kinetic technologies™

KTC3500

3.5V to 60V Input Boost/SEPIC/Flyback DC-DC Controller

Features

- Wide VIN Range: 3.5V to 60V (65V Abs Max)
- Support Boost, SEPIC, and Flyback Topologies
- Current Mode Control with Internal Slope Compensation
- Internal Startup Regulator
- Adjustable Switching Frequency from 100kHz to 1.2MHz
- 1.2V Feedback Voltage Reference with ±1% Accuracy
- 5µA Shutdown Supply Current
- 500µA Operating (Non-Switching) Current
- Programmable Soft-Start Time
- Integrated 10V Gate Driver with 3A / 2A Source / Sink Current Capability
- Precise Enable/Disable for Adjustable UVLO
- Multiple Protections for Safe Operation:
  - Built-in Cycle-by-Cycle Current Limit;
  - Input UVLO;
  - Over-Current Protection;
  - Short-Circuit Protection;
  - Output Over-Voltage Protection;
  - Thermal Shutdown.
- -40°C to 125°C Operating Junction Temperature Range
- Small 10-Lead DFN (3 mm x 3 mm) Package

Brief Description

KTC3500 is a low quiescent current DC/DC controller supporting boost, SEPIC, and flyback topologies. It can operate from a wide input ranging from 3.5V to 60V thus can support a variety of applications with input voltage from 5V, 12V, 24V, and 48V power rails and multicell batteries.

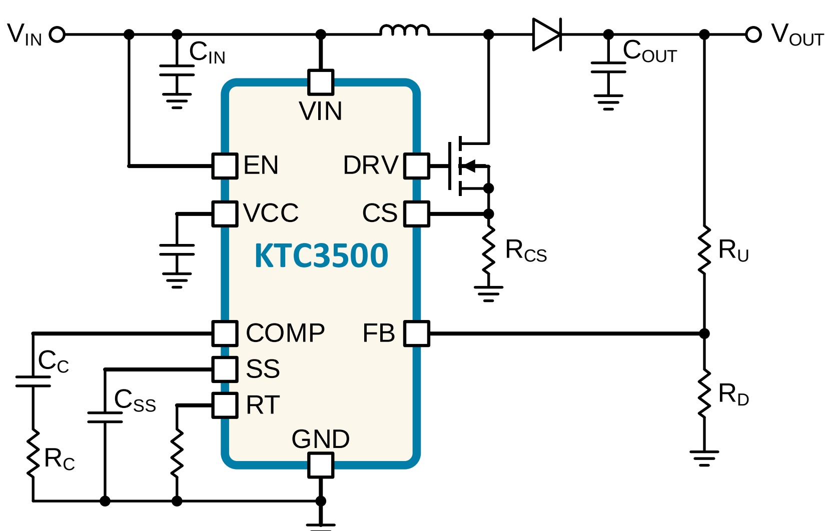
KTC3500 employs current-mode control with internal slope compensation for fast transient response as well as superior output voltage regulation. The device has an adjustable switching frequency from 100kHz to 1.2MHz, which provides flexibility and allows optimized design for various application needs. The device features an adjustable soft-start function to limit inrush current during start-up. The precision Enable/Disable can be used to set desired input under-voltage lockout threshold. The device has built-in protections including input voltage UVLO, output over-voltage-protection (OVP), cycle-by-cycle current limit, short-circuit protection and thermal shutdown.

KTC3500 is available in RoHS and Green compliant 10- Lead DFN (3 mm x 3 mm) Package.

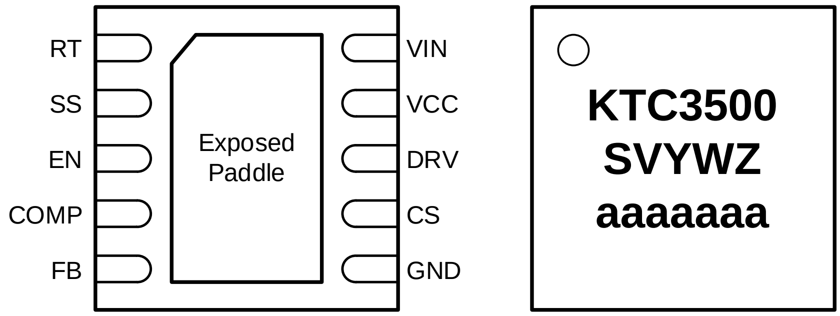
Applications

- 5V, 12V, 24V, and 48V Power Systems
- Power Amplifiers
- Automotive Start-Stop Systems
- Battery Powered Power Systems
- Tablets Accessories

Typical Applications



Pinout Diagram



Top Mark
DFN33-10 Package
(3.00mm x 3.00mm x 0.75mm)

SV = Device Code, YW = Date Code, Z = Serial Number
aaaaaaa = Serial Number of Assembly Lot

Pin Descriptions

Pin #	Name	Function
1	RT	Resistor timing. An external resistor from this pin to the GND pin programs the switching frequency between 100kHz and 1.2MHz.
2	SS	Soft-start programming pin. A capacitor between the SS pin and GND pin sets soft- start time.
3	EN	Enable pin. Floating this pin will enable the IC. Pull below 1.2V to enter low current standby mode. Pull below 0.4V to enter shutdown mode. The EN pin can be used to implement adjustable UVLO using two resistors.
4	COMP	Output of the internal transconductance error amplifier. The feedback loop compensation network is connected from this pin to GND.
5	FB	Error amplifier input and feedback pin for voltage regulation. Connect this pin to the center tap of a resistor divider to set the output voltage.
6	GND	Device Ground.
7	CS	Current sense pin. Connect an external current sensing resistor between this pin and GND. The voltage on this pin is used for both current control loop and overcurrent detection. The overcurrent protection threshold is 80mV typical.
8	DRV	Low-side gate driver output. Connect this pin to the gate of the low-side N-channel MOSFET. When VIN bias is removed, an internal 200kΩ resistor pulls LDRV to PGND.
9	VCC	Output of an internal LDO and power supply for internal control circuits and gate drivers. VCC is typically 10V. Connect a low-ESR ceramic capacitor from this pin to PGND. A capacitance ranging from 0.47µF to 10µF is recommended.
10	VIN	The input supply pin to the IC. Connect VIN to a supply voltage between 3.5V and 60V. It is acceptable for the voltage on the VIN pin to be different from the boost power stage input.
EP	Exposed Pad	The Power PAD should be connected to AGND. If possible, use thermal vias to connect to an internal ground plane for improved power dissipation.

Ordering Information

Part Number	Marking[1]	Operating Temperature	Package
KTC3500EVAC-TB	SVYWZ	-40°C to +125°C	DFN33-20

1. SV is the Device Code, YW = Date Code, Z = Serial Number

Absolute Maximum Ratings[2]

(T_A = 25°C unless otherwise noted)

Symbol	Description	Value	Units
V_{VIN}	VIN to GND	–0.3 to 65	V
V_{VCC}	VCC to GND	–0.3 to 15	V
V_{DRV}	DRV to GND	–0.3 to 15	V
V_{EN}	EN to GND	–0.3 to 65	V
$V_{I/O}$	All other I/O pins to GND	–0.3 to 7	V
T_j	Operating Temperature Range	-40 to 150	°C
T_S	Storage temperature	–65 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	260	°C

ESD and Ratings[3]

Symbol	Description	Value	Units
$V_{(ESD)}$	Human body model (HBM)	±2000	V
	Charged device model (CDM)	±750	V

Thermal Capabilities[4]

Symbol	Description	Value	Units
Θ_{JA}	Thermal Resistance – Junction to Ambient	48.2	°C/W
P_D	Maximum Continuous Power Dissipation at T_A = 25°C (T_J = 125°C)	2.07	W
$\Delta P_D/\Delta_T$	Derating Factor Above T_A = 25°C	-20.7	mW/°C

Recommended Operating Conditions

Symbol	Description	Value	Units
V_{VIN}	Supply Voltage	6 to 60	V
V_{VCC}	External voltage at VCC	9.5 to 14	V
Ta	Ambient temperature	-40 to 85	°C
Tj	Junction temperature	-40 to 125	°C

2. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.

3. ESD and Surge Ratings conform to JEDEC and IEC industry standards. Some pins may actually have higher performance.

4. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.

