA

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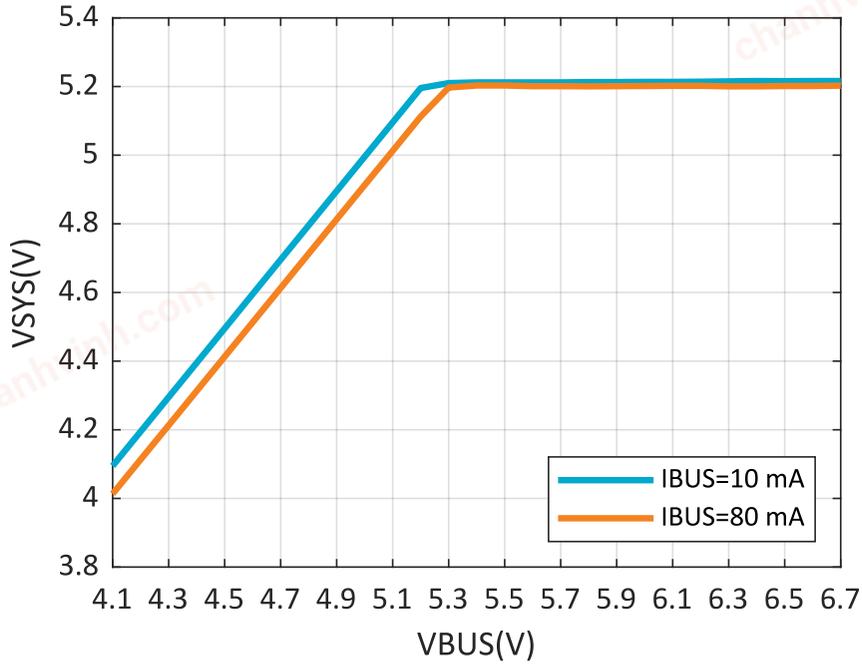


Figure 8: VSYS voltage vs. VBUS voltage, ILIM=100 mA

6.2 CHARGER — Battery charger

The battery charger is suitable for any general purpose applications with lithium-ion/lithium-polymer battery types.

The main features of the battery charger are the following:

- Linear charger for Li-ion/Li-poly battery chemistries
- Configurable charge current with a resistor connected to the **ICHG** pin (from 20 mA to 400 mA)
- Bidirectional power FET for dynamic power-path management
- Active current limitation when **VBAT** supplies VINT
- Selectable termination voltage through the **VTERMSET** pin
  - 4.1 V or 4.2 V on the standard V_{TERM} product
  - 4.25 V or 4.35 V on the high V_{TERM} product
- Automatic trickle, constant current, constant voltage, and end-of-charge/recharge cycle
- JEITA compliant battery thermal protection (NTC) with standard and extended temperature range

6.2.1 Charging cycle

Battery charging starts after a **VBUS** connection and the battery is detected.

If a battery is found, trickle charging begins. Fast charging starts when the battery voltage is above $V_{TRICKLE_FAST}$. After the battery voltage reaches V_{TERM}, the charger enters constant voltage charging. The battery voltage is maintained while monitoring current flow into the battery. When the current into the battery drops below I_{TERM}, charging is complete. The charger waits until the battery voltage is below $V_{RECHARGE}$ before starting a new charging cycle.

To charge the battery, VBUS voltage must be higher than VBAT voltage during the charge cycle. This means VBUS must be VBUS(V) > VBAT(V) + $V_{DROPOUT_VBUS}$. If this condition is not met the charge cycle stops.

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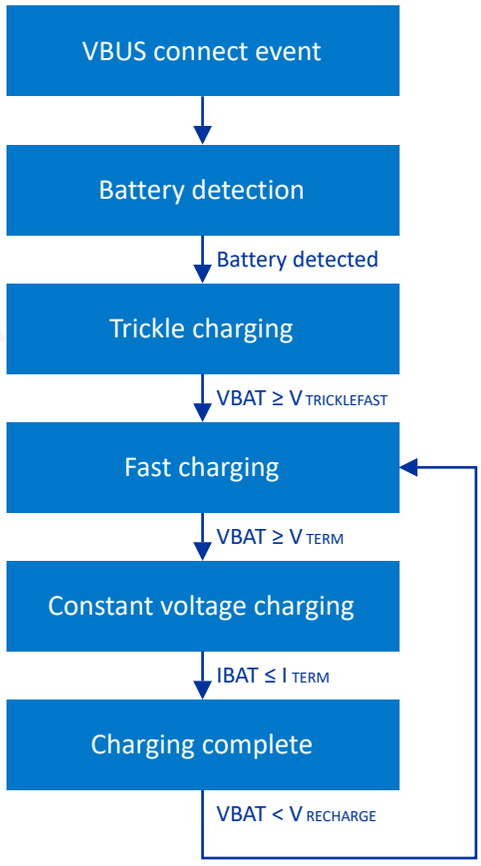


Figure 9: Charging cycle flow chart

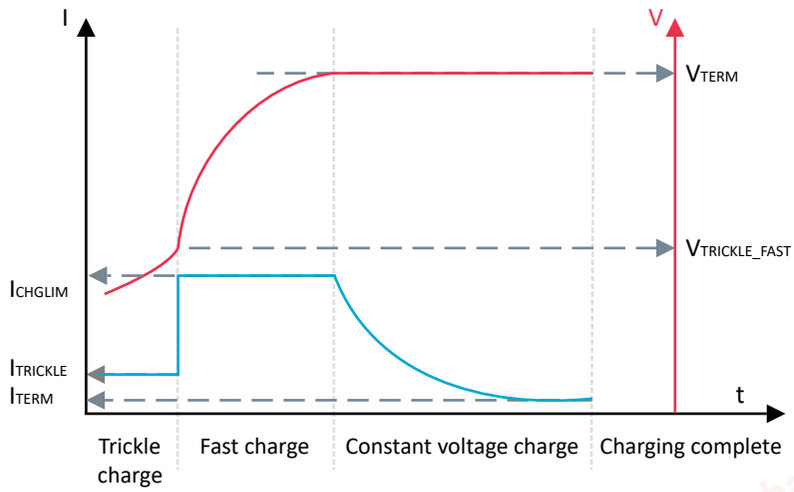


Figure 10: Charging cycle

6.2.2 Termination voltage (VTERMSET)

The termination voltage, V_{TERM}, is set using **VTERMSET** to support two values of battery charging termination voltage for the chosen product option.

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Product option	VTERMSET	V_{TERM} threshold
Standard V_{TERM}	LOW	4.1 V
Standard V_{TERM}	HIGH	4.2 V
High V_{TERM}	LOW	4.25 V
High V_{TERM}	HIGH	4.35 V

Table 12: VTERMSET

6.2.3 Termination and trickle charge current

Termination current and trickle charge current are set to a percentage of the charge current limit (I_{CHGLIM}).

See Electrical specification on page 26 for the limits.

6.2.4 Charge current limit (ICHG)

The charge current limit is set between 20 mA and 400 mA by connecting the R_{ICHG} resistor to the **ICHG** and **AVSS** pins.

The following equation gives the resistance to be connected based on the I_{CHGLIM}.

$$R_{ICHG} = \frac{625}{I_{CHGLIM}} - 1562.5$$

The following apply when the R_{ICHG} resistor is between 0 Ω and 30 kΩ.

- I_{CHGLIM} is the fast charge current limit in Amps
- R_{ICHG} is the resistance to be connected between the **ICHG** and **AVSS** pins in Ω

Common values are provided in the following table.

R_{ICHG} resistor value	Nominal charge current limit, I_{CHGLIM}	Error
0 (short to **AVSS**)	400 mA	± I_{CHGACC}%
1.5 kΩ	200 mA	± (I_{CHGACC} + $R_{ICHGACC}$)%
4.7 kΩ	100 mA	± (I_{CHGACC} + $R_{ICHGACC}$)%
11 kΩ	50 mA	± (I_{CHGACC} + $R_{ICHGACC}$)%
30 kΩ	20 mA	± (I_{CHGACC} + $R_{ICHGACC}$)%

Table 13: Common charge current values

Note: I_{CHGLIM} must be set at or below the safe charge current limit of the battery according to the battery specification.

6.2.5 Battery thermal protection using NTC thermistor (NTC)

Battery thermal protection is implemented in the following two ways.

- Using a battery pack with an integrated NTC thermistor

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- Connecting a thermistor between the **NTC** pin and the **AVSS** pin

The thermistor needs to have thermal contact with the battery and preferably within the battery pack. Recommended values for the NTC thermistor are found in the following table.

Parameter	Value	Unit
Nominal resistance at 25°C	10	kΩ
Resistance accuracy	1	%
B25/50 constant	3380	Kelvin
B25/85 constant	3434 to 3435	Kelvin
B constant accuracy	1	%

Table 14: Recommended NTC thermistor values

If the thermal protection feature is not used, then a 10 kΩ, ≤20% accuracy resistor should be connected between **NTC** and **AVSS** pins.

To provide JEITA compliant thermal protection, the charge current limit and termination voltage are adjusted according to the NTC thermistor measurement.

Temperature region	Battery temperature	Charging current	Termination voltage
Cold	T < 0°C	0 (OFF)	NA
Cool	0°C < T < 10°C	$I_{REDUCED}$	V_{TERM}
Nominal	10°C < T < 45°C	I_{CHGLIM}	V_{TERM}
Warm	45°C < T < 60°C	I_{CHGLIM}	V_{TERM}-V_{THIGH_DELTA}
Hot	T > 60°C	0 (OFF)	NA

Table 15: Battery temperature ranges

6.2.6 Charger thermal regulation

If the device junction temperature exceeds T_{HIGH} and CHARGER is in Fast Charge mode, the charge current is reduced to $I_{REDUCED}$.

6.2.7 Charger error conditions

A CHARGER error condition occurs when one of the following are present:

- A battery short (**VBAT** to **AVSS**)
- Battery voltage lower than $VBAT_{CHARGEMIN}$ after battery detection due to a fault with the battery
- Trickle charge timeout; see $TOUT_{TRICKLE}$
- Constant voltage charge/fast charge timeout; see $TOUT_{CHARGE}$
- Device internal error occurs when CHARGER is self-checking

After an error is detected, CHARGER is disabled, the charging error indication is activated, and the charging indication is deactivated. Error conditions are cleared when **VBUS** is disconnected and reconnected again.

Note: The constant voltage/fast charge timeout is the combined time spent in both constant voltage charge and fast charge, $TOUT_{CHARGE}$.

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6.2.8 Charging indication (CHG) and charging error indication (ERR)

The charging indication pin **CHG** and charging error indication pin **ERR** sink 5 mA of current when active. They are high impedance when disabled. This is suitable for driving LEDs or connecting to host GPIOs in a weak pull-up configuration.

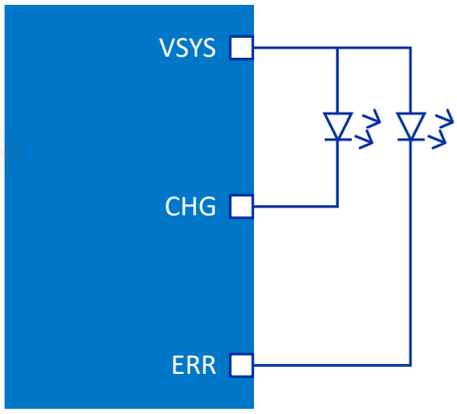


Figure 11: Configuration for connecting to LEDs

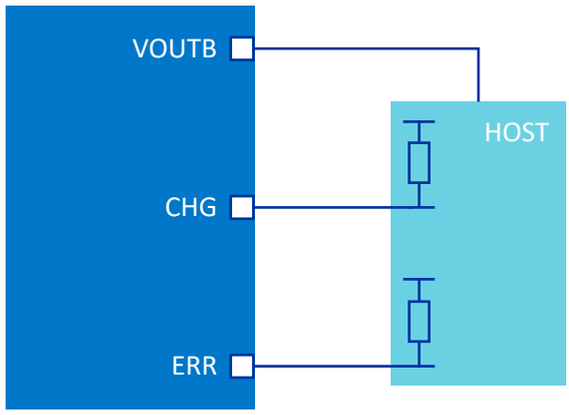


Figure 12: Configuration for connecting to a host

Note: To configure both LED indication and connection to a host, the GPIO input voltage range tolerance must be met, or an external circuit may be required. See Reference circuitry on page 50.

The charging indication pin, **CHG**, is active while the battery is charging.

The charging error indication pin, **ERR**, is activated when an error occurs, see Charger error conditions on page 24.

6.2.9 DPPM — Dynamic power-path management

CHARGER manages battery current flow to maintain VINT voltage.

The system load requirements are prioritized over battery charge current when **VBUS** is connected and the battery is charging. The battery is isolated when **VBUS** is connected and the battery is fully charged. SYSREG supplies the load unless the load exceeds SYSREG limits. When **VBUS** is disconnected, CHARGER switches to battery supply.

During charging, if the combined current load I_{LOAD} on VINT (including BUCK input current) and **VBAT** (I_{CHG}) exceeds the current provided by SYSREG (I_{LIM}), the battery charge current decreases to maintain the VINT voltage. The battery charger reduces the current to maintain the internal voltage: VINT = V(**VBAT**)+

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$V_{DROPOUT_CHARGER}$. If more current is required, CHARGER enters Supplement mode, switching to provide current from the battery, up to $IBAT_{LIM}$.

