

Design and Programming Examples for Lighting Management Unit LP5526

National Semiconductor
Application Note 1442
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January 2007



Introduction

This document provides information for customers who are using LP5526. The document is written to help design, layout and software engineers and thus reduce the time needed for successful design.

The first chapter describes the basic ideas of LP5526 with a few example solutions that utilize the main features. Example LED configurations are presented. The functionality of the part is introduced in the default and programmable modes together with example schematics and programming examples.

The second chapter introduces the layout guide. A 4-layer layout is shown and the critical layout rules are explained.

Chapter three presents the recommended external components and constraints.

An Evaluation Kit including the evaluation board and the PC interface software is available.

1. LP5526 Application

GENERAL SYSTEM OVERVIEW

LP5526 is a Lighting Management Unit for portable applications. It is used to drive display backlight, keypad LEDs, color LEDs and Flash LEDs. The device can drive 2 separately connected strings of LEDs with high voltage boost converter. The RGB driver allows driving either individual color LEDs or RGB LED from separate supply voltage, or it can be used to drive FLASH LEDs. The MAIN and SUB outputs are high resolution current mode drivers. RGB outputs can be used in switch mode and current mode. PWM control can be used for any selected outputs. The device is controlled through 2-wire low voltage I²C compatible interface that reduces the number of required connections.

LP5526 is offered in a tiny microSMD-25 package (2.54 mm x 2.54 mm).

FEATURES

- High efficiency high voltage boost converter with programmable output voltage
- 2 individual drivers for serial display backlight LEDs
- Automatic dimming controller
- Stand alone RGB controller
- Dedicated FLASH function
- Safety feature to avoid prolonged Flash
- 3 general purpose IO pins
- microSMD-25 Package: (2.54 mm x 2.54 mm x 0.6 mm)

APPLICATIONS

- Cellular Phones and PDAs
- MP3 players
- Digital cameras

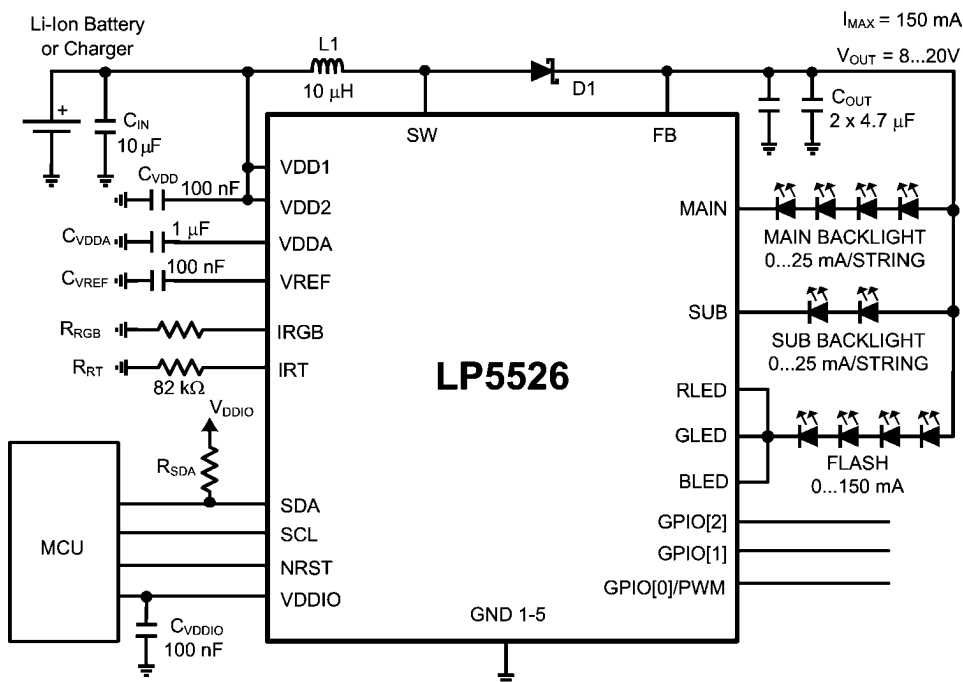


Fig 1. LP5526 Typical Application. RGB drivers driving FLASH LED.

