DESCRIPTION

The A7544 is a high current, high efficiency Synchronous Boost Convertor with power MOSFETs embedded and with output turn off true shutdown function for single cell Li-Ion and Li-polymer battery powered products. The A7544 only consumes a 70μA (typ) quiescent current at no load, and operates in power save PFM mode under light load, which make it very suitable for Always-On applications. It operates in a 500 kHz fixed-frequency PWM mode at 500 kHz under medium to heavy load conditions. It features a current mode control for fast transient response with internal compensation. The A7544 includes cycle-by-cycle current limit and over-temperature protection circuit.

With the A7544, a simple and flexible system design can be achieved, eliminating extra components, saving PCB space, and reducing BOM cost. The A7544 is suitable for iPad-like computers, smart phones and portable handheld devices

The A7544 is available in PSOP8 package.

ORDERING INFORMATION

Package Type	Part Number	
PSOP8	MP8	A7544MP8R
		A7544MP8VR
Note	V: Halogen free Package R: Tape & Reel	
AiT provides all RoHS products Suffix " V " means Halogen free Package		

FEATURES

- More than 93% Efficiency at I_{OUT}=2A V_{OUT} = 5V from 3.6V input. Low 70μA Quiescent Current
- Guaranteed 3.0A Output Current at V_{OUT} = 5V from 3.3V Input
- 500 kHz PWM Switching Frequency
- Synchronous and Embedded Power MOSFETs
- No Schottky Diode Required
- Internal Soft-Start to Limit Inrush Current
- Adjustable Output
- Output turn off true shutdown function
- Current Mode Operation with Internal Compensation
- For Excellent Line and Load Transient Response
- Overload/Short-Circuit Protection
- Shutdown Current <1μA
- Thermal Shutdown
- Available in PSOP8 Package

APPLICATION

- Power Bank
- Battery backup Units
- Battery Powered USB Hub
- Battery Powered Products
- Handheld devices Such as Smart Phone and Tablet PC

TYPICAL APPLICATION

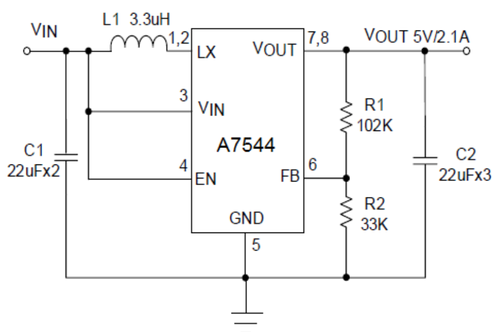
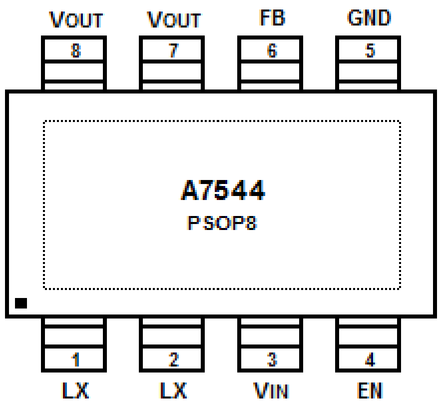


Figure 1 Typical Application Circuit

PIN DESCRIPTION



Top View

Pin #	Symbol	Function
1,2	LX	Inductor Node.
3	V_{IN}	IC Power Supply Input.
4	EN	Enable pin for the IC. Drive this pin high to enable the part, low to disable.
5	GND	IC Analog Ground.
6	FB	Convertor Feedback Input.
7,8	V_{OUT}	Convertor Output.
	EP	Exposed Pad (Power Ground), connect to the ground plane to optimize thermal performance. EP is internally connected to GND. EP must be connected to GND at a single point with a star ground connection.

