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# AP1534

## PWM CONTROL 2A STEP-DOWN CONVERTER

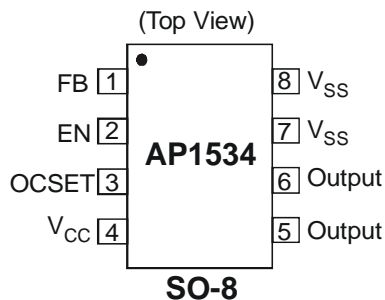
### Description

AP1534 consists of step-down switching regulator with PWM control. These devices include a reference voltage source, oscillation circuit, error amplifier, internal PMOS.

AP1534 provides low-ripple power, high efficiency, and excellent transient characteristics. The PWM control circuit is able to vary the duty ratio linearly from 0 up to 99%. This converter also contains an error amplifier circuit as well as a soft-start circuit that prevents overshoot at startup. An enable function, an over current protect function and a short circuit protect function are built inside, and when OCP or SCP happens, the operation frequency will be reduced from 300KHz to 50KHz. Also, an internal compensation block is built in to minimize external component count.

With the addition of an internal P-channel Power MOS, a coil, capacitors, and a diode connected externally, these ICs can function as step-down switching regulators. They serve as ideal power supply units for portable devices when coupled with the SO-8 mini-packages, providing such outstanding features as low current consumption. Since this converter can accommodate an input voltage up to 18V, it is also suitable for the operation via an AC adapter.

### Pin Assignments



### Features

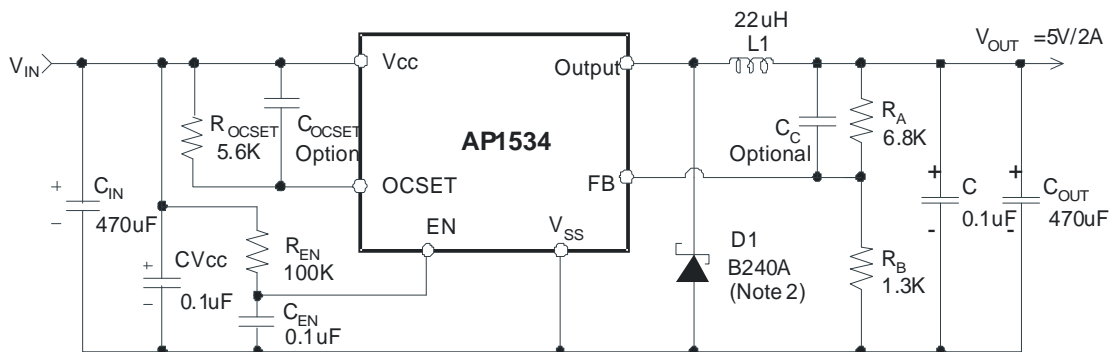
- Input voltage: 3.6V to 18V
- Output voltage: 0.8V to  $V_{CC}$
- Duty ratio: 0% to 99% PWM control
- Oscillation frequency: 300KHz typical
- Current limit, Enable function
- Thermal Shutdown function
- Built-in internal SW P-channel MOS
- SO-8: Available in "Green" Molding Compound (No Br, Sb)
- Lead Free Finish/RoHS Compliant (Note 1)

### Applications

- PC Motherboard
- LCD Monitor
- Graphic Card
- DVD-Video Player
- Telecom Equipment
- ADSL Modem
- Printer and other Peripheral Equipment
- Microprocessor Core Supply

Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at [http://www.diodes.com/products/lead\\_free.html](http://www.diodes.com/products/lead_free.html).

### Typical Application Circuit



Note:  $V_{OUT} = V_{FB} \times (1 + R_A / R_B)$   
 $R_B = 0.7K \sim 5K\Omega$

Notes: 2. Suggested DIODES Power Schottky P/N: B240/B340 series.