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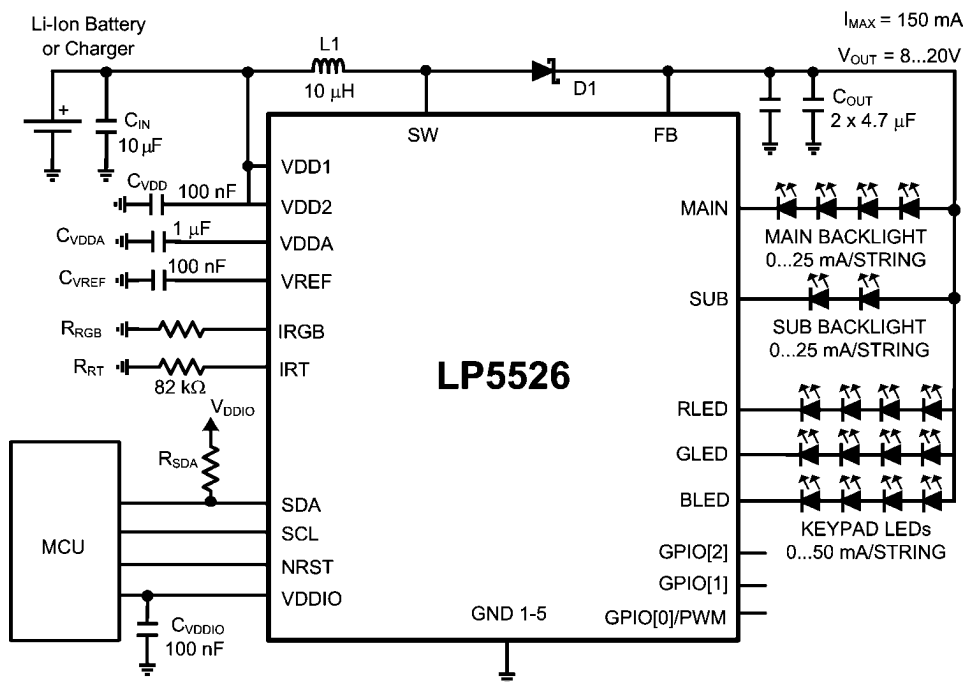


Fig 2. LP5526 Typical Application. RGB drivers driving KEYPAD LEDs.

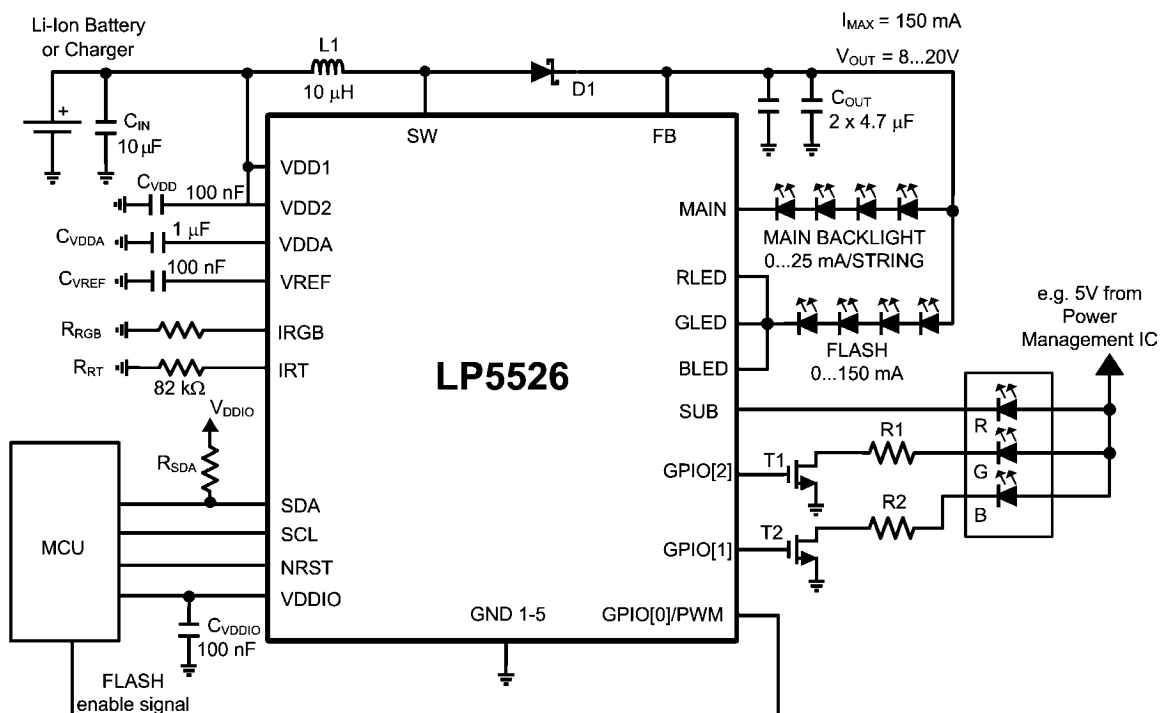


Fig 3. LP5526 driving backlight, flash and RGB LED with two NMOS transistors.