If a charge cycle ends and I_{LOAD} exceeds I_{LIM}, CHARGER connects the battery and enters Supplement mode to maintain VINT.

When **VBUS** and the battery are connected, the maximum supported load is I_{LIM} + $IBAT_{LIM}$.

When **VBUS** is disconnected, CHARGER sources current for VINT from the battery. In Supplement mode, or when **VBUS** is disconnected, VINT voltage is the same as the battery voltage.

VBUS connected	Battery connected	Load	CHARGER	VINT supply	VINT voltage
Yes	Yes	(I_{LOAD} + I_{CHGLIM}) < I_{LIM}	Charging	**VBUS**	V(**VBUS**)
Yes	Yes	(I_{LOAD} + I_{CHGLIM}) > I_{LIM} I_{LOAD} < I_{LIM}	Charging (I_{CHG} reduced)	**VBUS**	V(**VBAT**) + $VDROPOUT_{CHARGER}$
Yes	Yes	I_{LOAD} > I_{LIM}	Supplement mode	**VBUS** and **VBAT**	V(**VBAT**)[1]
Yes	No	I_{LOAD} < I_{LIM}	N/A	**VBUS**	V(**VBUS**)
No	Yes	I_{LOAD} ≤ $IBAT_{LIM}$	N/A	**VBAT**	V(**VBAT**)[1]

Table 16: Battery supply

[1]CHARGER has a resistance of $RON_{CHARGER}$ between **VBAT** and VINT. The voltage drop from **VBAT** to VINT is I_{BAT} x $RON_{CHARGER}$, where I_{BAT} is the current being drawn from the battery.

6.2.10 Electrical specification

Symbol	Description	Min.	Typ.	Max.	Unit
I_{CHGACC}	Fast Charge current accuracy for ICHG ≥ 50 mA, 0.1% accuracy external resistor		±10		%
I_{CHGACC}	Fast Charge current accuracy for ICHG < 50 mA, 0.1% accuracy external resistor		±15		%
V_{TERM0}	Standard termination voltage, **VTERMSET** = LOW	-	4.1	-	V
V_{TERM1}	Standard termination voltage, **VTERMSET** = HIGH	-	4.2	-	V
V_{TERM0}	High termination voltage, **VTERMSET** = LOW	-	4.25	-	V
V_{TERM1}	High termination voltage, **VTERMSET** = HIGH	-	4.35	-	V
$V_{TERMACC0}$	Termination voltage accuracy	-1	-	+1	%
V_{THIGH_DELTA}	VTERM voltage reduction at high temperature		100		mV
I_{TERM}	Termination current	8	10	12	% of ICHG

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Symbol	Description	Min.	Typ.	Max.	Unit
$I_{TRICKLE}$	Trickle charge current		10		% of ICHG
$I_{REDUCED}$	Fast charge current when device junction temperature is above T_{HIGH} or battery temperature is below $T_{NTCCOOL}$	-	50	-	% of ICHG
THIGH	High temperature threshold	-	100	-	°C
$THIGH_{HYST}$	High temperature hysteresis	-	10	-	°C
$V_{TRICKLE_FAST}$	Trickle to Fast Charge threshold	-	2.9	-	V
$V_{RECHARGE}$	Recharge threshold	-	97	-	% of VTERM
$VBAT_{CHARGEMIN}$	Minimum voltage during charge	-	2.1	-	V
$TOUT_{TRICKLE}$	Trickle charging timeout	-	10	-	min
$TOUT_{CHARGE}$	Timeout for Fast charging and constant current charging	-	7	-	hour
$V_{DROPOUT_CHARGER}$	VINT - **VBAT** voltage for charging	-	50	-	mV
$V_{DROPOUT_VBUS}$	Minimum VBUS - **VBAT** voltage for charging	-	140	-	mV
$T_{REDETECT}$	Period between detection events	-	500	-	ms
$IBAT_{LIM}$	Output current limit from battery in discharge	-	660	-	mA
$RON_{CHARGER}$	CHARGER resistance between **VBAT** and VINT in Discharge, **VBAT** = 3.7 V	-	130	230	mΩ
$VBAT_{POR}$	Power-on reset release voltage for **VBAT**	-	2.7	-	V
$VBAT_{BOR}$	Brownout reset trigger voltage for **VBAT** [1]	-	2.5	-	V
I_{SINK}	DC current (**CHG** and **ERR**)	-	5	-	mA
$TNTC_{COLD}$	JEITA cold temperature threshold (Thermistor: 10 kΩ, B25/50=3380 K)	-	0	-	°C
$RNTC_{COLD_FALLING}$	Resistance threshold from cool to cold	25.53	27.28	29.13	kΩ
$RNTC_{COLD_RISING}$	Resistance threshold from cold to cool	23.10	26.00	28.20	kΩ
$TNTC_{COOL}$	JEITA cool temperature threshold (Thermistor: 10 kΩ, B25/50=3380 K)	-	10	-	°C
$RNTC_{COOL_FALLING}$	Resistance threshold from nom. to cool	16.80	18.00	19.20	kΩ
$RNTC_{COOL_RISING}$	Resistance threshold from cool to nom.	15.50	17.10	18.60	kΩ
$TNTC_{WARM}$	JEITA warm temperature threshold (Thermistor: 10 kΩ, B25/50=3380 K)	-	45	-	°C
$RNTC_{WARM_FALLING}$	Resistance threshold from warm to nom.	4.86	5.13	5.43	kΩ
$RNTC_{WARM_RISING}$	Resistance threshold from nom. to warm	4.68	4.92	5.17	kΩ
$TNTC_{HOT}$	JEITA hot temperature threshold (Thermistor: 10 kΩ, B25/50=3380 K)	-	60	-	°C
$RNTC_{HOT_FALLING}$	Resistance threshold from hot to warm	3.04	3.19	3.35	kΩ

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Symbol	Description	Min.	Typ.	Max.	Unit
$RNTC_{HOT_RISING}$	Resistance threshold from warm to hot	2.90	3.02	3.15	kΩ

Table 17: CHARGER electrical specification

[1]Device enters BOR only if (V(VBUS) < $VBUS_{BOR}$) AND (V(VBAT) < $VBAT_{BOR}$).

6.2.11 Electrical characteristics

The following graphs show CHARGER electrical characteristics.

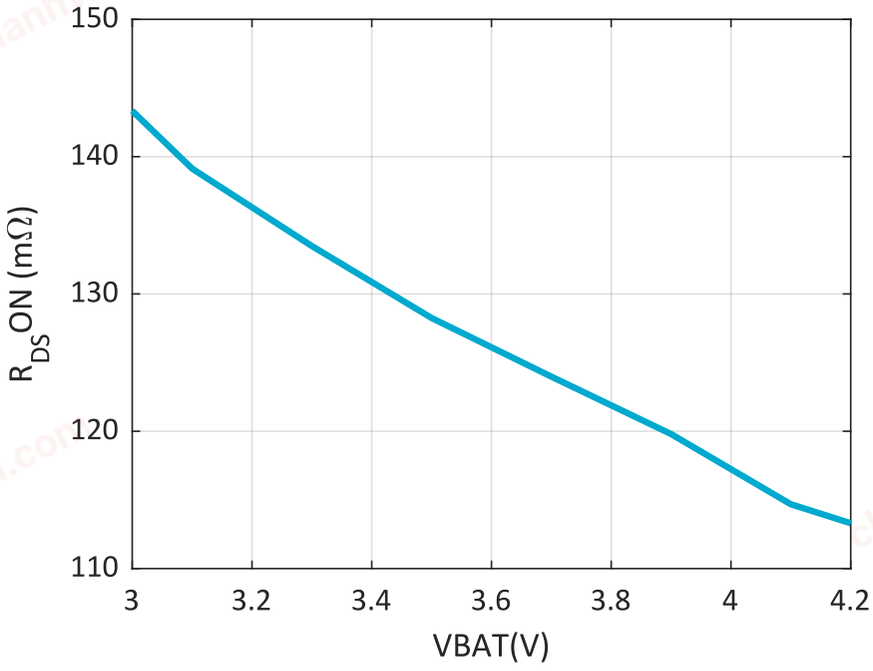


Figure 13: CHARGER RDS(ON) vs. VBAT voltage

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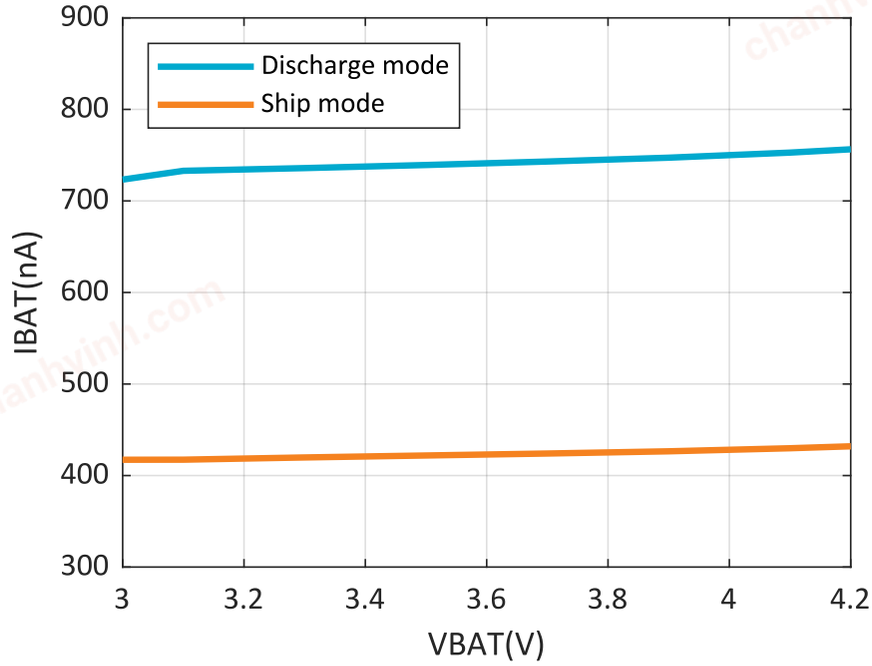


Figure 14: Quiescent VBAT current vs. VBAT voltage

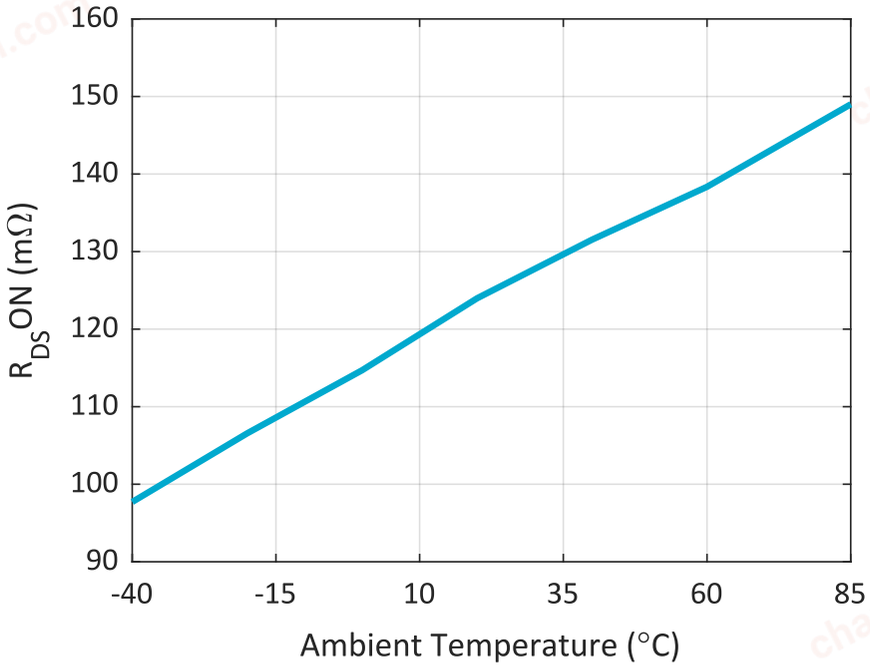


Figure 15: CHARGER RDS(ON) vs. temperature

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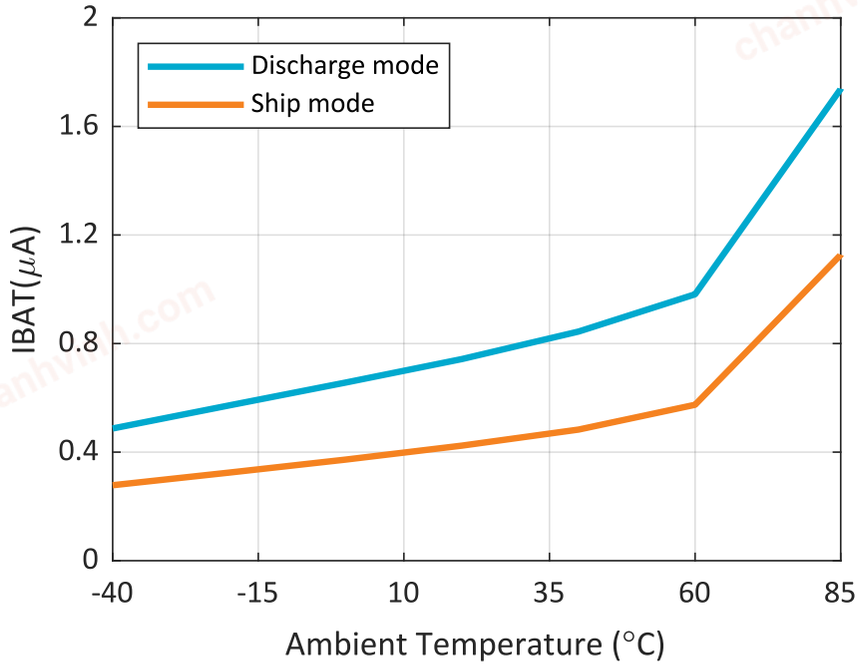