Electrical Characteristics[5]

Typical limits apply for Tj = 25°C and are provided for reference purposes only. Minimum and maximum limits apply over the junction temperature (TJ) range of –40°C to +125°C. VIN = 24 V and R_T = 25 kΩ, unless otherwise indicated.[6]

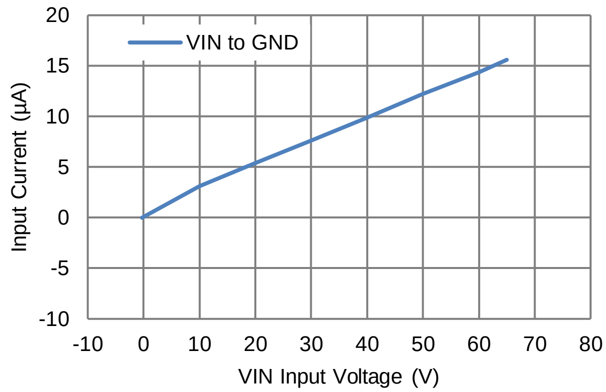
Symbol	Description	Conditions	Min	Typ	Max	Units
VCC						
V_{VCC}[7]	VCC regulation	12V ≤ VIN ≤ 60V, IVCC = 1mA	9.5	10	10.5	V
	VCC regulation	3.5V ≤ VIN < 12V, VCC = float		V_{IN}-0.05		V
I_{VCC}	Supply current	CVCC = 0μF, VCC = 10V		20		mA
$I_{VCC-LIM}$[8]	VCC current limit		25	50	70	mA
V_{VCC-HI}	VCC UVLO threshold		2.8	3.1	3.4	V
$V_{VCC-HYS}$	VCC UVLO hysteresis			200		mV
VIN						
I_{VIN_NOSW}	No switching current	VIN = 60V, VFB = 2V		500	800	µA
I_{VIN-SD}	Shutdown current	VIN = 60V, VEN = 0V, VCC = float		5	20	µA
Error Amplifier						
GBW	Gain Bandwidth			10		MHz
A_{DC}	DC Gain			65		dB
A_{GM}		V_{FB} = 1.24V, V_{COMP} = 1V	80	120	150	uS/V
FB						
V_{FB}	FB Pin Voltage		1.17	1.2	1.23	V
EN						
V_{EN-R}	Rising threshold		1.2	1.24	1.27	V
V_{EN-H}	Hysteresis			100		mV
Current Limit						
V_{CS}	Current limit threshold	Voltage at CS pin		80		mV
t_{BLK}	Leading edge blanking time			65		ns
R_{CS}	CS to GND impedance			1	5	MΩ
Soft-Start						
I_{SS}	Soft start capacitor charger current		21	30	40	µA
V_{SS-OFF}[9]	Soft-start to COMP offset		0.4	0.6	0.8	V
PWM						
D_{MIN}	Minimum duty cycle	Burst Mode		0		%
D_{MAX}	Maximum duty cycle	Fsw = 480KHz		90		%
Oscillator						
F_{SW}	Switching Frequency		100		1200	KHz
Driver						
R_{DSON_H}	Pull high FET on-resister			0.88	1.1	Ω
R_{DSON_L}	Pull low FET on-resister			0.55	0.7	Ω
OTP						
T_{SD}	Thermal shutdown threshold			150		°C
T_{SD_HYS}	Thermal shutdown hysteresis			20		°C

5. Device is guaranteed to meet performance specifications over the –40°C to +125°C operating temperature range by design, characterization and correlation with statistical process controls.
6. All minimum and maximum limits are specified by correlating the electrical characteristics to process and temperature variations and applying statistical process control. The junction temperature (TJ in °C) is calculated from the ambient temperature (TA in °C) and power dissipation (PD in Watts) as follows: TJ = TA + (PD • RθJA) where RθJA (in °C/W) is the package thermal impedance provided in the Thermal Information section.
7. VCC provides bias for the internal gate drive and control circuits.
8. Device is guaranteed to meet performance specifications over the –40°C to +125°C operating temperature range by design.
9. Device is guaranteed to meet performance specifications over the –40°C to +125°C operating temperature range by design.

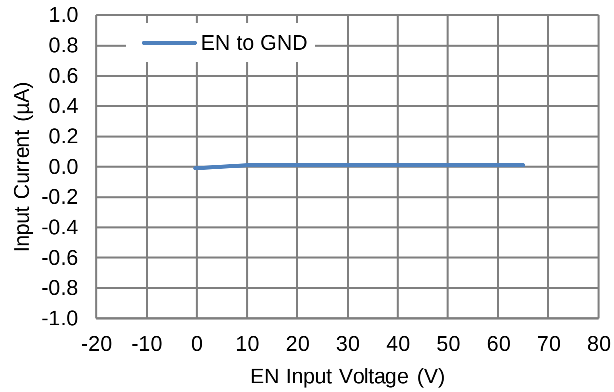
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

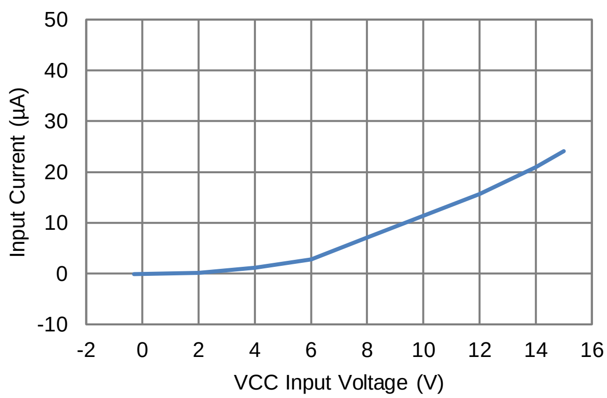
Current vs VIN Changes



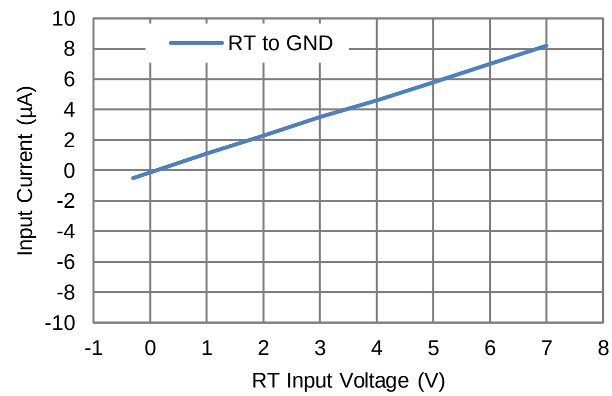
Current vs EN Change



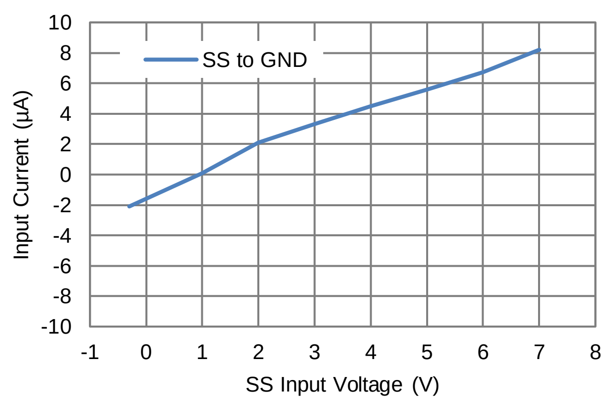
Input Current vs VCC (0-15V)



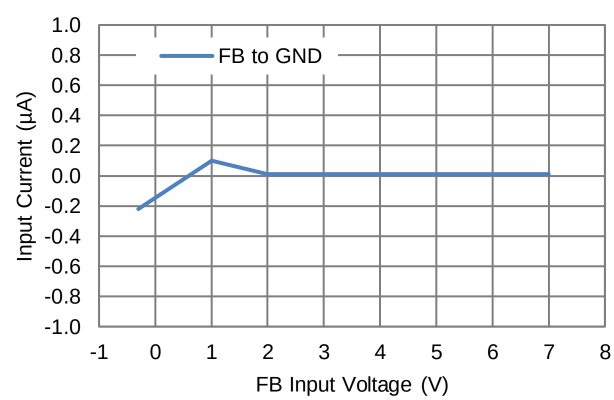
Input Current vs RT (V)



Input Current vs SS Input Voltage



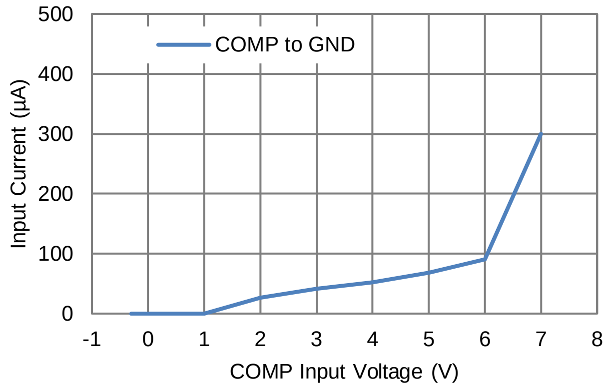
Input Current vs FB Voltage



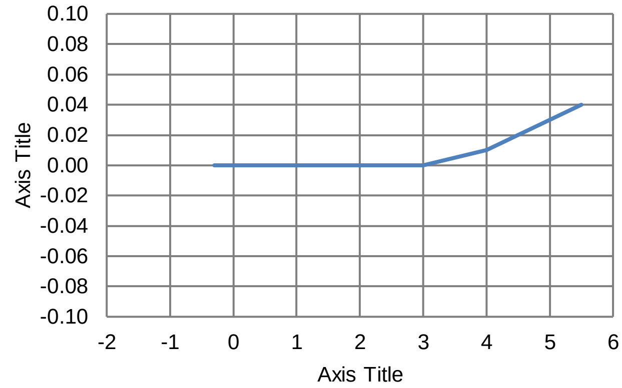
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

