



CJ9482 Series

■ INTRODUCTION:

CJ9482 is a monolithic 36V,3.1A step-down switching converter. CJ9482 integrates a 36V 79mΩ high side and a 36V, 62mΩ low side MOSFETs to provide 3.1A continuous load current over a 6.5V to 36V wide operating input voltage with 33V input over voltage protection. Peak current mode control provides fast transient responses and cycle-by-cycle current limiting. Programmable soft-start prevents inrush current at power.

■ APPLICATIONS:

- Televisions
- USB car charger
- Distributed Power Systems
- DVD,LCD TVs
- Set-Top-Box
- OLPC, Netbook
- Datacom, XDSL modems
- Portable charging devices

■ FEATURES:

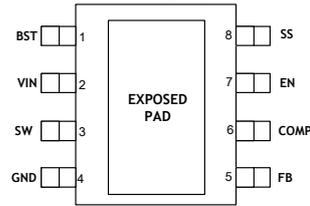
- Wide Input Range: 6.5V-36V
- With input Over Voltage Protection
- 3.1A continuous Output Current
- Programmable Soft-Start limits the inrush current at turn-on mode
- High Efficiency: Up to 95% at Light Load
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 300KHz Switching Frequency
- Input Under-Voltage Lockout
- Output Over-Voltage Protection
- 0.9V Reference for Low Output voltages
- Output short protection
- Thermal shutdown
- Available in ESOP8 Package

■ DEVICE INFORMATION:

PART NUMBER	PACKAGE
CJ9482E8	ESOP8

Electrical Characteristics

ESOP8 Package (Top View)



Pin-Functions

Pin		Description
Number	Name	
1	BST	Boot-Strap pin Connect a 0.1μF or greater capacitor between SW and BST to power the high side gate driver. Minimize BST and SW loop to reduce EMI.
2	VIN	Power Input. VIN supplies the power to the IC. Supply VIN with a 6.5V to 36V power source. Bypass VIN to GND with a large capacitor and at least another 0.1uF ceramic capacitor to eliminate noise on the input to the IC. Put the capacitors, especially 0.1uF ceramic capacitor as close as possible to VIN and GND pins. Minimize 0.1uF capacitor, VIN pin, GND pin loop to reduce EMI and voltage spike on high side power device.
3	SW	Power Switching pin. Connect this pin to the switching node of inductor.
4	GND	Ground.
5	FB	Feedback Input. FB senses the output voltage. Connect FB with a resistor divider connected between the output and ground. FB is a sensitive node. Keep FB away from SW and BST pin. It is better to connect a 47pF capacitor on FB pin to filter out possible coupling from other noisy node such as SW, BST, and VIN.
6	COMP	Connect compensation network to make the converter work stably.
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator; low to turn it off. EN pin is pulled to VIN internally by a larger resistor. No external resistor is needed to enable the part.
8	SS	This pin is used to program soft-start time, connect a cap to program soft-start time.
9	EPAD	Power ground and EPAD, for full load operation EPAD must be connected to PCB gnd.

Typical Application Schematic

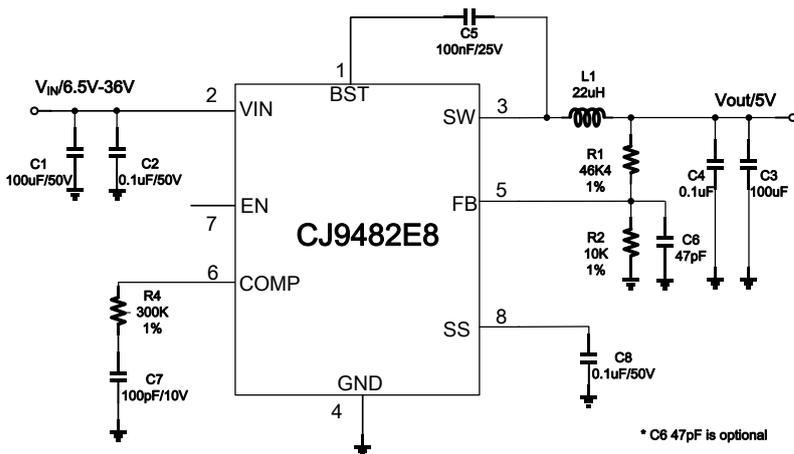


Fig. 1 Schematic

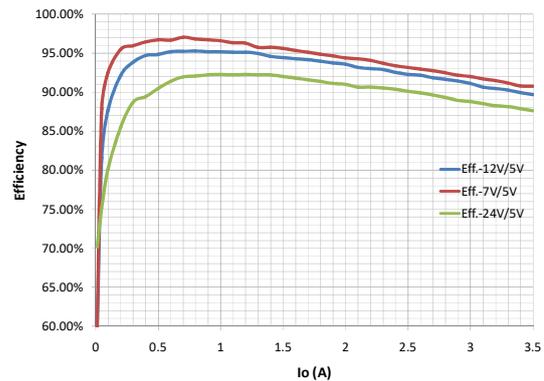


Fig. 2 Efficiency curve

Electrical Characteristics

■ Specifications

Absolute Maximum Ratings^(Note1)