Figure 16: Quiescent VBAT current vs. temperature

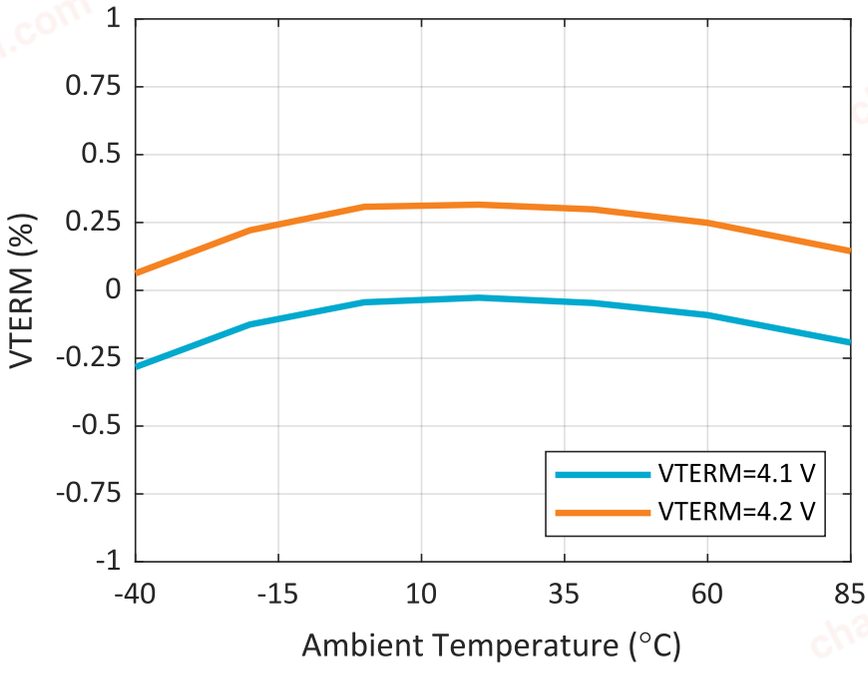


Figure 17: VTERM vs. temperature

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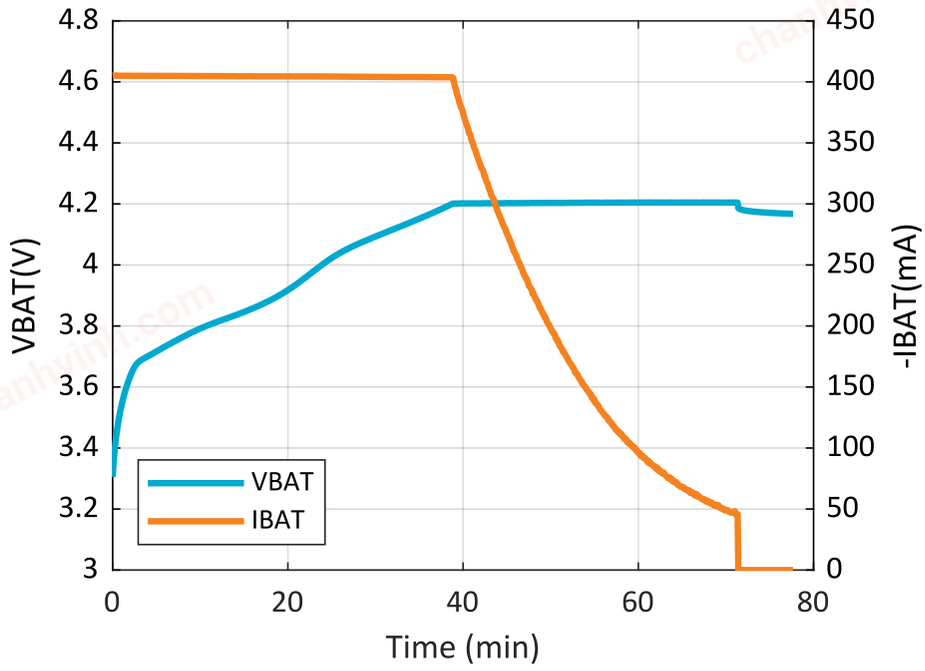


Figure 18: Charge profile with ISET=1

6.3 BUCK — Buck regulator

BUCK is a step-down DC/DC voltage regulator with the following features:

- High efficiency (low IQ) and low noise operation
- PWM and Hysteretic modes with automatic switching based on load
- **MODE** control pin for forcing PWM mode to minimize output voltage ripple
- Configurable output voltage between 1.8 V and 3.0 V

When VINT is above $VINT_{BUCKMIN}$, BUCK is enabled and its output voltage is available at VOUTB.

Hysteretic mode offers efficiency for the full range of supported load currents. PWM mode provides a clean supply operation due to a constant switching frequency, F_{BUCK}. This provides optimal coexistence with RF circuits. BUCK can automatically change between Hysteretic and PWM modes. Modes are controlled by the **MODE** pin. The state of the **MODE** pin can be changed at any time.

6.3.1 Output voltage selection (VOUTBSET0, VOUTBSET1)

BUCK output voltage selection pins **VOUTBSET0** and **VOUTBSET1** should be hardwired to **DEC**, **VSYS**, or **AVSS**. Do not toggle these pins during operation.

VOUTBSET1	VOUTBSET0	VOUTB voltage
LOW	LOW	1.8 V
LOW	HIGH	2.1 V
HIGH	LOW	2.7 V
HIGH	HIGH	3.0 V

Table 18: Output voltage selection

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For BUCK to supply the desired output voltage, VINT must be $V_{DROPOUT_BUCK}$ greater than the voltage on **VOUTB**.

When supplied from battery, the following equation gives the VINT, where I_{BAT} is the current being drawn from the battery:

$VINT = VBAT – I_{BAT} \times RON_{CHARGER}$

6.3.2 BUCK mode selection (MODE)

In Automatic mode, BUCK selects Hysteretic mode for low load currents, and PWM mode for high load currents.

This maximizes efficiency over the full range of supported load currents. In PWM mode, BUCK provides a clean supply operation due to constant switching frequency and lower voltage ripple. This allows for optimal coexistence with RF circuits. The **MODE** pin can be changed at any time.

MODE	BUCK operation mode
LOW	Automatic selection between Hysteretic and PWM modes
HIGH	PWM mode

Table 19: BUCK mode selection

6.3.3 Component selection

Recommended values for the inductor are shown in the following table.

Parameter	Value	Units
Nominal inductance	2.2	µH
Inductor tolerance	≤ 20	%
DC resistance (DCR)	≤ 400	mΩ
Saturation current (I_{sat})	≥ 350	mA
Maximum current (I_{max})	≥ 350	mA

Table 20: Inductor selection

The following table shows the minimum and maximum effective capacitance at VOUTB.

Recommended nominal capacitor	Min.	Max.
10 µF	6 µF	20 µF

Table 21: Output capacitor selection

6.3.4 Electrical specification

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Symbol	Description	Min.	Typ.	Max.	Unit
$VOUTB_{ACC}$	**VOUTB** accuracy under static conditions; no change in supply voltage, load current, or Buck operating mode	-2	-	8	%
$IOUTB_{SHORT}$	Short circuit current limit	-	-	400	mA
$I_{PWMTHRES}$	Load current threshold from Hysteretic to PWM mode (MODE = LOW)		90		mA
$I_{HYSTTHRES}$	Load current threshold from PWM to Hysteretic mode (MODE = LOW)		40		mA
$VOUTB_{RIPPLE_PWM}$	**VOUTB** ripple, MODE = HIGH or load current above $I_{PWMTHRES}$	-	-	10	mVpp
$VOUTB_{RIPPLE_HYST}$	VOUTB ripple, MODE = LOW and load current below $I_{PWMTHRES}$	-	-	80	mVpp
EFF_{BUCK}	Efficiency, **VOUTBSET** = 11 (VOUTB = 3.0 V), VINT = 3.7 V, IOUTB = 100 mA	-	93.5	-	%
$V_{DROPOUT_BUCK}$	Dropout voltage, V(**VOUTB**) - VINT	-	0.41		V
F_{BUCK}	Switching frequency for PWM mode	-	3.6	-	MHz
$T_{PWMMODE}$	Hysteretic to PWM mode transition time on **MODE** pin toggle	-	-	55	µs
$T_{HYSTMODE}$	PWM to Hysteretic mode transition time on **MODE** pin toggle	-	-	25	µs
T_{PWM}	Hysteretic to PWM mode transition time	-	-	90	µs
T_{HYST}	PWM to Hysteretic mode transition time	-	-	35	µs
T_{SETTLE}	Settling time to within 1% after load transient of 0 A to 100 mA	-	-	20	µs
$VINT_{BUCKMIN}$	Minimum VINT voltage for enabling BUCK	-	2.8	-	V

Table 22: BUCK electrical specification

6.3.5 Electrical characteristics

The following graphs show BUCK electrical characteristics.

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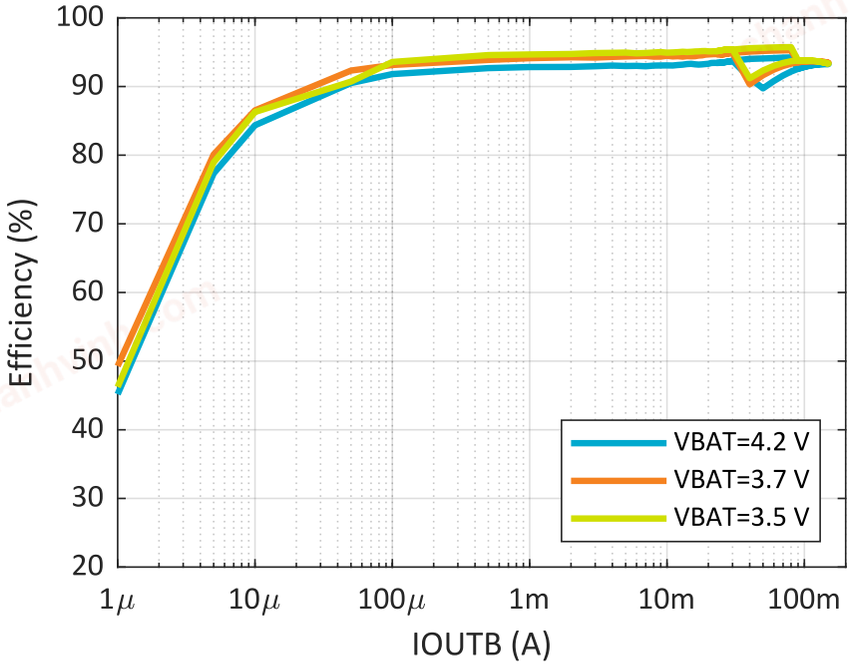


