

30V,2.5A Step-Down Switching Regulator

1 Features

- 2.5A continuous output current capability
- 6.5V to 30V wide operating input range with 33V input Over Voltage Protection
- Integrated 36V, 86mΩ high side and 36V, 74mΩ low side power MOSFET switches
- Up to 95% efficiency
- Programmable Soft-Start limits the inrush current at turn-on
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 300KHz Switching Frequency
- Input Under-Voltage Lockout. Output Over-Voltage Protection
- Over-Temperature Protection
- Thermally Enhanced ESOP-8 Package

- DVD, LCD Displays
- OLPC, Netbook
- Datacom, XDSL modems
- Distributed Power Systems
- USB car charger
- Portable charging device
- General purpose

3 Description

HM1482C is a monolithic 30V, 2.5A step-down switching regulator. HM1482C integrates a 36V 86mΩ high side and a 36V, 74mΩ low side MOSFETs to provide 2.5A continuous load current over a 6.5V to 30V wide operating input voltage with 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-up.

2 Applications

- Set-Top-Box
- Televisions

4 Typical Application Schematic & Efficiency

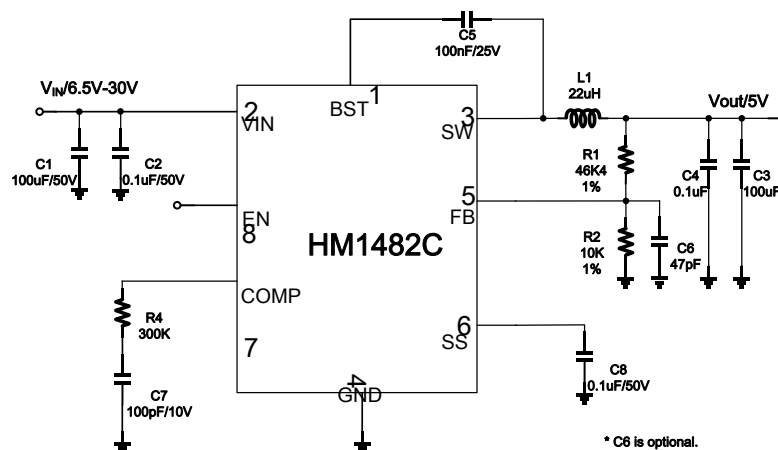


Fig. 1 Schematic

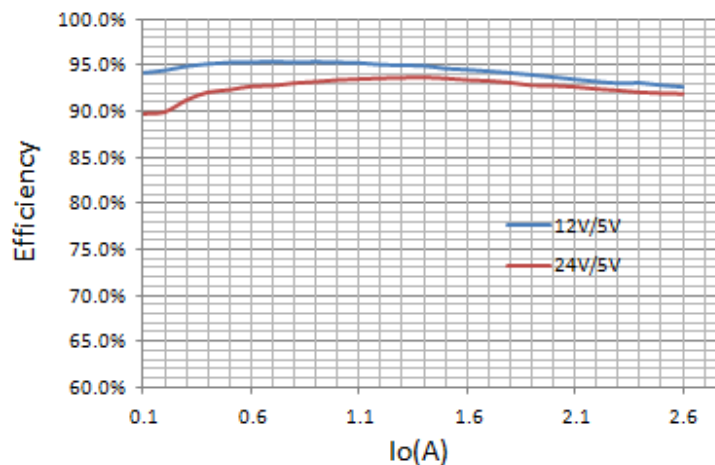
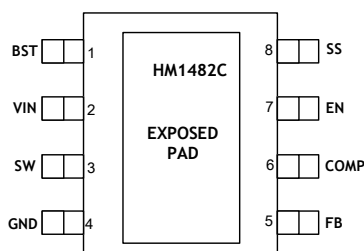


Fig. 2 Efficiency curve

5 Pin Configuration and Functions

ESOP-8 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.
2	VIN	Power Input. Vin supplies the power to the IC. Supply Vin with a 6.5V to 30V 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 close to Vin and GND pins.
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 ceramic capacitor between FB pin and GND pin.
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.
8	SS	This pin is used to program soft-start time, connect a cap to program soft-start time.

