

AN12325

Using the DC-DC feature

Rev. 2.0 — 17 February 2025

Application note

Document information

Information	Content
Keywords	AN12325, DC-DC converter, LPC55xx
Abstract	This application note provides a hardware design guide for the DC-DC converter on the LPC55xx devices and explains how to properly choose external components for the DC-DC converter.



1 Introduction

This application note provides a hardware design guide for the DC-DC converter on the LPC55xx devices and explains how to properly choose external components for the DC-DC converter. The main part of the document focuses on the critical parameters of external components and their implication of incorrect selection, including a PCB design example of the external component.

2 Theory and usage of DC-DC converters

DC-DC converters are used in portable electronic devices, such as cellular phones and laptop computers, which are supplied primarily from batteries. Such electronic devices often contain several subcircuits, each with its own voltage level requirement different from the level supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage lowers because its stored energy is drained. Switched DC-DC converters offer a method to increase the voltage from a partially lowered battery voltage and save space (instead of using multiple batteries to achieve the same goal).

Most DC-DC converter circuits also regulate the output voltage. Exceptions include high-efficiency LED power sources (which are DC-DC converters that regulate the current flowing through the LEDs) and simple charge pumps (which double or triple the output voltage).

Switching converters (such as buck converters) provide greater power efficiency as DC-DC converters than linear regulators, which are simpler circuits that dissipate power as heat, but do not step up the output current.

3 Hardware design guide

This chapter summarizes the hardware requirements for external components used for a proper functionality of the DC-DC internal converter. It contains the recommendation of appropriate component selection and the PCB drawing.

As there is power-up ramp condition specified in the device data sheet and chip errata, an external circuit to implement this ramp condition is needed, as mentioned in *Hardware Design Guidelines for LPC55(S)xx Microcontrollers* (document [AN13033](#)).

The LPC55xx family consists of six internal regulators (including the DC-DC converter) which are supplied by the main external supply domain (VBAT 1.8 V – 3.6 V). The connection of all the external components and the MCU needed for a proper DC-DC functionality is shown in [Figure 1](#).

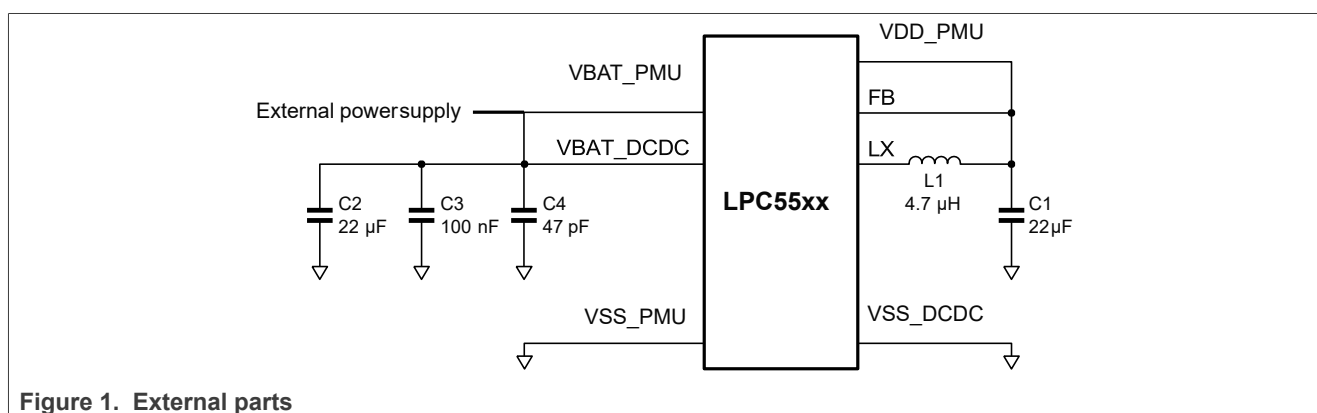


Figure 1. External parts

[Table 1](#) summarizes pin names and numbers for all packages.