Figure 19: VOUTB=3.0 system efficiency, MODE=AUTO

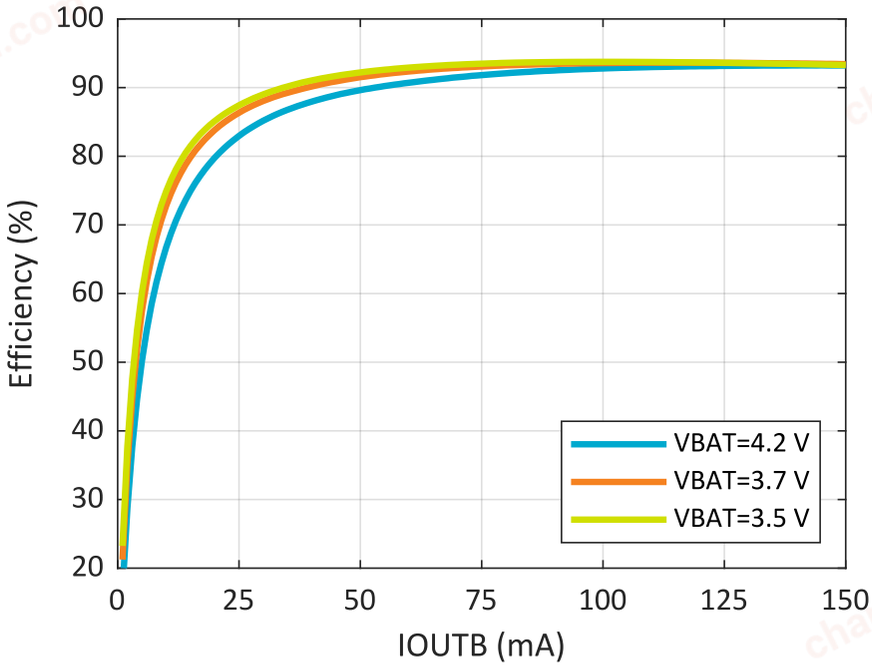


Figure 20: VOUTB=3.0 system efficiency, MODE=PWM

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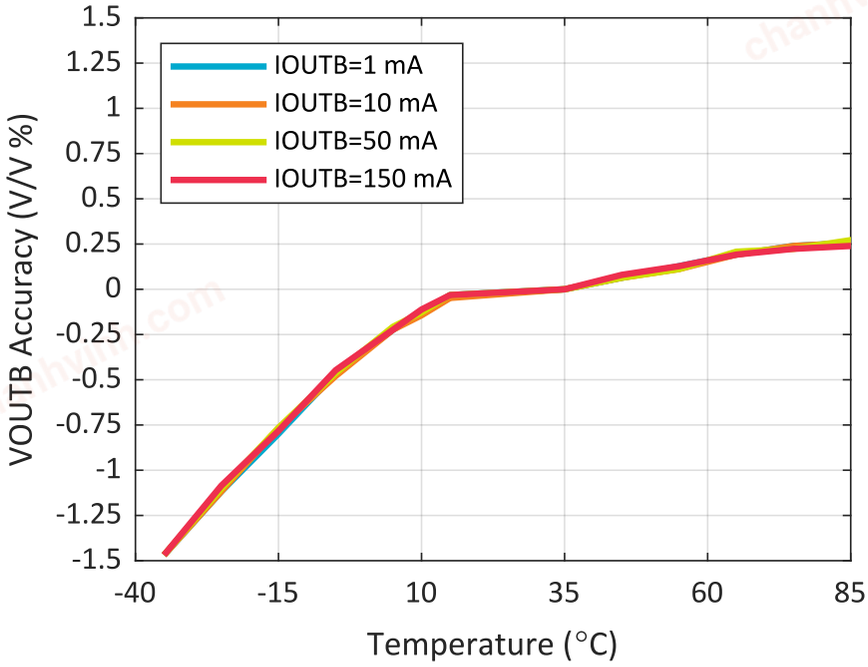


Figure 21: VOUTB=3.0: VOUTB vs. temperature (VBAT=4.2)

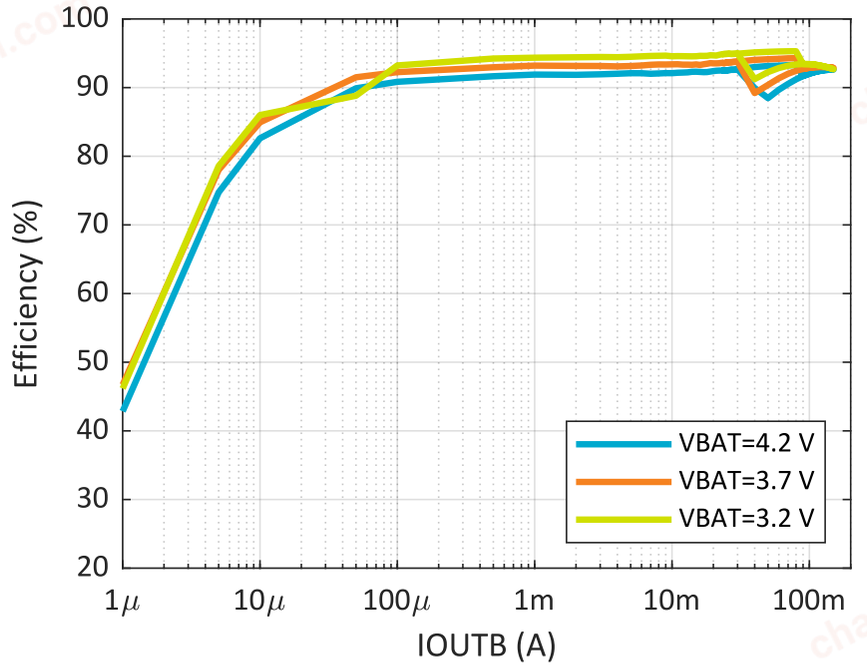


Figure 22: VOUTB=2.7 system efficiency, MODE=AUTO

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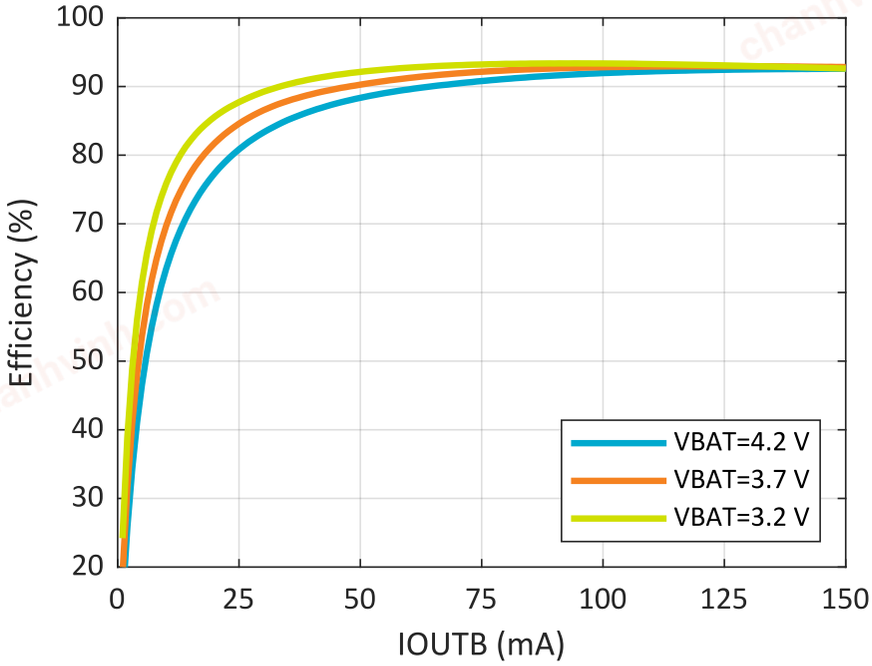


Figure 23: VOUTB=2.7 system efficiency, MODE=PWM

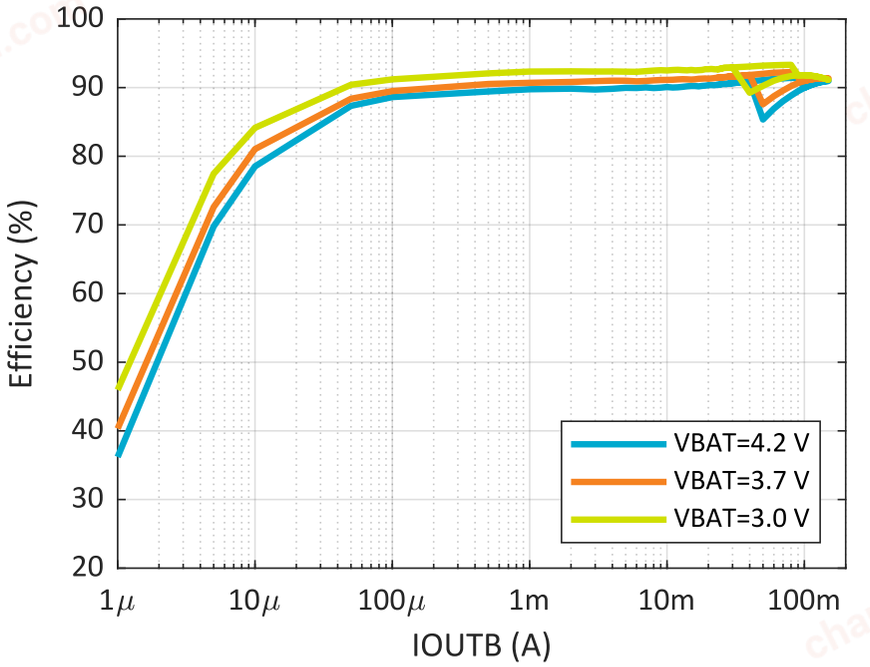


Figure 24: VOUTB=2.1 system efficiency, MODE=AUTO

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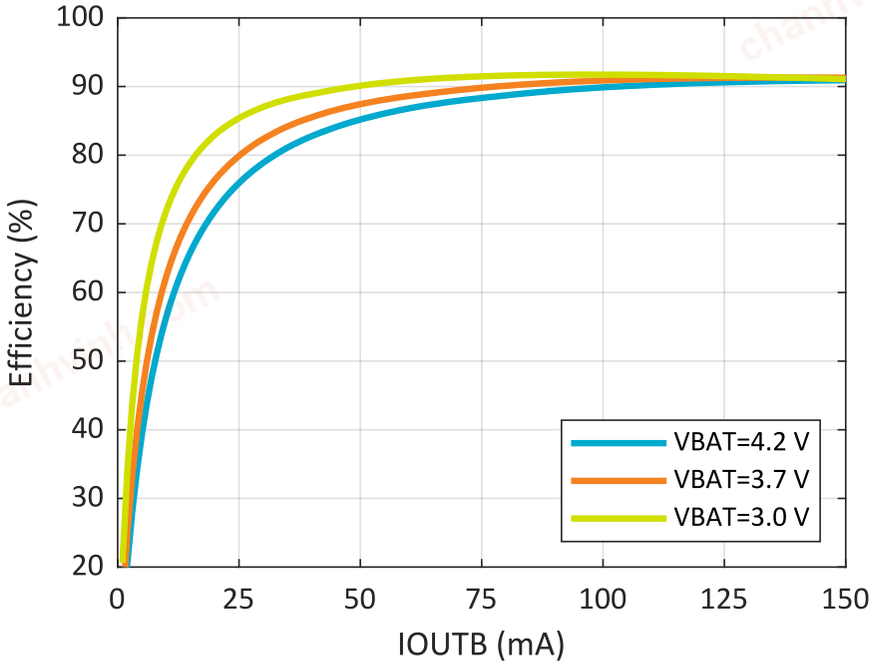


Figure 25: VOUTB=2.1 system efficiency, MODE=PWM

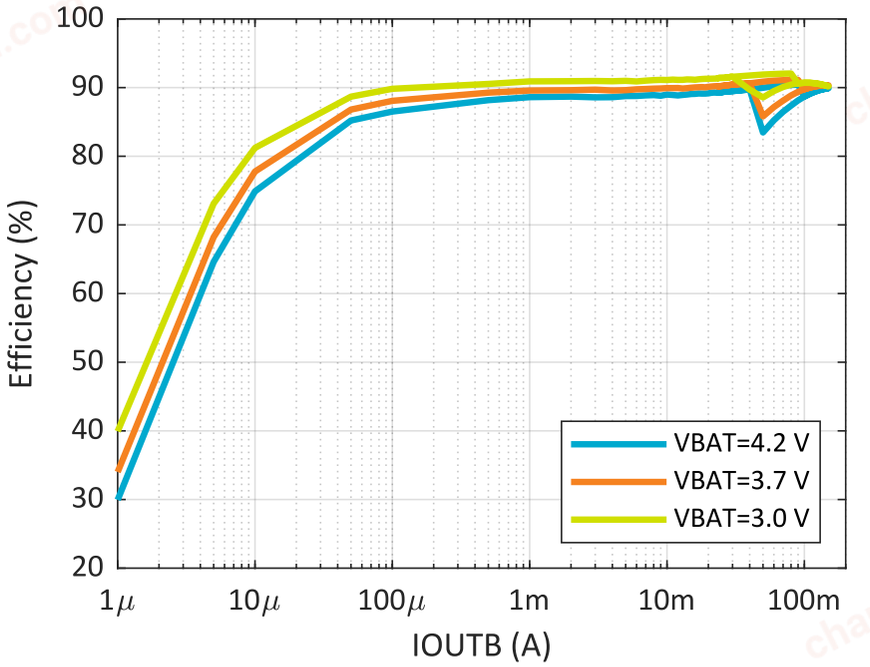


Figure 26: VOUTB=1.8 system efficiency, MODE=AUTO

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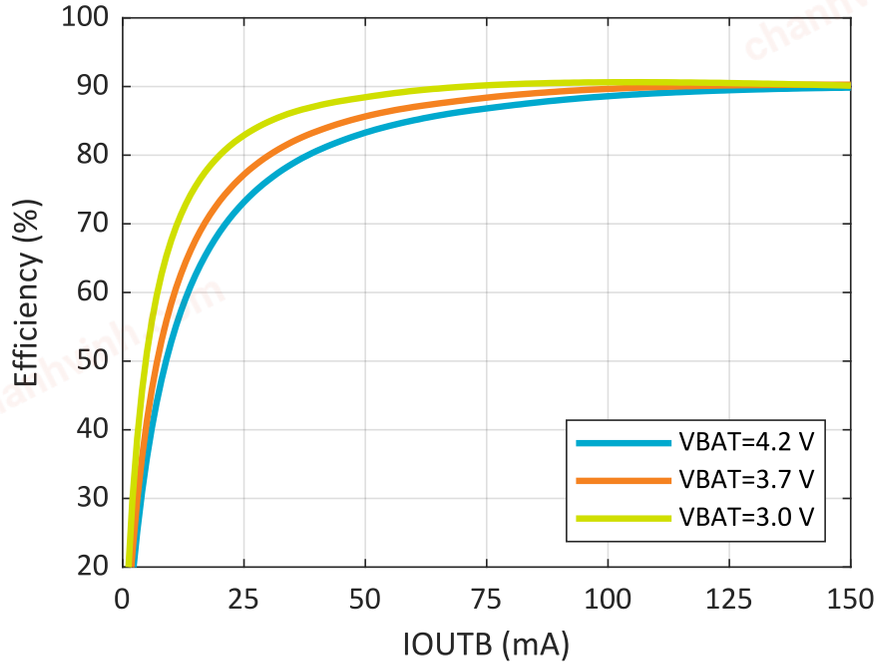