6 Device Marking Information

Part Number	Order Information	Package	Package Qty	Top Marking
HM1482C	HM1482C	ESOP-8	2500	HM1482C YYWW

HM1482C:Part Number
YYWW:Manufacturing Code

7 Specifications

7.1 Absolute Maximum Ratings^(Note1)

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

7.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T _{ST}	Storage Temperature Range	-65	150	°C
T _J	Junction Temperature		+150	°C
T _L	Lead Temperature		+260	°C
V _{ESD}	HBM Human body model		2	kV
	MM Charger device model		500	V

7.3 Recommended Operating Conditions ^(Note 2)

	PARAMETER	MIN	MAX	Unit
Input Voltages	V _{IN} to GND	6.5	30	V
	FB	-0.3	6	
	EN	-0.3	6	
Output Voltages	V _{OUT}	0.5	V _{IN} *D _{max}	V
Output Current	I _{OUT}	0	3.0	A
Temperature	Operating junction temperature range, T _J	-40	+125	°C

7.4 Thermal Information ^(Note 3)

Symbol	Description	ESOP-8	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.

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

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
BUCK CONVERTER						
MOSFET						
$R_{DS(ON)_H}$	High-Side Switch On-Resistance	$I_{OUT} = 1A$, $V_{OUT} = 3.3V$		86		mΩ
$R_{DS(ON)_L}$	Low-Side Switch On-Resistance	$I_{OUT} = 1A$, $V_{OUT} = 3.3V$		74		mΩ
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	$V_{FB} = 1.2V$		1		mA
CONTROL LOOP						
F_{osc}	Buck oscillator frequency			300		kHz
V_{FB}	Feedback Voltage			0.9		V
V_{FB_OVP}	Feedback Over-voltage Threshold			$1.1 * V_{FB}$		V
D_{max}	Maximum Duty Cycle ^(Note 4)			94		%
T_{on}	Minimum On Time ^(Note 4)			200		ns
PROTECTION						
I_{ocl_hs}	Upper Switch Current Limit	Minimum Duty Cycle		4.9		A
I_{ocl_ls}	Lower Switch Current Limit	From Drain to Source		4.5		A
V_{inovp}	Input Over voltage protection			33		V
I_{chg_ss}	Soft-Start Charge Current			3.9		uA
Th_{sdhys}	Thermal Shutdown Hysteresis ^(Note 4)			15		°C
D_{hiccup}	Hiccup duty cycle ^(Note 4)			10		%

Note:

4) Guaranteed by design, not tested in production.