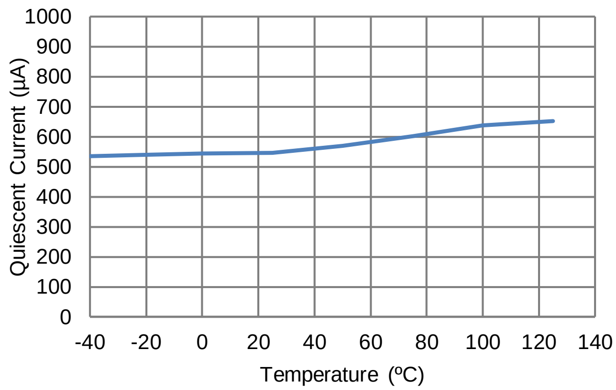
Input Current vs COMP Voltage Changes



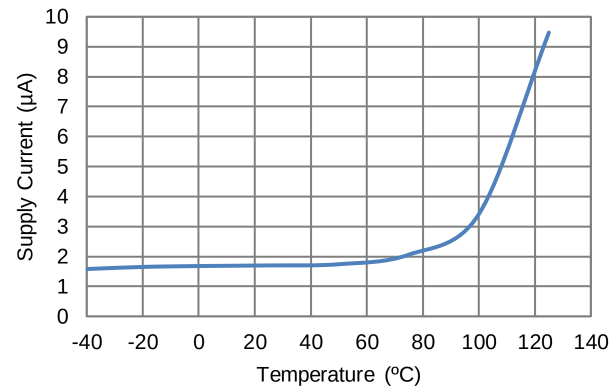
Input Current vs CS Voltage Changes (0-5.5V)



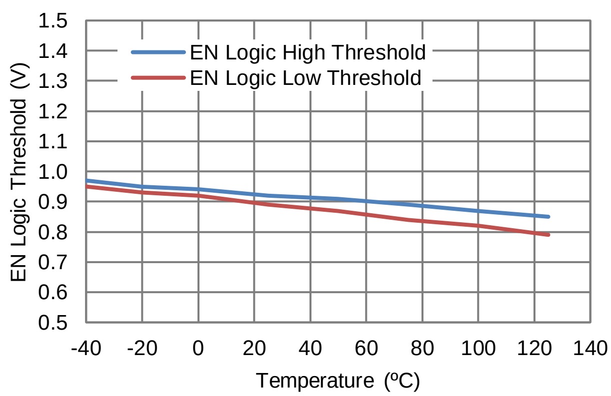
Quiescent Current vs Temperature



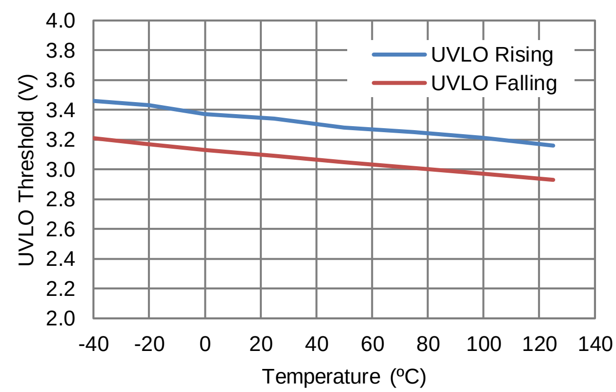
Supply Current vs Temperature



EN Threshold vs Temperature



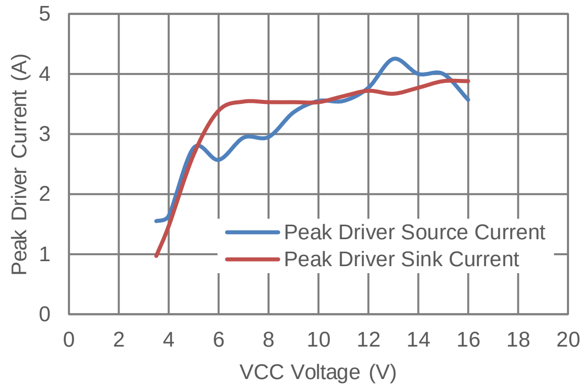
UVLO Threshold vs Temperature



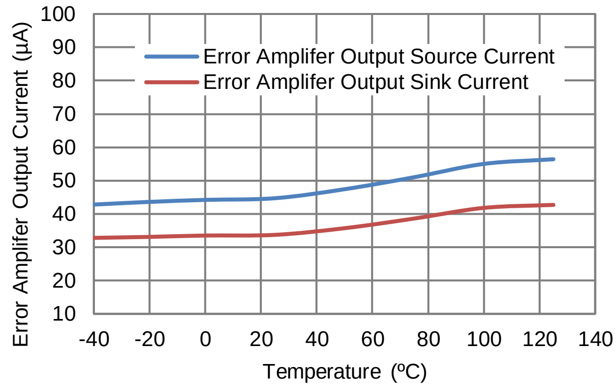
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

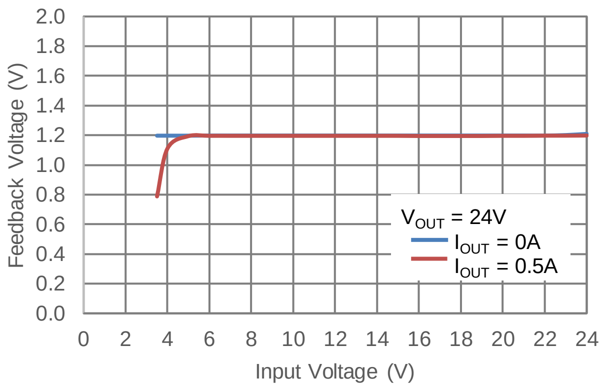
Peak driver Current vs VCC Changes



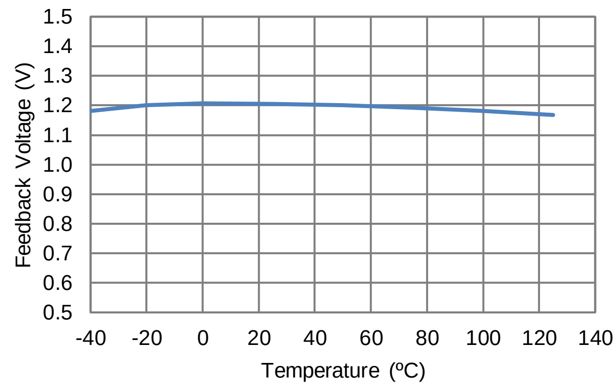
EA Current vs Temperature



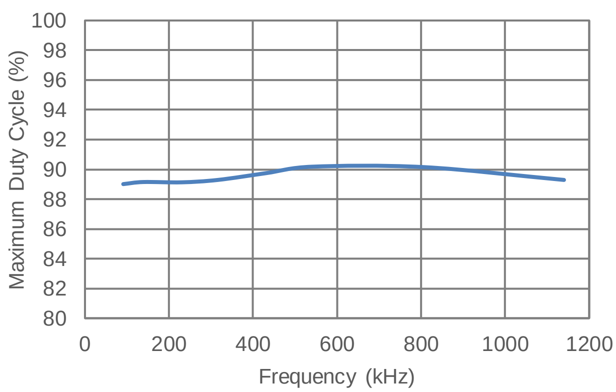
Feedback Voltage vs VIN Changes



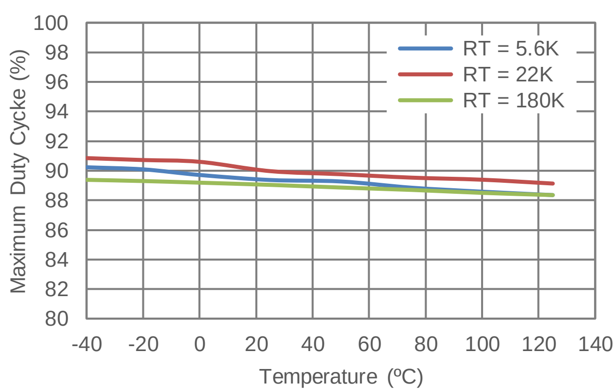
FB Voltage Changes vs Temperature



Maximum Duty Cycle vs Frequency



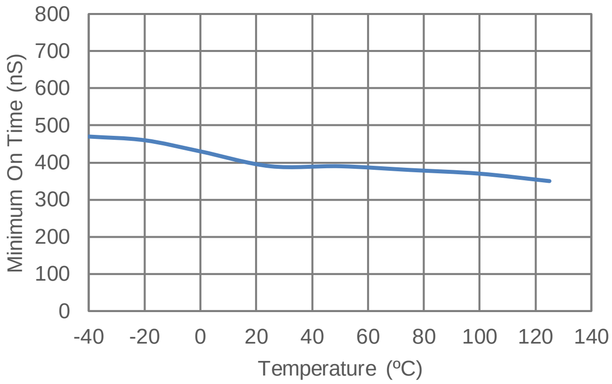
Maximum Duty Cycle vs Temperature



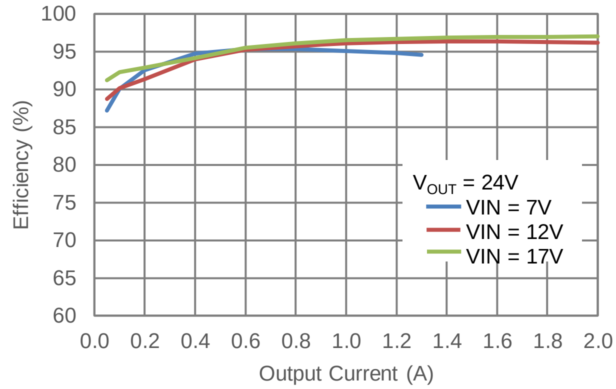
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