LP5526 Control Register Names and Default Values

ADDR (HEX)	REGISTER	D7	D6	D5	D4	D3	D2	D1	D0
00	Control Register	RGB_PWM 0	EN_RGB 0	CC_SW 1		RSW 0	GSW 0	BSW 0	
01	RGB	COLOR[3:0]				BRIGHT[2:0]			OVL
			0	0	0	0	0	0	0
02	RGB Max Current	safety_set 0 (read only)		IR[1:0]		IG[1:0]		IB[1:0]	
			0	0	0	0	0	0	0
03	WLED Control			SLOPE 0	FADE_SEL 0	EN_FADE 0	DISPL 0	EN_MAIN 0	EN_SUB 0
04	MAIN Current			MAIN[7:0]					
		0	0	0	0	0	0	0	0
05	SUB Current			SUB[7:0]					
		0	0	0	0	0	0	0	0
06	GPIO Control			EN_PWM_PIN 0		OEN[2:0]			
							0	0	0
07	GPIO Data					DATA[2:0]			
							0	0	0
0B	Enables		NSTBY 0	EN_BOOST 0		EN_FLASH 0	EN_AUTOLOAD 1		
0D	Boost Output			BOOST[7:0]					
		0	0	0	0	1	0	0	0
2B	PWM Enable	EN_SAFETY_R 0	EN_SAFETY_G 0	EN_SAFETY_B 0	EN_EXT_R_PWM 0	EN_EXT_G_PWM 0	EN_EXT_B_PWM 0	EN_MAIN_PWM 0	EN_SUB_PWM 0

Programming Examples

Table 1. Default conditions of all registers after power up or hardware reset

Register name	Register address (Hex)	Default Value (Hex)	Comment
CONTROL REGISTER	00H	20H	Device powers up in RGB switch mode by default.
RGB	01H	00H	All controls for RGB balance setting are reset.
RGB MAX CURRENT	02H	00H	RGB current settings are 0 and the safety bit is 0.
WLED CONTROL	03H	00H	The controls for the backlight LEDs are all 0, all backlights are disabled.
MAIN CURRENT	04H	00H	The current for the MAIN display backlighting is reset to 0 mA.
SUB CURRENT	05H	00H	The current for the SUB display backlighting is reset to 0 mA.
GPIO CONTROL	06H	00H	All GPIO are inputs as default, GPIO0 is not set to respond to external pulse at power up.
GPIO DATA	07H	00H	All data for GPIO is reset.
ENABLES	0BH	04H	Device powers up in standby mode (NSTBY=0), boost is disabled and with autoloading function on.
BOOST OUTPUT	0DH	08H	Boost default pre-program output value is 8V, V_{BOOST} will not occur until software enables the boost.
PWM_ENABLE	2BH	00H	All related PWM and strobe control signals are reset, including the safety enable bits for flash.

Table 2. Turning on the device with boost

Address(hex)	Data(hex)	Function
0BH	64H	During startup the device should be taken off from standby mode. This activates the device. Now device is enabled, autoloading still on and also boost was turned on with this same write. After device is taken off from standby mode and boost is enabled, a delay of 20 ms is required for the boost to come up.

Table 3. Turning off the device with boost

Address(hex)	Data(hex)	Function
0BH	04H	Turns off the boost and puts the device in standby mode.

Table 4. Turning on the SUB-display backlights with no fade in/out

Address(hex)	Data(hex)	Function
05H	96H	Writes the desired current value at which the sub led display needs to be initiated. For this example 96H (15 mA) is used. Refer to datasheet page 17 for adjustment table.
03H	01H	This sets the bit that enables the SUB display, now the SUB display is on at the programmed current.

Table 5. Turning off the SUB display backlights with no fade in/out

Address(hex)	Data(hex)	Function
03H	00H	The sub display is now turned off, the register with the sub display current setting still maintains the last current that was set. LEDs are turned off.
05H	00H	Resets the SUB current register back to 0 mA.

Table 6. Turning on the MAIN display backlights with no fade in/out

Address(hex)	Data(hex)	Function
04H	96H	Writes the desired current value at which the main led display needs to be initiated. For this example 96H (15 mA) is used. Refer to datasheet page 17 for adjustment table.
0DH	10H	Sets the boost output to 16V since the MAIN display uses 4 LEDs and a higher voltage is required.
03H	02H	This sets the bit that enables the MAIN display, now the MAIN display is on at the programmed current.

Table 7. Turning off the MAIN display backlights with no fade in/out

Address(hex)	Data(hex)	Function
03H	00H	MAIN display is now disabled.
0DH	08H	Sets the boost output voltage back to 8V.
04H	00H	Resets the MAIN current register back to 0 mA.

Table 8. Turn SUB display on with the fade in enabled

Address(hex)	Data(hex)	Function
03H	19H	The SUB display is now enabled, the fade in feature is enabled to react to the SUB display when a new current is written into the SUB current register. Fade in set to 1.3 second (full range change time).
05H	96H	Writes the required current into the sub display current register, the auto fade in will raise the led brightness automatically from 0 mA to 15 mA (96H) in 1.1 seconds. Note that current slope follows the datasheet dimming diagrams where 0 -> 15.5 mA change corresponds to 1.1 seconds.