ABSOLUTE MAXIMUM RATINGS

Input Supply Voltage	-0.3V~+6V
LX Voltage	-0.3V~+6V
V_{OUT} Voltages	-0.3V~+6V
FB Voltages	-0.3V~+6V
V_{IN} Voltage	-0.3V~+6V
EN Voltage	-0.3V~+6V
Package Thermal Resistance[NOTE1]	
θ_{JA}	50°C/W
θ_{JC}	10°C/W
Operating Temperature Range	-40°C ~+85°C
Storage Temperature Range	-65°C~+150°C
Lead Temperature (Soldering, 10s)	+260°C

Stress beyond above listed “Absolute Maximum Ratings” may lead permanent damage to the device. These are stress ratings only and operations of the device at these or any other conditions beyond those indicated in the operational sections of the specifications are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

NOTE1: Thermal Resistance is specified with approximately 1 square of 1oz copper.

ELECTRICAL CHARACTERISTICS[NOTE2]

V_{OUT} =5V, V_{IN}=3.6V, T_A = 25°C, Test Circuit of Figure 1, unless otherwise noted.

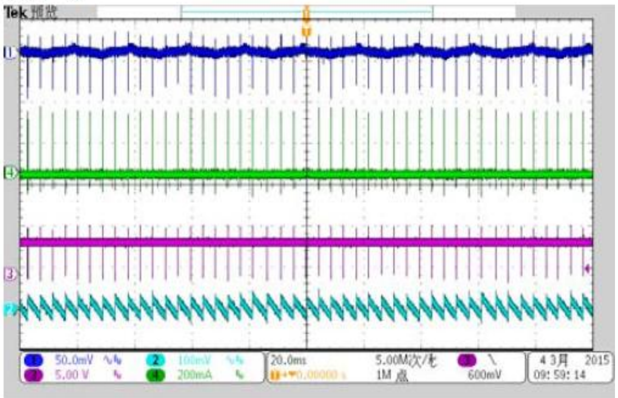
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input Voltage Range	V_{IN}		2.5		5	V
Output Voltage	V_{OUT}	Line and Load Regulation in CCM (I_L>150mA) V_{IN}=2.5V~4.5V	4.925	5	5.075	V
Input Quiescent current	I_{IN}	V_{IN} =3.6V, FB=1.28V No load, no switching (exclude input current from EN)		50	70	μA
Shutdown supply current	I_{IN}	EN=0		0.1	1	μA
Switching Frequency	F_{OSC}		0.35	0.5	0.65	MHz
FB Regulation Voltage	V_{FB}		1.208	1.23	1.246	V
FB Input Current	I_{FB}	FB=1.0V			100	nA
Maximum Duty Cycle	D_{max}	FB=0.95V	86	93	96	%
V_{OUT} Leakage Current	I_{PVOUT_LK}	EN=0 , V_{OUT}=5V		1	5	μA
LX Leakage Current	I_{LX_LK}	EN=0 , V_{OUT}=5V		1	5	μA
Switch ON Resistance	R_{ON}-N			52	70	mΩ
	R_{ON}-P			49	65	mΩ
Peak Current Limit	I_LIM			5		A
Efficiency		EN=1,V_{IN}=3.6V, V_{OUT}=5V, I_{OUT}=2A		93		%
Thermal Shutdown Threshold		Rising Edge, 20°C hysteresis		150		°C
EN Input High Level	Vih_EN		1.5		5.5	V
EN Input Low Level	Vil_EN		0		0.5	V
EN Internal Pull-Low Resistance	Rin_EN		200	250	300	kΩ