PARAMETER	DEFINITION	MIN	MAX	UNIT
Input Voltages	V _{IN} to GND	-0.3	36	V
	V _{EN} to GND	-0.3	6	
	V _{SS} to GND	-0.3	6	
	V _{FB} to GND	-0.3	6	
Output Voltages	V _{BST} to V _{SW}	-0.3	6	V
	V _{SW} to GND	-1	V _{IN} + 0.3	

Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T _{ST}	Storage Temperature Range	-55	150	°C
T _J	Operating Junction Temperature		+160	°C
T _L	Soldering Temperature		+260	°C
V _{ESD}	HMB Human Body Model		2	KV
	MM Machine Mode		400	V

Recommended Operating Conditions^(Note 2)

PARAMETER	DEFINITION	MIN	MAX	UNIT
Input Voltages	V _{IN} to GND	6.5	30	V
	EN	-0.3	5	
	SS	-0.3	5	
	FB	-0.3	5	
Output Voltages	V _{OUT}	0.5	V _{IN} *D _{max}	V
Output Current	I _{OUT}	0	3.1	A
Temperature	Operating junction temperature range, T _J	-40	+125	°C

Thermal Information^(Note 3)

SYMBOL	DESCRIPTION	ESOP8	UNIT
θ _{JA}	Junction to ambient thermal resistance	56	°C/W
θ _{JC}	Junction to case thermal resistance	45	

Notes:

- 1) Exceeding these ratings may damage the device.
- 2) The device function is not guaranteed outside of the recommended operating conditions.
- 3) Measured on approximately 1" square of 1 oz copper.

