AN12325

Using the DC-DC feature

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Application Note

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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 uses 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 sub-circuits, 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 in LPC5500) provide much higher power efficiency than DC-DC converters and linear regulators (simpler circuits that lower the voltage by dissipating the excess 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.

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.

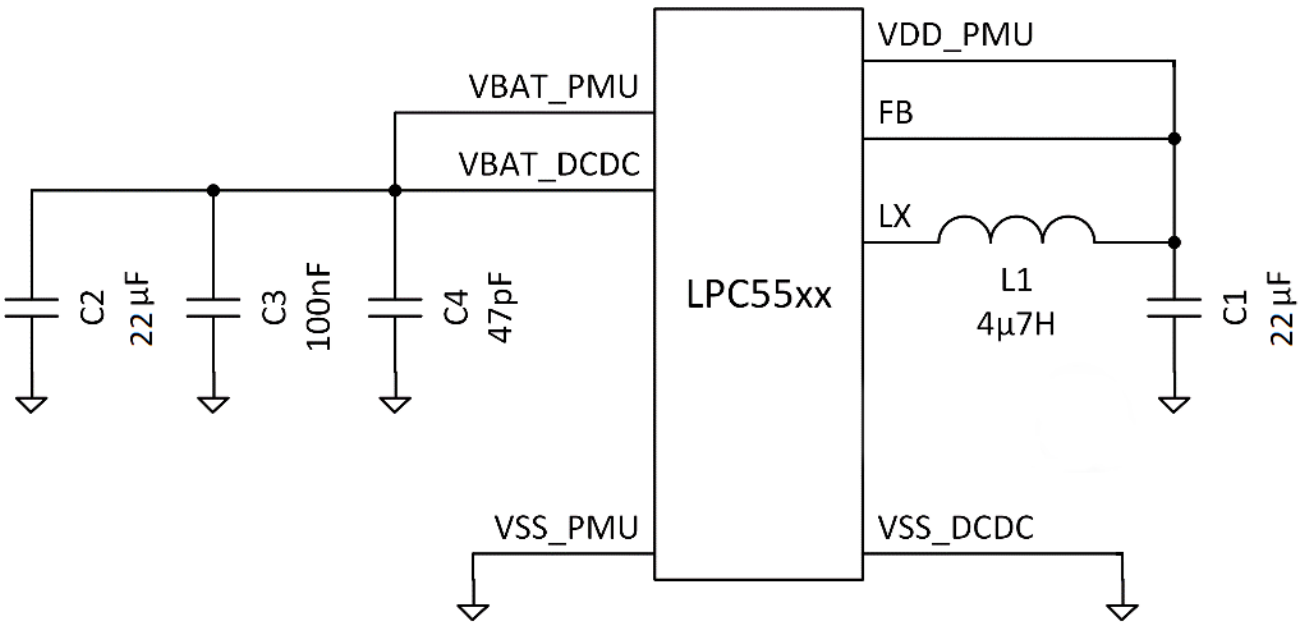

Figure 1. External parts

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	3.87	4.7	10	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- m F (or 20- m F) 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.

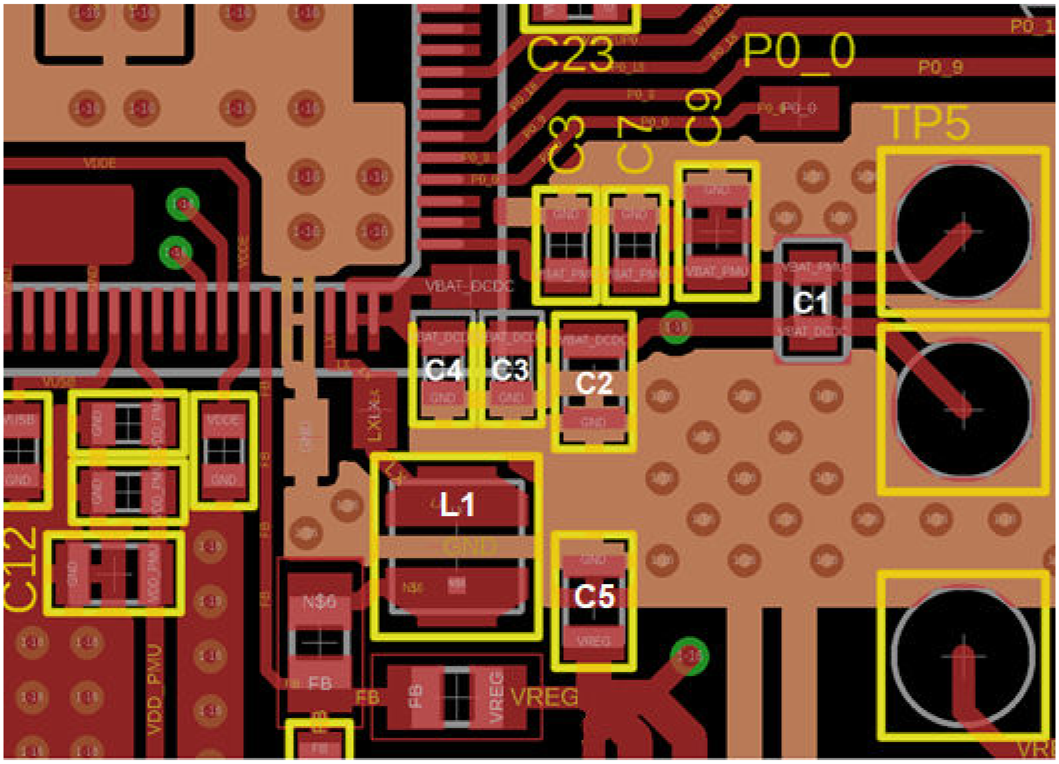

Figure 2. Ground connection

4 Conclusion

This application note summarizes all external components and PCB recommendations of the internal DC-DC converter used in LPC55xx. For a 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. A linear regulator can be used but it cannot achieve the same efficiency as switching regulators.

5 Revision history

Table 4. Revision history

Revision	Date	Substantive changes
1	22 July 2021	Updated Figure 1, Table 1, and Table 2.
0	February 2019	Initial release.

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