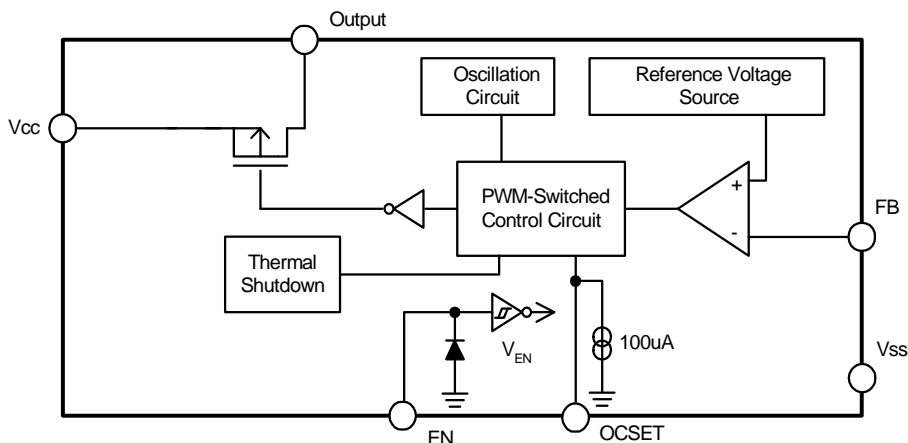
# AP1534

## PWM CONTROL 2A STEP-DOWN CONVERTER

### Pin Descriptions

Pin Name	Pin No.	Description
FB	1	Feedback pin
EN	2	Power-off pin H: Normal operation (Step-down operation) L: Step-down operation stopped (All circuits deactivated)
OCSET	3	Add an external resistor to set max output current
V <sub>CC</sub>	4	IC power supply pin
Output	5, 6	Switch Pin. Connect external inductor/diode here. Minimize trace area at this pin to reduce EMI
V <sub>SS</sub>	7, 8	GND Pin

### Functional Block Diagram



### Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
ESD HBM	Human Body Model ESD Protection	4.5	KV
ESD MM	Machine Model ESD Protection	150	V
V <sub>CC</sub>	VCC Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>SS</sub> + 20	V
V <sub>FB</sub>	Feedback Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>CC</sub>	V
V <sub>EN</sub>	EN Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>IN</sub>	V
V <sub>OUT</sub>	Switch Pin Voltage	V <sub>SS</sub> - 1.0 to V <sub>IN</sub>	V
P <sub>D</sub>	Power Dissipation	Internally limited	mW
T <sub>J</sub>	Operating Junction Temperature Range	-40 to +125	°C
T <sub>ST</sub>	Storage Temperature Range	-65 to +150	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.



# AP1534

## PWM CONTROL 2A STEP-DOWN CONVERTER

### Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Input Voltage	3.6	18	V
$I_{OUT}$	Output Current	0	2	A
$T_A$	Operating Ambient Temperature	-20	85	°C

### Electrical Characteristics ( $V_{IN} = 12V$ , $T_A = 25^\circ C$ , unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
$V_{FB}$	Feedback Voltage	$I_{OUT} = 0.1A$	0.784	0.8	0.816	V
$I_{FB}$	Feedback Bias Current	$I_{OUT} = 0.1A$	-	0.1	0.5	$\mu A$
$I_{SW}$	Switch Current	--	2.0	-	-	A
$I_{SHDN}$	Current Consumption During Power Off	$V_{EN} = 0V$	-	10	-	$\mu A$
$\frac{\Delta V_{OUT}}{V_{IN}}$	Line Regulation	$V_{IN} = 5V \sim 18V$	-	1	2	%
$\frac{\Delta V_{OUT}}{I_{OUT}}$	Load Regulation	$I_{OUT} = 0.1$ to 2A	-	0.2	0.5	%
$f_{OSC}$	Oscillation Frequency	Measure waveform at SW pin	240	300	400	KHz
$f_{OSC1}$	Frequency of Current Limit or Short Circuit Protect	Measure waveform at SW pin	-	50	-	KHz
$V_{IH}$	EN Pin Input Voltage	Evaluate oscillation at SW pin	2.0	-	-	V
$V_{IL}$		Evaluate oscillation stop at SW pin	-	-	0.8	
$I_{SH}$	EN Pin Input Leakage Current	--	-	20	-	$\mu A$
$I_{SL}$		--	-	-10	-	$\mu A$
$I_{OCSET}$	OCSET Pin Bias Current	--	75	90	105	$\mu A$
$R_{DS(ON)}$	Internal MOSFET $R_{DS(ON)}$	$V_{IN} = 5V, V_{FB} = 0V$	-	160	-	m $\Omega$
		$V_{IN} = 12V, V_{FB} = 0V$	-	100	-	
EFFI	Efficiency	$V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 2A$	-	91	-	%
$T_{SHDN}$	Thermal shutdown threshold		-	150	-	°C
$T_{HYS}$	Thermal shutdown hysteresis		-	55	-	°C
$\theta_{JA}$	Thermal Resistance Junction-to-Ambient	SO-8 (Note 3)	-	127	-	°C/W
$\theta_{JC}$	Thermal Resistance Junction-to-Case	SO-8 (Note 3)	-	28	-	°C/W