8 Typical Characteristics

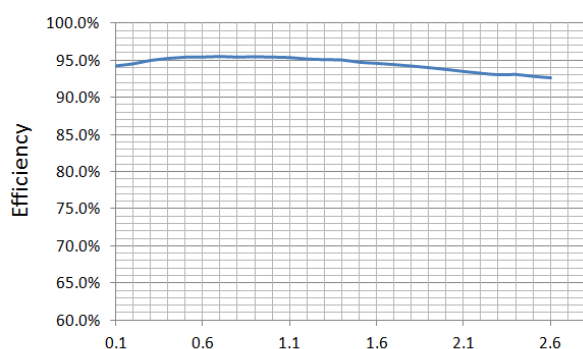


Fig. 3 Efficiency
Vin = 12V, Vout = 5V

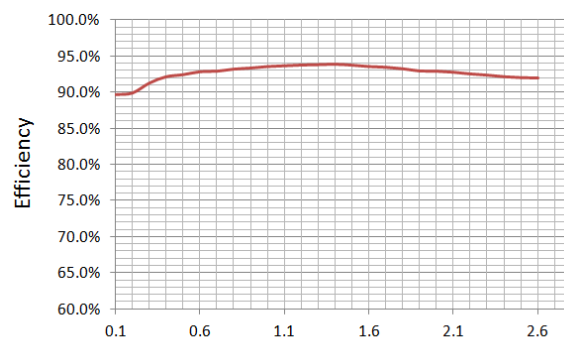


Fig. 4 Efficiency
Vin = 24V, Vout = 5V

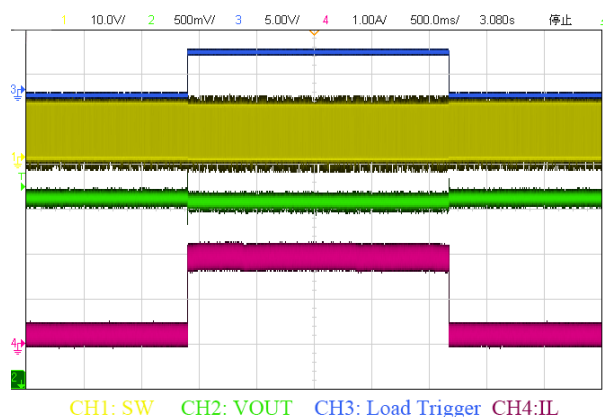


Fig. 5 Load transient 0.25A to 2A
Vin = 12V, Vout = 5V

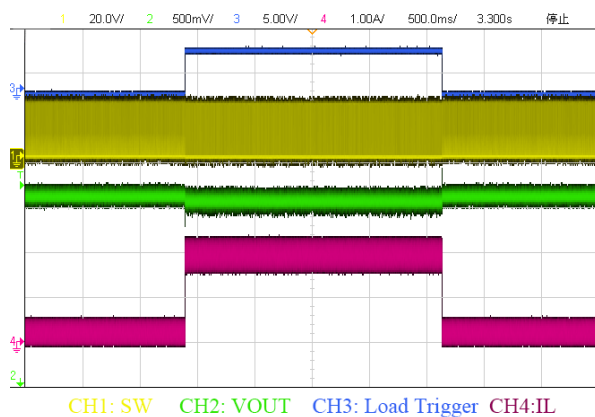


Fig. 6 Load transient 0.25A to 2A
Vin = 24V, Vout = 5V

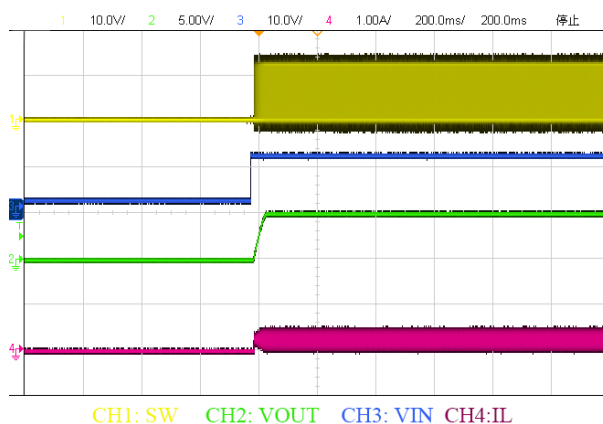


Fig. 7 Startup waveform, Iout = 0.25A
Vin = 12V, Vout = 5V

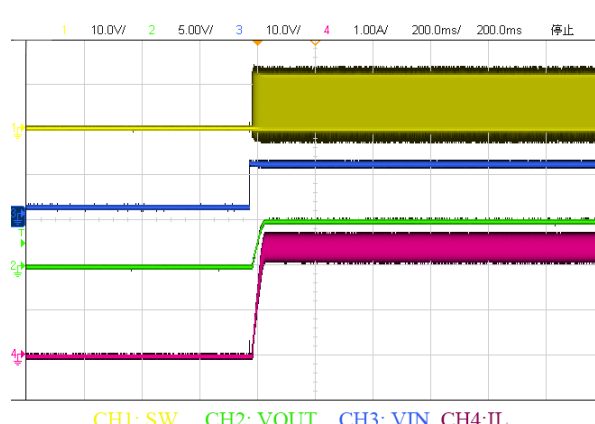


Fig. 8 Startup waveform, Iout = 2.4A
Vin = 12V, Vout = 5V



Fig. 9 Shutdown waveform, $I_{out} = 0.25A$



Fig. 10 Shutdown waveform, Iout = 2.4A



Fig. 11 Startup waveform, $I_{out} = 0.25A$



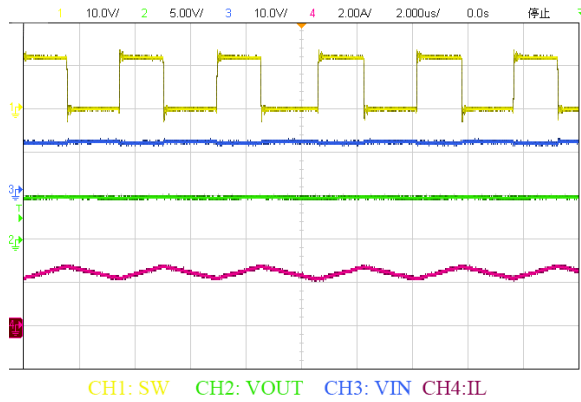
