2A 32V Synchronous Rectified Step-Down Converter TD1519

General Description

The TD1519 is a monolithic synchronous buck regulator. The device integrates two 90mΩ MOSFETs, and provides 2A of continuous load current over a wide input voltage of 4.75V to 32V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1μA.

This device, availablein an SOP8-PP package, provides a very compact solution with minimal external components.

Features

- 2A Output Current
- Wide 4.75V to 32V Operating Input Range
- Integrated 90mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 30V
- Up to 93% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

Package Types

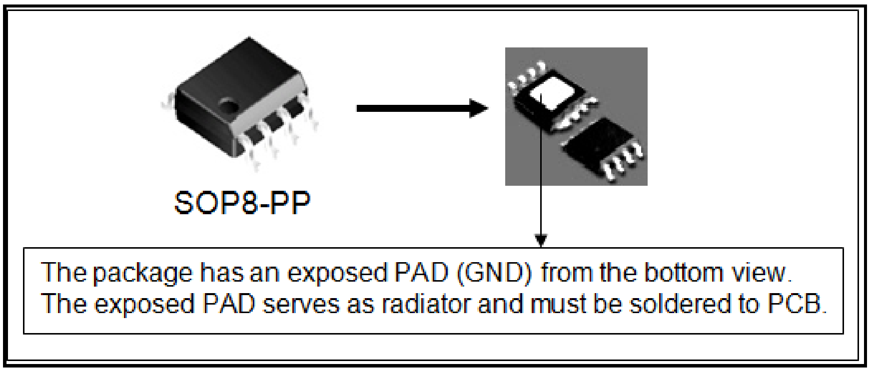


Figure 1. Package Types of TD1519

Pin Configurations

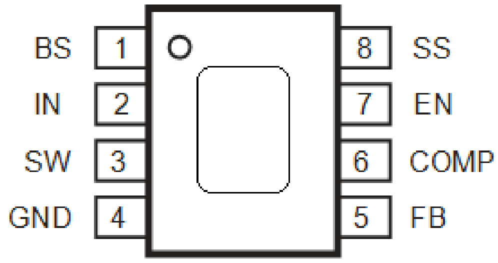
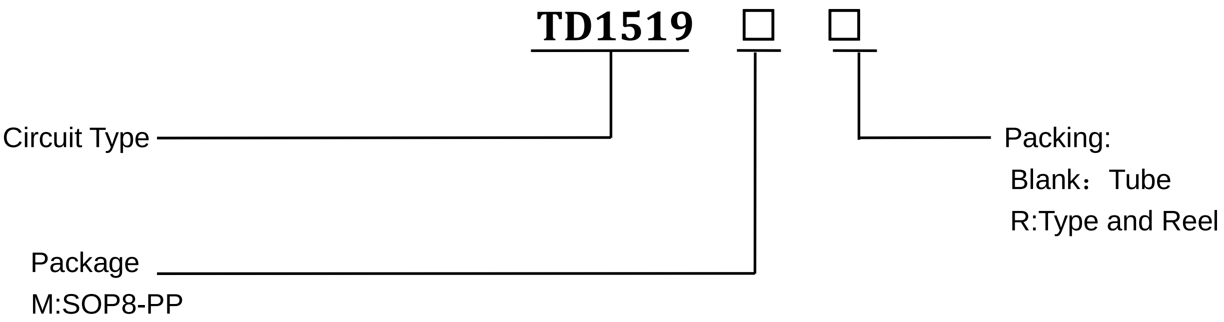


Figure 2 Pin Configuration of TD1519(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01µF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 32V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1µF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

Ordering Information



Function Block

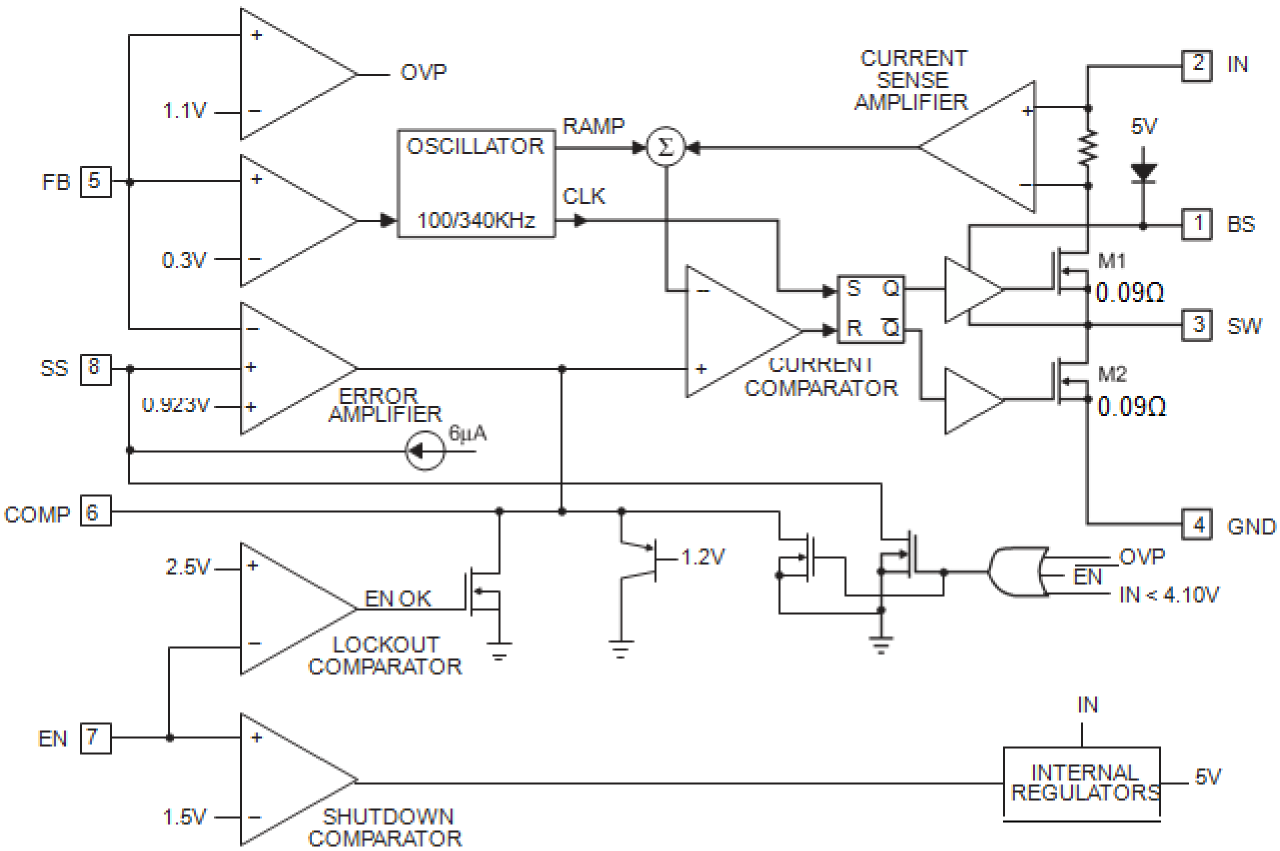


Figure 3 Function Block Diagram of TD1519

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 32	V
Switch Node Voltage	V_{SW}	30	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 30	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	90	ºC / W
Thermal Resistance-Junction to Case	RθJC	45	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	ΔIC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			90		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			90		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	4.0	5.8		A
Lower Switch Current Limit		From Drain to Source		0.9		A
COMP to Current Sense Transconductance	GCS			4.8		A/V
Oscillation Frequency	Fosc1			340		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		µA
Soft-Start Period		C_{SS} = 0.1µF		15		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

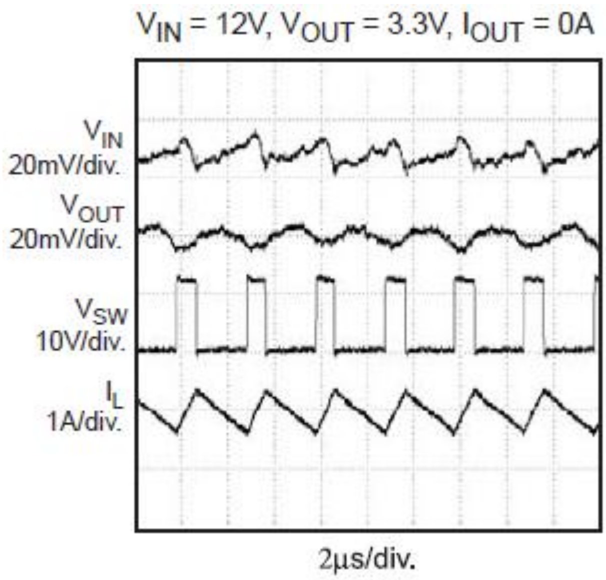


Figure 4. Steady State Test

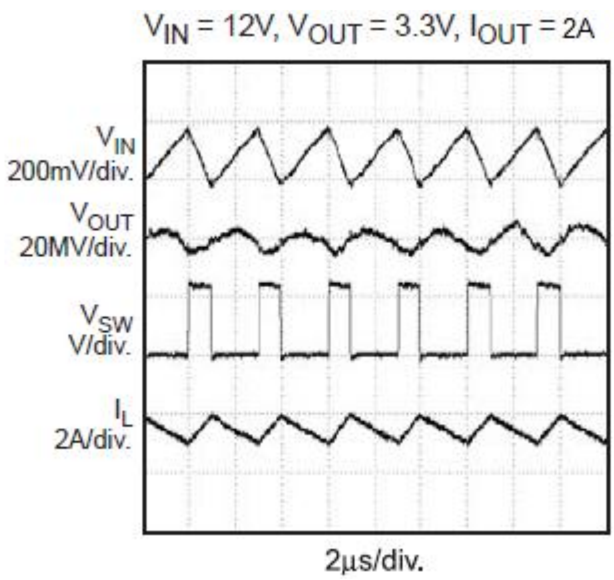


Figure 5. Steady State Test

2A 32V Synchronous Rectified Step-Down Converter TD1519A

General Description

The TD1519A is a monolithic synchronous buck regulator. The device integrates two 90mΩ MOSFETs, and provides 2A of continuous load current over a wide input voltage of 4.75V to 32V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1µA.

This device, availablein an SOP8-PP package, provides a very compact solution with minimal external components.

Features

- 2A Output Current
- Wide 4.75V to 32V Operating Input Range
- Integrated 90mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 30V
- Up to 93% Efficiency
- Programmable Soft-Start
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- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
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- Green Electronics/ Appliances
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Package Types

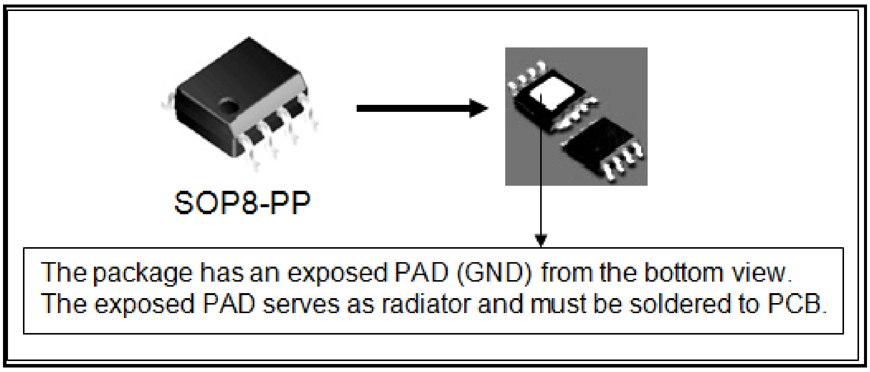


Figure 1. Package Types of TD1519

Pin Configurations

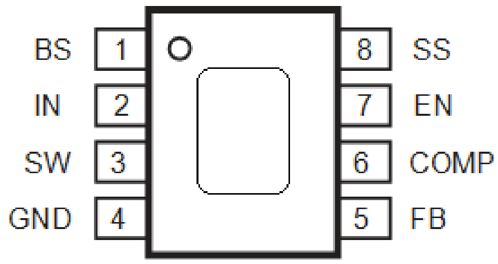


Figure 2 Pin Configuration of TD1519A(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01µF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 32V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1µF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

2A 32V Synchronous Rectified Step-Down Converter TD1519A

Ordering Information

TD1519A □ □

Circuit Type

Package
M:SOP8-PP

Packing:
Blank：Tube
R:Type and Reel

Function Block

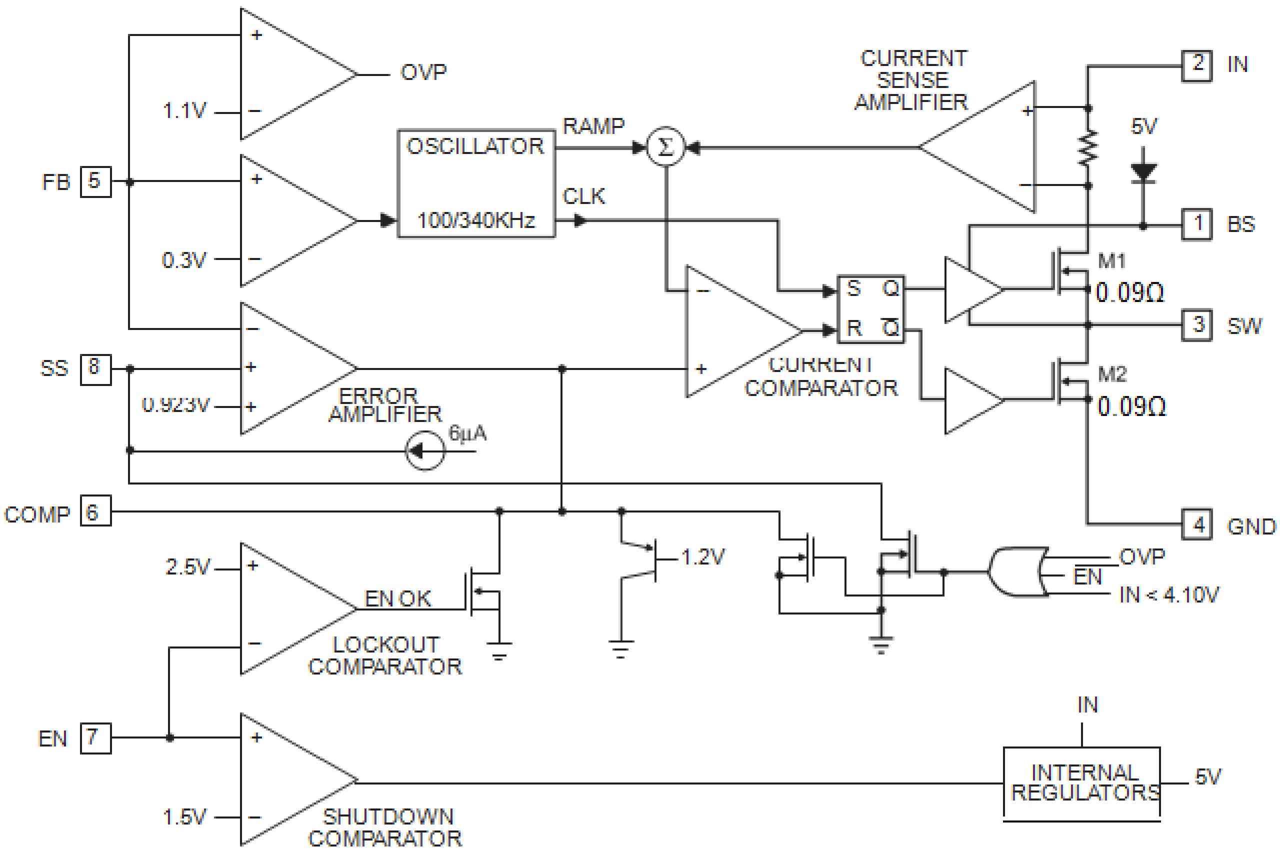


Figure 3 Function Block Diagram of TD1519A

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 32	V
Switch Node Voltage	V_{SW}	30	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 30	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	90	ºC / W
Thermal Resistance-Junction to Case	RθJC	45	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	∆IC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			90		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			90		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	4.0	5.8		A
Lower Switch Current Limit		From Drain to Source		0.9		A
COMP to Current Sense Transconductance	GCS			4.8		A/V
Oscillation Frequency	Fosc1			600		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		µA
Soft-Start Period		C_{SS} = 0.1µF		15		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