NOTE2: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

TYPICAL PERFORMANCE CHARACTERISTICS

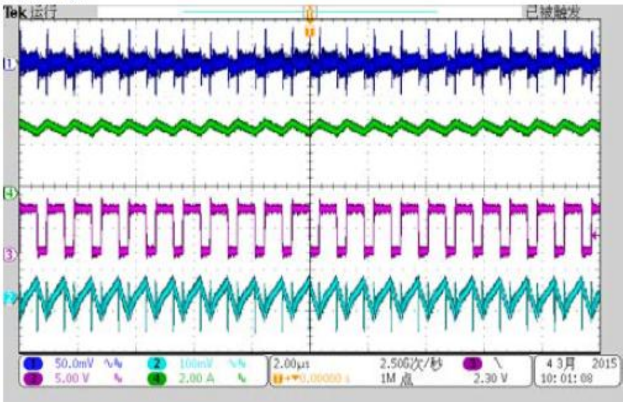
1. **Operation**(CH1=V_{IN},CH2=V_O,CH3=LX,CH4=I_{LX})

I_{OUT} =0



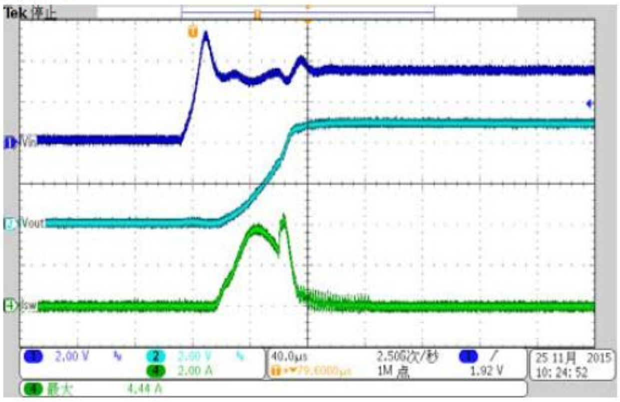
2. **Operation**(CH1=V_{IN},CH2=V_O,CH3=LX,CH4=I_{LX})