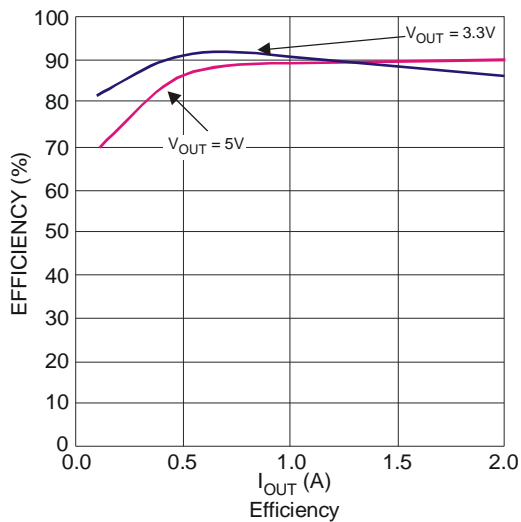
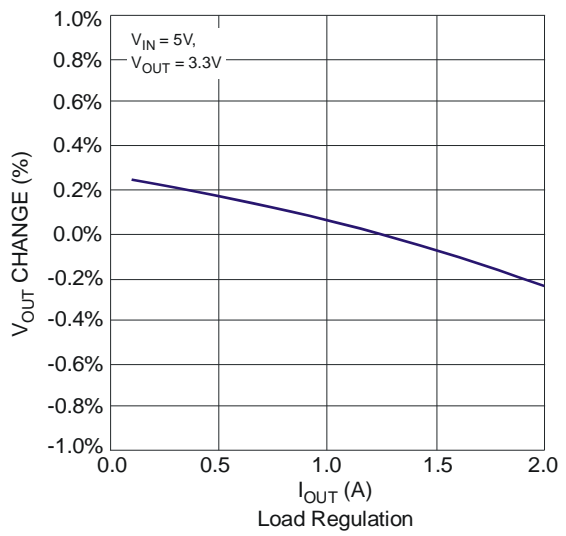
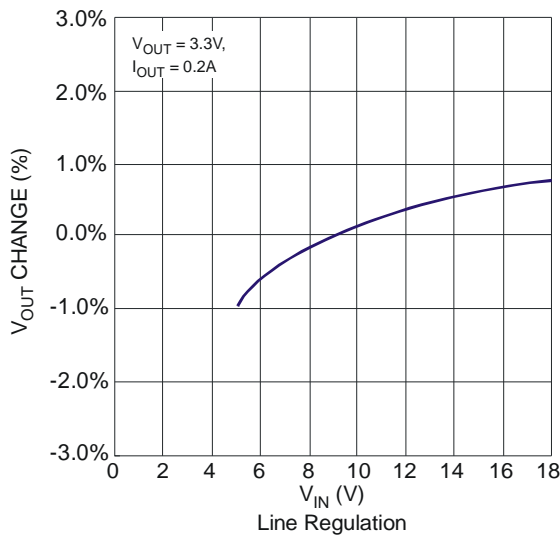
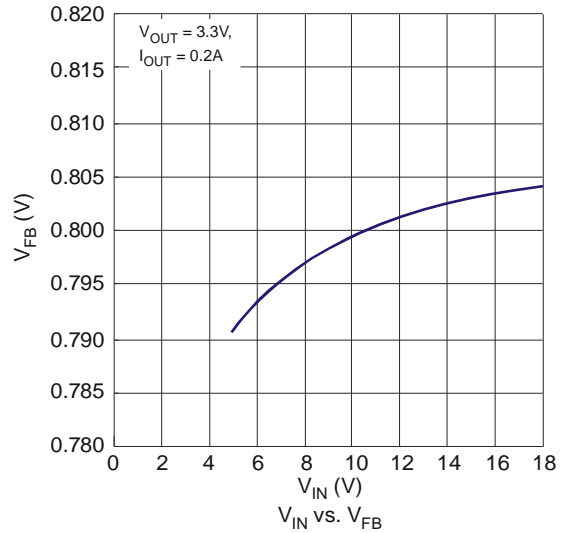
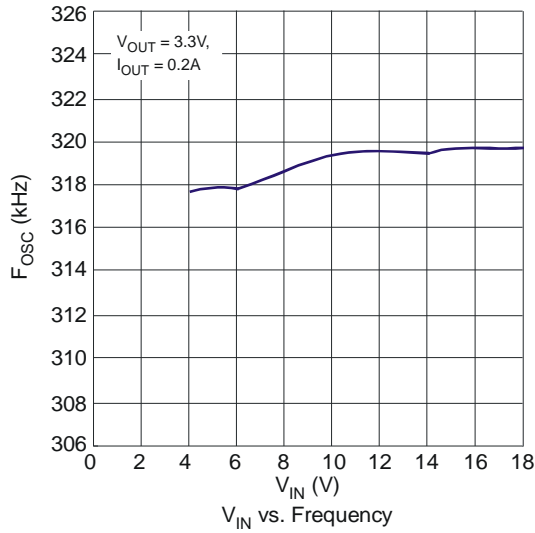
Notes: 3. Test condition for SO-8: Device mounted on FR-4 substrate PC board, 2oz copper, with minimum recommended pad layout. For better thermal performance, larger copper pad for heatsink is needed.