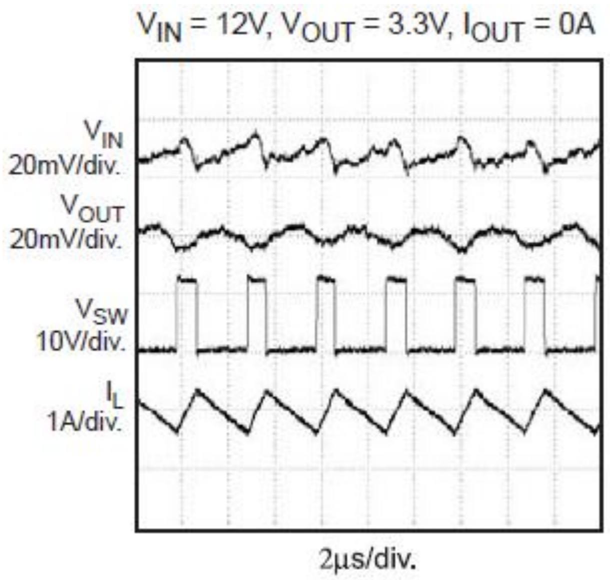


Figure 4. Steady State Test

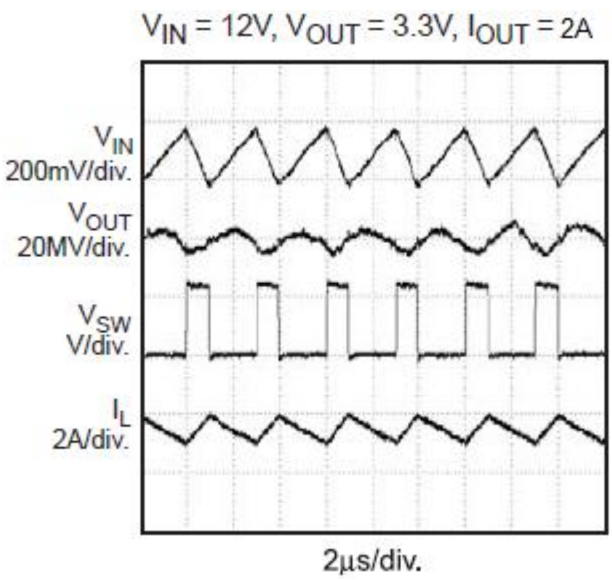
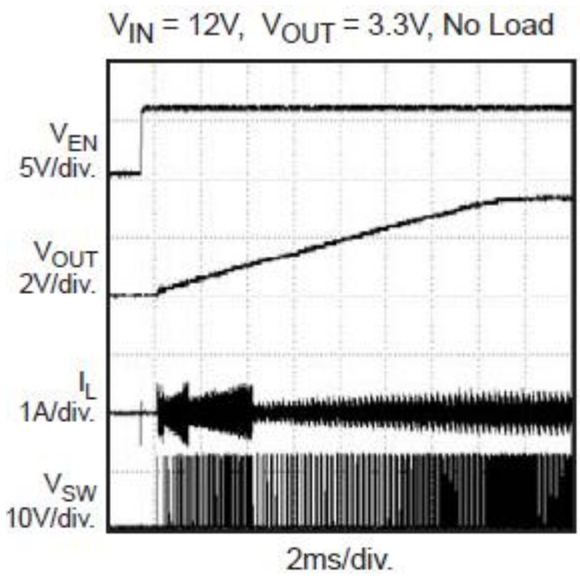


Figure 5. Steady State Test



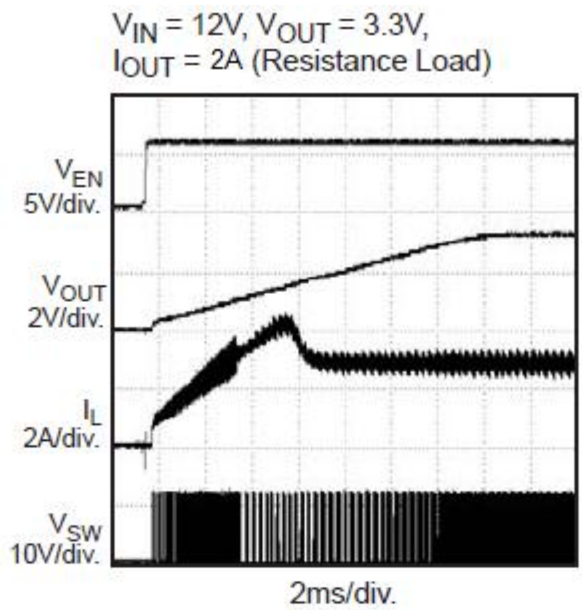


Figure 6. Startup through Enable

Figure 7. Startup through Enable

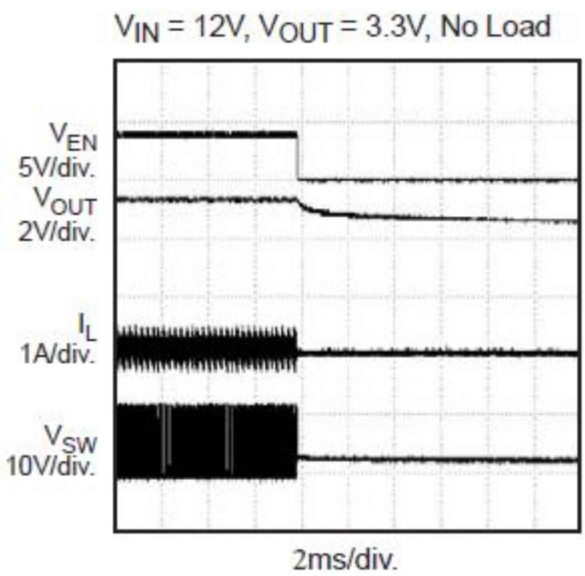


Figure 8. Shutdown through Enable

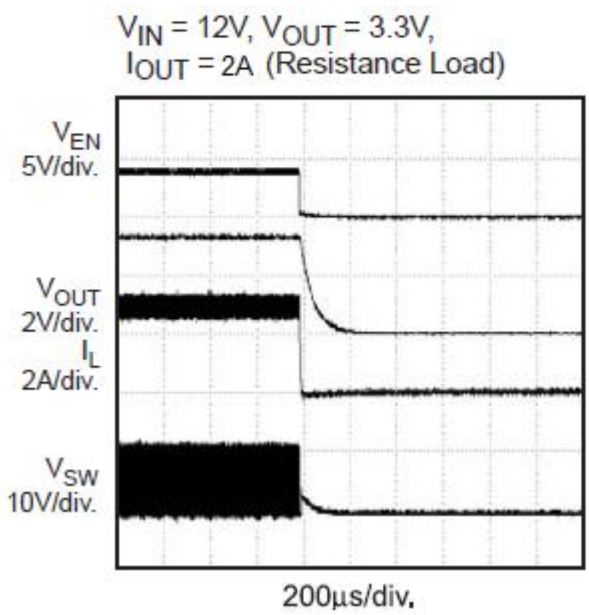


Figure 9. Shutdown through Enable

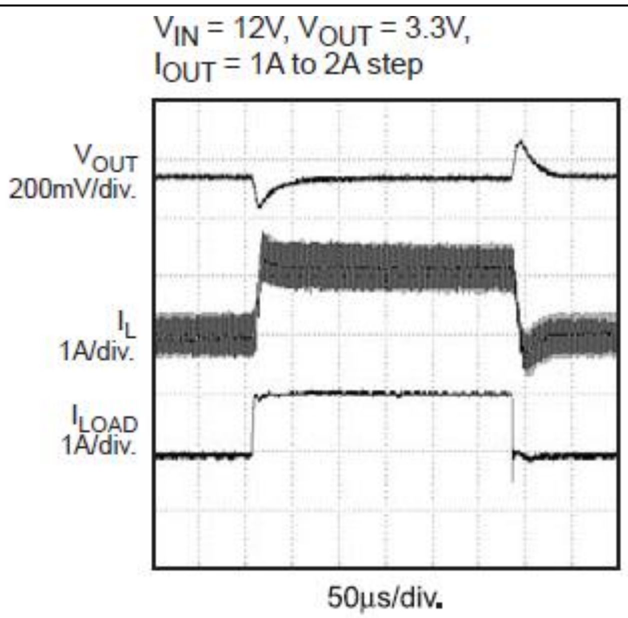


Figure 10. Load Transient Test

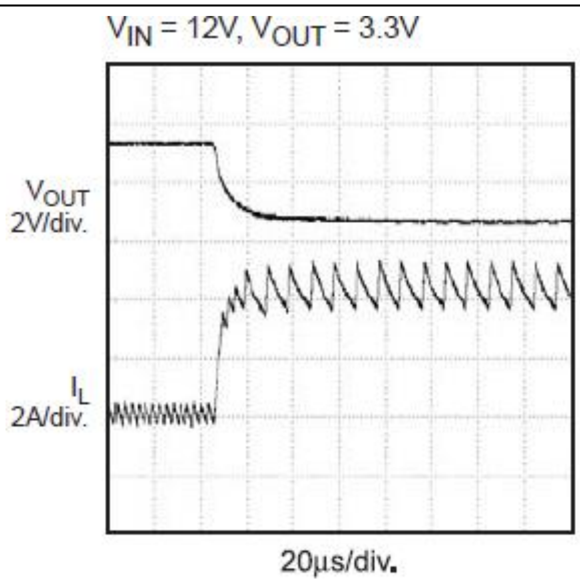


Figure 11. Short Circuit Test

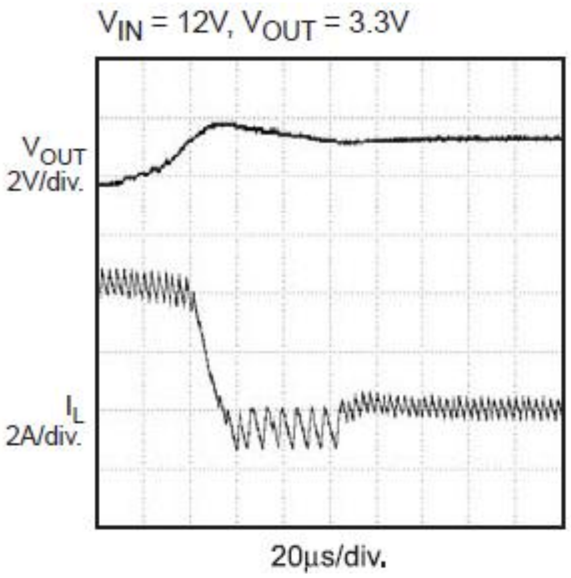


Figure 12. Short Circuit Recovery

Typical Application Circuit

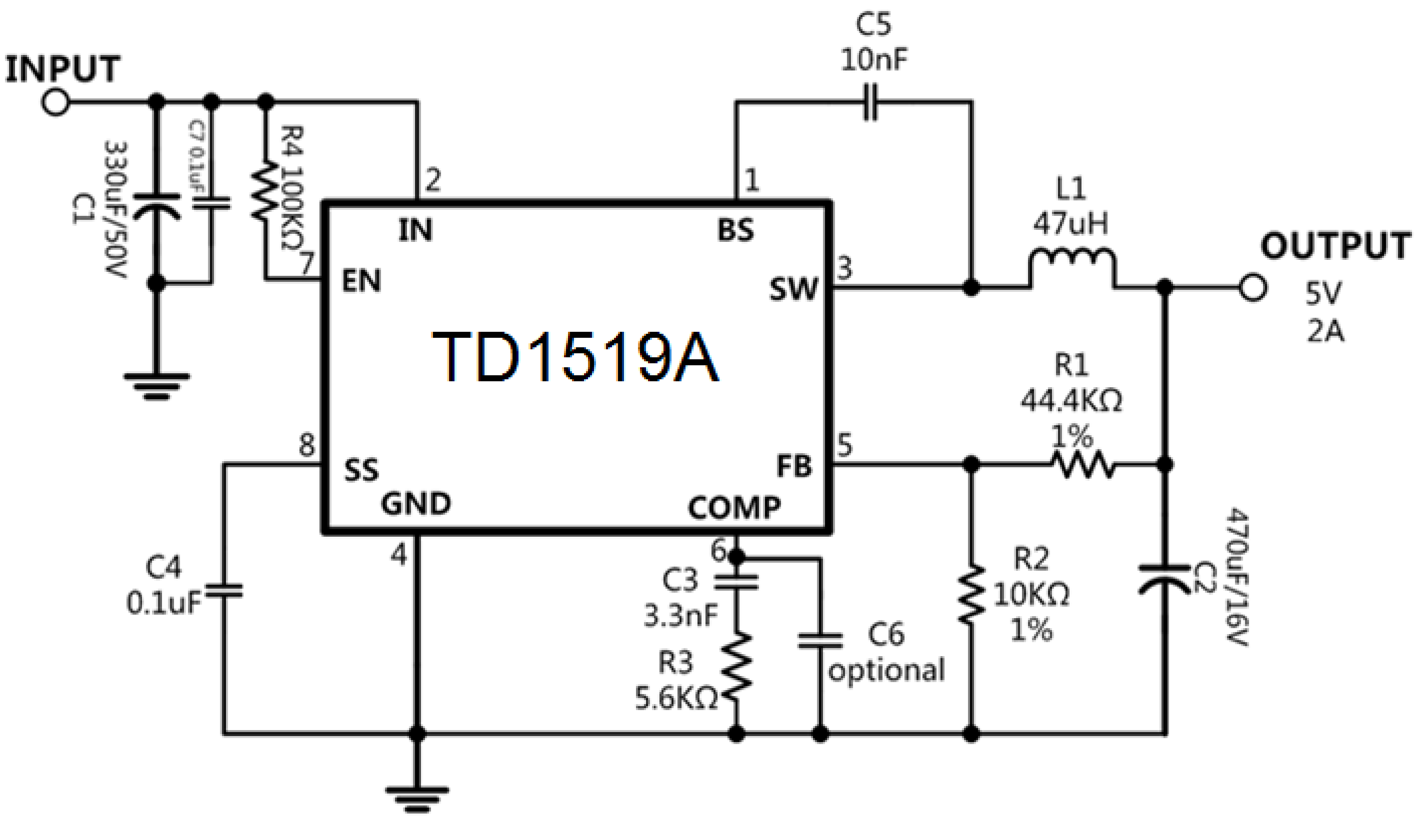


Fig13. TD1519A with 5V Output, 470μF/16V Electrolytic Output Capacitor

Function Description

Component Selection

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin.The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT} \frac{R2}{R1+R2}$$

Where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.Thus the output voltage is:

$$V_{OUT} = 0.923 \times \frac{R1+R2}{R2}$$

R2 can be as high as 100kΩ, but a typical value is 10kΩ. Using the typical value for R2, R1 is determined by:

$$R1 = 10.83 \times (V_{OUT} - 0.923)\ (k\Omega)$$

For example, for a 3.3V output voltage, R2 is 10kΩ, and R1 is 26.1kΩ.

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However,the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_S \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where I_{LOAD} is the load current.

The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirements.

Optional Schottky Diode

During the transition between high-side switch and low-side switch, the body diode of the lowside power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled between the SW pin and GND pin to improve overall efficiency. Table 1 lists example Schottky diodes and their Manufacturers.

Part Number	Voltage/Current	Vendor
B140	40V, 1A	Diodes, Inc.
SK14	40V, 1A	Diodes, Inc.
MBRS140	40V, 1A	International Rectifier

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C1) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at $V_{IN} = 2V_{OUT}$,where $I_{C1} = I_{LOAD}/2$. For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{C1 \times f_S} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where C1 is the input capacitance value.

Output Capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right)$$

Where C2 is the output capacitance value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^2 \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors,the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The TD1519 can be optimized for a wide range of capacitance and ESR values.

Compensation Components

TD1519 employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal transconductance error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system.

The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_{LOAD} \times G_{CS} \times A_{EA} \times \frac{V_{FB}}{V_{OUT}}$$

Where A_{VEA} is the error amplifier voltage gain;G_{CS} is the current sense transconductance and R_{LOAD} is the load resistor value.

The system has two poles of importance. One is due to the compensation capacitor (C3) and the output resistor of the error amplifier, and the other is due to the output capacitor and the load resistor. These poles are located at:

$$f_{P1} = \frac{G_{EA}}{2\pi \times C3 \times A_{VEA}}$$

$$f_{P2} = \frac{1}{2\pi \times C2 \times R_{LOAD}}$$

Where G_{EA} is the error amplifier transconductance.

The system has one zero of importance, due to the compensation capacitor (C3) and the compensation resistor (R3). This zero is located at:

$$f_{Z1} = \frac{1}{2\pi \times C3 \times R3}$$

The system may have another zero of importance, if the output capacitor has a large capacitance and/or a high ESR value. The zero,due to the ESR and capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \times C2 \times R_{ESR}}$$

In this case (as shown in Figure 14), a third pole set by the compensation capacitor (C6) and the compensation resistor (R3) is used to compensate the effect of the ESR zero on the loop gain. This pole is located at:

$$f_{P3} = \frac{1}{2\pi \times C6 \times R3}$$

The goal of compensation design is to shape the converter transfer function to get a desired loop gain. The system crossover frequency where the feedback loop has the unity gain is important. Lower crossover frequencies result in slower line and load transient responses,while higher crossover frequencies could cause system instability. A good rule of thumb is to set the crossover frequency below one-tenth of the switching frequency.

To optimize the compensation components, the following procedure can be used.

1. Choose the compensation resistor (R3) to set the desired crossover frequency.

Determine the R3 value by the following equation:

$$R3 = \frac{2\pi \times C2 \times f_C}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}} < \frac{2\pi \times C2 \times 0.1 \times f_S}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}}$$

Where f_C is the desired crossover frequency which is typically below one tenth of the switching frequency.

2. Choose the compensation capacitor (C3) to achieve the desired phase margin. For applications with typical inductor values, setting the compensation zero, f_{Z1}, below one-forth of the crossover frequency provides sufficient phase margin.

Determine the C3 value by the following equation:

$$C3 > \frac{4}{2\pi \times R3 \times f_C}$$

Where R3 is the compensation resistor.