Fig. 12 Startup waveform, $I_{out} = 2.4A$



Fig. 13 Shut down waveform, $I_{out} = 0.25A$

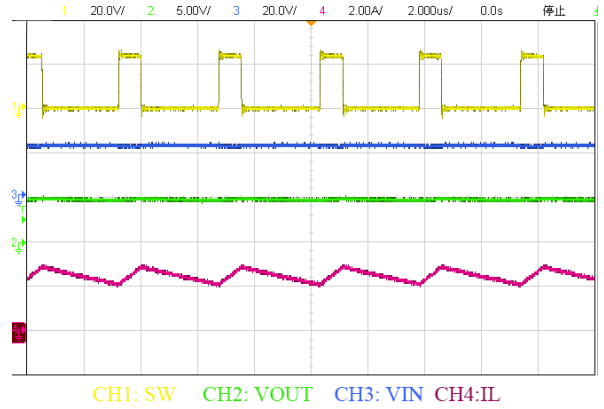


Fig. 14 Shutdown waveform, Iout = 2.4A



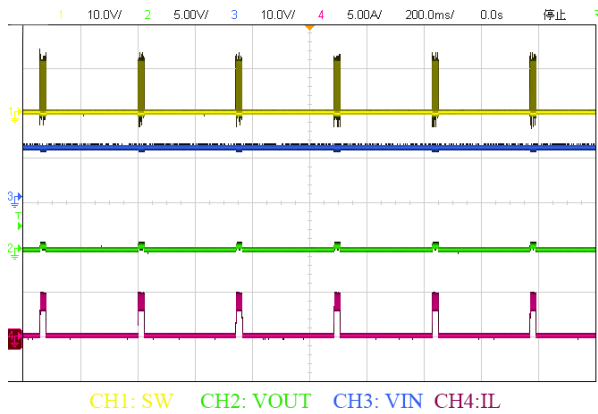
Vin = 12V, Vout = 5V

Fig. 15 Steady State, Iout = 2.4A



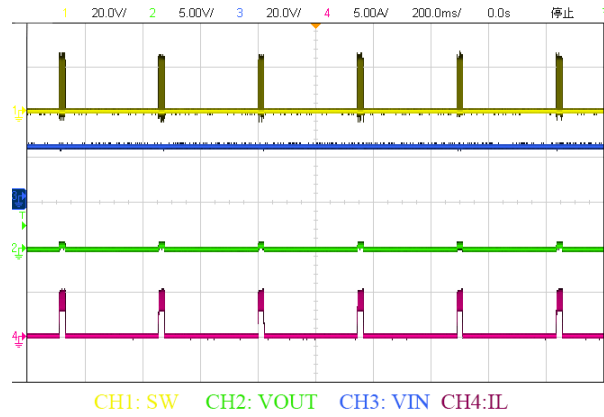
Vin = 24V, Vout = 5V

Fig. 16 Steady State, Iout = 2.4A



Vin = 12V, Vout = 5V

Fig. 17 Short Circuit waveform



Vin = 24V, Vout = 5V

Fig. 18 Short Circuit waveform

9 Detailed Description

9.1 Overview

HM1482C is an easy to use synchronous step-down DC-DC converter that operates from 6.5V to 30V supply voltage. It is capable of delivering up to 2.5A continuous load current with high efficiency and thermal performance in a very small solution size.