Table 9. Turn SUB display off with the fade out enabled

Address(hex)	Data(hex)	Function
05H	00H	Now the SUB display current is set to 0 mA. When the writing occurs, the current gets dimmed down from the preset current (15 mA) down to 0 mA in 1.1 seconds.
03H	00H	Disables the SUB display and resets all fade in/out features.

Table 10. Turn MAIN display on with fade in enabled

Address(hex)	Data(hex)	Function
0DH	10H	Sets the boost output to 16V since the MAIN display uses 4 LEDs, so higher voltage is required.
03H	0AH	This enables the MAIN display and sets the fade in feature to respond changes in MAIN display current. Fade in set to 1.3 seconds (full range).
04H	96H	This sets the current for the MAIN display to 15 mA. Once the register data is written the LED will fade in to programmed current in 1.1 seconds.

Table 11. Turn MAIN display off with fade out enabled

Address(hex)	Data(hex)	Function
04H	00H	Now the MAIN display current is set to 0 mA. When the writing occurs, the current gets dimmed down from the preset current (15 mA) down to 0 mA in 1.1 seconds.
0DH	08H	Sets the boost output back to the default 8V.
03H	00H	Turns off the MAIN display and also disables fade in/out feature.

Table 12. Turn on torch mode with the device set to flash and safety function on

Address(hex)	Data(hex)	Function
0DH	12H	Sets the boost output back to 18V to set up for the voltage required when driving.
06H	10H	Sets the GPIO0 pin to respond to the external flash strobe.
0BH	6CH	The flash feature is now enabled but flash LED is still off.
2BH	FCH	The safety bits are now set on for the RGB outputs and set also to respond to the PWM pulse.
00H	4EH	The RGB outputs are set to as current sinks, also all the RGB are set on. Device is now in pre-flash mode at 25% of the available current. At this point the device will react to an external pulse for flash.

Table 13. Reset the device after flash, and put in back into pre-flash mode and safety mode enabled

Address(hex)	Data(hex)	Function
02H	-	Reads the safety bit to check if it is set. If it is set, an error has occurred and flash trigger pulse has been on for over 1 second. Customer is to determine what actions to take with this error. Device is still functional and all functions are ready.
0BH	64H	Sets the flash enable bit low.
2BH	1CH	Sets the safety bits low.
0BH	6CH	Now the flash feature is back on, device is in pre-flash mode at 25% of the available current.
2BH	FCH	Re-enable the safety bits. Device is still in pre-flash mode with the safety feature enabled. This sequence should be used only when user is taking consecutive pictures back to back and only after a flash has occurred. This sequence resets the safety feature and counter after a flash.

Table 14. After flash or when getting out of the pre-flash mode with no flash, reset the device and leave the flash off, when no pictures are taken

Address(hex)	Data(hex)	Function
02H	-	Reads the safety bit to check if it is set. If it is set, an error has occurred and flash trigger pulse has been on for over 1 second. Customer is to determine what action to take with this error. Device is still functional and all functions are ready.
00H	00H	Turns off the RGB bank, leaving the RGB outputs in current sink mode.
0BH	64H	Turns off the flash enable bit.
2BH	00H	Disables safety feature and also disables PWM pulse.
0DH	08H	Sets the boost output back to the default 8V.

Table 15. Setting color for RGB LED after device reset. RGB LED with external power used.

Address(hex)	Data(hex)	Function
0BH	44H	Turns on the device with no boost converter.
00H	CEH	Turns on RGB_PWM mode, enable RGB function, sets the RGB outputs to current sink mode, enables all R, G and B outputs.
02H	3FH	Sets RGB max current to maximum.
01H	BCH	Sets color to deep pink and brightness to 50%. RGB LED is now on, and the color is deep pink.

Table 16. Turn off RGB outputs

Address(hex)	Data(hex)	Function
01H	00H	Resets color and sets brightness to 0. RGB LED turns off now.
02H	00H	Sets RGB max current to 0.
00H	20H	Turns off RGB function, sets the RGB mode back to default switch mode, turns off all R, , and B outputs.
0BH	04H	Turns off device.

2. Layout Guide

GENERAL RULES FOR LAYOUT

The evaluation board layout is an example of the recommended layout practices. It is a four-layer board with signal routing on top two layers, ground plane is on the middle and power supply plane is on the bottom layer. Two signal layers are on the top because micro-vias are used.

Ground plane is a single solid plane. The digital IO-signals are considered to be quiet regarding the power and ground planes. Of course the digital signals should be kept apart from the sensitive analog signals. The most sensitive signals are:

- V_{REF} bypass capacitor
- R_T timing resistor
- FB input

The placement and routing of the boost converter components has to be done carefully. The area of the two switching current loops should be minimized. The loops are shown on the Fig 4. The dotted loop shows the current path when the boost switch is conducting. The other loop shows the current path when the switch is off.

By placing the boost component on the same side of the chip (close to the SW pin), it is easier to get small current loops

and keep the ground plane intact under the high current paths.