I_{OUT} =2A



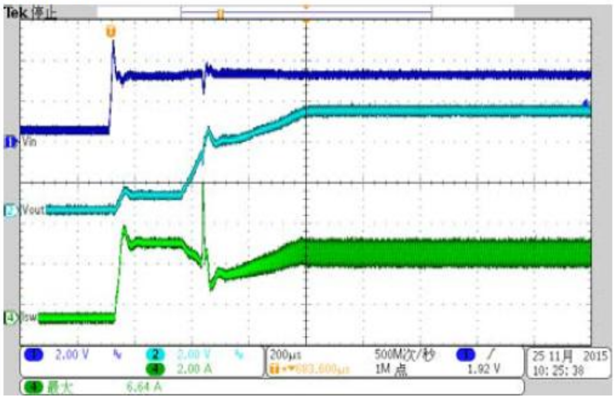
3. **Start Up**

I_{OUT} =0

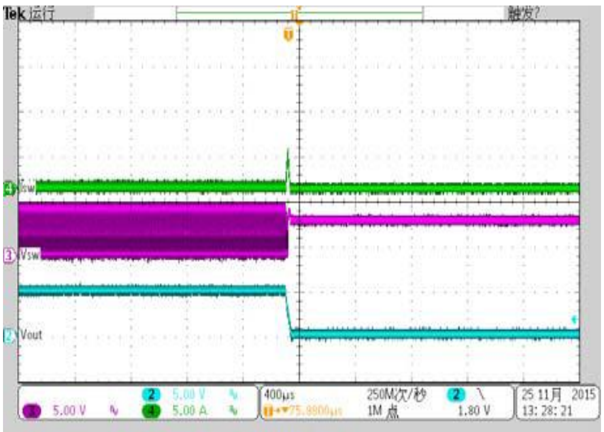


4. **Start Up**

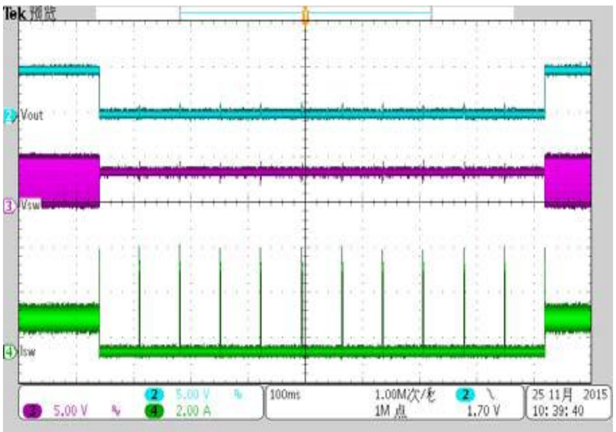
I_{OUT} =2A



5. **Over Current**

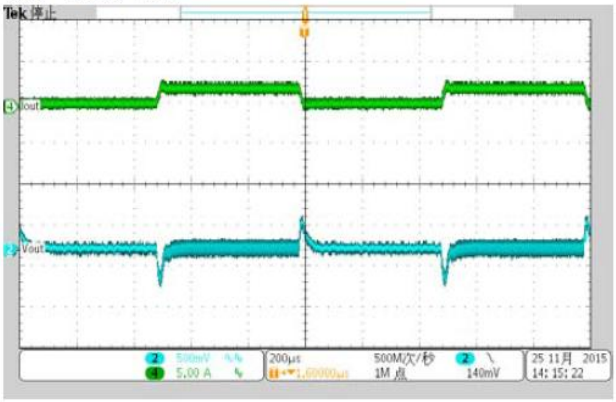


6. **Short Circuit**



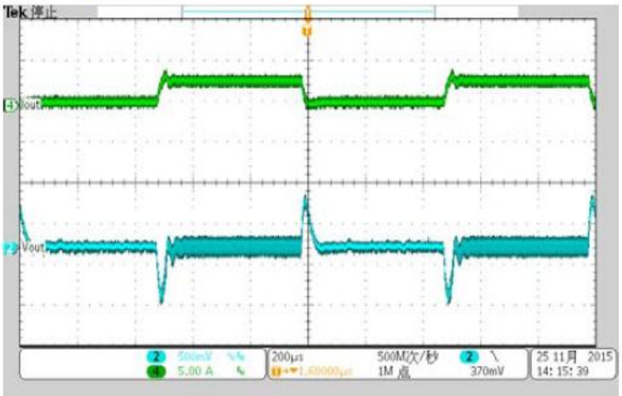
7. Load Transient Response

I_{OUT} =0.2A-1.5A

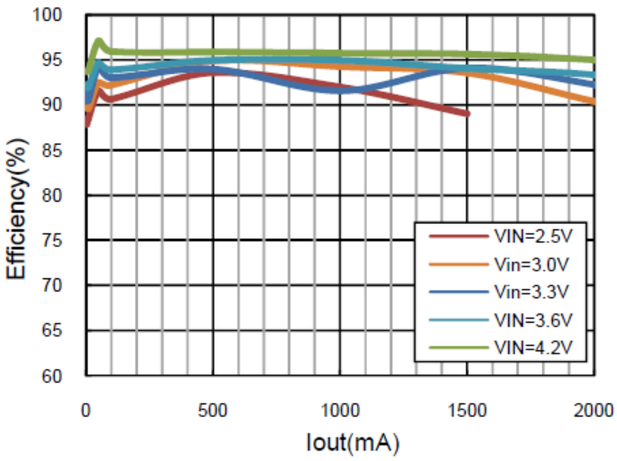


8. Load Transient Response

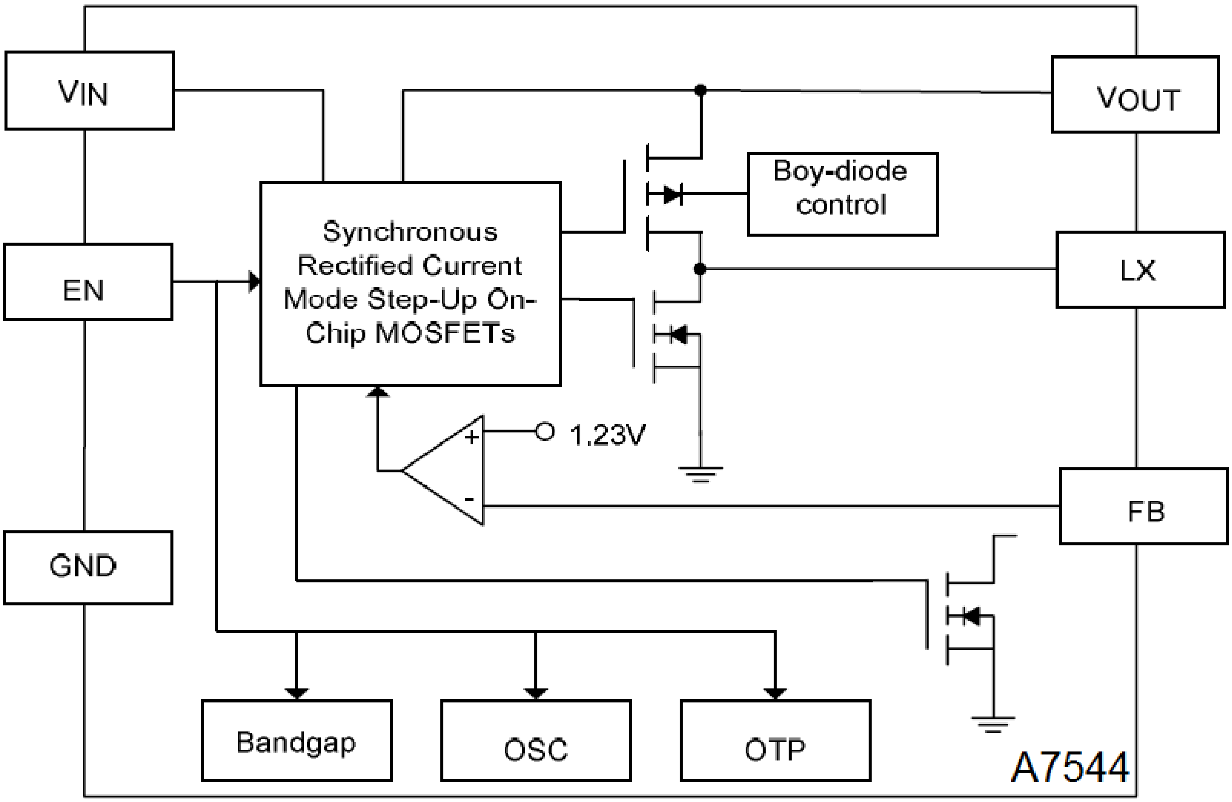
I_{OUT} =0.2A-2A



9. Efficiency vs. I_{OUT} @V_{OUT} =5V



BLOCK DIAGRAM



DETAILED INFORMATION

Application Information

Operation

The A7544 is current-mode boost DC-DC switching convertor using fixed-frequency PWM architecture with output true shutdown function. Under no load and light-load conditions, the convertor enters PFM power save mode, reducing switching frequency and minimizing IC quiescent current, consuming only 70μA of quiescent current. Under medium to heavy-load conditions, the convertor operates with 500kHz constant switching frequency thus enabling noise filtering. The A7544 is highly efficient, with internal and synchronous switches. Shutdown reduces the quiescent current to less than 0.1μA. Low quiescent current and high efficiency make this device ideal for portable equipment. The A7544 Boost DC-DC switching convertor typically generates a 5V output voltage from a single cell Li-Ion and Li-polymer battery input voltage. The minimum output peak current limit is 5A in PSOP8 package. When an over-current, short-circuit or thermal shutdown condition is encountered. The convertor will turn off until the overcurrent or over-temperature condition is removed. The A7544 is optimized for use in iPad-like computers, smart phones, portable handheld devices and other applications requiring low quiescent current for maximum battery life.