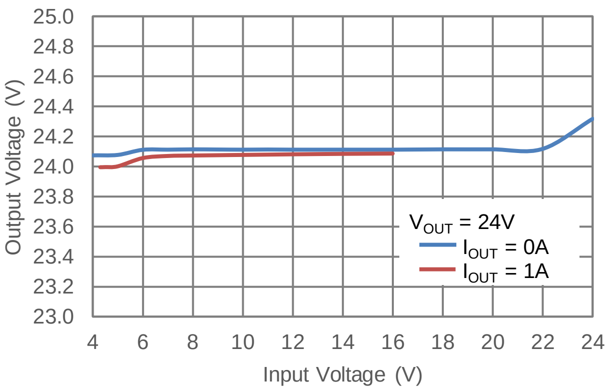
Minimum ON Time vs Temperature



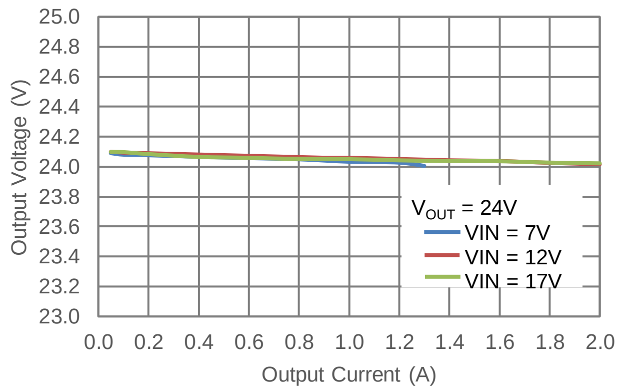
Efficiency vs Output Current



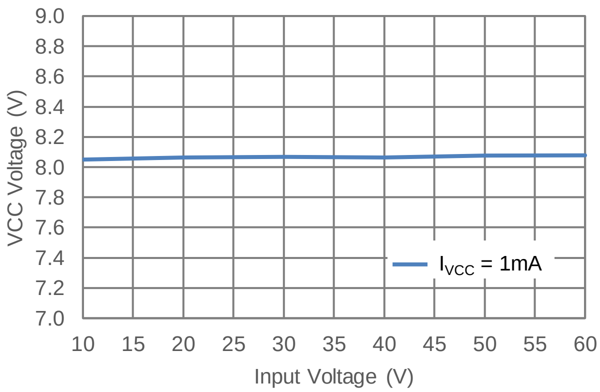
Line Regulation



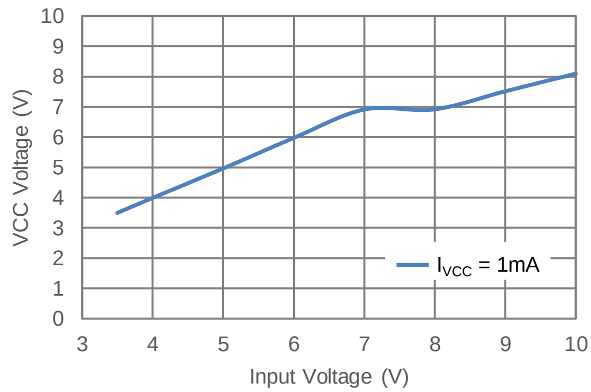
FB Load Regulation



VCC Voltage vs VIN Changes (VIN>10V)



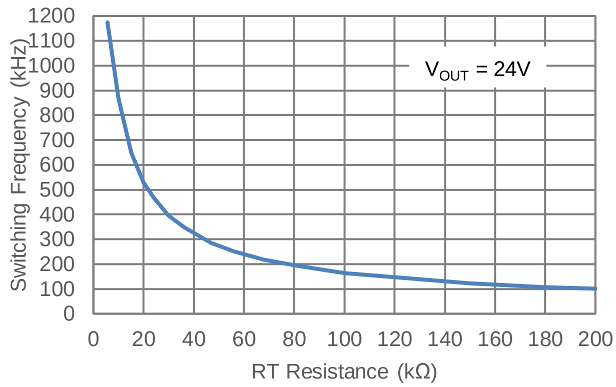
VCC Voltage vs VIN Changes (VIN<10V)



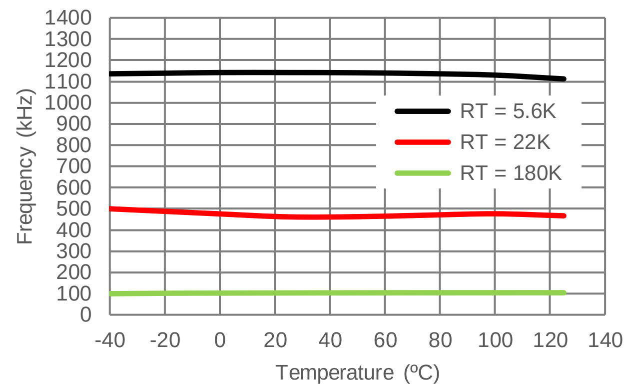
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

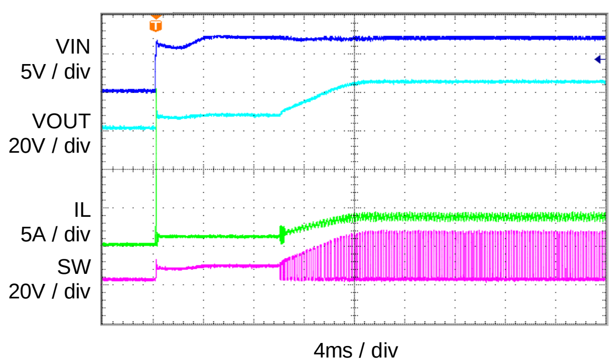
Switching Frequency vs. RT Resistance



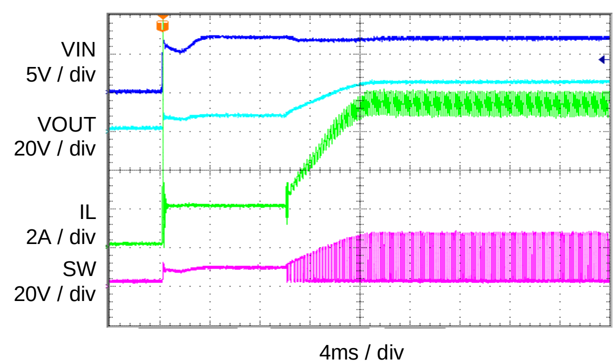
Frequency vs. Temperature



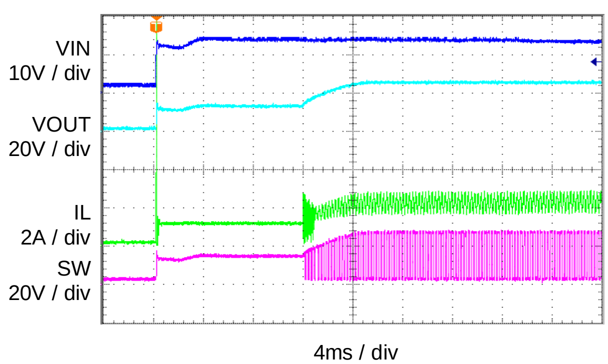
Power ON
(VIN = 7V, IOUT = 1A)



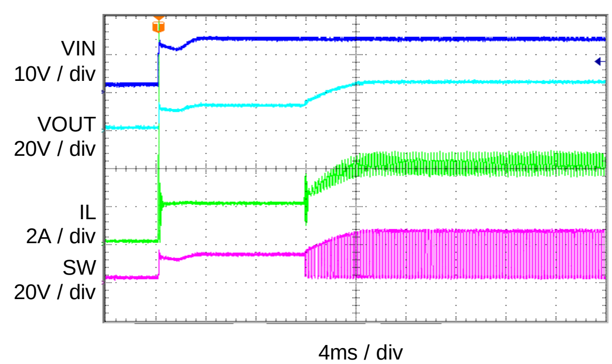
Power ON
(VIN = 7V, IOUT = 2A)