3. Determine if the second compensation capacitor (C6) is required. It is required if the ESR zero of the output capacitor is located at less than half of the switching frequency, or the following relationship is valid:

$$\frac{1}{2\pi \times C2 \times R_{ESR}} < \frac{f_S}{2}$$

If this is the case, then add the second compensation capacitor (C6) to set the pole f_{P3} at the location of the ESR zero. Determine the C6 value by the equation:

$$C6 = \frac{C2 \times R_{ESR}}{R3}$$

External Bootstrap Diode

An external bootstrap diode may enhance the efficiency of the regulator, the applicable conditions of external BST diode are:

- V_{OUT}=5V or 3.3V; and
- Duty cycle is high:

$$D = \frac{V_{OUT}}{V_{IN}} > 65\%$$

In these cases, an external BST diode is recommended from the output of the voltage regulator to BST pin, as shown in Fig.14

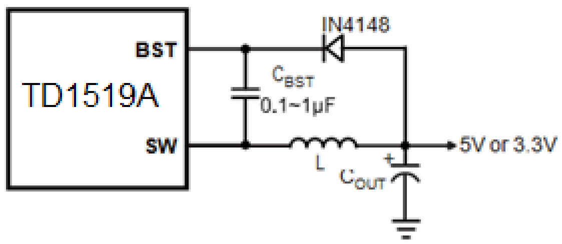
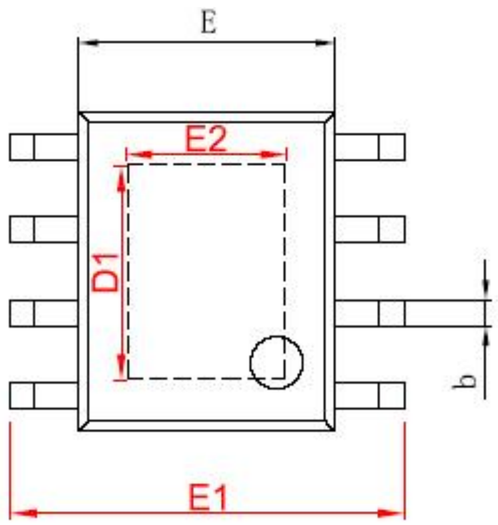


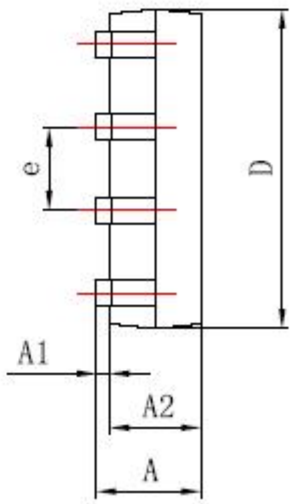
Figure14.Add Optional External Bootstrap Diode to Enhance Efficiency

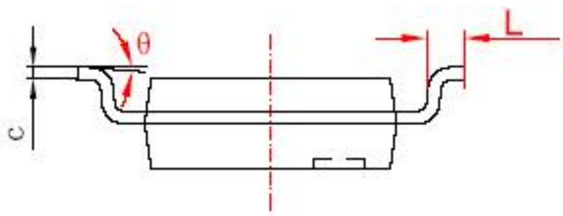
The recommended external BST diode is IN4148, and the BST cap is 0.1~1μF.

Package Information

SOP8-pp Package Outline Dimensions







	Dimensions In Millimeters		Dimensions In 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°

Design Notes

1.6A 32V Synchronous Rectified Step-Down Converte TD1529

General Description

The TD1529 is a monolithic synchronous buck regulator. The device integrates two 130mΩ MOSFETs, and provides 1.6A of continuous load current over a wide input voltage of 4.75V to 32V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1μA.

This device, availablein an SOP8 package, provides a very compact solution with minimal external components.

Features

- 1.6A Output Current
- Wide 4.75V to 32V Operating Input Range
- Integrated 130mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 30V
- Up to 93% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

Package Types

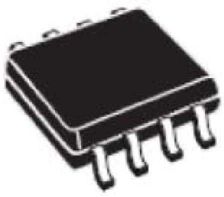


Figure 1. Package Types of TD1529

Pin Configurations

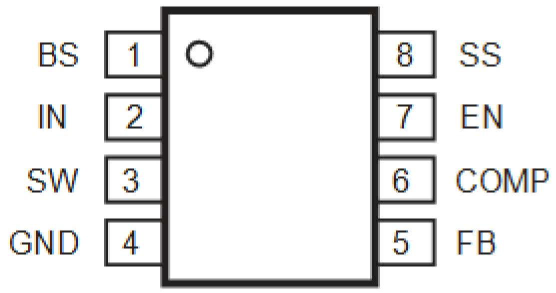


Figure 2 Pin Configuration of TD1529(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01μF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 32V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1μF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

Ordering Information

TD1529 □ □

Circuit Type

Package
P:SOP8

Packing:
Blank：Tube
R:Type and Reel

Function Block

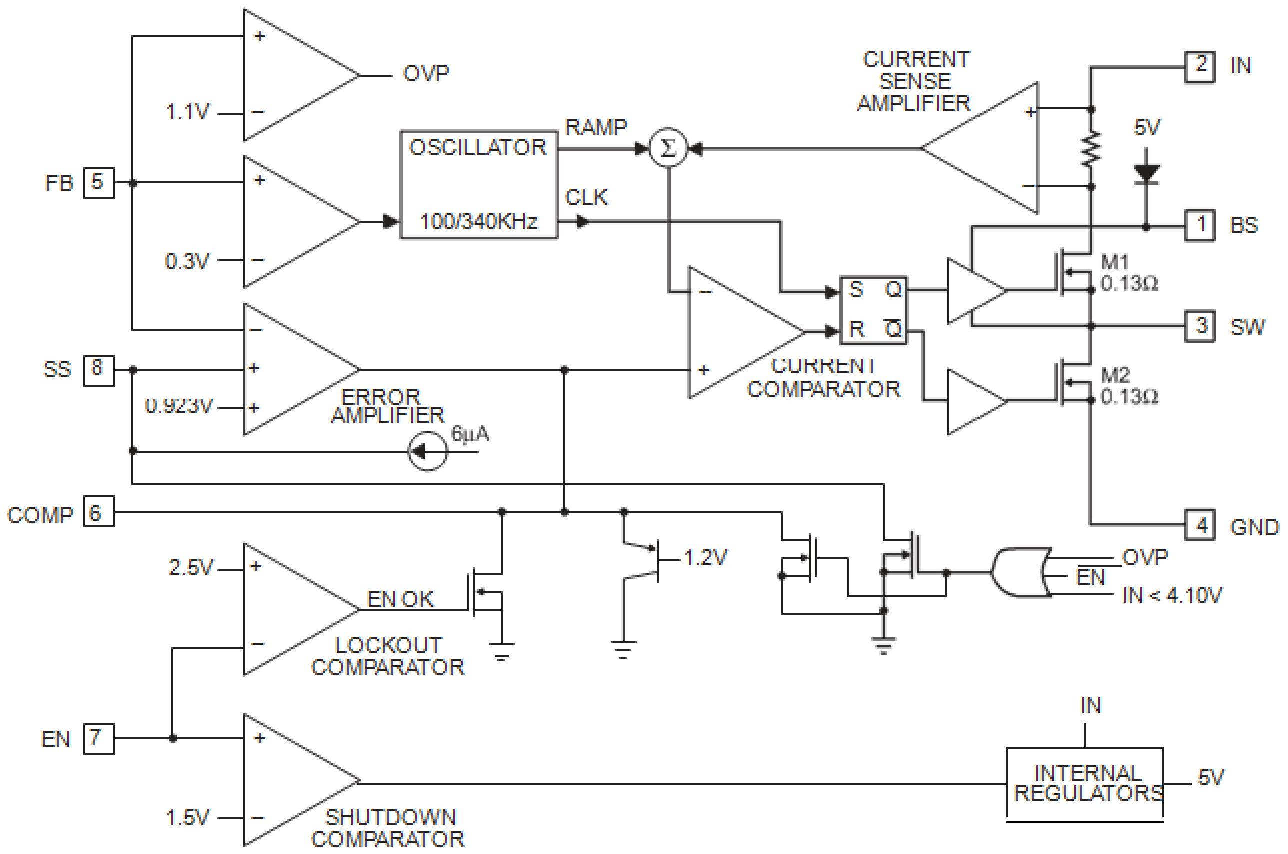


Figure 3 Function Block Diagram of TD1529

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 32	V
Switch Node Voltage	V_{SW}	30	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 30	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	90	ºC / W
Thermal Resistance-Junction to Case	RθJC	45	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	∆IC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			130		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			130		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	2.0	3.0		A
Lower Switch Current Limit		From Drain to Source		1.1		A
COMP to Current Sense Transconductance	GCS			3.5		A/V
Oscillation Frequency	Fosc1			340		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		μA
Soft-Start Period		C_{SS} = 0.1μF		1 5		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

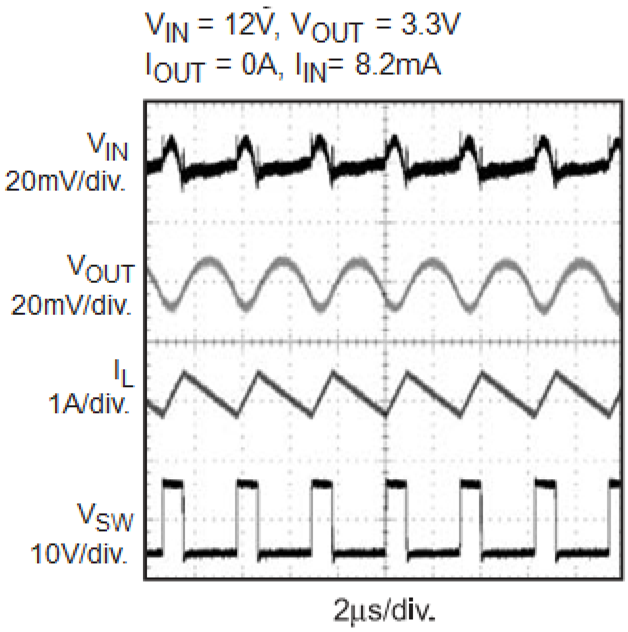


Figure 4. Steady State Test

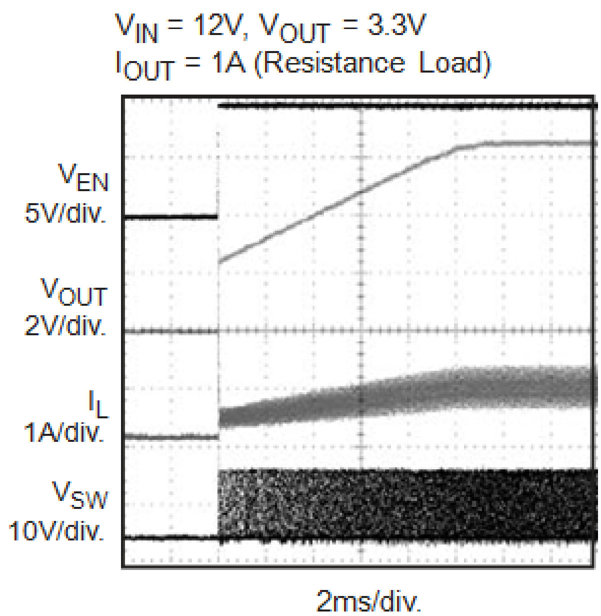


Figure 5. Startup through Enable

2A 23V Synchronous Rectified Step-Down Converte TD1482A

General Description

The TD1482A is a monolithic synchronous buck regulator. The device integrates two 130mΩ MOSFETs, and provides 2A of continuous load current over a wide input voltage of 4.75V to 23V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1μA.

This device, availablein an SOP8 package, provides a very compact solution with minimal external components.

Features

- 2A Output Current
- Wide 4.75V to 23V Operating Input Range
- Integrated 130mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 20V
- Up to 93% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

Package Types

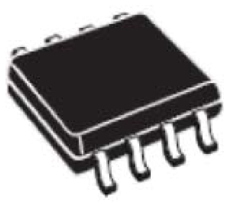


Figure 1. Package Types of TD1482A

Pin Configurations

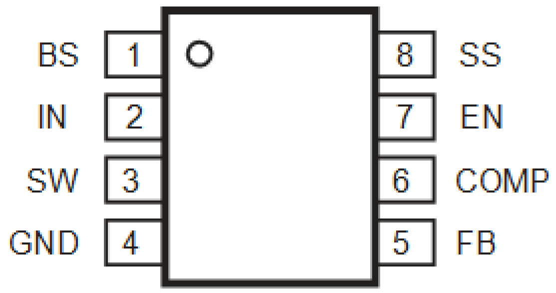


Figure 2 Pin Configuration of TD1482A(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01μF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 23V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1μF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

Ordering Information

TD1482A □ □

Circuit Type

Package
P:SOP8

Packing:
Blank：Tube
R:Type and Reel

Function Block

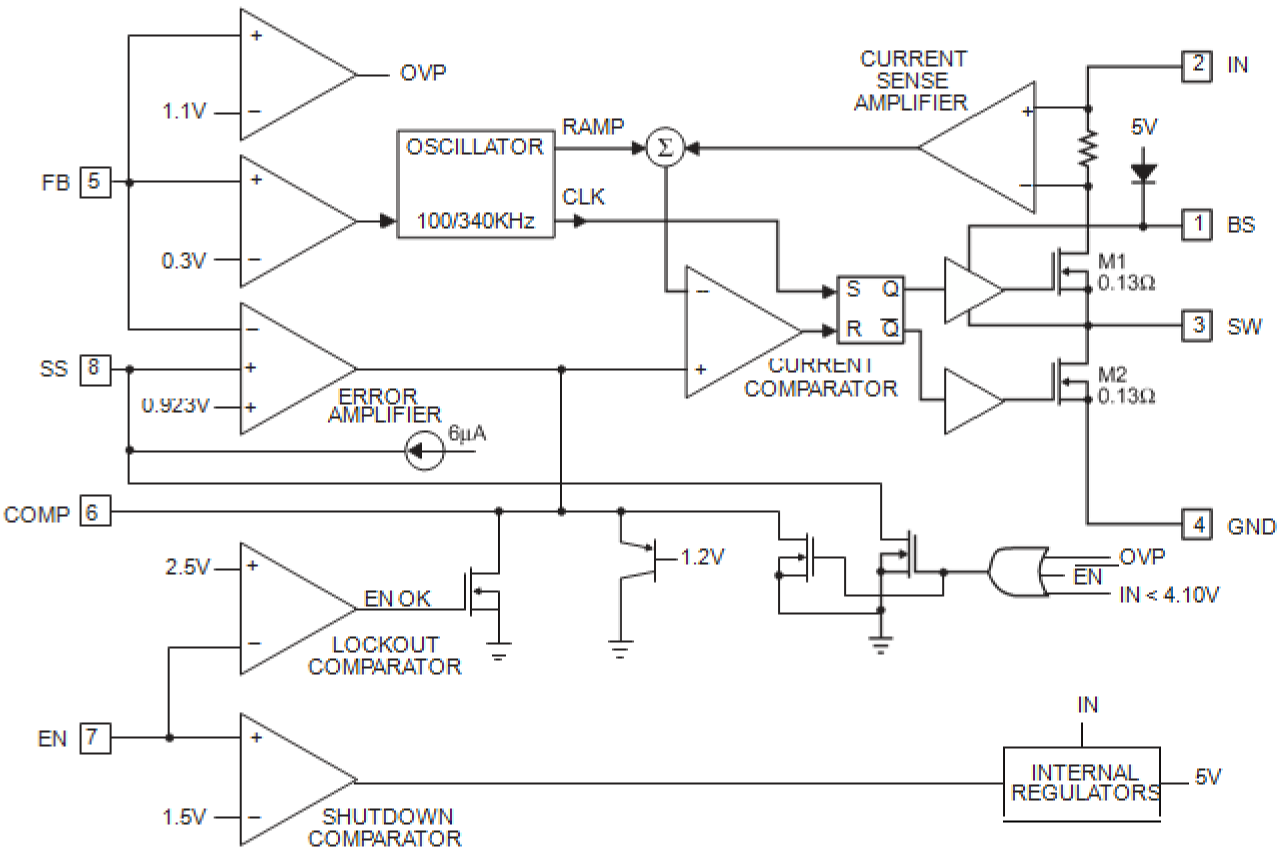


Figure 3 Function Block Diagram of TD1482A

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 23	V
Switch Node Voltage	V_{SW}	21	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 20	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Operating Ambient Temperature	T_A	-40 to 80	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	90	ºC / W
Thermal Resistance-Junction to Case	RθJC	45	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	ΔIC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			130		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			130		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	2.4	3.4		A
Lower Switch Current Limit		From Drain to Source		1.1		A
COMP to Current Sense Transconductance	GCS			3.5		A/V
Oscillation Frequency	Fosc1			340		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		μA
Soft-Start Period		C_{SS} = 0.1μF		1 5		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