This way other chip pins can be routed more easily without splitting the ground plane. If the chip is placed on the center of the boost components; the I²C lines, LED lines etc. cut the ground plane below the high current paths, and it also makes the layout design more difficult.

The traces forming the boost current loops should be wide and short. Minimum trace width should be 15 mils (0.38 mm). Connections to Ground and Power planes should be done with several vias, a good practice is to have one via per 200 mA of current.

We have found out that routing the high current signals of the boost converter only on the PCB top layer does not give optimal results for the boost performance. It seems a better approach to make all ground and V_{DD} connections as close to the component pads as possible using vias to planes. It is not recommended to wire the ground wires on the top layer.

Decoupling capacitors for the power inputs should be connected as close to the circuit as possible. Also resistor R_T and V_{REF} bypass capacitor should be close to the circuit.

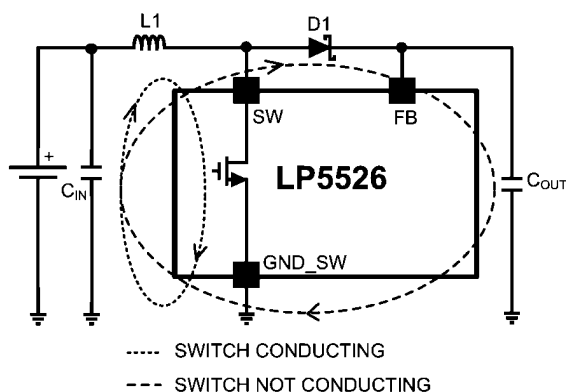


Fig 4. Boost Converter Current Loops

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Evaluation Board Schematics and PCB Layouts