Figure 27: VOUTB=1.8 system efficiency, MODE=PWM

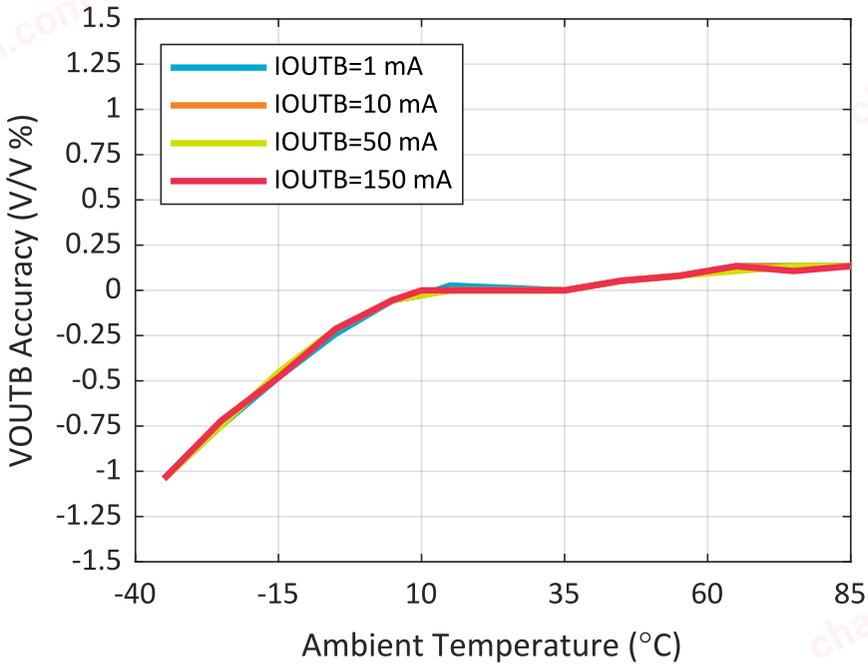


Figure 28: VOUTB=1.8 VOUTB vs. temperature (VBAT=4.2)

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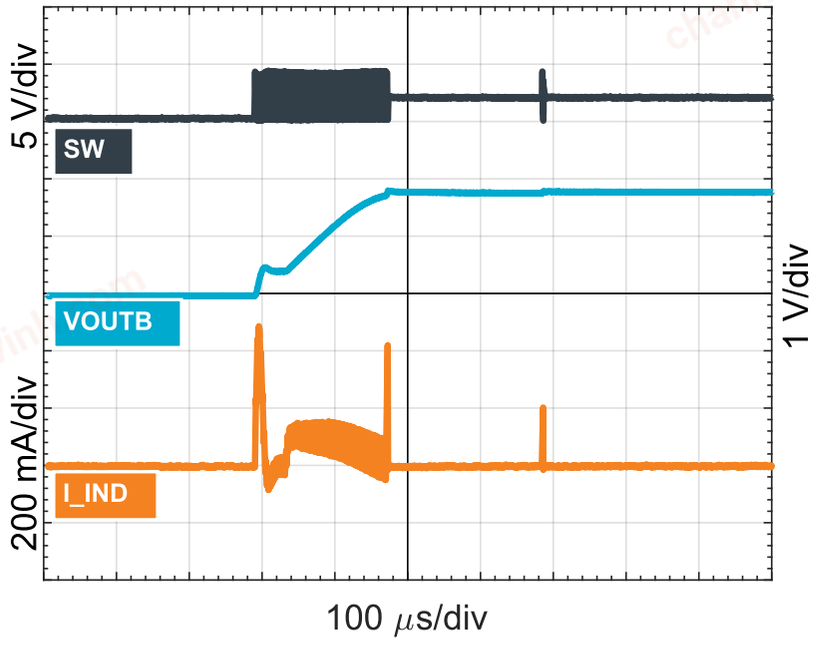


Figure 29: Startup with no load, soft start, Vout=1.8 V, VBAT=3.8 V

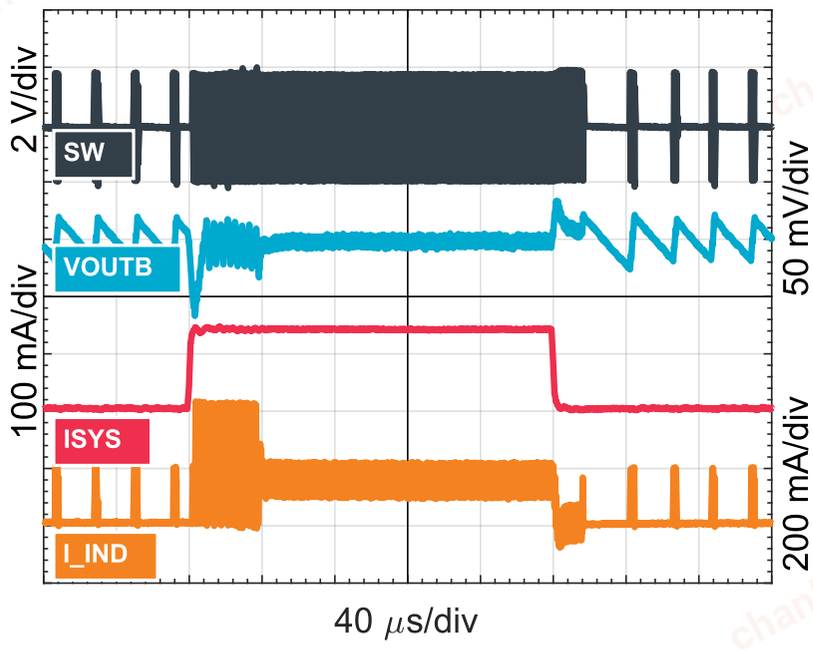


Figure 30: BUCK load transition in auto mode (MODE=0), Iout=10 mA → 150 mA → 10 mA (1 µs step), Vout=1.8 V, VBAT=3.8 V

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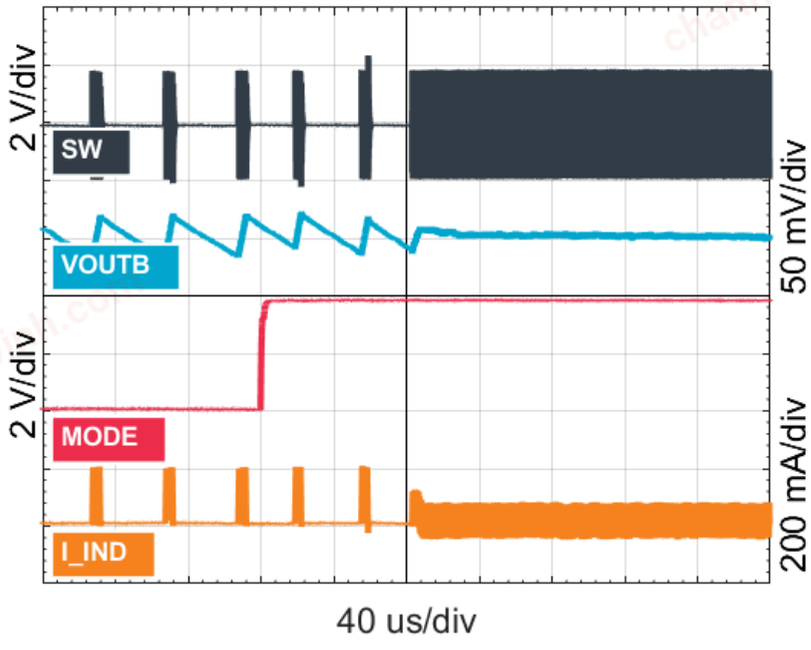


Figure 31: BUCK Mode transition, MODE pin 0 → 1, Vout=1.8 V Iout=10 mA

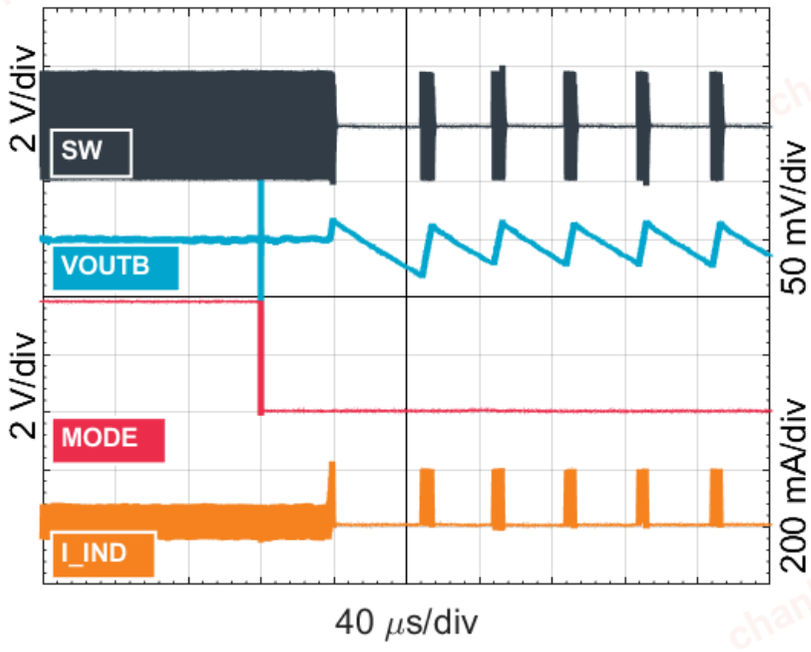


Figure 32: BUCK Mode transition, MODE pin 1 → 0, Vout=1.8 V Iout=10 mA

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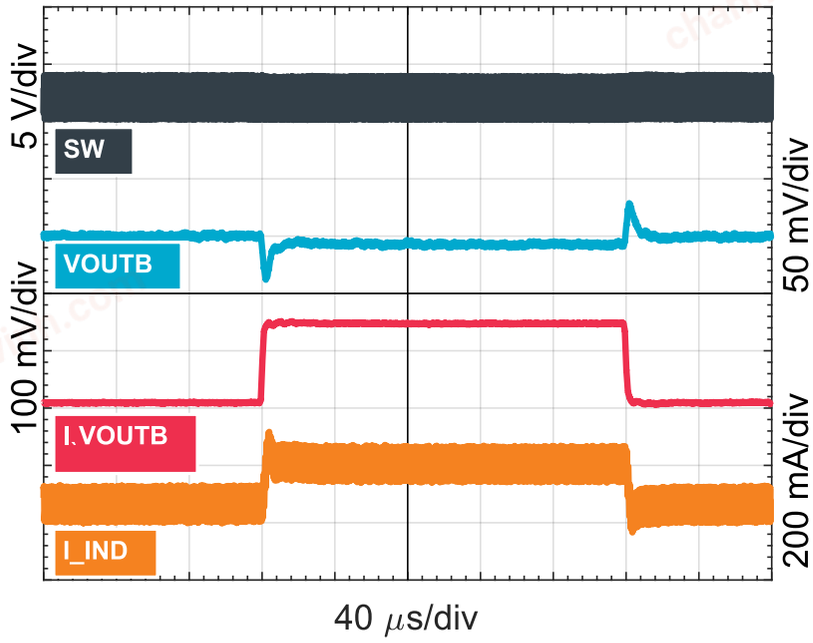


Figure 33: BUCK load transition in PWM mode (MODE=1), Iout=10 mA → 150 mA → 10 mA (1 µs step), Vout=1.8 V, VBAT=3.8 V

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7 Application

The following application example uses nPM1100 and an nRF5x wireless System on Chip (SoC). Any nRF52 or nRF53 series device with USB can be configured in the same way as this application. When using a device without USB, or for other configurations, see Reference circuitry on page 50.