Table 1. List of pin names and numbers for internal DC-DC converter

Symbol	64-pin HTQFP	98-pin VFBGA	100-pin HLQFP	Description
VBAT_DCDC	32	N13	49, 50	Supply of DC-DC output stage. DC-DC core supply (references and regulation stages).
VBAT_PMU	33	M13	51	Analog supply.
VDD_PMU	28	M9	39	Core supply. For applications with DC-DC converter, VDD_PMU, and FB are tied at PCB level.
FB	29	N9	45	Feedback node (regulated output) of DC-DC converter.
LX	31	N11	48	DC-DC converter power stage output.
VSS_PMU	-	M11	-	Star ground connection is managed to PCB ground plane.
VSS_DCDC	30	N12, M12	46, 47	Star ground connection is managed to PCB ground plane.

[Table 2](#) summarizes typical values and limitations for the external components of the DC-DC internal converter.

Table 2. External parts

Part	Min	Typ	Max	Unit
C1	10	22 (X5R or X7R)	47	μF
C2	10	22 (X5R or X7R)	47	μF
C3	80	100 (X5R or X7R)	120	nF
C4	38.7	47 (COG)	56.2	pF
L1	3.7	4.7	5.6	μH

3.1 Input decoupling capacitors

The 100-nF and 47-pF ceramic capacitors are the input decoupling capacitors for the DC-DC converter. The 10-μF (or 20-μF) input ceramic capacitor is used to decouple and power the internal DC-DC converter. All the decoupling capacitors must be placed close to the pin. For the capacitors, there is no ESR value restriction.

3.2 Output filter capacitor

This capacitor sets the voltage ripple value. A minimum value of the output capacitor is 10 μF and it is necessary for the correct functionality of the DC-DC converter. This capacitor also sets the voltage ripple value, which is very important for the USB power supply requirements.

If the value of the output capacitor is below the 10 μF, the voltage ripple is higher and it does not meet the requirements of the internal LDO. Values higher than 22 μF increase the possible noise current.

3.3 Power inductor

The typical inductor value for the most application ranges from 3.7 μH to 5.6 μH . These values are chosen according to the desired ripple current.

At the expense of a higher output-voltage ripple, small-value inductors result in a higher output current slew rate, improving the load transient response of the converter. Larger values of inductors lower the ripple current and reduce the core magnetic hysteresis losses.

Table 3 summarizes the typical values and limitations of the power inductor.