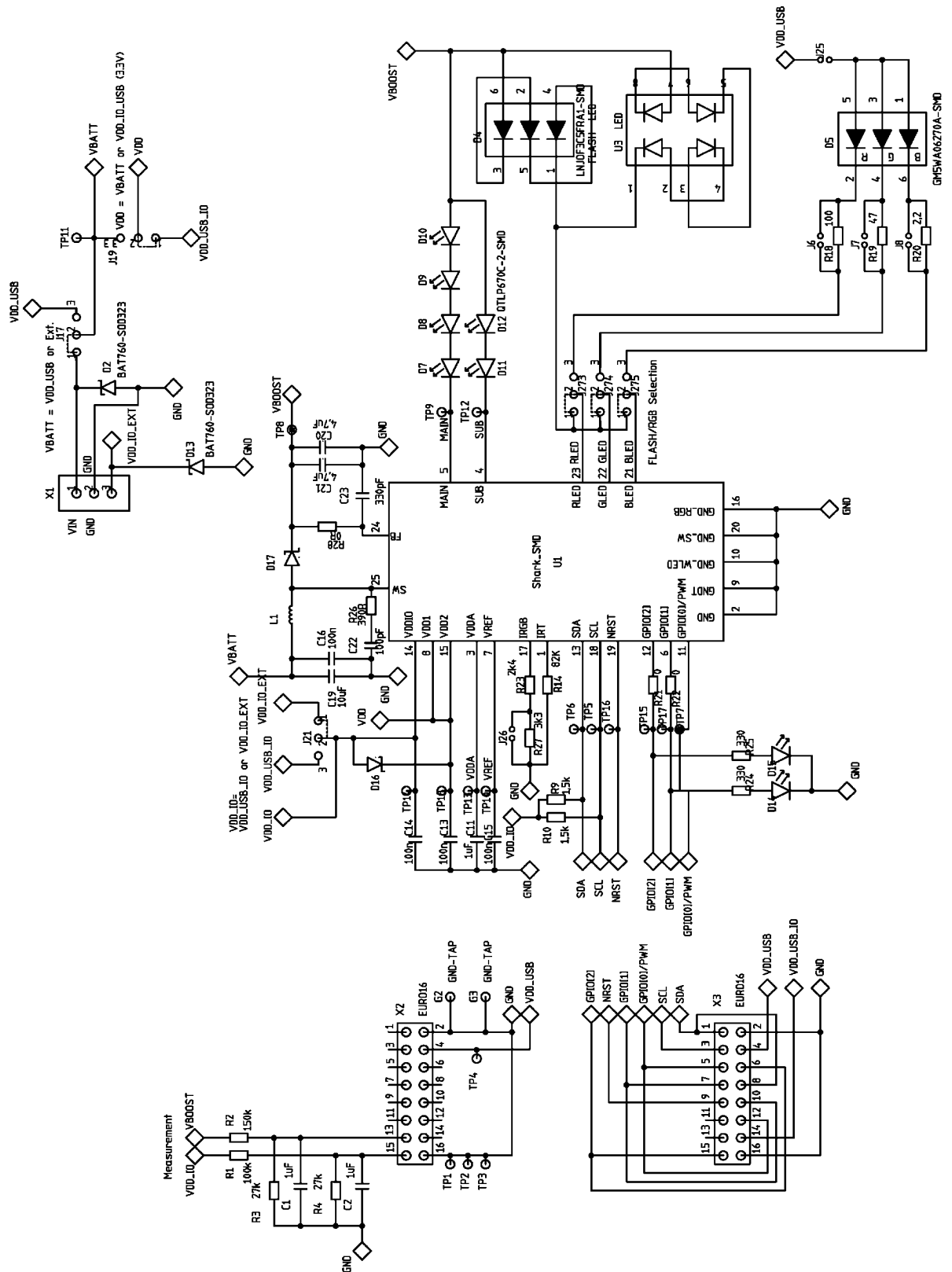


Fig 5. LP5526 Evaluation Board Schematic

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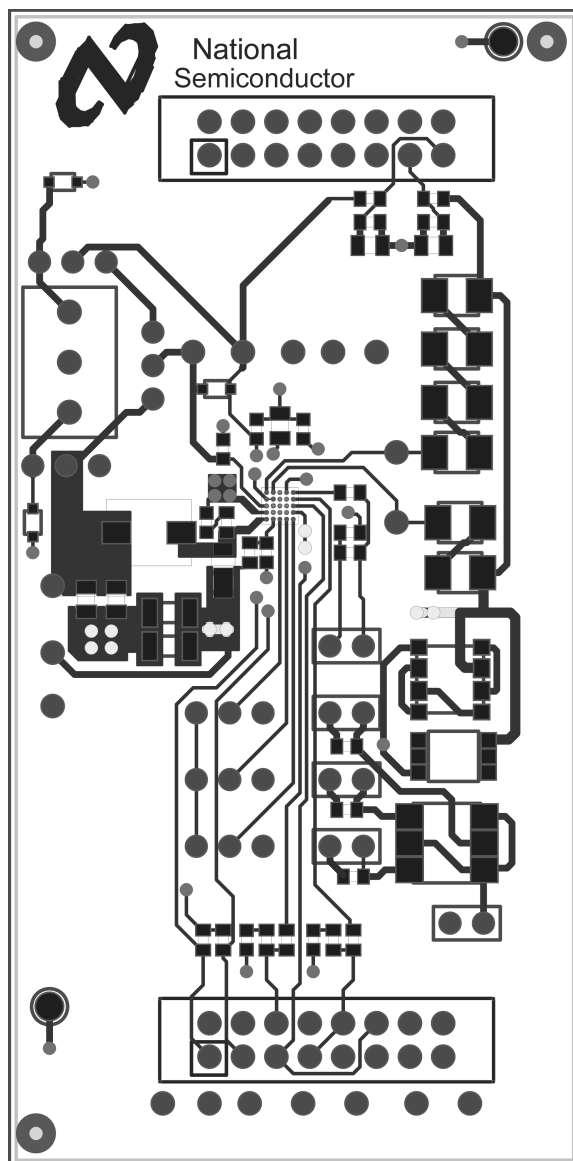