HM1482C employs fixed frequency peak current mode control to regulate the output voltage. The device is internally compensated, which reduces design time, and requires fewer external components. The switching frequency is fixed at 300 kHz to minimize inductor size and improve EMI performance.

9.2 Functional Block Diagram

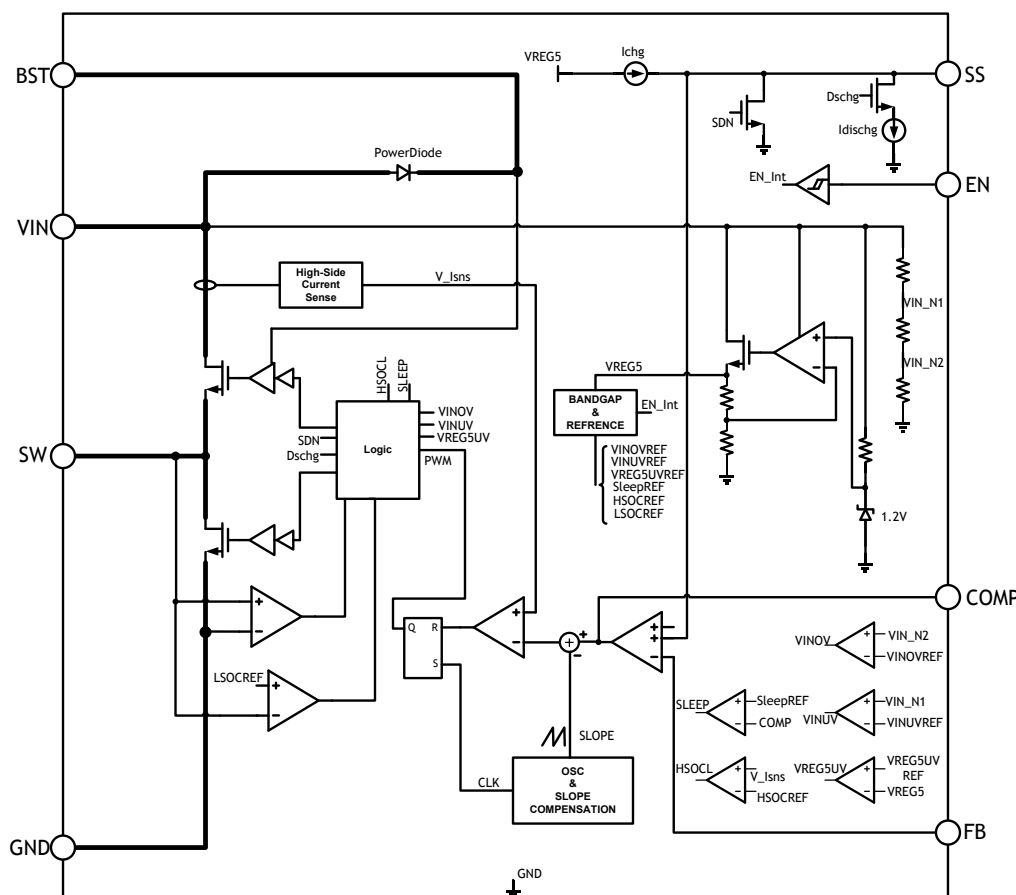


Fig.19 HM1482C Diagram

9.3 Peak Current Mode Control

HM1482C employs a fixed 300 kHz 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. HM1482C has a cycle-by-cycle peak current limit feature inside to help maintain load current in a safe region.

9.4 Sleep Operation for Light Load Efficiency

HM1482C has an internal feature to help improving light load efficiency. When output current is low, HM1482C will go into sleep mode.