The example application is for a design with the following configuration and features:

- nPM1100 BUCK regulator supplies the nRF5x device
- USB current limit negotiation
- Charging status monitoring using SoC GPIOs
- ICHG and VTERM configuration
- NTC thermistor in the battery pack
- Ship mode
- Battery monitoring circuit and low battery indication LED (the device must sample the battery voltage)

7.1 Schematic

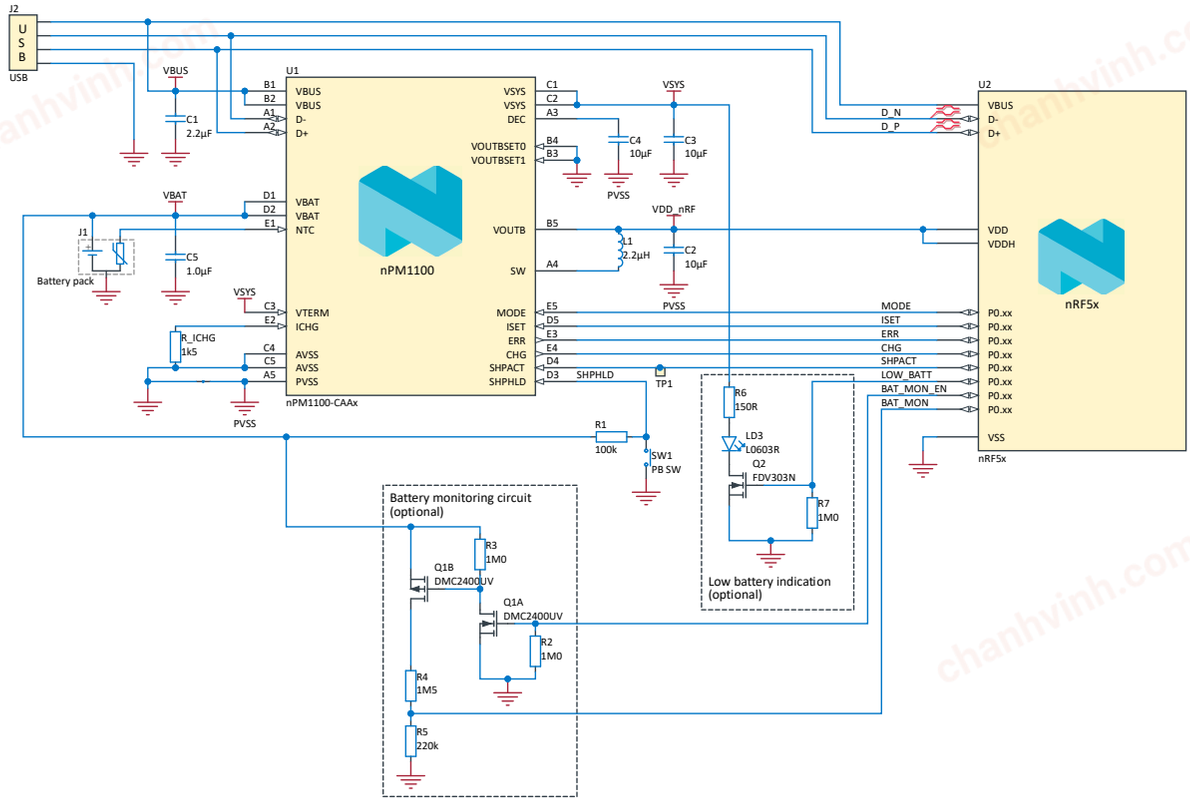


Figure 34: Application example

7.2 Supplying from BUCK

nRF5x is supplied by nPM1100 **VOUTB** at 1.8 V. BUCK mode (**MODE**) is controlled with a GPIO.

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An application should not be supplied directly from **VBAT** because it can disturb the battery charging process and may cause incorrect behavior from the charger. Instead, **VOUTB** and/or **VSYS** should be used to supply an application.

7.3 USB port negotiation

nRF5x can connect to a USB host.

Port negotiation can be performed after nPM1100 port detection. The nRF5x device and nPM1100 are both connected to USB in the application example. nPM1100 detects SDP or CDP/DCP. If SDP is detected, the USB device can negotiate with the USB host for higher current from **VBUS**.

- **D+** and **D–** pins are connected to both nPM1100 and nRF5x. The nRF5x SoC must wait until nPM1100 completes port detection before enabling its USB port. See USB port detection and VBUS current limiting on page 17 for port detection time after **VBUS** connection.
- An nRF5x GPIO is connected to the **ISET** pin and sets the **VBUS** current limit after negotiation. If CDP or DCP is detected, then a 500 mA limit is automatically set regardless of **ISET** state.
- **VBUS** is supplied to both nPM1100 and nRF5x to supply nPM1100 SYSREG and the nRF5x VBUS regulator.

See USB port detection and VBUS current limiting on page 17 for a detailed description.

7.4 Charging and error states

Pins **CHG** and **ERR** indicate charging and error states. See Charging indication (CHG) and charging error indication (ERR) on page 25 and Charger error conditions on page 24.

7.5 Termination voltage and current

For a product using standard V_{TERM}, the termination voltage is configured to 4.2 V. See Termination voltage (VTERMSET) on page 22. The same configuration would provide 4.35 V for a product using high V_{TERM}.

Charge current is configured to 200 mA (±10%) using a 1.5 kΩ (1%) resistor to ground on the **ICHG** pin. See Charge current limit (ICHG) on page 23.

7.6 NTC configuration

The **NTC** pin is connected to an external NTC thermistor which should be placed with thermal coupling to the battery pack. See Battery thermal protection using NTC thermistor (NTC) on page 23 for more information.

7.7 Ship mode

Ship mode is enabled at production time through an off-board circuit with a probe point on the **SHIPACT** pin.

An external button is in the circuit to exit Ship mode. If another circuit is present instead of a button, any signal that is able to pull the **SHIPHLD** pin low for the required period can be connected to that net. See Using Ship mode on page 10 for more information.

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7.8 Battery monitoring and low battery indication

The battery monitoring circuit allows the battery voltage to be sampled by the nRF5x ADC.

The transistors enable battery voltage sensing through a resistive divider. When not sampling, the transistors prevent current leakage to ground. The circuit is designed to ensure the voltage range on an analog input pin over the battery voltage is within the limits required by the nRF5x GPIO and ADC. A battery voltage of 2.8 V to 4.2 V is scaled down to 360 mV to 540 mV at **P0.xx** for sampling.

If software on nRF5x determines that the battery on nPM1100 is low, the **Low Bat LED** can be switched on through GPIO. This circuit sources the LED current from **VSYS**. **VSYS** will not be supplied after VBAT drops below $VBAT_{BOR}$ because CHARGER will isolate the battery when a brownout reset occurs. See Power-on reset (POR) and brownout reset (BOR) on page 10.

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8 Hardware and layout

8.1 Pin assignments

The pin assignment figures and tables describe the pinouts for the product variants of the chip.

8.1.1 WLCSP ball assignments

The ball assignment figure and table describe the assignments for this variant of the chip.

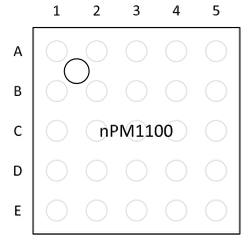


Figure 35: WLCSP ball assignments

Pin	Name	Function	Description	Recommended usage
A1	**D–**	Analog input	USB D- data line	
A2	**D+**	Analog input	USB D+ data line	
A3	**DEC**	Power	System decoupling capacitor	
A4	**SW**	Power	BUCK regulator output (to inductor)	
A5	**PVSS**	Power	Ground (DC/DC)	
B1	**VBUS**	Power	Input supply	
B2	**VBUS**	Power	Input supply	
B3	**VOUTBSET1**	Digital I/O	BUCK regulator output voltage selection	Toggle only when the device is in Power OFF
B4	**VOUTBSET0**	Digital I/O	BUCK regulator output voltage selection	Toggle only when the device is in Power OFF
B5	**VOUTB**	Power	BUCK regulator output	
C1	**VSYS**	Power	System voltage output; automatically enabled after power-on reset	
C2	**VSYS**	Power	System voltage output; automatically enabled after power-on reset	

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Pin	Name	Function	Description	Recommended usage
C3	**VTERMSET**	Digital I/O	Battery charging termination voltage selection	Toggle only when the device is in Power OFF
C4	**AVSS**	Power	Ground	
C5	**AVSS**	Power	Ground	
D1	**VBAT**	Power	Battery	
D2	**VBAT**	Power	Battery	
D3	**SHPHLD**	Digital I/O	Shipping mode hold	
D4	**SHPACT**	Digital I/O	Shipping mode activate	
D5	**ISET**	Digital I/O	**VBUS** current limit selection: 0 mA to 100 mA (SDP mode only) 1 mA to 500 mA	
E1	**NTC**	Analog input	NTC resistor	
E2	**ICHG**	Analog input	Charge current limiting resistor	
E3	**ERR**	Digital OUT	Open-drain LED driver; enabled when error condition in charging	
E4	**CHG**	Digital OUT	Open-drain LED driver; enabled when battery is charging	
E5	**MODE**	Digital I/O	0 - automatic 1 - Forced PWM	

Table 23: Ball assignments

Note: **VOUTBSET1** and **VOUTBSET0** balls are located close to **AVSS**, **DEC**, and **VSYS** to allow connection to tracks on the PCB without any via holes.

8.1.2 QFN24 pin assignments

The pin assignment figure and table describe the assignments for this variant of the chip.

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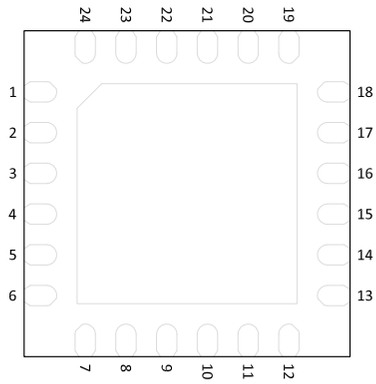


Figure 36: QFN pin assignments

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Pin	Name	Function	Description
1	VOUTB	Power	BUCK regulator output
2	VOUTBSET1	Digital I/O	BUCK regulator output voltage selection
3	VOUTBSET2	Digital I/O	BUCK regulator output voltage selection
4	NC		
5	ISET	Digital I/O	VBUS current limit selection: 0 mA to 100 mA (SDP mode only) 1 mA to 500 mA
6	SHPACT	Digital I/O	Shipping mode activate
7	MODE	Digital I/O	0 - automatic 1 - Forced PWM
8	CHG	Digital OUT	Open-drain LED driver; enabled when battery is charging
9	VTERMSET	Battery charging termination voltage selection	Toggle only when the device is in Power OFF
10	ERR	Digital OUT	Open-drain LED driver; enabled when error condition in charging
11	SHPHLD	Digital I/O	Shipping mode hold
12	ICHG	Analog input	Charge current limiting resistor
13	NC		
14	NTC	Analog input	NTC resistor
15	VBAT	Power	Battery
16	VSYS	Power	System voltage output; automatically enabled after power-on reset
17	VBUS	Power	Input supply
18	NC		
19	D-	Analog input	USB D- data line
20	D+	Analog input	USB D+ data line
21	DEC	Power	System decoupling capacitor
22	SW	Power	BUCK regulator output (to inductor)
23	PVSS	Power	Ground (DC/DC)
24	NC		

Table 24: QFN24 pin assignment

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8.2 Mechanical specifications

The mechanical specifications for the package shows the dimensions in millimeters.

8.2.1 WLCSP 2.075x2.075 mm package

Dimensions in millimeters for the WLCSP 2.075x2.075 mm package.

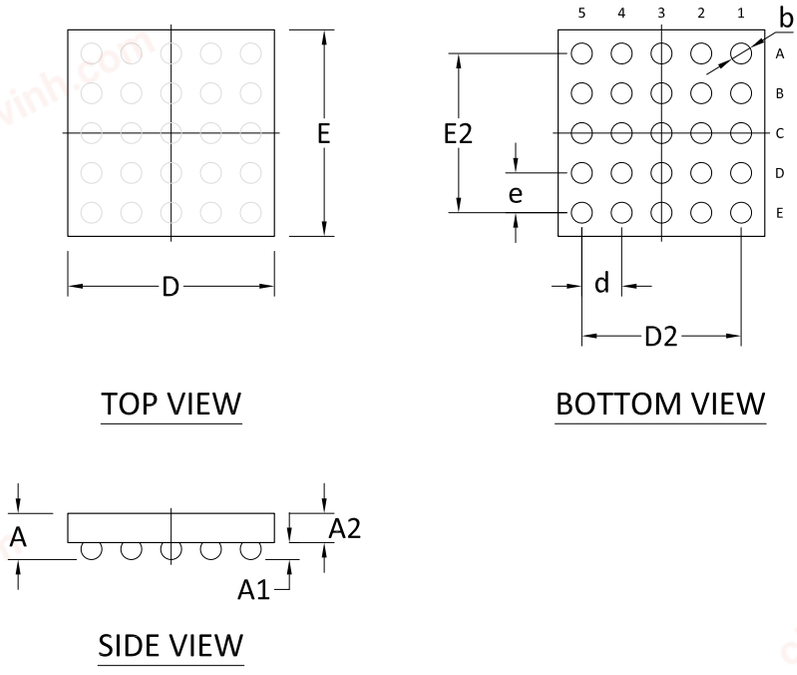


Figure 37: WLCSP 2.075x2.075 mm package

	A	A1	A2	b	D	E	D2	E2	d	e	K	L
Min.	0.406	0.14	0.266	0.195								
Nom.	0.464		0.294		2.075	2.075	1.6	1.6	0.4	0.4		
Max.	0.522	0.2	0.322	0.255								

Table 25: WLCSP dimensions in millimeters

8.2.2 QFN 4.0x4.0 mm package

Dimensions in millimeters for the QFN 4.0x4.0 mm package.