Fig 6. LP5526 Evaluation Board Top Layer PCB Layout. 20179810

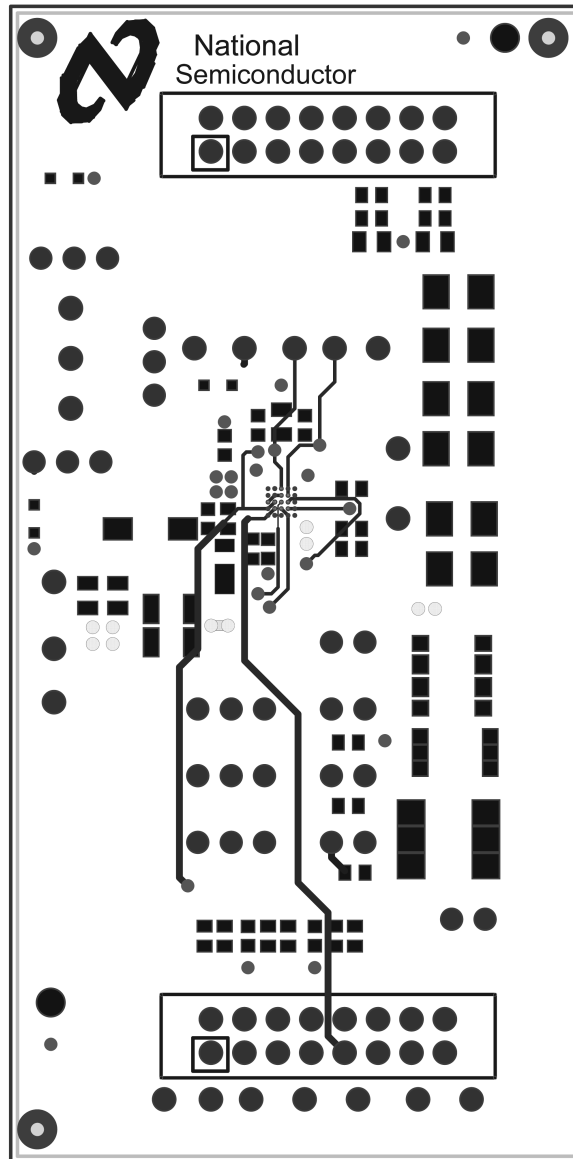
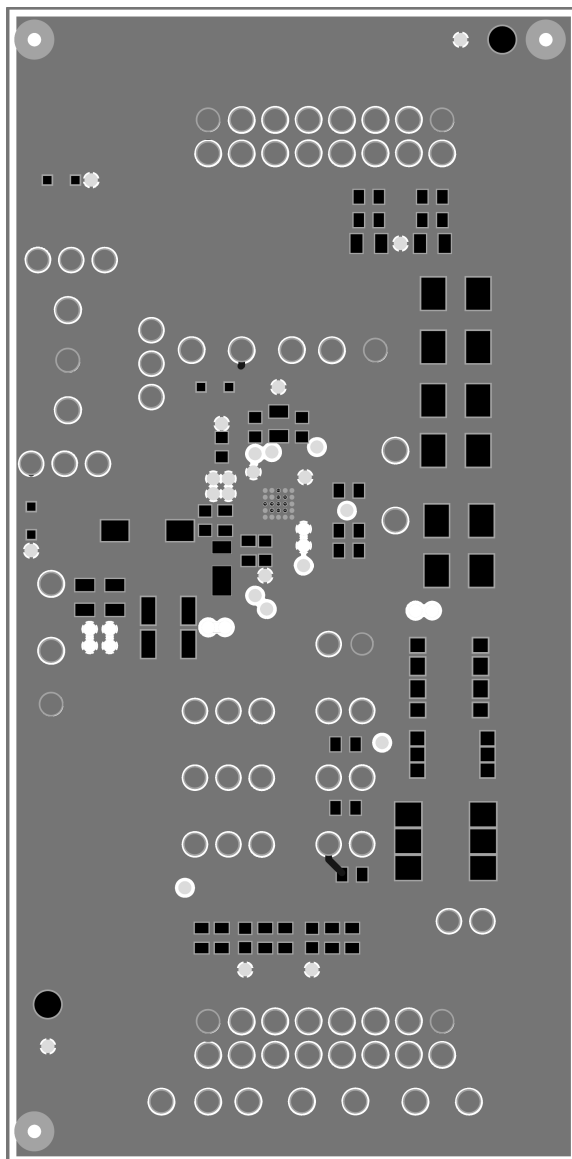
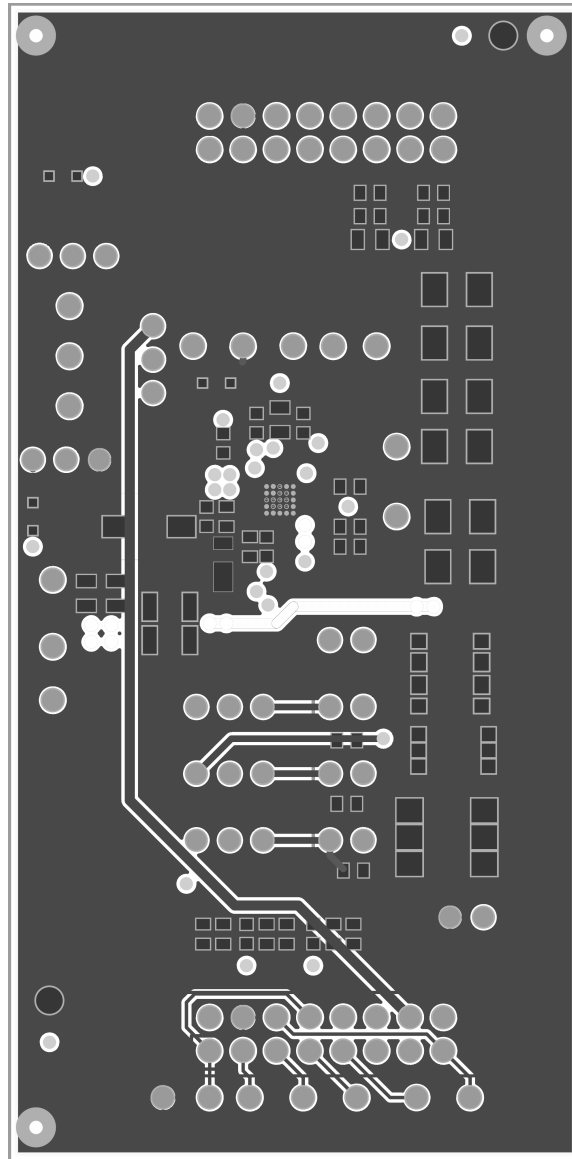


Fig 7. LP5526 Evaluation Board 2nd Layer PCB Layout. 20179811



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Fig 8. LP5526 Evaluation Board 3rd Layer PCB Layout.