Typical Applications

Design Requirements

The design parameters for the A7544 5V/2.1A typical application are listed in Table 1

Table 1 Design Parameters for typical Application

Design Parameters	Design Spec
Input Voltage Range	3.2V to 4.35V
Output Voltage	5V
Output current	2.1A
Output current limits	2.4A
Operating Frequency	500kHz

Diagram for A7544 typical Application

The diagram for the typical application is showed as the Figure 2.

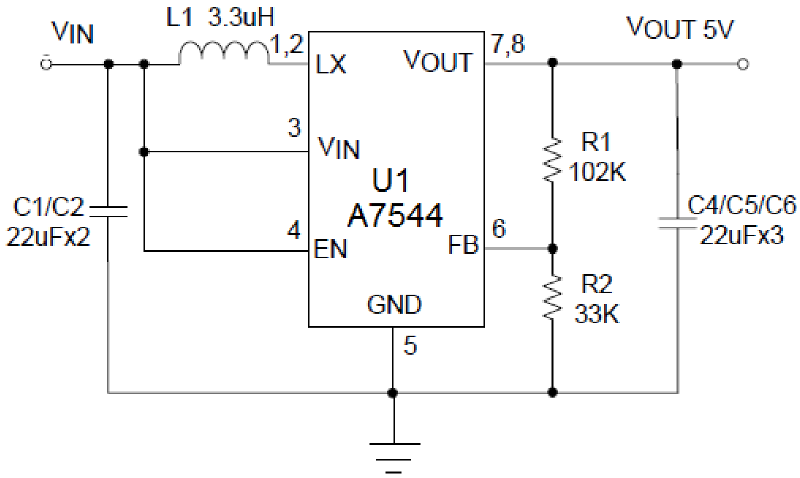


Figure 2 A7544 Typical Application Diagram

BOM for A7544 typical Application

Ref. No.	Values	Description
C1, C2	22μF/6.3V	0805 X5R Ceramic Cap
C4, C5, C6	22μF/10V	0805 X5R Ceramic Cap
L1	3.3μH	AiT-C PIA8040-3R3N
R1	102 kΩ	0603 Resistor
R2	33 kΩ	0603 Resistor

Programming the Output Voltage

The A7544's output voltage needs to be programmed via an external voltage divider at the FB pin (pin 6 of A7544). The following equation can be used to calculate R1 and R2.

$$V_{OUT} = V_{FB} \times \left(1+\frac{R_1}{R_2}\right) = 1.23V \times \left(1+\frac{R_1}{R_2}\right) \qquad (1)$$

For the best accuracy, the current following through R2 should be 100 times larger than FB pin leakage current. Changing R2 towards a lower value increases the robustness against noise injection. Changing R2 towards higher values reduces the FB divider current for achieving the lowest quiescent current under no load condition.

In this design example, 102 kohm and 33 kohm resistors are selected for R1 and R2. High accuracy like 1% Resistors are recommended for better output voltage accuracy.

Inductor Selection

For the Boost convertor, the average input current can be calculated by Equation 2:

$$I_{IN\_avg} = \frac{I_{OUT}}{1-D} \qquad (2)$$

Where:

D is the duty cycle

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \qquad (3)$$

The inductance of the inductor cab be calculated by Equation 4

$$L = \frac{V_{IN} \times D}{\Delta I_L \times f_{SW}} \qquad (4)$$

Where:

ΔI_L is the ripple current passing through the inductor, normally selecting 30% of the average input current as the ripple current of the inductor.