9.5 Setting Output Voltage

The output voltage is set with a resistor divider from the output node to the FB pin. The 1% resistance accuracy of this resistor divider is preferred. The output voltage value is set as equation (3) below. It is recommended to make $R2/R1=3.16$:

V_{ref} is the internal reference voltage of HM1482C, which is 1.2V.

9.6 Error Amplifier

The error amplifier compares the FB voltage against the internal reference (V_{ref}) and outputs a current proportional to the difference between these two signals. This output current charges or discharges the internal compensation network to generate the error amplifier output voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control-loop design.

9.7 Slope Compensation

In order to avoid sub-harmonic oscillation at high duty cycle, HM1482C adds a slope compensation ramp to the sensed signal of current flowing through high side switch.

9.8 Bootstrap Voltage provided by internal LDO

HM1482C has an internal LDO to provide energy consumed by high side switch. At BST pin, HM1482C 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 V_{in} and output voltage. However, when the voltage on the bootstrap capacitor is below bootstrap voltage refresh threshold, HM1482C 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.

9.9 Soft-Start

Connect a capacitor on SS pin to program soft-start time. HM1482C has a soft-start function to control the ramp up speed of output voltage and limit the input current surge during IC start-up.

9.10 Over-Current Protection and Hiccup

HM1482C has cycle-by-cycle peak current limit for both high side and low side switch. When high side switch current is higher than high side current limit, high side switch will be turned off. HM1482C will not turn on high side switch again until low side switch current is lower than low side switch current limit.

9.11 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.

9.12 Enable

HM1482C can be enabled by EN pin. EN pin internal threshold is set at 1V. Customer can adjust the startup voltage at input pin by this EN pin through resistor divider.

9.7 Setting Enable Threshold

HM1482C has an internal pull up resistor to make sure IC work when EN pin is float. If an application requires to control EN pin, use open drain or open collector output logic circuit to interface with it.

When system needs a higher V_{IN} UVLO threshold, the EN pin can be configured as shown in Figure 5 below.

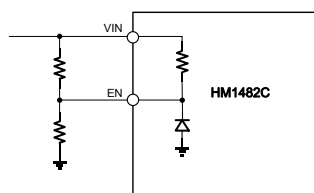


Fig.21 Adjustable V_{IN} Under voltage Lockout

10 Application and Implementation

10.1 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:

$$\frac{V_{OUT}}{f_s} \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (3)$$

Where V_{OUT} is the output voltage, V_{IN} is the input voltage, f_s is the switching frequency, and Δ_L 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:

$$I_{load} + \frac{V_{OUT}}{f_s} \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (4)$$

Where I_{load} is the load current.

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

10.2 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
SS25FA	50V/2A	Fairchild
B240A	40V/2A	Vishay

10.3 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:

$$I_{load} \sqrt{\frac{V_{OUT}}{V_{IN}} \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \quad (5)$$

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

$$\frac{I_{load}}{2} \quad (6)$$

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:

$$\frac{I_{load}}{f_s} \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (7)$$

C_{IN} is the input capacitance.

10.4 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:

$$\frac{L}{f_s} \left(1 - \frac{1}{f_s} \right) \left(\frac{1}{f_s} \right) \quad (8)$$

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:

$$\frac{L}{f_s} \left(1 - \frac{1}{f_s} \right) \quad (9)$$

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:

$$\frac{L}{f_s} \left(1 - \frac{1}{f_s} \right) \quad (10)$$

The characteristics of the output capacitor also affect the stability of the regulator. PL8 is optimized for a wide range of capacitance and ESR values.

10.5 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.

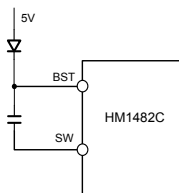


Fig. 22 External Bootstrap Diode

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

11 PCB Layout

11.1 Guideline

PCB layout is a critical portion of good power supply design. The following guidelines will help users design a PCB with the best power conversion efficiency, thermal performance, and minimized EMI.