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Fig 9. LP5526 Evaluation Board 4th Layer PCB Layout.

3. Recommended External Components

OUTPUT CAPACITOR, C_{OUT}

The output capacitor C_{OUT} directly affects the magnitude of the output ripple voltage. In general, the higher the value of C_{OUT} , the lower the output ripple magnitude. Multilayer ceramic capacitors with low ESR are the best choice. At the lighter loads, the low ESR ceramics offer a much lower V_{OUT} ripple than the higher ESR tantalums of the same value. At the higher loads, the ceramics offer a slightly lower V_{OUT} ripple magnitude than the tantalums of the same value. However, the dv/dt of the V_{OUT} ripple with the ceramics is much lower than the tantalums under all load conditions. Capacitor voltage rating must be sufficient, 25V is recommended.

Some ceramic capacitors, especially those in small packages, exhibit a strong capacitance reduction with the increased applied voltage. The capacitance value can fall to below half of the nominal capacitance. Too low output capacitance can make the boost converter unstable. Capacitors with max -50% DC bias effect at 20V is recommended.

Examples of suitable capacitors are: TDK C3216X5R1E475K, Panasonic ECJ3YB1E475K, ECJ4Y-B1E475K and ECJMF81E475K

INPUT CAPACITOR, C_{IN}

The input capacitor C_{IN} directly affects the magnitude of the input ripple voltage and to a lesser degree the V_{OUT} ripple. A higher value C_{IN} will give a lower V_{IN} ripple. Capacitor voltage rating must be sufficient, 10V is recommended.

OUTPUT DIODE, D1

A schottky diode should be used for the output diode. Peak repetitive current should be greater than inductor peak current (1500 mA) to ensure reliable operation. Schottky diodes with a low forward drop and fast switching speeds are ideal for increasing efficiency in portable applications. Choose a reverse breakdown voltage of the schottky diode significantly larger (~30V) than the output voltage. Do not use ordinary rectifier diodes, since slow switching speeds and long recovery times cause the efficiency and the load regulation to suffer. Examples of suitable diodes are: Central Semiconductor CMM5H1-40, Infineon BAS52-02V.

EMI FILTER COMPONENTS C_{SW} , R_{SW}

EMI filter (R_{SW} and C_{SW}) on the SW pin can be used to suppress EMI caused by fast switching. These components should be as near as possible to the SW pin to ensure reliable operation. 50V or greater voltage rating is recommended for capacitors.

INDUCTOR, L1

A 10uH shielded inductor is suggested for LP5526 boost converter. The inductor should have a saturation current rating higher than the RMS current it will experience during circuit operation (1300 mA). If the maximum output current is not needed on application, an inductor with lower saturation current can be chosen accordingly. Less than 300 mΩ ESR is suggested for high efficiency and sufficient output current.

Open core inductors cause flux linkage with circuit components and interfere with the normal operation of the circuit. This should be avoided. For high efficiency, choose an inductor with a high frequency core material such as ferrite to reduce the core losses. To minimize radiated noise, use a toroid, pot core or shielded core inductor. The inductor should be connected to the SW pin as close to the IC as possible. Examples of suitable inductors are: TDK SLF6028T-100M1R3, Coilcraft MSS6122-103MLB.

List of Recommended External Components

Symbol	Symbol explanation	Value	Unit	Type
C_{VDD1}	C between V_{DD1} and GND	100	nF	Ceramic, X7R, X5R
C_{VDD2}	C between V_{DD2} and GND	100	nF	Ceramic, X7R, X5R
C_{VDDA}	C between V_{DDA} and GND	1	μF	Ceramic, X7R, X5R
C_{OUT}	C between FB and GND	2x4.7 (1x10)	μF	Ceramic, X7R / X5R
	Minimum capacitance with 20V DC voltage	4.7	μF	
C_{IN}	C between battery voltage and GND	10	μF	Ceramic, X7R, X5R
L1	L between SW and V_{BAT}	10	μH	Shielded, low ESR, I_{SAT} 1.3A
C_{VREF}	C between V_{REF} and GND	100	nF	Ceramic, X7R, X5R
C_{VDDIO}	C between V_{DDIO} and GND	100	nF	Ceramic, X7R, X5R
R_{RT}	R between I_{RT} and GND	82	kΩ	1%
R_{RGB}	R between I_{RGB} and GND	2.4	kΩ	1%
D1	Rectifying diode, V_F at maximum load	0.3-0.5	V	Schottky diode
	Reverse voltage	30	V	
	Repetitive peak current	1.5	A	
C_{SW}	C in EMI filter	100	pF	Ceramic, X7R, X5R, 50V
R_{SW}	R in EMI filter	390	Ω	1%
LEDs				User defined

Notes

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