Electrical Characteristics

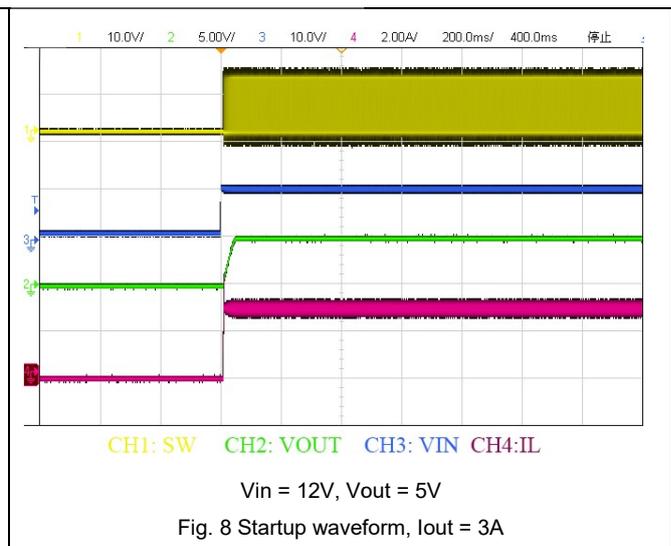
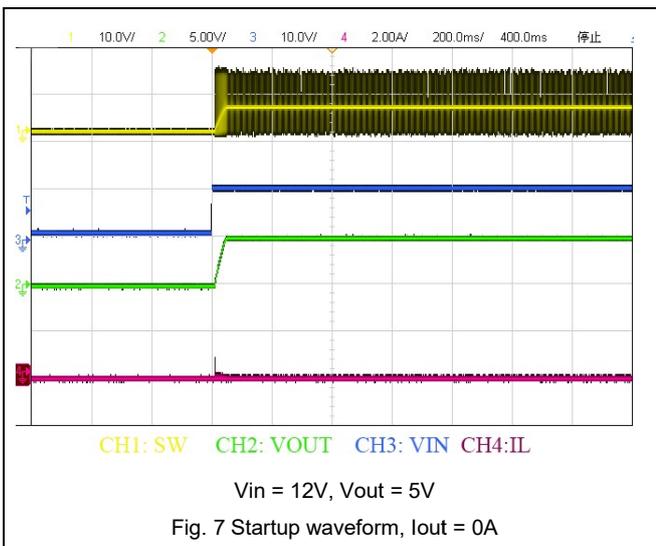
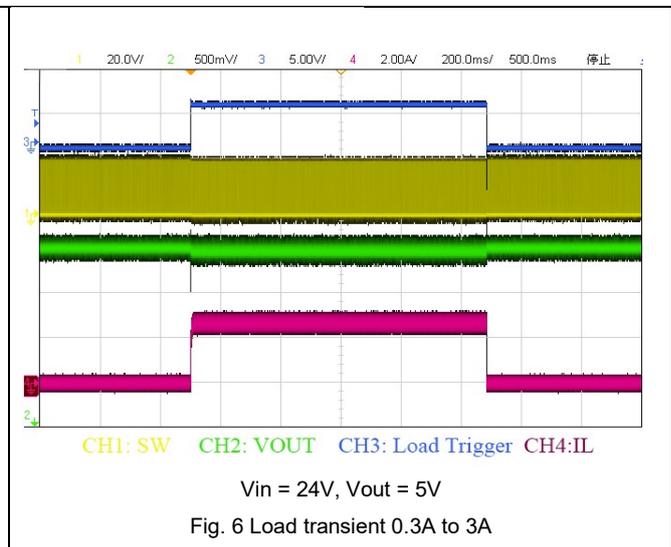
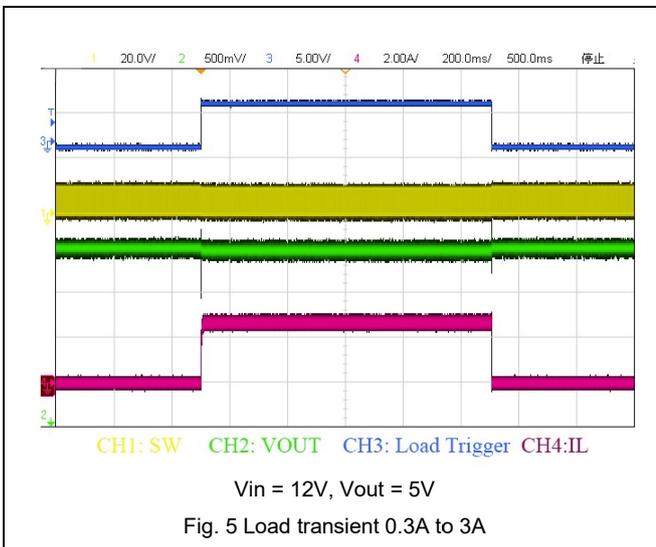
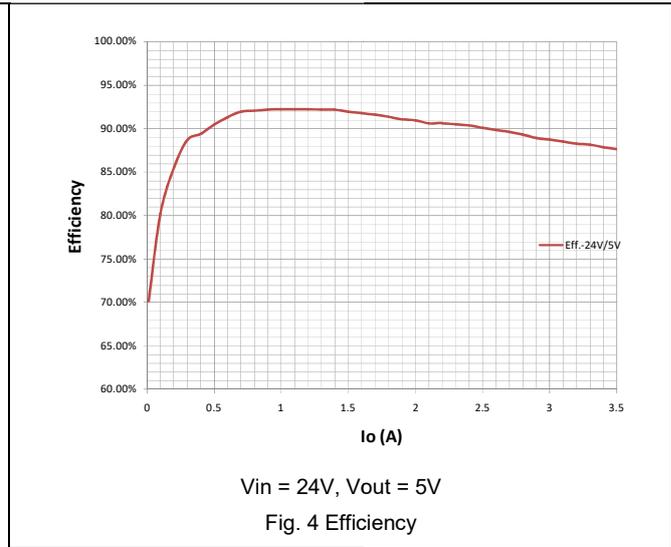
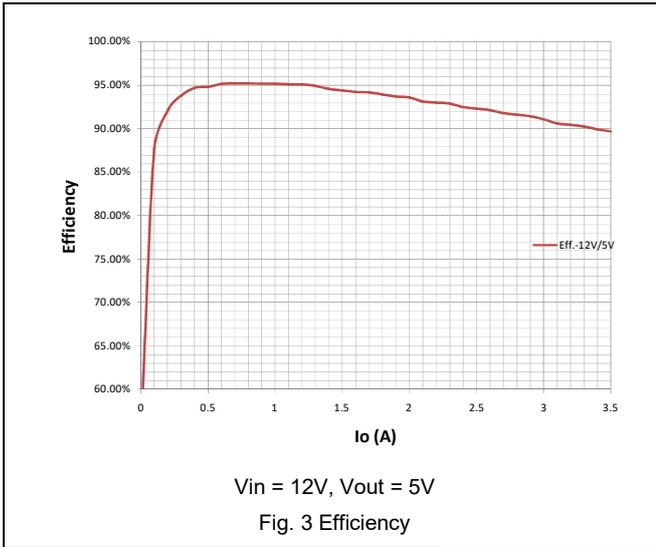
Electrical Characteristics (Typical at $V_{in} = 12V$, $T_J = 25^\circ C$ unless otherwise noted.)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
MOSFET						
I_{leak_sw}	High-Side Switch Leakage Current	$V_{EN} = 0V, V_{SW} = 0V$		0	10	μA
$R_{DS(ON)_H}$	High-Side Switch On-Resistance	$I_{OUT} = 1A, V_{OUT} = 3.3V$		79		$m\Omega$
$R_{DS(ON)_L}$	Low-Side Switch On-Resistance	$I_{OUT} = 1A, V_{OUT} = 3.3V$		62		$m\Omega$
SUPPLY VOLTAGE (VIN)						
V_{UVLO_up}	Minimum input voltage for startup				6.5	V
V_{UVLO_down}				6.0		V
V_{UVLO_hys}				0.5		V
$I_{Q-NONSW}$	Operating quiescent current	$V_{FB} = 1.1V$		1		mA