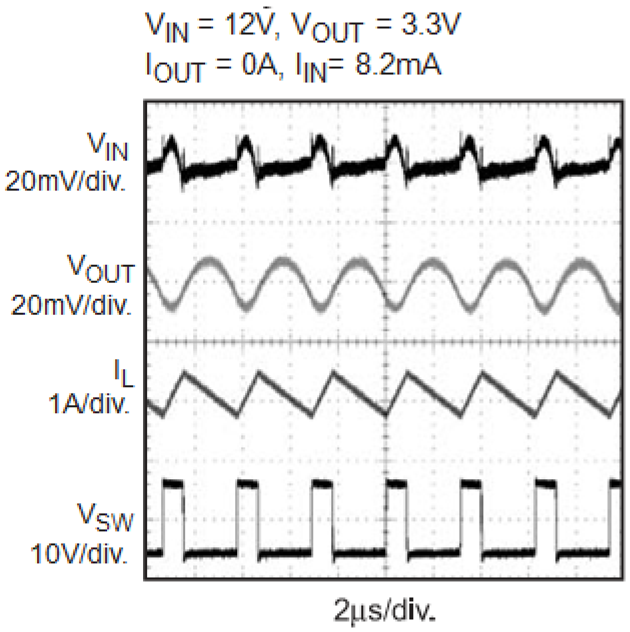


Figure 4. Steady State Test

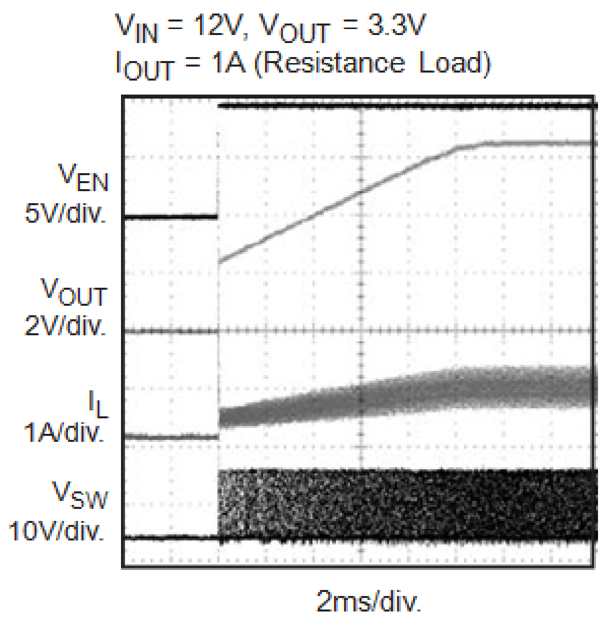


Figure 5. Startup through Enable

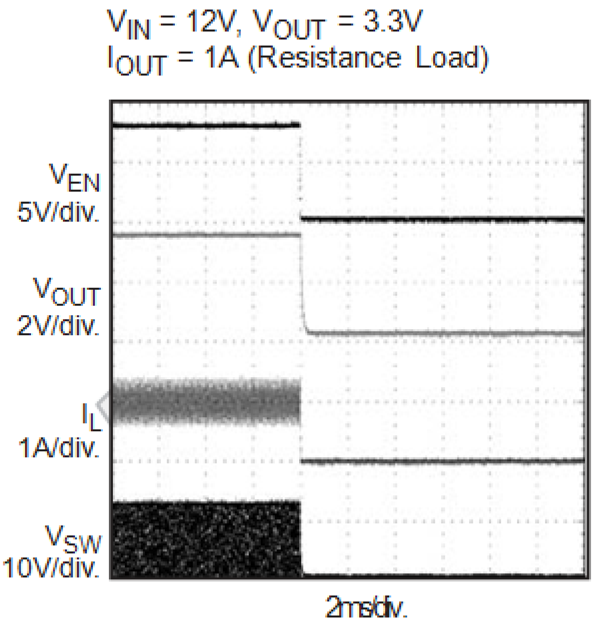


Figure 6. Shutdown through Enable

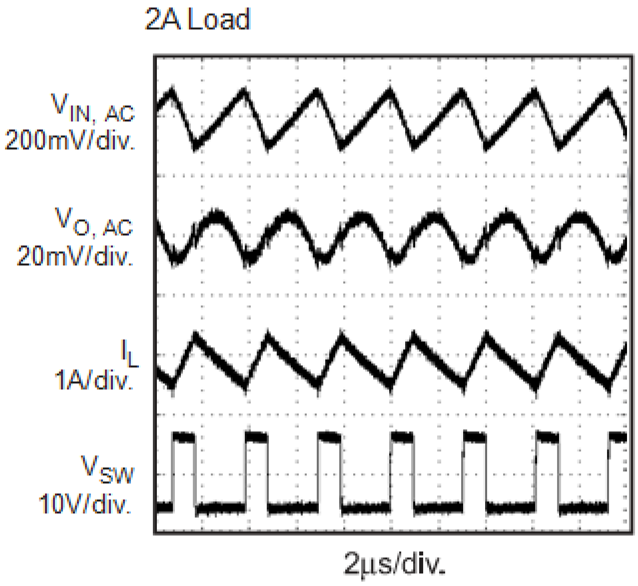


Figure 7. Heavy Load Operation

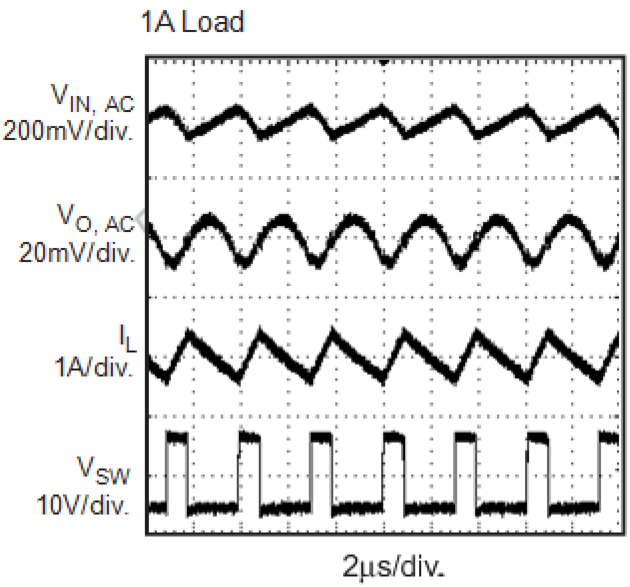


Figure 8.Medium Load Operation

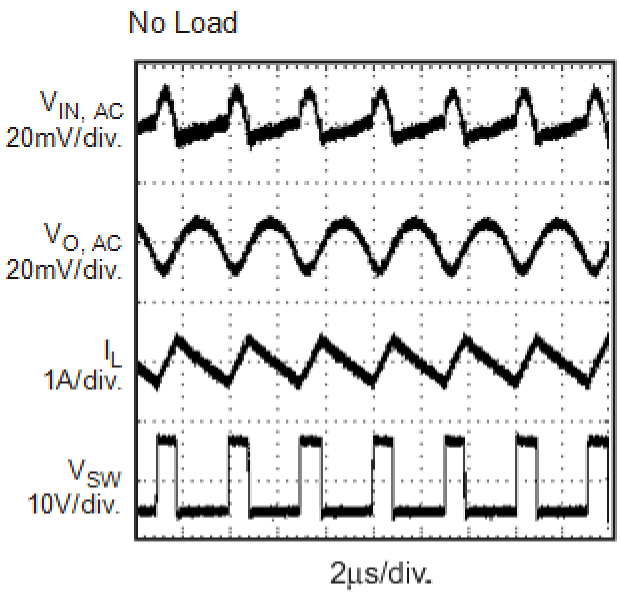


Figure 9.Light Load Operation

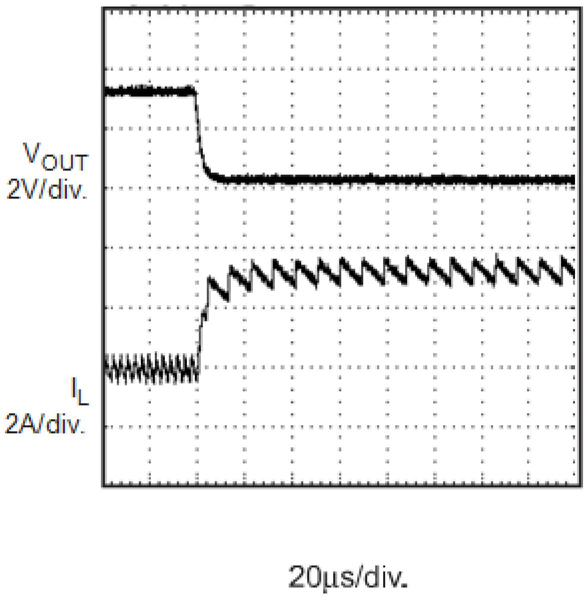


Figure 10. Short Circuit Protection

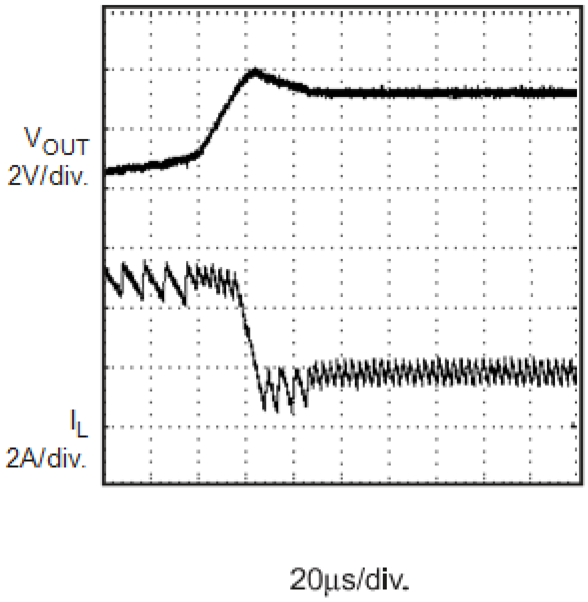


Figure 11. Short Circuit Recovery

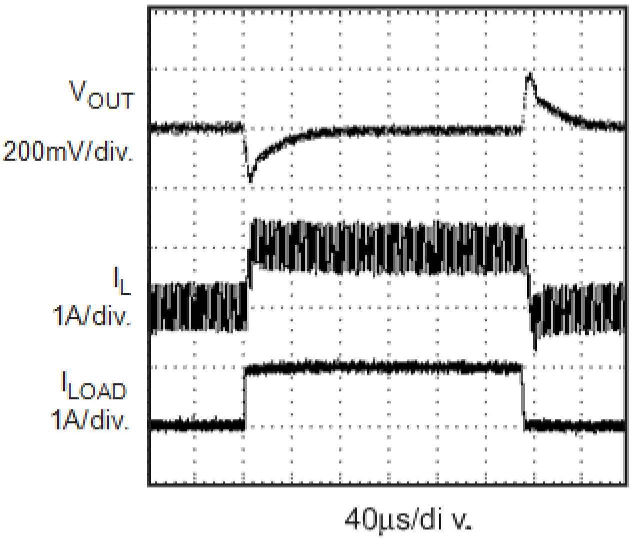


Figure 12. Load Transient

Typical Application Circuit

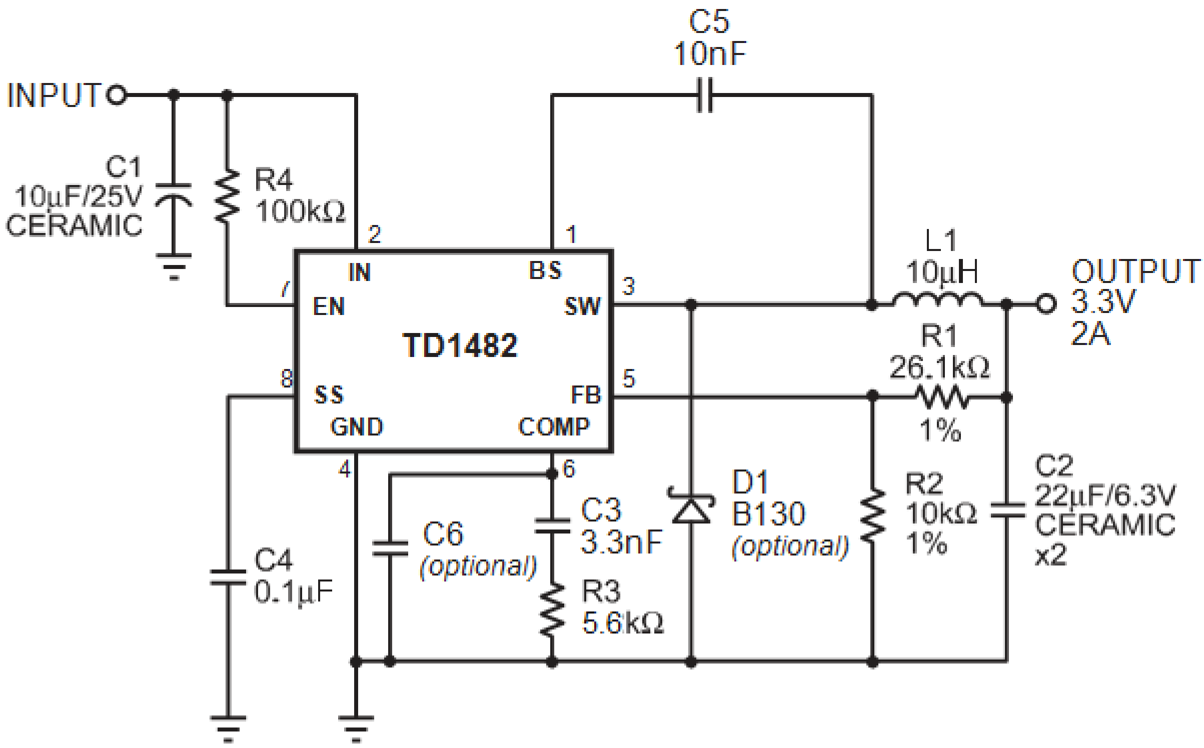


Fig13. TD1482A with 3.3V Output, 22µF/6.3V Ceramic Output Capacitor

Function Description

Component Selection

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin.The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT}\frac{R2}{R1+R2}$$

Where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.Thus the output voltage is:

$$V_{OUT} = 0.923 \times \frac{R1+R2}{R2}$$

R2 can be as high as 100kΩ, but a typical value is 10kΩ. Using the typical value for R2, R1 is determined by:

$$R1 = 10.83 \times (V_{OUT} - 0.923)\ (k\Omega)$$

For example, for a 3.3V output voltage, R2 is 10kΩ, and R1 is 26.1kΩ.

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However,the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_S \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where I_{LOAD} is the load current.

The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirements.

Optional Schottky Diode

During the transition between high-side switch and low-side switch, the body diode of the lowside power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled between the SW pin and GND pin to improve overall efficiency. Table 1 lists example Schottky diodes and their Manufacturers.

Part Number	Voltage/Current	Vendor
B130	30V, 1A	Diodes, Inc.
SK13	30V, 1A	Diodes, Inc.
MBRS130	30V, 1A	International Rectifier

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C1) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at $V_{IN} = 2V_{OUT}$,where $I_{C1} = I_{LOAD}/2$. For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{C1 \times f_S} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where C1 is the input capacitance value.

Output Capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right)$$

Where C2 is the output capacitance value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^{\ 2} \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors,the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The TD1482A can be optimized for a wide range of capacitance and ESR values.

Compensation Components

TD1482A employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal transconductance error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system.

The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_{LOAD} \times G_{CS} \times A_{EA} \times \frac{V_{FB}}{V_{OUT}}$$

Where A_{VEA} is the error amplifier voltage gain;G_{CS} is the current sense transconductance and R_{LOAD} is the load resistor value.

The system has two poles of importance. One is due to the compensation capacitor (C3) and the output resistor of the error amplifier, and the other is due to the output capacitor and the load resistor. These poles are located at:

$$f_{P1} = \frac{G_{EA}}{2\pi \times C3 \times A_{VEA}}$$

$$f_{P2} = \frac{1}{2\pi \times C2 \times R_{LOAD}}$$

Where G_{EA} is the error amplifier transconductance.

The system has one zero of importance, due to the compensation capacitor (C3) and the compensation resistor (R3). This zero is located at:

$$f_{Z1} = \frac{1}{2\pi \times C3 \times R3}$$

The system may have another zero of importance, if the output capacitor has a large capacitance and/or a high ESR value. The zero,due to the ESR and capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \times C2 \times R_{ESR}}$$

In this case (as shown in Figure 14), a third pole set by the compensation capacitor (C6) and the compensation resistor (R3) is used to compensate the effect of the ESR zero on the loop gain. This pole is located at:

$$f_{P3} = \frac{1}{2\pi \times C6 \times R3}$$

The goal of compensation design is to shape the converter transfer function to get a desired loop gain. The system crossover frequency where the feedback loop has the unity gain is important. Lower crossover frequencies result in slower line and load transient responses,while higher crossover frequencies could cause system instability. A good rule of thumb is to set the crossover frequency below one-tenth of the switching frequency.

To optimize the compensation components, the following procedure can be used.

1. Choose the compensation resistor (R3) to set the desired crossover frequency.

Determine the R3 value by the following equation:

$$R3 = \frac{2\pi \times C2 \times f_C}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}} < \frac{2\pi \times C2 \times 0.1 \times f_S}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}}$$

Where f_C is the desired crossover frequency which is typically below one tenth of the switching frequency.