1. The feedback network, resistor R_1 and R_2 , should be kept close to FB pin. V_{out} sense path should stay away from noisy nodes, such as SW and BST signals and preferably through a layer on the other side of shielding layer.
2. The input bypass capacitor C_1 and C_2 must be placed as close as possible to the V_{IN} pin and ground. Grounding for both the input and output capacitors should consist of localized top side planes that connect to the GND pin and PAD. It is a good practice to place a ceramic cap near the V_{IN} pin to reduce the high frequency injection current.
3. The inductor L should be placed close to the SW pin to reduce magnetic and electrostatic noise.
4. The output capacitor, C_{OUT} should be placed close to the junction of L and the diode D. The L, D, and C_{OUT} trace should be as short as possible to reduce conducted and radiated noise and increase overall efficiency.
5. The ground connection for C_1 , C_2 and C_3 , C_4 should be as small as possible and connect to system ground plane at only one spot (preferably at the C_{OUT} ground point) to minimize injecting noise into system ground plane.

11.2 Example

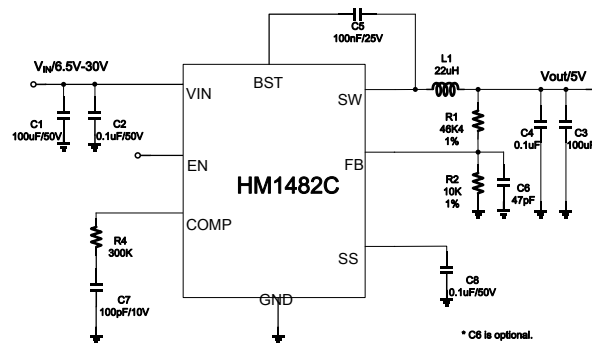


Fig. 23 Schematic

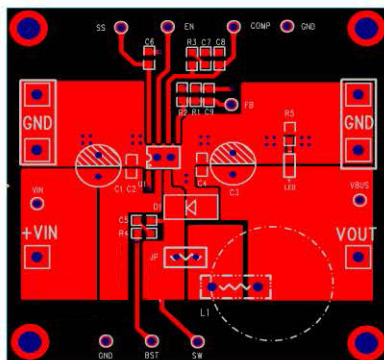


Fig. 24 Top layer layout

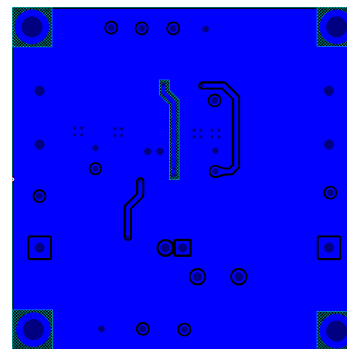
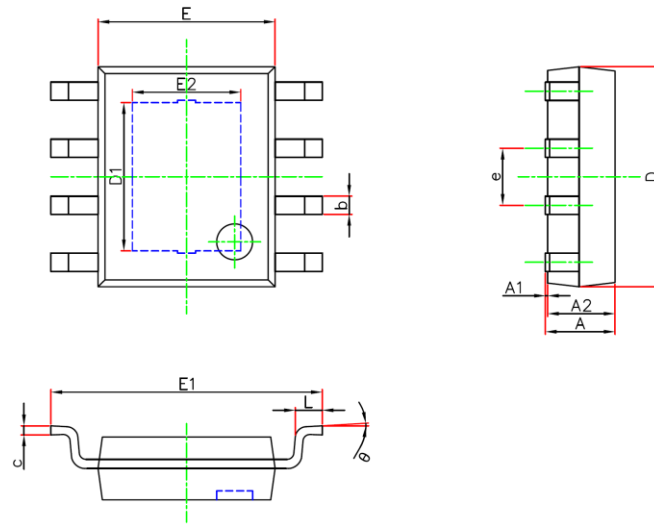


Fig. 25 Bottom layer layout

12 Packaging Information

SOP8/PP (95×130) 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°

13 Taping Orientation