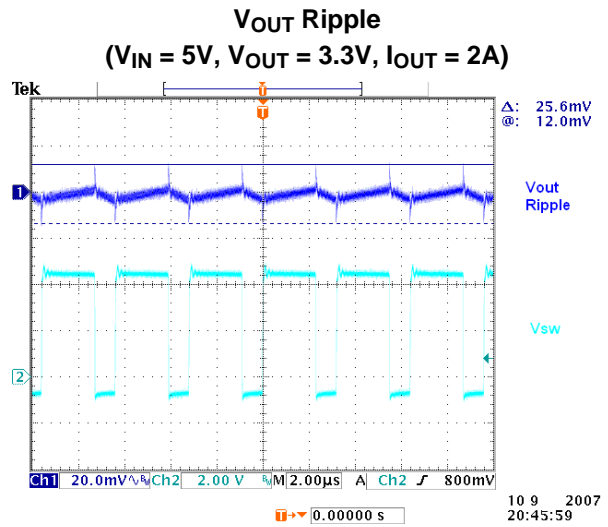
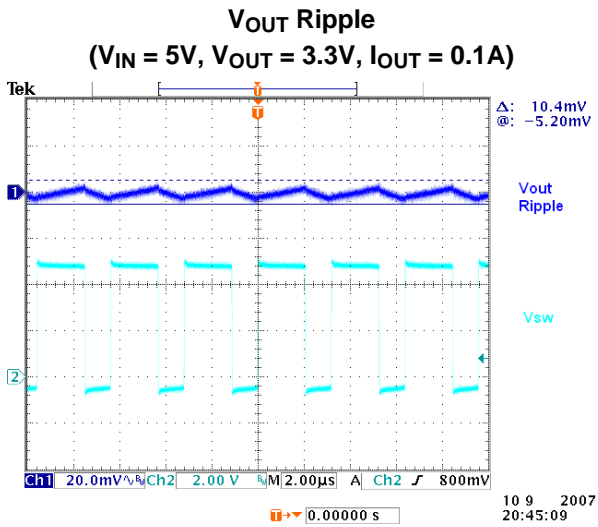
# AP1534

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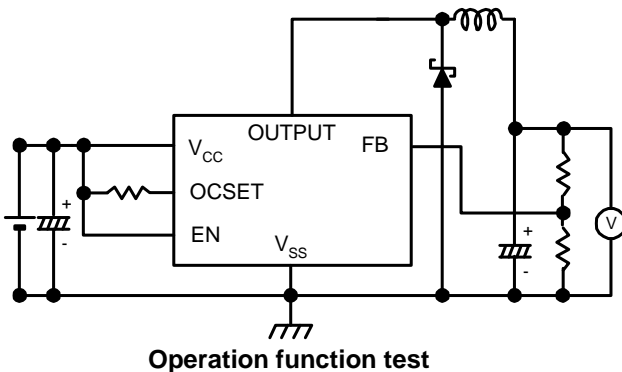
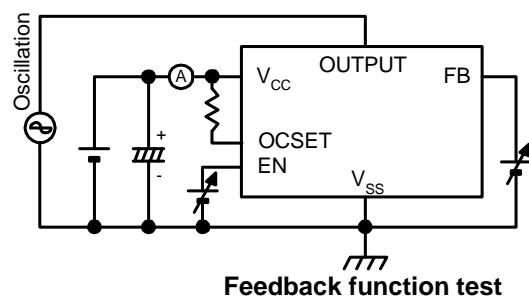
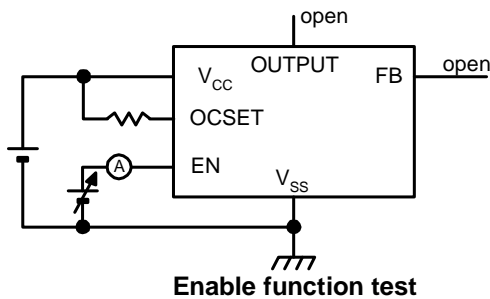
### Typical Performance Characteristics