When estimating the inductance of the inductor, the minimum input voltage，the maximum output current and the minimum switching frequency in the typical application should be used for the worst case calculation. In this example, the minimum V_{IN} is 3.2 V, maximum I_{OUT} is 2.4 A, and minimum f_{sw} is 350 kHz，so the average input current is 3.75 A, the inductance is 3.3 μH

It is advisable to select an inductor with a saturation current I_{SAT} higher than the possible peak current following through the inductor. The inductor's current rating I_{RMS} should be higher than the average input current. The inductor peak current can be calculated by the equation 5

$$I_{L\_peak} = I_{IN\_avg} + \frac{\Delta I_L}{2} \qquad (5)$$

Selecting a 3.3 μH inductor with insufficient saturation current can lead to excessive peak current in the convertor. This could eventually harm the device and reduce reliability. To leave enough margins, it is recommended to choose saturation current 20% to 30% higher than I_{L_peak}.

The following inductors are recommended to be used in designs:

Vendor	P/N	L(μH)	DCR(mΩ)	Isat(A)
AiT-C	PIA8040-3R3N	3.3	13	6.1
AiT-C	WSS1204-3R3NA	3.3	10.4	7.8
AiT-C	WSI07030-3R3M	3.3	19.9	8

Output Capacitor Selection

For the output capacitor, it is recommended to use small X5R or X7R ceramic capacitors placed as close as possible to the V_{OUT} and PGND EP pin of the IC. If, for any reason, the application requires the use of large capacitors which cannot be placed close to the IC, using a smaller ceramic capacitor of 1 μF or 0.1 μF in parallel to the large one is highly recommended. This small capacitor should be placed as close as possible to the V_{OUT} and PGND pin of the IC.

The A7544 requires at least 44 μF effective capacitance at output for stability consideration. Care must be taken when evaluating a capacitor's de-rating under bias. The bias can significantly reduce the effective capacitance. Ceramic capacitors can have losses of as much as 50% of their capacitance at rated voltage. Therefore, leave margin on the voltage rating to ensure adequate effective capacitance. In this example, three 22 μF capacitors of 10 V rating are used. The ESR impact on the output ripple must be considered as well if tantalum or electrolytic capacitors are used. Assuming there is enough capacitance such that the ripple due to the capacitance can be ignored, the ESR needed to limit the V_{Ripple} is:

$$V_{Ripple} = I_{L\_peak} \times ESR \qquad (6)$$

Input Capacitor Selection

Multilayer X5R or X7R ceramic capacitors are an excellent choice for input decoupling of the boost convertor as they have extremely low ESR and are available in small footprints. Input capacitors should be located as close as possible to the device. The required minimum effective capacitance at input for the A7544 is 10 μF. Considering the capacitor's de-rating under bias, a 22 μF input capacitor is recommended, and a 22 μF input capacitor should be sufficient for most applications. There is no limitation to use larger capacitors. It is recommended to put the input capacitor close to the V_{IN} and GND EP pin of the IC. If, for any reason, the input capacitor cannot be placed close to the IC, putting a small ceramic capacitor of 1 μF or 0.1 μF close to the IC's V_{IN} pin and GND pin is recommended.

Take care when a ceramic capacitor is used at the input and the power is being supplied through long wires, such as from a wall adapter. A load step at the output may cause ringing at the V_{IN} pin due to the inductance of the long wires. This ringing can couple to the output and be mistaken as loop instability or could even damage the part.

Additional bulk capacitance (electrolytic or tantalum) should in this circumstance be placed between C_{IN} and the power source to reduce ringing.

Layout Guidelines

For all switching power supplies, layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems. Therefore, use wide and short traces for the main current paths and the power ground tracks. The input capacitor, output capacitor, and the inductor should be placed as close as possible to the IC. Use a common ground node for power ground and a different one for control/analog ground to minimize the effects of ground noise. Connect these ground nodes near the ground pins of the IC. The most critical current path for all boost convertors is from the switching FET, through the synchronous FET, the output capacitors, and back to the ground of the switching FET. Therefore, the output capacitors and their traces should be placed on the same board layer as the IC and as close as possible between the V_{OUT} and PGND pins of the IC. See Figure 3 for the recommended layout.