CONTROL LOOP						
F_{oscb}	Buck oscillator frequency			300		kHz
V_{FB}	Feedback Voltage	$4.5V \leq V_{IN} \leq 36V$		0.9		V
V_{FB_OVP}	Feedback Over-voltage Threshold			0.99		V
D_{max}	Maximum Duty Cycle ^(Note 4)			94		%
T_{on}	Minimum On Time ^(Note 4)			100		ns
PROTECTION						
I_{ocl_hs}	Upper Switch Current Limit	Minimum Duty Cycle		5.9		A
I_{ocl_ls}	Lower Switch Current Limit	From Drain to Source		5.5		A
V_{inovp}	Input Over voltage protection			33		V
T_{hsd}	Thermal Shutdown ^(Note 4)			155		$^\circ C$
T_{hsdhys}	Thermal Shutdown Hysteresis ^(Note 4)			15		$^\circ C$
V_{IH}	EN High Voltage		1.2			V
V_{IL}	EN Low Voltage				1.1	V
I_{EN}	EN Input Current			1.6		μA
I_{chg_ss}	Soft-Start Charge Current			2.3		μA
I_{cmp_src}	Comp Source Current	$V_{FB} = 1.0V$		5.2		μA
I_{cmp_snk}	Comp Sink Current	$V_{FB} = 0.8V$		3.2		μA