**Typical Performance Characteristics (cont.)**



**Test Circuit**





# AP1534

## PWM CONTROL 2A STEP-DOWN CONVERTER

### Functional Description

#### PWM Control

The AP1534 is a DC/DC converter that employs pulse width modulation (PWM) scheme. Its pulse width varies in the range of 0% to 99%, based on the output current loading. The output ripple voltage caused by the PWM high frequency switching can easily be reduced through an output filter. Therefore, this converter provides a low ripple output supply over a broad range of input voltage & output current loading.

#### Under Voltage Lockout

The under voltage lockout circuit of the AP1534 assures that the high-side MOSFET driver remains in the off state whenever the supply voltage drops below 3.3V. Normal operation resumes once V<sub>CC</sub> rises above 3.5V.

#### Current Limit Protection

The current limit threshold is set by external resistor R<sub>OCSET</sub> connected from V<sub>CC</sub> supply to OCSET pin. The internal sink current I<sub>OCSET</sub> (90uA typical) across this resistor sets the voltage at OCSET pin. When the PWM voltage is less than the voltage at OCSET, an over-current condition is triggered.

The current limit threshold is given by the following equation:

$$I_{PEAK} \times R_{DS(ON)} = I_{OCSET} \times R_{OCSET}$$

$$I_{PEAK} > I_{OUT(MAX)} + \frac{(\Delta I)}{2}$$

where,

$$\Delta I = \frac{V_{IN} - V_{OUT}}{F_S \times L} \times \frac{V_{OUT}}{V_{IN}}$$

I<sub>PEAK</sub> is the output peak current; R<sub>DS(ON)</sub> is the MOSFET ON resistance; F<sub>S</sub> is the PWM frequency (300KHz typical). Also, the inductor value will affect the ripple current ΔI.

The above equation is recommended for input voltage range of 5V to 18V. For input voltage lower than 5V or ambient temperature over 100°C, higher R<sub>OCSET</sub> is recommended.

The recommended minimum R<sub>OCSET</sub> value is summarized below:

V <sub>IN</sub> (V)	V <sub>OUT</sub> (V)	R <sub>OCSET</sub> (Ω)
4	1	6.8K
5	3.3	5.6K
12	5	3.9K
18	12	4.7K

#### Inductor Selection

For most designs, the operates with inductors of 22μH to 33μH. The inductor value can be derived from the following equation:

$$L = \frac{V_{IN} - V_{OUT}}{f_S \times \Delta I} \times \frac{V_{OUT}}{V_{IN}}$$

Where ΔI<sub>L</sub> is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple current. Choose inductor ripple current approximately 15% of the maximum load current 2A, ΔI<sub>L</sub>=0.3A. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (2A+0.15A).

#### Input Capacitor Selection

This capacitor should be located close to the IC using short leads and the voltage rating should be approximately 1.5 times the maximum input voltage. The RMS current rating requirement for the input capacitor of a buck regulator is approximately 1/2 the DC load current. A low ESR input capacitor sized for maximum RMS current must be used. A 470μF low ESR capacitor for most applications is sufficient.

#### Output Capacitor Selection

The output capacitor is required to filter the output voltage and provides regulator loop stability. The important capacitor parameters are the 100KHz Equivalent Series Resistance (ESR), the RMS ripples current rating, voltage rating and capacitance value. For the output capacitor, the ESR value is the most important parameter. The output ripple can be calculated from the following formula.

$$V_{RIPPLE} = \Delta I_L \times ESR$$

The bulk capacitor's ESR will determine the output ripple voltage and the initial voltage drop after a high slew-rate transient.

An aluminum electrolytic capacitor's ESR value is related to the capacitance and its voltage rating. In most case, higher voltage electrolytic capacitors have lower ESR values. Most of the time, capacitors with much higher voltage ratings may be needed to provide the low ESR values required for low output ripple voltage.