Power ON
(VIN = 12V, IOUT = 1A)



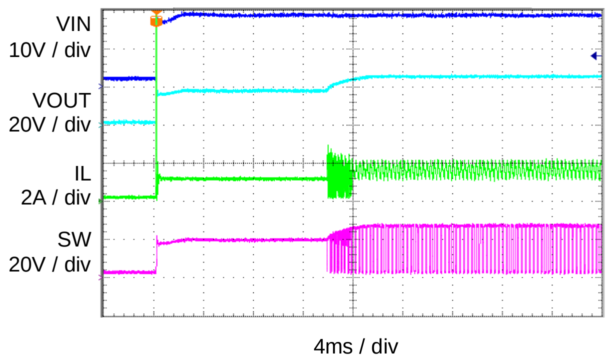
Power ON
(VIN = 12V, IOUT = 2A)



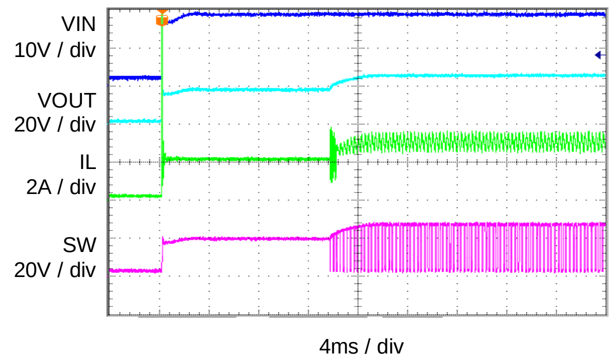
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

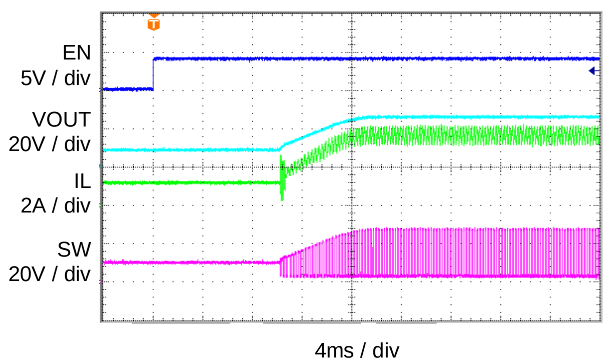
Power ON
(VIN = 17V, IOUT = 1A)



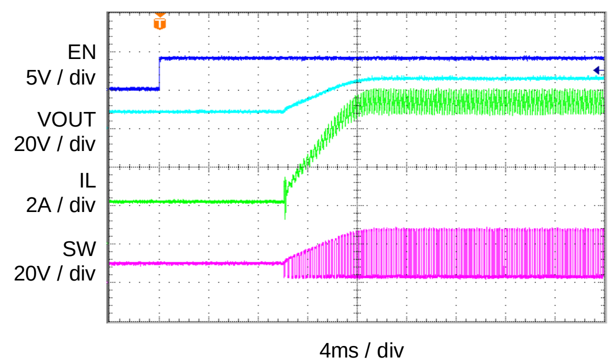
Power ON
(VIN = 17V, IOUT = 2A)



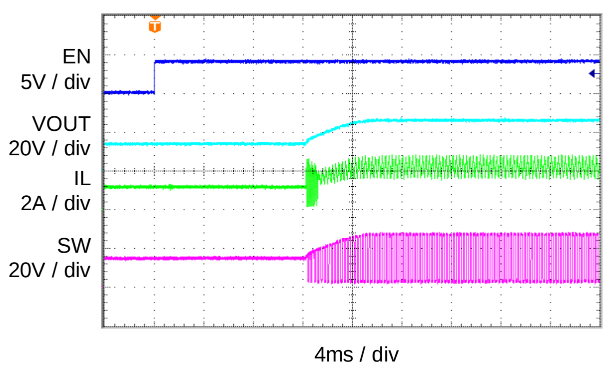
EN Soft Start
(VIN = 7V, IOUT = 1A)



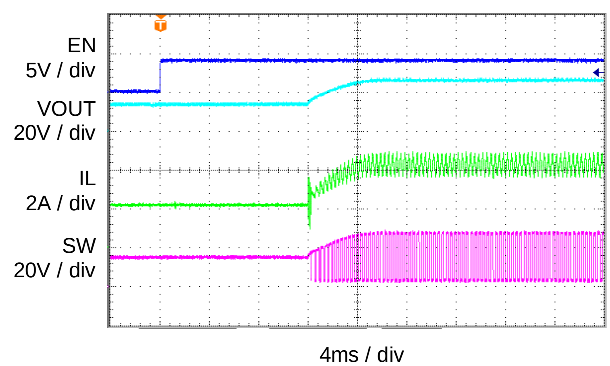
EN Soft Start
(VIN = 7V, IOUT = 2A)



EN Soft Start
(VIN = 12V, IOUT = 1A)



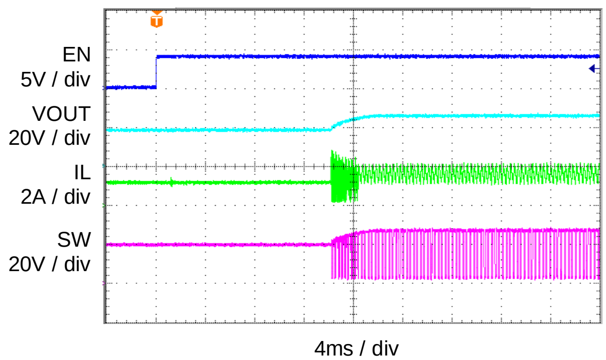
EN Soft Start
(VIN = 12V, IOUT = 2A)



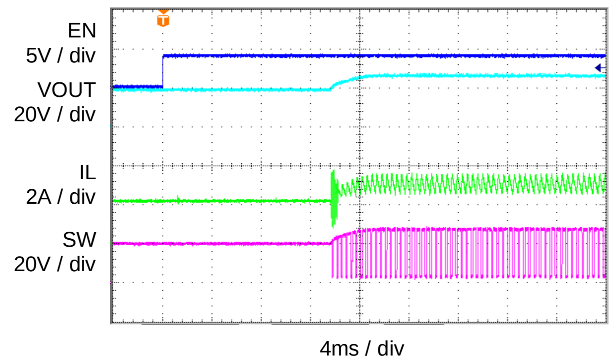
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

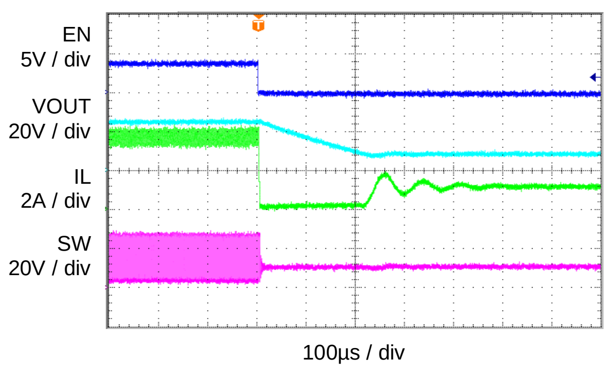
EN Soft Start
(VIN = 17V, IOUT = 1A)



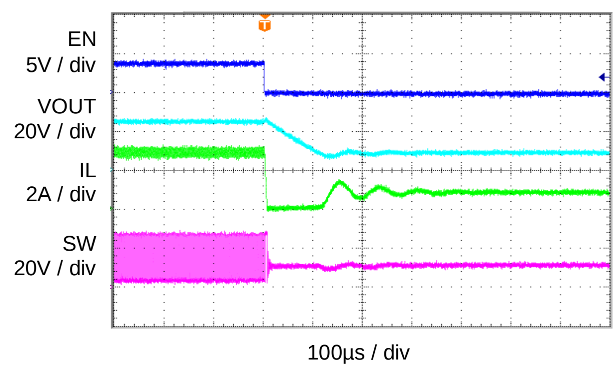
EN Soft Start
(VIN = 17V, IOUT = 2A)



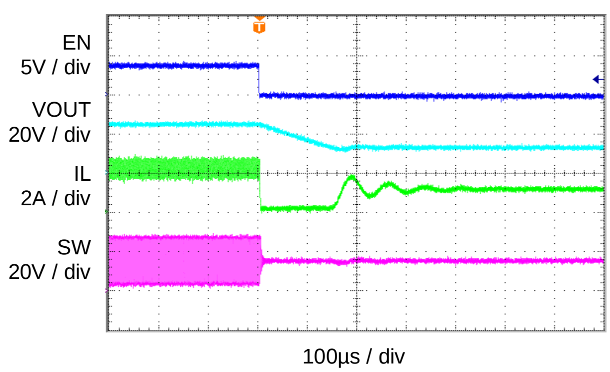
EN Shutdown
(VIN = 7V, IOUT = 1A)