2. Choose the compensation capacitor (C3) to achieve the desired phase margin. For applications with typical inductor values, setting the compensation zero, f_{Z1}, below one-forth of the crossover frequency provides sufficient phase margin.

Determine the C3 value by the following equation:

$$C3 > \frac{4}{2\pi \times R3 \times f_C}$$

Where R3 is the compensation resistor.

3. Determine if the second compensation capacitor (C6) is required. It is required if the ESR zero of the output capacitor is located at less than half of the switching frequency, or the following relationship is valid:

$$\frac{1}{2\pi \times C2 \times R_{ESR}} < \frac{f_S}{2}$$

If this is the case, then add the second compensation capacitor (C6) to set the pole f_{P3} at the location of the ESR zero. Determine the C6 value by the equation:

$$C6 = \frac{C2 \times R_{ESR}}{R3}$$

External Bootstrap Diode

An external bootstrap diode may enhance the efficiency of the regulator, the applicable conditions of external BST diode are:

- V_{OUT}=5V or 3.3V; and
- Duty cycle is high:

$$D = \frac{V_{OUT}}{V_{IN}} > 65\%$$

In these cases, an external BST diode is recommended from the output of the voltage regulator to BST pin, as shown in Fig.14

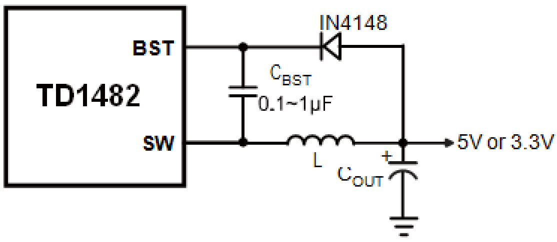
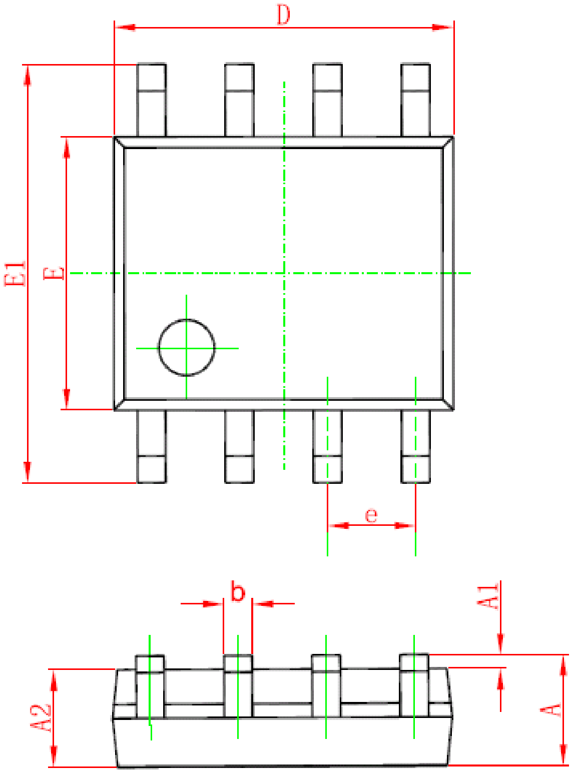


Figure14.Add Optional External Bootstrap Diode to Enhance Efficiency

The recommended external BST diode is IN4148, and the BST cap is 0.1~1μF.

Package Information

SOP8 Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	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
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Design Notes

3.2A 23V Synchronous Rectified Step-Down Converter TD1484A

General Description

The TD1484A is a monolithic synchronous buck regulator. The device integrates two 90mΩ MOSFETs, and provides 3.2A of continuous load current over a wide input voltage of 4.75V to 23V. Current mode control provides fast transient response and cycle-by-cycle current limit.
An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1μA.
This device, availablein an SOP8-PP package, provides a very compact solution with minimal external components.

Features

- 3.2A Output Current
- Wide 4.75V to 23V Operating Input Range
- Integrated 90mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 20V
- Up to 93% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

Package Types

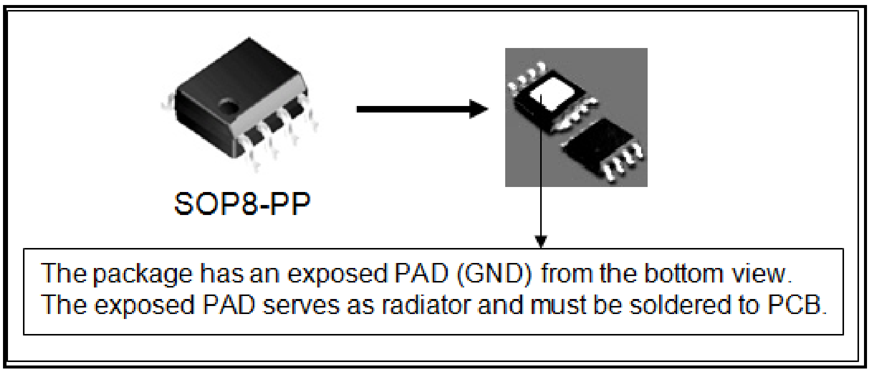


Figure 1. Package Types of TD1484A

Pin Configurations

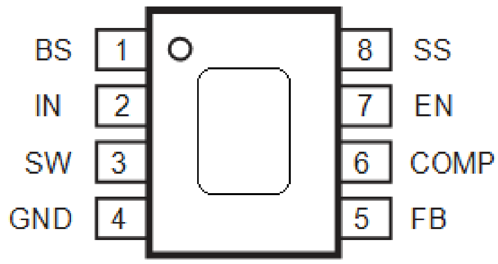
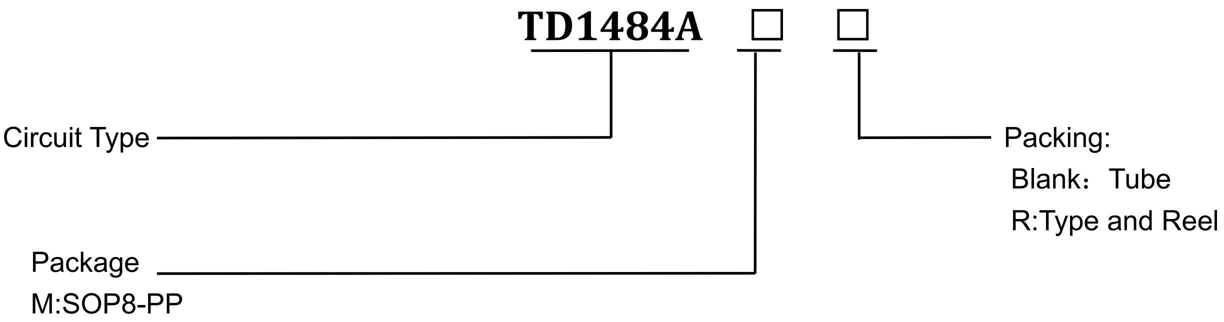


Figure 2 Pin Configuration of TD1484A(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01μF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 23V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1μF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

Ordering Information



Function Block

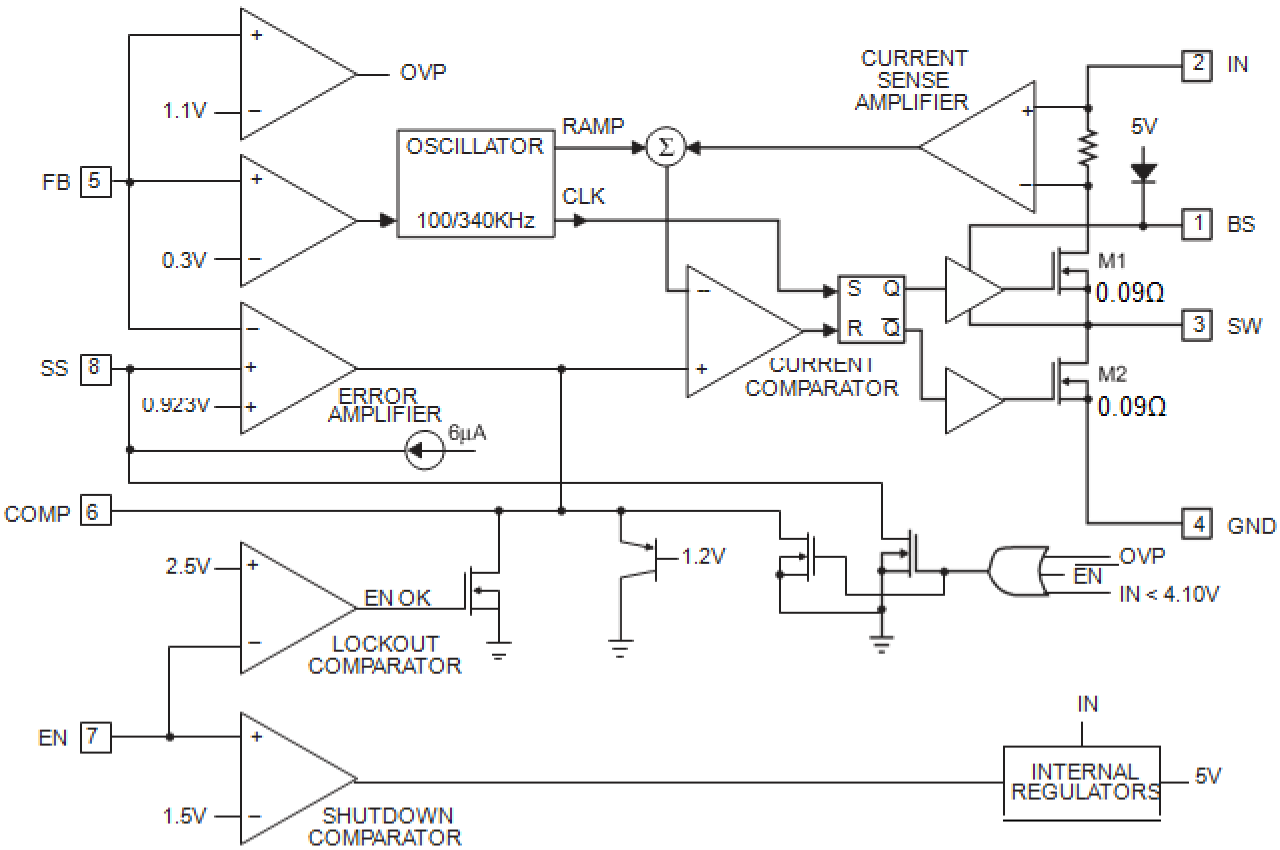


Figure 3 Function Block Diagram of TD1484A

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 23	V
Switch Node Voltage	V_{SW}	21	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 20	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	50	ºC / W
Thermal Resistance-Junction to Case	RθJC	10	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	∆IC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			90		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			90		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	4.0	5.8		A
Lower Switch Current Limit		From Drain to Source		0.9		A
COMP to Current Sense Transconductance	GCS			4.8		A/V
Oscillation Frequency	Fosc1			340		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		μA
Soft-Start Period		C_{SS} = 0.1μF		15		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