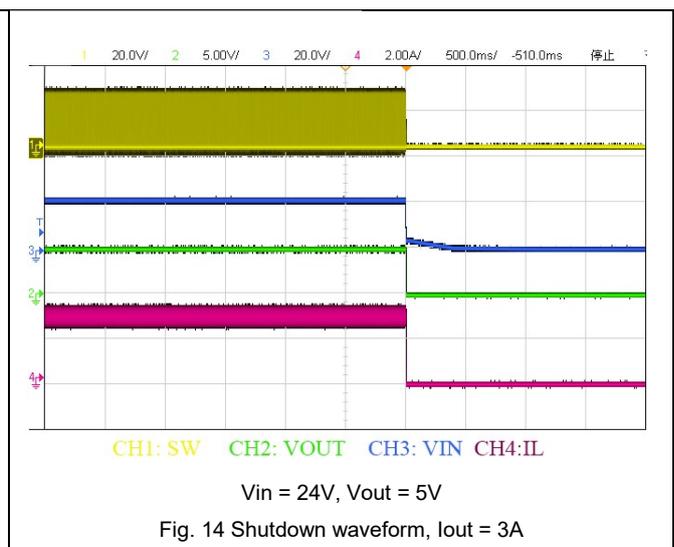
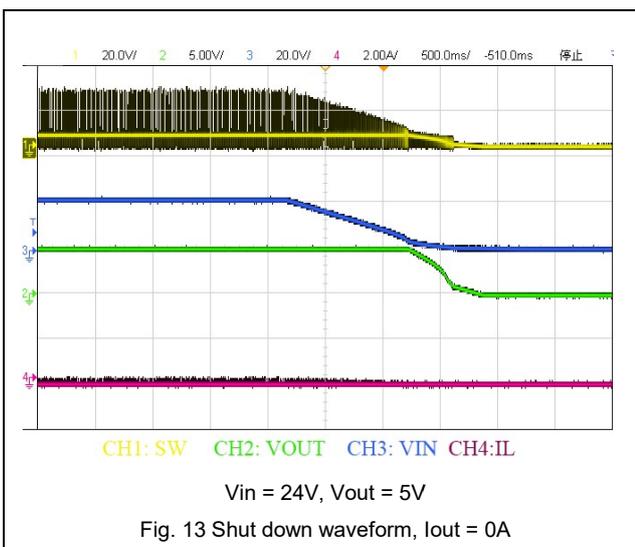
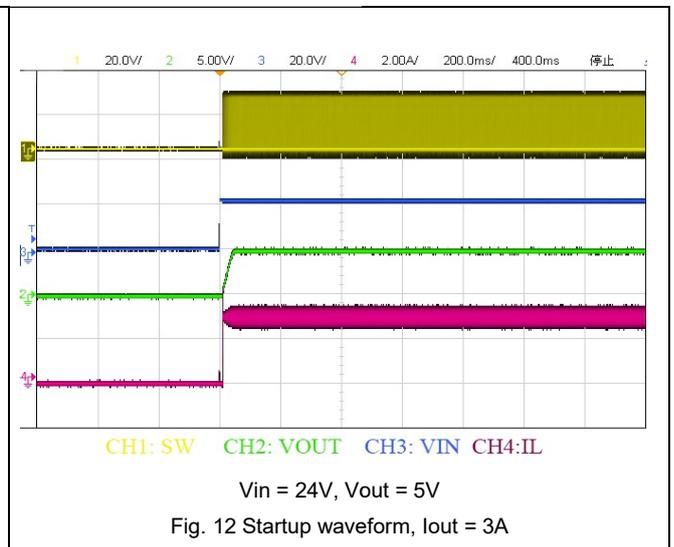
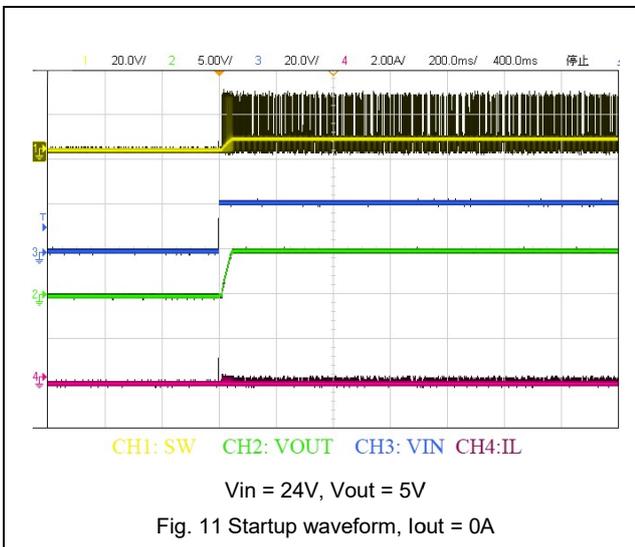
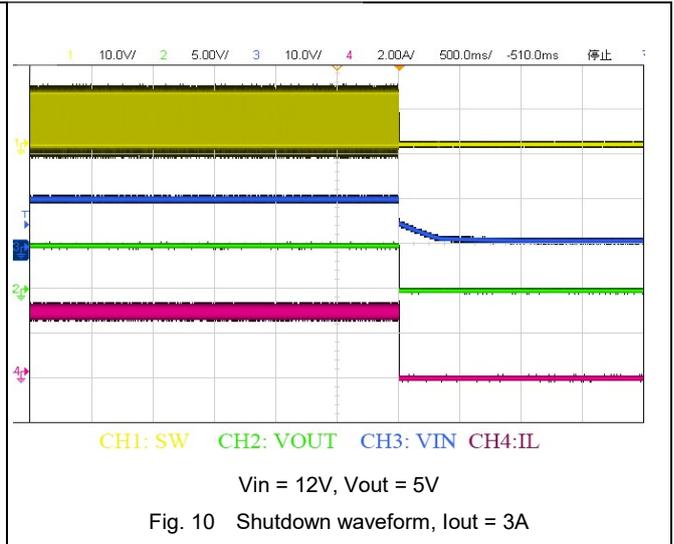
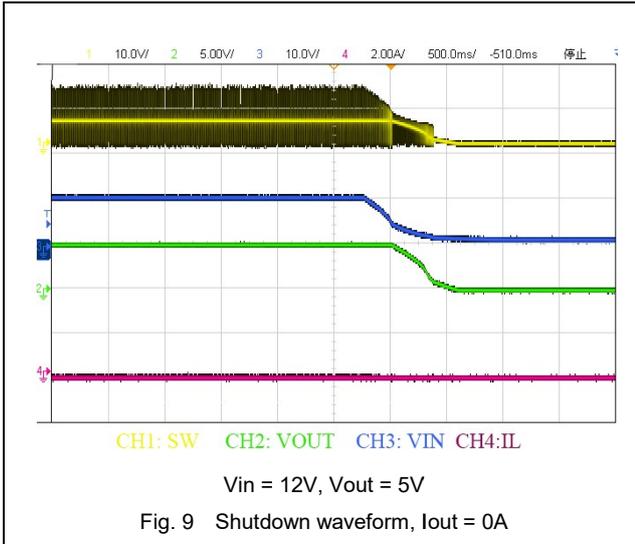
Note:

4) Guaranteed by design, not tested in production.

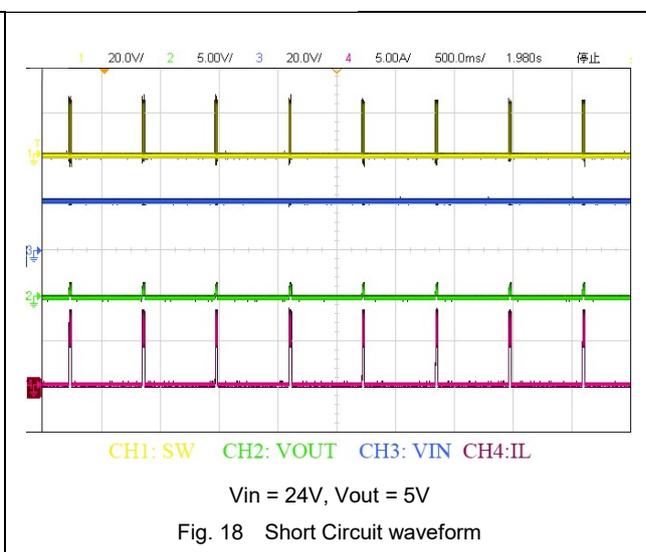
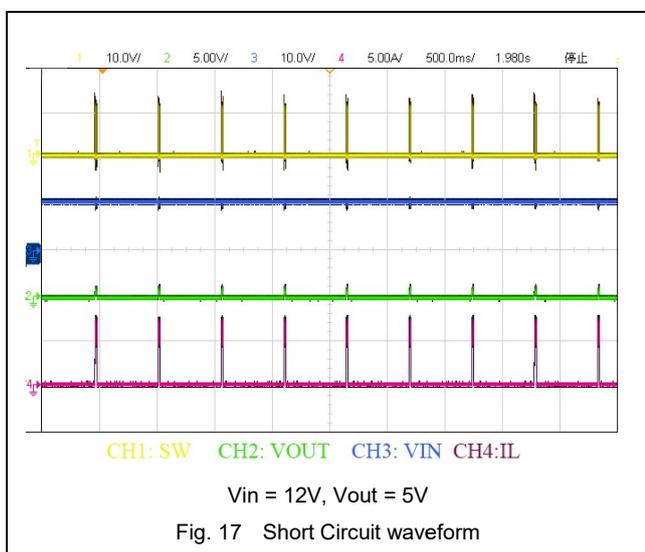
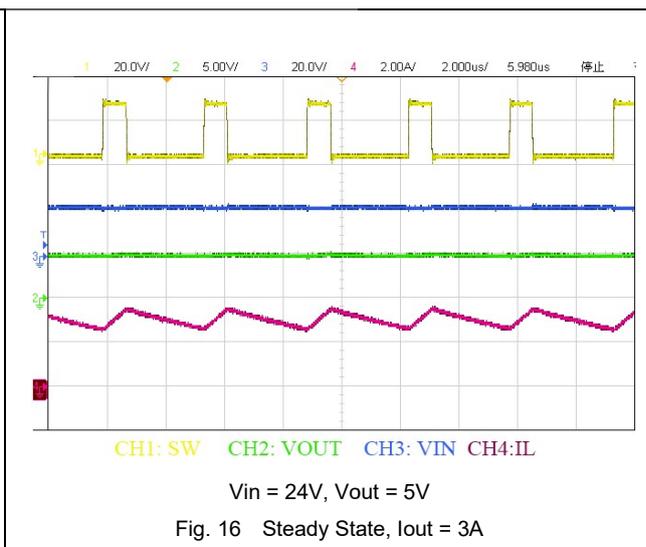
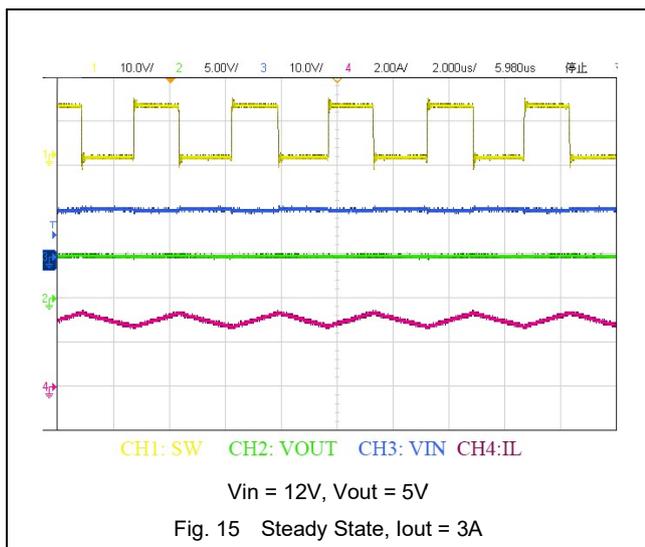
Typical Characteristics



Typical Characteristics



Typical Characteristics



Detail Description

■ Detail Description

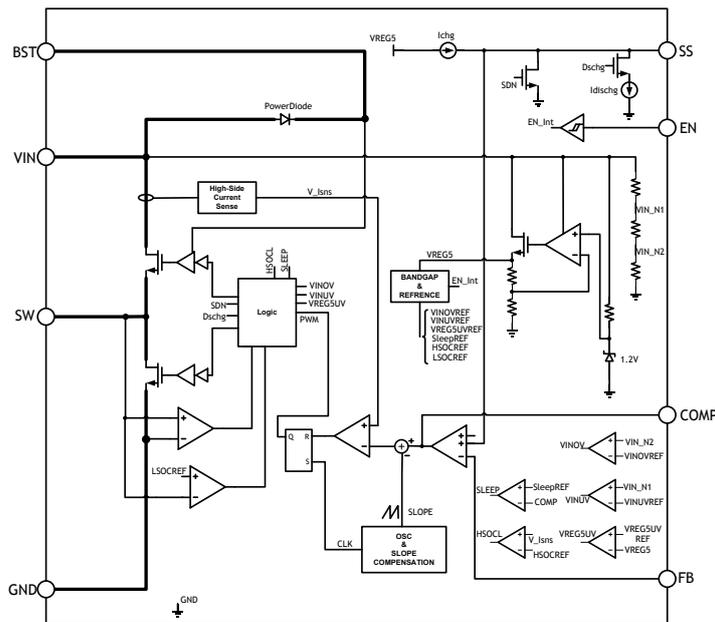
Overview

CJ9482E8 is an easy to use synchronous step-down DC-DC converter that operates from 6.5V to 36V supply voltage. It is capable of delivering up to 3.1A continuous load current with high efficiency and thermal performance in a very small solution size.