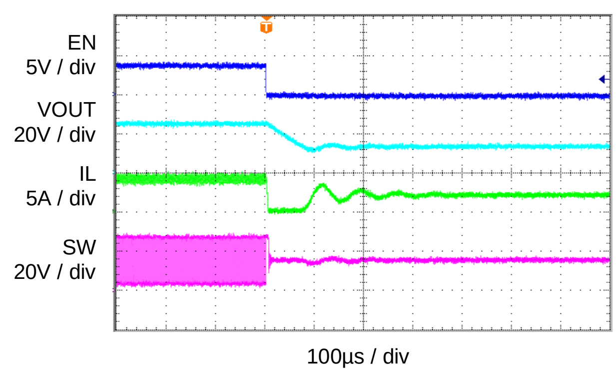
EN Shutdown
(VIN = 7V, IOUT = 2A)



EN Shutdown
(VIN = 12V, IOUT = 1A)



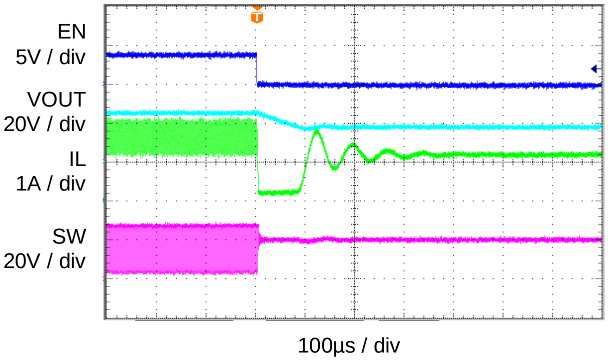
EN Shutdown
(VIN = 12V, IOUT = 2A)



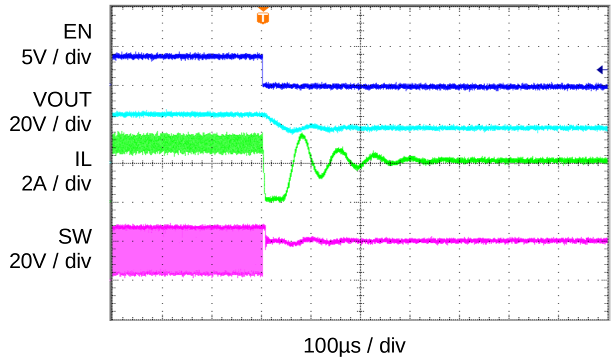
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

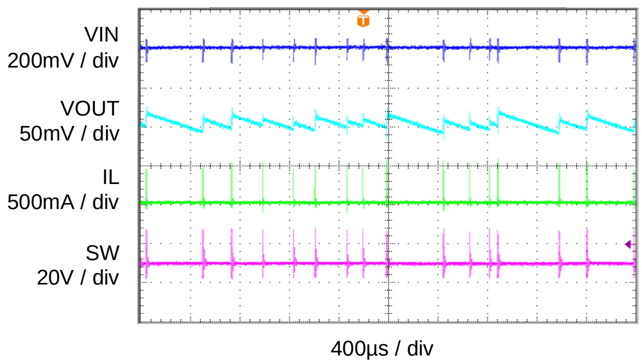
EN Shutdown
(VIN = 17V, IOUT = 1A)



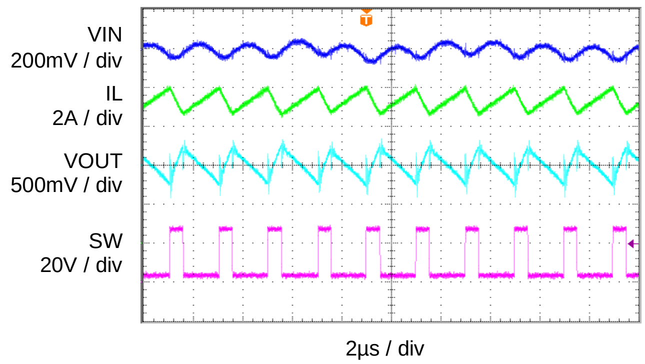
EN Shutdown
(VIN = 17V, IOUT = 2A)



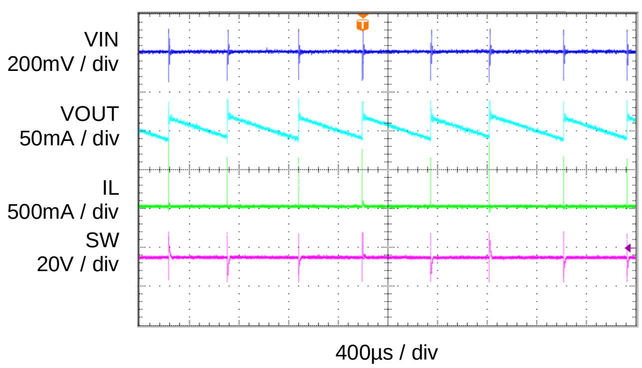
Working Waveform (Input and Output Ripples)
(VIN = 7V, IOUT = 0A)



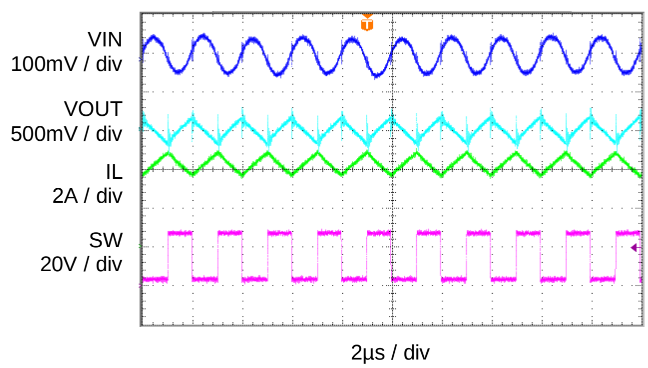
Working Waveform (Input and Output Ripples)
(VIN = 7V, IOUT = 2A)



Working Waveform (Input and Output Ripples)
(VIN = 12V, IOUT = 0A)



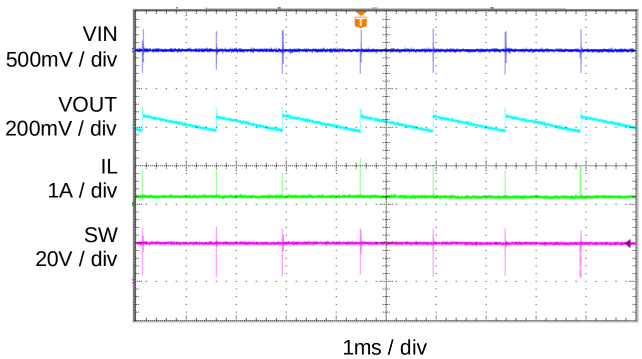
Working Waveform (Input and Output Ripples)
(VIN = 12V, IOUT = 2A)



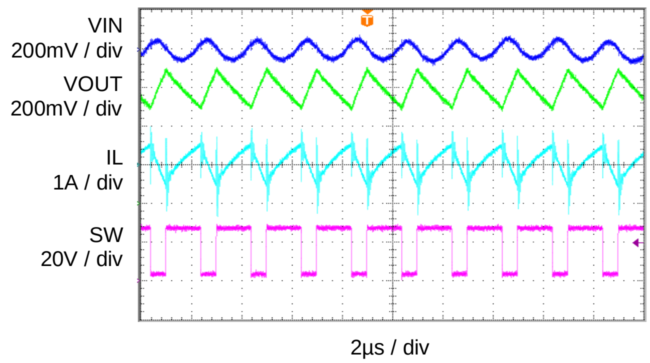
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

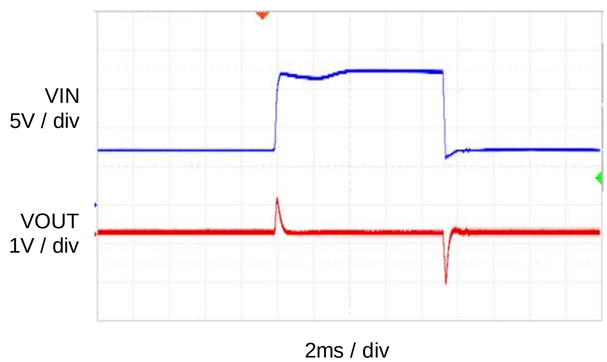
Working Waveform (Input and Output Ripples)
(VIN = 17V, IOUT = 0A)



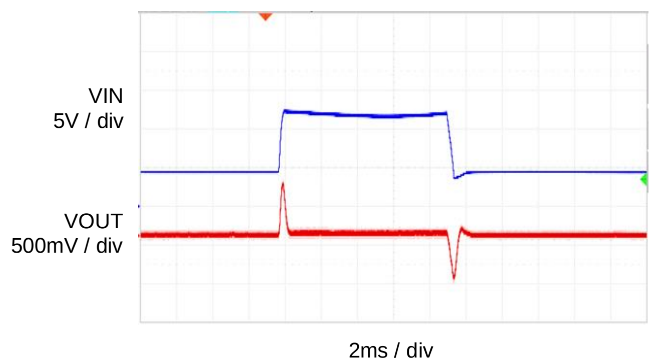
Working Waveform (Input and Output Ripples)
(VIN = 17V, IOUT = 2A)