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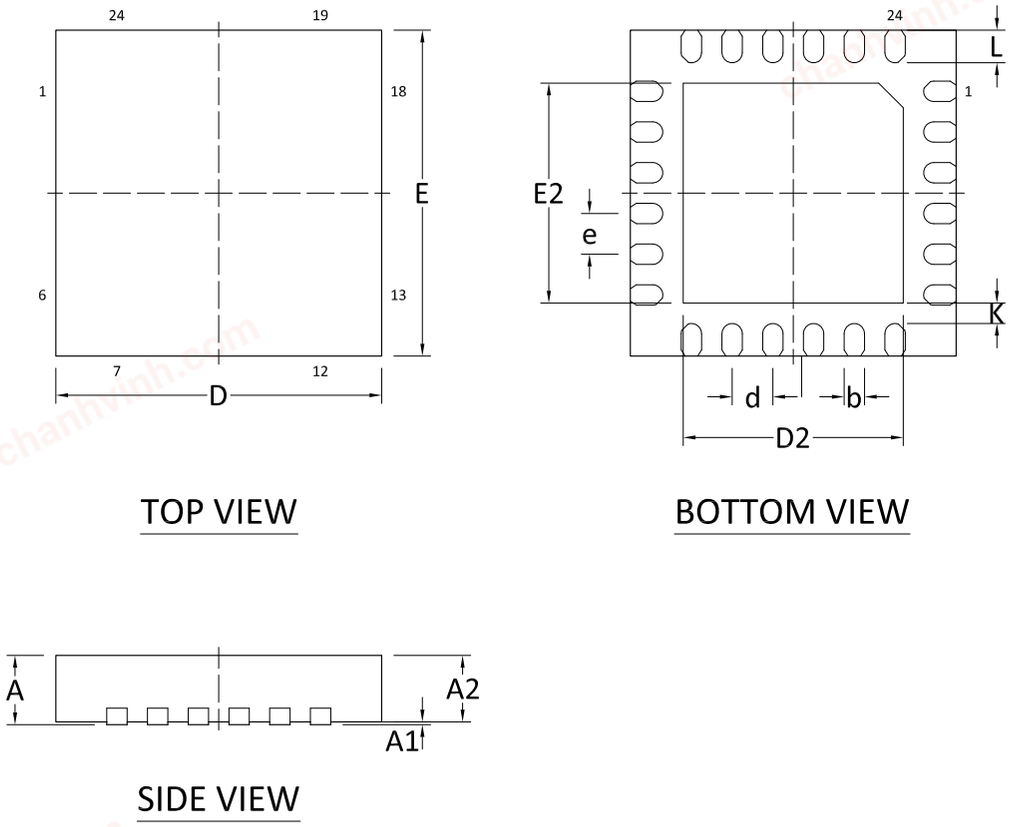


Figure 38: QFN 4.0x4.0 mm package

	A	A1	A2	b	D	E	D2	E2	e	K	L
Min.	0.80	0.00		0.20			2.60	2.60			0.35
Nom.	0.85	0.035	0.65	0.25	4.0	4.0	2.70	2.70	0.50	0.25	0.40
Max.	0.90	0.05		0.30			2.80	2.80			0.45

Table 26: QFN dimensions in millimeters

8.3 Reference circuitry

Documentation for the different package reference circuits, including Altium Designer files, PCB layout files, and PCB production files can be downloaded from www.nordicsemi.com.

The following reference circuits for nPM1100 QFN and WLCSP packages, based on the standard V_{TERM} product, show the schematics and components to support different configurations in a design.

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	Configuration 1	Configuration 2	Configuration 3
Description	Minimal configuration Fixed 100 mA **VBUS** limit	Minimal configuration Fixed 500 mA **VBUS** limit	Normal configuration USB port detection
BUCK	Not used	Not used	Configured
Ship mode	Not used	Not used	Configured
Battery NTC	Not used	Not used	Configured
V_{TERM}	**VTERMSET** = LOW	**VTERMSET** = LOW	**VTERMSET** = HIGH
ISET	**AVSS**	**VSYS**	**AVSS**
D–	**AVSS**	**AVSS**	USB
D+	NC	NC	USB
ICHG	4.7 kΩ 1%	0 Ω GND	1.5 kΩ GND
VOUTB	-	-	2V1

Table 27: PCB application configuration

8.3.1 Configuration 1

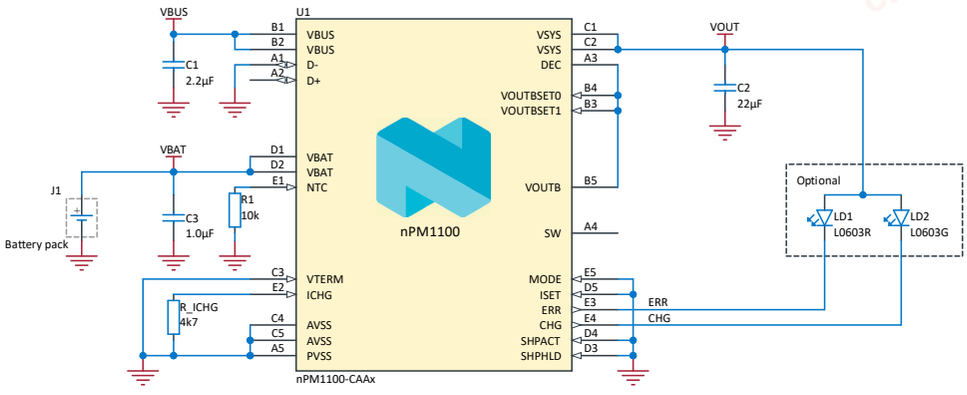


Figure 39: WLCSP schematic

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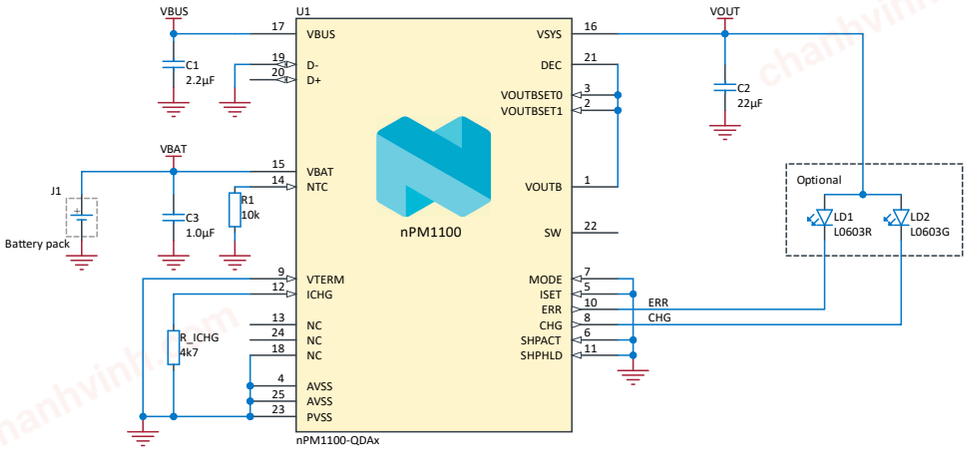


Figure 40: QFN schematic

Designator	Value	Description	Footprint
C1	2.2 µF	Capacitor, X5R, 25 V, ±20%	0603
C2	22 µF	Capacitor, X5R, 6.3 V, ± 20%	0603
C3	1.0 µF	Capacitor, X5R, 10 V, ± 20%	0201
J1	Battery pack	Battery pack	TP_2x1mm_TH
LD1	L0603R	LED, SMD, RED	0603
LD2	L0603G	LED, SMD, GREEN	0603
R1	10 kΩ	Resistor, 0.05 W, ±1%	0201
R_ICHG	4.7 kΩ	Resistor, 0.05 W, ±1%	0201
U1	nPM1100	Li-ion/Li-poly USB battery charger with high efficiency buck regulator	WLCSP-25 or QFN

Table 28: Configuration 1 reference circuitry

8.3.2 Configuration 2

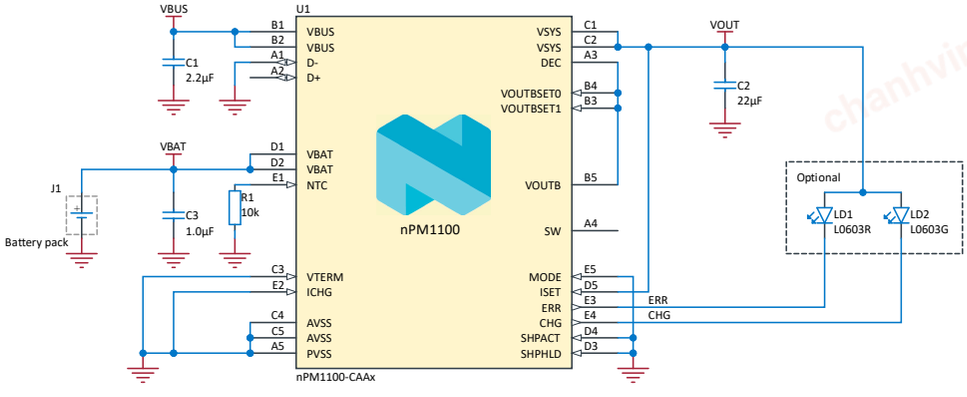


Figure 41: WLCSP schematic

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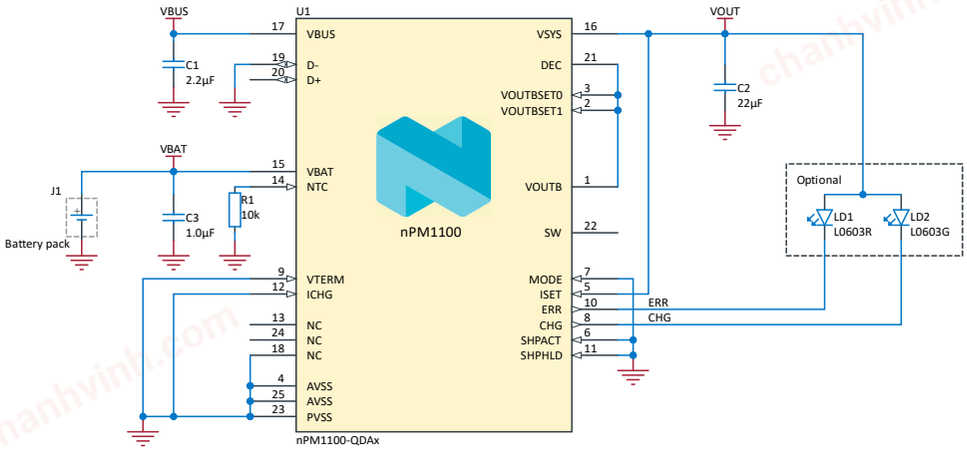


Figure 42: QFN schematic

Designator	Value	Description	Footprint
C1	2.2 µF	Capacitor, X5R, 25 V, ±20%	0603
C2	22 µF	Capacitor, X5R, 6.3 V, ±20%	0603
C3	1.0 µF	Capacitor, X5R, 10 V, ±20%	0201
J1	Battery pack	Battery pack	TP_2x1mm_TH
LD1	L0603R	LED, SMD, RED	0603
LD2	L0603G	LED, SMD, GREEN	0603
R1	10 kΩ	Resistor, 0.05 W, ±1%	0201
U1	nPM1100	Li-ion/Li-poly USB battery charger with a high efficiency buck regulator	WLCSP-25 or QFN

Table 29: Configuration 2 reference circuitry

8.3.3 Configuration 3

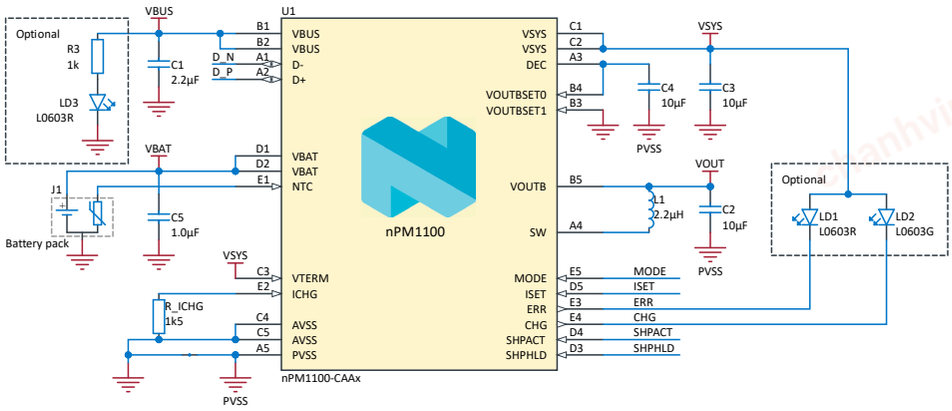


Figure 43: WLCSP schematic

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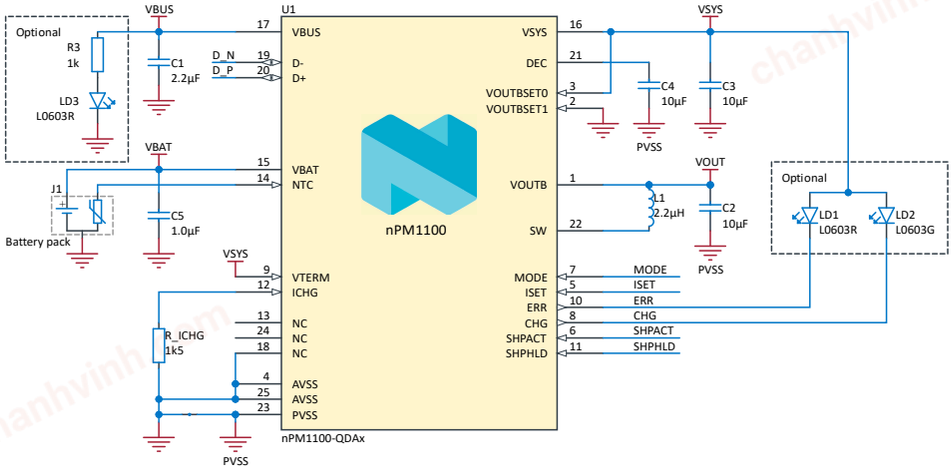


Figure 44: QFN schematic

Designator	Value	Description	Footprint
C1	2.2 µF	Capacitor, X5R, 25 V, ±20%	0603
C2, C3, C4	10 µF	Capacitor, X5R, 6.3 V, ±20%	0603
C5	1.0 µF	Capacitor, X5R, 10 V, ±20%	0201
J1	Battery pack	Battery pack with NTC	TP_3x1mm_TH
L1	2.2 µH	Inductor ±20%	0806
LD1, LD3	L0603R	LED, SMD, RED	0603
LD2	L0603G	LED, SMD, GREEN	0603
R3	1 kΩ	Resistor, 0.05 W, ±1%	0201
R_ICHG	1.5 kΩ	Resistor, 0.05 W, ±1%	0201
U1	nPM1100	Li-ion/Li-poly USB battery charger with a high efficiency buck regulator	WLCSP-25 or QFN

Table 30: Configuration 3 reference circuitry

8.3.4 PCB guidelines

A well designed PCB is necessary to achieve good performance. A poor layout can lead to loss in performance or functionality.