CJ9482E8 also integrates input over voltage and output over voltage protection. This feature helps customers to design a safe DC-DC converter easily.

The switching frequency is fixed at 300KHz to minimize inductor size and improve EMI performance. The soft-start time can be adjusted through SS pin capacitor.

Functional Block Diagram



CJ9482E8 Diagram

Peak Current Mode Control

CJ9482E8 employs a fixed 300KHz frequency peak current mode control. The output voltage is sensed by an external feedback resistor string on FB pin and fed to an internal error amplifier. The output of error amplifier will compare with high side current sense signal by an internal PWM comparator. When the second signal is higher than the first one, the PWM comparator will generate a turn-off signal to turn off high side switch. The output voltage of error amplifier will increase or decrease proportionally with the output load current. CJ9482E8 has a cycle-by-cycle peak current limit feature inside to help maintain load current in a safe region.

Sleep Operation for Light Load Efficiency

CJ9482E8 has an internal feature to help improving light load efficiency. When output current is low, CJ9482E8 will go into sleep mode.

Voltage Reference

Internal circuit produces a precise $\pm 1.5\%$ voltage reference over temperature supported by CJ9482E8.

Setting Output Voltage

The output voltage is set with a resistor divider from the output node to the FB pin. 1% resistance accuracy of this resistor divider is preferred. The output voltage value is set as equation 1 below (R1 is the upper resistor, R2 is the lower resistor).

$$V_{out} = V_{ref} \times \frac{R_1 + R_2}{R_2} \quad (1)$$

V_{ref} is the internal reference voltage of CJ9482E8, which is 0.9V.

Detailed Description

Setting Enable Threshold

When the voltage at EN pin exceeds the threshold, CJ9482E8 begins to work. When keeping EN low (below threshold), CJ9482E8 stops working. The quiescent current of CJ9482E8 is very low to maintain a good shut down operation for system.

CJ9482E8 has an internal pull up resistor to make sure IC work when EN pin is float. If an application requires controlling EN pin, use open drain or open collector output logic circuit to interface with it.

When system needs a higher VIN UVLO threshold, the EN pin can be configured as shown in Figure 20 below.

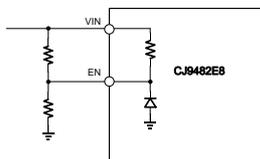


Fig. Adjustable VIN Under voltage Lockout

Error Amplifier

CJ9482E8 has a trans-conductance error amplifier. It compares FB voltage with the lower one between 0.9V reference voltage and the soft-start voltage appearing at SS pin. The frequency compensation components are placed at COMP pin.

Slope Compensation

In order to avoid sub-harmonic oscillation at high duty cycle, CJ9482E8 adds a slope compensation ramp to the sensed signal of current flowing through high side switch.

Bootstrap Voltage provided by internal LDO

CJ9482E8 has an internal LDO to provide energy consumed by high side switch. At BST pin, CJ9482E8 needs a small ceramic capacitor like 100nF between BST and SW pin to provide gate-drive voltage for high side switch. The bootstrap capacitor is charged when high side is off. In Continuous-Current-Mode, the bootstrap capacitor will be charged when low side is on. The bootstrap capacitor voltage will be maintained at about 5.3V. When IC works under sleep mode, what value the bootstrap capacitor is charged depends on the difference of VIN and output voltage. However, when the voltage on the bootstrap capacitor is below bootstrap voltage refresh threshold, CJ9482E8 will force low side on to charge bootstrap capacitor. Connecting an external diode from the output of regulator to the BST pin will also work and increase the efficiency of the regulator when output is high enough.

In order to improve EMI performance, a resistor can be connected between BST pin and bootstrap capacitor to slow down the turn-on speed of high side power switch.

Soft-Start and Hiccup

CJ9482E8 needs a capacitor at SS pin to support soft-start function. The soft-start time can be adjusted by setting different soft-start capacitor at this pin. There is an internal 2.3uA current to charge SS capacitor when it starts to work. The capacitor is also used to configure the short circuit hiccup rest time. After soft-start period is ended, when $V_{FB} < 0.3V$, CJ9482E8 will go into hiccup mode to limit average load current. CJ9482E8 will exit hiccup mode once the over current condition is removed.

High Side Over-Current Protection

In CJ9482E8, high-side MOSFET current is sensed. This sensed signal will compare the lower voltage between COMP pin voltage and over current threshold. High-side MOSFET will be turned off when the sensed current reaches the lower voltage. In normal operation, COMP pin voltage will be lower. If the over current threshold is lower, CJ9482E8 enters over current protection mode.

Over-Current Protection

When the low-side MOSFET is turned on, the conduction current is monitored and the SW voltage is sensed. When the difference between GND and SW is higher than an internal threshold, it means CJ9482E8 is under over current mode. The high side switch won't be turned on until low side MOSFET's current is lower than the over current limit.