**Functional Description (cont.)**

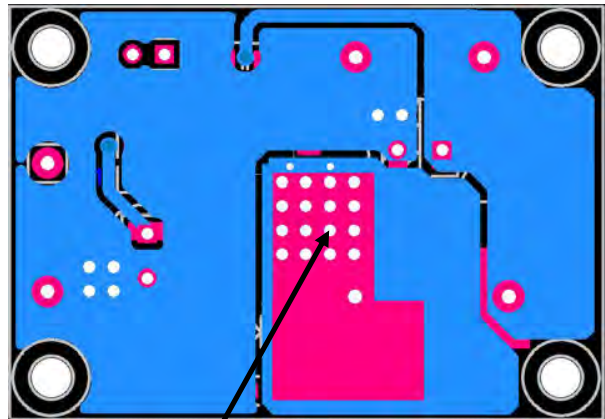
**PCB Layout Guide**

If you need low  $T_C$  &  $T_J$  or large  $P_D$  (Power Dissipation), The dual SW pins (5 & 6) and  $V_{SS}$  pins(7 & 8) on the SO-8 package are internally connected to die pad, The evaluation board should be allowed for maximum copper area at output (SW) pins.

1. Connect FB circuits ( $R_A$ ,  $R_B$ ,  $C_C$ ) as closely as possible and keep away from inductor flux for pure  $V_{FB}$ .
2. Connect  $C_{VCC}$  to Vcc and  $V_{SS}$  pin as closely as possible to get good power filter effect.
3. Connect  $R_{OCSET}$  to Vcc and OCSET pin as closely as possible.
4. Connect ground side of the  $C_{IN}$  & D1 &  $C_{OUT}$  as closely as possible and use ground plane for best performance.

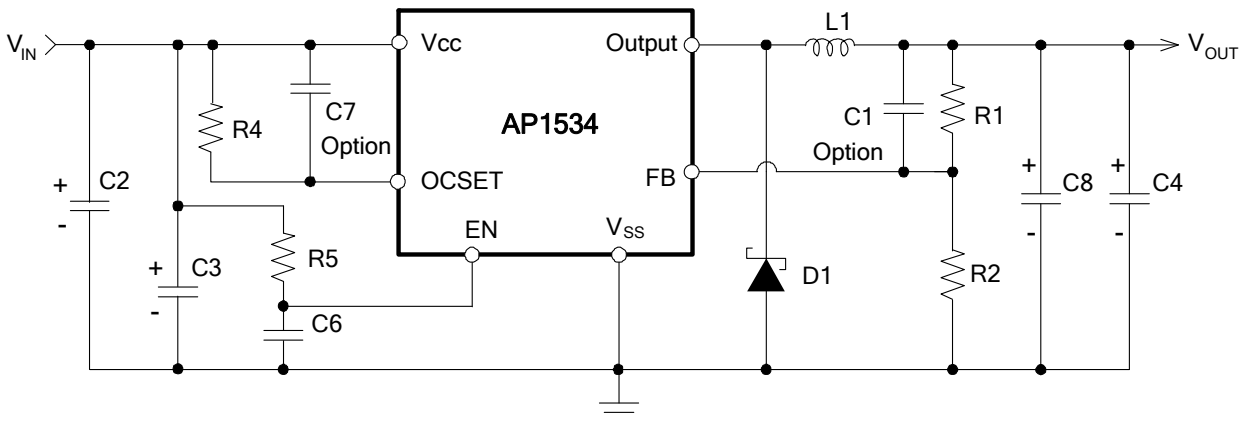
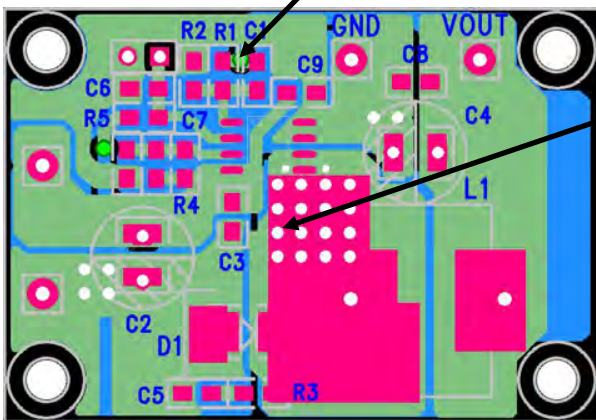
Connect FB circuits closer and keep away from L1.

**Bottom Side Layout Guide**



Use vias to conduct the heat into the backside of PCB layer. The heat sink at output (SW) pins should be allowed for maximum solder-painted area.

**Top Side Layout Guide**



Layout numbering comparison







**AP1534**

**PWM CONTROL 2A STEP-DOWN CONVERTER**

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