To ensure functionality, it is essential to follow the schematics and layout references closely.

A PCB with a minimum of two layers, including a ground plane, is recommended for optimal performance.

The DC supply voltage should be decoupled with high performance capacitors as close as possible to the supply pins. See the reference schematic in Configuration 1 on page 51 for recommended decoupling capacitor values.

Long power supply lines on the PCB should be avoided. All device grounds, VDD connections, and VDD bypass capacitors must be connected as close as possible to the device.

8.3.5 PCB layout example

The PCB layouts are shown here for WLCSP followed by QFN.

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For all available reference layouts, see the Reference Layout section on the Downloads tab for nPM1100 on www.nordicsemi.com.

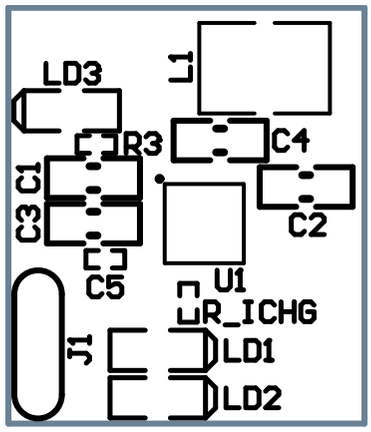


Figure 45: Top silk layer WLCSP

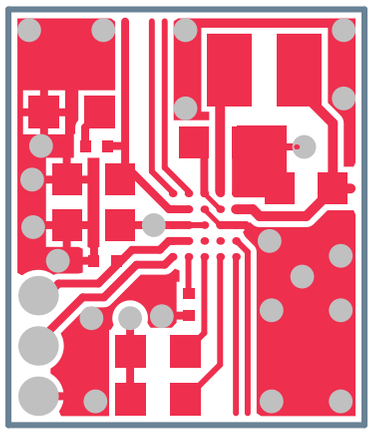


Figure 46: Top layer WLCSP

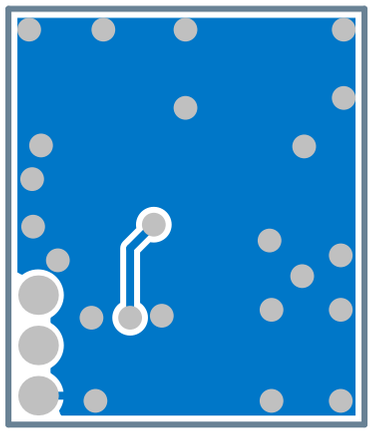


Figure 47: Bottom layer WLCSP

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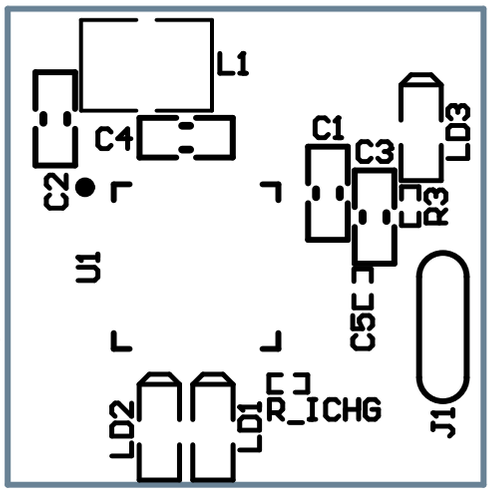


Figure 48: Top silk layer QFN

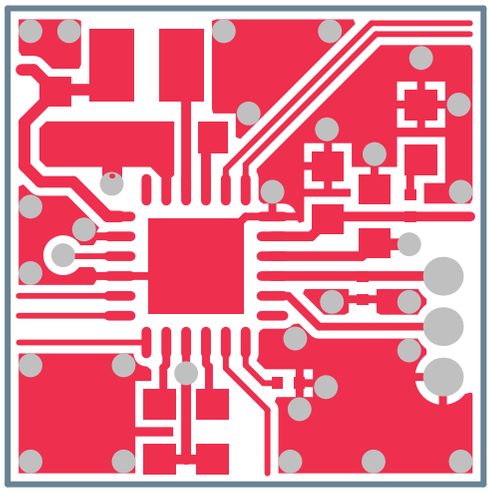


Figure 49: Top layer QFN

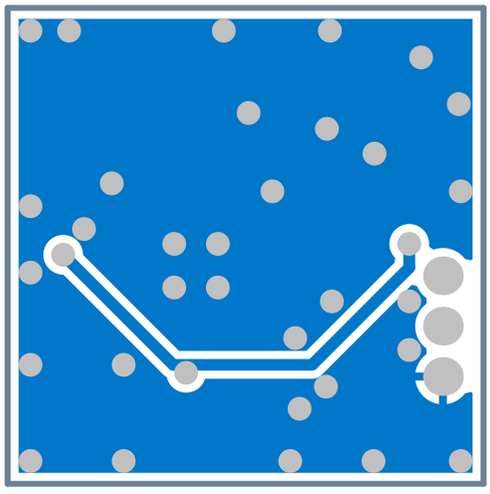


Figure 50: Bottom layer QFN

Note: No components in the bottom layer.

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9 Ordering information

This chapter contains information on IC marking, ordering codes, and container sizes.

9.1 IC marking

The nPM1100 PMIC package is marked as shown in the following figure.

N	P	M	1	1	0	0
<P	P>	<V	V>	<H>	<P>	
<Y	Y>	<W	W>	<L	L>	

Figure 51: IC marking

9.2 Box labels

The following figures define the box labels used for the nPM1100 device.



Figure 52: Inner box label

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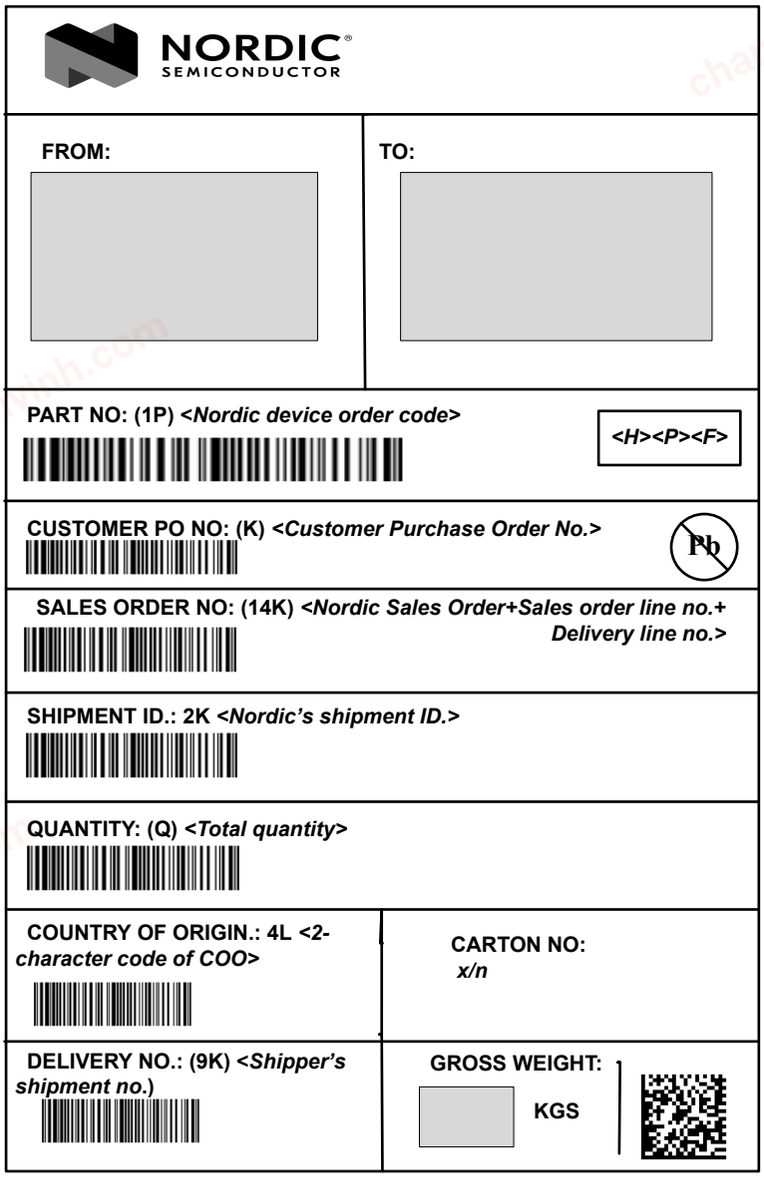


Figure 53: Outer box label

9.3 Order code

The following tables define the nPM1100 order codes and definitions.

n	P	M	1	1	0	0	-	<P	P>	<V	V>	-	<C	C>

Figure 54: Order code

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Abbreviation	Definition and implemented codes
N11/nPM11	nPM11 series product
00	Part code
<PP>	Package variant code
<VV>	Function variant code
<H><P><F>	Build code H - Hardware version code P - Production configuration code (production site, etc.) F - Firmware version code (only visible on shipping container label)
<YY><WW><LL>	Tracking code YY - Year code WW - Assembly week number LL - Wafer lot code
<CC>	Container code
eX	2nd Level Interconnect Symbol where value of X is based on J-STD-609

Table 31: Abbreviations

9.4 Code ranges and values

The following tables define the nPM1100 code ranges and values.

<PP>	Package	Size (mm)	Pin/Ball count	Pitch (mm)
CA	WLCSP	2.075x2.075	25	0.4
QD	QFN	4.0x4.0	24	0.5

Table 32: Package variant codes

<VV>	Flash (kB)	V_{TERM}
AA	n/a	Standard
AB	n/a	High

Table 33: Function variant codes

<H>	Description
[A . . Z]	Hardware version/revision identifier (incremental)

Table 34: Hardware version codes

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<P>	Description
[0 . . 9]	Production device identifier (incremental)
[A . . Z]	Engineering device identifier (incremental)

Table 35: Production configuration codes

<F>	Description
[A . . N, P . . Z]	Version of preprogrammed firmware
[0]	Delivered without preprogrammed firmware

Table 36: Production version codes

<YY>	Description
[16 . . 99]	Production year: 2016 to 2099

Table 37: Year codes

<WW>	Description
[1 . . 52]	Week of production

Table 38: Week codes

<LL>	Description
[AA . . ZZ]	Wafer production lot identifier

Table 39: Lot codes

<CC>	Description
R7	7" Reel
R	13" Reel

Table 40: Container codes

9.5 Product options

The following tables define the nPM1100 product options.

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Order code	MOQ[1]	Comment
nPM1100-CAAA-R	N/A	Discontinued
nPM1100-CAAA-R7	N/A	
nPM1100-CAAA-E-R	7000 pcs	
nPM1100-CAAA-E-R7	1500 pcs	
nPM1100-CAAB-R	4000 pcs	
nPM1100-CAAB-R7	1500 pcs	
nPM1100-QDAA-R	4000 pcs	
nPM1100-QDAA-R7	1500 pcs	
nPM1100-QDAB-R	4000 pcs	
nPM1100-QDAB-R7	1500 pcs	

Table 41: nPM1100 order codes

Order code	Description
nPM1100-EK	Standard V_{TERM} evaluation kit
nPM1100-EKHV	High V_{TERM} evaluation kit

Table 42: Development tools order code

[1] Minimum Ordering Quantity

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