When the low side MOSFET current reaches zero, it will be immediately turned off to improve conversion efficiency.

Thermal Shutdown

The internal thermal-shutdown circuitry forces the device to stop switching if the junction temperature exceeds 155°C typically. When the junction temperature drops below 140°C, IC will start to work again.

Application and Implementation

■ Application and Implementation

Inductor Selection

An inductor is required to supply constant current to the load while being driven by the switched input voltage. A larger value inductor will result in less current ripple and lower output voltage ripple. However, the larger value inductor will have larger physical size, higher DC resistance, and/or lower saturation current. A good rule to calculate the inductance is to allow the peak-to-peak ripple current in the inductor to be approximately 25% of the maximum load current. At the same time, it is needed to make sure that the peak inductor current is below the inductor saturation current. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_s \times \Delta L} \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \quad (2)$$

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

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

$$I_{L_P} = I_{load} + \frac{V_{OUT}}{2 \times f_s \times L} \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \quad (3)$$

Where I_{load} is the load current.

The choice of inductor material mainly depends on the price vs. size requirements and EMI constraints.

Optional Schottky Diode

During the transition between the high-side switch and low-side switch, the body diode of the low-side power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled with low side MOSFET to improve overall efficiency. Table 2 lists example Schottky diodes and their Manufacturers.

Table 2 – Diode Selection Guide

Part Number	Voltage/Current Rating	Vendor
SS26	60V/2A	JSCJ
SS24	40V/2A	JSCJ

Input Capacitors Selection

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the converter. It is recommend to use low ESR capacitors to optimize the performance. Ceramic capacitor is preferred, but tantalum or low-ESR electrolytic capacitors may also meet the requirements. It is better to choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C_{IN}) absorbs the input switching current, a good ripple current rating is required for the capacitor. The RMS current in the input capacitor can be estimated by:

$$I_{CIN} = I_{load} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}} \right)} \quad (4)$$

The worst-case condition occurs at $V_{IN} = 2 \times V_{OUT}$, where:

$$I_{CIN} = \frac{I_{load}}{2} \quad (5)$$

For simplification, choose the input capacitor whose RMS current rating is greater than half of the maximum load current. When electrolytic or tantalum capacitors are used, a small, high quality ceramic capacitor, i.e. 0.1 μ F, should be placed as close to the IC as possible. When ceramic capacitors are used, make sure that they have enough capacitance to maintain voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta V_{IN} = \frac{I_{load}}{f_s \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \quad (6)$$

C_{IN} is the input capacitance.

Output Capacitors Selection

The output capacitor (C_{OUT}) 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:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_s \times C_{OUT}}\right) \quad (7)$$

Where L is the inductor value, R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor and C_{OUT} is the output capacitance value. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly determined by the capacitance. For simplification, the output voltage ripple can be estimated by:

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

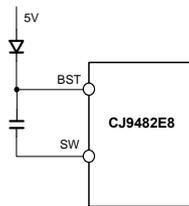
In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR} \quad (9)$$

The characteristics of the output capacitor also affect the stability of the regulator. CJ9482E8 is optimized for a wide range of capacitance and ESR values.

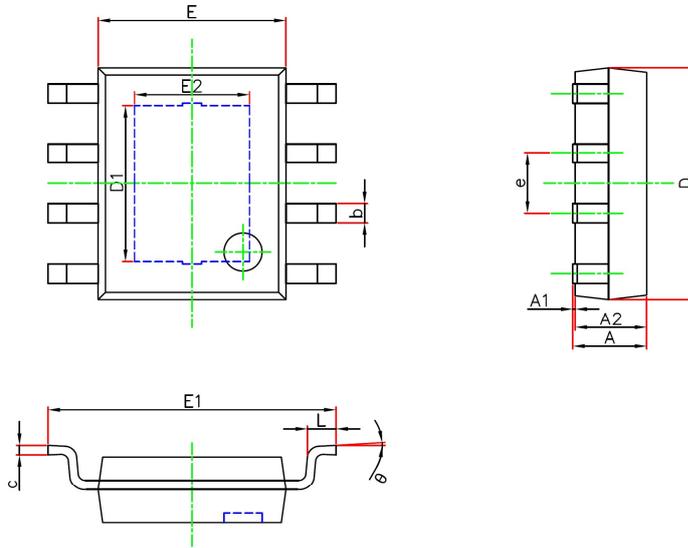
External Bootstrap Diode

It is recommended that an external bootstrap diode could be added when the system has a 5V fixed input or the power supply generates a 5V output. This helps improve the efficiency of the regulator. The bootstrap diode can be a low cost one such as IN4148 or BAT54.



This diode is also recommended for high duty cycle operation (when $(V_{OUT}/V_{IN}) > 65\%$) and high output voltage ($V_{OUT} > 12V$) applications.

ESOP8 Package Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.300	1.700	0.051	0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
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°

NOTICE

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