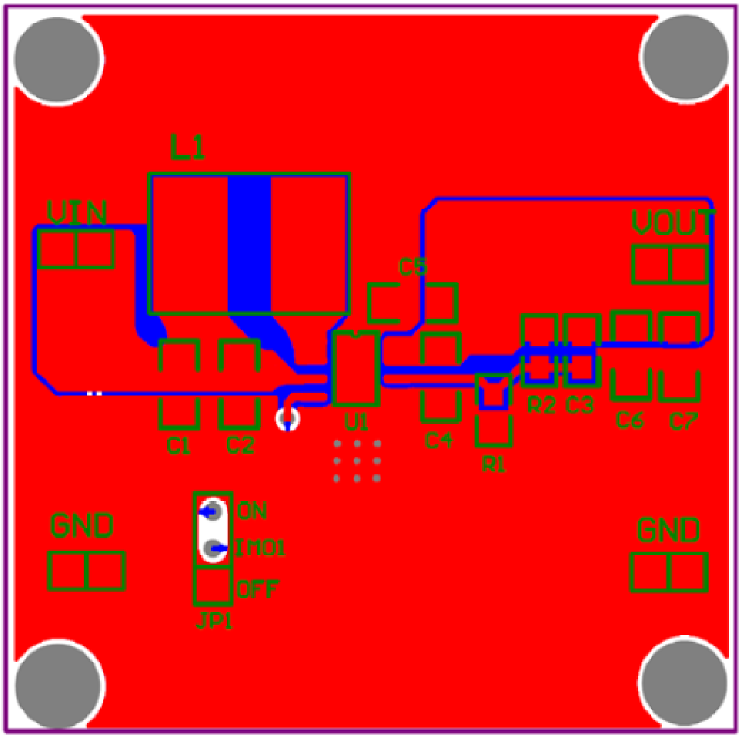
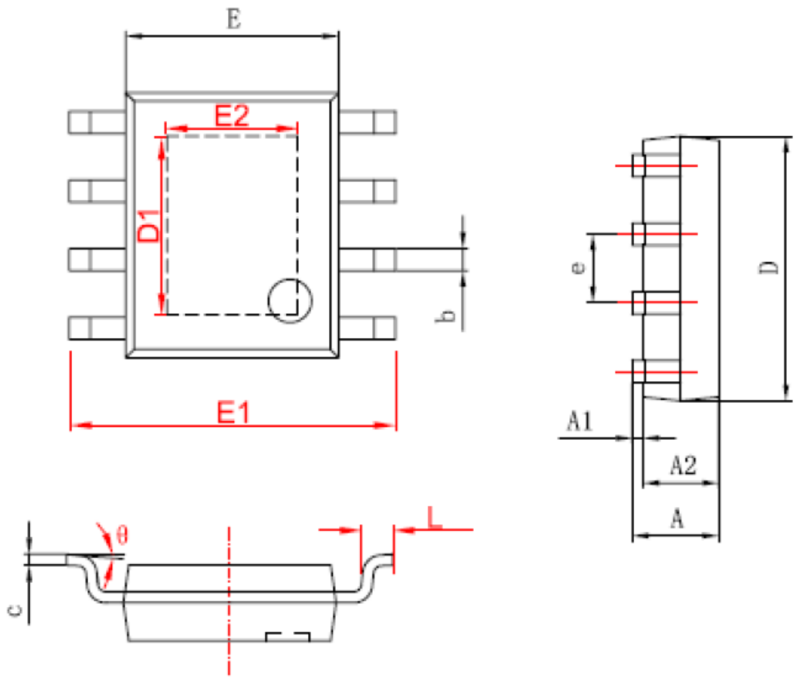


Figure 3 A7544 Recommended PCB Layout

PACKAGE INFORMATION

Dimension in PSOP8(EXP PAD) Package (Unit: mm)



Symbol	Millimeters		Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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