Table 3. Power inductor

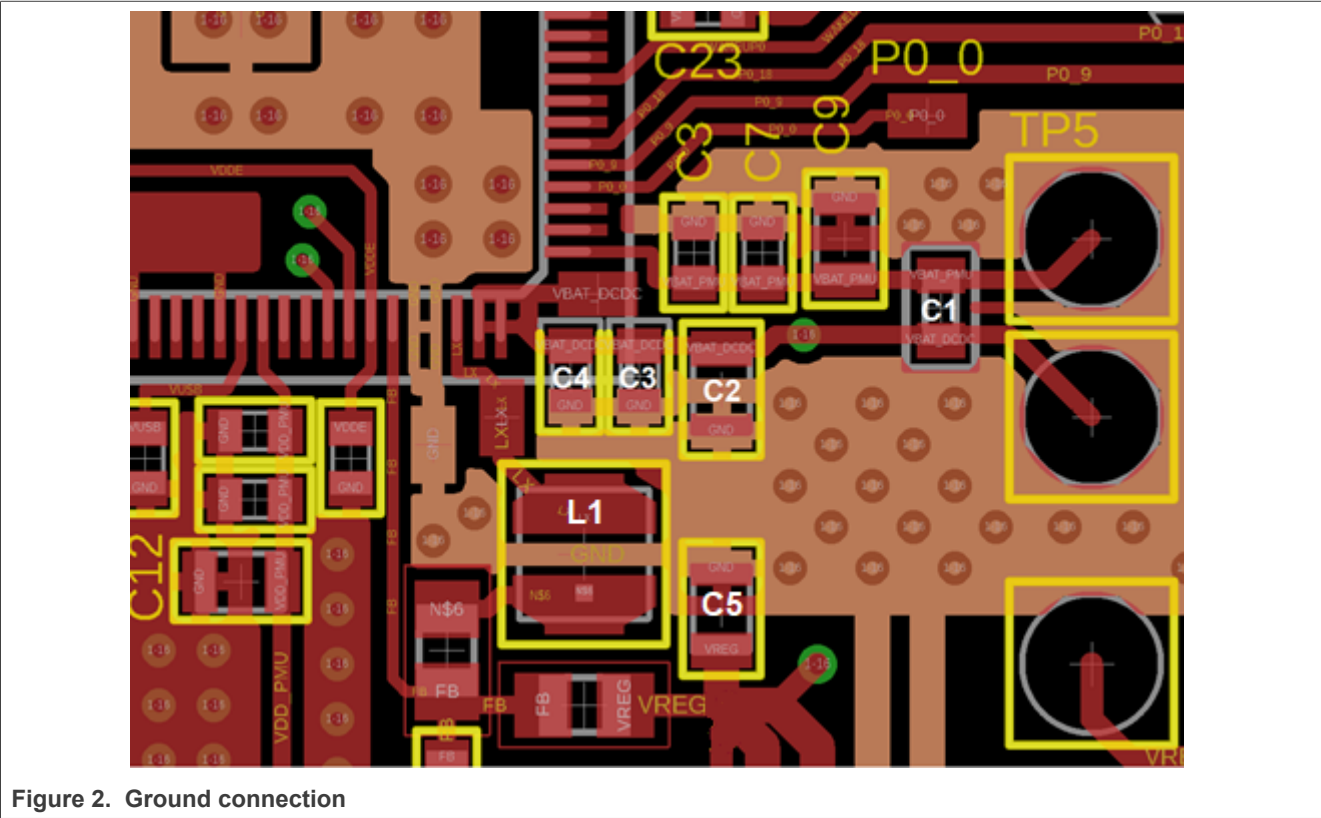
Parameter	Min	Typ	Max	Unit
Inductance value	3.7	4.7	5.6	μH
Saturation current	350	500	-	mA

3.3.1 Saturation current limitation

The minimum value of the saturation current is 350 mA. The recommended saturation current is 500 mA (or higher).

3.4 PCB guide line

To reduce the series resistance from the DC-DC inductor, keep the traces as thick and as short as possible. The ground between the inputs of capacitors C2, C3, C4, the DC-DC ground pads, and the output capacitor C1 must be on the same plane. It is not possible to use a via or a strap connection. Figure 2 shows a proper DC-DC ground connection.



4 Conclusion

This application note summarizes all external components and PCB recommendations of the internal DC-DC converter used in LPC55xx. For proper functionality, follow all of these recommendations in your designs with LPC55xx. Efficiency is often the main purpose to use a DC-DC converter. The use of DC-DC converters increases the efficiency of the conversion from battery voltage to a low supply voltage.

5 Revision history

Table 4. Revision history

Document ID	Release date	Description
AN12325 v.2.0	17 February 2025	• Updated component values and Figure 1
AN12325 v.1	22 July 2021	• Updated Figure 1 , Table 1 , and Table 2
AN12325 v.0	February 2019	• Initial version

Legal information

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <https://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this document expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

HTML publications — An HTML version, if available, of this document is provided as a courtesy. Definitive information is contained in the applicable document in PDF format. If there is a discrepancy between the HTML document and the PDF document, the PDF document has priority.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

NXP B.V. — NXP B.V. is not an operating company and it does not distribute or sell products.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

Contents

1 Introduction 2

2 Theory and usage of DC-DC converters 2

3 Hardware design guide 2

3.1 Input decoupling capacitors 3

3.2 Output filter capacitor 3

3.3 Power inductor 4

3.3.1 Saturation current limitation 4

3.4 PCB guide line 4

4 Conclusion 5

5 Revision history 5

Legal information 6

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.