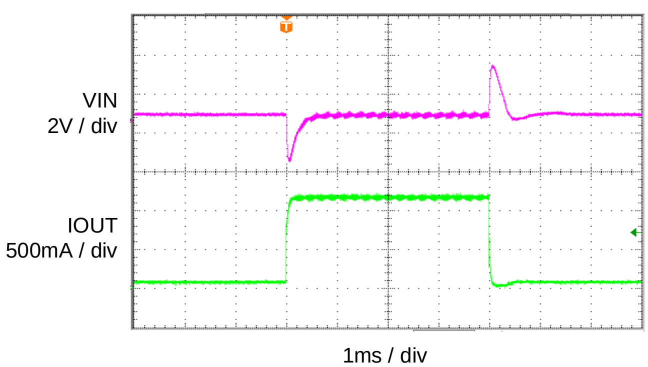
Line Transient Response
(VIN = 7V-17V, IOUT = 0.5A (tr = 236µs, td = 580µs))



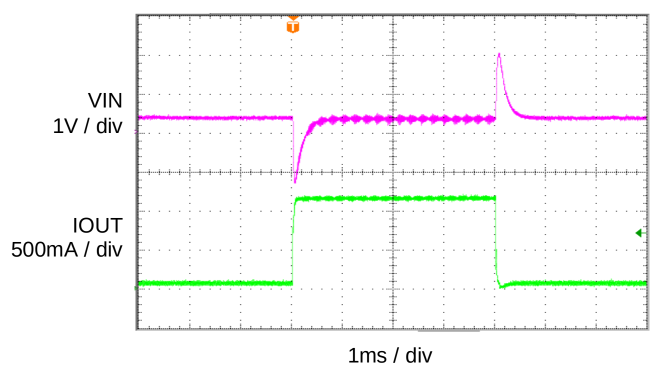
Line Transient Response
(VIN = 4V-12V, IOUT = 0.5A (tr = 230µs, td = 370µs))



Load Transient Response
(VIN = 7V, IOUT = 0.1A–1.2A (Tr = 100µs, Td = 80µs))



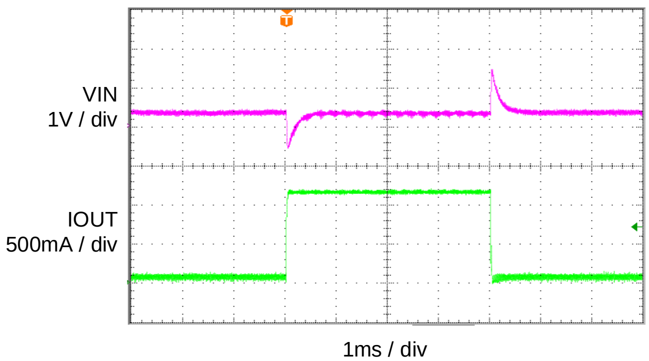
Load Transient Response
(VIN = 12V, IOUT = 0.1A–1.2A (Tr = 100µs, Td = 80µs))



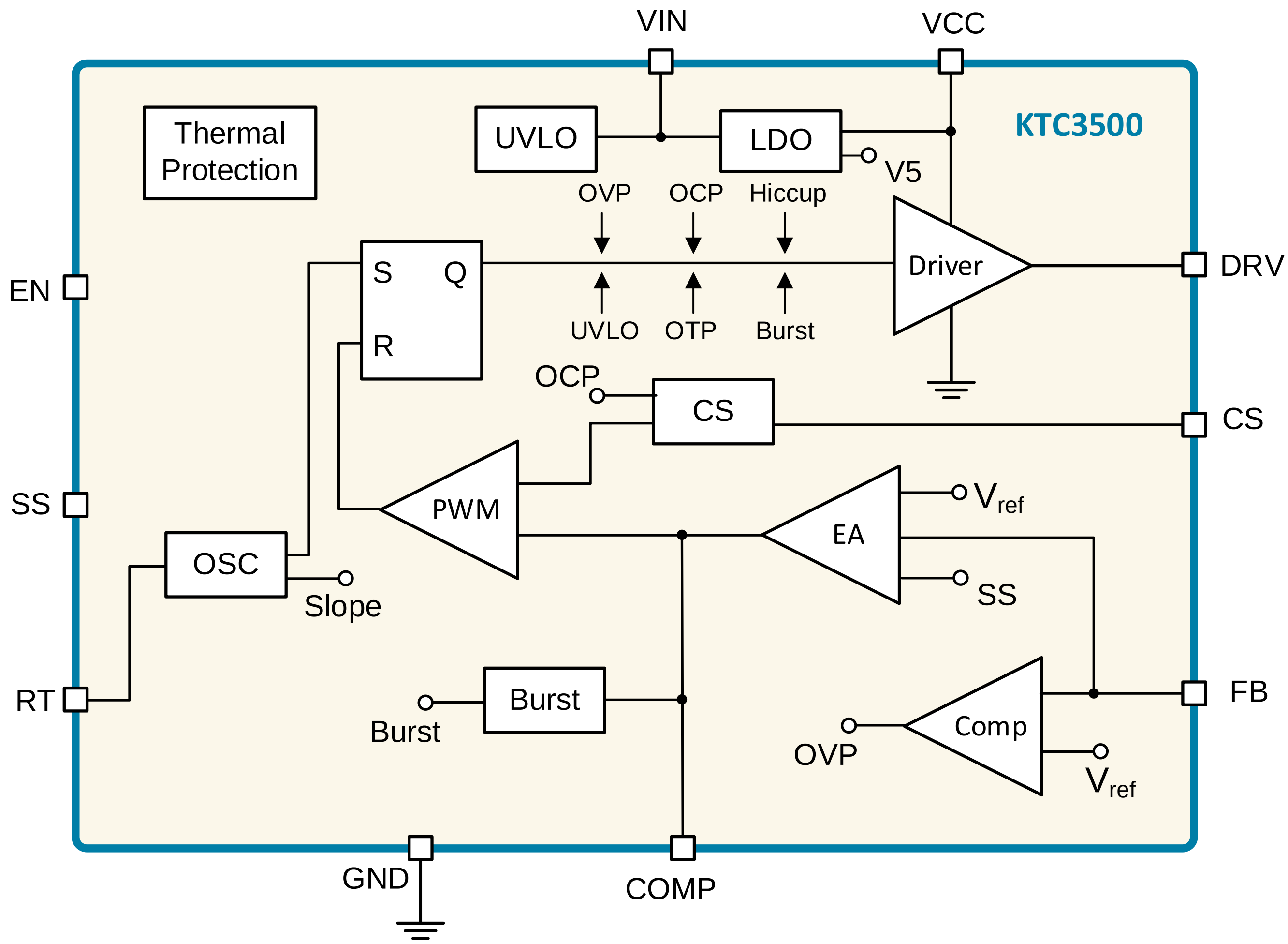
Typical Characteristics

Unless otherwise specified, V_{IN} = 12 V, T_A = 25°C.

Load Transient Response
(VIN = 17V, IOUT = 0.1A–1.2A (Tr = 100µs, Td = 80µs))



Block Diagram



Functional Description

Overview

KTC3500 is a low quiescent current DC/DC controller supporting non-synchronous boost, SEPIC, and flyback topologies. It employs current-mode control with internal slope compensation for fast transient response as well as superior output voltage regulation. The device has an adjustable switching frequency from 100kHz to 1.2MHz, which provides flexibility and allows optimized design for various application needs.

KTC3500 features an adjustable soft-start function to limit inrush current during start-up. The precision Enable/Disable can be used to set desired input under-voltage lockout threshold. The device has built-in protections including input voltage UVLO, output over-voltage-protection (OVP), cycle-by-cycle current limit, short-circuit protection and thermal shutdown. The device operates over a wide input voltage range from 3.5V to 60V with operating junction temperature range from -40°C to 125°supporting a variety of applications.

Enable

KTC3500 controller is turned on and off using the EN pin. If the EN pin is high or floating the regulator is enabled. Pulling the EN pin low will disable the regulator. EN pin maximum rating voltage allows connection to Vin pin for simple control. Enable high logic threshold is 1.24V with a 0.1V hysteresis voltage.

Connecting a resistive divider between EN and VIN sets the input start-up voltage with hysteresis and can be used to implement adjustable UVLO.

Soft-Start

To provide a controlled startup, a capacitor is required on the SS pin. At device power on, the SS capacitor is slowly charged by an internal 30µA current source, increasing the switching frequency thereby limiting the input in-rush current.

Frequency

Switching frequency can be programmed by an external resistor, connected between R_T pin to GND, as shown in circuit schematic. The switching frequency during CCM (continuous current mode), is constant and reduces during DCM (discontinuous current mode). During light load, the regulator will enter burst mode, only switching to replenish the output capacitor to save power and therefore increase the system efficiency.