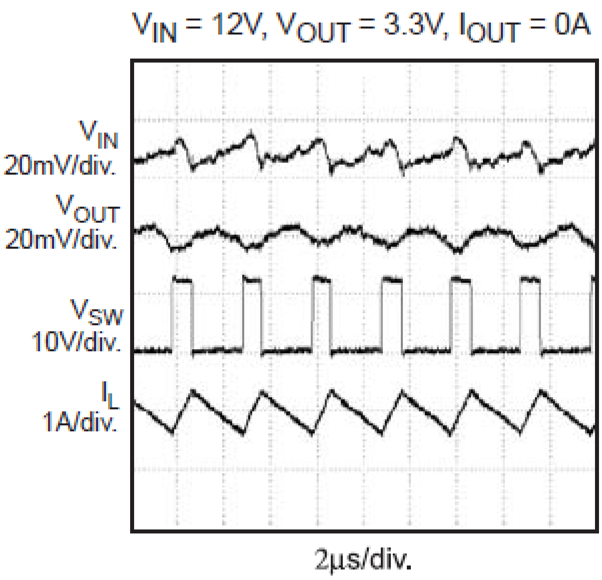


Figure 4. Steady State Test

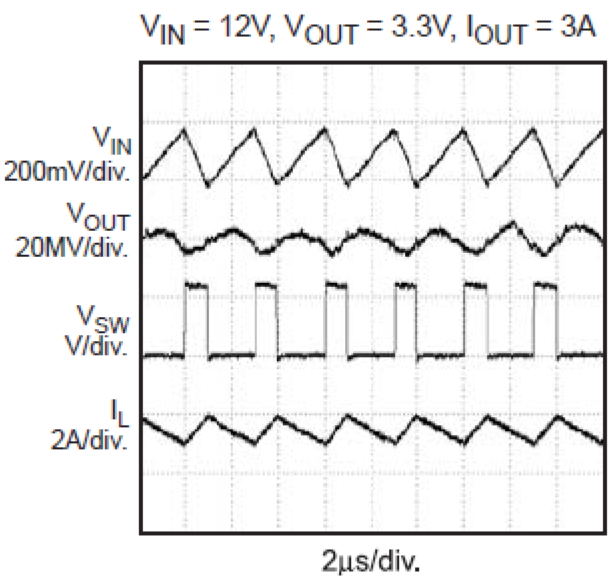


Figure 5. Steady State Test

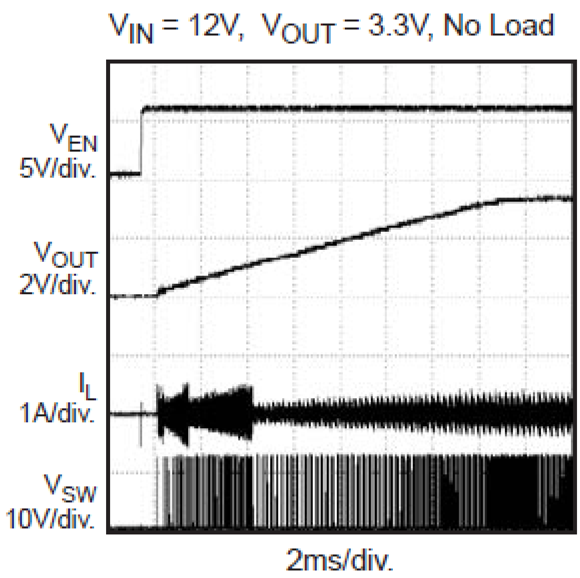


Figure 6. Startup through Enable

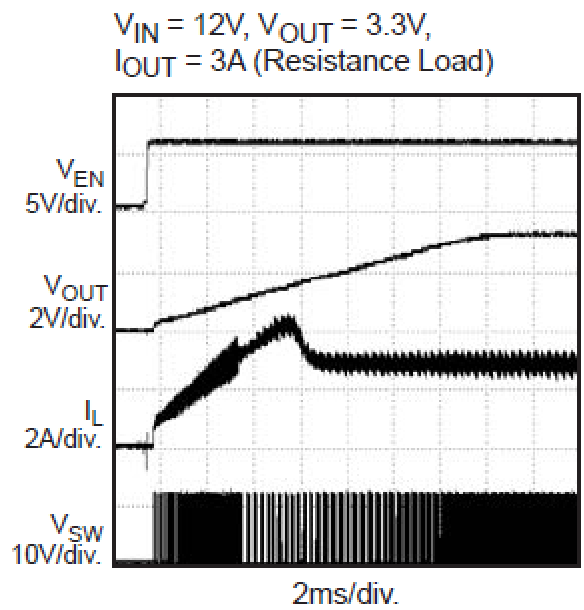


Figure 7. Startup through Enable

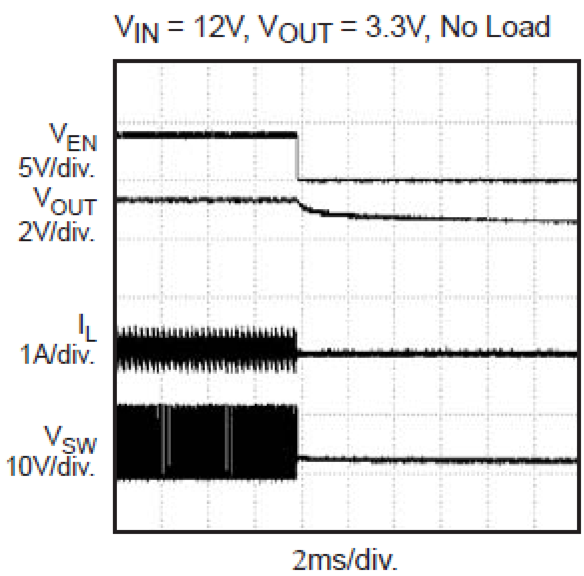


Figure 8. Shutdown through Enable

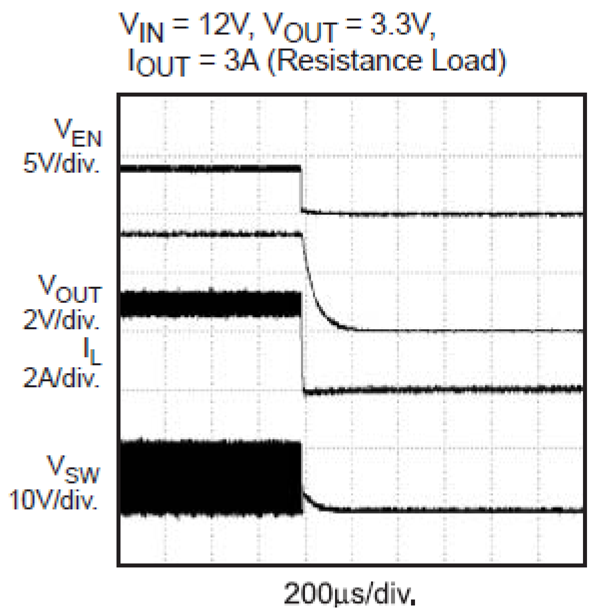


Figure 9. Shutdown through Enable

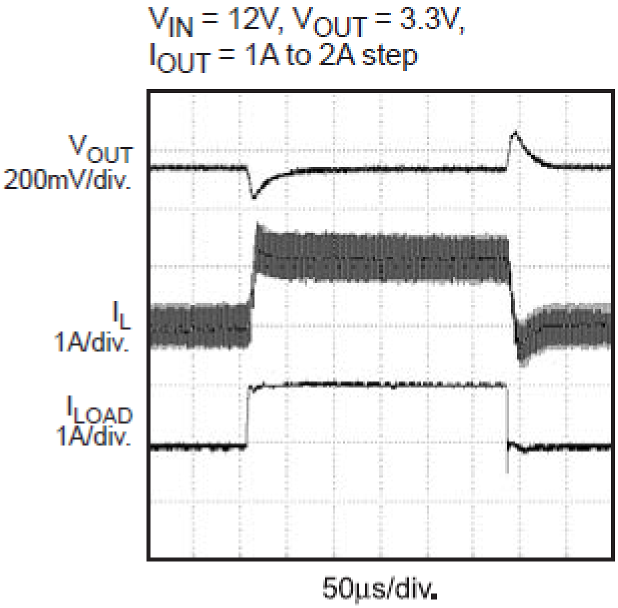


Figure 10. Load Transient Test

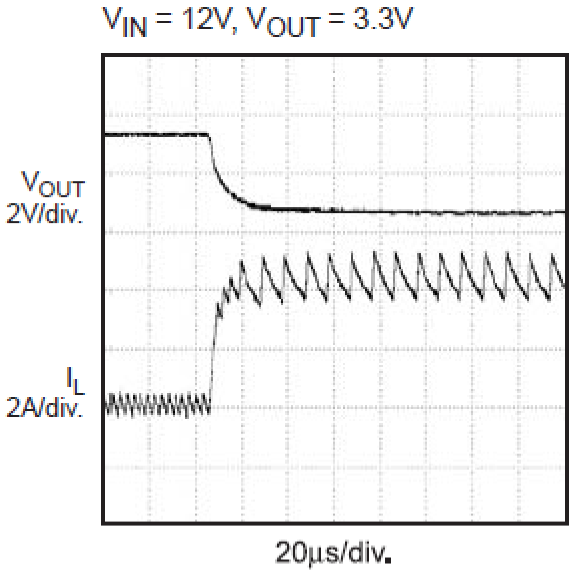


Figure 11. Short Circuit Test

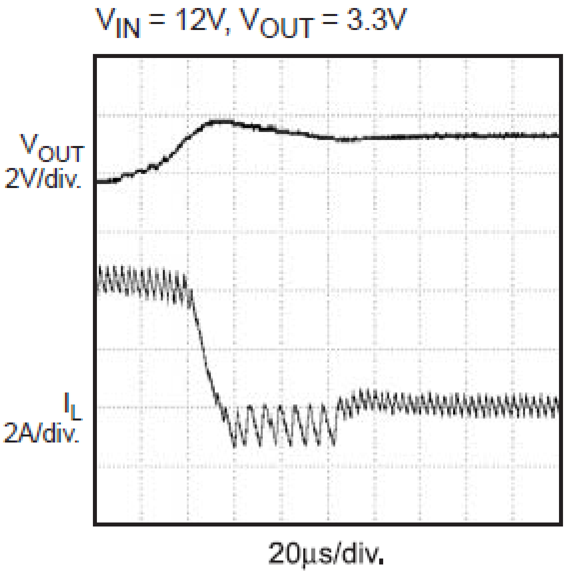


Figure 12. Short Circuit Recovery

Typical Application Circuit

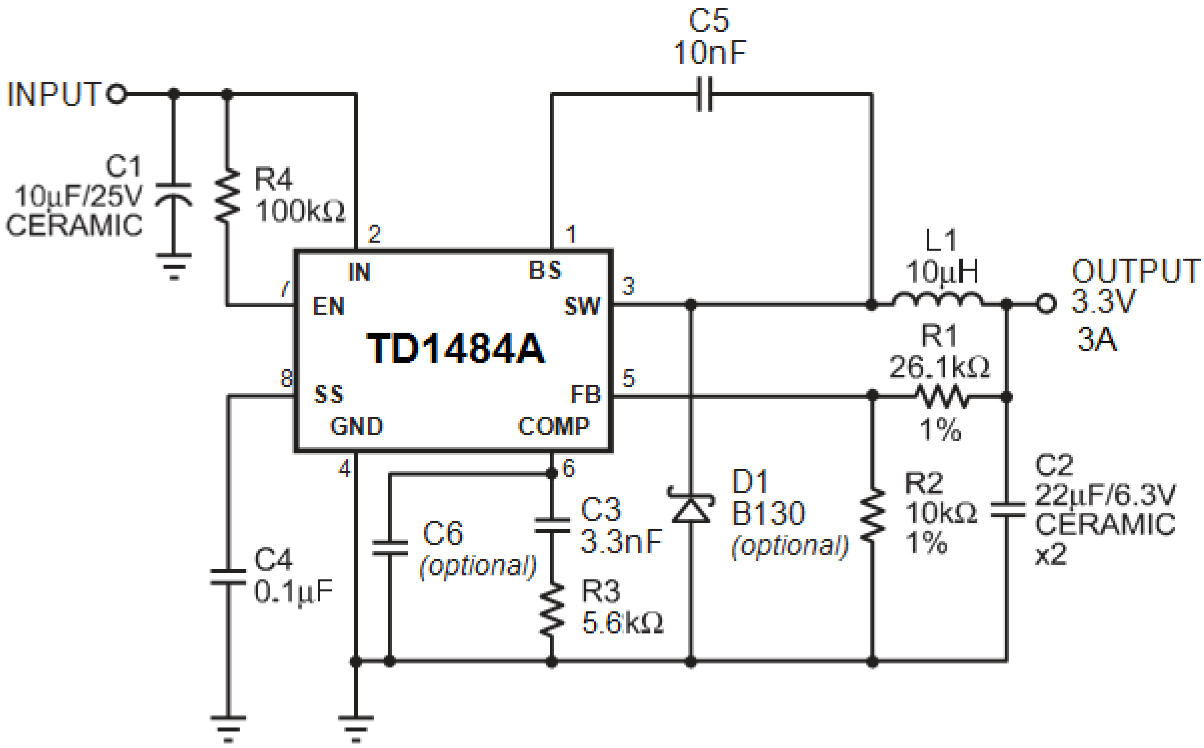


Fig13. TD1484A with 3.3V Output, 22µF/6.3V Ceramic Output Capacitor

Function Description

Component Selection

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin.The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT}\frac{R2}{R1+R2}$$

Where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.Thus the output voltage is:

$$V_{OUT} = 0.923 \times \frac{R1+R2}{R2}$$

R2 can be as high as 100kΩ, but a typical value is 10kΩ. Using the typical value for R2, R1 is determined by:

$$R1 = 10.83 \times (V_{OUT} - 0.923)\ (k\Omega)$$

For example, for a 3.3V output voltage, R2 is 10kΩ, and R1 is 26.1kΩ.

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However,the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_S \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_S is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where I_{LOAD} is the load current.

The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirements.

Optional Schottky Diode

During the transition between high-side switch and low-side switch, the body diode of the lowside power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled between the SW pin and GND pin to improve overall efficiency. Table 1 lists example Schottky diodes and their Manufacturers.

Part Number	Voltage/Current	Vendor
B130	30V, 1A	Diodes, Inc.
SK13	30V, 1A	Diodes, Inc.
MBRS130	30V, 1A	International Rectifier

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C1) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at $V_{IN} = 2V_{OUT}$,where $I_{C1} = I_{LOAD}/2$. For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{C1 \times f_S} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where C1 is the input capacitance value.

Output Capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right)$$

Where C2 is the output capacitance value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^{\,2} \times L \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors,the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The TD1484A can be optimized for a wide range of capacitance and ESR values.

Compensation Components

TD1484A employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal transconductance error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system.

The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_{LOAD} \times G_{CS} \times A_{EA} \times \frac{V_{FB}}{V_{OUT}}$$

Where A_{VEA} is the error amplifier voltage gain;G_{CS} is the current sense transconductance and R_{LOAD} is the load resistor value.

The system has two poles of importance. One is due to the compensation capacitor (C3) and the output resistor of the error amplifier, and the other is due to the output capacitor and the load resistor. These poles are located at:

$$f_{P1} = \frac{G_{EA}}{2\pi \times C3 \times A_{VEA}}$$

$$f_{P2} = \frac{1}{2\pi \times C2 \times R_{LOAD}}$$

Where G_{EA} is the error amplifier transconductance.

The system has one zero of importance, due to the compensation capacitor (C3) and the compensation resistor (R3). This zero is located at:

$$f_{Z1} = \frac{1}{2\pi \times C3 \times R3}$$

The system may have another zero of importance, if the output capacitor has a large capacitance and/or a high ESR value. The zero,due to the ESR and capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \times C2 \times R_{ESR}}$$

In this case (as shown in Figure 14), a third pole set by the compensation capacitor (C6) and the compensation resistor (R3) is used to compensate the effect of the ESR zero on the loop gain. This pole is located at:

$$f_{P3} = \frac{1}{2\pi \times C6 \times R3}$$

The goal of compensation design is to shape the converter transfer function to get a desired loop gain. The system crossover frequency where the feedback loop has the unity gain is important. Lower crossover frequencies result in slower line and load transient responses,while higher crossover frequencies could cause system instability. A good rule of thumb is to set the crossover frequency below one-tenth of the switching frequency.

To optimize the compensation components, the following procedure can be used.

1. Choose the compensation resistor (R3) to set the desired crossover frequency.

Determine the R3 value by the following equation:

$$R3 = \frac{2\pi \times C2 \times f_C}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}} < \frac{2\pi \times C2 \times 0.1 \times f_S}{G_{EA} \times G_{CS}} \times \frac{V_{OUT}}{V_{FB}}$$

Where f_C is the desired crossover frequency which is typically below one tenth of the switching frequency.

2. Choose the compensation capacitor (C3) to achieve the desired phase margin. For applications with typical inductor values, setting the compensation zero, f_{Z1}, below one-forth of the crossover frequency provides sufficient phase margin.

Determine the C3 value by the following equation:

$$C3 > \frac{4}{2\pi \times R3 \times f_C}$$

Where R3 is the compensation resistor.

3. Determine if the second compensation capacitor (C6) is required. It is required if the ESR zero of the output capacitor is located at less than half of the switching frequency, or the following relationship is valid:

$$\frac{1}{2\pi \times C2 \times R_{ESR}} < \frac{f_S}{2}$$

If this is the case, then add the second compensation capacitor (C6) to set the pole f_{P3} at the location of the ESR zero. Determine the C6 value by the equation:

$$C6 = \frac{C2 \times R_{ESR}}{R3}$$

External Bootstrap Diode

An external bootstrap diode may enhance the efficiency of the regulator, the applicable conditions of external BST diode are:

- V_{OUT}=5V or 3.3V; and
- Duty cycle is high:

$$D = \frac{V_{OUT}}{V_{IN}} > 65\%$$

In these cases, an external BST diode is recommended from the output of the voltage regulator to BST pin, as shown in Fig.14

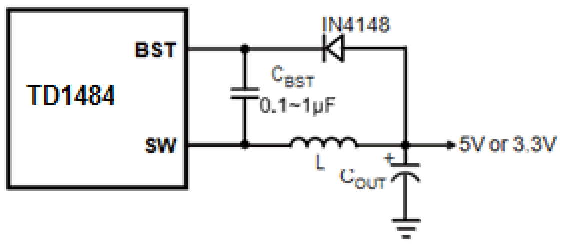
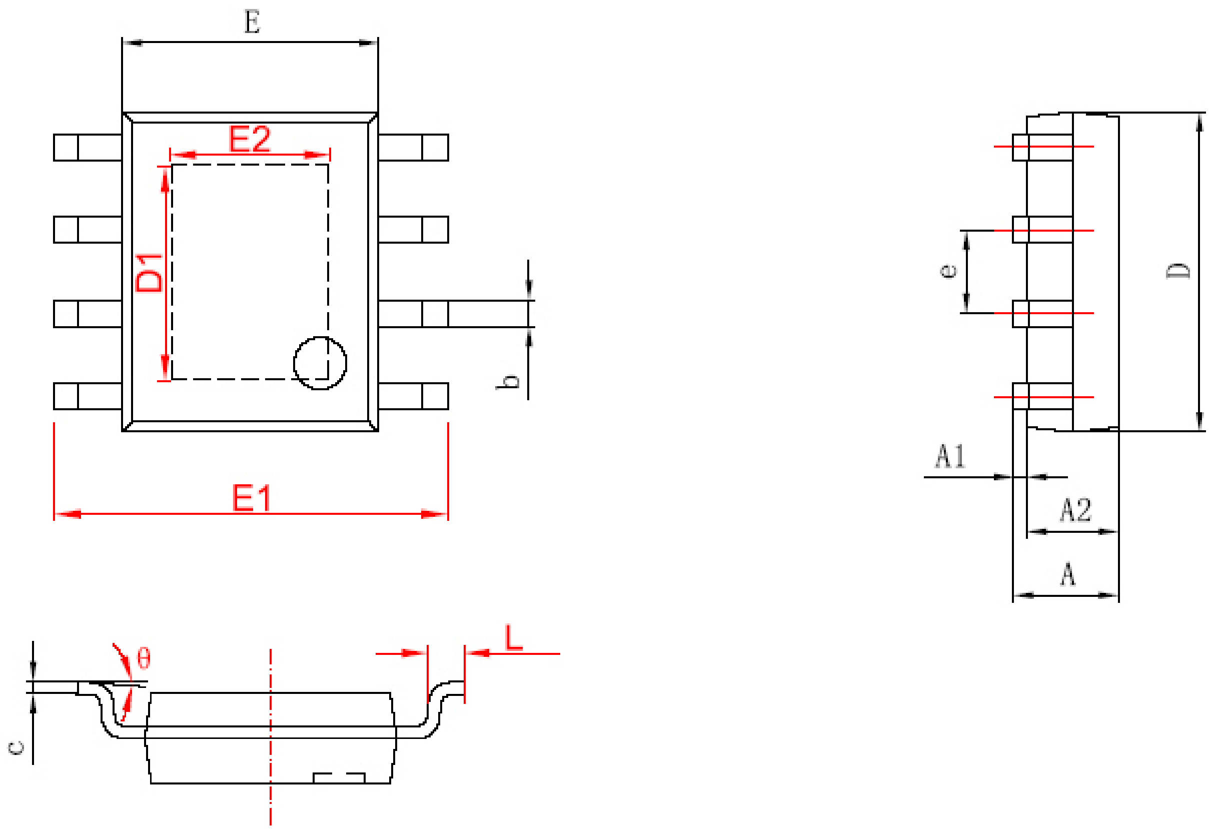


Figure14.Add Optional External Bootstrap Diode to Enhance Efficiency

The recommended external BST diode is IN4148, and the BST cap is 0.1~1μF.

Package Information

SOP8-pp Package Outline Dimensions



	Dimensions In Millimeters		Dimensions In 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°

Design Notes

3A 23V Synchronous Rectified Step-Down Converter TD1484B

General Description

The TD1484B is a monolithic synchronous buck regulator. The device integrates two 90mΩ MOSFETs, and provides 3A of continuous load current over a wide input voltage of 4.75V to 23V. Current mode control provides fast transient response and cycle-by-cycle current limit.

An adjustable soft-start prevents inrush current at turn-on, and in shutdown mode the supply current drops to 1μA.

The TD1484B regulates the output voltage in automatic PSM/PWM mode operation, depending on the outputcurrent, for high efficiency operation over light to full load current.

This device, available in an SOP8-PP package, provides a very compact solution with minimal external components.