Current Sense

An external resistance is required on CS pin to GND for the current sense signal function. The voltage on this pin is used for both current control loop and overcurrent detection. The overcurrent protection threshold is 80mV typical.

Feedback loop (FB and COMP Pins)

The external resistance divider from the output is used for the feedback voltage over FB pin to GND as input for the internal transconductance error amplifier. The COMP pin is the output of the same error amplifier. An external RC compensation network connected between COMP and GND pins compensates the converter control loop to provide system stability. For further details please refer to the typical application circuit schematic.

DRV

Low-side N-channel MOSFET gate driver output. Connect this pin to the gate of the low-side N-channel MOSFET. When VIN bias is removed, an internal 200kΩ resistor pulls this pin to GND.

VCC

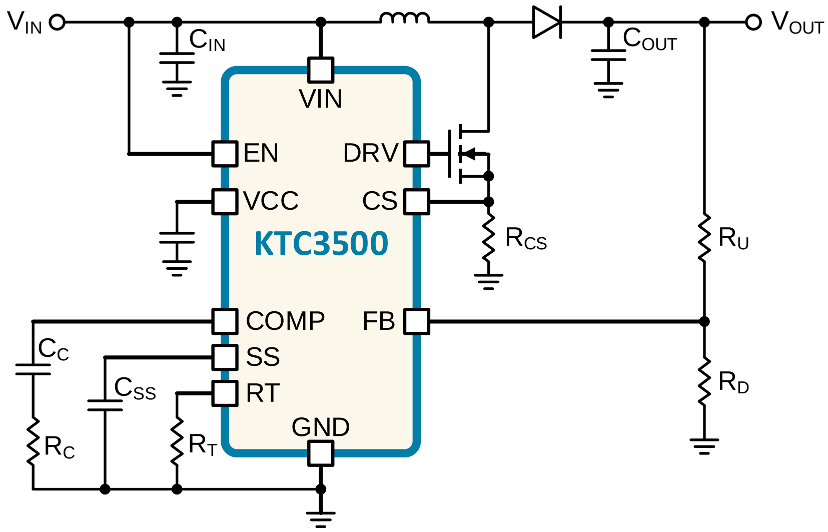
Output of an internal LDO and power supply for internal control circuits and gate drivers. VCC is typically 10V. Connect a low-ESR ceramic capacitor from this pin to GND. A capacitance ranging from 0.47µF to 10µF is recommended.

Thermal Protection

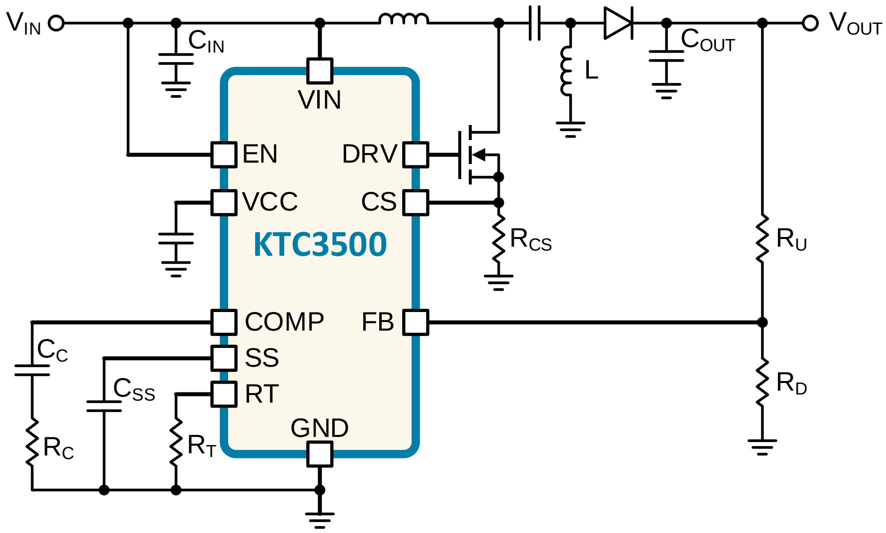
The KTC3500 provides thermal protection by the continuous monitoring of the die junction temperature. Thermal protection is triggered when the die junction temperature reaches 150°C. When the die junction temperature falls below 120°C, the KTC3500 will be turned on again.

Typical Application Circuits

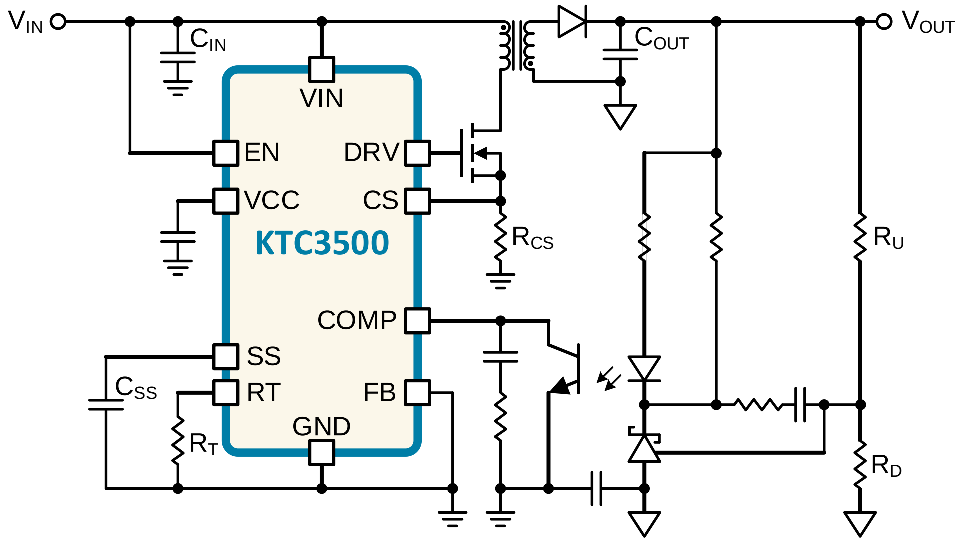
Typical application circuit of KTC3500 in non-synchronous non-Synchronous boost, SEPIC, and flyback topologies are shown below.



Application Circuit for Boost Converter



Application Circuit for Sepic Converter



Application Circuit for Flyback Converter

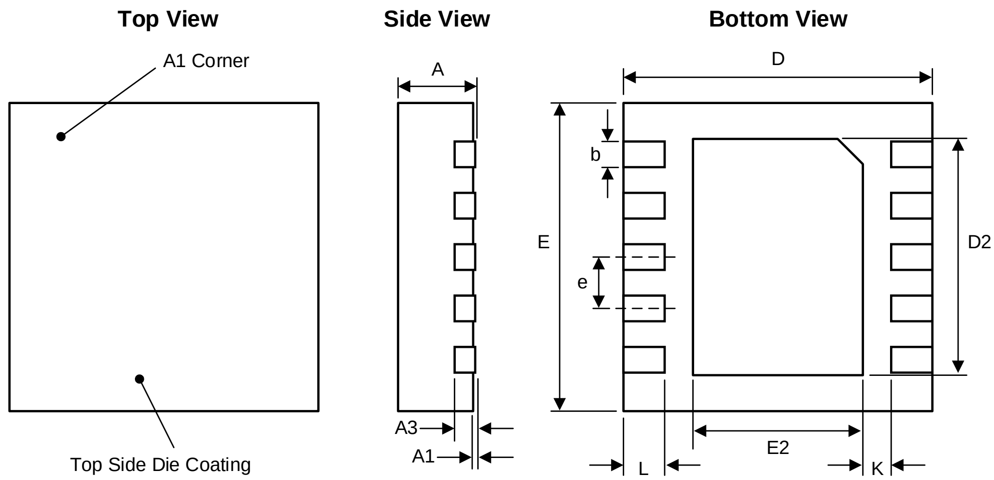
PCB Layout Guidelines

The following guidelines are recommended for optimum performance.

1. Keep the power stage loop area as small as possible.
2. Use a single point connection between signal GND and output power GND
3. Ground all the control capacitors to their respective grounds and place the control circuit capacitors close to the IC to decouple noise.
4. In Flyback circuit topology, keep the primary and secondary control circuit trace far away from noise sources (such as primary switch node and secondary switch node).
6. Keep FB and COMP pins far from high noise sources. In some high output current applications, a typically 10kΩ resistor is suggested to insert between FB pin and output resistor divider network to filter noise.
7. As snubber circuit like RCD should be used to limit peak voltage on the SW pin at turn-off.

Packaging Information

DFN33-10 (3.00mm x 3.00mm x 0.75mm)



Dimension	mm		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3	0.203 REF		
b	0.18	0.25	0.30
D	3.00 BSC		
D2	2.20	2.30	2.35
E	3.00 BSC		
E2	1.55	1.65	1.70
e	0.50 BSC		
K	0.20	–	–
L	0.30	0.40	0.50

Recommended Footprint