Features

- 3A Output Current
- Wide 4.75V to 23V Operating Input Range
- Integrated 90mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 20V
- Up to 93% Efficiency
- Pulse Save Mode(PSM)/PWM Mode Operation
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340KHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

Package Types

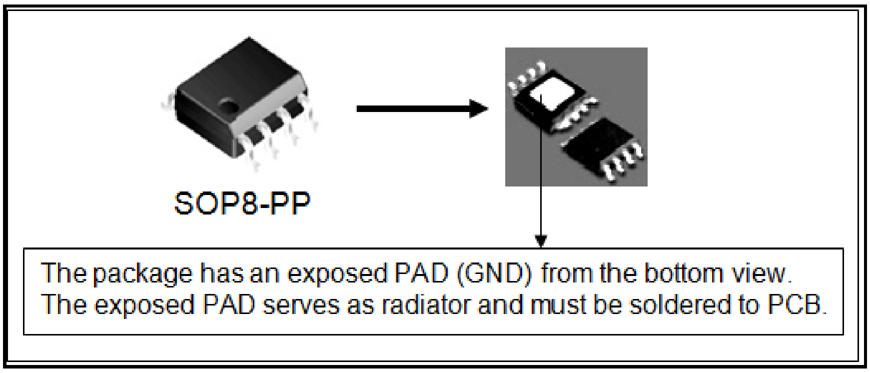


Figure 1. Package Types of TD1484B

Pin Configurations

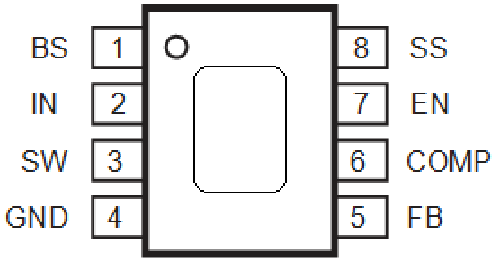


Figure 2 Pin Configuration of TD1484B(Top View)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01µF or greater capacitor from SW to BS to power the high side switch.
2	IN	Power Input. IN supplies the power to the IC, as well as the step-down converter switches. Drive IN with a 4.75V to 23V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See *Input Capacitor*.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BS to power the high-side switch.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V. See *Setting the Output Voltage*.
6	COMP	Compensation Node. COMP is used to compensate the regulation control loop. Connect a series RC network from COMP to GND to compensate the regulation control loop. In some cases, an additional capacitor from COMP to GND is required. See *Compensation Components.*
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off. Pull up with 100kΩ resistor for automatic startup.
8	SS	Soft-Start Control Input. SS controls the soft start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1µF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected.

Ordering Information

TD1484B □ □

Circuit Type

Package
M:SOP8-PP

Packing:
Blank：Tube
R:Type and Reel

Function Block

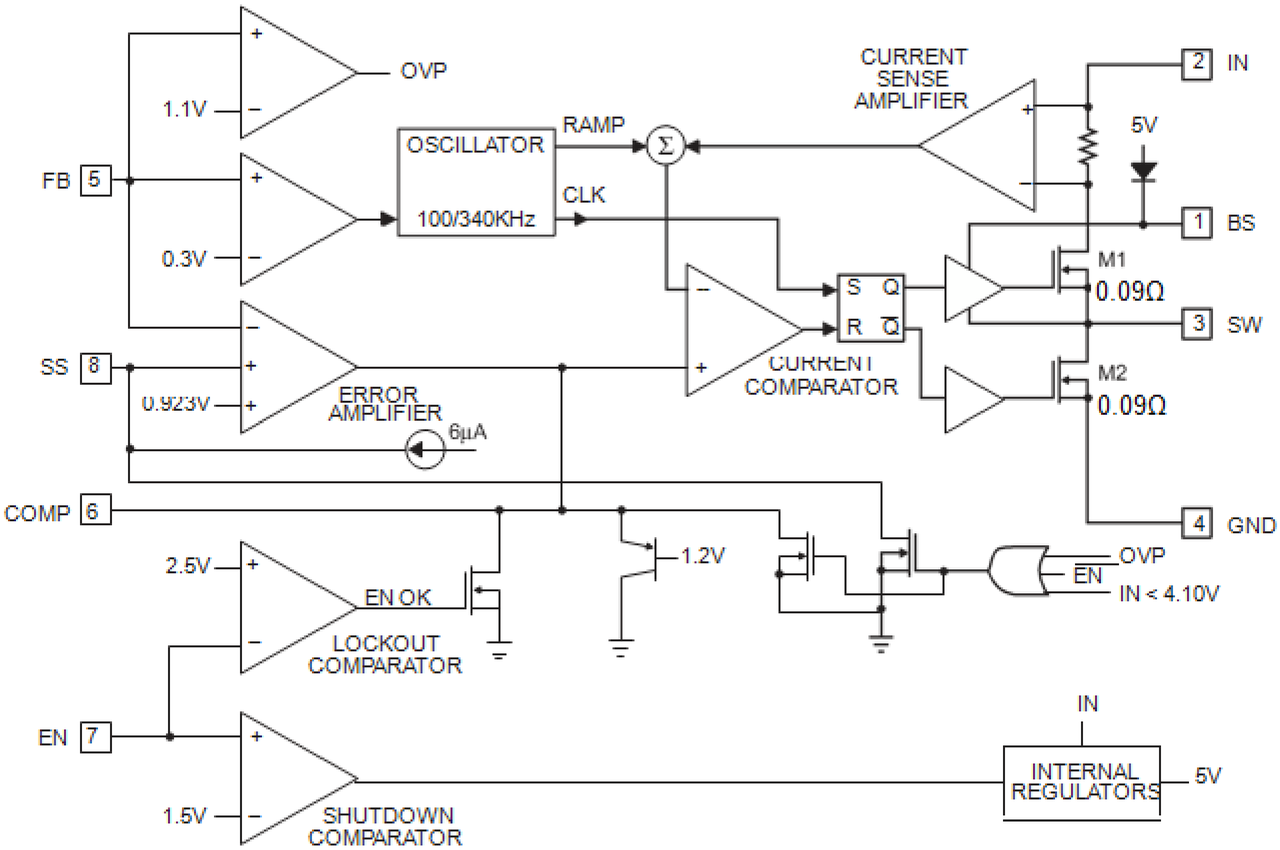


Figure 3 Function Block Diagram of TD1484B

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{IN}	-0.3 to 23	V
Switch Node Voltage	V_{SW}	21	V
Boost Voltage	V_{BS}	V_{SW} – 0.3V to V_{SW}+6V	V
Output Voltage	V_{OUT}	0.923V to 20	V
All Other Pins		–0.3V to +6V	V
Operating Junction Temperature	T_J	150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10 sec)	T_{LEAD}	260	ºC
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	RθJA	50	ºC / W
Thermal Resistance-Junction to Case	RθJC	10	ºC / W

Electrical Characteristics

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Shutdown Supply Current		VEN = 0V		1	3.0	μA
Supply Current		VEN = 2.0V; VFB = 1.0V		1.3	1.5	mA
Feedback Voltage	VFB	4.75V ≤ VIN ≤ 23V	0.900	0.923	0.946	V
Feedback Overvoltage Threshold				1.1		V
Error Amplifier Voltage Gain *	AEA			400		V/V
Error Amplifier Transconductance	GEA	ΔIC = ±10μA		800		μA/V
High-Side Switch On Resistance *	RDS(ON)1			90		mΩ
Low-Side Switch On Resistance *	RDS(ON)2			90		mΩ
High-Side Switch Leakage Current		VEN = 0V, VSW = 0V			10	μA
Upper Switch Current Limit		Minimum Duty Cycle	4.0	5.8		A
Lower Switch Current Limit		From Drain to Source		0.9		A
COMP to Current Sense Transconductance	GCS			4.8		A/V
Oscillation Frequency	Fosc1			340		KHz
Short Circuit Oscillation Frequency	Fosc2	VFB = 0V		100		KHz
Maximum Duty Cycle	DMAX	VFB = 1.0V		90		%
Minimum On Time *				220		ns
EN Shutdown Threshold Voltage		VEN Rising	1.1	1.5	2.0	V
EN Shutdown Threshold Voltage Hysteresis				210		mV
EN Lockout Threshold Voltage			2.2	2.5	2.7	V
EN Lockout Hysterisis				210		mV

Electrical Characteristics(Cont.)

V_{IN} = 12V, T_a = 25℃ unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Under Voltage Lockout Threshold		V_{IN} Rising	3.80	4.10	4.40	V
Input Under Voltage Lockout Threshold Hysteresis				210		mV
Soft-Start Current		V_{SS} = 0V		6		μA
Soft-Start Period		C_{SS} = 0.1μF		15		ms
Thermal Shutdown *				160		°C

Typical Performance Characteristics

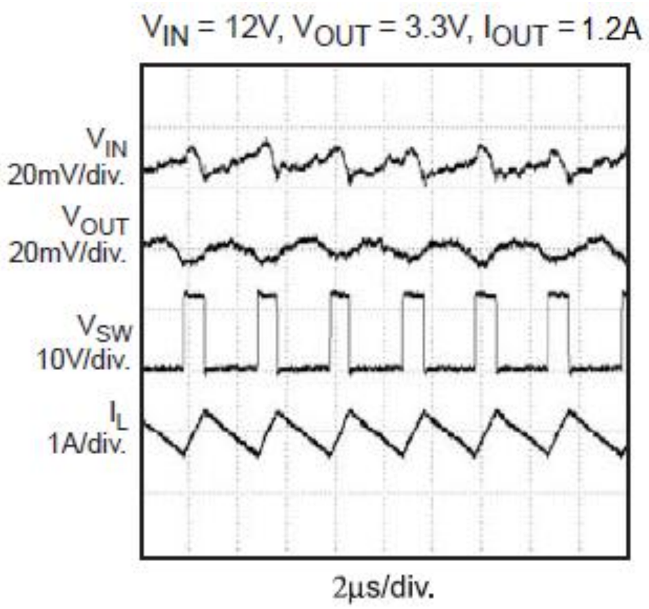


Figure 4. Steady State Test

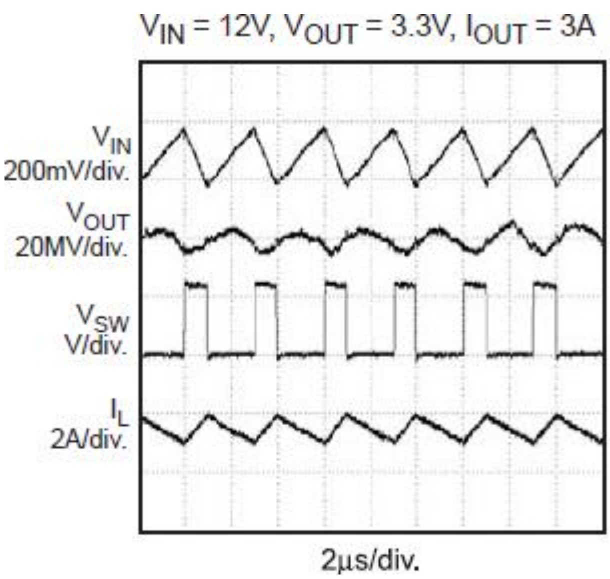


Figure 5. Steady State Test

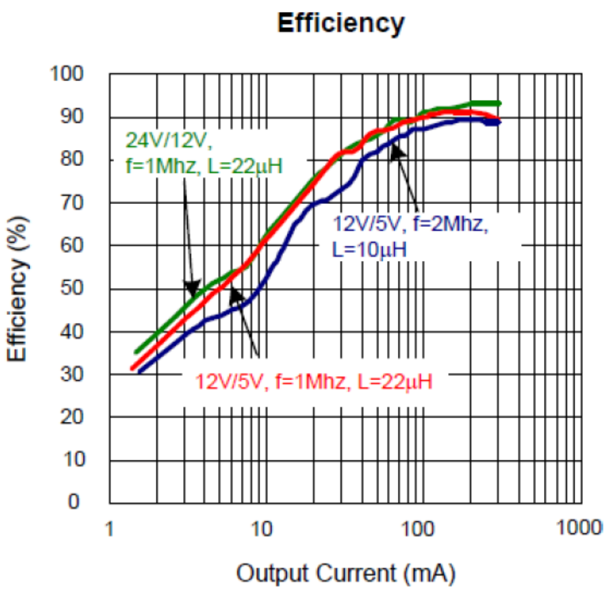
40V, 600Ma, 2MHz/1MHz synchronous Buck Converter TD1465

General Description

TD1465 is a 600mA synchronous buck converter with integrated 900mΩ power MOSFETs. The TD1465 design with a current-mode control scheme, can convert wide input voltage of 4.5V to 40V to the output voltage adjustable from 0.8V to 75%V_{IN} to provide excellent output voltage regulation.

The TD1465 equipped with Power-on-reset, soft start and whole protections (under-voltage, over temperature and current-limit) into a single package.

This device, available SOT-23-6 provides a very compact system solution of external components and PCB area.



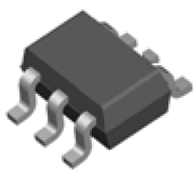
Features

- Wide Input Voltage from 4.5V to 40V
- 600mA Output Current
- High Efficiency over 85% from Load Current 30mA to 100mA @ V_{OUT}>=5V
- Low EMI Converter
- Adjustable Output Voltage from 0.8V to 75%V_{IN}
- Integrated 900mΩ High/Low Side MOSFET
- 1M or 2Mhz Switching Frequency
- Stable with Low ESR Capacitors
- Power-On-Reset Detection
- Over-Temperature Protection
- Current-Limit Protection
- Enable/Shutdown Function
- Available in SOT-23-6 packages
- Lead Free and Green Devices Available (RoHS compliant).

Applications

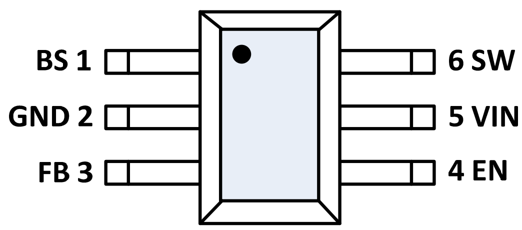
- Smart Electronic equipments

Package Types



SOT23-6

Pin Configurations



(Top view)

Pin Description

Pin Number	Pin Name	Description
1	BS	High-Side Gate Drive Boost Input. BS supplies the voltage to drive the high-side N-channel MOSFET. At least 10nF capacitor should be connected from SW to BS to supply the high side switch.
2	GDN	Signal and power ground.
3	FB	Output feedback Input. The TD1465 senses the feedback voltage via FB and regulates the voltage at 0.8V. Connecting FB with a resistor-divider from the converter's output sets the output voltage from 0.8V to 75%V_{IN}.
4	EN	Enable Input. EN is a digital input that turns the regulator on or off. EN threshold is 1.4V with 0.2V hysteresis. Pull up with 1MΩ resistor for automatic startup.
5	VIN	Power Input. VIN supplies the power (4.5V to 40V) to the control circuitry, gate drivers and step-down converter switches. Connecting a ceramic bypass capacitor and a suitably large capacitor between VIN and GND eliminates switching noise and voltage ripple on the input to the IC.
6	SW	Power Switching Output. It is the Drain of the N-Channel power MOSFET to supply power to the output LC filter.

Ordering Information

TD1465□ □ □

Circuit Type

Frequency: A-1MHz B-2MHz

Package

T：SOT23-6

Packing:

Blank：Tube

R: Tape and Reel

Function Block

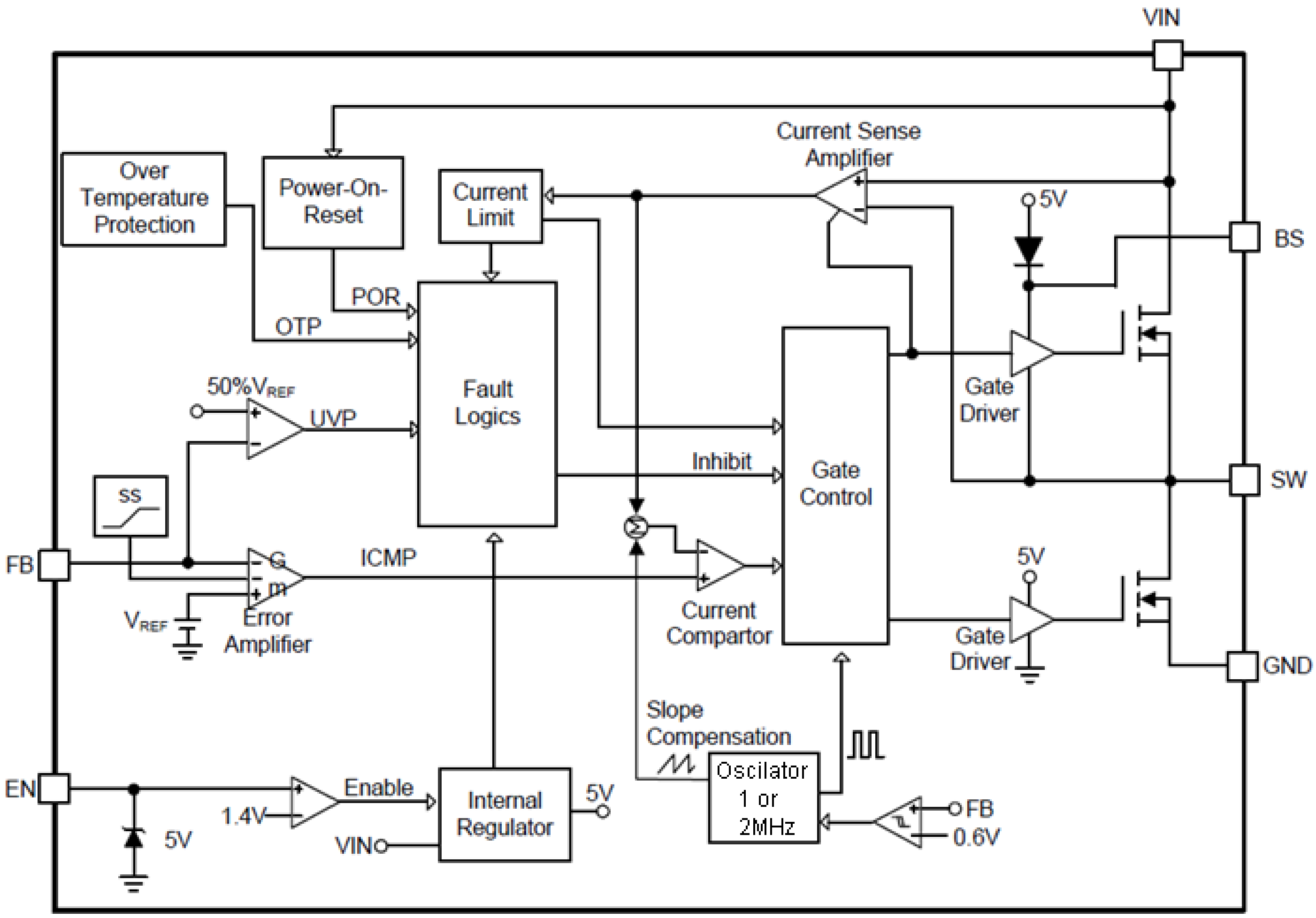


Figure1 Function Block Diagram of TD1465

Absolute Maximum Ratings (Note1)

Symbol	Parameter		Rating	Unit
V_{IN}	VIN Supply Voltage（VIN to Gnd）		-0.3 ~ 45	V
V_{SW}	SW to GND Voltage	Pulse Width > 20ns	-1 ~ 45	V
		Pulse Width < 20ns	-3 ~ 45	V
	EN, FB to GND Voltage		-0.3 ~ 6	V
V_{BS}	BS to GND Voltage		V_{SW} - 0.3 ~ V_{SW} +6	V
V_{BS-SW}	BS to SW Voltage		-0.3 ~ 6	V
P_D	Power Dissipation		Internally Limited	W
T_J	Junction Temperature		150	°C
T_{STG}	Storage Temperature		-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)		260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2) SOT-23-6	250	°C/W

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operation Conditions (Note3)

Symbol	Parameter		Range	Unit
V_{IN}	VIN Supply Voltage		4.5 ~ 40	V
V_{OUT}	Converter Output Voltage		0.8V ~ 75%V_{IN}	V
I_{OUT}	Converter Output Current	Continue	0 ~ 300	mA
		< 10ms	0 ~ 600	mA
	V_{OUT}/V_{IN} Maximum Ratio(Note 4)	TD1465A	75	%
		TD1465B	65	%
	V_{OUT}/V_{IN} Minimum Ratio(Note 5)	TD1465A	12	%
		TD1465B	15	%

T_A	Ambient Temperature	-40 ~ 85	°C
T_J	Junction Temperature	-40 ~ 125	°C

Note 3: Refer to the typical application circuit

Note 4: In applications where he V_{OUT}/V_{IN} ratio exceeds the Maximum Ratio and when output loading is sufficient to make the converter enter PWM mode, the V_{OUT} voltage will probably drop.

Note 5: When operating below the V_{OUT}/V_{IN} Minimum Ratio, the converter has the likelihood of entering PSM mode in spite of loading is heavy. However, In PSM mode, the V_{OUT} voltage is still regulated well.

Electrical Characteristics

Unless otherwise specified, these specifications apply over V_{IN}=12V, V_{EN}=3V and T_A = -40 to 85°C. Typical values are at T_A=25°C

Symbol	Parameter	Test Conditions	TD1465A/B			Unit
			Min	Typ	Max	
SUPPLY CURRENT						
I_{VIN}	V_{IN} Supply Current	V_{FB}=1V, SW=NC	-	0.85	1.2	mA
I_{VIN_SD}	V_{IN} Shutdown Supply Current	V_{EN}=0V	-	1	10	μA
POWER-ON-RESET (POR)						
	V_{IN} POR Voltage Threshold	V_{IN} Rising	3.7	3.9	4.1	V
	V_{IN} POR Hysteresis		-	0.6	-	V
REFERENCE VOLTAGE						
V_{REF}	Reference Voltage		-	0.8	-	V
	Output Voltage Accuracy	T_J=25°C, I_{OUT}=10mA	-3	-	+3	%
I_{FB}	FB input current		-	10	50	nA
OSCILLATOR AND DUTY CYCLE						
F_{SW}	Switching Frequency	TD1465B	1600	2000	2400	kHz
		TD1465A	800	1000	1200	kHz
	Minimum on-time		-	60	80	ns

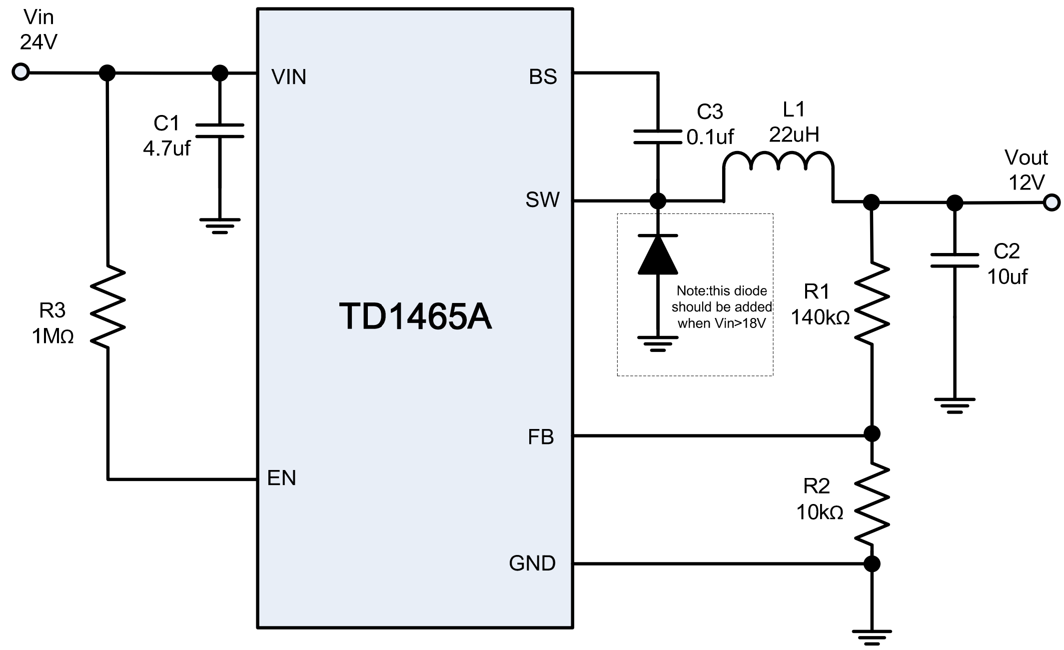
Electrical Characteristics

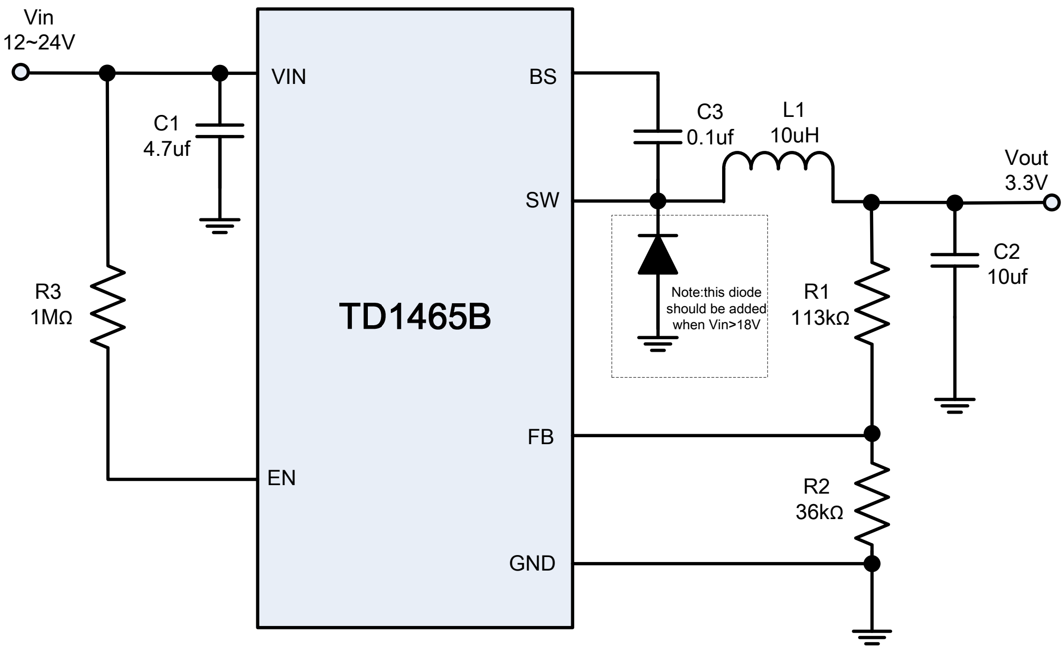
T_A=+25°C and V_{CC}=15V, unless otherwise specified.

Symbol	Parameter	Test Conditions	TD1465A/B			Unit
			Min	Typ	Max	
POWER MOSFET						
	High Side MOSFET Resistance		-	900	-	mΩ
	Low Side MOSFET Resistance		-	900	-	mΩ
	High Side Switch Leakage Current	V_{EN}=0V, V_{IN}=40V, V_{SW}=0V	-	-	2	µA
	Low Side Switch Leakage Current	V_{EN}=0V, V_{IN}=40V, V_{SW}=0V	-	-	2	µA
	Dead-time		-	10	-	ns
PROTECTIONS						
I_{LIM}	High Side MOSFET Current-Limit		0.6	0.7	0.8	A
	Under-Voltage Protection (UVP)		40	50	60	%V_{REF}
	Over-Temperature Protection		-	150	-	°C
	Over-Temperature Hysteresis		-	30	-	°C
SOFT-START, ENABLE						
t_{SS}	Soft Start Time		-	1	-	ms
	EN Rising Threshold Voltage	V_{IN}=4.5V ~ 40V	1.2	1.4	1.6	V
	EN Falling Threshold Hysteresis	V_{IN}=4.5V ~ 40V	-	0.2	-	V
	EN Turn on delay		-	50	-	µS
	EN Input Current	V_{EN}=2V	-	2	-	µA
	EN Clamp High		4	5	6	V
	EN Input Current	V_{EN}=6V	-	-	10	µA

Note 6: Techcode guarantee the SW maximum duty cycle. The maximum percentage of converter output over input voltage depends on load current.

Typical Application Circuit





Application Information

Main Control Loop

The TD1465 is a constant frequency, synchronous rectifier and current-mode switching regulator. In normal operation, the internal upper power MOSFET is turned on each cycle. The peak inductor current at which ICMP turn off the upper MOSFET is controlled by the voltage on the COMP node, which is the output of the error amplifier(EAMP). An external resistive divider connected between V_{out} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. When the load current increases, it causes a slightly decrease in V_{FB} relative to the 0.8V reference, which in turn causes the COMP voltage to increase until the average inductor current matches the new load current.

V_{IN} Power-On-Reset (POR)

The TD1465 keep monitoring the voltage on V_{IN} pin to prevent wrong logic operations which may occur when V_{IN} voltage is not high enough for the internal control circuitry to operate. The V_{IN} POR has a rising threshold of 3.9V (typical) with 0.6V of hysteresis.

After the VIN voltages exceed its respective POR thresholds, the IC starts a start-up process and then ramps up the output voltage to the setting of output voltage. Connect a RC network from EN to GND to set a turn-on delay that can be used to sequence the output voltages of multiple devices.

Enable/Shutdown

Driving EN to ground places the TD1465 in shutdown. When in shutdown, the internal power MOSFETes turn off, all internal circuitry shuts down and the quiescent supply current of VIN reduces to <10μA, the EN under-voltage-lockout (UVLO) has a rising threshold of 1.4V(typical) with 0.2V of hysteresis.

Soft-Start

The TD1465 provides built-in soft-start function to limit the inrush current. The soft-start time is 1ms。

Bootstrap Capacitor

The TD1465 is a N-channel MOSFET step down converter. The MOSFET requires a gate voltage that is higher than input voltage, thus a boost capacitor should be connected between SW and BST pins to drive the gate of the N-channel MOSFET. Typical boostrap capacitor value is from 10nF to 100nF.

Over-Current-Protection and Hiccup

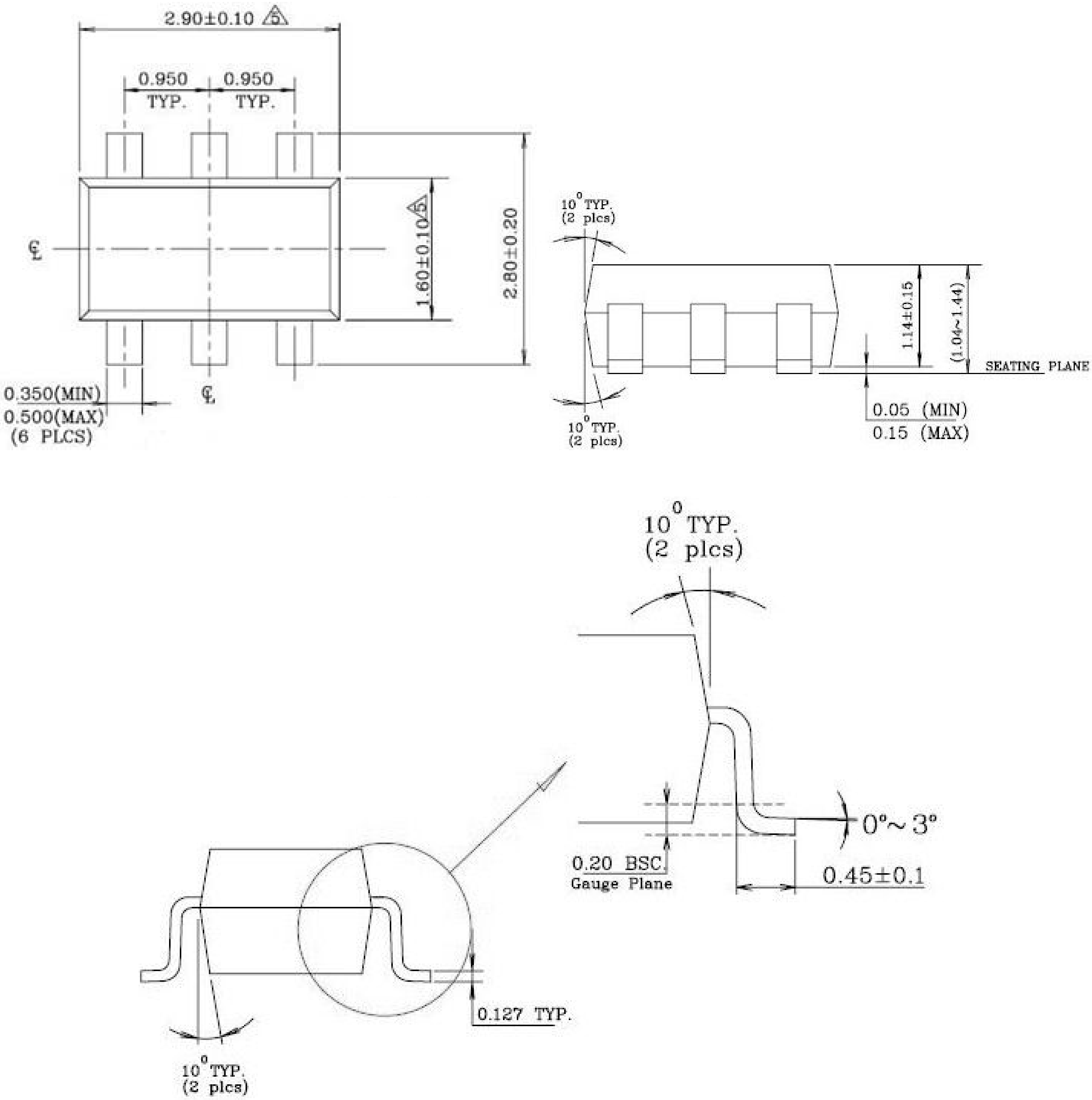
The TD1465 has a cycle-by-cycle over-current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, the output voltage drops until FB is below the Under-Voltage (UV) threshold below the reference. Once UV is triggered, the TD1465 enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-shorted to ground. The average short circuit current is greatly reduced to alleviate thermal issues and to protect the regulator. The TD1465 exits the hiccup mode once the over-current condition is removed.

Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the TD1465. When the junction temperature exceeds 150^{o}C, a thermal sensor turns off the N-channel power MOSFET, allowing the device to cool down. The thermal sensor allows the converter to start a start-up process and regulate the output voltage again after the junction temperature cools by 30^{o}C. The OTP designed with a 30^{o}C hysteresis lowers the average T_J during continuous thermal overload conditions, increasing life time of the TD1465.

Package Information

SOT23-6 Package Outline Dimensions



Design Notes